Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 01-8

MEASUREMENT OF OXYGEN TRANSFER EFFICIENCIES IN SELECTED AERATION TANKS AT THE NORTH SIDE WATER RECLAMATION PLANT

March 2001

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ACKNOWLEDGMENTS

The assistance given by Mr. Dale MacDonald, Research Scientist I; Ms. Paula Michiels, Laboratory Technician II; Mr. Syed Hussaini, contract laboratory technician; Ms. Diane Reidy, Laboratory Technician II; Mr. Saeed Farooqui, Laboratory Technician II; Mr. Robert Young, Laboratory Technician I; and Ms. Ilyse Mackoff, Laboratory Technician I, is greatly appreciated.

The authors also wish to acknowledge the assistance of the staff of the Maintenance and Operations Department at the North Side Water Reclamation Plant, particularly Ms. Mary Moscinski, Mr. James Vey, Ms. Kathleen Budzyn, and Mr. William Davis and other treatment plant operators, during the field tests.

Particular thanks are due Ms. Laura Franklin for her diligence in typing and proofreading the manuscript of this report.

DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

SUMMARY

In response to a request from the management of the North Side Water Reclamation Plant (NSWRP), the Research and Development (R&D) Department conducted a study to measure the oxygen transfer efficiencies (OTEs) in selected aeration tanks at the NSWRP using the off-gas technique between July and October 1999. OTE is defined as the percentage reduction of oxygen in the air leaving the surface of the aeration tank versus the oxygen in the air entering the aeration tank through the diffuser plates. The off-gas technique is a technique that can be used to measure OTE under normal plant operation conditions. This technique measures the oxygen content in the off-gas of an aeration tank, which is the air mixture exiting the surface of the tank and collected in an off-gas hood positioned to float on the surface of the aeration tank, and comparing it with the oxygen content in the ambient air. The OTE tests, which are called off-gas tests in this report, were conducted at the NSWRP with off-gas hoods 10 feet long and 3 feet wide and an AERATOR-RATOR™ off-gas analyzer.

There are four aeration batteries at the NSWRP. In Batteries A, B and C, each battery has 12 aeration tanks, and each tank is a one-pass, plug-flow type tank with two bays

separated by a wall in the middle, except for Tank C12, which has only one wider bay. In Battery D, there are 7 aeration tanks, and each tank has two passes.

The scope of this study included (i) conducting a series of off-gas tests in one selected aeration tank in Battery B to evaluate the effect of cleaning the diffuser plates on OTE; (ii) performing off-gas tests to determine OTE in several tanks in Batteries A, B, and C in which all diffuser plates were installed in 1986; (iii) conducting off-gas tests in 3 aeration tanks in Battery D at the locations that were chosen in a previous study in 1995 to follow up the OTE change in these tanks; and (iv) conducting additional off-gas tests to investigate the factors that may influence the dissolved oxygen (DO) levels in the aeration tanks.

The off-gas tests at the NSWRP could be divided into three phases according to the main objectives of this study. In Phase I, a series of off-gas tests were conducted between July 29 and August 26, 1999, in aeration Tank B6, before and after the diffuser plates in the west bay of Tank B6 were cleaned, to determine whether cleaning of the diffuser plates increased the OTEs. In Phase II, off-gas tests in 10 selected aeration tanks in Batteries A, B and C (A1, A3, A12, B3, B6, B11, C1, C3, C4, and C12) were conducted between August 11 and

October 18, 1999, to evaluate the performance of the diffuser plates in these tanks. In Phase III, off-gas tests were carried out between October 21 and 29, 1999, in 3 aeration tanks in Battery D (D5, D6, and D7), as a follow-up of the study conducted in 1995 to compare the performance of diffuser plates installed at different times.

All off-gas tests were conducted under reasonably controlled conditions, although the positioning of the off-gas hoods, which were used to collect the air mixture exiting the water surface in an aeration tank, varied in the different phases of the study. At the NSWRP, air flow to each aeration tank can be set and controlled, but the sewage flow can only be measured and adjusted for the entire battery. Throughout the off-gas tests, sewage flow to the test battery was adjusted to 50 million gallons per day (MGD) or close to it depending on the conditions of the plant operation on the day of the test. In Batteries A, B and C, the air flow to each test tank was set at 2100 standard cubic feet per minute (scfm), unless otherwise noted. In Battery D, the air flow to each test tank was set at 2800 scfm without exception.

The daily variations of DO concentration, water temperature, and atmospheric pressure were taken into consideration by converting OTEs obtained under test conditions to standardized OTE (SOTE) at 20°C, 1 atmosphere pressure, and the maximum DO deficit. SOTE was used as the main parameter for the evaluation of aeration tank OTE.

To obtain reliable data, off-gas tests were repeated at the same test stations on different days. In Phase I of the study, off-gas tests were performed five times at almost each test station both before and after cleaning the diffuser plates in the west bay of Tank B6 over a period of a month. In Phase II of the study, off-gas tests were repeated twice at each test station on two different days with one exception in tank B6 over a period of ten weeks. In Phase III of the study, similar to the test conducted in 1995, OTEs were measured five times at each test station in D5, D6 and D7 on five different days over a period of nine days.

Off-gas tests in 13 selected aeration tanks in Batteries A, B, C, and D at the NSWRP were conducted for 35 actual days over a period of three months. The data collected during this study were used to determine OTEs and SOTEs using the equations described in detail later in this report. The results of the off-gas tests conducted in three phases in 1999 at the NSWRP are presented and discussed in this report.

CONCLUSIONS

The following conclusions were drawn from the analyses of the data collected during the off-gas tests at the NSWRP in 1999:

1. Cleaning of the diffuser plates in the west bay of Tank B6 did not significantly improve the SOTEs at the three test stations. However, after cleaning, the average off-gas flow rates in the west bay increased noticeably, compared to no increase in the east bay of Tank B6 which was not cleaned. This may indicate a reduction in clogging across the diffuser plates after cleaning.
2. DO profiles in the west and east bays of Tank B6 were not noticeably changed after the diffuser plates in the west bay were cleaned. The DO concentrations in the west bay were still much lower compared to the corresponding locations in the east bay.
3. The results of off-gas tests conducted at 57 test stations in 10 aeration tanks in Batteries A, B, and C indicated that bay average SOTEs,

ranging from 0.0983 to 0.138, did not vary as much as bay average DOs, ranging from 0.45 to 4.10 mg/L, and there was no observable correlation between bay average SOTE and DO. The average SOTEs for individual test stations (three test stations per one aeration bay) ranged from 0.0733 to 0.165. Generally, lower SOTE values were found in the locations close to the influent end of an aeration bay.

4. The results from the off-gas tests in Batteries A, B, and C also indicated that the bay average DO concentrations generally varied with the bay average off-gas flows, not with SOTEs. The bay average DO concentrations, in most cases, increased with the bay average off-gas flow rates, although a linear regression analysis between these two variables showed that the R square coefficient was only 0.42. Results also indicated that Tanks C1 and A12 may be receiving insufficient air due to their positions along the air distribution line, and that bays B6 West, C3 West, and C4 West have low bay average DO concentrations even though the indicated air supply

is sufficient. Possible clogging or leakage of the air distribution lines in these three bays, as well as the need for increased capacity to deliver more air to Tanks C1 and A12 should be investigated.

5. It was observed that off-gas flows at the off-gas test stations increased linearly with an increase in air flows to the corresponding aeration tanks. The relatively low off-gas flow rates in both east and west bays of Tanks C1 and A12 were probably due to the diversion of air into the influent channels. However, the relatively low off-gas flow rates in the west bays of Tanks B6 (9.22 scfm) and C4 (10.78 scfm), compared to the corresponding east bays (12.45 scfm for B6 and 14.42 scfm for C4), may be due to the uneven air distribution in these aeration tanks. The uneven distribution of air flow could be due to clogging of certain diffuser plates or leakage through the joints.

6. Statistical analyses of the 1999 study data collected in Tanks D5, D6, and D7 indicated that significantly higher SOTEs (see Table 8, p. 65)

were obtained in the selected test locations of Tanks D6 and D7, where the diffuser plates (installed in 1993) were relatively newer, compared to those (installed in 1961) in Tank D5. In 1995, when the last set of measurements were made in these tanks, no such differences were discernible between the older and the newer diffuser plates. However, in the 1995 study, there were considerably larger variations in the daily SOTE values collected at each test location. Due to the wide variability in the SOTE values, significant differences between the 1995 and 1999 data were not discernible. Therefore, we cannot conclusively state whether or not the older diffuser plates are exhibiting a deterioration in performance with time. Further investigation of the changes in OTE of the diffuser plates with passage of time is recommended to determine whether the decrease in OTE results from clogging of the diffuser plates.

7. SOTE at the test locations in Batteries A, B, and C decreased slightly (about 10 to 20 percent) as the air flow to the tanks increased,

whereas DO concentrations at the corresponding locations increased significantly within the operational range of tank air flow from 1200 to 2500 scfm in Batteries A, B, and C.

INTRODUCTION

Aeration used for supplying oxygen in activated sludge wastewater treatment plants is the major source of energy consumption in plant operations, representing 50 to 90 percent of the total plant energy requirement (1). Therefore, energy efficient aeration devices have been widely used by wastewater treatment plants employing the activated sludge process. For porous diffuser aeration systems, fine pore aeration devices have proven to be more energy efficient than their coarse pore counterpart (1).

Aeration systems with fine pore plates are used in the aeration basins of the water reclamation plants (WRPs) owned and operated by the Metropolitan Water Reclamation District of Greater Chicago (District). Various studies to evaluate the performance of the diffuser plates at the District's WRPs have been conducted since 1922 (2), as the operating cost of blowing air into the wastewater is very significant. In 1995, approximately $1,100,000 per month was spent on electricity for the plant operation at the District's Stickney WRP. Of this, nearly 50 percent was used for aeration of mixed liquor in the activated sludge tanks and air lift pumps (2). According to the plant operation data, the average monthly usage of electricity for operating the District's NSWRP was 4,810,000 kilowatt-hours (kWh) in 1998, and, of this, 54 percent was used to blow air into the aeration tanks. As the operating costs for aerating the mixed liquor at these large WRPs are substantial, a small improvement in aeration efficiency means considerable cost savings. For example, an increase of aeration efficiency by 5 percent at the NSWRP would result in annual cost savings of approximately $125,000, assuming the cost of electricity at $0.08/kWh.

The aeration efficiency in an aeration tank can be evaluated using the OTE of the aeration devices installed in the tank. Aeration devices are rated for their OTEs in clean water under standard conditions by the vendors. However, the OTEs of the aeration devices under the process conditions are very different from those obtained in the clean water under standard conditions, because many factors, such as wastewater characteristics, basin geometry, process load, and water temperature, affect the aeration system performance (3).

The OTE of aeration devices under the process conditions can be measured using several proven technologies summarized and recommended by American Society of Civil Engineers (ASCE) (4). Of non-steady state, off-gas, and inert gas tracer methods, the off-gas method allows rapid and relatively precise measurements of OTEs with little disturbance to the process. This method was developed by Redmon et al. (5) and used for determination of the OTE of diffuser plates at the District's Calumet and Stickney WRPs in a previous study (2). This technique measures the oxygen content of the air exiting the aeration basin (off-gas) and compares the oxygen content of the off-gas to that of the ambient air. The OTE under the process conditions is calculated as the percentage reduction of oxygen mass of the ambient air that passed through aeration.

The diffuser plates in the aeration basins at the NSWRP have been in operation for many years. Of interest to the WRP operations staff was the current OTE of these diffuser plates and whether the OTE could be improved by cleaning the plates. Therefore, the management of the NSWRP requested the R&D Department to conduct a study to measure the OTE of the diffuser plates in the selected aeration tanks at the NSWRP. The objectives of this study were as follows:

1. To evaluate the effectiveness of cleaning the diffuser plates in the west side of aeration Tank B6 in terms of improving the OTE.
2. To evaluate the OTE of the diffuser plates in selected tanks in Batteries A, B, and C.

3. To conduct off-gas tests in Battery D at 6 test stations in 3 aeration tanks, for comparing the OTEs obtained in tests conducted in the present study (1999) with those OTEs obtained from the tests conducted in 1995 by the R&D Department.

The off-gas tests were conducted in the summer and fall of 1999 by the R&D Department with the help of M&O personnel at the NSWRP. This report describes the methodology of the off-gas tests conducted, equipment used, and the results obtained from this study.

MATERIALS AND METHODS

OTE Measurements

The OTE of submerged diffuser plates can be measured using an off-gas technique. With this technique, the air (off-gas) exiting the water surface of an aeration tank is collected with an off-gas hood and analyzed for its oxygen content. The percent reduction of oxygen mass in the off-gas collected under the hood compared to the oxygen in the ambient air is defined as the OTE under the process condition, i.e., the field OTE (OTE_f). In order to compare the OTEs measured at various test locations and times, OTE_fs have to be converted to standard OTEs. The conversion is performed for the standard condition, namely, at 20°C, one atmospheric pressure, and a maximum DO deficit. The process of measuring OTE_f using the off-gas technique is called an off-gas test in this study.

The off-gas tests in this study were conducted using an Aerator-Rator Off-Gas Analyzer (6). In this analyzer, the off-gas collected with an off-gas hood first passes through a stripping column to remove carbon dioxide and water vapor. Then, the oxygen content of the dried off-gas is measured by a built-in oxygen sensor. Under the assumption that the nitrogen mass in the inlet and outlet air passing through the liquid in an aeration tank remains the same and no significant denitrification occurs in the tank, the percentage reduction of oxygen mass after aeration is calculated using the ratios of oxygen to nitrogen mole fraction in the off-gas and ambient air. The flow rate of the off-gas captured under the off-gas hood is simultaneously measured with a built-in rotameter in the analyzer during an off-gas test.

The calculation of OTE_f from the data collected during an off-gas test is made based on the following equations:

$$OTE_f = \frac{R_R - R_{OG}}{R_R} \tag{1}$$

where OTE_f = OTE as a decimal fraction under field conditions

R_R and R_{OG} = mole ratios of oxygen to nitrogen in the reference air, i.e., ambient air, and in the off-gas

R_R is given by:

$$R_R = \frac{F_R}{1 - F_R} \tag{2}$$

where F_R = mole fraction of oxygen in the dry ambient air,

$$F_R = 0.2095.$$

R_{OG} is computed by:

$$R_{OG} = \frac{F_{OG}}{1 - F_{OG}} \quad (3)$$

where F_{OG} = mole fraction of oxygen in the CO_2-removed, dried off-gas, which is given by:

$$F_{OG} = 0.2095 \frac{M_{OG}}{M_R} \quad (4)$$

where M_{OG} and M_R = millivolt output readings of the oxygen sensor for off-gas and reference air.

The conversion of OTE_f to SOTE is conducted according to the following equations:

$$SOTE = \beta \cdot C_{s,20} \frac{OTE_f}{C_F^* - C} * 1.024^{(20-T)} \quad (5)$$

where β = the ratio of process wastewater saturation value of DO to that of clean water, assumed at $\beta = 0.99$ in this study

$C_{s,20}$ = clean water saturation DO at one atmosphere and 20°C (mg/L)

T = liquid temperature in the aeration tank during the off-gas tests (°C)

C = DO at the test station in the off-gas test (mg/L)

C_F^* = average saturation DO in the wastewater, which is given by:

$$C_F^* = C_{F,20}^* \frac{P_b}{P_s} \cdot \frac{C_{s,t}}{C_{s,20}} \cdot \beta \tag{6}$$

where P_b = atmospheric pressure during the test (in. Hg)

P_s = standard atmospheric pressure, P_s = 29.92 in. Hg.

$C_{s,t}$ = clean water saturation DO at one atmosphere pressure and the test temperature (mg/L)

$C_{F,20}^*$ = average clean water saturation DO in the aeration tank at standard temperature, 20°C (mg/L)

which is given by:

$$C_{F,20}^* = \frac{D / 2 + 33.9}{33.9} \cdot C_{s,20} \tag{7}$$

where D = the depth of diffuser plates under the water (ft)

33.9 = the value of water depth in feet equivalent to one atmosphere

Off-Gas Tests at the NSWRP

The aeration tanks at the NSWRP consist of four batteries; namely, Batteries A, B, C, and D. In Batteries A, B, and C, each battery has 12 tanks, and each tank has one pass and two bays, except Tank C12, which has only one bay with the width being twice as that of the other bays in these three batteries. The dimensions for all bays in these three batteries except Tank C12 are 420 feet long, 17 feet wide, and 15 feet deep. In Battery D, there are 7 aeration tanks, and each tank has two passes. The dimensions of each pass are 265 feet long, 34 feet wide, and 15 feet deep.

The diffuser plates in Batteries A, B, and C are made of silica with permeability ranging from 33 to 39. Permeability is defined as the volume of air, in cubic feet per minute, passing through one square foot of diffuser, tested dry, at two inches of water differential pressure under standard conditions of temperature and humidity (1). The plates were installed in 1986. The diffuser plates in Battery D are made of alumina with a permeability of 39. The plates in Tanks D1 to D5 were installed in 1961, and in Tanks D6 and D7, the plates were installed in 1993.

Measurements of the OTEs of the diffuser plates at the NSWRP were made from July 29 through October 29, 1999. The study was divided into three phases. Phase I was designed to evaluate the performance of the diffuser plates in Tank B6 before (August 9, 1999) and after cleaning (August 17, 1999) the diffuser plates.

Phase II was designed to evaluate the performance of the diffuser plates in selected tanks in Batteries A, B, and C under the same aeration conditions. Phase III was a follow-up study to a similar study conducted in 1995, in order to determine changes in the OTE of three aeration tanks of Battery D versus years of service.

Phase I off-gas tests were conducted in Tank B6 only. The diffuser plates in the west bay of Tank B6 were steam or hot water cleaned by the NSWRP personnel between August 10 and 16, 1999. The off-gas tests in this bay were conducted before and after the cleaning of the diffuser plates. At the same time, the off-gas tests were also conducted in the east bay of Tank B6, where the diffuser plates were not cleaned. The test results obtained in the east bay were used as controls. Therefore, the comparisons of performance can be made between either the test bay and the control bay, or before and after cleaning the diffuser plates in the same bay. To account for the daily variations, five tests were conducted under the same operating conditions on five different days both before and after cleaning the diffuser plates in the west bay of Tank B6. During the off-gas tests, mixed liquor samples from each test station were taken for the analysis of suspended solids (SS) and biological oxygen demand (BOD_5) in the supernatant.

In Phase II, 10 aeration tanks were selected for testing the performance of the diffuser plates. The tanks selected were A1, A3, A12, B3, B6, B11, C1, C3, C4, and C12. Attempts were made to maintain identical operating conditions for each test. During the off-gas tests in these tanks, the air flow to each test tank was set at the same flow rate, and the sewage flow to each battery was maintained almost identical. OTEs were measured in both bays of these tanks except for Tank C12, which has only one bay. Off-gas tests were performed twice in each test tank on two different days except for Tank B6. Arithmetic average values of the test results were used for evaluating the data.

The off-gas tests for Phase III were conducted in aeration Tanks D5, D6, and D7, similar to the tests carried out in 1995. The same test locations as those used in the 1995 study were used in this study. The operating conditions in the 1995 study were not known in the preparation of this report. In this study, however, the air flow to each test tank and the sewage flow to Battery D during each off-gas test were maintained constant. To account for the daily variations, the off-gas tests in each tank were made five times on five different days. Arithmetic average values of the test results were used for the analyses of the data.

A summary of all the tests conducted in the three phases is presented in Table 1.

Test Locations

The aeration pattern in all aeration tanks at the NSWRP is a spiral flow pattern. The diffuser plates are placed on one side of the tank bottom in the lateral direction, and installed in tubs perpendicular to the tank length. The average distance between two adjacent tubs is nearly four feet in Batteries A, B, and C. The actual distance between any two adjacent tubs varies along the longitudinal direction of the tank with the distance being closer towards the influent end. The side where the diffuser plates were placed in an aeration bay is called the diffuser plate side in this report.

The locations of the off-gas tests in this study were selected to obtain a good representation of the OTEs occurring in the aeration tanks and were based on consideration of the aeration tank configuration, which differed somewhat in the different batteries.

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TABLE 1

SUMMARY OF THE OFF-GAS TESTS CONDUCTED AT THE NSWRP IN 1999

Phase	Duration	Tanks Studied	Purpose
I	7/29/99-8/26/99	B6	Evaluation of effect of cleaning on the performance of the different plates
II	8/21/99-10/18/99	A1, A3, A12, B3, B6, B11, C1, C3, C4, C12	Evaluation of OTEs of the various diffuser plates
III	10/21/99-10/29/99	D5, D6, D7	Evaluation of change in OTE of the diffuser plate with time in service

For Phase I and Phase II of the study, in Batteries A, B and C, six test stations were set up in each test tank with three stations in each bay, except in the aeration Tank C12. The three test stations were located at the 1/4, 1/2, and 3/4 points along the tank length from the influent end. Two hood positions next to each other at each test station were used to capture most of the off-gas released under the hood (10 feet by 3 feet in dimension). The off-gas hood was placed in a position parallel to the tank length and close to the walkway between the east and west bays of an aeration tank. Figure 1 shows a plan view of the off-gas test stations in Battery B. Figure 2 shows a cross-section view of two off-gas hood positions at the same off-gas test station. The set-up of test stations and hood positions in other tanks in Batteries A, B, and C was the same as in Tank B6, except in C12. In Tank C12, which has only one bay as shown in Figure 3, three test stations were set up similar to Batteries A, B, and C. However, in Tank C12, taking advantage of its width, three, or in some cases four, hood positions were used at one station. The off-gas hood at all positions was parallel to the tank length. At the first position, the hood was positioned one-half to one foot away from the wall of the walkway on the diffuser plate

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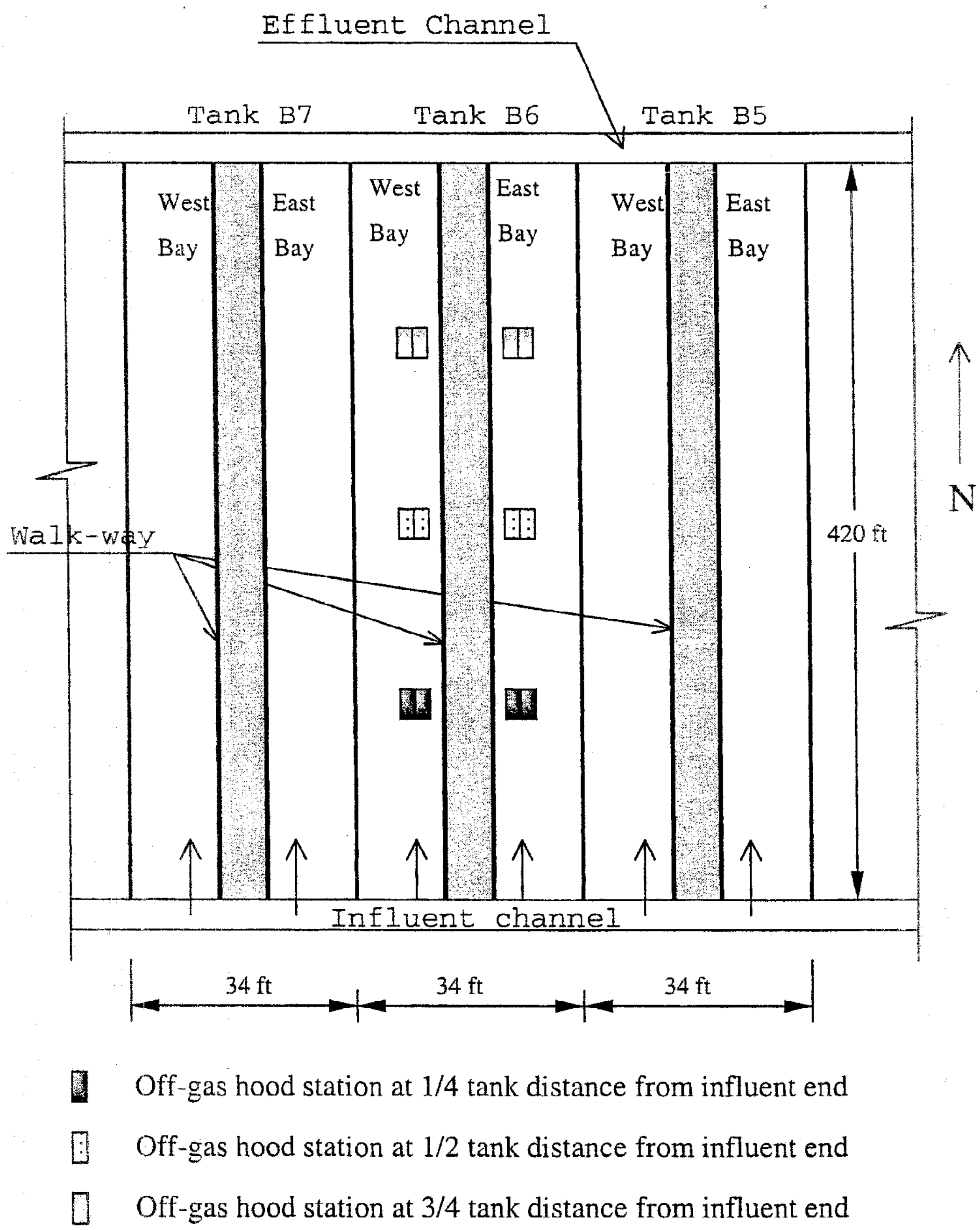
FIGURE 1

PLAN VIEW OF OFF-GAS TEST STATIONS IN AN AERATION TANK IN BATTERY B AT THE NSWRP



Note: Not to scale.

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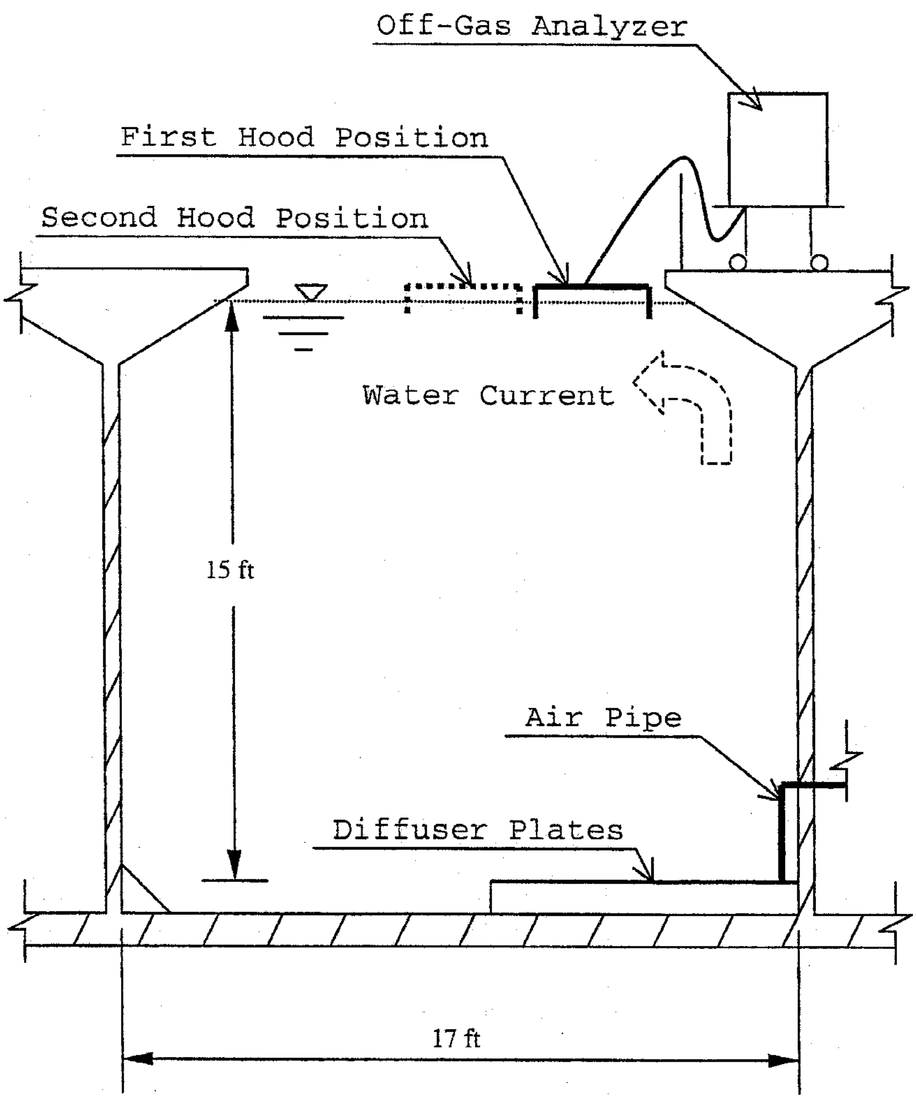
FIGURE 2

CROSS-SECTIONAL VIEW OF TWO OFF-GAS HOOD POSITIONS AT A TEST STATION IN BATTERIES A, B, AND C



Note: Not to scale.

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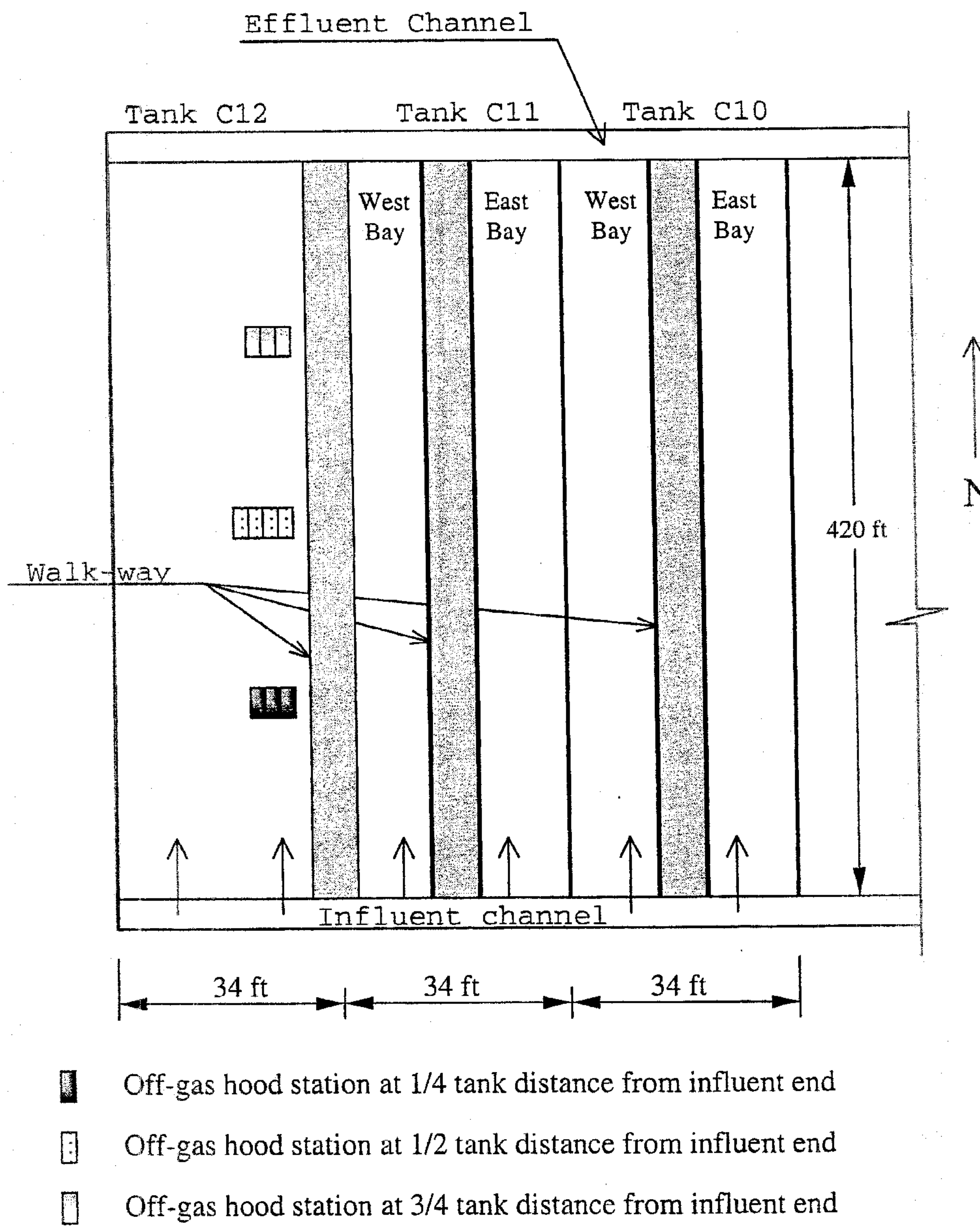
FIGURE 3

PLAN VIEW OF OFF-GAS TEST STATIONS AND HOOD POSITIONS IN AERATION TANK C12 AT THE NSWRP



Note: Not to scale.

side. The second hood position was next to the first one, and the third one next to the second one.

For Phase III, according to the locations selected in the previous study, two test stations were set up in each of Tanks D5, D6, and D7, as shown in Figure 4. The two stations were located at the 1/4 and 1/2 points along the entire aeration tank from the influent end, respectively. More precisely, one station was at the middle of the first pass, and the second at about 30 feet downstream from the influent end of the second pass to avoid the effect of the end wall. Only one hood position was used at each test station. The hood was positioned parallel to the tank length with the nearest edge being two feet away from the wall of the walkway on the diffuser plate side.

Test Procedures

An individual off-gas test consisted of four steps: positioning the off-gas hood, balancing the off-gas flow, recording the test data, and calculating the results. A test station was marked with paint on the walkway, where air pipes are located and diffuser plates are nearby. The off-gas hood was moved to the test position, and tied to the railing on the walkway. To be consistent, the off-gas hood was placed at the

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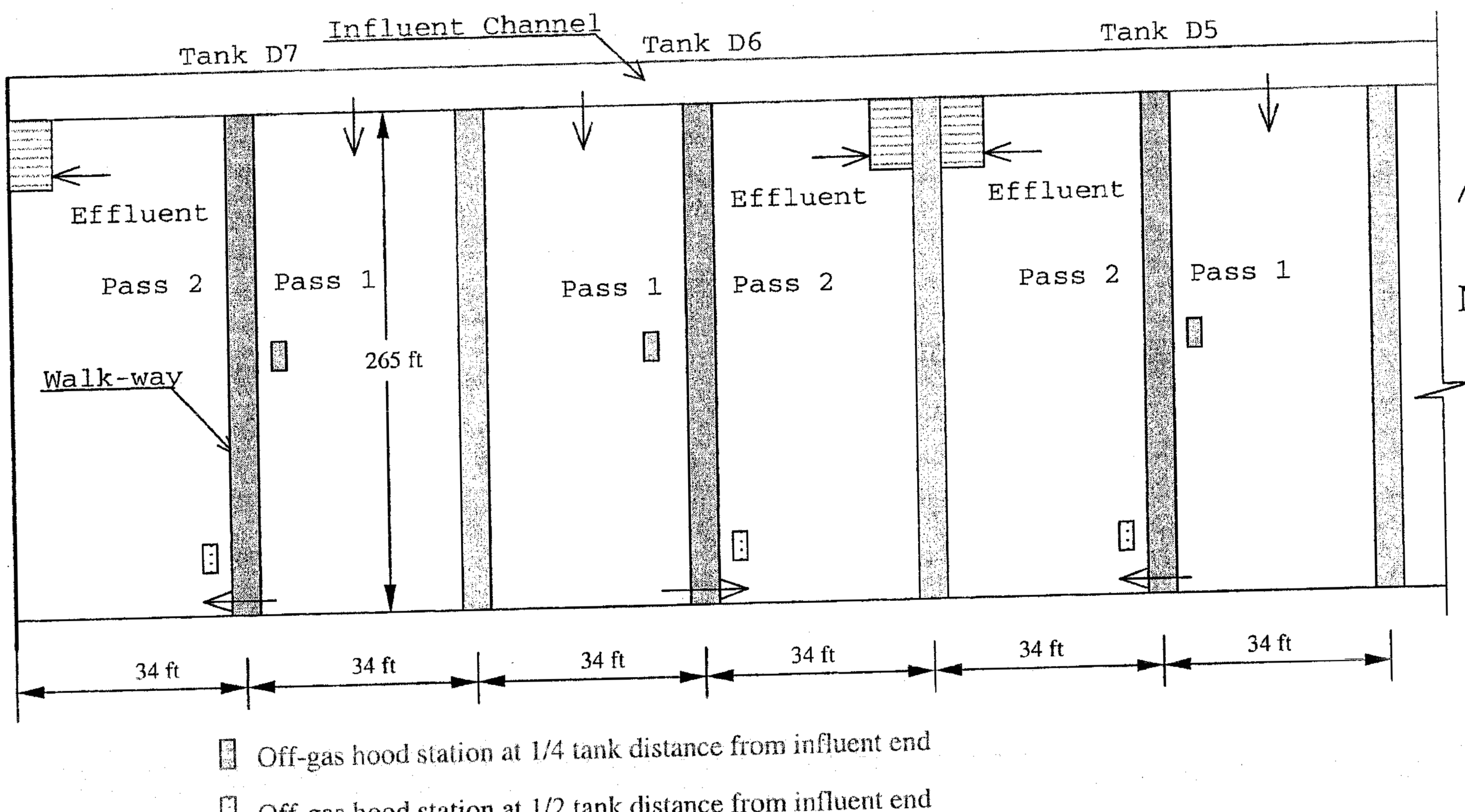
FIGURE 4

PLAN VIEW OF OFF-GAS TEST STATIONS AND HOOD POSITIONS IN AERATION TANKS D5, D6, and D7 AT THE NSWRP



Note: Not to scale.

same position according to the paint mark on the walkway whenever an off-gas test was conducted at this location.

After the off-gas hood was secured to the position, the next step was to balance the off-gas flow. Balancing the off-gas flow was carried out by adjusting the valves that regulate the gas flow through the analyzer, and by watching the vertical position of the off-gas hood in the water and off-gas pressure under the hood via a manometer in the analyzer. A constant vertical hood position and a close to atmospheric pressure inside the hood were indications of a balanced off-gas flow. The off-gas flow was defined as the air flow passing through the diffuser plates and captured by an off-gas hood (10 ft x 3 ft) when the air exited the water surface.

The data recording started after the off-gas flow was balanced. The oxygen content of the reference air and the off-gas were shown in the analyzer in millivolts. First, the oxygen content of the reference air was set to 100.0 ± 0.1 millivolts. Then, the switch that controls the gas flowing through the analytical cell of the analyzer was turned from reference to off-gas, and the oxygen content of the off-gas was recorded. The reading for the reference air was always checked and recorded before a reading for off-gas was recorded. In addition to the oxygen content, off-gas temperature and flow rate, water temperature, and DO were also recorded as one set of readings. Six to nine sets of readings were collected at each test position to account for the variability.

The field data were used to determine OTE_f and SOTE using the equations described in the previous section. The field off-gas flow rate was converted to standard conditions using the temperature correction factor given in the manual of the analyzer. For the test station with two or more hood positions, the average OTE_f and SOTE at each station were computed using a weighted average method. The off-gas flow rate at each hood position was used as the weight in the calculation. For example, the weighted average of SOTE for a test station with two hood positions is given by:

$$SOTE = \frac{SOTE_1 \cdot OG\,Flow_1 + SOTE_2 \cdot OG\,Flow_2}{OG\,Flow_1 + OG\,Flow_2}$$

where $SOTE_1$ and $SOTE_2$ = the mean SOTEs at the first and second hood positions, respectively.

$OG\,Flow_1$ and $OG\,Flow_2$ = the mean off-gas flow rates at the first and second hood positions (scfm), respectively.

The off-gas flow rate at any test station with two or more hood positions was the sum of each individual off-gas flow rate. The DO at a test station was the arithmetic mean of all DO measurements at the station.

A DO profile for a test aeration bay was made during the off-gas test. To make a DO profile, several DO values along the aeration bay, in which an off-gas test was being conducted, were measured during the off-gas testing. DOs were measured using a portable DO meter (YSI Model 58 Dissolved Oxygen Meter) equipped with a YSI DO probe and a submersible stirrer.

Statistical Analysis

In this study, one of the objectives was to test whether the means of a particular parameter were the same at different test locations. The test for the equality of two or more means can be done using parametric or non-parametric methods. The parametric method was used if the data met the assumptions that (1) they came from normal population and (2) the variances among the different locations were the same. If the data did not pass both the assumptions, then the Wilcoxon rank-sum test was used for comparing two means, and the Kruskal-Wallis test was used for comparing more than two means. To test the hypothesis that the data came from a normal population, a Shapiro-Wilk's test was performed. The test for equality of variances was done using an F-test or Bartlett's test if the data came from a normal population. An F-test was used for comparing two variances, and a Bartlett's test was used for comparing more than two variances.

RESULTS AND DISCUSSION

Effectiveness of Cleaning Diffuser Plates

The aeration of mixed liquor at the NSWRP is accomplished by blowing air into the aeration tanks through submerged diffuser plates. The OTEs in the aeration tanks are measures of the performance of the diffuser plates. The performance of the diffuser plates may deteriorate with time, because of clogging or deterioration of the plates. In order to examine the effectiveness of steam and/or hot water cleaning of diffuser plates on improving the OTE in an aeration tank, the off-gas technique was used to measure OTEs at selected test stations in Tank B6 before and after cleaning the diffuser plates in the west bay. The results of the off-gas tests in Tank B6 are presented and discussed in this section.

BEFORE CLEANING

Off-gas tests in the east and west bays of Tank B6 were conducted five times at 6 test stations on July 29, August 3, 5, 6, and 9, 1999. The diffuser plates in Tank B6 were in use for 13 years, and were never cleaned.

During the tests, the air flow to the entire tank was set at 2100 scfm, and the sewage flow to Battery B at 50 MGD. The precise control of air flow and sewage flow to each bay is not possible under the present controlling mechanism of the air flow and sewage flow to the aeration tanks at the NSWRP. The data collected from each station during the tests are listed in Appendix Table AI-1.

The individual field OTE, i.e., OTE_f, and SOTE at each hood position were calculated according to the equations described previously. The averages of field OTEs and SOTEs at each position and each station, along with the off-gas flow rates, are summarized in Table 2. The numbers in the parentheses are the standard deviations. The average values of OTE_fs and SOTEs at each test station are weighted averages using off-gas flow rates as the weights. The off-gas flow rate at each station was the sum of off-gas flow rates at the two hood positions. The average DO concentrations, along with the proper standard deviations, at each test station are also included in Table 2.

The variations of OTE_f and SOTE at each hood position were similar. The coefficients of variation for OTE_f and SOTE at most test stations were less than 15 percent. The variation of off-gas flows measured in the second hood positions was larger than those in the first hood position. Compared to OTE_f and SOTE, DO and off-gas flow rates were more variable.

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TABLE 2

SUMMARY OF OFF-GAS TEST RESULTS BEFORE CLEANING THE DIFFUSER PLATES IN THE WEST BAY OF TANK B6 AT THE NSWRP JULY 29 THROUGH AUGUST 9, 1999

	First Hood Position			Second Hood Position			Weighted Average*			
Station	Ave. $OTE_{f,1}$ (SD***)	Ave. $SOTE_1$ (SD)	Ave. OG $Flow_1$ scfm (SD)	Ave. $OTE_{f,2}$ (SD)	Ave. $SOTE_2$ (SD)	Ave. OG $Flow_2$ scfm (SD)	OTE_f	SOTE	OG Flow** scfm (SD)	DO mg/L (SD)
B6 E 1/4	0.121 (0.013)	0.100 (0.012)	4.36 (0.52)	0.151 (0.045)	0.126 (0.038)	2.01 (0.81)	0.130	0.108	6.37	0.38 (0.08)
B6 E 1/2	0.106 (0.006)	0.0976 (0.006)	10.96 (0.75)	0.146 (0.005)	0.139 (0.005)	5.98 (0.79)	0.120	0.112	16.94	1.48 (0.24)
B6 E 3/4	0.0701 (0.011)	0.120 (0.011)	9.21 (0.47)	0.0931 (0.013)	0.153 (0.017)	5.50 (0.39)	0.0787	0.133	14.71	5.37 (0.68)
B6 W 1/4	0.119 (0.006)	0.0995 (0.006)	4.76 (0.41)	0.164 (0.009)	0.136 (0.008)	2.27 (0.15)	0.134	0.111	7.03	0.40 (0.11)
B6 W 1/2	0.145 (0.009)	0.120 (0.009)	3.21 (0.34)	0.163 (0.024)	0.135 (0.021)	1.83 (0.39)	0.152	0.126	5.04	0.34 (0.06)
B6 W 3/4	0.158 (0.005)	0.137 (0.005)	2.91 (0.47)	0.195 (0.023)	0.166 (0.021)	1.46 (0.31)	0.170	0.147	4.37	0.72 (0.20)

*OTE_f = ($OTE_{f,1}$ * OG $Flow_1$ + $OTE_{f,2}$ * OG $Flow_2$) / (OG $Flow_1$ + OG $Flow_2$). Same for SOTE.
**OG Flow stands for off-gas flow. OG Flow = OG $Flow_1$ + OG $Flow_2$.
***SD = Standard deviation.

In general, the OTE_f measured at the second hood position is higher than that at the first hood position, and so is SOTE. This phenomenon appears to be the result of the spiral type aeration used at the NSWRP and the positioning of the off-gas hood in this study. The diffuser plates are laterally located on one side of the aeration bay. As can be seen in Figure 2, at the first hood position, the entire off-gas hood was placed above the diffuser plates. The off-gas captured under the hood was composed of the air bubbles, which had higher rising velocities and straight trajectory from the plates to the water surface, and of some air bubbles which were carried over by the lateral water current from the wall on the diffuser plates side. At the second hood position, only part of the off-gas hood was located straight above the diffuser plates. Many air bubbles captured under this hood position may have been carried by the lateral water current, and thus had curvature trajectory and longer retention time. The longer the air bubbles stay in the water, the more oxygen is transferred from the air into the water.

Theoretically, the overall OTE in a spiral type of aeration tanks is measured by collecting all the off-gas in the lateral direction using the off-gas technique. In practice, it is very difficult to catch all the off-gas in the lateral direction because of the tank structure and the limited size of the off-gas hood. By using two hood positions in the lateral direction, a good portion of off-gas was captured, and the weighted average of OTE using off-gas flow rates as weights could represent more closely the overall value of OTE than the OTE calculated using one hood position only. Therefore, two hood positions at each test station were used in the Phase I and II investigation.

The average DOs at the test locations in the west bay were found to be much lower than those in the east bay. To confirm this phenomenon, DO profiles, which were defined as the DO values along the length of the tank, were made during the off-gas testing for the aeration bays, where off-gas tests were conducted. Figure 5 represents the average DO profiles for the east and west bays of Tank B6 before cleaning the diffuser plates in the west bay. The error bars in the figure represent one standard deviation at the locations where DOs were measured.

AFTER CLEANING

The diffuser plates in the west bay of Tank B6 were steam and/or hot water cleaned by the personnel of the NSWRP during August 10 to 16, 1999. This aeration tank was filled with

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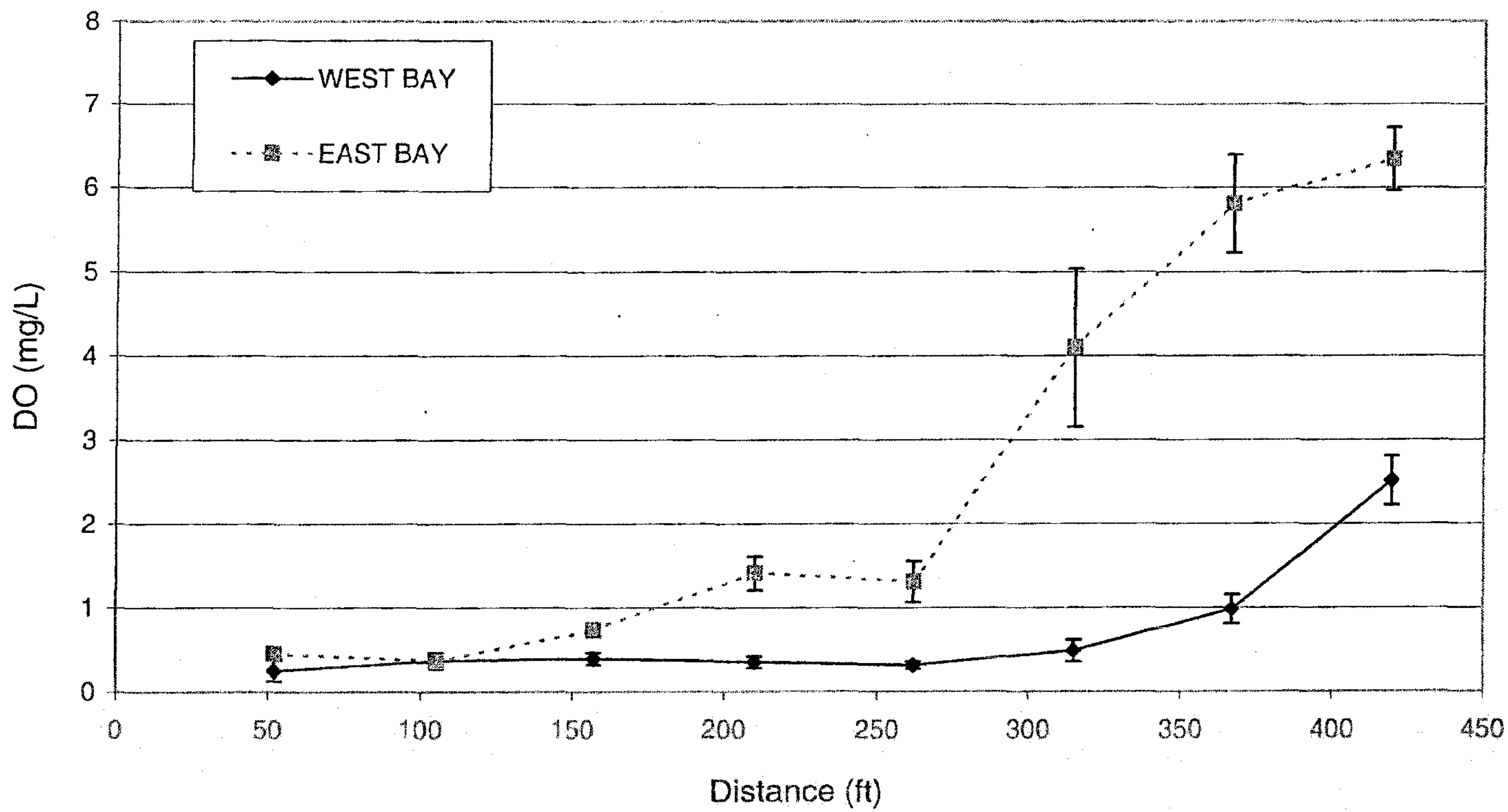
FIGURE 5

AVERAGE DO PROFILES DURING THE OFF-GAS TESTING IN THE EAST AND WEST BAYS OF TANK B6 AT THE NSWRP BEFORE CLEANING THE DIFFUSER PLATES IN WEST BAY JULY 29 THROUGH AUGUST 9, 1999



mixed liquor and fed with pre-settled sewage in the morning of August 17, 1999. Off-gas tests were again conducted five times at the same locations in the east and west bays of Tank B6 on August 17, 18, 23, 25 and 26, 1999. During the tests, the air flow rate in Tank B6 was set at 2100 scfm, and the sewage flow to Battery B at 50 MGD, which were the same as those in the tests before cleaning. The data obtained during these off-gas tests are listed in Appendix Table AI-2.

The OTE_f and SOTE at each hood position were calculated using the equations described in the Materials and Methods section, based on the data recorded during the field tests. Table 3 presents the averages of OTE_fs, SOTEs, and off-gas flow rates at each hood position and station with the corresponding standard deviations in the parentheses. As before, a weighted average method was used to compute the average values of OTE_f and SOTE for each test station with the off-gas flow rates as the weights. The sum of the off-gas flow rates measured at the two hood positions was considered as the off-gas flow rate for the corresponding station. The average DO concentrations with the corresponding standard deviations in the parentheses are also included in Table 3.

The data obtained in this set of tests appeared to be less variable than the ones in the tests conducted before the

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TABLE 3

SUMMARY OF OFF-GAS TEST RESULTS AFTER CLEANING THE DIFFUSER PLATES IN THE WEST BAY OF TANK B6 AT THE NSWRP AUGUST 17 THROUGH 26, 1999

	First Hood Position			Second Hood Position			Weighted Average*			
Station	Ave. $OTE_{f,1}$ (SD***)	Ave. $SOTE_1$ (SD)	Ave. OG $Flow_1$ scfm (SD)	Ave. $OTE_{f,2}$ (SD)	Ave. $SOTE_2$ (SD)	Ave. OG $Flow_2$ scfm (SD)	OTE_f	SOTE	OG Flow** scfm (SD)	DO mg/L (SD)
B6 E 1/4	0.114 (0.003)	0.106 (0.004)	8.16 (0.21)	0.151 (0.006)	0.141 (0.008)	4.80 (0.50)	0.127	0.119	12.96	1.41 (0.23)
B6 E 1/2	0.0611 (0.010)	0.105 (0.004)	10.59 (0.69)	0.0793 (0.014)	0.136 (0.004)	6.35 (0.70)	0.0679	0.116	16.94	5.45 (0.90)
B6 E 3/4	0.0633 (0.002)	0.131 (0.004)	4.45 (0.56)	0.0796 (0.003)	0.165 (0.007)	2.32 (0.58)	0.0689	0.142	6.77	6.28 (0.21)
B6 W 1/4	0.131 (0.012)	0.111 (0.010)	4.08 (0.42)	0.162 (0.011)	0.136 (0.009)	2.67 (0.58)	0.143	0.121	6.75	0.45 (0.15)
B6 W 1/2	0.144 (0.005)	0.128 (0.006)	5.59 (0.59)	0.185 (0.006)	0.164 (0.007)	2.90 (0.32)	0.158	0.141	8.49	0.99 (0.13)
B6 W 3/4	0.139 (0.007)	0.129 (0.007)	5.67 (0.45)	0.181 (0.009)	0.168 (0.010)	2.65 (0.40)	0.153	0.142	8.32	1.40 (0.09)

*OTE_f = ($OTE_{f,1}$ * OG $Flow_1$ + $OTE_{f,2}$ * OG $Flow_2$) / (OG $Flow_1$ + OG $Flow_2$). Same for SOTE.
**OG Flow stands for off-gas flow. OG Flow = OG $Flow_1$ + OG $Flow_2$.
***SD = Standard deviation.

cleaning. The coefficients of variation for most of the individual OTE_fs and SOTEs were less than 10 percent. The variations of OTE_f and SOTE in both hood positions were similar. The variation of off-gas flows measured in the second hood positions were larger than those in the first hood position. DO levels and off-gas flow rates were more variable compared to OTE_f and SOTE.

The calculated OTE_fs and SOTEs based on the recorded field data indicated that the values of OTE_fs and SOTEs for the second hood positions were higher than those for the corresponding first hood positions. This trend was consistent with that observed in the tests conducted before cleaning the diffuser plates in the west bay of Tank B6.

The average DO at the test stations in the west bay was still much lower than that in the east bay even after cleaning the plates. DO profiles along these two aeration bays were also made during the off-gas tests. Figure 6 presents the average DO profiles for the east and west bays of Tank B6 after the diffuser plates in the west bay were cleaned. The error bars represent one standard deviation at the proper locations.

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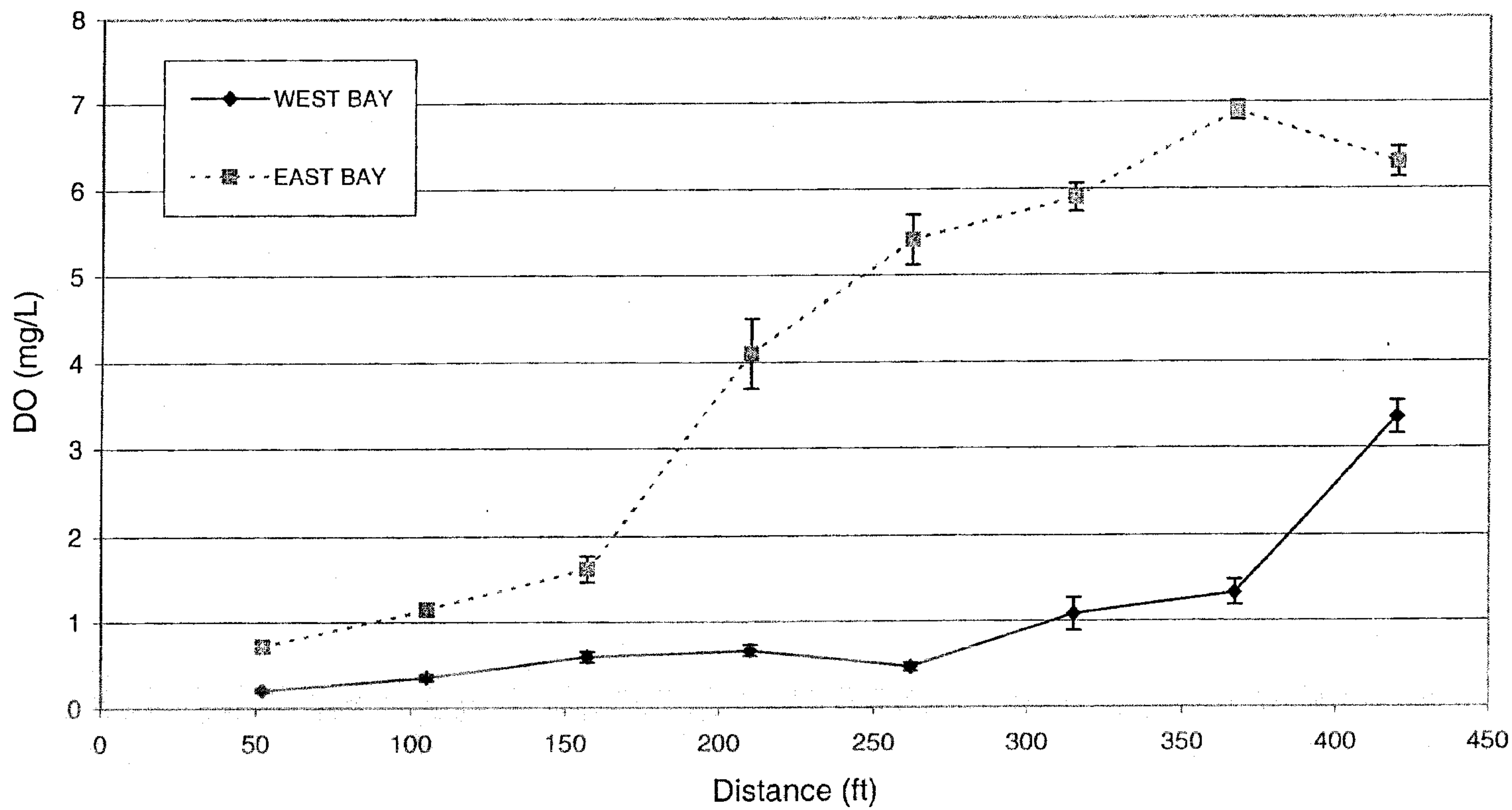
FIGURE 6

AVERAGE DO PROFILES DURING THE OFF-GAS TESTING IN THE EAST AND WEST BAYS OF TANK B6 AT THE NSWRP AFTER CLEANING THE DIFFUSER PLATES IN THE WEST BAY
AUGUST 17 THROUGH 26, 1999



EVALUATION OF EFFECTIVENESS OF CLEANING

The diffuser plates in the west bay of aeration Tank B6 were cleaned using steam and/or hot water between August 10 and 16, 1999. The effectiveness of cleaning of the diffuser plates in the west bay of aeration Tank B6 was evaluated using the results obtained from the off-gas tests before and after cleaning the diffuser plates. The results from the off-gas tests conducted in the east bay at the same time period were used as controls because the plates in the east bay were not cleaned during this off-gas study.

The main parameters that were comparable under variable field conditions were SOTEs and off-gas flow rates from the off-gas tests conducted before and after cleaning the diffuser plates. SOTEs are the standardized OTEs, which are theoretically corrected for the changes of the field conditions, such as DO, water temperature, and atmospheric pressure. The off-gas flow rates were measured at a pressure close to the atmospheric pressure and corrected to a constant temperature of 70°F during calculation. The comparison of SOTE and off-gas flow, along with OTE_f and DO, at the off-gas test stations before and after the cleaning of plates in the west and east bays of Tank B6 are listed in Table 4. The changes of SOTE and off-gas flow after cleaning are presented in the table in

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TABLE 4

COMPARISON OF THE MAIN PARAMETERS IN EAST AND WEST BAYS DURING
OFF-GAS TESTS BEFORE AND AFTER CLEANING OF THE DIFFUSER PLATES IN WEST BAY OF TANK B6

	SOTE		Change (%)	Off-Gas Flow (scfm)		Change (%)	DO (mg/L)		OTE_f	
	Before	After		Before	After		Before	After	Before	After
West										
B6 W 1/4	0.111	0.121	9.0	7.03	6.75	-4.0	0.40	0.45	0.134	0.143
B6 W 1/2	0.126	0.141	11.9	5.04	8.49	68.5	0.34	0.99	0.152	0.158
B6 W 3/4	0.147	0.142	-3.4	4.37	8.32	90.4	0.72	1.40	0.170	0.153
Average	0.128	0.135	5.2	5.48	7.85	43.3	0.49	0.95	0.152	0.151
East										
B6 E 1/4	0.108	0.119	10.2	6.37	12.96	103.5	0.38	1.41	0.130	0.127
B6 E 1/2	0.112	0.116	3.6	16.94	16.94	0.0	1.48	5.45	0.120	0.0679
B6 E 3/4	0.133	0.142	6.8	14.71	6.77	-54.0	5.37	6.28	0.0787	0.0689
Average	0.118	0.126	6.8	12.67	12.22	-3.6	2.41	4.38	0.110	0.0879

percent with a positive number referring to an increase and a negative number to denote a decrease.

As noted, changes of SOTEs at the test stations occurred in both bays of Tank B6 after the diffuser plates in the west bay were cleaned. In the test bay, namely, B6 West Bay, SOTE increased by 9.0 and 11.9 percent at two of the three test stations, while it decreased by 3.4 percent at the other station after cleaning the plates. The average value of SOTE from the three test stations was 5.2 percent higher compared to the average value of SOTE before cleaning the plates. However, the increase of SOTE values was probably not due to the cleaning of the diffuser plates, because a similar degree of increase in SOTE also occurred in the control bay, namely, B6 East Bay, in which the diffuser plates were not cleaned during the off-gas tests. As can be seen in Table 4, SOTEs at all three test stations in the east bay were higher, when measured in the tests conducted after the plates in B6 West Bay were cleaned, and the average values of the SOTEs increased by 6.8 percent compared to those obtained before cleaning.

The off-gas flow rates at some of the test stations in both bays had noticeable changes after the diffuser plates in B6 West Bay were cleaned. Table 5 presents the results of statistical analysis on the difference of the means of off-gas

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TABLE 5

RESULTS OF STATISTICAL ANALYSIS ON THE DIFFERENCE OF MEANS OF OFF-GAS FLOW AND SOTE AT THE TEST STATIONS BEFORE AND AFTER CLEANING THE DIFFUSER PLATES IN WEST BAY OF TANK B6*

	Off-Gas Flow	SOTE
B6 W 1/4	Insignificant	Significant
B6 W 1/2	Significant	Significant
B6 W 3/4	Significant	Insignificant
B6 E 1/4	Significant	Significant
B6 E 1/2	Insignificant	Significant
B6 E 3/4	Significant	Significant

*The diffuser plates in the west bay of tank B6 were steam and/or hot water cleaned between August 10 and 16, 1999.

flow rates before and after cleaning the plates, along with those of SOTEs. At four out of six test stations, the difference of off-gas flows between the tests before and after cleaning the plates was statistically significant ($P < 0.05$). Of the four stations at which significant changes of off-gas flow occurred after cleaning, two were in the west bay and the other two in the east bay. The off-gas flow at the two stations in the west bay increased after cleaning the plates, while in the east bay the off-gas flow at one station increased and at the other station decreased. The average value of off-gas flow at the three test stations in the west bay increased by 43.3 percent, whereas in the east bay it decreased by 3.6 percent after the plates in the west bay were cleaned. This indicated that the air distribution between the west and east bays within Tank B6 was somewhat changed after the cleaning, as the total air flow to this tank was kept the same (2100 scfm) in the off-gas tests conducted throughout this phase of the study.

As expected, the change of SOTE and off-gas flow was accompanied by a change in the DO concentrations. A higher SOTE and off-gas flow should result in a higher DO concentration. Before this study, it was found through the measurement of DO profiles by the NSWRP personnel that the DO concentrations in the west bay of Tank B6 were much lower than those in the east bay, particularly in the second half of the tank, under normal operating conditions. It was hoped that the cleaning of the diffuser plates would improve the DO profile in the west bay of Tank B6 but it did not happen.

The average DO concentrations at the off-gas test stations during the off-gas tests are included in Table 4. As can be seen, DOs at all the test stations increased to various degrees after the cleaning. However, the DO concentrations were still much lower in the west bay, compared with those in the east bay. The results of DOs at the off-gas test stations were consistent with the DO profiles, as shown in Figures 5 and 6, made in both test and control bays during the off-gas tests. The increase of DO concentration in an aeration tank is caused not only by improved efficiency of oxygen transfer, but also by increased air supply (which will be discussed in later sections), weak or low strength wastewater characteristics and other factors, like cold temperatures. In this study, as the water temperature varied in a small range (from 23.3 to 24.0°C) and the total air flow to the tank remained constant (2100 scfm) throughout the tests, the increase of DOs in both test and control bays after the cleaning might have been caused by the change in the wastewater characteristics which affect the OTE under the process conditions as well.

The higher SOTEs, measured after cleaning in both tests and control bays, were probably due to the change of wastewater characteristics based on the above discussion. It appeared that the significant difference in DO concentrations between the west and east bays of Tank B6 was not caused by the difference in the OTE of the diffuser plates in these bays, but might have been caused by the uneven air distribution and/or other factors, such as uneven distribution of sewage which needs to be confirmed through further investigation. Evidently, the cleaning of the diffuser plates in the west bay did not improve the SOTEs at the selected test locations.

In summary, the results of off-gas tests indicated that SOTEs at the selected test locations were not improved significantly through the cleaning of the possibly clogged diffuser plates. However, the air distribution between the two bays within Tank B6 was altered to a certain degree after the cleaning, but the change was not sufficient enough to raise the DO concentrations in the west bay, nor to lower the DO concentrations in the east bay.

The higher concentrations of DO in the east bay was most likely caused by the larger air flow entering this bay, although other factors might also have played a role in affecting DOs. The reasons for the uneven distribution of air to the two bays within the same aeration tank might be due to clogging, leakage at joints, poor quality of plate installation, and/or variation in quality of the diffuser plates.

OTE in Batteries A, B, and C

In this phase of the study, off-gas tests were conducted in 10 selected aeration tanks in Batteries A, B and C at the NSWRP, 3 each in Batteries A and B, and 4 in Battery C, during the period August 11 through October 18, 1999. The aeration tanks in these three batteries are single pass, plug-flow type tanks with two bays in each tank. Tank C12 is an exception, having only one bay with the width being twice of that of the other bays in these batteries. Three off-gas test stations were set up in each aeration bay, like those in Tank B6, at the 1/4, 1/2 and 3/4 points along the length of the tank from the influent end. Two hood positions were used at each test station for all the tanks except for Tank C12. In Tank C12, taking advantage of its width, three hood positions were used at the 1/4 and 3/4 tank length point stations, and four hood positions at the 1/2 tank length point station. In this section, the data of the off-gas tests in these aeration tanks are presented and discussed, arranged in two subsections based on the tank configurations.

PLUG FLOW, SINGLE PASS, TWO BAY AERATION TANKS

Two runs of off-gas tests were conducted in the east and west bay of each tank (Tanks A1, A3, A12, B3, B11, C1, C3, and C4) on two different days except for Tank B6 in which only one test run was made nearly five weeks after the diffuser plates in the west bay were cleaned. During these tests, air flow to each tank was set at 2100 scfm, and sewage flow to each battery at 50 MGD. The data obtained from the off-gas tests at each station are listed in Appendix Table AI-3.

The individual OTE_f and SOTE at each hood position were calculated as described earlier in this report. For each test run, the averages of OTE_f and SOTE at each off-gas test station were the weighted averages using off-gas flow rates as the weights. The off-gas flow rate at each station was the sum of off-gas flow rates at the two hood positions, and the DO at each station was the arithmetic mean of DO measurements at the station. These mean values are presented in Table 6. The numbers in the parentheses are the standard deviations for the corresponding DOs from four average values obtained at the two hood positions in the two test runs.

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TABLE 6

SUMMARY OF THE RESULTS OF THE OFF-GAS TESTS CONDUCTED IN SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Station	Averages*		Off-Gas Flow (scfm)	DO** (mg/L)
	OTE_f	SOTE		
A1 E 1/4	0.138	0.120	10.56	0.77 (0.10)
A1 E 1/2	0.0958	0.106	18.84	2.98 (1.51)
A1 E 3/4	0.0565	0.111	17.47	6.30 (2.00)
Bay Average	0.0969	0.112	15.62	3.35
A1 W 1/4	0.110	0.0959	13.08	0.85 (0.62)
A1 W 1/2	0.109	0.102	14.75	1.49 (0.54)
A1 W 3/4	0.0783	0.0970	15.83	3.82 (2.00)
Bay Average	0.0992	0.0983	14.55	2.05
A3 E 1/4	0.134	0.113	10.31	0.56 (0.07)
A3 E 1/2	0.142	0.133	13.60	1.55 (0.62)
A3 E 3/4	0.112	0.116	14.54	2.33 (1.67)
Bay Average	0.129	0.121	12.82	1.48
A3 W 1/4	0.118	0.105	11.65	1.02 (0.40)
A3 W 1/2	0.0967	0.120	14.12	3.79 (2.16)
A3 W 3/4	0.0468	0.112	14.26	7.03 (0.28)
Bay Average	0.0873	0.113	13.34	3.95
A12 E 1/4	0.120	0.100	6.58	0.26 (0.06)
A12 E 1/2	0.133	0.114	10.40	0.58 (0.09)
A12 E 3/4	0.133	0.117	8.30	0.88 (0.30)
Bay Average	0.128	0.110	8.43	0.57

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TABLE 6 (Continued)

SUMMARY OF THE RESULTS OF THE OFF-GAS TESTS CONDUCTED IN SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Station	Averages*		Off-Gas Flow (scfm)	DO** (mg/L)
	OTE_f	SOTE		
A12 W 1/4	0.119	0.0982	7.47	0.21 (0.03)
A12 W 1/2	0.144	0.120	6.06	0.33 (0.08)
A12 W 3/4	0.131	0.115	9.91	0.82 (0.16)
Bay Average	0.131	0.111	7.81	0.45
B3 E 1/4	0.147	0.120	4.27	0.22 (0.11)
B3 E 1/2	0.127	0.108	6.75	0.76 (0.10)
B3 E 3/4	0.136	0.125	10.84	1.43 (0.15)
Bay Average	0.137	0.118	7.29	0.80
B3 W 1/4	0.136	0.113	7.69	0.39 (0.07)
B3 W 1/2	0.151	0.130	10.02	0.81 (0.07)
B3 W 3/4	0.111	0.125	11.23	3.12 (1.11)
Bay Average	0.133	0.123	9.65	1.44
B6 E 1/4	0.126	0.109	13.31	0.78 (0.00)
B6 E 1/2	0.124	0.111	12.77	1.09 (0.00)
B6 E 3/4	0.0704	0.133	11.26	6.12 (0.07)
Bay Average	0.107	0.118	12.45	2.66
B6 W 1/4	0.118	0.0983	10.10	0.39 (0.04)
B6 W 1/2	0.146	0.125	12.63	0.70 (0.10)
B6 W 3/4	0.197	0.165	4.94	0.44 (0.04)
Bay Average	0.154	0.130	9.22	0.51

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TABLE 6 (Continued)

SUMMARY OF THE RESULTS OF THE OFF-GAS TESTS CONDUCTED IN SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Station	Averages*		Off-Gas Flow (scfm)	DO** (mg/L)
	OTE_f	SOTE		
B11 E 1/4	0.122	0.104	11.02	0.51 (0.03)
B11 E 1/2	0.136	0.120	11.48	0.92 (0.09)
B11 E 3/4	0.123	0.121	14.04	1.85 (0.33)
Bay Average	0.127	0.115	12.18	1.09
B11 W 1/4	0.116	0.112	11.33	1.76 (0.42)
B11 W 1/2	0.0727	0.108	7.85	4.84 (0.64)
B11 W 3/4	0.0759	0.136	7.92	5.69 (0.90)
Bay Average	0.0882	0.119	9.03	4.10
C1 E 1/4	0.118	0.0973	2.71	0.16 (0.09)
C1 E 1/2	0.127	0.105	5.63	0.25 (0.05)
C1 E 3/4	0.123	0.110	8.29	1.01 (0.08)
Bay Average	0.123	0.104	5.54	0.47
C1 W 1/4	0.0887	0.0733	8.35	0.19 (0.05)
C1 W 1/2	0.147	0.124	6.43	0.38 (0.06)
C1 W 3/4	0.137	0.123	10.63	1.03 (0.16)
Bay Average	0.124	0.107	8.47	0.53
C3 E 1/4	0.124	0.104	8.66	0.36 (0.03)
C3 E 1/2	0.106	0.113	19.30	2.54 (0.18)
C3 E 3/4	0.0552	0.113	14.83	6.47 (0.20)
Bay Average	0.0950	0.110	14.26	3.12

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TABLE 6 (Continued)

SUMMARY OF THE RESULTS OF THE OFF-GAS TESTS CONDUCTED IN SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Station	Averages*		Off-Gas Flow (scfm)	DO** (mg/L)
	OTE_f	SOTE		
C3 W 1/4	0.170	0.141	4.44	0.23 (0.04)
C3 W 1/2	0.155	0.135	8.65	0.70 (0.07)
C3 W 3/4	0.152	0.137	9.39	1.12 (0.11)
Bay Average	0.159	0.138	7.49	0.68
C4 E 1/4	0.111	0.0941	15.57	0.52 (0.06)
C4 E 1/2	0.134	0.123	14.67	1.32 (0.22)
C4 E 3/4	0.0774	0.118	13.01	5.07 (1.26)
Bay Average	0.107	0.112	14.42	2.30
C4 W 1/4	0.108	0.0909	13.84	0.49 (0.03)
C4 W 1/2	0.144	0.123	8.61	0.61 (0.05)
C4 W 3/4	0.143	0.126	9.88	0.94 (0.10)
Bay Average	0.131	0.113	10.78	0.68

*The values of OTE_f and SOTE at each station were the arithmetic mean of two runs except for the stations in B6, which had only one run, and the OTE_f and SOTE for each run were the weighted averages of those at the two hood positions.

**The values at each station were the arithmetic mean of those from two runs except for the stations in B6, at which the values were the arithmetic mean of those from one run.

Figures in parentheses represent standard deviations.

The average SOTEs at 54 off-gas test stations in 18 aeration bays ranged from 0.0733 (at Station C1 W 1/4) to 0.165 (at Station B6 W 3/4). Theoretically, SOTE should not be affected by DO concentration, water temperature, and barometric pressure. However, the wastewater characteristics could influence SOTE, which is commonly defined as α factor. The α factor is a ratio of process SOTE to clean water SOTE, and has been found to be significantly lower at the influent end in a plug-flow type of aeration tank (3). All the SOTEs obtained in this study were process SOTEs. In this phase of the study, of the 18 selected aeration bays, 14 bays had the lowest SOTE at the station near the influent end. The variation in SOTEs at the same off-gas hood position between the two test runs was generally small (see Appendix Table AI-3). The difference of SOTEs among the test stations, therefore, could be due to either the performance difference of the diffuser plates at these locations, or the influence of wastewater characteristics, or a combination of the two.

Assuming that the arithmetic average of SOTEs from the three test stations in each bay could represent the mean SOTE for that bay, the average SOTEs for the 18 tested aeration bays ranged from 0.0983 to 0.138, as listed in Table 6. The variation of the bay average SOTE was small, and one standard deviation was 0.0091. This indicated that the performance of the diffuser plates in each aeration bay was fairly similar.

However, DO concentrations, which are widely used to control the aeration, showed drastic variations among the selected aeration bays during the off-gas tests, as well as at some test locations. The variation of DOs at the same test location between two runs was probably due to the variation in wastewater characteristics and operational parameters, such as return sludge flow rates and mixed liquor suspended solids (MLSS). As can be seen in Table 6, however, at most test locations the variations of DOs between two test runs were small, but the bay average DOs were quite different which implies that other factors might have played a role.

Figures 7 through 9 present the average DO profiles for the 18 selected aeration bays in Batteries A, B, and C, which were made during the off-gas tests. It is obvious that the DO profiles in the different aeration bays were quite different, although the air flow to each aeration tank during the tests was kept approximately the same at 2100 scfm. In addition to a certain degree of variation in wastewater characteristics and some operational parameters, which was reflected by the DO variations between two runs of off-gas tests at a few test stations, other factors must have played a significant role in

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FIGURE 7

AVERAGE DO PROFILES FOR SELECTED AERATION BAYS IN BATTERY A
DURING THE OFF-GAS TESTS AT THE NSWRP

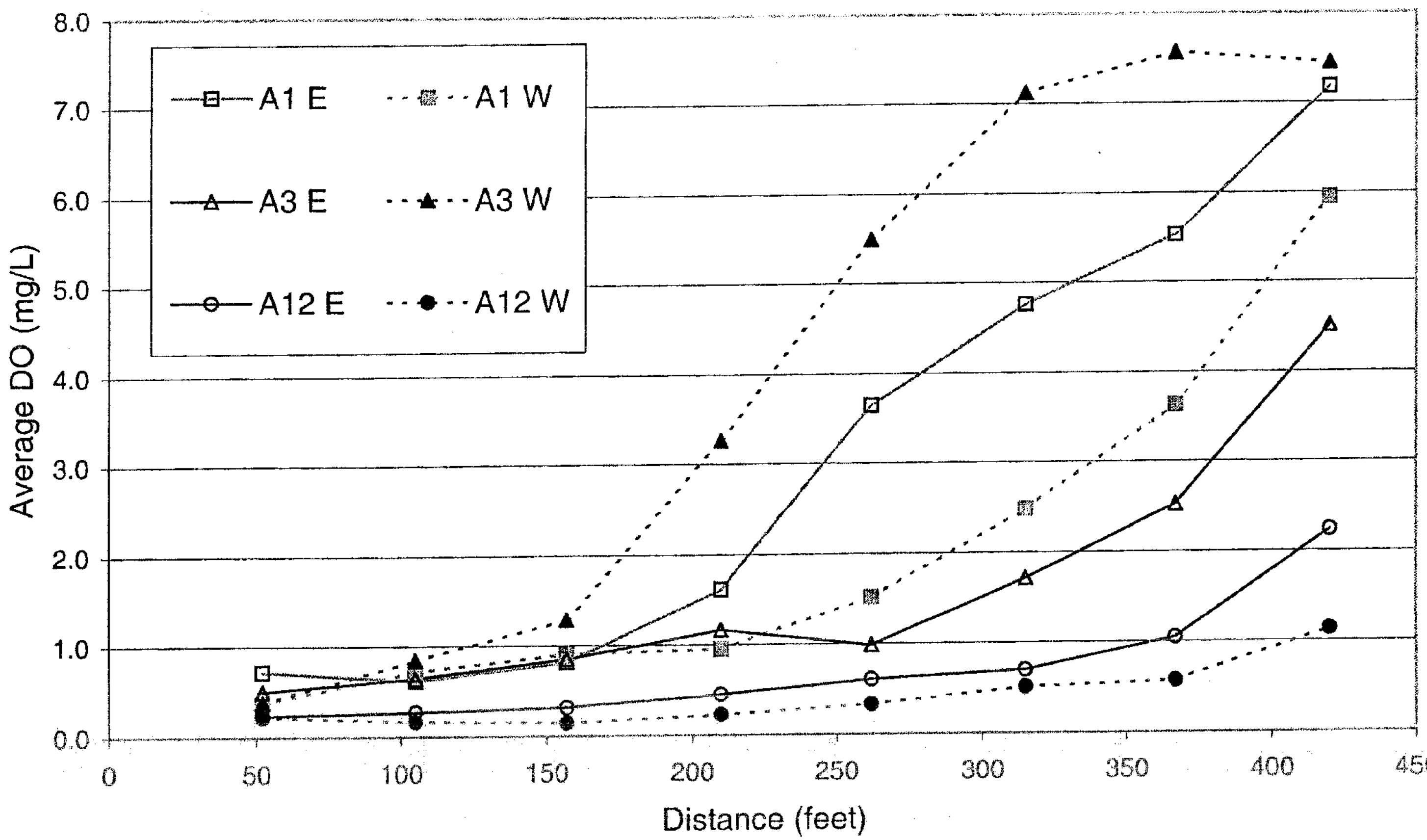

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FIGURE 8

AVERAGE DO PROFILES FOR SELECTED AERATION BAYS IN BATTERY B DURING THE OFF-GAS TESTS AT THE NSWRP

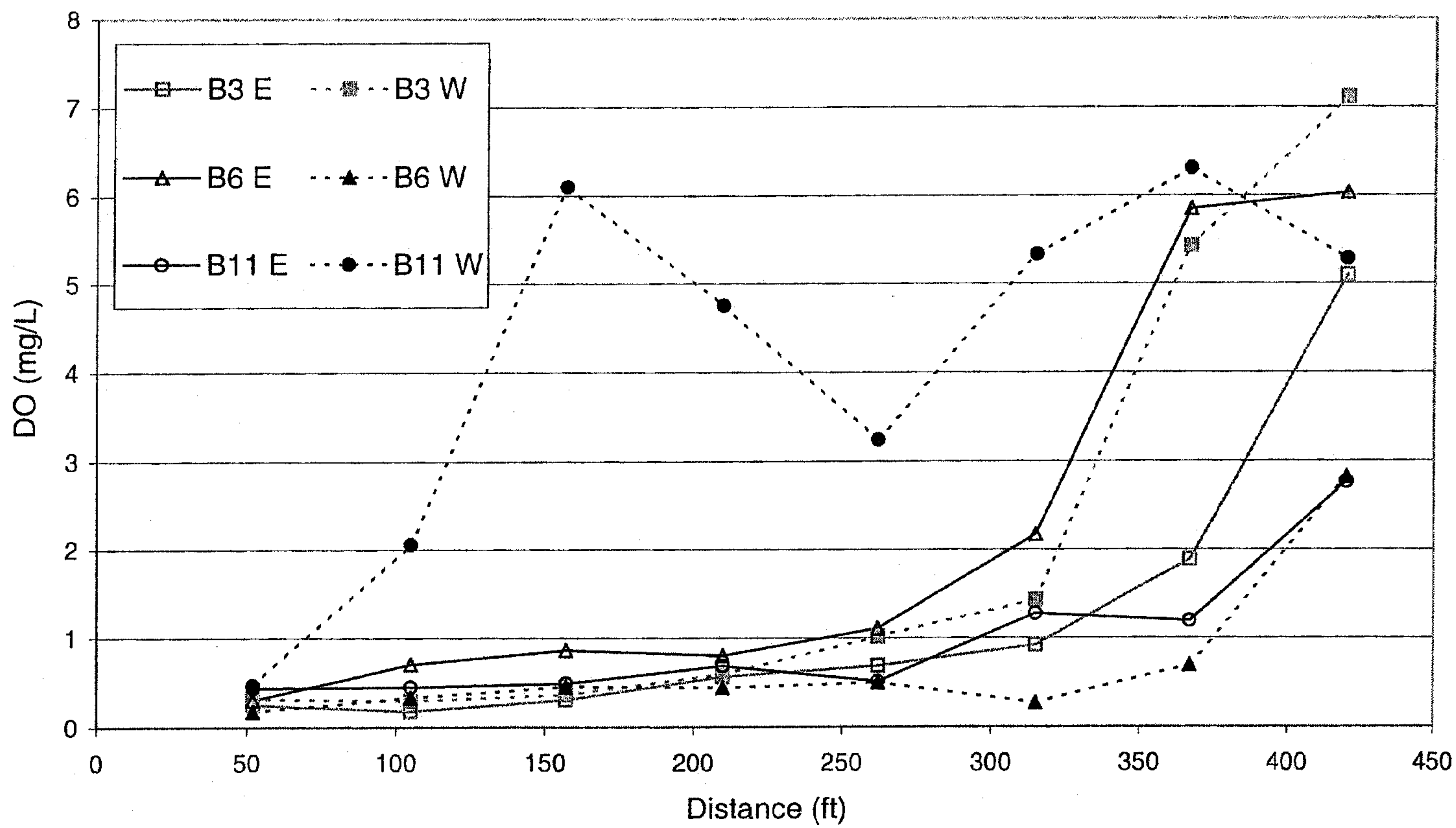

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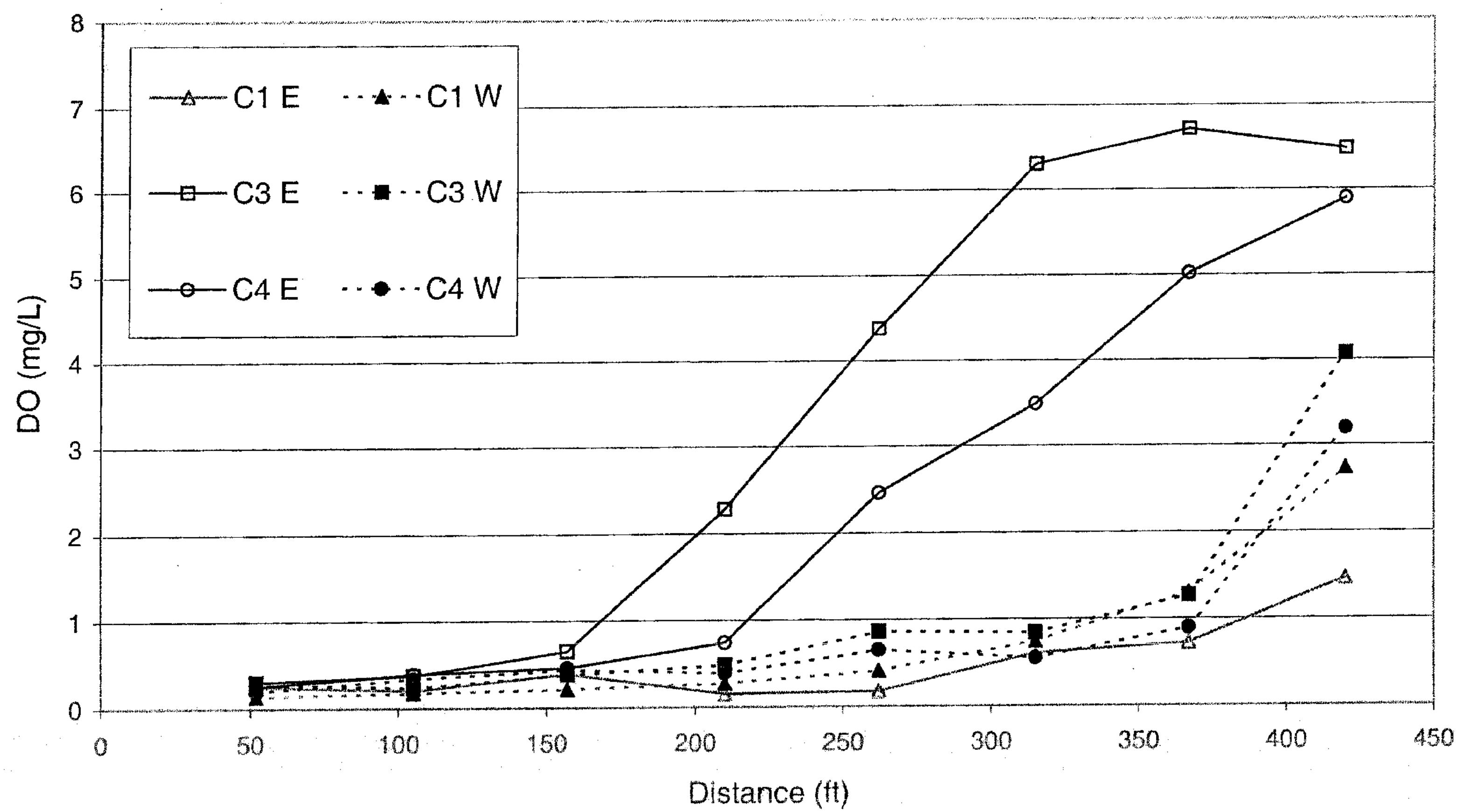
FIGURE 9

AVERAGE DO PROFILES FOR SELECTED AERATION BAYS IN BATTERY C
DURING THE OFF-GAS TESTS AT THE NSWRP



affecting the DO concentrations in these aeration bays, because the variations of DOs between two test runs at most test locations were small.

It was observed in the study that the uneven distribution of air flow in the aeration bays, which was corroborated by the measured off-gas flow rates at the various test locations, could have played a large role in determining the DO concentrations. For example, the bay average off-gas flow in the east bay of Tank C3, which was 14.26 scfm, was higher than that in the west bay of Tank C3, which was only 7.49. Accordingly, as can be seen in Figure 9, DO profiles also showed that DOs in the east bay of Tank C3 were proportionally higher than those in the west bay.

The effect of air flow on DOs may be demonstrated using the bay average off-gas flow rates and the corresponding bay average DOs from all the selected aeration bays. Figure 10 presents the bay average DOs and SOTEs versus bay average off-gas flow rates in the selected aeration bays in Batteries A, B, and C. Although a linear regression analysis between the bay average DOs and off-gas flow rates showed a poor correlation between these two parameters, as the R square coefficient for the linear regression was only 0.42, a clear trend that bay average DO increased as bay average off-gas flow increased

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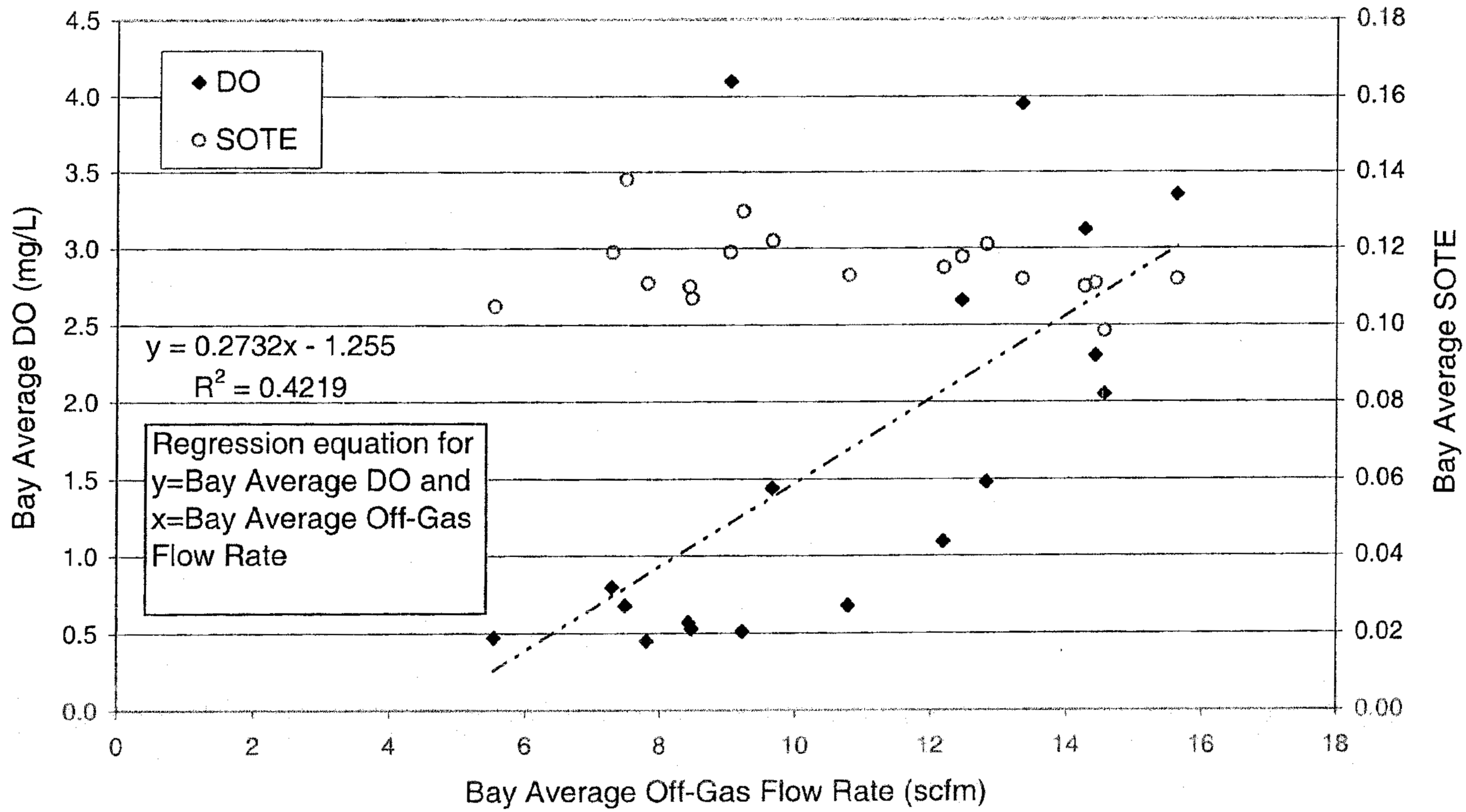
FIGURE 10

BAY AVERAGE DO AND SOTE VERSUS OFF-GAS FLOW RATE FOR SELECTED AERATION BAYS IN BATTERIES A, B, AND C DURING THE OFF-GAS TESTS AT THE NSWRP



can be observed in Figure 10. On the other hand, most of the bay average SOTEs were in the range of 0.10 to 0.13 with bay average off-gas flow varying from 5 to 16 scfm. It appeared that bay average SOTE did not vary with bay average off-gas flow.

Due to the existing tank configuration, air flow to each aeration tank, which has two separate bays, in Batteries A, B, and C at the NSWRP is able to be measured and controlled, but not within each bay. Generally, uneven air distribution between the two bays of the same aeration tank resulted in relatively higher air flow in one bay, and hence higher DOs. There were exceptions in two aeration tanks in which the DOs in both bays of the same aeration tank were relatively lower. These two aeration tanks, A12 and C1, were located at the one end of each battery, and part of the air to these tanks was diverted into the influent channel to aerate and mix the settled sewage with returned sludge. As possible evidence, the bay average off-gas flow rates in both bays of each of these two tanks were relatively lower, compared to those in the other tanks tested.

PLUG FLOW, SINGLE PASS, ONE BAY AERATION TANK, C12

Two runs of off-gas tests were conducted in Tank C12 on two different days with the first run on September 16, 1999, and the second run on October 18, 1999. As indicated earlier, this tank is one wide tank with no east and west bay as in the aeration tanks of Batteries A, B, and C. The air flow to the tank was set at 2100 scfm in the first run and 2300 scfm in the second run. The sewage flow to Battery C was set at 50 MGD in both test runs. The data obtained at each hood position from the two runs of off-gas tests are listed in Appendix Table AI-4.

The average values of the main parameters at each test station, which were measured during the off-gas tests and calculated from the field test data, are presented in Table 7. The values of OTE_f and SOTE at each test station in this table were the weighted averages using the off-gas flow rates as the weights. The off-gas flow rate at each station was the sum of off-gas flow rates at the corresponding hood positions. The DO at each station was the arithmetic mean of DO measurements at the station. The results for each run were separately listed in the table, because the air flows to the tank in these two runs were slightly different. The average values

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TABLE 7

AVERAGE VALUES OF THE OFF-GAS TEST RESULTS AT EACH TEST STATION IN TANK C12 AT THE NSWRP

Test	Location	OTEf	SOTE	DO (mg/L)	Off-Gas Flow (scfm)
--------------------With 3 Hood Positions--------------------					
1st Run	C12 1/4	0.139	0.116	0.46	18.46
2nd Run	C12 1/4	0.135	0.115	0.51	19.28
1st Run	C12 1/2	0.162	0.139	0.71	17.52
2nd Run	C12 1/2	0.150	0.134	1.07	18.60
1st Run	C12 3/4	0.108	0.114	2.50	32.31
2nd Run	C12 3/4	0.0861	0.123	4.82	32.63
-------------------------Tank Average*-------------------------					
1st Run	Average	0.136	0.123	1.23	22.76
2nd Run	Average	0.124	0.124	2.13	23.51

*The values in this section were the arithmetic means computed based on the data from the three stations with three hood positions only.

for Tank C12 were the arithmetic means of the values obtained from the three stations.

Similar to the other tanks in Batteries A, B, and C, the SOTE in this plug flow, single pass, one bay aeration tank, Tank C12, at the influent end was also lower. The relatively low SOTE obtained at Station C12 3/4, which was the closest to the effluent end, was due to the burst of large air bubbles at this particular location. Visual observation and the measured off-gas flow rates (see Appendix Table AI-4) confirmed that the unusually high air flow on the diffuser plate side occurred at this location, resulting in relatively low SOTE because of decreased air-water surface area and reduced retention time of air bubbles. The burst of large air bubbles was likely due to broken diffuser plates or leakage from joints at this particular location.

The average SOTE in Tank C12 was numerically higher than most of the bay average SOTEs in the other tanks in Batteries A, B, and C, as shown in Tables 6 and 7, although statistical analysis indicated that the difference in most cases was not statistically significant at 95 percent confidence level ($P < 0.05$). In Tank C12, due to its wider tank configuration without separation of bays and diffuser plate placement, air bubbles were spread to a wider region, and did not coalesce into bigger ones. It was observed that the off-gas flow rates from the first three hood positions were similar, so was SOTE, except for Station C12 3/4, at which the diffuser plates were possibly broken or there was leakage through joints of the diffuser plates. Figure 11 presents the SOTEs and off-gas flow rates versus hood positions at Station C12 1/2, where four hood positions were utilized during the off-gas tests. Significant decrease of off-gas flow occurred only in the fourth hood position, which was the farthest one from the diffuser plate side, resulting in a higher SOTE at this position. However, in the other tanks with two bays in Batteries A, B, and C, the off-gas flow at the second hood position, which was further away from the diffuser side, was significantly lower than that at the first hood position. This indicated that the air bubbles in Tank C12 might have longer retention time in the water at the same tank air flow rate, resulting in higher SOTE.

DO concentrations along the tank were measured during the off-gas tests. Tank C12 is a single pass, one bay aeration tank with its length in the south and north direction. The diffuser plates are located on the east side. The DOs on both east and west sides of the tanks were measured at the same

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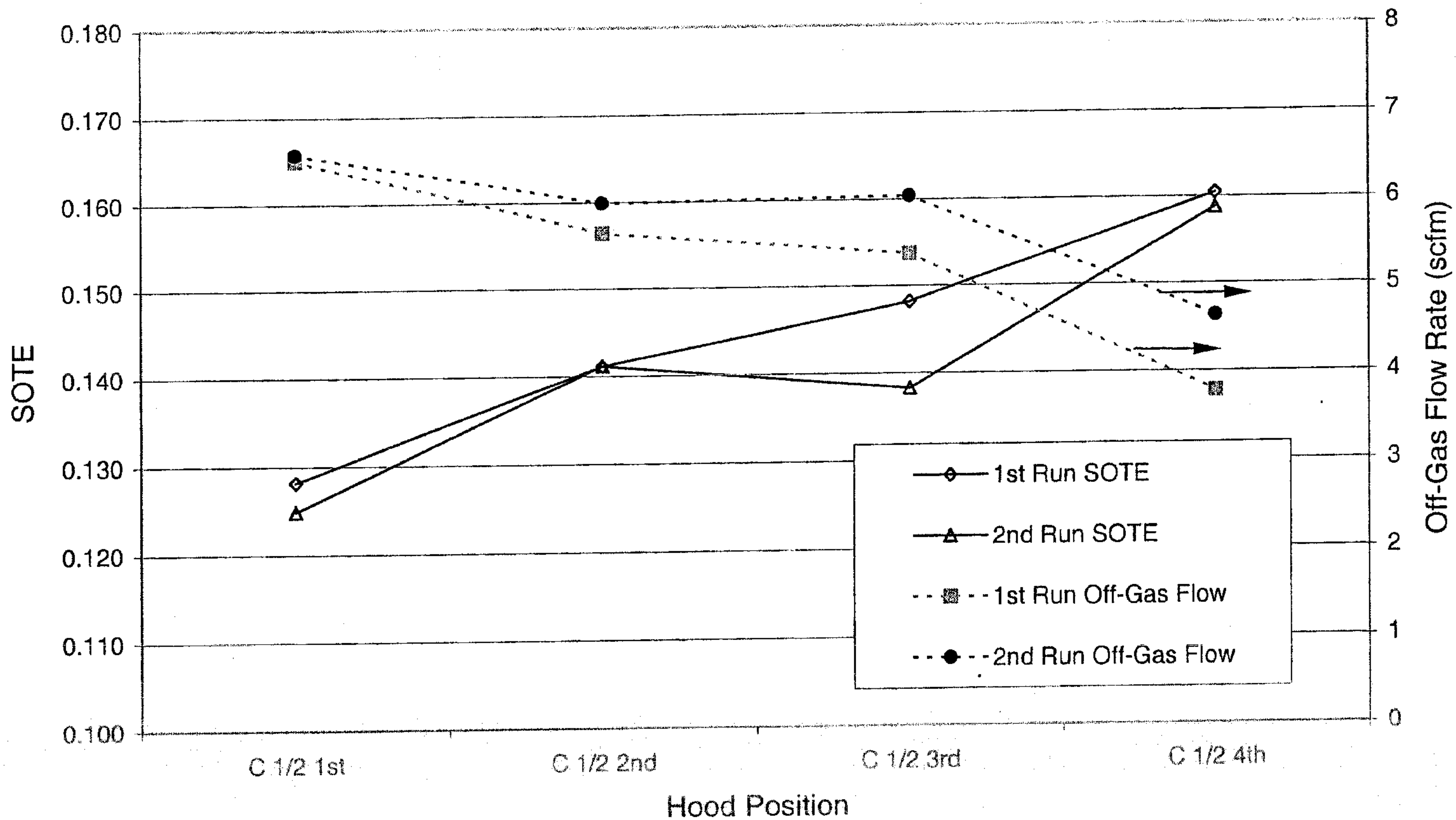
FIGURE 11

SOTE AND OFF-GAS FLOW RATE VERSUS HOOD POSITION DURING THE TWO RUNS OF OFF-GAS TESTS IN TANK C12 AT THE NSWRP



time, whenever a DO profile was made. The DO profiles for both test runs are presented in Figure 12.

It is obvious in Figure 12 that the DOs at the same lateral position on both east and west sides were very similar to each other, even though the DOs towards the effluent end were slightly lower at a tank air flow rate of 2100 scfm, compared to those at 2300 scfm. This indicated that the lateral mixing in this wider tank was adequate. However, the agitation due to water current, as visually observed in this tank, was not as strong as that in the other tanks with narrower tank width. As the diffuser plates in Tank C12 are the same type as those in the other tanks in Batteries A, B and C, the higher SOTE observed in this tank may be attributed to the slower rising water and air bubble velocities caused by the weaker water current.

In summary, the average SOTEs at 57 off-gas test stations in 10 aeration tanks varied from 0.0733 to 0.165 with the lower ones being generally found in the locations close to the influent end. The bay average SOTEs from 19 selected bays were less variable, ranging from 0.0983 to 0.138. The diffuser plates in these tanks were of the same type, and were all installed in 1986. Statistical analysis showed that most of the bay average SOTEs were not significantly different.

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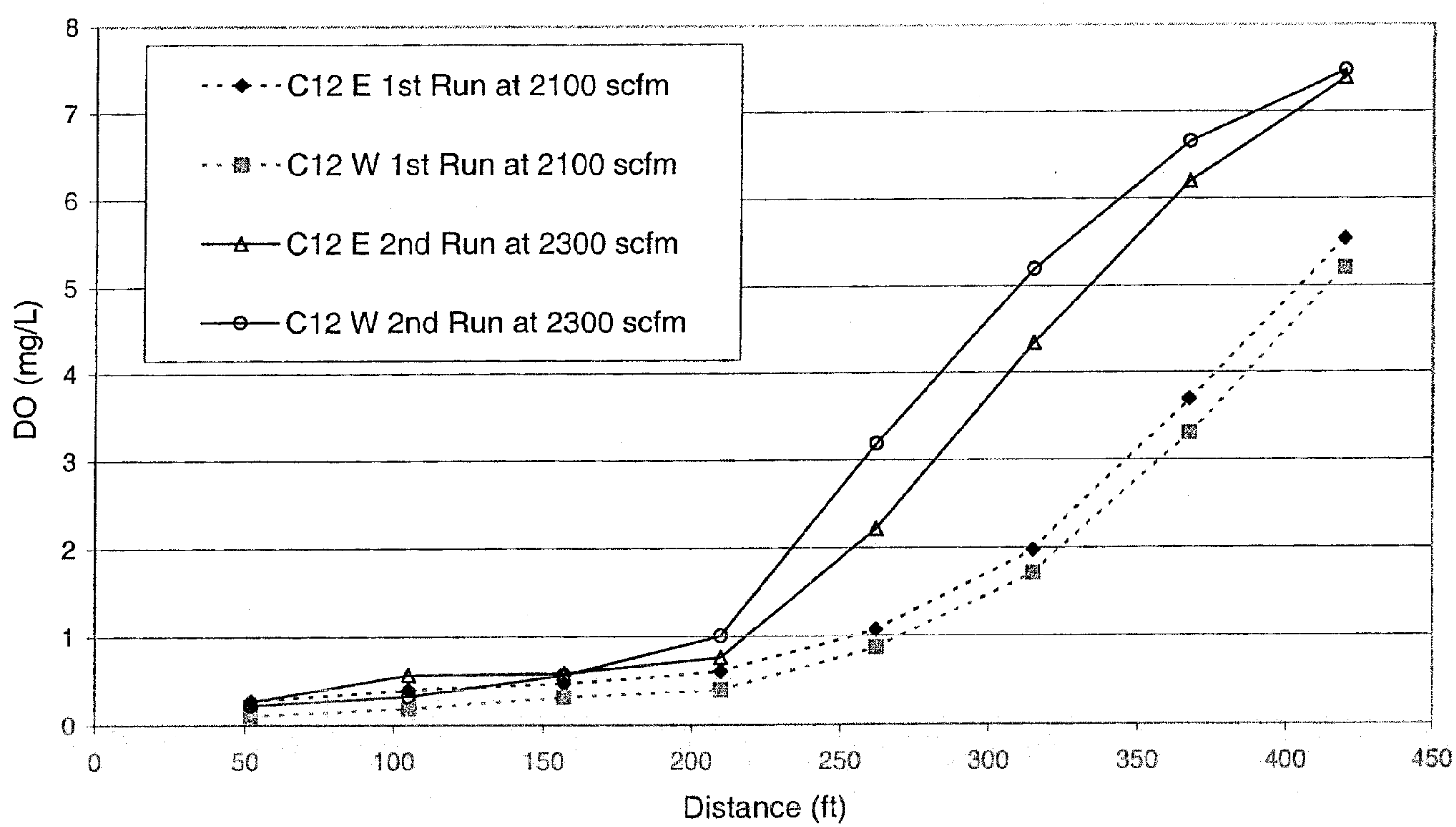
FIGURE 12

DO PROFILES FOR TANK C12 DURING THE TWO RUNS OF OFF-GAS TESTS WITH AIR FLOW RATES OF 2100 AND 2300 SCFM AT THE FIRST AND SECOND RUNS



However, the bay average DO concentrations in the selected aeration bays varied widely from 0.45 to 4.10 mg/L, under similar test conditions with the air flow to the test tanks that have two bays always being 2100 scfm, during the off-gas tests. It was postulated that the variation of DOs was due to the uneven distribution of air flow between the bays, as reflected by the off-gas flow rates measured during the tests, and possibly other factors, such as sewage flow distribution and variation in wastewater characteristics. The reasons for uneven distribution of the air flow might be local clogging and fouling of the diffuser plates, leakage from joints, and/or non-uniform installation of plates. A wider tank configuration, such as Tank C12, may provide better OTE compared to the narrow ones, such as the other tanks in Batteries A, B, and C.

Off-Gas Tests in Battery D

The diffuser plates in Battery D are of alumina with permeability of 39. The plates in Tanks D1 to D5 were installed in 1961, and the plates in Tanks D6 and D7 were installed in 1993. In 1995, off-gas tests were conducted in three aeration tanks, D5, D6, and D7, at the NSWRP to evaluate the performance of the diffuser plates installed at different times. In

1999, the off-gas tests were conducted at approximately the same locations as in a 1995 study (unpublished data) to reexamine the OTE after several years of operation. The results from both studies are presented and discussed in this section.

As in the previous 1995 study, five runs of off-gas tests at each test station were performed in this study on five different days between October 21 to 29, 1999. There were two off-gas test stations in each aeration tank, located at the 1/4 and 1/2 points along the tank from the influent end. One hood position, which was two feet away from the wall on the diffuser plate side, was used at each test station. The air flow to each tank was set at 2800 scfm, and the sewage flow to the battery was set at 50 MGD. The data obtained from each run of the off-gas tests at each station are listed in Appendix Table AI-5.

The daily variations of the main parameters in the off-gas tests of this study were relatively small, compared to the results from the 1995 study. The coefficients of variation for SOTEs from all test stations ranged from 2 to 8 percent. The coefficients of variation for off-gas flow rates were similar, ranging from 2 to 10 percent. The DOs had the largest daily variation, with the coefficients of variation ranging from 11 to 25 percent.

Table 8 presents the mean SOTEs and the corresponding standard deviations (in parentheses) for both 1995 and 1999 studies. The results of SOTE from the two studies were somewhat different (Table 8). The off-gas tests in the current study were completed within a period of 10 days, whereas in the 1995 study, the off-gas tests were conducted over a period of 30 days. The air and sewage flows were carefully controlled in the current study. The test conditions in the 1995 study were not strictly controlled, but instead were requested to be maintained as constantly as possible. Therefore, a statistical comparison between the results of the two studies was not made. However, an empirical comparison of the SOTE values shows that the average SOTE values in the 1999 study were somewhat higher than those recorded in 1995 (0.0628 to 0.1152 in 1995 vs. 0.100 to 0.154 in 1999).

The variation of SOTE at the same test location could partially be due to the hourly and daily changes in wastewater characteristics. Figure 13 presents the daily average values of SOTE and DO versus the time of the tests conducted at the two test stations in Tank D7 in the 1999 study. It is obvious that these two parameters varied with the time of the day they were measured, even though the sewage flow to the battery and

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TABLE 8

MEAN AND STANDARD DEVIATION OF SOTEs FROM THE OFF-GAS TESTS IN AERATION TANKS D5, D6 AND D7 AT THE NSWRP IN 1995 AND 1999

Station	Year Plates Installed	SOTE in 1995 Study*		SOTE in 1999 Study	
		Mean	SD**	Mean	SD
D5 1/4	1961	0.0817	(0.0203)	0.100	(0.0073)
D6 1/4	1993	0.0984	(0.0294)	0.123	(0.0091)
D7 1/4	1993	0.0801	(0.0297)	0.154	(0.0127)
D5 1/2	1961	0.1152	(0.0317)	0.125	(0.0020)
D6 1/2	1993	0.0838	(0.0309)	0.131	(0.0019)
D7 1/2	1993	0.0628	(0.0198)	0.138	(0.0079)

*Data were obtained from Mr. James Vey, senior civil engineer, at the NSWRP in 1999.

**SD = Standard Deviation.

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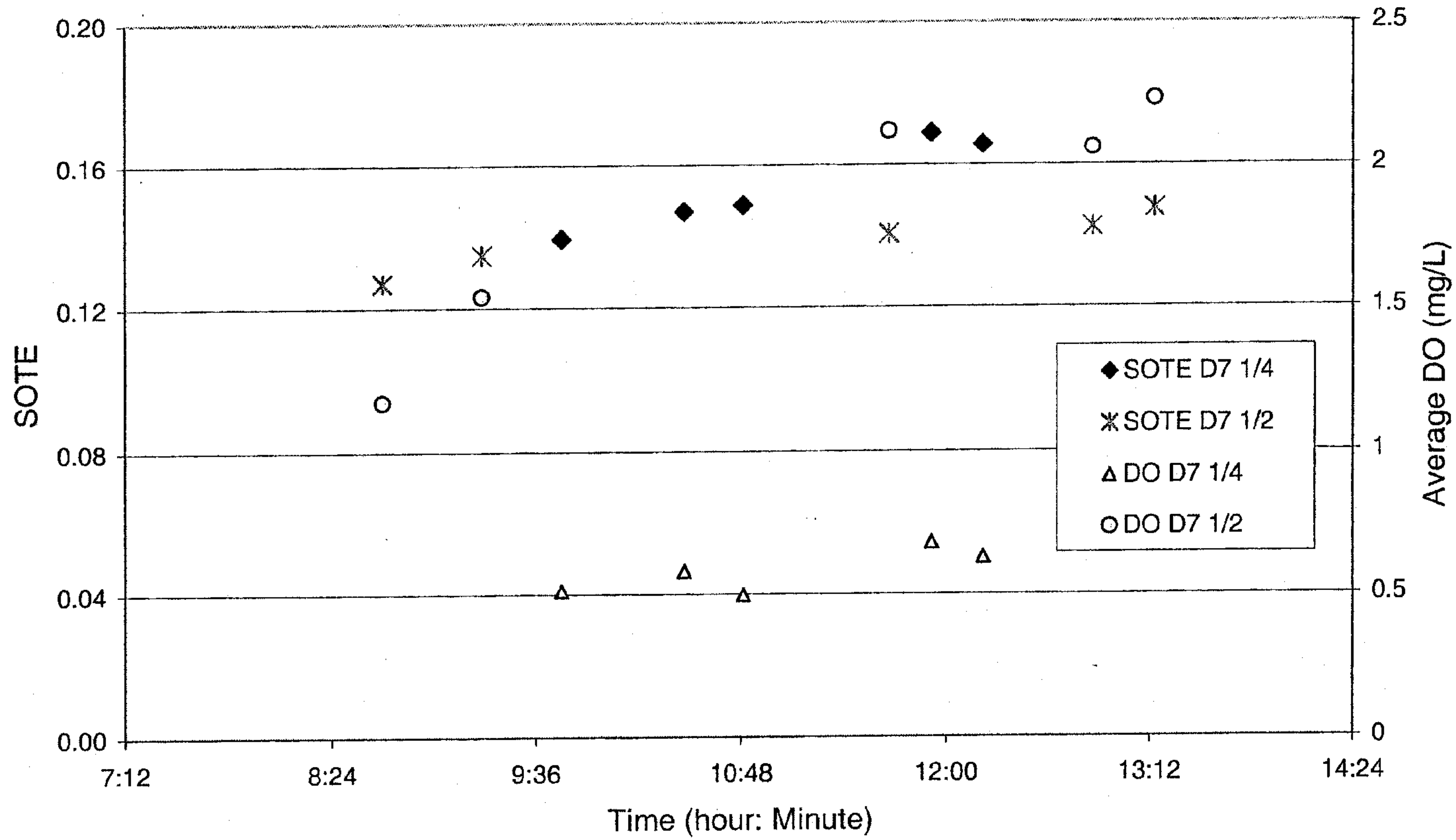
FIGURE 13

SOTE AND AVERAGE DO MEASURED AT DIFFERENT TIMES OF THE DAY DURING THE OFF-GAS TESTS CONDUCTED IN TANK D7 AT THE NSWRP IN 1999



air flow to the tank were carefully controlled during the off-gas tests. Similar phenomena were also observed in Tanks D5 and D6.

The variation of DO concentrations at the test locations in the 1999 study appeared to be larger than the variation of SOTE as indicated by the data presented in Appendix Table AI-5. The large variation in the DOs was also observed in the DO profiles, which were made during the off-gas tests for aeration tanks D5, D6, and D7, as shown in Figures 14 through 16. As can be seen, the variation in DOs occurred mostly in the second passes of these aeration tanks.

Statistical analysis of comparing the mean SOTEs obtained at the test stations in Tanks D5, D6, and D7 in the 1999 study was performed using the Kruskal-Wallis test. The statistical results (not shown) indicated that the mean SOTEs at the corresponding stations in different tanks were significantly different at a 95 percent confidence level ($P < 0.05$). At both the 1/4 and 1/2 stations, Tank D7 had the highest average SOTEs, and Tank D5 had the lowest. It appeared that higher SOTEs were obtained when the diffuser plates were relatively new (6 years old in D7 versus 38 years old in D5). The results obtained in the 1995 study were not consistent with and comparable to the results obtained in the 1999 study. This may

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FIGURE 14

DO PROFILES FOR TANK D5 MADE DURING THE OFF-GAS TESTS
AT THE NSWRP IN 1999

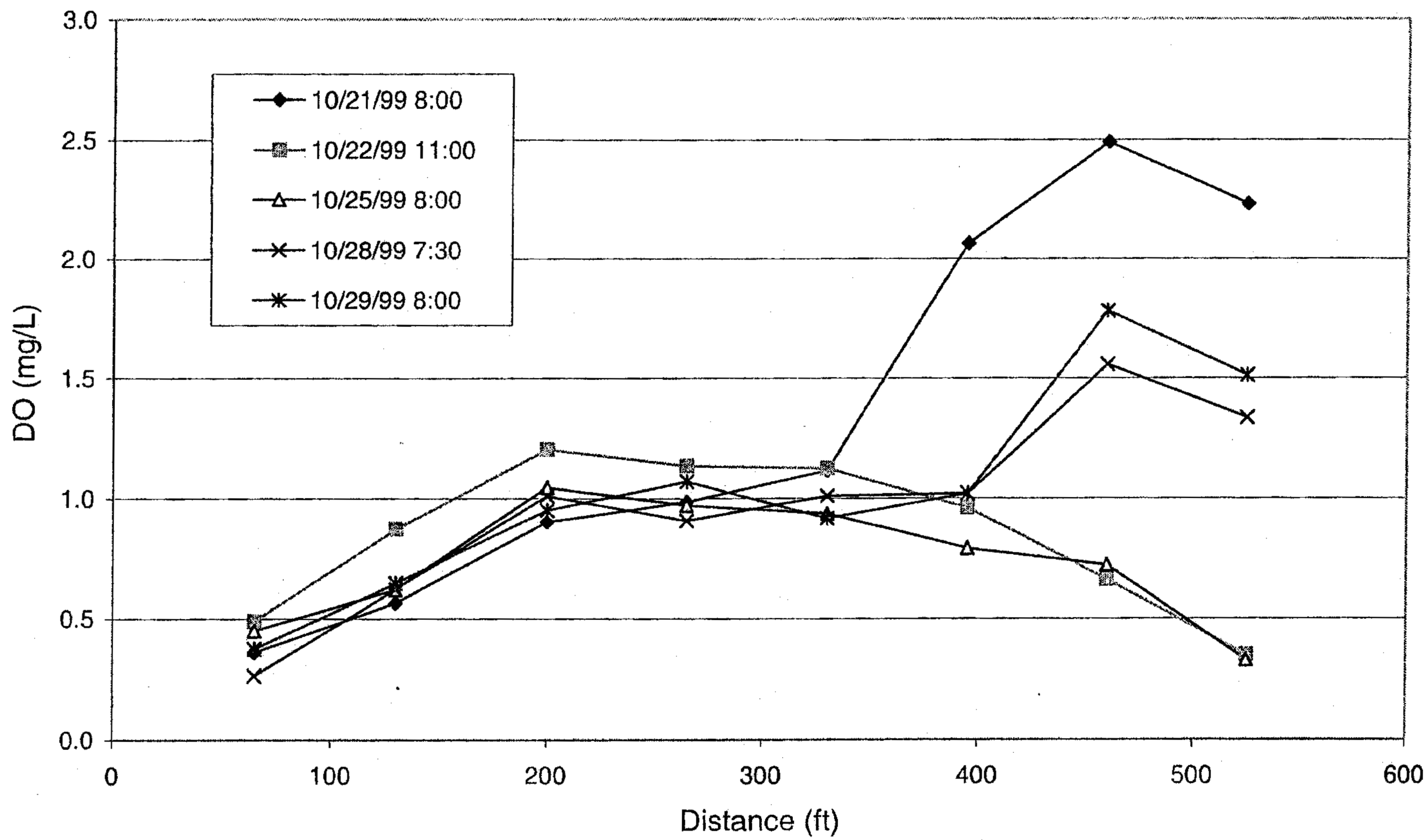

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FIGURE 15

DO PROFILES FOR TANK D6 MADE DURING THE OFF-GAS TESTS AT THE NSWRP IN 1999

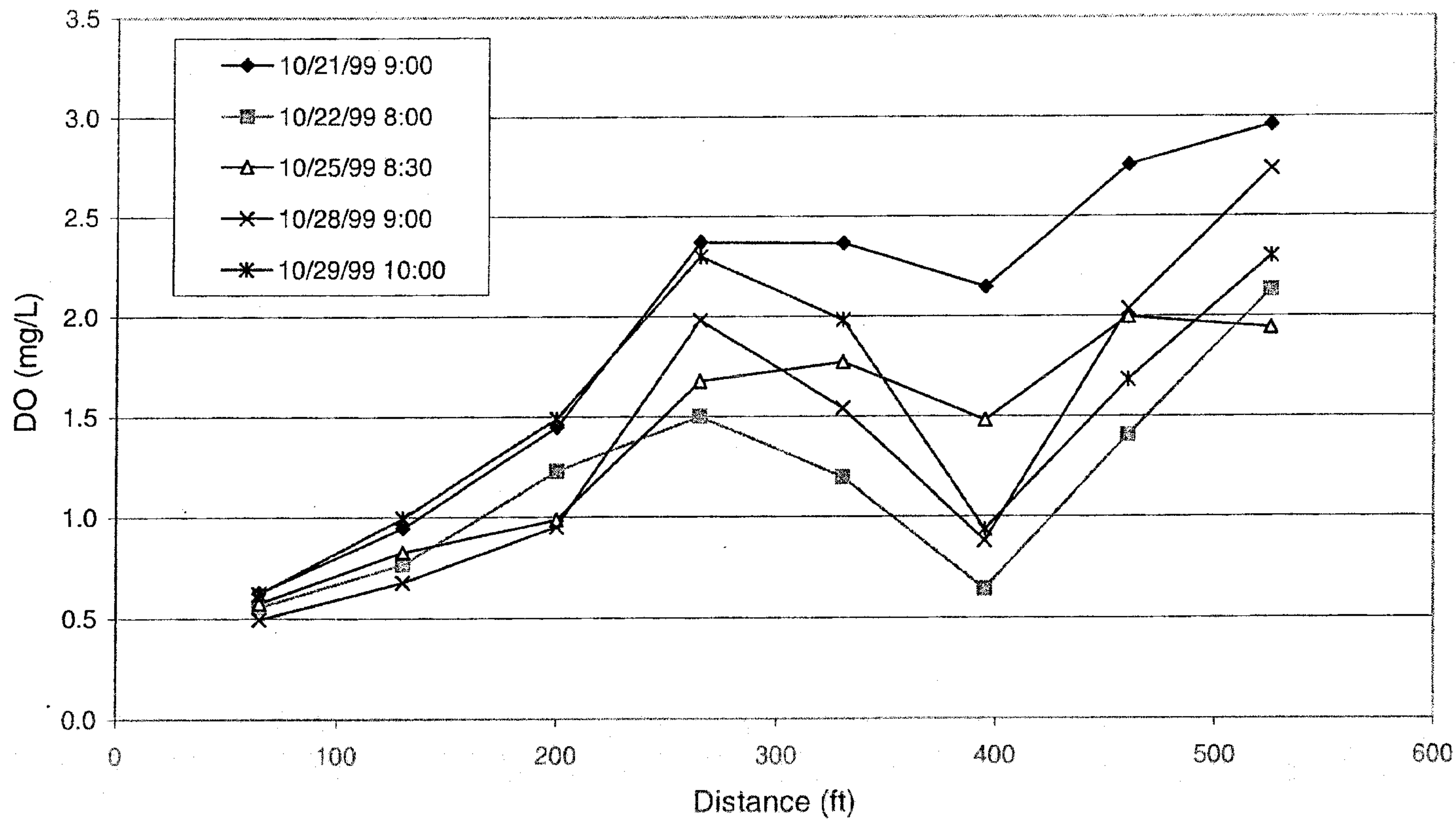

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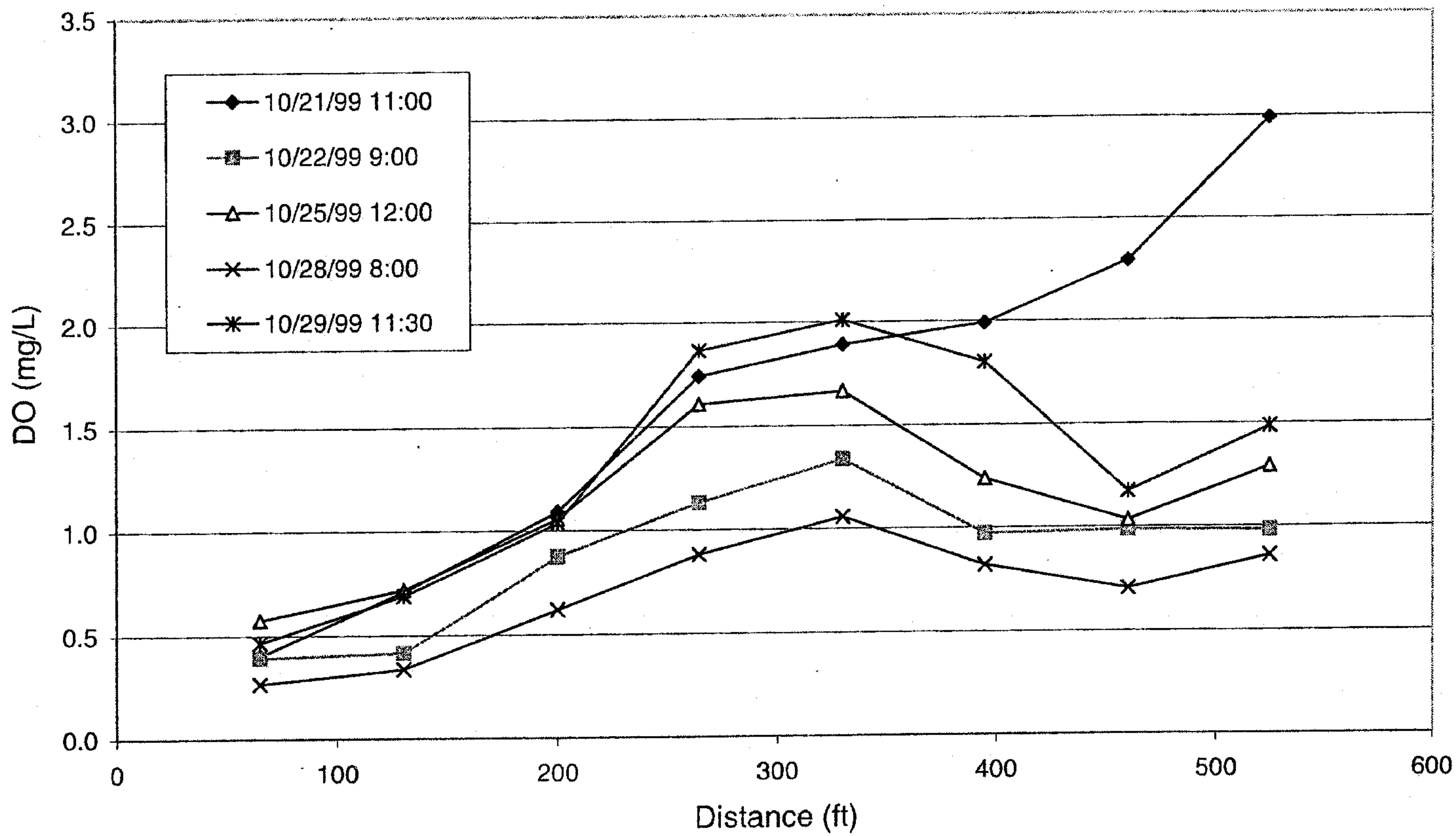
FIGURE 16

DO PROFILES FOR TANK D7 MADE DURING THE OFF-GAS TESTS AT THE NSWRP IN 1999



presumably be due to the uncontrolled nature of the 1995 study. Further investigation needs to be conducted to make a more definite conclusion that the SOTEs of plates installed in 1993 are higher than those installed in 1961.

In summary, the results from two off-gas studies conducted at Tanks D5, D6, and D7 of the NSWRP in 1995 and 1999 were inconsistent in terms of SOTE. The possible changes of wastewater characteristics and the uncontrolled test conditions of the 1995 study were probably the reasons for the difference in the results of the 1995 and 1999 studies. An evaluation of the performance of the diffuser plates with regards to their OTE over a prolonged period of operation of the aeration batteries will be made in the future.

Effect of Air Flow Rate on OTE

In order to study the effect of air flow rate on the OTE of diffuser plates under field conditions, off-gas tests were conducted at two test stations, located in the east and west bays of Tank B6, respectively, under five different air flow rates on August 20, 1999. The test locations were chosen randomly for this study. Both test stations were located at the 1/4 point along the length of the aeration tank from the influent end. Only one hood position was used in this study, and the hood was placed parallel to the length of the tank, one foot away from the walkway on the diffuser plates' side. Twenty minutes after the air flow in the tank was adjusted to the designed level, the off-gas tests started immediately one after another, and DO concentrations along the aeration bays were also measured at the same time. The data obtained for this part of the study are listed in Appendix Table AI-6. DO profiles along the east and west bays of Tank B6, made during the off-gas tests, are presented in Appendix Figures AI-1 and AI-2.

The off-gas flow rates at each test station increased with an increase in tank air flow. Figure 17 presents the off-gas flow rates at both test stations versus tank air flow rate. At each test station, off-gas was collected from the hood fastened at a fixed location, regardless of the change of tank air flow rates, and off-gas flow rates were measured using the rotameter built into the off-gas analyzer. The air to Tank B6, which supplies air to both east and west bays at the same time, was set and controlled at the control room of the NSWRP. As can be seen in Figure 17, the off-gas flow rates at both test stations increased linearly as the tank air flow rates increased in the range of 1200 to 2500 scfm, although the off-gas flow rates at the two test station were quite

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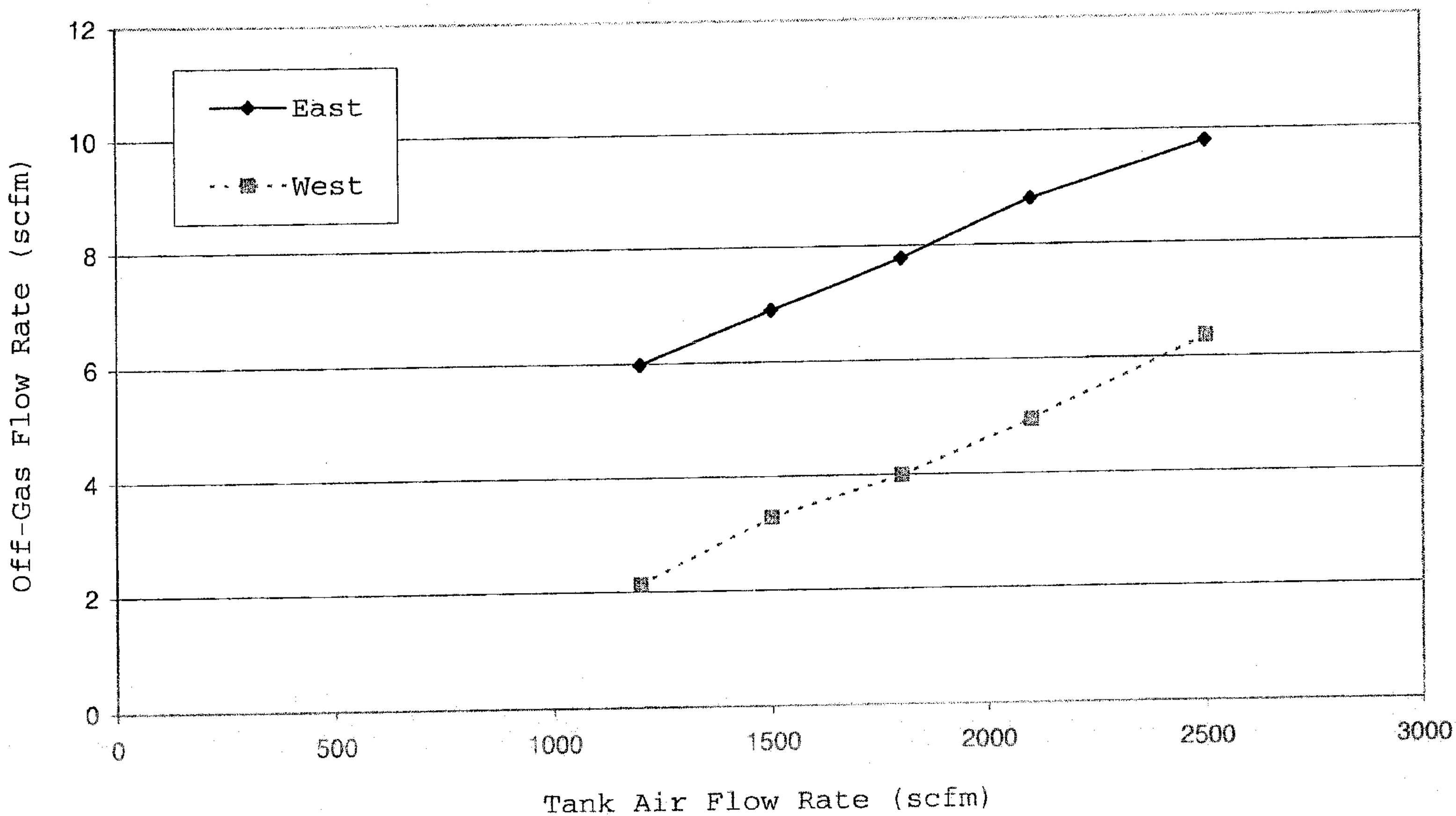
FIGURE 17

OFF-GAS FLOW RATE AS A FUNCTION OF TANK AIR FLOW RATE OBTAINED DURING THE OFF-GAS TESTS AT TANK B6 OF THE NSWRP ON AUGUST 20, 1999



different. It appeared that at this location more air was diverted to the east bay than to the west bay, as the size of both hoods used in the east and west bays was exactly the same.

The effect of air flow on OTE was examined using the relationship between the off-gas flow, which was the air flow passing through the diffuser plates under the hood, and SOTE. A linear correlation between the off-gas flow at a particular location and the air flow to the entire aeration tank was established (see Figure 17). Figure 18 presents SOTEs and DOs versus off-gas flow rates at both test stations. It was noted that SOTE decreased slightly as off-gas flow rate increased in the range of 2.13 to 6.36 scfm at the west bay station and 5.98 to 9.79 scfm at the east bay station. The normal operational range of air flow to an aeration tank in Batteries A, B, and C at the NSWRP was from 1200 to 2500 scfm. In this range, the decrease of SOTE due to the increase of tank air flow was less than 10 to 20 percent at the test locations.

However, DO concentration at the test locations increased significantly as air flow increased. As shown in Figure 18, the DO concentrations at both test stations increased nearly 3 to 4 times when the tank air flow rate changed from 1200 to 2500 scfm, and the off-gas flow rate increased from 2.13 to

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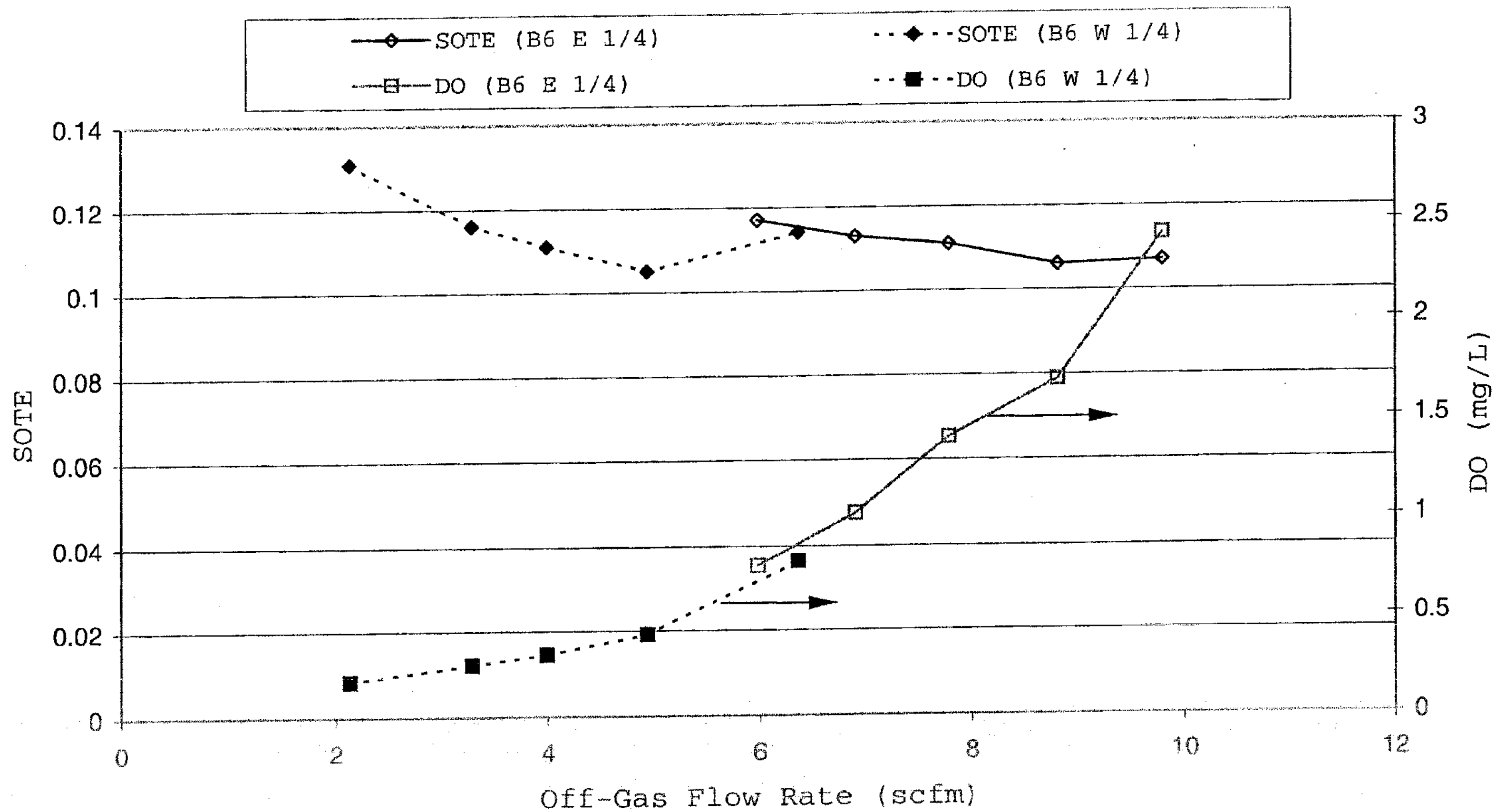
FIGURE 18

SOTE AND DO VERSUS OFF-GAS FLOW RATE AT THE TEST STATIONS OF B6 E 1/4 AND B6 W 1/4 DURING THE OFF-GAS TESTS AT THE NSWRP ON AUGUST 20, 1999



6.36 scfm at the west bay location and from 5.98 to 9.79 scfm at the east bay location, despite SOTE decreasing slightly.

In summary, the air flow at a particular location in an aeration tank, which was measured as off-gas flow in the tests, increased linearly with an increase in the air flow to the entire tank. The variation of air flow had minor effect on SOTE, but had a significant influence on DO. SOTEs at the test locations decreased about 10 to 20 percent when tank air flow increased from 1200 to 2500 scfm, whereas DOs at these locations had three to fourfold increase.

REFERENCES

1. U. S. Environmental Protection Agency, 1989, Design Manual: Fine Pore Aeration Systems, EPA/625/1-89/023, Office of Research and Development, Cincinnati, OH.

2. O'Brien, P., J. S. Jain, S. S. Soszynski, P. Tata, S. J. Sedita and C. Lue-Hing, 1998, "Determination of the Oxygen Transfer Efficiency of Diffuser Plates at the Calumet and Stickney Water Reclamation Plants," Report No. 98-14, Metropolitan Water Reclamation District of Greater Chicago.

3. Water Environment Federation and American Society of Civil Engineers, 1998, Design of Wastewater Treatment Plants (4th Ed.), Volume II, WEF, Alexandria, VA, and ASCE, Reston, VA.

4. American Society of Civil Engineers, 1997, Standard Guidelines for In-Process Oxygen Transfer Testing, ASCE-18-96, ASCE, Reston, VA.

5. Redmon, D. T., W. C. Boyle, and L. Ewing, 1983, "OTE Measurements in Mixed Liquor Using Off-Gas Techniques," Journal of the Water Pollution Control Federation, vol. 55, pp. 1338.

6. Operating Manual for the Aerator-Rator Off-Gas Analyzer, Ewing Engineering Company, Milwaukee, Wisconsin, 1987.

APPENDIX

VALUES OF MAIN PARAMETERS OBTAINED DURING OFF-GAS TESTS IN SELECTED AERATION TANKS AT THE NORTH SIDE WATER RECLAMATION PLANT IN 1999

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------1st Hood Position at B6 E 1/4----------							
7/29/99	100.1	88.3	0.60	23.3	3.52	0.145	0.1241
7/29/99	100.1	88.8	0.50	23.3	3.52	0.139	0.1178
7/29/99	100.1	88.2	0.50	23.3	3.52	0.146	0.1239
7/29/99	100.0	87.9	0.40	23.3	3.52	0.148	0.1247
7/29/99	100.0	88.2	0.40	23.3	3.52	0.145	0.1217
7/29/99	100.1	88.2	0.40	23.3	3.52	0.146	0.1226
8/3/99	100.1	92.0	0.25	23.4	4.39	0.100	0.0817
8/3/99	100.1	91.5	0.28	23.4	4.39	0.106	0.0869
8/3/99	99.8	91.1	0.29	23.4	4.41	0.108	0.0882
8/3/99	100.1	91.5	0.25	23.4	4.41	0.106	0.0866
8/3/99	100.0	91.2	0.32	23.4	4.42	0.109	0.0893
8/3/99	99.9	91.7	0.29	23.4	4.42	0.102	0.0832
8/5/99	99.9	90.3	0.35	23.7	4.46	0.119	0.0982
8/5/99	99.9	90.1	0.36	23.7	4.46	0.121	0.1003
8/5/99	100.0	90.8	0.31	23.7	4.42	0.114	0.0937
8/5/99	99.9	90.5	0.30	23.7	4.42	0.116	0.0957
8/5/99	100.0	90.4	0.33	23.7	4.42	0.118	0.0979
8/5/99	99.9	90.4	0.27	23.7	4.42	0.117	0.0964
8/6/99	100.1	90.3	0.38	23.7	4.47	0.121	0.1003
8/6/99	100.0	90.4	0.36	23.7	4.45	0.118	0.0982
8/6/99	99.9	90.3	0.32	23.7	4.45	0.119	0.0979
8/6/99	100.1	90.6	0.34	23.7	4.47	0.117	0.0969
8/6/99	100.0	90.5	0.33	23.7	4.47	0.117	0.0969
8/6/99	100.0	90.4	0.35	23.7	4.47	0.118	0.0981
8/9/99	100.0	90.3	0.44	23.6	5.85	0.120	0.1000
8/9/99	100.0	90.7	0.33	23.6	4.93	0.115	0.0950
8/9/99	100.0	90.6	0.31	23.6	4.47	0.116	0.0958
8/9/99	99.9	90.4	0.38	23.6	4.93	0.117	0.0975
8/9/99	99.9	90.0	0.42	23.6	5.00	0.122	0.1019
8/9/99	99.9	90.7	0.32	23.6	4.69	0.114	0.0940
Average		90.2	0.36	23.5	4.36	0.121	0.100
Standard Deviation		1.10	0.08	0.17	0.52	0.013	0.012

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Oxygen in Gas (mV) Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
2nd Hood Position at B6 E 1/4							
7/29/99	99.9	86.8	0.50	23.2	1.61	0.160	0.1363
7/29/99	100.1	86.8	0.50	23.2	1.58	0.162	0.1380
7/29/99	100.1	83.9	0.60	23.2	1.58	0.196	0.1686
7/29/99	100.0	83.9	0.50	23.3	1.58	0.195	0.1660
7/29/99	100.1	83.1	0.60	23.3	1.55	0.206	0.1765
7/29/99	100.0	82.7	0.50	23.3	1.55	0.209	0.1778
8/3/99	100.1	93.2	0.31	23.4	3.63	0.086	0.0702
8/3/99	100.0	93.4	0.32	23.4	3.63	0.082	0.0674
8/3/99	99.9	94.2	0.33	23.4	3.63	0.071	0.0584
8/3/99	100.0	94.0	0.43	23.4	3.63	0.075	0.0620
8/3/99	99.9	94.3	0.44	23.4	3.63	0.070	0.0581
8/3/99	99.9	94.4	0.43	23.4	3.63	0.069	0.0570
8/5/99	100.1	90.2	0.35	23.7	1.76	0.122	0.1010
8/5/99	100.0	89.5	0.38	23.7	1.76	0.129	0.1074
8/5/99	100.1	89.8	0.36	23.7	1.76	0.127	0.1051
8/5/99	100.2	88.7	0.36	23.7	1.76	0.141	0.1168
8/5/99	100.0	89.1	0.39	23.7	1.76	0.134	0.1115
8/5/99	100.0	88.9	0.37	23.7	1.76	0.136	0.1132
8/6/99	100.1	87.7	0.43	23.7	1.67	0.152	0.1266
8/6/99	100.0	87.9	0.37	23.7	1.67	0.148	0.1231
8/6/99	100.0	87.3	0.31	23.7	1.67	0.155	0.1282
8/6/99	100.0	87.5	0.36	23.7	1.67	0.153	0.1269
8/6/99	100.0	87.9	0.35	23.7	1.67	0.148	0.1228
8/6/99	99.9	87.0	0.33	23.7	1.66	0.158	0.1305
8/9/99	100.0	83.8	0.49	23.6	1.16	0.196	0.1651
8/9/99	99.9	83.4	0.43	23.6	1.13	0.200	0.1672
8/9/99	99.9	83.1	0.42	23.6	1.49	0.204	0.1700
8/9/99	99.9	82.9	0.35	23.6	1.79	0.206	0.1707
8/9/99	99.9	84.1	0.33	23.6	1.98	0.192	0.1588
8/9/99	99.9	86.1	0.37	23.6	2.00	0.169	0.1400
8/9/99	99.9	84.5	0.41	23.6	1.47	0.187	0.1562
8/9/99	99.9	84.5	0.39	23.6	1.49	0.187	0.1559
Average		87.6	0.41	23.5	2.01	0.151	0.126
Standard Deviation		3.78	0.08	0.18	0.81	0.045	0.038

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------1st Hood Position at B6 E 1/2----------------------							
7/29/99	99.9	90.9	1.42	23.5	10.41	0.111	0.1043
7/29/99	99.9	90.8	1.41	23.5	10.41	0.113	0.1054
7/29/99	99.9	90.6	1.45	23.5	10.41	0.115	0.1081
7/29/99	100.0	90.6	1.44	23.5	10.39	0.116	0.1090
7/29/99	99.9	90.6	1.41	23.5	10.39	0.115	0.1076
7/29/99	99.9	90.5	1.39	23.5	10.39	0.116	0.1085
8/3/99	100.0	91.6	1.11	23.5	10.34	0.104	0.0925
8/3/99	100.0	91.4	0.99	23.5	10.34	0.106	0.0935
8/3/99	100.0	91.7	1.14	23.5	10.34	0.103	0.0918
8/3/99	100.0	91.9	1.03	23.5	10.34	0.100	0.0885
8/3/99	100.0	91.7	1.09	23.5	10.16	0.103	0.0913
8/3/99	100.0	92.0	0.98	23.5	10.33	0.099	0.0870
8/5/99	100.0	91.8	1.27	23.8	11.83	0.102	0.0926
8/5/99	100.0	91.4	1.38	23.8	11.83	0.106	0.0983
8/5/99	99.9	91.8	1.40	23.8	12.01	0.100	0.0930
8/5/99	99.9	91.7	1.45	23.8	12.19	0.102	0.0946
8/5/99	100.0	92.0	1.44	23.8	12.10	0.099	0.0922
8/5/99	100.0	92.2	1.35	23.8	12.01	0.097	0.0890
8/6/99	100.0	91.1	1.27	23.8	10.00	0.110	0.1003
8/6/99	100.1	91.1	1.22	23.8	10.51	0.111	0.1008
8/6/99	100.0	91.0	1.25	23.8	10.51	0.111	0.1012
8/6/99	100.0	91.1	1.26	23.9	10.50	0.110	0.1002
8/6/99	100.0	91.1	1.33	23.9	10.42	0.110	0.1010
8/6/99	100.0	91.2	1.22	23.8	10.68	0.109	0.0987
8/9/99	100.0	91.9	1.69	23.7	11.49	0.100	0.0960
8/9/99	99.9	91.6	1.71	23.7	11.57	0.103	0.0987
8/9/99	99.9	91.7	1.61	23.7	11.57	0.102	0.0964
8/9/99	100.0	91.8	1.55	23.7	11.92	0.102	0.0956
8/9/99	100.0	91.8	1.53	23.7	12.09	0.102	0.0954
8/9/99	99.9	91.6	1.60	23.7	11.29	0.103	0.0974
Average		91.4	1.35	23.7	10.96	0.106	0.0976
Standard Deviation		0.49	0.20	0.15	0.75	0.006	0.006

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Oxygen in Gas (mV) Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------2nd Hood Position at B6 E 1/2----------------------							
7/29/99	99.9	88.0	1.45	23.5	4.78	0.146	0.137
7/29/99	100.0	88.1	1.44	23.5	4.78	0.146	0.137
7/29/99	100.0	87.8	1.45	23.5	4.78	0.149	0.141
7/29/99	100.1	87.5	1.44	23.5	4.75	0.154	0.145
7/29/99	100.0	87.9	1.45	23.5	4.75	0.148	0.140
7/29/99	100.1	87.8	1.44	23.5	4.75	0.151	0.141
8/3/99	99.9	88.9	1.32	23.5	5.70	0.135	0.123
8/3/99	100.0	87.7	1.25	23.5	5.70	0.151	0.136
8/3/99	100.0	87.4	1.32	23.5	5.70	0.154	0.140
8/3/99	100.0	87.8	1.27	23.5	5.61	0.149	0.135
8/3/99	100.1	87.5	1.35	23.5	5.52	0.154	0.141
8/3/99	100.1	87.8	1.30	23.5	5.52	0.151	0.137
8/5/99	100.0	88.2	1.68	23.8	5.80	0.145	0.138
8/5/99	100.0	88.2	1.63	23.8	6.39	0.145	0.138
8/5/99	100.1	88.5	1.71	23.8	7.06	0.142	0.136
8/5/99	100.1	88.7	1.68	23.8	6.89	0.140	0.134
8/5/99	100.1	88.5	1.70	23.8	6.47	0.142	0.136
8/5/99	100.1	88.6	1.68	23.8	6.64	0.141	0.135
8/6/99	100.0	88.0	1.66	23.9	5.96	0.147	0.140
8/6/99	100.0	87.9	1.60	23.9	6.38	0.148	0.140
8/6/99	100.0	87.6	1.88	23.9	6.21	0.152	0.149
8/6/99	100.1	87.8	1.82	23.9	6.21	0.151	0.146
8/6/99	100.1	88.2	1.69	23.9	6.55	0.146	0.139
8/6/99	100.1	88.1	1.74	23.9	6.47	0.147	0.141
8/9/99	100.0	88.3	1.84	23.7	7.32	0.144	0.140
8/9/99	100.1	88.8	1.87	23.7	7.48	0.139	0.136
8/9/99	100.1	88.5	1.86	23.7	6.04	0.142	0.139
8/9/99	100.1	88.5	1.91	23.7	6.21	0.142	0.140
8/9/99	100.1	88.1	1.89	23.7	6.47	0.147	0.144
8/9/99	100.0	88.8	1.92	23.7	6.55	0.138	0.135
Average		88.1	1.61	23.7	5.98	0.146	0.139
Standard Deviation		0.42	0.22	0.16	0.79	0.005	0.005

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------1st Hood Position at B6 E 3/4----------							
7/29/99	100.0	93.9	5.26	23.8	8.34	0.0759	0.126
7/29/99	99.9	93.9	5.16	23.8	8.33	0.0748	0.122
7/29/99	99.9	93.9	5.22	23.8	8.67	0.0748	0.124
7/29/99	100.0	93.9	5.20	23.8	8.67	0.0759	0.125
7/29/99	100.0	93.8	5.05	23.7	8.67	0.0772	0.123
7/29/99	100.0	94.0	5.06	23.7	8.67	0.0747	0.119
8/3/99	100.0	94.5	5.15	23.7	9.05	0.0686	0.108
8/3/99	100.1	94.5	5.06	23.7	9.14	0.0697	0.108
8/3/99	100.1	94.6	5.10	23.7	9.06	0.0685	0.107
8/3/99	100.1	94.5	5.17	23.7	9.06	0.0697	0.110
8/3/99	100.1	94.6	5.09	23.7	9.06	0.0685	0.107
8/3/99	100.0	94.5	5.13	23.7	9.06	0.0686	0.108
8/5/99	100.0	95.0	6.35	24.0	9.62	0.0624	0.131
8/5/99	100.0	95.0	6.40	24.0	9.62	0.0624	0.133
8/5/99	100.1	94.9	6.47	24.0	9.70	0.0648	0.141
8/5/99	100.1	94.9	6.43	24.0	9.78	0.0648	0.139
8/5/99	100.1	94.8	6.30	24.0	9.96	0.0661	0.137
8/5/99	100.1	94.9	6.35	24.0	9.61	0.0648	0.136
8/6/99	100.0	92.9	4.62	24.0	9.67	0.0882	0.128
8/6/99	100.0	93.2	4.66	24.0	9.58	0.0845	0.124
8/6/99	100.0	93.0	4.56	24.0	9.92	0.0869	0.125
8/6/99	100.0	93.1	4.68	24.0	9.66	0.0857	0.126
8/6/99	100.0	92.9	4.65	24.0	9.57	0.0882	0.129
8/6/99	100.0	93.1	4.68	24.0	9.82	0.0857	0.126
8/9/99	100.0	95.8	6.02	23.9	9.21	0.0525	0.102
8/9/99	100.1	95.7	6.11	23.9	9.13	0.0550	0.109
8/9/99	100.0	95.5	6.16	23.9	8.96	0.0563	0.112
8/9/99	100.0	95.5	6.10	23.9	8.78	0.0563	0.111
8/9/99	100.0	95.6	6.09	23.9	8.96	0.0550	0.108
8/9/99	100.0	95.6	6.12	23.9	8.96	0.0550	0.109
Average		94.4	5.48	23.9	9.21	0.0701	0.120
Standard Deviation		0.90	0.67	0.13	0.47	0.011	0.011

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
--------2nd Hood Position at B6 E 3/4--------							
7/29/99	100.0	92.8	4.72	23.8	5.28	0.0894	0.134
7/29/99	100.0	92.7	4.74	23.8	5.13	0.0906	0.136
7/29/99	100.0	92.7	4.75	23.8	5.13	0.0906	0.137
7/29/99	100.0	92.1	4.72	23.8	5.09	0.0979	0.147
7/29/99	100.0	91.8	4.74	23.8	5.05	0.1015	0.153
7/29/99	100.0	91.8	4.75	23.8	5.13	0.1015	0.153
8/3/99	100.1	92.6	4.92	23.7	5.31	0.0929	0.140
8/3/99	100.0	92.6	4.84	23.7	5.25	0.0918	0.137
8/3/99	100.1	92.6	4.95	23.7	5.25	0.0929	0.141
8/3/99	100.1	92.6	4.89	23.7	5.25	0.0929	0.140
8/3/99	100.0	92.6	4.91	23.7	5.25	0.0918	0.138
8/3/99	100.0	92.8	4.94	23.7	5.20	0.0894	0.136
8/5/99	99.9	92.5	6.06	24.0	5.35	0.0919	0.180
8/5/99	100.0	92.6	6.08	24.0	5.87	0.0918	0.180
8/5/99	99.9	92.6	6.19	24.0	5.79	0.0907	0.183
8/5/99	100.0	92.9	6.24	24.0	5.96	0.0882	0.180
8/5/99	99.9	92.7	6.16	24.0	5.95	0.0895	0.179
8/5/99	99.9	92.7	6.10	24.0	6.04	0.0895	0.177
8/6/99	100.0	90.7	4.35	24.0	5.56	0.1148	0.159
8/6/99	100.0	90.5	4.51	24.0	5.48	0.1172	0.167
8/6/99	99.9	90.9	4.68	24.0	6.00	0.1113	0.164
8/6/99	99.9	90.8	4.44	24.0	5.91	0.1125	0.159
8/6/99	100.0	90.7	4.59	24.0	5.91	0.1148	0.166
8/6/99	100.0	90.8	4.58	24.0	5.91	0.1136	0.164
8/9/99	100.0	94.4	5.87	23.9	4.97	0.0698	0.130
8/9/99	100.0	94.0	5.98	23.9	4.89	0.0747	0.143
8/9/99	99.9	93.8	5.95	23.9	5.44	0.0760	0.145
8/9/99	99.9	94.0	6.05	23.9	6.22	0.0736	0.143
8/9/99	99.9	93.8	5.97	23.9	6.06	0.0760	0.145
8/9/99	99.9	94.0	6.03	23.9	5.36	0.0736	0.143
Average		92.5	5.26	23.9	5.50	0.0931	0.153
Standard Deviation		1.09	0.68	0.12	0.39	0.013	0.017

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Oxygen in Gas (mV) Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
---1st Hood Position at B6 W 1/4---							
7/29/99	100.1	90.4	0.7	23.3	4.44	0.120	0.1037
7/29/99	100.1	90.1	0.8	23.3	4.44	0.123	0.1079
7/29/99	100.1	89.6	0.5	23.3	5.26	0.129	0.1097
7/29/99	100.2	89.7	0.7	23.3	5.26	0.129	0.1119
7/29/99	100.2	89.7	0.7	23.3	5.26	0.129	0.1119
8/3/99	99.9	90.7	0.30	23.3	4.20	0.114	0.0932
8/3/99	99.9	90.5	0.37	23.3	4.20	0.116	0.0959
8/3/99	99.9	90.6	0.52	23.3	4.20	0.115	0.0963
8/3/99	99.9	90.4	0.44	23.3	4.20	0.117	0.0975
8/3/99	100.0	90.7	0.49	23.4	4.20	0.115	0.0959
8/3/99	100.1	90.8	0.34	23.4	4.19	0.115	0.0944
8/5/99	100.0	90.7	0.40	23.6	5.21	0.115	0.0956
8/5/99	100.1	90.8	0.38	23.6	5.20	0.115	0.0953
8/5/99	100.0	91.0	0.36	23.6	5.20	0.111	0.0922
8/5/99	100.0	91.0	0.38	23.6	5.20	0.111	0.0924
8/5/99	100.1	91.0	0.36	23.6	5.20	0.112	0.0931
8/5/99	100.1	91.0	0.36	23.6	5.10	0.112	0.0931
8/6/99	99.9	90.3	0.35	23.7	4.53	0.119	0.0982
8/6/99	99.9	90.4	0.27	23.6	4.54	0.117	0.0964
8/6/99	99.9	90.4	0.28	23.7	4.54	0.117	0.0965
8/6/99	99.9	90.6	0.26	23.6	4.54	0.115	0.0944
8/6/99	100.1	90.8	0.33	23.6	4.54	0.115	0.0948
8/6/99	100.0	90.8	0.29	23.6	4.52	0.114	0.0935
8/9/99	100.0	89.8	0.40	23.5	5.36	0.126	0.1047
8/9/99	100.0	89.8	0.41	23.5	4.86	0.126	0.1048
8/9/99	100.1	89.7	0.38	23.5	4.89	0.128	0.1064
8/9/99	100.0	89.8	0.39	23.5	4.84	0.126	0.1046
8/9/99	100.0	89.6	0.33	23.5	5.01	0.128	0.1059
8/9/99	100.0	89.7	0.32	23.5	4.99	0.127	0.1048
Average		90.4	0.42	23.5	4.76	0.119	0.0995
Standard Deviation		0.49	0.14	0.14	0.41	0.006	0.006

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------2nd Hood Position at B6 W 1/4----------------------							
7/29/99	99.9	88.6	0.60	23.3	2.41	0.139	0.119
7/29/99	100.1	86.7	0.53	23.3	2.41	0.164	0.139
7/29/99	100.1	86.2	0.47	23.3	2.41	0.169	0.144
7/29/99	100.1	85.4	0.55	23.3	2.41	0.179	0.153
7/29/99	100.1	85.6	0.47	23.3	2.41	0.176	0.149
7/29/99	100.1	86.0	0.49	23.3	2.41	0.172	0.146
8/3/99	100.1	87.4	0.36	23.4	2.42	0.155	0.128
8/3/99	100.1	87.3	0.35	23.4	2.40	0.156	0.129
8/3/99	100.0	87.3	0.30	23.4	2.40	0.155	0.127
8/3/99	100.1	87.1	0.37	23.4	2.40	0.159	0.131
8/3/99	100.1	87.4	0.39	23.4	2.40	0.155	0.128
8/3/99	100.0	87.0	0.36	23.4	2.40	0.159	0.131
8/5/99	99.9	87.6	0.38	23.6	2.20	0.151	0.125
8/5/99	99.9	86.9	0.38	23.6	2.18	0.159	0.132
8/5/99	99.9	86.8	0.37	23.6	2.18	0.160	0.133
8/5/99	100.0	86.5	0.36	23.6	2.34	0.165	0.137
8/5/99	100.0	86.7	0.37	23.6	2.31	0.163	0.135
8/5/99	99.9	86.9	0.38	23.6	2.31	0.159	0.132
8/5/99	100.1	86.9	0.34	23.6	2.31	0.161	0.133
8/6/99	100.0	87.6	0.33	23.6	2.00	0.152	0.126
8/6/99	100.0	86.9	0.33	23.6	2.02	0.160	0.132
8/6/99	100.0	86.5	0.36	23.6	2.02	0.165	0.137
8/6/99	100.0	86.4	0.32	23.6	2.02	0.166	0.137
8/6/99	100.0	86.4	0.35	23.6	2.01	0.166	0.138
8/6/99	100.0	86.1	0.29	23.6	2.01	0.170	0.140
8/6/99	100.0	86.1	0.31	23.6	2.01	0.170	0.140
8/9/99	100.0	86.3	0.38	23.5	2.32	0.167	0.139
8/9/99	100.0	86.2	0.33	23.5	2.31	0.168	0.139
8/9/99	100.0	85.8	0.36	23.5	2.31	0.173	0.144
8/9/99	100.0	85.9	0.35	23.5	2.31	0.172	0.143
8/9/99	100.0	85.2	0.36	23.5	2.31	0.180	0.149
8/9/99	100.0	85.3	0.33	23.5	2.31	0.179	0.148
Average		86.6	0.38	23.5	2.27	0.164	0.136
Standard Deviation		0.76	0.07	0.12	0.15	0.009	0.008

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
---1st Hood Position at B6 W 1/2---							
7/29/99	100	87.4	0.5	23.4	3.61	0.154	0.131
7/29/99	100	87.3	0.4	23.4	3.61	0.155	0.131
7/29/99	99.9	87.3	0.4	23.4	3.59	0.154	0.130
7/29/99	99.8	87.2	0.5	23.4	3.59	0.155	0.131
7/29/99	99.8	87.2	0.5	23.4	3.59	0.155	0.131
7/29/99	99.8	87.1	0.4	23.4	3.59	0.156	0.131
8/3/99	100.0	90.7	0.34	23.4	2.87	0.115	0.094
8/3/99	100.0	89.9	0.36	23.4	2.87	0.124	0.103
8/3/99	100.0	88.9	0.26	23.4	2.86	0.136	0.111
8/3/99	100.0	88.7	0.27	23.4	2.86	0.139	0.113
8/3/99	100.0	88.4	0.25	23.4	2.86	0.142	0.116
8/3/99	100.0	88.3	0.27	23.4	2.86	0.144	0.117
8/5/99	100.0	89.2	0.33	23.7	3.27	0.133	0.110
8/5/99	100.0	89.0	0.35	23.7	3.19	0.135	0.112
8/5/99	100.1	88.4	0.34	23.7	3.24	0.143	0.119
8/5/99	100.1	88.3	0.32	23.7	3.27	0.145	0.119
8/5/99	100.1	88.4	0.35	23.7	3.35	0.143	0.119
8/5/99	100.1	88.3	0.31	23.7	3.35	0.145	0.119
8/6/99	100.0	88.3	0.36	23.7	2.73	0.144	0.119
8/6/99	100.0	88.2	0.38	23.7	2.89	0.145	0.120
8/6/99	100.1	88.3	0.33	23.7	2.84	0.145	0.119
8/6/99	100.0	88.1	0.33	23.7	2.81	0.146	0.121
8/6/99	100.1	88.1	0.35	23.7	2.76	0.147	0.122
8/6/99	100.1	88.2	0.35	23.7	2.81	0.146	0.121
8/9/99	100.0	87.8	0.35	23.6	3.65	0.149	0.124
8/9/99	100.0	87.6	0.29	23.6	3.59	0.152	0.125
8/9/99	100.0	87.7	0.32	23.6	3.50	0.151	0.124
8/9/99	99.9	87.5	0.32	23.6	3.47	0.152	0.126
8/9/99	99.9	87.6	0.30	23.6	3.45	0.151	0.124
8/9/99	99.9	87.3	0.28	23.6	3.47	0.154	0.127
Average		88.2	0.35	23.6	3.21	0.145	0.120
Standard Deviation		0.82	0.07	0.14	0.34	0.009	0.009

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
2nd Hood Position at B6 W 1/2							
7/29/99	100.0	86.4	0.33	23.4	1.72	0.166	0.139
7/29/99	100.0	86.2	0.31	23.4	1.74	0.168	0.140
7/29/99	100.0	86.7	0.3	23.4	1.74	0.163	0.135
7/29/99	99.9	86.4	0.33	23.4	1.72	0.165	0.138
7/29/99	99.9	86.4	0.31	23.4	1.72	0.165	0.138
7/29/99	99.9	86.2	0.3	23.4	1.65	0.167	0.139
8/3/99	100.0	89.6	0.32	23.5	2.55	0.128	0.105
8/3/99	100.1	90.0	0.28	23.5	2.55	0.124	0.102
8/3/99	100.0	90.2	0.27	23.5	2.55	0.121	0.099
8/3/99	100.1	90.4	0.28	23.5	2.55	0.120	0.098
8/3/99	100.0	91.1	0.29	23.5	2.55	0.110	0.090
8/3/99	100.1	91.1	0.28	23.5	2.52	0.111	0.091
8/5/99	100.0	87.7	0.32	23.8	1.63	0.151	0.124
8/5/99	100.1	86.8	0.32	23.7	1.63	0.162	0.134
8/5/99	100.1	86.4	0.31	23.8	1.63	0.167	0.138
8/5/99	100.1	86.0	0.35	23.8	1.63	0.172	0.142
8/5/99	100.1	85.7	0.30	23.8	1.66	0.175	0.144
8/5/99	100.1	85.4	0.33	23.8	1.63	0.179	0.148
8/6/99	100.0	85.1	0.35	23.7	1.68	0.181	0.150
8/6/99	100.0	85.3	0.31	23.7	1.51	0.179	0.148
8/6/99	100.1	85.4	0.32	23.7	1.46	0.179	0.148
8/6/99	100.0	84.7	0.30	23.7	1.32	0.186	0.153
8/6/99	100.1	84.7	0.29	23.7	1.34	0.187	0.154
8/6/99	100.0	84.2	0.30	23.7	1.48	0.192	0.158
8/9/99	100.0	84.7	0.41	23.6	1.83	0.186	0.155
8/9/99	100.0	85.1	0.38	23.6	1.83	0.181	0.151
8/9/99	100.1	85.4	0.36	23.6	1.80	0.179	0.148
8/9/99	100.1	85.5	0.42	23.6	1.80	0.178	0.148
8/9/99	100.1	85.4	0.39	23.6	1.80	0.179	0.149
8/9/99	100.1	85.2	0.41	23.6	1.80	0.181	0.151
Average		86.6	0.33	23.6	1.83	0.163	0.135
Standard Deviation		2.06	0.04	0.14	0.38	0.024	0.021

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------1st Hood Position at B6 W 3/4----------							
7/29/99	100.0	87.7	0.64	23.6	2.83	0.151	0.130
7/29/99	99.9	87.6	0.65	23.6	2.70	0.151	0.130
7/29/99	99.9	87.3	0.63	23.6	2.64	0.154	0.133
7/29/99	100.0	87.2	0.61	23.6	2.54	0.157	0.134
7/29/99	100.0	87.4	0.64	23.6	2.54	0.154	0.133
7/29/99	100.0	87.3	0.65	23.6	2.54	0.155	0.134
8/3/99	100.0	87.0	0.63	23.6	2.24	0.159	0.135
8/3/99	100.0	86.8	0.68	23.6	2.24	0.161	0.137
8/3/99	99.9	86.8	0.67	23.6	2.24	0.160	0.136
8/3/99	100.0	86.6	0.55	23.6	2.24	0.164	0.137
8/3/99	100.1	86.5	0.65	23.6	2.27	0.166	0.141
8/3/99	100.0	86.3	0.66	23.6	2.24	0.167	0.142
8/5/99	100.1	87.4	0.92	23.9	2.98	0.155	0.136
8/5/99	99.9	86.9	1.12	23.9	2.98	0.159	0.143
8/5/99	100.0	86.8	1.08	23.9	2.98	0.161	0.144
8/5/99	100.0	87.0	1.11	23.9	2.95	0.159	0.142
8/5/99	100.0	86.7	1.12	23.9	2.95	0.163	0.146
8/5/99	100.0	86.7	1.07	23.9	2.98	0.163	0.145
8/6/99	100.0	86.9	0.96	23.9	3.70	0.160	0.141
8/6/99	100.0	87.3	0.97	23.9	3.63	0.155	0.137
8/6/99	100.0	86.9	0.9	23.9	3.93	0.160	0.140
8/6/99	100.0	87.0	0.87	23.9	3.20	0.159	0.139
8/6/99	100.0	87.2	0.88	23.9	3.20	0.157	0.137
8/6/99	100.0	86.9	0.89	23.9	3.53	0.160	0.140
8/9/99	100.0	86.8	0.89	23.7	3.20	0.161	0.141
8/9/99	99.9	87.2	0.91	23.7	3.16	0.156	0.137
8/9/99	99.9	87.2	0.79	23.7	3.16	0.156	0.135
8/9/99	99.9	87.5	0.86	23.7	3.14	0.152	0.133
8/9/99	99.9	87.8	0.89	23.7	3.18	0.148	0.130
8/9/99	100.0	87.5	0.87	23.7	3.12	0.153	0.134
Average		87.1	0.83	23.7	2.91	0.158	0.137
Standard Deviation		0.36	0.18	0.14	0.47	0.005	0.005

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 BEFORE CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Oxygen in Gas (mV) Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------2nd Hood Position at B6 W 3/4----------------------							
7/29/99	100.1	84.2	0.41	23.6	1.18	0.193	0.162
7/29/99	100.1	83.5	0.37	23.6	1.14	0.201	0.168
7/29/99	100.1	83.8	0.38	23.6	1.14	0.197	0.166
7/29/99	100.2	82.2	0.41	23.6	1.14	0.217	0.182
7/29/99	100.1	83.0	0.37	23.6	1.16	0.207	0.173
7/29/99	100.0	83.3	0.38	23.6	1.16	0.202	0.170
8/3/99	100.1	85.7	0.50	23.6	2.02	0.175	0.146
8/3/99	100.0	86.3	0.45	23.6	2.02	0.167	0.139
8/3/99	100.1	87.5	0.54	23.6	2.02	0.154	0.129
8/3/99	100.0	89.0	0.52	23.6	2.02	0.135	0.113
8/3/99	100.0	88.4	0.41	23.6	1.82	0.142	0.118
8/3/99	100.1	88.0	0.51	23.6	1.82	0.148	0.124
8/5/99	100.0	83.3	0.83	23.9	1.66	0.202	0.176
8/5/99	100.0	83.0	0.83	23.9	1.68	0.206	0.179
8/5/99	100.1	82.5	0.81	23.9	1.66	0.213	0.184
8/5/99	100.0	83.1	0.87	23.9	1.66	0.205	0.179
8/5/99	100.1	83.1	0.80	23.9	1.66	0.206	0.178
8/5/99	100.0	83.1	0.82	23.9	1.66	0.205	0.178
8/6/99	100.0	83.9	0.76	23.9	1.23	0.195	0.169
8/6/99	100.0	84.1	0.66	23.9	1.25	0.193	0.165
8/6/99	100.0	82.9	0.59	23.9	1.25	0.207	0.175
8/6/99	100.0	82.0	0.65	23.9	1.25	0.217	0.185
8/6/99	100.0	81.8	0.74	23.9	1.27	0.220	0.189
8/6/99	100.1	82.0	0.64	23.9	1.25	0.218	0.186
8/9/99	100.1	83.1	0.75	23.7	1.26	0.206	0.177
8/9/99	100.1	83.2	0.65	23.7	1.26	0.204	0.175
8/9/99	100.1	83.5	0.71	23.7	1.26	0.201	0.173
8/9/99	100.1	83.2	0.68	23.7	1.26	0.204	0.175
8/9/99	100.0	83.2	0.69	23.7	1.26	0.203	0.174
8/9/99	100.0	83.1	0.70	23.7	1.26	0.205	0.176
Average		84.0	0.61	23.7	1.46	0.195	0.166
Standard Deviation		1.95	0.16	0.14	0.31	0.023	0.021

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
------------------------1st Hood Position at B6 E 1/4----------------------							
8/17/99	100.0	91.1	1.88	23.8	8.62	0.110	0.108
8/17/99	100.0	91.1	1.90	23.8	7.93	0.110	0.108
8/17/99	99.9	91.0	1.83	23.8	8.09	0.110	0.107
8/17/99	99.9	90.9	1.77	23.8	7.75	0.111	0.108
8/17/99	100.0	91.2	1.74	23.8	7.66	0.109	0.105
8/17/99	99.9	90.9	1.66	23.8	7.85	0.111	0.106
8/18/99	99.9	90.6	1.08	23.8	8.06	0.115	0.103
8/18/99	100.0	90.8	0.98	23.8	7.97	0.114	0.100
8/18/99	100.0	91.1	1.02	23.8	8.13	0.110	0.098
8/18/99	100.1	91.3	1.04	23.8	8.13	0.109	0.097
8/18/99	100.0	91.1	1.06	23.8	8.13	0.110	0.098
8/18/99	99.9	90.8	1.05	23.8	8.13	0.113	0.100
8/23/99	100.1	91.0	1.33	23.5	8.27	0.112	0.104
8/23/99	100.0	91.0	1.30	23.5	8.27	0.111	0.102
8/23/99	100.1	91.2	1.29	23.5	8.36	0.110	0.101
8/23/99	100.1	90.8	1.25	23.5	8.36	0.115	0.105
8/23/99	100.0	91.0	1.30	23.5	8.36	0.111	0.102
8/23/99	100.1	90.9	1.36	23.5	8.36	0.114	0.105
8/25/99	100.0	90.6	1.38	23.1	8.28	0.116	0.108
8/25/99	100.0	90.6	1.37	23.1	8.12	0.116	0.108
8/25/99	100.0	90.5	1.42	23.1	8.12	0.117	0.110
8/25/99	100.1	90.7	1.45	23.1	8.36	0.116	0.109
8/25/99	100.0	90.4	1.42	23.1	8.27	0.118	0.111
8/25/99	100.0	90.4	1.35	23.1	8.18	0.118	0.110
8/26/99	100.0	90.5	1.43	23.1	8.35	0.117	0.110
8/26/99	99.9	90.2	1.41	23.1	8.17	0.120	0.112
8/26/99	99.9	90.5	1.41	23.1	8.35	0.116	0.109
8/26/99	100.0	90.5	1.39	23.1	8.00	0.117	0.109
8/26/99	100.0	90.6	1.36	23.1	8.00	0.116	0.108
8/26/99	100.0	90.6	1.36	23.1	8.17	0.116	0.108
Average		90.8	1.39	23.5	8.16	0.114	0.106
Standard Deviation		0.29	0.25	0.32	0.20	0.003	0.004

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
---------------------2nd Hood Position at B6 E 1/4----------------------							
8/17/99	100.0	88.1	1.81	23.8	4.58	0.146	0.142
8/17/99	100.0	88.2	1.71	23.8	4.61	0.145	0.139
8/17/99	100.1	88.0	1.65	23.8	4.61	0.148	0.141
8/17/99	100.0	88.3	1.61	23.8	4.61	0.144	0.136
8/17/99	100.0	88.2	1.66	23.8	4.61	0.145	0.138
8/17/99	99.9	88.3	1.62	23.8	4.61	0.143	0.135
8/18/99	100.0	88.4	1.09	23.8	3.86	0.142	0.127
8/18/99	100.0	88.2	1.05	23.8	3.86	0.145	0.129
8/18/99	100.0	88.2	1.10	23.8	5.44	0.145	0.130
8/18/99	100.1	88.4	1.14	23.8	5.36	0.143	0.129
8/18/99	100.1	88.3	1.11	23.8	5.66	0.145	0.130
8/18/99	100.1	88.4	1.07	23.8	5.66	0.143	0.128
8/23/99	99.9	87.5	1.37	23.5	4.48	0.152	0.141
8/23/99	99.9	87.8	1.40	23.5	4.48	0.148	0.138
8/23/99	100.0	87.9	1.39	23.5	4.38	0.148	0.138
8/23/99	100.1	87.8	1.40	23.5	4.49	0.151	0.140
8/23/99	99.9	87.7	1.35	23.5	4.69	0.150	0.138
8/23/99	99.9	87.7	1.41	23.5	4.69	0.150	0.139
8/25/99	100.0	86.8	1.47	23.1	4.39	0.161	0.152
8/25/99	100.1	87.0	1.52	23.1	4.41	0.160	0.152
8/25/99	100.0	87.0	1.45	23.1	4.50	0.159	0.150
8/25/99	100.0	87.0	1.50	23.1	4.53	0.159	0.150
8/25/99	100.1	87.1	1.48	23.1	4.58	0.159	0.150
8/25/99	100.1	87.0	1.49	23.1	4.60	0.160	0.151
8/26/99	100.0	87.2	1.50	23.1	5.11	0.157	0.148
8/26/99	100.0	87.5	1.46	23.1	5.31	0.153	0.144
8/26/99	100.1	87.3	1.51	23.1	5.53	0.156	0.148
8/26/99	100.1	87.3	1.45	23.1	5.57	0.156	0.147
8/26/99	100.1	87.4	1.48	23.1	5.38	0.155	0.146
8/26/99	100.1	87.1	1.51	23.1	5.31	0.159	0.150
Average		87.7	1.43	23.5	4.80	0.151	0.141
Standard Deviation		0.53	0.20	0.32	0.50	0.006	0.008

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------1st Hood Position at B6 E 1/2----------------------							
8/17/99	100.1	95.7	6.08	23.9	10.71	0.0550	0.108
8/17/99	100.1	95.8	6.12	23.9	10.71	0.0537	0.107
8/17/99	100.1	95.9	5.99	23.9	8.31	0.0525	0.101
8/17/99	100.1	95.9	6.03	23.9	10.62	0.0525	0.102
8/17/99	100.1	95.7	6.10	23.9	10.62	0.0550	0.109
8/17/99	100.1	95.6	6.08	23.9	10.79	0.0562	0.110
8/18/99	99.9	93.7	3.98	23.9	9.02	0.0772	0.101
8/18/99	99.9	93.9	3.97	23.9	10.15	0.0748	0.098
8/18/99	100.0	93.9	3.89	23.9	10.68	0.0759	0.098
8/18/99	100.0	93.9	4.02	23.9	11.39	0.0759	0.100
8/18/99	99.9	93.9	4.04	23.9	11.56	0.0748	0.099
8/18/99	100.0	93.9	4.07	23.9	11.66	0.0759	0.101
8/23/99	99.9	94.3	4.72	23.6	10.18	0.0699	0.104
8/23/99	99.9	94.5	4.75	23.6	10.18	0.0674	0.101
8/23/99	100.0	94.5	4.66	23.6	10.17	0.0686	0.101
8/23/99	100.0	94.5	4.85	23.6	11.22	0.0686	0.104
8/23/99	99.9	94.5	4.82	23.6	11.58	0.0674	0.102
8/23/99	99.9	94.5	4.84	23.6	11.57	0.0674	0.102
8/25/99	100.0	95.2	5.84	23.1	10.27	0.0600	0.111
8/25/99	100.0	95.3	5.80	23.1	10.36	0.0587	0.108
8/25/99	100.0	95.3	5.86	23.1	10.55	0.0587	0.110
8/25/99	100.0	95.3	5.93	23.1	10.72	0.0587	0.111
8/25/99	100.0	95.4	5.95	23.1	10.72	0.0575	0.110
8/25/99	100.0	95.5	6.01	23.1	10.72	0.0563	0.109
8/26/99	100.0	96.0	6.43	23.2	10.62	0.0501	0.107
8/26/99	99.9	96.0	6.48	23.2	10.45	0.0489	0.106
8/26/99	99.9	96.0	6.46	23.2	10.46	0.0489	0.105
8/26/99	99.9	96.0	6.49	23.2	10.46	0.0489	0.106
8/26/99	99.9	96.0	6.46	23.2	10.73	0.0489	0.105
8/26/99	99.9	96.0	6.51	23.2	10.64	0.0489	0.107
Average		95.1	5.44	23.5	10.59	0.0611	0.105
Standard Deviation		0.82	0.93	0.34	0.69	0.010	0.004

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------2nd Hood Position at B6 E 1/2----------------------							
8/17/99	100.1	94.2	5.66	23.9	5.47	0.0734	0.131
8/17/99	100.1	94.4	5.70	23.9	5.47	0.0710	0.128
8/17/99	100.1	94.3	5.71	23.9	5.47	0.0722	0.130
8/17/99	100.1	94.3	5.72	23.9	5.47	0.0722	0.131
8/17/99	99.9	94.0	5.69	23.9	7.20	0.0736	0.132
8/17/99	100.0	93.9	5.82	23.9	7.19	0.0759	0.141
8/18/99	99.9	91.8	4.02	23.9	6.43	0.1004	0.132
8/18/99	99.9	91.5	4.08	23.9	6.17	0.1040	0.138
8/18/99	99.9	91.6	4.10	23.9	5.89	0.1028	0.137
8/18/99	100.1	92.1	4.09	23.9	6.09	0.0990	0.132
8/18/99	100.0	92.1	4.12	23.9	6.17	0.0979	0.131
8/18/99	100.0	92.0	4.14	23.9	6.17	0.0991	0.133
8/23/99	100.1	92.7	4.95	23.6	5.31	0.0917	0.142
8/23/99	100.0	92.9	4.97	23.6	5.51	0.0882	0.137
8/23/99	100.0	92.8	5.02	23.6	5.51	0.0894	0.140
8/23/99	100.0	93.0	4.89	23.6	7.09	0.0869	0.133
8/23/99	99.9	93.0	4.90	23.6	7.79	0.0858	0.132
8/23/99	99.9	92.8	4.91	23.6	7.79	0.0882	0.136
8/25/99	100.0	94.2	6.06	23.1	6.80	0.0723	0.141
8/25/99	100.0	94.2	6.09	23.1	6.89	0.0723	0.142
8/25/99	100.0	94.3	6.11	23.1	6.80	0.0710	0.141
8/25/99	100.1	94.4	6.09	23.1	6.80	0.0710	0.140
8/25/99	100.1	94.5	6.10	23.1	6.81	0.0697	0.138
8/25/99	100.1	94.4	6.08	23.1	6.81	0.0710	0.139
8/26/99	100.0	94.8	6.44	23.2	5.88	0.0649	0.139
8/26/99	100.1	94.9	6.46	23.2	5.79	0.0648	0.140
8/26/99	100.1	95.0	6.51	23.2	6.07	0.0636	0.139
8/26/99	100.1	95.2	6.48	23.2	6.41	0.0611	0.132
8/26/99	100.0	94.9	6.50	23.2	6.57	0.0637	0.138
8/26/99	100.0	95.1	6.52	23.2	6.58	0.0612	0.134
Average		93.6	5.46	23.5	6.35	0.0793	0.136
Standard Deviation		1.16	0.87	0.34	0.70	0.014	0.004

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Oxygen in Gas (mV) Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------1st Hood Position at B6 E 3/4----------------------							
8/17/99	100.0	95.0	6.38	24.1	3.39	0.0624	0.133
8/17/99	99.9	95.1	6.36	24.1	3.44	0.0600	0.127
8/17/99	99.9	95.0	6.42	24.1	3.69	0.0613	0.132
8/17/99	99.9	95.0	6.37	24.1	3.82	0.0613	0.130
8/17/99	99.9	95.0	6.36	24.1	3.99	0.0613	0.130
8/17/99	99.9	94.9	6.45	24.1	3.84	0.0625	0.135
8/18/99	100.0	94.8	5.96	24.0	4.37	0.0649	0.124
8/18/99	100.1	94.7	6.01	24.0	4.34	0.0673	0.130
8/18/99	100.1	94.7	5.93	24.0	4.37	0.0673	0.128
8/18/99	100.1	94.8	5.94	24.0	4.37	0.0661	0.126
8/18/99	100.1	94.8	6.05	24.0	4.34	0.0661	0.129
8/18/99	100.1	94.8	5.98	24.0	4.34	0.0661	0.127
8/23/99	99.9	94.8	6.16	23.7	4.33	0.0637	0.128
8/23/99	100.0	94.9	6.20	23.7	4.48	0.0637	0.129
8/23/99	99.9	94.8	6.16	23.7	4.51	0.0637	0.128
8/23/99	100.0	95.0	6.25	23.7	4.63	0.0624	0.128
8/23/99	100.0	95.0	6.20	23.7	4.86	0.0624	0.127
8/23/99	99.9	94.9	6.29	23.7	4.96	0.0625	0.130
8/26/99	100.0	95.0	6.49	23.3	5.22	0.0624	0.136
8/26/99	99.9	95.0	6.53	23.3	5.17	0.0613	0.135
8/26/99	100.0	95.0	6.54	23.3	5.06	0.0624	0.138
8/26/99	99.9	94.9	6.48	23.3	5.06	0.0625	0.136
8/26/99	99.9	94.9	6.45	23.3	5.13	0.0625	0.135
8/26/99	99.9	94.9	6.53	23.3	5.20	0.0625	0.137
Average		94.9	6.27	23.8	4.45	0.0633	0.131
Standard Deviation		0.11	0.21	0.32	0.56	0.002	0.004

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
------2nd Hood Position at B6 E 3/4------							
8/17/99	99.9	93.8	6.44	24.1	1.57	0.0760	0.164
8/17/99	100.0	93.9	6.46	24.1	1.51	0.0759	0.165
8/17/99	99.9	93.9	6.48	24.1	1.51	0.0748	0.163
8/17/99	99.9	93.8	6.45	24.1	1.51	0.0760	0.165
8/17/99	99.9	93.8	6.37	24.1	1.60	0.0760	0.161
8/17/99	100.0	94.1	6.49	24.1	1.79	0.0735	0.161
8/18/99	100.1	93.6	5.99	24.0	2.35	0.0808	0.155
8/18/99	100.1	93.3	5.92	24.0	2.14	0.0844	0.160
8/18/99	100.1	93.4	5.94	24.0	2.00	0.0832	0.158
8/18/99	100.1	93.3	5.96	24.0	1.90	0.0844	0.161
8/18/99	100.1	93.4	5.93	24.0	1.81	0.0832	0.158
8/18/99	100.1	93.4	5.98	24.0	1.76	0.0832	0.160
8/23/99	100.0	93.8	6.24	23.7	2.80	0.0772	0.158
8/23/99	100.0	93.7	6.26	23.7	2.78	0.0784	0.161
8/23/99	100.0	93.6	6.20	23.7	2.80	0.0796	0.162
8/23/99	100.0	93.7	6.32	23.7	2.79	0.0784	0.164
8/23/99	100.0	93.7	6.28	23.7	2.79	0.0784	0.162
8/23/99	100.0	93.7	6.22	23.7	2.79	0.0784	0.160
8/26/99	100.0	93.4	6.47	23.3	2.97	0.0821	0.178
8/26/99	100.0	93.5	6.45	23.3	3.02	0.0808	0.174
8/26/99	99.9	93.4	6.46	23.3	3.00	0.0809	0.175
8/26/99	100.0	93.4	6.46	23.3	2.97	0.0821	0.177
8/26/99	99.9	93.4	6.54	23.3	2.80	0.0809	0.178
8/26/99	99.9	93.3	6.52	23.3	2.80	0.0821	0.180
Average		93.6	6.28	23.8	2.32	0.0796	0.165
Standard Deviation		0.23	0.22	0.32	0.58	0.003	0.007

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------1st Hood Position at B6 W 1/4----------------------							
8/17/99	100.1	90.3	0.80	23.6	4.23	0.121	0.105
8/17/99	100.1	90.3	0.75	23.6	4.20	0.121	0.104
8/17/99	100.1	90.2	0.72	23.6	4.19	0.122	0.105
8/17/99	100.1	90.0	0.73	23.6	4.24	0.124	0.107
8/17/99	100.0	90.2	0.70	23.6	4.27	0.121	0.104
8/17/99	100.1	90.1	0.71	23.6	4.38	0.123	0.106
8/18/99	100.1	90.5	0.47	23.7	4.44	0.118	0.099
8/18/99	100.0	90.5	0.44	23.7	4.39	0.117	0.098
8/18/99	100.1	90.5	0.48	23.7	4.37	0.118	0.099
8/18/99	100.1	90.7	0.44	23.7	4.37	0.116	0.097
8/18/99	100.0	90.6	0.46	23.7	4.40	0.116	0.097
8/18/99	100.1	90.4	0.43	23.7	4.40	0.120	0.100
8/23/99	100.0	89.6	0.44	23.3	3.33	0.128	0.108
8/23/99	99.9	89.4	0.40	23.3	3.35	0.129	0.108
8/23/99	99.9	89.1	0.34	23.3	3.33	0.133	0.111
8/23/99	99.9	89.2	0.40	23.3	3.28	0.132	0.110
8/23/99	99.9	89.1	0.36	23.3	3.28	0.133	0.111
8/23/99	99.9	89.1	0.33	23.3	3.28	0.133	0.111
8/25/99	100.1	88.0	0.42	22.9	4.20	0.148	0.125
8/25/99	100.1	88.6	0.38	22.9	3.99	0.141	0.119
8/25/99	100.1	87.8	0.40	22.9	3.99	0.151	0.127
8/25/99	100.1	87.6	0.39	22.9	3.99	0.153	0.129
8/25/99	100.1	87.7	0.38	22.9	3.94	0.152	0.128
8/25/99	100.1	87.5	0.38	22.9	3.99	0.154	0.130
8/26/99	100.1	89.1	0.32	23.0	4.41	0.135	0.113
8/26/99	100.1	89.1	0.34	23.0	4.41	0.135	0.113
8/26/99	100.0	89.0	0.33	23.0	4.41	0.135	0.113
8/26/99	100.0	88.8	0.31	23.0	4.41	0.138	0.115
8/26/99	100.0	89.0	0.32	23.0	4.41	0.135	0.113
8/26/99	100.1	88.8	0.35	23.0	4.41	0.139	0.116
Average		89.4	0.46	23.3	4.08	0.131	0.111
Standard Deviation		0.98	0.15	0.32	0.42	0.012	0.010

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Oxygen in Gas (mV) Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------2nd Hood Position at B6 W 1/4----------------------							
8/17/99	100.1	87.1	0.82	23.6	3.42	0.159	0.138
8/17/99	100.0	87.5	0.72	23.6	3.42	0.153	0.132
8/17/99	100.0	87.4	0.75	23.6	3.46	0.154	0.133
8/17/99	100.0	87.6	0.69	23.6	3.46	0.152	0.130
8/17/99	100.0	87.5	0.67	23.6	3.46	0.153	0.131
8/17/99	100.1	87.6	0.70	23.6	3.46	0.153	0.131
8/18/99	100.1	88.3	0.43	23.7	3.34	0.145	0.121
8/18/99	100.0	88.1	0.40	23.7	3.34	0.146	0.122
8/18/99	100.0	88.2	0.44	23.7	3.34	0.145	0.121
8/18/99	100.0	88.0	0.44	23.7	3.34	0.147	0.123
8/18/99	100.1	87.7	0.43	23.7	3.30	0.152	0.127
8/18/99	100.0	87.8	0.46	23.7	3.30	0.149	0.125
8/23/99	100.0	86.8	0.38	23.3	2.00	0.161	0.135
8/23/99	100.0	86.6	0.36	23.3	2.00	0.164	0.137
8/23/99	100.0	86.1	0.34	23.3	2.02	0.170	0.141
8/23/99	100.0	86.3	0.30	23.3	2.02	0.167	0.139
8/23/99	100.0	86.1	0.32	23.3	2.02	0.170	0.141
8/23/99	100.0	86.4	0.33	23.3	2.00	0.166	0.138
8/25/99	99.9	85.6	0.50	22.9	2.26	0.174	0.148
8/25/99	99.9	84.2	0.43	22.9	2.26	0.191	0.161
8/25/99	100.1	85.4	0.47	22.9	2.25	0.179	0.152
8/25/99	100.0	86.6	0.41	22.9	2.25	0.164	0.138
8/25/99	99.9	85.9	0.40	22.9	2.25	0.171	0.144
8/25/99	99.9	85.8	0.39	22.9	2.25	0.172	0.145
8/25/99	99.9	85.6	0.38	22.9	2.25	0.174	0.147
8/25/99	99.9	86.0	0.40	22.9	2.25	0.170	0.143
8/26/99	100.0	86.2	0.27	23.0	2.37	0.168	0.140
8/26/99	99.9	85.6	0.31	23.0	2.48	0.174	0.145
8/26/99	100.0	87.2	0.32	23.0	2.48	0.157	0.131
8/26/99	99.9	87.1	0.31	23.0	2.48	0.157	0.131
8/26/99	100.0	87.0	0.31	23.0	2.49	0.159	0.132
8/26/99	99.9	86.5	0.29	23.0	2.47	0.164	0.136
Average		86.7	0.44	23.3	2.67	0.162	0.136
Standard Deviation		0.97	0.15	0.33	0.58	0.011	0.009

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------------------1st Hood Position at B6 W 1/2----------------------							
8/17/99	100.0	88.1	1.10	23.7	4.86	0.146	0.131
8/17/99	99.9	88.1	1.14	23.7	4.86	0.145	0.131
8/17/99	100.0	88.1	1.09	23.7	4.86	0.146	0.131
8/17/99	100.1	88.3	1.08	23.7	4.86	0.145	0.129
8/17/99	100.0	88.0	1.07	23.7	4.86	0.147	0.132
8/17/99	100.1	88.4	1.06	23.7	4.86	0.143	0.128
8/18/99	100.1	89.1	0.79	23.7	5.27	0.135	0.117
8/18/99	99.9	89.1	0.83	23.7	5.40	0.133	0.116
8/18/99	100.1	88.9	0.82	23.7	5.40	0.137	0.120
8/18/99	100.0	88.8	0.77	23.7	5.40	0.138	0.119
8/18/99	99.9	88.8	0.72	23.7	5.40	0.137	0.118
8/18/99	100.0	88.8	0.82	23.7	5.40	0.138	0.120
8/23/99	99.9	88.1	0.99	23.3	5.34	0.145	0.129
8/23/99	99.9	88.0	1.00	23.3	5.36	0.146	0.130
8/23/99	100.1	88.4	0.96	23.3	5.34	0.143	0.127
8/23/99	100.0	88.4	1.02	23.3	5.35	0.142	0.127
8/23/99	100.0	88.3	1.00	23.3	5.35	0.144	0.128
8/23/99	100.0	88.3	1.02	23.3	5.33	0.144	0.128
8/25/99	100.0	87.8	1.23	22.9	6.48	0.149	0.137
8/25/99	100.0	87.8	1.20	22.9	6.65	0.149	0.137
8/25/99	100.1	88.4	1.20	22.9	6.65	0.143	0.131
8/25/99	100.1	88.4	1.00	22.9	6.57	0.143	0.129
8/25/99	100.1	88.3	1.00	22.9	6.57	0.145	0.130
8/26/99	100.1	88.0	0.94	23.1	5.81	0.148	0.132
8/26/99	100.0	87.7	0.90	23.1	6.00	0.151	0.133
8/26/99	100.1	87.9	0.95	23.1	5.89	0.149	0.133
8/26/99	100.0	87.9	0.92	23.1	5.89	0.148	0.131
8/26/99	100.1	87.9	0.90	23.1	6.09	0.149	0.132
8/26/99	100.0	88.0	0.95	23.1	6.09	0.147	0.131
Average		88.3	0.98	23.4	5.59	0.144	0.128
Standard Deviation		0.39	0.13	0.32	0.59	0.005	0.006

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
----------2nd Hood Position at B6 W 1/2----------							
8/17/99	100.0	85.4	1.20	23.7	2.45	0.178	0.161
8/17/99	100.0	84.9	1.10	23.7	2.42	0.184	0.165
8/17/99	100.0	84.6	1.07	23.7	2.45	0.187	0.167
8/17/99	100.0	84.3	1.09	23.7	2.42	0.191	0.171
8/17/99	100.0	84.5	1.07	23.7	2.42	0.188	0.168
8/17/99	100.0	84.4	1.06	23.7	2.42	0.190	0.169
8/18/99	100.1	86.0	0.80	23.7	2.88	0.172	0.149
8/18/99	100.1	85.8	0.76	23.7	2.87	0.174	0.150
8/18/99	100.0	85.5	0.79	23.7	2.89	0.177	0.153
8/18/99	100.1	85.6	0.82	23.7	2.89	0.176	0.153
8/18/99	100.1	85.2	0.82	23.7	2.92	0.181	0.158
8/18/99	100.1	85.1	0.81	23.7	2.92	0.182	0.158
8/23/99	99.9	84.2	1.19	23.3	3.29	0.191	0.174
8/23/99	100.1	84.8	1.07	23.3	3.29	0.186	0.167
8/23/99	100.0	85.0	1.09	23.3	3.28	0.182	0.164
8/23/99	100.0	84.8	1.03	23.3	3.30	0.185	0.165
8/23/99	100.0	84.8	1.06	23.3	3.28	0.185	0.166
8/23/99	100.0	84.9	1.07	23.3	3.28	0.184	0.165
8/26/99	100.0	84.2	1.02	23.1	3.08	0.192	0.172
8/26/99	100.1	84.5	1.05	23.1	3.03	0.189	0.170
8/26/99	100.1	84.1	1.03	23.1	3.06	0.194	0.174
8/26/99	100.0	85.0	1.01	23.0	2.93	0.182	0.163
8/26/99	100.1	84.6	1.05	23.0	2.88	0.188	0.169
8/26/99	100.1	84.4	1.03	23.0	2.93	0.190	0.171
Average		84.9	1.00	23.4	2.90	0.185	0.164
Standard Deviation		0.52	0.13	0.28	0.32	0.006	0.007

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Oxygen in Gas (mV) Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
-----1st Hood Position at B6 W 3/4-----							
8/17/99	100.0	88.6	1.58	23.9	5.31	0.140	0.132
8/17/99	100.0	88.7	1.47	23.9	5.47	0.139	0.130
8/17/99	100.0	88.8	1.54	23.9	5.47	0.138	0.130
8/17/99	100.1	88.8	1.51	23.9	5.60	0.139	0.130
8/17/99	100.1	88.9	1.49	23.9	5.66	0.137	0.129
8/17/99	100.1	88.9	1.49	23.9	5.83	0.137	0.129
8/18/99	100.1	89.2	1.32	23.8	5.33	0.134	0.123
8/18/99	100.0	89.4	1.26	23.8	5.33	0.130	0.119
8/18/99	100.0	89.5	1.28	23.8	5.33	0.129	0.118
8/18/99	100.0	89.1	1.27	23.8	5.33	0.134	0.122
8/18/99	100.0	89.3	1.29	23.8	5.47	0.132	0.120
8/18/99	100.0	89.4	1.26	23.8	5.42	0.130	0.119
8/23/99	100.0	88.7	1.30	23.4	6.47	0.139	0.128
8/23/99	100.1	88.6	1.33	23.4	6.38	0.141	0.130
8/23/99	100.0	88.8	1.29	23.4	6.39	0.138	0.127
8/23/99	100.1	88.9	1.36	23.4	6.39	0.137	0.127
8/23/99	100.1	89.0	1.35	23.4	6.39	0.136	0.126
8/23/99	100.1	88.6	1.38	23.4	6.39	0.141	0.131
8/26/99	100.0	87.6	1.34	23.1	5.16	0.152	0.141
8/26/99	100.0	88.1	1.36	23.1	5.13	0.146	0.136
8/26/99	99.9	87.7	1.36	23.1	5.57	0.150	0.139
8/26/99	100.0	87.9	1.34	23.1	5.41	0.148	0.138
8/26/99	99.9	87.6	1.39	23.1	5.41	0.151	0.141
8/26/99	99.9	87.9	1.43	23.1	5.43	0.147	0.138
Average		88.7	1.37	23.6	5.67	0.139	0.129
Standard Deviation		0.58	0.09	0.33	0.45	0.007	0.007

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 AFTER CLEANING DIFFUSER PLATES IN WEST BAY

Date	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
---2nd Hood Position at B6 W 3/4---							
8/17/99	100.1	85.4	1.61	23.9	2.58	0.179	0.170
8/17/99	100.1	84.9	1.55	23.9	2.58	0.185	0.174
8/17/99	100.0	85.2	1.57	23.9	2.58	0.180	0.170
8/17/99	100.0	85.4	1.46	23.9	2.58	0.178	0.166
8/17/99	100.0	85.2	1.49	23.9	2.58	0.180	0.169
8/17/99	100.0	85.4	1.50	23.9	2.58	0.178	0.167
8/18/99	99.9	86.8	1.30	23.7	2.60	0.160	0.147
8/18/99	100.0	86.2	1.28	23.8	2.60	0.168	0.154
8/18/99	100.0	86.2	1.34	23.8	2.60	0.168	0.155
8/18/99	100.0	85.9	1.27	23.8	2.60	0.172	0.157
8/18/99	99.9	85.7	1.33	23.8	2.60	0.173	0.159
8/18/99	99.9	85.8	1.29	23.8	2.60	0.172	0.157
8/23/99	100.0	85.1	1.45	23.4	3.32	0.181	0.170
8/23/99	100.0	85.3	1.42	23.4	3.30	0.179	0.167
8/23/99	100.1	85.6	1.47	23.4	3.23	0.176	0.166
8/23/99	100.1	85.1	1.41	23.4	3.20	0.182	0.170
8/23/99	100.1	85.3	1.37	23.4	3.20	0.180	0.167
8/23/99	100.1	85.2	1.43	23.4	3.20	0.181	0.169
8/26/99	100.0	84.0	1.46	23.2	2.15	0.194	0.183
8/26/99	99.9	83.7	1.41	23.2	2.17	0.197	0.184
8/26/99	100.0	84.0	1.39	23.2	2.15	0.194	0.181
8/26/99	100.0	84.1	1.45	23.2	2.17	0.193	0.181
8/26/99	99.9	84.2	1.42	23.2	2.15	0.191	0.179
8/26/99	99.9	84.1	1.47	23.2	2.15	0.192	0.181
Average		85.2	1.42	23.6	2.65	0.181	0.168
Standard Deviation		0.80	0.09	0.29	0.40	0.009	0.010

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3

DATA FROM THE OFF-GAS TESTS CONDUCTED IN THE SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Date	Station (Position)	DO (mg/L)	Temperature (°C)	OTE_f	SOTE	Off-Gas Flow (scfm)
9/1/99	A1 E 1/4 (1st)	0.72	23.6	0.124	0.107	7.39
9/1/99	A1 E 1/4 (2nd)	0.67	23.6	0.158	0.134	4.41
9/1/99	A1 E 1/2 (1st)	1.57	23.7	0.100	0.0946	10.89
9/1/99	A1 E 1/2 (2nd)	1.77	23.7	0.130	0.125	7.90
9/1/99	A1 E 3/4 (1st)	4.42	23.8	0.0664	0.0926	10.98
9/1/99	A1 E 3/4 (2nd)	4.71	23.8	0.0896	0.132	5.94
10/6/99	A1 E 1/4 (1st)	0.83	20.30	0.127	0.112	5.73
10/6/99	A1 E 1/4 (2nd)	0.87	20.30	0.160	0.141	3.59
10/6/99	A1 E 1/2 (1st)	4.16	20.40	0.0733	0.0955	12.00
10/6/99	A1 E 1/2 (2nd)	4.41	20.37	0.0889	0.120	6.89
10/6/99	A1 E 3/4 (1st)	8.04	20.40	0.0352	0.105	11.63
10/6/99	A1 E 3/4 (2nd)	8.02	20.38	0.0447	0.133	6.39
9/1/99	A1 W 1/4 (1st)	0.28	23.5	0.103	0.0842	6.54
9/1/99	A1 W 1/4 (2nd)	0.35	23.5	0.140	0.116	3.33
9/1/99	A1 W 1/2 (1st)	0.99	23.7	0.101	0.0895	8.75
9/1/99	A1 W 1/2 (2nd)	1.05	23.7	0.130	0.116	4.90
9/1/99	A1 W 3/4 (1st)	2.05	23.8	0.0868	0.0863	6.12
9/1/99	A1 W 3/4 (2nd)	2.15	23.8	0.112	0.113	5.23
10/6/99	A1 W 1/4 (1st)	1.37	20.20	0.0907	0.0838	10.31
10/6/99	A1 W 1/4 (2nd)	1.40	20.20	0.128	0.119	5.97
10/6/99	A1 W 1/2 (1st)	1.89	20.28	0.0932	0.0911	9.37
10/6/99	A1 W 1/2 (2nd)	2.02	20.25	0.127	0.125	6.49
10/6/99	A1 W 3/4 (1st)	5.63	20.30	0.0513	0.0848	12.56
10/6/99	A1 W 3/4 (2nd)	5.44	20.30	0.0710	0.114	7.75
9/2/99	A3 E 1/4 (1st)	0.52	23.80	0.109	0.0917	7.93
9/2/99	A3 E 1/4 (2nd)	0.50	23.75	0.137	0.115	4.89
9/2/99	A3 E 1/2 (1st)	1.00	23.90	0.125	0.110	10.08
9/2/99	A3 E 1/2 (2nd)	1.03	23.90	0.170	0.150	5.48
9/2/99	A3 E 3/4 (1st)	0.88	24.00	0.117	0.102	9.10
9/2/99	A3 E 3/4 (2nd)	0.88	24.00	0.142	0.124	4.61
9/30/99	A3 E 1/4 (1st)	0.57	20.80	0.135	0.115	5.52
9/30/99	A3 E 1/4 (2nd)	0.65	20.80	0.173	0.149	2.28
9/30/99	A3 E 1/2 (1st)	2.00	20.80	0.129	0.127	8.01
9/30/99	A3 E 1/2 (2nd)	2.16	20.80	0.173	0.174	3.62
9/30/99	A3 E 3/4 (1st)	3.86	20.80	0.0910	0.114	9.55
9/30/99	A3 E 3/4 (2nd)	3.69	20.80	0.111	0.136	5.82

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

DATA FROM THE OFF-GAS TESTS CONDUCTED IN THE SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Date	Station (Position)	DO (mg/L)	Temperature (°C)	OTE_f	SOTE	Off-Gas Flow (scfm)
9/2/99	A3 W 1/4 (1st)	0.69	23.80	0.100	0.0857	7.62
9/2/99	A3 W 1/4 (2nd)	0.67	23.80	0.132	0.113	4.22
9/2/99	A3 W 1/2 (1st)	1.89	24.00	0.108	0.105	8.79
9/2/99	A3 W 1/2 (2nd)	1.94	24.00	0.143	0.140	4.11
9/2/99	A3 W 3/4 (1st)	6.82	24.10	0.0470	0.112	9.49
9/2/99	A3 W 3/4 (2nd)	6.76	24.20	0.063	0.147	4.85
9/30/99	A3 W 1/4 (1st)	1.30	20.80	0.113	0.104	7.49
9/30/99	A3 W 1/4 (2nd)	1.44	20.78	0.147	0.137	3.95
9/30/99	A3 W 1/2 (1st)	5.72	20.80	0.0661	0.112	9.43
9/30/99	A3 W 1/2 (2nd)	5.61	20.80	0.0857	0.142	5.90
9/30/99	A3 W 3/4 (1st)	7.28	20.80	0.0383	0.0929	9.48
9/30/99	A3 W 3/4 (2nd)	7.26	20.80	0.0478	0.115	4.70
9/8/99	A12 E 1/4 (1st)	0.26	23.80	0.115	0.0947	4.43
9/8/99	A12 E 1/4 (2nd)	0.20	23.80	0.153	0.125	1.46
9/8/99	A12 E 1/2 (1st)	0.48	24.00	0.115	0.0970	7.99
9/8/99	A12 E 1/2 (2nd)	0.53	24.00	0.153	0.129	2.61
9/8/99	A12 E 3/4 (1st)	0.64	24.10	0.124	0.106	4.23
9/8/99	A12 E 3/4 (2nd)	0.60	24.10	0.165	0.141	2.32
10/7/99	A12 E 1/4 (1st)	0.34	20.30	0.102	0.0856	4.51
10/7/99	A12 E 1/4 (2nd)	0.24	20.30	0.135	0.113	2.76
10/7/99	A12 E 1/2 (1st)	0.69	20.35	0.128	0.112	7.17
10/7/99	A12 E 1/2 (2nd)	0.63	20.38	0.172	0.149	3.04
10/7/99	A12 E 3/4 (1st)	1.17	20.47	0.117	0.107	7.01
10/7/99	A12 E 3/4 (2nd)	1.10	20.47	0.151	0.137	3.03
9/8/99	A12 W 1/4 (1st)	0.18	23.80	0.116	0.0950	4.87
9/8/99	A12 W 1/4 (2nd)	0.24	23.80	0.153	0.126	2.37
9/8/99	A12 W 1/2 (1st)	0.28	23.82	0.144	0.119	3.61
9/8/99	A12 W 1/2 (2nd)	0.28	23.83	0.165	0.137	2.18
9/8/99	A12 W 3/4 (1st)	0.70	23.93	0.118	0.102	8.43
9/8/99	A12 W 3/4 (2nd)	0.66	23.90	0.164	0.140	3.81
10/7/99	A12 W 1/4 (1st)	0.23	20.27	0.101	0.0844	5.42
10/7/99	A12 W 1/4 (2nd)	0.20	20.28	0.131	0.109	2.27
10/7/99	A12 W 1/2 (1st)	0.30	20.30	0.114	0.0956	3.48
10/7/99	A12 W 1/2 (2nd)	0.44	20.30	0.164	0.140	2.86
10/7/99	A12 W 3/4 (1st)	0.92	20.40	0.117	0.105	5.17
10/7/99	A12 W 3/4 (2nd)	0.98	20.40	0.156	0.140	2.41

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

DATA FROM THE OFF-GAS TESTS CONDUCTED IN THE SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Date	Station (Position)	DO (mg/L)	Temperature (°C)	OTE_f	SOTE	Off-Gas Flow (scfm)
8/30/99	B3 E 1/4 (1st)	0.35	23.50	0.113	0.0929	3.84
8/30/99	B3 E 1/4 (2nd)	0.28	23.50	0.155	0.127	2.04
8/30/99	B3 E 1/2 (1st)	0.82	23.60	0.0922	0.0794	2.09
8/30/99	B3 E 1/2 (2nd)	0.86	23.60	0.188	0.163	1.85
8/30/99	B3 E 3/4 (1st)	1.46	23.70	0.112	0.103	6.45
8/30/99	B3 E 3/4 (2nd)	1.61	23.70	0.165	0.155	3.01
9/20/99	B3 E 1/4 (1st)	0.14	22.60	0.163	0.132	1.37
9/20/99	B3 E 1/4 (2nd)	0.11	22.50	0.169	0.136	1.30
9/20/99	B3 E 1/2 (1st)	0.65	22.60	0.116	0.0988	7.66
9/20/99	B3 E 1/2 (2nd)	0.70	22.60	0.182	0.155	1.90
9/20/99	B3 E 3/4 (1st)	1.25	22.70	0.124	0.112	7.97
9/20/99	B3 E 3/4 (2nd)	1.39	22.70	0.178	0.163	4.24
8/30/99	B3 W 1/4 (1st)	0.38	23.50	0.107	0.0883	6.29
8/30/99	B3 W 1/4 (2nd)	0.40	23.50	0.165	0.136	2.13
8/30/99	B3 W 1/2 (1st)	0.85	23.60	0.132	0.114	6.73
8/30/99	B3 W 1/2 (2nd)	0.88	23.60	0.175	0.152	3.60
8/30/99	B3 W 3/4 (1st)	2.17	23.70	0.114	0.114	7.49
8/30/99	B3 W 3/4 (2nd)	2.15	23.70	0.151	0.151	3.37
9/20/99	B3 W 1/4 (1st)	0.47	22.52	0.139	0.116	3.81
9/20/99	B3 W 1/4 (2nd)	0.30	22.50	0.160	0.132	3.15
9/20/99	B3 W 1/2 (1st)	0.73	22.68	0.136	0.116	6.30
9/20/99	B3 W 1/2 (2nd)	0.78	22.62	0.189	0.163	3.42
9/20/99	B3 W 3/4 (1st)	3.95	22.70	0.0879	0.112	7.91
9/20/99	B3 W 3/4 (2nd)	4.19	22.70	0.115	0.151	3.68
9/22/99	B6 E 1/4 (1st)	0.78	22.10	0.112	0.0968	8.04
9/22/99	B6 E 1/4 (2nd)	0.79	22.10	0.147	0.127	5.27
9/22/99	B6 E 1/2 (1st)	1.06	22.18	0.111	0.0988	8.17
9/22/99	B6 E 1/2 (2nd)	1.12	22.20	0.149	0.134	4.59
9/22/99	B6 E 3/4 (1st)	6.06	22.20	0.0631	0.118	7.25
9/22/99	B6 E 3/4 (2nd)	6.17	22.20	0.0837	0.160	4.01
9/22/99	B6 W 1/4 (1st)	0.43	22.10	0.106	0.0889	6.47
9/22/99	B6 W 1/4 (2nd)	0.36	22.10	0.138	0.115	3.63
9/22/99	B6 W 1/2 (1st)	0.63	22.10	0.131	0.112	8.46
9/22/99	B6 W 1/2 (2nd)	0.78	22.20	0.176	0.153	4.17
9/22/99	B6 W 3/4 (1st)	0.42	22.20	0.183	0.153	3.31
9/22/99	B6 W 3/4 (2nd)	0.47	22.22	0.226	0.190	1.63

TABLE AI-3 (Continued)

DATA FROM THE OFF-GAS TESTS CONDUCTED IN THE SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Date	Station (Position)	DO (mg/L)	Temperature (°C)	OTE_f	SOTE	Off-Gas Flow (scfm)
8/11/99	B11 E 1/4 (1st)	0.56	23.90	0.113	0.0960	7.68
8/11/99	B11 E 1/4 (2nd)	0.51	23.90	0.142	0.120	4.57
8/11/99	B11 E 1/2 (1st)	0.86	23.90	0.121	0.106	8.59
8/11/99	B11 E 1/2 (2nd)	0.84	23.90	0.182	0.159	3.66
8/11/99	B11 E 3/4 (1st)	1.56	24.00	0.110	0.105	9.67
8/11/99	B11 E 3/4 (2nd)	1.56	24.00	0.148	0.141	5.26
9/23/99	B11 E 1/4 (1st)	0.50	22.10	0.110	0.0938	5.70
9/23/99	B11 E 1/4 (2nd)	0.49	22.10	0.136	0.116	4.10
9/23/99	B11 E 1/2 (1st)	0.98	22.10	0.118	0.105	7.49
9/23/99	B11 E 1/2 (2nd)	1.01	22.10	0.166	0.149	3.22
9/23/99	B11 E 3/4 (1st)	2.19	22.20	0.108	0.110	8.53
9/23/99	B11 E 3/4 (2nd)	2.08	22.20	0.151	0.152	4.63
8/11/99	B11 W 1/4 (1st)	1.47	24.15	0.110	0.103	7.77
8/11/99	B11 W 1/4 (2nd)	1.33	24.11	0.155	0.143	3.15
8/11/99	B11 W 1/2 (1st)	4.17	24.40	0.0690	0.0936	6.66
8/11/99	B11 W 1/2 (2nd)	4.49	24.48	0.107	0.154	1.93
8/11/99	B11 W 3/4 (1st)	5.03	24.40	0.0790	0.125	4.67
8/11/99	B11 W 3/4 (2nd)	4.79	24.40	0.100	0.151	1.91
9/23/99	B11 W 1/4 (1st)	2.21	22.20	0.0968	0.0988	8.61
9/23/99	B11 W 1/4 (2nd)	2.02	22.20	0.141	0.141	3.13
9/23/99	B11 W 1/2 (1st)	5.07	22.20	0.0610	0.0947	5.35
9/23/99	B11 W 1/2 (2nd)	5.62	22.23	0.0887	0.153	1.76
9/23/99	B11 W 3/4 (1st)	6.52	22.30	0.0602	0.127	6.03
9/23/99	B11 W 3/4 (2nd)	6.40	22.32	0.0780	0.160	3.23
9/9/99	C1 E 1/4 (1st)	0.22	23.65	0.124	0.102	1.68
9/9/99	C1 E 1/4 (2nd)	0.09	23.60	0.134	0.109	1.40
9/9/99	C1 E 1/2 (1st)	0.19	23.60	0.111	0.0913	4.18
9/9/99	C1 E 1/2 (2nd)	0.30	23.60	0.197	0.163	1.57
9/9/99	C1 E 3/4 (1st)	0.97	23.70	0.109	0.0972	2.21
9/9/99	C1 E 3/4 (2nd)	0.92	23.70	0.134	0.119	1.85
10/11/99	C1 E 1/4 (1st)	0.27	20.50	0.101	0.0850	1.32
10/11/99	C1 E 1/4 (2nd)	0.09	20.40	0.115	0.0948	1.01
10/11/99	C1 E 1/2 (1st)	0.24	20.50	0.107	0.0893	4.21
10/11/99	C1 E 1/2 (2nd)	0.28	20.40	0.163	0.137	1.30
10/11/99	C1 E 3/4 (1st)	1.06	20.50	0.113	0.102	7.72
10/11/99	C1 E 3/4 (2nd)	1.10	20.50	0.148	0.134	4.81

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

DATA FROM THE OFF-GAS TESTS CONDUCTED IN THE SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Date	Station (Position)	DO (mg/L)	Temperature (°C)	OTE_f	SOTE	Off-Gas Flow (scfm)
9/9/99	C1 W 1/4 (1st)	0.13	23.60	0.0804	0.0657	4.54
9/9/99	C1 W 1/4 (2nd)	0.20	23.60	0.112	0.0925	1.90
9/9/99	C1 W 1/2 (1st)	0.34	23.70	0.129	0.107	3.98
9/9/99	C1 W 1/2 (2nd)	0.44	23.70	0.186	0.157	1.98
9/9/99	C1 W 3/4 (1st)	0.89	23.70	0.122	0.108	5.26
9/9/99	C1 W 3/4 (2nd)	0.91	23.70	0.165	0.146	3.35
10/11/99	C1 W 1/4 (1st)	0.19	20.40	0.0800	0.0666	7.65
10/11/99	C1 W 1/4 (2nd)	0.26	20.40	0.110	0.0925	2.61
10/11/99	C1 W 1/2 (1st)	0.31	20.50	0.132	0.111	5.25
10/11/99	C1 W 1/2 (2nd)	0.44	20.50	0.193	0.164	1.65
10/11/99	C1 W 3/4 (1st)	1.12	20.60	0.117	0.106	8.38
10/11/99	C1 W 3/4 (2nd)	1.21	20.60	0.169	0.156	4.27
9/13/99	C3 E 1/4 (1st)	0.38	22.90	0.112	0.0933	5.26
9/13/99	C3 E 1/4 (2nd)	0.39	22.90	0.159	0.133	2.33
9/13/99	C3 E 1/2 (1st)	2.75	23.00	0.0971	0.106	10.05
9/13/99	C3 E 1/2 (2nd)	2.61	23.00	0.122	0.131	7.12
9/13/99	C3 E 3/4 (1st)	6.30	23.10	0.0521	0.106	9.04
9/13/99	C3 E 3/4 (2nd)	6.30	23.10	0.0661	0.135	4.85
10/14/99	C3 E 1/4 (1st)	0.33	20.30	0.105	0.088	6.77
10/14/99	C3 E 1/4 (2nd)	0.35	20.30	0.158	0.133	2.95
10/14/99	C3 E 1/2 (1st)	2.44	20.30	0.0938	0.0982	13.01
10/14/99	C3 E 1/2 (2nd)	2.36	20.30	0.121	0.125	8.42
10/14/99	C3 E 3/4 (1st)	6.57	20.40	0.0490	0.100	9.65
10/14/99	C3 E 3/4 (2nd)	6.70	20.40	0.0601	0.126	6.13
9/13/99	C3 W 1/4 (1st)	0.22	22.90	0.169	0.139	2.68
9/13/99	C3 W 1/4 (2nd)	0.30	22.90	0.202	0.167	2.27
9/13/99	C3 W 1/2 (1st)	0.76	23.00	0.141	0.123	5.91
9/13/99	C3 W 1/2 (2nd)	0.76	23.00	0.198	0.172	2.53
9/13/99	C3 W 3/4 (1st)	1.24	23.00	0.144	0.132	4.70
9/13/99	C3 W 3/4 (2nd)	1.19	23.05	0.184	0.167	3.46
10/14/99	C3 W 1/4 (1st)	0.21	20.20	0.148	0.123	2.08
10/14/99	C3 W 1/4 (2nd)	0.21	20.20	0.165	0.137	1.86
10/14/99	C3 W 1/2 (1st)	0.63	20.20	0.137	0.118	6.00
10/14/99	C3 W 1/2 (2nd)	0.64	20.20	0.185	0.160	2.85
10/14/99	C3 W 3/4 (1st)	0.99	20.30	0.127	0.114	6.93
10/14/99	C3 W 3/4 (2nd)	1.07	20.30	0.172	0.156	3.68

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

DATA FROM THE OFF-GAS TESTS CONDUCTED IN THE SELECTED AERATION TANKS OF BATTERIES A, B, AND C AT THE NSWRP

Date	Station (Position)	DO (mg/L)	Temperature (°C)	OTE_f	SOTE	Off-Gas Flow (scfm)
9/15/99	C4 E 1/4 (1st)	0.50	23.10	0.104	0.0870	10.90
9/15/99	C4 E 1/4 (2nd)	0.60	23.08	0.132	0.112	6.79
9/15/99	C4 E 1/2 (1st)	1.52	23.12	0.116	0.109	9.27
9/15/99	C4 E 1/2 (2nd)	1.50	23.12	0.159	0.149	5.99
9/15/99	C4 E 3/4 (1st)	6.19	23.20	0.0491	0.0966	9.12
9/15/99	C4 E 3/4 (2nd)	6.11	23.20	0.0680	0.131	5.16
10/15/99	C4 E 1/4 (1st)	0.48	20.20	0.0955	0.0809	8.72
10/15/99	C4 E 1/4 (2nd)	0.49	20.20	0.130	0.110	4.73
10/15/99	C4 E 1/2 (1st)	1.12	20.23	0.116	0.105	9.11
10/15/99	C4 E 1/2 (2nd)	1.15	20.20	0.167	0.151	4.97
10/15/99	C4 E 3/4 (1st)	4.21	20.30	0.0858	0.113	7.83
10/15/99	C4 E 3/4 (2nd)	3.76	20.30	0.124	0.152	3.91
9/15/99	C4 W 1/4 (1st)	0.45	23.00	0.0961	0.0804	7.67
9/15/99	C4 W 1/4 (2nd)	0.51	23.00	0.121	0.102	5.34
9/15/99	C4 W 1/2 (1st)	0.57	23.00	0.124	0.105	5.41
9/15/99	C4 W 1/2 (2nd)	0.68	23.00	0.166	0.143	3.16
9/15/99	C4 W 3/4 (1st)	0.89	23.00	0.128	0.112	6.93
9/15/99	C4 W 3/4 (2nd)	0.89	23.00	0.168	0.147	2.74
10/15/99	C4 W 1/4 (1st)	0.51	20.12	0.0990	0.0841	9.24
10/15/99	C4 W 1/4 (2nd)	0.50	20.10	0.126	0.107	5.43
10/15/99	C4 W 1/2 (1st)	0.59	20.20	0.132	0.113	5.67
10/15/99	C4 W 1/2 (2nd)	0.60	20.20	0.178	0.153	2.98
10/15/99	C4 W 3/4 (1st)	0.88	20.30	0.132	0.116	7.03
10/15/99	C4 W 3/4 (2nd)	1.09	20.30	0.179	0.161	3.06

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-4

RESULTS OF THE OFF-GAS TESTS CONDUCTED IN AERATION TANK C12 AT THE NSWRP WITH AIR FLOW OF 2100 SCFM ON 9/16/1999 AND 2300 SCFM ON 10/18/1999

Date	Hood Position	DO (mg/L)	Temperature (°C)	OTE_f	SOTE	Off-Gas Flow (scfm)
9/16/99	C12 1/4 1st	0.47	22.9	0.132	0.111	6.57
10/18/99	C12 1/4 1st	0.51	20.0	0.127	0.108	7.03
9/16/99	C12 1/4 2nd	0.45	22.8	0.140	0.117	6.08
10/18/99	C12 1/4 2nd	0.51	20.0	0.137	0.116	6.56
9/16/99	C12 1/4 3rd	0.47	22.8	0.146	0.122	5.81
10/18/99	C12 1/4 3rd	0.51	19.9	0.144	0.122	5.69
9/16/99	C12 1/2 1st	0.64	22.9	0.151	0.128	6.50
10/18/99	C12 1/2 1st	1.01	20.0	0.140	0.125	6.57
9/16/99	C12 1/2 2nd	0.77	22.9	0.164	0.141	5.64
10/18/99	C12 1/2 2nd	1.06	20.0	0.158	0.141	5.99
9/16/99	C12 1/2 3rd	0.72	22.9	0.173	0.148	5.37
10/18/99	C12 1/2 3rd	1.14	20.0	0.154	0.138	6.04
9/16/99	C12 1/2 4th	0.69	22.9	0.188	0.160	3.77
10/18/99	C12 1/2 4th	1.17	20.0	0.176	0.159	4.64
9/16/99	C12 3/4 1st	2.72	23.0	0.0811	0.0874	15.13
10/18/99	C12 3/4 1st	5.18	20.0	0.0666	0.102	13.54
9/16/99	C12 3/4 2nd	2.43	23.0	0.121	0.125	9.55
10/18/99	C12 3/4 2nd	4.76	20.0	0.0918	0.130	9.76
9/16/99	C12 3/4 3rd	2.36	23.0	0.147	0.152	7.63
10/18/99	C12 3/4 3rd	4.53	19.9	0.108	0.148	9.34

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5

RESULTS OF OXYGEN TRANSFER EFFICIENCY TESTS CONDUCTED IN THE SELECTED AERATION TANKS OF BATTERY D AT THE NSWRP

Station	Date	OTEf	SOTE	DO mg/L	Water T °C	OG Flow scfm	Starting Time
D5 1/4	10/21/99	0.112	0.0975	0.73	19.6	4.15*	8:50
D5 1/4	10/22/99	0.123	0.111	0.95	19.5	11.25	12:24
D5 1/4	10/25/99	0.110	0.0955	0.71	19.1	11.51	9:09
D5 1/4	10/28/99	0.117	0.104	0.94	18.9	11.33	12:21
D5 1/4	10/29/99	0.106	0.0936	0.90	19.0	10.92	9:20
Mean		0.114	0.100	0.84		11.25	
SD		0.007	0.007	0.12		0.25	
CV (%)		5.9	7.3	14.0		2.2	
D5 1/2	10/21/99	0.131	0.122	1.41	19.6	5.64*	10:28
D5 1/2	10/22/99	0.132	0.124	1.32	19.5	9.73	11:55
D5 1/2	10/25/99	0.137	0.124	1.13	19.1	9.79	11:12
D5 1/2	10/28/99	0.138	0.127	1.35	19.0	9.33	11:51
D5 1/2	10/29/99	0.140	0.126	1.04	19.2	8.84	8:31
Mean		0.135	0.125	1.25		9.42	
SD		0.004	0.002	0.16		0.44	
CV (%)		3.0	1.6	12.5		4.6	
D6 1/4	10/21/99	0.148	0.134	1.12	19.5	8.74	11:17
D6 1/4	10/22/99	0.131	0.117	0.79	19.6	8.85	8:39
D6 1/4	10/25/99	0.138	0.123	0.95	19.0	8.52	10:31
D6 1/4	10/28/99	0.128	0.111	0.72	18.9	8.70	9:24
D6 1/4	10/29/99	0.143	0.129	1.13	18.9	8.51	11:04
Mean		0.138	0.123	0.94		8.66	
SD		0.008	0.009	0.19		0.15	
CV (%)		5.9	7.4	19.7		1.7	
D6 1/2	10/21/99	0.121	0.133	2.82	19.6	11.82	9:45
D6 1/2	10/22/99	0.126	0.128	2.27	19.6	11.86	10:20
D6 1/2	10/25/99	0.131	0.133	2.21	19.1	11.49	9:43
D6 1/2	10/28/99	0.128	0.130	2.24	19.0	11.88	10:13
D6 1/2	10/29/99	0.123	0.131	2.65	19.1	11.92	9:56
Mean		0.126	0.131	2.44		11.79	
SD		0.004	0.002	0.28		0.17	
CV (%)		3.2	1.5	11.4		1.5	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5 (Continued)

RESULTS OF OXYGEN TRANSFER EFFICIENCY TESTS CONDUCTED IN THE SELECTED AERATION TANKS OF BATTERY D AT THE NSWRP

Station	Date	OTEf	SOTE	DO mg/L	Water T °C	OG Flow scfm	Starting Time
D7 1/4	10/21/99	0.194	0.169	0.68	19.5	5.55	11:55
D7 1/4	10/22/99	0.160	0.139	0.51	19.5	6.04	9:45
D7 1/4	10/25/99	0.192	0.166	0.63	18.9	5.19	12:13
D7 1/4	10/28/99	0.174	0.149	0.50	18.8	5.52	10:49
D7 1/4	10/29/99	0.171	0.147	0.58	18.9	5.72	10:28
Mean		0.178	0.154	0.58		5.60	
SD		0.014	0.013	0.08		0.31	
CV (%)		8.1	8.3	13.3		5.5	
D7 1/2	10/21/99	0.145	0.148	2.23	19.6	9.65	13:14
D7 1/2	10/22/99	0.140	0.135	1.54	19.6	10.85	9:17
D7 1/2	10/25/99	0.143	0.142	2.06	19.0	9.93	12:52
D7 1/2	10/28/99	0.140	0.127	1.17	18.9	8.47	8:42
D7 1/2	10/29/99	0.140	0.140	2.12	19.0	9.01	11:40
Mean		0.142	0.138	1.82		9.58	
SD		0.002	0.008	0.45		0.91	
CV (%)		1.5	5.7	24.7		9.5	

*The value is not used to calculate the mean due to a leak on the hood.
T stands for temperature, and OG for off-gas.
SD stands for standard deviation, and CV for coefficient of variation.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 UNDER VARIOUS AIR FLOW RATES ON AUGUST 20, 1999

Tank Air Flow Rate (scfm)	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
At B6 E 1/4							
1200	100.0	89.0	0.81	23.1	6.33	0.135	0.117
1200	100.0	88.7	0.75	23.1	6.07	0.139	0.120
1200	100.1	89.2	0.77	23.0	5.98	0.134	0.116
1200	100.1	89.2	0.75	23.1	5.87	0.134	0.115
1200	100.1	89.0	0.76	23.1	5.87	0.136	0.118
1200	100.1	89.1	0.72	23.1	5.87	0.135	0.116
1200	100.1	89.1	0.73	23.1	5.87	0.135	0.116
Average		89.0	0.76	23.1	5.98	0.135	0.117
Standard Deviation		0.17	0.03	0.04	0.17	0.0017	0.0015
1500	100.0	89.5	1.06	23.1	6.66	0.129	0.115
1500	100.0	89.7	1.02	23.1	6.66	0.127	0.112
1500	100.1	89.8	1.00	23.1	6.90	0.127	0.112
1500	100.1	89.8	1.01	23.1	6.90	0.127	0.112
1500	100.1	89.9	0.97	23.1	7.07	0.126	0.111
1500	100.0	89.7	0.96	23.1	7.17	0.127	0.112
1500	100.1	89.6	1.10	23.1	7.00	0.129	0.115
Average		89.7	1.02	23.1	6.91	0.127	0.113
Standard Deviation		0.13	0.05	0.00	0.20	0.0014	0.0018
1800	100.0	90.3	1.39	23.1	7.91	0.120	0.110
1800	100.0	90.2	1.37	23.1	7.73	0.121	0.111
1800	100.0	90.3	1.39	23.1	7.82	0.120	0.110
1800	99.9	90.1	1.40	23.1	7.82	0.121	0.112
1800	100.0	90.1	1.39	23.1	7.72	0.122	0.113
1800	99.9	90.0	1.45	23.1	7.72	0.122	0.113
1800	100.0	90.3	1.39	23.1	7.72	0.120	0.110
Average		90.2	1.40	23.1	7.78	0.121	0.111
Standard Deviation		0.12	0.02	0.00	0.07	0.0011	0.0012

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 UNDER VARIOUS AIR FLOW RATES ON AUGUST 20, 1999

Tank Air Flow Rate (scfm)	Oxygen in Gas (mV) Reference	Oxygen in Gas (mV) Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
2100	99.9	90.8	1.71	23.2	8.78	0.113	0.108
2100	100.0	91.1	1.69	23.2	8.96	0.110	0.105
2100	100.0	91.1	1.73	23.2	8.86	0.110	0.105
2100	99.9	91.0	1.72	23.2	8.78	0.110	0.105
2100	100.0	91.0	1.70	23.2	8.78	0.111	0.106
2100	99.9	90.8	1.69	23.2	8.78	0.113	0.107
2100	99.9	91.2	1.62	23.2	8.77	0.108	0.102
Average		91.0	1.69	23.2	8.81	0.111	0.106
Standard Deviation		0.15	0.04	0.00	0.07	0.0017	0.0019
2500	100.0	91.6	2.45	23.0	9.90	0.104	0.109
2500	99.9	91.7	2.35	23.0	9.99	0.102	0.105
2500	99.9	91.5	2.41	23.0	9.90	0.104	0.108
2500	100.0	92.0	2.42	23.0	8.86	0.0991	0.103
2500	99.9	91.5	2.52	23.0	10.59	0.104	0.110
2500	100.0	91.8	2.38	23.0	9.81	0.102	0.105
2500	99.9	91.6	2.45	23.0	9.46	0.103	0.107
Average		91.7	2.43	23.0	9.79	0.102	0.107
Standard Deviation		0.18	0.06	0.00	0.53	0.0018	0.0024
At B6 W 1/4							
1200	100.0	86.6	0.24	23.0	2.13	0.164	0.134
1200	100.0	86.7	0.19	23.0	2.13	0.163	0.133
1200	100.0	87.0	0.17	23.0	2.13	0.159	0.129
1200	100.0	86.7	0.18	23.0	2.13	0.163	0.132
1200	100.0	87.1	0.16	23.0	2.13	0.158	0.128
1200	100.1	87.0	0.17	23.0	2.13	0.160	0.130
1200	100.1	87.1	0.16	23.0	2.13	0.159	0.129
Average		86.9	0.18	23.0	2.13	0.161	0.131
Standard Deviation		0.21	0.03	0.00	0.00	0.0023	0.0022

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6 (Continued)

DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 UNDER VARIOUS AIR FLOW RATES ON AUGUST 20, 1999

Tank Air Flow Rate (scfm)	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
1500	100.0	88.3	0.33	23.0	3.21	0.144	0.119
1500	100.0	88.0	0.25	23.0	3.19	0.147	0.121
1500	100.0	88.0	0.21	23.0	3.33	0.147	0.120
1500	100.0	88.3	0.28	23.0	3.31	0.144	0.118
1500	100.0	89.1	0.25	23.0	3.31	0.134	0.110
1500	100.1	88.9	0.24	23.0	3.31	0.137	0.113
1500	100.1	88.9	0.28	23.0	3.31	0.137	0.113
Average		88.5	0.26	23.0	3.28	0.141	0.116
Standard Deviation		0.46	0.04	0.00	0.06	0.0052	0.0042
1800	100.0	88.6	0.29	23.1	3.98	0.140	0.115
1800	100.0	88.7	0.32	23.0	3.94	0.139	0.115
1800	100.0	88.8	0.27	23.0	3.98	0.138	0.113
1800	100.0	89.1	0.30	23.0	4.01	0.134	0.110
1800	100.1	89.3	0.30	23.1	4.01	0.133	0.109
1800	100.1	89.3	0.34	23.1	4.03	0.133	0.110
1800	100.0	89.4	0.32	23.1	4.03	0.130	0.108
Average		89.0	0.31	23.1	3.99	0.135	0.111
Standard Deviation		0.33	0.02	0.05	0.03	0.0036	0.0029
2100	100.0	89.8	0.41	23.1	4.96	0.126	0.105
2100	99.9	89.6	0.38	23.1	5.01	0.127	0.105
2100	99.9	89.6	0.39	23.1	4.94	0.127	0.106
2100	99.9	89.5	0.46	23.1	4.93	0.128	0.107
2100	99.9	89.8	0.40	23.1	4.91	0.125	0.104
2100	99.9	89.7	0.41	23.1	4.94	0.126	0.105
2100	99.9	89.5	0.39	23.1	4.92	0.128	0.107
Average		89.6	0.41	23.1	4.94	0.127	0.105
Standard Deviation		0.13	0.03	0.00	0.04	0.0013	0.0012

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6 (Continued)

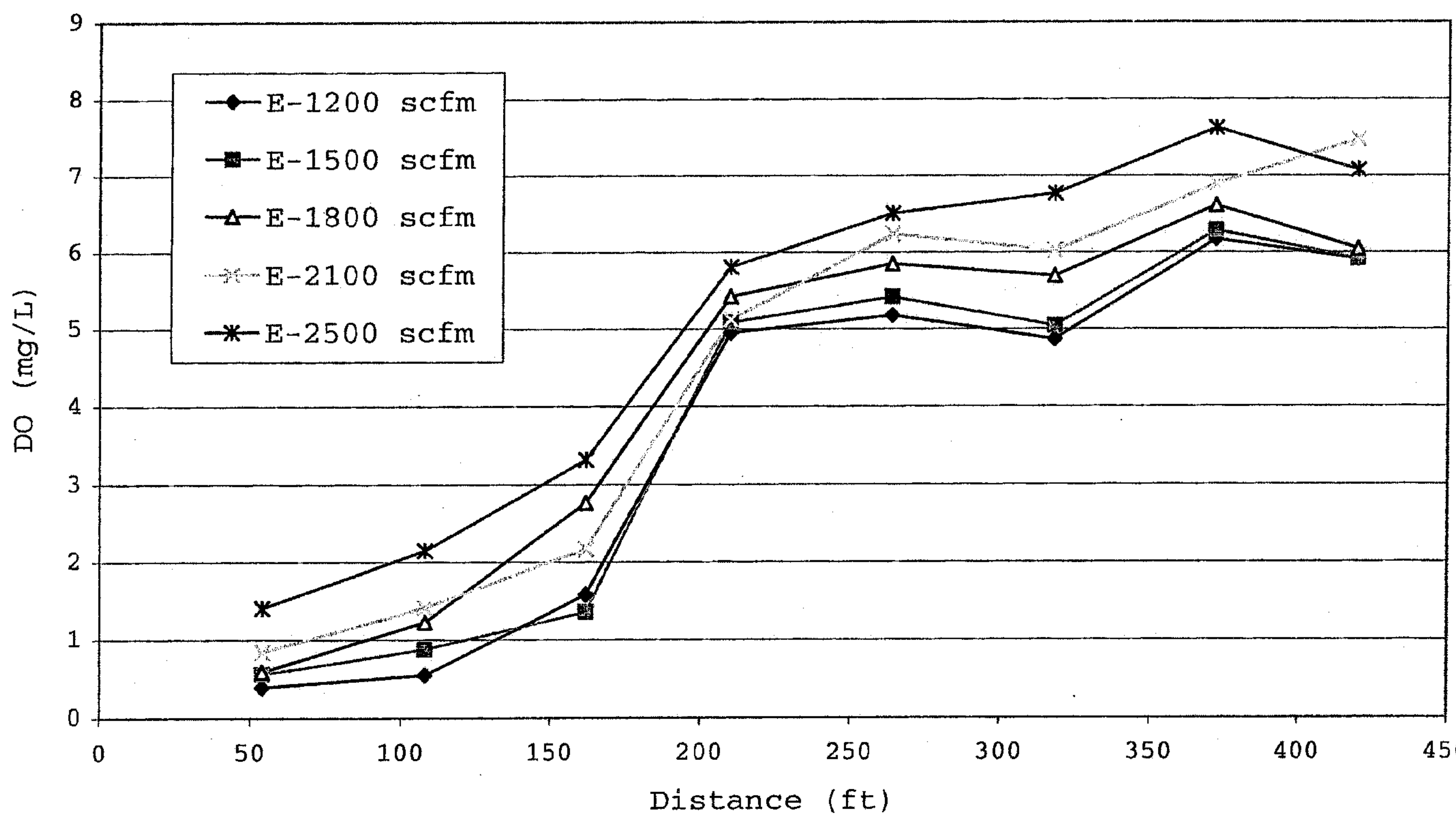
DATA FROM OFF-GAS TESTS CONDUCTED AT TANK B6 UNDER VARIOUS AIR FLOW RATES ON AUGUST 20, 1999

Tank Air Flow Rate (scfm)	Oxygen in Gas (mV) Reference	Off-gas	DO (mg/L)	Temperature (°C)	Off-Gas Flow (scfm)	OTE_f	SOTE
2500	99.9	89.2	0.78	23.0	6.35	0.132	0.114
2500	100.0	89.2	0.80	23.0	6.26	0.133	0.115
2500	100.0	89.1	0.76	23.0	6.34	0.134	0.116
2500	100.0	89.3	0.82	23.0	6.34	0.132	0.114
2500	100.0	89.2	0.79	23.0	6.41	0.133	0.115
2500	100.0	89.3	0.72	23.0	6.41	0.132	0.113
2500	100.0	89.4	0.78	23.0	6.41	0.130	0.113
Average		89.2	0.78	23.0	6.36	0.132	0.114
Standard Deviation		0.10	0.03	0.00	0.06	0.0012	0.0011

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE AI-1

DO PROFILES IN THE EAST BAY OF TANK B6 UNDER VARIOUS AIR FLOW RATES DURING OFF-GAS TESTS AT THE NSWRP ON AUGUST 20, 1999



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE AI-2

DO PROFILES IN THE WEST BAY OF TANK B6 UNDER VARIOUS AIR FLOW RATES DURING OFF-GAS TESTS AT THE NSWRP ON AUGUST 20, 1999