pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF CLEAN WATER

Susquehanna River at Rockville, 2013 to 2016

Continuous Instream Monitoring Report

Prepared by: Mark Hoger
October 21, 2019

WATERBODY AND SITE DESCRIPTIONS

Stream Code: 06685
Steam Name: Susquehanna River
HUC: 02050305 – Lower Susquehanna-Swatara

West Site Description
Site Code: 133783592-002
Site Name: Susquehanna River at Rockville (West)
Latitude: 40.33368 **Longitude:** -76.91709
Off a large rock outcropping, 222 meters (m) upstream of the Rockville train bridge and 67 m from the right descending bank

Middle Site Description
Site Code: 133783592-003
Site Name: Susquehanna River at Rockville (Middle)
Latitude: 40.33449 **Longitude:** -76.91419
On the back side of a large rock outcropping, 221 m upstream of the Rockville train bridge and 325 m from the right descending bank

East Site Description
Site Code: 133783592-004
Site Name: Susquehanna River at Rockville (East)
Latitude: 40.33679 **Longitude:** -76.90797
Off a small bedrock outcropping, 266 m upstream of the Rockville train bridge and 125 m from the left descending bank

County: Dauphin
Drainage Area: 61,123 km^2
Strahler Stream Order: 8
Designated Use: Warm Water Fishes (WWF)

BACKGROUND AND HISTORY

The Susquehanna River is the largest tributary to the Chesapeake Bay. The watershed of the Susquehanna River at Rockville, Pennsylvania encompasses much of central Pennsylvania and parts of southcentral New York (Figure 1). Land use varies throughout the watershed with forest dominating the Allegheny Plateau in the upper portions and agriculture becoming more prevalent in the lower parts of the watershed. Overall, land use of the watershed at Rockville consists of 61% forest, 27% agriculture, and 7% developed land. The designated aquatic life use of the Susquehanna River at Rockville is Warm Water Fishes (WWF).

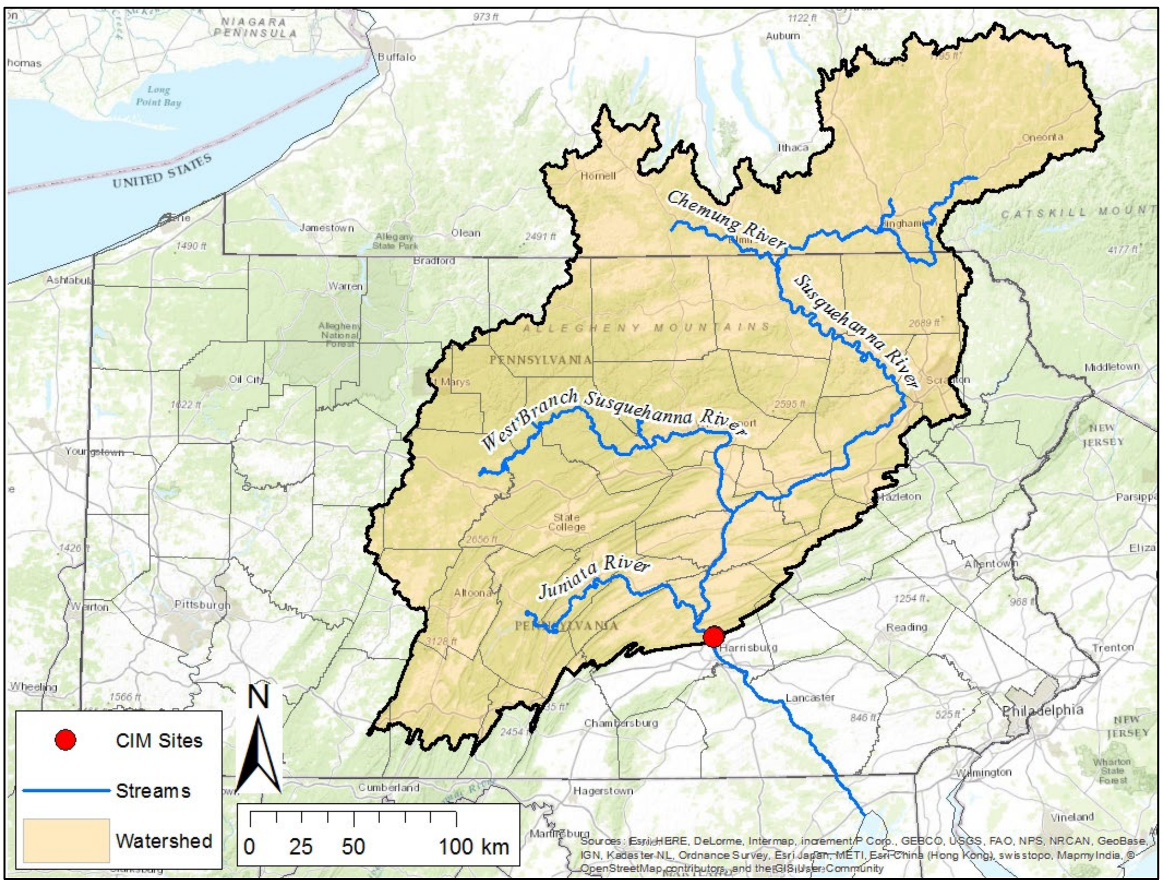

Figure 1. Watershed of the Susquehanna River at the Rockville CIM location.

Data collected by Pennsylvania Department of Environmental Protection (DEP) staff in 2012 identified three distinct water quality zones at this location on the river due to the incomplete mixing of the Juniata River, the West Branch Susquehanna River, and the mainstem Susquehanna River (Figure 2). The three continuous instream monitoring (CIM) sites described above were positioned to fall within each of these zones (Figure 2).

In addition to the CIM sites, a transect across the width of the river was established in 2012 to characterize water quality and determine the mixing pattern of the three major river influences according to the *In-situ Field Meter and Transect Data Collection*

Protocol (Hoger 2018b). Discrete water quality measurements were taken at 17 equidistant points (ROCK1 to ROCK17) across the transect starting at the right descending bank, an additional point was established at each of three sonde locations (ROCK2.5, ROCK6.5, and ROCK14.5 for the west, middle and east sites, respectively).

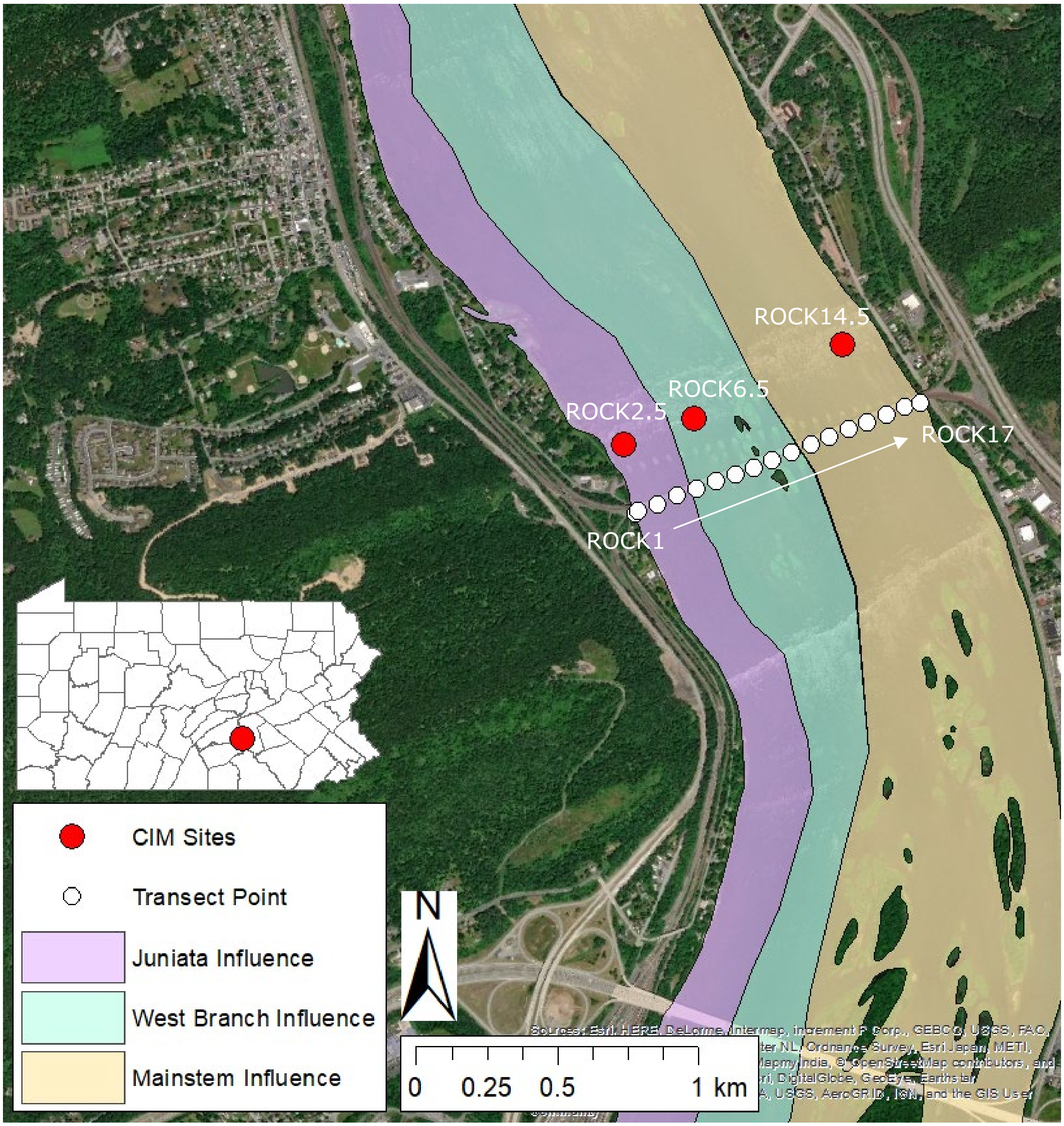

Figure 2. Map of the three Susquehanna River CIM sites and cross-sectional transect sampling locations at Rockville within the three major water quality influence zones. The displayed delineations of the three major water quality influence zones characterize baseflow conditions as determined by repeated transect sampling.

Water quality data at these sites were initially collected as part of the Susquehanna River Project investigating health and recruitment issues of smallmouth bass. These sites have since become long-term monitoring stations to inform ongoing studies and trend analyses. This report focuses only on the CIM data and chemical grab samples collected from 2013 to 2016. Other data collected at this location include benthic macroinvertebrate and fish community surveys, periphyton and algal analyses, and analyses of emerging contaminants in sediment and water.

OBJECTIVES

The primary objective of this report is to characterize temporal and spatial patterns in various physical and chemical water quality parameters in the Susquehanna River at Rockville.

WATER QUALITY PARAMETERS

Five water quality parameters were measured using CIM at the Rockville site (Table 1).

Table 1. Water quality parameters monitored by CIM.

Parameter	Units
Water Temperature	°C
Specific Conductance (@ 25°C)	$\mu S/cm^c$
pH	Standard Units (SU)
Dissolved Oxygen (DO)	mg/L
Turbidity	Formazin Nephelometric Unit (FNU)

EQUIPMENT

Water quality sondes from Yellow Springs Instruments (YSI) were used to collect CIM data at all three sites each year. The first three years, YSI 6920 V2 sondes were used. In 2016, YSI EXO2 sondes were used.

In 2013 and 2014, sondes were housed in a 24-inch length of 4-inch diameter schedule 80 PVC pipe with holes drilled to allow water to flow through the pipe. One end of the pipe was capped, and a notch was cut to accommodate the metal attachment bar on the top of the sondes. The attachment bars were clipped to an eye-bolt attached to rebar driven into the river bed. The attachment bars were also clipped to a cable attached to a second piece of rebar located just upstream of the first.

Due to difficulty in accessing the equipment during high flow conditions, the deployment method was changed beginning in 2015. Ten-foot lengths of 4-inch diameter PVC pipe were anchored to rock outcroppings, creating chutes to slide the sondes into, and a stopper was used at the bottom of the pipe to contain the sonde within the chamber. Cables were attached to the sonde and then to pins driven into the rock outcroppings to facilitate retrieval of the sonde from the chute and as a backup anchoring mechanism securing the sonde if the chutes were damaged by debris.

PERIOD OF RECORD

Continuous data were recorded from late winter or spring until late fall when the macroinvertebrate sample was collected in November each year (Table 2). Sondes were deployed earlier each year to document changes in water quality near the beginning of each growing season. Each year, sondes were removed before winter to prevent damage from ice. The sonde was visited several times throughout each deployment period to download data, to check calibration, and for cleaning. Each sonde recorded water quality parameter measurements once every 30 minutes.

Table 2. Continuous data period of record.

Year	Deployment	Removal
2013	May 07	November 18
2014	April 25	November 12
2015	April 09	November 10
2016	February 23	November 21

DATA

Cross-Sectional Surveys

To monitor variations in the transitions between influence zones throughout the year, cross-sectional transect surveys were conducted several times each year at various flows. Transect data were analyzed by comparing each survey point to ROCK14.5 (Figure 3), the east sonde site (Figure 2). The east site was selected as the reference site because it represents the mainstem Susquehanna River influence (Figure 2). For temperature and pH, the difference in readings between ROCK14.5 and each transect point was considered significant if the difference was greater than 0.5 units. For specific conductance, DO, and turbidity, the difference was considered significant if it was greater than 10% of the ROCK14.5 reading. When transects were conducted when turbidity was low (less than 10 FNU), a difference of one FNU was equivalent to a 10% difference.

Continuous Monitoring

Continuous data were collected and evaluated following DEP's *Continuous Physicochemical Data Collection Protocol* (Hoger et al. 2018). Grades and corrections were based on a combined evaluation of sensor fouling and calibration error. Gaps in the CIM data are attributable either to equipment or battery failure or to removal of data that did not meet usability standards due to excessive sensor fouling or calibration error. Annual CIM data at all three sites are charted together to illustrate cross-sectional differences in water quality (Figures 4 to 23). Due to year-to-year differences in the timing of data collection and to data missing from some sites but not from others, comparison of the summary CIM data should be made with caution.

River discharge data from the United States Geological Survey (USGS) station 01570500, Susquehanna River at Harrisburg, Pennsylvania, are provided, in cubic feet per second (cfs), alongside the CIM data (Figures 4 to 23). This USGS gaging station is located off Harrisburg's City Island, approximately 9.6 river kilometers downstream of the Rockville CIM sites.

Discrete Water Chemistry Sampling
Grab samples were collected several times each year at each of the three Rockville CIM sites (Table 3) according to DEP's *Discrete Water Chemistry Data Collection Protocol* (Shull 2013). Initial grab samples were analyzed using DEP's standard analysis code (SAC) 612, which includes general chemistry parameters, dissolved and total nutrients, and total metals. Beginning in 2014, dissolved metals were added to the suite of analytes for many grab samples. In 2016, the discrete samples were analyzed using the newly created SAC 087, which is SAC 612 plus the dissolved metals analytes. SAC 618 and SAC 779 were used to obtain concentrations of suspended sediment and acid-soluble aluminum, respectively. A complete list of grab sample analytes can be found in Table 3.

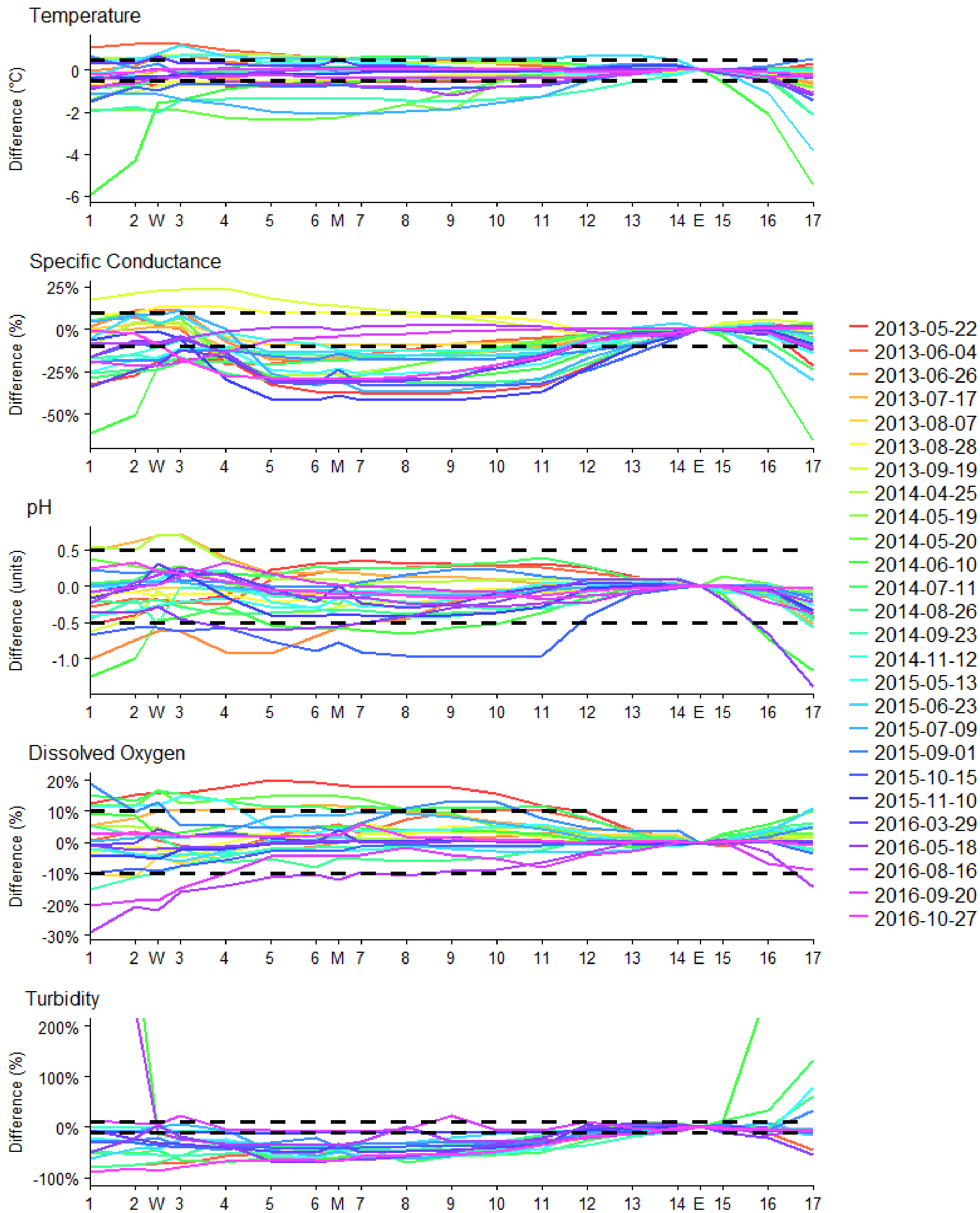

Figure 3. Cross-section surveys at Rockville showing relative difference in readings compared to the Rockville east site. Transect points include ROCK1 to ROCK17, plus the west (W), middle (M), and east (E) sonde locations. Dashed, black lines indicate thresholds of significance. Turbidity chart cutoff at 200%, but differences were higher along one or both banks on June 10, 2014 and August 16, 2016.

2013 Water Temperature:	*West*	Min: 9.59 °C	Average: 21.50 °C	Max: 31.46 °C
	Middle	Min: 4.15 °C	Average: 20.26 °C	Max: 33.21 °C
	East	Min: 3.90 °C	Average: 21.04 °C	Max: 32.64 °C

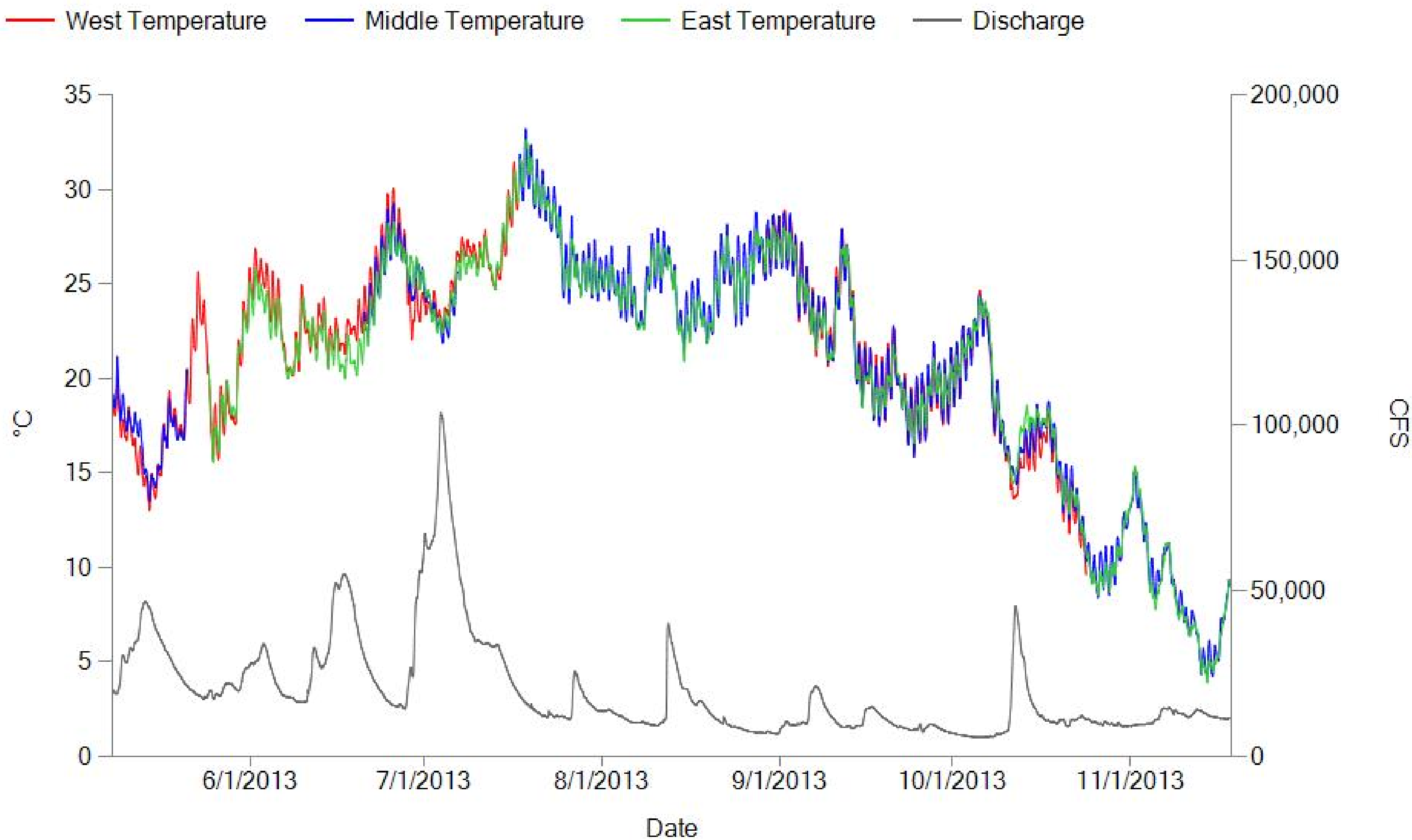

Figure 4. Continuous water temperature (°C) and discharge (cfscfs) at the three Rockville sites from May 7, 2013 to November 18, 2013.

2014 Water Temperature:	*West*	Min: 6.13 °C	Average: 19.88 °C	Max: 29.92 °C
	Middle	Min: 6.52 °C	Average: 20.25 °C	Max: 30.07 °C
	East	Min: 6.77 °C	Average: 20.62 °C	Max: 29.29 °C

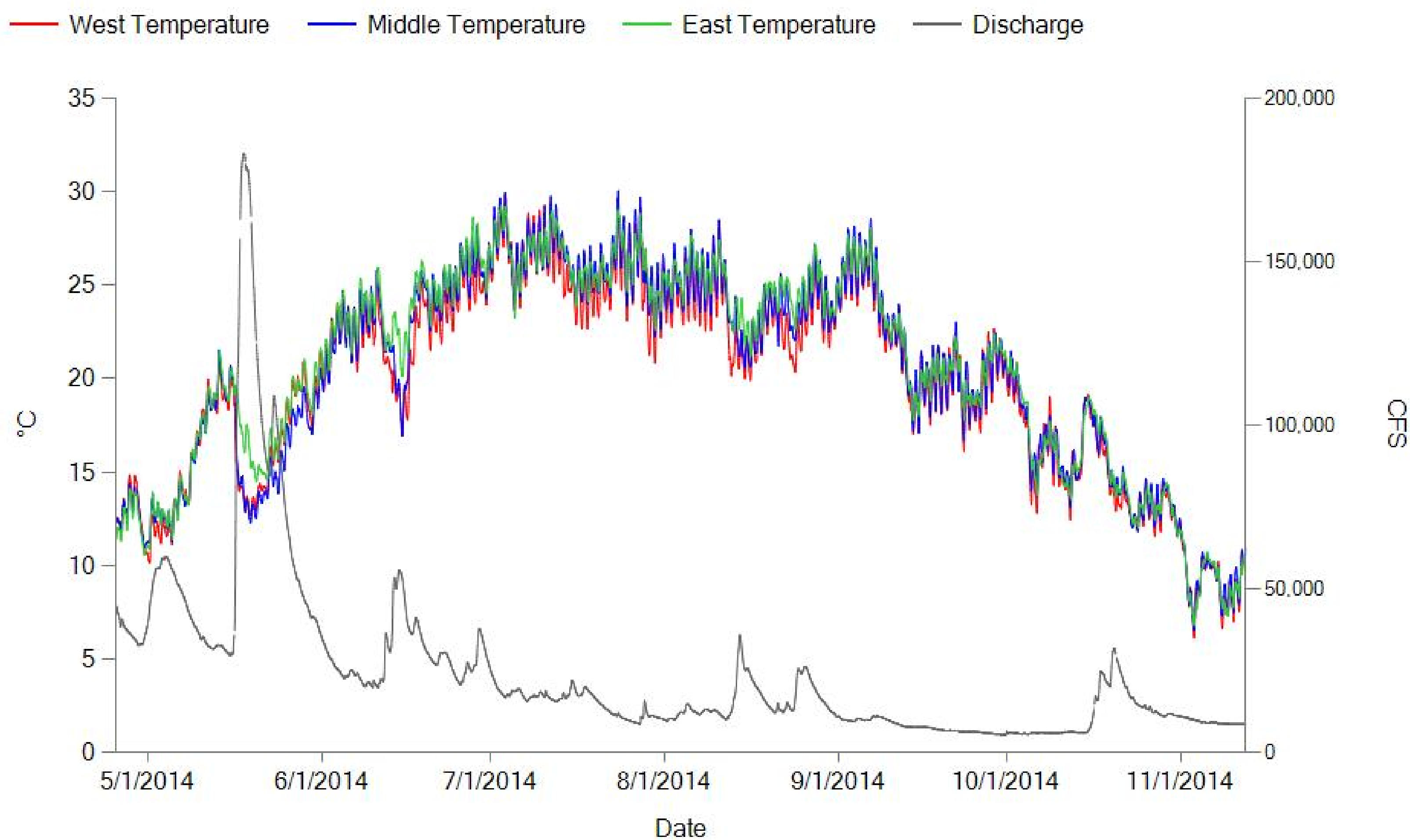

Figure 5. Continuous water temperature (°C) and discharge (cfscfs) at the three Rockville sites from April 25, 2014 to November 12, 2014.

2015 Water Temperature:	*West*	Min: 7.39 °C	Average: 20.19 °C	Max: 30.71 °C
	Middle	Min: 5.85 °C	Average: 20.78 °C	Max: 31.37 °C
	East	Min: 4.85 °C	Average: 20.41 °C	Max: 30.37 °C

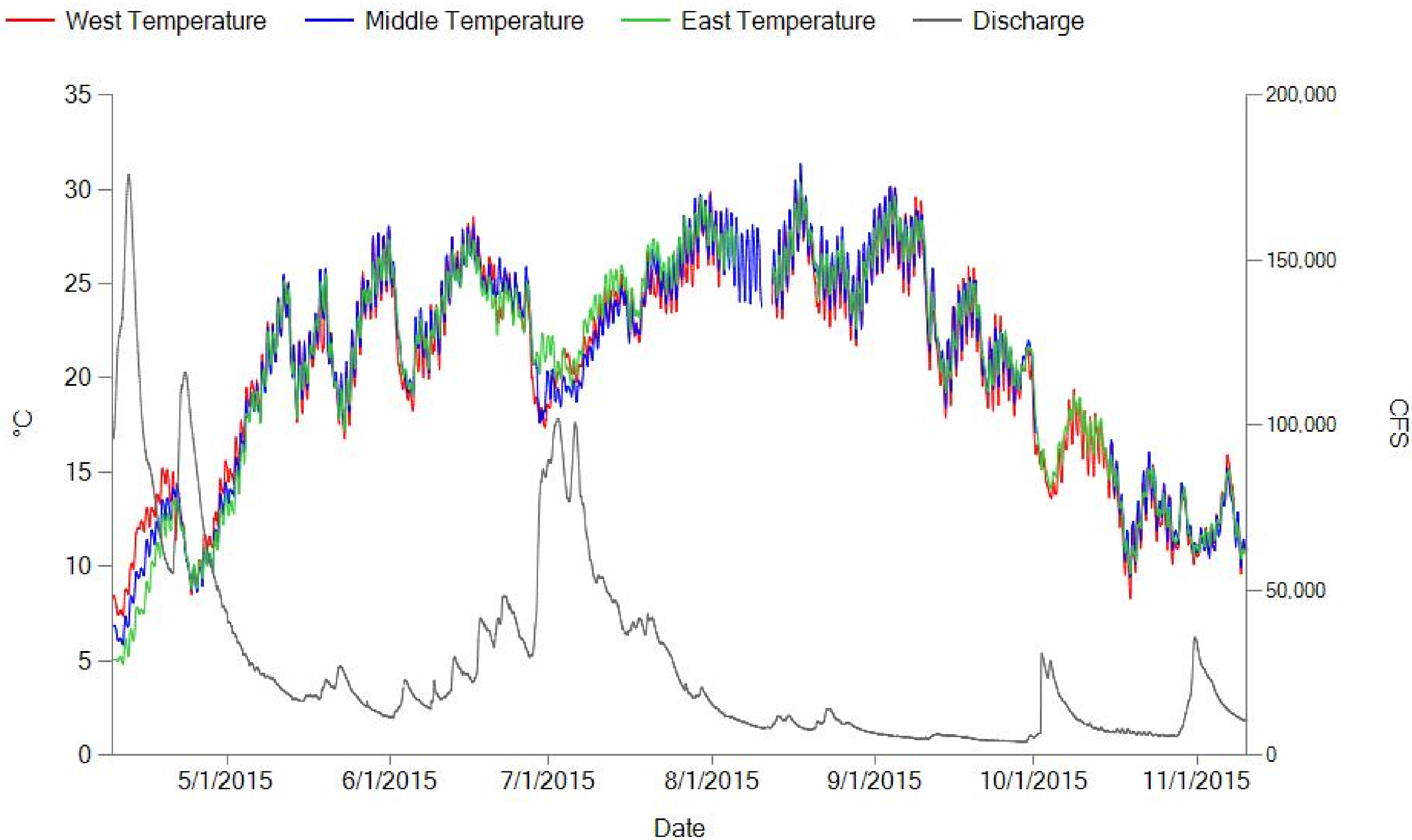

Figure 6. Continuous water temperature (°C) and discharge (cfscfs) at the three Rockville sites from April 9, 2015 to November 10, 2015.

2016 Water Temperature:	*West*	Min: 2.41 °C	Average: 18.69 °C	Max: 32.09 °C
	Middle	Min: 2.10 °C	Average: 18.67 °C	Max: 31.86 °C
	East	Min: 2.43 °C	Average: 18.65 °C	Max: 31.56 °C

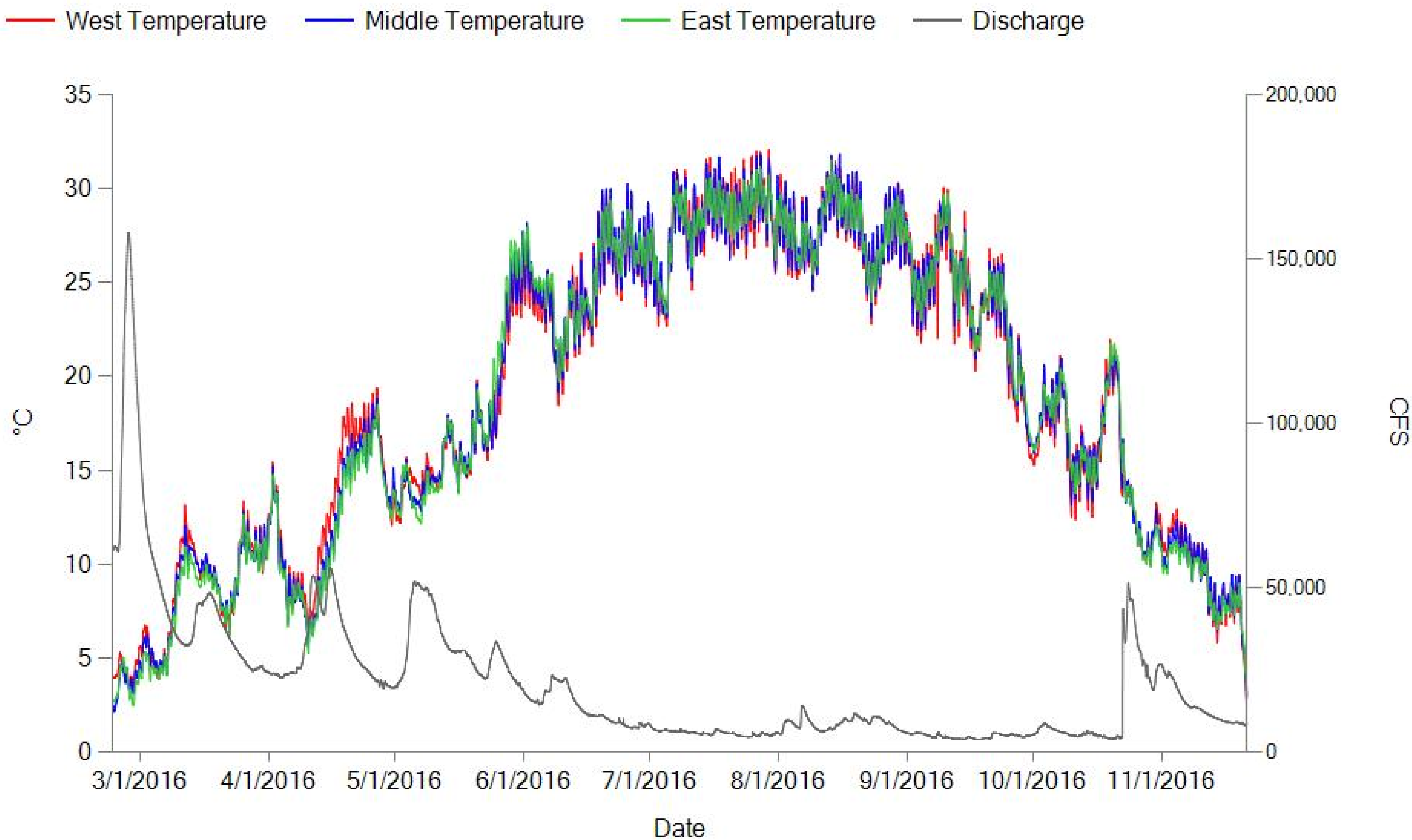

Figure 7. Continuous water temperature (°C) and discharge (cfscfs) at the three Rockville sites from February 23, 2016 to November 21, 2016.

2013 Specific Conductance:	*West*	Min: 108.6 µS/cm^c	Average: 251.3 µS/cm^c	Max: 341.5 µS/cm^c
	Middle	Min: 131.4 µS/cm^c	Average: 245.7 µS/cm^c	Max: 351.5 µS/cm^c
	East	Min: 152.7 µS/cm^c	Average: 265.1 µS/cm^c	Max: 340.0 µS/cm^c

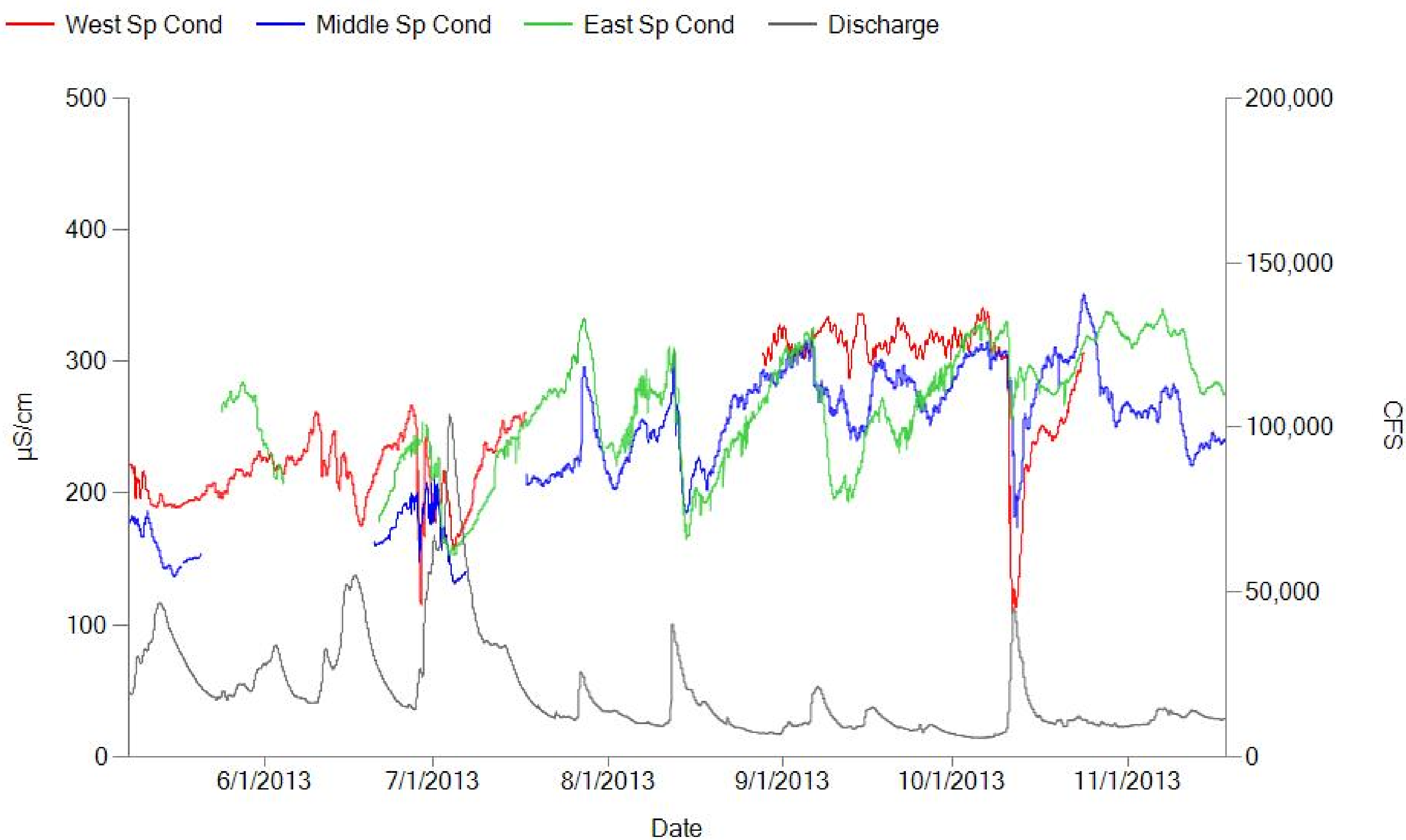

Figure 8. Continuous specific conductance (µS/cm^c) and discharge (cfscfs) at the three Rockville sites from May 7, 2013 to November 18, 2013.

2014 Specific Conductance: *West* Min: 79.0 µS/cm^c Average: 245.0 µS/cm^c Max: 312.3 µS/cm^c
Middle Min: 84.0 µS/cm^c Average: 236.6 µS/cm^c Max: 336.7 µS/cm^c
East Min: 136.6 µS/cm^c Average: 289.9 µS/cm^c Max: 422.0 µS/cm^c

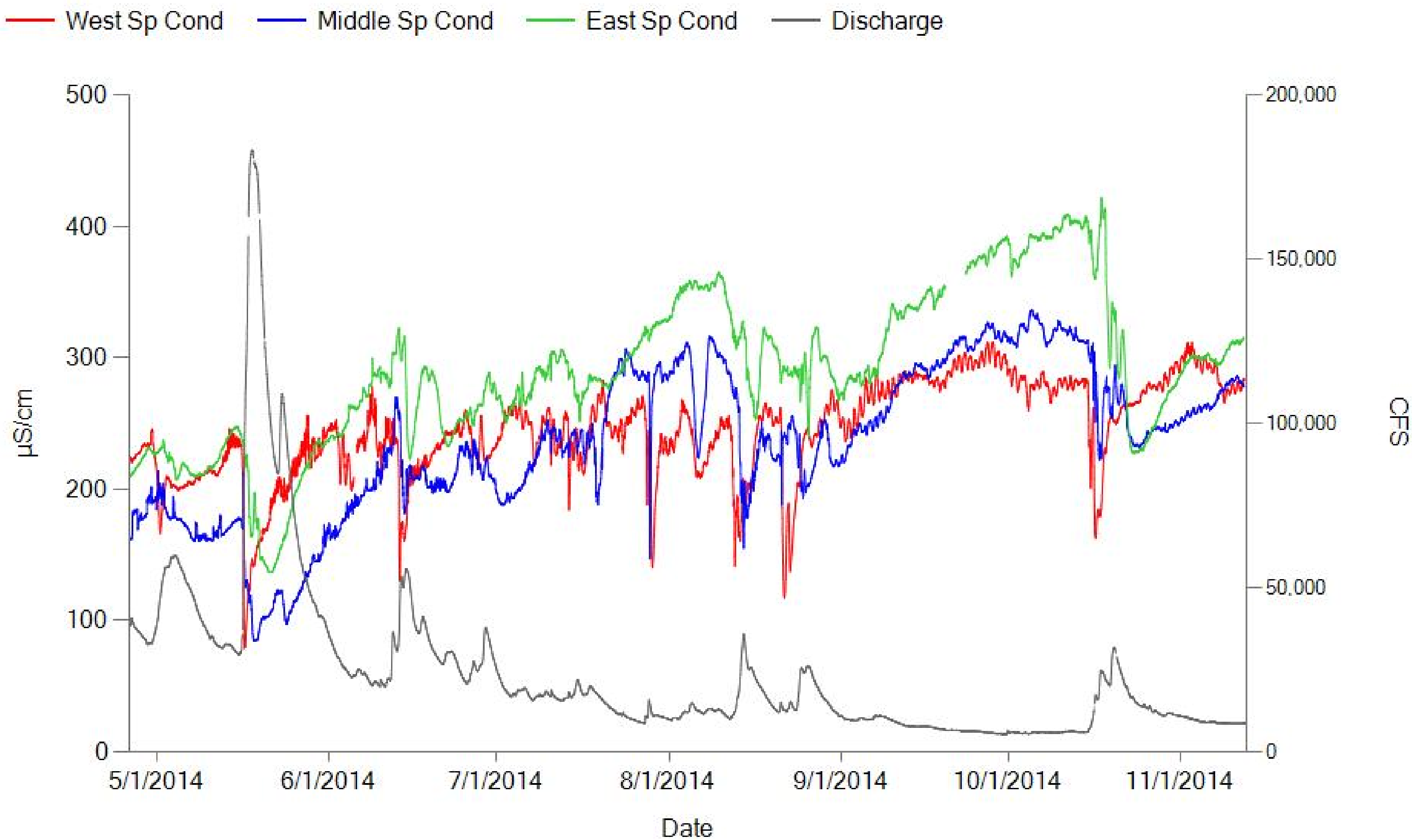

Figure 9. Continuous specific conductance (µS/cm^c) and discharge (cfscfs) at the three Rockville sites from April 25, 2014 to November 12, 2014.

2015 Specific Conductance: *West* Min: 107.9 µS/cm[c] Average: 267.7 µS/cm[c] Max: 350.7 µS/cm[c]
Middle Min: 101.6 µS/cm[c] Average: 242.1 µS/cm[c] Max: 372.0 µS/cm[c]
East Min: 126.4 µS/cm[c] Average: 312.3 µS/cm[c] Max: 470.5 µS/cm[c]

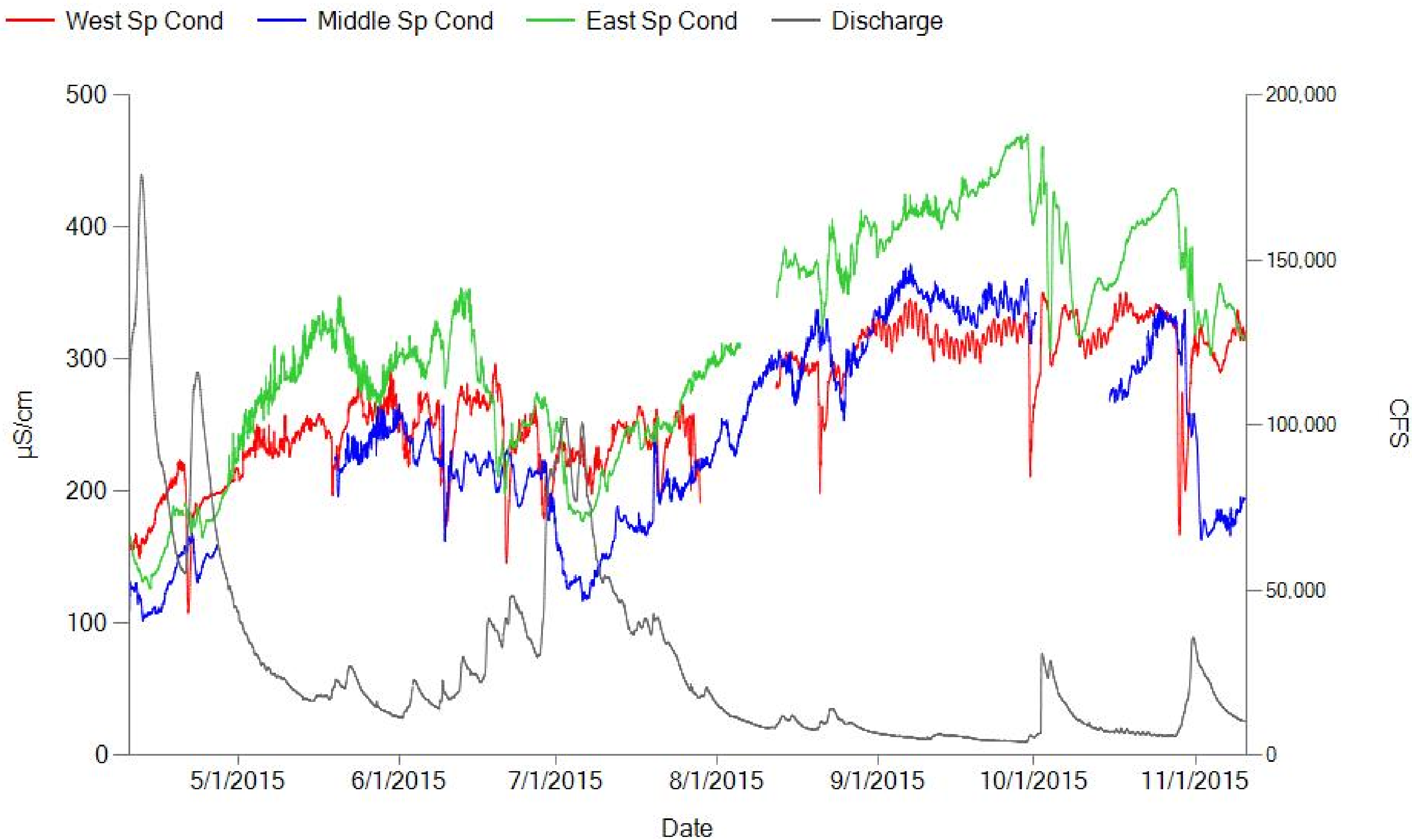

Figure 10. Continuous specific conductance (µS/cm[c]) and discharge (cfscfs) at the three Rockville sites from from April 9, 2015 to November 10, 2015.

2016 Specific Conductance:	*West*	Min: 130.0 µS/cm^{c}	Average: 262.7 µS/cm^{c}	Max: 386.4 µS/cm^{c}
	Middle	Min: 131.1 µS/cm^{c}	Average: 257.0 µS/cm^{c}	Max: 407.9 µS/cm^{c}
	East	Min: 143.5 µS/cm^{c}	Average: 300.2 µS/cm^{c}	Max: 488.4 µS/cm^{c}

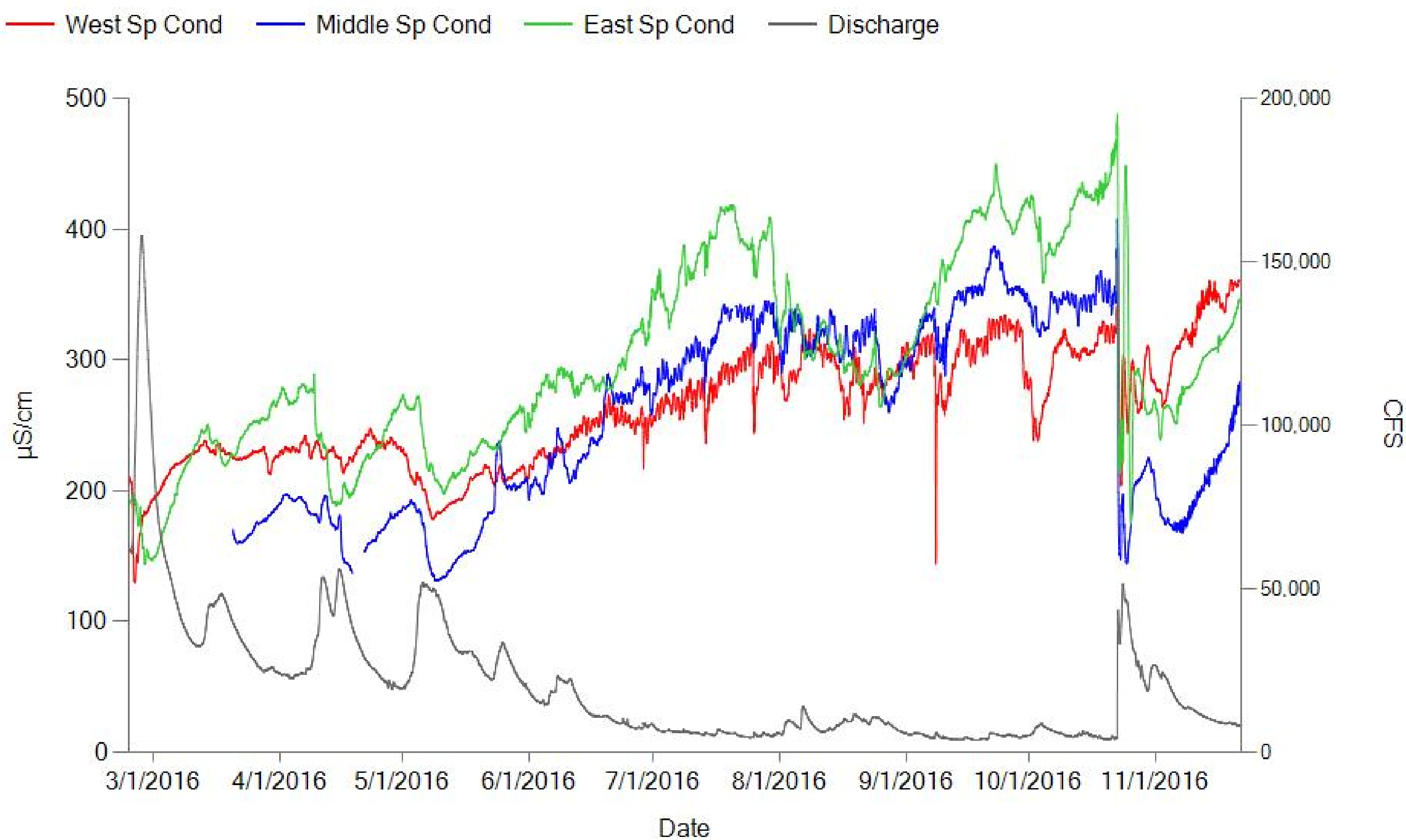

Figure 11. Continuous specific conductance (µS/cm^{c}) and discharge (cfscfs) at the three Rockville sites from February 23, 2016 to November 21, 2016.

2013 pH:

	West	Min: 7.07 SU	Average: 8.17 SU	Max: 8.97 SU
	Middle	Min: 7.04 SU	Average: 8.02 SU	Max: 9.32 SU
	East	Min: 7.30 SU	Average: 8.20 SU	Max: 9.20 SU

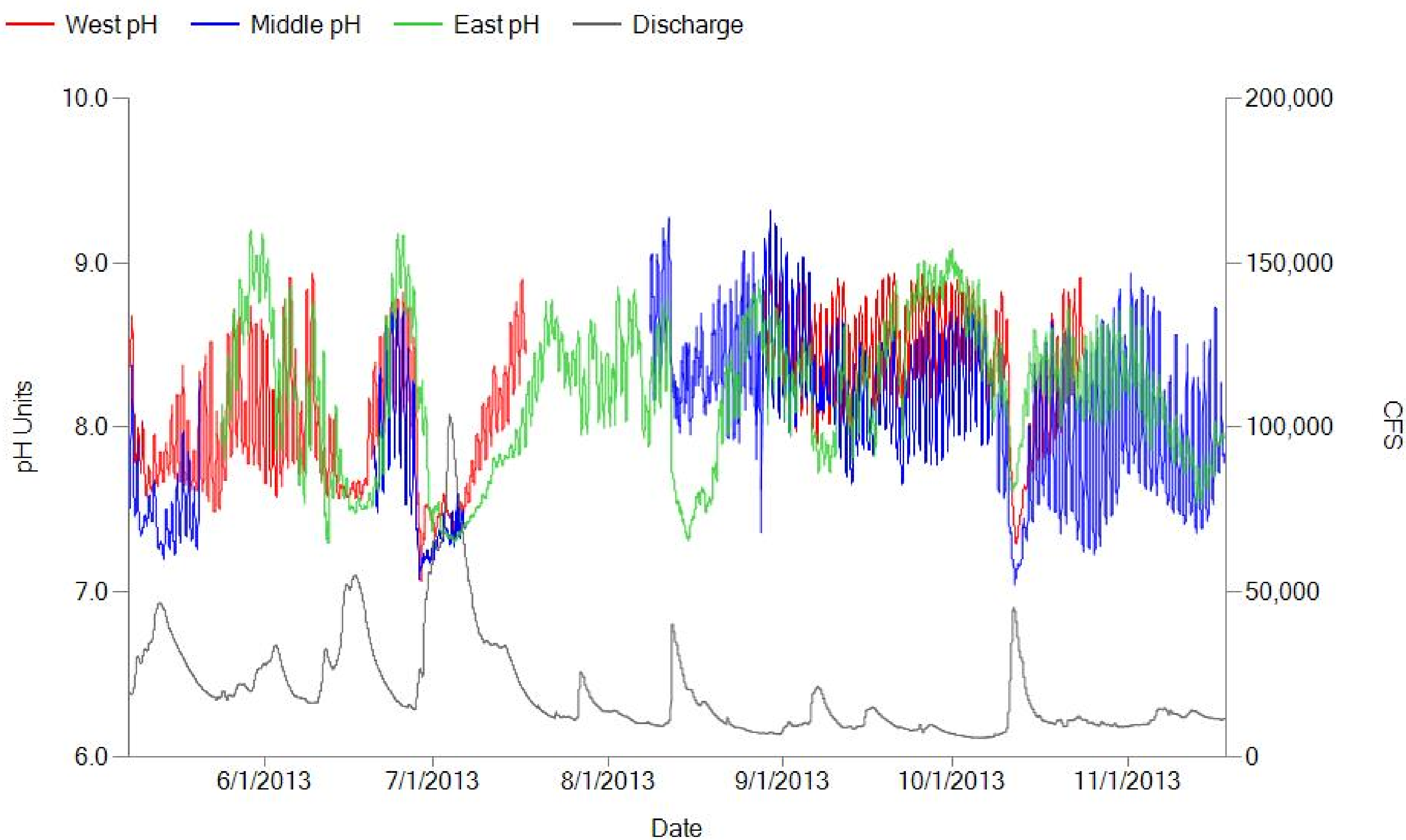

Figure 12. Continuous pH and continuous discharge (cfscfs) at the three Rockville sites from May 7, 2013 to November 18, 2013.

2014 pH:	*West*	Min: 6.72 SU	Average: 8.35 SU	Max: 9.55 SU
	Middle	Min: 6.51 SU	Average: 8.14 SU	Max: 9.10 SU
	East	Min: 7.09 SU	Average: 8.31 SU	Max: 9.33 SU

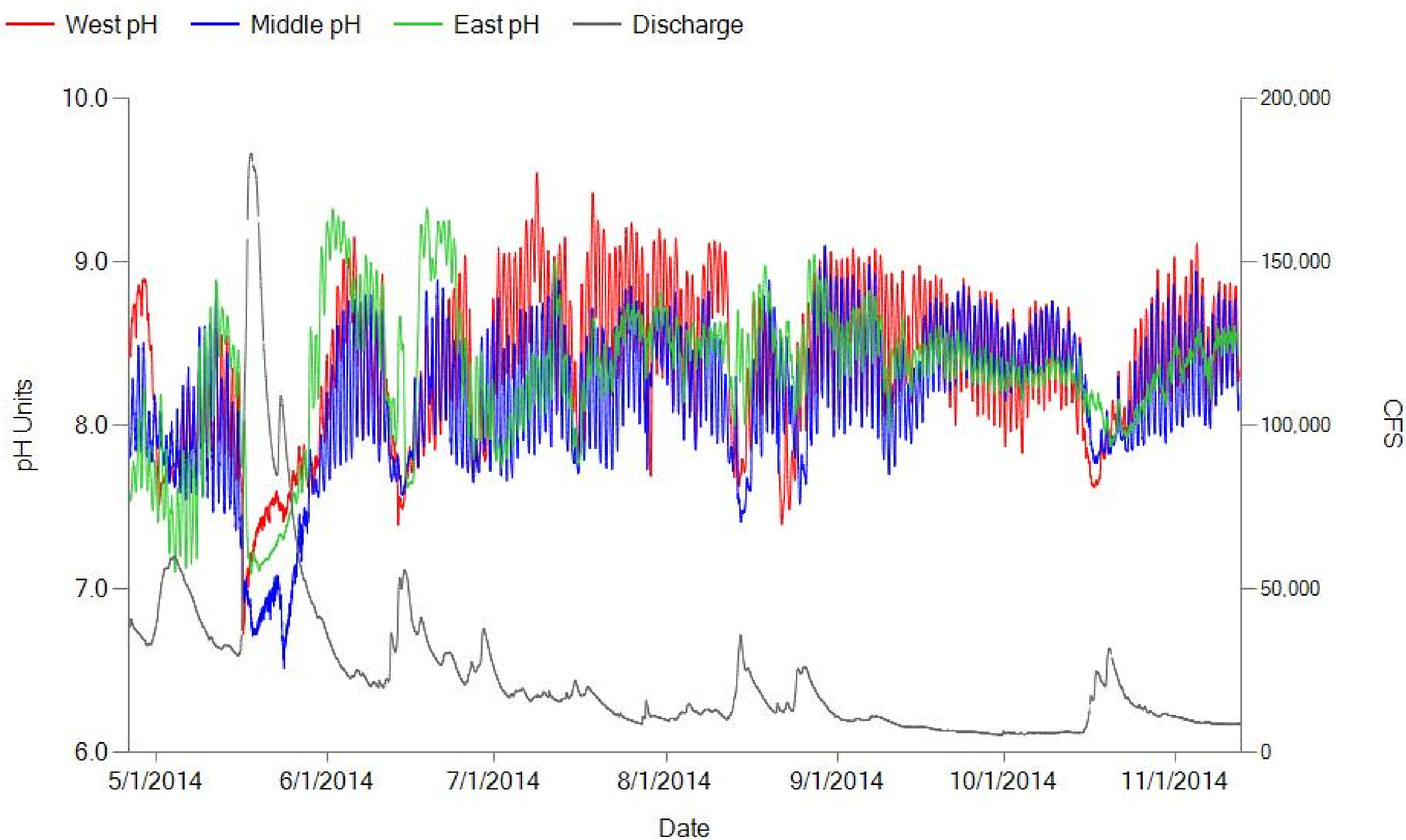

Figure 13. Continuous pH and continuous discharge (cfscfs) at the three Rockville sites from April 25, 2014 to November 12, 2014.

2015 pH:				
	West	Min: 7.01 SU	Average: 8.24 SU	Max: 9.23 SU
	Middle	Min: 6.99 SU	Average: 8.00 SU	Max: 8.91 SU
	East	Min: 7.38 SU	Average: 8.25 SU	Max: 9.13 SU

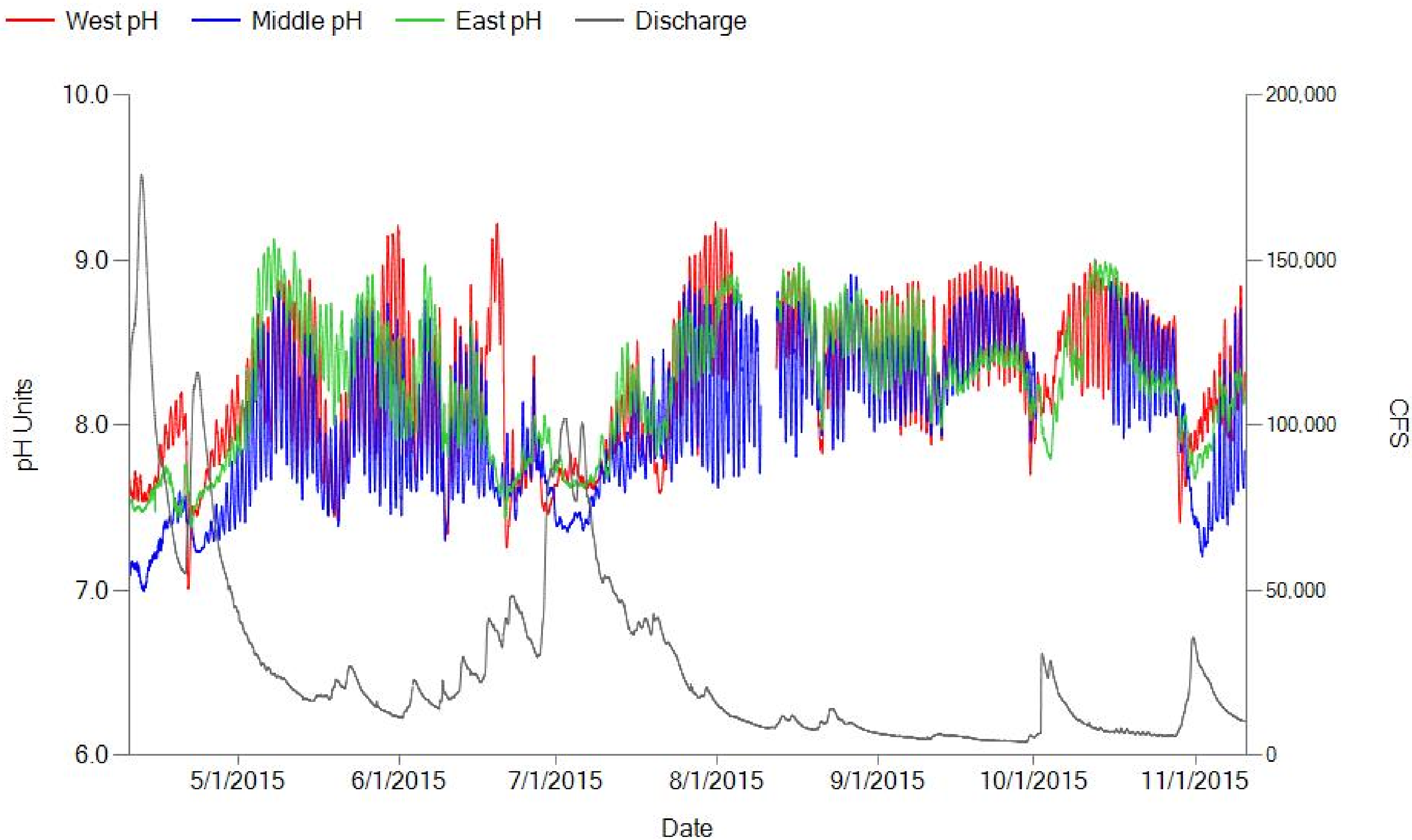

Figure 14. Continuous pH and continuous discharge (cfscfs) at the three Rockville sites from April 9, 2015 to November 10, 2015.

2016 pH:	*West*	Min: 7.25 SU	Average: 8.38 SU	Max: 9.26 SU
	Middle	Min: 7.19 SU	Average: 8.22 SU	Max: 9.34 SU
	East	Min: 7.32 SU	Average: 8.13 SU	Max: 9.05 SU

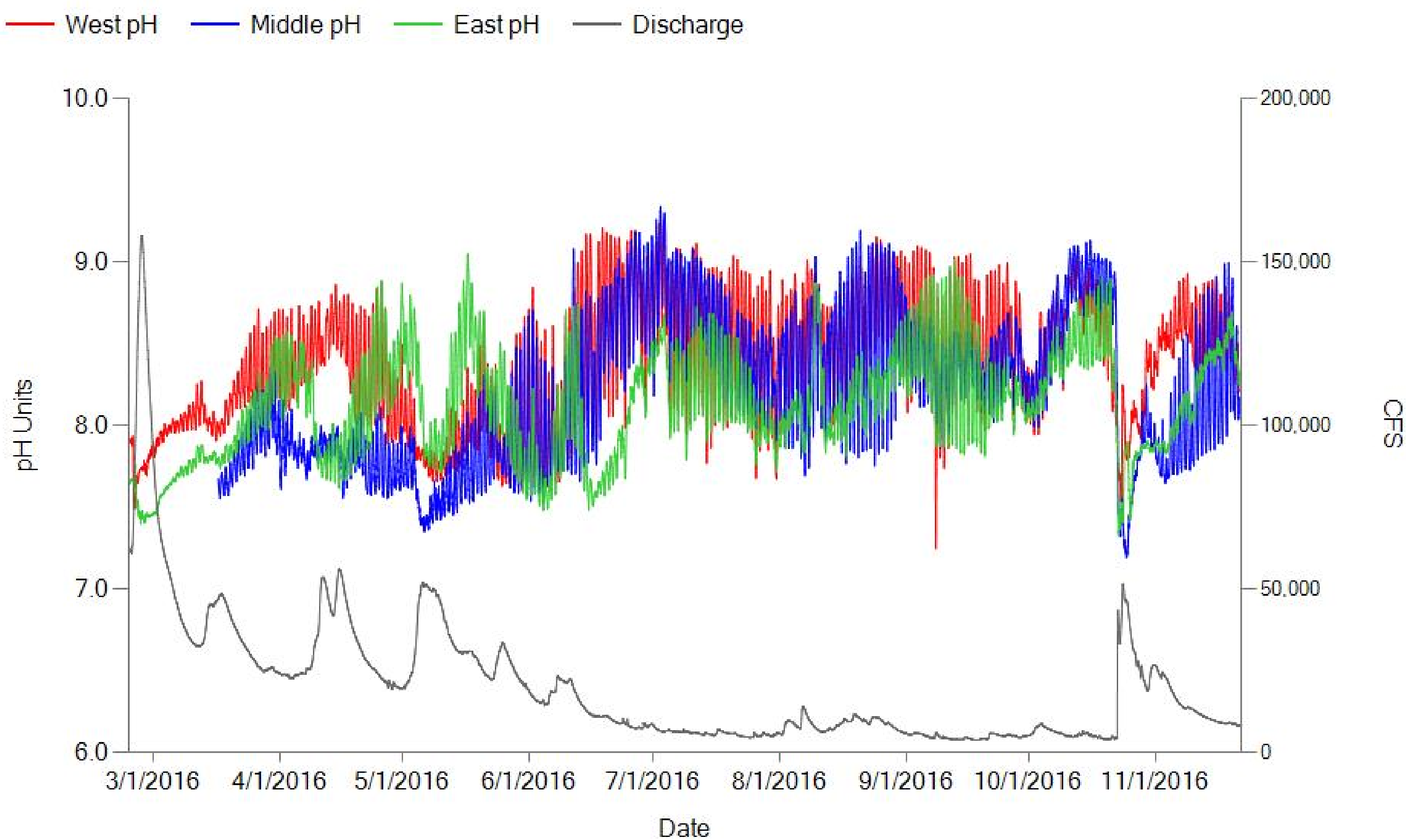

Figure 15. Continuous pH and continuous discharge (cfscfs) at the three Rockville sites from February 23, 2016 to November 21, 2016.

2013 Dissolved Oxygen:	*West*	Min: 5.90 mg/L	Average: 8.82 mg/L	Max: 12.88 mg/L
	Middle	Min: 6.31 mg/L	Average: 9.29 mg/L	Max: 14.76 mg/L
	East	Min: 6.45 mg/L	Average: 9.21 mg/L	Max: 13.75 mg/L

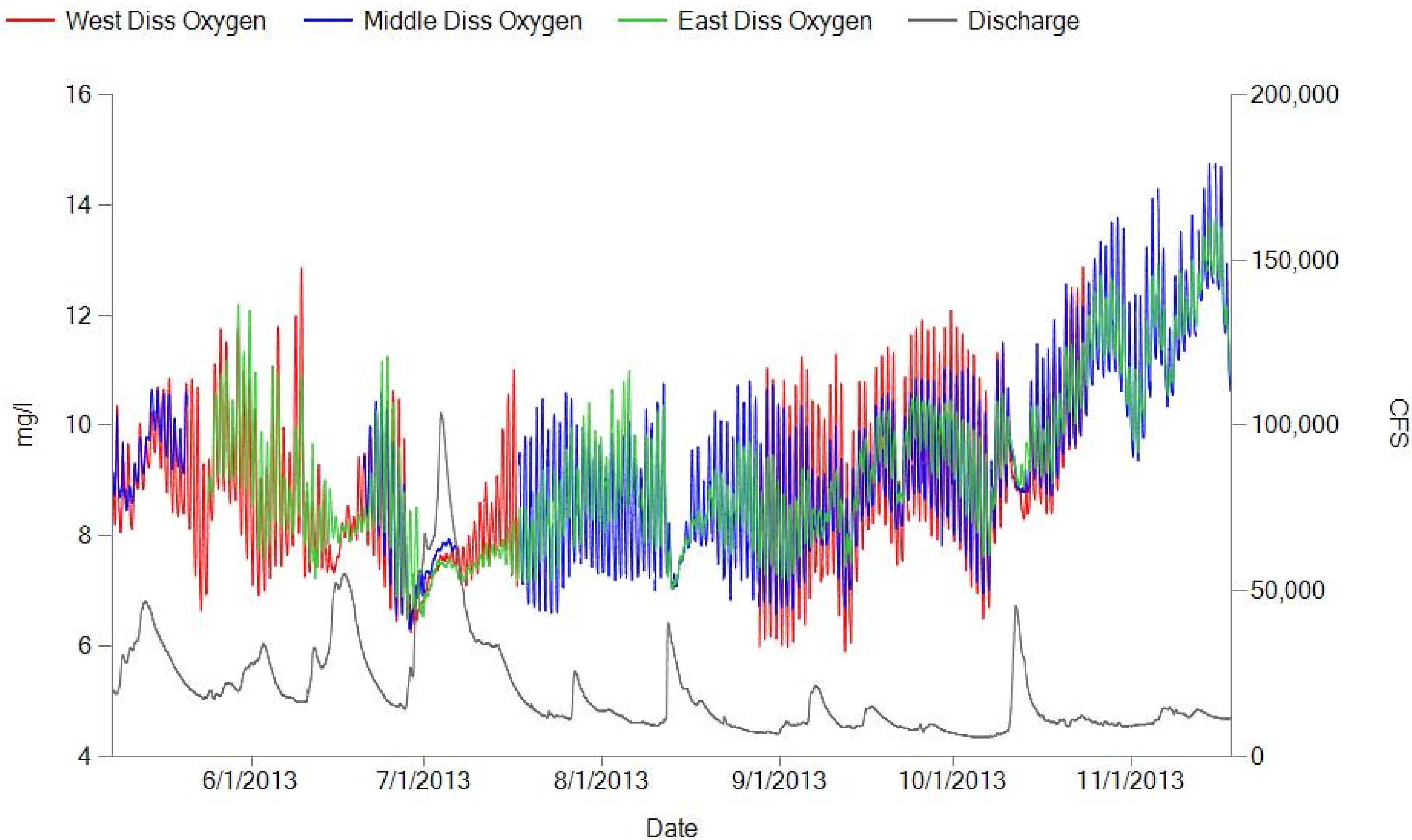

Figure 16. Continuous dissolved oxygen (mg/L) and discharge (cfs) at the three Rockville sites from May 7, 2013 to November 18, 2013.

2014 Dissolved Oxygen:	*West*	Min: 5.70 mg/L	Average: 9.41 mg/L	Max: 14.30 mg/L
	Middle	Min: 6.69 mg/L	Average: 9.27 mg/L	Max: 13.33 mg/L
	East	Min: 6.70 mg/L	Average: 9.26 mg/L	Max: 12.56 mg/L

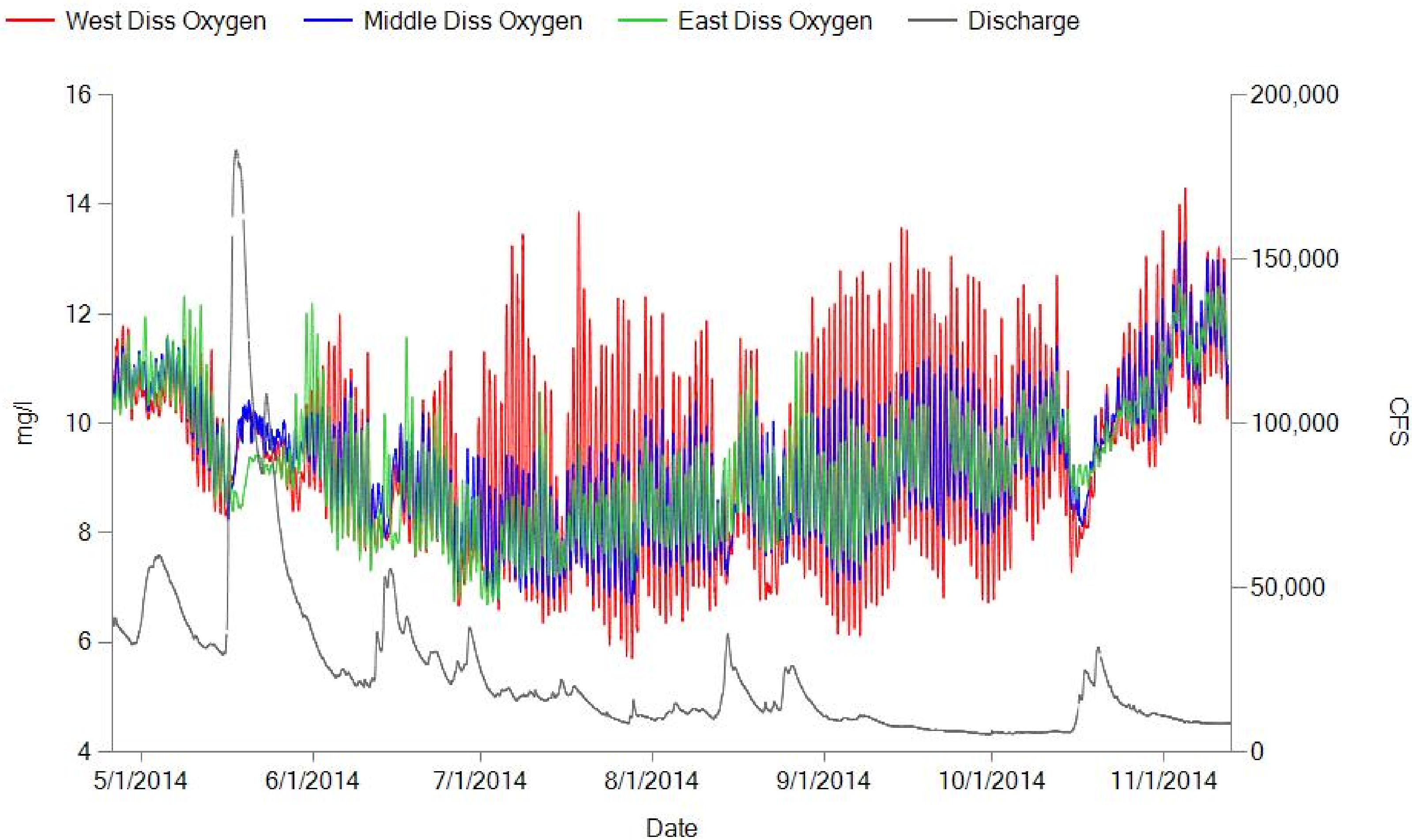

Figure 17. Continuous dissolved oxygen (mg/L) and discharge (cfs) at the three Rockville sites from April 25, 2014 to November 12, 2014.

2015 Dissolved Oxygen:	*West*	Min: 5.39 mg/L	Average: 9.44 mg/L	Max: 14.46 mg/L
	Middle	Min: 5.59 mg/L	Average: 9.22 mg/L	Max: 12.78 mg/L
	East	Min: 6.70 mg/L	Average: 9.15 mg/L	Max: 12.10 mg/L

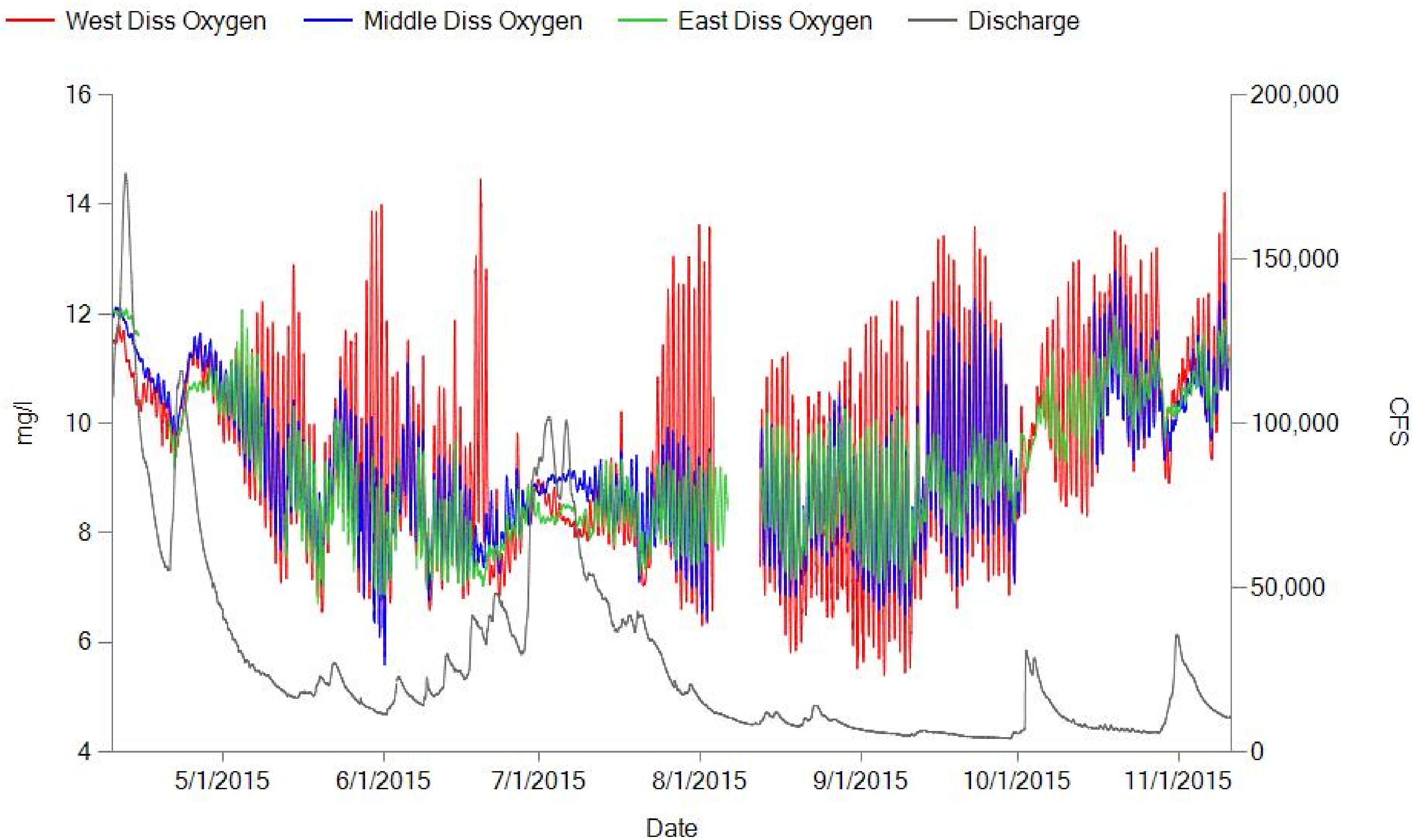

Figure 18. Continuous dissolved oxygen (mg/L) and discharge (cfs) at the three Rockville sites from April 9, 2015 to November 10, 2015.

2016 Dissolved Oxygen:	*West*	Min: 4.13 mg/L	Average: 9.73 mg/L	Max: 13.95 mg/L
	Middle	Min: 5.41 mg/L	Average: 9.35 mg/L	Max: 13.41 mg/L
	East	Min: 6.22 mg/L	Average: 9.51 mg/L	Max: 13.18 mg/L

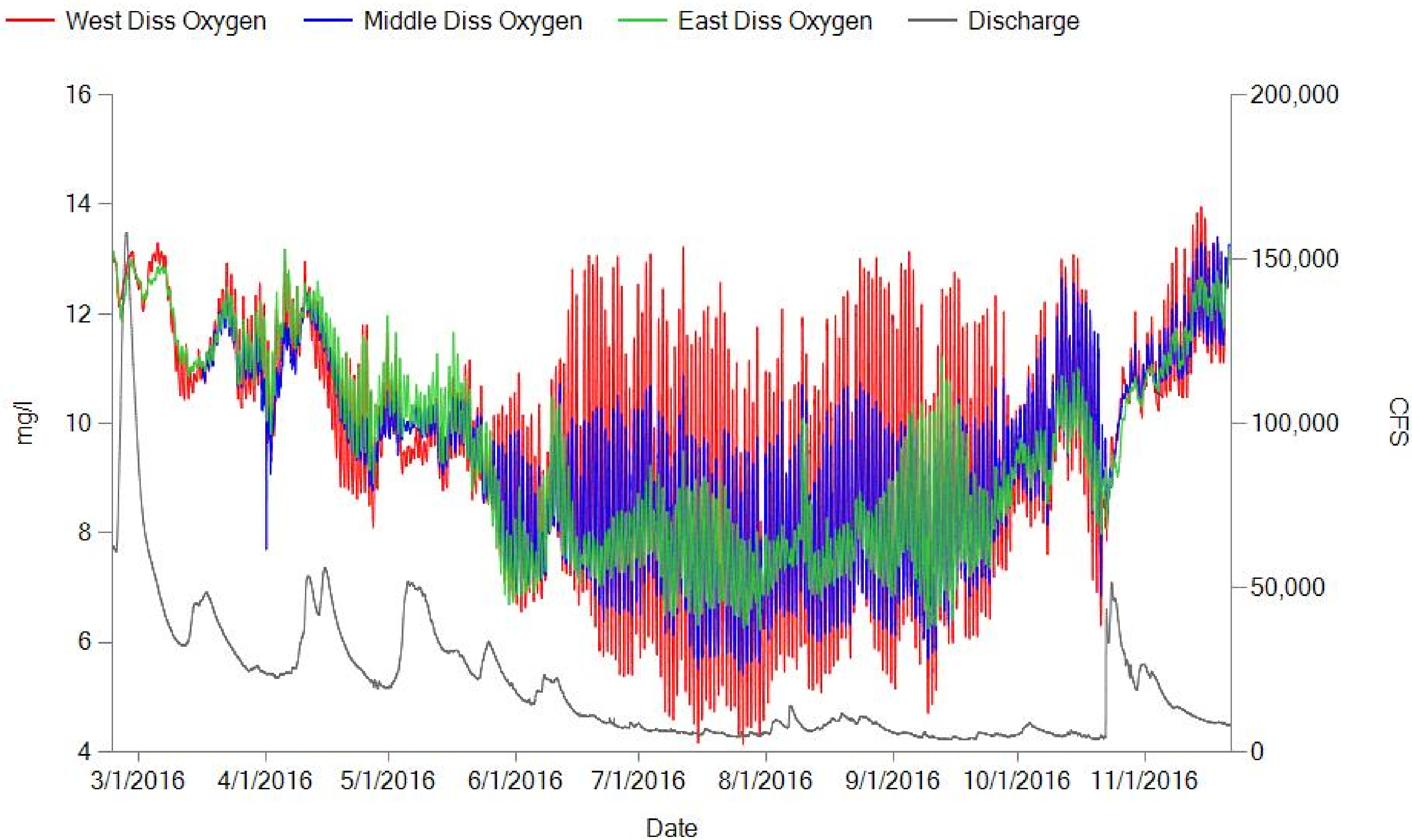

Figure 19. Continuous dissolved oxygen (mg/L) and discharge (cfs) at the three Rockville sites from February 23, 2016 to November 21, 2016.

2013 Turbidity:	*West*	Min: 1.7 FNU	Average: 23.8 FNU	Max: 288.2 FNU
	Middle	Min: NA	Average: NA	Max: NA
	East	Min: NA	Average: NA	Max: NA

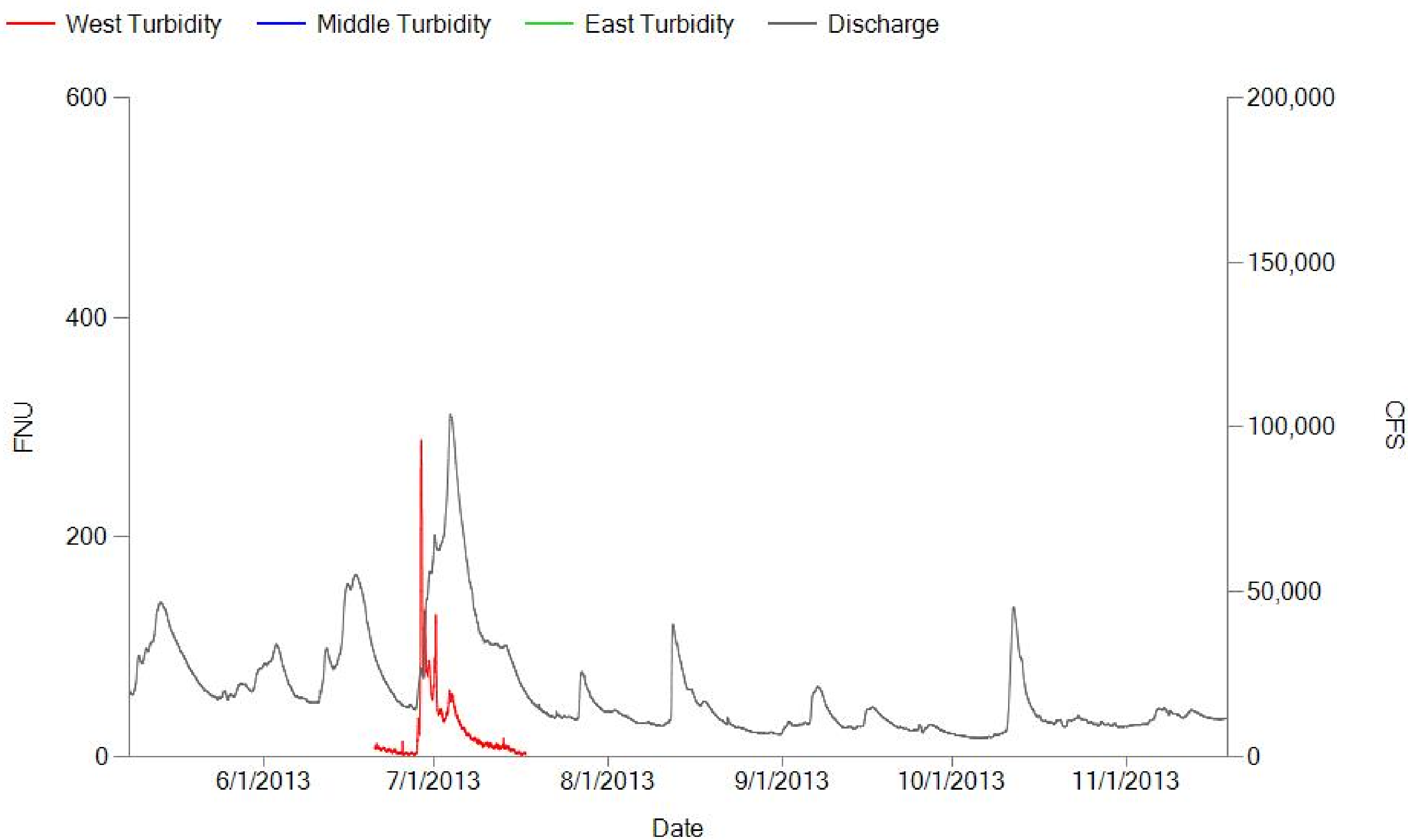

Figure 20. Continuous turbidity (FNU) and discharge (cfs) at the three Rockville sites from May 7, 2013 to November 18, 2013. Due to issues with fouling and calibration, only a small section from the west site passed the quality assurance procedures.

2014 Turbidity:	*West*	Min: 0.7 FNU	Average: 10.0 FNU	Max: 151.4 FNU
	Middle	Min: 1.1 FNU	Average: 10.1 FNU	Max: 151.6 FNU
	East	Min: 3.0 FNU	Average: 17.0 FNU	Max: 194.5 FNU

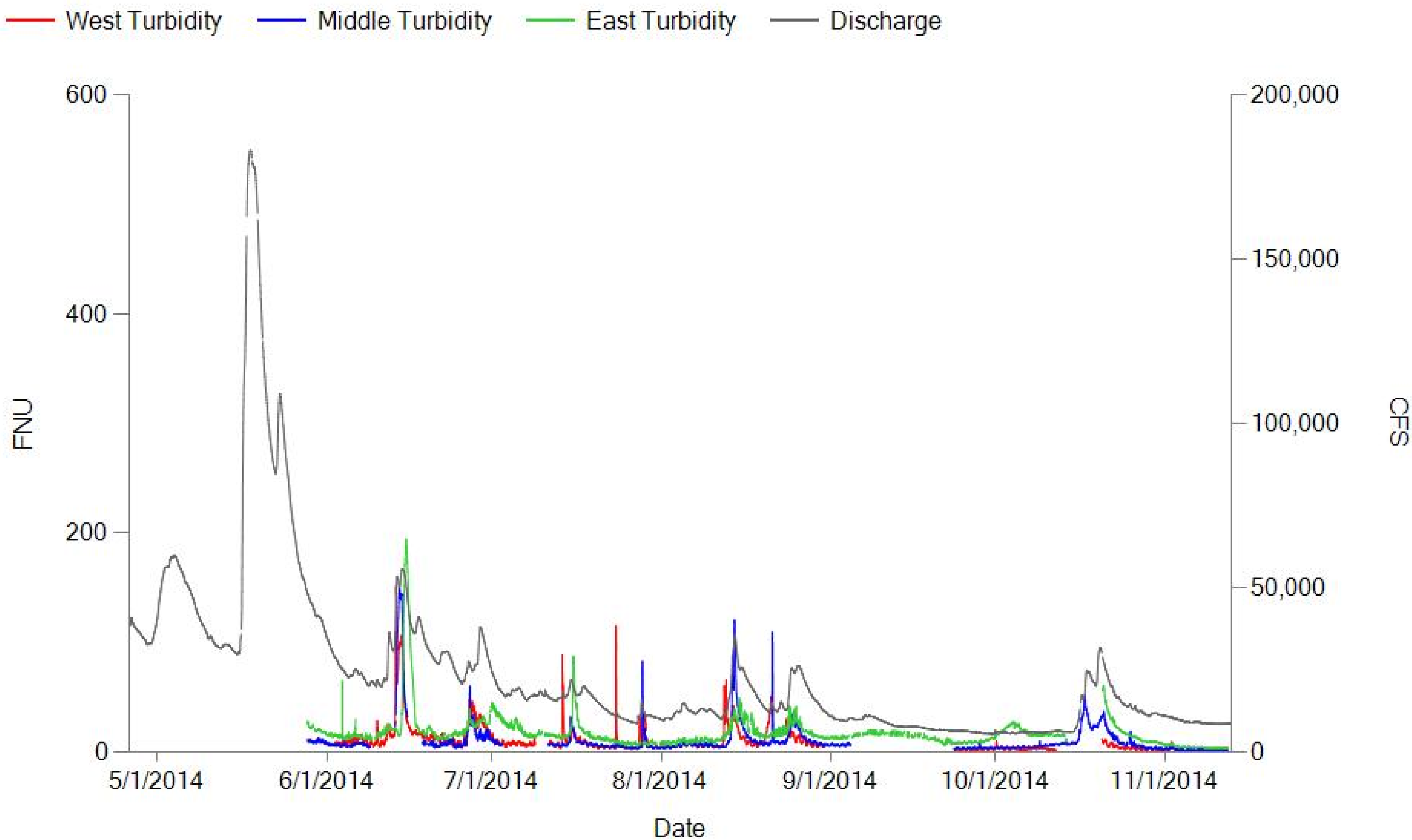

Figure 21. Continuous turbidity (FNU) and discharge (cfs) at the three Rockville sites from April 25, 2014 to November 12, 2014.

2015 Turbidity:	*West*	Min: 0.9 FNU	Average: 14.5 FNU	Max: 420.0 FNU
	Middle	Min: 0.1 FNU	Average: 11.3 FNU	Max: 536.5 FNU
	East	Min: 0.9 FNU	Average: 21.7 FNU	Max: 455.8 FNU

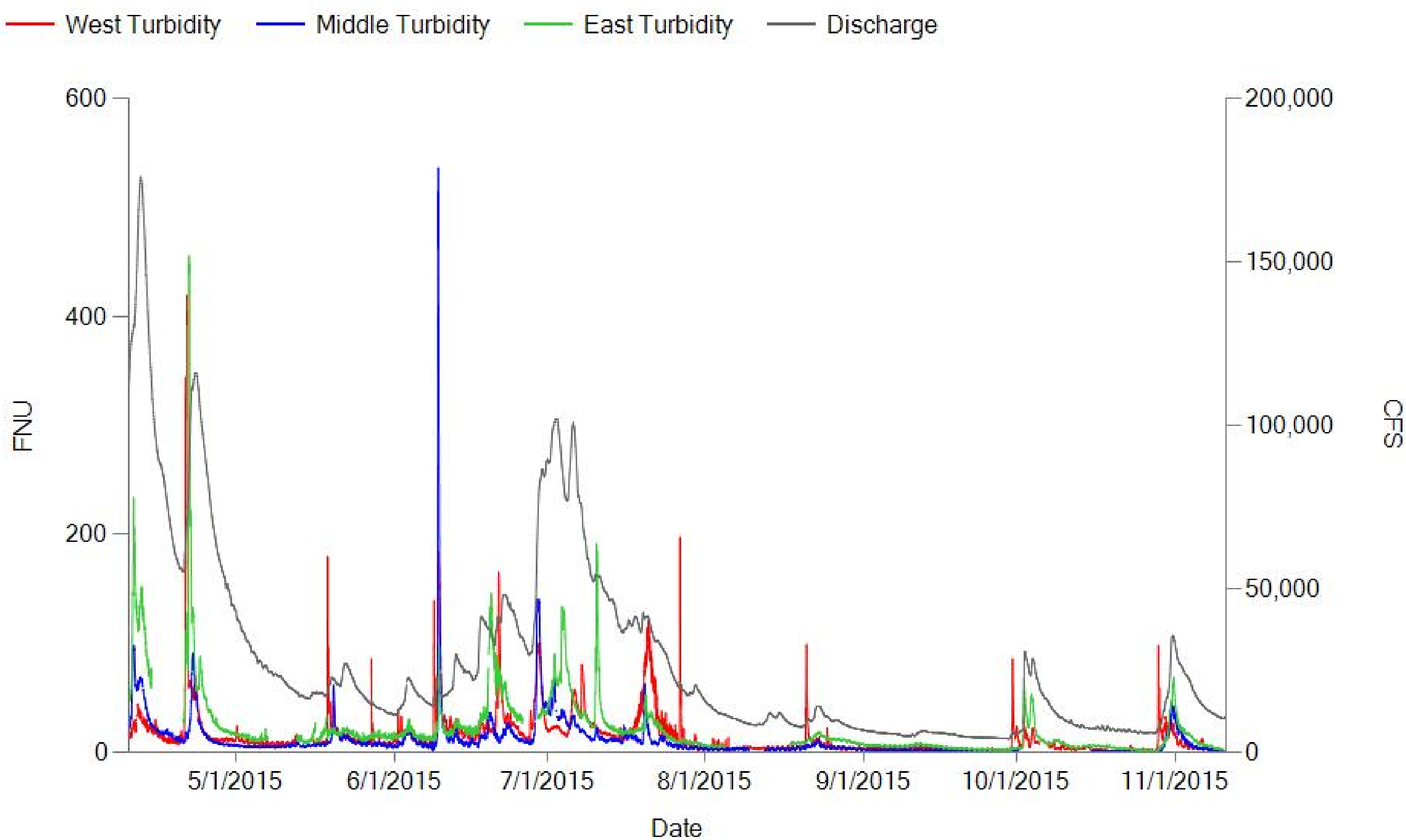

Figure 22. Continuous turbidity (FNU) and discharge (cfs) at the three Rockville sites from April 9, 2015 to November 10, 2015.

2016 Turbidity:	*West*	Min: 0.7 FNU	Average: 6.9 FNU	Max: 364.5 FNU
	Middle	Min: 0.0 FNU	Average: 5.8 FNU	Max: 60.6 FNU
	East	Min: 0.5 FNU	Average: 14.1 FNU	Max: 1,103.9 FNU

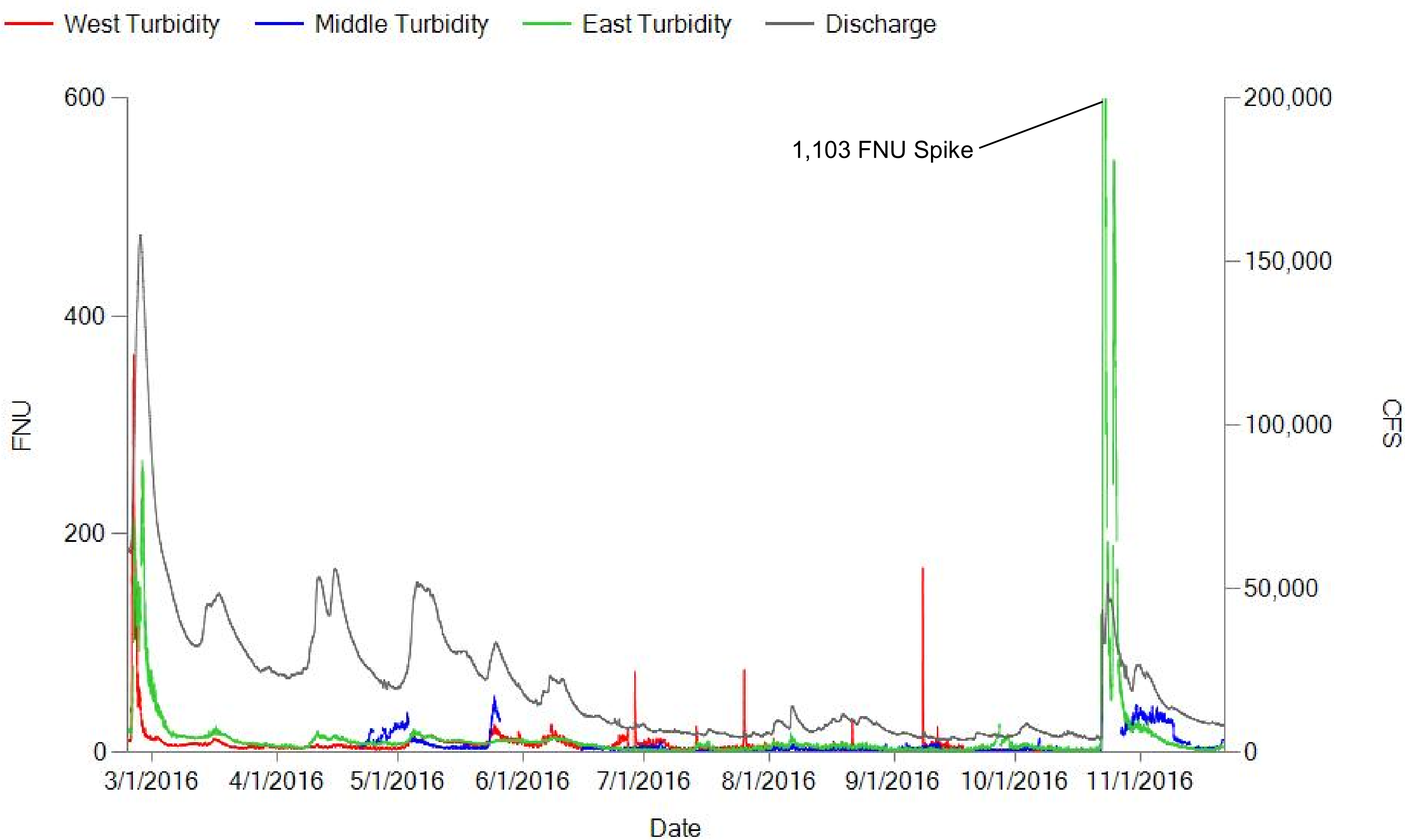

Figure 23. Continuous turbidity (FNU) and discharge (cfs) at the three Rockville sites from February 23, 2016 to November 21, 2016. A large spike on October 23 at the East site was cut off to maintain a consistent y-axis with other years that did not excessively compact other readings.

Table 3. Summary of discrete chemical sample results at the three Rockville CIM sites.

			WEST				MIDDLE				EAST			
	PARAMETER	UNITS	n	nd	Mean	Median	n	nd	Mean	Median	n	nd	Mean	Median
METALS AND IONS	ALUMINUM ACID SOLUBLE	µg/L	8	8	NA	NA	8	6	384	384	8	6	293	293
	ALUMINUM D	µg/L	21	10	23	13	21	9	25	19	22	10	28	23
	ALUMINUM T	µg/L	31	0	202	137	33	0	319	160	33	0	784	273
	BARIUM T	µg/L	35	0	44	40	36	0	33	32	37	0	35	32
	BORON T	µg/L	35	22	30	20	36	25	37	21	37	20	28	20
	BROMIDE	µg/L	37	19	12.4	12.3	36	11	20.7	20.5	37	9	26.3	24.9
	CADMIUM D	µg/L	13	12	0.268	0.268	13	12	0.400	0.400	13	12	0.57	0.57
	CALCIUM T	mg/L	35	0	26.7	26.9	36	0	21.8	21.0	37	0	25.1	25.6
	CHLORIDE T	mg/L	35	0	17	16	34	0	13	10	36	0	28	28
	COPPER D	µg/L	23	22	4.12	4.12	23	23	NA	NA	24	24	NA	NA
	COPPER T	µg/L	34	12	1.33	1.13	36	14	1.51	1.25	37	8	3.38	2.14
	IRON D	µg/L	24	3	41	35	24	10	39	31	25	4	61	36
	IRON T	µg/L	35	0	349	218	36	0	555	250	37	0	1460	602
	LEAD D	µg/L	24	24	NA	NA	24	24	NA	NA	25	25	NA	NA
	LEAD T	µg/L	35	13	0.481	0.303	36	13	0.666	0.397	37	9	1.376	0.872
	LITHIUM D	µg/L	13	13	NA	NA	13	13	NA	NA	13	13	NA	NA
	LITHIUM T	µg/L	14	14	NA	NA	15	13	4	4	14	13	4	4
	MAGNESIUM T	mg/L	35	0	7.8	7.4	36	0	7.1	6.7	37	0	7.3	6.6
	MANGANESE D	µg/L	24	14	19	18	24	11	21	16	25	12	23	15
	MANGANESE T	µg/L	35	0	41	35	36	0	104	79	37	0	135	109
	NICKEL D	µg/L	13	13	NA	NA	13	13	NA	NA	13	13	NA	NA
	NICKEL T	µg/L	35	34	32	32	36	33	16	13	37	35	19	19
	POTASSIUM T	mg/L	16	0	1.872	1.795	17	1	1.551	1.374	17	0	1.893	1.775
	SELENIUM T	µg/L	35	27	1.00	0.55	36	28	1.18	0.92	37	25	1.05	0.80
	SODIUM T	mg/L	35	0	10.1	9.7	36	0	8.5	7.3	37	0	17.0	16.8
	STRONTIUM T	µg/L	36	0	307	287	37	0	161	132	38	0	111	107
	SULFATE T	mg/L	35	0	22.0	20.0	34	0	37.7	37.8	36	0	33.6	29.3
	ZINC D	µg/L	24	20	12	12	24	23	15	15	25	23	13	13
	ZINC T	µg/L	35	14	13	10	35	12	12	9	37	7	16	14
NUTRIENTS	AMMONIA D	mg/L	34	12	0.033	0.028	35	19	0.027	0.023	36	12	0.029	0.020
	AMMONIA T	mg/L	34	13	0.035	0.026	35	16	0.028	0.023	36	12	0.031	0.020
	NITRATE & NITRITE D	mg/L	37	0	0.808	0.754	37	0	0.519	0.490	37	0	0.470	0.427
	NITRATE & NITRITE T	mg/L	37	0	0.800	0.750	36	0	0.481	0.478	37	3	0.489	0.410
	NITROGEN D	mg/L	23	0	1.094	1.023	24	0	0.677	0.689	25	0	0.670	0.528
	NITROGEN T	mg/L	35	0	1.099	0.981	35	0	0.709	0.717	37	1	0.804	0.741
	ORTHO PHOSPHORUS D	mg/L	37	6	0.013	0.011	37	11	0.008	0.006	37	12	0.011	0.008
	ORTHO PHOSPHORUS T	mg/L	37	6	0.012	0.010	36	9	0.008	0.007	38	10	0.014	0.009
	PHOSPHORUS D	mg/L	37	1	0.017	0.015	37	8	0.012	0.009	37	2	0.012	0.011
	PHOSPHORUS T	mg/L	37	0	0.030	0.029	37	1	0.025	0.019	37	0	0.047	0.031
PHYSICAL/OTHER	ALKALINITY	mg/L	37	0	78.0	77.4	37	0	45.5	38.2	38	0	59.4	62.2
	GLYPHOSATE	µg/L	8	8	NA	NA	8	8	NA	NA	8	8	NA	NA
	HARDNESS T	mg/L	35	0	99	99	36	0	83	79	37	0	93	92
	OSMOTIC PRESSURE	mOsm	22	1	4	3	21	3	3	4	24	4	4	4
	pH	SU	37	0	8.28	8.30	37	0	7.79	8.00	38	0	8.11	8.05
	SPECIFIC COND	µS/cm[c]	35	0	250.2	239.0	36	0	382.4	209.5	38	0	276.1	284.0
	SSC - TOTAL	PPM	21	0	11.7	8.4	20	0	16.3	8.8	20	0	28.6	13.5
	SSC - COARSE	PPM	21	0	2.5	2.2	20	0	3.7	2.0	20	0	3.2	2.7
	SSC - FINE	PPM	21	0	9.2	5.3	20	0	12.6	5.9	20	0	25.4	9.8
	TDS	mg/L	36	0	156	155	35	0	150	136	37	0	182	170
	TOC	mg/L	36	0	2.700	2.700	36	0	2.200	2.200	36	0	3.100	2.700
	TSS	mg/L	36	16	14	12	35	17	22	10	37	8	40	20

Means and medians were calculated from measurements greater than the relevant detection limit.
n = number of samples. nd = number of non-detects. NA = mean/median not available, all data were non-detect

EVALUATION

The evaluation of CIM data incorporates water quality criteria from 25 Pa. Code § 93.7 and the 99% frequency rule from 25 Pa. Code § 96.3(c) as described in Hoger 2018a. Each reading represents a period of time equal to the recording interval. Because the sondes at this site recorded measurements every 30 minutes, 176 exceedances measured over a 365-day period constitutes a percentage greater than 1% (176 x 30 minutes = 5,280 minutes or 1.004% of a year). The evaluations in this report include 99% frequency rule calculations but do not include protected use assessment determinations.

Annual Variation and Critical Conditions

A major determinant of variation in water quality is the amount, timing, and location of precipitation in the watershed upstream of a site. Elevated precipitation will result in increased surface water discharge, which can moderate some instream conditions stressful for certain forms of aquatic life. In past surveys, DEP has documented that elevated discharge can reduce the magnitudes of daily fluctuations of DO, pH, and temperature, and can increase daily minimum DO and decrease daily maximum pH and temperature.

Figure 24 shows the large variation in stream discharge of the Susquehanna River at Harrisburg during the four summers covered by this report. These data demonstrate the difficulty in accurately assessing water quality in complex river systems with a temporally limited dataset. The first three years of the study were characterized by elevated flow through the critical summer and early fall periods. In 2016, however, a notable decrease in precipitation led to a prolonged decrease in flow and measurable changes in water quality.

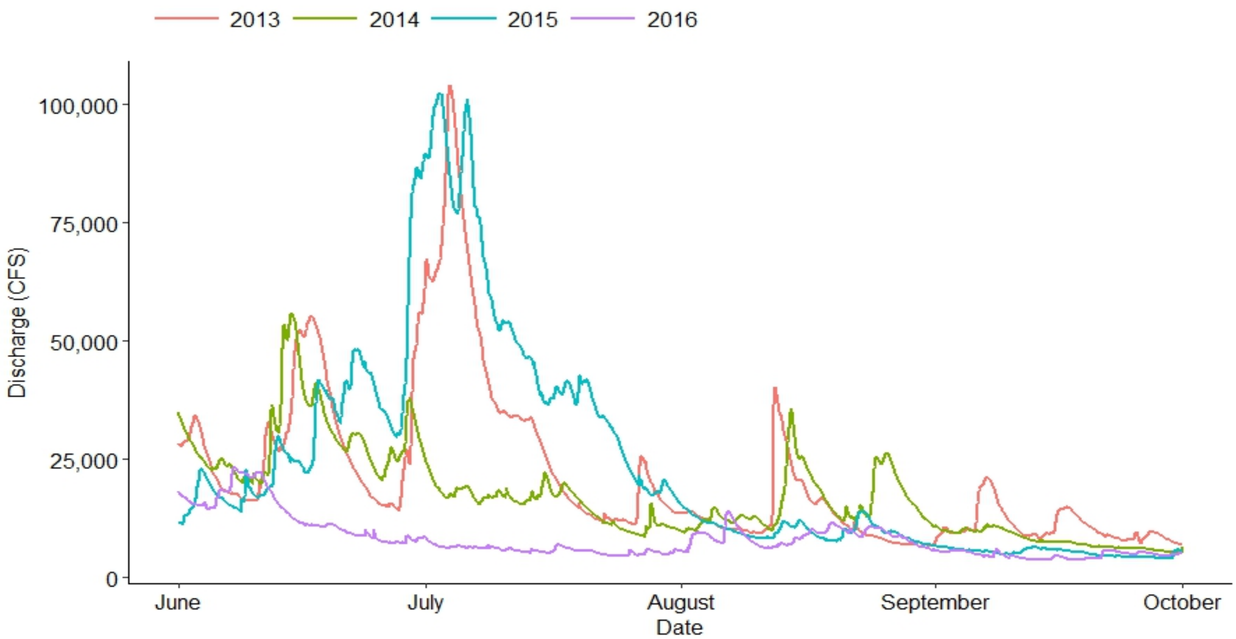

Figure 24. Stream discharge data from USGS station 01570500, Susquehanna River at Harrisburg, for the summer and early fall of 2013 to 2016.

Cross-Sectional Surveys

Transect survey data indicate significant cross-sectional differences in all five water quality parameters across the width of the river (Figure 3). The specific conductance data most clearly show the three distinct water quality zones created by incomplete mixing of flows from the Juniata River along the west bank, the West Branch Susquehanna River in the middle of the channel, and the mainstem Susquehanna River along the east bank (Figure 3). Downstream of confluences with smaller tributaries, the cross-sectional data also show distinct, often significant, differences in water quality along each bank attributable to incomplete mixing of tributary flows.

CIM, Temperature

Temperature varied only slightly among the three Rockville CIM sites. The greatest differences were observed during elevated flow events because these events were the result of precipitation that falls unevenly in the three major sub-watersheds (i.e., Juniata River, West Branch Susquehanna River, mainstem Susquehanna River). These differences in precipitation lead to differing levels of influence on temperature and other parameters. Instream temperatures over 30°C occurred at all sites nearly every year, and water temperatures reached over 32°C at Rockville Middle and Rockville East in 2016 (Figures 4 to 7) when mid-summer flows were low (Figure 24). These elevated water temperatures are attributed to the wide and shallow physical characteristics of the Susquehanna River at this location, which allow for strong light penetration and heat absorption.

CIM, Specific Conductance

Specific conductance is commonly used to indicate human impacts to a stream. During baseflow conditions, Rockville East typically had the highest specific conductance and

Rockville West had the lowest (Figures 8 to 11). This relationship is complicated during the spring due to frequent rainfall. During periods of frequent rainfall (Figure 24), varying degrees of precipitation-driven dilution determines the relationship of specific conductance among the three CIM sites (Figures 8 to 11) rather than anthropogenic effects. At all three CIM sites and in all four years, specific conductance increased throughout the year (Figures 8 to 11) as water levels dropped (Figure 24), a trend that was most pronounced at Rockville East (Figures 8 to 11).

CIM, pH

Although there were large variations between sites and years, exceedances of the pH water quality criterion (6.0 to 9.0, inclusive) constituted greater than 1% of the year in at least one 365-day period at all three sites (Table 4). All exceedances were of the maximum criterion, the minimum criterion was not exceeded at any site in any year. The greatest number of pH criterion exceedances in any rolling 365-day period during the period of record at Rockville was determined to be: June 21, 2014 to June 20, 2015 for the West site; October 20, 2015 to October 19, 2016 for the Middle site; and June 24, 2013 to June 23, 2014 for the East site (Table 4). During the low flows and critical conditions observed during 2016, the west and middle sites showed an expected response of increased exceedances of the maximum pH criterion (Figure 15). A different response, however, was observed at the Rockville East site which had its lowest number of exceedances in 2016 and its highest number of exceedances in 2014, a year characterized by frequent high flow events (Figures 12 to 15). So, although annual differences in water quality are influenced by the amount and timing of flow as previously discussed, there are other underlying drivers that should be investigated.

Table 4. Annual exceedances of pH water quality criteria.

Year	Rockville West		Rockville Middle		Rockville East	
	No.	%	No.	%	No.	%
2013	0	0.00	123	0.70	181	1.03
2014	666	3.80	11	0.06	507	2.89
2015	204	1.16	0	0.00	79	0.45
2016	565	3.22	560	3.20	10	0.06
rolling year	734	4.19	560	3.20	590	3.37

Percent calculations are percentages of each year.
Red text indicates > 1% exceedance frequency.

CIM, Dissolved Oxygen

All sites met the WWF 5.0 mg/L minimum DO criterion at least 99% of the time. The only exceedances of this criterion were at Rockville West in 2016 (Figure 19), which had 151 exceedances representing 0.86% of that year. Although the average of daily DO readings never varied much among the three sites, there were striking differences in the magnitude of diel swings, particularly in the summer (Figures 16 to 19, Figure 25). In the summer of 2016, the magnitude of diel DO swings at Rockville West were often double those of Rockville Middle and triple those at Rockville East (Figure 19, Figure 25). Large diel changes in DO are evidence of eutrophication where high nutrient loads, long photoperiods, and low flow critical conditions drive strong diel cycles of photosynthesis and respiration (McGarrell 2018). These daily DO swings became great enough at the West site for many days in 2016 that overnight respiration consumed enough DO to bring levels below the WWF minimum DO criterion (Figure 19). When flows were elevated, critical conditions were mitigated and large swings in DO were not observed (Figures 16 to 19).

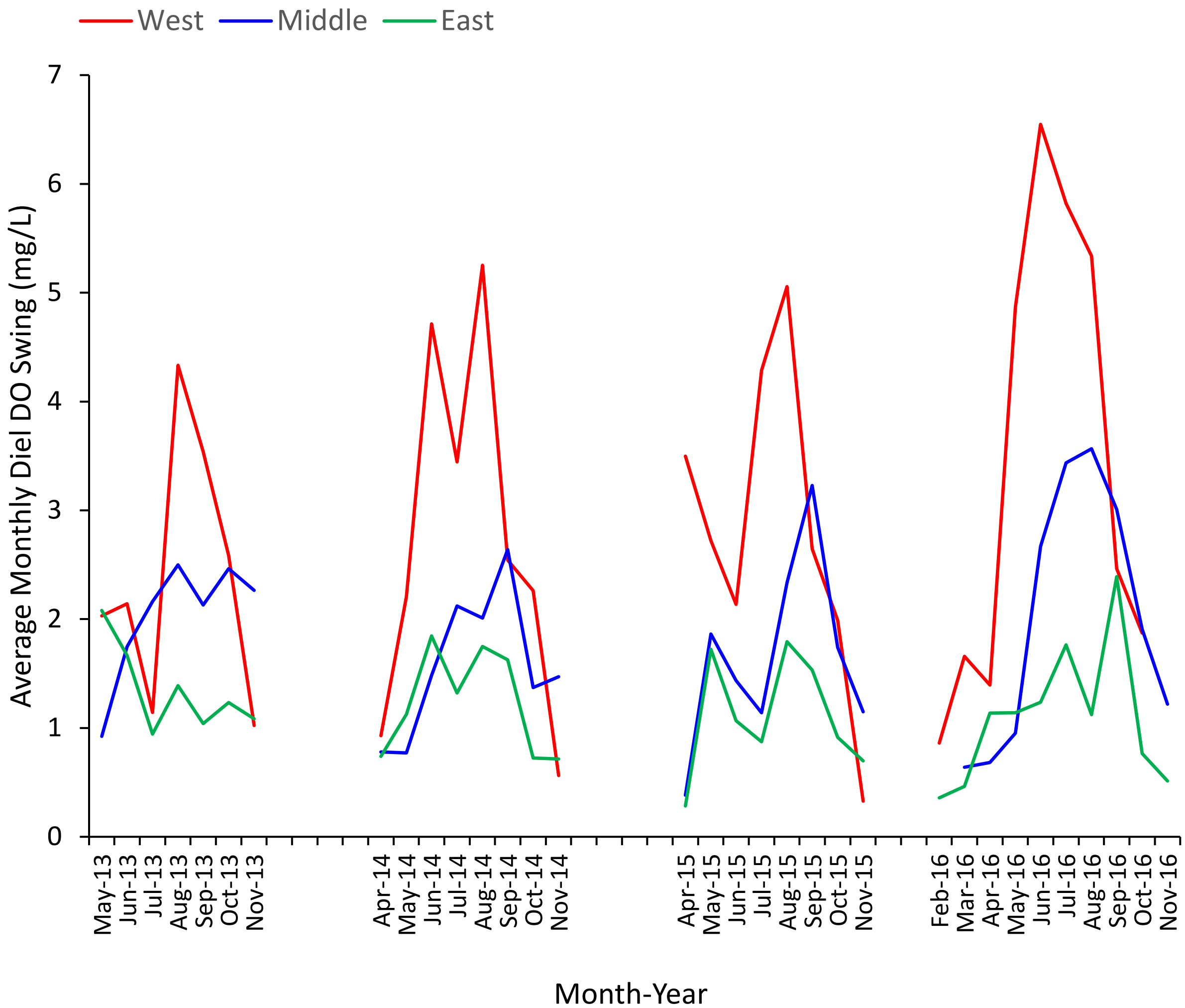

Figure 25. Monthly averages of diel DO swings at the three Rockville CIM sites from 2013 to 2016.

CIM, Turbidity

Large turbidity spikes occurred at all three Rockville CIM sites throughout the survey. These spikes in turbidity did not always correspond well with discharge measured at the Harrisburg USGS station due to differences in the timing and amount of precipitation in the respective sub-watersheds (Figures 20 to 23). Baseflow turbidity values were notably higher at Rockville East compared with Rockville West and Middle (Figures 21 to 23, 26). Higher turbidity may be a contributing factor to the lower diel swings of DO and pH observed at the East site since increased turbidity attenuates light penetration, which reduces photosynthetic activity.

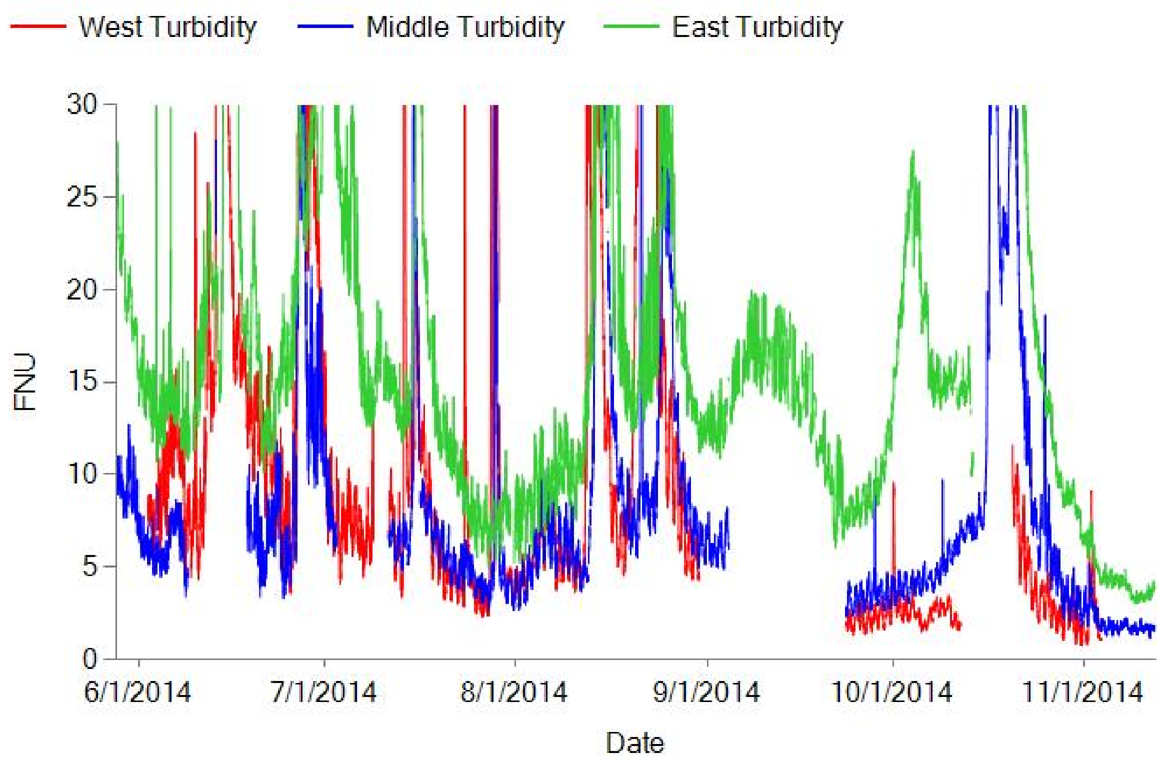

Figure 26. Turbidity readings at all Rockville CIM sites from 2014. Y-axis cut off at 30 FNU to better show baseflow measurements.

Discrete Water Chemistry Sampling
Results from chemical analyses of the grab samples (Table 3) are consistent with the CIM data. Metal and ion constituents were generally higher at Rockville East where median total aluminum, iron, lead, and manganese were roughly double the other two sites (Table 3). These higher metal and ion concentrations are consistent with the CIM finding that specific conductance was higher during baseflow at Rockville East. Nutrient constituents (i.e., nitrogen, nitrate and nitrite, and ortho phosphorus) were approximately twice the levels at Rockville West than at Rockville Middle and East (Table 3), which is consistent with the much greater diel DO swings found at Rockville West. Also, as expected based on the turbidity results, suspended sediment concentrations (SSCs) were greater at Rockville East (Table 3).

SUMMARY

The four years of data collected at the Rockville location on the Susquehanna River documented large variations in water quality at the three sites. Annual and intra-site variation was heavily influenced by differences in the timing and amount of precipitation in the three major sub-watersheds. The moderating effects of frequent elevated-flow events on constituents like temperature, pH, and DO were observed most readily in 2013 and 2015. These elevated flows during the critical summer and early fall periods obscured potential water quality issues. In 2016, however, this critical period was characterized by much lower flows, higher water temperatures, a higher rate of maximum pH criterion exceedances, increases in the magnitudes of diel DO swings, and exceedances of the minimum DO criterion. More investigation is needed to elucidate the driving forces of the pH criterion exceedances, particularly why pH at Rockville East did not respond as adversely to low flow conditions as did pH at the west and middle sites.

Despite differences in response to flow conditions, maximum pH criterion exceedances were documented at all three sites at some point during the survey. The Rockville West site, which is strongly influenced by the Juniata River, regularly had the highest number of pH criterion exceedances. Given the exceedances of the minimum DO criterion observed at the Rockville West site in the summer and early fall of 2016, it would not be surprising to observe exceedances of the minimum DO criterion at this site in future surveys during similarly extended periods of low flow. DEP will continue to monitor water quality at the Rockville location to document any changes that may occur and to better understand this complex and dynamic system.

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