



**River Falls
Hydroelectric Project
P-10489**

**Dissolved Oxygen and
Temperature Monitoring**

**Interim Report on 2019
Monitoring Season**

Prepared for:

**River Falls Municipal
Utilities
River Falls, WI**

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River Falls Hydroelectric Project, P-10489

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Background

River Falls (WI) Municipal Utilities is preparing an application for a new hydropower license for the River Falls Hydroelectric Project. The Project consists of two developments, from upstream to downstream Junction Falls and Powell Falls. Junction Falls Dam and Powell Falls Dam impound Lake George and Lake Louise respectively on the Kinnickinnic River. The entire Project is within the city limits of River Falls.

In response to resource agency requests the applicant is conducting a two-year program to monitor summer dissolved oxygen and water temperatures in the Kinnickinnic River in the project vicinity. This interim report presents the data collected at four locations in the summer of 2019, beginning in mid-July and ending in mid-September. The study plan calls for a second season of monitoring from May 1, 2020 to September 15, 2020.

Study Procedure

Instrumentation installation, maintenance, and data downloads were conducted by personnel of Ayres Associates throughout late summer 2019 as described below.

Equipment

Four HOBO U26-001 DO data loggers were installed with auxiliary components including a data shuttle, base station, anti-fouling guard, sensor cap, and data management software. The product specifications for DO list an accuracy of 0.2 mg/L and monitoring range of zero to 30 mg/L. Temperature accuracy of the sondes was listed as 0.2 degrees Celsius and an operating range of -5 to 40 degrees C. The loggers were calibrated using a 3-step lab calibration method, which is valid for 6 months after calibration. Gain and offset adjustment values were determined from the elevations of the installation sites.

Independent “grab sample” readings were taken at the time of data retrieval and recorded in the field. The purpose of the grab samples was to determine if stratification is occurring in Lake George and to take upstream and downstream readings around each sonde at different depths within the shallow water column. The instrument used was a YSI Model 55 handheld oxygen and temperature meter. Calibration of the meter occurred prior to the start of the project and intermittently throughout the course of the summer. Calibration procedures were conducted in accordance with the operations manual for the unit. Product specifications list the DO accuracy of 0.3 mg/L and a monitoring range of 0 to 20 mg/L. Temperature accuracy is listed as 0.2 C with a range of -5 to 45 degrees C.

Monitoring Locations

The instruments were placed at four locations as follows:

1. Project Inflow, upstream of Lake George in a free-flowing reach of river downstream from the Division Street bridge. This instrument recorded dissolved oxygen and temperature for flow entering the project area and prior to passage through the project impoundments, powerhouses or spillways. Flow in this location is shallow, fast-moving, and well mixed.

2. Lake George, the impoundment of Junction Falls Dam. The unit was installed approximately 600 feet upstream of Junction Falls Dam. According to the Lathrop-Lillie equation provided in the WDNR's Wisconsin 2020 Consolidated Assessment and Listing Methodology (WisCALM) document, Lake George is considered a shallow, mixed (unstratified) water body. This calculation is based on a 16-acre surface area and 10-foot maximum depth as shown in the 2016 Interfluvial "Sediment Assessment Report" for Lake George.
3. Junction Falls Outflow, downstream of Junction Falls Dam and powerhouse. The intent of this placement was to capture Lake George outflows while avoiding or minimizing effects from the South Fork of the Kinnickinnic, which enters on the opposite side of the river (southeast) from the powerhouse outfall. Grab samples were collected from both the South Fork outflow and the instrument location to provide a comparison between the streamflow sources. The instrument location was in a relatively deep and slow-moving pool below the dam.
4. Powell Falls Outflow, approximately 200 feet downstream from Powell Falls Dam. This is a free-flowing reach of river.

Once installed, the instrument locations were surveyed with a GPS. The instrument locations are shown in Figure 1.

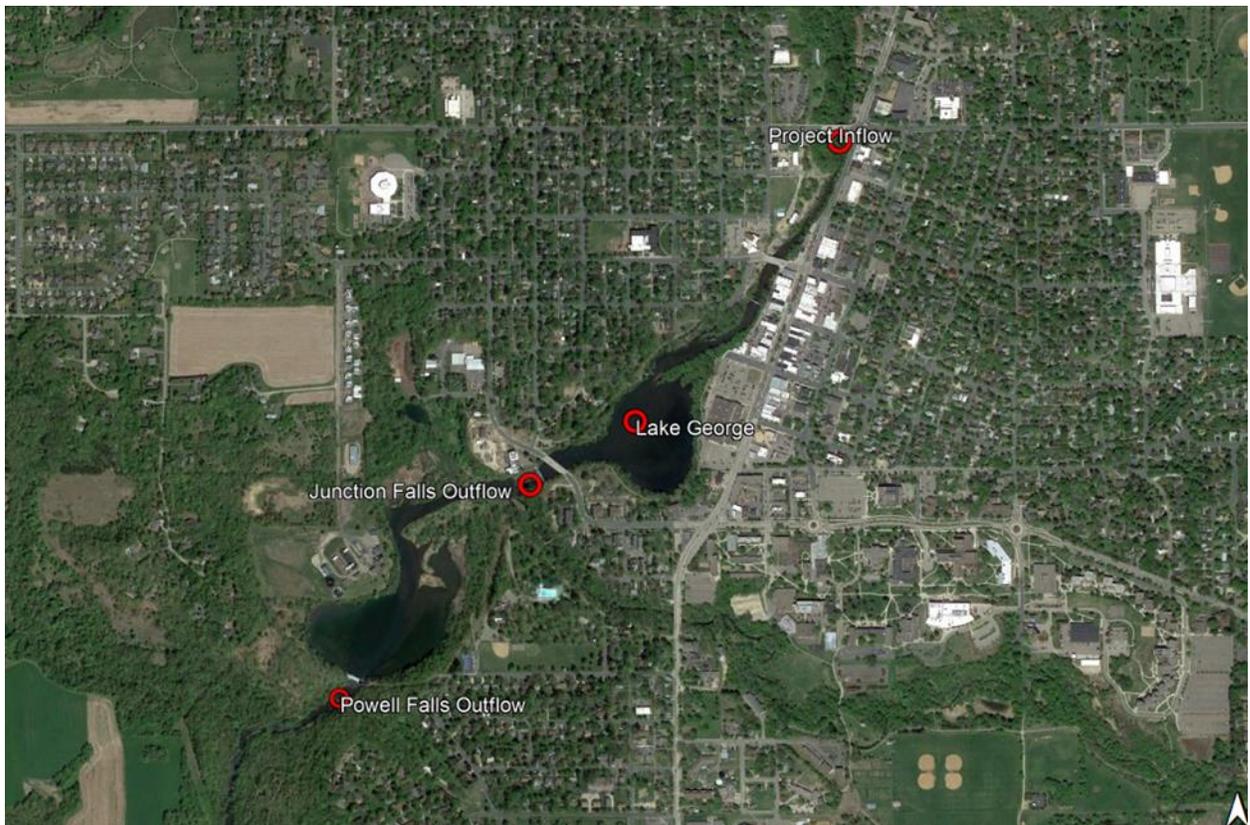


Figure 1: Monitor Locations

Installation

Each sensor was attached to a slotted (.01") PVC pipe, anchored with one or more cinder blocks, and positioned approximately in the middle of the water column. Buoys were attached to the pipes to assist in retrieving the unit should it become detached from the anchor block. Figure 2 shows a typical installation.



Figure 2: Monitor installation downstream of Junction Falls Dam

Reading and Download Frequency

The instruments were programmed to record dissolved oxygen concentrations and water temperatures at 15-minute intervals, around the clock. Data were downloaded approximately every two weeks as weather, flow conditions, and other instrument maintenance needs permitted.

(Note: the anchor and buoy for the “project inflow” monitoring location unit were vandalized almost immediately upon setup, prior to deployment of the data logger. The data logger was then installed with additional contact and security information but was then removed or stolen sometime between July 23 and August 2. The unit was then replaced in a less conspicuous location, with the result that very limited “project inflow” readings are available before August 2.)

Table 1 lists the data logger locations, water depths, and recording dates.

Table 1: Dissolved Oxygen/Temperature Recording Locations and Dates

Location	GPS Coordinates	Water Depth (ft) on 7-18-2019	Recording Dates	Comments
Project Inflow	N 44.8619 W 92.6244	2.2	7/18 – 7/23 8/2 – 8/5 * 8/6 – 9/17	Free flowing reach, water depth varied throughout recording period. * <i>temperature sensor appears to have been at or above water surface August 2 – August 5</i>
Lake George	N 44.8558 W 92.6315	4.2	7/18 – 9/16	
Junction Falls Outflow	N 44.8550 W 92.6344	3.9	7/18 – 9/17	
Powell Falls Outflow	N 44.8505 W 92.6393	2.9	7/18 – 9/17	Free flowing reach, water depth varied throughout recording period

Additional Data Collection

Additional data were collected as follows:

- Algae cover in Lake George during data download visits. Algae cover was recorded photographically and visually estimated as a percentage of the lake's surface area.
- Independent grab sample measurements of dissolved oxygen and temperature at the data logger sites during data download visits. These samples were taken within the top 18 inches of the water column using a YSI handheld temperature/DO meter.
- Water column measurements were taken at the time of installation and intermittently throughout the course of the study to establish a vertical profile. Due to the small water depths and Lake George being classified as a mixed (unstratified) water body, a mid-depth measurement (sonde) and near surface measurements (grab sample) were used to measure the vertical profile.
- Daily average air temperatures for River Falls, downloaded from the AccuWeather website.
- Daily flows at USGS stream gage 05342000, located approximately eight river miles downstream of Powell Falls. The drainage area at the USGS gage is 23 percent larger than that at Powell Falls and 48 percent larger than that at Junction Falls. Therefore, the USGS gage flows should be seen as an index to the streamflow at the study location, not the actual local flow rate.

Applicable Water Quality Standards

The Kinnickinnic River is designated a Class I trout stream by the state of Wisconsin. This designation applies to the free-flowing reaches of river but not to the impounded sections, Lake George and Lake Louise. Wisconsin's Administrative Code NR 102.04 states: *Dissolved oxygen in classified trout streams shall not be artificially lowered to less than 6.0 mg/L at any time, nor shall the dissolved oxygen be lowered to less than 7.0 mg/L during spawning season.*

For waters that are not designated trout streams, NR 102.04 specifies a minimum dissolved oxygen concentration of 5.0 mg/L.

Chapter NR 102.25 also presents monthly temperature standards for cold-water fisheries and for lakes and impoundments as shown in Table 2:

Table 2: Temperature Standards for Wisconsin Lakes and Cold-Water Streams (Wisconsin Administrative Code, Chapter NR 102)

Month	Maximum Temperature Standard (degrees Fahrenheit)		
	Ambient	Sub-Lethal	Acute
<i>Lakes and Impoundments</i>			
July	72	79	86
August	71	79	86
September	63	72	84
<i>Streams - Cold Water Fisheries</i>			
July	64	67	73
August	63	65	73
September	57	60	72

Ambient water is determined by a grab sample at a particular time and place, sub-lethal criteria are evaluated by weekly average maximum temperatures and acute criteria are evaluated according to the daily maximum temperature.

Monitoring Results

15-Minute Dissolved Oxygen and Temperature Readings

Plots of dissolved oxygen concentration, water temperature, daily air temperature, and flow for the season and for each month separately, at each instrument location, are included as Appendix A.

Table 3 summarizes the data logger readings in comparison to the above listed criteria. The applicable minimum dissolved oxygen concentration for cold water fisheries (trout streams) is 6 mg/L, as the study was conducted outside of the spawning season. Wisconsin's minimum dissolved oxygen concentration standard for lakes and impoundments is 5 mg/L.

Table 3: Summary of Recorded Dissolved Oxygen Concentrations

Location	Measured Dissolved Oxygen Range (mg/L) for Season	Percent of readings < 6.0 mg/L (trout stream standard)	Percent of readings < 5.0 mg/L (other water body standard)
Inflow	7.0 – 13.0	0 %	0 %
Lake George	0.0 – 13.0	37 %	28 %
Junction Falls Outflow	2.9 – 13.5	4 %	3 %
Powell Falls Outflow	0.7 – 12.2	29 %	18 %

Table 4: Summary of Recorded Temperatures

Location	Temperature					
	Maximum 15-minute Reading, °F (Acute Criteria Shown by Month for Cold Water Stream/ Lake)			Average Reading, °F (Ambient Criteria Shown by Month for Cold Water Stream/Lake)		
	July (73/86)	August (73/86)	September (72/84)	July (64/72)	August (63/71)	September (57/63)
Inflow	64	63	62	60	60	56
Lake George	78	65	62	61	59	57
Junction Falls Outflow	78	65	63	62	60	57
Powell Falls Outflow	80	82	66	63	61	58

Table 5 and Table 6, below, are provided to illustrate typical daily variations in time and space. Tables 5 and 6 provide “snapshots” of the monitor readings throughout the study reach at 4:00 a.m. and 4:00 p.m. at semi-monthly intervals. The same data are also included for the dates on which the highest water temperature and the lowest dissolved oxygen concentration were recorded downstream of Powell Falls Dam.

Table 5: Dissolved Oxygen Concentrations Through Study Reach, Selected Dates and Times

Date	Time	Dissolved Oxygen Concentration (mg/L)			
		Project Inflow	Lake George	Junction Falls Outflow	Powell Falls Outflow
July 20	4:00 a.m.	8.5	7.7	7.8	6.7
	4:00 p.m.	8.8	8.6	9.2	9.3
August 1	4:00 a.m.	N/A	6.3	7.6	7.7
	4:00 p.m.	N/A	7.6	11.1	9.2
August 10 *	4:00 a.m.	8.9	7.1	7.8	4.3
	4:00 p.m.	11.1	7.8	9.4	3.1
August 15	4:00 a.m.	8.7	6.6	8.4	5.4
	4:00 p.m.	11.1	8.8	11.2	4.9
August 31	4:00 a.m.	9.5	4.4	9.9	4.0
	4:00 p.m.	11.4	9.8	10.9	4.1
Sept. 15	4:00 a.m.	9.3	8.4	9.9	8.2
	4:00 p.m.	10.7	6.2	9.7	6.8
* Date of minimum recorded DO concentration (0.7 mg/L) at Powell Falls Outflow site					

Table 6: Water Temperatures Through Study Reach, Selected Dates and Times

Date	Time	Water Temperature (degrees Fahrenheit)			
		Project Inflow	Lake George	Junction Falls Outflow	Powell Falls Outflow
July 19*	4:00 a.m.	58.4	59.1	60.7	61.6
	4:00 p.m.	62.9	64.5	65.1	66.2
July 20	4:00 a.m.	60.4	61.1	62.8	63.8
	4:00 p.m.	59.8	60.8	62.1	62.8
August 1	4:00 a.m.	N/A	57.2	59.0	60.0
	4:00 p.m.	N/A	63.6	63.3	64.5
August 15	4:00 a.m.	57.8	58.3	59.5	60.2
	4:00 p.m.	61.2	62.4	63.4	64.3
August 31	4:00 a.m.	53.6	54.4	55.3	56.5
	4:00 p.m.	56.1	56.8	57.5	58.2
Sept. 15	4:00 a.m.	54.1	54.5	54.9	55
	4:00 p.m.	55.9	56.9	57.7	58.6
* Date of maximum recorded water temperature (67.9°) at Powell Falls Outflow site					

Other Field Measurements

During the data download visits, grab samples using the YSI meter for dissolved oxygen and temperature were taken in the top 18" of the water column. These were taken at the data loggers and other locations near each instrument site, as described in Tables 7a – 7d. Additionally, the percent of algae cover on Lake George was visually estimated and photographed during each field visit. The data downloads and grab samples were always performed in the morning, usually between 9:00 and 10:30 a.m.

Table 7a: Field Measurements at Project Inflow Site

Date	Mid-Depth DO (mg/L) and Water Temperature (°F) per Hobo data logger	Near Surface DO (mg/L) and Water Temperature (°F) at data logger location, using the YSI meter	Other Measurements/Observations
July 23, 2019	9.5 mg/L, 57°	N/A – instrument malfunction	
Aug. 2, 2019	N/A; sensor removed/stolen	5.9 mg/L, 57°	5.6 mg/L, 57° - 150 ft upstream of instrument site
Aug. 13, 2019	10.3 mg/L, 57°	10.4 mg/L, 55°	
Sept. 4, 2019	9.5 mg/L, 57°	9.5 mg/L, 56°	
Sept. 17, 2019	10.2 mg/L, 57°	10.2 mg/L, 56°	Removed Hobo for season

Table 7b: Field Measurements at Lake George Monitoring Site

Date	Mid-Depth DO (mg/L) and Water Temperature (°F) per Hobo data logger	Near Surface DO (mg/L) and Water Temperature (°F) at data logger location using the YSI meter	Other Measurements/Observations
July 18, 2019	N/A; not yet deployed	5.2 mg/L, 61°	50 percent algae cover
July 23, 2019	4.3 mg/L, 58°	N/A – instrument malfunction	50 percent algae cover
Aug. 2, 2019	6.0 mg/L, 60°	6.2 mg/L, 59°	6.4 mg/L, 58° 225' upstream of data logger; 30 percent algae cover
Aug. 13, 2019	7.6 mg/L, 57°	10.2 mg/L, 58°	25 percent algae cover
Sept. 4, 2019	0 mg/L, 57°	4.6 mg/L, 58°	25 percent algae cover
Sept. 17, 2019	5.6 mg/L, 58°	9.1 mg/L, 58°	15 percent algae cover; removed Hobo for season

Table 7c: Field Measurements at Junction Falls Outflow

Date	Mid-Depth DO (mg/L) and Water Temperature (°F) per Hobo data logger	Near Surface DO (mg/L) and Water Temperature (°F) at data logger location using the YSI meter	Other Measurements/Observations
July 18, 2019	N/A; not yet deployed	5.2 mg/L, 63°	4.5 mg/L, 63° near S Fork inflow
July 23, 2019	9 mg/L, 59°	N/A – instrument malfunction	3.4 mg/L, 59° near S Fork inflow
Aug. 2, 2019	8.6 mg/L, 60°	7.3 mg/L, 60°	7.0 mg/L, 59° near S Fork inflow
Aug. 13, 2019	7.3 mg/L, 58°	8.8 mg/L, 59°	8.6 mg/L, 59° near S Fork inflow
Sept. 4, 2019	7.0 mg/L, 58°	7.1 mg/L, 57°	7.3 mg/L, 57° near S Fork inflow
Sept. 17, 2019	7.9 mg/L, 58°	7.9 mg/L, 59°	8.4 mg/L, 58° near S Fork inflow; removed Hobo for season

Table 7d: Field Measurements at Powell Falls Outflow

Date	Mid-Depth DO (mg/L) and Water Temperature (°F) per Hobo data logger	Near Surface DO (mg/L) and Water Temperature (°F) at data logger location using the YSI meter	Other Measurements/Observations
July 18, 2019	N/A not deployed	4 mg/L, 61°	
July 23, 2019	9.0 mg/L, 61°	N/A – instrument malfunction	
Aug. 2, 2019	6.1 mg/L, 61°	6.9 mg/L, 62°	7.6 mg/L, 60° below east end of dam
Aug. 13, 2019	9.5 mg/L, 62°	8.5 mg/L, 59°	7.3 mg/L, 58° 20 yds downstream of Hobo location
Sept. 4, 2019	5.4 mg/L, 59°	6.2 mg/L, 58°	6.2 mg/L, 57° 20 yds downstream of Hobo location
Sept. 17, 2019	6.5 mg/L, 58°	6.8 mg/L, 59°	6.9 mg/L, 59° 20 yds downstream of Hobo location; Hobo removed for season

Summary and Comments – 2019 Monitoring Season

The following general observations are based on the data summarized above and plotted in Appendix A.

- Flows entering the project area from the upper (unregulated) Kinnickinnic River consistently met state criteria for cold water fisheries, with dissolved oxygen concentrations never dropping below 7 mg/L and temperatures below 60° F, characteristic of a baseflow-dominated stream.
- From the upstream to the downstream limits of the study area, measured water temperatures typically increased by 3 to 4 degrees F on a given sampling day (Table 6).
- Measured dissolved oxygen concentrations generally decreased from upstream to downstream in the study area, although the amount of decrease was highly variable (Table 5).
- Dissolved oxygen concentrations at the three sites in or downstream of the dams' impoundments dropped well below 6 mg/L during some periods. In Lake George and at the outfall from Lake Louise, dissolved oxygen concentrations fell below the Class 1 trout stream standard in 37 percent and 29 percent of measurements respectively. Higher daytime water temperatures and reduced levels of dissolved oxygen are typical of small lakes in summer and would be expected in the project impoundments.
- The Junction Falls outflow showed fewer exceedances of the dissolved oxygen standard, possibly due to mixing in and below the spillway, and also possibly due to the introduction of flow from the South Fork near the sampling site.
- A comparison of the YSI near-surface grab samples and the Hobo mid-depth readings shows little evidence of stratification except in Lake George, where the near-surface reading often showed noticeably higher DO concentrations than the mid-depth reading.
- The 2019 sampling season did not include extreme hydrometeorological conditions. Streamflows throughout the study period were in approximately the top 30 percent of baseflows recorded for their respective months, based on the USGS gage period of record. The largest runoff event to occur during the sampling period peaked at 580 cubic feet per second, about 35 percent of the estimated two-year flood at the gage site (USGS Scientific Investigations Report 2016-5140) . Daily average temperatures were moderate, ranging from 55 °F to 75 °F.

Appendix A
Data Plots

