GEI Consultants

Consulting
Engineers and
Scientists

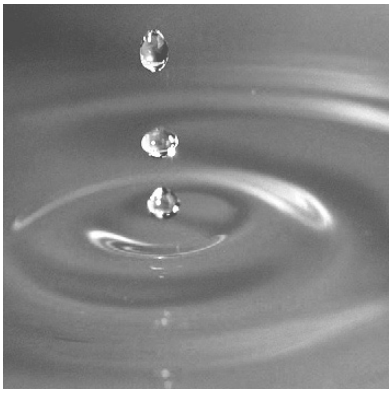
2016 Water Quality Monitoring Report

Little Chute
Hydroelectric Project
FERC No. 2588-007
Little Chute, Wisconsin

Submitted to:
Kaukauna Utilities

Submitted by:
GEI Consultants, Inc.
3159 Voyager Drive
Green Bay, Wisconsin 54311

November 30, 2016
Project No. 1609770



Faith Zangl
Staff Engineer

Roger A. Miller, P.G., C.P.G.
Senior Hydrogeologist

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1.0 Project Background

Article 403 of the City of Kaukauna's current license for the Little Chute Project (FERC No. 2588) requires the City to file a water quality plan. The City filed the plan on August 14, 2000, and FERC issued an Order Approving Water Quality Plan on August 24, 2000. The order calls for the licensee to monitor dissolved oxygen (DO) and temperature upstream and downstream of the project for the period from June 15 through September 30 for the first year (2001) and then once every five years for the duration of the license.

In 2016, the City of Kaukauna retained GEI Consultants, Inc., of Green Bay, Wisconsin, to conduct monitoring for the current period.

Instrumentation consisted of Hach HL4 sondes outfitted with sensors positioned upstream and downstream from the project to record hourly temperature and dissolved oxygen (DO) data. HL4 technology is more compact with longer battery life. Each sonde had a backup temperature probe to the real time data probe and was equipped with LDO (Luminescent Dissolved Oxygen) technology. Data were stored onboard the sonde data logger and downloaded to a computer for in-season analysis and compliance purposes initially at biweekly intervals in June and then at 7 to 10 day intervals for the remainder of the study. After each download, the DO probe was calibrated prior to redeployment. Limited data losses and calibration issues are discussed and logged in Appendix D.

Sondes were deployed and monitoring compliance data began June 16, 2016, and the first results were downloaded on June 27, 2016. Sondes had been factory calibrated but were recalibrated prior to deployment in 2016. Probes were calibrated according to manufacturer recommendations at each data download and analyzed for WQMP compliance. Sondes were retrieved, calibrated, and removed from operation on October 3, 2016, after the close of the monitoring season on September 30.

This report presents monitoring data, statistics, water quality compliance information, quality assurance data, and a description of equipment outages as required by the Order Approving Water Quality Plan. Graphs comparing the hourly and averaged daily upstream and downstream dissolved oxygen and temperature readings are provided in Appendix A. The corresponding raw data is included as Appendix B and provided on disk in Excel format in Appendix C as an attached CD-ROM. A copy of this report is also provided as a PDF file on the same CD-ROM.

2.0 Results

Fox River inflows are under the control of Army Corps of Engineers (Corps) and outflows are nearly synchronous to inflows at the dam. Figures in Appendix A show discharge in the Fox River during the study period, as measured at a U.S. Geological Survey monitoring station in Appleton, Wisconsin (USGS Station 04084445). Fox River discharge ranged between 5,500 cfs and 8,000 cfs from June 15 to June 21. Flows dropped about 2,500 cfs to 3,500 cfs from June 21 to July 7. Flows increased to 4,500 cfs from July 7 to July 13. Flows dropped to 800 cfs to 3,500 cfs from July 13 to July 25. Flows increased to 4,000 cfs to 8,000 cfs from July 25 through August 2. Flows decreased to 700 cfs to 3,500 cfs from August 2 through August 26. Flows increased from 4,500 cfs to 5,000 cfs from August 26 through August 30. Flows decreased from 2,500 cfs to 3,600 cfs from August 30 to September 6. Flows increased to 6,000 cfs to 10,000 cfs from September 6 to September 15. Flows decreased to 1,900 cfs to 4,000 cfs from September 15 to September 21. Flows increased to above 4,000 cfs for the reminder of the monitoring period. High water also included significant bedload movement and may have been contributed to equipment outages and resulting data gaps observed.

According to the FERC order approving the Water Quality Monitoring Plan for the Little Chute Project dated August 24, 2000 (Appendix E), upstream and downstream probes should be deployed from June 15 through September 30, "unless flows in the river are above 4,000 cubic feet per second, which would inhibit safe deployment of the probes." Flows exceeded this threshold for approximately 40% of the monitoring period. Nevertheless, sondes were deployed for the vast majority (94%) of the study period[1]. The shaded areas of the Figures in Appendix A depict the time periods when Fox River flow rose higher than 4,000 cfs during the study period. In general, high flows lead to better conditions for temperature and dissolved oxygen and would tend to reduce any differences between headwater and tailwaters due to low reservoir residence times and more mixing in the water column. The data corroborate this. For both upstream and downstream dissolved oxygen and temperature data, the daily averages of the difference between the daily means were graphed (Figures 4, 5, and 6, Appendix A) and the standard deviation of the difference between the daily means calculated (Table 1, Appendix A).

Results of the study show that temperature variation of upstream and downstream environments displayed nearly identical patterns of temporal variation (i.e., no differences). Dissolved oxygen differences between upstream and downstream environments were also negligible when erroneous data from equipment outages were eliminated.

The average daily DO ranged between 5.1 mg/L and 9.4 mg/L for the entire study upstream and downstream except for a period between July 2 and July 6 where the upstream sonde likely experienced significant sedimentation. The sonde was serviced on July 6, and the DO increased accordingly. This data was clipped from the Figures 1 and 4 in Appendix A. The original

[1] The sondes were initially deployed on June 16, 2016 during a period of flows exceeding 4,000 cfs that began before the target start date for monitoring of June 15, 2016.

unabridged/raw data is included as Figures 1 and 4 in Appendix B. The summary of clipped data and data outages are included in Table 2 of Appendix A and in Appendix D.

When compiling the unabridged data, the mean of the difference in the average daily dissolved oxygen concentration was -0.38 mg/L (upstream minus downstream) with a standard deviation of ± 0.99 mg/L. The unabridged data set included four days in which the daily DO average difference exceeded 2 mg/L. As explained in Table 2 of Appendix A, data from July 2 through July 6 was clipped from the final data set due to observed sedimentation and was remedied by recalibration and redeployment of the upstream sonde. After compiling the clipped data, the mean of the difference in the average daily dissolved oxygen concentration was reduced to -0.18 mg/L with a standard deviation of ± 0.24 mg/L. When both data sets were available and by omitting DO data from the upstream probe during periods of significant sedimentation and/or biofouling, at no time did upstream and downstream vary by greater than 2 mg/L for five or more consecutive days, a condition indicated as a cause for special discussion with the WDNR according to the FERC order. A comparison of the daily means for dissolved oxygen concentration and temperature are provided in Appendix A (Table 1).

The mean of the difference in the daily temperature averages was -0.04°C (upstream minus downstream) with a standard deviation of ± 0.04°C. (The negative sign indicates that the daily averages for upstream temperature were lower than downstream; however, the mean difference in daily averages was less than the error variance of the recording instrument - i.e., zero).

Little Chute met WQMP criteria for temperature and dissolved oxygen in 2016. Temperature never exceeded the 89°F maximum criterion; and differences between DO upstream and downstream never exceeded 2 mg/L for more than one day after the erroneous data was omitted.

The upstream and downstream monitoring equipment was calibrated at least every two weeks at which time the data were also checked. The pre- and post-calibration DO values were compared and never differed by more than 0.99 mg/L at the downstream probe, or 0.21 mg/L at the upstream probe. Accordingly, DO data are considered acceptable, because pre- and post-calibration readings were within 1.0 mg/L at least 70% of the time. Calibration summaries for the upstream and downstream monitoring units are provided in Appendix A.

3.0 Conclusions

Table 2 of Appendix A and Appendix D explain data gaps, outages, and rationale for revised data sets. Based on missing data, data out of normally expected ranges, equipment failure, and equipment tampering, the original data sets were modified and were not used to re-compute the daily averages. Since data were downloaded approximately every seven to ten days, a failure early in the sample period could lead to several days of missing data. This explains why some days have missing averages either upstream or downstream of the project. Calibration of the instruments enabled us to check unit functionality and identify erroneous data from the periods prior to calibration. Calibration also confirmed the reliability of data during many of the sampling periods.

We obtained reliable DO readings from one or both probes for 94% of the study period even though flows were in excess of 4,000 cfs for approximately 40% of the period. Days in which both DO probes were providing good data showed no daily variances greater than required by the FERC License.

Based on consistently similar values during all times when both probes were functioning simultaneously, we concluded there is no reason to suspect divergence may have occurred unnoticed when one probe was out of service for either DO or temperature. As discussed earlier, the high flows kept temperature nearly identical both upstream and downstream. Turbulence along with low residence times in the reservoir also contributed to similar DO values upstream and downstream. With or without data corrections, computations show that the data were within compliance for all variables in the FERC License.

Hach's latest technology HL4 sondes were deployed in 2016. They are smaller, more compact and have improved electronics and battery life compared to the older MS-5 sondes employed in 2011. The HL4 sondes may also have manufacturing issues including periodic battery housing leakage, although this did not require replacement sondes to be deployed. Rather, cracked battery housings (two instances) were replaced with new ones.

The data provide confidence that the projects in 2016 met the WQMP criteria as follows: (1) average daily temperatures were within the natural range of the river and no greater than 89°F; and (2) average daily dissolved oxygen was always above 5 ppm (mg/L) with upstream and downstream differences greater than 2 mg/L never occurring on any sequential day (5 days is the criterion). Sonde malfunctions and fouling occurred and caused data gaps; however, no variable provided less than 94 days of data at the Little Chute upstream and downstream locations. With the exception of a three-day period from August 1 through August 3, complete records were obtained for every variable for the entire season. Daily averages from the collective data set were always in compliance with the WQMP. Further, the correlated patterns

and close relationships of the upstream and downstream variables during the 94 to 101 days when comparative data were available support the conclusion that no criteria were ever violated.

In summary, we conclude that the Little Chute project has met the WQMP criteria for 2016. Overall, data and findings presented in WQMRs for previous monitoring periods under this FERC License in 2001, 2006, and 2011 are consistent with the 2016 monitoring period.

Appendix A

Figures (Clipped Data)

Tables (Clipped Data)

Figure 1. Hourly Dissolved Oxygen Readings, Upstream and Downstream of the Little Chute Hydroelectric Plant
FERC No. 2588 on the Fox River in Little Chute, Wisconsin

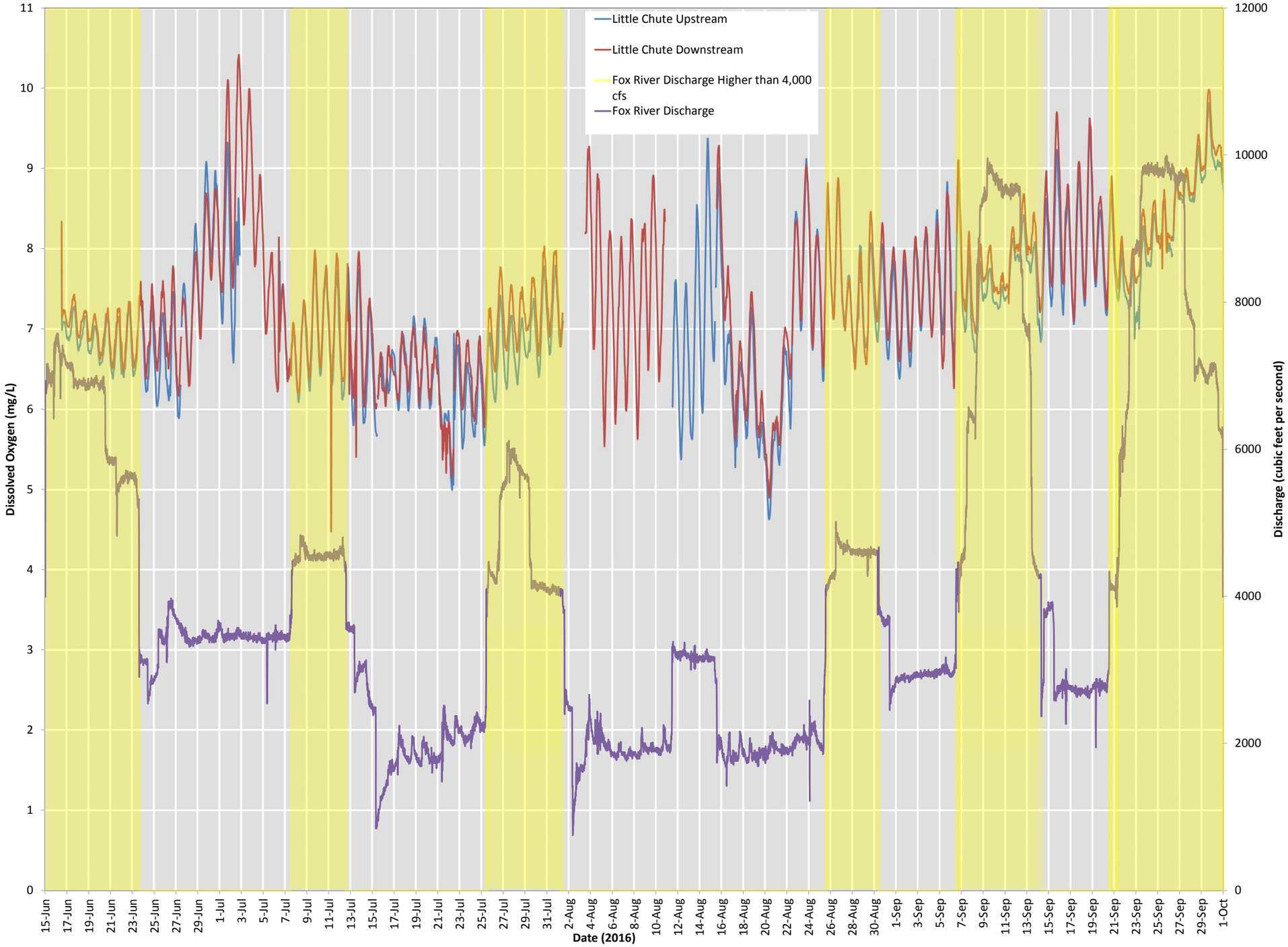

Figure 2. Hourly Temperature Readings, Upstream and Downstream of the Little Chute Hydroelectric Plant
FERC No. 2588 on the Fox River in Little Chute, Wisconsin

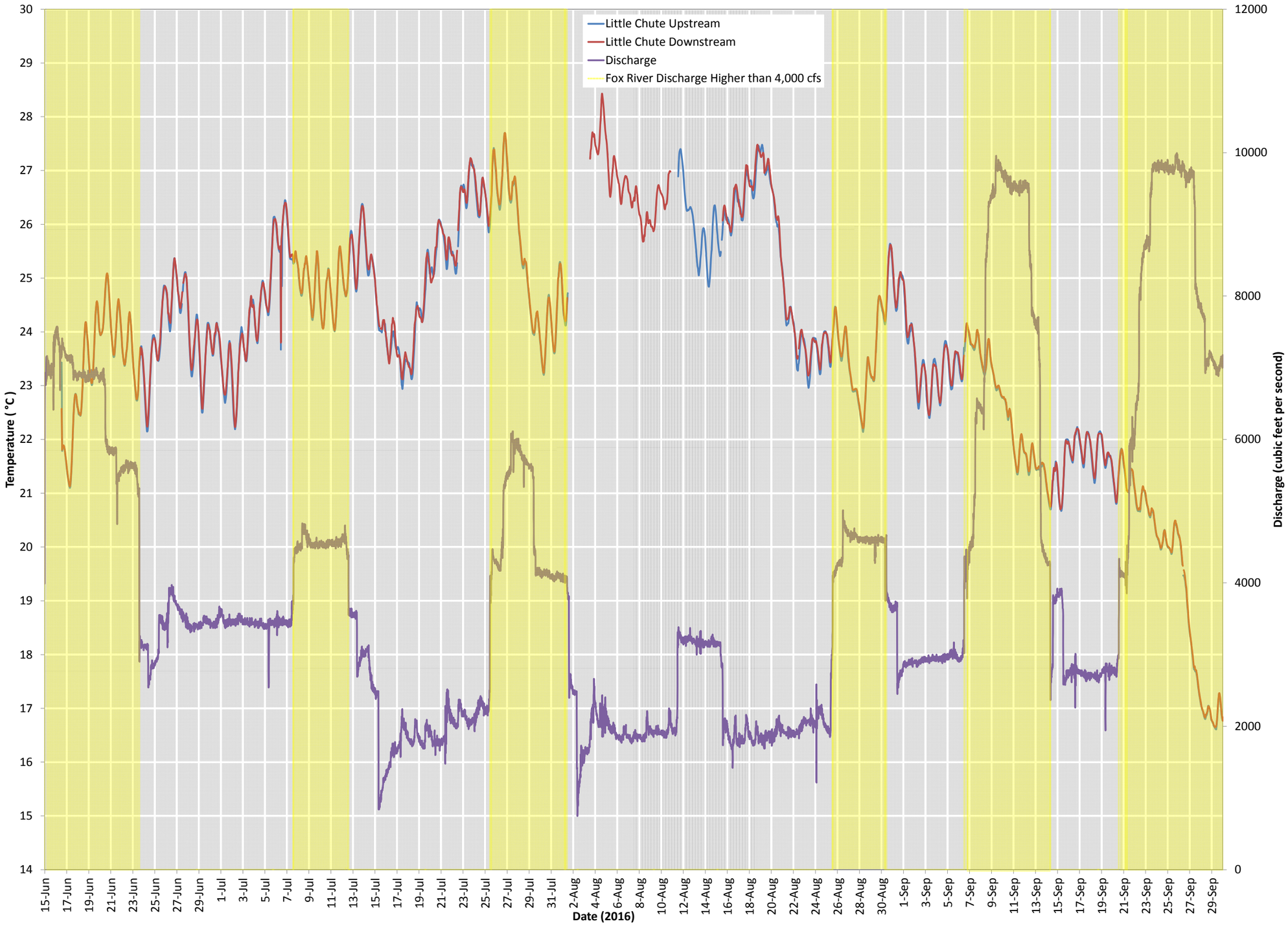

Figure 3. Hourly Electrical Conductivity Readings, Upstream and Downstream of the Little Chute Hydroelectric Plant
FERC No. 2588 on the Fox River in Little Chute, Wisconsin

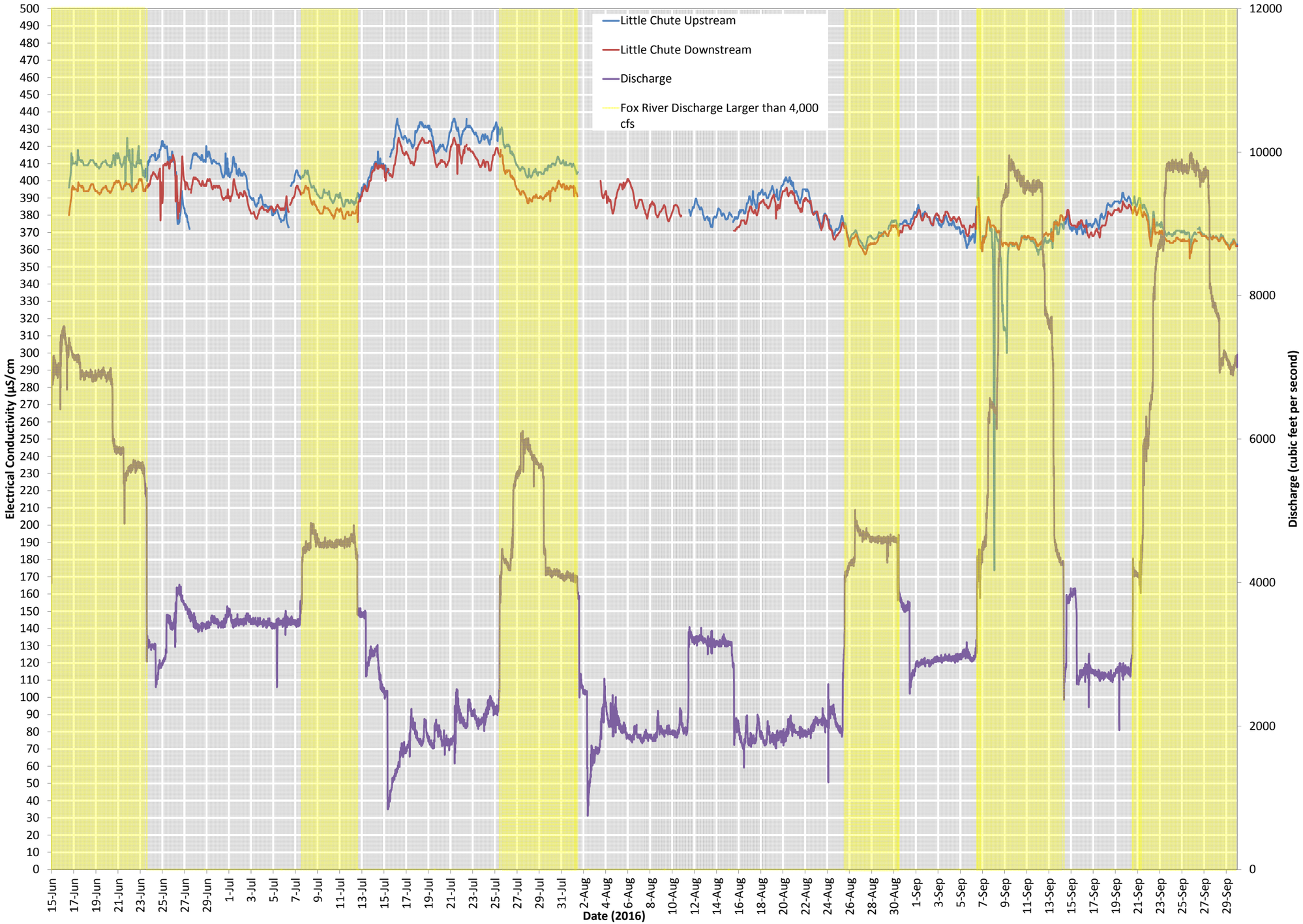

Figure 4. Daily Dissolved Oxygen Readings, Upstream and Downstream of the Little Chute Hydroelectric Plant
FERC No. 2588 on the Fox River in Little Chute, Wisconsin

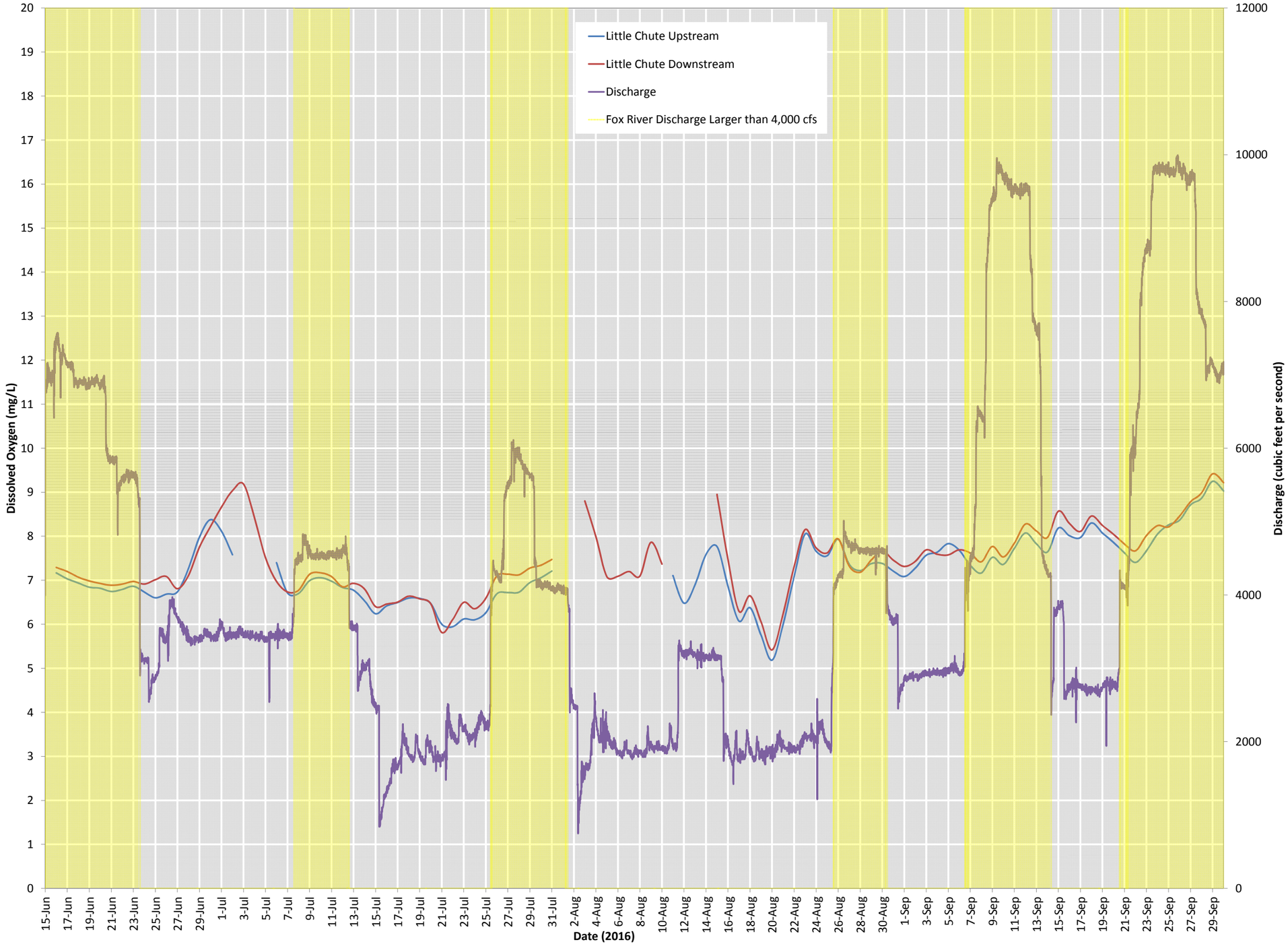

Figure 5. Daily Temperature Readings, Upstream and Downstream of the Little Chute Hydroelectric Plant
FERC No. 2588 on the Fox River in Little Chute, Wisconsin

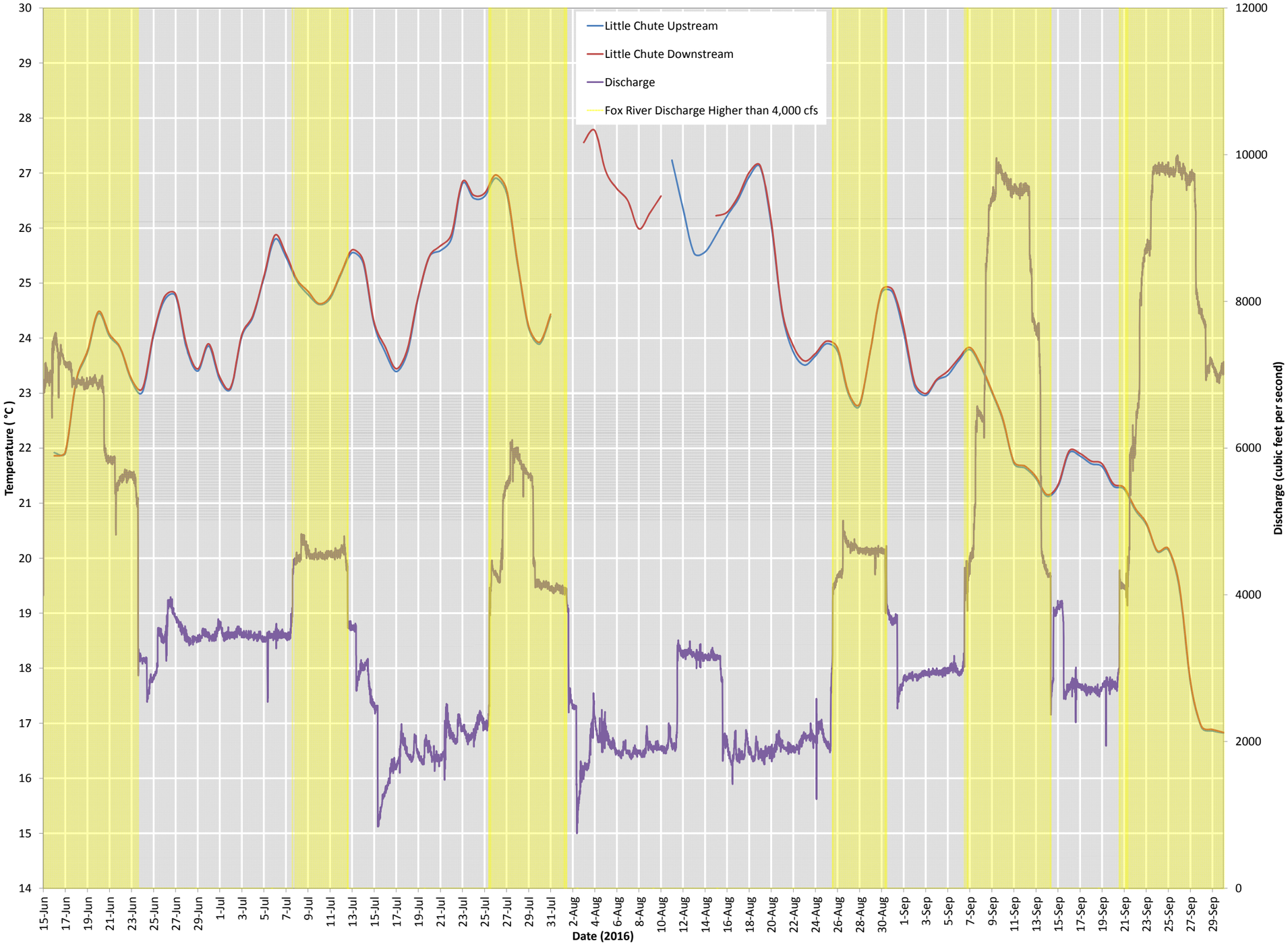

Figure 6. Daily Electrical Conductivity Readings, Upstream and Downstream of the Little Chute Hydroelectric Plant
FERC No. 2588 on the Fox River in Little Chute, Wisconsin

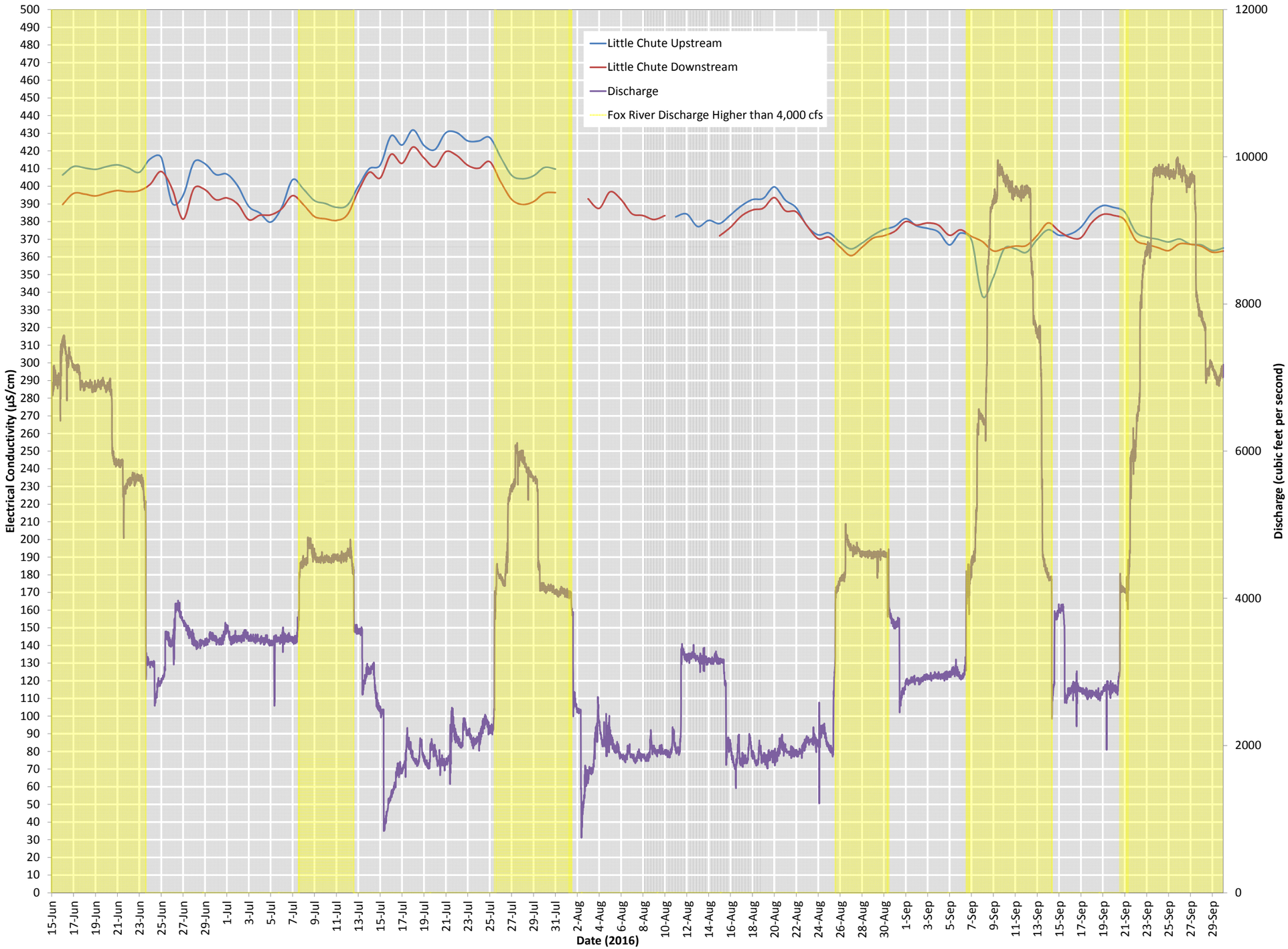

Table 1.
Little Chute, FERC No. 2588 on the Fox River In Little Chute, Wisconsin
Little Chute Daily Averages of Upstream and Downstream Dissolved Oxygen and Temperature Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Date with flow >4,000 cfs?	Dissolved Oxygen (mg/L)			Temperature (°C)		
		Upstream	Downstream	Difference	Upstream	Downstream	Difference
6/16/2016	Yes	7.17	7.29	-0.12	21.92	21.86	0.06
6/17/2016	Yes	7.03	7.20	-0.17	21.91	21.93	-0.03
6/18/2016	Yes	6.94	7.07	-0.13	23.22	23.25	-0.03
6/19/2016	Yes	6.84	6.98	-0.14	23.73	23.77	-0.04
6/20/2016	Yes	6.82	6.93	-0.11	24.45	24.48	-0.04
6/21/2016	Yes	6.74	6.89	-0.14	24.03	24.07	-0.04
6/22/2016	No	6.79	6.91	-0.12	23.80	23.82	-0.02
6/23/2016	No	6.86	6.97	-0.11	23.22	23.26	-0.03
6/24/2016	No	6.73	6.91	-0.18	23.03	23.09	-0.06
6/25/2016	No	6.60	7.01	-0.41	24.05	24.08	-0.04
6/26/2016	No	6.69	7.09	-0.40	24.70	24.75	-0.06
6/27/2016	No	6.74	6.81	-0.07	24.76	24.80	-0.03
6/28/2016	No	7.26	7.10	0.16	23.81	23.87	-0.06
6/29/2016	No	7.98	7.75	0.23	23.40	23.44	-0.04
6/30/2016	No	8.38	8.22	0.16	23.86	23.90	-0.04
7/1/2016	No	8.12	8.66	-0.54	23.24	23.29	-0.05
7/2/2016	No	7.58	9.03	-1.45	23.08	23.11	-0.02
7/3/2016	No		9.19		24.03	24.06	-0.03
7/4/2016	No		8.42		24.38	24.41	-0.03
7/5/2016	No		7.51		25.09	25.12	-0.03
7/6/2016	No	7.40	6.97	0.43	25.80	25.87	-0.07
7/7/2016	No	6.71	6.74	-0.02	25.47	25.53	-0.05
7/8/2016	Yes	6.70	6.77	-0.07	25.03	25.07	-0.03
7/9/2016	Yes	6.99	7.13	-0.14	24.79	24.85	-0.06
7/10/2016	Yes	7.06	7.17	-0.11	24.61	24.63	-0.01
7/11/2016	Yes	6.98	7.08	-0.10	24.72	24.75	-0.04
7/12/2016	Yes	6.83	6.85	-0.02	25.17	25.19	-0.02
7/13/2016	Yes	6.77	6.93	-0.16	25.55	25.60	-0.05
7/14/2016	No	6.53	6.80	-0.27	25.37	25.41	-0.05
7/15/2016	No	6.36	6.54	-0.18	24.00	23.96	0.04
7/16/2016	No	6.42	6.46	-0.04	23.74	23.84	-0.10
7/17/2016	No	6.49	6.50	-0.01	23.39	23.44	-0.05
7/18/2016	No	6.60	6.64	-0.04	23.73	23.79	-0.06
7/19/2016	No	6.59	6.58	0.01	24.74	24.77	-0.03
7/20/2016	No	6.47	6.47	0.00	25.48	25.48	0.00
7/21/2016	No	6.00	5.82	0.19	25.59	25.68	-0.09
7/22/2016	No	5.95	6.11	-0.16	25.81	25.88	-0.08
7/23/2016	No	6.12	6.50	-0.38	26.81	26.84	-0.03
7/24/2016	No	6.10	6.35	-0.25	26.55	26.60	-0.05
7/25/2016	No	6.26	6.59	-0.33	26.57	26.63	-0.06
7/26/2016	Yes	6.69	7.09	-0.40	26.91	26.97	-0.06
7/27/2016	Yes	6.72	7.14	-0.42	26.64	26.70	-0.06
7/28/2016	Yes	6.73	7.12	-0.39	25.34	25.39	-0.05
7/29/2016	Yes	6.95	7.28	-0.33	24.18	24.22	-0.04
7/30/2016	Yes	7.06	7.34	-0.28	23.89	23.93	-0.03
7/31/2016	Yes	7.21	7.47	-0.26	24.40	24.43	-0.04
8/1/2016	Yes						
8/2/2016	Yes						
8/3/2016	No		8.80			27.56	
8/4/2016	No		7.99			27.77	
8/5/2016	No		7.08			27.03	
8/6/2016	No		7.09			26.72	
8/7/2016	No		7.20			26.50	
8/8/2016	No		7.10			25.99	
8/9/2016	No		7.86			26.28	
8/10/2016	No		7.37			26.58	

Table 1.
Little Chute, FERC No. 2588 on the Fox River In Little Chute, Wisconsin
Little Chute Daily Averages of Upstream and Downstream Dissolved Oxygen and Temperature Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Date with flow >4,000 cfs?	Dissolved Oxygen (mg/L)			Temperature (°C)		
		Upstream	Downstream	Difference	Upstream	Downstream	Difference
8/11/2016	No	7.11			27.23		
8/12/2016	No	6.48			26.35		
8/13/2016	No	6.89			25.54		
8/14/2016	No	7.59			25.57		
8/15/2016	No	7.76	8.95	-1.19	25.88	26.23	-0.35
8/16/2016	No	6.86	7.46	-0.61	26.22	26.29	-0.07
8/17/2016	No	6.07	6.30	-0.22	26.52	26.57	-0.05
8/18/2016	No	6.38	6.65	-0.27	26.94	27.01	-0.08
8/19/2016	No	5.75	6.05	-0.30	27.11	27.13	-0.02
8/20/2016	No	5.19	5.42	-0.23	26.06	26.13	-0.07
8/21/2016	No	6.00	6.24	-0.24	24.44	24.48	-0.04
8/22/2016	No	7.08	7.31	-0.23	23.75	23.86	-0.11
8/23/2016	No	8.05	8.15	-0.10	23.51	23.59	-0.08
8/24/2016	No	7.66	7.74	-0.08	23.68	23.72	-0.05
8/25/2016	No	7.56	7.62	-0.06	23.90	23.94	-0.05
8/26/2016	No	7.93	7.94	-0.01	23.77	23.83	-0.06
8/27/2016	Yes	7.36	7.32	0.04	22.98	23.02	-0.04
8/28/2016	Yes	7.22	7.18	0.04	22.77	22.80	-0.04
8/29/2016	Yes	7.38	7.46	-0.08	23.78	23.80	-0.01
8/30/2016	Yes	7.38	7.67	-0.29	24.82	24.87	-0.04
8/31/2016	No	7.21	7.46	-0.25	24.83	24.88	-0.05
9/1/2016	No	7.08	7.31	-0.23	24.11	24.20	-0.09
9/2/2016	No	7.27	7.43	-0.15	23.13	23.18	-0.05
9/3/2016	No	7.57	7.69	-0.12	22.96	22.99	-0.03
9/4/2016	No	7.64	7.59	0.05	23.23	23.25	-0.02
9/5/2016	No	7.83	7.58	0.25	23.33	23.40	-0.07
9/6/2016	No	7.68	7.69	-0.01	23.59	23.63	-0.04
9/7/2016	Yes	7.34	7.62	-0.28	23.79	23.83	-0.04
9/8/2016	Yes	7.16	7.42	-0.25	23.47	23.51	-0.04
9/9/2016	Yes	7.52	7.77	-0.25	23.01	23.04	-0.03
9/10/2016	Yes	7.36	7.53	-0.17	22.50	22.53	-0.03
9/11/2016	Yes	7.72	7.84	-0.12	21.72	21.75	-0.03
9/12/2016	Yes	8.07	8.28	-0.20	21.64	21.67	-0.04
9/13/2016	Yes	7.83	8.12	-0.29	21.45	21.48	-0.03
9/14/2016	Yes	7.64	7.97	-0.33	21.13	21.16	-0.03
9/15/2016	Yes	8.19	8.57	-0.38	21.31	21.33	-0.02
9/16/2016	No	8.01	8.29	-0.28	21.91	21.95	-0.04
9/17/2016	No	7.97	8.11	-0.14	21.86	21.90	-0.05
9/18/2016	No	8.30	8.46	-0.16	21.72	21.76	-0.05
9/19/2016	No	8.07	8.25	-0.17	21.66	21.71	-0.05
9/20/2016	No	7.86	8.05	-0.18	21.31	21.35	-0.04
9/21/2016	No	7.62	7.82	-0.20	21.25	21.28	-0.03
9/22/2016	Yes	7.41	7.67	-0.26	20.87	20.91	-0.03
9/23/2016	Yes	7.67	8.02	-0.35	20.61	20.64	-0.03
9/24/2016	Yes	8.05	8.24	-0.19	20.12	20.14	-0.02
9/25/2016	Yes	8.26	8.21	0.05	20.15	20.17	-0.03
9/26/2016	Yes	8.36	8.45	-0.09	19.45	19.50	-0.06
9/27/2016	Yes	8.71	8.78	-0.07	17.74	17.78	-0.04
9/28/2016	Yes	8.86	8.98	-0.12	16.93	16.95	-0.02
9/29/2016	Yes	9.25	9.42	-0.17	16.86	16.89	-0.03
9/30/2016	Yes	9.03	9.22	-0.19	16.82	16.83	-0.01
Minimum		5.19	5.42	-1.45	16.82	16.83	-0.35
Average		7.21	7.45	-0.18	23.64	23.83	-0.04
Maximum		9.25	9.42	0.43	27.23	27.77	0.06
Standard Deviation		0.75	0.79	0.24	2.20	2.28	0.04
Number of Data Points		94	101	90	97	101	93

Table 2.
Little Chute, FERC No. 2588 on the Fox River in Little Chute, Wisconsin
Summary of Data Gaps and Clipped Data

Time Period	Little Chute Upstream				Little Chute Downstream			
	DO		EC		DO		EC	
	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification
6/15/2016								
6/16/2016								
6/17/2016								
6/18/2016								
6/19/2016								
6/20/2016								
6/21/2016								
6/22/2016								
6/23/2016								
6/24/2016								
6/25/2016								
6/26/2016								
6/27/2016								
6/28/2016								
6/29/2016								
6/30/2016								
7/1/2016								
7/2/2016	7/2/16 22:00 to 7/6/16 11:00	7/6/16 Notes: Sonde experienced moderate biofouling						
7/3/2016								
7/4/2016								
7/5/2016								
7/6/2016								
7/7/2016								
7/8/2016								
7/9/2016								
7/10/2016								
7/11/2016								
7/12/2016								
7/13/2016								
7/14/2016								
7/15/2016								
7/16/2016								
7/17/2016								
7/18/2016								
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7/22/2016								
7/23/2016								
7/24/2016								
7/25/2016								
7/26/2016								
7/27/2016								
7/28/2016								
7/29/2016								
7/30/2016								
7/31/2016								
8/1/2016	Data gap from 8/1/16 13:00 to 8/11/16 13:00 due to cracked battery housing				Data gap from 8/1/16 12:00 to 8/3/16 13:00 due to cracked battery housing			
8/2/2016								
8/3/2016								
8/4/2016								
8/5/2016								
8/6/2016								
8/7/2016								
8/8/2016								
8/9/2016								
8/10/2016								
8/11/2016								
8/12/2016					8/10/2016 21:00 to 8/15/16 11:00	Sonde found out of water	8/10/2016 21:00 to 8/15/16 11:00	Sonde found out of water
8/13/2016								
8/14/2016								
8/15/2016								
8/16/2016								
8/17/2016								
8/18/2016								
8/19/2016								
8/20/2016								
8/21/2016								
8/22/2016								

Table 2.
Little Chute, FERC No. 2588 on the Fox River in Little Chute, Wisconsin
Summary of Data Gaps and Clipped Data

Time Period	Little Chute Upstream				Little Chute Downstream			
	DO		EC		DO		EC	
	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification
8/23/2016								
8/24/2016								
8/25/2016								
8/26/2016								
8/27/2016								
8/28/2016								
8/29/2016								
8/30/2016								
8/31/2016								
9/1/2016								
9/2/2016								
9/3/2016								
9/4/2016								
9/5/2016								
9/6/2016								
9/7/2016								
9/8/2016								
9/9/2016								
9/10/2016								
9/11/2016								
9/12/2016								
9/13/2016								
9/14/2016								
9/15/2016								
9/16/2016								
9/17/2016								
9/18/2016								
9/19/2016								
9/20/2016								
9/21/2016								
9/22/2016								
9/23/2016								
9/24/2016								
9/25/2016								
9/26/2016								
9/27/2016								
9/28/2016								
9/29/2016								
9/30/2016								

Table 3
Little Chute, FERC No. 2588 on the Fox River In Little Chute, Wisconsin
Little Chute Upstream Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	**Conductivity (µS/cm)**			**LDO (mg/L)**		
		Before	Standard	% Difference	Before	After	% Difference
14289H400114	6/15/2016	1390	1412	1.6%	8.63	8.65	0.2%
14289H400114	6/27/2016	1411	1412	0.1%	8.00	7.99	0.1%
14289H400114	7/6/2016	1412	1412	0.0%	7.90	7.82	1.0%
14289H400114	7/15/2016	1415	1412	0.2%	8.56	8.61	0.6%
14289H400114	7/22/2016	1406	1412	0.4%	7.16	7.35	2.6%
14289H400114	8/1/2016	1409	1412	0.2%	7.01	7.22	2.9%
14289H400114 - Water infiltration in cracked battery housing; lost data from 8/1 to 8/8	8/8/2016						
14289H400114 - Sonde replaced	8/11/2016	1403.5	1412	0.6%	8.29	8.32	0.4%
14289H400114	8/15/2016	1414	1412	0.1%	7.96	7.93	0.4%
14289H400114	8/22/2016	1409	1412	0.2%	8.22	8.33	1.3%
14289H400114	8/29/2016	1414	1412	0.1%	8.01	8.07	0.7%
14289H400114	9/6/2016	1409	1412	0.2%	7.70	7.67	0.4%
14289H400114	9/16/2016	1405	1412	0.5%	8.85	8.78	0.8%
14289H400114	9/26/2016	1408	1412	0.3%	8.87	9.04	1.9%

Table 4
Little Chute, FERC No. 2588 on the Fox River In Little Chute, Wisconsin
Little Chute Downstream Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)			LDO (mg/L)		
		Before	Standard	% Difference	Before	After	% Difference
15035H400228	6/15/2016	1406	1412	0.4%	8.67	8.62	0.6%
15035H400228	6/27/2016	1425	1412	0.9%	8.08	7.75	4.3%
15035H400228	7/6/2016	1398	1412	1.0%	7.73	8.06	4.1%
15035H400228	7/15/2016	1412	1412	0.0%	8.79	8.77	0.2%
15035H400228	7/22/2016	1420	1412	0.6%	6.14	7.13	13.9%
15035H400228 - Battery housing cracked; removed sonde from operation until battery housing replaced	8/1/2016	1415	1412	0.2%	7.66	7.60	0.8%
15035H400228 - Battery housing replaced	8/3/2016	1397	1412	1.1%	8.80	8.44	4.3%
15035H400228	8/8/2016	1424	1412	0.8%	7.87	7.89	0.3%
15035H400228 - Sonde found above water; data clipped from 8/10/16 21:00 to 8/15/16 11:00	8/15/2016	1408	1412	0.3%	7.54	7.73	2.5%
15035H400228	8/22/2016	1387	1412	1.8%	8.89	8.80	1.0%
15035H400228	8/29/2016	1410	1412	0.1%	7.48	7.85	4.7%
15035H400228	9/6/2016	1411	1412	0.1%	7.64	7.57	0.9%
15035H400228	9/16/2016	1407	1412	0.4%	8.74	8.58	1.9%
15035H400228	9/26/2016	1401	1412	0.8%	9.15	9.13	0.2%

Appendix B

Figures (Unabridged Data)

Figure 1 Raw Data Little Chute Hourly Dissolved Oxygen

Figure 4 Raw Data Little Chute Daily Dissolved Oxygen

Tables (Unabridged Data)

Table 1 Raw Data Little Chute Upstream and Downstream Daily Averages

Figure 1. Hourly Dissolved Oxygen Readings, Upstream and Downstream of the Little Chute Hydroelectric Plant
FERC No. 2588 on the Fox River in Little Chute, Wisconsin

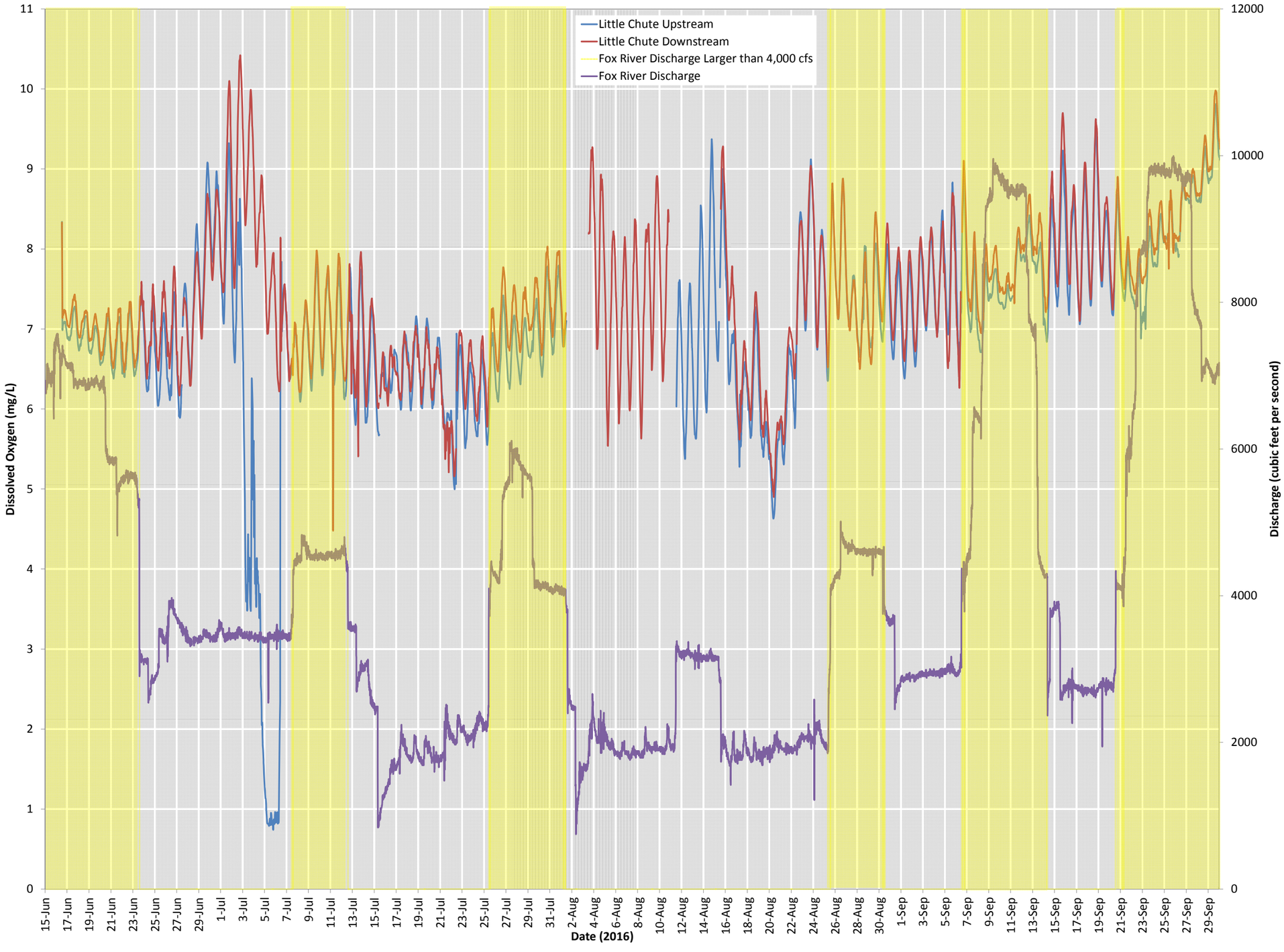

Figure 4. Daily Dissolved Oxygen Readings, Upstream and Downstream of the Little Chute Hydroelectric Plant
FERC No. 2588 on the Fox River in Kaukauna, Wisconsin

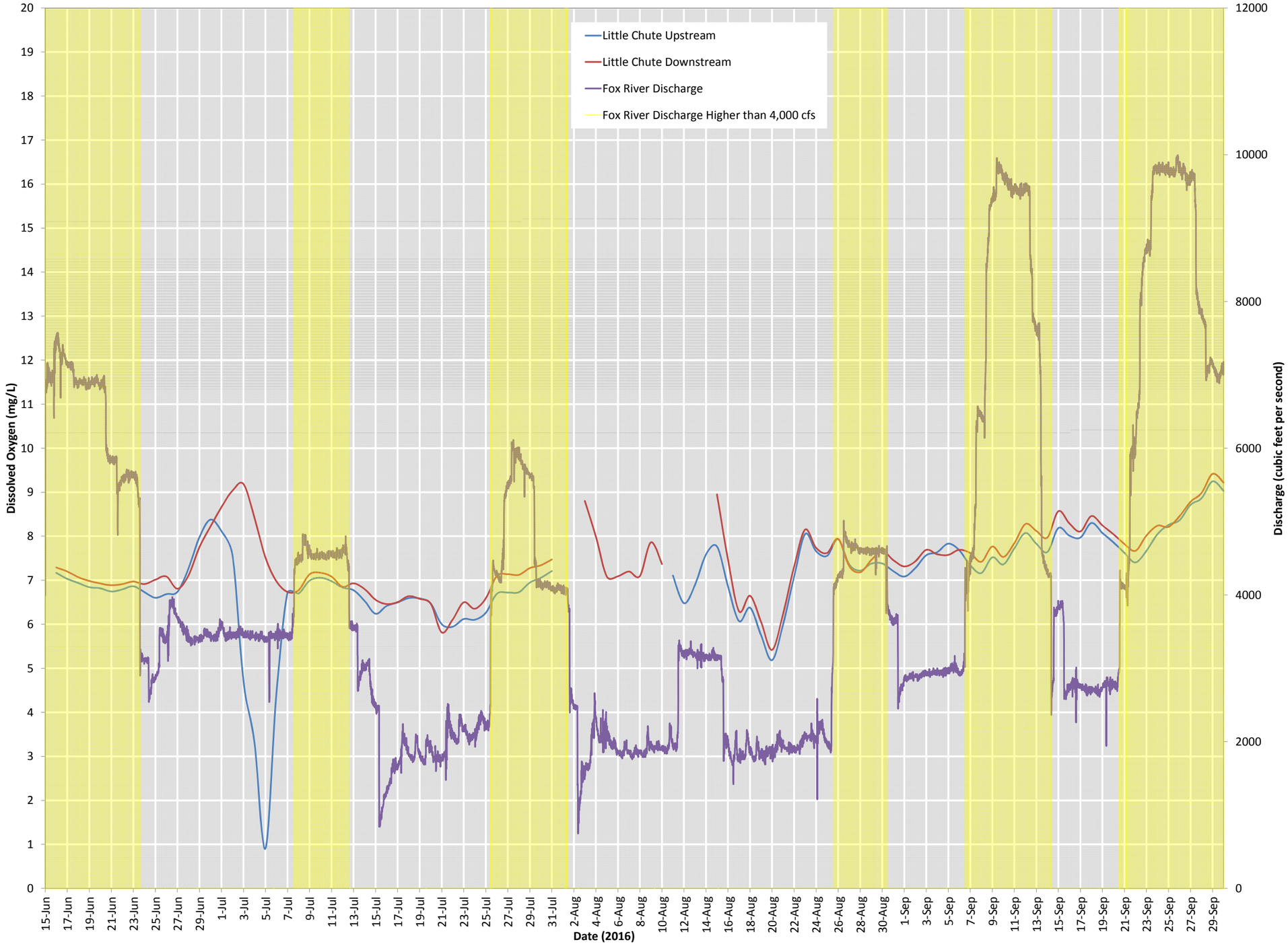

Table 1.
Little Chute, FERC No. 2588 on the Fox River In Little Chute, Wisconsin
Little Chute Daily Averages of Upstream and Downstream Dissolved Oxygen and Temperature Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference
6/16/2016	7.17	7.29	-0.12	21.92	21.86	0.06
6/17/2016	7.03	7.20	-0.17	21.91	21.93	-0.03
6/18/2016	6.94	7.07	-0.13	23.22	23.25	-0.03
6/19/2016	6.84	6.98	-0.14	23.73	23.77	-0.04
6/20/2016	6.82	6.93	-0.11	24.45	24.48	-0.04
6/21/2016	6.74	6.89	-0.14	24.03	24.07	-0.04
6/22/2016	6.79	6.91	-0.12	23.80	23.82	-0.02
6/23/2016	6.86	6.97	-0.11	23.22	23.26	-0.03
6/24/2016	6.73	6.91	-0.18	23.03	23.09	-0.06
6/25/2016	6.60	7.01	-0.41	24.05	24.08	-0.04
6/26/2016	6.69	7.09	-0.40	24.70	24.75	-0.06
6/27/2016	6.74	6.81	-0.07	24.76	24.80	-0.03
6/28/2016	7.26	7.10	0.16	23.81	23.87	-0.06
6/29/2016	7.98	7.75	0.23	23.40	23.44	-0.04
6/30/2016	8.38	8.22	0.16	23.86	23.90	-0.04
7/1/2016	8.12	8.66	-0.54	23.24	23.29	-0.05
7/2/2016	7.57	9.03	-1.46	23.08	23.11	-0.02
7/3/2016	4.72	9.19	-4.47	24.03	24.06	-0.03
7/4/2016	3.31	8.42	-5.11	24.38	24.41	-0.03
7/5/2016	0.91	7.51	-6.60	25.09	25.12	-0.03
7/6/2016	4.44	6.97	-2.53	25.80	25.87	-0.07
7/7/2016	6.71	6.74	-0.02	25.47	25.53	-0.05
7/8/2016	6.70	6.77	-0.07	25.03	25.07	-0.03
7/9/2016	6.99	7.13	-0.14	24.79	24.85	-0.06
7/10/2016	7.06	7.17	-0.11	24.61	24.63	-0.01
7/11/2016	6.98	7.08	-0.10	24.72	24.75	-0.04
7/12/2016	6.83	6.85	-0.02	25.17	25.19	-0.02
7/13/2016	6.77	6.93	-0.16	25.55	25.60	-0.05
7/14/2016	6.53	6.80	-0.27	25.37	25.41	-0.05
7/15/2016	6.36	6.54	-0.18	24.00	23.96	0.04
7/16/2016	6.42	6.46	-0.04	23.74	23.84	-0.10
7/17/2016	6.49	6.50	-0.01	23.39	23.44	-0.05
7/18/2016	6.60	6.64	-0.04	23.73	23.79	-0.06
7/19/2016	6.59	6.58	0.01	24.74	24.77	-0.03
7/20/2016	6.47	6.47	0.00	25.48	25.48	0.00
7/21/2016	6.00	5.82	0.19	25.59	25.68	-0.09
7/22/2016	5.95	6.11	-0.16	25.81	25.88	-0.08
7/23/2016	6.12	6.50	-0.38	26.81	26.84	-0.03
7/24/2016	6.10	6.35	-0.25	26.55	26.60	-0.05
7/25/2016	6.26	6.59	-0.33	26.57	26.63	-0.06
7/26/2016	6.69	7.09	-0.40	26.91	26.97	-0.06
7/27/2016	6.72	7.14	-0.42	26.64	26.70	-0.06
7/28/2016	6.73	7.12	-0.39	25.34	25.39	-0.05
7/29/2016	6.95	7.28	-0.33	24.18	24.22	-0.04
7/30/2016	7.06	7.34	-0.28	23.89	23.93	-0.03
7/31/2016	7.21	7.47	-0.26	24.40	24.43	-0.04
8/1/2016						
8/2/2016						
8/3/2016		8.80			27.56	
8/4/2016		7.99			27.77	
8/5/2016		7.08			27.03	
8/6/2016		7.09			26.72	
8/7/2016		7.20			26.50	
8/8/2016		7.10			25.99	
8/9/2016		7.86			26.28	
8/10/2016		7.37			26.58	

Table 1.
Little Chute, FERC No. 2588 on the Fox River In Little Chute, Wisconsin
Little Chute Daily Averages of Upstream and Downstream Dissolved Oxygen and Temperature Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference
8/11/2016	7.11			27.23		
8/12/2016	6.48			26.35		
8/13/2016	6.89			25.54		
8/14/2016	7.59			25.57		
8/15/2016	7.76	8.95	-1.19	25.88	26.23	-0.35
8/16/2016	6.86	7.46	-0.61	26.22	26.29	-0.07
8/17/2016	6.07	6.30	-0.22	26.52	26.57	-0.05
8/18/2016	6.38	6.65	-0.27	26.94	27.01	-0.08
8/19/2016	5.75	6.05	-0.30	27.11	27.13	-0.02
8/20/2016	5.19	5.42	-0.23	26.06	26.13	-0.07
8/21/2016	6.00	6.24	-0.24	24.44	24.48	-0.04
8/22/2016	7.08	7.31	-0.23	23.75	23.86	-0.11
8/23/2016	8.05	8.15	-0.10	23.51	23.59	-0.08
8/24/2016	7.66	7.74	-0.08	23.68	23.72	-0.05
8/25/2016	7.56	7.62	-0.06	23.90	23.94	-0.05
8/26/2016	7.93	7.94	-0.01	23.77	23.83	-0.06
8/27/2016	7.36	7.32	0.04	22.98	23.02	-0.04
8/28/2016	7.22	7.18	0.04	22.77	22.80	-0.04
8/29/2016	7.38	7.46	-0.08	23.78	23.80	-0.01
8/30/2016	7.38	7.67	-0.29	24.82	24.87	-0.04
8/31/2016	7.21	7.46	-0.25	24.83	24.88	-0.05
9/1/2016	7.08	7.31	-0.23	24.11	24.20	-0.09
9/2/2016	7.27	7.43	-0.15	23.13	23.18	-0.05
9/3/2016	7.57	7.69	-0.12	22.96	22.99	-0.03
9/4/2016	7.64	7.59	0.05	23.23	23.25	-0.02
9/5/2016	7.83	7.58	0.25	23.33	23.40	-0.07
9/6/2016	7.68	7.69	-0.01	23.59	23.63	-0.04
9/7/2016	7.34	7.62	-0.28	23.79	23.83	-0.04
9/8/2016	7.16	7.42	-0.25	23.47	23.51	-0.04
9/9/2016	7.52	7.77	-0.25	23.01	23.04	-0.03
9/10/2016	7.36	7.53	-0.17	22.50	22.53	-0.03
9/11/2016	7.72	7.84	-0.12	21.72	21.75	-0.03
9/12/2016	8.07	8.28	-0.20	21.64	21.67	-0.04
9/13/2016	7.83	8.12	-0.29	21.45	21.48	-0.03
9/14/2016	7.64	7.97	-0.33	21.13	21.16	-0.03
9/15/2016	8.19	8.57	-0.38	21.31	21.33	-0.02
9/16/2016	8.01	8.29	-0.28	21.91	21.95	-0.04
9/17/2016	7.97	8.11	-0.14	21.86	21.90	-0.05
9/18/2016	8.30	8.46	-0.16	21.72	21.76	-0.05
9/19/2016	8.07	8.25	-0.17	21.66	21.71	-0.05
9/20/2016	7.86	8.05	-0.18	21.31	21.35	-0.04
9/21/2016	7.62	7.82	-0.20	21.25	21.28	-0.03
9/22/2016	7.41	7.67	-0.26	20.87	20.91	-0.03
9/23/2016	7.67	8.02	-0.35	20.61	20.64	-0.03
9/24/2016	8.05	8.24	-0.19	20.12	20.14	-0.02
9/25/2016	8.26	8.21	0.05	20.15	20.17	-0.03
9/26/2016	8.36	8.45	-0.09	19.45	19.50	-0.06
9/27/2016	8.71	8.78	-0.07	17.74	17.78	-0.04
9/28/2016	8.86	8.98	-0.12	16.93	16.95	-0.02
9/29/2016	9.25	9.42	-0.17	16.86	16.89	-0.03
9/30/2016	9.03	9.22	-0.19	16.82	16.83	-0.01
Minimum	0.91	5.42	-6.60	16.82	16.83	-0.35
Average	7.05	7.45	-0.38	23.64	23.83	-0.04
Maximum	9.25	9.42	0.25	27.23	27.77	0.06
Standard Deviation	1.11	0.79	0.99	2.20	2.28	0.04
Number of Data Points	97	101	93	97	101	93

Appendix C

CD-ROM of Water Quality Monitoring Report and Data

Appendix D

Description of 2016 Sonde Outages, Replacements, and Comments

APPENDIX D
Description of Little Chute HL4 Sonde Outages, Replacements and Comments

After installing new HL4 Hach Sondes at two agency approved locations in June 2016, GEI serviced each location at weekly to biweekly intervals. Parts of the data set were also compromised by the following history of mechanical failures and replacements:

6/16/16 **LITTLE CHUTE UPSTREAM SONDE S/N H400114 and LITTLE CHUTE DOWNSTREAM SONDE S/N H400228. SONDES S/N H400114 and H400228** were deployed at Little Chute Upstream and Downstream, respectively.

8/1/16 **LITTLE CHUTE DOWNSTREAM SONDE S/N H400228**. The protective battery casing on the sonde cracked during battery replacement. **GEI temporarily removed SONDE S/N H400228** until a new battery casing could be acquired from HACH. Data was lost from 8-1-2016 through 8-3-2016. **SONDE S/N H400228** was redeployed with a new protective battery casing on 8-3-2016.

8/3/16 **LITTLE CHUTE UPSTREAM SONDE S/N H400114. SONDE S/N H400114** was removed from the water and was covered with algae and sediment. The Sonde would not connect to the computer during the attempted data download. GEI attempted to replace the battery and observed the battery cavity as being filled with water and algae. GEI called HACH to troubleshoot the issue. Based on recommendations of HACH, **GEI temporarily removed SONDE S/N H400114**. Data was lost from 8-1-2016 through 8-11-2016. **SONDE S/N H400114** was redeployed with a new protective battery casing on 8-11-2016.

8/15/16 **LITTLE CHUTE DOWNSTREAM SONDE S/N H400228. SONDE S/N H400228** was observed as having been removed from the water and set along the riverbank. Clear evidence of tampering with the unit and damage to the deployment chord was observed. The sonde was recalibrated and GEI replaced the battery. **GEI redeployed SONDE S/N H400228** with a new chord.

Appendix E

FERC Order Approving Water Quality Monitoring Program
(Issued August 24, 2000)

92 FERC ¶ 62,170

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

City of Kaukauna — Project No. 2588-007

ORDER APPROVING WATER QUALITY MONITORING PLAN

(Issued August 24, 2000)

The City of Kaukauna (licensee) filed, on August 14, 2000, its water quality monitoring plan under article 403 of the license for the Little Chute Project (FERC No. 2588). The project is located on the Fox River, in the Village of Combined Locks, in Outagamie County, Wisconsin.

BACKGROUND

Article 403 requires the licensee to file, for Commission approval, a plan to monitor water quality in the project area. The plan is required to include a description of the methods which will be used to collect dissolved oxygen (DO) and water temperature data from the project area every five years for the term of the license. In addition, the licensee is required to cooperate with any future plans developed by state or federal agencies to remove contaminated sediments from the lower Fox River. Such cooperation by the licensee may include, for example, providing reasonable access to project facilities and may also include brief and temporary modification of project operations to allow safe working conditions for agency personnel. The licensee is also required to prepare the plan after consultation with the Wisconsin Department of Natural Resources (WDNR).

LICENSEE'S PLAN

The licensee proposes that Hydrolab DataSonde probes, or their equivalent, be deployed at locations upstream and downstream of the project. The probes would be deployed from June 15 through September 30, unless flows in the river are above 4,000 cubic feet per second, which would inhibit safe deployment of the probes. The probes would continuously monitor and record DO and water temperature at 1-hour intervals during this period. The upstream probe would be located at the upstream end of the project's reservoir to provide information on the DO and water temperature as it enters the project. The downstream probe would be located approximately 100 yards below the powerhouse and in the discharge flow. Routine profile monitoring of the reservoir will not be included since results of previous monitoring provided evidence that the reservoir does not stratify significantly.

The data generated from the proposed monitoring will be surveyed biweekly. Should a comparison of the DO data from the upstream and downstream monitoring show a daily average difference between locations of greater than 2 milligrams per liter (mg/L) for a period of five consecutive days or more, discussions will be initiated with the WDNR to determine the cause of the difference. It may be determined during those discussions that profile monitoring should be implemented to help explain the differences.

The probes at each location will be calibrated every 10 to 14 days. Calibration will be performed by using the air calibration method recommended by the manufacturer. Prior to calibration, the oxygen concentration of air readings will be recorded. These data will be compared to post-calibration air oxygen concentrations to derive data on meter error or drift. At the end of the monitoring period, the DO data will be considered acceptable if the meters at each location provide readings during the pre- and post-calibration comparison that is within 1 mg/L at least 70 percent of the time. Should a problem with meeting this calibration standard become apparent during the sampling period, the WDNR will be advised and a plan devised to ensure that the calibration standard is met for the remainder of the sampling period.

A report of the findings during the sampling period will contain: raw data; graphs comparing hourly DO readings from upstream and downstream locations; graphs comparing hourly temperature readings from upstream and downstream locations; basis statistics; quality assurance data and comparison percentage; and a description of all mechanical or other complications in monitoring experienced during the sampling period. The report will be submitted to the WDNR and the Commission by December 31, 2001, and every 5 years thereafter, for the term of the license, unless the WDNR and the licensee agree that future water quality monitoring is no longer necessary.

AGENCY COMMENTS

The WDNR, by letter dated August 2, 2000, concurred with the licensee's proposed plan.

DISCUSSION AND CONCLUSIONS

The licensee's plan to monitor water quality at the project satisfies the requirements of article 403. The licensee will monitor DO and water temperature upstream and downstream of the project for the period from June 15 through September 30 for the first year (2001) and then once every five years for the duration of the license.

The licensee will provide a report following the monitoring season to the WDNR and the Commission by December 31 of the monitoring year.

The licensee states that the monitoring will continue through the term of the license unless the licensee and the WDNR agree that monitoring is no longer needed. In the event that it is determined that monitoring is no longer need at the project, the licensee would need to file with the Commission, for approval, a request to discontinue monitoring and include concurrence from the WDNR.

The licensee's plan to monitor water quality fulfills the requirements of article 403 and should, therefore, be approved.

The Director orders:

(A) The licensee's water quality monitoring plan for the Little Chute Project (FERC No. 2588), filed on August 14, 2000, is approved.

(B) This order constitutes final agency action. Requests for rehearing by the Commission may be filed within 30 days of the date of issuance of this order, pursuant to 18 CFR § 385.713.

Rebecca Martin

Rebecca Martin
Team Leader
Division of Hydropower Administration
and Compliance

Appendix F

Map of Monitoring Locations

Locations of upstream and downstream sites for water quality monitoring, Little Chute Hydroelectric Project, June 15 through September 30, 2016.