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2016 Water Quality Monitoring Report

Badger-Rapide Croche
Hydroelectric Project
FERC No. 2677-030
Kaukauna, Wisconsin

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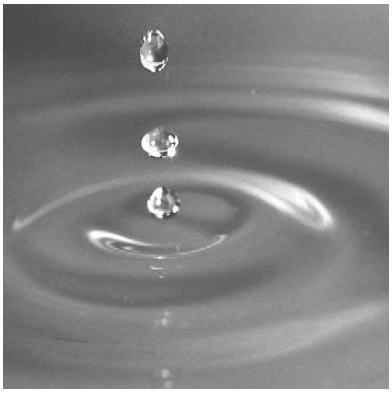

Roger A. Miller, P.G., C.P.G.
Senior Hydrogeologist

John Pizzimenti
Senior Consultant

Table of Contents

List of Appendices

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1.0 Project Background

This is the third year of water quality monitoring of the two-dam Badger-Rapide Croche Hydroelectric Project (FERC Project 2677) located on the Fox River. The project is owned and operated by City of Kaukauna, Wisconsin (Kaukauna Utilities). Details of the first year and methods are contained in a similar Reports dated January 26, 2015, and January 26, 2016, respectively.

Kaukauna Utilities followed the same approved Water Quality Monitoring Plan (WQMP) in 2014 and 2015, and again in 2016. The WQMP directed the licensee to monitor dissolved oxygen (DO), pH, and temperature variables on an hourly and daily basis upstream and downstream of the project for the period from June 15 through September 30 for the three consecutive years (2014-2016). We also monitored conductivity as it functions in computation of DO. The Report is organized in four sections: 1.0 Project Background; 2.0 Methods and Instruments; 3.0 Results; and 4.0 Conclusions.

1.1 Organization of the Report

This section (Section 1.0) is an abbreviated description of the project including the purpose and organization of the report. More details can be found in the 2014 and 2015 reports.

Section 2.0, Methods and Instruments, summarizes the instrumentation, locations, and procedures used to collect and analyze the data including calibration, criteria, and goals.

Section 3.0, Results, (1) describes the 2016 data and (2) compares hourly and daily upstream and downstream: hydrology (discharge data), DO, pH, and temperature data. The data are placed in context of (1) compliance criteria, (2) quality assurance data, and (3) communications with agencies as required by the WQMP. The tables and graphs of the data discussed in Section 3.0 appear in Appendix A. Tables and graphs of unabridged data are contained in Appendix B. Corresponding raw/unabridged data are presented in Appendix C in CD-ROM in Excel format. An electronic copy of this report is also saved as a PDF file in Appendix C.

Sections 4.1 presents Conclusions for 2016 which address quality of the data, equipment, and compliance. We also collectively summarize the entire FERC required 3-year data collection period (2014 – 2016) in Section 4.2.

2.0 Methods and Instrumentation

2.1 Data Collection Sites

Monitoring of Badger occurred at the same three agency-approved locations used in 2014 and 2015: (1) 500 feet upstream of Kaukauna Dam near the intake of the power canal; (2) downstream of Badger Powerhouse prior to confluence with the historic channel; and (3) at the downstream end of the Kaukauna Dam bypass (historic) channel prior to confluence with the tailrace of the Badger Powerhouse (Table 1 and Figure 1).

Rapide Croche data were collected at the same two agency-approved locations upstream and downstream of the dam near the intake and discharge points of the powerhouse (Table 1 and Figure 1). The downstream location was maintained at the less publically accessible point behind locked fencing after vandalism during the 2014 season.

2.2 Water Quality Criteria

The WQMP requires that Kaukauna Utilities monitor and report to Wisconsin Department of Natural Resources (WDNR) during the sampling season if data exceed the following criteria:

- Dissolved Oxygen - The dissolved oxygen (DO) content in surface waters may not be lowered to less than 5 milligrams per liter (mg/L) at any time. Differences in DO daily averages upstream and downstream of Kaukauna and Rapide Croche dams shall be no greater than 2 mg/L for five consecutive days. Calibration of the dissolved oxygen sensors is performed every one to two weeks with a variance criterion goal of less than 1 mg/L 70% of the time.
- Temperature - There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The temperature shall not exceed 89° F (31.5° C) for warmwater fish.
- pH - The pH shall be within the range of 6.0 to 9.0, with no daily average change greater than 0.5 units outside the estimated natural seasonal maximum and minimum.

2.3 Instrumentation and Data Collection

Instrumentation consisted of five new technology Hach HL4 sondes outfitted with sensors to record hourly temperature, pH, 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 7-10 day intervals for the remainder of the study. After each download, the DO probe and pH probes were recalibrated against standard solutions prior to redeployment.

Reserve sondes of the same design were kept on hand for rapid redeployment and were utilized as needed during the study when sondes were damaged or failed to calibrate. Data losses and calibration issues are discussed and logged in Appendix E.

Sondes were first deployed on June 13, 2016, for pre-season testing. Monitoring compliance data began June 15, 2016, and the first results were downloaded on June 27, 2016. Sondes were recalibrated during pre-season testing. Pre-season test data were downloaded to confirm all probe operations and calibrations. 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.

3.0 Results

3.1 Overview of Results

Three probe or sonde outages during the season led to data gaps for some variables at some locations. The raw data are provided in a separate CD-ROM. Computations of seasonal averages are based on a "cleaned" data set that removed missing data or data that were demonstrably inaccurate for reasons documented in this report. Statistics are based on accounting for missing data and for removing biased or inaccurate data. Procedures for cleaning up the data removal were as follows:

1. We tentatively identified questionable data using anomalous trends such as unexplained rapid and chronic directional changes or sudden or extreme outliers to normal data. A potential cause was then sought. For example: the Badger Upstream DO values rose and varied erratically between July 22 to August 1. These readings were associated with DO calibration issues and potential water leakage into the battery chamber (cracked battery sleeve) observed on the download August 1 (Appendix B, Figure 4 Raw Data). Strong directional deviations from normal trends were usually traced to one or more observed causes after data downloads such as: visible physical damage to the instrument, battery failure, burial in sediment, water leakage into the instrument, biofouling by algae, plants, or invertebrates, calibration out of normal range, and inability to recalibrate the instrument.
2. We then associated calibration data, field notes, battery data, and photos for the time periods corresponding to the date range of the anomalous data. For example: in the August 1, 2016, calibration notes, the DO probe for the Badger Upstream sonde failed to calibrate after three attempts and was returned to the manufacturer for service.
3. Based on synchronous calibration data, field notes, or photographic evidence of damaged sensors, the raw data were removed beginning where the change in direction could be noted or where data provided suspect deviations from normal trends or values.
4. Some failures such as water leakage into a sonde caused more than one variable to become erratic. Since battery failure can affect all variables collected, synchronous periods were denoted when all data were lost for more than one variable.

A summary of clipped data and data gaps for all five stations is included in Table 9, the unabridged data plots and tables are included in Appendix B, and the clipped data plots and tables are included in Appendix A. Photographic examples of sonde conditions are provided in Appendix D.

3.2 Daily Average Dissolved Oxygen and Discharge Data Badger Hydro

Badger water quality is described for all three variables and calibration at three locations (Sections 3.2, 3.3, 3.4, 3.5, 3.6, and 3.7). Then, Rapide Croche water quality is described for all three variables and calibration at two locations (Sections 3.8, 3.9, and 3.10).

Fox River inflows are under the control of Army Corps of Engineers (Corps) and outflows are nearly synchronous to inflows at the dam. Figure 2 (and others) shows daily 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 exceeded 7,000 cfs on June 15. Flows dropped to 3,000 cfs from June 21 to 25. Summer discharge remained near 2,000 cfs but varied occasionally up to 5,000 - 6,000 cfs before approaching 10,000 cfs in early and late September. These high flows created safety hazards in monitoring the bypass reach downstream of Badger Hydro, creating data gaps in the early and late season at this monitoring station.

Changes in discharge affect water clarity, water velocity, temperature, and algal abundance, and these affect DO levels in the Fox River. Despite large controlled discharges by the Corps on June 15-July 5 and September 9-15, upstream and downstream levels of DO at Badger remained highly correlated and mostly stable around 7-9 mg/L (Figure 6).

Upstream DO data were available all season except for a 13-day data gap from July 22 to August 3 due to a sonde calibration malfunction and potential water leakage issues. The daily average for DO fluctuated between 5.2-9.6 mg/L (Figure 6). DO averaged 7.6 mg/L for the season (Table 2).

Bypass DO levels fluctuated between 5.7 and 9.5 mg/L daily average (Table 3). DO averaged 7.7 mg/L in the bypass (Table 3). Bypass DO averaged slightly higher than observed upstream. Similar to prior years, two data gaps occurred June 15 to July 7 and September 26 to September 30 due to due to high flows and corresponding unsafe monitoring conditions at this railroad trestle station (Table 9; Figure 6).

Downstream DO data were not affected by outages. DO daily averages varied from 5.0 mg/L to 9.4 mg/L, but averaged 7.4 mg/L for the season, similar to the upstream average. Downstream values closely paralleled upstream DO (Figure 6). The maximum daily average DO (mg/L) was 9.5 mg/L and 9.4 mg/L for upstream and downstream, respectively, and the minimum was 5.7 mg/L and 5.0 mg/L for upstream and downstream, respectively (Table 2). The largest daily average DO difference between upstream and downstream was 0.90 mg/L on July 19. Accordingly, there were no daily differences that exceeded 2.0 mg/L during the season.

Sometime during the deployment interval from August 22 to 29, 2016, the upstream sonde detached from its anchor cable and sank to the bottom of 25-foot-deep power canal. A backup sonde was deployed at this station on August 29 and the detached sonde was recovered by a professional diving team on September 16. The original sonde was found resting on the bottom of the canal within the PVC protective shroud that remained affixed with the 20-pound downrigger weight. Accordingly, the detached sonde had not been transported significantly

downstream from the monitoring station. The sonde was also found to have continued recording water quality data from August 22 until it was retrieved on September 16. Figures 10, 11, 12, and 13 compare hourly DO, temperature, pH, and electrical conductivity, respectively, between the upstream sonde which sank to the channel bottom and the replacement sonde deployed at this monitoring station starting on August 29. Hourly temperature data are identical for the two sondes. DO varied consistently for both units, although the unit resting on the bottom of the channel recorded about 0.1 to 0.5 mg/L less than the replacement unit suspended in the channel at the monitoring station. The pH readings for the two sondes were identical for the first several days, then pH for the detached unit began to drift slightly lower than the replacement sonde by up to about 0.5 pH units on September 16. Electrical conductivity readings for the two sondes were generally consistent. It is common that pH and DO are typically lower near or in bottom sediments due to suppressed oxygen conditions that occur from biodegradation. We conclude both units were functioning normally albeit in different mico-environments.

Based on overall data consistency between the sonde on the channel bottom and the replacement sonde, data for August 22 to 29 from the sonde which detached from its mooring sometime during this period was included in the data summary tables and figures for the Badger Upstream station.

Conclusions: The data show Fox River DO varies from about 5 mg/L to 9.5 mg/L over the summer but is nearly identical and synchronous upstream and downstream of Kaukauna Dam, rarely differing by 0.5 mg/L (Figure 6). Daily data demonstrate Badger Hydro meets WQMP criteria for minimum (5 mg/L DO) and no more than 2 mg/L average difference for 5 consecutive days.

3.3 Temperature Data - Badger

Figure 7 shows daily average temperature data and the discharge in the Fox River during the study period. The seasonal low temperatures at the three sensors were all near ~20°C (50°F) in June and September. The summer range fluctuated between 22°C (72°F) and 27°C (81°F) from mid-June to early September.

Upstream, downstream and bypass daily average temperatures (Figure 7) vary consistently through the season and are nearly identical in August and September. Table 2 provides details of the data showing the average daily difference between upstream and downstream was less than 0.25°C for the monitoring season. Hourly temperature patterns are typically within 2°C of the daily mean and exhibit expected diurnal sawtooth patterns (Figure 3; Tables 2 and 3).

Upstream average temperature was less than downstream by approximately 1-2°C in the June 21 to 27 and July 16 to 22 datasets. The originally-deployed upstream sonde was repaired by Hach in August after erratic DO and temperature data were recorded from July 22 to August 1 and significant calibration issues (for DO) were encountered on August 1. It is possible a malfunction in the sonde electronics biased the upstream temperature data, particularly for the monitoring period leading up to July 22. Nevertheless, this data was retained in Table 2 and Figures 3 and 7, because the upstream temperature data still exhibited typical diurnal fluctuations and remained synchronous with the downstream data.

Hourly and daily graphs verify that there was not a single day in which daily temperature of any of the sensors exceeded 27.7°C (82°F). From July 22 to August 1, erratic temperature readings were recorded due to a malfunctioning sonde. The data set is comprised of: 99 daily temperature averages upstream and 108 daily temperature averages downstream out of 108 possible sampling dates. There were 82 daily temperature averages in the bypass are due to data gaps early and late in the season when high flows prevented safe monitoring at this station on railroad trestle.

Conclusions: Available daily data at all three locations confirm that the Badger Hydro meets WQMP criteria for temperature (31.5°C/89°F). The 1-2°C difference during 14 days in June and July reflects the electrical malfunction that occurred in the upstream sonde. Previous years' data showed nearly perfect correlation between upstream and downstream temperatures at all locations.

3.4 pH Data - Badger

The pH data are summarized on Tables 2 and 3 and plotted on Figures 4 and 8. No data gaps were experienced for pH during the monitoring season, except for at the Bypass station during early and late season periods of high flow when a sonde was not deployed at this station (see Section 3.2). Daily averages were computed for a total of 108, 108, and 82 days for the upstream, downstream and bypass reach, respectively. Accordingly, there is complete record of pH at the monitoring stations for periods of safe deployment.

The combined data corroborate that daily average pH ranged from 8.2-9.1 and 8.1-9.2 for upstream vs. downstream locations, respectively. The pH exceeded 9.0 only on five days of the season at either or both the upstream and downstream sites (Table 2). The seasonal average pH at the upstream (8.6) and downstream (8.5) were nearly identical as were daily differences (Table 2). Average daily minimums and maximums differed by only 0.15 and 0.04 pH units respectively for the season (Table 2). Upstream and downstream daily average pH did not differ by more than 0.5 pH units (Table 2 and Figure 8).

Values also remained constant from day to day at both sondes changing only 0.0-0.45 pH units at both upstream and downstream locations (Tables 4 and 5).

Conclusions: Although some daily average pH values exceeded 9.0 during the study, seasonal averages were less than 9.0. The pH of the Fox River is at times "naturally" in excess of 9.0 when algae are abundant (summer). The calcium/magnesium rich geology of the Fox River also contributes to atypically higher pH (alkalinity) compared to other Wisconsin streams. Hence, pH > 9.0 should not be considered unnatural for this watershed (https://www.uwgb.edu/watershed/data/monitoring/ph.htm).

3.5 Calibration and Performance of Badger Upstream, Downstream, and Bypass

3.5.1 Calibration Technique

Tables 10, 11, and 12 summarize the Badger calibration data for upstream, downstream, and bypass sondes, respectively. Performance and calibration data are provided for three variables

plus conductivity (Figures 5 and 9). (Conductivity is used by the Hach technology to compute DO values.) Temperature did not require calibration or adjustment during the study period.

GEI followed Hach calibration techniques every download period. Typically the probes were visibly contaminated with sediment and algae that needed cleaning at each calibration download, less so when intervals were one week compared to two weeks. After the probe was cleaned, the instrument was electronically "recalibrated" and the "restored" instrument calibration difference was also recorded.

After the data were compiled, they were reviewed and tabulated. The before and after calibration measurements were recorded and expressed in % difference from standards. For example the LDO Hach probe has an accuracy of 0.2 mg/L. A reading of 8.0 is not statistically different from 7.8 to 8.2. Differences greater than 0.4 mg/L would be considered measurably different. Accuracy for conductivity probe was +/- 0.5%, and for pH probe was +/- 0.2 pH units. Thus, any differences less than the accuracy of the instruments would be equivalent to no statistical difference.

3.5.2 Conductivity Calibrations Badger Upstream

The conductivity calibrations of upstream (Table 10) showed slight instrument drift at times during the study with 2 readings out of 16 outside the standard of 1% (+/- 0.5%). The data appear slightly higher early in the season when conductivity ranged from 375 to 425 μS/cm compared 350 to 400 μS/cm most of the season (Figure 5). Calibrations were mostly within the standard of +/- 0.5% (14 of 16 = 88%). Inability to calibrate the upstream sonde was encountered on August 1 and lead to replacement of the sonde.

3.5.3 Dissolved Oxygen Calibrations Badger Upstream

The pre- and post-calibration percentage difference of upstream DO calibrations ranged from 0.1% to 16.3 %. The pre- and post- calibration readings only deviated by more than 1.0 mg/L during 1 out of 16 events (6%). Accordingly, DO calibration variances were less than 1 mg/L 94% of the time and therefore exceeded the WQMP variance criterion goal of less than 1 mg/L at least 70% of the time (Table 10). DO calibration was inconsistent on August 1. The sonde was removed for maintenance and replaced by another unit.

3.5.4 pH Calibrations Badger Upstream

The pre- and post-calibration differences ranged from 0.0% to 1.6% and from 0.0% to 1.5% for pH 7.0 and 10.0 standard calibrations, respectively (Table 10). Criteria for the pH 7 (6.8-7.2) and pH 10 (9.8-10.2) were met in all calibrations. The pH calibration could not be completed on August 1, because of the inability to calibrate DO (prior calibration in the sequence). The sonde was removed for maintenance and replaced by another unit. Values also remained constant from day to day at both sondes changing only 0.0-0.45 pH units at both upstream and downstream locations (Tables 4 and 5).

3.5.5 Conductivity Calibrations Badger Downstream

The conductivity calibrations of downstream (Table 11) showed slight instrument drift at times during the study with 2 readings out of 16 outside the standard of 1% (+/- 0.5%). Calibrations were mostly within the standard of +/- 0.5% (14 of 16 = 88%).

3.5.6 Dissolved Oxygen Calibrations Badger Downstream

The pre- and post-calibration percentage difference of downstream DO calibrations ranged from 0.1% to 11%. The pre- and post- calibration readings did not deviate by more than 1.0 mg/L during any events. Accordingly, DO calibration variances were less than 1 mg/L 100% of the time and therefore exceeded the WQMP variance criterion goal of less than 1 mg/L at least 70% of the time (Table 11).

3.5.7 pH Calibrations Badger Downstream

The pre- and post-calibration differences ranged from 0.1% to 2.7% and from 0.0% to 2.2% for pH 7 and 10 standard calibrations, respectively (Table 9). Criteria for the pH 7 (6.8-7.2) and pH 10 (9.8-10.2) were met in all calibrations, except for one slight deviation from pH 10 at 10.22 pH units on August 1.

3.5.8 Conductivity Calibrations Badger Bypass

As summarized on Table 12, 8 of 10 (80%) calibrations met the probe accuracy of 1% (+/- 0.5%) and two calibrations were slightly outside the probe accuracy (1.6% and 3.0%). The sonde was subjected to substantial physical disturbance and was removed during early and late season periods of high flows.

3.5.9 Dissolved Oxygen Calibrations Badger Bypass

As shown on Table 12, the pre- and post-calibration percentage difference of Badger Bypass DO calibrations ranged from 0.5% to 3.3%. The pre- and post- calibration readings did not deviate by more than 1.0 mg/L during any events. Accordingly, DO calibration variances were less than 1 mg/L 100% of the time and therefore exceeded the WQMP variance criterion goal of less than 1 mg/L at least 70% of the time (Table 12).

3.5.10 pH Calibrations Badger Bypass

The pre- and post-calibration differences ranged from 0.3% to 3.6% and from 0.1% to 2.4% for pH 7 and 10 standard calibrations, respectively (Table 12). Criteria for the pH 7.0 (6.8-7.2) and pH 10.0 (9.8-10.2) were met in all calibrations, except for one slight deviation from pH 7 at 6.75 pH units on July 15.

3.6 Summary of Badger Data

Badger met WQMP criteria for temperature and dissolved oxygen in 2016. Temperature never exceeded the 89°F maximum criterion; DO never was less than 5 mg/L, and daily average differences between DO upstream and downstream never exceeded 2 mg/L. The pH seasonal averages were less than 9.0 at all three probes. Daily averages on a few days exceeded 9.0, but only slightly. Northeast Wisconsin streams exceed pH values of 9.0 depending on the time of year due to the carbonate geology of the region and algal blooms (https://www.uwgb.edu/watershed/data/monitoring/ph.htm).

Badger instruments encountered occasional physical stresses and these contributed one calibration issue at upstream leading to sonde replacement. The problem of biofouling causing calibration issues was reduced again in 2016 compared to 2014 and 2015 due to more frequent downloads, probe servicing, and cleanings. The clipped data set demonstrates that there are no significant differences in the water quality upstream or downstream of Kaukauna Dam and the project is meeting the goals of the WQMP.

3.7 Dissolved Oxygen - Data Rapide Croche

The daily average DO levels both upstream and downstream were always greater than 5 mg/L and less than or equal to 10.5 mg/L during the study (Table 6). Rapide Croche upstream and downstream daily DO data were similar through most of the season with a seasonal average difference of 0.31 mg/L (Table 6). Upstream daily average DO (mg/L) for the season was 7.9 (n=108) vs. 7.6 (n=95) downstream. Differences were less than 2 mg/L every day of the study period. The available data show that both variables were tightly correlated throughout most of the season (Table 6 and Figures 14 and 18).

Upstream DO was consistently higher than downstream (0.5 to 1.5 mg/L higher) during a period of lower river discharge in midsummer (August 2 to 10). This modest difference is interpreted to reflect diurnal algal production in the more stagnant upstream monitoring station which increased DO relative to the more turbulent downstream station. When river flows increased again after August 10, upstream and downstream DO exhibited tighter correlation (Figure 14).

Two data gaps were indicated in the downstream data during the study: one caused by battery failure and leakage from July 15 to 19 and the second caused by an apparent log file programming error (likely operator error) from September 6 to 16 (Table 9). No data gaps were experienced at the upstream station and no unreliable data was identified, which had been encountered in previous years due to biofouling or physical disturbance of the sondes. There were also no data losses from human disturbance of the sonde behind the locked gate as experienced prior to increasing security in 2014.

Conclusions: Available daily DO average (mg/L) met the WQMP criterion of 5.0 mg/L minimum at Rapide Croche. There were no cases when upstream vs. downstream daily average DO differed by more than 2.0 mg/L. Therefore, DO data met the WQMP criteria.

3.8 Temperature Data - Rapide Croche

Seasonal weather and discharge affect the overall temperatures in the Fox River. These were nearly identical to patterns and extremes observed four miles upstream at Badger. Figures 15 and 19 show that upstream and downstream daily temperatures at Rapide Croche were nearly identical. The graphs verify average daily temperatures never exceeded 27°C (81°F) and thus met the 89°F maximum criterion in the WQMP. The average daily upstream vs. downstream temperature was 24.2°C (75.5°F) vs. 24.4°C (76°F), a difference of 0.2°C (0.5°F).

Hourly temperature patterns are typically within 2°C of the daily mean and exhibit expected diurnal sawtooth patterns (Figure 14). Hourly temperatures were more variable in the upstream location, especially during low flow conditions of early August when the hourly peak temperatures briefly exceeded 29°C (84°F) on August 3 and 11 (Figure 14).

Data gaps in downstream temperature were identical as reported for DO when the sonde's battery failed from water leakage (July 15-19) and an apparent log file programming error occurred (September 6-16). A total of 108 daily temperature averages were documented upstream and 95 downstream. The tight correlations of upstream and downstream make it unlikely that missing data could have contradicted observed data.

Conclusions: Daily and hourly data confirm that the Rapide Croche met WQMP criteria for temperature.

3.9 pH Data - Rapide Croche

The seasonal minimum and maximum daily average pH ranged from of 7.9 to 9.0 upstream and 8.0 to 9.0 downstream (Table 4). The upstream and downstream averages for pH for the season were both 8.4 with an average difference of 0.02 pH units (Table 6). Minimum and seasonal daily averages meet the WQMP criterion of a pH between 6.0 and 9.0. Differences between upstream and downstream were always less than 0.4 pH units (Table 6). Never were daily changes in pH greater than 0.5 pH units either upstream or downstream (Tables 7 and 8).

Figure 20 illustrates that pH daily averages varied between pH 8 and 9 during the monitoring season. Data gaps in downstream pH were identical as reported for DO and temperature when the sonde's battery failed from water leakage (July 15-19) and an apparent log file programming error occurred (September 6-16). Despite the missing data, daily shifts in pH were always gradual and never more than 0.5 pH units or less difference between upstream and downstream on the 95 days when there were data to compare. The maximum daily change upstream and downstream was also less than 0.5 pH units the entire season (Table 6). Values also remained constant from day to day at both sondes, changing only 0.0-0.3 pH units at both upstream and downstream locations (Tables 7 and 8).

Conclusion: Rapide Croche upstream probably provided the most accurate pH data set for the season of all the locations in the study. Successful calibration during all events plus no mechanical outages or replacements made it the most reliable record. Although there were data gaps downstream, the existing data show average daily pH was within 8.0-9.0 and most frequently within 0.1 pH units compared to upstream. The data support a conclusion of no

differences greater than 0.5 pH units occurred between upstream and downstream Rapide Croche nor between sequential days. Therefore, Rapide Croche met the criteria of the WQMP during the 2016 sampling period.

3.10 Calibration and Performance of Rapide Croche Sondes Upstream and Downstream

3.10.1 Calibration Technique

Calibration data records for the upstream and downstream sondes are shown in Tables 13 and 14, respectively. Refer to section 3.5.1 for general calibration procedures. Both upstream and downstream units met calibration criteria for DO and pH in more than 90% of the samples when data was available. The upstream unit was replaced on July 15 due to inability to calibrate until the fifth attempt. The unit was returned to the manufacturer for servicing and a replacement sonde was utilized through the remainder of the monitoring season at the upstream station. Although the downstream unit experienced a cracked battery housing on July 15, the housing was replaced on July 19 and the unit was successfully recalibrated. Data loss occurred for the downstream unit due to battery failure and leakage from July 15 to 19 and an apparent log file programming error (likely operator error) from September 6 to 16 (see Appendix E for details). Upstream and downstream are discussed together due to similar results for each variable.

3.10.2 Conductivity Calibrations Rapide Croche Upstream and Downstream

The conductivity calibrations for Rapide Croche Upstream (Table 13) and Rapide Croche Downstream (Table 14) showed low instrument drift during the entire study except for 6 out of 16 events in the upstream calibration data (Table 13) and 4 out of 15 events in the downstream calibration data (Table 14) slightly above 1% difference. Instrument issues prevented calibrations on two occasions downstream. Moderate levels of conductivity ranged from 370 to 450 μS/cm during the season (Figure 21).

3.10.3 Dissolved Oxygen Calibrations Rapide Croche Upstream and Downstream

The DO calibrations at Rapide Croche Upstream (Table 13) and Rapide Croche Downstream (Table 14) also showed stable probe performance during the entire study with only one pre- and post- calibration reading at each station deviating by more than 1.0 mg/L. Thus 15 of 16 calibrations (94%) for upstream and 14 of 15 calibrations (93%) for downstream did not deviate by more than 1.0 mg/L during any events. Accordingly, DO calibrations exceeded the WQMP variance criterion goal of less than 1 mg/L at least 70% of the time (Tables 13 and 14).

3.10.4 pH Calibrations Rapide Croche Upstream and Downstream

The pH calibrations for Rapide Croche Upstream (Table 13) were all (100%) within the probe accuracy for the 7 and 10 standards of +/- 0.2 pH units. The pH calibrations for Rapide Croche Downstream (Table 14) were within the probe accuracy, except for two slight deviations from pH 7.0 (6.73) and pH 10.0 (9.78) near the beginning of the monitoring season.

4.0 Conclusions

4.1 Conclusions for 2016

This is the third year of a three-year sampling program. The goal of the program is to determine whether operations of the new Badger-Rapide Croche Hydroelectric Project are meeting the WQMP criteria established by FERC in its Order for New License.

The data provide confidence that the Project in 2016 met the WQMP criteria as follows: (1) average daily temperatures were within the natural range of the river, not greater than 89°F, and upstream and downstream temperatures were nearly identical and highly correlated; (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) and most of the synchronous readings showing no statistically significant differences upstream and downstream (i.e., were within the range of instrument accuracy of +/- 0.2 mg/L); and (3) pH ranges were between 8.0 and 9.0 except for a few days when pH daily average drifted to as high as 9.18. The natural carbonate geology of the Fox River basin and summer algal blooms can produce pH values above 9.0, but this was observed rarely and at levels less than 9.2 daily average.

Sonde and probe malfunctions occurred and caused some data gaps; however, no variable provided less than 95 days of data at Rapide Croche or Badger upstream and downstream locations out of a possible 108 sampling days. Collectively, complete records were obtained for every variable for the entire season—i.e., there was never any day when pH, DO, and temperature were not available at one of the monitoring stations. 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 95-108 days when comparative data were available support the conclusion that no criteria were ever violated.

Calibration goals were met at most stations for most variables. When calibrations were not met, it was either the exception or the result of occasional instrument malfunctions disabling calibration.

The trends and the existing data all show similar upstream and downstream values consistent with WQMP criteria. In summary, we conclude that the Badger-Rapide Croche Project has met the WQMP criteria for the third year of the sampling period.

4.2 Conclusions for 2014 to 2016

Monitoring of the Project has been completed in conformance with the WQMP over the past three years. The goal of the program is to determine whether operations of the new Badger-Rapide Croche Hydroelectric Project are meeting the WQMP criteria established by FERC in its Order for New License. More importantly, data have demonstrated that there is almost no difference in water quality variables studied between upstream and downstream locations of the

Project. This is expected because inflows are nearly identical to outflows and the storage capacities of the reservoirs are small.

The data demonstrate with high statistical confidence that the Projects in 2014, 2015, and 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; (2) average daily dissolved oxygen was always above 5 ppm (mg/L) with upstream and downstream differences never greater than 2 mg/L in 2016 or never occurred on any sequential days in 2014 or 2015; and (3) pH ranges were between 8.0 and 9.0 except for a few days when pH daily average drifted to as high as 9.18 (2015 and 2016) and above 9.2 (2014) when effects of biofouling and algal blooms were more pronounced. Additionally, we note that pH did not change more than 0.5 pH units on any sequential days, excluding two dates in 2014 when calibration and human disturbance issues biased the pH data. The natural carbonate geology of the Fox River basin and summer algal blooms can produce pH values above 9.0, but this was observed rarely and at levels less than 9.2 daily average in 2015 and 2016. The slightly elevated pH values above 9.0 observed in 2014 are explained by the carbonate geology of the Fox River basin combined with summer algal blooms, and are considered natural. DO was also in compliance with the WQMP because the daily average difference between upstream and downstream never exceeded 2 mg/L for five consecutive days during the three monitoring seasons.

Recommendations following the 2014 and 2015 monitoring seasons were implemented and led to improvements in data quality and consistency for subsequent seasons. As recommended in the 2014 WQMR, sondes with improved technology (Hach HL4 sondes) were deployed in 2015 and 2016. The new sondes are smaller, more compact and have improved electronics and battery life compared to the MS-5 sondes employed in 2014. Also, the sonde at Rapide Croche downstream was relocated so that it was deployed with a cable from within a fenced area. The new location prevented subsequent human disturbance of the sonde at this station in the latter portion of the 2014 season and in 2015 and 2016.

As recommended in the 2015 WQMR, deployment of the bypass sampling unit was appropriately delayed until peak flows were over around July 1. This monitoring station is not critical to hydropower operations because flows are not subject to the hydro units and the discharge levels of 6,000-12,000 cfs significantly reduce any potential for upstream and downstream differences to be meaningful. As described in the 2016 WQMR, the sonde at the bypass station was not deployed during periods of high flows early and late in the season that prevented safe access to this station on the railroad trestle. We also recommend relocation of the downstream Badger monitoring station to an area less susceptible to sedimentation and damage from burial in mud (within approximately 50-100 feet of the original station) and/or modifying the attachment such that the sonde would remain suspended above the bottom of the channel. The sonde was deployed approximately 50 feet further downstream in 2016 and did not experience significant sedimentation similar to 2015 which led to an improved dataset.

Data quality and acquisition were also improved through increased frequency of cleaning and calibration intervals from biweekly in 2014 to every 7-10 days in midsummer in 2015 and 2016. The increased cleaning and calibration scheduled reduced the impact of biofouling and sedimentation on the equipment and datasets during the latter portion of the midsummer monitoring intervals, and allowed for any equipment issues to be identified and addressed

sooner. This led to fewer and shorter data gaps. The strong correlation of the data reinforced the conclusion that it was highly improbable that any variable was out of compliance during any data gap experienced.

Per the FERC Order approving the WQMP and based on three years of water quality monitoring data, we also provide recommendations for discontinuing monitoring. As described in this report, the data demonstrate with high statistical confidence that the Project in 2014, 2015, and 2016 met the WQMP criteria. Accordingly, we recommend that monitoring be suspended unless Kaukauna Utilities changes operations of the Project or FERC requires that Kaukauna Utilities change such operations.

Appendix A

Figures (Clipped Data)

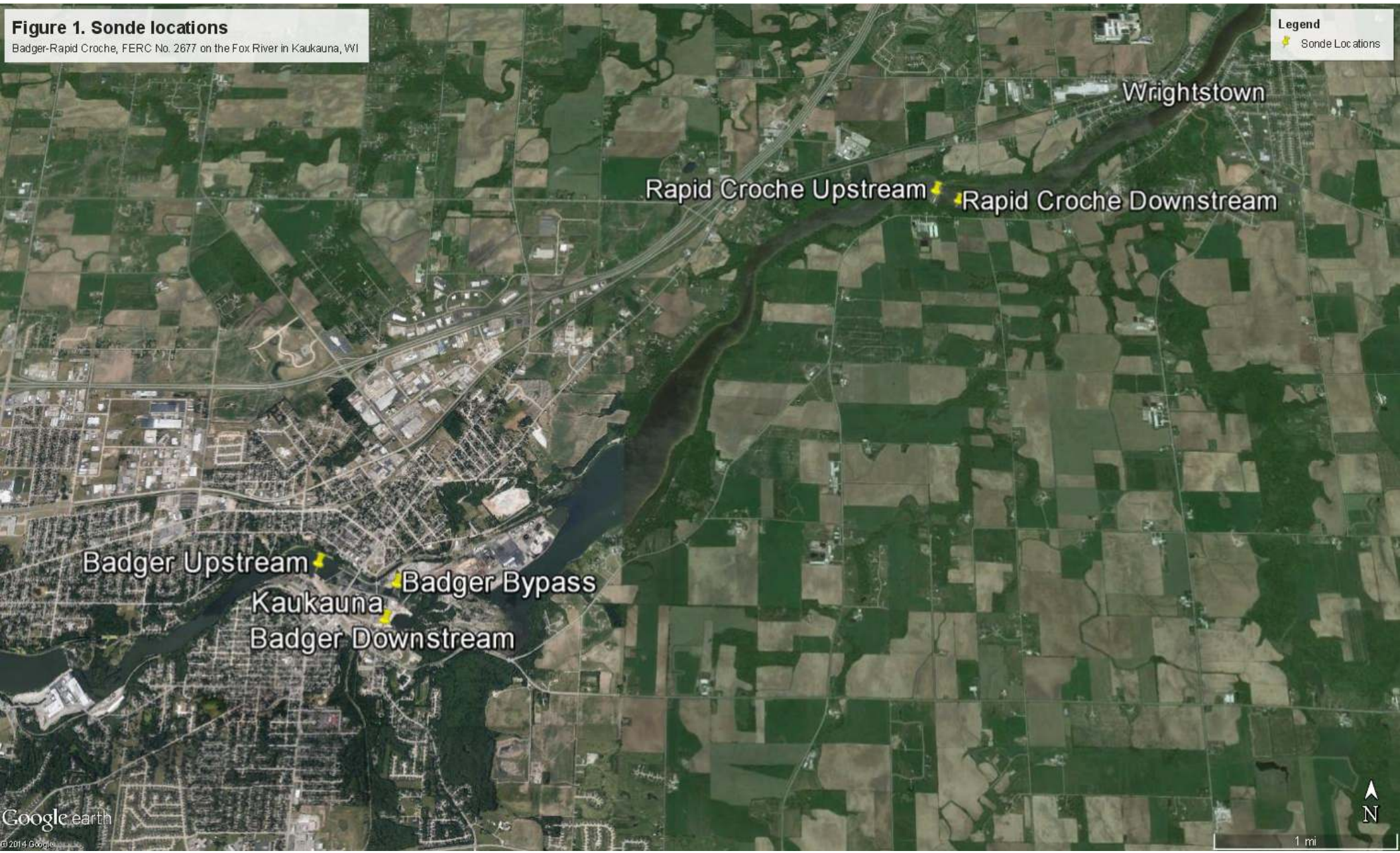
Figure 1. Sonde locations
Badger-Rapid Croche, FERC No. 2677 on the Fox River in Kaukauna, WI
Legend
Sonde Locations
Wrightstown
Rapid Croche Upstream
Rapid Croche Downstream
Badger Upstream
Badger Bypass
Kaukauna
Badger Downstream
Google earth
© 2014 Google
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Figure 2. Hourly Dissolved Oxygen Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

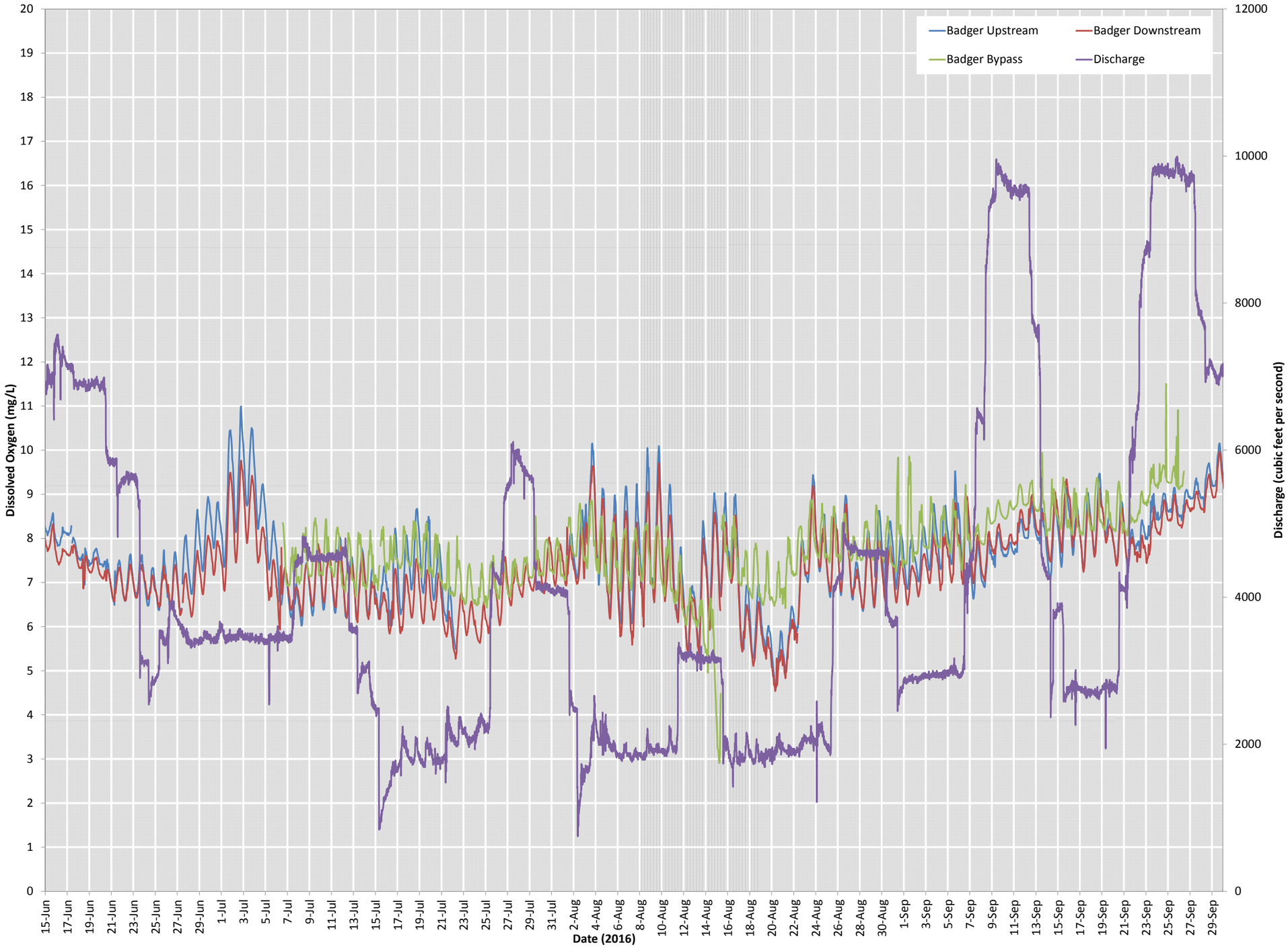

Figure 3. Hourly Temperature Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

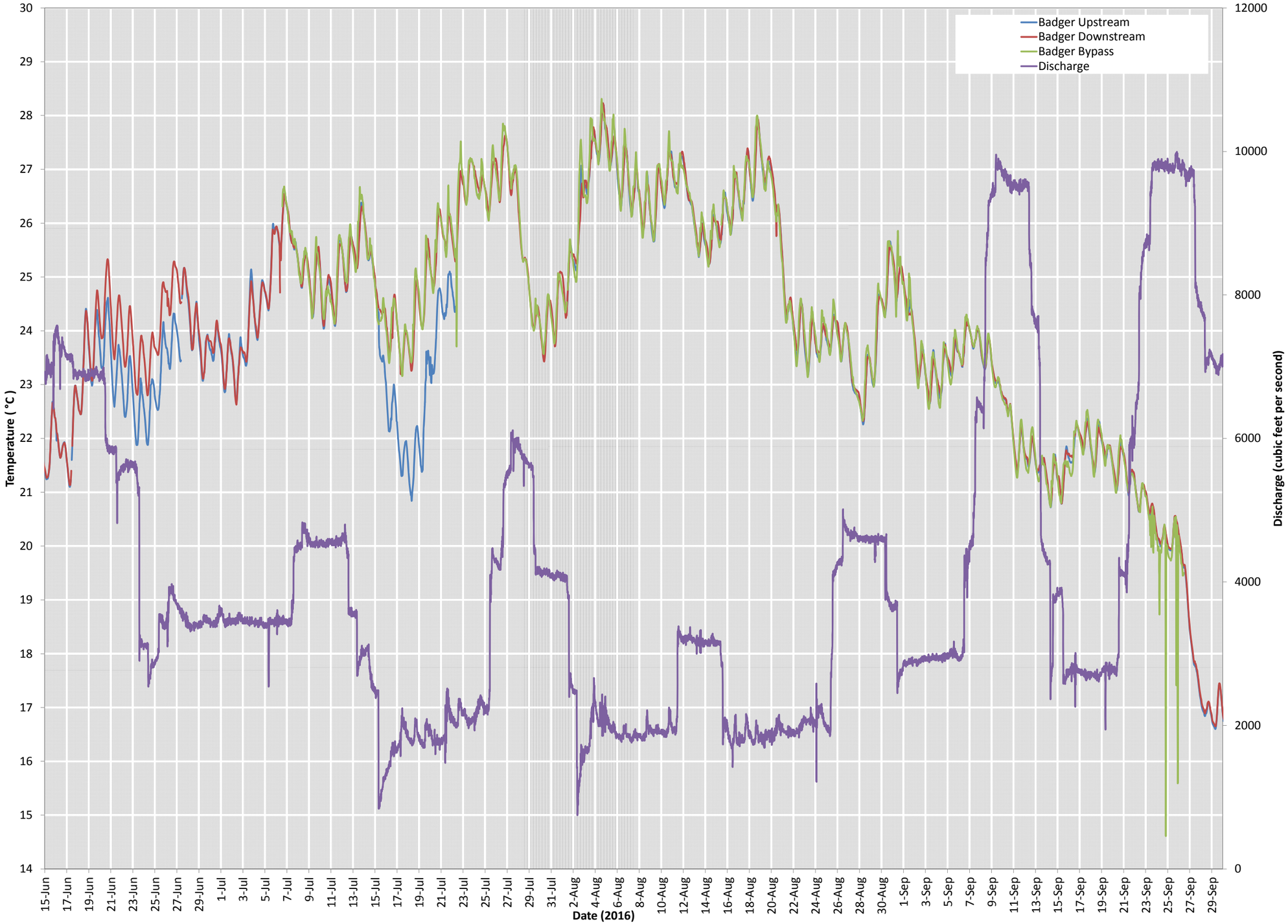

Figure 4. Hourly pH Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

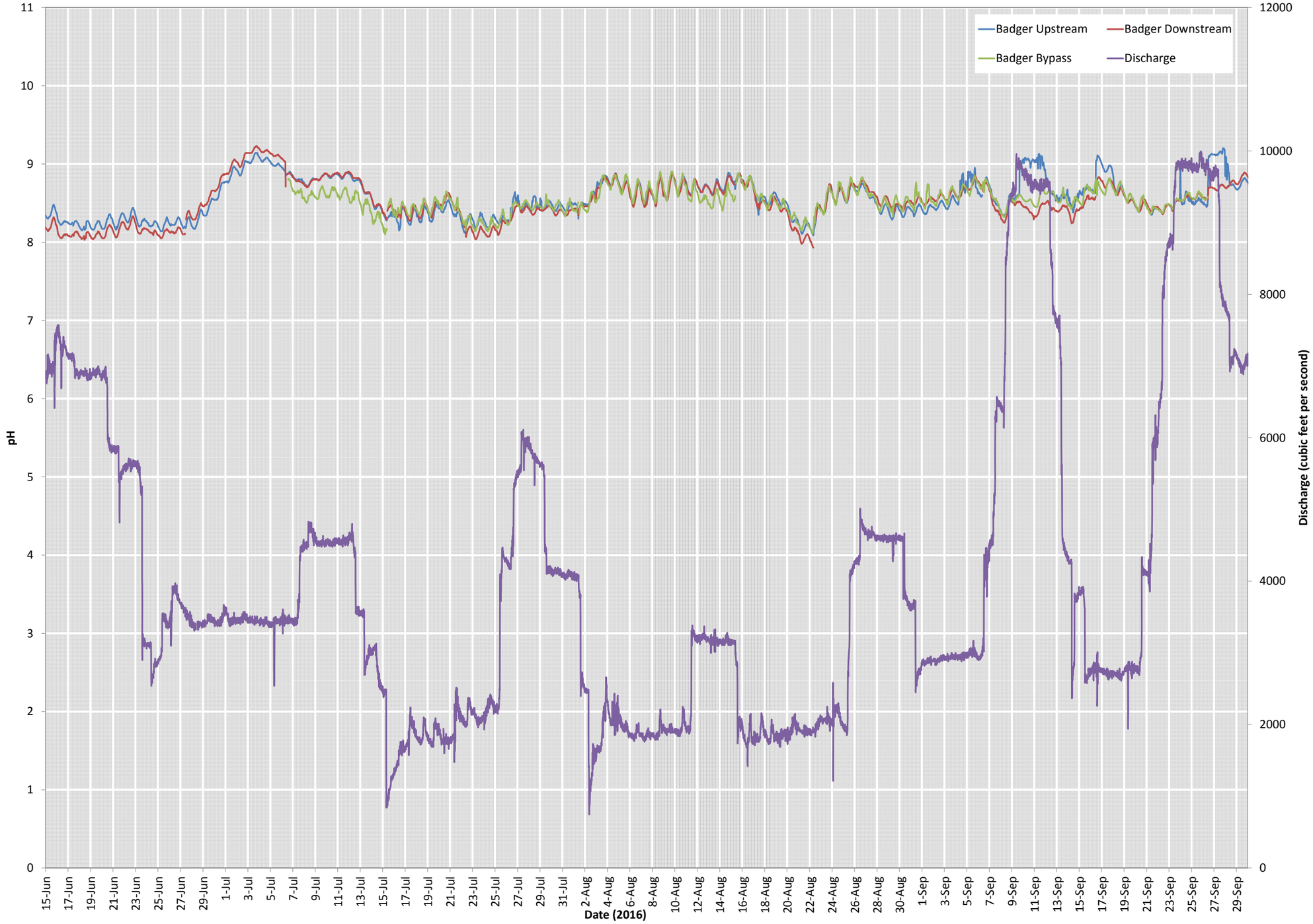

Figure 5. Hourly Electrical Conductivity Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

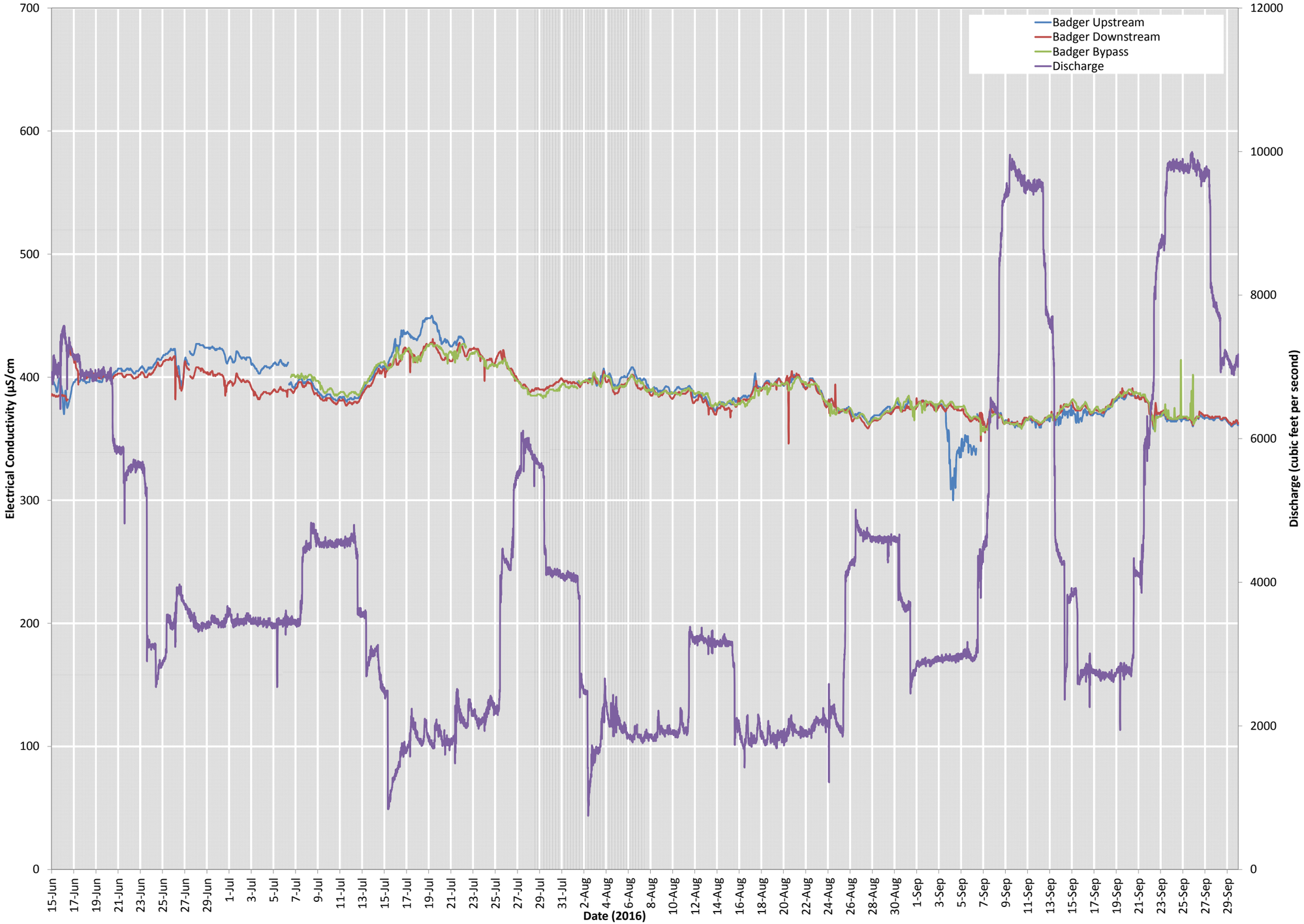

Figure 6. Daily Dissolved Oxygen Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

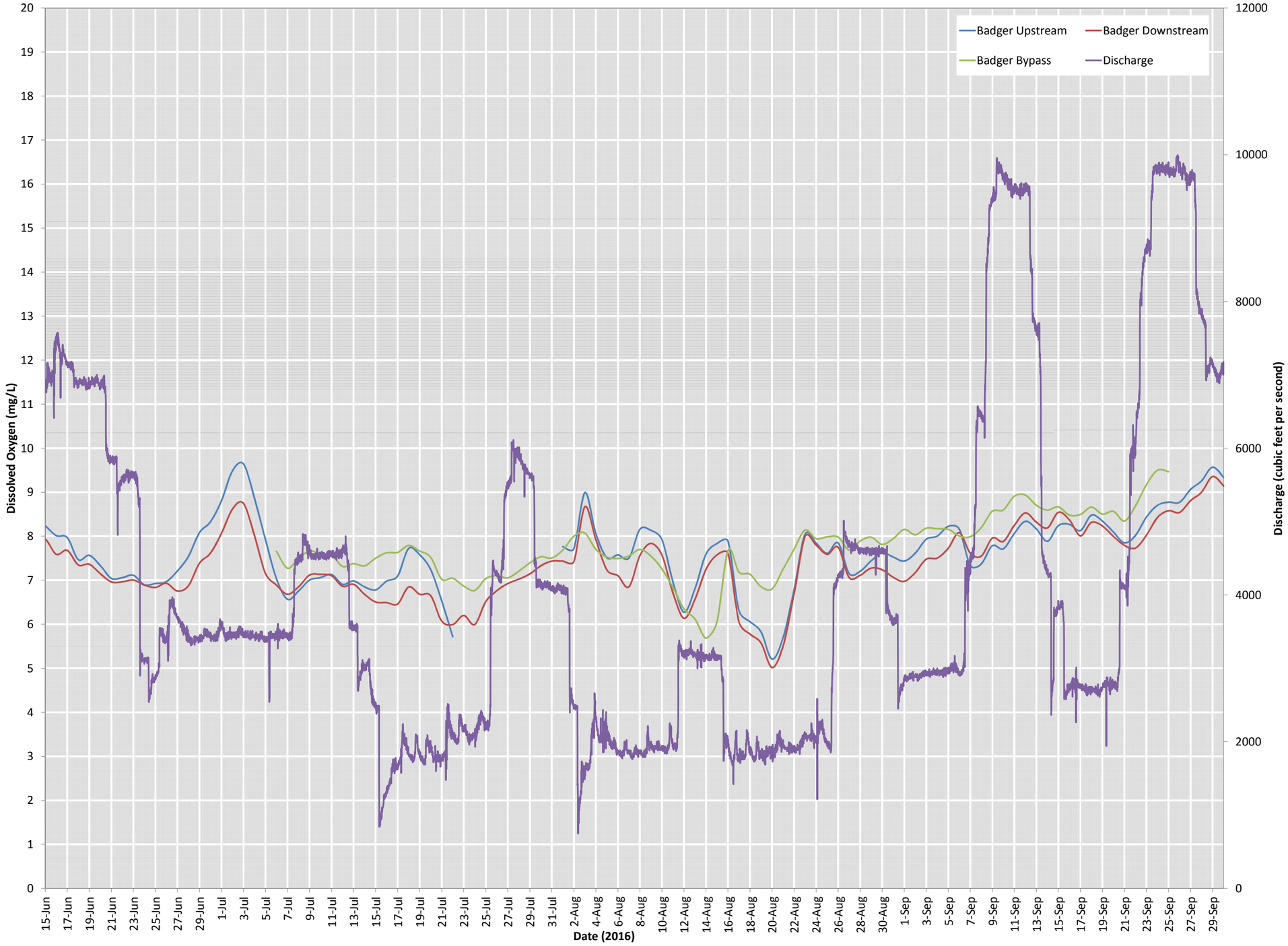

Figure 7. Daily Temperature Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

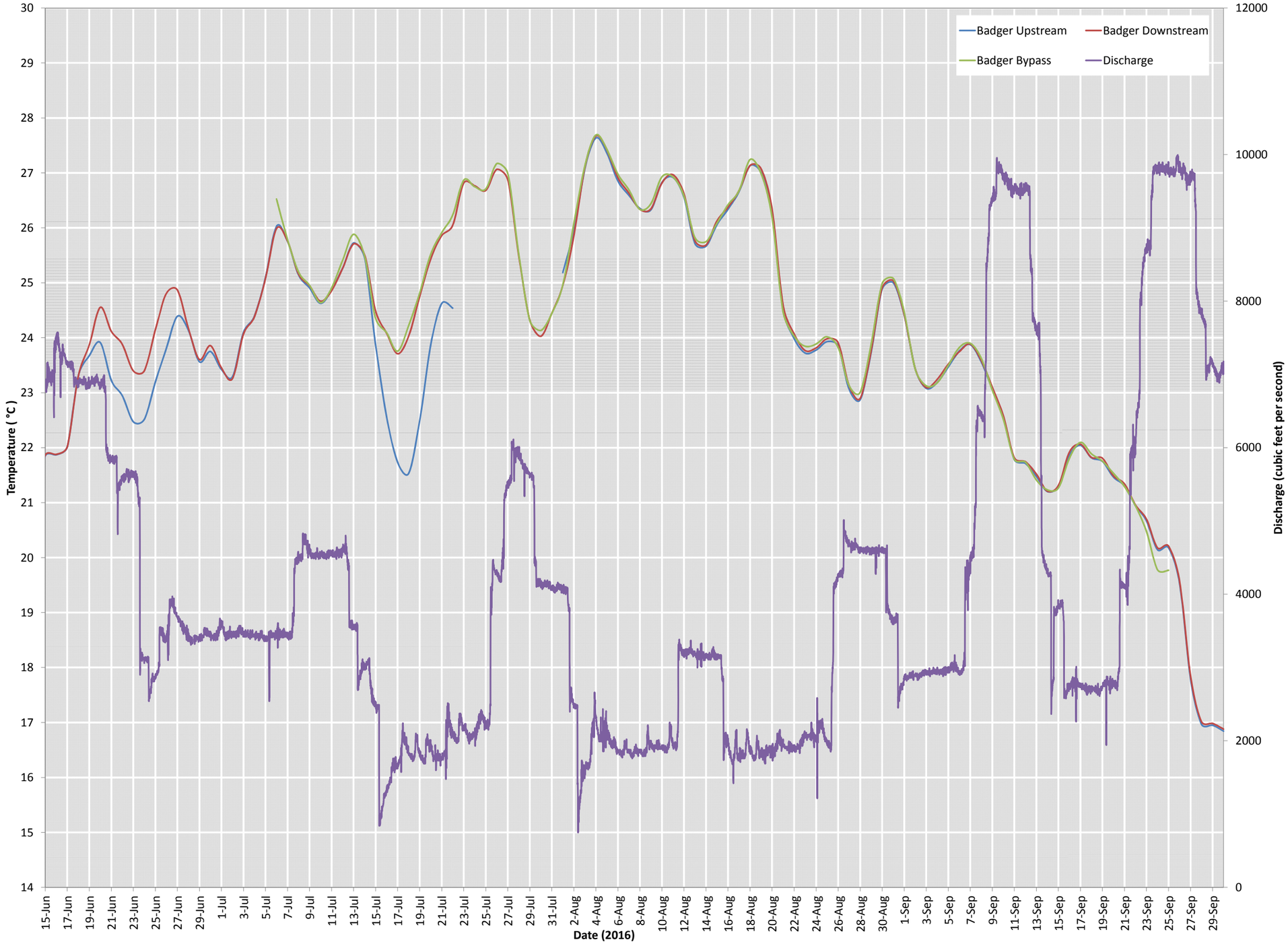

Figure 8. Daily pH Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

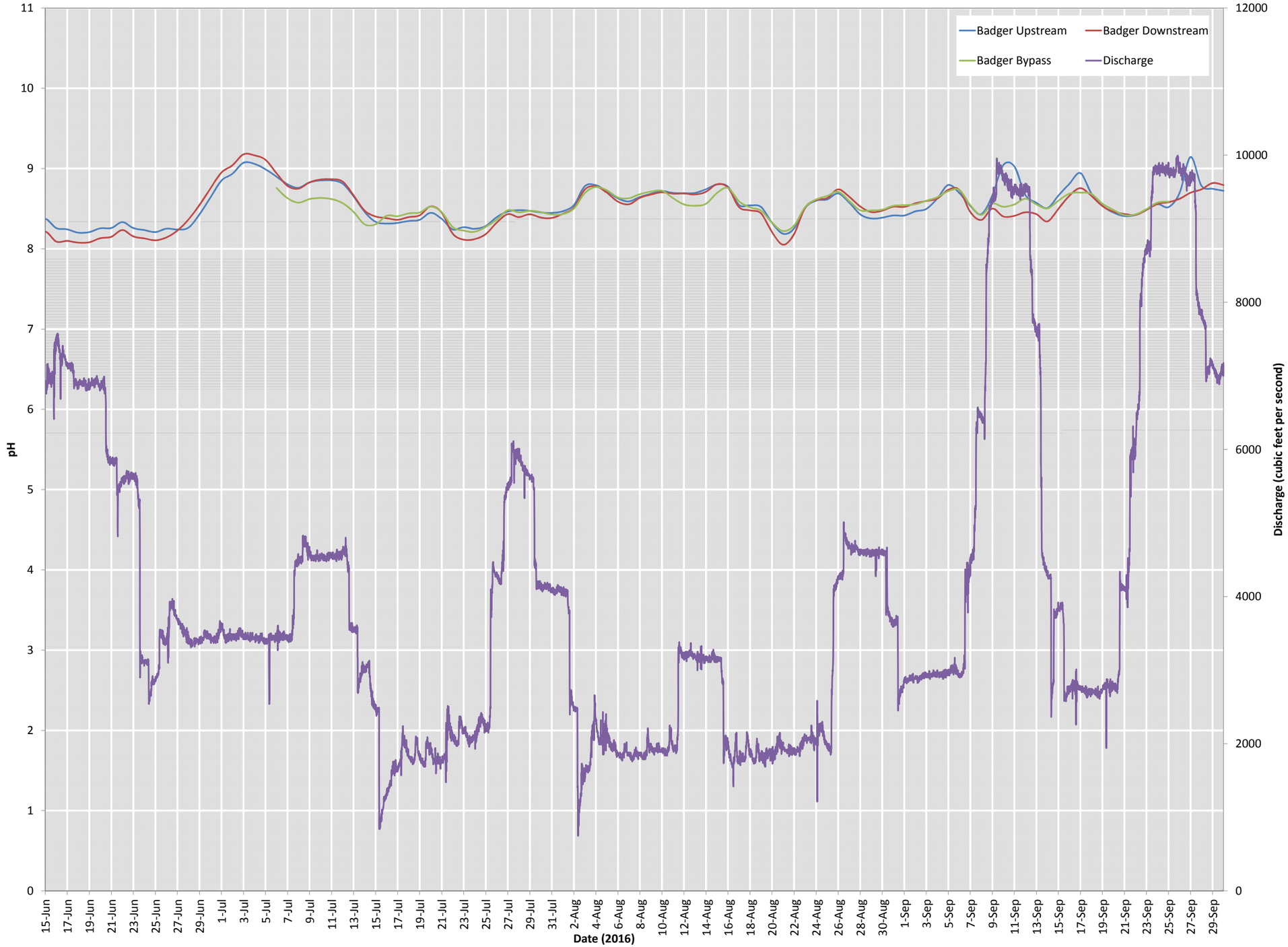

Figure 9. Daily Electrical Conductivity Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

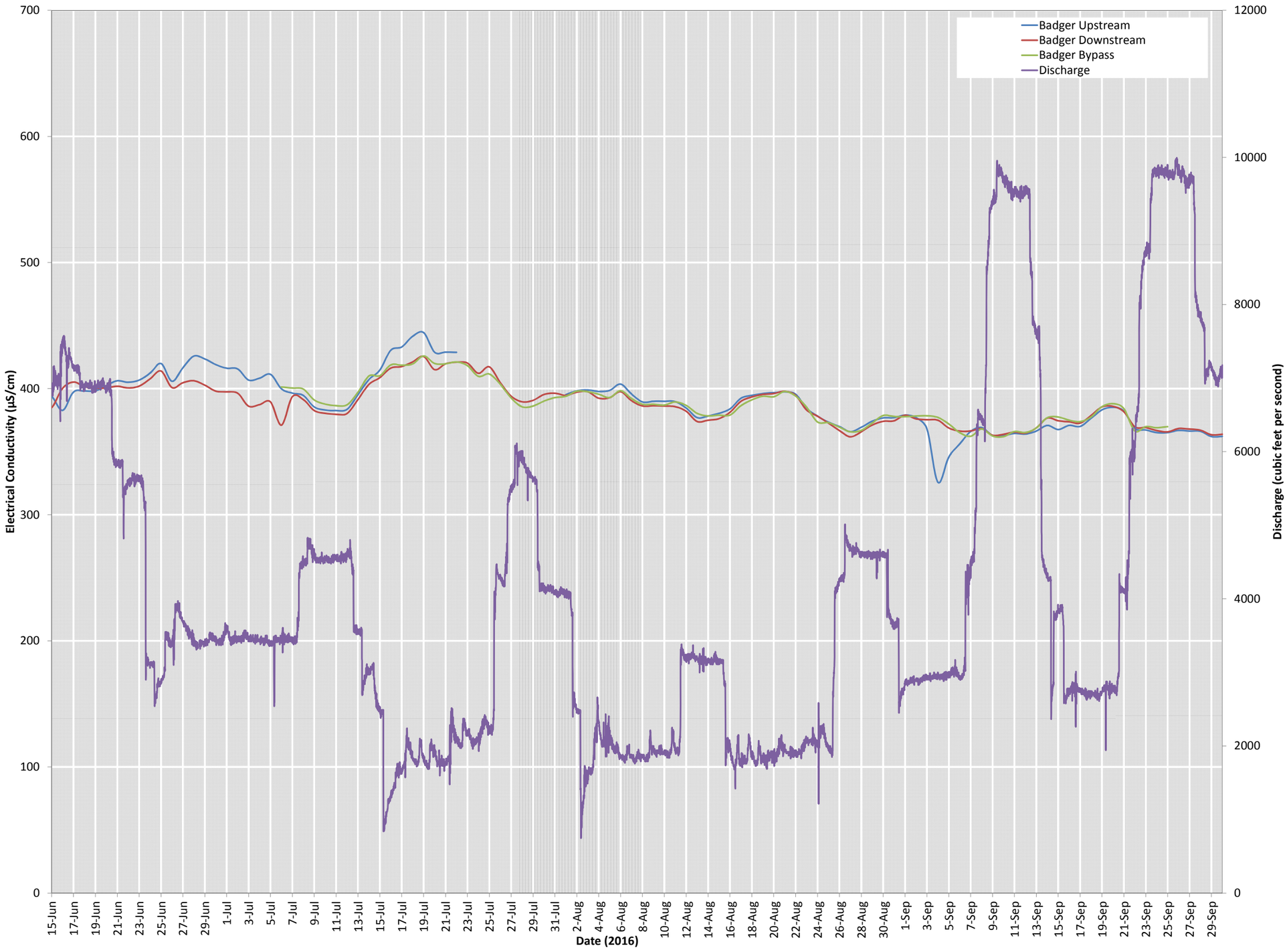

Figure 10. Comparison of Dissolved Oxygen Readings, Upstream Surface and Upstream Bottom of Canal of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

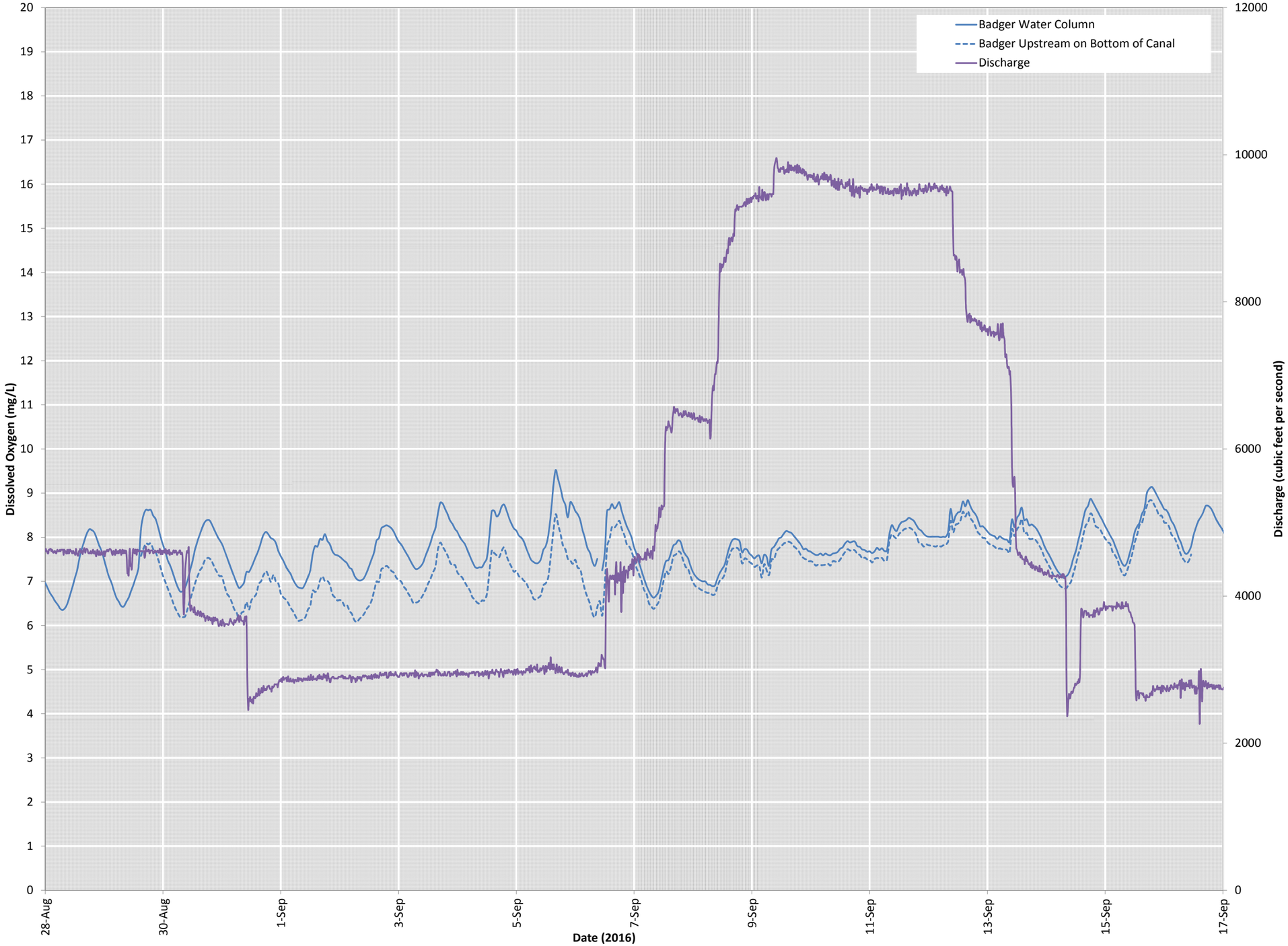

Figure 11. Comparison of Temperature Readings, Upstream Water Column and Upstream Bottom of Canal of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

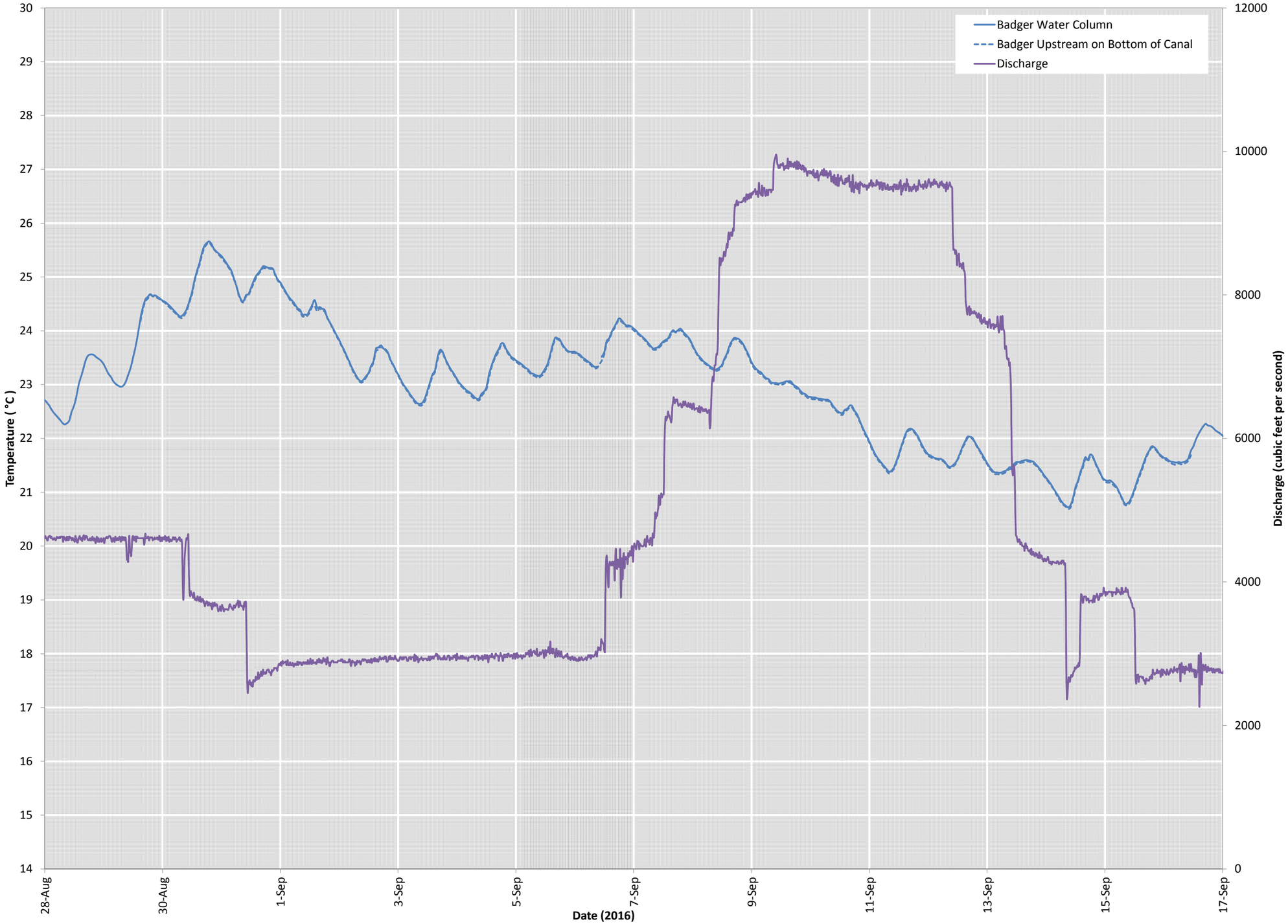

Figure 12. Comparison of pH Readings, Upstream Water Column and Upstream Bottom of Canal of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

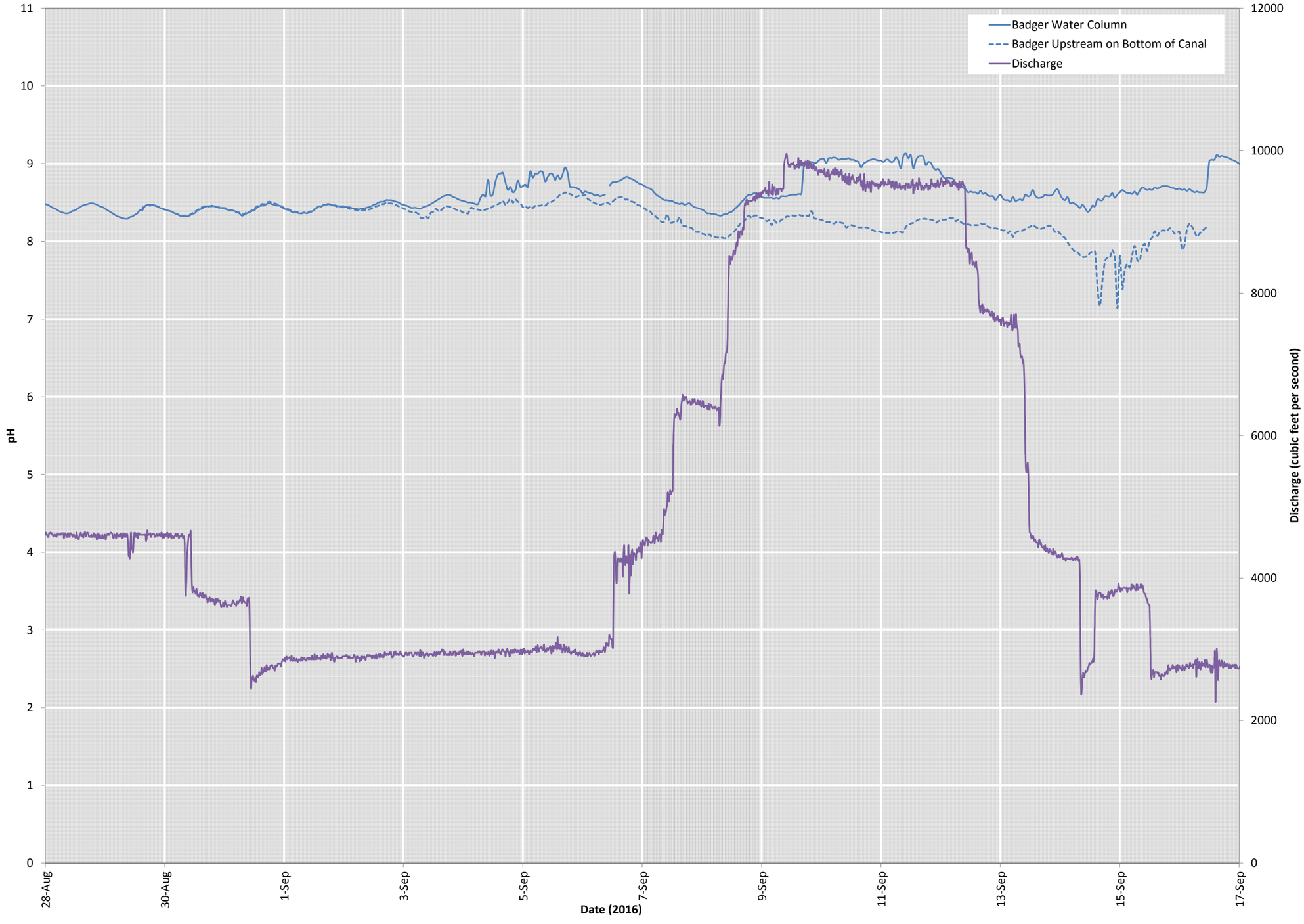

Figure 13. Comparison of Electrical Conductivity Readings, Upstream Water Column and Upstream Bottom of Canal of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

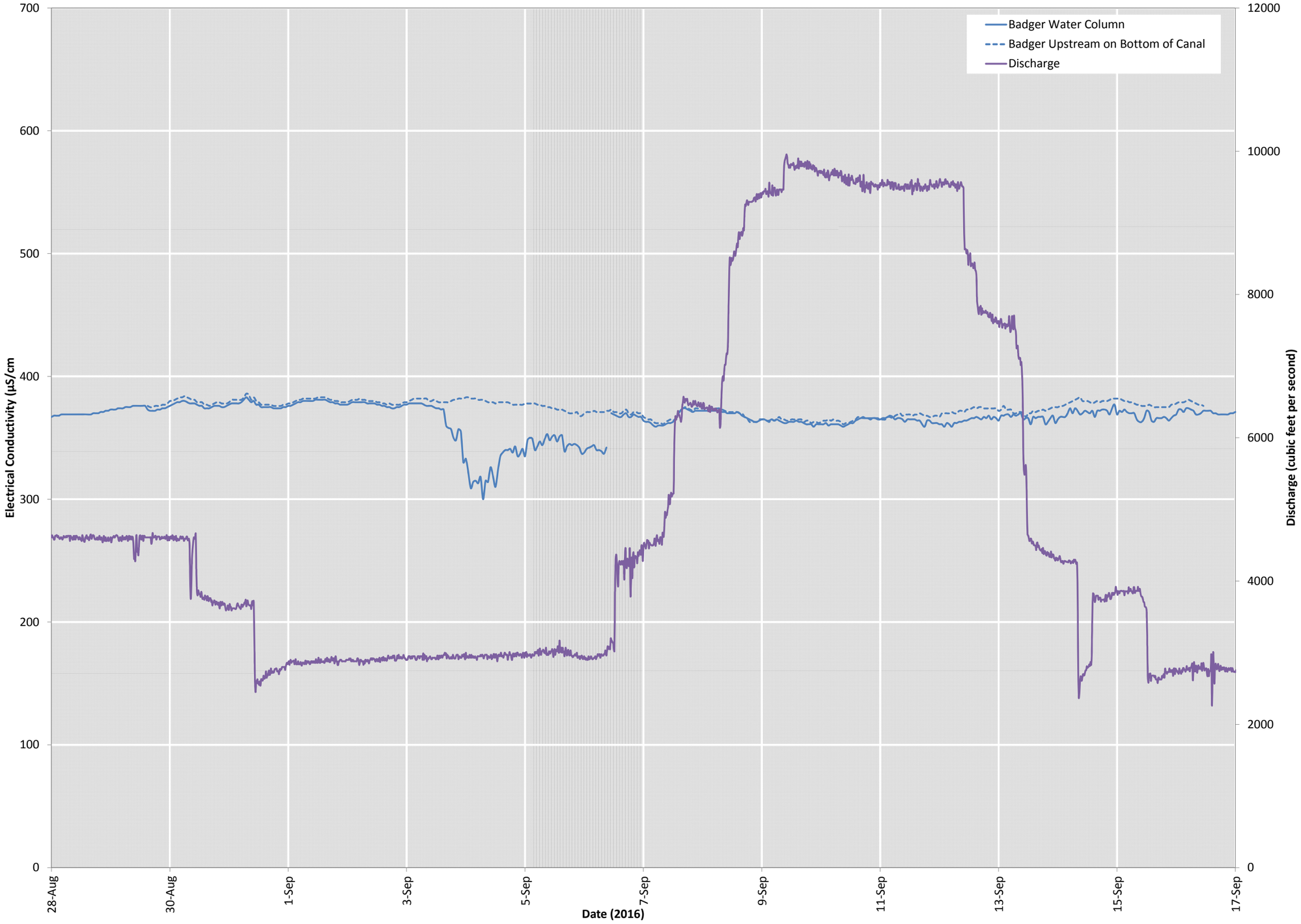

Figure 14. Hourly Dissolved Oxygen Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

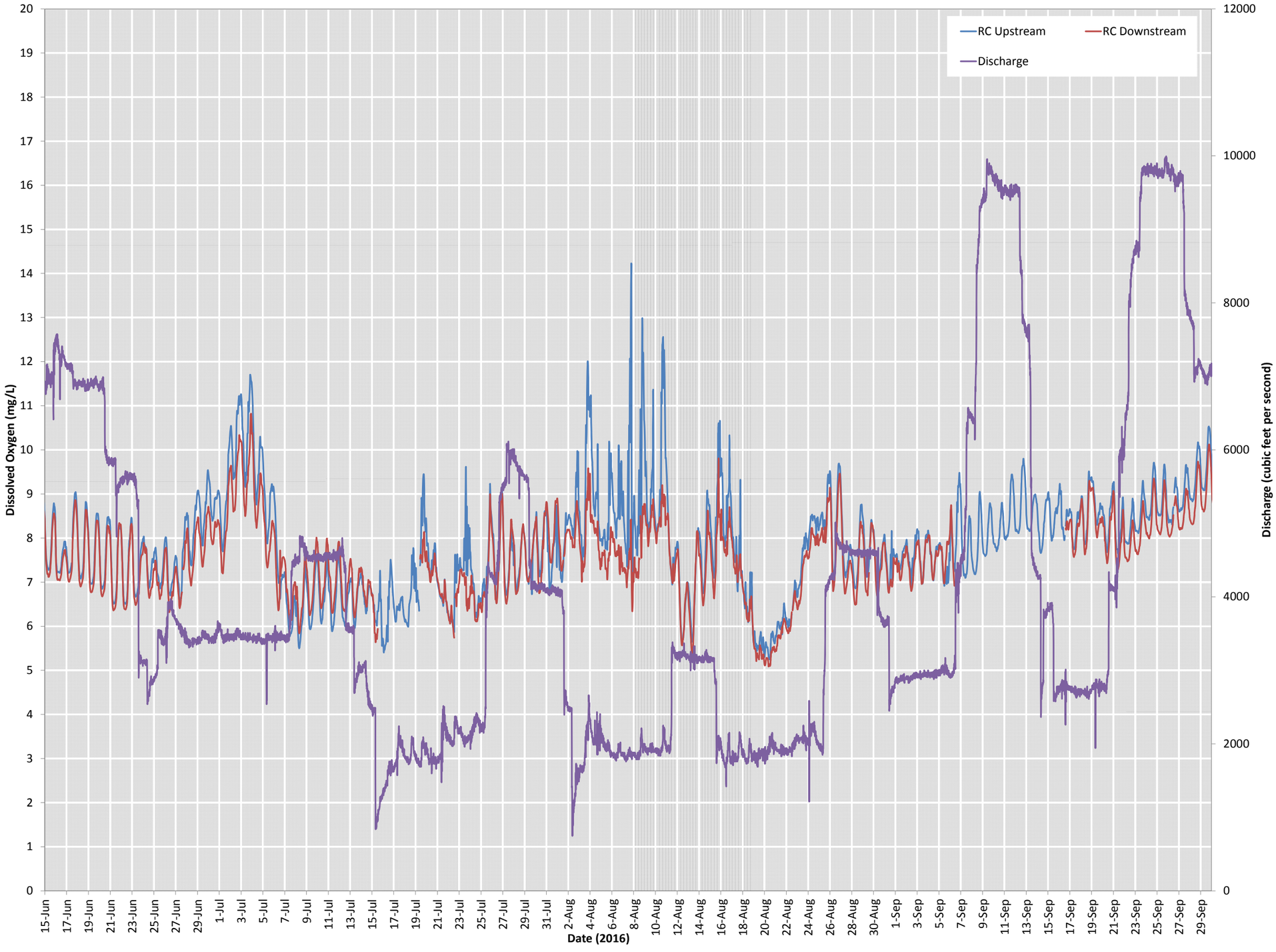

Figure 15. Hourly Temperature Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

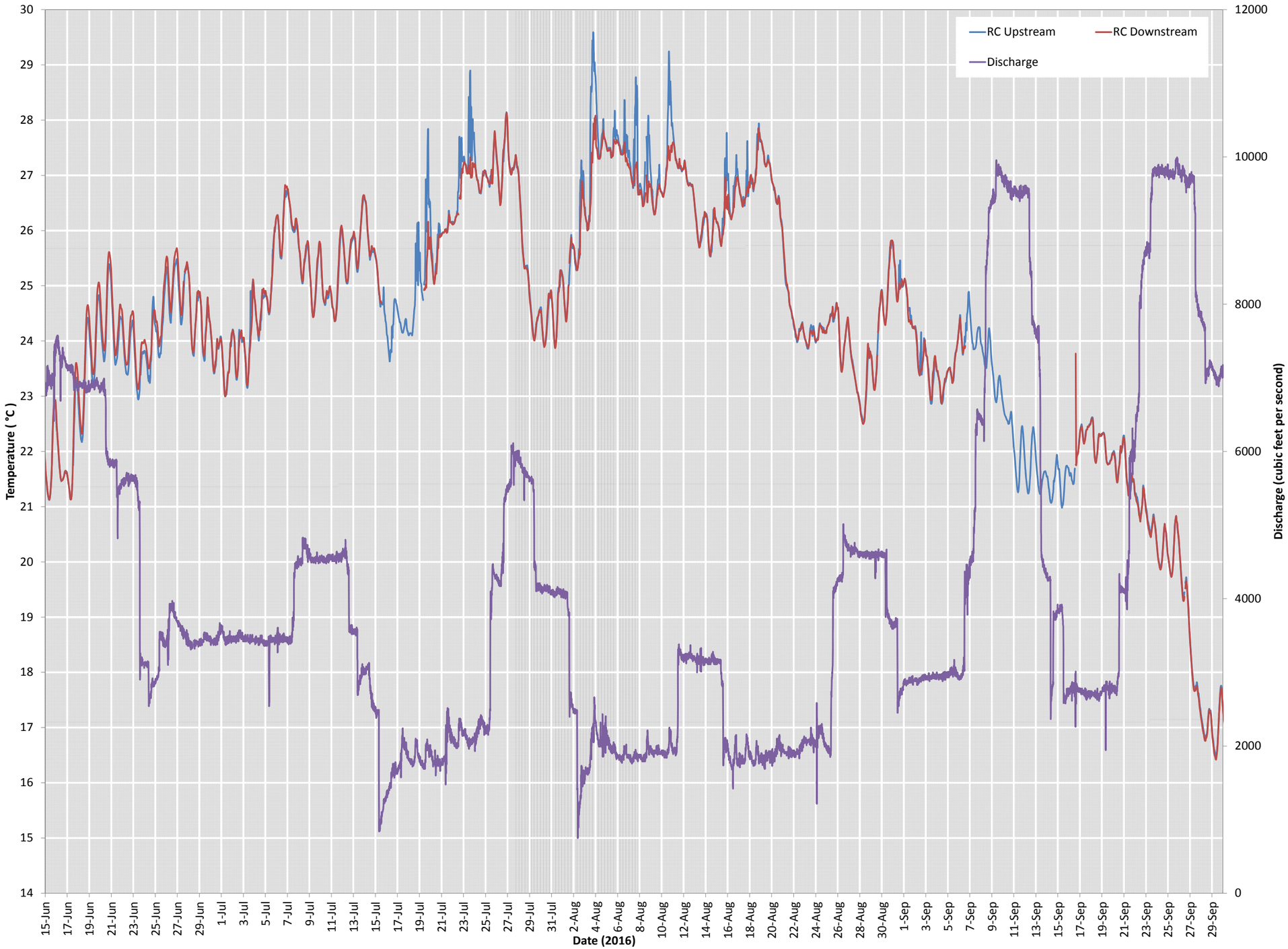

Figure 16. Hourly pH Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

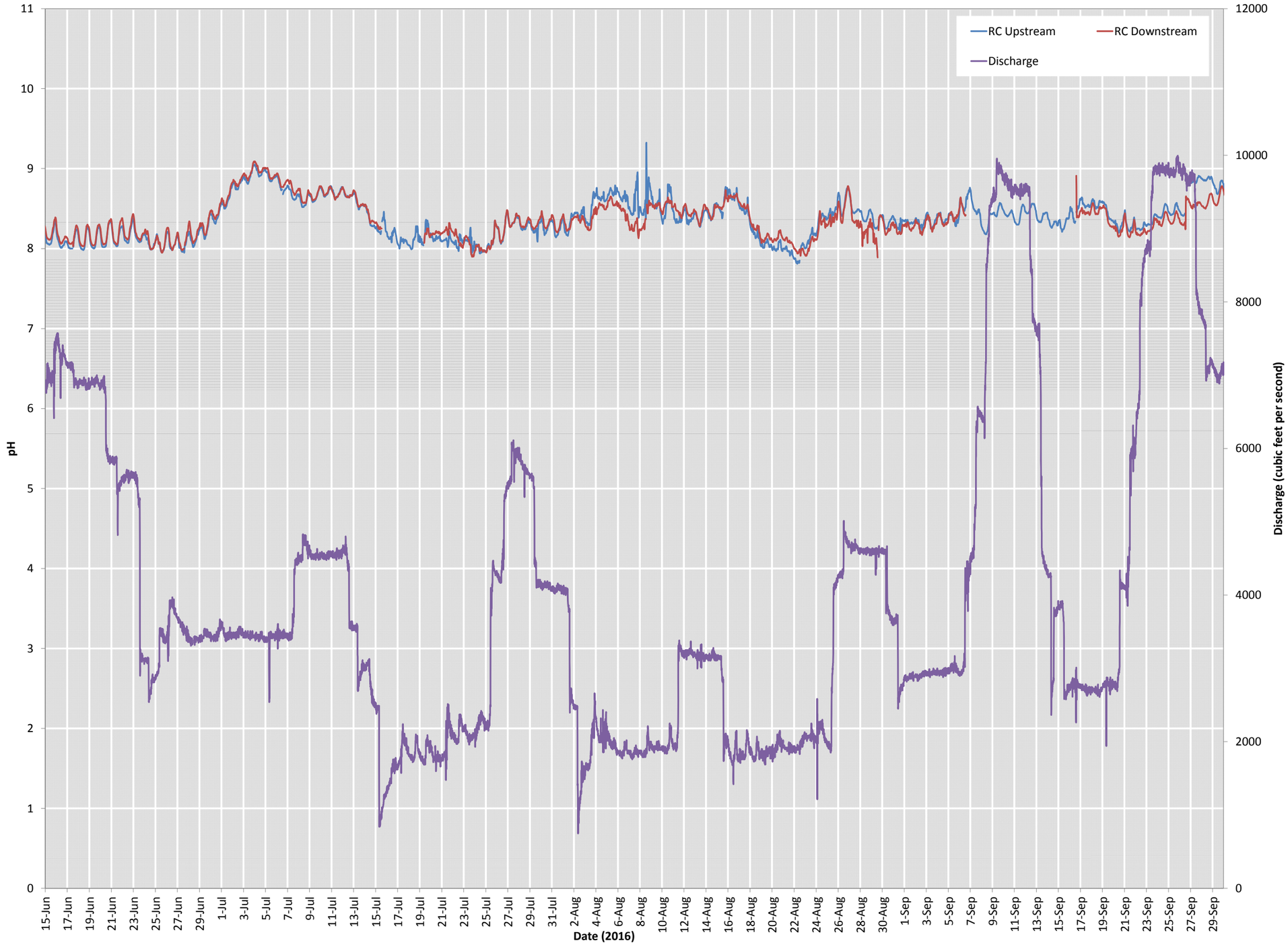

Figure 17. Hourly Electrical Conductivity Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

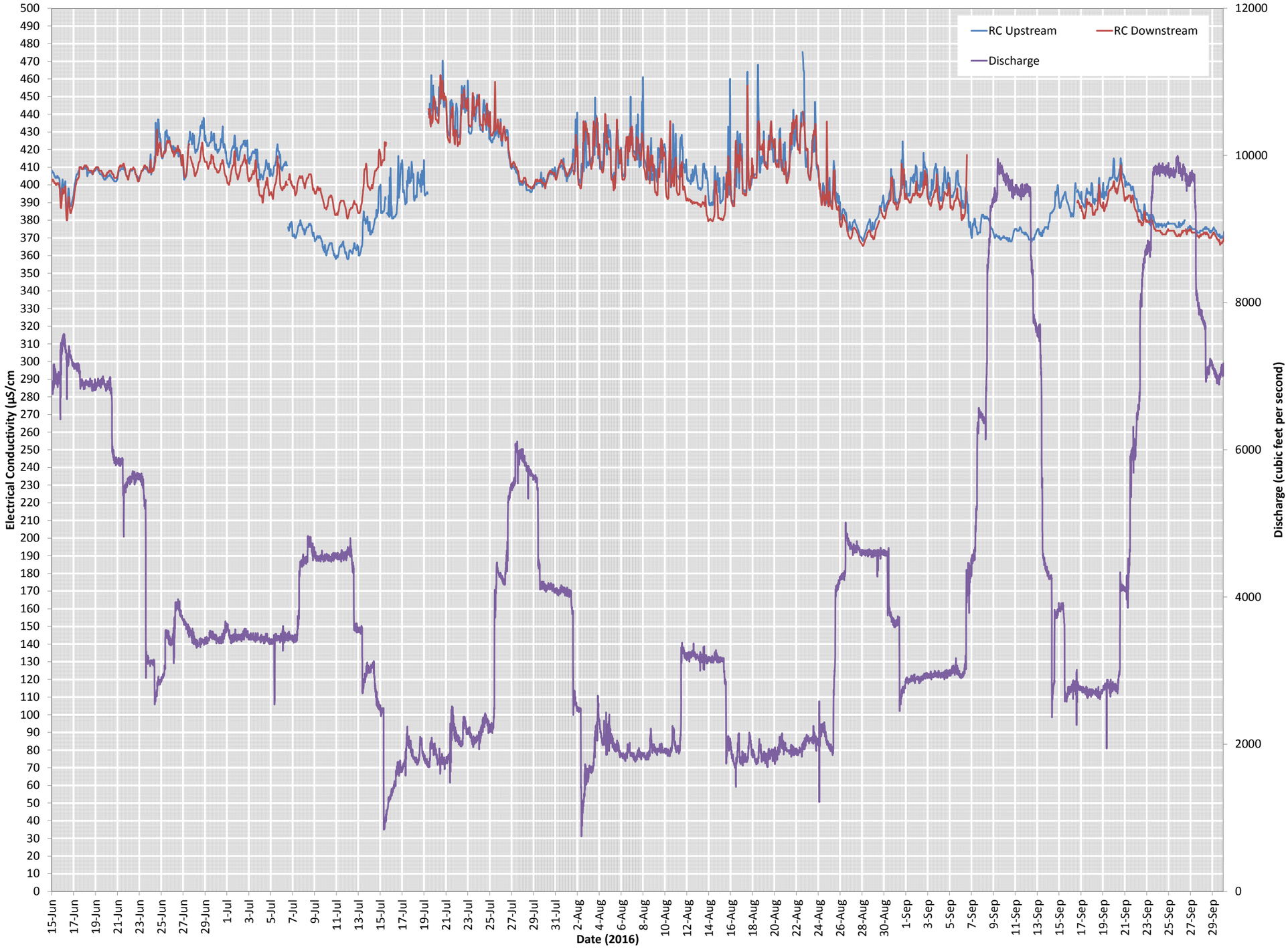

Figure 18. Daily Dissolved Oxygen Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

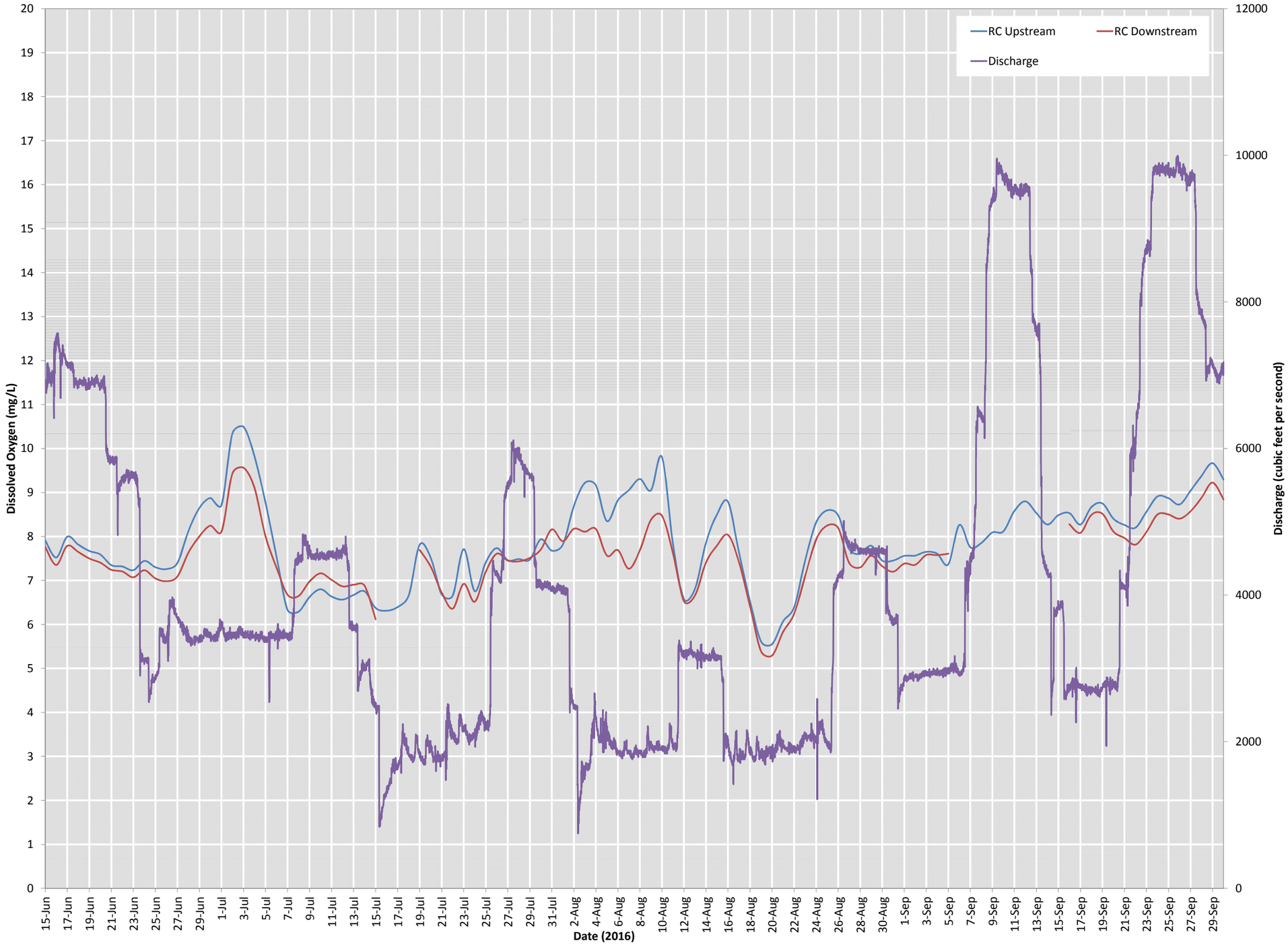

Figure 19. Daily Temperature Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

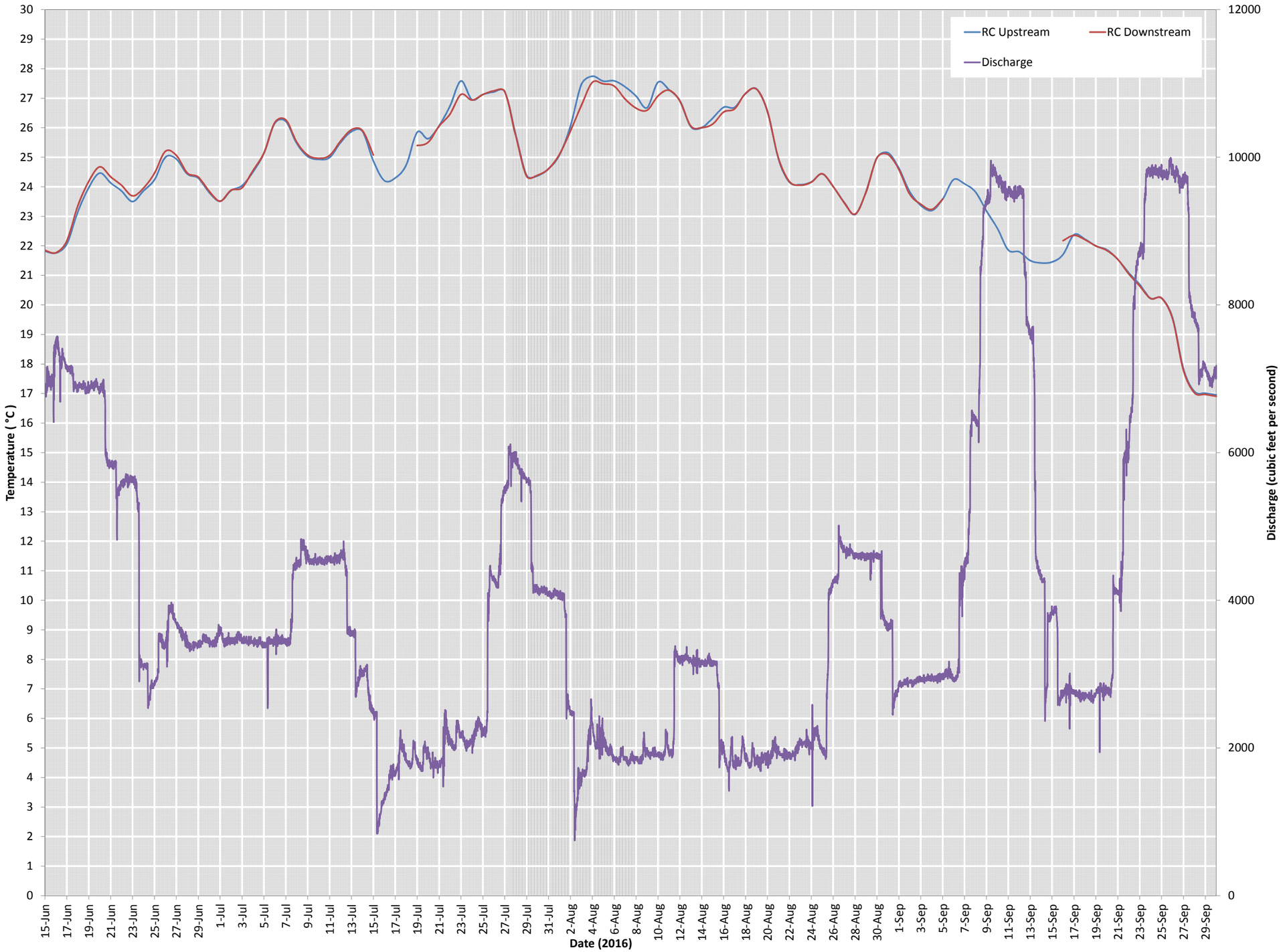

Figure 20. Daily pH Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

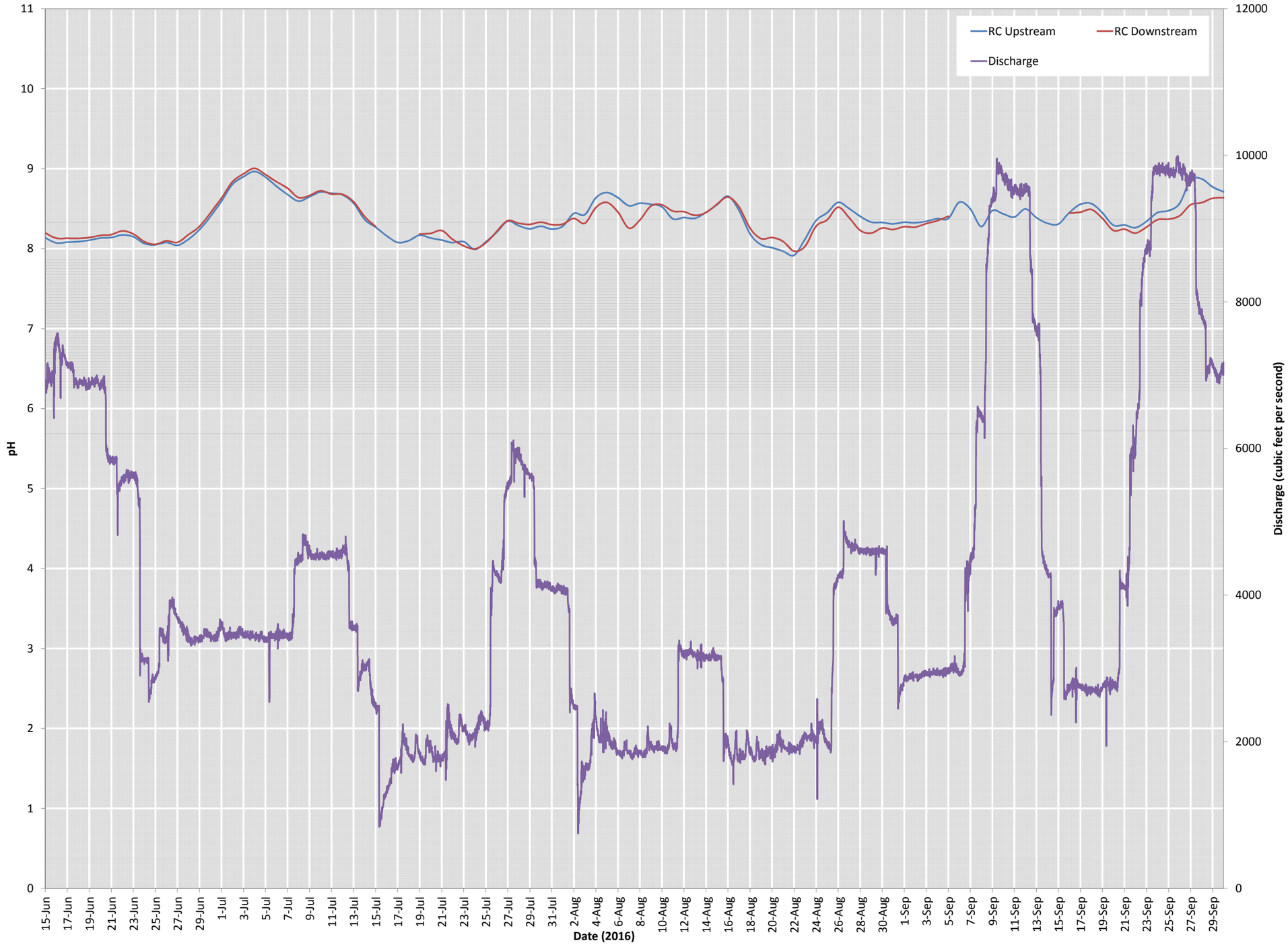

Figure 21. Daily Electrical Conductivity Readings, Upstream and Downstream of the Rapide Croche Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

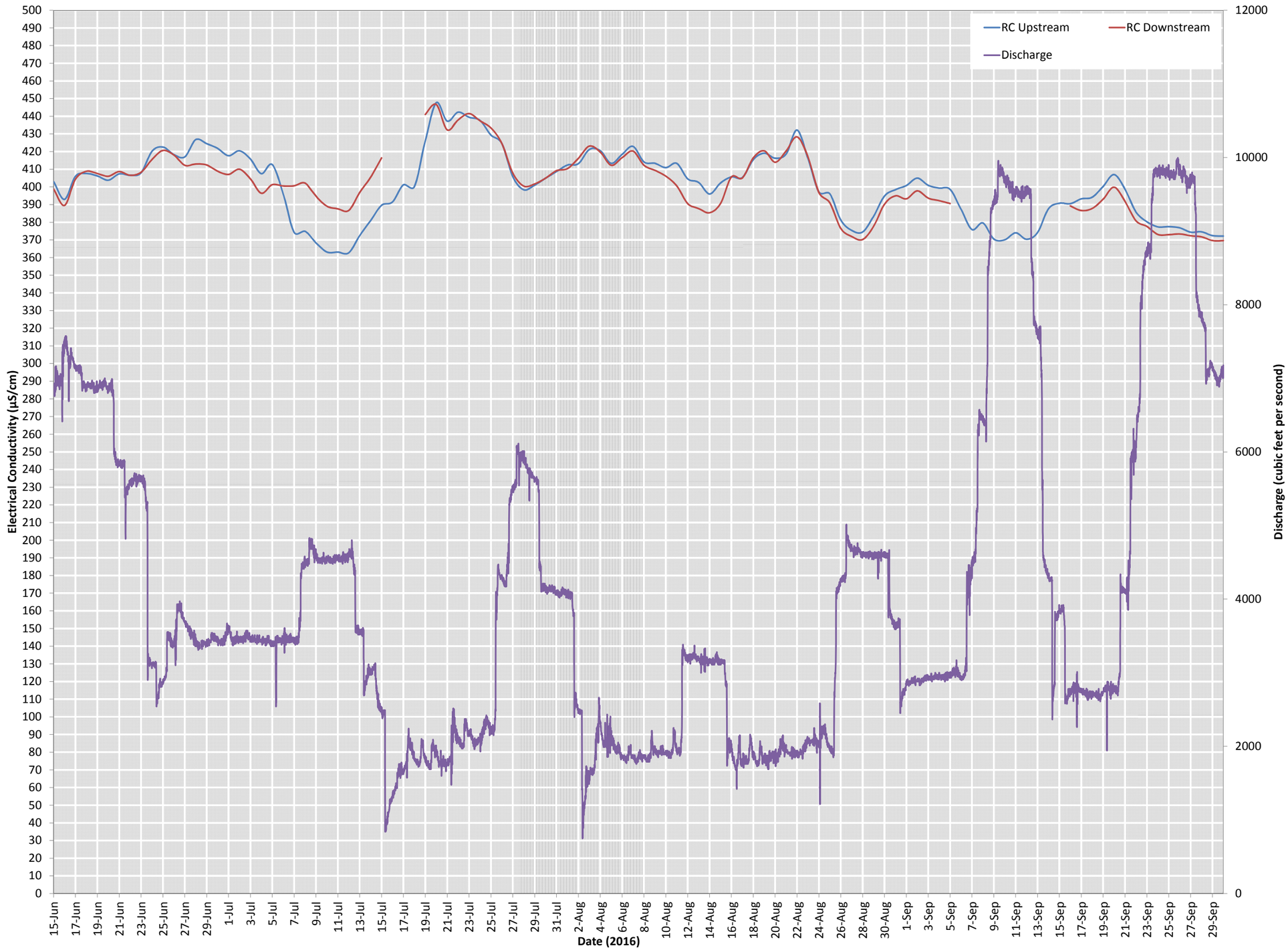

Table 1.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Sonde Locations

		GPS Coordinates	
		Latitude	Longitude
Badger	Upstream	44.2814	-88.2734
	Downstream	44.2768	-88.2652
	Bypass	44.2797	-88.2641
Rapide Croche	Upstream	44.3157	-88.1986
	Downstream	44.3148	-88.1958

Table 2.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
6/15/2016	8.24	7.94	0.30	21.85	21.86	-0.01	8.37	8.21	0.16
6/16/2016	8.01	7.59	0.42	21.87	21.88	-0.01	8.26	8.09	0.17
6/17/2016	7.97	7.68	0.29	22.01	22.02	0.00	8.24	8.10	0.14
6/18/2016	7.47	7.35	0.12	23.31	23.30	0.01	8.20	8.08	0.12
6/19/2016	7.57	7.36	0.20	23.67	23.87	-0.20	8.21	8.08	0.13
6/20/2016	7.33	7.15	0.19	23.91	24.55	-0.64	8.26	8.13	0.12
6/21/2016	7.04	6.96	0.08	23.23	24.12	-0.89	8.26	8.15	0.11
6/22/2016	7.06	6.96	0.10	22.95	23.88	-0.93	8.33	8.23	0.10
6/23/2016	7.11	7.00	0.11	22.47	23.40	-0.92	8.26	8.15	0.10
6/24/2016	6.90	6.89	0.01	22.52	23.40	-0.88	8.23	8.13	0.10
6/25/2016	6.93	6.84	0.09	23.19	24.14	-0.95	8.21	8.11	0.10
6/26/2016	6.97	6.93	0.04	23.81	24.81	-1.00	8.25	8.14	0.11
6/27/2016	7.21	6.76	0.45	24.39	24.87	-0.48	8.24	8.23	0.01
6/28/2016	7.54	6.88	0.67	24.14	24.17	-0.04	8.26	8.36	-0.10
6/29/2016	8.08	7.39	0.70	23.56	23.60	-0.04	8.43	8.54	-0.12
6/30/2016	8.33	7.62	0.71	23.75	23.86	-0.11	8.64	8.75	-0.11
7/1/2016	8.81	8.06	0.74	23.42	23.45	-0.03	8.85	8.95	-0.10
7/2/2016	9.49	8.62	0.87	23.29	23.26	0.03	8.93	9.04	-0.11
7/3/2016	9.64	8.75	0.90	24.09	24.07	0.03	9.07	9.18	-0.10
7/4/2016	8.86	8.02	0.85	24.39	24.38	0.01	9.06	9.16	-0.11
7/5/2016	7.92	7.15	0.77	25.10	25.08	0.02	8.99	9.11	-0.12
7/6/2016	7.03	6.89	0.14	26.03	25.99	0.04	8.90	8.94	-0.04
7/7/2016	6.57	6.68	-0.11	25.75	25.76	-0.01	8.80	8.78	0.02
7/8/2016	6.76	6.85	-0.09	25.15	25.16	-0.01	8.76	8.75	0.01
7/9/2016	7.00	7.12	-0.11	24.91	24.95	-0.04	8.83	8.83	0.00
7/10/2016	7.06	7.13	-0.07	24.63	24.66	-0.04	8.85	8.86	-0.01
7/11/2016	7.13	7.10	0.03	24.87	24.86	0.01	8.85	8.87	-0.01
7/12/2016	6.91	6.86	0.04	25.27	25.26	0.00	8.81	8.84	-0.03
7/13/2016	6.98	6.91	0.08	25.73	25.71	0.02	8.65	8.67	-0.01
7/14/2016	6.85	6.68	0.17	25.46	25.51	-0.05	8.46	8.48	-0.02
7/15/2016	6.78	6.51	0.28	23.87	24.49	-0.61	8.34	8.40	-0.07
7/16/2016	6.98	6.49	0.49	22.56	24.08	-1.52	8.31	8.38	-0.07
7/17/2016	7.10	6.46	0.64	21.73	23.71	-1.98	8.32	8.36	-0.04
7/18/2016	7.72	6.85	0.88	21.53	24.03	-2.50	8.35	8.40	-0.05
7/19/2016	7.58	6.68	0.90	22.49	24.75	-2.26	8.36	8.42	-0.06
7/20/2016	7.24	6.65	0.59	23.86	25.43	-1.57	8.45	8.53	-0.08
7/21/2016	6.54	6.07	0.46	24.62	25.86	-1.23	8.37	8.45	-0.08
7/22/2016	5.72	5.99	-0.27	24.54	26.05	-1.51	8.24	8.19	0.05
7/23/2016		6.20			26.82		8.27	8.11	0.16
7/24/2016		5.99			26.76		8.25	8.12	0.13
7/25/2016		6.52			26.68		8.28	8.18	0.10
7/26/2016		6.76			27.06		8.40	8.33	0.07
7/27/2016		6.93			26.88		8.46	8.43	0.03
7/28/2016		7.03			25.49		8.48	8.39	0.09
7/29/2016		7.14			24.32		8.47	8.43	0.04
7/30/2016		7.33			24.03		8.45	8.39	0.06
7/31/2016		7.43			24.44		8.45	8.38	0.06
8/1/2016	7.76	7.43	0.33	25.19	24.95	0.23	8.47	8.44	0.03
8/2/2016	7.72	7.43	0.29	25.95	25.85	0.10	8.54	8.51	0.03
8/3/2016	8.99	8.67	0.32	27.08	27.10	-0.03	8.78	8.74	0.04
8/4/2016	8.06	7.92	0.14	27.63	27.67	-0.04	8.79	8.78	0.01
8/5/2016	7.51	7.23	0.28	27.36	27.42	-0.06	8.72	8.70	0.02
8/6/2016	7.57	7.10	0.47	26.85	26.91	-0.06	8.63	8.59	0.04
8/7/2016	7.50	6.85	0.65	26.59	26.63	-0.04	8.59	8.55	0.04
8/8/2016	8.16	7.56	0.60	26.35	26.34	0.01	8.65	8.64	0.01
8/9/2016	8.13	7.84	0.30	26.33	26.35	-0.02	8.69	8.68	0.01
8/10/2016	7.92	7.57	0.35	26.83	26.82	0.01	8.72	8.70	0.01

Table 2.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
8/11/2016	6.96	6.71	0.25	26.92	26.97	-0.05	8.70	8.69	0.01
8/12/2016	6.28	6.14	0.14	26.56	26.62	-0.06	8.69	8.69	0.00
8/13/2016	6.81	6.57	0.24	25.71	25.76	-0.05	8.70	8.68	0.02
8/14/2016	7.59	7.25	0.35	25.67	25.69	-0.02	8.74	8.71	0.03
8/15/2016	7.83	7.58	0.26	26.06	26.13	-0.07	8.80	8.81	0.00
8/16/2016	7.89	7.61	0.28	26.34	26.38	-0.04	8.77	8.76	0.01
8/17/2016	6.31	6.05	0.26	26.66	26.68	-0.02	8.54	8.52	0.03
8/18/2016	6.06	5.78	0.28	27.13	27.13	0.00	8.54	8.48	0.06
8/19/2016	5.83	5.57	0.25	27.01	27.08	-0.07	8.52	8.44	0.08
8/20/2016	5.21	5.02	0.19	26.29	26.35	-0.05	8.32	8.21	0.11
8/21/2016	5.69	5.50	0.19	24.52	24.59	-0.07	8.25	8.05	0.20
8/22/2016	6.79	6.69	0.10	23.99	24.07	-0.08	8.51	8.18	0.33
8/23/2016	8.05	8.00	0.05	23.72	23.77	-0.05	8.60	8.51	0.09
8/24/2016	7.84	7.80	0.05	23.78	23.82	-0.04	8.61	8.61	0.01
8/25/2016	7.61	7.59	0.02	23.93	23.98	-0.05	8.69	8.63	0.06
8/26/2016	7.85	7.75	0.10	23.85	23.91	-0.06	8.58	8.74	-0.16
8/27/2016	7.15	7.06	0.09	23.06	23.13	-0.06	8.43	8.65	-0.22
8/28/2016	7.20	7.11	0.09	22.87	22.90	-0.03	8.38	8.53	-0.15
8/29/2016	7.44	7.28	0.16	23.74	23.77	-0.03	8.45	8.46	-0.01
8/30/2016	7.62	7.24	0.38	24.89	24.91	-0.02	8.39	8.48	-0.09
8/31/2016	7.53	7.07	0.46	25.00	25.04	-0.04	8.42	8.52	-0.11
9/1/2016	7.44	6.97	0.46	24.42	24.43	-0.01	8.41	8.52	-0.11
9/2/2016	7.61	7.17	0.44	23.43	23.43	0.00	8.47	8.57	-0.10
9/3/2016	7.93	7.48	0.45	23.08	23.10	-0.02	8.50	8.60	-0.10
9/4/2016	8.00	7.50	0.50	23.19	23.24	-0.06	8.63	8.63	0.00
9/5/2016	8.22	7.73	0.50	23.47	23.52	-0.05	8.79	8.73	0.06
9/6/2016	8.16	8.08	0.08	23.76	23.75	0.01	8.70	8.73	-0.04
9/7/2016	7.34	7.62	-0.28	23.88	23.88	-0.01	8.53	8.46	0.08
9/8/2016	7.37	7.55	-0.18	23.56	23.59	-0.03	8.43	8.36	0.07
9/9/2016	7.79	7.96	-0.17	23.06	23.10	-0.04	8.67	8.50	0.16
9/10/2016	7.71	7.88	-0.17	22.55	22.58	-0.03	9.04	8.40	0.64
9/11/2016	8.06	8.25	-0.18	21.78	21.82	-0.03	9.03	8.41	0.62
9/12/2016	8.34	8.53	-0.19	21.71	21.75	-0.03	8.67	8.45	0.22
9/13/2016	8.16	8.32	-0.16	21.48	21.52	-0.04	8.57	8.43	0.14
9/14/2016	7.89	8.19	-0.30	21.20	21.21	-0.01	8.51	8.34	0.17
9/15/2016	8.24	8.54	-0.30	21.30	21.31	-0.01	8.66	8.50	0.17
9/16/2016	8.27	8.37	-0.10	21.86	21.92	-0.06	8.81	8.66	0.15
9/17/2016	8.13	8.01	0.12	22.04	22.06	-0.02	8.94	8.76	0.19
9/18/2016	8.48	8.31	0.17	21.82	21.82	-0.01	8.69	8.66	0.03
9/19/2016	8.34	8.23	0.11	21.75	21.81	-0.06	8.54	8.53	0.00
9/20/2016	8.10	8.00	0.10	21.47	21.49	-0.02	8.45	8.46	-0.01
9/21/2016	7.85	7.79	0.06	21.31	21.34	-0.04	8.41	8.43	-0.03
9/22/2016	8.02	7.73	0.29	20.95	20.96	-0.01	8.42	8.42	0.00
9/23/2016	8.44	8.03	0.41	20.67	20.70	-0.03	8.48	8.49	0.00
9/24/2016	8.70	8.43	0.28	20.14	20.18	-0.03	8.56	8.56	0.00
9/25/2016	8.77	8.58	0.19	20.18	20.21	-0.03	8.52	8.58	-0.06
9/26/2016	8.77	8.54	0.23	19.54	19.58	-0.04	8.69	8.62	0.07
9/27/2016	9.06	8.81	0.25	17.80	17.85	-0.05	9.14	8.70	0.45
9/28/2016	9.26	9.00	0.26	16.97	17.01	-0.05	8.78	8.74	0.04
9/29/2016	9.57	9.36	0.21	16.95	16.98	-0.03	8.75	8.82	-0.07
9/30/2016	9.34	9.14	0.20	16.84	16.88	-0.04	8.72	8.79	-0.07
Minimum	5.21	5.02	-0.30	16.84	16.88	-2.50	8.20	8.05	-0.22
Average	7.64	7.35	0.24	23.64	24.02	-0.22	8.56	8.52	0.04
Maximum	9.64	9.36	0.90	27.63	27.67	0.23	9.14	9.18	0.64
Standard Deviation	0.85	0.81	0.28	2.28	2.27	0.51	0.23	0.25	0.13
Number of Data Points	99	108	99	99	108	99	108	108	108

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
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			
7/3/2016			
7/4/2016			
7/5/2016			
7/6/2016	26.52	8.76	7.66
7/7/2016	25.79	8.63	7.27
7/8/2016	25.20	8.58	7.50
7/9/2016	24.95	8.62	7.66
7/10/2016	24.64	8.63	7.61
7/11/2016	24.91	8.62	7.57
7/12/2016	25.41	8.57	7.31
7/13/2016	25.88	8.46	7.38
7/14/2016	25.48	8.31	7.33
7/15/2016	24.36	8.30	7.50
7/16/2016	24.09	8.41	7.62
7/17/2016	23.76	8.41	7.63
7/18/2016	24.22	8.44	7.79
7/19/2016	24.82	8.45	7.66
7/20/2016	25.52	8.53	7.52
7/21/2016	25.91	8.46	7.03
7/22/2016	26.23	8.27	7.05
7/23/2016	26.87	8.23	6.87
7/24/2016	26.75	8.21	6.77
7/25/2016	26.71	8.27	7.04
7/26/2016	27.17	8.36	7.10

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
7/27/2016	26.99	8.48	7.05
7/28/2016	25.53	8.45	7.20
7/29/2016	24.32	8.47	7.39
7/30/2016	24.13	8.46	7.53
7/31/2016	24.44	8.43	7.51
8/1/2016	24.96	8.43	7.69
8/2/2016	26.07	8.50	8.00
8/3/2016	27.13	8.70	8.07
8/4/2016	27.69	8.77	7.70
8/5/2016	27.43	8.73	7.53
8/6/2016	26.97	8.64	7.50
8/7/2016	26.69	8.63	7.55
8/8/2016	26.34	8.68	7.70
8/9/2016	26.44	8.71	7.55
8/10/2016	26.93	8.72	7.26
8/11/2016	26.93	8.63	6.83
8/12/2016	26.58	8.55	6.35
8/13/2016	25.82	8.54	6.12
8/14/2016	25.75	8.56	5.69
8/15/2016	26.09	8.70	6.06
8/16/2016	26.42	8.76	7.68
8/17/2016	26.67	8.59	7.19
8/18/2016	27.24	8.52	7.14
8/19/2016	26.99	8.47	6.85
8/20/2016	26.19	8.33	6.80
8/21/2016	24.47	8.22	7.25
8/22/2016	24.03	8.29	7.71
8/23/2016	23.85	8.52	8.14
8/24/2016	23.89	8.61	7.94
8/25/2016	24.02	8.66	7.98
8/26/2016	23.83	8.71	7.98
8/27/2016	23.13	8.60	7.69
8/28/2016	23.01	8.48	7.89
8/29/2016	23.88	8.48	7.98
8/30/2016	24.99	8.49	7.81
8/31/2016	25.08	8.54	7.94
9/1/2016	24.47	8.54	8.15
9/2/2016	23.43	8.55	8.03
9/3/2016	23.13	8.60	8.18
9/4/2016	23.18	8.64	8.17
9/5/2016	23.50	8.72	8.16
9/6/2016	23.82	8.73	8.01

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
9/7/2016	23.90	8.54	7.99
9/8/2016	23.62	8.42	8.20
9/9/2016	23.05	8.56	8.57
9/10/2016	22.52	8.52	8.60
9/11/2016	21.79	8.55	8.91
9/12/2016	21.74	8.62	8.93
9/13/2016	21.41	8.55	8.70
9/14/2016	21.23	8.50	8.59
9/15/2016	21.27	8.60	8.67
9/16/2016	21.81	8.69	8.48
9/17/2016	22.10	8.70	8.50
9/18/2016	21.89	8.68	8.66
9/19/2016	21.75	8.56	8.50
9/20/2016	21.53	8.48	8.56
9/21/2016	21.30	8.42	8.35
9/22/2016	20.94	8.43	8.69
9/23/2016	20.48	8.50	9.17
9/24/2016	19.78	8.58	9.50
9/25/2016	19.77	8.59	9.47
9/26/2016			
9/27/2016			
9/28/2016			
9/29/2016			
9/30/2016			

Minimum	19.77	8.21	5.69
Average	24.51	8.53	7.74
Maximum	27.69	8.77	9.50
Standard Deviation	2.01	0.13	0.72
Number of Data Points	82	82	82

Table 4.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Upstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/27/2016	9/28/2016	9.14	8.78	-0.36
9/11/2016	9/12/2016	9.03	8.67	-0.36
9/17/2016	9/18/2016	8.94	8.69	-0.25
8/16/2016	8/17/2016	8.77	8.54	-0.23
8/19/2016	8/20/2016	8.52	8.32	-0.20
7/13/2016	7/14/2016	8.65	8.46	-0.19
9/6/2016	9/7/2016	8.70	8.53	-0.16
7/12/2016	7/13/2016	8.81	8.65	-0.16
9/18/2016	9/19/2016	8.69	8.54	-0.15
8/26/2016	8/27/2016	8.58	8.43	-0.15
7/21/2016	7/22/2016	8.37	8.24	-0.13
7/14/2016	7/15/2016	8.46	8.34	-0.13
6/15/2016	6/16/2016	8.37	8.26	-0.11
8/25/2016	8/26/2016	8.69	8.58	-0.11
9/7/2016	9/8/2016	8.53	8.43	-0.10
9/5/2016	9/6/2016	8.79	8.70	-0.10
9/12/2016	9/13/2016	8.67	8.57	-0.10
7/6/2016	7/7/2016	8.90	8.80	-0.10
7/5/2016	7/6/2016	8.99	8.90	-0.09
8/5/2016	8/6/2016	8.72	8.63	-0.09
9/19/2016	9/20/2016	8.54	8.45	-0.08
7/20/2016	7/21/2016	8.45	8.37	-0.07
8/4/2016	8/5/2016	8.79	8.72	-0.07
6/22/2016	6/23/2016	8.33	8.26	-0.07
8/20/2016	8/21/2016	8.32	8.25	-0.07
7/4/2016	7/5/2016	9.06	8.99	-0.07
9/13/2016	9/14/2016	8.57	8.51	-0.07
8/29/2016	8/30/2016	8.45	8.39	-0.06
8/27/2016	8/28/2016	8.43	8.38	-0.05
9/20/2016	9/21/2016	8.45	8.41	-0.04
7/7/2016	7/8/2016	8.80	8.76	-0.04
6/17/2016	6/18/2016	8.24	8.20	-0.04
7/11/2016	7/12/2016	8.85	8.81	-0.04
8/6/2016	8/7/2016	8.63	8.59	-0.04
9/24/2016	9/25/2016	8.56	8.52	-0.04
9/28/2016	9/29/2016	8.78	8.75	-0.04
8/15/2016	8/16/2016	8.80	8.77	-0.03
6/24/2016	6/25/2016	8.23	8.21	-0.02
9/29/2016	9/30/2016	8.75	8.72	-0.02
6/23/2016	6/24/2016	8.26	8.23	-0.02
8/10/2016	8/11/2016	8.72	8.70	-0.02
7/15/2016	7/16/2016	8.34	8.31	-0.02
8/18/2016	8/19/2016	8.54	8.52	-0.02
7/29/2016	7/30/2016	8.47	8.45	-0.02
7/23/2016	7/24/2016	8.27	8.25	-0.02
9/10/2016	9/11/2016	9.04	9.03	-0.02

Table 4.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Upstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
6/16/2016	6/17/2016	8.26	8.24	-0.02
7/3/2016	7/4/2016	9.07	9.06	-0.01
6/26/2016	6/27/2016	8.25	8.24	-0.01
7/28/2016	7/29/2016	8.48	8.47	-0.01
7/30/2016	7/31/2016	8.45	8.45	-0.01
8/17/2016	8/18/2016	8.54	8.54	0.00
8/11/2016	8/12/2016	8.70	8.69	0.00
8/31/2016	9/1/2016	8.42	8.41	0.00
7/10/2016	7/11/2016	8.85	8.85	0.00
6/20/2016	6/21/2016	8.26	8.26	0.00
8/12/2016	8/13/2016	8.69	8.70	0.00
6/18/2016	6/19/2016	8.20	8.21	0.01
7/16/2016	7/17/2016	8.31	8.32	0.01
8/3/2016	8/4/2016	8.78	8.79	0.01
8/23/2016	8/24/2016	8.60	8.61	0.01
7/18/2016	7/19/2016	8.35	8.36	0.01
9/21/2016	9/22/2016	8.41	8.42	0.01
7/27/2016	7/28/2016	8.46	8.48	0.02
7/31/2016	8/1/2016	8.45	8.47	0.02
6/27/2016	6/28/2016	8.24	8.26	0.02
7/9/2016	7/10/2016	8.83	8.85	0.02
7/17/2016	7/18/2016	8.32	8.35	0.02
8/30/2016	8/31/2016	8.39	8.42	0.03
7/22/2016	7/23/2016	8.24	8.27	0.03
9/2/2016	9/3/2016	8.47	8.50	0.03
8/9/2016	8/10/2016	8.69	8.72	0.03
7/24/2016	7/25/2016	8.25	8.28	0.04
8/8/2016	8/9/2016	8.65	8.69	0.04
6/25/2016	6/26/2016	8.21	8.25	0.04
8/13/2016	8/14/2016	8.70	8.74	0.05
6/19/2016	6/20/2016	8.21	8.26	0.05
9/1/2016	9/2/2016	8.41	8.47	0.05
8/7/2016	8/8/2016	8.59	8.65	0.06
8/14/2016	8/15/2016	8.74	8.80	0.06
9/22/2016	9/23/2016	8.42	8.48	0.06
7/8/2016	7/9/2016	8.76	8.83	0.07
8/28/2016	8/29/2016	8.38	8.45	0.07
7/26/2016	7/27/2016	8.40	8.46	0.07
9/23/2016	9/24/2016	8.48	8.56	0.07
6/21/2016	6/22/2016	8.26	8.33	0.07
8/1/2016	8/2/2016	8.47	8.54	0.08
8/24/2016	8/25/2016	8.61	8.69	0.08
7/1/2016	7/2/2016	8.85	8.93	0.09
7/19/2016	7/20/2016	8.36	8.45	0.09
8/22/2016	8/23/2016	8.51	8.60	0.09
7/25/2016	7/26/2016	8.28	8.40	0.11

Table 4.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Upstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/3/2016	9/4/2016	8.50	8.63	0.13
9/16/2016	9/17/2016	8.81	8.94	0.13
7/2/2016	7/3/2016	8.93	9.07	0.14
9/15/2016	9/16/2016	8.66	8.81	0.15
9/14/2016	9/15/2016	8.51	8.66	0.16
6/28/2016	6/29/2016	8.26	8.43	0.16
9/4/2016	9/5/2016	8.63	8.79	0.17
9/25/2016	9/26/2016	8.52	8.69	0.18
6/30/2016	7/1/2016	8.64	8.85	0.21
6/29/2016	6/30/2016	8.43	8.64	0.21
9/8/2016	9/9/2016	8.43	8.67	0.23
8/2/2016	8/3/2016	8.54	8.78	0.24
8/21/2016	8/22/2016	8.25	8.51	0.26
9/9/2016	9/10/2016	8.67	9.04	0.38
9/26/2016	9/27/2016	8.69	9.14	0.45

Table 5.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Downstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/6/2016	9/7/2016	8.73	8.46	-0.28
7/21/2016	7/22/2016	8.45	8.19	-0.26
8/16/2016	8/17/2016	8.76	8.52	-0.24
8/19/2016	8/20/2016	8.44	8.21	-0.23
7/13/2016	7/14/2016	8.67	8.48	-0.19
7/12/2016	7/13/2016	8.84	8.67	-0.17
7/5/2016	7/6/2016	9.11	8.94	-0.17
7/6/2016	7/7/2016	8.94	8.78	-0.16
8/20/2016	8/21/2016	8.21	8.05	-0.16
9/18/2016	9/19/2016	8.66	8.53	-0.13
6/15/2016	6/16/2016	8.21	8.09	-0.12
8/27/2016	8/28/2016	8.65	8.53	-0.12
8/5/2016	8/6/2016	8.70	8.59	-0.11
9/7/2016	9/8/2016	8.46	8.36	-0.10
9/9/2016	9/10/2016	8.50	8.40	-0.10
9/17/2016	9/18/2016	8.76	8.66	-0.10
8/26/2016	8/27/2016	8.74	8.65	-0.09
9/13/2016	9/14/2016	8.43	8.34	-0.09
8/4/2016	8/5/2016	8.78	8.70	-0.08
6/22/2016	6/23/2016	8.23	8.15	-0.08
7/20/2016	7/21/2016	8.53	8.45	-0.08
7/22/2016	7/23/2016	8.19	8.11	-0.07
7/14/2016	7/15/2016	8.48	8.40	-0.07
8/28/2016	8/29/2016	8.53	8.46	-0.07
9/19/2016	9/20/2016	8.53	8.46	-0.07
7/4/2016	7/5/2016	9.16	9.11	-0.06
8/15/2016	8/16/2016	8.81	8.76	-0.04
7/29/2016	7/30/2016	8.43	8.39	-0.04
8/17/2016	8/18/2016	8.52	8.48	-0.04
8/18/2016	8/19/2016	8.48	8.44	-0.04
7/27/2016	7/28/2016	8.43	8.39	-0.04
7/7/2016	7/8/2016	8.78	8.75	-0.03
8/6/2016	8/7/2016	8.59	8.55	-0.03
9/20/2016	9/21/2016	8.46	8.43	-0.03
7/11/2016	7/12/2016	8.87	8.84	-0.03
9/29/2016	9/30/2016	8.82	8.79	-0.03
6/24/2016	6/25/2016	8.13	8.11	-0.02
6/23/2016	6/24/2016	8.15	8.13	-0.02
9/12/2016	9/13/2016	8.45	8.43	-0.02
7/15/2016	7/16/2016	8.40	8.38	-0.02
6/17/2016	6/18/2016	8.10	8.08	-0.02
7/16/2016	7/17/2016	8.38	8.36	-0.02
8/10/2016	8/11/2016	8.70	8.69	-0.02
8/12/2016	8/13/2016	8.69	8.68	-0.01
7/3/2016	7/4/2016	9.18	9.16	-0.01
9/21/2016	9/22/2016	8.43	8.42	-0.01

Table 5.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Downstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
7/30/2016	7/31/2016	8.39	8.38	-0.01
8/31/2016	9/1/2016	8.52	8.52	0.00
9/5/2016	9/6/2016	8.73	8.73	0.00
7/10/2016	7/11/2016	8.86	8.87	0.00
8/11/2016	8/12/2016	8.69	8.69	0.00
6/18/2016	6/19/2016	8.08	8.08	0.00
7/23/2016	7/24/2016	8.11	8.12	0.01
6/16/2016	6/17/2016	8.09	8.10	0.01
9/10/2016	9/11/2016	8.40	8.41	0.01
8/29/2016	8/30/2016	8.46	8.48	0.02
6/20/2016	6/21/2016	8.13	8.15	0.02
9/24/2016	9/25/2016	8.56	8.58	0.02
7/18/2016	7/19/2016	8.40	8.42	0.02
8/24/2016	8/25/2016	8.61	8.63	0.02
8/9/2016	8/10/2016	8.68	8.70	0.03
9/2/2016	9/3/2016	8.57	8.60	0.03
9/3/2016	9/4/2016	8.60	8.63	0.03
7/17/2016	7/18/2016	8.36	8.40	0.03
8/13/2016	8/14/2016	8.68	8.71	0.03
7/28/2016	7/29/2016	8.39	8.43	0.04
7/9/2016	7/10/2016	8.83	8.86	0.04
6/25/2016	6/26/2016	8.11	8.14	0.04
8/3/2016	8/4/2016	8.74	8.78	0.04
8/8/2016	8/9/2016	8.64	8.68	0.04
9/25/2016	9/26/2016	8.58	8.62	0.04
9/27/2016	9/28/2016	8.70	8.74	0.04
9/11/2016	9/12/2016	8.41	8.45	0.04
9/1/2016	9/2/2016	8.52	8.57	0.04
8/30/2016	8/31/2016	8.48	8.52	0.05
6/19/2016	6/20/2016	8.08	8.13	0.05
7/31/2016	8/1/2016	8.38	8.44	0.05
7/24/2016	7/25/2016	8.12	8.18	0.06
9/22/2016	9/23/2016	8.42	8.49	0.06
9/23/2016	9/24/2016	8.49	8.56	0.07
8/1/2016	8/2/2016	8.44	8.51	0.07
9/26/2016	9/27/2016	8.62	8.70	0.07
7/8/2016	7/9/2016	8.75	8.83	0.08
9/28/2016	9/29/2016	8.74	8.82	0.08
8/7/2016	8/8/2016	8.55	8.64	0.08
6/21/2016	6/22/2016	8.15	8.23	0.08
6/26/2016	6/27/2016	8.14	8.23	0.08
7/1/2016	7/2/2016	8.95	9.04	0.09
8/23/2016	8/24/2016	8.51	8.61	0.09
9/16/2016	9/17/2016	8.66	8.76	0.09
8/14/2016	8/15/2016	8.71	8.81	0.09
7/26/2016	7/27/2016	8.33	8.43	0.11

Table 5.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Downstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/4/2016	9/5/2016	8.63	8.73	0.11
8/25/2016	8/26/2016	8.63	8.74	0.11
7/19/2016	7/20/2016	8.42	8.53	0.11
8/21/2016	8/22/2016	8.05	8.18	0.13
7/2/2016	7/3/2016	9.04	9.18	0.14
6/27/2016	6/28/2016	8.23	8.36	0.14
9/8/2016	9/9/2016	8.36	8.50	0.14
7/25/2016	7/26/2016	8.18	8.33	0.14
9/14/2016	9/15/2016	8.34	8.50	0.16
9/15/2016	9/16/2016	8.50	8.66	0.16
6/28/2016	6/29/2016	8.36	8.54	0.18
6/30/2016	7/1/2016	8.75	8.95	0.20
6/29/2016	6/30/2016	8.54	8.75	0.21
8/2/2016	8/3/2016	8.51	8.74	0.23
8/22/2016	8/23/2016	8.18	8.51	0.33

Table 4.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
6/15/2016	7.91	7.76	0.15	21.83	21.85	-0.02	8.13	8.20	-0.06
6/16/2016	7.52	7.35	0.17	21.76	21.77	-0.01	8.07	8.13	-0.06
6/17/2016	7.99	7.79	0.21	22.07	22.17	-0.10	8.08	8.13	-0.05
6/18/2016	7.81	7.65	0.17	23.15	23.36	-0.21	8.09	8.13	-0.04
6/19/2016	7.67	7.50	0.17	23.97	24.18	-0.21	8.10	8.14	-0.03
6/20/2016	7.59	7.41	0.19	24.47	24.68	-0.21	8.13	8.16	-0.03
6/21/2016	7.35	7.24	0.11	24.13	24.34	-0.21	8.14	8.17	-0.04
6/22/2016	7.32	7.20	0.11	23.85	24.05	-0.20	8.17	8.22	-0.05
6/23/2016	7.23	7.07	0.16	23.50	23.69	-0.19	8.15	8.18	-0.03
6/24/2016	7.44	7.23	0.21	23.86	23.96	-0.10	8.06	8.09	-0.02
6/25/2016	7.30	7.05	0.25	24.24	24.46	-0.22	8.05	8.05	-0.01
6/26/2016	7.26	6.98	0.27	25.00	25.20	-0.20	8.08	8.10	-0.02
6/27/2016	7.40	7.09	0.31	24.94	25.06	-0.13	8.04	8.08	-0.04
6/28/2016	8.12	7.63	0.49	24.43	24.47	-0.03	8.12	8.17	-0.06
6/29/2016	8.65	8.00	0.64	24.29	24.33	-0.04	8.24	8.28	-0.04
6/30/2016	8.87	8.25	0.63	23.81	23.85	-0.04	8.40	8.45	-0.05
7/1/2016	8.71	8.10	0.61	23.51	23.52	-0.01	8.59	8.63	-0.04
7/2/2016	10.35	9.44	0.91	23.87	23.89	-0.01	8.80	8.83	-0.03
7/3/2016	10.50	9.56	0.93	24.04	23.96	0.08	8.90	8.93	-0.04
7/4/2016	9.82	9.11	0.72	24.50	24.55	-0.05	8.96	9.00	-0.04
7/5/2016	8.77	8.00	0.77	25.14	25.14	-0.01	8.89	8.93	-0.03
7/6/2016	7.54	7.29	0.25	26.16	26.18	-0.02	8.78	8.85	-0.07
7/7/2016	6.33	6.68	-0.34	26.22	26.27	-0.05	8.68	8.76	-0.08
7/8/2016	6.29	6.65	-0.36	25.47	25.52	-0.05	8.59	8.64	-0.05
7/9/2016	6.62	6.98	-0.35	25.03	25.08	-0.05	8.65	8.66	-0.02
7/10/2016	6.80	7.16	-0.36	24.93	24.97	-0.04	8.71	8.72	-0.02
7/11/2016	6.63	7.01	-0.38	24.99	25.06	-0.07	8.69	8.68	0.01
7/12/2016	6.56	6.87	-0.30	25.50	25.55	-0.05	8.67	8.68	-0.01
7/13/2016	6.67	6.90	-0.23	25.87	25.93	-0.06	8.57	8.59	-0.02
7/14/2016	6.75	6.88	-0.13	25.88	25.90	-0.03	8.36	8.40	-0.04
7/15/2016	6.37	6.12	0.26	24.87	25.07	-0.20	8.27	8.28	-0.01
7/16/2016	6.31			24.21			8.16		
7/17/2016	6.39			24.30			8.08		
7/18/2016	6.65			24.74			8.10		
7/19/2016	7.81	7.69	0.12	25.85	25.40	0.45	8.17	8.18	-0.01
7/20/2016	7.52	7.32	0.20	25.63	25.50	0.13	8.13	8.19	-0.06
7/21/2016	6.68	6.73	-0.04	26.07	26.05	0.02	8.11	8.23	-0.12
7/22/2016	6.65	6.36	0.29	26.73	26.46	0.27	8.07	8.11	-0.04
7/23/2016	7.71	6.92	0.79	27.58	27.13	0.46	8.09	8.03	0.05
7/24/2016	6.75	6.52	0.24	26.95	26.94	0.02	7.99	8.00	-0.01
7/25/2016	7.41	7.20	0.22	27.12	27.12	0.00	8.08	8.07	0.01
7/26/2016	7.74	7.61	0.13	27.21	27.25	-0.03	8.20	8.21	-0.01
7/27/2016	7.46	7.45	0.00	27.23	27.22	0.00	8.34	8.35	-0.01
7/28/2016	7.49	7.43	0.05	25.78	25.73	0.05	8.29	8.32	-0.03
7/29/2016	7.47	7.51	-0.04	24.38	24.36	0.03	8.25	8.30	-0.06
7/30/2016	7.94	7.70	0.23	24.37	24.39	-0.02	8.28	8.33	-0.05
7/31/2016	7.68	8.16	-0.49	24.61	24.61	0.00	8.24	8.30	-0.06
8/1/2016	7.81	7.89	-0.08	25.08	25.10	-0.02	8.28	8.31	-0.03
8/2/2016	8.69	8.17	0.52	26.05	25.89	0.16	8.44	8.38	0.06
8/3/2016	9.22	8.11	1.11	27.47	26.76	0.71	8.42	8.32	0.11
8/4/2016	9.16	8.17	0.99	27.74	27.53	0.21	8.64	8.51	0.12
8/5/2016	8.35	7.57	0.78	27.58	27.49	0.09	8.70	8.58	0.12
8/6/2016	8.82	7.69	1.13	27.59	27.41	0.18	8.64	8.46	0.18
8/7/2016	9.06	7.27	1.79	27.38	26.97	0.41	8.54	8.26	0.28
8/8/2016	9.31	7.71	1.60	26.81	26.57	0.24	8.57	8.36	0.21
8/9/2016	9.05	8.38	0.67	26.68	26.59	0.09	8.55	8.53	0.02
8/10/2016	9.80	8.47	1.33	27.54	27.08	0.46	8.52	8.55	-0.02
8/11/2016	7.83	7.62	0.21	27.29	27.27	0.02	8.37	8.47	-0.10
8/12/2016	6.57	6.53	0.04	26.91	26.90	0.01	8.39	8.46	-0.07
8/13/2016	6.81	6.66	0.15	26.03	26.06	-0.02	8.38	8.41	-0.04
8/14/2016	7.86	7.41	0.45	26.01	26.00	0.00	8.45	8.45	0.00
8/15/2016	8.50	7.79	0.71	26.33	26.13	0.20	8.55	8.55	-0.01
8/16/2016	8.79	8.04	0.75	26.69	26.53	0.16	8.66	8.64	0.01
8/17/2016	7.63	7.41	0.22	26.69	26.64	0.05	8.48	8.52	-0.04
8/18/2016	6.53	6.41	0.12	27.15	27.16	-0.01	8.18	8.25	-0.07
8/19/2016	5.61	5.39	0.22	27.31	27.30	0.01	8.05	8.12	-0.08

Table 4.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
8/20/2016	5.55	5.29	0.26	26.55	26.55	0.00	8.01	8.14	-0.13
8/21/2016	6.07	5.83	0.24	24.94	24.98	-0.04	7.97	8.09	-0.12
8/22/2016	6.39	6.35	0.04	24.16	24.06	0.10	7.92	7.97	-0.05
8/23/2016	7.45	7.10	0.35	24.07	24.06	0.02	8.12	8.03	0.09
8/24/2016	8.32	7.93	0.39	24.17	24.15	0.01	8.35	8.28	0.07
8/25/2016	8.59	8.25	0.34	24.44	24.44	-0.01	8.45	8.36	0.09
8/26/2016	8.49	8.20	0.29	24.01	24.01	0.00	8.58	8.52	0.06
8/27/2016	7.71	7.40	0.31	23.48	23.47	0.02	8.50	8.39	0.11
8/28/2016	7.61	7.30	0.31	23.06	23.07	-0.01	8.40	8.23	0.18
8/29/2016	7.79	7.56	0.23	23.82	23.82	0.00	8.33	8.19	0.14
8/30/2016	7.45	7.32	0.13	24.98	24.98	0.00	8.33	8.26	0.07
8/31/2016	7.45	7.20	0.25	25.15	25.10	0.06	8.31	8.24	0.07
9/1/2016	7.56	7.38	0.18	24.63	24.58	0.05	8.33	8.27	0.06
9/2/2016	7.57	7.36	0.21	23.83	23.75	0.08	8.32	8.27	0.05
9/3/2016	7.65	7.58	0.07	23.37	23.41	-0.04	8.34	8.31	0.03
9/4/2016	7.61	7.57	0.03	23.19	23.23	-0.04	8.37	8.35	0.03
9/5/2016	7.37	7.61	-0.24	23.58	23.58	0.00	8.38	8.40	-0.03
9/6/2016	8.26			24.24			8.58		
9/7/2016	7.76			24.10			8.50		
9/8/2016	7.85			23.83			8.28		
9/9/2016	8.09			23.18			8.47		
9/10/2016	8.12			22.59			8.43		
9/11/2016	8.58			21.86			8.39		
9/12/2016	8.80			21.80			8.50		
9/13/2016	8.53			21.50			8.39		
9/14/2016	8.27			21.42			8.32		
9/15/2016	8.48			21.46			8.31		
9/16/2016	8.53	8.28	0.25	21.71	22.18	-0.47	8.45	8.44	0.01
9/17/2016	8.27	8.08	0.19	22.38	22.36	0.02	8.55	8.46	0.10
9/18/2016	8.67	8.49	0.18	22.23	22.21	0.02	8.56	8.49	0.07
9/19/2016	8.75	8.52	0.24	22.00	21.99	0.00	8.45	8.38	0.07
9/20/2016	8.40	8.11	0.29	21.87	21.84	0.02	8.29	8.23	0.06
9/21/2016	8.26	7.97	0.30	21.54	21.54	0.00	8.29	8.24	0.05
9/22/2016	8.20	7.81	0.39	21.09	21.05	0.04	8.26	8.19	0.07
9/23/2016	8.56	8.10	0.46	20.70	20.64	0.05	8.34	8.27	0.07
9/24/2016	8.91	8.50	0.41	20.22	20.22	0.01	8.45	8.36	0.09
9/25/2016	8.87	8.50	0.37	20.23	20.23	0.01	8.47	8.37	0.11
9/26/2016	8.73	8.40	0.32	19.58	19.53	0.04	8.56	8.41	0.15
9/27/2016	9.04	8.57	0.47	17.83	17.78	0.05	8.86	8.55	0.31
9/28/2016	9.38	8.88	0.50	17.07	17.03	0.04	8.87	8.57	0.30
9/29/2016	9.67	9.23	0.44	17.01	16.97	0.04	8.77	8.63	0.14
9/30/2016	9.29	8.84	0.45	16.95	16.91	0.05	8.71	8.64	0.07
Minimum	5.55	5.29	-0.49	16.95	16.91	-0.47	7.92	7.97	-0.13
Average	7.87	7.57	0.31	24.24	24.39	0.02	8.38	8.36	0.02
Maximum	10.50	9.56	1.79	27.74	27.53	0.71	8.96	9.00	0.31
Standard Deviation	0.99	0.79	0.40	2.36	2.39	0.16	0.24	0.23	0.09
Number of Data Points	108	95	95	108	95	95	108	95	95

Table 6.

Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin

Rapide Croche Upstream Day to Day Differences for pH Data

Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
8/17/2016	8/18/2016	8.48	8.18	-0.29
9/7/2016	9/8/2016	8.50	8.28	-0.22
7/13/2016	7/14/2016	8.57	8.36	-0.20
8/16/2016	8/17/2016	8.66	8.48	-0.18
9/19/2016	9/20/2016	8.45	8.29	-0.16
8/10/2016	8/11/2016	8.52	8.37	-0.15
8/18/2016	8/19/2016	8.18	8.05	-0.14
7/5/2016	7/6/2016	8.89	8.78	-0.12
9/18/2016	9/19/2016	8.56	8.45	-0.11
9/12/2016	9/13/2016	8.50	8.39	-0.11
7/15/2016	7/16/2016	8.27	8.16	-0.11
7/12/2016	7/13/2016	8.67	8.57	-0.10
7/6/2016	7/7/2016	8.78	8.68	-0.10
8/6/2016	8/7/2016	8.64	8.54	-0.10
9/28/2016	9/29/2016	8.87	8.77	-0.10
7/14/2016	7/15/2016	8.36	8.27	-0.10
8/27/2016	8/28/2016	8.50	8.40	-0.10
7/23/2016	7/24/2016	8.09	7.99	-0.10
6/23/2016	6/24/2016	8.15	8.06	-0.08
7/7/2016	7/8/2016	8.68	8.59	-0.08
7/16/2016	7/17/2016	8.16	8.08	-0.08
9/6/2016	9/7/2016	8.58	8.50	-0.08
8/26/2016	8/27/2016	8.58	8.50	-0.08
8/28/2016	8/29/2016	8.40	8.33	-0.07
9/13/2016	9/14/2016	8.39	8.32	-0.07
7/4/2016	7/5/2016	8.96	8.89	-0.07
8/5/2016	8/6/2016	8.70	8.64	-0.06
6/15/2016	6/16/2016	8.13	8.07	-0.06
9/29/2016	9/30/2016	8.77	8.71	-0.06
7/27/2016	7/28/2016	8.34	8.29	-0.06
8/21/2016	8/22/2016	7.97	7.92	-0.05
8/20/2016	8/21/2016	8.01	7.97	-0.04
9/9/2016	9/10/2016	8.47	8.43	-0.04
7/28/2016	7/29/2016	8.29	8.25	-0.04
9/10/2016	9/11/2016	8.43	8.39	-0.04
7/19/2016	7/20/2016	8.17	8.13	-0.04
8/19/2016	8/20/2016	8.05	8.01	-0.04
6/26/2016	6/27/2016	8.08	8.04	-0.04
7/30/2016	7/31/2016	8.28	8.24	-0.04
9/21/2016	9/22/2016	8.29	8.26	-0.03
7/21/2016	7/22/2016	8.11	8.07	-0.03
8/9/2016	8/10/2016	8.55	8.52	-0.03
7/20/2016	7/21/2016	8.13	8.11	-0.02
6/22/2016	6/23/2016	8.17	8.15	-0.02
7/11/2016	7/12/2016	8.69	8.67	-0.02
8/30/2016	8/31/2016	8.33	8.31	-0.02

Table 6.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Upstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
7/10/2016	7/11/2016	8.71	8.69	-0.02
6/24/2016	6/25/2016	8.06	8.05	-0.02
8/2/2016	8/3/2016	8.44	8.42	-0.01
8/8/2016	8/9/2016	8.57	8.55	-0.01
9/14/2016	9/15/2016	8.32	8.31	-0.01
8/12/2016	8/13/2016	8.39	8.38	-0.01
9/1/2016	9/2/2016	8.33	8.32	-0.01
8/29/2016	8/30/2016	8.33	8.33	0.00
9/4/2016	9/5/2016	8.37	8.38	0.00
9/20/2016	9/21/2016	8.29	8.29	0.00
6/20/2016	6/21/2016	8.13	8.14	0.01
6/17/2016	6/18/2016	8.08	8.09	0.01
9/17/2016	9/18/2016	8.55	8.56	0.01
6/16/2016	6/17/2016	8.07	8.08	0.01
7/22/2016	7/23/2016	8.07	8.09	0.01
9/27/2016	9/28/2016	8.86	8.87	0.02
8/11/2016	8/12/2016	8.37	8.39	0.02
6/18/2016	6/19/2016	8.09	8.10	0.02
9/2/2016	9/3/2016	8.32	8.34	0.02
8/31/2016	9/1/2016	8.31	8.33	0.02
7/17/2016	7/18/2016	8.08	8.10	0.02
9/24/2016	9/25/2016	8.45	8.47	0.02
6/19/2016	6/20/2016	8.10	8.13	0.03
6/25/2016	6/26/2016	8.05	8.08	0.03
8/7/2016	8/8/2016	8.54	8.57	0.03
6/21/2016	6/22/2016	8.14	8.17	0.03
9/3/2016	9/4/2016	8.34	8.37	0.03
7/29/2016	7/30/2016	8.25	8.28	0.03
7/31/2016	8/1/2016	8.24	8.28	0.04
7/8/2016	7/9/2016	8.59	8.65	0.06
7/9/2016	7/10/2016	8.65	8.71	0.06
8/4/2016	8/5/2016	8.64	8.70	0.06
7/3/2016	7/4/2016	8.90	8.96	0.06
7/18/2016	7/19/2016	8.10	8.17	0.07
8/13/2016	8/14/2016	8.38	8.45	0.07
6/27/2016	6/28/2016	8.04	8.12	0.08
9/22/2016	9/23/2016	8.26	8.34	0.08
9/25/2016	9/26/2016	8.47	8.56	0.09
7/24/2016	7/25/2016	7.99	8.08	0.09
8/14/2016	8/15/2016	8.45	8.55	0.10
7/2/2016	7/3/2016	8.80	8.90	0.10
8/24/2016	8/25/2016	8.35	8.45	0.10
9/11/2016	9/12/2016	8.39	8.50	0.10
9/16/2016	9/17/2016	8.45	8.55	0.10
8/15/2016	8/16/2016	8.55	8.66	0.11
9/23/2016	9/24/2016	8.34	8.45	0.11

Table 6.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Upstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
6/28/2016	6/29/2016	8.12	8.24	0.12
7/25/2016	7/26/2016	8.08	8.20	0.12
8/25/2016	8/26/2016	8.45	8.58	0.13
7/26/2016	7/27/2016	8.20	8.34	0.14
9/15/2016	9/16/2016	8.31	8.45	0.14
8/1/2016	8/2/2016	8.28	8.44	0.16
6/29/2016	6/30/2016	8.24	8.40	0.17
6/30/2016	7/1/2016	8.40	8.59	0.19
9/8/2016	9/9/2016	8.28	8.47	0.20
8/22/2016	8/23/2016	7.92	8.12	0.20
9/5/2016	9/6/2016	8.38	8.58	0.20
7/1/2016	7/2/2016	8.59	8.80	0.21
8/3/2016	8/4/2016	8.42	8.64	0.21
8/23/2016	8/24/2016	8.12	8.35	0.23
9/26/2016	9/27/2016	8.56	8.86	0.29

Table 6.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Downstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
8/17/2016	8/18/2016	8.52	8.25	-0.27
8/6/2016	8/7/2016	8.46	8.26	-0.20
7/13/2016	7/14/2016	8.59	8.40	-0.19
8/27/2016	8/28/2016	8.39	8.23	-0.16
9/19/2016	9/20/2016	8.38	8.23	-0.15
8/26/2016	8/27/2016	8.52	8.39	-0.13
8/18/2016	8/19/2016	8.25	8.12	-0.13
7/14/2016	7/15/2016	8.40	8.28	-0.12
8/16/2016	8/17/2016	8.64	8.52	-0.12
8/21/2016	8/22/2016	8.09	7.97	-0.12
8/5/2016	8/6/2016	8.58	8.46	-0.12
7/7/2016	7/8/2016	8.76	8.64	-0.12
7/21/2016	7/22/2016	8.23	8.11	-0.11
9/18/2016	9/19/2016	8.49	8.38	-0.11
7/6/2016	7/7/2016	8.85	8.76	-0.10
6/23/2016	6/24/2016	8.18	8.09	-0.10
7/12/2016	7/13/2016	8.68	8.59	-0.09
7/22/2016	7/23/2016	8.11	8.03	-0.08
8/10/2016	8/11/2016	8.55	8.47	-0.08
7/4/2016	7/5/2016	9.00	8.93	-0.08
7/5/2016	7/6/2016	8.93	8.85	-0.07
6/15/2016	6/16/2016	8.20	8.13	-0.07
8/2/2016	8/3/2016	8.38	8.32	-0.06
9/21/2016	9/22/2016	8.24	8.19	-0.05
8/20/2016	8/21/2016	8.14	8.09	-0.05
8/12/2016	8/13/2016	8.46	8.41	-0.05
7/10/2016	7/11/2016	8.72	8.68	-0.04
6/22/2016	6/23/2016	8.22	8.18	-0.04
7/23/2016	7/24/2016	8.03	8.00	-0.04
8/28/2016	8/29/2016	8.23	8.19	-0.03
6/24/2016	6/25/2016	8.09	8.05	-0.03
7/27/2016	7/28/2016	8.35	8.32	-0.03
7/30/2016	7/31/2016	8.33	8.30	-0.03
6/26/2016	6/27/2016	8.10	8.08	-0.02
8/30/2016	8/31/2016	8.26	8.24	-0.02
7/28/2016	7/29/2016	8.32	8.30	-0.01
8/11/2016	8/12/2016	8.47	8.46	-0.01
9/1/2016	9/2/2016	8.27	8.27	-0.01
7/11/2016	7/12/2016	8.68	8.68	0.00
6/17/2016	6/18/2016	8.13	8.13	0.00
6/16/2016	6/17/2016	8.13	8.13	0.00
9/24/2016	9/25/2016	8.36	8.37	0.01
7/31/2016	8/1/2016	8.30	8.31	0.01
7/19/2016	7/20/2016	8.18	8.19	0.01
9/29/2016	9/30/2016	8.63	8.64	0.01
6/20/2016	6/21/2016	8.16	8.17	0.01
6/18/2016	6/19/2016	8.13	8.14	0.01
8/19/2016	8/20/2016	8.12	8.14	0.01
9/16/2016	9/17/2016	8.44	8.46	0.01
8/9/2016	8/10/2016	8.53	8.55	0.01
9/20/2016	9/21/2016	8.23	8.24	0.02
6/19/2016	6/20/2016	8.14	8.16	0.03

Table 6.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Downstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/27/2016	9/28/2016	8.55	8.57	0.03
7/8/2016	7/9/2016	8.64	8.66	0.03
7/29/2016	7/30/2016	8.30	8.33	0.03
9/17/2016	9/18/2016	8.46	8.49	0.03
8/31/2016	9/1/2016	8.24	8.27	0.03
9/3/2016	9/4/2016	8.31	8.35	0.04
7/20/2016	7/21/2016	8.19	8.23	0.04
8/13/2016	8/14/2016	8.41	8.45	0.04
9/25/2016	9/26/2016	8.37	8.41	0.04
6/25/2016	6/26/2016	8.05	8.10	0.04
9/2/2016	9/3/2016	8.27	8.31	0.04
6/21/2016	6/22/2016	8.17	8.22	0.05
9/28/2016	9/29/2016	8.57	8.63	0.06
9/4/2016	9/5/2016	8.35	8.40	0.06
7/9/2016	7/10/2016	8.66	8.72	0.06
8/22/2016	8/23/2016	7.97	8.03	0.06
8/4/2016	8/5/2016	8.51	8.58	0.06
8/29/2016	8/30/2016	8.19	8.26	0.06
7/3/2016	7/4/2016	8.93	9.00	0.07
8/1/2016	8/2/2016	8.31	8.38	0.07
7/24/2016	7/25/2016	8.00	8.07	0.07
9/22/2016	9/23/2016	8.19	8.27	0.07
8/24/2016	8/25/2016	8.28	8.36	0.08
8/15/2016	8/16/2016	8.55	8.64	0.09
9/23/2016	9/24/2016	8.27	8.36	0.09
6/27/2016	6/28/2016	8.08	8.17	0.10
7/2/2016	7/3/2016	8.83	8.93	0.10
8/7/2016	8/8/2016	8.26	8.36	0.10
6/28/2016	6/29/2016	8.17	8.28	0.10
8/14/2016	8/15/2016	8.45	8.55	0.10
7/26/2016	7/27/2016	8.21	8.35	0.13
9/26/2016	9/27/2016	8.41	8.55	0.14
7/25/2016	7/26/2016	8.07	8.21	0.14
8/25/2016	8/26/2016	8.36	8.52	0.16
6/29/2016	6/30/2016	8.28	8.45	0.17
8/8/2016	8/9/2016	8.36	8.53	0.17
6/30/2016	7/1/2016	8.45	8.63	0.18
8/3/2016	8/4/2016	8.32	8.51	0.20
7/1/2016	7/2/2016	8.63	8.83	0.20
8/23/2016	8/24/2016	8.03	8.28	0.25
7/15/2016	7/16/2016	8.28		
7/16/2016	7/17/2016			
7/17/2016	7/18/2016			
7/18/2016	7/19/2016		8.18	
9/5/2016	9/6/2016	8.40		
9/6/2016	9/7/2016			
9/7/2016	9/8/2016			
9/8/2016	9/9/2016			
9/9/2016	9/10/2016			
9/10/2016	9/11/2016			
9/11/2016	9/12/2016			
9/12/2016	9/13/2016			

Table 6.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Downstream Day to Day Differences for pH Data
Difference = Day 2 - Day 1 Value

Date Range (shading = service date)		pH		
Day 1	Day 2	Day 1	Day 2	Difference
9/13/2016	9/14/2016			
9/14/2016	9/15/2016			
9/15/2016	9/16/2016		8.44	

Table 9.
Badger-Rapide Croche, FERC No. 2677 on the Fox River in Kaukauna, Wisconsin
Summary of Data Gaps and Clipped Data

Time Period	Badger Upstream						Badger Downstream						Badger Bypass						RC Upstream						RC Downstream					
	DO		pH		EC		DO		pH		EC		DO		pH		EC		DO		pH		EC		DO		pH		EC	
	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification
6/15/2016													Fox River flow above 6,000 cfs; sonde not placed into service between 6/15/16 and 7/6/16 14:00																	
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																														
7/3/2016																														
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																									Data Gap between 7/15/16 14:00 and 7/19/16 10:00 due to cracked battery casing.					
7/17/2016																														
7/18/2016																														
7/19/2016																														
7/20/2016																														
7/21/2016																														
7/22/2016	7/22/16 10:00 to 8/1/16 08:00	8/1/16 Calibration Records: DO difficult to calibrate, replaced sonde on 8/3/16			7/22/16 10:00 to 8/1/16 08:00	Large recorded change in conductivity before and after calibration																								
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	Sonde removed 8/1/16 due to cracked battery casing and replaced on 8/3/16.																													
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																														

Table 9.
Badger-Rapide Croche, FERC No. 2677 on the Fox River in Kaukauna, Wisconsin
Summary of Data Gaps and Clipped Data

Time Period	Badger Upstream						Badger Downstream						Badger Bypass						RC Upstream						RC Downstream					
	DO		pH		EC		DO		pH		EC		DO		pH		EC		DO		pH		EC		DO		pH		EC	
	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification	Clipped Data	Justification
8/11/2016																														
8/12/2016																														
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																														
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																									Data gap between 9/6/16 15:00 and 9/16/16 15:00 due to data collection programming input error.					
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													Fox River flow approaching 10,000 cfs; Removed sonde from service on 9/26/16 11:00																	
9/28/2016																														
9/29/2016																														
9/30/2016																														

Table 10
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Upstream Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)			LDO (mg/L)			pH					
								pH 7			pH 10		
		Calibration			Calibration			Calibration			Calibration		
		Before	Standard	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
15226H400365	6/9/2016	1396.4	1412	1.1%	7.90	8.74	9.6%	7.11	7.00	1.6%	10.09	10.00	0.9%
15226H400365	6/13/2016	1407	1412	0.4%	9.15	9.22	0.8%	6.88	7.00	1.7%	9.94	10.00	0.6%
15226H400365	6/17/2016	1410	1412	0.1%	8.65	8.62	0.3%	6.99	7.00	0.1%	10.00	10.00	0.0%
15226H400365	6/27/2016	1412	1412	0.0%	7.55	7.89	4.3%	7.00	7.00	0.0%	9.89	10.00	1.1%
15226H400365	7/6/2016	1420	1412	0.6%	8.27	8.05	2.7%	7.01	7.00	0.1%	9.89	10.00	1.1%
15226H400365	7/15/2016	1412	1412	0.0%	8.70	8.65	0.6%	6.98	7.00	0.3%	9.87	10.00	1.3%
15226H400365	7/22/2016	1419	1412	0.5%	7.30	8.12	10.1%	6.98	7.00	0.3%	10.01	10.00	0.1%
15226H400365 - DO was difficult to calibrate; returned to service until replacement arrives	8/1/2016	1410	1412	0.1%	7.86	7.88	0.3%	6.99	7.00	0.1%	9.99	10.00	0.1%
14265H400094 - Replacement Sonde	8/3/2016	1428	1412	1.1%	7.05	8.42	16.3%	6.89	7.00	1.6%	9.97	10.00	0.3%
14265H400094	8/8/2016	1423	1412	0.8%	8.22	8.23	0.1%	6.96	7.00	0.6%	9.92	10.00	0.8%
14265H400094	8/15/2016	1407	1412	0.4%	8.36	8.30	0.7%	7.04	7.00	0.6%	10.02	10.00	0.2%
14265H400094	8/22/2016	1414	1412	0.1%	9.28	9.04	2.7%	6.94	7.00	0.9%	9.93	10.00	0.7%
15226H400365 - The cable of Sonde 14265H400094 broke and the sonde sunk to the bottom of the river channel	8/29/2016	1419	1412	0.5%	7.15	7.52	4.9%	7.06	7.00	0.9%	10.08	10.00	0.8%
15226H400365	9/6/2016	1408	1412	0.3%	8.58	8.01	7.1%	6.89	7.00	1.6%	9.85	10.00	1.5%
15226H400365	9/16/2016	1418	1412	0.4%	8.23	8.22	0.1%	6.98	7.00	0.3%	9.94	10.00	0.6%
15226H400365	9/26/2016	1414	1412	0.1%	9.35	9.24	1.2%	6.93	7.00	1.0%	9.90	10.00	1.0%

Table 11
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Downstream Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)			LDO (mg/L)			pH					
								pH 7			pH 10		
		Calibration			Calibration			Calibration			Calibration		
		Before	Standard	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
14262H400091	6/9/2016	1365.4	1412	3.3%	8.47	8.48	0.1%	6.97	7.00	0.4%	9.89	10.00	1.1%
14262H400091	6/13/2016	1386	1412	1.8%	9.55	9.22	3.6%	6.81	7.00	2.7%	9.77	10.00	0.0
14262H400091	6/17/2016	1410	1412	0.1%	7.12	8.00	11.0%	7.03	7.00	0.4%	9.98	10.00	0.2%
14262H400093 (Calibration in lab when sonde returned from Hach repair)	6/24/2016	1408.5	1412	0.2%	8.57	8.61	0.5%	7.01	7.00	0.1%	9.97	10.00	0.0
14262H400091 - calibration error message; replaced sonde with 14262H400093	6/27/2016	1405	1412	0.5%	8.57	8.07	6.2%	6.87	7.00	1.9%	9.90	10.00	0.0
14262H400093	7/6/2016	1415	1412	0.2%	7.45	7.98	6.6%	7.19	7.00	2.7%	10.11	10.00	1.1%
14262H400093	7/15/2016	1411	1412	0.1%	8.73	8.77	0.5%	6.90	7.00	1.4%	9.80	10.00	2.0%
14262H400093	7/22/2016	1409	1412	0.2%	7.76	7.87	1.4%	7.08	7.00	1.1%	10.22	10.00	2.2%
14262H400093	8/1/2016	1413	1412	0.1%	8.03	7.96	0.9%	7.01	7.00	0.1%	9.99	10.00	0.1%
14262H400093	8/8/2016	1413	1412	0.1%	8.62	8.41	2.5%	6.85	7.00	2.1%	9.87	10.00	1.3%
14262H400093	8/15/2016	1408	1412	0.3%	8.06	8.23	2.1%	6.97	7.00	0.4%	9.98	10.00	0.2%
14262H400093	8/22/2016	1410	1412	0.1%	9.02	8.87	1.7%	6.85	7.00	2.1%	9.78	10.00	2.2%
14262H400093	8/29/2016	1409	1412	0.2%	8.23	8.48	2.9%	7.17	7.00	2.4%	10.15	10.00	1.5%
14262H400093	9/6/2016	1408	1412	0.3%	7.8	7.98	2.3%	7.09	7.00	1.3%	10.00	10.00	0.0%
14262H400093	9/16/2016	1414	1412	0.1%	8.35	7.96	4.9%	6.92	7.00	1.1%	9.96	10.00	0.4%
14262H400093	9/26/2016	1406	1412	0.4%	9.51	9.30	2.3%	6.90	7.00	1.4%	9.80	10.00	2.0%

Table 12
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Bypass Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)			LDO (mg/L)			pH					
								pH 7			pH 10		
		Calibration			Calibration			Calibration			Calibration		
		Before	Standard	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
15268H400386	7/6/2016	1369.5	1412	3.0%	8.31	8.27	0.5%	6.95	7.00	0.7%	10.02	10	0.2%
15268H400386	7/15/2016	1422	1412	0.7%	9.03	8.77	3.0%	6.75	7.00	3.6%	9.76	10	2.4%
15268H400386	7/22/2016	1434	1412	1.6%	7.73	7.70	0.4%	7.03	7.00	0.4%	10.19	10.00	1.9%
15268H400386	8/1/2016	1398	1412	1.0%	7.20	7.81	7.8%	7.09	7.00	1.3%	9.99	10	0.1%
15268H400386	8/8/2016	1410	1412	0.1%	8.28	8.20	1.0%	6.90	7.00	1.4%	9.87	10.00	1.3%
15268H400386	8/15/2016	1407	1412	0.4%	7.95	8.22	3.3%	6.94	7.00	0.9%	9.99	10	0.1%
15268H400386	8/22/2016	1416	1412	0.3%	8.85	8.77	0.9%	6.84	7.00	2.3%	9.97	10	0.3%
15268H400386	8/29/2016	1405	1412	0.5%	8.14	8.24	1.2%	7.05	7.00	0.7%	9.98	10	0.2%
15268H400386	9/6/2016	1417	1412	0.4%	7.71	7.74	0.4%	7.06	7.00	0.9%	10.04	10	0.4%
15268H400386	9/16/2016	1418	1412	0.4%	8.23	8.22	0.1%	6.98	7.00	0.3%	9.94	10	0.6%
15268H400386	9/26/2016	Pulled Sonde due to strong river current											

Table 13
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Upstream Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)			LDO (mg/L)			pH					
								pH 7 Calibration			pH 10 Calibration		
		Calibration			Calibration			Calibration			Calibration		
		Before	Standard	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
14265H400094	6/9/2016	1417	1412	0.4%	8.40	8.6	2.3%	7.04	7.00	0.6%	10.00	10.00	0.0%
14265H400094	6/13/2016	1412	1412	0.0%	9.37	9.17	2.2%	6.88	7.00	1.7%	9.94	10.00	0.6%
14265H400094	6/17/2016	1414	1412	0.1%	8.37	8.49	1.4%	7.00	7.00	0.0%	9.99	10.00	0.1%
14265H400094	6/27/2016	1391	1412	1.5%	7.15	7.87	9.1%	6.99	7.00	0.1%	9.95	10.00	0.5%
14265H400094	7/6/2016	1411	1412	0.1%	9.31	8.16	14.1%	7.02	7.00	0.3%	9.91	10.00	0.9%
14265H400094 - there was difficulty calibrating; removed sonde from operation for servicing. Calibrated on 5th attempt.	7/15/2016	1435	1412	1.6%	10.15	9.69	4.7%	6.93	7.00	1.0%	9.95	10.00	0.5%
14262H400091 - replacement sonde	7/19/2016	1397	1412	1.1%	8.59	8.39	2.4%	7.00	7.00	0.0%	9.98	10.00	0.2%
14262H400091	7/22/2016	1416	1412	0.3%	6.34	7.12	11.0%	6.85	7.00	2.1%	9.96	10.00	0.4%
14262H400091	8/1/2016	1411	1412	0.1%	7.71	7.43	3.8%	6.96	7.00	0.6%	9.96	10.00	0.4%
14262H400091	8/8/2016	1346	1412	4.7%	8.35	7.88	6.0%	6.99	7.00	0.1%	9.96	10.00	0.4%
14262H400091	8/15/2016	1413	1412	0.1%	7.62	7.67	0.7%	7.00	7.00	0.0%	9.99	10.00	0.1%
14262H400091	8/22/2016	1426	1412	1.0%	8.82	8.46	4.3%	6.99	7.00	0.1%	9.93	10.00	0.7%
14262H400091	8/29/2016	1407	1412	0.4%	7.66	7.85	2.4%	7.02	7.00	0.3%	10.06	10.00	0.6%
14262H400091	9/6/2016	1431	1412	1.3%	7.52	7.62	1.3%	6.98	7.00	0.3%	9.95	10.00	0.5%
14262H400091	9/16/2016	1398	1412	1.0%	8.39	8.13	3.2%	7.03	7.00	0.4%	10.02	10.00	0.2%
14262H400091	9/26/2016	1428	1412	1.1%	9.53	9.27	2.8%	6.95	7.00	0.7%	9.85	10.00	1.5%

Table 14
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Rapide Croche Tailrace Station - Sonde Calibration Data

Sonde Serial Number (Bold = Changed Sondes)	Date	Conductivity (µS/cm)			LDO (mg/L)			pH					
								pH 7			pH 10		
		Calibration			Calibration			Calibration			Calibration		
		Before	Standard	% Difference	Before	After	% Difference	Initial	Reference	% Difference	Initial	Reference	% Difference
14267H400097	6/9/2016	1405.4	1412	0.5%	8.60	8.65	0.6%	7.04	7.00	0.6%	9.96	10.00	0.4%
14267H400097	6/13/2016	1400	1412	0.8%	9.20	9.00	2.2%	6.73	7.00	3.9%	9.78	10.00	2.2%
14267H400097	6/17/2016	1413	1412	0.1%	8.43	8.40	0.4%	6.96	7.00	0.6%	9.98	10.00	0.2%
14267H400097	6/27/2016	1432	1412	1.4%	7.58	7.66	1.0%	7.00	7.00	0.0%	9.98	10.00	0.2%
14267H400097	7/6/2016	1414	1412	0.1%	7.55	7.49	0.8%	6.99	7.00	0.1%	9.93	10.00	0.7%
14267H400097 - Battery housing cracked; removed sonde from operation until battery housing replaced	7/15/2016												
14267H400097 - Battery housing replaced	7/19/2016	1392	1412	1.4%	6.71	7.98	15.9%	7.06	7.00	0.9%	10.07	10.00	0.7%
14267H400097	7/22/2016	1387	1412	1.8%	6.58	7.13	7.7%	7.08	7.00	1.1%	10.03	10.00	0.3%
14267H400097	8/1/2016	1429	1412	1.2%	7.83	7.59	3.2%	7.05	7.00	0.7%	10.00	10.00	0.0%
14267H400097	8/8/2016	1411	1412	0.1%	7.96	7.90	0.8%	7.01	7.00	0.1%	9.99	10.00	0.1%
14267H400097	8/15/2016	1404	1412	0.6%	7.55	7.65	1.3%	7.00	7.00	0.0%	9.99	10.00	0.1%
14267H400097	8/22/2016	1427	1412	1.1%	8.76	8.41	4.2%	7.04	7.00	0.6%	9.99	10.00	0.1%
14267H400097	8/29/2016	1400	1412	0.8%	7.39	7.84	5.7%	7.04	7.00	0.6%	10.09	10.00	0.9%
14267H400097	9/6/2016	1423	1412	0.8%	7.49	7.61	1.6%	7.02	7.00	0.3%	9.99	10.00	0.1%
14267H400097	9/16/2016	1418	1412	0.4%	8.63	8.32	3.7%	7.02	7.00	0.3%	9.91	10.00	0.9%
14267H400097	9/26/2016	1413	1412	0.1%	9.56	9.29	2.9%	6.85	7.00	2.1%	9.86	10.00	1.4%

Appendix B

Unabridged Data

Figure 2 Raw Data Badger Hourly Dissolved Oxygen

Figure 3 Raw Data Badger Hourly Temperature

Figure 4 Raw Data Badger Hourly pH

Figure 5 Raw Data Badger Hourly Electrical Conductivity

Figure 6 Raw Data Badger Daily Dissolved Oxygen

Figure 7 Raw Data Badger Daily Temperature

Figure 8 Raw Data Badger Daily pH

Figure 9 Raw Data Badger Daily Electrical Conductivity

Table 2 Raw Data Badger Upstream and Downstream Daily Averages

Table 3 Raw Data Badger Bypass Daily Averages

Figure 2. Hourly Dissolved Oxygen Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

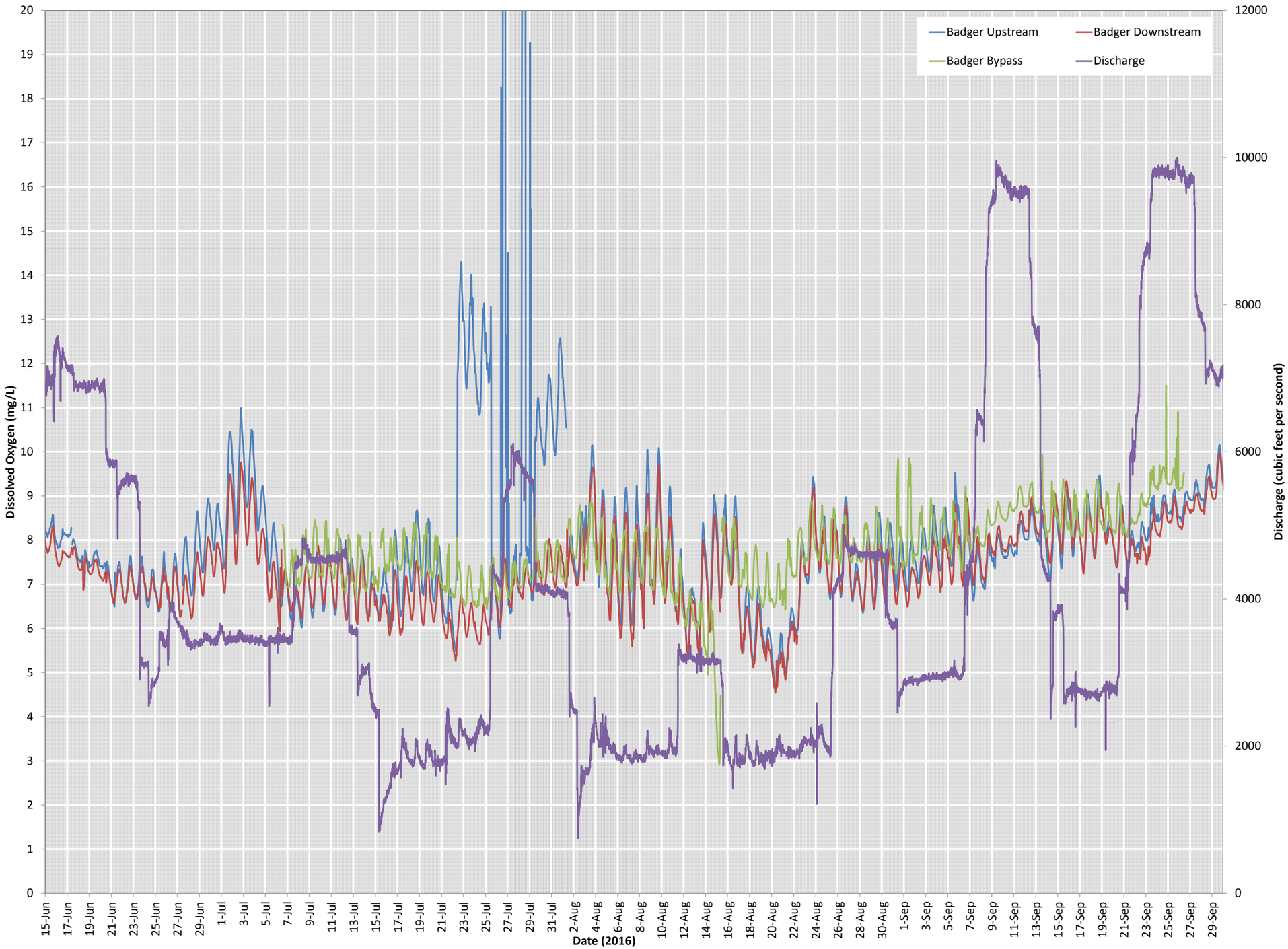

Figure 3. Hourly Temperature Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

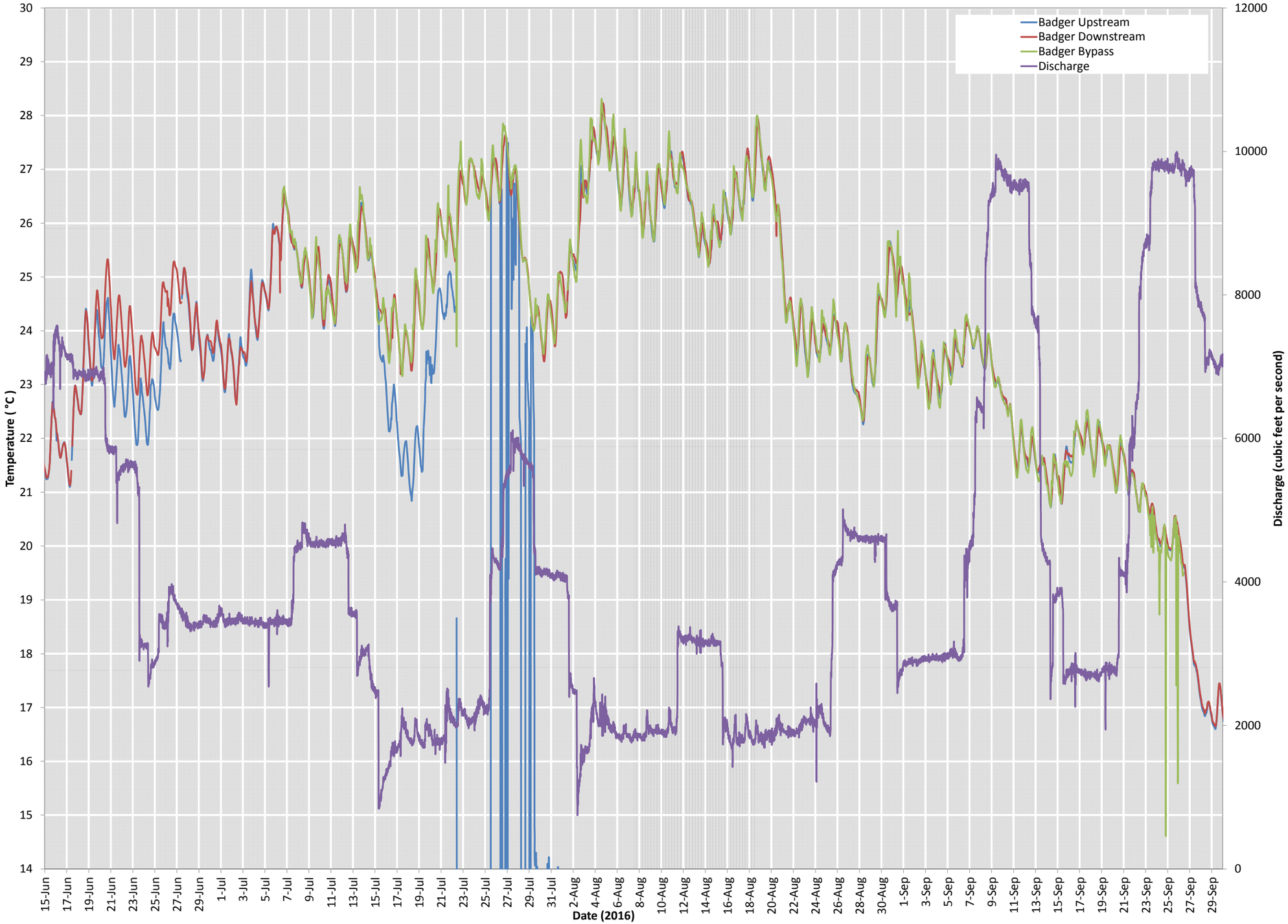

Figure 4. Hourly pH Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

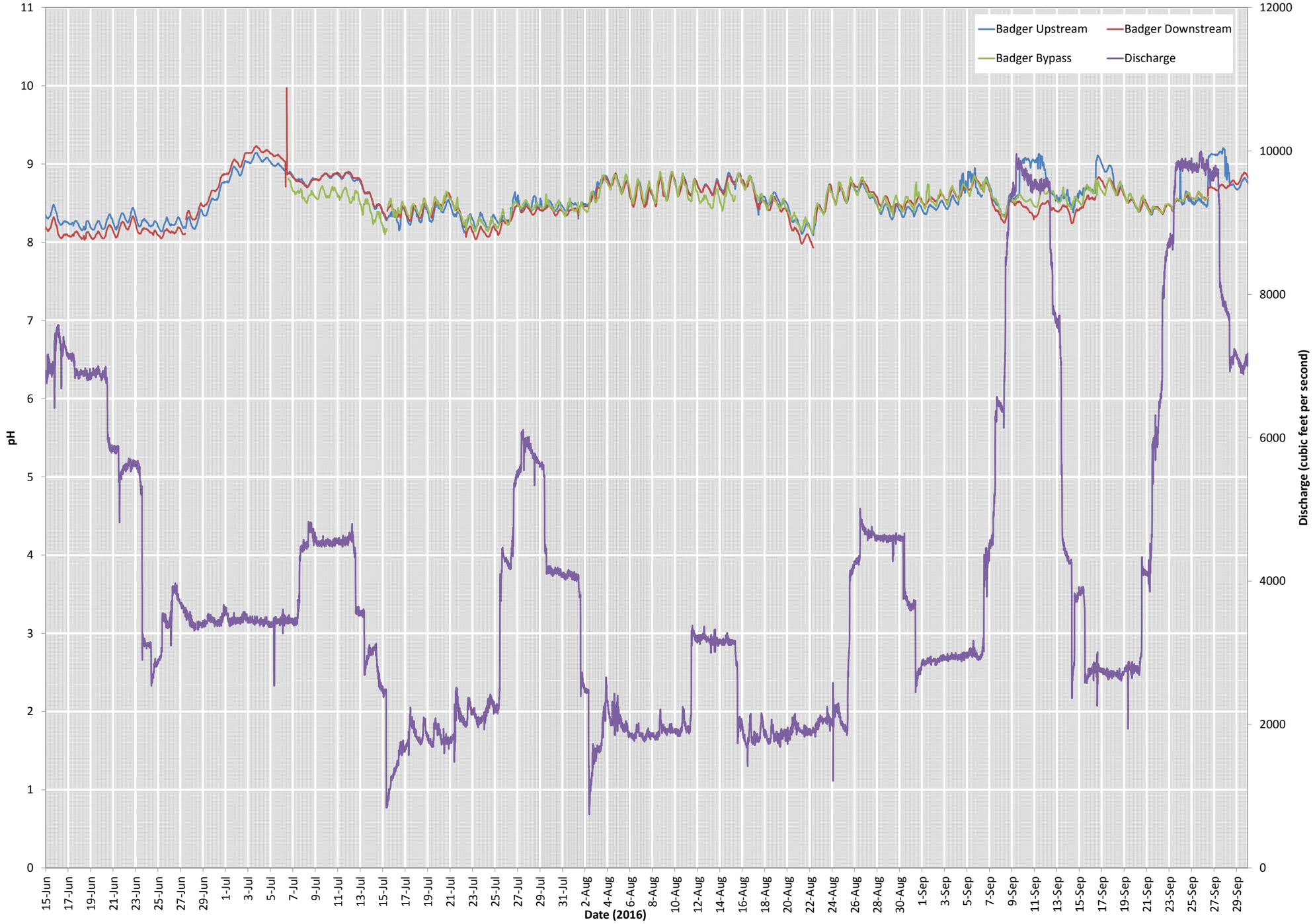

Figure 5. Hourly Electrical Conductivity Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

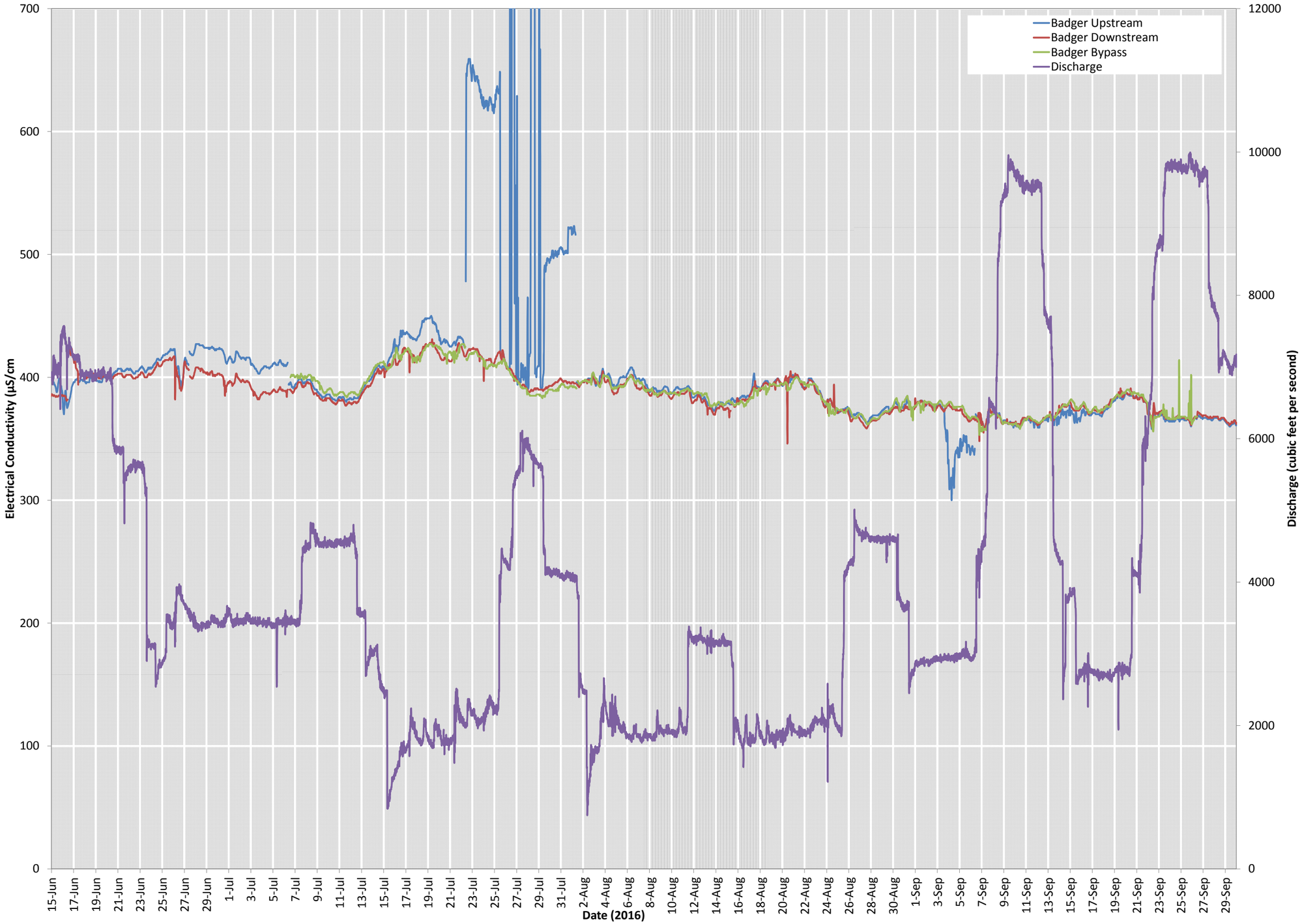

Figure 6. Daily Dissolved Oxygen Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

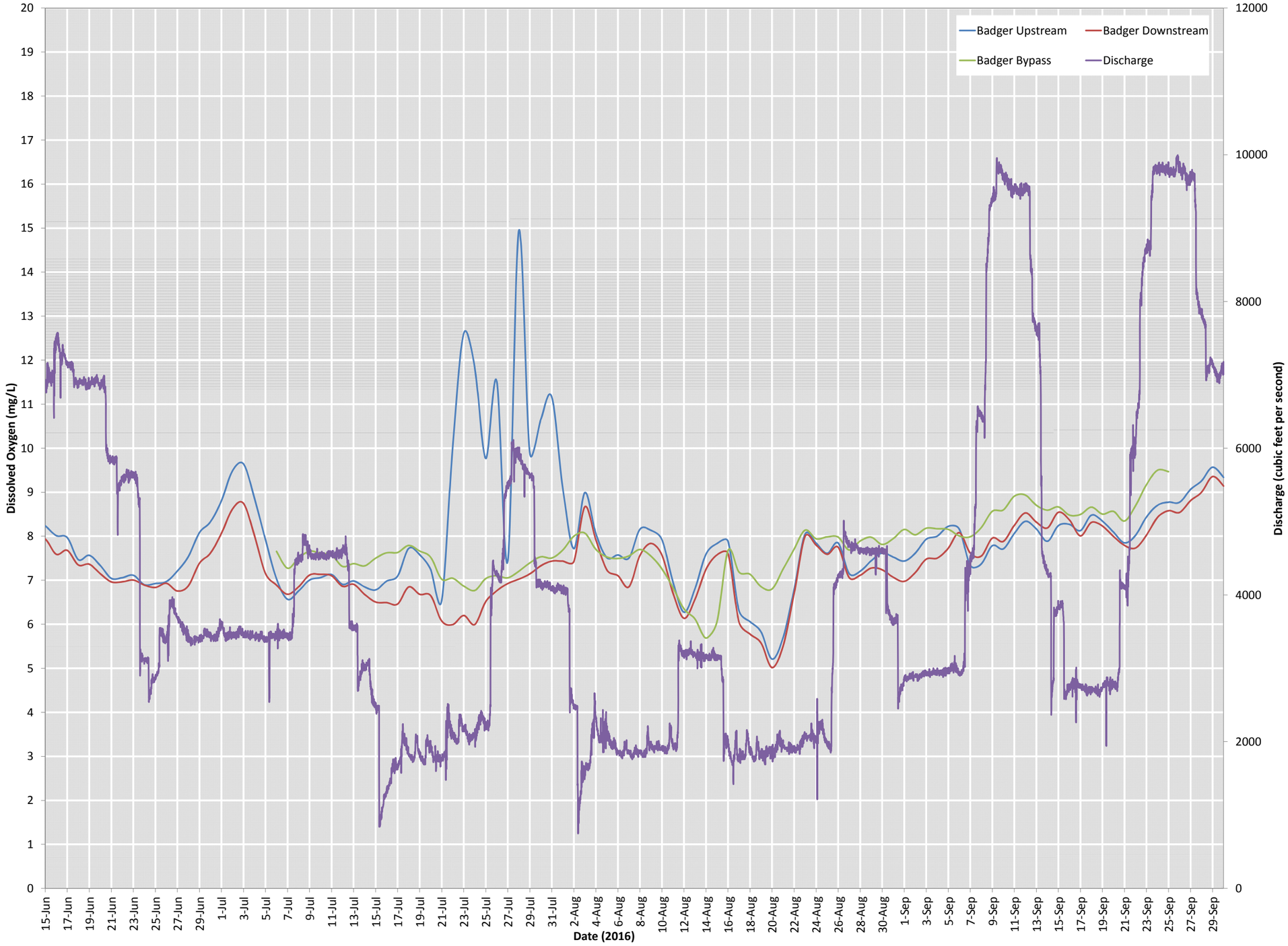

Figure 7. Daily Temperature Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

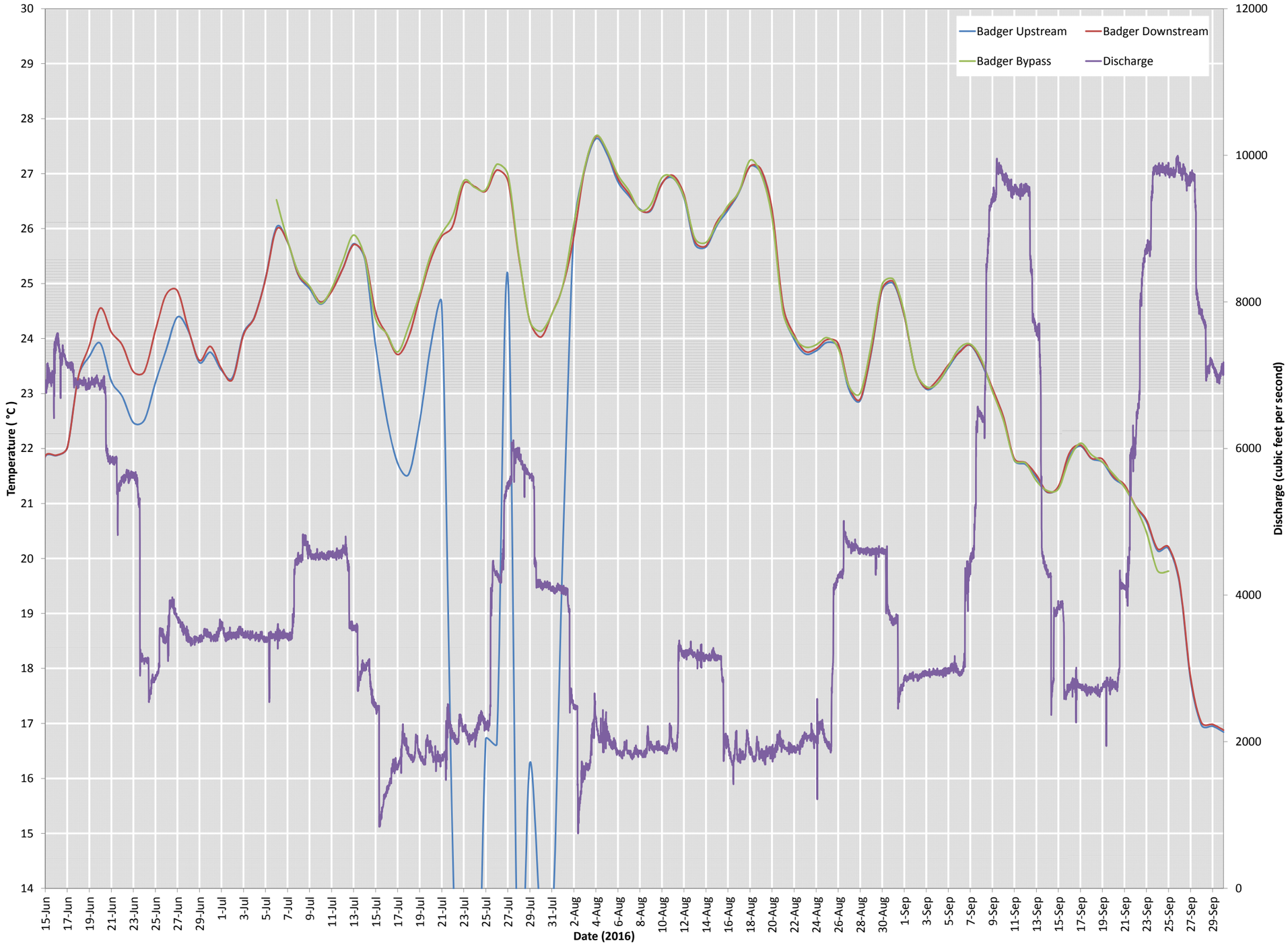

Figure 8. Daily pH Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

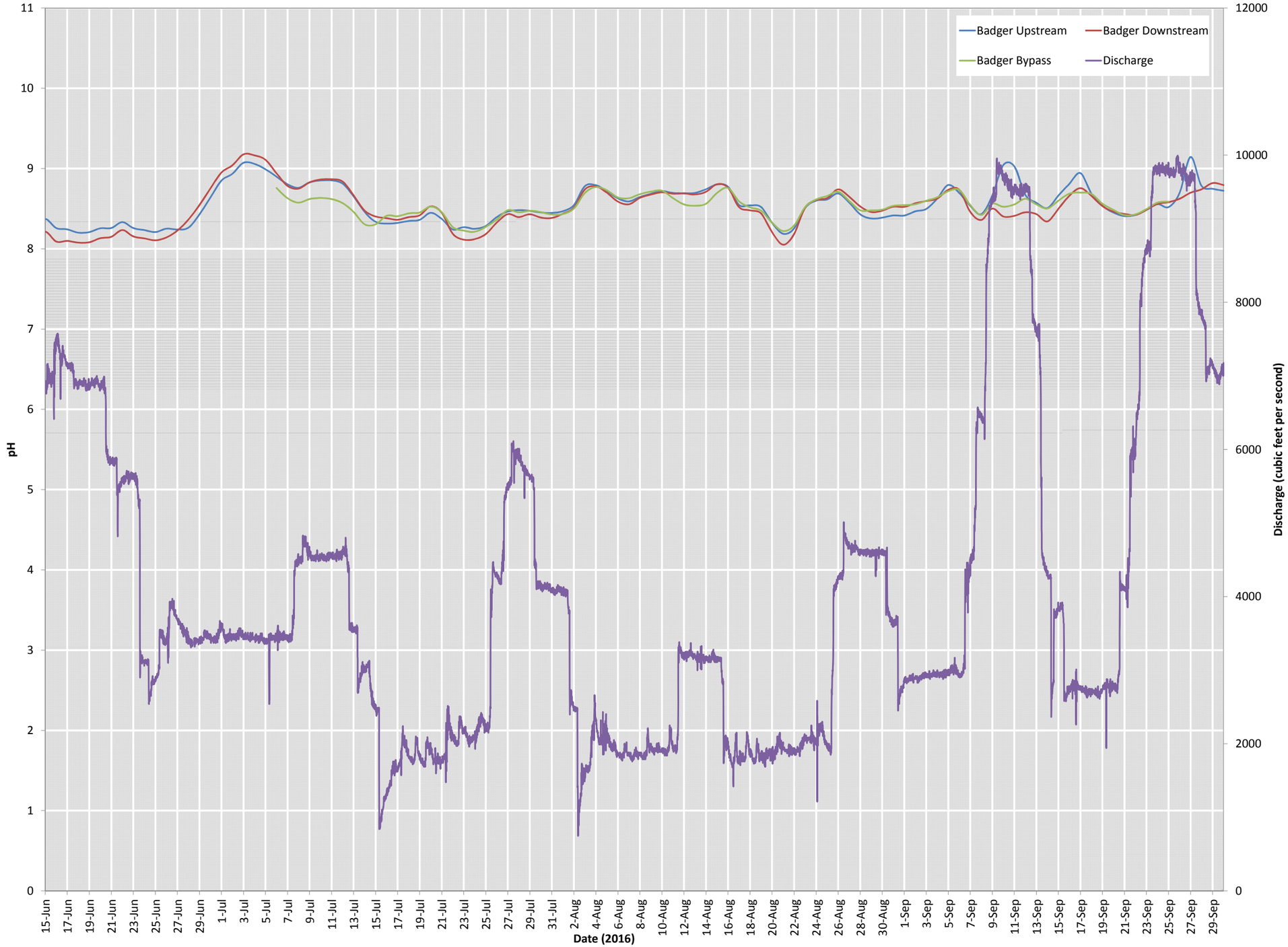

Figure 9. Daily Electrical Conductivity Readings, Upstream, Downstream, and along the Bypass of the Badger Hydroelectric Plant
FERC No. 2677 on the Fox River in Kaukauna, Wisconsin

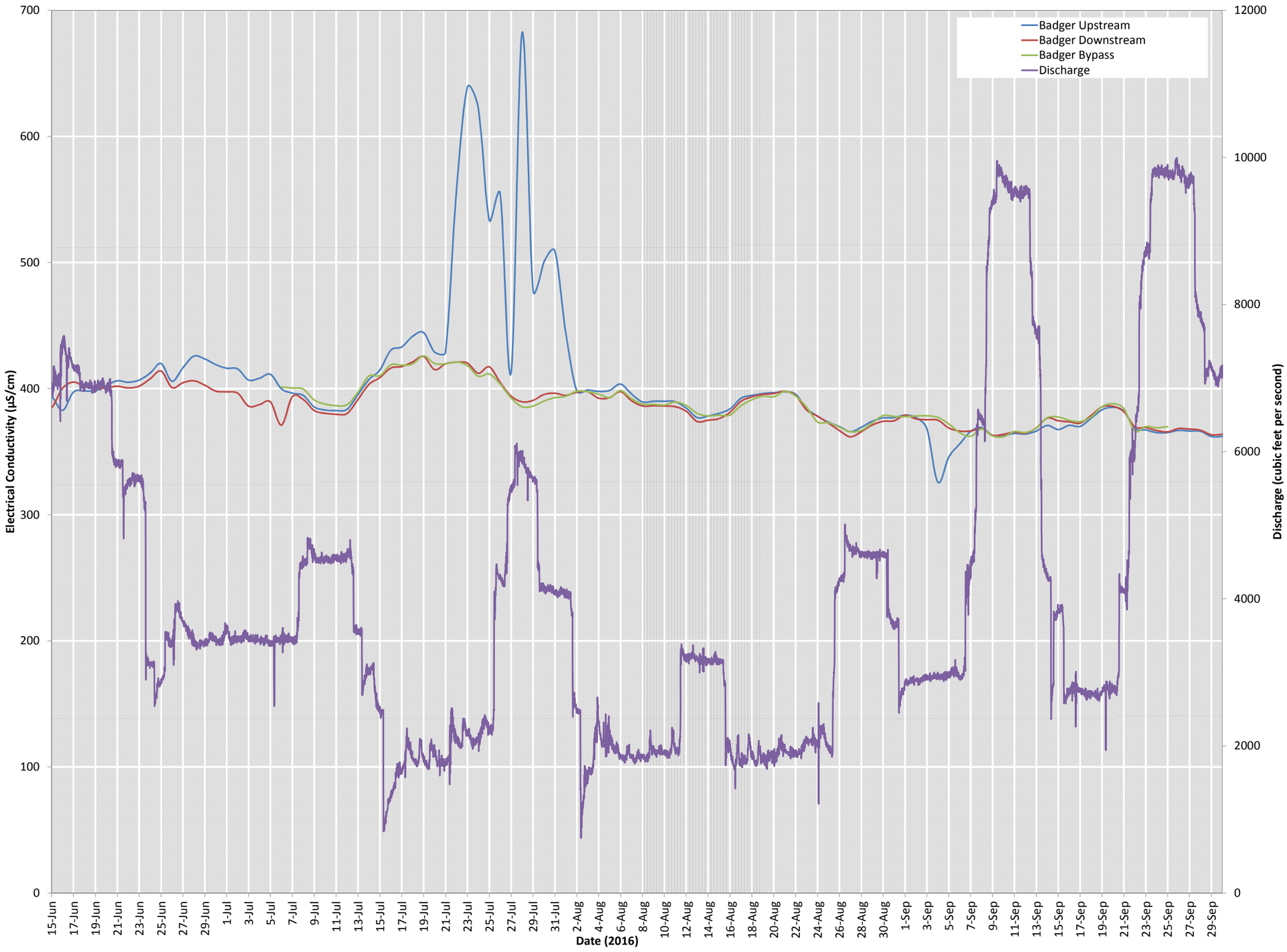

Table 2.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
6/15/2016	8.24	7.94	0.30	21.85	21.86	-0.01	8.37	8.21	0.16
6/16/2016	8.01	7.59	0.42	21.87	21.88	-0.01	8.26	8.09	0.17
6/17/2016	7.97	7.68	0.29	22.01	22.02	0.00	8.24	8.10	0.14
6/18/2016	7.47	7.35	0.12	23.31	23.30	0.01	8.20	8.08	0.12
6/19/2016	7.57	7.36	0.20	23.67	23.87	-0.20	8.21	8.08	0.13
6/20/2016	7.33	7.15	0.19	23.91	24.55	-0.64	8.26	8.13	0.12
6/21/2016	7.04	6.96	0.08	23.23	24.12	-0.89	8.26	8.15	0.11
6/22/2016	7.06	6.96	0.10	22.95	23.88	-0.93	8.33	8.23	0.10
6/23/2016	7.11	7.00	0.11	22.47	23.40	-0.92	8.26	8.15	0.10
6/24/2016	6.90	6.89	0.01	22.52	23.40	-0.88	8.23	8.13	0.10
6/25/2016	6.93	6.84	0.09	23.19	24.14	-0.95	8.21	8.11	0.10
6/26/2016	6.97	6.93	0.04	23.81	24.81	-1.00	8.25	8.14	0.11
6/27/2016	7.21	6.76	0.45	24.39	24.87	-0.48	8.24	8.23	0.01
6/28/2016	7.54	6.88	0.67	24.14	24.17	-0.04	8.26	8.36	-0.10
6/29/2016	8.08	7.39	0.70	23.56	23.60	-0.04	8.43	8.54	-0.12
6/30/2016	8.33	7.62	0.71	23.75	23.86	-0.11	8.64	8.75	-0.11
7/1/2016	8.81	8.06	0.74	23.42	23.45	-0.03	8.85	8.95	-0.10
7/2/2016	9.49	8.62	0.87	23.29	23.26	0.03	8.93	9.04	-0.11
7/3/2016	9.64	8.75	0.90	24.09	24.07	0.03	9.07	9.18	-0.10
7/4/2016	8.86	8.02	0.85	24.39	24.38	0.01	9.06	9.16	-0.11
7/5/2016	7.92	7.15	0.77	25.10	25.08	0.02	8.99	9.11	-0.12
7/6/2016	7.03	6.89	0.14	26.03	25.99	0.04	8.90	8.94	-0.04
7/7/2016	6.57	6.68	-0.11	25.75	25.76	-0.01	8.80	8.78	0.02
7/8/2016	6.76	6.85	-0.09	25.15	25.16	-0.01	8.76	8.75	0.01
7/9/2016	7.00	7.12	-0.11	24.91	24.95	-0.04	8.83	8.83	0.00
7/10/2016	7.06	7.13	-0.07	24.63	24.66	-0.04	8.85	8.86	-0.01
7/11/2016	7.13	7.10	0.03	24.87	24.86	0.01	8.85	8.87	-0.01
7/12/2016	6.91	6.86	0.04	25.27	25.26	0.00	8.81	8.84	-0.03
7/13/2016	6.98	6.91	0.08	25.73	25.71	0.02	8.65	8.67	-0.01
7/14/2016	6.85	6.68	0.17	25.46	25.51	-0.05	8.46	8.48	-0.02
7/15/2016	6.78	6.51	0.28	23.87	24.49	-0.61	8.34	8.40	-0.07
7/16/2016	6.98	6.49	0.49	22.56	24.08	-1.52	8.31	8.38	-0.07
7/17/2016	7.10	6.46	0.64	21.73	23.71	-1.98	8.32	8.36	-0.04
7/18/2016	7.72	6.85	0.88	21.53	24.03	-2.50	8.35	8.40	-0.05
7/19/2016	7.58	6.68	0.90	22.49	24.75	-2.26	8.36	8.42	-0.06
7/20/2016	7.24	6.65	0.59	23.86	25.43	-1.57	8.45	8.53	-0.08
7/21/2016	6.54	6.07	0.46	24.62	25.86	-1.23	8.37	8.45	-0.08
7/22/2016	10.03	5.99	4.04	14.66	26.05	-11.38	8.24	8.19	0.05
7/23/2016	12.61	6.20	6.41	8.37	26.82	-18.44	8.27	8.11	0.16
7/24/2016	11.84	5.99	5.84	8.50	26.76	-18.26	8.25	8.12	0.13
7/25/2016	9.77	6.52	3.25	16.71	26.68	-9.97	8.28	8.18	0.10
7/26/2016	11.52	6.76	4.76	16.63	27.06	-10.44	8.40	8.33	0.07
7/27/2016	7.44	6.93	0.52	25.15	26.88	-1.73	8.46	8.43	0.03
7/28/2016	14.94	7.03	7.91	11.75	25.49	-13.75	8.48	8.39	0.09
7/29/2016	9.90	7.14	2.75	16.28	24.32	-8.05	8.47	8.43	0.04
7/30/2016	10.65	7.33	3.32	13.39	24.03	-10.63	8.45	8.39	0.06
7/31/2016	11.16	7.43	3.73	13.10	24.44	-11.35	8.45	8.38	0.06
8/1/2016	9.09	7.43	1.65	20.15	24.95	-4.80	8.47	8.44	0.03
8/2/2016	7.72	7.43	0.29	25.95	25.85	0.10	8.54	8.51	0.03
8/3/2016	8.99	8.67	0.32	27.08	27.10	-0.03	8.78	8.74	0.04
8/4/2016	8.06	7.92	0.14	27.63	27.67	-0.04	8.79	8.78	0.01
8/5/2016	7.51	7.23	0.28	27.36	27.42	-0.06	8.72	8.70	0.02
8/6/2016	7.57	7.10	0.47	26.85	26.91	-0.06	8.63	8.59	0.04
8/7/2016	7.50	6.85	0.65	26.59	26.63	-0.04	8.59	8.55	0.04
8/8/2016	8.16	7.56	0.60	26.35	26.34	0.01	8.65	8.64	0.01
8/9/2016	8.13	7.84	0.30	26.33	26.35	-0.02	8.69	8.68	0.01
8/10/2016	7.92	7.57	0.35	26.83	26.82	0.01	8.72	8.70	0.01

Table 2.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Upstream and Downstream Dissolved Oxygen, Temperature, and pH Data
Difference = Upstream - Downstream
**Note: Shaded dates = service date (data downloads and calibration)

Date (shading = service date)	Dissolved Oxygen (mg/L)			Temperature (°C)			pH		
	Upstream	Downstream	Difference	Upstream	Downstream	Difference	Upstream	Downstream	Difference
8/11/2016	6.96	6.71	0.25	26.92	26.97	-0.05	8.70	8.69	0.01
8/12/2016	6.28	6.14	0.14	26.56	26.62	-0.06	8.69	8.69	0.00
8/13/2016	6.81	6.57	0.24	25.71	25.76	-0.05	8.70	8.68	0.02
8/14/2016	7.59	7.25	0.35	25.67	25.69	-0.02	8.74	8.71	0.03
8/15/2016	7.83	7.58	0.26	26.06	26.13	-0.07	8.80	8.81	0.00
8/16/2016	7.89	7.61	0.28	26.34	26.38	-0.04	8.77	8.76	0.01
8/17/2016	6.31	6.05	0.26	26.66	26.68	-0.02	8.54	8.52	0.03
8/18/2016	6.06	5.78	0.28	27.13	27.13	0.00	8.54	8.48	0.06
8/19/2016	5.83	5.57	0.25	27.01	27.08	-0.07	8.52	8.44	0.08
8/20/2016	5.21	5.02	0.19	26.29	26.35	-0.05	8.32	8.21	0.11
8/21/2016	5.69	5.50	0.19	24.52	24.59	-0.07	8.19	8.05	0.14
8/22/2016	6.79	6.69	0.10	23.99	24.07	-0.08	8.25	8.18	0.07
8/23/2016	8.05	8.00	0.05	23.72	23.77	-0.05	8.51	8.51	0.00
8/24/2016	7.84	7.80	0.05	23.78	23.82	-0.04	8.60	8.61	-0.01
8/25/2016	7.61	7.59	0.02	23.93	23.98	-0.05	8.61	8.63	-0.02
8/26/2016	7.85	7.75	0.10	23.85	23.91	-0.06	8.69	8.74	-0.05
8/27/2016	7.15	7.06	0.09	23.06	23.13	-0.06	8.58	8.65	-0.07
8/28/2016	7.20	7.11	0.09	22.87	22.90	-0.03	8.43	8.53	-0.10
8/29/2016	7.44	7.28	0.16	23.74	23.77	-0.03	8.38	8.46	-0.08
8/30/2016	7.62	7.24	0.38	24.89	24.91	-0.02	8.39	8.48	-0.09
8/31/2016	7.53	7.07	0.46	25.00	25.04	-0.04	8.42	8.52	-0.11
9/1/2016	7.44	6.97	0.46	24.42	24.43	-0.01	8.41	8.52	-0.11
9/2/2016	7.61	7.17	0.44	23.43	23.43	0.00	8.47	8.57	-0.10
9/3/2016	7.93	7.48	0.45	23.08	23.10	-0.02	8.50	8.60	-0.10
9/4/2016	8.00	7.50	0.50	23.19	23.24	-0.06	8.63	8.63	0.00
9/5/2016	8.22	7.73	0.50	23.47	23.52	-0.05	8.79	8.73	0.06
9/6/2016	8.16	8.08	0.08	23.76	23.75	0.01	8.70	8.73	-0.04
9/7/2016	7.34	7.62	-0.28	23.88	23.88	-0.01	8.53	8.46	0.08
9/8/2016	7.37	7.55	-0.18	23.56	23.59	-0.03	8.43	8.36	0.07
9/9/2016	7.79	7.96	-0.17	23.06	23.10	-0.04	8.67	8.50	0.16
9/10/2016	7.71	7.88	-0.17	22.55	22.58	-0.03	9.04	8.40	0.64
9/11/2016	8.06	8.25	-0.18	21.78	21.82	-0.03	9.03	8.41	0.62
9/12/2016	8.34	8.53	-0.19	21.71	21.75	-0.03	8.67	8.45	0.22
9/13/2016	8.16	8.32	-0.16	21.48	21.52	-0.04	8.57	8.43	0.14
9/14/2016	7.89	8.19	-0.30	21.20	21.21	-0.01	8.51	8.34	0.17
9/15/2016	8.24	8.54	-0.30	21.30	21.31	-0.01	8.66	8.50	0.17
9/16/2016	8.27	8.37	-0.10	21.86	21.92	-0.06	8.81	8.66	0.15
9/17/2016	8.13	8.01	0.12	22.04	22.06	-0.02	8.94	8.76	0.19
9/18/2016	8.48	8.31	0.17	21.82	21.82	-0.01	8.69	8.66	0.03
9/19/2016	8.34	8.23	0.11	21.75	21.81	-0.06	8.54	8.53	0.00
9/20/2016	8.10	8.00	0.10	21.47	21.49	-0.02	8.45	8.46	-0.01
9/21/2016	7.85	7.79	0.06	21.31	21.34	-0.04	8.41	8.43	-0.03
9/22/2016	8.02	7.73	0.29	20.95	20.96	-0.01	8.42	8.42	0.00
9/23/2016	8.44	8.03	0.41	20.67	20.70	-0.03	8.48	8.49	0.00
9/24/2016	8.70	8.43	0.28	20.14	20.18	-0.03	8.56	8.56	0.00
9/25/2016	8.77	8.58	0.19	20.18	20.21	-0.03	8.52	8.58	-0.06
9/26/2016	8.77	8.54	0.23	19.54	19.58	-0.04	8.69	8.62	0.07
9/27/2016	9.06	8.81	0.25	17.80	17.85	-0.05	9.14	8.70	0.45
9/28/2016	9.26	9.00	0.26	16.97	17.01	-0.05	8.78	8.74	0.04
9/29/2016	9.57	9.36	0.21	16.95	16.98	-0.03	8.75	8.82	-0.07
9/30/2016	9.34	9.14	0.20	16.84	16.88	-0.04	8.72	8.79	-0.07
Minimum	5.21	5.02	-0.30	8.37	16.88	-18.44	8.19	8.05	-0.12
Average	7.98	7.35	0.63	22.73	24.02	-1.29	8.56	8.52	0.04
Maximum	14.94	9.36	7.91	27.63	27.67	0.10	9.14	9.18	0.64
Standard Deviation	1.38	0.81	1.34	3.72	2.27	3.59	0.23	0.25	0.12
Number of Data Points	108	108	108	108	108	108	108	108	108

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
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			
7/3/2016			
7/4/2016			
7/5/2016			
7/6/2016	26.52	8.76	7.66
7/7/2016	25.79	8.63	7.27
7/8/2016	25.20	8.58	7.50
7/9/2016	24.95	8.62	7.66
7/10/2016	24.64	8.63	7.61
7/11/2016	24.91	8.62	7.57
7/12/2016	25.41	8.57	7.31
7/13/2016	25.88	8.46	7.38
7/14/2016	25.48	8.31	7.33
7/15/2016	24.36	8.30	7.50
7/16/2016	24.09	8.41	7.62
7/17/2016	23.76	8.41	7.63
7/18/2016	24.22	8.44	7.79
7/19/2016	24.82	8.45	7.66
7/20/2016	25.52	8.53	7.52
7/21/2016	25.91	8.46	7.03
7/22/2016	26.23	8.27	7.05
7/23/2016	26.87	8.23	6.87
7/24/2016	26.75	8.21	6.77
7/25/2016	26.71	8.27	7.04
7/26/2016	27.17	8.36	7.10

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
7/27/2016	26.99	8.48	7.05
7/28/2016	25.53	8.45	7.20
7/29/2016	24.32	8.47	7.39
7/30/2016	24.13	8.46	7.53
7/31/2016	24.44	8.43	7.51
8/1/2016	24.96	8.43	7.69
8/2/2016	26.07	8.50	8.00
8/3/2016	27.13	8.70	8.07
8/4/2016	27.69	8.77	7.70
8/5/2016	27.43	8.73	7.53
8/6/2016	26.97	8.64	7.50
8/7/2016	26.69	8.63	7.55
8/8/2016	26.34	8.68	7.70
8/9/2016	26.44	8.71	7.55
8/10/2016	26.93	8.72	7.26
8/11/2016	26.93	8.63	6.83
8/12/2016	26.58	8.55	6.35
8/13/2016	25.82	8.54	6.12
8/14/2016	25.75	8.56	5.69
8/15/2016	26.09	8.70	6.06
8/16/2016	26.42	8.76	7.68
8/17/2016	26.67	8.59	7.19
8/18/2016	27.24	8.52	7.14
8/19/2016	26.99	8.47	6.85
8/20/2016	26.19	8.33	6.80
8/21/2016	24.47	8.22	7.25
8/22/2016	24.03	8.29	7.71
8/23/2016	23.85	8.52	8.14
8/24/2016	23.89	8.61	7.94
8/25/2016	24.02	8.66	7.98
8/26/2016	23.83	8.71	7.98
8/27/2016	23.13	8.60	7.69
8/28/2016	23.01	8.48	7.89
8/29/2016	23.88	8.48	7.98
8/30/2016	24.99	8.49	7.81
8/31/2016	25.08	8.54	7.94
9/1/2016	24.47	8.54	8.15
9/2/2016	23.43	8.55	8.03
9/3/2016	23.13	8.60	8.18
9/4/2016	23.18	8.64	8.17
9/5/2016	23.50	8.72	8.16
9/6/2016	23.82	8.73	8.01

Table 3.
Badger-Rapide Croche, FERC No. 2677 on the Fox River In Kaukauna, Wisconsin
Badger Daily Averages of Bypass Dissolved Oxygen, Temperature, and pH Data

Date (shading = service date)	Temp °C	pH Units	LDO mg/l
9/7/2016	23.90	8.54	7.99
9/8/2016	23.62	8.42	8.20
9/9/2016	23.05	8.56	8.57
9/10/2016	22.52	8.52	8.60
9/11/2016	21.79	8.55	8.91
9/12/2016	21.74	8.62	8.93
9/13/2016	21.41	8.55	8.70
9/14/2016	21.23	8.50	8.59
9/15/2016	21.27	8.60	8.67
9/16/2016	21.81	8.69	8.48
9/17/2016	22.10	8.70	8.50
9/18/2016	21.89	8.68	8.66
9/19/2016	21.75	8.56	8.50
9/20/2016	21.53	8.48	8.56
9/21/2016	21.30	8.42	8.35
9/22/2016	20.94	8.43	8.69
9/23/2016	20.48	8.50	9.17
9/24/2016	19.78	8.58	9.50
9/25/2016	19.77	8.59	9.47
9/26/2016			
9/27/2016			
9/28/2016			
9/29/2016			
9/30/2016			

Minimum	19.77	8.21	5.69
Average	24.51	8.53	7.74
Maximum	27.69	8.77	9.50
Standard Deviation	2.01	0.13	0.72
Number of Data Points	82	82	82

Appendix C

CD-ROM of Water Quality Monitoring Report and Data

Appendix D

Photo Log

Appendix D - Photo Log

Project No.: 1602010

Photo No. 1 Example of moderate biofouling of sonde at Badger Upstream (8/8/16).

Photo No. 2 Example of sonde biofouling at Badger Downstream (8/8/16).

Appendix D - Photo Log

Project No.: 1602010

Photo No. 3 Diver preparing to retrieve detached Badger Upstream sonde on 9/16/16.

Photo No. 4 Badger Upstream sonde after retrieval by diver on 9/16/16.

Appendix E

Description of 2016 Sonde Outages, Replacements, and Comments

APPENDIX E
Description of HL4 Sonde Outages, Replacements and Comments

After installing new HL4 Hach Sondes at five agency approved locations in June/July 2016, GEI serviced each location at weekly to biweekly intervals. As communicated with the WDNR, the sonde at the Badger Bypass station was not restored until flows subsided in early July 2016, and it was considered safe for personnel and equipment to redeploy this sonde from a railroad trestle. The sonde at the Badger Bypass station was also removed in late September, also due to high flows. Additionally, variations in the datasets were also documented as a result of the following history of calibration anomalies, mechanical issues, and equipment replacement.

6/17/16 **BADGER DOWNSTREAM SONDE S/N H400091**. LDO sensor was not calibrating correctly in the field. Sonde had moderate biofouling and small aquatic organisms on sensors. DO calibration failed several times; GEI thoroughly cleaned sensors. GEI was able to recalibrate **SONDE S/N H400091** and replace the battery. **GEI redeployed SONDE S/N H400091.**

6/27/16 **BADGER DOWNSTREAM SONDE S/N H400091**. LDO sensor was not calibrating correctly in the field. Based on concerns about avoiding loss of data, **GEI replaced SONDE S/N H400091 with SONDE S/N H400093** under warranty, after it was received from the manufacturer (Hach) following pH sensor replacement. **GEI calibrated and deployed backup SONDE S/N H400093 on 6/27/2016.**

6/27/16 **RAPID CROCHE DOWNSTREAM SONDE S/N H400097**. Received battery error message during the download of data. GEI was able to recalibrate **SONDE S/N H400097** and replace the battery. **GEI redeployed SONDE S/N H400097.**

7/6/16 **BADGER BYPASS SONDE S/N H400386. SONDE S/N H400386** was deployed after lab calibration and decrease in river flow rate.

7/6/2016 **RAPID CROCHE UPSTREAM SONDE S/N H400094**. Conductivity readings were unstable during field calibration; error messages were observed. **GEI redeployed SONDE S/N H400094** after successful recalibration in the field.

7/15/16 **RAPID CROCHE DOWNSTREAM SONDE S/N H400097**. The protective battery casing on the sonde cracked during battery replacement. **GEI temporarily removed SONDE S/N H400097** until a new battery casing could be acquired from HACH. Data was lost from 7-15-2016 through 7-19-2016. **SONDE S/N H400097** was redeployed with a new protective battery casing on 7-19-2016.

7/19/16 **RAPID CROCHE UPSTREAM SONDE S/N H400094**. The protective battery casing on the sonde cracked during battery replacement. **GEI temporarily removed SONDE S/N H400094** until a new battery casing could be acquired from HACH. **SONDE S/N H400094** was replaced with backup **SONDE S/N H400091** on 7-19-2016.

8/1/16 **BADGER UPSTREAM SONDE S/N H400365**. The protective battery casing on the sonde cracked during battery replacement. **GEI temporarily removed SONDE S/N H400365** until a new battery casing could be acquired from HACH. Data was lost from 8-1-2016 through 8-3-2016. DO

calibration was inconsistent. Review of DO and electrical conductivity data from 7-22-2016 to 8-1-2016 indicated significant variability above and below typical ranges. Accordingly, this data was considered suspect due to possible battery casing leakage and was omitted from the final dataset. **SONDE S/N H400094** was deployed in place of **SONDE S/N H400365** on 8-3-2016, because of the observed battery casing and calibration issues.

8/22/16 to 8/29/16 During this deployment interval, **BADGER UPSTREAM SONDE S/N H400094 detached from its anchor cable** and apparently sunk to the bottom with the 20-lb. lead weight affixed to the PVC protective shroud. The bottom at this location consisted of stone rip-rap and the depth of the river at this location is about 20-feet. The sonde continued recording water quality data from depth.

8/29/16 **BADGER UPSTREAM SONDE S/N H400094**. The sonde cable was observed to be broken and presumed to be anchored to the river bottom by the 20-lb weight. A new battery casing was installed on **SONDE S/N H400365. SONDE S/N H400365 was deployed in its place at BADGER UPSTREAM until arrangements could be made to retrieve SONDE S/N H400094.**

9/6/16 to 9/16/16 **RAPID CROCHE DOWNSTREAM SONDE S/N H400097**. Data did not record due to apparent programming error in the log file setup. Confirmed sonde programming with the manufacturer. **SONDE S/N H400097** was redeployed after successful calibration and log file set up.

9/16/16 **SONDE S/N H400094 was recovered by a professional diving company**; no data was lost. GEI cleaned and recalibrated **SONDE S/N H400365** and redeployed the unit at the **BADGER UPSTREAM** location on 9-16-2016.

9/26/2016 **BADGER BYPASS SONDE S/N H400386** was removed from the river for the year due to high flow rates for the Fox River (approaching10,000CFS).