pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF CLEAN WATER

Juniata River at Lewistown Narrows, 2013 to 2015

Continuous Instream Monitoring Report

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WATERBODY AND SITE DESCRIPTIONS

Stream Code: 11414
Stream Name: Juniata River
HUC: 02050304 – Lower Juniata

Site Description:
Site Code: 66205361-001
Site Name: Juniata River at Lewistown Narrows
Latitude: 40.58264 **Longitude:** -77.53278
Approximately 6.0 stream kilometers upstream from the Pennsylvania Fish and Boat Commission's Lewistown Narrows Boat Access, approximately 25 meters from the left descending bank.

County: Mifflin
Drainage Area: 7,184 km^2
Strahler Stream Order: 7
Designated Use: Warm Water Fishes

BACKGROUND AND HISTORY

The Juniata River is a freestone stream and one of the larger tributaries to the Susquehanna River. The watershed of the Juniata River at Lewistown Narrows encompasses all or parts of Somerset, Bedford, Fulton, Cambria, Blair, Huntingdon, Centre, Snyder, Mifflin, and Juniata counties in southcentral Pennsylvania (Figure 1). The basin is predominately characterized by ridge and valley topography with land use consisting of 70% forest, 21% agriculture, and 8% developed land. The designated aquatic life use of the Juniata River at Lewistown Narrows is Warm Water Fishes (WWF).

In addition to the continuous instream monitoring (CIM) site described above, a transect across the width of the river was established at Lewistown Narrows according to the Pennsylvania Department of Environmental Protection's (DEP's) *In-situ Field Meter and Transect Data Collection Protocol* (Hoger 2018b) to characterize mixing patterns and identify any distinct zones of water quality across the width of the river. Discrete water quality measurements were taken at nine equidistant points (LTOWN1 to LTOWN9) across the transect starting at the right descending bank, approximately 30 m downstream of the sonde (Figure 1). The LTOWN8 is located directly downstream of the sonde location (Figure 1).

Water quality data at this site were initially collected as part of the Susquehanna River Project investigating health and recruitment issues of smallmouth bass. This report focuses on only the CIM data and chemical grab samples collected from 2013 to 2015. 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.

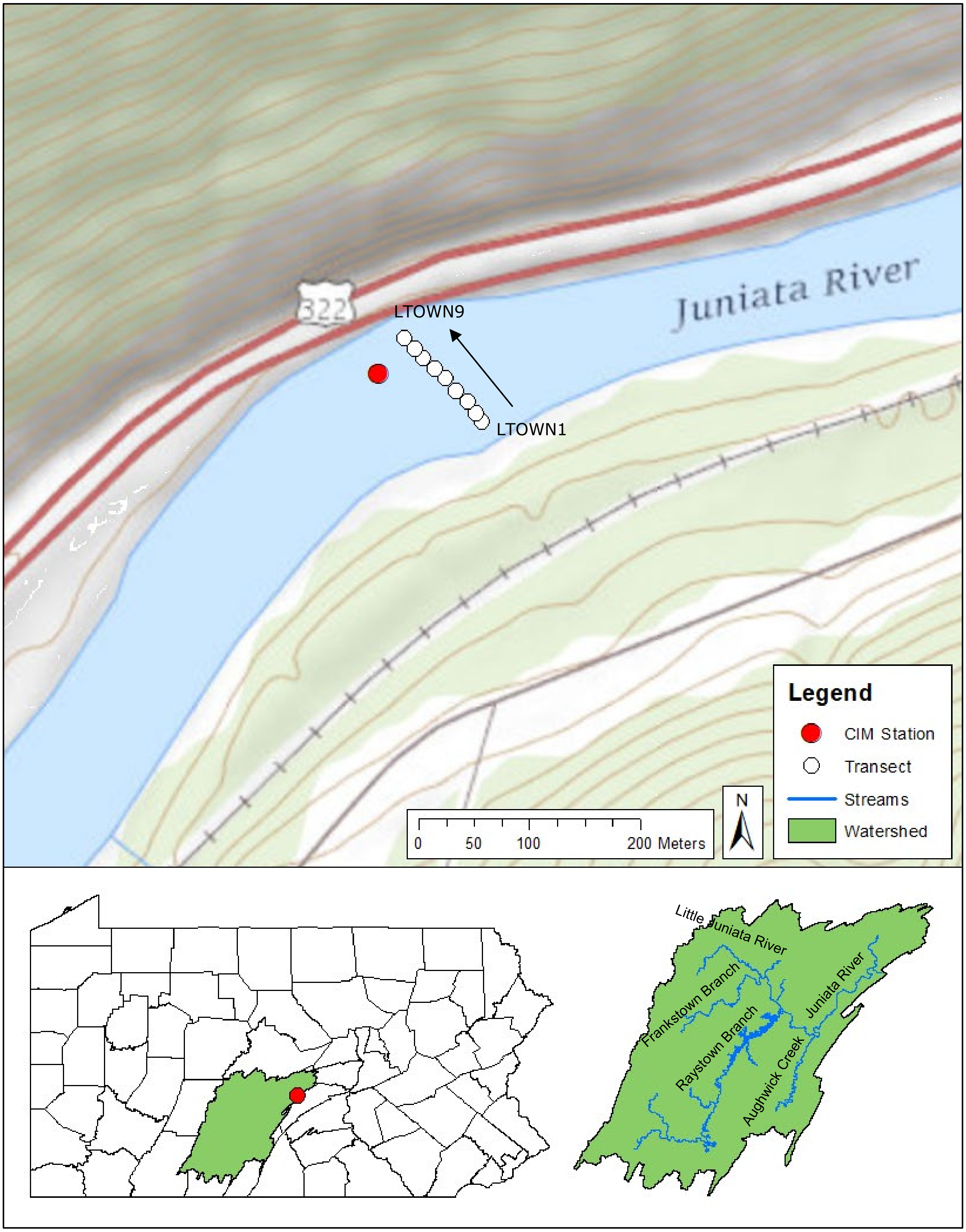

Figure 1. Map of the Juniata River CIM site and cross-sectional transect sampling locations at Lewistown Narrows.

PRIMARY OBJECTIVES

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

WATER QUALITY PARAMETERS

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

Table 1. Water quality parameters monitored by CIM.

Parameter	Units
Water Temperature	°C
Specific Conductance (@ 25°C)	μS/cm[c]
pH	Standard Units (SU)
Dissolved Oxygen (DO)	mg/L
Turbidity	Formazin Nephelometric Unit (FNU)

EQUIPMENT

A Yellow Springs Instruments (YSI) 6920 V2 water quality sonde was used to collect CIM data at the Lewistown Narrows site each year.

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 sonde. The attachment bar was clipped to an eye-bolt attached to rebar driven into the river bed. The attachment bar was also clipped to a cable attached to a second piece of rebar located just upstream of the first.

PERIOD OF RECORD

Continuous data were recorded from spring until late fall when the fall 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, the sonde was 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. The sondes recorded water quality parameter measurements once every 30 minutes.

Table 2. Continuous data period of record.

Year	Deployment	Removal
2013	May 03	November 19
2014	April 23	November 14
2015	April 06	November 04

DATA

Cross-Sectional Surveys

To monitor variations in water quality throughout the year, cross-sectional transect surveys were conducted numerous times. Cross-section survey data were analyzed by comparing each survey point to LTOWN8 (Figure 2), the transect point that was directly downstream of the sonde site (Figure 1). For temperature and pH, the difference in readings between LTOWN8 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 LTOWN8 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. To show year-to-year variations in water quality, the three years of CIM data for each parameter are overlaid in the plots below (Figures 4 to 8). Due to year-to-year differences in the timing of data collection and to data missing from some years but not others, comparison of the summary CIM data should be made with caution.

River discharge data from the United States Geological Survey (USGS)station 01564895, Juniata River at Lewistown, Pennsylvaniaare provided , in cubic feet per second (CFS), below (Figure 3). This USGS gaging station is located at the State Route 103 bridge approximately 5.3 stream kilometers upstream of the Lewistown Narrows CIM location.

Discrete Water Chemistry Sampling

Grab samples were collected several times each year at the Lewistown Narrows CIM site (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. SAC 618 was used to obtain suspended sediment concentrations. A complete list of grab sample analytes can be found in Table 3.

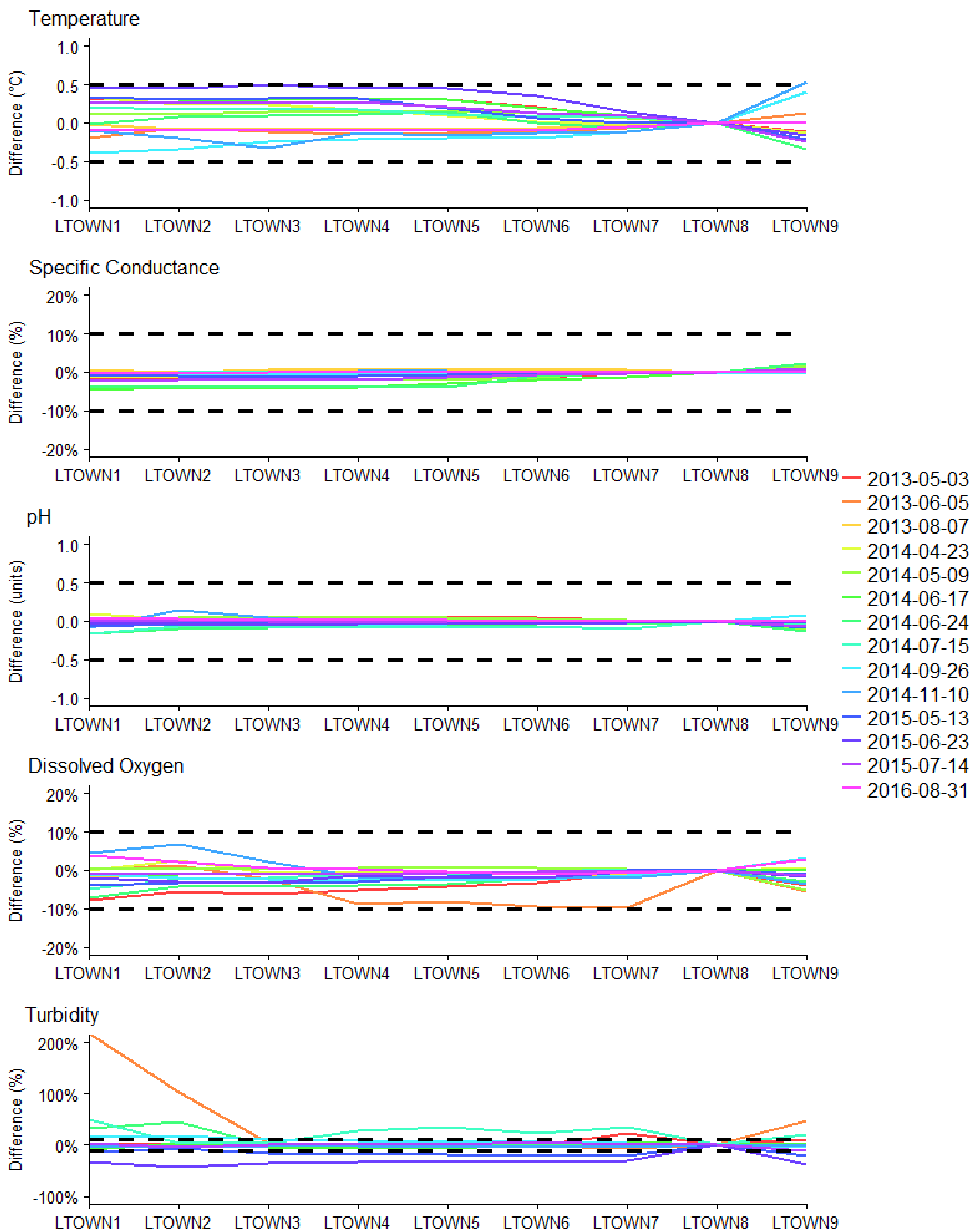

Figure 2. Cross-section surveys at Lewistown Narrows showing relative difference in readings compared to LTOWN8 over four years. Dashed black lines indicate thresholds of significance.

Discharge:	*2013*	Min: 398 cfs	Average: 2,630 cfs	Max: 26,731 cfs
	2014	Min: 500 cfs	Average: 2,766 cfs	Max: 27,664 cfs
	2015	Min: 455 cfs	Average: 1,970 cfs	Max: 28,900 cfs

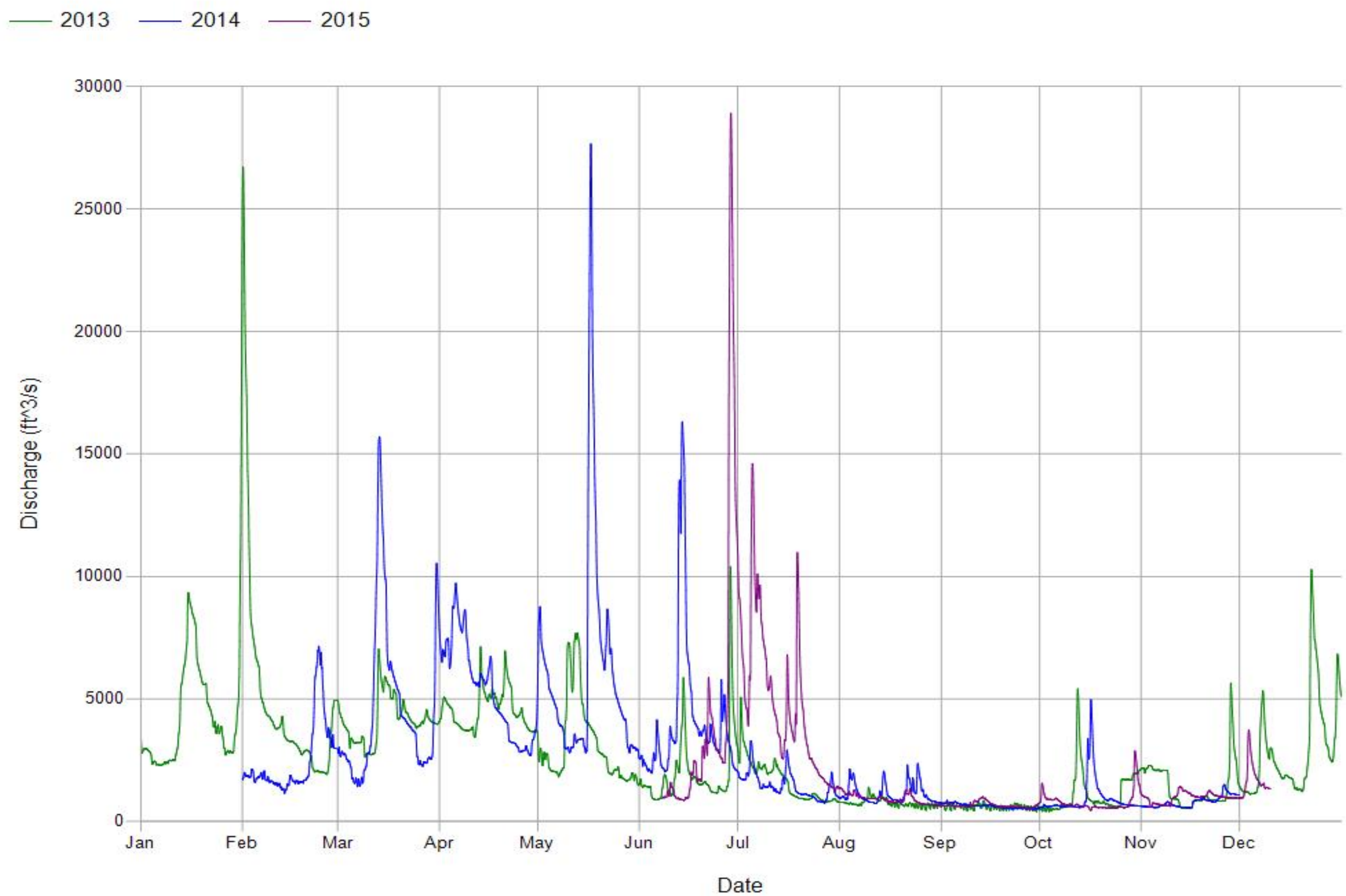

Figure 3. Continuous discharge at USGS station 01564895, Juniata River at Lewistown, from 2013 to 2015.

Water Temperature:	*2013*	Min: 4.86 °C	Average: 20.13 °C	Max: 31.46 °C
	2014	Min: 6.57 °C	Average: 18.96 °C	Max: 27.49 °C
	2015	Min: 8.28 °C	Average: 19.77 °C	Max: 28.54 °C

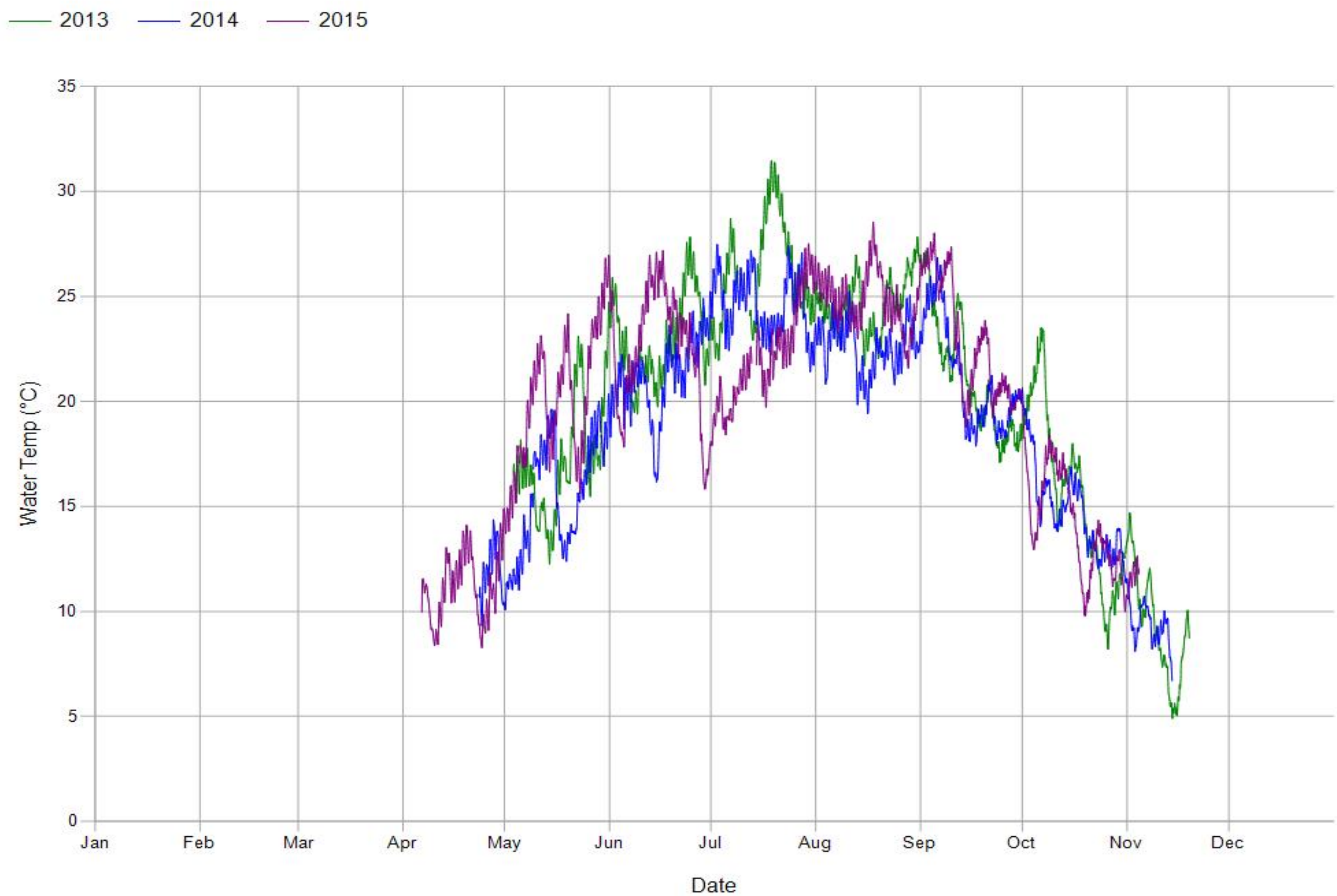

Figure 4. Continuous water temperature at the Juniata River at Lewistown Narrows CIM site from 2013 to 2015.

Specific Conductance:	*2013*	Min: 198.0 µS/cm[c]	Average: 298.1 µS/cm[c]	Max: 372.0 µS/cm[c]
	2014	Min: 110.9 µS/cm[c]	Average: 290.9 µS/cm[c]	Max: 368.4 µS/cm[c]
	2015	Min: 174.6 µS/cm[c]	Average: 301.3 µS/cm[c]	Max: 412.0 µS/cm[c]

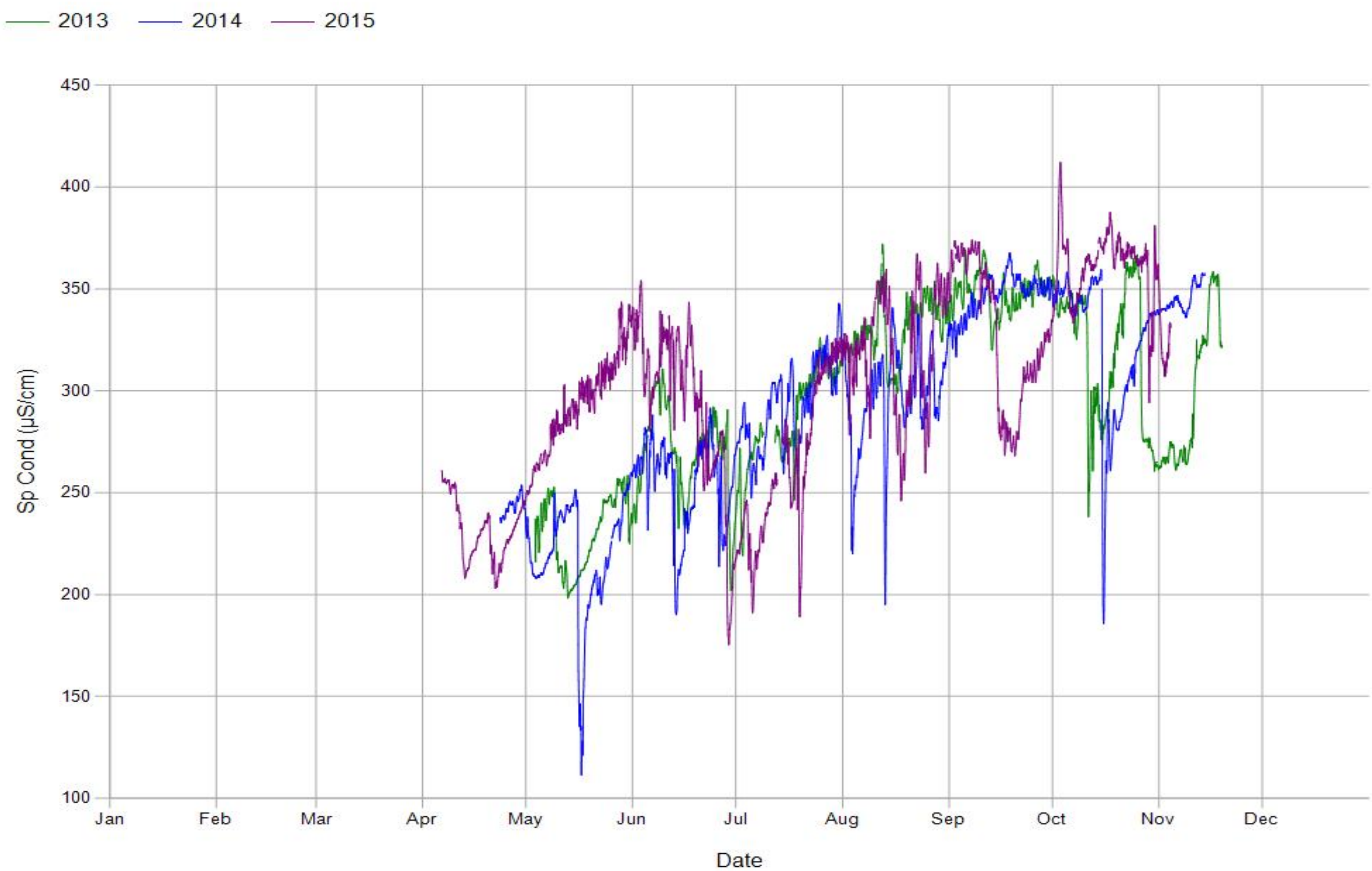

Figure 5. Continuous specific conductance at the Juniata River at Lewistown Narrows CIM site from 2013 to 2015.

pH:	*2013*	Min: 7.50 SU	Average: 8.18 SU	Max: 9.27 SU
	2014	Min: 6.98 SU	Average: 8.26 SU	Max: 9.54 SU
	2015	Min: 7.65 SU	Average: 8.25 SU	Max: 9.00 SU

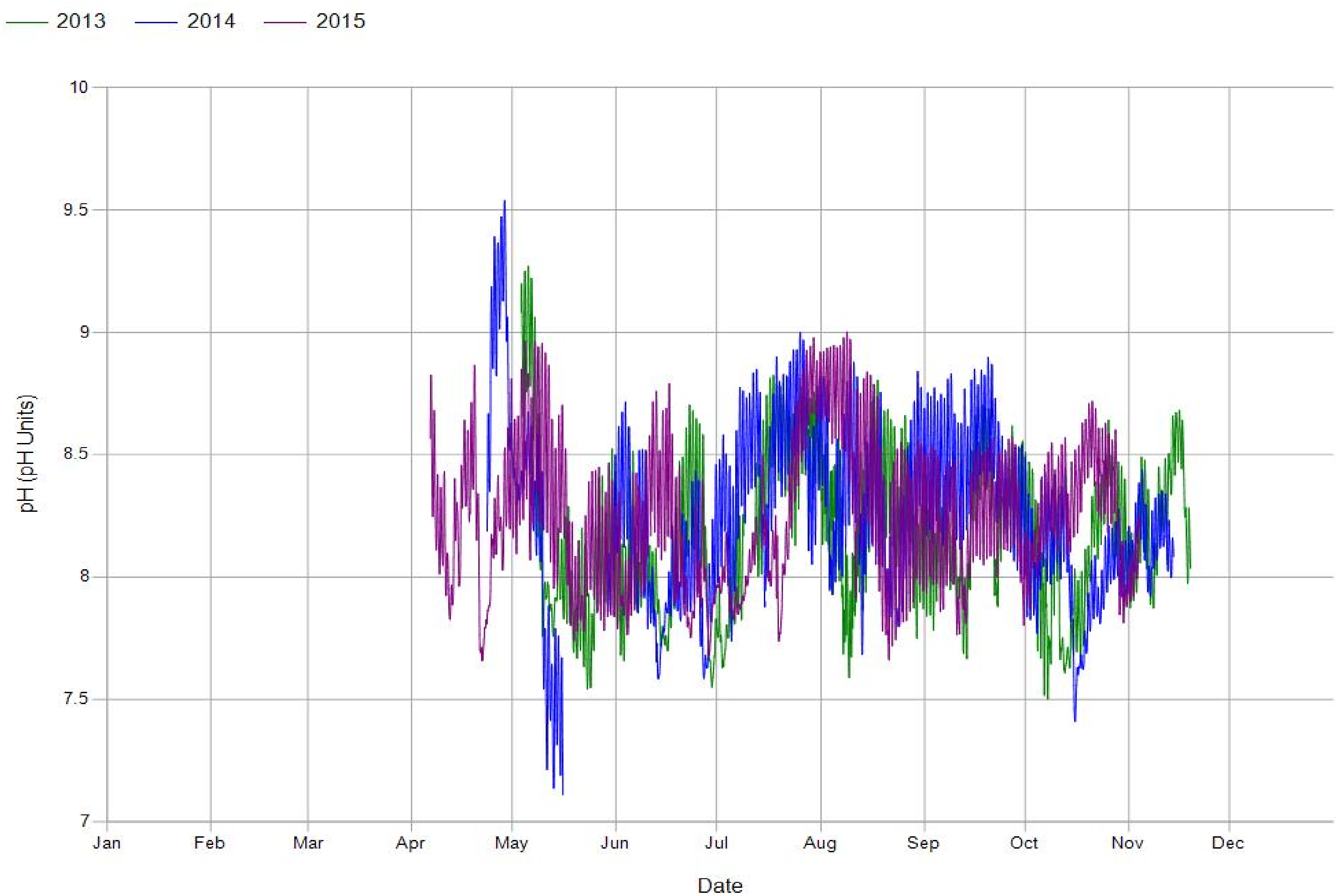

Figure 6. Continuous pH at the Juniata River at Lewistown Narrows CIM site from 2013 to 2015.

Dissolved Oxygen:	*2013*	Min: 5.55 mg/L	Average: 8.81 mg/L	Max: 13.77 mg/L
	2014	Min: 6.36 mg/L	Average: 9.06 mg/L	Max: 12.97 mg/L
	2015	Min: 5.53 mg/L	Average: 9.16 mg/L	Max: 12.99 mg/L

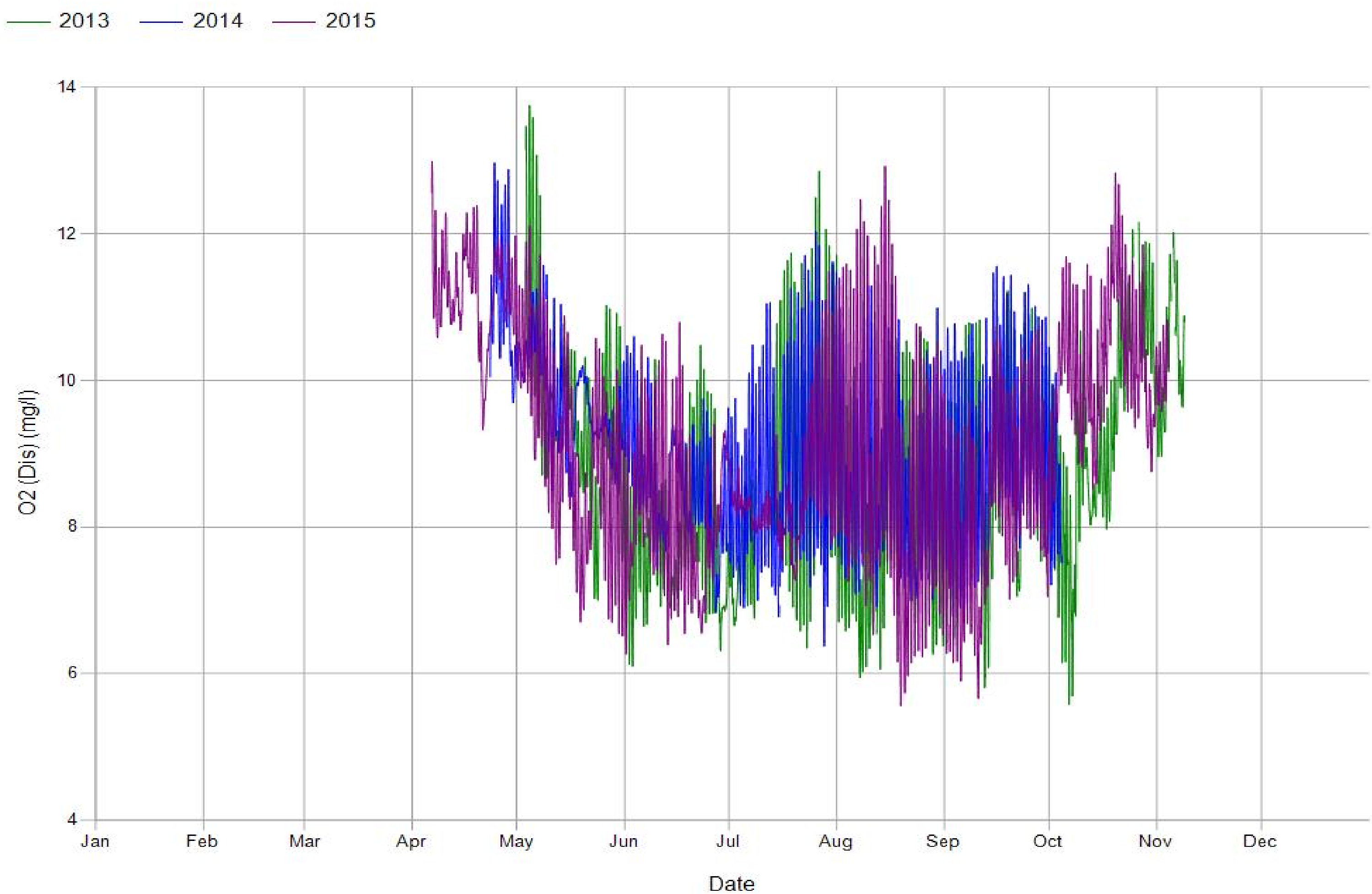

Figure 7. Continuous dissolved oxygen at the Juniata River at Lewistown Narrows CIM site from 2013 to 2015.

Turbidity:	*2013*	Min: 0.0 FNU	Average: 5.7 FNU	Max: 105.3 FNU
	2014	Min: 2.0 FNU	Average: 9.9 FNU	Max: 239.4 FNU
	2015	Min: 1.1 FNU	Average: 11.6 FNU	Max: 184.9 FNU

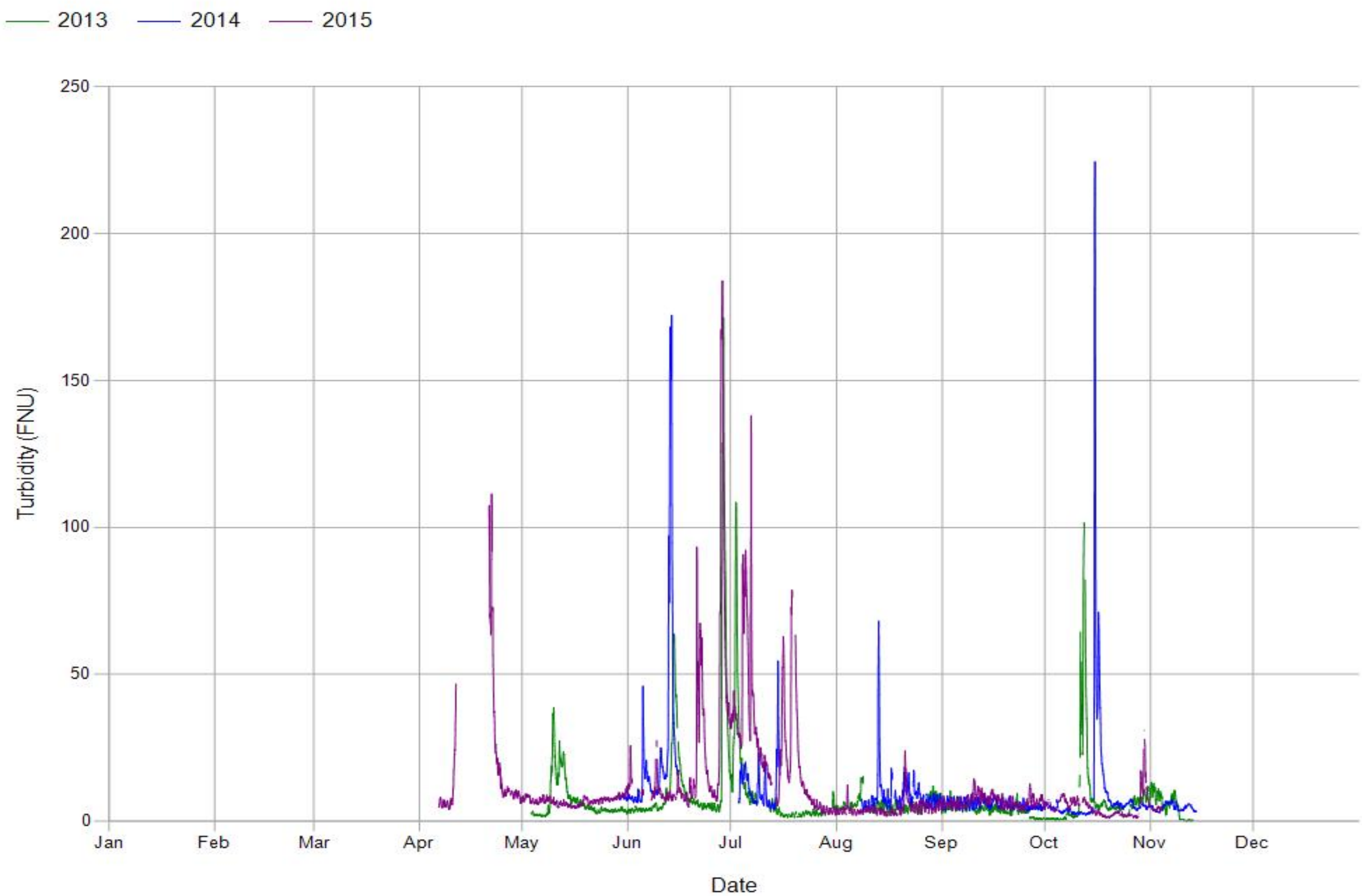

Figure 8. Continuous turbidity at the Juniata River at Lewistown Narrows CIM site from 2013 to 2015.

Table 3. Summary of discrete chemical sample results at the Lewistown Narrows CIM site.

	PARAMETERS	UNITS	JUNIATA RIVER AT LEWISTOWN NARROWS			
			n	nd	mean	median
METALS AND IONS	ALUMINUM D	µg/L	7	6	6	6
	ALUMINUM T	µg/L	18	0	179	112
	BARIUM T	µg/L	18	0	42	43
	BORON T	µg/L	18	7	23	20
	BROMIDE	µg/L	19	2	13.491	12.524
	CALCIUM T	mg/L	18	0	32.1	33.6
	CHLORIDE T	mg/L	19	0	19	19
	COPPER D	µg/L	7	7	NA	NA
	COPPER T	µg/L	19	0	1.63	1.18
	IRON D	µg/L	7	1	28	25
	IRON T	µg/L	18	0	284	183
	LEAD D	µg/L	7	6	1.260	1.260
	LEAD T	µg/L	19	0	0.519	0.477
	LITHIUM T	µg/L	1	0	3	3
	MAGNESIUM T	mg/L	18	0	10.0	9.7
	MANGANESE D	µg/L	7	4	13	15
	MANGANESE T	µg/L	18	0	31	30
	NICKEL T	µg/L	18	18	NA	NA
	POTASSIUM T	mg/L	2	0	2.458	2.458
	SELENIUM T	µg/L	19	13	0.618	0.490
	SODIUM T	mg/L	18	0	11.064	11.090
	STRONTIUM T	µg/L	18	0	308	294
	SULFATE T	mg/L	19	0	25.490	27.648
	ZINC D	µg/L	7	4	8	10
	ZINC T	µg/L	18	5	10	8
NUTRIENTS	AMMONIA D	mg/L	18	2	0.038	0.029
	AMMONIA T	mg/L	18	1	0.036	0.033
	NITRATE & NITRITE D	mg/L	19	0	1.131	1.140
	NITRATE & NITRITE T	mg/L	19	0	1.119	1.113
	NITROGEN D	mg/L	18	0	1.402	1.477
	NITROGEN T	mg/L	18	0	1.413	1.444
	ORTHO PHOSPHORUS D	mg/L	19	0	0.021	0.019
	ORTHO PHOSPHORUS T	mg/L	19	0	0.021	0.022
	PHOSPHORUS D	mg/L	19	0	0.027	0.026
	PHOSPHORUS T	mg/L	19	0	0.040	0.035
PHYSICAL/OTHER	ALKALINITY	mg/L	19	0	96.9	103.8
	GLYPHOSATE	µg/L	5	5	NA	NA
	HARDNESS T	mg/L	18	0	122	126
	OSMOTIC PRESSURE	mOsm	18	1	4	4
	pH	SU	19	0	8.25	8.30
	SPECIFIC COND	µS/cm[c]	19	0	301.4	322.0
	SSC - COARSE	PPM	7	0	2.0	1.7
	SSC - FINE	PPM	7	0	9.0	5.9
	TDS	mg/L	18	0	184	186
	TOC	mg/L	18	0	2.590	2.425
	TSS	mg/L	18	8	12	10

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.

While precipitation events occurred frequently in the spring of 2013 and 2014, the magnitudes of springtime precipitation events were greater in 2014 (Figure 3). Discharge data from the spring of 2015 were not available (Figure 3), however, turbidity data from this period suggest a major discharge event in late April 2015 (Figure 8). There were no major flow events (i.e., over 10,000 CFS) in April of 2013 or 2014 (Figure 3). Despite variations in the timing and magnitude of flow events, annual maximum and minimum discharge remained fairly consistent in each year (Figure 3). All three years exhibited a period of consistently low discharge in August and September with a few small precipitation events in August 2014 (Figure 3).

Cross-Sectional Surveys

The transect survey data indicate a well-mixed river at Lewistown Narrows (Figure 2). Differences in specific conductance and pH across the width of the river were very small in all 14 transect surveys (Figure 2). Temperature and DO showed greater variability across the width of the river in several transect surveys, but the differences with LTOWN8 were always within the ±0.5°C and ±10% thresholds, respectively (Figure 2). The highest differences in turbidity compared to LTOWN8 were along the banks (LTOWN1 and LTOWN2 on the right descending bank and LTOWN9 on the left descending bank; Figure 2).

CIM, Temperature

Annual average water temperature was greatest in 2013 and 2015 (Figure 4). While the greatest maximum water temperature was observed in 2013, 2015 temperatures were above those recorded in 2013 and 2014 throughout much of the spring. Water temperatures were then reduced relative to the other years in late June of 2015 during and after the very high flow event (i.e., over 25,000 CFS) at the end of June (Figures 3 and 4).

CIM, Specific Conductance

Specific conductance CIM measurements exhibited a relatively consistent pattern in 2013 and 2014, following the typical trend of reduced specific conductance during and after higher-flow events in the spring and slowly increasing specific conductance during sustained periods of reduced flow in late summer (Figures 3 and 5). From mid-May to mid-June of 2015, specific conductance CIM measurements were approximately 50 µS/cm[c] greater than in the previous two years (Figure 5). These higher specific conductance values are characteristic of sustained baseflow conditions observed elsewhere during the CIM sonde deployments, such as from late July through early October of 2013 (Figures 3 and 5). Discharge data were not available from USGS station 01564895 before early June in 2015 to determine if reduced discharge was the cause for the elevated specific conductance readings in May and June of that year; however, the 2015 turbidity CIM data also suggest sustained baseflow conditions during May of 2015 (Figure 8). Annual average specific conductance was highest in 2015, however, annual average specific conductance was similar all three years (Figure 5). Specific conductance responded as expected during most major flow events – decreasing due to dilution from surface runoff – with a few occurrences of elevated specific conductance at the crest of, or during the descending limb of, a flow event; this atypical pattern was most evident in October 2015 (Figures 3, 5, and 9).

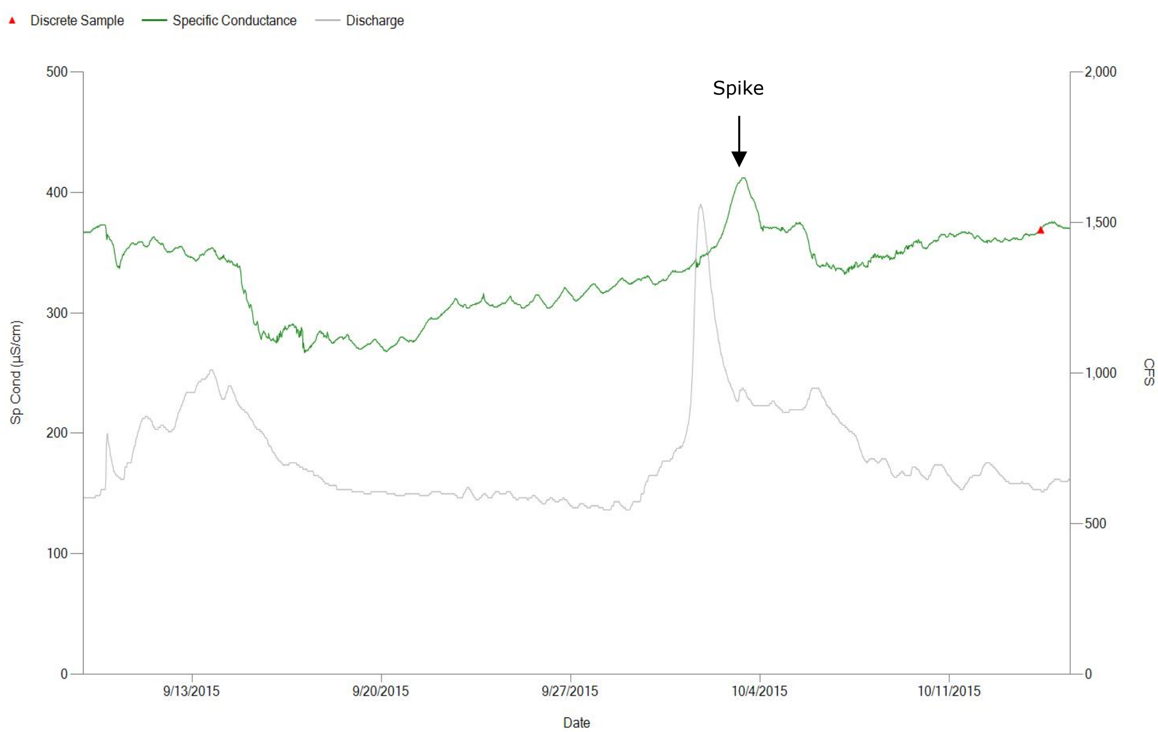

Figure 9. Example of an atypical specific conductance spike during a high-flow event at the Lewistown Narrows CIM site on the Juniata River. Response of specific conductance to increased discharge is slightly delayed in part because discharge data were collected approximately 5.3 stream kilometers upstream.

CIM, pH
The maximum pH criterion of 9.0 was exceeded on the Juniata River at Lewistown in all three years. The greatest number of exceedances for a rolling 365-day period occurred from April 30, 2013 to April 29, 2014 (Figure 6, Table 4). The pH criterion maximum was exceeded by 302 readings during this 365-day period, representing a criterion exceedance frequency of 1.7% (Table 4). Looking at calendar years, the greatest number of exceedances occurred in 2014 (Table 4). No pH values were recorded less than the minimum criterion (6.0) during the CIM period of record, and the annual minimum pH values were similar each year (Figure 6). The CIM pH data displayed the typical diel pattern of increased pH during the daylight hours caused by photosynthetic activity and decreased pH overnight caused by cellular respiration (Figure 6). The CIM pH data also showed the commonly observed depressions in pH during higher-flow events (Figures 3 and 6).

Table 4. Annual exceedances of pH water quality criteria.

Year	pH Exceedance	
	No.	%
2013	106	0.60
2014	196	1.12
2015	4	0.02
rolling year	302	1.72

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

CIM, Dissolved Oxygen
Continuous DO data did not show any exceedances of the WWF minimum DO water quality criterion of 5.0 mg/L. Maximum daily DO fluctuations were largest in 2013 and 2015, with diel ranges exceeding 5.0 mg/L (Figure 7). The largest daily DO fluctuations were during the critical low-flow late summer periods in all three years (Figure 7).

CIM, Turbidity
Large turbidity spikes occurred throughout the CIM period of record (Figure 8), generally corresponding in time and magnitude to elevated discharge events (Figure 3). Year-to-year comparisons of the turbidity CIM data should be made cognizant of the fact that usable CIM turbidity data are not available prior to early May in 2013 and prior to late May in 2014 (Figure 8). Although 2015 has the highest recorded annual average turbidity (Figure 8), the annual average turbidity for 2013 and 2014 are likely skewed low by the fact that numerous substantial higher-flow events occurred each of those years prior to useable turbidity data being available (Figures 3 and 8).

Discrete Water Chemistry Sampling
Results from chemical analyses of the grab samples (Table 3) are consistent with the CIM data. Concentrations of most metal analytes were generally low in all samples, except for aluminum and iron, which were found at higher concentrations during elevated discharge collections. Concentrations of chloride and sodium were overall greater in 2015 than the preceding two years. Concentrations of total nitrogen and total phosphorus were consistent across all samples.

SUMMARY

In 2014, the CIM data collected from the Juniata River at Lewistown Narrows documented exceedances of the maximum pH criterion at a frequency greater than 1% of the year (Table 4), with all the exceedances occurring in late April and early May (Figure 6). The years with the most pH maximum criterion exceedances (2013 and 2014) were characterized by relatively low flows during this critical springtime period (Figure 3). In 2015, river discharge data are not available during the spring critical period (Figure 3), but the CIM turbidity data suggest that flows were elevated during at least part of this critical period, with a spike in turbidity around the third week of April (Figure 8). Elevated springtime flows may have been a large driver of the fewer exceedances of the maximum pH criterion observed in 2015. Continuous DO data demonstrated no exceedances of the WWF minimum water quality criterion. The findings presented in this report provide baseline data and analyses that will support future studies of water quality at the Juniata River at Lewistown Narrows site.

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