APPENDIX

Methods and Results of Field Surveys Collected in 1977 and 1978
on the Upper Wisconsin River for the Development
of a water quality computer model

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Abstract

Measurements of water quality, time-of-travel, dispersion coefficients, and sediment oxygen demand (SOD) of the Upper Wisconsin River were determined in 1977 and 1978. This information was collected to provide an information base for the calibration and verification of the Qual-III water quality model. This model will be used to formulate the wasteload allocations for water quality limited segments in sections of the Upper Wisconsin River.

A noticeable improvement in water quality was found when compared to previous water quality surveys. This was reflected in increased dissolved oxygen levels over previous surveys, although the dissolved oxygen standard for fish and aquatic life (5 mg/l) was still not met in some segments of the river.

Field measurements of sediment oxygen demand, corrected to 20°C, usually ranged from 0.5 to 3.0 gO_2/m^2/day. This method suffered from large experimental error and the results could not be used to establish a relationship between SOD and substrate type or location. The average SOD rates using the core procedure on sediment samples collected during the 1977-1978 winter period were 0.12 g O_2/m^2/day at 4°C and 0.59 gO_2/m^2/day at 20°C. The latter rate corresponded to an estimated summer *in situ* rate of approximately 1.0 g O_2/m^2/day at 20°C when a seasonal correction was considered. A definite relationship between substrate and SOD at 4°C was not evident using the core method.

A discussion of the SOD temperature correction coefficient used in the Qual-III model is made. The core results indicate that the formulation for temperature correction deviates from that predicted from 4 and 20^{o}C SOD rates. This deviation does not present a problem with present modelling efforts since the model is not being used under such wide temperature fluctuations.

Acknowledgements

Survey participants included: Robert Martini, 208 Task Force Leader; Robert Young, Field Team Leader; and James Hamala, Richard Rhinehardt, Jack Taylor and John Sullivan, field team members. John Rogers was responsible for project design and also assisted in field surveys. Illustrations were prepared by John Sullivan. Dean Hammermeister, a graduate student of the University of Wisconsin - Stevens Point, was responsible for sediment oxygen demand determination using sediment cores and also provided valuable insight on the core SOD methodology and analysis. Special acknowledgement is given to the Natural Resources Department, University of Wisconsin - Stevens Point, for use of their facilities.

Introduction

These studies were conducted to gather information necessary for the development of a water quality computer model (Qual-III) for the Upper Wisconsin River. The computer model was developed by the Wisconsin Department of Natural Resources to assist in the determination of wasteload allocations for the Upper Wisconsin River. The establishment of wasteload allocations is part of the areawide water quality management planning process under Section 301 of the Federal Clean Water Act. This national law requires that, wherever possible, waters of every state should reach "fishable and swimmable" quality by 1983.

The objectives of these investigations were:

1. To collect information on water quality for the calibration of a computer model.

2. To determine time-of-travel measurements and longitudinal dispersion coefficients for segments of the Upper Wisconsin River.

3. To determine rates of sediment oxygen demand under summer and winter conditions. To study the relationship between substrate and rates of sediment oxygen demand.

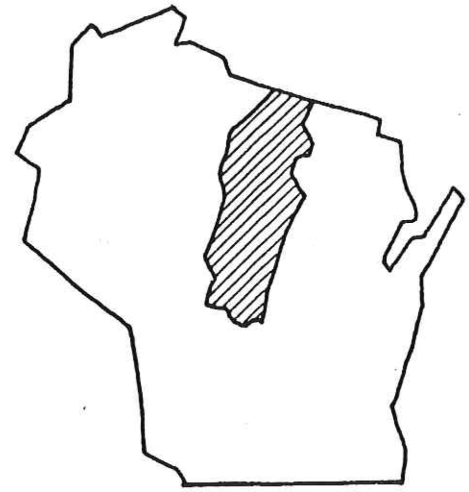
These studies were funded by the Upper Wisconsin River Task Force (supported by U.S. EPA grants) located in Rhinelander, Wisconsin. The Task Force is under the direction of the Wisconsin Department of Natural Resources and has the responsibility of developing the water quality management plans for the Upper Wisconsin River Basin.

Materials and Methods

Water Quality Surveys

Water quality surveys of the Upper Wisconsin River were conducted by Department personnel in June and August of 1977 and 1978. The parameters normally measured were: Dissolved Oxygen (DO), temperature, organic nitrogen, ammonia nitrogen, nitrate and nitrite nitrogen, total phosphorus, dissolved ortho-phosphorus, chlorophyll a, biochemical oxygen demand (BOD), and total and volatile residues (not filtered). Additional measurements were made of pH, conductivity, secchi disc depth, and light extinction, but are not presented in this report because of infrequent sampling. Water samples were normally depth-composited in waters that were greater than 3 meters deep. Surface grab samples (0-0.5 m) were collected in shallower areas where the flow and turbulence were high.

Intensive sampling of dissolved oxygen (DO) was accomplished during the surveys by using electronic oxygen meters and probes (Yellow Springs Instruments, Model 54). The meters were air calibrated according to the manufacturer's instructions after approximately every third DO measurement. Dissolved oxygen readings were usually made at mid-depth when the water depth was less than 3 m deep, and at the surface, middle, and bottom in waters that were greater than 3 m deep. In wide sections of the river, such as in the impoundments, 2 to 5 stations were sampled across the river. The DO values reported in this report represent an average mid-depth sample at a particular sampling station.



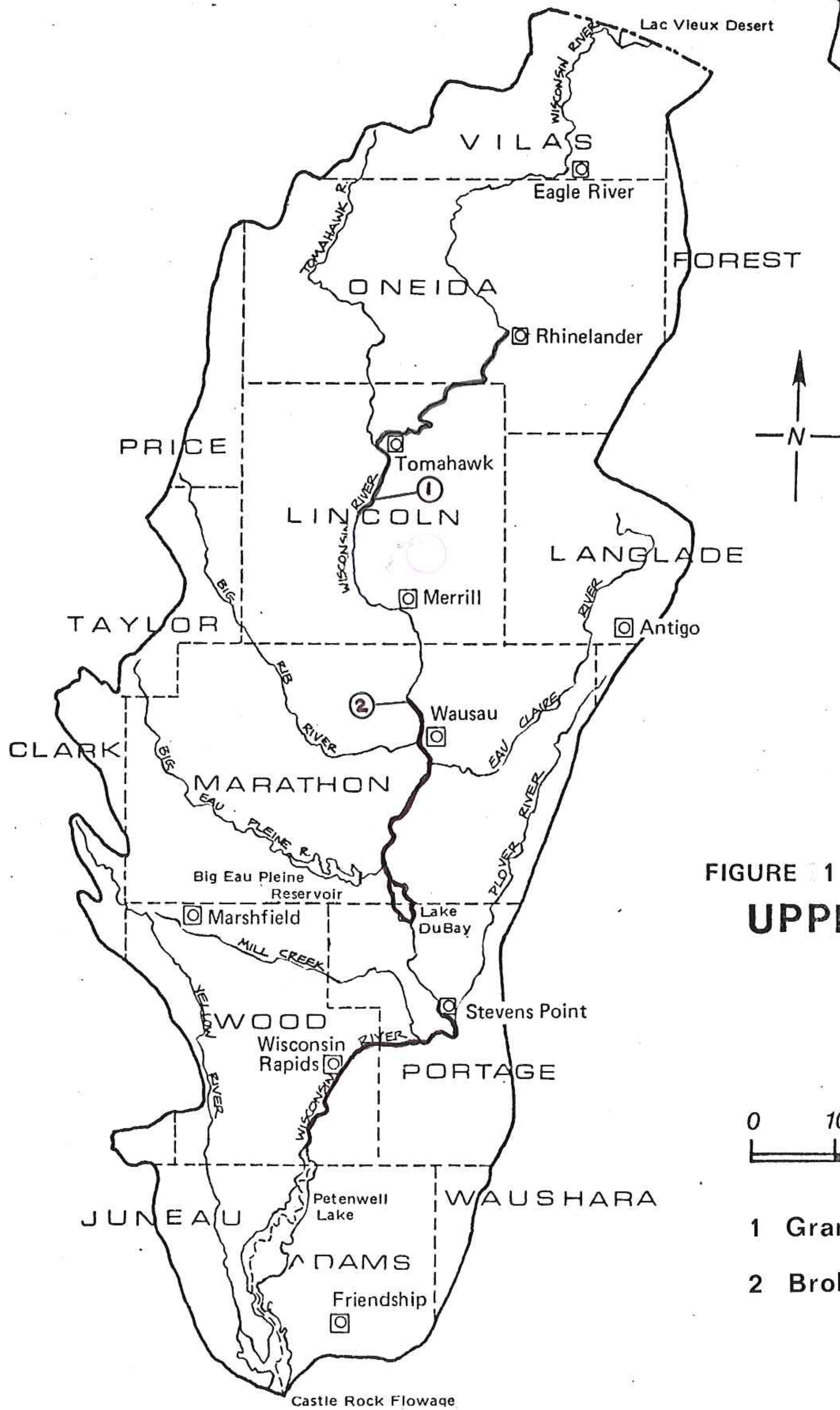


FIGURE 1

UPPER WISCONSIN RIVER BASIN

1 Grandmother Dam

2 Brokaw

Over 100 stations were sampled for DO throughout the Upper Wisconsin River during intensive water quality surveys. These stations were concentrated in three main segments: Rhinelander to Grandmother Dam, Brokaw to Lake DuBay, and Stevens Point to the Petenwell Flowage (Fig. 1). Sampling was concentrated in these segments since these areas usually experienced lower DO concentrations as a result of higher BOD loadings as determiend in previous investigations (4).

Dye-Tracer Investigations

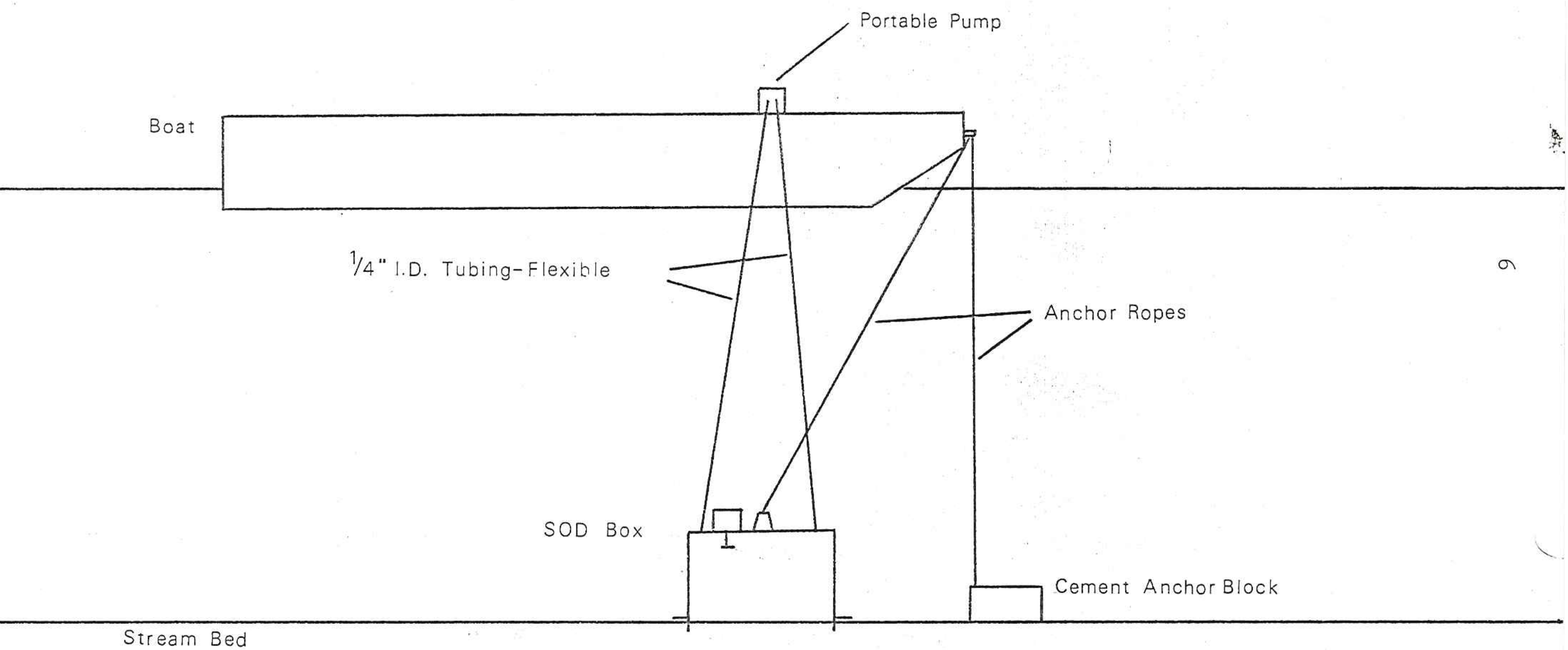
In the winter months of 1977-1978 dye tracing studies were conducted in several segments of the Upper Wisconsin River. These dye studies were necessary to determine time-of-travel and dispersion coefficients for the Qual-III water quality computer model. The dye used was Rhodamine WT. The dye was added in three portions (usually 10 minutes apart) at the starting point. The three additions were 20, 60, and 20 percent of the total dye volume used for that particular segment. The dye was delivered from a plastic three gallon pail at sites in the river where lateral addition (across the channel) or complete lateral mixing was possible. This was normally accomplished by adding the dye at bridge sites or below the tailrace of power dams. The dye was monitored using Amnico and Turner (model 111) fluorimeters that were set up for continuous flow-through sampling in the field or single sampling in the laboratory. Flow-through sampling was possible at dam sites where sampling of the main flow was possible and a power supply was available. An ISCO automatic water sampler was used to collect samples at one hour intervals when flow-through sampling was not attempted. These samples were returned to the Environmental Task Force Laboratory at the University of Wisconsin-Stevens Point where the relative fluorescence was determined with the Amnico fluorimeter.

Dye curves were prepared for each segment by plotting relative fluorescence against time. These curves were least squares fit to a theoretical dispersion equation for modelling purposes. There were two parameters that were fit: the average velocity between the sampling points, and the dispersion coefficient. The time-of-travel was determined from the average velocity and the length of the segment.

In-Situ Sediment Oxygen Demand Measurements

Measurements of sediment oxygen demand (SOD) were determined in the field during the summer periods of 1977 and 1978 using *in-situ* chambers that were constructed by Department personnel. The chamber design and the procedure for field measurements followed that used in other research (1,2). A diagram of the SOD chamber and associated field sampling equipment is presented in Figure 2. The chambers were made from 46 cm diameter opaque fiberglass cylinders that were open on one end. Two different size chambers were constructed. The large chamber was 46 cm tall and had a volume-to-area ratio of 0.28. A smaller chamber was 20 cm tall and had a volume-to-area ratio of 0.18. The smaller box was designed to facilitate field sampling by shortening the incubation time. Oxygen depletion would occur faster in the smaller box because the volume of overlying water was less.

Figure 2. Field sampling equipment for in situ sediment oxygen demand measurements.



The chambers were mixed internally with an 8 cm diameter propeller. The propeller was driven by an electric motor that was encased in a plexiglass compartment above the chamber. A 10 cm diameter porthole was placed in the center at the top of the chamber. This hole was sealed with a removable metal plug that could be controlled from the surface. This opening allowed water to pass through the unit as it was lowered to the bottom. This provided for the entrapment of ambient bottom water and reduced the possibility of disturbing the sediment-water interface (2). A small bleed hole was placed at the top edge of the chamber to facilitate removal of trapped air when the unit was initially placed in the water. The bleed hole was sealed with a bolt before the unit was lowered to the bottom. A 20 cm skirt of plexiglass surrounded the bottom edge of the chambers to minimize sinking into soft substrates. Lead weights were added to this skirt to help balance the unit and to ensure a proper seal between the bottom edge of the chamber and the sediment surface. Water samples were obtained from inside the chamber by using 3/8 in O.D. plastic tygon tubing that was adapted to the top of the chamber. Water was withdrawn from the unit using a portable peristallic pump. Dissolved oxygen and temperature measurements were determined with an electronic oxygen meter and probe (Yellow Springs Instruments, Model 54).

A saturated salt solution (NaCl) was injected into the chamber using the tygon tubing and peristallic pump to determine the effectiveness of the chamber-to-sediment seal. The amount of salt added was enough to raise the chamber water conductivity to at least twice the conductivity of ambient river water. A marked drop in conductivity in a 3 to 4 hour period indicated an ineffective seal with the river bottom.

Water samples for biochemical oxygen demand (BOD) correction were collected from inside the chamber after a 10-15 minute stabilization period. These samples were placed in dark bottles, attached to a line and returned to the same depth as the SOD chamber. The initial and final dissolved oxygen concentration was normally determined with the electronic oxygen meter and probe. In 1978, the Winkler analysis for dissolved oxygen was also used to establish the change in dissolved oxygen in BOD measurements.

The general field procedure used to measure _in situ_ SOD is given below:

1. The propeller was started, chamber was placed in water and the trapped air was removed through the porthole and bleed hole.

2. The chamber was lowered carefully to the river bottom.

3. A salt solution was injected and circulated into the chamber. The unit was allowed to stabilize for about 10 to 15 minutes.

4. Water was collected with a peristaltic pump for BOD correction. The initial dissolved oxygen, temperature, and conductivity were taken. The BOD bottles were returned to the same depth as the chamber.

5. Interim and final dissolved oxygen, temperature, and conductivity readings were taken at about 4 hours and/or 24 hours. The final dissolved oxygen concentrations of the BOD bottles were determined at the end of the incubation period.

6. The box was retrieved and notes were made regarding the presence or absence of snails and the depth of box penetration.

The ambient SOD ($gO_2/m^2/day$) was determined from the equation:

$$SOD = \frac{DO\ change(mg/l)}{day} \times \frac{Chamber\ Volume\ (l)}{Chamber\ Area\ (m^2)} \times \frac{1\ g}{1000\ mg}$$

where the dissolved oxygen change represents the oxygen consumed in the chamber minus that attributable to BOD. The results were presented at a standard temperature (20°C) by the following equation:

$$SOD\ @\ 20^{\circ}C = \frac{SOD\ (field)}{(1.1 - (0.00175\ T))^{t-20}}$$

where T represents the temperature in degrees centigrade (4). At a temperature of 20°C no correction factor is necessary.

Sediment Analysis and Description

Sediment samples were collected during in situ SOD studies with a coring device and Eckman dredge to determine the depth and nature of a particular sediment. The description of the coring device is given below. The sediment cores were used to describe the depth, number of layers, color, texture, and other features considered important. An Eckman dredge was used to collect a sample of the upper 2 to 3 cm of sediment for laboratory analysis. Sediment samples were analyzed for percent organic matter and particle size.

Measurements of SOD Using Sediment Cores

The core method was used to measure SOD during the 1977-1978 winter period (1,2). Sediment cores were collected through the ice by a coring device developed by the Environmental Task Force at the University of Wisconsin - Stevens Point (Fig. 3). The apparatus was made by placing a check valve at the end of 1 inch O.D. steel pipe. The pipe, with check value, was adapted to a 50 cm long clear acrylic tubing (8.9 in I.D.) using appropriate metal and plastic fittings. A sediment core was obtained by slowly pushing the coring device into the substrate to a depth of about 30 to 50 cm. The core was returned to the surface in a vertical position and the bottom was sealed with a rubber stopper before removal from the water. The plastic tubing with the intact core was separated from the piping and fittings and sealed with a rubber stopper. Cores could be collected from depths as great as 6.0 m by varying the length of steel piping. The sediment cores were placed inside a wooden box to exclude light and were returned to the laboratory within 8 hours.

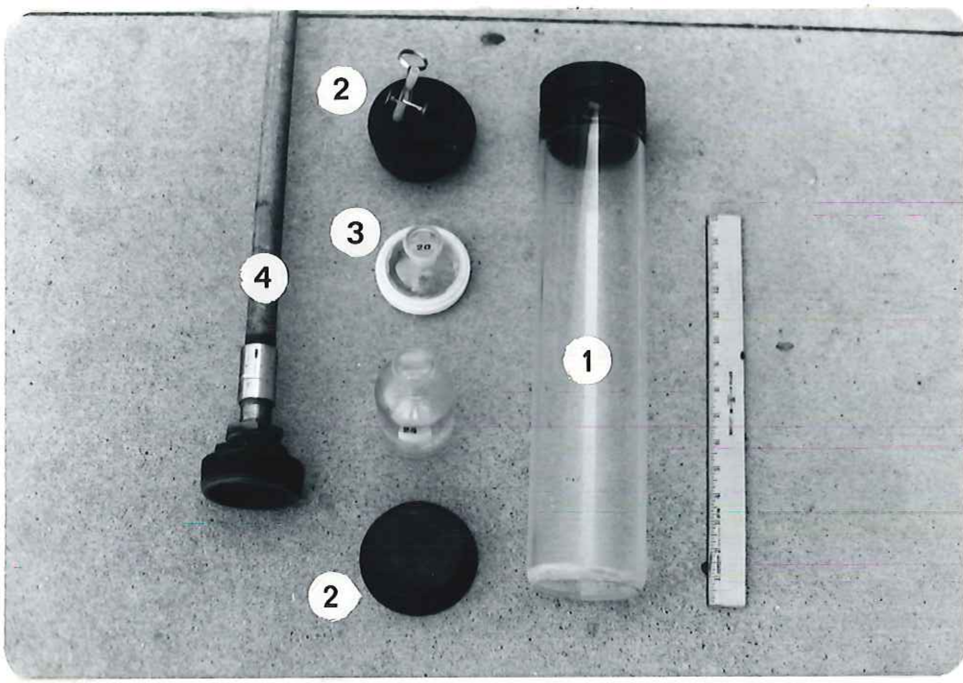


Figure 3. Equipment used for the collection of sediment cores for sediment oxygen demand analysis. 1. Acrylic core with female ABS clean out joint. 2. Rubbert stoppers. 3. Glass top for laboratory SOD analysis. 4. Steel piping with check valve and male adapter to ABS clean out joint. Photo obtained from D. Hammermeister .

A soil auger was used to obtain sediment cores from gravel substrates that could not be sampled with the latter device. Sediment cores were made by packing the substrate collected with the soil auger into the plastic cores, filled with water, and sealed with rubber stoppers. Sampling with the soil auger was limited to those areas with a gravel substrate where the water depth was less than 1.5 meters.

Approximately 3 liters of water were collected from the surface at each core sampling site. This water was used to replace water in the cores that was lost during transport and to establish a BOD correction.

At the end of each sampling day, cores were returned to the laboratory and incubated at 4 or 20 degrees centigrade. Cores incubated at $4^{o}C$ were allowed to stabilize for one to two days prior to SOD determination. The overlying water in these cores was mixed every 12 hours and compressed air was added when necessary to maintain an aerobic environment. Compressed air was bubbled continuously at a slow rate into $20^{o}C$ cores during the stabilization period to keep the water mixed and oxygenated.

At the end of the stabilization period, the top rubber stoppers were replaced by the upper half of a glass DO bottle (Fig. 3). The glass top was made by cutting a 300 ml DO bottle in half and cementing the bottle to a threaded plastic ring (PVC clean out plug). Core water and BOD water was exchanged several times by siphoning being careful not to disturb the sediment-water interface. Dissolved oxygen measurements of the 4°C cores began 12 hours after initial set up. The DO levels in these cores and corresponding BOD bottles were determined at 12 hour intervals for 60 hours using a Weston Stack (Model 330) DO meter and probe. The DO meter was calibrated at the incubation temperature and standardized using the Winkler analysis for dissolved oxygen. The overlying water in the cores was allowed to mix thoroughly for 5 to 10 minutes by the mixing action of the probe before a DO reading was made. Twenty degree centigrade cores and BOD's were mixed and monitored more frequently. The DO measurements for the 20°C tests began about 8 hours after set up and were determined at 3 to 4 hour intervals until 5 measurements were made. At the end of the tests, the volume of water in the cores was measured with a graduated cylinder and a description of the sediment was made.

The rate of sediment oxygen demand was determined by regressing the net demand (change in core DO - the BOD) against the incubation period in days. The slope of this line represents the rate of oxygen consumption by the sediments in mg/l/day. The slope was incorporated into the equation below to express the demand on an areal basis(1).

$$\underset{(gO_2/m^2/day)}{\text{SOD}} = \text{Slope (mg/l/day)} \times \frac{\text{core water volume (l)}}{\text{core area } (m^2)} \times \frac{1\text{g}}{1000\text{ mg}}$$

Results and Discussion

Dissolved Oxygen Surveys

The results of the dissolved oxygen (DO) surveys in the Upper Wisconsin River in the summer months of 1977 and 1978 (Figs. 4, 5, and 6) showed improvements over previous surveys conducted in 1974-1976(4). However, the dissolved oxygen standards are still not met in some segments. The results of the water quality surveys for the 1977 and 1978 summer periods are presented in Appendix A and B. A discussion of nitrogen, phosphorus, and chlorophyll data are presented in a report of the algae dynamics of the Upper Wisconsin River (3).

The August 1977 DO survey showed two segments that were below the 5 mg/l water quality standard for fish and aquatic life (Fig. 4). The first of these segments was below Rothschild Dam to Lake DuBay where the DO level fell to about 4.5 ppm. This was a considerable improvement when compared to previous DO surveys. Past surveys indicated much lower DO readings (0-1 mg/l) over a larger segment of the river (Brokaw to DuBay Dam). The increased dissolved oxygen levels in this segment are attributed to improved wastewater treatment by the major industrial sources (primarily paper mills) in this reach. A second segment (Biron Dam to Ten Mile Creek) experienced severe DO depletion during the August 1977 survey which paralleled results of previous surveys. The Nekoosa-Port Edwards industrial joint treatment plant was not operating efficiently until September 1977 and probably delayed the improvement of water quality in this segment. The dissolved oxygen levels in the segment from Rhinelander

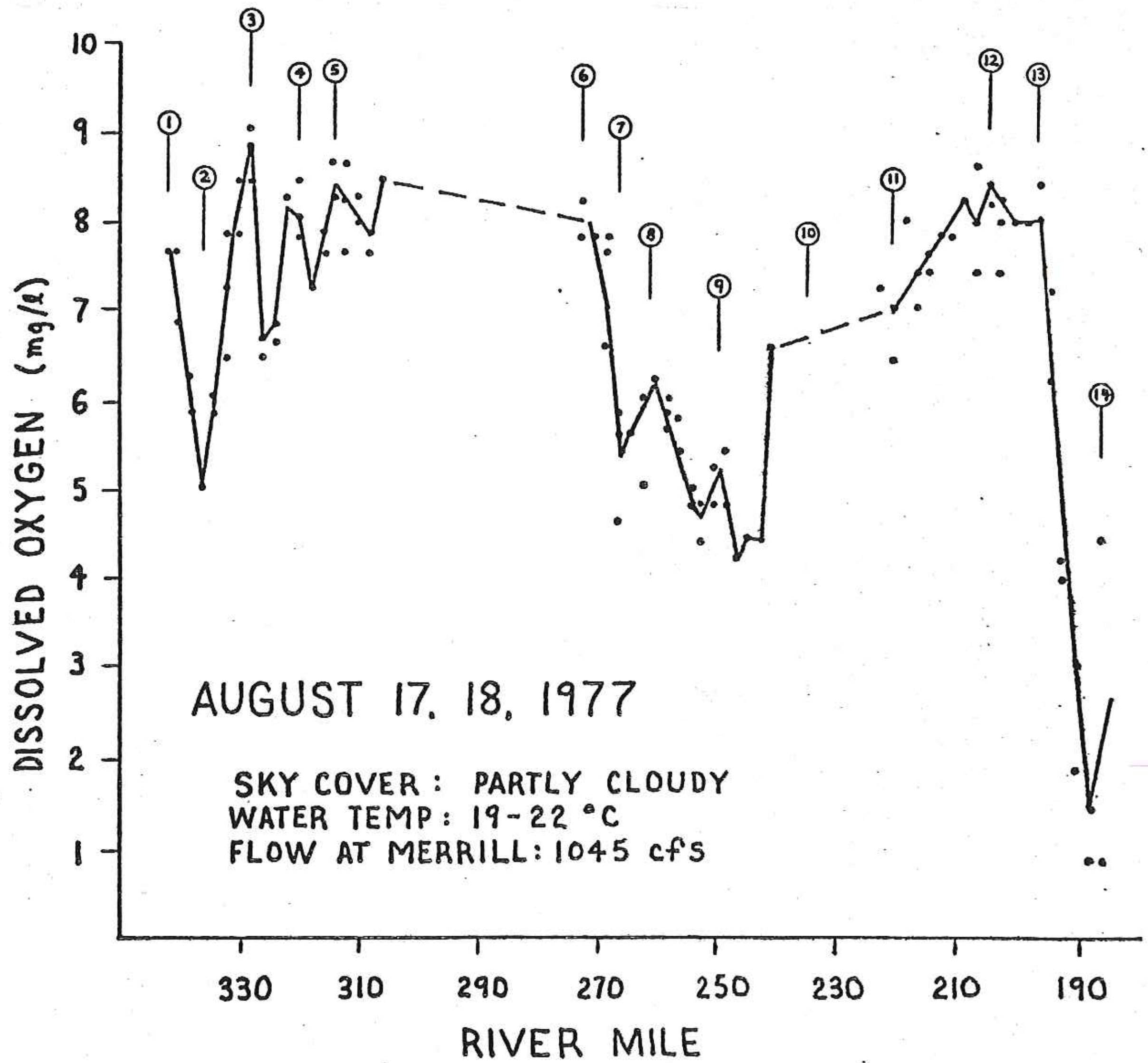


Figure 4. Dissolved oxygen profile of the Upper Wisconsin River in August of 1977. The encircled numbers indicate specific sites. These are: 1. Rhinelander Dam, 2. Hat Rapids Dam, 3. 1 mile below Negro Island, 4. Kings Dam, 5. Tomahawk Dam, 6. Brokaw, 7. Wausau Dam, 8. Rothschild Dam, 9. Mosinee Dam, 10. Dubay Dam, 11. Upper Stevens Point Dam, 12. Biron Dam, 13. Centralia Dam, 14. Ten Mile Creek. The flow at Merrill is the average weekly discharge for the week ending August 14, 1977.

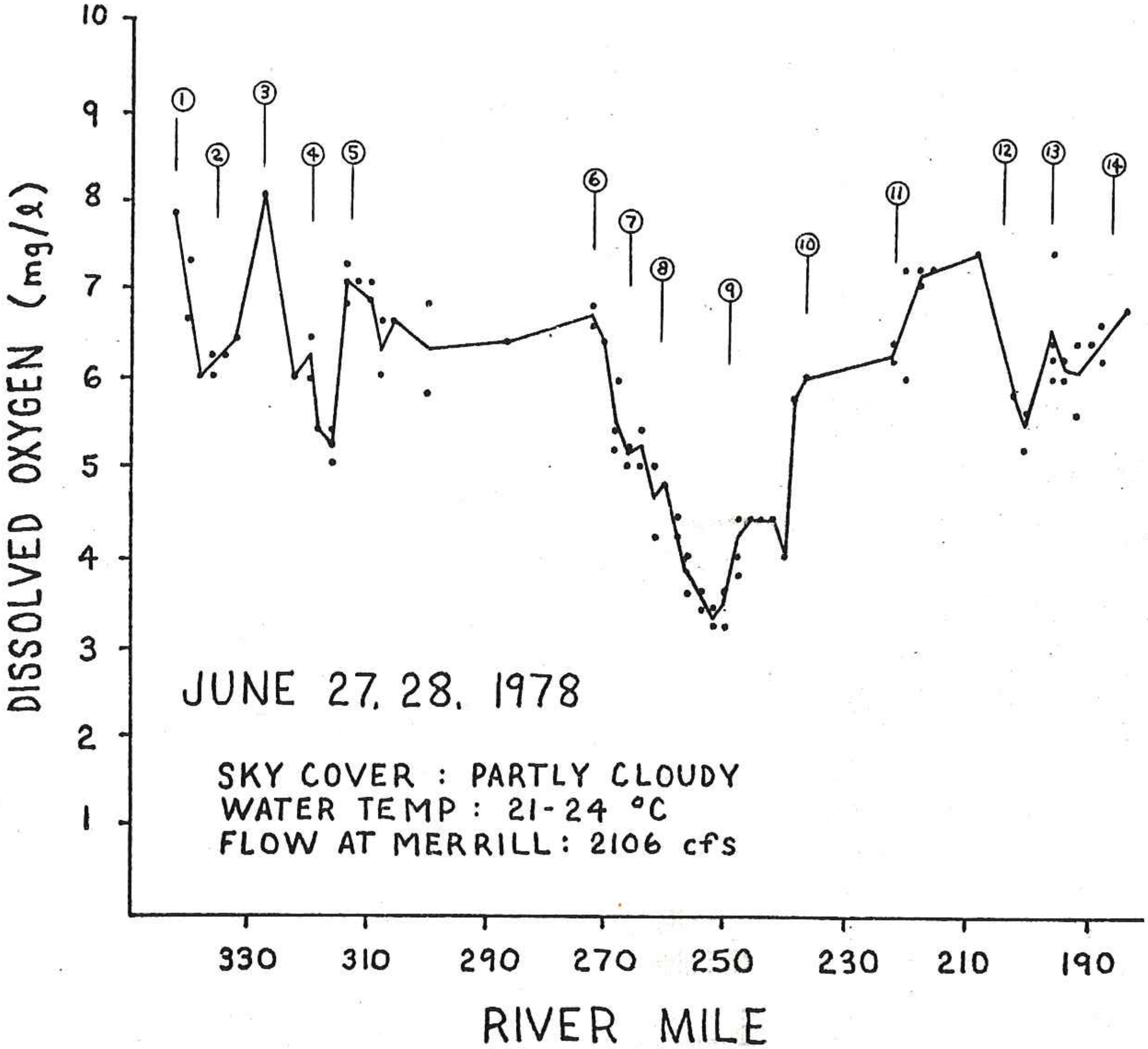


Figure 5. Dissolved oxygen profile of the Upper Wisconsin River in June of 1978. The encircled numbers indicate specific sites. These are: 1. Rhinelander Dam, 2. Hat Rapids Dam, 3. 1 mile below Negro Island, 4. Kings Dam, 5. Tomahawk Dam, 6. Brokaw, 7. Wausau Dam, 8. Rothschild Dam, 9. Mosinee Dam, 10. DuBay Dam, 11. Upper Stevens Point Dam, 12. Biron Dam, 13. Centralia Dam, 14. Ten Mile Creek. The flow at Merrill is the average weekly discharge for the week ending August 2, 1978.

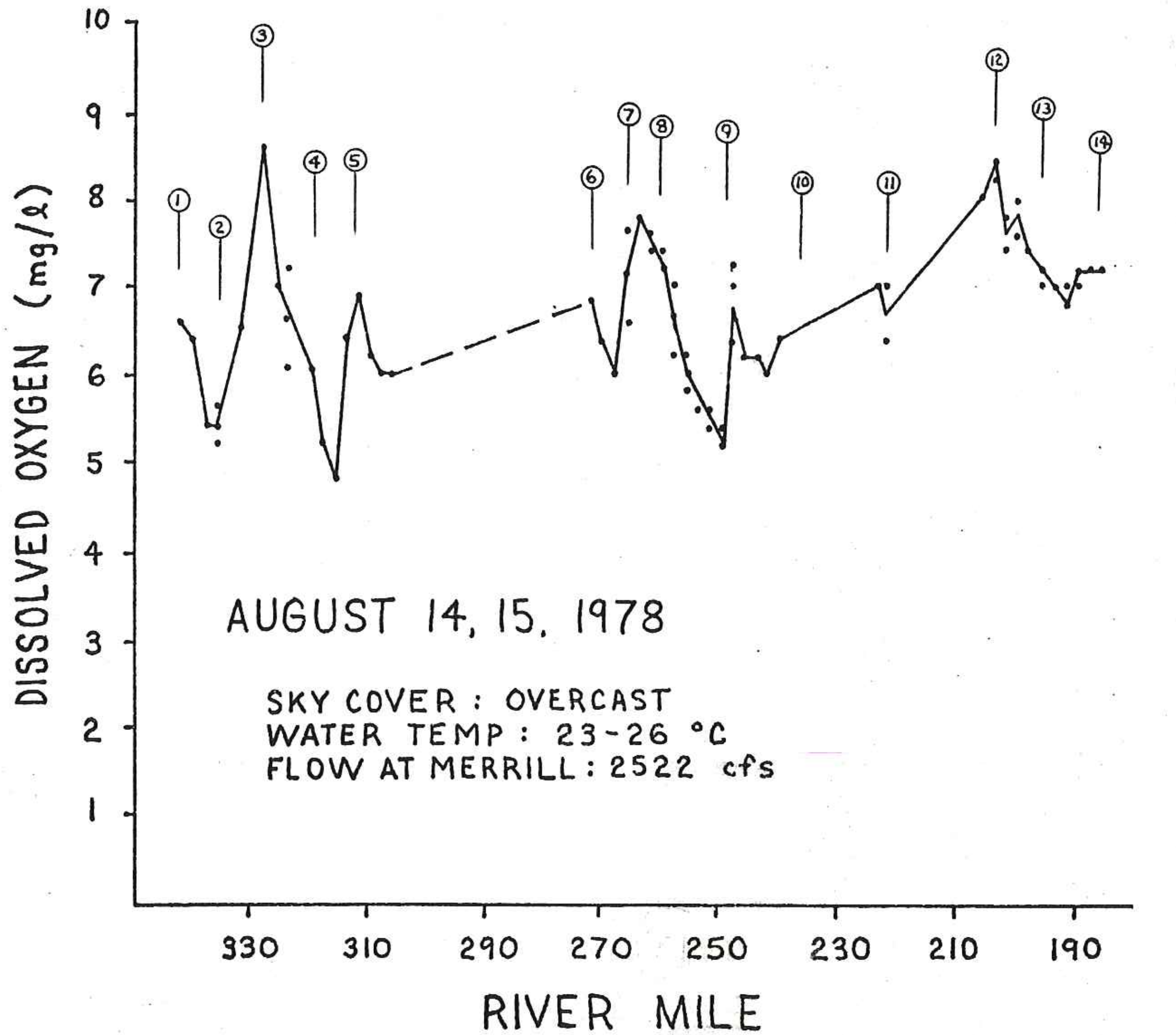


Figure 6. Dissolved oxygen profile of the Upper Wisconsin River in August of 1978. The encircled numbers indicate specific sites. These are: 1. Rhinelander Dam, 2. Hat Rapids Dam, 3. 1 mile below Negro Island, 4. Kings Dam, 5. Tomahawk Dam, 6. Brokaw, 7. Wausau Dam, 8. Rothschild Dam, 9. Mosinee Dam, 10. DuBay Dam, 11. Upper Stevens Point Dam, 12. Biron Dam, 13. Centralia Dam, 14. Ten Mile Creek. The flow at Merrill is the average weekly discharge for the week ending August 20, 1978.

to Crescent Creek (mile 329) did not drop below the 5 mg/l standard. Past surveys indicated this segment did not meet the dissolved oxygen variance of 3.0 mg/l (6). The improved water quality in this reach is a reflection of the upgraded pollution control facilities at St. Regis Paper Company and Rhinelander's municipal sewage treatment plant.

The June 1978 DO profile (Fig. 5) was similar to the DO profile for the August 1977 survey. The exception was an improvement in the water quality in the Biron to Petenwell Segment. In addition, the dissolved oxygen sag below Rothschild Dam was more pronounced in the June 1978 survey, but did not fall below the 3.0 mg/l variance.

The August 1978 DO survey provided an interesting contrast to previous surveys (Fig. 5). Dissolved oxygen levels were above the 5 mg/l water quality standard with an exception of a sample collected below King's Dam. The improved water quality is partly attributed to increased flows as compared to previous surveys. In addition, the impoundment above Wausau Dam was completely drawn down to facilitate dam repairs. This apparently influenced the DO profile in this segment. The DO levels recovered unusually fast below Wausau Papers (River Mile 271) as compared to previous surveys. This response was probably due to aeration because of the riffle area exposed above Wausau Dam when the impoundment was drawn down. In addition, the combination of increased flows in August and reduced time-of-travel between Wausau Papers and Wausau Dam may have shifted the dissolved oxygen sag downstream into Lake Wausau. Increased DO levels in the segment between Lake Wausau and Mosinee Dam during the

August 1978 survey were also associated with lower BOD loading from Wausau Papers. The BOD loading from Wausau Papers was about 9,000 lbs./day during the August 1978 survey and about 17,000 lbs/day for the June 1978 survey as indicated on their Self Monitoring Reports.

Dye-Tracer Investigations

The main objective of the dye studies was to obtain time-of-travel measurements and dispersion coefficients for low flow conditions. However, measurements at low flow were not possible because of high precipitation during the fall period of 1977. The results of the dye studies are summarized in Table 1. The main factors influencing dispersion and time-of-travel are: flow; distance between points, and the physical characteristics of the river channel. The high dispersion coefficient for the segment between Rothschild Dam to Mosinee Dam may be due to high flow during the dye study. The impact of ice cover on dispersion could not be established in this work. Additional dye studies are planned during low flow conditions.

In-Situ Sediment Oxygen Demand

The results of *in situ* SOD analysis for the 1977 and 1978 summer periods are presented in Appendix B. There were many problems encountered in the field SOD measurements. These problems were: ineffective chamber-to-sediment seal, SOD variation with changes in incubation time, uncertainty in box volume as a result of sinking, break down in chamber mixing

Table 1. Results of dye-tracer investigations on the Upper Wisconsin River during the 1977-1978 winter period.

Site of dye addition	Volume of dye used (qt)	River Segment	Mean time of travel (hr)	Dispersion Coefficient (ft^2/sec)	Distance (miles)	Flow (cfs) / Site
Rhinelander, Hwy 8 Bridge	12	Rhinelander to Hat Rapids Dam	18.0	105	5.6	871 Hat Rapids Dam
Tomahawk Dam, Tailrace	18	Tomahawk Dam to Grandmother Dam	18.9	100	7.0	1770 Tomahawk Dam
Wausau Papers, Effluent pipe	25	Wausau Papers to Wausau Dam	10.1	160	5.4	2800 Wausau Dam
		Wausau Dam to Rothschild Dam	28.4	168	7.2	2520 Wausau Dam
Rothschild Dam, Tailrace	12	Rothschild Dam to Mosinee Dam	9.0	880	9.5	5550 Rothschild Dam
Biron Dam, Tailrace	30	Biron Dam to Wis. Rapids Dam	9.5	147	3.4	3390 Wis. Rapids Dam
		Wis. Rapids Dam to Centralia Dam	6.0	90	2.7	3860 Wis. Rapids Dam
		Centralia Dam to Nekoosa Dam	13.1	454	5.8	3600 Wis. Rapids Dam

device, increase in DO levels in BOD bottles, BOD rate greater than SOD, and malfunctioning of the DO meter and probe. These factors should be considered when reviewing the results. Based on the above information each SOD measurement was rated as "good" (no problems encountered in this test), "fair" (minor problems that may have influenced results), and "unsatisfactory" (serious problems that affected results). Unsatifactory tests were not considered in this report. The minimum and maximum SOD values reported in this work are a range based on the smallest and largest SOD values that could be calculated from the experimental data for a particular site. The maximum values usually represented short-term incubation periods (less than five hours), whereas minimum values were obtained for longer periods. The reason for the difference in SOD rates between short- and long-term incubation periods was not established. It was possibly due to an early rapid oxygen demand resulting from the disturbance of the sediment-water interface.

Most of the SOD measurements, corrected to 20°C, varied between 0.5 and 3.0 $gO_2/m^2/day$. The 20°C rates determined for the 1977 period were greater than those reported for the 1978 study period. The estimated average SOD rate $\left(\frac{\text{min.} + \text{max}}{2}\right)$ corrected to 20°C was 1.6 and 0.9 $gO_2/m^2/day$ for the 1977 and 1978 surveys, respectively. The reason for this difference is not known. The range of SOD values is lower than a range of 1.0 to 7.0 $gO_2/m^2/day$ found in other rivers in the United States and England (2).

There was no apparent relationship between the *in situ* SOD and the substrate type or depth. If a relationship does exist between the substrate and *in situ* SOD it was probably masked by the extreme variation in SOD measurements as a result of poor accuracy and precision of the field SOD method. The relationshp between substrate type and SOD was tested further using the core SOD method. The results of the tests are discussed later in this report.

Abundant snail populations were observed in some areas of the river during the 1977 and 1978 summer periods. Their contribution to the sediment oxygen demand was expected since snails were commonly found attached to the inside of the SOD chamber when the unit was retrieved. Snail respiration measurements were performed to establish their significance to SOD. This was accomplished by placing different size snails (1-12 cm^3) into Erlenmeyer flasks containing river water, sealed, and then incubated in the dark at 20°C. Controls were run on flasks containing river water to determine a BOD correction. The results indicated the specific demand per unit volume of snail was highest for the small volume snails, but the total demand per snail was similar for all size fractions. The average demand was 1.9 mgO_2/snail/day. This corresponds to an average areal demand of 0.012 gO_2/m^2/day based on the chambers used in this research. It was not uncommon to find 10 to 20 snails within the chamber during field SOD surveys. This indicates that the snail contribution to SOD could amount to approximately 10 to 25 percent of the total SOD in substrates with a total demand of 1 gO_2/m^2/day. The significance of snail respiratory demand would be even larger in substrates with lower SOD or in areas of increased snail density. The impact of snail respiratory demand in field SOD studies was not really known since the actual number per unit area of substrate was not established.

Sediment Analysis and Description

Ten major areas were found in the Upper Wisconsin River with soft, deep sediment deposits (Table 2). The percent organic matter at these sites ranged from 3.5 to 19.0. Particle size was highly variable between sites, with mixtures of sand and silts common. Substrates in areas of fast current were predominantly sands and gravel, with little accumulations of soft, overlying sediments. In general, the deepest accumulations of soft sediments occurred immediately above dams, below major pulp and paper mills where the water current was low, and at the headwaters of impoundments. Sediment mapping of the Upper Wisconsin River was attempted in a few segments. The mapping was based on the collection of sediment cores and an estimate of the percent composition of sand, silt, clay, and organic material from field observations. This data was not very accurate when compared to laboratory tests of sediment texture and organic matter content. As a result, the construction of a reliable and accurate sediment map was not possible without extensive laboratory analysis. In addition, the lack of a definite relationship between *in situ* SOD and substrate type did not warrant further sediment investigation.

Table 2. Major areas of the Upper Wisconsin River with soft, deep sediment deposits. The description of substrates was made from field observations.

Site	Sediment depth and substrate description
Upper Hat Rapids Flowage	75-200cm, wood fibers and wood chips
Entrance to Lake Alice	25cm, fine organic material
Lake Mohawksin @ Hwy 51	55cm, fine organic material
Above Tomahawk Dam	70- 80cm, soft organic material
Grandmother Flowage	18- 30cm, soft organic material
Mosinee Flowage	30- 60cm, fine organic and wood fibers
Lake DuBay @ Hwy 34	130cm, grey-black gelatinous mud
Above DuBay Dam	20-120cm, grey-black gelatinous mud
Above Biron Dam	45- 30cm, soft organic material

Measurement of SOD using Sediment Cores

The collection of undisturbed sediment cores during the 1977-1978 winter period was useful for the estimation of *in situ* SOD rates and also allowed further analysis of SOD-substrate relationships. The core SOD data was not as variable as the results obtained from *in situ* studies using SOD chambers. This was partly due to replicate sampling of SOD by using 2-3 cores per site. In addition, the core technique could be controlled under laboratory conditions and did not suffer from the many problems (chamber seal, erroneous BOD readings, uncertainty in volume of overlying water, etc.) encountered using the *in situ* method. The results of the core SOD method are presented in Appendix E and summarized by substrate type in Table 3.

Table 3. The relationship between $4^{o}C$ SOD ($gO_2/m^2/day$) and substrate type. Each site represents a minimum of two samples per site.

Statistic	(1) Gravel (soil auger)	(2) % sand greater than 75%	(3) High Org. Matter Content	(4) High Org. Matter & Wood Fibers	(5) High Org. Matter in Impoundments* (less than %5 sand)
Mean	0.10	0.11	0.13	0.16	0.14
S.D.	0.40	0.04	0.05	0.03	0.05
No. of sites	6	10	23	4	16

* below paper mills.

Most SOD rates were determined at 4°C because an estimate of the *in situ* winter oxygen demand was sought. The actual river sediment temperature was probably 0 to 2°C (similar to water temperature) and, therefore, the core SOD procedure may have overestimated the *in situ* rate. An estimate of the winter SOD using the core method could not be determined at a colder temperature because the environmental chamber used to incubate cores was unstable below 4°C. An extra sediment core was collected at a few locations to determine a 20°C SOD rate. These measurements were made to estimate summer *in situ* rates and a temperature correction coefficient for the Qual-III model.

The range and average 4°C SOD rates are illustrated by river mile in Figure 7. There was no apparent pattern between location and sediment oxygen demand. Twenty degree rates were not graphed because of an insufficient sample size. The average 4°C SOD rate for the 49 sites sampled was 0.12 $gO_2/m^2/day$ with a coefficient of variation of 39.4 percent. The rates were arranged into five groups to test the relationship between SOD demand and substrate type (Table 2). The classification of substrate type was done by visual observation of the cores. One-way analysis of variance was used to test the differences in substrate averages. The test indicated the five means were not significantly different. However, a test between groups with greater than 75% sand and cores with high organic matter and wood fibers indicated a significant difference in sample means. The gravel substrates yielded the lowest 4°C SOD values but were also the most variable. This variation was probably due to pronounced substrate disturbance since these cores were hand packed in the field. The results indicate that substrate type may

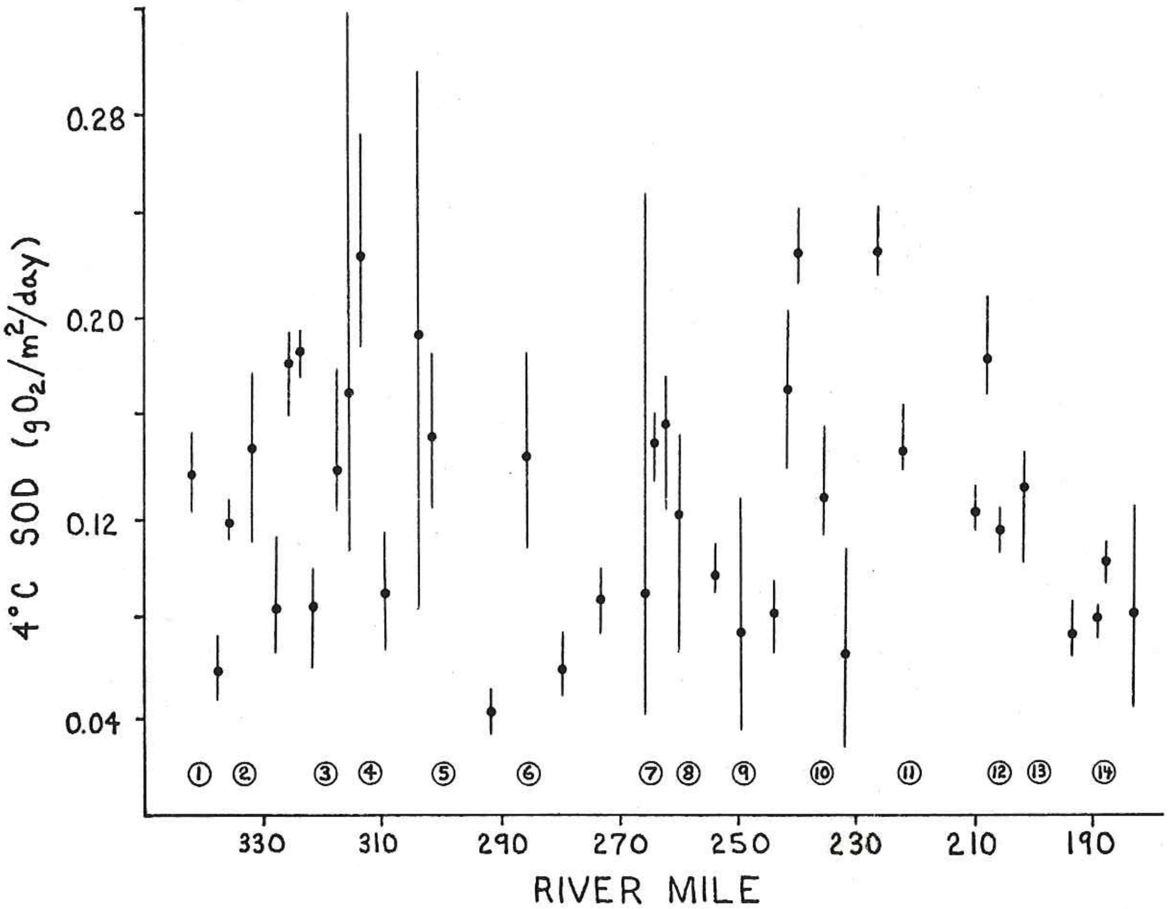


Figure 7. The average (dot) and range (line) of 4°C sediment oxygen demand rates determined by the core method. The encircled numbers indicate specific sites. These are: 1. Rhinelander Dam, 2. Hat Rapids Dam, 3. 1 mile below Negro Island, 4. Kings Dam, 5. Tomahawk Dam, 6. Brokaw, 7. Wausau Dam, 8. Rothschild Dam, 9. Mosinee Dam, 10. DuBay Dam, 11. Upper Stevens Point Dam, 12. Biron Dam, 13. Centralia Dam, 14. Ten Mile Creek.

influence 4°C SOD but its impact remains obscure. The relationship between substrate type and 20°C core values may have yielded larger differences but this could not be established in this study.

A comparison of 4 and 20°C core SOD rates were made on 20 samples collected during the 1977-1978 winter period. The average SOD rates for these two temperatures were 0.11 and 0.59 $gO_2/m^2/day$, respectively. The four and 20 degree averages compare very well with SOD data collected on sediments of the Big Eau Pleine Reservoir (1). Research on the Big Eau Pleine Reservoir indicated that 20°C core values collected in the winter underestimate the summer, *in situ*, 20°C SOD rate by approximately 40 percent. Using this relationship, the average 20°C SOD rate of 0.58 $gO_2/m^2/day$ for the winter samples corresponds to an estimated SOD rate of 0.98 $gO_2/m^2/day$ for the summer period. This is within the range of SOD data collected during *in situ* studies on the Upper Wisconsin River.

The 4 and 20°C SOD rates were used to calculate and verify the temperature correction formulation used in the Qual-III model (5). The reaction rate for sediment oxygen demand is temperature dependent and is expressed as:

$$K_t = K_{20} \ \theta^{T-20}$$

where K_t is the SOD rate at a specified temperature, K_{20} is the SOD rate at 20°C, θ is the temperature correction coefficient, and T is the temperature in degrees centrigrade. Based on the winter SOD core results the average 4 and 20°C SOD rates were 0.11 and 0.59 $gO_2/m^2/day$, respectively. This corresponds to a temperature adjustment coefficient of 1.11 using the above equation. In the Qual-III model the formulation for the temperature correction coefficient varies as a function of temperature:

$$\Theta = -0.00175\ T + 1.1$$

Therefore, at 4°C a temperature adjustment factor of 1.09 would be predicted. This coefficient compares favorably with the observed data, but apparently underestimates the correction coefficient at 4°C. This means an estimation of 4°C SOD rates from 20°C rates would be overestimated, in contrast, 4°C SOD rates would under estimate 20°C rates. This finding does not affect the present modelling effort since the Qual-III model is not being used under such wide temperature fluctuations. However, the formulation for temperature correction for SOD would need adjustment if extreme temperature ranges (4 to 20°C) are modelled.

Conclusions

The water quality of the Upper Wisconsin River has improved as reflected in increased dissolved oxygen concentrations in recent surveys. However, dissolved oxygen standard for fish and aquatic life (5 mg/l) was still not met in some segments of the river.

Dispersion coefficients and time-of-travel measurements were not made during low flow conditions. High flows may have been responsible for the unusually high dispersion data for the Rothschild to Mosinee segment. The affect of ice cover on time-of-travel and dispersion measurements could not be established.

In situ measurements of sediment oxygen demand utilizing SOD chambers normally ranged from about 0.5 to 3.0 gO_2m^2/day (corrected to 20°C). The method used suffered from large experimental error and could not be used to establish a relationship between SOD and substrate type. Snail respiratory demand may be an important contributor to the total SOD in some areas. However, the significance of snail contribution to SOD could not be clearly established because snail densities were not determined.

The results of SOD measurements determined by the coring procedure were not as variable as results utilizing *in situ* sediment chambers. Various substrates exhibited different 4°C SOD rates, however, the differences were not very large. The average winter SOD using sediment cores was 0.12 gO_2/m^2/day at 4°C. An estimated summer SOD was made using cores collected during the winter by incubating them at 20°C. An average summer SOD of approximately 1.0 gO_2/m^2/day was estimated and is in agreement with the average *in situ* rates determined. An estimate of the temperature coefficient was made using the core SOD data for 4 and 20°C. The coefficient determined was larger than what would be predicted in the Qual-III model. This indicated the estimation of winter 4°C SOD rates from 20°C rates would be too large; whereas, 4°C rates would underestimate 20°C SOD rates. This deviation is not presently a problem since the Qual-III model is not being used under such wide temperature fluctuations. However, an adjusted temperature correction procedure for SOD should be considered if modelling of a wider temperature range is anticipated.

Further use of the field technique for SOD analysis is not recommended until some of the problems with the procedure used are solved. The core method was more valuable because the results were not as variable as the *in situ* technique. In addition, the relationships between substrate type and SOD and temperature and SOD could be studied in more detail with the core procedure. A definite relationship between substrate and SOD was not established. Therefore, a single SOD rate that is temperature dependent is recommended for the Qual-III water quality model in light of the present data.

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Appendix A

Results of the August 1977 water quality survey on the Upper Wisconsin River.

Date	Location	River Mile	Temp. (°C)	DO	BOD_5 Tot.	BOD_5 Filt.	ON	NH_3 N	NO_2^+ NO_3^- N	TP	SP	CHL-a (µg/1)	Solids SS	Solids VSS
8/17/77	Rhinelander Dam	341.7	ND	ND	6.8	5.3	0.7	<0.02	0.02	0.07	0.006	16	3	0
8/17/77	Hat Rapids Dam	335.3	20.0	5.0	ND	3.7	1.2	0.31	0.19	0.09	0.007	19	7	7
8/17/77	Lake Alice @ Co. Trk. A	323.7	19.5	6.6	ND	2.8	0.8	0.06	0.77	0.05	0.012	6	2	2
8/18/77	Below Kings Dam	319.3	20.0	8.0	ND	2.5	0.9	0.02	0.24	0.05	<0.004	42	7	6
8/18/77	Below Tomahawk Dam	312.8	19.5	8.7	ND	3.7	0.7	<0.02	<0.02	0.07	0.004	33	8	8
8/18/77	Grandmother Dam	305.9	20.5	8.4	ND	3.7	1.0	<0.02	<0.02	0.07	0.004	33	10	10
8/17/77	Brokaw	271.5	18.0	8.3	4.5	3.4	0.8	<0.02	<0.02	0.06	<0.004	38	10	6
8/17/77	Below Wausau Dam	265.5	20.0	5.5	12.0	10.0	1.1	0.54	0.03	0.09	0.004	47	16	8
8/18/77	Below Rothschild Dam	258.2	19.5	5.5	4.9	3.7	0.8	0.36	0.10	0.11	0.021	38	10	4
8/18/77	Mosinee Dam	248.9	21.0	5.4	6.8	3.7	1.1	0.17	0.16	0.13	0.015	56	18	8
8/18/77	Below Big Eau Pleine Res.	239.1	20.5	6.5	6.8	4.5	1.1	0.13	0.12	0.14	0.023	56	14	6
8/17/77	Below Stevens Point Dam	222.3	20.0	7.1	6.8	4.9	1.3	0.07	0.10	0.14	0.024	37	12	2
8/17/77	Biron Dam	205.3	20.5	7.3	7.4	5.3	1.3	<0.02	0.02	0.15	0.035	47	9	1
8/18/77	Below Centralia Dam	197.8	20.0	8.0	3.3	2.5	1.3	0.03	0.03	0.15	0.029	55	15	11
8/18/77	Petenwell Dam	171.9	22.0	9.4	4.1	1.8	1.1	<0.02	<0.02	0.12	0.025	34	12	10

Appendix A (continued)

Results of the June 1978 water quality survey on the Upper Wisconsin River.

Date	Location	River Mile	Temp. (°C)	DO	BOD_5	ON	NH_3-N	NO_2+ NO_3- N	TP	SP	CHL-a (µg/l)	Solids SS	Solids VSS
6/27/78	Rhinelander Dam	341.7	21.0	7.8	3.3	0.7	<0.02	<0.02	0.06	0.006	15	4	4
6/27/78	Below Pelican River	339.8	21.0	6.6	4.9	1.0	0.04	0.06	0.06	<0.004	11	6	6
6/27/78	Hat Rapids Flowage	337.7	22.0	6.1	4.5	0.9	0.06	0.08	0.06	<0.004	ND	6	6
6/27/78	Hat Rapids Dam	335.3	22.0	6.2	3.7	1.2	0.13	0.13	0.08	0.005	22	5	5
6/27/78	Below Negro Island	327.9	24.0	8.0	4.1	1.0	0.03	0.33	0.05	0.006	14	6	6
6/28/78	Lake Alice @ County Trunk A	323.7	23.0	6.7	ND	0.9	0.11	0.37	0.06	0.012	15	5	4
6/28/78	Lake Mohawksin @ Hwy. 51	316.5	20.5	5.1	3.7	0.9	0.15	0.30	0.08	0.013	10	3	3
6/28/78	Below Tomahawk Dam	312.8	23.0	7.0	4.1	1.1	0.03	0.16	0.07	0.007	ND	6	6
6/28/78	Grandmother Dam	305.9	23.0	6.6	4.1	0.8	0.04	0.18	0.09	0.014	22	4	4
6/28/78	Merrill Dam	286.1	23.0	6.4	3.7	0.8	0.03	0.26	0.06	0.018	ND	3	0
6/27/78	Brokaw	271.5	22.0	6.7	2.9	0.8	<0.02	0.29	0.07	0.032	7	4	4
6/27/78	Wausau Dam	265.6	24.0	5.2	4.1	1.0	0.12	0.29	0.08	0.018	7	5	4
6/27/78	Rothschild Dam	258.4	23.5	4.4	ND	1.0	0.39	0.31	0.09	0.028	ND	ND	ND
6/28/78	Below Formost	255.8	24.0	3.9	4.5	0.9	0.35	0.38	0.09	0.038	8	4	4
6/28/78	Below Mosinee Dam	247.2	24.0	4.4	5.7	1.1	0.27	0.44	0.13	0.038	18	8	5
6/28/78	Dubay Dam	235.5	24.0	6.1	ND	1.1	0.10	0.30	0.09	0.034	20	4	4
6/27/78	Below Stevens Point Dam	222.5	23.2	6.4	3.7	1.1	0.03	0.35	0.09	0.026	22	6	5
6/27/78	Biron Flowage	208.1	24.0	7.5	4.9	1.4	0.02	0.42	0.17	0.045	15	12	6
6/28/78	Below Wis. Rapids Dam	201.8	22.5	5.8	4.5	1.0	0.10	0.47	0.13	0.047	26	8	6
6/28/78	Below Pt. Edwards Dam	195.7	23.0	6.1	ND	1.0	0.06	0.52	0.13	0.049	26	8	4
6/28/78	Below Nekoosa Dam	192.9	23.5	6.5	5.7	1.0	0.18	0.54	0.16	0.060	28	8	6
6/29/78	Petenwell Dam	171.9	27.0	7.9	ND	1.4	0.02	0.41	0.14	0.029	56	8	8

Appendix A (continued)

Results of the August 1978 water quality survey on the Upper Wisconsin River.

Date	Location	River Mile	Temp. (°C)	DO	ON	NH_3-N	NO_2+ NO_3-N	TP	SP	CHL-a (μg/l)	Solids SS	Solids VSS
8/14/78	Rhinelander Dam	341.7	23.0	6.7	0.7	0.02	<0.02	0.05	0.007	17	2	2
8/14/78	Below Pelican River	339.8	24.0	6.5	1.3	0.16	0.10	0.06	0.007	ND	ND	ND
8/14/78	Hat Rapids Dam	335.3	25.0	6.0	1.3	0.18	0.10	0.04	0.005	23	6	3
8/14/78	Below Negro Island	327.9	27.0	8.7	0.8	0.02	0.34	0.04	0.008	15	5	2
8/14/78	Lake Alice @ Co. Trk. A	323.7	26.0	7.3	1.0	0.05	0.28	0.07	0.008	17	6	2
8/15/78	Lake Mohawksin @ Hwy. 51	316.5	23.0	4.8	0.9	0.08	0.26	0.09	0.023	11	6	1
8/15/78	Lake Mohawksin @ Hwy. 86	313.9	24.0	6.4	0.9	0.05	0.12	0.07	0.017	ND	ND	ND
8/15/78	Grandmother Dam	305.9	20.0	6.1	1.0	0.04	0.14	0.09	0.020	25	5	5
8/15/78	Below Wausau Dam	265.5	25.0	7.7	0.9	0.27	0.22	0.05	0.012	15	6	5
8/16/78	Below Stevens Point Dam	222.5	23.5	7.1	1.2	0.06	0.25	0.10	0.025	38	11	4
8/15/78	Centralia Dam	199.2	26.0	7.6	1.3	0.04	0.27	0.09	0.014	56	12	4

Appendix B

Dissolved oxygen levels and water temperature in the Upper Wisconsin River during the summer of 1977. Values represent mid-depth samples unless otherwise indicated.

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
341.7	Phillips St. Bridge, Rhldr.	6/21	7.7	21
		7/01	7.6	20
		7/07	8.5	26
		7/11	5.8	24.5
		7/12	6.5	23
		7/13	6.8	23
		7/14	5.9	22
		7/15	6.9	23.5
		7/18	6.8	25
		8/02	6.9	27
		9/02	7.9	20
340.8	Highway 8 Bridge, Rhldr.	6/21	7.3	22
		7/06	7.8	25
		7/21	6.6	27*
		7/22	ND	26*
		9/16	6.9	16
		9/23	7.1	14
339.8	Near Crescent School	6/21	6.6	22.5
		7/06	6.4	24
338.7	2/5 mi. W. of Timber L.	6/21	6.0	21.5
		7/06	6.4	24
		7/21	6.3	26*
		7/22	7.1	28*
337.7	1 mi. E. of Loon L.	6/21	5.5	20.5
		7/06	6.0	24
		8/15	6.7	21
		9/16	6.1	15
		9/22	7.2	14
336.5	1 mi. E. of Cook L.	6/21	5.3	21
		7/06	5.8	23
		7/15	4.4	24.5
		7/22	4.8	27*
		9/16	5.9	16
		9/23	6.8	14

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
335.3	Above Hat Rapids Dam	6/21	5.5	20.5
		7/06	6.1	23
		7/11	4.9	24.5
		7/12	4.5	23
		7/13	4.6	23.5
		7/14	4.9	24
		7/18	4.8	25.5
		7/21	5.9*	26
		7/22	5.0	20
		8/02	5.0	24.5
		8/04	4.6	23
		8/11	4.7	21
335.1	Hat Rapids Road Bridge	6/21	6.2	21.5
		7/07	6.7	25.5
		7/11	5.4	24
		7/12	5.0	23
		7/13	5.8	23.5
		7/14	5.3	24.5
		7/15	5.2	24.5
		7/18	5.2	25
		8/02	5.4	22
		8/04	4.6	22
		8/11	5.6	21
		9/02	5.2	20
333.7	1.3 mi. Above Crescent Cr.	6/21	6.8	22
332.5	Off Camp 10 Road	6/21	7.6	22.5
329.0	½ mi. Above Negro Island	6/22	8.1	21
327.9	Below Negro Island	6/22	6.6	20
		7/11	7.0	23.5
		9/14	7.0	16
		9/22	7.6	14
236.4	½ mi. Above Spring Cr.	6/22	5.6	20
		7/11	5.5	23
		9/14	6.6	16
		9/22	7.4	14
324.8	At Theilers Resort	6/22	6.6	22
		7/11	5.0	23
323.7	Co. Trk. A, Lake Alice	6/22	6.4	20.5
		7/25	4.7	24
		8/29	6.2	20.5
		8/20	7.1	20.5
		9/01	5.8	20

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
322.6	2/3 mi. E. of Sump L.	6/22	6.5	21
		9/01	6.1	20
320.7	½ mi. S. of Mabel L.	6/22	9.5	20.5
319.4	Above Kings Dam	6/22	9.7	21
319.3	Kings Dam Tailwater	6/22	8.9	21
		7/12	5.2	23
		7/13	7.2	24
		7/14	7.4	24
		9/21	6.8	15
		9/28	7.9	14
317.8	1/3 mi. Above Muskellunge Cr.	6/23	7.5	20
		7/12	5.9	23
		7/13	6.9	23.5
		7/14	8.0	26
		9/21	6.2	15
		9/28	8.2	14
316.5	Hwy. 51, Lake Mohawksin	6/23	7.7	20
		7/19	5.6	26.5
		8/19	8.3	18.5
		9/21	6.1	15
		9/28	7.9	14
315.8	Mt. & W. R.R. Bridge, Lake Mohawksin	6/23	7.9	20
		8/19	7.1	18.5
		8/22	8.2	19
		8/23	8.8	18
313.9	STH 86 - Tomahawk Lake Mohawksin	6/23	8.0	19.5
		8/23	8.6	18
313.0	Above Lake Mohawksin Dam	6/23	7.4	19.5
		7/20	7.2	27
		9/01	7.6	20
		9/02	8.0	20
312.8	Tailwater L. Mohawksin	6/23	7.3	19.5
		7/07	7.5	25
		7/22	7.6	27
		8/31	7.6	21
312.3	Spirit River	6/24	8.3	21
		7/07	6.1	25.5
		7/22	5.8	26

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
312.0	Below mouth of Spirit R.	6/24	8.2	20.5
		7/01	8.3	20
		7/07	7.4	25.5
		7/22	7.6	26
		9/20	7.2	15
311.3	½ mi. above Scanawan Creek	6/24	8.3	20.5
		7/07	7.5	25
		7/22	7.5	25.5
310.3	½ mi. Below Scanawan Creek	6/24	8.4	20.5
		7/07	7.4	25.5
		7/22	7.1	25
309.3	½ mi. Above Bauer's Creek	6/24	8.1	20.5
		7/07	6.9	25.5
		7/21	8.1	27
		7/22	6.0	24
308.1	1 mi. below Bauer's Creek	6/24	7.0	20.5
		7/07	6.2	25
		7/21	7.9	26.5
		9/26	7.0	14
		9/29	6.9	14
307.3	1.3 mi. Above Grandmother Dam	6/24	6.2	20.5
		7/07	5.8	25
		7/21	4.9	26
		9/20	6.3	15
		9/26	6.6	14
		9/29	6.9	14
305.9	Above Grandmother Dam	6/24	6.3	20
		7/07	7.5	25.5
		7/20	5.7	27.0
		7/21	5.6	25.5
		9/20	5.7	15
		9/26	6.9	14
		9/29	7.1	14
300.8	Above Grandfather Dam	6/24	6.3	21.5

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
299.4	Below Grandfather Dam	6/24	6.8	22
		8/24	8.0	18.5
		9/24	9.1	18.5
		8/25	8.0	18.5
		8/25	8.5	18.5
		8/26	8.2	19.5
		8/26	8.4	19
		8/26	8.2	19
290.5	Above Alexander Dam	6/27	7.4	22
		8/25	8.3	18.5
290.3	Below Alexander Dam	6/27	8.5	23
289.1	Oregon St. - Merrill	6/27	9.8	24.5
286.3	Prairie River at Merrill	6/27	7.5	24
286.1	Below Merrill Dam	6/27	7.5	24
284.0	Off CTH "W"	6/27	8.3	24
283.4	1 mi. SE of Heinrich L.	6/27	8.8	24
281.6	New USH 51 Bel. Wis. Dam E.	6/27	10.4	26
278.0	Near County Line Creek	6/28	8.8	24
274.4	Near Granite Heights	6/28	9.2	25
271.5	CTH "WW" - Brokaw	6/21	8.4	20.5
		7/01	8.1	20.5
		8/12	8.1	19
		8/17	8.3	18
		8/23	8.2	18.5
271.0	1/3 mi. Bl. Brokaw	6/21	8.1	20.5
		7/01	7.9	20.5
		7/27	6.7	22
		8/17	7.8	17
268.8	3/4 mi. NW of Restlawn Cem.	6/21	6.6	20
		7/01	6.8	20
		7/27	6.4	23
		8/17	7.7	17.5
		8/23	6.5	20
		8/24	7.0	18.6
		9/27	9.0	14

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
267.9	¼ mi. Above Jim Moore Creek	6/21	6.2	21.5
		7/01	5.9	21
		7/27	6.3	24.5
		8/17	7.4	18
		8/24	6.3	20
267.4	Bt. Landing near CTH "W"	6/21	6.3	21.5
		7/01	6.4	21
		7/27	6.8	24.5
		8/11	6.2	21
		8/12	6.3	20
		8/17	6.5	18.5
		8/23	4.7	20
267.0		6/21	6.4	22
		7/01	6.2	21
		8/17	6.6	18.5
		8/24	5.8	20
		9/27	6.8	14
266.2	¼ mi. Bl. Bridge St. Wausau	6/21	6.0	21
		7/01	6.0	22
		8/17	5.8	18.5
		8/23	5.2	20
		8/24	6.1	20
265.9	P&P R.R. Bridge - Wausau	6/21	6.1	21.5
265.6	Above Wausau Dam	6/21	5.8	21
		7/01	5.7	22
		8/11	4.2	20.5
		8/12	4.8	20.5
		8/17	4.5	19
		8/23	5.3	20
		8/24	6.8	20
		9/27	8.0	14
265.5	Below Wausau Dam	6/21	6.2	22.5
		7/01	5.4	22
		7/05	6.7	24
		7/06	6.1	27.5
		7/18	4.5	25.5
		8/17	5.5	20

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
264.7	CTH "N" - Wausau	6/21	5.9	22
		7/01	4.8	21.5
		7/06	6.2	27
		8/17	5.4	20
		9/02	7.7	21
362.6	Mouth of Rib River	6/22	9.0	21.5
		7/06	6.3	27
		7/18	5.3	26
264.1	Below Wausau STP	6/21	5.7	22
		9/23	7.9	15
262.9	L. Wausau Off Boat Landing	6/21	5.5	22
		7/01	4.3	21.6
		7/06	6.8	27
		7/18	4.0	25
		8/17	6.0	20
		9/02	6.8	21
		9/23	7.8	15
261.9	Below Asylum Point	6/21	5.0	21
		7/19	3.7	26.5
		8/17	4.9	19
		9/23	7.3	14.5
260.7	2 mi. Above Rothschild Dam	6/21	5.3	21
		7/19	3.9	25
		8/17	6.0	19.5
259.3	3/4 mi. Above Rothschild Dam	6/21	5.0	21
		8/17	5.9	20
		9/02	6.1	21
258.4	Above Rothschild Dam	6/22	4.4	21.5
		7/05	6.6	25
		7/20	4.8	26
		8/17	5.8	20
257.7	3/4 mi. Below Rothschild Dam	6/22	4.3	22
		7/05	4.6	23.5
		8/18	6.0	20
256.3	Hwy. 51 Bridge - Below Weyerhaeuser	9/02	5.0	21

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
256.9	Off Military Road	6/22	5.2	22
		7/29	5.2	24.5
		8/18	5.7	20
255.0	3/4 mi. above Black Creek	6/22	4.6	22.5
		7/29	5.3	25
		8/18	5.5	20
254.3	Mouth of Black Creek	6/22	4.5	22.5
		7/29	5.0	25.5
		8/18	5.0	20.5
253.3	Above Four-Mile Creek	6/22	4.0	22
		7/29	5.0	25
		8/18	4.7	20
		9/08	6.0	
252.8	Below Four-Mile Creek	6/23	3.2	20.5
		7/29	4.8	25
		8/01	4.0	22.5
		8/18	4.5	20
		9/13	6.1	17
252.1	Near North End ½ Moon L.	6/23	3.0	20.5
		8/01	4.0	23
		8/18	4.3	20
251.4	Near South end ½ Moon Lake	6/23	3.1	21
		8/01	3.9	23
		8/10	4.2	20
		9/07	6.0	ND
		9/08	6.2	ND
250.2	Above Mosinee Flowage	6/23	3.3	21
		8/18	4.8	20.5
		9/07	6.0	ND
249.3	Above Mosinee Dam	6/23	4.0	21
		8/18	5.1	20
		9/02	5.4	21
		9/13	6.5	18
249.1	STH 153	7/05	6.9	25
		8/18	5.4	20.5

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
248.9	¼ mi. Below Mosinee Papers	6/23	4.2	21.5
		7/01	4.8	21.5
		7/06	4.6	25.5
		7/21	3.1	26.5
248.7	½ mi. Below Mosinee Papers	6/23	4.0	21.5
		7/06	5.2	25
		7/21	4.7	27.5
248.1	1 mi. Below Mosinee Papers	6/23	2.5	22.5
	East Channel	6/23	0.6	23
		7/06	5.0	25
	East Channel	7/21	0.2	29.5
		7/21	2.5	27
		8/18	4.3	20.5
247.2	2 mi. Below Mosinee Papers	6/23	3.6	21.5
		7/06	3.2	27
		7/21	3.2	27
		8/18	4.6	20.5
245.9	¼ mi. Below Hog Creek	6/23	3.5	21.5
		7/06	5.1	25
		7/21	3.4	27.5
		8/18	4.2	20
244.3	3/4 mi. SE of BM 1152	6/23	3.2	22
		7/06	5.5	25
		7/21	3.0	26.5
		8/18	4.17	20.5
		9/15	6.5	18
242.9	NW of BM 1136	6/24	2.5	21.5
		7/06	5.9	25
		7/21	3.3	27
		8/18	4.6	20.5
		9/15	6.5	18
241.0	South end of Big Island	6/24	6.6	21.5
	1.5 mi. above CMS & P&P R.R. Bridge	6/24	4.5	21.5
		7/25	5.5	25
		8/18	6.7	20.5
240.9	2/3 mi. above CMSP&P RR Br.	6/24	4.5	22
		7/26	3.5	24
		9/29	7.9	15

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
240.1	STH 34 - Lake DuBay	6/24	3.8	22
		7/26	4.1	23.5
		8/18	6.7	20.5
239.1	Near Knowlton Cemetery	6/24	5.2	22
		9/29	7.7	15
237.0	1.5 mi. Above DuBay Dam	6/24	5.6	22
		7/27	5.7	24
		9/19	5.5	17.5
235.5	Above DuBay Dam	6/24	7.0	21.5
		7/29	7.2	25
		9/19	6.3	17.5
235.3	DuBay Dam - Tailwater	6/27	5.3	22.5
		8/05	4.2	22
234.8	.8 mi. Below DuBay Dam	6/27	5.7	22
		8/05	4.8	23
234.2	1.5 mi. Below DuBay Dam	6/27	4.8	22
		8/05	4.1	22.5
233.6	USH 51 Below Second Lake	6/27	5.8	23
		8/03	5.19	22
		8/08	4.8	23.5
230.7	1.8 mi. Above Second Lake	6/27	5.7	23
		8/08	4.8	23.5
229.9	.8 mi. Above Second Lake	6/27	5.8	23.5
		8/08	4.9	23.5
228.6	Below Second Lake	6/27	6.7	23.5
		8/08	4.9	23.5
228.6	1.2 mi. Below Second Lake	6/27	6.7	25
		8/08	5.8	25
		8/09	5.4	23.5
226.4	Rocky Run	6/27	6.6	24.5
225.0	2.2 mi. Above USH 10 Bridge	6/27	7.7	26
223.6	Bukolt Pk. - Stevens Point	6/27	7.5	25

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
223.0	USH 10 - Stevens Point	6/27	6.4	24
222.5	Above Stevens Point Dam	6/27	7.1	24.5
		6/29	7.1	23
222.3	Near RR Bridge Stevens Point	8/17	7.0	20
221.2	.9 mi. Below St. Point Dam	6/29	5.3	23.5
219.8	Below Cons. Papers	6/28	5.5	24.5
		8/01	6.6	25
218.4	Mid-Channel Bl. Nepco-Whiting	6/28	5.5	24.5
		8/01	6.8	23
218.1	NE side of Fields Island	6/28	5.8	25
		8/01	7.1	24
218.5	West Ch. Bl. Nepco-Whiting	6/28	6.3	25
218.1	Below Foremost Foods	6/28	5.8	24
		8/01	7.3	23
216.1	Below Fields Island	8/01	7.7	23
215.1	Boat Landing, below Plover	6/28	5.8	24
		8/01	7.5	24
		8/17	7.2	19
213.6	Hayes Avenue	6/28	5.7	24
		8/02	7.1	23
		8/17	7.4	19.5
		9/21	8.3	15
211.9	3.1 mi. Above Pleasure Isl.	6/28	6.5	24
		8/02	7.8	23
		8/17	8.2	20
209.4	1 mi. Above Pleasure Island	6/29	7.1	22.5
		8/02	9.0	23
		8/17	8.8	20
208.1	Boat Landing Above Biron	6/29	7.5	22.5
		8/17	8.2	20
205.3	Above Biron Dam	6/29	6.7	23
		8/17	7.2	20.5
		9/21	8.1	15

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
205.1	Below Cons. Papers, Biron	6/29	6.7	24
204.1	Off River Road - Biron	6/29	7.2	24.5
202.5	G.B. & W. RR Br.-Wis. Rapids	6/30	5.9	23.5
202.0	Above Wis. Rapids Dam	6/30	5.7	23.5
201.8	Jackson St. Bridge	6/30	5.4	24
		7/05	7.8	26.5
		7/08	5.8	26.5
		8/18*	8.2	20
		8/25	7.5	20
201.7	STH 13	6/30	5.4	23
200.9	C&NW RR Bridge	6/30	5.8	23.5
		7/05	8.4	25.5
		7/08	6.4	26.5
		8/18	8.1	19.5
		8/25	8.0	20.5
200.5	Above Wis. Rapids STP	6/30	6.4	23.5
		8/25	8.1	20
200.2	Below Wis. Rapids STP	6/30	6.4	23.5
		8/25	8.1	20
199.2	Above Centralia Dam	7/08	6.2	27
		8/18	7.9	20
		8/25	7.4	20
197.8	Above Port Edwards Dam	6/30	6.1	23.5
		7/08	7.4	27.5
		8/18	8.1	20
		8/30	6.3	21.5
196.6	200 yds. Below Nepco-Port Edwards	6/29	6.8	24
		7/05	6.7	24
		8/08	6.6	25
		8/18	8.6	20
195.7	Harvey Creek Below Port Edwards	7/05	6.8	24
		8/18	8.1	20
195.0	Near Moccasin Creek	6/29	7.0	24
		7/05	6.6	24
		8/08	6.3	25

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
194.4	Riverside Park Nekoosa	6/29	7.3	24.5
		7/05	6.8	24.5
		8/08	6.3	25
		8/18	7.1	20
		9/28	8.1	16
193.8	STH 73 - Nekoosa	6/29	6.2	25
		7/05	7.0	24
		7/08	5.1	26
		8/08	6.3	25
		8/18	6.1	20
193.5	Above Nekoosa Dam	6/29	4.6	23.5
		7/04	5.1	24
		8/08	4.3	34.5
192.9	½ mi. Below Nepco-Nekoosa	6/30	4.2	23.5
		7/05	6.6	25.5
		7/13	4.3	26.5
		8/09	3.9	24.5
		8/18	4.1	21.5
192.3	1.25 mi. Below Nepco-Nekoosa	6/30	3.3	23.5
		7/05	6.8	25
		7/08	4.4	27
		7/13	4.4	26.5
		8/09	3.5	24
191.6	¼ mi. Below Nekoosa STP	6/30	2.9	23.5
		7/05	7.3	25
		7/15	2.0	26.5
		8/09	3.0	24
		8/18	3.6	21
190.7	1 mi. NW of Ross Lake	6/30	3.1	23
		7/05	6.8	24.5
		7/15	1.4	26
		8/10	2.1	23
		8/18	2.9	20.5
189.4	Below Nekoosa, CTH "AA"	6/30	2.7	23
		7/05	7.9	25.5
		8/10	1.5	22.5
		8/18	2.0	20.6

Appendix B (continued)

River Mile	Site Location	Date	Dissolved Oxygen* (mg/l)	Temp.* (°C)
188.4	1.3 mi. NW of Greenhill Cemetery	6/30	2.5	23
		7/04	7.4	26
		8/10	1.3	23
		8/18	1.4	22
187.3	1.5 mi. SW of Greenhill Cemetery	6/30	2.4	23
		7/05	4.1	25.5
		8/10	1.1	22.5
		8/18	0.7	20.5
		9/26	8.8	16
186.1	SE of Greenwood Cemetery	6/30	3.1	23.5
		8/15	0.5	22.5
		8/18	0.7	21
		9/26	8.5	16
185.2	Upper Petenwell Flowage	6/30	5.8	23
		8/18	4.0	20.5
171.9	Above Petenwell Dam	8/18	9.4	22

* Surface sample.

Appendix C

In situ sediment oxygen measurements of the Upper Wisconsin River for the summer period of 1977. SOD data was corrected to 20°C.

Location	River Mile	Quality of Test	SOD @ 20°C ($gO_2/m^2/day$) Min.	Max.
300 yds above Mosinee Dam	249.3	Fair	1.1	1.3+
Mouth of Big Eau Pleine, Lake DuBay	241.8	Fair	0.3	0.6
Hat Rapids Flowage	336.5	Fair	0	1.0
Hat Rapids Flowage	337.5	Fair	1.7	2.7
300 yds Above Du Bay Dam	235.6	Good	0.8	1.1
Grandmother Dam	305.9	Fair	1.3	2.2
Below Spirit River	312.0	Good	3.5	4.2+
Below Kings Dam	319.3	Fair	1.5	2.1
Near Boat Landing, Lake Wausau	263.0	Good	1.6	1.9
Center Lake Wausau	261.9	Good	1.1	4.6
Above Petenwell Flowage	187.3	Good	0.8	1.9
Hat Rapids Flowage	337.3	Fair	1.2	1.6
About 2 miles above Grandmother Dam	308.1	Good	1.6	2.7
Above Wausau Dam	267.9	Good	0.5	5.4+
River Bend Below Kings Dam	318.9	Good	1.1	1.4
Highway 51 Bridge	316.5	Good	1.0	3.9
Lake DuBay	237.4	Good	0.9	1.2
Lake DuBay, Behind Island	238.1	Good	0.1	1.7
DuBay, Above Knowlton Br. on Right	239.3	Good	0.4	0.8
1½ miles above Grandmother Dam	307.3	Fair	1.6	2.4
2 miles above Grandmother Dam	307.9	Fair	0.4	1.9

\+ sandy substrate

Appendix D

In situ sediment oxygen demand measurements of the Upper Wisconsin River for the summer period of 1978.

Location	River Mile	Quality of Test	SOD ($gO_2/m^2/day$) Min.	SOD ($gO_2/m^2/day$) Max.	Temp. (°C)	SOD @ 20°C ($gO_2/m^2/day$) Min.	SOD @ 20°C ($gO_2/m^2/day$) Max.
Hat Rapids Flowage	338.9	Good	0.71	1.20	22.0	0.6	1.1
Hat Rapids Flowage	337.6	Good	0.32	0.80	21.0	0.3	0.8
Hat Rapids Flowage	335.4	Fair	0.63	1.00	21.0	0.6	0.9
Hat Rapids Flowage	335.3	Fair	1.07	1.20	22.0	1.0	1.1
Above Spring Creek	327.7	Good	0.89	2.40	21.0	0.8	2.2
Above Spring Creek	326.9	Good	0.58	2.20	21.0	0.5	2.1
Above Spring Creek	325.9	Good	0.24	2.30	22.0	0.2	2.0
Below Spring Creek	325.3	Good	1.02	1.40	21.0	0.9	1.3
Lake Alice	323.8	Fair	0.90	1.40	24.5	0.7	1.1
Lake Alice	320.7	Fair	0.80	1.80	24.0	0.6	1.4
Lake Alice	319.9	Fair	1.20	2.60	23.0	1.0	2.2
Lake Mohawksin	317.5	Good	1.07	1.88	23.0	0.9	1.6
Lake Mohawksin	315.5	Good	0.59	0.86	22.0	0.5	0.7
Below Spirit River	311.3	Fair	0.54	0.70	23.0	0.4	0.6
Above Grandmother Dam	306.2	Fair	0.61	0.76	23.0	0.5	0.6
Above Alexander Dam	291.9	Fair	0.12	0.51	23.0	0.1	0.4
Above Alexander Dam	290.5	Fair	0.92	1.98	22.5	0.8	1.7
Lake Wausau	262.7	Fair	0.51	1.45	20.0	0.5	1.4
Lake Wausau	261.9	Fair	1.37	1.52	23.0	1.2	1.3
Lake Wausau	259.4	Fair	0.78	1.75	20.0	0.8	1.8
Lake Wausau	259.3	Good	0.74	0.89	23.0	0.6	0.7

Appendix D (continued)

Location	River Mile	Quality of Test	SOD ($gO_2/m^2/day$) Min.	SOD ($gO_2/m^2/day$) Max.	Temp. (^oC)	SOD @ 20°C ($gO_2/m^2/day$) Min.	SOD @ 20°C ($gO_2/m^2/day$) Max.
Above Mosinee Dam	250.2	Fair	1.36	1.54	23.0	1.1	1.3
Above Mosinee Dam	249.5	Fair	0.15	0.32	21.0	0.1	0.3
Lake DuBay	239.1	Fair	0.11	0.60	22.0	0.1	0.5
Lake DuBay	237.0	Fair	0.10	0.18	22.0	0.1	0.2
Petenwell Flowage	187.0	Fair	0.21	0.61	23.0	0.2	0.5

Appendix E

Results of sediment oxygen demand for the Upper Wisconsin River using the core method. Cores were collected during the 1977-78 winter period.

Location	River Mile	Sample Description Texture (% Sand)	Sample Description Organic Content	N	SOD @ 24^oC^1 ($gO_2/m^2/day$) Avg.	Min.	Max.
Boom Lake, 200 yds N. of Hodag Park. Depth: 4.0m	342.0	75	Organic Surface Layer	2	0.134	0.119	0.149
Boom Lake, 100 yds above Phillips Street Bridge, 20 yds off east bank. Depth: 20m	341.2	50	Wood chips on surface	2	0.141	0.128	0.154
Below Rhinelander, 25 yds from west bank. Depth: 1.8m	337.2	50	Medium	3	0.058	0.036	0.074
200 yds above Hat Rapids Dam, 25 yds from east bank. Depth: 4.0m	335.3	25	High	3	0.116	0.110	0.119
Off Ski Hill Road, 15 yds from east bank. Depth: 0.5m	332.8*	Course Sand & Gravel	Low	2	0.142	0.107	0.177
Above Spring Creek, 50 yds from west bank. Depth: 1.0m	327.0	25	High	3	0.082	0.063	0.109
2 mi. above Cty. Trk A, 30 yds from west bank Depth: 2.5m	325.6	25	High	3	0.178	0.161	0.196
Lake Alice, 50 yds below Cty. Trk A 25 yds from east bank. Depth: 2.5m	323.6	25	High	3	0.182	0.174	0.191
Lake Alice, off Shorewood Road 150 yds from S. shore Depth: 1.2m	321.0	25	High	3	0.080	0.052	0.096
Below Kings Dam, 20 yds from south bank. Depth: 2.0m	318.3	25	High	3	0.140	0.118	0.175
Lake Mohawksin, 50 yds above Hwy. 51 Br., 100 yds from N bank. Depth: 2.0m	316.7	50	High	3	0.168	0.115	0.263
Lake Mohawksin, near mouth of Tomahawk River. Depth: 3.0m	315.7	5	High	2 1	0.128 (0.585)	0.120 -	0.137 -
Lake Mohawksin, 100 yds below Hwy. 86 Br. Depth: 4.0m	313.7	5	High	3	0.224	0.180	0.269
Below Spirit River, 20 yds from west bank. Depth: 1.5m	309.7	50	High	3	0.089	0.067	0.110
300 yds above Grandmother Dam, 30 yds from west bank. Depth: 1.5m	306.1	5	High	3	0.152	0.136	0.161

Appendix E (continued)

Location	River Mile	Sample Description: Texture (% Sand)	Sample Description: Organic Content	N	SOD @24°C[1] ($gO_2/m^2/day$) Avg.	Min.	Max.
Below Grandmother Dam, at wayside on Hwy. 107, 5 yds from east bank. Depth: 1.0m	303.8*	Course sand & gravel	Low	2	0.190	0.079	0.300
½ mi. above Grandfather Dam, 200 yds from west bank. Depth: 2.0m	301.2	75	Medium	2	0.152	0.123	0.180
2.5 mi. above Alexander Dam, Off Hwy 107, 100yds from east bank. Depth: 3.5m	292.9	5	High	2 1	0.037 (0.265)	0.029 -	0.045 -
100 yds above Merrill Dam, 40 yds from north bank. Depth: 2.0m	286.2	95	Organic Surface Layer	3	0.143	0.107	0.181
1 mi. below Pine River, 20 yds from east bank. Depth: 1.0m	279.6*	Course Sand & Gravel	Low	2 1	0.057 (0.599)	0.045 -	0.069 -
Granite Heights, 40 yds from west bank. Depth: 1.5m	274.9*	Course Sand & Gravel	Low	2 1	0.085 (0.513)	0.071	0.099
Above Wausau Dam, off Schofield Park, 25 yds from west bank. Depth: 2.5m	266.0	95	Organic Surface Layer	2	0.084	0.077	0.090
Above Wausau Dam, 40 yds from west bank. Depth: 4.0m	265.1	50	High-Wood Chips Wood Fiber	3	0.200	0.138	0.249
Above Wausau Dam, 10 yds from east bank. Depth: 2.0m	265.0	75	Low	2 1	0.043 (0.388)	0.040	0.046
Lake Wausau, 3/4 mi. below STP, 100 yds from west bank. Depth: 1.5m	263.0	95	Organic Surface	2 2	0.146 (0.907)	0.133 0.893	0.160 0.921)
Lake Wausau, entrance of Rib River Depth: 1.5m	262.6	75	Medium	2	0.161	0.144	0.178
Lake Wausau, off Bluegill Park, 30 yds from east bank. Depth: 4.0m	261.5	50	Organic Surface Layer	2	0.120	0.119	0.121
Lake Wausau, 1 mi. west of mouth of Eau Claire River. Depth: 2.5m	260.5	50	Medium	2 1	0.092 (0.506)	0.044 -	0.123 -

Appendix E (continued)

Location	River Mile	Sample Description: Texture (% Sand)	Sample Description: Organic Content	N	SOD @ 4°C[1] ($gO_2/m^2/day$): Avg.	Min.	Max.
Lake Wausau, 1 mi. above Hwy 29 Bridge. Depth: 4.0m	259.0	5	High	2	0.148	0.143	0.154
Below Rothschild Dam, 30 yds from west bank. Depth: 1.5m	254.4	75	Low	2	0.092	0.084	0.101
¼ mi above Mosinee Dam, 20 yds from east bank. Depth: 2.0m	249.2	4	Medium	2	0.081	0.034	0.128
¼ mi. above Mosinee Dam, off boat landing. Depth: 1.0m	249.2	5	High	2 1	0.066 (1.144)	0.061 -	0.072 -
Entrance to Lake DuBay, 15 yds from west bank. Depth: 2.0	244.4	5	High	2	0.078	0.067	0.089
Lake DuBay, ½ mi. above Hwy 34, 50 yds from east bank, Depth: 2.0m	242.0	5	High	2	0.168	0.138	0.199
Lake DuBay, off Lake DuBay Shore Road boat landing. Depth: 3.0m	239.6	25	High	2 2	0.227 (0.546	0.210 0.532	0.243 0.561)
Lake DuBay, off Wambold Rd., 50 50 yds from north bank. Depth: 1.5m	238.0	50	Medium	2 1	0.090 (0.890)	0.090 -	0.091 -
Lake DuBay, off Cty. Trk E., 30 yds from west bank. Depth: 5.0m	235.3	5	High	1	0.073	-	-
Lake DuBay, ½ mi. above dam, 20 yds from north bank. Depth: 4.0m	236.0	5	High	2 1	0.131 (0.467)	0.109 -	0.153 -
Below DuBay Dam, 15 yds from west bank. Depth: 1.7m	232.0*	95	Low	2	0.064	0.022	0.105
Stevens Point Flowage, 30 yds from west bank. Depth: 1.5m	226.0	5	High	2 1	0.225 (0.675)	0.213 -	0.238 -
Stevens Point Flowage, below Hwy. 10 Br., 30 yds from east bank. Depth: 4.0m	222.7	25	High	2 1	0.147 (0.486)	0.135 -	0.159 -
Biron Flowage, 150 yds from north bank. Depth: 3.0m	209.2	75	Medium	2 1	0.119 (0.674)	0.111 -	0.127 -
Biron Flowage, 150 yds from north bank. Depth: 3.0m	207.3	25	High	3	0.186	0.167	0.205
Biron Flowage, just above dam on north side. Depth: 4.0m	205.3	5	High	2 1	0.113 (0.626)	0.103 -	0.123 -

Appendix E (continued)

Location	River Mile	Sample Description Texture (% Sand)	Organic Content	N	SOD @ 4°C[1] ($gO_2/m^2/day$) Avg.	Min.	Max.
Above Wisconsin Rapids Dam 50 yds from east bank. Depth: 3.0m	202.0	5	High	2 1	0.124 (0.565)	0.104 -	0.143 -
Above Nekoosa Dam, 25 yds from west bank. Depth: 3.0m	193.5	95	Organic Surface Layer	5	0.80	0.057	0.102
Below Nekoosa STP, 50 yds from west bank. Depth: 2.5m	190.2	95	Organic Surface Layer	2 2	0.760 (0.232	0.073 0.176	0.078 0.289)
Entrance to Petenwell Flowage, 20 yds from west bank. Depth: 1.0m	187.6	50	High	2 1	0.103 (0.402)	0.099 -	0.107 -
Petenwell Flowage, off Yellow Banks, 100 yds from west bank. Depth: 3.0m	184.4	25	High	3	0.80	0.037	0.122

[1] A value in parentheses indicates an SOD determined at 20°C.

* An asterisk indicates a core taken with a soil auger.