

THE ROUGE RIVER PROJECT
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Rouge River National Wet Weather Demonstration Project

Wayne County, Michigan

TECHNICAL MEMORANDUM 1996 Sediment Oxygen Demand Studies

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Rouge River National Wet Weather Demonstration Project

MISSION STATEMENT

The mission of the Rouge River National Wet Weather Demonstration Project is to demonstrate effective solutions to water quality problems facing an urban watershed highly impacted by wet weather and develop potential solutions and implement projects which will lead to the restoration of water quality in the Rouge River. The project will address both conventional and toxic pollutants to:

- provide a safe and healthy recreational river resource for present and future generations;
- re-establish a healthy and diverse ecosystem within the Rouge River Watershed;
- protect downstream water resources such as the Detroit River and Lake Erie; and
- help ensure compliance with federal, state and local environmental laws which protect human health and the environment.

This will be accomplished through the development, implementation and financial integration of technical, social and institutional frameworks leading to cost-efficient and innovative watershed-based solutions to wet weather problems. This watershed-based national demonstration project will provide other municipalities across the nation facing similar problems with guidance and potentially effective solutions.

ABSTRACT

In situ sediment oxygen demand (SOD) measurements were made at eight stations on the Main Branch of the Rouge River between August and October 1996. SOD measurements were attempted at a ninth station, but were not successful due to excessively rocky sediments. Results were similar to the 1995 work, in that sandy sediments exhibited low to moderate SODs (0.97 to 2.23 g O₂/m²/day), while silty sediments exhibited higher SODs (3.59 to 5.41 g O₂/m²/day). Silty, high-SOD sediments were restricted to Beverly Impoundment and the lower portion of the Main Branch, from Plymouth Road downstream to Schafer Road. High-SOD sediments in the lower portion of the Main Branch were not uniformly distributed across the stream channel width, occupying 10 to 50 percent of the channel width in some locations. It is recommended that additional SOD measurements be made at a subset of the 1995 and 1996 stations, perhaps in 1998, to evaluate the effects of CSO abatement structures on the river sediments.

PREFACE

The Rouge River and its watershed are a primary source of pollution to the Great Lakes. The Clean Water Act of 1972 intended to make waterways "fishable and swimmable" by 1983. Although that goal has not been reached, great progress has been made in improving water quality in most waterways. The Rouge River Remedial Action Plan (RAP) provided a basis for which The Rouge River National Wet Weather Demonstration Project (Rouge Project) efforts were created: it identified the major sources of pollution and measured the relative contributions of each. The RAP is the continuing foundation for the Rouge Project and presents a framework for addressing the problems within the Rouge River by looking beyond treatment and focusing instead on prevention methods.

The Rouge Project was established under the initial Rouge Grant 1 from the United States Environmental Protection Agency, Region 5, and enabled Wayne County to initiate a comprehensive watershed-wide pollution-control approach that addresses combined sewer overflow (CSO), stormwater management, and other nonpoint source controls through the application of innovative technologies, progressive financial and institutional arrangements, and creative public involvement and education programs.

Rouge Grant 2 provides the framework for the progression and implementation of Project goals as Wayne County continues its mission to develop potential solutions and implement projects which will lead to the restoration of water quality in the Rouge River. The Project will address both conventional and toxic pollutants to:

- provide a safe and healthy recreational river resource for present and future generations;
- re-establish a healthy and diverse ecosystem within the Rouge River Watershed;
- protect downstream water resources such as the Detroit River and Lake Erie; and
- help ensure compliance with federal, state, and local environmental laws which protect human health and environment.

This will be accomplished through the development, implementation, and financial integration of technical, social, and institutional frameworks leading to cost-efficient and innovative watershed-based solutions to wet weather problems. This watershed-based national demonstration project will provide other municipalities across the nation facing similar problems with guidance and potentially effective solutions.

Under Rouge Grant 2, the Rouge Project will build on lessons learned from Grant 1 efforts and focus on further integration of the goals of the overall Mission. To this end, Rouge Grant 2 concentrates on the following key Project areas:

- **Watershed Management** will continue under Rouge Grant 2 with the development and evaluation of wet weather and stormwater alternatives, the planning of long-term monitoring

programs, and the ongoing efforts to enhance instream water quality, monitor rain and flow levels, interpret data analysis, and present recommendations.

- **Nonpoint Source Pollution Control** will provide for the stormwater management, permit applications, and development of financial and institutional alternatives for wet-weather watershed management in concert with enhanced efforts to establish institutional partnerships. Toward the goal of institutional partnering, several community projects will be undertaken with watershed communities. Additional efforts include the inventory of wetlands and measurement of pollutant loads from abandoned dumps and air deposition with possible remediation of some sites.
- **CSO Construction Coordination** will continue to monitor the construction of CSO demonstration projects established under Grant 1. Additional planning and assistance will allow project coordinators to make additional recommendations on the design criteria of future CSO abatement facilities.
- **Public Involvement and Information** will reach and interact with more stakeholders, institutions, and regulatory agencies, thus fostering a renewed understanding and continued commitment to reducing pollution, and continuing the transfer of watershed management approaches way beyond the project. It will be the central mechanism for transmittal of the Project's Decision Support System tools, processes, and information necessary for sustaining a watershed management support system directly to varied audiences both within and outside the Rouge watershed.

Additional information on the Rouge River Project is available from many sources, including the Wayne County Department of Environment (WCDOE) and the Rouge Program Office (RPO).

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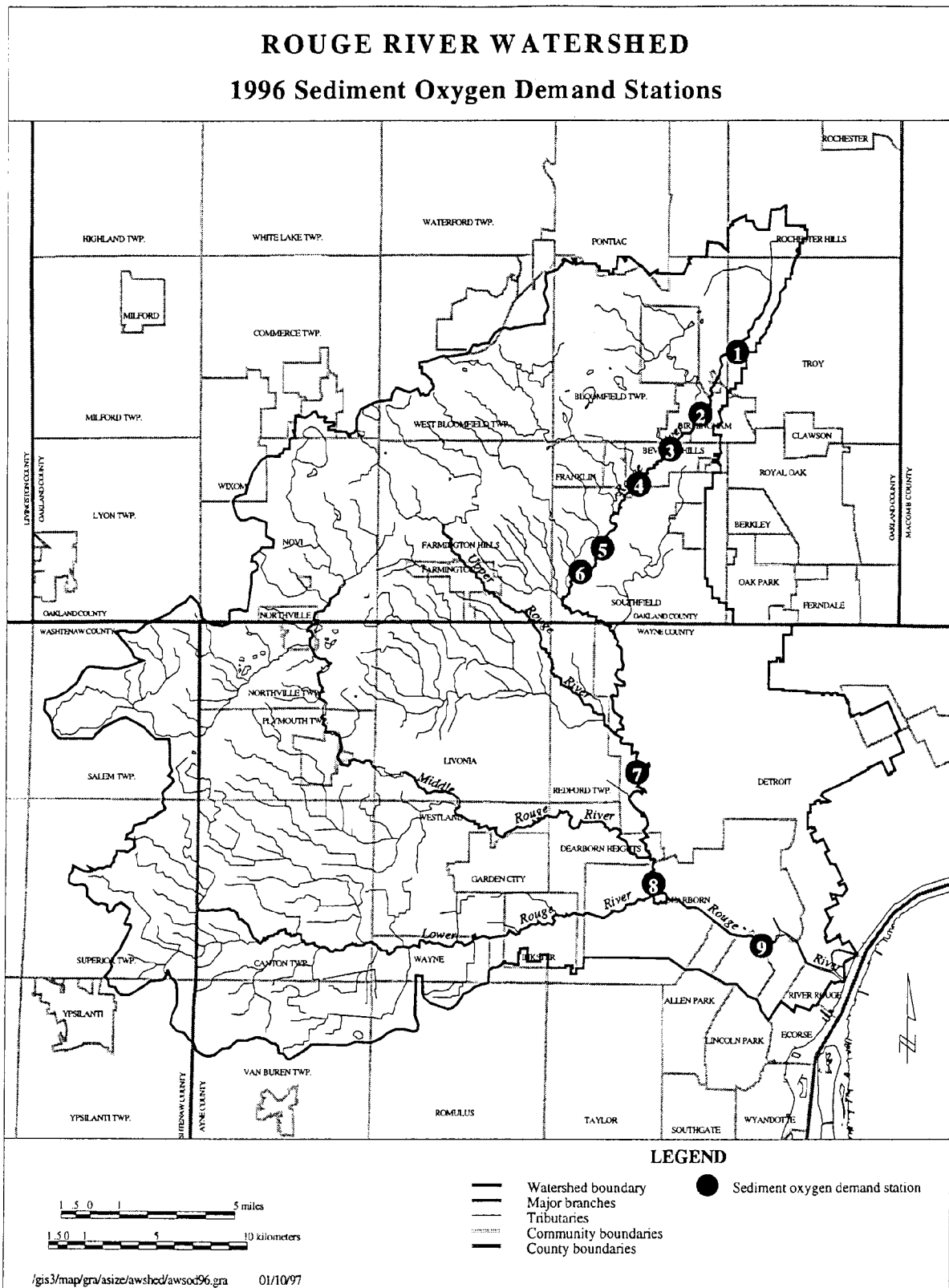
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1.0 INTRODUCTION. This report presents data from sediment oxygen demand (SOD) measurements collected on the Rouge River in 1996. This 1996 study was a follow-up to the sediment oxygen demand (SOD) measurements made on the Rouge River in 1995 (RPO, 1996). The 1995 studies were conducted to establish baseline SOD conditions and provide input to the Rouge River oxygen budget models. The 1995 study found that:

- Sediments were generally sandy, and SODs generally low ($< 1.5 \text{ g O}_2/\text{m}^2/\text{day}$), at most of the 14 stations sampled in 1995.
- Silt deposits were generally restricted to small, local deposits, except in the Middle Branch impoundments (Phoenix Lake, Newburgh Lake, etc.) and some areas of the lower Main Branch, and these silt deposits exhibited variable but generally higher SODs (2 to $5 \text{ g O}_2/\text{m}^2/\text{day}$).

The report on the 1995 study results recommended measuring SOD at additional stations on the Main Branch, especially downstream of known CSO discharges and in the lower part of the Branch. This report presents those data, from eight locations along the Main Branch (*Figure 1-1*).

**Figure 1-1:
1996 Sediment Oxygen Demand Stations**



2.0 INVESTIGATIVE APPROACH AND METHODS. Details of the investigative approach and methods used in this study are provided in the SOD Field Sampling Plan (RPO, 1994), and in the 1995 SOD report (RPO, 1996). A brief summary is provided below.

SOD was measured using an *in situ* technique. A chamber of known dimensions is placed on the sediments and the decline in dissolved oxygen (DO) concentration inside the chamber is measured over time. The volume of water and area of sediment enclosed by the chamber are known, permitting the calculation of an oxygen consumption rate coefficient, with units of grams oxygen consumed by the sediment bacteria, per square meter of sediment, per day (g O₂/m²/day). Duplicate or triplicate SOD measurements were made at each station, and a single water oxygen demand (WOD) measurement was also taken. Data are presented as ambient temperature and normalized to 20 °C.

Stations were chosen to provide spatial coverage in areas of the Main Branch not tested in 1995, especially locations downstream of CSO discharges and in the lower part of the Branch, downstream of Plymouth Road.

3.0 RESULTS AND DISCUSSION.

3.1 SEDIMENT CHARACTERISTICS AND AMBIENT STREAM MEASUREMENTS.

Sediment types at the nine stations sampled in 1996 exhibited a consistent spatial distribution (*Table 3-1*). Sands and gravels were common in the upper portion of the study area, from Wattles Road (Station 1) downstream to Beech Road (Station 6). Silts dominated at each station in the lower portion of the study area, from Plymouth Road (Station 7) downstream to Schafer Road (Station 9). Sediment composition at the specific point in the river where the SOD measurements were made was not necessarily reflective of the sediment at that location in the river in general; silt deposits were intentionally sought out, to evaluate “worst case” SOD conditions. The issue of sediment

Table 3.1
Sediment Composition at the 1996 SOD Stations

| Location [Map No.] | Sediment Type | Representative of General Location? |
|---|--------------------------------|---|
| Wattles Road, Troy [1] | Cobble/gravel/sand/silt | Yes |
| 15 Mile Road, Birmingham [2] | Sand/silt/gravel | No; elsewhere = coarser sand and gravel |
| Beverly Impoundment, Beverly Hills [3] | Sandy silt | No; representative of river channel, but impoundment = silt |
| Lahser Road, Beverly Hills [4] | Silty sand/small gravel | Yes |
| Civic Center Drive, Southfield [5] | Gray silt/silty sand, detritus | No; elsewhere = coarser sand and gravel |
| Beech Road, Southfield [6] | Silty sand | Yes |
| Plymouth Road, Detroit [7] | Silt/sand | Yes; silt along channel margins, sand in mid-channel |
| U/S of UM-D Dam, Dearborn [8] | Gelatinous oily silt | No; silt along channel margins, sand in mid-channel |
| Schafer Road, Dearborn [9] | Black oily silt | No; silt in mid-channel, bare concrete elsewhere |

representativeness is particularly important at three locations:

- Beverly Impoundment: the sandy silt deposit where the SOD was measured was representative of the river channel, but not of the sediments in the impoundment, which were thick deposits of silt. The importance of these silt deposits to the oxygen balance in the Main Branch is debatable.
- Upstream of the dam at the University of Michigan - Dearborn: the silt deposit measured for SOD probably occupies no more than 25 to 30 % of the channel width, occurring as ribbons on both sides of the channel, with sand in the middle.
- Schafer Road (in the concrete channel): the silt deposit sampled for SOD was 6" to > 12" thick, and occupies 40 to 50 % of the channel width at this location. Similar material has been observed near the bridges at Rotunda Road and Greenfield Road, though its distribution in the concrete channel in general is unknown.

Ambient water column DO concentrations ranged from 3.16 to 8.85 mg/L. DOs were particularly low at the Plymouth Road and Schafer Road locations (3.16 to 3.46 mg/L), and even these concentrations were above those measured in early to mid-August (< 2 mg/L). Weather played a role in these low DOs; precipitation in July and August 1996 was unusually low, and consequently river flows were also unusually low. Measured DOs in the lower part of the Main Branch, from Plymouth Road downstream to Schafer Road, during this time were consistently less than 2.5 mg/L. This was probably due to a combination of high SODs and low oxygen reaeration in this low-gradient part of the river.

Ambient water temperatures ranged from 14.5 to 27.0 °C. Uchrin and Ahlert (1985) recommend that ambient temperature be above 15 °C for accurate SOD measurements.

In-stream water velocity at the nine stations ranged from 0.0 to 0.56 ft/s. Water depths at which SOD measurements were taken ranged from 1.2 to 2.6 feet, except for the Schafer Road location in the concrete channel (Michigan Avenue downstream to the ship turning basin), which was 3.5 feet deep and was sampled from a boat.

3.2 SEDIMENT OXYGEN DEMAND VALUES. Similar to 1995, the variability of replicate SOD values from a single station (2-3 per station) was low to moderate, while the variability of mean SOD values between stations was higher (*Table 3.2*). Specific points are discussed below:

- Within-station SOD variability was low to moderate, with the coefficient of variation of replicate SOD measurements (n = 2 or 3) ranging from 9 % to 48 % and averaging 26 %.
- Between-station SOD variability was high. The water- and temperature-corrected SOD values varied by greater than a factor of five, ranging from 0.97 to 5.41 g O₂/m²/day. A

spatial pattern was evident: SOD values from 15 Mile Road downstream to Beech Road ranged from 0.97 to 2.23 g O₂/m²/day, while those between Plymouth Road and Schafer Road were higher, ranging from 3.59 to 5.41 g O₂/m²/day. This may have been due to a decrease in stream gradient between Beech Road and Plymouth Road, resulting in the deposition of high-SOD silts accumulating in the lower part of the Branch.

- Highest SOD values were associated with silty sediments which often contained noticeable amounts of oil. The spatial distribution of these high-SOD sediments is apparently not uniform, however, and this may moderate their affect on the oxygen balance of the river (see discussion in Section 3.1).
- Data from Beverly Impoundment and upstream of the dam at UM-D may underestimate the true SOD at these stations, since the water temperatures were relatively low (13.6 to 15.6 °C), and the temperature correction calculation performed on the data may be inadequate to account for the lower metabolic rates of the sediment bacteria.
- Water oxygen demand (WOD; *Table 3.2*) was variable, like in 1995, accounting for 6 to 61% of the ambient SOD. The higher WOD values presumably are due to high BODs at these stations.

3.3 COMPARISON OF 1995 AND 1996 SOD AT A RE-SAMPLED STATION. SOD measurements were made at the same location at 15 Mile Road in Birmingham in 1995 and 1996 (*Table 3.3*). SOD at this station was quite consistent between years, as was the WOD. The consistency of this limited temporal replication suggests that the data from the two different years may be treated as a single data set, reflecting the baseline SOD at all 22 stations prior to completion of the CSO retention structures.

Table 3.2
1996 Rouge River SOD and Water Oxygen Demand Values

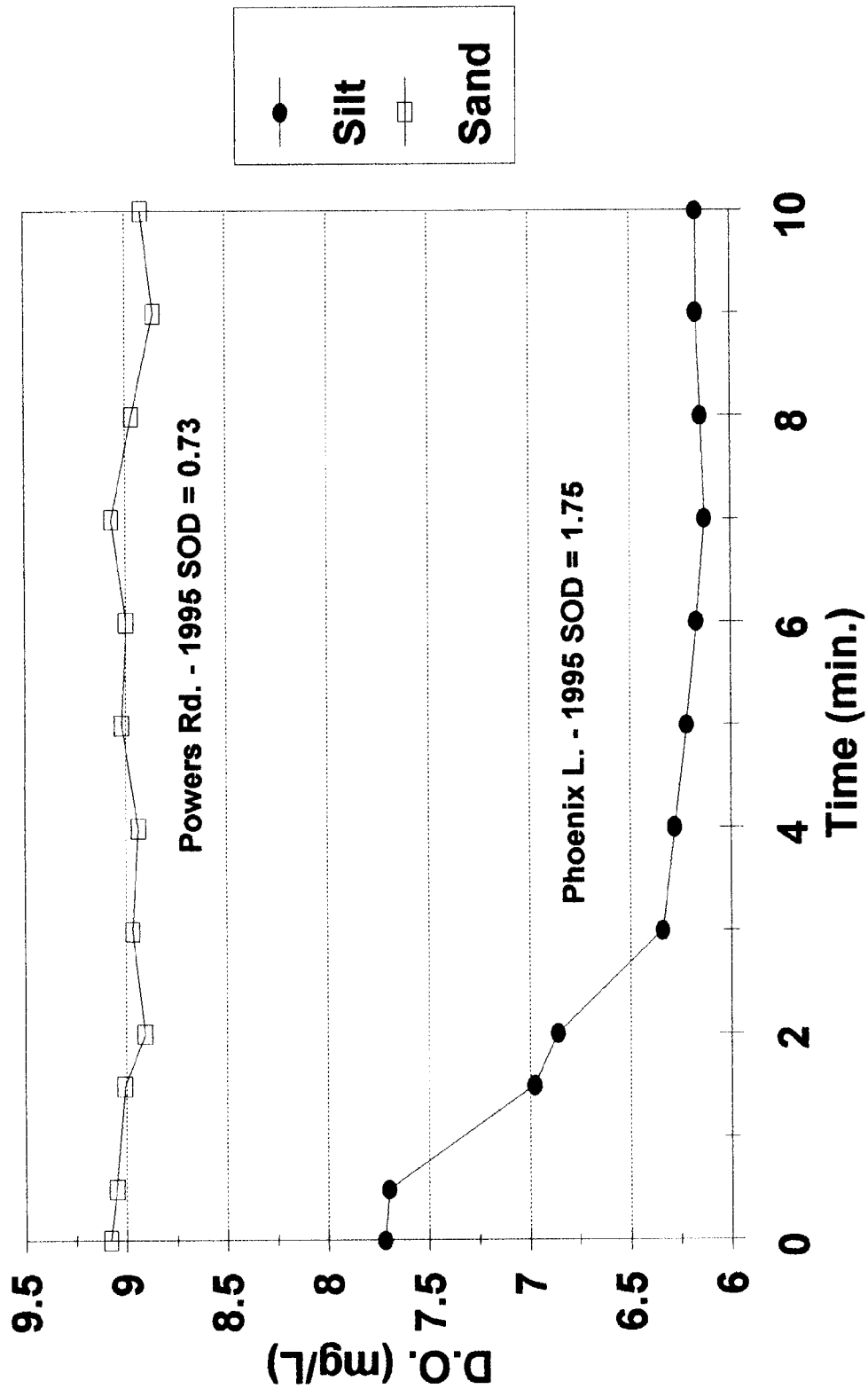
| Location [Map No.] | Mean Water Temp. (°C) | Mean SOD at ambient temperature (g O₂/m²/day) [Std. Dev.] | Mean SOD at 20°C, corrected for WOD (g O₂/m²/day) [Std. Dev.] | WOD/SOD (%) |
|---|---|--|--|------------------------|
| Wattles Road, Troy [1] | SOD could not be measured; substrate too rocky for chambers to seal properly. | | | |
| 15 Mile Road, Birmingham [2] | 22.0 | 2.55 [0.31] | 1.62 [0.27] | 28 |
| Beverly Impoundment, Beverly Hills [3] | 14.0 | 1.71 [0.17] | 0.97 [0.21] | 61 |
| Lahser Road, Beverly Hills [4] | 22.0 | 1.66 [0.62] | 1.16 [0.56] | 20 |
| Civic Center Drive, Southfield [5] | 19.6 | 3.30 [0.41] | 2.23 [0.45] | 35 |
| Beech Road, Southfield [6] | 20.7 | 1.88 [0.36] | 1.27 [0.34] | 29 |
| Plymouth Road, Detroit [7] | 19.8 | 4.02 [1.59] | 3.59 [1.59] | 12 |
| U/S of UM-D Dam, Dearborn [8] | 14.9 | 4.30 [0.45] | 5.41 [0.49] | 8 |
| Schafer Road, Dearborn [9] | 22.7 | 5.31 [1.43] | 4.23 [1.01] | 6 |

Table 3.3
Comparison of 1995 and 1996 SOD Values from 15 Mile Road (Birmingham)

| Year | Mean SOD at ambient temperature (g O₂/m²/day) [Std. Dev.] | Mean SOD at 20°C, corrected for WOD (g O₂/m²/day) [Std. Dev.] | WOD/SOD (%) |
|-------------|--|--|--------------------|
| 1995 | 2.58 [1.04] | 1.50 [0.92] | 30 |
| 1996 | 2.55 [0.31] | 1.62 [0.27] | 28 |

3.4 “STIRRED SEDIMENT” EXPERIMENT. A “stirred sediment” experiment was performed to investigate the magnitude of oxygen consumption by resuspended sediment. A plastic cylinder, enclosing 254 square inches of sediment, was placed on the river bottom at two locations from the 1995 SOD study (Powers Road and Phoenix Lake). Water column DO at time₀ was measured, and the sediment inside the cylinder was resuspended by stirring with a stick for a few seconds at 0, 0.5, 1.5, and 2.5 minutes. Water column DO inside the cylinder was monitored out to 10 minutes. The resuspended sandy sediments at Powers Road exhibited a low SOD in 1995 (0.73 g O₂/m²/day), and did not decrease the DO inside the plastic cylinder (*Figure 3.1*). The resuspended sediments at Phoenix Lake (1995 SOD = 1.75 g O₂/m²/day), conversely, decreased the DO inside the cylinder by about 1.5 mg/L (approximately 20 % of the ambient DO). The decline in DO leveled off soon after sediment stirring was stopped, and the DO concentration remained relatively constant for the remainder of the experiment. These data suggest that sandy sediment (the dominant sediment type in most of the Rouge River) does not exert a significant oxygen demand on the water column when resuspended (e.g., by storms, etc.), while resuspended silty sediment may exert a short-lived oxygen demand. This may be especially significant for the high-SOD sediment examined in this 1996 study (> 5 g O₂/m²/day).

Fig. 3-1. Stirred Sediment Experiment



4.0 CONCLUSIONS AND RECOMMENDATIONS. SOD values from the eight locations on the Main Branch sampled in 1996 exhibited a spatial pattern, with low to moderate values between 15 Mile Road and Beech Road (0.97 to 2.23 g O₂/m²/day), and higher values between Plymouth Road and Schafer Road (3.59 to 5.41 g O₂/m²/day). These values are comparable to those measured in 1995 (RPO, 1996), and were consistent with the sediment type observed; mixes of gravel, sand, and silt between 15 Mile Road and Beech Road, and silty sediment from Plymouth Road downstream to Schafer Road. This spatial distribution of SOD and sediment type may be due to a decrease in stream gradient between Beech Road and Plymouth Road, which would result in the deposition of silts in this lower part of the Branch. The distribution of high-SOD silt in the lower part of the Main Branch is apparently not uniform, however, and in some reaches constitutes only 10 to 50 percent of the river channel width. This should be considered when evaluating the influence of these silty, high-SOD sediments on the dissolved oxygen budget of the river.

It is recommended that additional SOD measurements be taken at a subset of these stations, perhaps in 1998, as part of the long-term monitoring program, to evaluate the effects of the Phase I CSO basins on the river.

5.0 REFERENCES.

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