

SALT CREEK / DUPAGE RIVER WORK GROUP

**STREAM DISSOLVED OXYGEN IMPROVEMENT
FEASIBILITY STUDY
FOR
SALT CREEK AND EAST BRANCH OF THE
DUPAGE RIVER**



**FINAL DATA REPORT
SOD MEASUREMENT SURVEY
EAST BRANCH DUPAGE RIVER & SALT CREEK**

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TABLE OF CONTENTS

1.0 OBJECTIVE.....1

2.0 METHOD.....1

2.1 Quality Control2

3.0 SAMPLING STATIONS2

4.0 FIELD MEASUREMENTS.....2

5.0 DATA ANALYSIS3

6.0 CONCLUSIONS.....4

ATTACHMENT 1: MURPHY AND HICKS (1986)

ATTACHMENT 2: FIELD DATA SHEETS

LIST OF TABLES

TABLE 1: SEDIMENT OXYGEN DEMAND (SOD) SURVEY LOCATIONS.....4

TABLE 2 TO TABLE 9: SOD MEASUREMENT STATION ID - EB1 TO EB84

TABLE 10 TO TABLE 17: SOD MEASUREMENT STATION ID - SC1 TO SC8.....4

TABLE 18: SUMMARY OF IN-SITU SOD4

LIST OF FIGURES

FIGURE 1: IN-SITU SOD MEASUREMENT CHAMBER.....4

FIGURE 2: DEPLOYMENT OF SOD MEASUREMENT CHAMBERS4

FIGURE 3: SOD SURVEY LOCATIONS IN EB DUPAGE RIVER.....4

FIGURE 4: SOD SURVEY LOCATIONS IN SALT CREEK4

FIGURE 5 TO FIGURE 12: DO VS. TIME FOR SOD STATIONS EB1 TO EB8.....4

FIGURE 13 TO FIGURE 20: DO VS. TIME FOR SOD STATIONS SC1 TO SC84

1.0 Objective

The purpose of this field survey was to collect data providing independent estimates of the sediment oxygen demand (SOD) in the East Branch DuPage River and Salt Creek that are being modeled for dissolved oxygen as part of the Stream Dissolved Oxygen Improvement Feasibility Study for Salt Creek and East Branch of the DuPage River. The field surveys were performed concurrently with the continuous DO monitoring coordinated by the Conservation Foundation. Selected steady-state DO monitoring data will be compared to the models as a validation check of QUAL2K simulations in Task 2 of the Feasibility Study. As water temperature affects SOD, it is advantageous to conduct the SOD survey during high temperatures that are appropriate for the modeling evaluations of alternatives, i.e., conditions assumed in the TMDL studies of these rivers (approximately 76 °F or 24.4 °C for Salt Creek)¹.

2.0 Method

The in-situ method, which by name means the measurements are made in the native location rather than in a laboratory, was employed (Murphy and Hicks 1986, refer to Attachment 1 of this report). SOD measurement chambers designed by EPA Region 4 were used in conjunction with circulating water pumps and DO probes as described in Murphy and Hicks 1986. See Figure 1 for a diagram of In-Situ SOD Measurement Chamber. Two SOD chambers were placed in contact with the bottom sediments to measure the total DO depletion rate. A “blank” chamber that is enclosed at the bottom was used to measure the DO depletion attributable to the water processes, which are the biochemical oxygen demand (BOD) exertion and biotic respiration. In general, the chambers, which are opaque, were not placed within the photic zone where photosynthesis occurred. Light and dark BOD bottles were also deployed as a backup to the “blank” chamber and to measure photosynthetic effects, if any. The SOD rate is then calculated using the following equation:

$$\text{SOD} = (V/A) * (b_1 - b_2) / 1000$$

where SOD = sediment oxygen demand rate (g/m²/day)

b₁ = rate of change of DO concentration in the SOD chamber (mg/L/d)

b₂ = rate of change of DO concentration in the “blank” chamber (mg/L/d)

V = volume of chamber (L)

A = area of chamber (m²)

The three chambers were transported by boat (see Figure 2) to the designated SOD station for deployment by the sampling crew. Water depth recorded at the stations varied between 1.4 ft and 2.7 ft. While the chamber was being lowered to the bottom, water and trapped air was vented from the open ports on the top of the chambers. Ambient bottom water was ultimately enclosed in the chambers for the SOD measurements. The enclosed chambers were left for a minimum of 15 minutes while any resuspended sediment settled to the bottom before the DO measurements

¹ Temperature of TMDL alternative conditions for East Branch DuPage River was not given in the TMDL Report. It will be assumed the same as that of Salt Creek.

began. DO and temperature in each of the three chambers were measured every ten minutes for duration of at least 1.5 hours. The DO meter/probes used with the SOD chambers were YSI models 550 and 550A.

2.1 Quality Control

DO meters/probes were calibrated using the normal air calibration procedure. DO readings on the three DO meters/probes at each sampling station were checked by the field crew for agreement within 0.5 mg/L. In addition, the initial and final DO in the light and dark bottles were measured by Winkler titration and the DO probe used in the first chamber (referred to as Probe 1) for another check on the accuracy of the probe measurements.

3.0 Sampling Stations

The bottom substrate composed of fine grained sediments (clay, silt and sand) are conducive to measuring SOD; coarse materials (gravel, cobbles and boulders) are not because it is difficult to seal the bottom of the chamber. High SOD rate is associated generally with a high organic content of the sediment. Slow moving reaches of the river are areas where fine-grained, organic sediments are likely to be found. The impoundments and pools formed by dams and other obstructions (e.g., debris) were identified by the reconnaissance survey (Task 1) and the helicopter fly-over DVD. Eight sampling stations were selected on each of the two waterways for in-situ SOD measurement. When the field crews arrived at each station, the river bottom was viewed or probed to estimate the percent bottom coverage of fine-grained sediment. The width and depth of the river were also measured and recorded. The fine-grained sediment area was identified as a suitable location for deployment of SOD measurement chambers. Sampling locations on East Branch DuPage River and Salt Creek are presented in Figures 3 and 4, respectively. Also, refer to Table 1 for descriptions of sampling locations and river miles.

4.0 Field Measurements

As stated previously, elevated water temperature was preferred for these measurements to reduce the modeling uncertainty associated with applying a temperature adjustment coefficient based on the literature. In order to capture high water temperature, SOD measurements were conducted during the summer months. Field measurements were performed on eight days, when there was no precipitation on that day, and the preceding day, starting on July 31, 2006 and ending on September 1, 2006. On each day of the field survey, SOD was measured at two stations. Water temperature from all 16 surveys ranged from 21.5 °C to 34.4 °C with an average of 25.9 °C. Tables 2 through 17 present raw data taken by the field crew during the survey.

5.0 Data Analysis

All data recorded in the field were key-entered into Excel for analysis and graphical presentation (The field data sheets are included as Attachment 2 to this report). DO in each of the two replicate chambers and one blank chamber were plotted against time and the data were analyzed by regression analysis to determine the “best-fit” linear equation. The measured data and the slopes are presented graphically for each set of measurements in Figures 5 through 20. Table 18 presents a summary of the calculated SOD of all 16 survey stations.

In general the time series of DO data follow linear trends and the regression analyses resulted in highly correlated sets of data with r-squared² values greater than 0.97. One exception is at Station EB8 (Figure 12), which shows an abrupt decrease in the DO of all three chambers between 10:45 AM and 11:10 AM. The light and dark bottle data do not show a change in DO similar to the drop from 6.0 to 3.0 mg/L found in the blank chamber. The exact cause of the disturbances in the chambers has not been determined; however, a malfunction of the power supply to the DO meters or fouling of the meter membranes is a possible explanation. Nevertheless, the data collected prior to 10:45 only at this station were used in the analyses of the DO uptake rates.

The measurements of DO in the light and dark bottles by the Winkler titration generally yielded lower DO than the probe measurements. Laboratory analysis of the reagent used in the field, following the field survey, found a difference in the normality that would effectively increase the Winkler DO by 20%. This explains part, but not all, of the differences. Water sampling and analyses of potential analytical interferences (nitrate, iron and total organic carbon) was performed but was not able to pinpoint the exact cause of the discrepancy. Because the light and dark bottle measurements are a backup to the blank chamber measurements and the blank chamber data were sufficient, there was no reason to rely on the Winkler DO data. Hence, the issue of the Winkler DO results was averted.

Differences between the two SOD measurements at a given station varied. Large differences may indicate that the sediment composition varies spatially at that station, whereas small differences indicate a relatively uniform sediment composition. An average of the two SOD measurements is reported in Table 18.

The conventional way of reporting SOD data is at a base water temperature of 20 °C. The Arrhenius temperature adjustment equation was used to convert SOD rates from the ambient temperature to 20 °C.

$$\begin{aligned} \text{SOD}(t) &= \text{SOD}(20) * \Theta^{(T-20)} \\ \Rightarrow \text{SOD}(20) &= \text{SOD}(t) / \Theta^{(T-20)} \end{aligned}$$

where SOD(t) = SOD at temperature T
SOD(20) = SOD at 20 °C
Θ = temperature correction coefficient

² r is defined statistically as the correlation coefficient; r-squared is simply r².

A typical Θ value for SOD is 1.08, which means there is an 8% change in SOD for a 1 °C change in temperature. Similarly, a 10 °C lower temperature (than 20 °C) yields an SOD rate that is 46% that of the base (20 °C) rate. Temperature adjusted to 20 °C for all stations are also found in Table 18.

6.0 Conclusions

The SOD measured at ambient temperature in the East Branch (EB) ranged from a minimum of 0.67 g/m²/day to a maximum of 9.53 g/m²/day and similarly in Salt Creek (SC) ranged from a minimum of 0.09 g/m²/day to a maximum of 5.74 g/m²/day. The higher SOD in EB is in part attributable to the higher ambient temperature that occurred in EB as compared to SC. Station-averaged temperature-adjusted SOD in EB was in the range of 1.13 to 3.61 g/m²/day, as compared to the range of 0.47 to 3.59 g/m²/day in SC. This suggests that the SOD in EB is slightly greater than the SOD in SC. The 20 °C SOD rates used in the preliminary QUAL2K modeling of EB and SC were in the range from 1.0 to 2.5 g/m²/day.

The results of the SOD survey will be used to evaluate the SOD parameters in the QUAL2K model of East Branch DuPage River and Salt Creek. The modeled parameters will be adjusted based on the results of this field study.