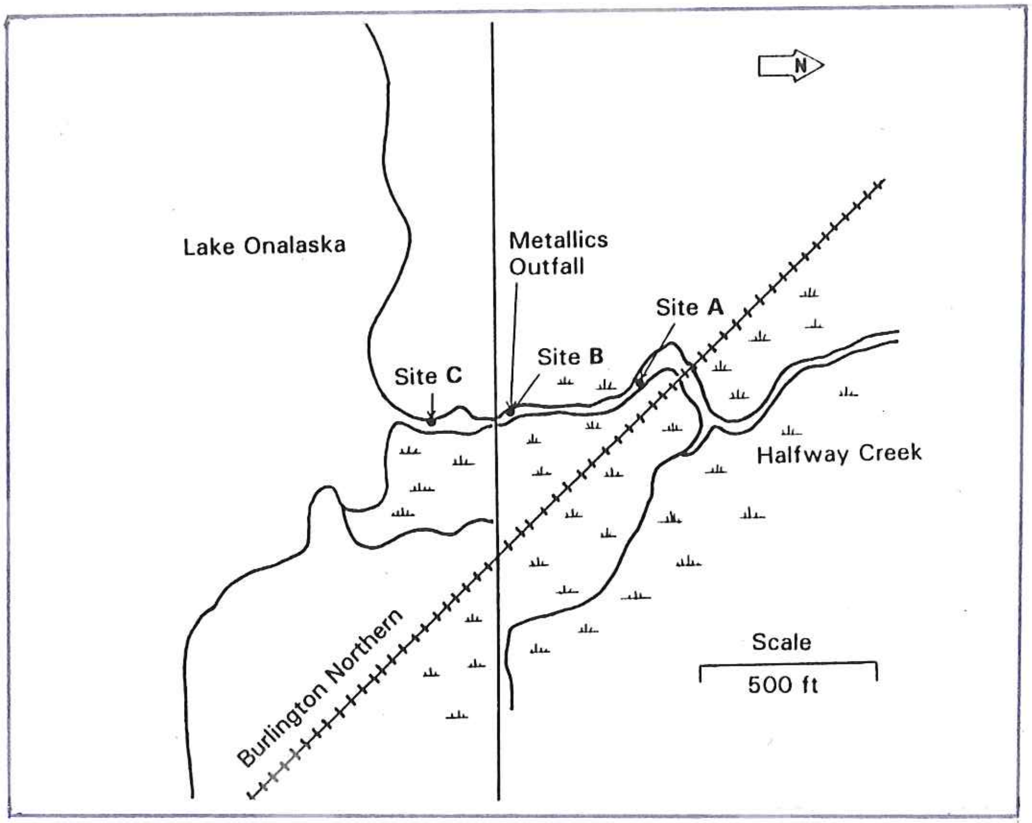
Continuous Water Quality Monitoring Survey in Halfway Creek Upstream and Downstream of Metallics Incorporated's Outfall



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INTRODUCTION

Metallics Incorporated began discharging process wastewater to Halfway Creek in 1988. This discharge has generated considerable local interest and has been the subject of many meetings of the Lake Onalaska Protection and Rehabilitation District. In addition, the U.S. Fish and Wildlife Service has played a role in the WPDES permit negotiations with the permittee and the Department since Metallics' outfall is within the Upper Mississippi River Wildlife and Fish Refuge.

Metallics is a metal etching facility located in Brice Prairie just a few miles west of Onalaska, Wisconsin. The facility's wastewater includes metal finishing wastewater, non-contact cooling water (NCCW), industrial rinse water, sanitary wastewater and boiler blowdown. Metal finishing wastewater and NCCW are monitored separately and then are combined and treated before being discharged to the mouth of Halfway Creek about 0.5 miles east of the facility. The total flow amounts to about 20,000 to 25,000 gpd with an equal portion coming from finishing wastewaters and NCCW. The remaining wastewaters are routed to land treatment systems near their facility.

The purpose of this survey was to evaluate potential water quality impacts associated with the Metallics' discharge using automated monitoring equipment. A second purpose was to evaluate the effectiveness of the monitoring equipment over an extended field sampling period.

Study Area

Halfway Creek is a "flashy" 44 mi^2 watershed (including Sand Lake Coulee Creek) that drains to Lake Onalaska at Pool 7 of the Upper Mississippi River. The 10-year, 7-day average low flow of Halfway Creek was estimated to be 3.8 cfs at CTH ZN west of Midway, Wisconsin (Holmstrom, 1979). An estimate of Sand Lake Coulee Creek was not available but would likely be less than 1 cfs since its watershed is only 8 mi^2. Maximum 2-year flows are reported to be 540 and 280 cfs for Halfway Creek and Sand Lake Coulee Creek, respectively (Vierbicher Associates, Inc. 1995).

Land use for the entire Halfway Creek watershed comprises 45% wooded, 42% agricultural, 4.5% urban with the remainder open space (Vierbicher Associates, Inc 1995). Gully, streambank, and soil erosion from both agricultural and urban lands are contributing to high sediment loads. Sediment traps have been placed in the marsh area near Midway and at the mouth of Halfway Creek in Lake Onalaska to reduce downstream transport.

This monitoring study was limited to the last several hundred feet of Halfway Creek prior to its discharge to Lake Onalaska (Figure 1).

Site A was located in the center of the stream about 400 ft above CTH Z. Patches of sand substrate were present near the center with black silty material along the edges. Sago pondweed was very abundant and covered approximately 80 % of the stream's cross-section. The width was about 25 ft and had an average depth of approximately 1 ft. The current velocity was about 1 ft/s.

Site B was located 9 feet below the Metallics' outfall and 27 feet above the CTH Z culvert. Sago pond weed was common and the substrate was dominated by black silty material with some sand. The stream width was about 20 feet and had an average depth of about 1 ft. The current velocity was slightly less than 1 ft/s.

Site C was located about 200 ft below CTH Z and upstream from the open water portion of Lake Onalaska. Sago pondweed and coontail were common and were growing in a silty substrate. The channel width was about 15 ft and the average depth was approximately 1.5 ft. The current velocity was noticeably lower at this location (0.3 ft/s) due to the influence of Lake Onalaska and the larger cross section. Additional site information is provided in Table 1.

METHODS

Continuous automatic water quality monitoring equipment was placed at all three sites on September 25, 1996. The parameters included dissolved oxygen (DO), pH, conductivity, and temperature. A Hydrolab DataSonde® 3 unit was placed at Site A and YSI model 6000 units were placed at Sites B and C. The units were mounted to a small metal stake near the central portion of the stream. Submerged aquatic vegetation was removed in the immediate vicinity of the units to avoid fouling the sensors with plant material and other debris. The equipment was mounted at mid-depth or deeper to help conceal the units and to help avoid entanglement with floating debris.

The automatic monitoring units were pre-calibrated in the laboratory and set to log field data at 30 minute intervals. The Hydrolab unit was provided by the WDNR's Resource Trend Analysis Field Station at Onalaska, Wisconsin. The YSI units were obtained from the WDNR's Western Region office at Eau Claire, Wisconsin.

Field monitoring equipment included a YSI SCT conductivity meter, YSI model 57 dissolved oxygen and temperature meter, certified thermometer and a Marsh-McBirney model 201D current meter. Field monitoring equipment was used to take grab sample measurements at approximately 2-4 day intervals during the study period at each of the three sites. These grab samples provided a field check to verify the accuracy of the automatic monitoring equipment. Continuous monitoring probes were flushed with site water and debris was removed from the probes after making the field verification measurement.

Upon completion of the monitoring period on October 9, 1996, the continuous monitoring equipment was placed in a large pail of Halfway Creek water for post calibration verification. The units were then transported to the lab where the data were downloaded to a PC. Data were imported to a Lotus version 3.1 spreadsheet for evaluation and graphical analysis. Both grab and continuous conductivity measurements were adjusted to 25°C for reporting purposes.

Standard metallic minnow traps were placed at Site A on September 29, 1996 to collect feral fish for an in-situ bioassay. Ten young-of-year bluegills collected from these traps were placed in

Metallics' wastewater plume on October 2, 1996. The upstream portion of the minnow trap was oriented just a few inches east of effluent pipe termination. Due to insufficient number of bluegills, no upstream control was possible. The effluent-exposed bluegills were checked after 3 and 7 days to assess survival and general condition.

RESULTS and DISCUSSION

General Information

Stream stage levels and flows increased markedly after deployment of the monitoring equipment on September 25. This was associated with moderate precipitation falling in the basin between September 25 and 27 as recorded at the Holmen wastewater treatment plant. The plant operator reported 0.45 and 1.2 inches on September 25 and 26, respectively. Stage levels increased about 1 ft at Sites A and B based on the September 27 survey. Stream velocities exhibited the highest values (0.6-1.5 ft/s) on this date (Table 2). Water clarity decreased substantially during the runoff period due to increased suspended materials. There was no substantial precipitation or runoff for the remainder of the monitoring period.

Floating plant debris accumulated around the continuous monitoring probes during various periods. This problem was especially noted at Site A following the initial runoff period. Accumulation of heavy vegetation around the monitoring probes at Site A could have influenced the monitoring results at this location. However, no data were logged at this site due to a complete loss of battery power during the deployment period. Partial power failure also occurred in the continuous monitoring equipment deployed at Site C and resulted in a loss of data at this site after October 3.

Moderate accumulation of plant debris on the monitoring equipment was noted at times at Site C. However, probe fouling was not so severe as to cause complete isolation with ambient stream water at this site. There were no problems with probe fouling at Site B.

Water Temperature

The YSI continuous monitoring equipment provided very accurate water temperature data based on a comparison to grab measurements with a certified thermometer. The relative percent difference (R%D) between the automated equipment and grab samples ranged from 0 to 2% (Table 2).

Stream temperatures ranged from 6 to 19°C during the monitoring period (Figure 2A). Daily temperature fluctuations were about 4 to 8°C and are likely characteristic of fall weather. A relatively large daily temperature change of 10°C was noted between October 2 and 3. The flat temperature profile recorded on September 26 and 27 reflected a period of cloud cover and runoff.

Grab measurements at Site A and continuous temperature measurements made at Sites B and C were essentially identical (Figure 2A). The thermal discharge from Metallics (Figure 3A) or groundwater inputs did not contribute to any measurable changes in stream temperatures observed in the study reach.

Dissolved Oxygen

Field verification of the continuous monitoring DO data at Sites B and C indicated very good agreement to grab samples collected with independent equipment (Table 2). The R%D between the continuous monitors and grab samples ranged from 0 to 4.7 %.

DO concentrations (Figure 2B) and DO saturation (Figure 2C) showed moderately large diurnal variations following the initial runoff period. These diurnal "swings" are typical of a stream that is moderately to heavily vegetated by submersed macrophytes. There was little change in DO between the three sites. This would indicate photosynthetic and respiratory processes (ie. chemical and sediment oxygen demand) were similar in the stream reach. The lack of diurnal DO swings during September 26 and 27 resulted from cloud cover and turbid water which greatly reduced photosynthetic activity during this period.

Metallics' effluent does not contain organic wastes or wastes that would contribute to a significant chemical oxygen demand. The effluent does contain small amounts of ammonia nitrogen that could result in a small oxygen demand due to nitrification. However, the small ammonia loads and the short travel time to the downstream monitoring sites wouldn't be expected to contribute to a measurable DO depletion in the study reach.

Conductivity

Grab conductivity measurements made with the YSI SCT meter yielded values that were substantially greater than the continuous monitoring equipment (Table 2). The R%D between grab measurements and those recorded with the two YSI continuous monitoring devices ranged from 36 to 61%. Post calibration checks using various conductivity standards could not isolate the problem. Therefore, the continuous monitoring data were adjusted to yield data comparable to grab measurements collected with the YSI SCT meter. Although the accuracy of the conductivity measurements remain in question, the data are still valuable for assessing temporal trends and spatial differences.

Adjusted continuous conductivity measurements at Sites B and C were influenced by the initial runoff period and by Metallics' discharge at Site B. The initial runoff event contributed to a dilution of dissolved solids in the stream as reflected by the downward conductivity profile (Figure 2D). This is best illustrated by the conductivity measurements recorded at Site C. Measurements at Site B were similarly affected, but this station had an unusual and unexplained flat response between September 27 and 28.

Sporadic spikes in corrected conductivity measurements recorded at Site B (Figure 2D) reflect pulses of Metallics' wastewater discharge. The conductivity of Metallics' effluent was measured during the initial deployment on September 25 and ranged from 2,300 to 2,500 μS/cm at 25°C. These conductivity measurements are typical of a wastewater discharge that has moderate amounts of dissolved solids. Chloride concentrations in Metallics' wastewater was likely the principal agent contributing to these conductivity fluctuations observed at Site B. September and October discharge monitoring results reported by Metallics indicated chloride concentrations of 506 and 307 mg/L, respectively.

Changes in stream turbulence and flow in combination with Metallics' effluent conductivity variability resulted in the "spiky" pattern observed at Site B. This pattern was absent on weekends when there was no wastewater discharge (Figure 3A). Grab conductivity measurements made at Site B with the YSI SCT meter (Table 2) also showed moderate variation and was again attributed to Metallics' discharge.

Grab conductivity measurements collected across the stream immediately above CTH Z culvert and about 25 ft below Metallics' outfall indicated a distinct sub-surface effluent plume along the right descending bank. The plume was just off the bottom in about 2 ft of water and was approximately 1 ft wide. There was no discernable conductivity plume noted at Site C and likely reflects increased mixing processes, especially below the CTH Z culvert where increased turbulence was noted.

pH

No grab pH measurements were made to compare to the continuous monitoring equipment. Pre- and post-calibration checks did not indicate any problems with the pH measurements.

Site B pH had consistently lower pH than Site C (Figure 2E). However, this difference was only about 0.2 pH units which was equivalent to the reported accuracy of the YSI 6000 monitors. The maximum difference between these sites seemed to be greater during the morning hours prior to daylight. The reason for this response was not determined. The pH differences between the two sites was not expected since temperature and dissolved measurements were very similar. Metallics' effluent was not believed to be a factor since the pH differences were still present during weekends when Metallics was not discharging wastewater (Figure 3A and B). It was suspected the spatial pH difference was primarily due to instrument error.

Caged Fish Bioassay

Feral young-of-year bluegills deployed adjacent to Metallics' discharge and within the effluent plume did not indicate acute toxicity based on a 7-day deployment period. The fish appeared healthy and active based on observations made after 3 and 7-days. No measurements of chronic toxicity were performed.

SUMMARY and CONCLUSIONS

A continuous water quality monitoring survey was conducted above and below Metallics' discharge to Halfway Creek between September 25 and October 9, 1996. Power failures with two of three automatic monitors resulted in partial to complete loss of continuous monitoring data during the deployment period. However, continuous monitoring data collected at two sites below the Metallics' outfall in combination with grab sampling above the discharge, provided sufficient information to make assessments of the wastewater impacts on Halfway Creek water quality.

Metal finishing wastewater flows (exclusive of noncontact cooling water) from Metallics ranged from about 5,000 to 14,000 gpd during the study period. There was no discharge reported during Saturdays and Sundays.

Metallics' effluent was found to have moderately high conductivity (2,300-2,500 μS/cm @ 25°C) in comparison to the receiving stream (516-593 μS/cm @ 25°C) based on grab measurements at and above the outfall, respectively. The wastewater was not completely mixed into the stream at the point of discharge based on downstream conductivity measurements. A conductivity plume was detected with grab sampling equipment just above the CTH Z culvert. Continuous monitoring data exhibited pulses of wastewater-induced conductivity fluctuations at a monitoring site 9 ft below the outfall. The accuracy of the conductivity data remain in question due to a disagreement in conductivity results between grab measurements collected with the YSI SCT meter and the YSI 6000 continuous monitoring equipment.

The Metallics' effluent was believed to have no measurable impact on the receiving water temperature, DO or pH. Grab measurements of water temperature and DO collected with a YSI 57 field meter or certified thermometer provided excellent agreement with the YSI 6000 continuous monitors.

Deployment of feral young-of-year bluegills in the Metallics' wastewater plume did not indicate acute toxicity during a 7-day exposure period.

REFERENCES

Holmstrum, B.K. 1979. Low-flow characteristics of streams in the Trempealeau-Black River Basin, Wisconsin, Open-File Report 79-9. U.S. Geological Survey, Madison, WI, 70 p.

Vierbicher Associates, Inc. 1995. Final report Hydraulic and Sedimentation Study Town of Onalaska, WI, Reedsburg, WI.

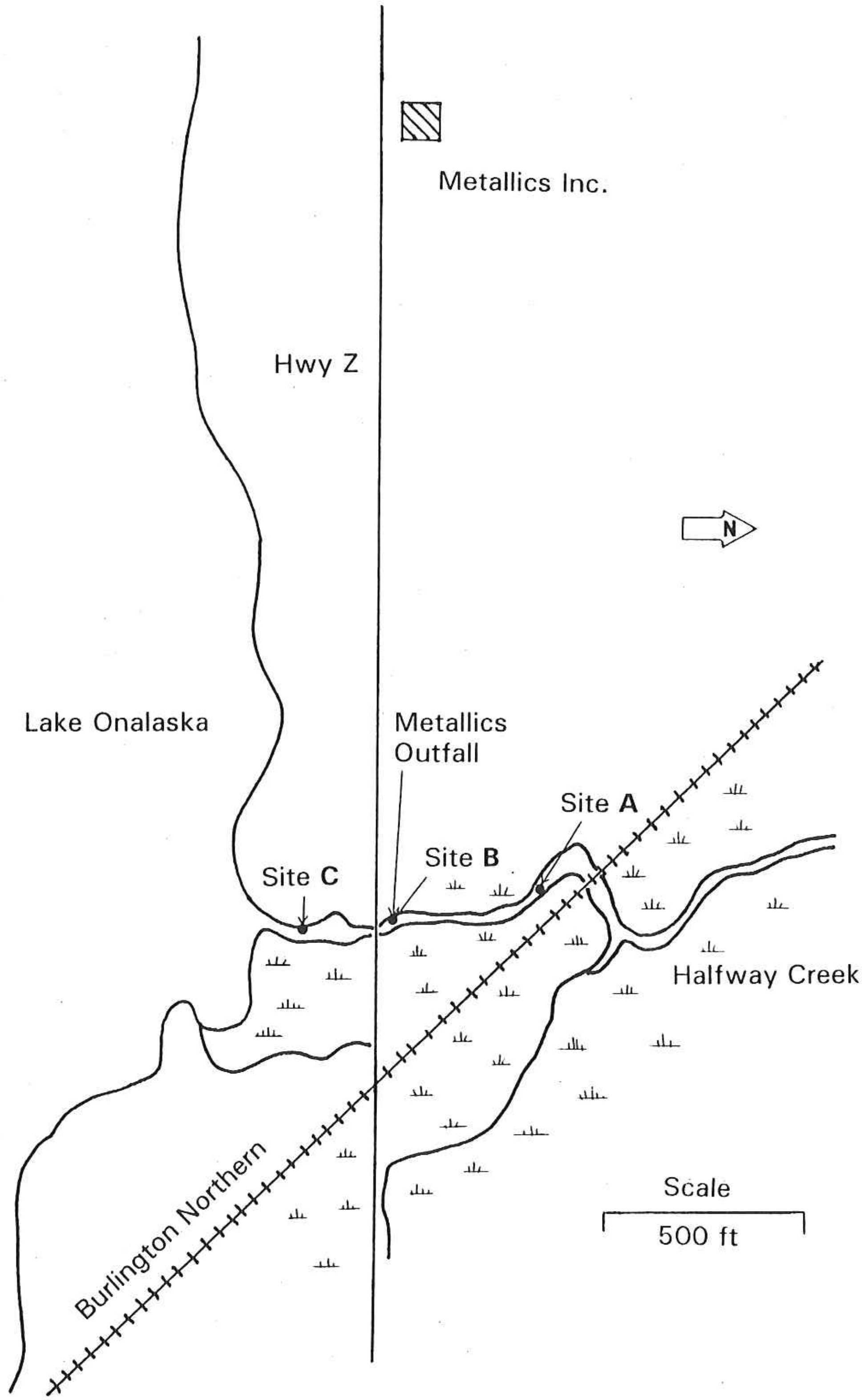

Figure 1. Halfway Creek Study Area

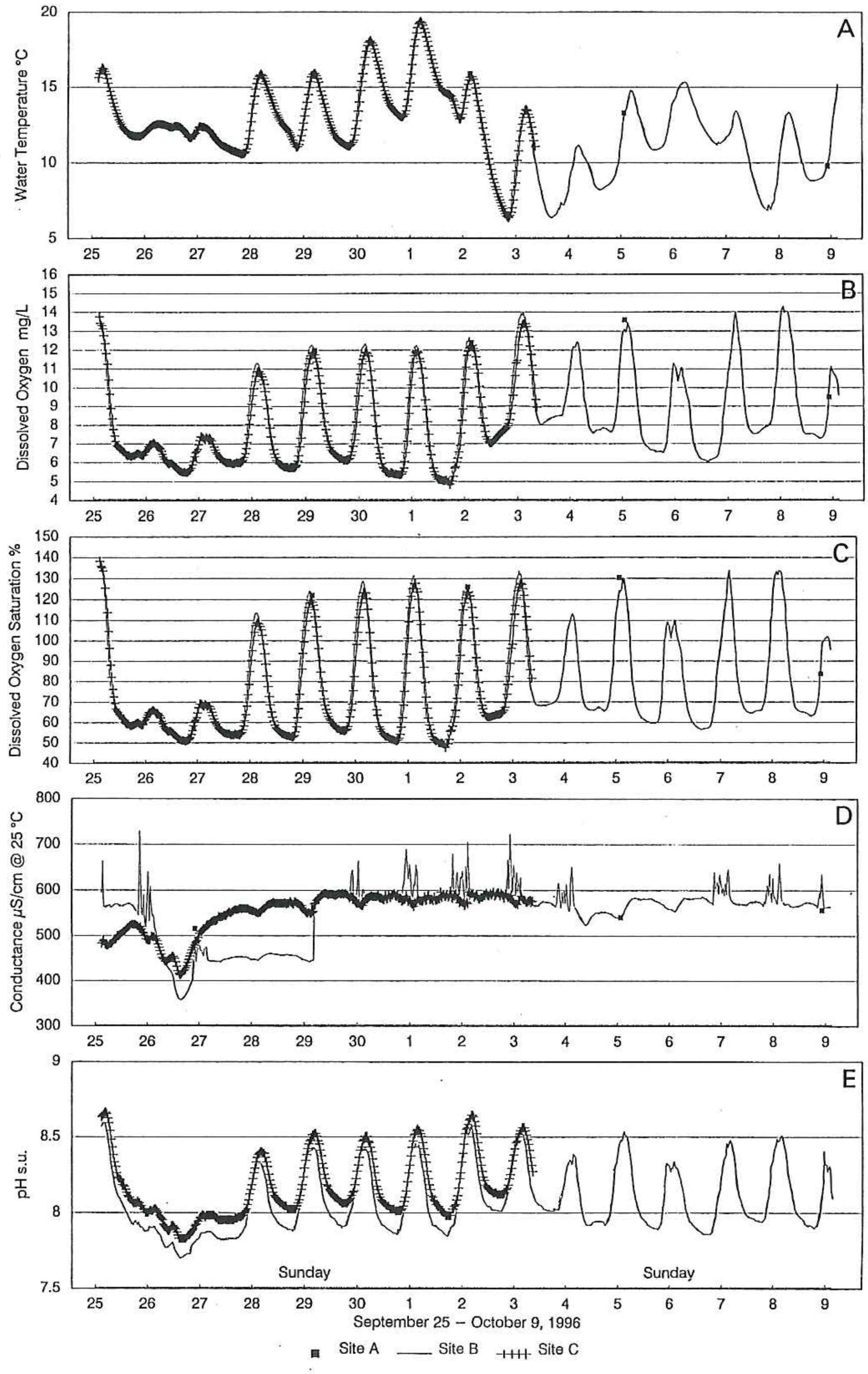

Figure 2. Water quality monitoring in Halfway Creek above (Site A) and below (Sites B & C) Metallics' wastewater discharge to Halfway Creek during later September and early October 1996. The data include: water temperature (**A**), dissolved oxygen (**B**), dissolved oxygen saturation (**C**), conductivity (**D**), and pH (**E**). Site A data are grab sample measurements. Site B and C data represent automatic monitoring data collected at 30 minute intervals.

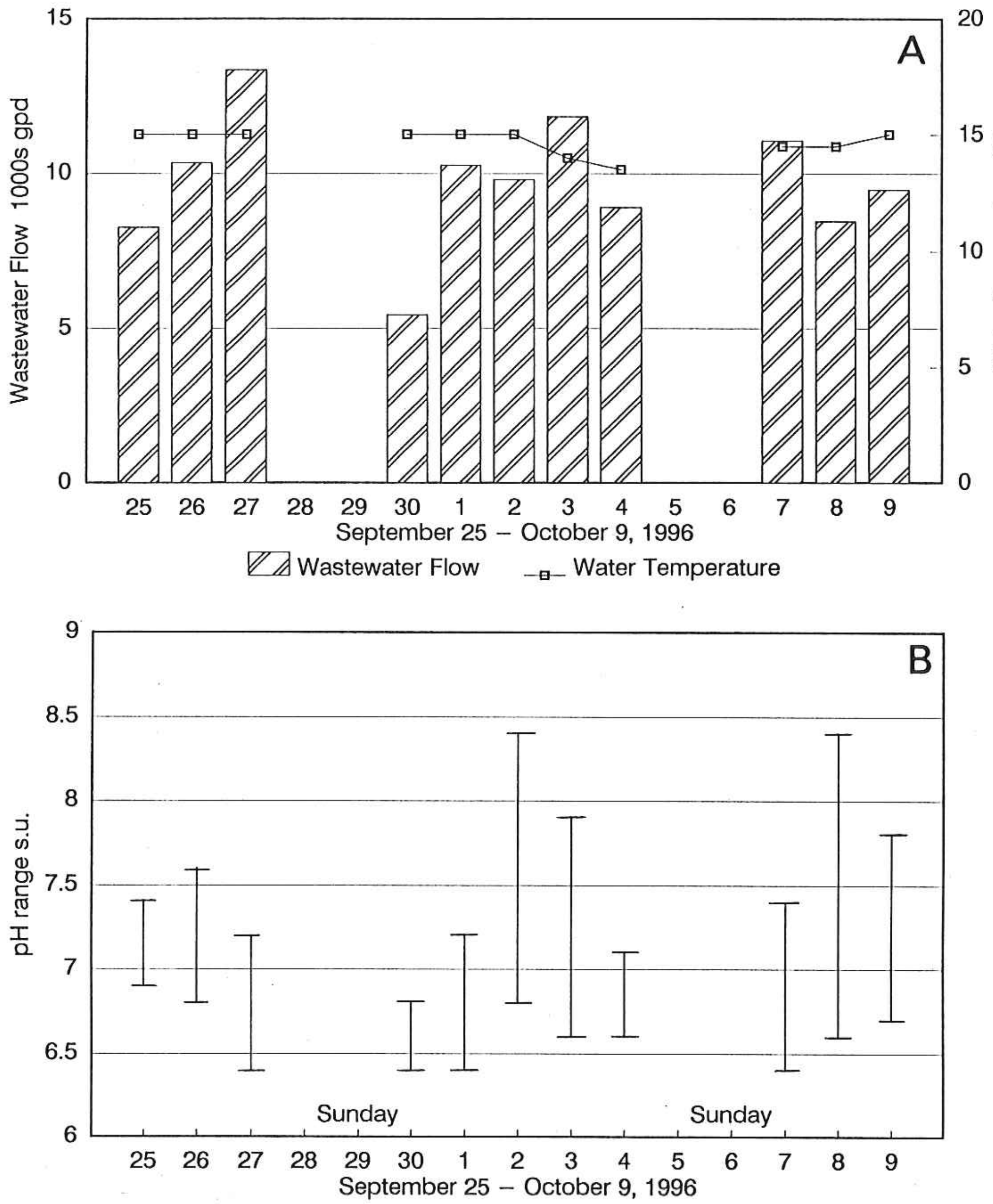

Figure 3. **A.** Metallics' wastewater flow and temperature. The flow data do not include non-contact cooling water. **B.** Metallics' effluent pH range. Data obtained from discharge monitoring reports submitted to the Wisconsin Department of Natural Resources by Metallics, Inc. for September and October 1996.

Table 1. Monitoring site information for Halfway Creek water quality survey conducted between September 25 and October 9, 1996.

Site	(1) Latitude deg. min.	(1) Longitude deg. min.	(2) Depth ft	(2) Current Velocity ft/s	Auto. Monitor Used	Specific Site Comments
A	43 55.039	91 15.574	1.5	1.0	Hydrolab DataSonde	Center of stream about 400 ft upstream of CTH Z. Sandy substrate with silty material under sand. Sago pondweed was abundant. Some elodea and coontail was also present. Water quality and physical measurements were made at a depth of 1 ft. Substantial black silty material along the edge.
B	43 54.978	91 15.556	1.7	0.8	YSI Model 6000UPG	Just west of stream's center about 9 feet below Metallic's Inc. outfall pipe and 27 feet above CTY Z culvert. Substrate was silty with patches of sands over fine material. Sago pondweed was common. Water quality and physical measurements were made at a depth of 1.3 feet.
C	43 54.939	91 15.542	2.0	0.3	YSI Model 6000UPG	Just west of stream's center about 200 feet below CTH Z culvert. Substrate was silty. Lemna was abundant. Sago and coontail were common. Water quality and physical measurments were made at a depth of 1.5 feet.

1 - An average of 100 fixes measured October 9, 1996 in 2D differential mode. North American Datum 1983.

2 - Measured on September 25, 1996.

Table 2. Water Quality Monitoring data for Halfway Creek based on field grab samples and continous automatic monitoring equipment. Automatic monitoring data were derived from the nearest logged values collected at 30 minute intervals.

					Temperature C			Dissolved Oxygen mg/L			Specific Conductance µS/cm @ 25C				
Date	Site	Time 24hr	Total Depth ft	Sample Depth ft	Grab	Auto. Mon.	R%D	Grab	Auto. Mon.	R%D	Grab	Auto. Mon.	R%D	Vel. ft/s	Comments
9-25-96	A	9:45	1.5	1.0	nd	nd	nd	nd	nd	nd	nd	nd	nd	1.0	Installed Hydrolab monitor
	B	11:45	1.7	1.3	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.8	Installed YSI monitor
	C	12:30	2.0	1.5	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.3	Installed YSI monitor
9-27-96	A	10:00	2.5	1.5	11.7	nd	nd	6.2	nd	nd	516	nd	nd	1.3	Moderate veg. near probe, turbid
	B	11:25	2.3	1.8	11.9	12.0	-0.8	6.6	6.9	-4.4	533-600	324	54.5	1.5	No veg. near probe, turbid
	C	11:45	2.1	1.6	12.2	12.0	1.7	6.6	6.8	-3.0	519	342	41.1	0.6	Moderate veg. on probe, turbid
9-29-96	A	15:50	2.2	1.1	15.9	nd	nd	12.0	nd	nd	563	nd	nd	0.9	Heavy veg. around probe
	B	16:05	2.0	1.5	15.8	16.0	-1.3	11.9	11.9	0.0	564-582	306	60.8	0.9	No veg. near probe
	C	16:25	2.2	1.5	15.9	15.9	0.0	11.8	11.6	1.7	563	390	36.3	0.3	No veg. near probe
10-2-96	A	15:25	2.0	1.0	15.9	nd	nd	12.4	nd	nd	593	nd	nd	0.8	Moderate veg. near probe
	B	16:00	1.7	1.1	15.5	15.8	-1.9	12.0	12.3	-2.5	605-611	402	40.8	0.7	No veg. near probe.
	C	16:25	1.8	1.1	15.6	15.6	0.0	11.8	12.1	-2.5	597	407	37.8	0.3	Some veg. around probe.
10-5-96	A	13:45	2.0	1.1	13.3	nd	nd	13.6	nd	nd	541	nd	nd	0.9	Heavy veg. near probe
	B	14:05	2.0	1.4	13.1	13.2	-0.8	13.3	12.9	3.1	550	368	39.7	0.7	No veg. near probe
	C	14:25	2.1	1.5	13.4	nd	nd	13.0	nd	nd	546	nd	nd	0.4	No veg. near probe
10-9-96	A	10:20	nd	nd	9.8	nd	nd	9.5	nd	nd	557	nd	nd	0.8	Mod. veg. Pulled probe at 10:35
	B	11:00	1.9	1.2	10.2	10.2	0.0	10.4	10.5	-1.0	572-613	403	38.1	0.9	No veg. Pulled probe at 11:15
	C	11:25	2.0	1.3	10.3	nd	nd	9.9	nd	nd	563	nd	nd	0.3	Mod. veg. Pulled probe at 11:32
10-9-96	Pail	12:05	nd	nd	11.2	10.9*	2.7	10.5	11.0*	-4.7	550*	384*	35.5	nd	Calibration check at landing

R%D = Relative percent difference. Note: the mid range of grab conductance values were used where necessary.
nd = no data
Vel = Current velocity
Auto. Mon = Automatic monitor
* - Automatic Monitor from Site B