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Tailwater Monitoring During Periods of No Release; Cooper River Rediversion Canal: A Case Study

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Purpose

This technical note describes a case study involving use of a remote water quality monitor to identify potentially harmful water quality conditions in the tailwater and undertake preventive action.

Background

The Cooper River Rediversion Project, located near St. Stephen, SC, and operated by the U.S. Army Engineer District, Charleston, is a 10-mile-long canal that rediverts water from Lake Moultrie back to the Santee River (Figure 1). The St. Stephen Powerhouse, located midway along the canal, controls the releases from Lake Moultrie to the Santee River. This increased flow in the Santee River is necessary to aid navigation in Charleston Harbor. The powerhouse contains three turbines, capable of maximum total release of approximately 18,000 cfs. The canal is nutrient-rich, highly productive, and supports a thriving fishery.

In June 1991, a major fish kill occurred at the site. After 5 to 6 months of continuous releases, sufficient debris and mats of aquatic vegetation had accumulated on the intake trash racks to require halting generation to clean the racks. Seven days following cessation of generation, dead fish were observed in the tailrace. A large number of fish were found, including 5,000 to 6,000 large catfish, many weighing 20 lb or more. Though not proven, insufficient dissolved oxygen (DO) concentration (0.3 mg/L) was thought to have been responsible for the deaths.

The decision was made to attempt to dilute the water in the canal with well-oxygenated reservoir water. Because the main generators were still inoperable and the project had no tainter gates to spill water, the only release capacity was a fish lift that delivered approximately 200 cfs of lake water. After operators started the fish lift,



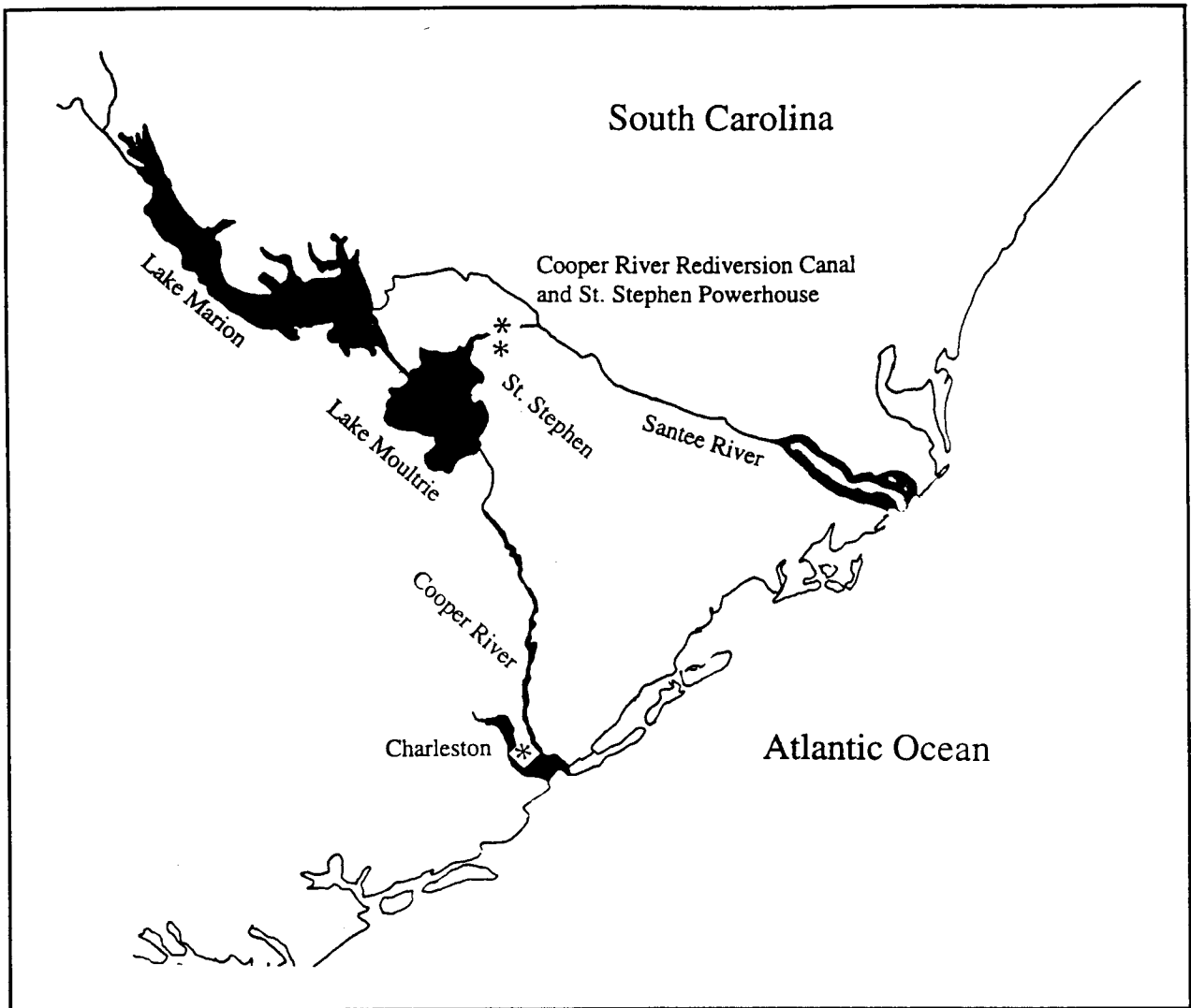


Figure 1. Study site, Cooper River Rediversion Canal

conditions in the tailrace improved. The anoxic water was subsequently displaced into the Santee River, however, where a second fish kill occurred.

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Initial Investigation

Personnel of the Corps' Charleston District and the U.S. Army Engineer Waterways Experiment Station, working with the South Carolina Wildlife and Marine Resources Department, determined that sufficient DO concentrations must be maintained in the tailrace to prevent future fish kills. To meet this objective, they devised a plan involving tailrace monitoring and supplemental releases for water quality enhancement.

After the powerhouse resumed normal operation, the resource manager manually recorded daily oxygen and temperature profiles in the tailrace near the powerhouse during nonrelease periods. Longitudinal transects of the canal and more intensive sampling during nongeneration periods supplemented daily monitoring. When the DO concentration in the tailwater decreased below 4 mg/L, the resource manager requested that the powerhouse release oxygenated water from Lake Moultrie to flush the canal.

Manual sampling provided useful data to understand the spatial and temporal dynamics of DO in the tailrace, but also prevented several problems. Extensive labor was required to adequately sample the tailrace. It was impossible to manually sample often enough to record the rapid diel changes in DO. Lowest DO concentrations typically occurred in the early morning between 0600 and 0730 hr; thus, measurements made during normal working hours were not representative of the worst water quality conditions. Hence, manual sampling was not suitable as a permanent monitoring solution. The decision was made to install a permanent remote monitor.

Remote Monitor Solution

The results of manual sampling indicated that anoxia first developed from the bottom of the canal near the dam and progressed both vertically toward the surface and longitudinally down the canal. Since the minimum DO concentrations were near the dam and on the bottom of the canal, a location on the wing wall of the dam was selected to represent the "worst case" situation.

The monitor system consisted of a water quality sonde, a wet well, and a computer to record data (Figure 2). The wet well, installed on the wing wall on the south side of the tailrace (Figure 3), was constructed of 6-in. schedule-40 polyvinyl chloride pipe. The bottom 10 ft of the pipe had 0.75-in. holes approximately every 2 in. to allow exchange of water. A cap installed on the lower end of the well prevented the sonde from dropping through and possibly becoming entangled.

A Hydrolab H20 water quality sonde (Hydrolab Corporation, Austin, TX) measured temperature, DO, pH, and specific conductivity. The sonde was connected to the powerhouse control room using conduit-encased cable. A waterproof Hydrolab cable was used along the wing wall where there was danger of submersion. Phone line (24-gauge, 4-wire) was used elsewhere. Inside the control room, a 12-V power supply provided power for the sonde. The cable from the sonde interfaced with a dedicated computer located in the resource manager's office via a serial port (RS 232) connection. An uninterruptible power supply (UPS) protected the system from power failure and surges. The sonde was set up, calibrated, and maintained according to standards detailed in the Hydrolab H20 operating manual.

Communication software having remote control capabilities (Norton pcANYWHERE AWREMOTE) allowed the resource manager to record data from the sonde. A modem and communication software (pcANYWHERE AWHOST) allowed remote users to view data or transfer stored files to their own computers. Because of this, the resource manager could call when not in the office, view tailwater conditions, and if necessary, request water quality enhancing releases.

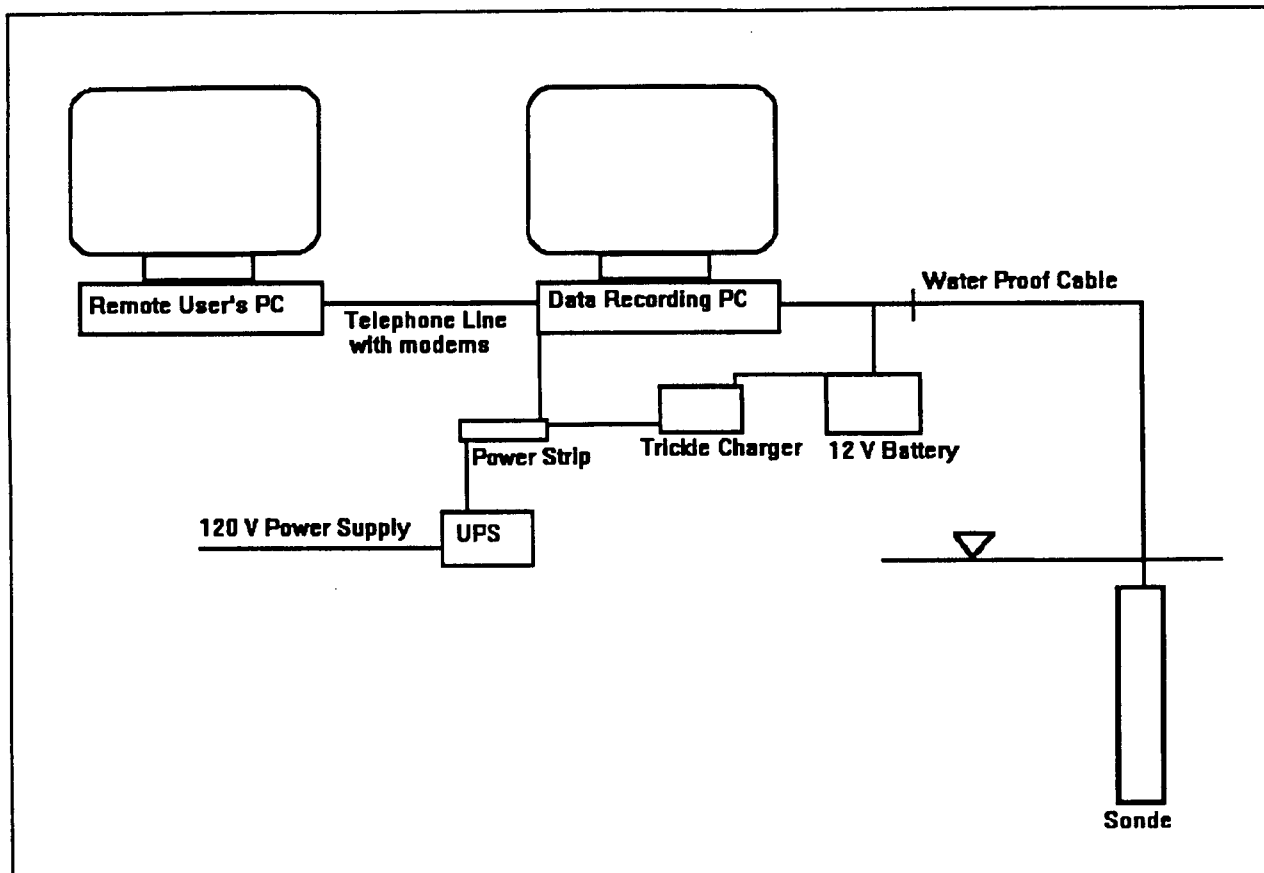


Figure 2. Schematic of typical monitor setup

A second sonde was kept on hand in the event of failure of the first. Also, the resource manager could calibrate the spare sonde while in the control room and then exchange it with the sonde in the wet well. The resource manager then cleaned, serviced, and stored the sonde from the field until the next calibration period. The resource manager calibrated the unit weekly.

The only notable difficulty in installing and starting the system was an initial attempt to record data on a nondedicated computer using Microsoft WINDOWS. This system, while possible in theory, proved difficult in practice because of problems associated with multitasking and the need for simultaneous communication through three serial ports in the computer. This configuration is not recommended.

A factory-set computer having an internal modem, a dedicated bus or PS/2 mouse port, and one spare serial port (GATEWAY 2000 4DX-33) was used successfully. However, the computing needs of the monitor system are minimal, and an inexpensive dedicated PC is adequate, preferable to attempting to multitask the monitoring operation.

The cost of a monitor system for temperature, DO, pH, and specific conductivity, consisting of one sonde, computer, and associated hardware and software, excluding installation labor, is approximately \$5,625 (Table 1).

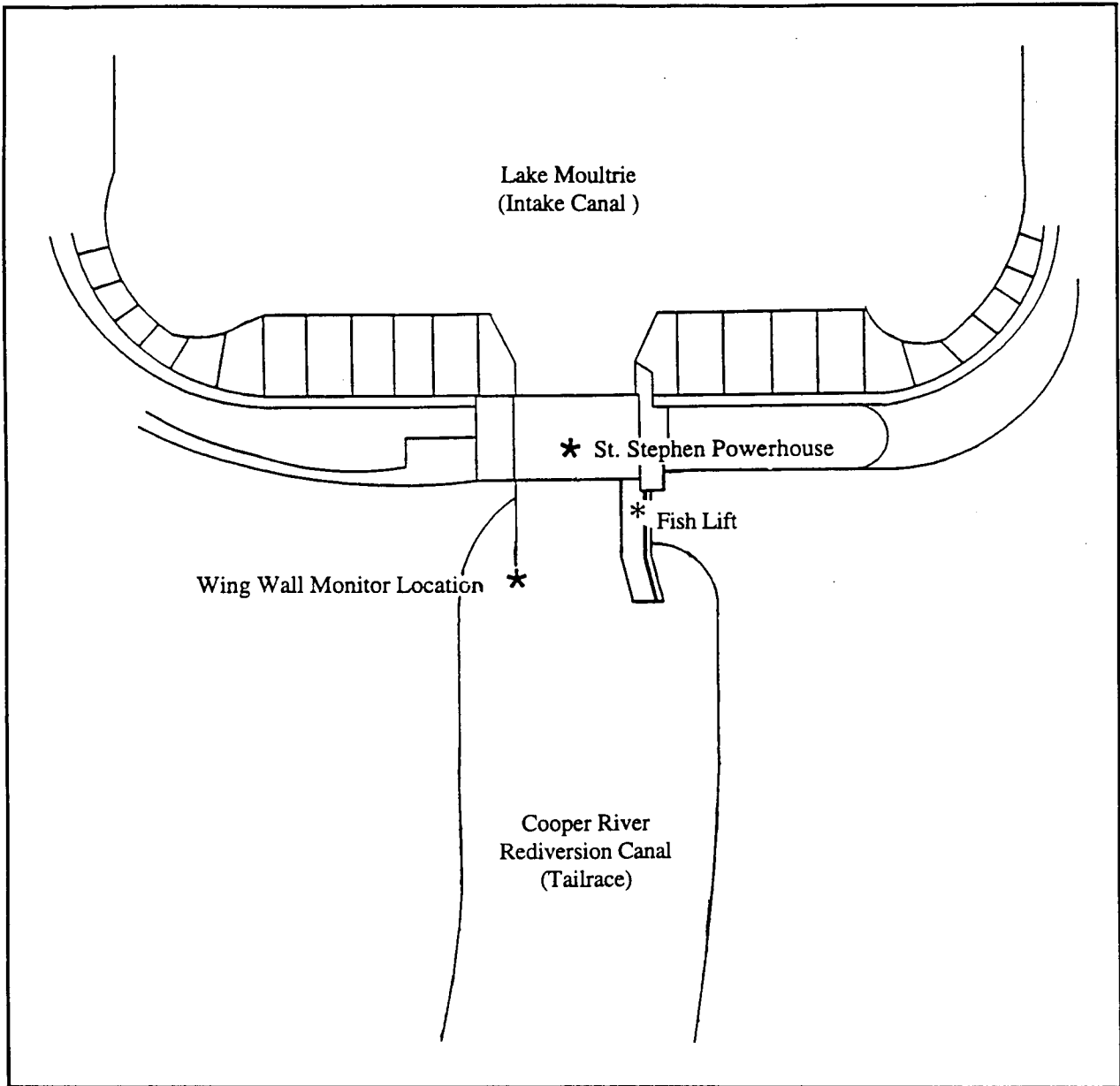


Figure 3. Plan view of St. Stephen dam monitoring site

Table 1 Cost of Materials for Monitor System	
Monitor System Components	Cost
Hydrolab H20 multiparameter water quality sonde (for DO, temperature, specific conductivity, and pH)	\$3,000
Weighted sensor guard	\$65
Underwater cable (25 m)	\$575
Battery to H20 cable	\$65
12-V battery	\$30
12-V trickle charger	\$20
Computer with built-in modem	\$1,500
Uninterrupted power supply	\$150
Power strip	\$20
Assorted pipe for wet well; conduit for H20 cable; assorted phone line and connections	\$200
Total	\$5,625

Monitor Use

Originally, the same criterion was used with the remote monitor as with the manual sampling described earlier. When the DO concentration in the tailrace decreased below 4.0 mg/L, the operator released water from the dam, flushing the tailrace with water having a greater DO concentration. The resource manager found that the monitor system provided a temporal record that allowed him to confidently make decisions regarding the necessity of release for water quality maintenance. Also, the temporal record demonstrated compliance with the management criterion for maintaining sufficient DO in the fishery.

The procedure satisfied the South Carolina Wildlife and Marine Resources Department, but the public utility that owned the reservoir became concerned about the frequency of releases during critical summer periods. This caused Charleston District personnel to reexamine the release criterion.

The monitor provided a temporal record of DO, temperature, pH, and specific conductivity. A close inspection of this record revealed a diel variation of DO concentration (Figure 4). During periods when releases had not occurred for several days, natural variations of DO concentration greater than 3.5 mg/L in a 12-hr period were observed. Variations were due to photosynthesis increasing DO concentrations during daylight hours and respiration decreasing DO concentrations at night.

Noting this variation, the Charleston District adopted a release criterion of requiring the release of water whenever the DO concentration dropped below 3.0 mg/L for 8 hr or longer (Figure 5). This decreased the number of water quality-enhancing releases

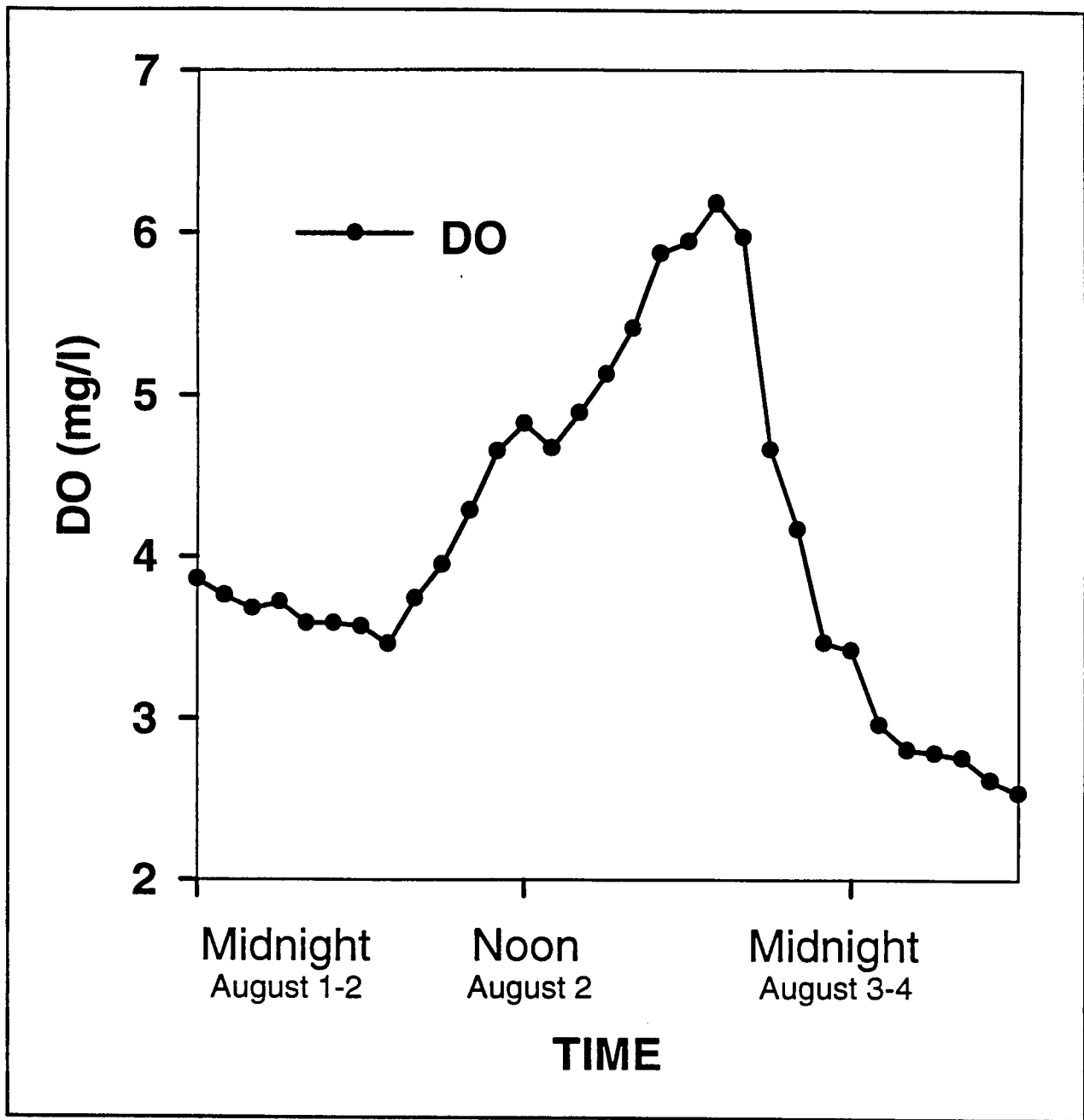


Figure 4. Natural diel variation of dissolved oxygen (during periods of no-release), August 1-4, 1993

because the tailrace is often reoxygenated to an acceptable concentration by photosynthesis. Because the data were collected at the wing wall, which had the minimum DO concentration of the tailwater, the majority of the tailwater had a DO concentration greater than that recorded by the monitor. Since establishment of this criterion, no fishery problems related to insufficient DO have occurred.

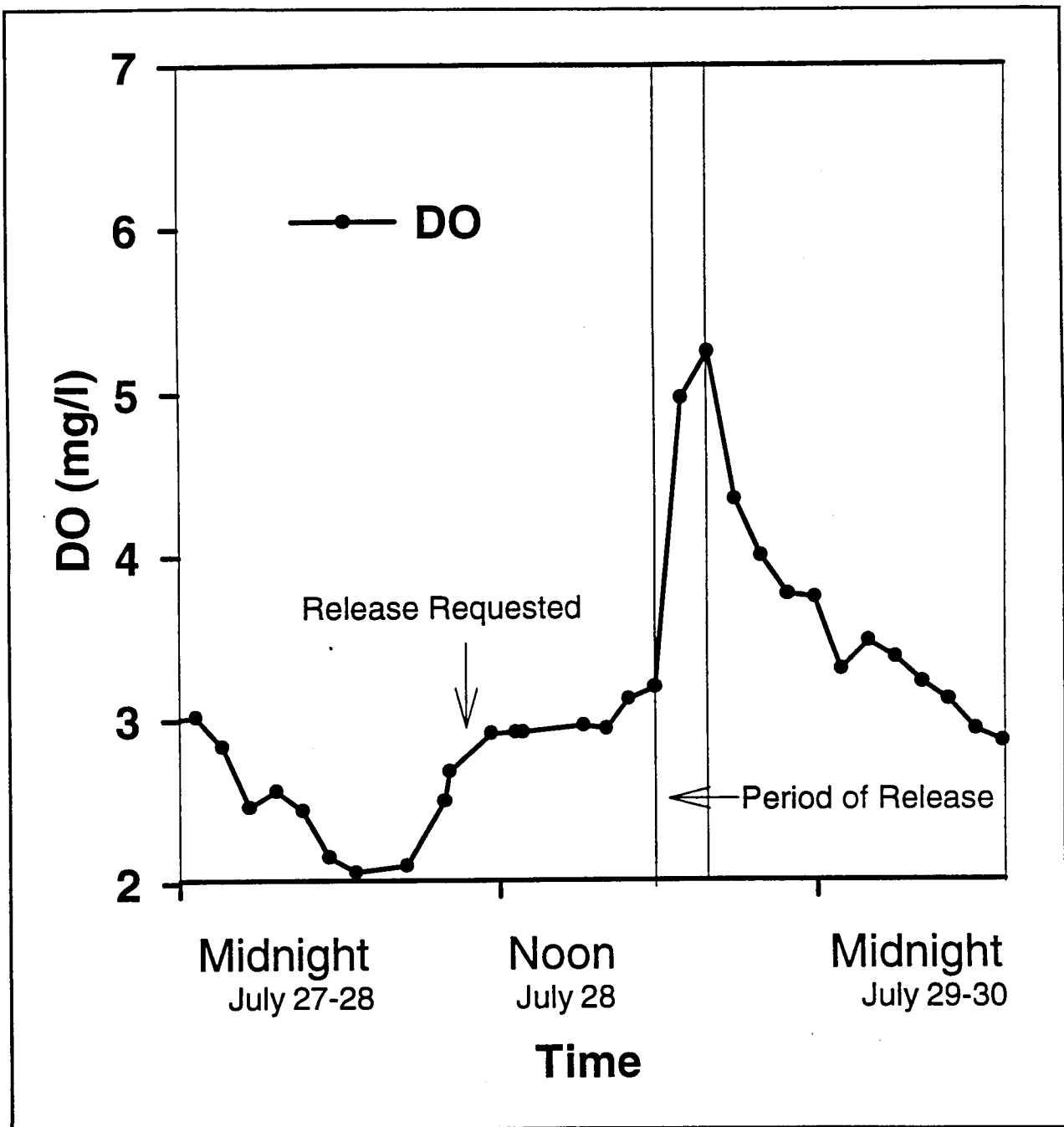


Figure 5. Release to enhance water quality, July 1993

Conclusions

The use of a remote water quality monitor at St. Stephen Powerhouse enabled the resource manager to identify potentially harmful water quality conditions in the tailwater and take preventive action. The monitor has allowed him to determine when to request water quality-enhancing releases and provided him with a record to validate his decisions. Further, the monitor aids the resource manager in minimizing the

number of releases and scheduling them during peak power needs, thus conserving hydropower resources while meeting the needs of the fishery resource.

Point of Contact

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