Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

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INVESTIGATION OF FINAL EFFLUENT AMMONIA SPIKE INCIDENTS ON APRIL 7 AND JULY 22, 2000, AT THE STICKNEY WATER RECLAMATION PLANT AND THE IMPACT OF MAJOR AMMONIA-CONTRIBUTING SOURCES

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DISCLAIMER

SUMMARY AND CONCLUSIONS

The proposed reissued NPDES permit for the Stickney WRP requires ammonia-nitrogen (ammonia) in the final effluent not to exceed a maximum daily concentration of 5 mg/L, in addition to continuation of the monthly average concentration limit contained in the current expired permit. In the current expired NPDES permit, the ammonia limit is seasonal and set at a maximum monthly average concentration of 2.5 mg/L (April-October) and 4.0 mg/L (November-March). Twice in the year 2000 thus far, on April 7 and again on July 22, the daily ammonia concentration in the final effluent of the Stickney WRP exceeded 5 mg/L.

As a result of these two incidents, the Maintenance and Operations (M&O) Department expressed a concern and requested the Research and Development (R&D) Department to identify major ammonia contributing sources to the Stickney WRP and to determine the likely cause(s) of ammonia spikes (i.e., exceedence of the proposed daily ammonia limits) in the final effluent of the Stickney WRP on April 7 and July 22, 2000. In response to this request from the M&O Department, the R&D Department conducted the study described in this report.

The main objectives of this study were (1) to identify main sources contributing ammonia to the Stickney WRP, (2) to assess the impact of variation in ammonia concentrations from the ammonia contributing sources on the performance of ammonia removal at the Stickney WRP, and (3) to analyze the operating data of the Stickney WRP for possible causes of the two incidents of ammonia spikes in the final effluent, resulting in daily average ammonia concentrations in the final effluent exceeding 5.0 mg/L.

The study consisted of two parts, namely: (1) ammonia source investigation and (2) analysis of the data collected before, during, and after the ammonia spikes occurred in the effluent.

Source investigation was conducted for the period August 14 through September 5, 2000, and focused on examining the four major previously identified ammonia-contributing sources in addition to the regular domestic loading, which is considered the normal background ammonia load. These four sources are TARP pumpback, discharge from Corn Products Corporation (CPC), centrate from the post-digestion centrifuges (Post-DC), and overflow from the sludge lagoons in the Lawndale Avenue Solids Management Area (LASMA).

For monitoring ammonia discharges from CPC, Post-DC, and LASMA, auto-samplers were used during the period August 14 through September 5, 2000, to collect hourly samples at five sampling stations. Later, it was found that the hourly samples for Post-DC contained an unknown amount of process water, which made the calculation of ammonia loading impossible. It was decided to sample the centrate directly to obtain more reliable information for estimation of Post-DC ammonia loading. Thus, 41 random grab samples were collected during September 13 through September 20, 2000 directly from the centrate in the Post-DC Building at the Stickney WRP. The average ammonia concentration of the centrate was used to estimate the daily ammonia loadings from the Post-DC during August 14 through September 5, 2000.

For determining the ammonia contribution from the TARP pumpback, monitoring data routinely collected, including the flow rates and concentrations of ammonia and BOD_5 in the TARP pumpback for the period August 14 to September 5, 2000 were examined. The flow rates for the first three sources were also estimated. For estimating the ammonia contribution in the domestic sewage for the period August 14 to September 5, 2000, the ammonia loadings of the above-mentioned four sources were subtracted from the total ammonia load entering the Stickney WRP.

Investigation of the possible causes of the daily average ammonia concentrations in the final effluent of the Stickney WRP exceeding 5.0 mg/L on April 7 and July 22, 2000 started with the collection of historical data a few days before and after the incidents. These data included the ammonia and BOD_5 concentrations in the raw sewage and the influent of the aeration tanks, hourly sewage flow rates, the amount of air supplied to the aeration tanks, and dissolved oxygen (DO) levels in the aeration tanks. Available information on the five sources contributing ammonia to the Stickney WRP pertaining to the two incidents was also collected.

The mass loading of ammonia contributed from each source to the Stickney WRP was calculated using its daily average flow rate and its mean ammonia concentration. The variation of ammonia concentrations at various locations was examined by computing the coefficient of variation (CV) and analyzing ammonia concentration profiles. For the investigation of the ammonia spike incidents, the BOD_5 and ammonia loads to the aeration tanks in each shift before and after the incidents were examined. The theoretical amount of air required by the aeration tanks to satisfy the influent carbonaceous and nitrogenous oxygen demand was calculated to determine whether the air supplied to the aeration tanks during the ammonia spike incidents was adequate.

The following conclusions can be drawn from this study:

1. There are four major ammonia-contributing sources to the Stickney WRP, in addition to the domestic sources. These are the TARP pumpback, wastewater from CPC, centrate from the Post-DC, and overflow from the sludge lagoons at LASMA. These four sources contributed 51 percent of the total ammonia loading to the Stickney WRP during the source investigation period August 14 through September 5, 2000. The average ammonia contribution from each source was: 8.2 percent from the TARP pumpback, 11.0 percent from CPC, 10.8 percent from Post-DC, and 21.0 percent from LASMA. The remaining 49 percent was from domestic sources. Obviously, this is the major source as compared to the four individual sources.

2. During the period of source investigation (August 14 through September 5, 2000), the TARP pumpback ammonia loading had the most

variability among the four individual sources, contributing from 0 to 21.7 percent of the total ammonia on a daily average basis. Considering that the TARP pumpback usually occurs only within a few hours of the day during dry weather, the impact from TARP pumpback can be quite significant. The discharge from CPC was found to be the second most variable source, contributing from 0 to 16.9 percent of the total ammonia on a daily average basis. The ammonia loadings in the Post-DC centrate and overflows from LASMA were much less variable, compared to the TARP pumpback and the discharge from CPC. The variability of ammonia loadings for Post-DC and LASMA was from 6.5 to 14.9 percent and from 9.4 to 26.7 percent, respectively, of the total ammonia loadings, on a daily average basis.

3. The causes of the two incidents of final effluent ammonia spikes appear to be different in nature. The April 7, 2000 incident appears to have resulted from a combination of high ammonia concentrations in the raw sewage, high ammonia load to the aeration tanks, and low DO levels in

the aeration tanks. The high ammonia load to the Stickney WRP on April 7, 2000, was likely due to the first flush of the sewer system, as the flow rate of the raw sewage to the Stickney WRP increased from 600 MGD to over 1,200 MGD in the early afternoon of April 7, 2000, as a result of rainfall.

4. The July 22, 2000 incident appears to have resulted from low DO levels in the aeration tanks, which led to inefficient nitrification on that day. As the daily average ammonia concentration in the raw sewage and ammonia load to the aeration tanks was only slightly higher than normal, the unusually high ammonia concentration in the final effluent could not have been caused by the ammonia load alone on that day.

   Considering the short time (three to nine hours) it takes for the TARP pumpback to travel from the pump station to the aeration tanks, the TARP pumpback between the night of July 21 and early morning of July 22, which exerted a high BOD_5 and contained a high concentration of ammonia, could have been responsible for causing the low

DO levels in the aeration tanks in the first and second shifts on July 22, 2000.

The DO levels in the aeration tanks remained low during the daytime on that day indicating that the supply of oxygen was insufficient. It was also found that only two blowers were in service during the daytime on this day. The DOs in the aeration tanks started to increase and ammonia concentration in the final effluent started to decrease during the third shift after a third blower was put into service, around 7:30 p.m. on that day.

RECOMMENDATIONS

In order to avoid future incidents of ammonia spikes in the final effluent of the Stickney WRP and violation of the limit in the proposed reissued permit, the following recommendations are made:

1. Make better use of the existing weather service information on rainfall to better prepare for greater demands on the activated sludge system due to higher raw sewage flows and TARP pumpback loadings.
2. Be more proactive in the use of a third blower to ensure that sufficient air is delivered to the aeration tanks, when effluent ammonia concentrations begin to rise.
3. Make better use of the existing ammonia analyzer located at the preliminary settling tanks to act as an early warning system to alert operators to higher than normal ammonia concentrations entering the aeration tanks.
4. As new automated controls are installed at the Stickney WRP, establish two set points for DO levels in the aeration tanks, one in Pass 2 and

the other in Pass 4 to control air supply to the aeration tanks more effectively to meet the oxygen demand of occasional slugs of high BOD_5 and ammonia loadings to the aeration tanks.

INTRODUCTION

Background

In response to a memorandum dated July 3, 2000, from Mr. Thomas K. O'Connor, Chief of M&O, to Mr. Richard Lanyon, Director of the R&D Department, a meeting was held on July 25, 2000 between the M&O staff at the Stickney WRP and the staff of the Environmental Monitoring and Research Division at the Dr. Cecil Lue-Hing Research and Development Complex to discuss the problem of elevated ammonia levels in the final effluent of the Stickney WRP. Specifically, the discussion in the July 25, 2000 meeting centered around the spikes in ammonia levels on April 7 (5.81 mg/L) and July 22, 2000 (6.41 mg/L) in the 24-hour composite final effluent of the Stickney WRP.

The main concern was that the elevated ammonia levels in the final effluent on April 7 and July 22 could have caused NPDES permit violations if the proposed new NPDES permit limits were to be applied. To address this concern, R&D initiated a study to investigate sources of ammonia discharges into the Stickney WRP and the resulting ammonia load from each such source. In addition, R&D also undertook to investigate the possible cause(s) of the spikes in ammonia levels in the final effluent of the Stickney WRP experienced on April 7, 2000 and July 22, 2000.

Stickney WRP Process Description

The Stickney WRP is a secondary sewage treatment plant, which has grit removal, primary settling tanks, Imhoff tanks, single-stage activated sludge aeration tanks, and final settling tanks as the main sewage treatment processes. Two streams of raw sewage enter the Stickney WRP. These are the West Side plant and Southwest plant, which have separate pre-settling treatment in Imhoff tanks and preliminary settling tanks, respectively, before being combined in the aeration tanks.

The flow rates of raw sewage to the Stickney West Side and Southwest plants and the total volumes of the Imhoff and preliminary settling tanks are different, as are the hydraulic retention times (HRT). For the mean raw sewage flows of 316 and 470 MGD (million gallons per day) for the Stickney West Side and Southwest plants for the first seven months of the year 2000, the HRTs in the Imhoff and preliminary settling tanks are 11 and 1.1 hours, respectively. The combined, pre-settled sewage, which has a flow rate of 786 MGD, then is biologically treated in the aeration tanks with a nominal HRT of

6.4 hours. This biologically-treated sewage is settled in the final settling tanks for another 3.8 hours before being discharged as the final effluent.

Ammonia in the two streams of raw sewage discharged to the Stickney WRP is mostly oxidized in the aeration tanks through single-stage biological nitrification. Theoretically, nearly 4.6 pounds of DO is needed to oxidize one pound of ammonia to nitrate. Nitrifying bacteria are sensitive organisms and can be inhibited by a wide variety of inhibitors. Maintaining DO above 1 mg/L is essential for biological nitrification to occur in the absence of inhibitors. If DO levels drop below 1 mg/L, oxygen becomes the limiting factor for ammonia conversion, and the nitrification process slows significantly or even ceases (1).

The removal of ammonia in the aeration tanks depends upon the population of nitrifying bacteria, the rate of nitrification, which is affected by temperature and DO, and other factors like influent ammonia concentration and HRT. The daily ammonia concentrations in the raw sewage entering the Stickney WRP ranged from 4.27 to 23.13 mg/L, with an average of 13.63 mg/L in the first nine months of the year 2000, as shown in Table 1. The monthly average of the ammonia concentration was

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TABLE 1

AMMONIA CONCENTRATIONS IN THE INFLUENT AND EFFLUENT OF THE STICKNEY WRP
JANUARY THROUGH SEPTEMBER 2000

Month	Ammonia in Raw Sewage Weighted Average* in mg/L as NH_3-N			Ammonia in Final Effluent in mg/L as NH_3-N			Mean Removal (%)
	Mean	Min	Max	Mean	Min	Max	
Jan. 2000	16.69	11.05	22.80	0.77	0.07	5.04	95.4
Feb. 2000	16.12	10.06	23.01	1.18	0.08	4.86	92.7
Mar. 2000	17.42	13.88	23.13	1.20	0.17	3.54	93.1
Apr. 2000	13.09	4.27	22.48	0.62	0.06	5.81	95.3
May 2000	10.75	4.93	17.44	0.32	0.07	1.80	97.0
Jun. 2000	10.06	5.84	14.47	0.35	0.07	1.13	96.5
Jul. 2000	12.40	5.71	20.31	0.62	0.07	6.41	95.0
Aug. 2000	13.58	8.44	19.22	0.65	0.09	3.93	95.2
Sep. 2000	12.61	4.58	19.47	0.25	0.08	0.75	98.0

*Raw sewage to the Stickney Southwest and West Side plants was analyzed for ammonia separately, and a weighted average was calculated using the sewage flow rates as the weighting factor.

in the range of 10.06 to 17.42 mg/L. Despite the variation in influent ammonia concentrations and seasonal change in temperatures, on an average, more than 95 percent of the influent ammonia is removed through the sewage treatment processes at the Stickney WRP. As can be seen in Table 1, the monthly average ammonia removal efficiency ranged from 92.7 to 98.0 percent in the first nine months of year 2000.

Cause(s) of Ammonia Nitrogen Spikes in the Final Effluent

In the two incidents experienced on April 7, and July 22, 2000, the daily average ammonia concentration in the final effluent of the Stickney WRP exceeded 5.0 mg/L. High effluent ammonia concentrations can be caused by several factors or combination thereof. They are:

1. Shock ammonia loading due to an instantaneous high ammonia concentration or high ammonia load in the influent,
2. Insufficient amount of nitrifying bacteria due to toxicity or low sludge retention time (SRT), and
3. Low concentration of dissolved oxygen in aeration tanks (i.e., < 1 mg/L), which can be caused by insufficient supply of oxygen or increased

demand of oxygen by increased amounts of oxygen-consuming substances.

OBJECTIVES

The present study was designed:

1. To identify major sources contributing ammonia to the Stickney WRP,
2. To determine the load of ammonia per day from each of the sources identified,
3. To determine cause(s) of ammonia level spikes in the final effluent of the Stickney WRP experienced on April 7, and July 22, 2000, and
4. To come up with recommendations to avoid such ammonia spikes in the future.

METHODOLOGY

Wastewater flow rates and associated ammonia concentrations were collected for each identified ammonia source to the Stickney WRP in order to determine the daily load of ammonia from each source. To examine the variation in ammonia concentration over a 24-hour period, an hourly sampling study was designed for the four identified ammonia-contributing sources during August 14 through September 5, 2000. In addition, pertinent data before, during, and after each incident of the ammonia spikes experienced on April 7, 2000 and July 22, 2000 were examined to determine possible cause(s) of the ammonia spikes.

Source Investigation

Four ammonia-contributing sources are identified and investigated in this study. These sources are the TARP pumpback, discharge from CPC, centrate from Post-DC and overflow from the sludge lagoons at LASMA. Source investigation included reviewing existing data, sampling the sources with no existing data, and analyzing the data. Normal background ammonia loads from domestic sources were also tabulated.

TARP pumpback is routinely monitored by the M&O Department at a sampling point, located before the pumpback enters the wet well at the Stickney Southwest plant, for its quality and quantity, and the data are recorded in the R&D Department Laboratory Information Management System (LIMS). The ammonia concentrations in TARP pumpback and the corresponding flow rates were directly obtained from LIMS.

For the three other sources, hourly sampling was conducted from August 14 through September 5, 2000 to collect data on ammonia concentrations. Five sampling stations were selected to collect these hourly samples. Two of the sampling stations were located at CPC, which are named as CP-2AT and CP-6AT. The third one was located in an interceptor, SW12, which is about one mile downstream of CPC and intercepts the wastewater from CPC and other residential and commercial sewage in this area. The fourth one was located in a manhole immediately downstream of the post-digestion centrifuges. The fifth one was located at LASMA for monitoring the overflows from the sludge lagoons. Figure 1 shows the locations of the five sampling stations.

Auto-samplers were installed at each sampling station to collect samples every hour during the sampling period. All the samples collected by the auto-samplers were analyzed for ammonia. All ammonia concentrations in this report were expressed as ammonia-nitrogen in milligrams per liter. The

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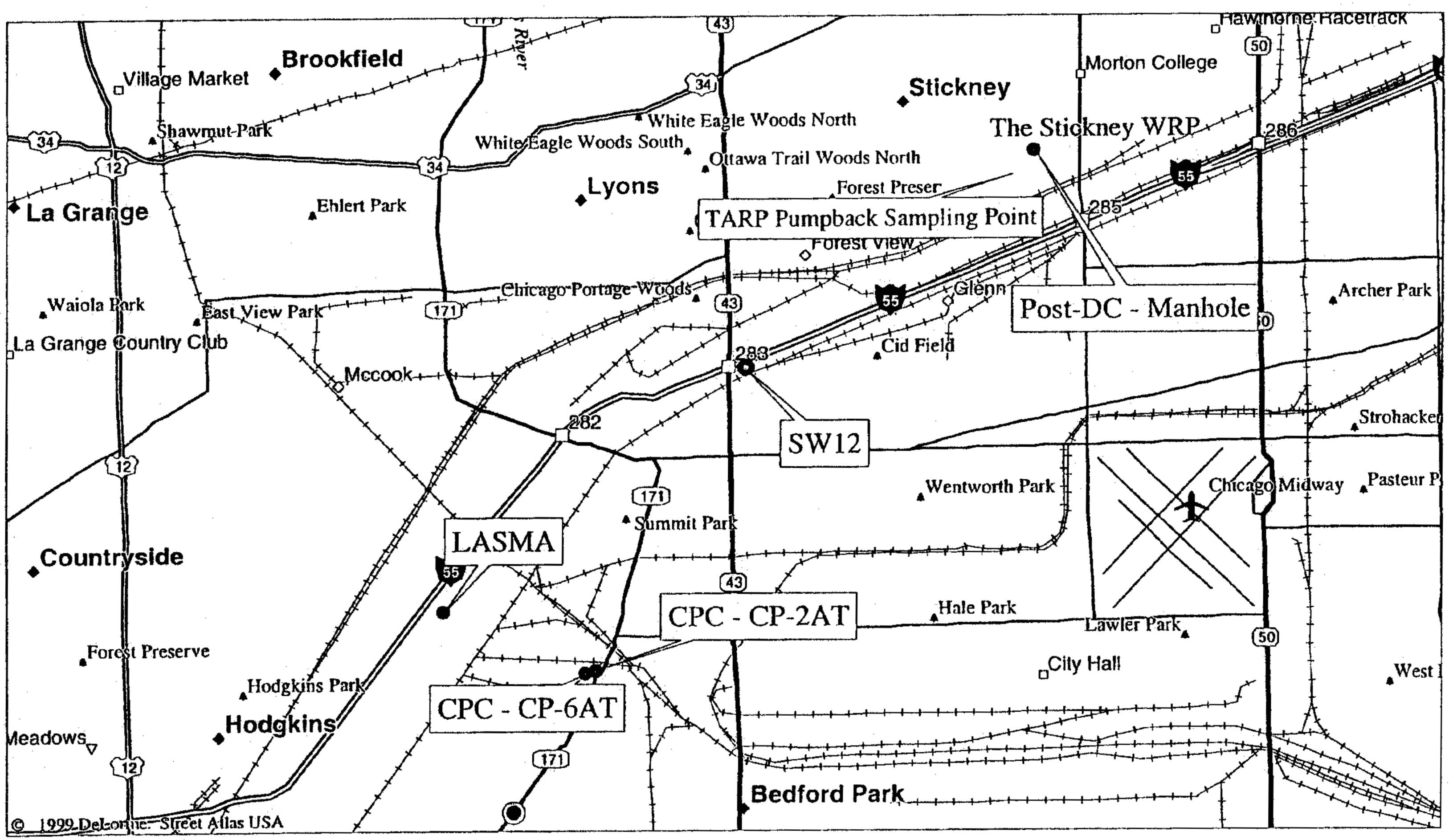
FIGURE 1

SAMPLING LOCATION FOR THE AMMONIA STUDY
AUGUST THROUGH SEPTEMBER 2000



loadings of ammonia calculated for this report were also expressed as ammonia-nitrogen.

The ammonia concentrations of the wastewater sampled in the manhole immediately downstream of the post-digestion centrifuges were found to be relatively low, averaging 9.97 mg/L. Later, it was learned that the centrate was diluted with process water before entering the manhole to prevent scaling in the pipes. However, the amount of process water used for dilution was unknown. Therefore, the measurement of ammonia concentration in the centrate without dilution was made between September 13 through 20, 2000. Grab samples of centrate were taken from each working centrifuge once per day for five days. The samples were analyzed for ammonia using an ammonia electrode (ORION Model 95-12), calibrated with commercially available standard solutions.

To calculate the daily amount of ammonia generated at each source, the data of wastewater flow rates along with ammonia concentrations from these sources were also collected. The daily discharge rates from the two locations at CPC during August 14 to 20, 2000, were recorded by the R&D's IWD personnel. The daily discharge rates of the flows from CPC during August 21 through September 5 were estimated using the average discharge rates from the historical data. The estimated average daily discharge rates were 6.8 MGD at CP-2AT and 0.19 MGD at CP-6AT. The flow rates at SW12 were not measured.

The daily flow rate of centrate was estimated by subtracting wet sludge cake volume from the daily sludge volume pumped through the post-digestion centrifuges. The daily sludge volume and the weight of wet sludge cake were obtained from the M&O Department operation records. The specific gravity of the wet sludge cake was assumed to be 1.0 in the calculation of the wet sludge cake volume.

The recorded daily overflow rates from LASMA during August 22 to 28, 2000 averaged 2.84 MGD, ranging from 2.77 to 2.92 MGD, according to the flow chart obtained from the M&O Department operation records. In absence of the availability of the actual flow rate during the study period August 14 though September 5, 2000, a flow rate of 2.84 MGD was used for the study.

The data analysis included the calculations of daily average loading of ammonia and the coefficient of variation of ammonia concentrations. The loading of ammonia generated at each source was calculated using the daily average concentration of ammonia and the corresponding flow rate from each source.

Analysis of Ammonia Spike Incidents

This part of the study focused on whether the amount of ammonia in the influent raw sewage to the Stickney WRP was unusually high and whether the amount of oxygen supplied to the aeration tanks was sufficient to achieve complete nitrification on the days of the incidents. The historical data for ammonia and BOD_5 entering the aeration tanks a few days before and after the two incidents were collected. In addition, data on the quantity of air supplied and DO concentration in the aeration tanks were also examined. Analytical data were obtained from LIMS. The hourly sewage flows entering the Stickney Southwest plant and West Side plant, the air flow rates to the aeration tanks, and DO concentration in the aeration tanks on each operation shift were obtained from M&O Department operation records.

The loadings of ammonia and BOD_5 to the Stickney WRP and aeration tanks were calculated using their respective concentrations and flow rates. The daily average concentrations of ammonia nitrogen and BOD_5 in 24-hour composite samples of raw sewage, primary effluent, and Imhoff tank effluent were obtained from LIMS. The daily average flow rates were used to calculate the daily loadings of ammonia and BOD_5, and the shift average flow rates were employed to estimate the loading of ammonia and BOD_5 entering the plant in each shift.

In order to determine the possible cause of ammonia spikes in the final effluent on April 7, 2000 and July 22, 2000, the hourly concentration of ammonia in the final effluent on these two occasions would have been very useful. However, the M&O Department has data only for the incident experienced on July 22, 2000.

DATA ANALYSIS AND DISCUSSION OF RESULTS

Source Investigation

An investigation for sources contributing ammonia to the raw sewage entering the Stickney WRP was conducted during the period August through September 2000. Four major sources contributing ammonia, excluding the domestic sources, were identified as TARP, CPC, Post-DC and LASMA. For two sources, i.e., CPC and LASMA, of the four identified sources, hourly samples were collected during August 14 through September 5 from four sampling stations. Daily mean, minimum and maximum values of ammonia concentrations analyzed for these hourly samples are presented in Appendix Table AI-1.

Hourly sampling for the centrate from Post-DC was unsuccessful. Later, the centrate was sampled 41 times between September 13 and 20, 2000. The summary of ammonia concentrations in the centrate is presented in Appendix Table AI-2.

The routine monitoring data for TARP pumpback volume and ammonia concentrations in the pumpback available from LIMS were used to estimate the ammonia loading from TARP.

The results obtained in this study are analyzed and presented in two parts. The first part includes the total daily ammonia load to the Stickney WRP and the estimated ammonia loading contribution from each of the four major sources. The second part examines the variation in ammonia concentrations.

AMMONIA CONTRIBUTION FROM VARIOUS SOURCES

Table 2 presents the daily ammonia loads to the Stickney WRP and the estimated loads of ammonia from the four major contributing sources during August 14 through September 5, 2000. In Table 2, the daily ammonia loads to the Stickney WRP are the sum of the loads of ammonia to both the Stickney Southwest and West Side plants. During this period, as can be seen in Table 2, the daily average load of ammonia to the Stickney Southwest plant accounted for 77.0 percent of the total load of ammonia to the entire Stickney WRP, ranging from 63.4 to 94.5 percent.

This trend appears to be normal as can be seen from the data from January through July 2000 (Appendix Table AI-3). In January through July of 2000, the daily average load of ammonia to the Stickney Southwest plant accounted for 73.5 percent of the total ammonia load to the Stickney WRP with a range of 50.5 to 91.8 percent. The mean ammonia load to the Stickney WRP was 79,562 pounds per day during this study period, and 82,444 pounds per day for January through July of 2000.

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TABLE 2

AMMONIA LOADS TO THE STICKNEY WRP AND TO THE STICKNEY SOUTHWEST PLANT
AND FROM FOUR MAJOR AMMONIA-CONTRIBUTING SOURCES
AUGUST 14 THROUGH SEPTEMBER 5, 2000

Date	NH_3-N to Stickney lb/d	NH_3-N to SW Plant lb/d	Portion SW/Stickney (%)	TARP NH_3-N lb/d	TARP Portion* (%)	CPC** NH_3-N lb/d	CPC** Portion (%)	POST-DC*** NH_3-N lb/d	POST-DC*** Portion (%)	LASMA NH_3-N lb/d	LASMA Portion (%)
8/14/00	81,870	56,577	69.1	0	0	8,996	11.0	6,762	8.3	20,884	25.5
8/15/00	78,105	60,292	77.2	13,919	17.8	12,472	16.0	5,036	6.5	19,557	25.0
8/16/00	75,295	58,142	77.2	0	0	9,198	12.2	6,693	9.0	16,597	22.0
8/17/00	74,379	52,661	70.8	16,172	21.7	5,964	8.0	6,700	9.1	6,987	9.4
8/18/00	72,102	56,643	78.6	9,883	13.7	6,025	8.4	8,325	11.6	11,306	15.7
8/19/00	75,662	47,993	63.4	10,838	14.3	8,105	10.7	10,332	13.8	13,319	17.6
8/20/00	78,612	54,401	69.2	3,887	4.9	5	0.0	5,343	6.8	15,285	19.4
8/21/00	69,682	46,680	67.0	0	0	ND****	ND	7,583	11.0	18,605	26.7
8/22/00	68,821	48,765	70.9	696	1.0	9,769	14.2	7,740	11.3	13,132	19.1
8/23/00	84,160	67,935	80.7	3,674	4.4	9,721	11.6	9,708	11.6	17,372	20.6
8/24/00	89,034	84,179	94.5	4,622	5.2	7,531	8.5	8,814	10.0	17,822	20.0
8/25/00	72,082	62,924	87.3	1,496	2.1	12,157	16.9	9,201	12.9	17,485	24.3
8/26/00	83,027	66,009	79.5	11,148	13.4	9,185	11.1	9,714	11.8	19,448	23.4
8/27/00	87,695	70,958	80.9	0	0	10,052	11.5	10,172	11.7	17,782	20.3
8/28/00	76,334	58,880	77.1	1,248	1.6	10,972	14.4	11,273	14.9	16,916	22.2
8/29/00	89,801	72,573	80.8	5,034	5.6	8,505	9.5	8,574	9.6	17,986	20.0
8/30/00	83,506	67,913	81.3	0	0	8,416	10.1	9,419	11.4	18,879	22.6
8/31/00	87,085	67,519	77.5	495	0.6	11,068	12.7	9,876	11.4	18,954	21.8
9/5/00	84,431	67,341	79.8	0	0	9,615	11.4	10,731	12.7	19,968	23.6
MEAN	79,562	61,494	77.0	6,393	8.2	8,764	11.0	8,526	10.8	16,752	21.0
MIN.	68,821	46,680	63.4	495	0.6	5	0.0	5,036	6.5	6,987	9.4
MAX.	89,801	84,179	94.5	16,172	21.7	12,472	16.9	11,273	14.9	20,884	26.7
STD. DEV.	6,639	9,609	7.4	5,348	7.1	2,811	3.7	1,795	2.2	3,433	4.0
CV (%)*****	8.3	15.6	9.6	83.6	86.6	32.1	33.7	21.1	20.2	20.5	18.8

*The portion is a ratio of each individual amount to the total amount entering the Stickney WRP in percent.
**CPC = Corn Products Corporation.
***Post-DC = Post-digestion centrate.
****ND = No data.
*****CV based on daily averages.

The ammonia loading from the four major sources studied accounted for 51.0 percent of the total load of ammonia to the Stickney WRP and 66.2 percent of the total load of ammonia to the Stickney Southwest plant on a daily average basis during August 14 through September 5, as can be seen in Table 2. The remaining ammonia load is from predominantly domestic sources. No significant ammonia loading from these four sources enters the Stickney West Side plant. Thus, this ammonia loading is considered as the normal background level.

TARP pumpback only occurs after the tunnel is partially or completely filled. Of the 19 days of this study, TARP pumping took place on 13 days. The ammonia concentrations, which were measured from composite samples, and flow rates for the TARP pumpback between August 14 to September 5, 2000 are given in Appendix Table AI-4. The daily average ammonia loading from TARP pumpback was 6,393 pounds, which represented 8.2 percent of the total amount of ammonia to the Stickney WRP.

CPC is a continuous, ammonia-contributing source to the Stickney WRP. Two streams of wastewater are discharged into the sewer at CPC, both of which were monitored for ammonia concentrations between August 14 and September 5, 2000. The daily average ammonia concentrations, which were the arithmetic mean values of the hourly samples, and discharge rates from the two locations at CPC are given in Appendix Table AI-5. As shown in Table 2, the daily average quantity of ammonia generated at CPC during this study period was 8,764 pounds accounting for 11.0 percent of the total ammonia load to the Stickney WRP.

The centrate from the post-digestion centrifuges at the Stickney WRP is also a continuous source and is discharged to the Stickney Southwest plant. The daily flow rate of centrate was estimated by subtracting wet sludge cake volume from the daily sludge volume pumped through the post-digestion centrifuges. The average ammonia concentration of 564 mg/L in the centrate, as shown in Appendix Table AI-2, was used to estimate the ammonia loading to the Stickney Southwest plant through post-digestion centrate. The data for estimating the daily ammonia loads from Post-DC can be found in Appendix Table AI-6. The daily average ammonia loading rate to the Stickney Southwest plant from the centrate was 8,526 pounds accounting for 10.8 percent of the total ammonia entering the Stickney WRP (see Table 2).

The overflow from the sludge lagoons at LASMA contains high concentrations of ammonia, averaging 701 mg/L, as can be seen in Table AI-1. The overflow from LASMA also returns to the Stickney Southwest plant. The daily average ammonia loading rate from LASMA was computed using the daily mean ammonia concentrations, which were the arithmetic averages of hourly concentrations and the average daily flow rates recorded by the M&O Department. The data used for this calculation are presented in Appendix Table AI-7. The average daily load of ammonia from LASMA to the Stickney Southwest plant between August 14 to September 5, 2000 was 16,752 pounds, representing 21.0 percent of the total ammonia loading entering the Stickney WRP during that period (Table 2).

In summary, during the sampling period August 14 to September 5, 2000, LASMA contributed 16,752 pounds per day ammonia to the Stickney Southwest plant, which is the largest contributor of ammonia of all the four major sources considered. CPC ranked second with an average rate of 8,764 pounds per day. Post-digestion centrate and TARP pumpback ranked third and fourth with average rates of ammonia generation of 8,526 and 6,393 pounds per day, respectively. The sum of ammonia from these four sources accounted for nearly 51 percent of the total amount entering the Stickney WRP or about 66 percent of the amount entering the Stickney Southwest plant during the period of this investigation.

VARIATION OF AMMONIA CONCENTRATIONS IN AMMONIA CONTRIBUTING SOURCES

The daily variation of the ammonia loads to the Stickney WRP along with the ammonia loads from the four major sources during August 14 through September 5, 2000 is also given in Table 2. The daily ammonia load to the Stickney WRP varied from 68,821 to 89,801 pounds of ammonia per day with a mean of 79,562 pounds per day during this period. The coefficient of variation (CV) of the daily ammonia loads to the Stickney WRP was 8.5 percent. Compared to this variation in the total amount of ammonia entering the Stickney WRP, the variation in the amounts of ammonia contribution from the four major sources during the same period was significantly higher. The CVs of daily ammonia loads from TARP, CPC, Post-DC and LASMA were 83.6, 32.1, 21.1 and 20.5 percent, respectively, as shown in Table 2.

The daily load of ammonia from TARP had the widest range in the percentage of the proportion of the contribution of the total ammonia load to the Stickney WRP among the four major sources, ranging from 0.6 to 21.7 percent. As the ammonia concentrations in TARP pumpback were measured from composite samples, hourly variation of ammonia load from TARP pumpback could not be computed. TARP pumpback usually occurs for a few hours at night during weekdays and daytime on weekends. As the daily amount of ammonia from TARP is typically discharged in a few hours, the actual impact of ammonia from TARP to the Stickney WRP could be significant during certain periods of TARP pumping.

The variation of daily amounts of ammonia from CPC ranked second with a CV of 32.1 percent. The hourly variation of ammonia from CPC was estimated using the hourly concentrations measured during August 14 to September 5, 2000. Three sampling stations, CP-2AT, CP-6AT, and SW12, were set up during the sampling period to monitor the hourly changes of ammonia concentrations from CPC. The summary of ammonia concentrations measured at these three stations during the sampling period is presented in Appendix Table AI-1. Of the two stations at CPC, where the wastewater from CPC is discharged into the sewer, CP-2AT has higher mean ammonia concentration and higher discharge rate, accounting for about 97 percent of the total ammonia discharge from CPC. Therefore, only the hourly ammonia concentrations at CP-2AT were used for analysis of the variation in ammonia concentrations for CPC. Station SW12 is a sewer interceptor downstream of CPC. The lower mean concentration at SW12, compared to that at CP-2AT, as shown in Table 3, was likely due to the dilution by sewage and/or

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TABLE 3

SUMMARY OF AMMONIA DATA FROM VARIOUS SOURCES
AUGUST 14 THROUGH SEPTEMBER 5, 2000

Parameter	NH_3-N Concentrations (mg/L)				
	CP-2AT	CP-6AT	SW12	POST-DC*	LASMA
No. of Samples	371	454	444	41	444
Mean	159.69	8.78	63.70	572.4	712.28
Min.	0.06	0.01	0.04	428.5	48.00
Max.	655.59	489.35	249.80	706.4	1,009.01
Standard Deviation	118.74	51.65	44.41	84.0	169.07
CV** (%)	74.4	588.4	69.7	14.7	23.7

*POST-DC = Post-digestion centrate. Samples collected September 13-20, 2000.

**CV = Coefficient of variation based on hourly samples.

infiltration in the sewer. As CPC is the main ammonia contributor in this area, the variation of ammonia concentrations at SW12 should reflect the variation of the amount of ammonia discharged from CP-2AT.

Figures 2 through 4 present the hourly ammonia concentrations measured at CP-2AT and SW12 during the sampling period of August 14 to September 1, 2000. As can be seen in these figures, the hourly ammonia concentrations at both CP-2AT and SW12 varied substantially, and most of the peaks at these two locations matched closely. The peaks at CP-2AT were relatively sharper, compared to those at the downstream location SW12. The peaks at both locations generally lasted only a few hours. The variation of ammonia concentrations at both locations appeared to be random, and no clear pattern of daily variations could be established. The daily average ammonia concentrations at these two locations, as given in Table AI-1, were less variable, compared to the hourly concentrations, as given in Table 3, 32.5 percent of CV for daily versus 74.4 percent for hourly at CP-2AT and 21.0 percent versus 69.7 percent at SW12.

The ammonia load contributed by the post-digestion centrifuges depends upon the flow rate of centrate, which in turn depends on the number of centrifuges working at a certain

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FIGURE 2

HOURLY AMMONIA CONCENTRATIONS AT CP-2AT AND SW12
AUGUST 14 THROUGH 20, 2000

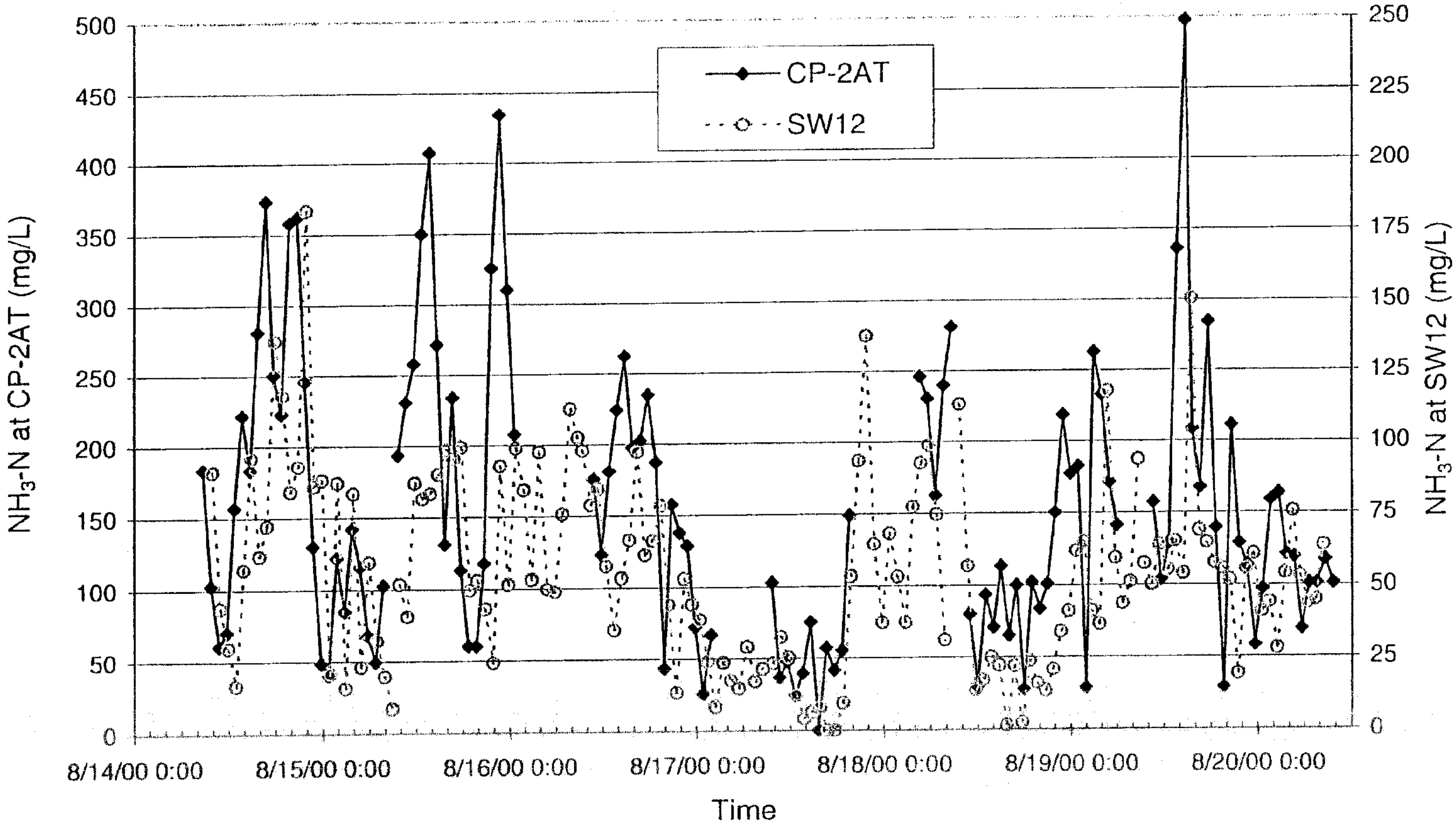

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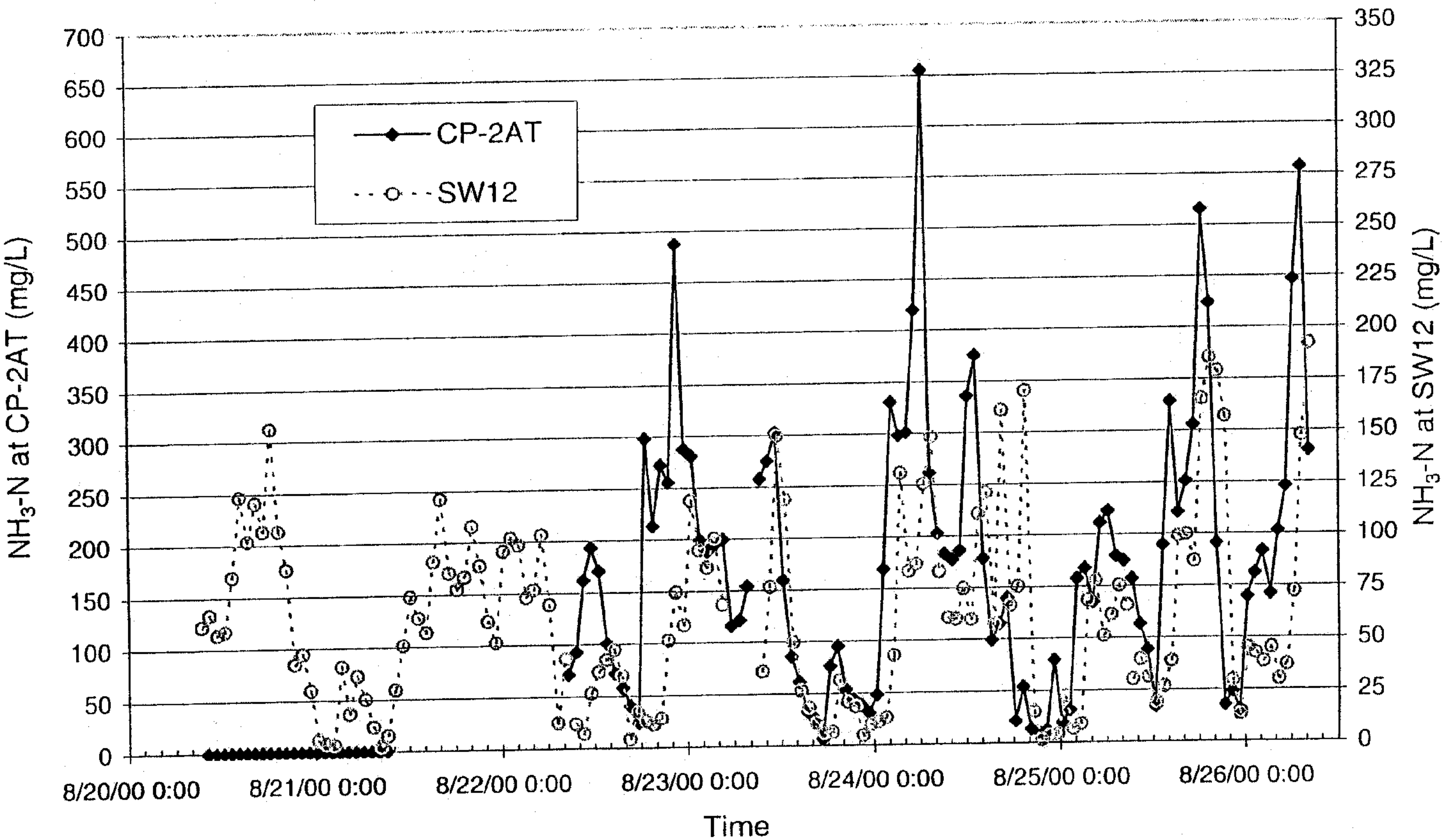
FIGURE 3

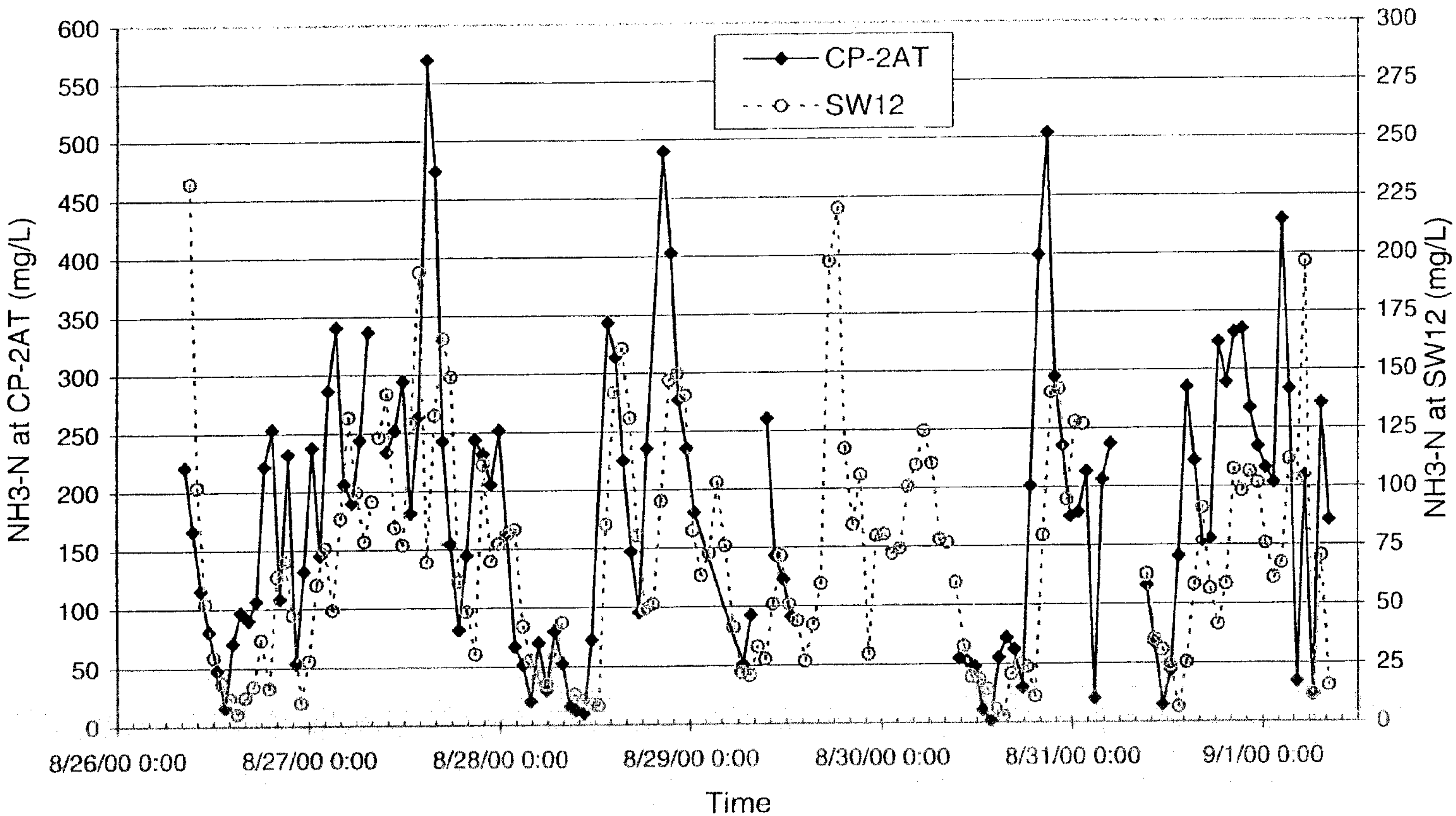
HOURLY AMMONIA CONCENTRATIONS AT CP-2AT AND SW12
AUGUST 20 THROUGH 26, 2000



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 4

HOURLY AMMONIA CONCENTRATIONS AT CP-2AT AND SW12
AUGUST 26 THROUGH SEPTEMBER 1, 2000



time, as the ammonia concentrations of the centrate from Post-DC are relatively less variable. The mean ammonia concentration in centrate from Post-DC was 564 mg/L, ranging from 430 to 710 mg/L, based on the analysis of 41 grab samples during the five-day sampling period in September 2000. The variation in daily amount of ammonia from Post-DC ranked third with a CV of 21.1 percent.

The hourly ammonia concentrations at LASMA during the sampling period of August 14 through September 1, 2000 are presented in Figures 5 through 7. As can be seen from these figures, the hourly ammonia concentrations in the overflow from the sludge lagoons at LASMA had less variation than CPC. Of the four sampling stations, LASMA had the smallest variation in hourly ammonia concentrations with a CV of 23.7 percent, as shown in Table 3. It may be noted that the CV for sampling at Post-DC was not included in this comparison as sample size was much smaller at this location. According to the M&O Department operation records from April 25 to August 29 of 2000, the hourly overflow rates from the sludge lagoons at LASMA were relatively constant. Therefore, the variation in the ammonia load from LASMA was small.

In summary, based on the analysis of the data collected during this investigation, the average amounts of ammonia

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 5

HOURLY AMMONIA CONCENTRATIONS IN THE OVERFLOW FROM LASMA
AUGUST 14 THROUGH 20, 2000

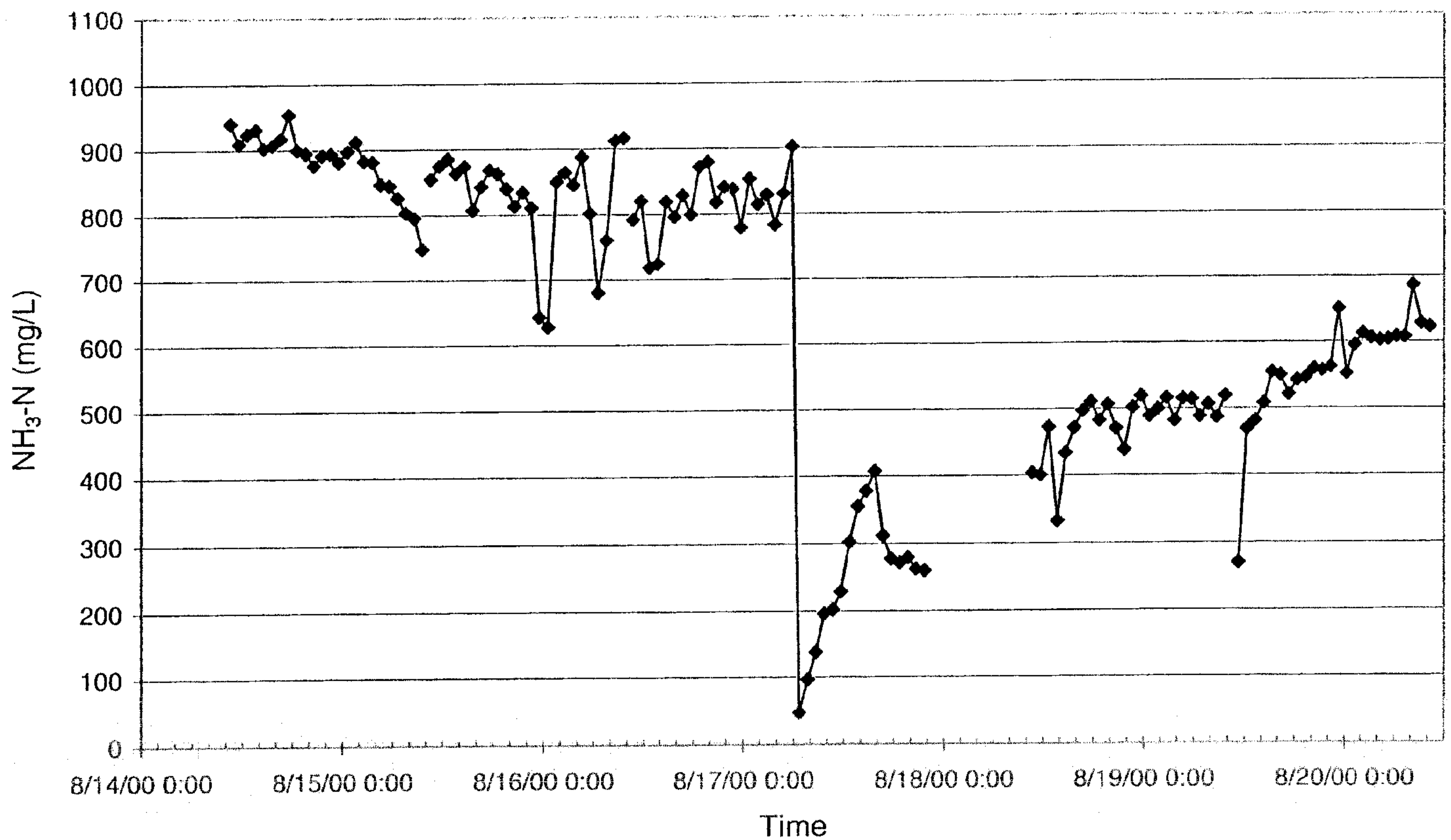


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FIGURE 6

HOURLY AMMONIA CONCENTRATIONS IN THE OVERFLOW FROM LASMA
AUGUST 20 THROUGH 26, 2000

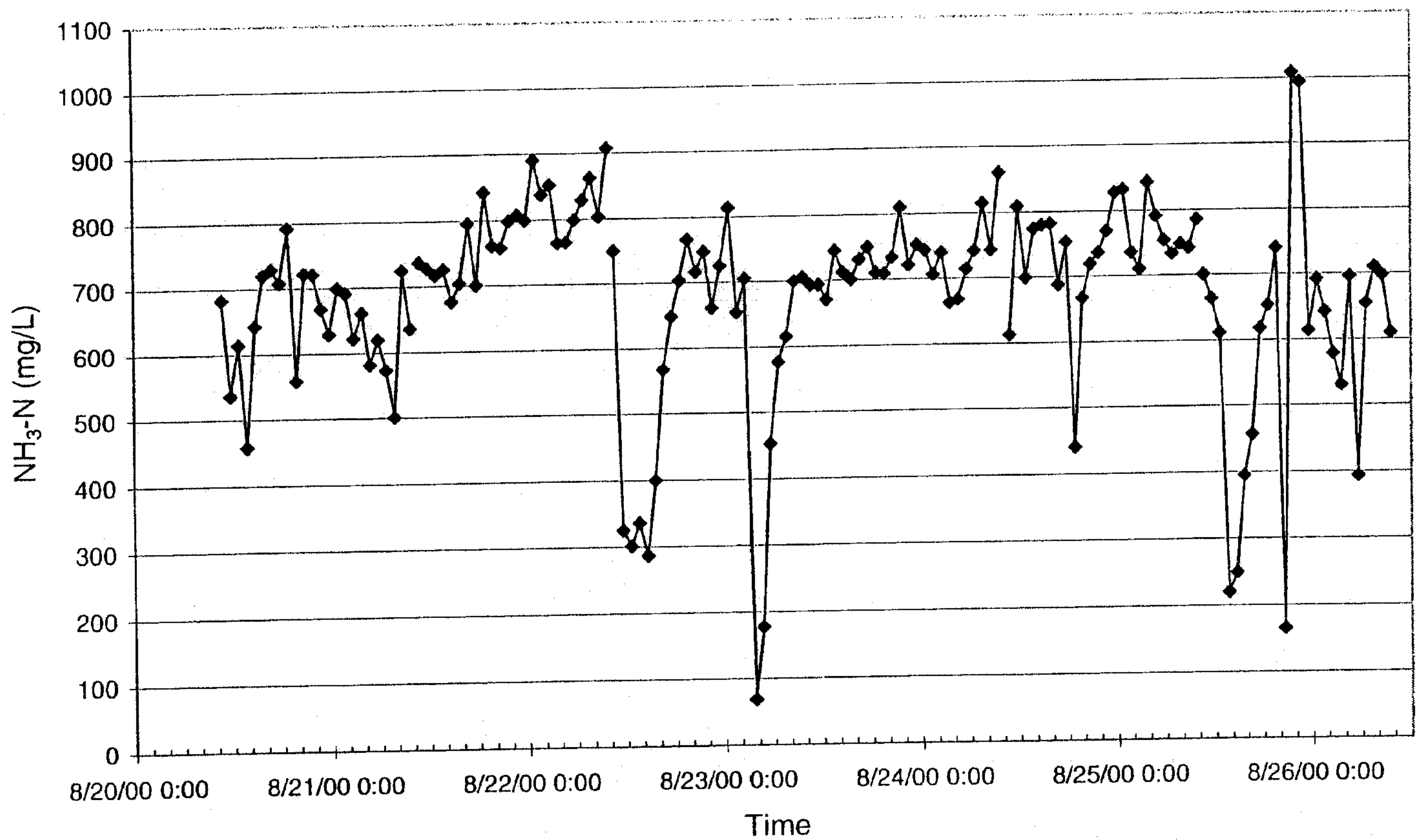

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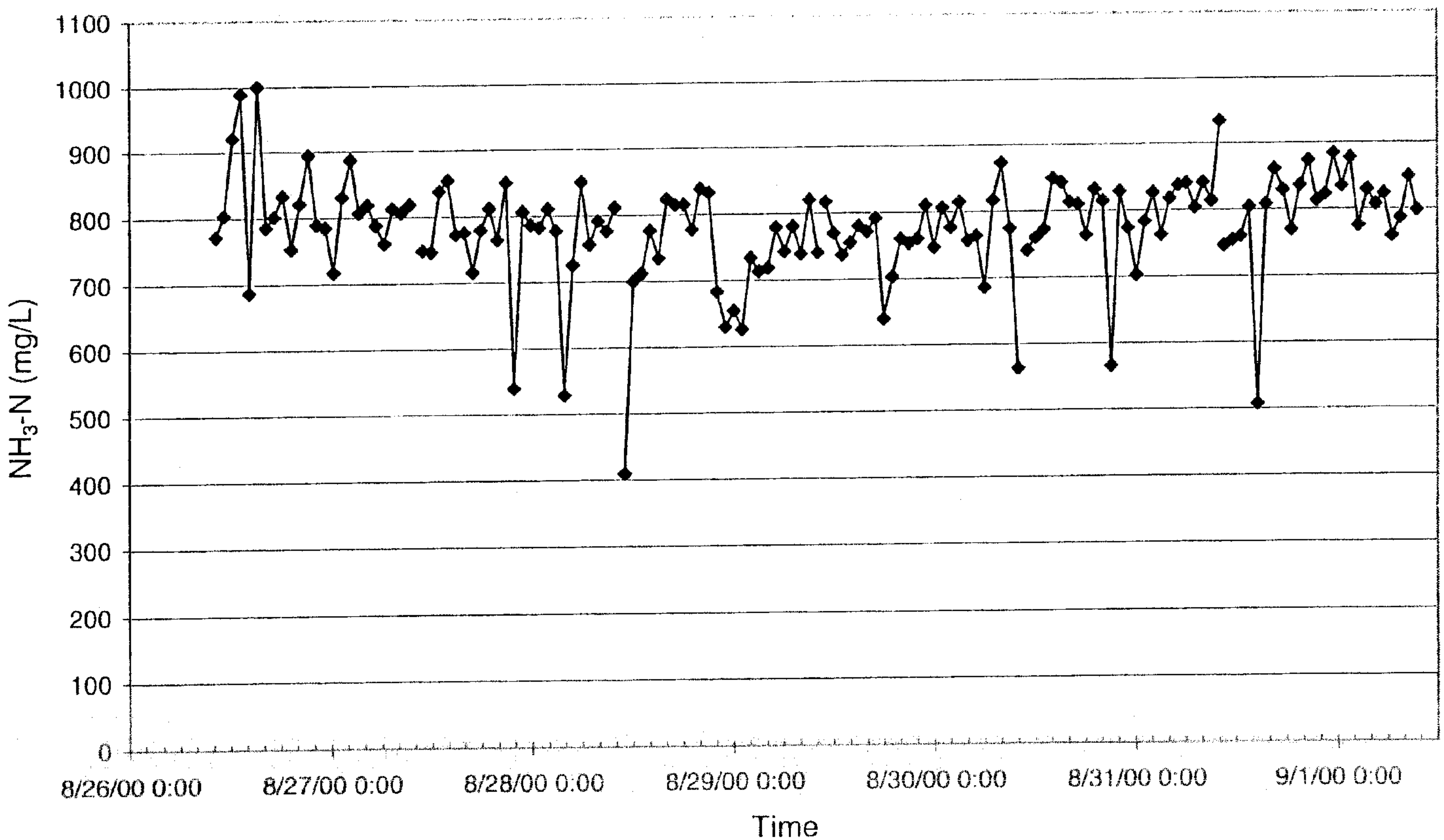
FIGURE 7

HOURLY AMMONIA CONCENTRATIONS IN THE OVERFLOW FROM LASMA
AUGUST 26 THROUGH SEPTEMBER 1, 2000



produced from the four sources, TARP, CPC, Post-DC and LASMA, were 6,393, 8,764, 8,526, and 16,752 pounds per day, respectively, during August 14 to September 5, 2000. During the same period, the average ammonia load to the Stickney WRP was 79,562 pounds per day, including 18,068 pounds per day of ammonia to the Stickney West Side plant, which can be considered as background ammonia from sewage in the service area.

The daily variation in ammonia from the TARP pumpback was the highest with a CV of 83.6 percent, and the lowest from LASMA with 20.5 percent. The hourly variation of ammonia concentrations in the wastewater discharged from CPC was substantial. However, the peak concentrations usually lasted for a very short period of time, and the peaks tended to be slightly spread when the wastewater flowed to a downstream interceptor, namely SW12. The hourly ammonia concentrations in the overflow from LASMA were less variable, compared to those from CPC and interceptor SW12. Similar trend was noted in Post-DC samples, although they were sampled less frequently.

Analysis of Two Incidents of Ammonia Spikes in the Stickney WRP Final Effluent

APRIL 7 INCIDENT

Table 4 presents the daily average BOD_5 and ammonia loads to the aeration tanks at the Stickney WRP between April 1 to

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

DAILY BOD_5 AND AMMONIA LOADS TO THE STICKNEY WRP
APRIL 1 THROUGH 14, 2000

	WS IMEF*		SW PREF**		Sewage Flow		BOD_5 Load			NH_3-N Load			Effluent
	BOD_5	NH_3-N	BOD_5	NH_3-N	WS	SW	WS	SW	Total	WS	SW	Total	NH_3-N
Date	mg/L	mg/L	mg/L	mg/L	MGD	MGD	K lb/d	K lb/d	K lb/d	K lb/d	K lb/d	K lb/d	mg/L
4/1/00	94	10.60	320	23.18	315	317	246.9	846.0	1,093.0	27.8	61.3	89.1	0.27
4/2/00	49	9.23	247	28.59	249	230	101.8	473.8	575.6	19.2	54.8	74.0	0.20
4/3/00	119	9.43	200	27.80	312	228	309.6	380.3	690.0	24.5	52.9	77.4	0.10
4/4/00	84	9.43	245	29.32	255	273	178.6	557.8	736.5	20.1	66.8	86.8	0.71
4/5/00	102	9.46	318	23.78	253	344	215.2	912.3	1,127.6	20.0	68.2	88.2	2.82
4/6/00	90	10.10	210	13.85	211	365	158.4	639.3	797.6	17.8	42.2	59.9	0.13
4/7/00	100	10.90	157	26.12	280	597	233.5	781.7	1,015.2	25.5	130.1	155.5	5.81
4/8/00	93	5.14	149	10.15	413	567	320.3	704.6	1,024.9	17.7	48.0	65.7	0.35
4/9/00	70	5.85	187	16.39	341	381	199.1	594.2	793.3	16.6	52.1	68.7	0.06
4/10/00	77	7.31	220	21.04	313	354	201.0	649.5	850.5	19.1	62.1	81.2	0.06
4/11/00	94	8.78	250	18.57	250	446	196.0	929.9	1,125.9	18.3	69.1	87.4	0.26
4/12/00	82	9.02	203	16.36	267	432	182.6	731.4	914.0	20.1	58.9	79.0	0.32
4/13/00	80	9.35	262	16.71	271	403	180.8	880.6	1,061.4	21.1	56.2	77.3	0.18
4/14/00	118	9.51	560	23.97	219	352	215.5	1644.0	1,859.5	17.4	70.4	87.7	1.26
AVERAGE	89	8.87	252	21.13	282	378	210.0	766.1	976.1	20.4	63.8	84.1	0.90
MIN	49	5.14	149	10.15	211	228	101.8	380.3	575.6	16.6	42.2	59.9	0.06
MAX	119	10.90	560	29.32	413	597	320.3	1644.0	1,859.5	27.8	130.1	155.5	5.81

*WS IMEF = Effluent from Imhoff tanks at the West Side plant.
**SW PREF = Effluent from preliminary settling tanks at the Southwest plant.

14, 2000. The calculated daily BOD_5 load on April 7 was 1,015 thousand pounds per day (Klb/d), which was slightly higher than average, as shown in Table 4, but was not the highest during this period. However, the calculated daily ammonia load on April 7 was 155.5 Klb/d, which was extremely high, compared to the average of 84.1 Klb/d during the first two weeks of April of 2000.

Table 5 presents the shift average data for sewage flows, BOD_5 loads, ammonia loads, air flows to the aeration tanks, ratios of air to oxygen-consuming waste, and daily average ammonia concentrations in the final effluent. The ratio of air to oxygen-consuming waste is calculated by dividing air flow rate by BOD_5 load plus 4.6 times ammonia load, because oxidizing a pound of ammonia to nitrate requires 4.6 pounds of oxygen. The ratio of air to oxygen-consuming waste can be used for comparison purposes, as to whether or not sufficient air is supplied for degradation of the organic waste and ammonia in the aeration tanks. As can be seen in Table 5, the ammonia load increased from 112.3 Klb/day to 145.8 Klb/day from first shift to second shift on April 7 and to 200.5 Klb/day in the third shift. This increase in oxygen consuming waste load led to the decrease in the ratio of air to oxygen-consuming substances. More air was provided to the system beginning at

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

SHIFT AVERAGES OF FLOW RATES, BOD_5, AMMONIA LOADS, AND AIR FLOW RATES
TO THE STICKNEY WRP AERATION TANKS
APRIL 4 THROUGH 8, 2000

Shift	Flow Rate (MGD)			BOD_5 Load (K lb/d)			NH_3 Load (K lb/d)			Air Flow	Air/Waste	Final NH_3-N
	WS	SW	Total	WS	SW	Total	WS	SW	Total	(kcfm)	(ft^3/lb)	(mg/L)
4/4 1st	349	321	670	245	655	900	27.5	78.4	105.9	425	441	
4/4 2nd	227	210	437	159	429	588	17.8	51.4	69.2	425	675	
4/4 3rd	210	241	451	147	492	639	16.5	58.8	75.4	426	623	0.71
4/5 1st	311	548	859	264	1454	1718	24.5	108.7	133.2	426	263	
4/5 2nd	263	258	520	223	683	906	20.7	51.1	71.8	423	493	
4/5 3rd	190	205	395	162	544	705	15.0	40.7	55.6	425	637	2.82
4/6 1st	191	406	597	143	712	855	16.1	46.9	63.0	422	531	
4/6 2nd	209	259	468	157	453	610	17.6	29.9	47.5	425	739	
4/6 3rd	235	401	636	176	703	879	19.8	46.3	66.1	423	515	0.13
4/7 1st	196	434	630	164	568	732	17.8	94.5	112.3	424	489	
4/7 2nd	243	568	751	203	744	946	22.1	123.7	145.8	423	377	
4/7 3rd	373	765	1138	311	1002	1312	33.9	166.6	200.5	588	379	5.81
4/8 1st	403	811	1214	312	1008	1320	17.3	68.7	85.9	593	498	
4/8 2nd	404	458	862	314	569	882	17.3	38.7	56.1	594	750	
4/8 3rd	439	464	903	341	576	917	18.8	39.3	58.1	590	717	0.35

7:20 p.m. on April 7, 2000, when a third blower was put in service. However, the estimated ratio of air to oxygen-consuming substances did not show an improvement until the morning of April 8, 2000.

Figure 8 presents the hourly sewage flow rates to the Stickney WRP during April 5 to 8, 2000. As can be seen, the total sewage flow started surging from 12:00 noon on April 7 and went over 1,200 MGD at 2:00 p.m. and stayed above 1,000 MGD for the rest of the day due to the rainfall on this day. As the hourly ammonia concentrations in the final effluent are unavailable, the time of actual high ammonia concentration leading to daily average ammonia concentration of 5.81 mg/L in the final effluent on April 7 cannot be pinpointed. However, it can be said that a combination of the high sewage flow and high concentrations of BOD_5 and ammonia in the sewage on April 7 may have been responsible for carrying high amounts of oxygen-consuming waste, particularly ammonia, into the treatment plant, leading to insufficient oxygen in the aeration tanks to oxidize the amount of ammonia in the tanks.

Table 6 presents the shift average operation data for sewage and air flows to each aeration battery, DO values recorded half an hour before the end of each shift from DO probes installed in the selected aeration tanks, and the

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FIGURE 8

HOURLY SEWAGE FLOW TO THE STICKNEY WRP
APRIL 5 THROUGH 8, 2000

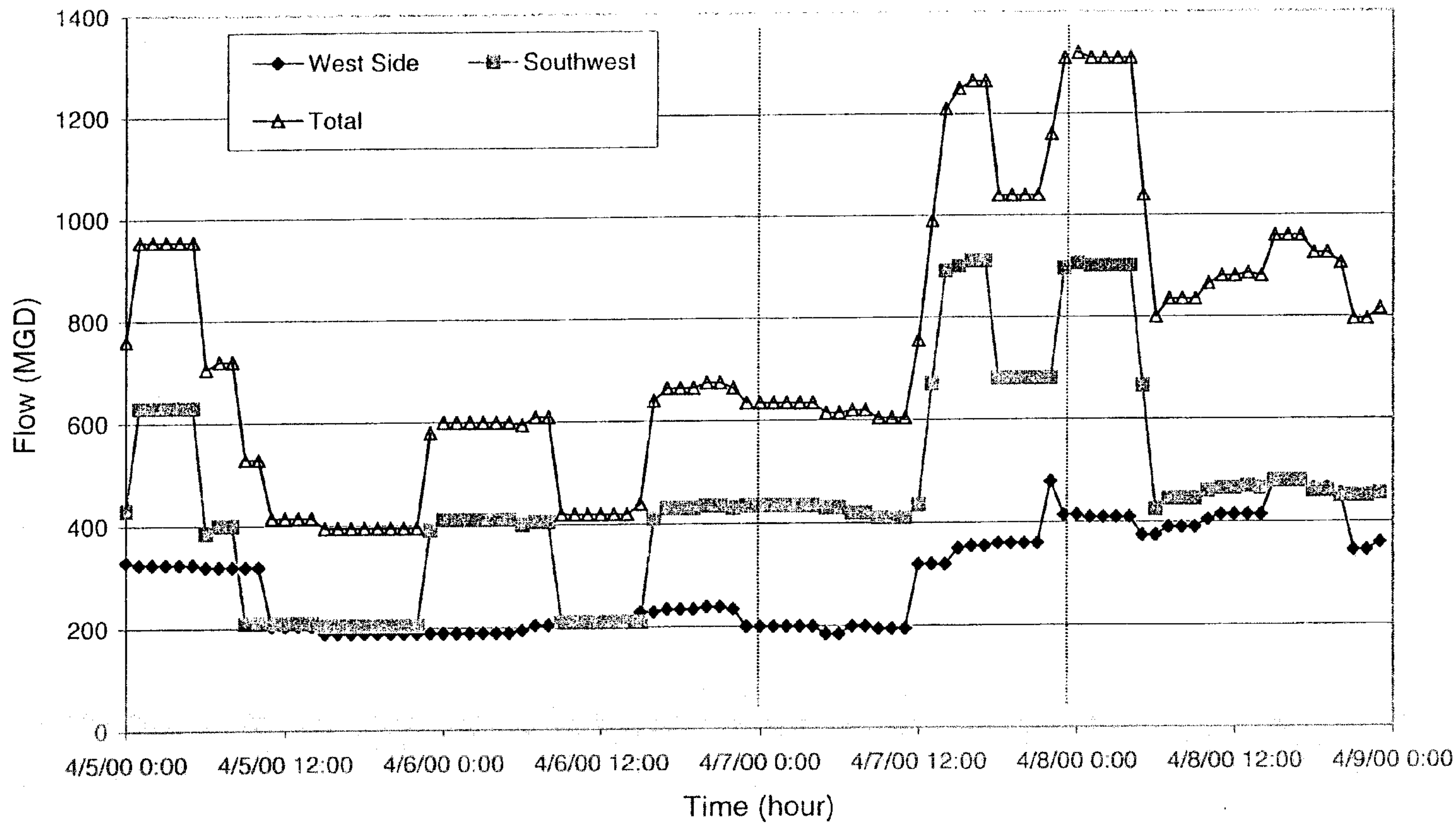

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TABLE 6

OPERATING DATA FOR AERATION BATTERIES AT THE STICKNEY WRP
APRIL 3 THROUGH 8, 2000

Date	Shift	Sewage Flow (MGD)	Air Flow (Kcfm)	Air/Sewage Ratio ft^3/gal	DO(mg/L) Tank 1 Pass 2	DO(mg/L) Tank 1 Pass 4	DO(mg/L) Tank 4 Pass 2	DO(mg/L) Tank 4 Pass 4	DO(mg/L) Tank 6 Pass 2	DO(mg/L) Tank 6 Pass 4	Average DO* (mg/L)
Battery A											
4/3/00	1	142	104	1.06	3.7	9.6	6.4	10.0	8.1	9.7	7.9
	2	106	105	1.42	5.0	9.5	8.6	9.9	8.9	9.9	8.6
	3	148	106	1.03	6.9	9.9	9.9	9.9	9.9	9.9	9.4
4/4/00	1	166	106	0.92	2.4	9.9	3.7	10.0	4.9	10.0	6.8
	2	99	105	1.53	3.5	3.5	6.5	7.9	7.9	8.8	6.4
	3	106	105	1.42	4.0	9.0	8.0	9.0	9.0	6.0	7.5
4/5/00	1	225	105	0.67	2.5	9.8	4.3	10.0	5.3	10.0	7.0
	2	114	104	1.32	0.9	1.0	0.9	0.9	1.3	1.3	1.1
	3	93	105	1.63	4.7	8.7	8.9	9.1	8.8	9.0	8.2
4/6/00	1	150	104	1.00	2.1	8.8	6.2	9.4	7.6	9.3	7.2
	2	108	104	1.39	1.2	4.8	1.3	7.8	2.4	8.8	4.4
	3	168	105	0.90	7.7	8.8	9.9	9.2	9.1	9.1	9.0
4/7/00	1	153	105	0.99	0.8	1.0	0.6	1.3	0.8	7.2	2.0
	2	212	105	0.71	0.6	0.4	0.3	0.3	0.4	0.4	0.4
	3	290	139	0.69	0.6	0.5	0.4	0.5	0.5	0.9	0.6
4/8/00	1	308	140	0.65	1.9	2.5	2.7	2.8	3.2	4.5	2.9
	2	228	140	0.88	5.4	8.5	7.2	7.9	5.5	7.3	7.0
	3	224	139	0.89	6.4	9.9	9.1	9.9	8.8	9.9	9.0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6 (Continued)

OPERATING DATA FOR AERATION BATTERIES AT THE STICKNEY WRP
APRIL 3 THROUGH 8, 2000

Date	Shift	Sewage Flow (MGD)	Air Flow (Kcfm)	Air/Sewage Ratio ft^3/gal	DO(mg/L) Tank 1 Pass 2	Tank 1 Pass 4	Tank 4 Pass 2	Tank 4 Pass 4	Tank 6 Pass 2	Tank 6 Pass 4	Average DO* (mg/L)
Battery B											
4/3/00	1	140	105	1.08	7.5	8.8	7.5	10.0	9.3	9.6	8.8
	2	106	104	1.41	8.1	9.0	7.2	8.0	9.8	9.8	8.7
	3	147	104	1.02	0.1	9.0	8.8	9.9	9.9	9.9	7.9
4/4/00	1	165	104	0.91	4.4	9.1	3.1	10.0	5.1	9.9	6.9
	2	99	106	1.55	1.2	5.8	5.5	8.5	7.3	8.4	6.1
	3	105	107	1.47	7.0	9.2	6.3	8.1	7.0	9.2	7.8
4/5/00	1	221	107	0.70	0.1	9.0	4.0	10.0	6.2	10.0	6.6
	2	116	107	1.33	1.9	1.7	1.2	1.8	2.0	1.2	1.6
	3	93	107	1.67	8.4	7.5	9.3	9.2	9.4	8.7	8.8
4/6/00	1	146	107	1.05	0.1	8.0	7.1	9.4	8.8	9.0	7.1
	2	109	108	1.43	3.7	7.1	2.5	8.8	4.1	8.6	5.8
	3	167	108	0.93	0.1	8.0	9.9	9.5	9.7	9.2	7.7
4/7/00	1	149	108	1.05	0.1	4.6	1.3	6.3	2.2	7.8	3.7
	2	208	108	0.75	0.9	1.5	0.6	0.9	1.0	0.6	0.9
	3	289	146	0.73	0.1	0.3	0.6	0.1	1.1	0.8	0.5
4/8/00	1	289	146	0.73	0.1	4.1	4.6	5.1	4.9	4.5	3.9
	2	206	153	1.07	9.0	9.0	9.0	9.0	9.5	10.0	9.3
	3	222	146	0.95	0.1	9.9	9.9	9.9	9.9	9.9	8.3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6 (Continued)

OPERATING DATA FOR AERATION BATTERIES AT THE STICKNEY WRP
APRIL 3 THROUGH 8, 2000

		Sewage	Air	Air/Sewage	DO(mg/L)						Average
		Flow	Flow	Ratio	Tank 1		Tank 4		Tank 6		DO*
Date	Shift	(MGD)	(Kcfm)	ft^3/gal	Pass 2	Pass 4	Pass 2	Pass 4	Pass 2	Pass 4	(mg/L)
Battery C											
4/3/00	1	146	101	1.00	3.7	10.0	7.5	9.4	9.0	10.0	8.3
	2	108	102	1.37	8.4	9.7	7.6	9.7	9.2	9.6	9.0
	3	144	101	1.01	9.7	9.9	7.8	9.8	9.9	9.9	9.5
4/4/00	1	158	102	0.93	2.7	10.0	4.7	10.0	4.8	10.0	7.0
	2	98	101	1.48	7.5	8.8	7.0	8.9	8.6	8.6	8.2
	3	100	101	1.45	9.0	9.0	7.9	8.1	7.8	9.0	8.5
4/5/00	1	204	101	0.71	4.7	10.0	6.0	10.0	6.4	10.0	7.9
	2	111	100	1.29	0.9	3.3	1.6	2.7	1.3	1.4	1.9
	3	83	101	1.75	9.1	9.1	7.6	9.2	9.2	9.2	8.9
4/6/00	1	111	100	1.29	7.8	10.0	7.0	9.6	8.6	10.0	8.8
	2	104	101	1.40	1.5	9.3	2.7	9.0	2.3	7.9	5.5
	3	163	98	0.87	9.0	9.9	7.4	9.8	9.4	9.9	9.2
4/7/00	1	141	98	1.00	0.6	4.5	0.7	7.6	0.9	7.4	3.6
	2	186	98	0.76	0.3	1.0	0.9	0.9	0.6	1.1	0.8
	3	287	137	0.69	0.5	2.0	0.6	1.8	0.6	1.3	1.1
4/8/00	1	291	138	0.68	3.2	7.0	2.9	6.5	3.2	7.0	5.0
	2	209	135	0.93	7.5	10.0	7.1	10.0	6.5	10.0	8.5
	3	219	136	0.89	7.6	9.9	7.0	9.9	8.5	9.9	8.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6 (Continued)

OPERATING DATA FOR AERATION BATTERIES AT THE STICKNEY WRP
APRIL 3 THROUGH 8, 2000

Date	Shift	Sewage Flow (MGD)	Air Flow (Kcfm)	Air/Sewage Ratio ft^3/gal	DO (mg/L) Tank 1 Pass 2	DO (mg/L) Tank 1 Pass 4	DO (mg/L) Tank 4 Pass 2	DO (mg/L) Tank 4 Pass 4	DO (mg/L) Tank 6 Pass 2	DO (mg/L) Tank 6 Pass 4	Average DO* (mg/L)
----Battery D----											
4/3/00	1	163	113	1.00	1.7	5.9	1.5	1.5	0.9	6.8	3.1
	2	112	113	1.45	3.0	6.5	3.6	8.5	1.6	7.1	5.1
	3	133	113	1.22	3.4	6.7	5.4	5.1	2.6	0.1	3.9
4/4/00	1	173	113	0.94	1.0	5.8	1.0	1.3	0.8	6.0	2.7
	2	125	113	1.30	2.3	6.1	3.2	6.0	1.3	6.9	4.3
	3	165	113	0.99	1.6	6.3	1.3	1.7	1.0	7.2	3.2
4/5/00	1	219	113	0.74	1.3	3.0	0.9	0.8	0.9	0.1	1.2
	2	139	112	1.16	0.8	0.9	0.6	0.7	0.6	1.7	0.9
	3	150	112	1.08	1.3	6.5	4.5	3.0	1.1	7.0	3.9
4/6/00	1	193	111	0.83	0.8	5.9	0.8	1.5	0.6	0.1	1.6
	2	126	112	1.28	0.8	5.7	1.8	2.6	0.7	5.8	2.9
	3	164	112	0.98	5.5	6.5	6.8	5.0	4.9	0.1	4.8
4/7/00	1	185	113	0.88	0.7	4.4	0.7	3.4	0.6	5.1	2.5
	2	224	112	0.72	0.3	0.3	0.4	0.5	0.3	0.1	0.3
	3	279	166	0.86	0.7	0.5	0.5	0.6	0.6	0.1	0.5
4/8/00	1	266	169	0.91	4.4	7.0	6.6	3.3	4.7	0.1	4.4
	2	234	166	1.02	8.3	9.5	8.8	9.4	9.0	9.8	9.1
	3	219	169	1.11	7.7	9.6	9.9	8.0	7.7	0.1	7.2

*Average DO was computed based on six measured DO values in Tanks 1, 4, and 6.

average DO values for each battery. The average DO for each battery on each shift was calculated based on six values obtained from six DO probes. The average DO values for all the aeration batteries on the second and third shifts of April 7 were 0.6 and 0.7 mg/L, respectively, which were much lower than the average DO values of above 2 mg/L on the other shifts between April 3 to 8. It is speculated that the unusually large amounts of oxygen-consuming waste carried to the aeration tanks by the surge of sewage flow through the first flush of the sewers caused the low DO situation in the aeration tanks. At this low DO level, as low as 0.6 mg/L, nitrification of the wastewater must have been seriously impaired.

It appears that the combination of high ammonia load in the influent and low DOs in the aeration tanks caused the average daily ammonia concentration in the final effluent to be as high as 5.81 mg/L due to impaired nitrification. Most likely, the unusually high load of ammonia to the Stickney WRP was due to the first flush in the sewer system, which also brought higher-than-average amount of BOD_5 to the plant. This surge of raw sewage flow to the Stickney WRP from 600 to 1,200 MGD occurred during the second shift on April 7, and lasted until the first shift on April 8, 2000, because of the rainfall starting at 10:00 a.m. on April 7.

An effluent NH_3-N concentration of 2.82 mg/L, which was the second highest value observed during this period, occurred on April 5, 2000, and was associated with a high BOD_5 loading rate of 1127.6 Klb/d and a low average DO concentration, ranging from 0.9 to 1.9 in the batteries during some shifts.

JULY 22 INCIDENT

Table 7 presents the daily average BOD_5 and ammonia loads to the aeration tanks at the Stickney WRP between July 16 and 29, 2000, covering July 22, the day of the incident. The calculated daily BOD_5 load of 685 Klb/d on July 22 was about 23 percent higher than the average, as shown in Table 7, but not the highest (778 Klb/d) during this period. The calculated daily ammonia load of 97.1 Klb/d on July 22 was the third highest between July 16 and 29, 2000.

Table 8 presents the shift average data for sewage flows, BOD_5 loads, ammonia loads, air flows to the aeration tanks, ratios of air to oxygen-consuming waste, and daily average ammonia concentrations from daily composite samples in the final effluent. As can be seen, the first shift on July 22, 2000 had the highest BOD_5 and ammonia loads of the day, which resulted in 448 cubic feet air per pound of oxygen consuming waste, which was very low, compared to 579 cubic feet per

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7

DAILY BOD_5 AND AMMONIA LOADS TO THE STICKNEY WRP
JULY 16 THROUGH 29, 2000

	WS IMEF*		SW PREF**		Sewage Flow		BOD_5 Load			NH_3-N Load			Effluent
	BOD_5	NH_3-N	BOD_5	NH_3-N	WS	SW	WS	SW	Total	WS	SW	Total	NH_3-N
Date	mg/L	mg/L	mg/L	mg/L	MGD	MGD	K lb/d	K lb/d	K lb/d	K lb/d	K lb/d	K lb/d	mg/L
7/16/00	54	6.95	73	9.51	260	374	117.1	227.7	344.8	15.1	29.7	44.7	0.16
7/17/00	55	7.68	95	14.36	262	343	120.2	271.8	391.9	16.8	41.1	57.9	0.10
7/18/00	75	8.23	112	14.51	232	360	145.1	336.3	481.4	15.9	43.6	59.5	0.17
7/19/00	72	8.85	112	16.03	228	361	136.9	337.2	474.1	16.8	48.3	65.1	0.17
7/20/00	74	9.29	130	14.25	225	367	138.9	397.9	536.8	17.4	43.6	61.0	0.14
7/21/00	94	9.70	117	16.82	239	379	187.4	369.8	557.2	19.3	53.2	72.5	0.30
7/22/00	88	13.00	152	21.20	263	388	193.0	491.9	684.9	28.5	68.6	97.1	6.41
7/23/00	65	10.20	107	15.05	289	366	156.7	326.6	483.3	24.6	45.9	70.5	0.11
7/24/00	59	9.72	90	17.33	338	272	166.3	204.2	370.5	27.4	39.3	66.7	0.12
7/25/00	75	9.87	124	20.52	241	331	150.7	342.3	493.1	19.8	56.6	76.5	0.45
7/26/00	75	10.40	207	22.99	248	361	155.1	623.2	778.3	21.5	69.2	90.7	2.92
7/27/00	79	10.80	135	21.75	289	436	190.4	490.9	681.3	26.0	79.1	105.1	1.43
7/28/00	82	9.64	145	15.87	315	457	215.4	552.7	768.1	25.3	60.5	85.8	1.48
7/29/00	108	7.56	99	18.91	411	455	370.2	375.7	745.9	25.9	71.8	97.7	1.68
Average	75	9.42	121	17.08	274	375	174.5	382.0	556.5	21.5	53.6	75.1	1.12
Min.	54	6.95	73	9.51	225	272	117.1	204.2	344.8	15.1	29.7	44.7	0.10
Max.	108	13.00	207	22.99	411	457	370.2	623.2	778.3	28.5	79.1	105.1	6.41

*WS IMEF = Effluent from Imhoff tanks at the West Side plant.
**SW PREF = Effluent from preliminary settling tanks at the Southwest plant.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 8

SHIFT AVERAGES OF FLOW RATES, BOD_5, AMMONIA LOADS, AND AIR FLOW RATES
TO THE STICKNEY WRP AERATION TANKS
JULY 20 THROUGH 23, 2000

	Flow Rate (MGD)			BOD_5 Load (K lb/d)			NH_3 Load (K lb/d)			Air Flow	Air/Waste	Final NH_3-N
Shift	WS	SW	Total	WS	SW	Total	WS	SW	Total	(kcfm)	(ft^3/lb)	(mg/L)
7/20 1st	223	384	607	138	416	554	17.3	45.6	63	423	722	
7/20 2nd	220	235	455	136	255	391	17.0	27.9	45	424	1,022	
7/20 3rd	229	469	698	142	508	650	17.8	55.7	73	424	618	0.14
7/21 1st	241	403	643	189	393	581	19.5	56.5	76	423	655	
7/21 2nd	218	249	467	171	243	414	17.6	34.9	53	423	929	
7/21 3rd	260	464	724	204	453	656	21.0	65.1	86	423	579	0.30
7/22 1st	334	458	792	245	580	825	36.3	80.9	117	424	448	
7/22 2nd	231	319	551	170	405	575	25.1	56.5	82	425	644	
7/22 3rd	226	373	599	166	472	638	24.5	65.9	90	429	586	6.41
7/23 1st	233	401	633	126	358	484	19.8	50.3	70	499	892	
7/23 2nd	284	217	501	154	194	347	24.1	27.2	51	501	1,236	
7/23 3rd	351	462	813	190	412	602	29.8	58.0	88	499	714	0.11

pound in the previous shift. The daily average ratio of 579 cubic feet air per pound of oxygen-consuming waste on July 22 was the lowest between July 20 though 23, 2000.

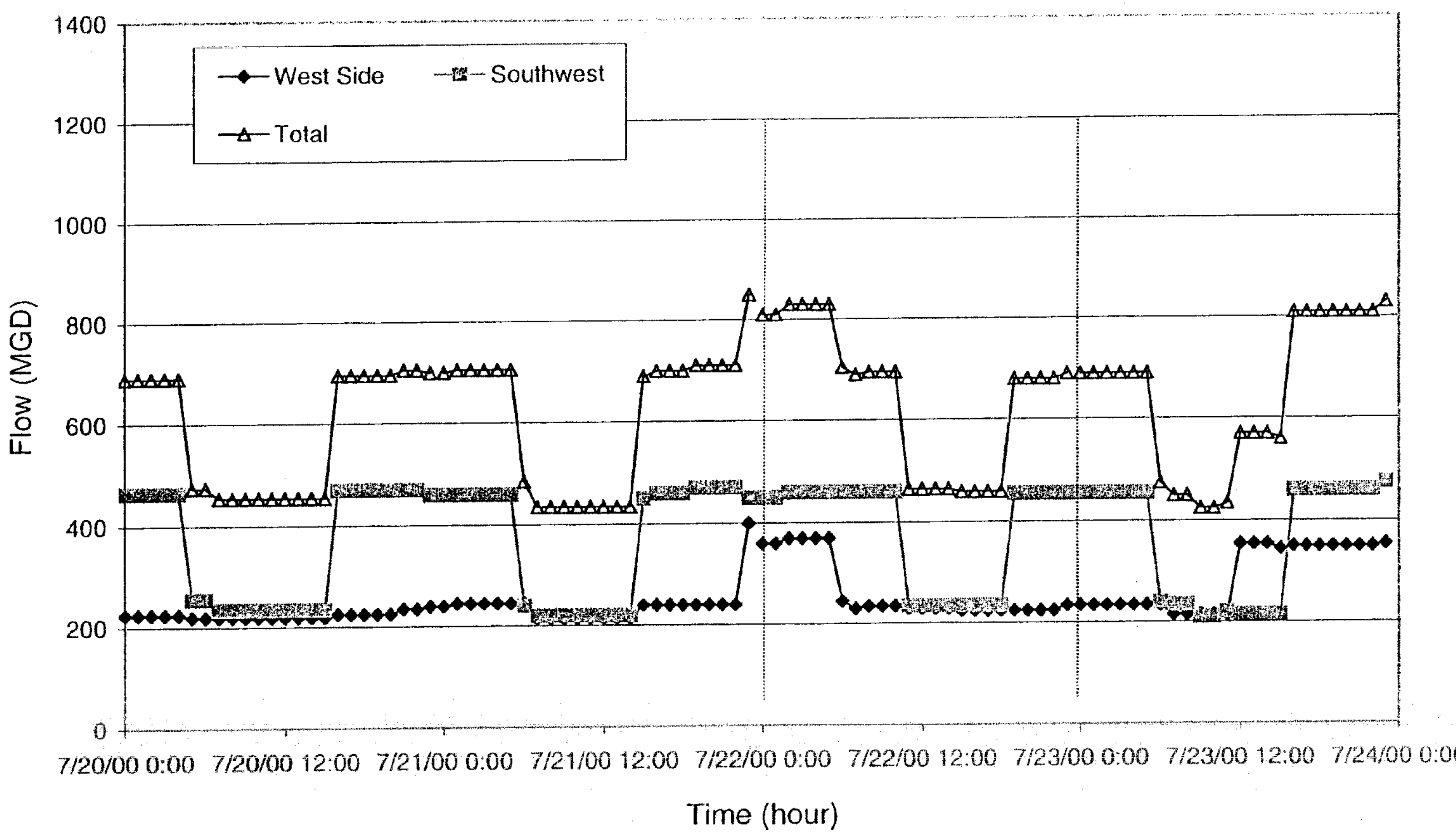
Figure 9 presents the hourly sewage flow rates to the Stickney WRP including West Side and Southwest plants during July 20 to 23, 2000. These hourly sewage flows had similar daily pattern during these four days, except that the sewage flows to the West Side plant in the first shift of July 22 and third shift of July 23 were higher than normal, resulting in slightly higher total sewage flows to the Stickney WRP in these two shifts. However, the daily average sewage flow to the Stickney WRP on July 22 was close to the average value of the July 16 to 29, 2000 period, as shown in Table 7.

Table 9 presents the shift average operation data for sewage and air flows to each aeration battery, DO values recorded half an hour before the end of each shift from DO probes installed in the selected aeration tanks, and the average DO values for each battery from first shift on July 19 to third shift on July 24, 2000. As can be seen, the average DO values for all the batteries decreased from 2.1 mg/L in the first shift to 0.9 mg/L in the second shift on July 22. During these two shifts, only two blowers were operating, according to the M&O Department operation records. A third blower

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 9

HOURLY SEWAGE FLOW TO THE STICKNEY WRP
JULY 20 THROUGH 23, 2000



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9

OPERATING DATA FOR AERATION BATTERIES AT THE STICKNEY WRP
JULY 19 THROUGH 24, 2000

Date	Shift	Sewage Flow (MGD)	Air Flow (KCFM)	Air/Sewage Ratio ft^3/Gal	DO (mg/L) Tank 1 Pass 2	DO (mg/L) Tank 1 Pass 4	DO (mg/L) Tank 4 Pass 2	DO (mg/L) Tank 4 Pass 4	DO (mg/L) Tank 6 Pass 2	DO (mg/L) Tank 6 Pass 4	Average DO* (mg/L)
Battery A											
7/19/00	1	150	104	1.00	1.4	5.8	1.7	3.6	1.1	6.8	3.4
	2	102	104	1.47	1.3	6.1	1.2	4.8	2.0	6.6	3.7
	3	165	104	0.91	2.9	6.0	4.2	6.5	6.5	6.9	5.5
7/20/00	1	142	104	1.05	1.3	4.1	0.8	3.0	1.2	6.4	2.8
	2	100	104	1.50	1.6	6.4	1.7	5.6	2.0	6.8	4.0
	3	167	104	0.90	3.9	5.9	5.4	6.5	6.5	6.9	5.9
7/21/00	1	158	103	0.94	0.9	6.1	1.1	6.5	1.1	6.8	3.8
	2	104	103	1.43	1.4	4.3	1.2	1.9	1.6	6.2	2.8
	3	176	103	0.84	1.8	5.7	2.7	6.3	5.6	6.9	4.8
7/22/00	1	196	103	0.76	0.8	1.7	0.9	2.7	0.8	5.9	2.1
	2	125	106	1.22	0.9	0.3	0.6	0.3	0.7	0.5	0.6
	3	134	106	1.14	1.0	0.6	0.8	0.6	1.0	2.8	1.1
7/23/00	1	143	121	1.22	1.6	5.8	2.0	6.5	2.3	7.0	4.2
	2	106	121	1.64	7.2	7.4	7.0	7.2	7.5	7.8	7.4
	3	186	120	0.93	5.4	8.9	6.2	7.2	7.1	7.6	7.1
7/24/00	1	160	121	1.09	2.4	6.4	1.9	4.9	2.5	7.5	4.3
	2	16	70	6.30	5.4	6.3	5.9	5.8	6.0	6.6	6.0
	3	O/S**	-	-	-	-	-	-	-	-	-

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9 (Continued)

OPERATING DATA FOR AERATION BATTERIES AT THE STICKNEY WRP
JULY 19 THROUGH 24, 2000

Date	Shift	Sewage Flow (MGD)	Air Flow (KCFM)	Air/Sewage Ratio ft^3/Gal	DO(mg/L) Tank 1 Pass 2	DO(mg/L) Tank 1 Pass 4	DO(mg/L) Tank 4 Pass 2	DO(mg/L) Tank 4 Pass 4	DO(mg/L) Tank 6 Pass 2	DO(mg/L) Tank 6 Pass 4	Average DO* (mg/L)
Battery B											
7/19/00	1	159	107	0.97	0.3	5.4	1.1	6.1	2.0	6.4	3.6
	2	112	107	1.38	1.4	5.3	1.5	6.2	1.8	6.2	3.7
	3	168	107	0.92	2.2	7.9	3.8	6.8	6.8	6.7	5.7
7/20/00	1	152	108	1.02	0.7	4.3	0.8	3.0	1.2	6.4	2.7
	2	110	108	1.41	2.0	5.6	1.5	5.5	1.9	6.6	3.9
	3	176	108	0.88	2.3	6.7	4.4	6.8	4.5	6.7	5.2
7/21/00	1	160	108	0.97	1.1	7.8	0.9	5.0	2.0	6.4	3.9
	2	113	108	1.38	3.1	4.3	1.3	5.3	2.2	5.9	3.7
	3	178	108	0.87	1.4	7.8	1.8	6.5	4.8	6.7	4.8
7/22/00	1	196	108	0.79	1.1	1.8	0.7	3.0	1.7	5.1	2.2
	2	140	106	1.09	0.4	0.6	0.6	0.9	1.6	0.8	0.8
	3	152	109	1.03	1.8	1.6	0.8	1.4	1.8	1.4	1.5
7/23/00	1	163	122	1.08	1.0	7.0	1.1	5.8	2.0	7.0	4.0
	2	123	123	1.44	7.7	7.5	6.8	7.3	7.0	7.8	7.4
	3	216	123	0.82	6.2	7.3	4.1	7.1	7.2	7.6	6.6
7/24/00	1	183	121	0.95	2.5	2.7	1.6	4.8	2.4	5.7	3.3
	2	179	115	0.93	3.1	7.2	2.9	6.9	5.2	7.5	5.5
	3	185	90	0.70	0.6	6.6	1.8	6.7	2.7	7.2	4.3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9 (Continued)

OPERATING DATA FOR AERATION BATTERIES AT THE STICKNEY WRP
JULY 19 THROUGH 24, 2000

Date	Shift	Sewage Flow (MGD)	Air Flow (KCFM)	Air/Sewage Ratio ft^3/Gal	DO(mg/L)						Average DO* (mg/L)
					Tank 1		Tank 4		Tank 6		
					Pass 2	Pass 4	Pass 2	Pass 4	Pass 2	Pass 4	
Battery C											
7/19/00	1	147	99	0.97	2.4	6.5	3.4	6.5	1.9	6.4	4.5
	2	98	99	1.45	3.0	5.8	2.9	3.4	2.2	6.0	3.9
	3	158	99	0.90	5.2	7.5	7.5	6.7	7.0	6.1	6.7
7/20/00	1	140	98	1.01	2.8	4.6	1.7	5.5	2.2	5.1	3.7
	2	90	99	1.58	2.6	6.7	3.4	6.8	3.1	6.2	4.8
	3	164	99	0.87	6.7	6.7	6.8	6.8	6.4	6.1	6.6
7/21/00	1	160	99	0.89	1.5	4.5	2.2	6.4	1.7	6.1	3.7
	2	113	99	1.26	3.3	5.7	1.1	6.0	2.6	5.4	4.0
	3	178	99	0.80	3.9	7.5	6.7	6.7	6.3	6.1	6.2
7/22/00	1	197	99	0.72	1.7	3.1	2.2	3.9	1.6	4.0	2.8
	2	129	98	1.09	1.5	1.7	3.9	1.6	1.2	1.0	1.8
	3	140	98	1.01	1.2	2.6	3.8	2.5	1.0	1.7	2.1
7/23/00	1	153	122	1.15	1.7	7.0	2.7	5.4	2.3	7.1	4.4
	2	111	122	1.58	7.7	8.0	7.1	8.0	7.0	7.4	7.5
	3	197	122	0.89	6.4	6.9	6.2	7.2	7.1	7.6	6.9
7/24/00	1	173	122	1.02	3.6	5.8	5.0	5.6	2.9	5.4	4.7
	2	172	106	0.89	5.9	7.3	6.1	7.2	5.4	6.8	6.5
	3	173	107	0.89	3.0	7.1	5.2	7.1	3.1	6.6	5.4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9 (Continued)

OPERATING DATA FOR AERATION BATTERIES AT THE STICKNEY WRP
JULY 19 THROUGH 24, 2000

Date	Shift	Sewage Flow (MGD)	Air Flow (KCFM)	Air/Sewage Ratio ft^3/Gal	DO(mg/L) Tank 1 Pass 2	DO(mg/L) Tank 1 Pass 4	DO(mg/L) Tank 4 Pass 2	DO(mg/L) Tank 4 Pass 4	DO(mg/L) Tank 6 Pass 2	DO(mg/L) Tank 6 Pass 4	Average DO* (mg/L)
---Battery D---											
7/19/00	1	174	113	0.94	0.7	3.7	1.5	3.7	1.0	3.8	2.4
	2	150	114	1.09	1.4	3.8	4.2	4.0	1.7	5.9	3.5
	3	169	113	0.96	1.1	5.0	1.8	0.8	1.0	3.1	2.1
7/20/00	1	173	113	0.94	0.6	2.1	1.5	3.7	0.7	2.4	1.8
	2	155	113	1.05	3.1	4.5	4.7	5.0	3.1	5.6	4.3
	3	192	113	0.85	2.1	4.3	2.2	4.1	2.2	5.2	3.4
7/21/00	1	166	113	0.98	0.7	4.0	0.5	3.9	0.7	2.6	2.1
	2	136	113	1.20	0.8	2.1	1.8	3.7	0.9	3.6	2.2
	3	193	113	0.84	0.8	1.6	0.9	0.5	0.9	1.8	1.1
7/22/00	1	202	114	0.81	0.8	1.0	0.8	1.2	2.1	1.5	1.2
	2	157	115	1.05	0.7	0.5	0.6	0.2	0.5	0.3	0.5
	3	174	116	0.96	0.9	0.8	1.0	1.0	0.7	1.8	1.0
7/23/00	1	173	134	1.12	1.7	5.5	2.7	5.6	1.1	3.4	3.3
	2	162	135	1.20	6.0	6.1	7.4	5.6	6.5	6.3	6.3
	3	214	134	0.90	1.8	6.4	6.9	2.8	2.2	3.4	3.9
7/24/00	1	181	134	1.07	1.1	6.0	6.2	2.2	1.6	3.4	3.4
	2	180	122	0.98	1.3	6.0	6.8	1.9	1.7	3.3	3.5
	3	203	159	1.13	1.7	5.6	5.5	2.4	1.3	3.2	3.3

*Average DO was computed based on six measured DO values in Tanks 1, 4 and 6.
**The aeration battery was out of service.

was put into service at 7:30 p.m. on July 22. As a result, DO increased to 1.4 mg/L at the end of the third shift. The average DO value on July 22 was the lowest during the period July 19 through 24, 2000.

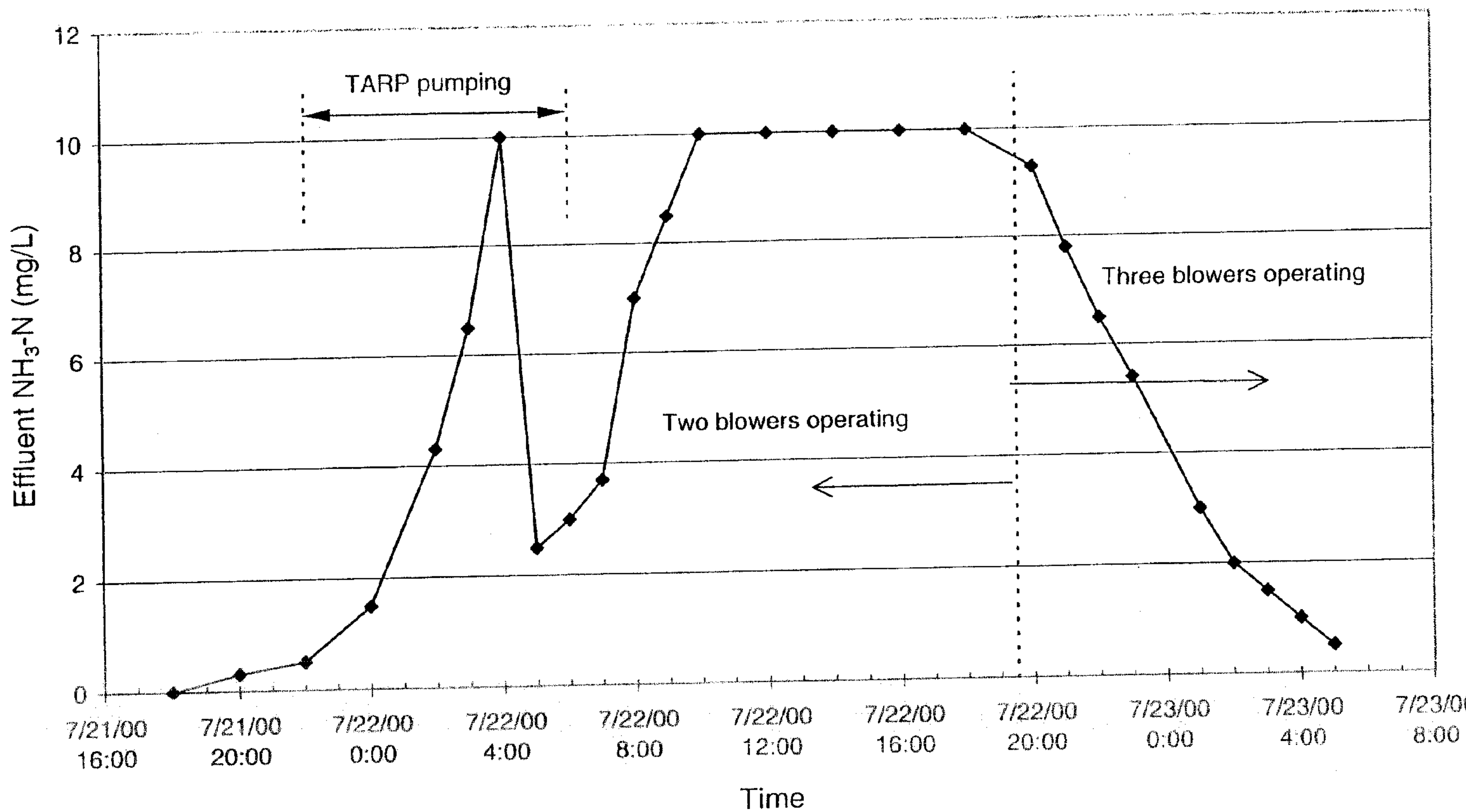
Figure 10 shows the hourly ammonia concentrations in the final effluent of the Stickney WRP monitored by an ammonia analyzer between July 21 and 23, 2000. Ammonia concentration increased sharply up to 10 mg/L, which was the highest concentration that the analyzer can record, during the first shift of July 22 until 4:00 a.m., and then dropped to below 4 mg/L at the end of the first shift. However, the ammonia concentration kept rising at the beginning of the second shift, and went up to 10 mg/L or beyond at 10:00 a.m. on that day. This high concentration lasted for more than 8 hours before it started to decrease at about 8:00 p.m. in the evening of July 22. Apparently, the daily average ammonia concentration of 6.41 mg/L in the final effluent was due to the ammonia peaks at 4:00 a.m. and between 10:00 a.m. and 8:00 p.m. on July 22, 2000.

The high values of ammonia in the effluent were presumably due to low DOs in the aeration tanks, and not due to the daily BOD_5 and ammonia loads to the Stickney WRP as they were only slightly higher than normal on July 22, 2000. Low DOs in

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 10

AMMONIA CONCENTRATIONS IN THE FINAL EFFLUENT OF THE STICKNEY WRP
JULY 21 THROUGH 23, 2000



the aeration tanks resulted presumably due to the high BOD_5 and ammonia loads occurring during the first shift on that day.

ESTIMATION OF AMMONIA LOADS DUE TO MAJOR SOURCES DURING THE INCIDENTS

From the available data, ammonia loadings from four major ammonia-contributing sources to the Stickney WRP before and after the two incidents were estimated. These four sources were TARP pumpback, and discharges from CPC, Post-DC, and LASMA.

Table 10 presents the flow rates and waste loads from the TARP pumpback during the two incidents in April and July of 2000. Operation records indicated that the TARP pumpback usually occurred between late night and early morning during weekdays and during daytimes on weekends. Between April 6 and 7, 2000, the TARP pumpback started at 10:05 p.m. on April 6 and stopped at 7:30 a.m. on April 7. Approximately, all of the waste loads from TARP pumpback on April 7 went to the Stickney WRP during the first shift. These waste loads were 8.0 Klb of ammonia and 125.7 Klb of BOD_5. Between July 21 and 22, 2000, the TARP pumpback started at 10:05 p.m. on July 21 and stopped at 6:00 a.m. on July 22. Apparently, all of the waste loads from TARP pumpback on July 22 went to the Stickney

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 10

VOLUME PUMPED AND OXYGEN-CONSUMING WASTE LOADS FROM TARP PUMPBACK DURING THE TWO INCIDENTS IN APRIL AND JULY, 2000

Date	Volume Pumped MG	NH_3-N mg/L	BOD_5 mg/L	NH_3-N K lb/d	BOD_5 K lb/d
4/4/00	0	9.68	72	0.0	0.0
4/5/00	68	27.79	283	15.8	160.5
4/6/00	17	23.06	225	3.3	31.9
4/7/00	67	14.31	225	8.0	125.7
4/8/00	87	15.89	269	11.5	195.2
4/9/00	143	13.69	155	16.3	184.9
4/10/00	52	7.86	76	3.4	33.0
7/19/00	0	ND*	ND	0.0	0.0
7/20/00	17	ND	ND	ND	ND
7/21/00	33	29.48	310	8.1	85.3
7/22/00	88	32.17	93	23.6	68.3
7/23/00	84	17.76	59	12.4	41.3
7/24/00	74	9.88	45	6.1	27.8
7/25/00	5	ND	ND	ND	ND

*No data were available.

WRP during the first six hours. These waste loads were 23.6 Klb of ammonia and 68.3 Klb of BOD_5.

Table 11 presents the ammonia concentrations and flow rates of wastewater discharged from CPC and monitored by the IWD during February through July of 2000. The monitoring data on the two days (April 7 and July 22, 2000), when the incidents of high ammonia concentration in the final effluent of the Stickney WRP occurred, were unavailable. During the 6 months period, 34 days of data were collected, which gave the mean daily ammonia load of 10.53 Klb/d with a range of 0.29 to 18.82 Klb/d.

The amounts of ammonia from Post-DC were estimated using the average ammonia concentration of 564 mg/L, obtained in this study, and the flow rates of the centrate on April 7 and July 22, 2000. According to the M&O Department operation records, the volume of sludge pumped through the post-digestion centrifuges were 1.773 MG (million gallons) for April 7, and 1.859 MG for July 22, and the weights of wet sludge cake after dewatering were 831.9 tons for April 7 and 1,223 tons for July 22, respectively. Based on this information, the estimated flow rates of the centrate were 1.57 MGD for both April 7 and July 22, 2000.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 11

AMMONIA CONCENTRATIONS AND FLOW RATES OF WASTEWATER
DISCHARGED FROM CORN PRODUCTS CORPORATION
FEBRUARY TO JULY 2000

	Site 1 (2AT)		Site 2 (6AT)		
	NH_3-N	Flow*	NH_3-N	Flow*	Load**
Date	mg/L	MGD	mg/L	MGD	K lb/d
2/1/00	255.86	6.0*	1.12	0.16*	12.8
2/2/00	210.79	6.0*	0.11	0.16*	10.5
2/3/00	213.20	6.0*	4.35	0.16*	10.7
2/7/00	270.85	6.0*	0.08	0.16*	13.6
2/8/00	246.26	6.0*	0.08	0.16*	12.3
2/9/00	0.06	6.0*	251.39	0.16*	0.3
Mean	199.50		42.86		10.04
3/13/00	293.58	5.32	0.46	0.106	13.0
3/14/00	216.16	5.91	0.77	0.105	10.7
3/15/00	285.53	5.82	1.24	0.147	13.9
3/16/00	1.52	5.17	214.3	0.126	0.3
3/17/00	197.67	4.56	0.24	0.157	7.5
3/18/00	291.88	5.53	2.05	0.133	13.5
3/19/00	175.91	7.04	0.28	0.190	10.3
Mean	208.89	5.62	31.33	0.14	9.88
4/24/00	301.29	6.06	0.9	0.174	15.2
4/25/00	243.53	5.85	0.17	0.159	11.9
4/26/00	224.65	6.20	0.42	0.176	11.6
4/27/00	184.31	6.43	0.07	0.179	9.9
4/28/00	307.06	5.99	0.09	0.159	15.3
4/29/00	162.35	5.69	0.65	0.162	7.7
4/30/00	296.84	5.86	0.71	0.163	14.5
Mean	245.72	6.01	0.43	0.17	12.31

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 11 (Continued)

AMMONIA CONCENTRATIONS AND FLOW RATES OF WASTEWATER DISCHARGED FROM CORN PRODUCTS CORPORATION FEBRUARY TO JULY 2000

	Site 1 (2AT)		Site 2 (6AT)		
	NH_3-N	Flow*	NH_3-N	Flow*	Load**
Date	mg/L	MGD	mg/L	MGD	K lb/d
6/12/00	253.93	6.0*	-	-	12.7
6/13/00	150.62	6.0*	0.09	0.16*	7.5
6/14/00	186.32	6.0*	1.11	0.16*	9.3
6/15/00	292.09	6.0*	0.94	0.16*	14.6
6/16/00	213.97	6.0*	0.17	0.16*	10.7
6/17/00	176.41	6.0*	1.42	0.16*	8.8
6/18/00	244.28	6.0*	1.13	0.16*	12.2
Mean	216.80		0.81		10.85
7/5/00	339.20	6.55	0.18	0.163	18.5
7/6/00	178.51	5.61	0.05	0.180	8.4
7/7/00	250.85	0.22	0.41	0.195	0.5
7/8/00	180.98	12.47	0.37	0.164	18.8
7/9/00	178.36	7.12	0.06	0.177	10.6
7/10/00	0.41	6.22	214.19	0.173	0.3
7/11/00	185.24	6.01	0.97	0.218	9.3
Mean	187.65	6.31	30.89	0.181	9.48
Total No. of Samples	34	21	33	21	34
Mean	212.07	6.0	21.23	0.16	10.53
Min.	0.06	0.22	0.05	0.105	0.29
Max.	339.20	12.47	251.39	0.218	18.82

*Mean daily flows, which were calculated using the known 21 daily flows, were assigned to those days in which ammonia concentrations were measured, but daily flows were not available.

**Ammonia load is the sum of ammonia discharged from both sites.

According to the M&O Department operation records, the overflow rate from LASMA on July 22 was 3.2 MGD. The overflow rate from LASMA on April 7 was unavailable, but an average of 2.8 MGD was recorded in the last week of April of 2000. This average overflow rate was used to estimate the amount of ammonia from LASMA on April 7, 2000. The average ammonia concentration of 701 mg/L, which was obtained in this study, was used to estimate the amounts of ammonia from LASMA on both days of April 7 and July 22, 2000.

Table 12 presents the ammonia loads in thousand pounds to the aeration tanks at the Stickney WRP in each operation shift during April 7 and July 22, 2000, and from the four sources, TARP, CPC, Post-DC, and LASMA, and percent of each. Included in Table 12 is also the ammonia load from the Stickney West Side plant, which receives no wastewater from TARP, CPC, Post-DC, or LASMA. As can be seen, the amounts of ammonia from TARP accounted for 21 and 60 percent of the total ammonia entering the aeration tanks in the first shift on April 7 and July 22, respectively, although they only represented 5 and 24 percent of the daily total. The diurnal variation of ammonia from CPC is unknown on those two days. If it is assumed that the maximum daily amount of ammonia, from the February-to-July monitoring, entered the Stickney WRP on April 7 and July 22,

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 12

AMMONIA LOADS IN THOUSAND POUNDS IN EACH SHIFT FROM VARIOUS SOURCES TO THE AERATION TANKS AT THE STICKNEY WRP DURING AMMONIA SPIKE INCIDENTS ON APRIL 7 AND JULY 22, 2000

		To Aeration	From WS IMEF		From TARP[1]		From CPC[2]		From Post-DC[3]		From LASMA[4]	
Date	Shift	Tanks (AT)	Loads	% of AT	Loads	% of AT	Loads	% of AT	Loads	% of AT	Loads	% of AT
4/7/00	1st	37.5	5.9	16	8.0	21	6.3	17	2.5	7	5.5	15
4/7/00	2nd	49.2	7.9	16	0.0		6.3	13	2.5	5	5.5	11
4/7/00	3rd	67.1	11.6	17	0.0		6.3	9	2.5	4	5.5	8
Daily Total		153.8	25.4	17	8.0	5	18.9	12	7.5	5	16.4	11
7/22/00	1st	39.1	12.1	31	23.6	60	6.3	16	2.5	6	6.2	16
7/22/00	2nd	27.1	8.3	31	0.0		6.3	23	2.5	9	6.2	23
7/22/00	3rd	30.2	8.2	27	0.0		6.3	21	2.5	8	6.2	21
Daily TOTAL		96.4	28.6	30	23.6	24	18.9	20	7.5	8	18.7	19

[1]Assuming that all the ammonia from TARP entered the aeration tanks.

[2]Assuming that the maximum daily amount of ammonia during February-to-July monitoring entered the aeration tanks evenly on both days.

[3]Assuming that the ammonia concentration was 564 mg/L in the centrate on both days, and the flow rates were 1.57 MGD on both days as well.

[4]Assuming that the ammonia concentration was 701 mg/L in the overflow on both days, and flow rates were 2.8 MGD on April 7 and 3.2 MGD on July 22.

2000, the ammonia from CPC would account for 12 and 20 percent of the daily total on these two days, respectively. The estimated amounts of ammonia from Post-DC and LASMA represented 5 and 11 percent of the daily total to the aeration tanks on April 7, and 8 and 19 percent on July 22, 2000, respectively.

In summary, the two incidents of unusually high ammonia concentrations in the final effluent of the Stickney WRP occurred because of different causes. On April 7 when the first incident occurred, a surge of raw sewage flow due to the rainfall on that day brought an unusually high ammonia load of 155.5 Klb/d into the aeration tanks. As a consequence, DOs in the aeration tanks dropped to very low levels, below 1 mg/L. This reduced the nitrification rates, affecting adversely the removal of ammonia. Therefore, it was concluded that the combination of an extremely high ammonia load to the Stickney WRP and low DO levels in the aeration tanks caused this incident. It is speculated that the first flush of the sewer system by a high sewage flow might have played a role in this case.

On July 22 when the second incident occurred at the Stickney WRP, the daily average ammonia load of 97.1 Klb/d to the aeration tanks was only 30 percent above the average load of 75.1 Klb/d for the adjacent two weeks. The flow-weighted average ammonia concentration in the raw sewage to the

Stickney WRP was 14.5 mg/L, which was only slightly higher than the mean value of 13.63 mg/L, for the first nine months of year 2000. However, the DO levels in the aeration tanks on that day were low, and the average values of DO in all batteries were 2.1, 0.9 and 1.4 mg/L for the first, second and third shifts, respectively. The ammonia profile in the final effluent of the Stickney WRP between July 21 and July 23 (see Figure 10) indicated that the peaks of high ammonia concentration, 10 mg/L or higher, occurred twice, and the second peak lasted for more than eight hours, mainly in the late second shift and early third shift. The operation records showed that there were only two blowers in operation during that period. Therefore, the poor nitrification due to the low DOs in the aeration tanks appeared to be the main cause of this incident. However, the factors that caused the low DO levels in the aeration tanks are not obvious and are somewhat complex. High BOD_5 and ammonia concentrations in the TARP pumpback (see Table 10) in the late night hours of July 21 and early morning hours of July 22 might have triggered the decrease of DO in the aeration tanks during the day of July 22.

REFERENCE

1. Metcalf & Eddy, Inc. (1991) Wastewater Engineering: Treatment, Disposal, and Reuse (Third Edition), Revised by G. Tchobanoglous and F. L. Burton. Irwin McGraw-Hill, Boston, Massachusetts.

APPENDIX AI

COMPLETE DATA SETS

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1

DAILY MEAN, MINIMUM AND MAXIMUM VALUES OF NH3-N CONCENTRATIONS (mg/L)
AT CP-2AT, CP-6AT, SW12, AND LASMA
AUGUST 14 THROUGH SEPTEMBER 5, 2000

Date	CP-2AT			CP-6AT			SW12			LASMA		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
8/14	165.92	40.48	373.70	1.01	0.08	8.78	66.96	8.58	183.42	882.28	748.40	954.66
8/15	231.81	60.33	434.61	1.32	0.04	3.15	73.56	24.34	112.63	826.23	628.09	916.75
8/16	151.49	25.84	262.55	0.04	0.03	0.05	46.94	8.54	97.92	701.17	48.00	903.01
8/17	112.09	0.16	281.54	0.06	0.05	0.14	45.29	0.04	137.70	295.19	202.33	407.87
8/18	121.82	27.96	263.31	0.05	0.04	0.06	41.39	1.69	117.64	477.65	333.28	519.86
8/19	154.99	28.95	497.87	0.19	0.04	0.79	57.44	19.20	150.36	562.69	270.67	686.16
8/20	0.09	0.06	0.39	0.09	0.07	0.30	58.30	2.23	156.38	645.76	458.20	792.47
8/21	NS*	NS	NS	162.19	0.07	489.35	71.92	7.63	121.21	786.02	676.41	907.61
8/22	177.47	24.41	488.11	0.09	0.07	0.11	46.03	4.41	118.93	558.85	68.76	813.80
8/23	176.60	6.74	655.59	0.05	0.04	0.07	54.64	4.75	149.96	730.83	663.73	860.91
8/24	136.82	10.12	375.41	0.10	0.04	0.72	61.72	1.56	170.19	739.42	441.11	843.94
8/25	220.84	30.87	557.28	0.35	0.01	6.68	77.15	13.22	192.18	596.10	165.28	1,009.01
8/26	166.86	16.40	341.18	0.04	0.02	0.19	59.69	5.42	232.06	820.43	687.37	1,000.41
8/27	182.62	16.44	570.37	0.06	0.03	0.48	83.79	17.68	193.96	766.94	529.03	855.42
8/28	199.32	10.27	489.93	0.15	0.06	0.77	74.52	8.50	160.76	733.46	409.60	839.31
8/29	154.51	91.24	260.42	0.08	0.05	0.47	84.80	26.82	220.13	759.87	564.05	873.45
8/30	152.90	2.05	504.07	0.11	0.07	0.27	55.67	2.84	141.94	797.59	566.39	934.64
8/31	201.08	15.03	428.99	0.08	0.07	0.09	67.39	6.49	196.41	800.76	507.77	884.63
9/5	174.67	54.01	377.92	0.09	0.06	0.56	77.08	14.69	249.80	843.57	748.61	902.59
Grand Total												
Mean	160.10			8.74			63.38			701.31		
Min	0.09	0.06		0.04	0.01		41.39	0.04		295.19	48.00	
Max	231.81		655.59	162.19		489.35	84.80		249.80	882.28		1,009.01
Std Dev	50.60			37.16			13.29			146.98		
CV (%)	31.6			425.0			21.0			21.0		

*No samples were collected on this day due to a problem with the auto-sampler.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2

SUMMARY OF AMMONIA CONCENTRATIONS FOR POST-DIGESTION CENTRATE
SEPTEMBER 13 THROUGH 20, 2000

Sampling Date	Number of Samples	NH_3-N in mg/L			
		Mean	Min	Max	SD*
9/13/00	9	550.8	529.2	571.6	13.2
9/14/00	6	462.8	428.5	482.8	19.8
9/18/00	8	498.4	433.7	601.2	48.8
9/19/00	8	657.1	625.9	706.4	28.7
9/20/00	10	649.1	541.3	695.1	47.0
Total	41	563.6			

*SD = Standard deviation.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

	Southwest Raw			West Side Raw			Total	Ratio
Date	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
1/2/00	324	28.77	77,741	213	9.87	17,533	95,274	81.6
1/3/00	384	31.15	99,760	244	9.67	19,678	119,438	83.5
1/4/00	453	20.91	78,998	164	8.47	11,585	90,583	87.2
1/5/00	343	22.27	63,706	217	9.63	17,428	81,134	78.5
1/6/00	362	24.67	74,481	257	10.30	22,077	96,558	77.1
1/7/00	359	25.82	77,307	219	10.70	19,543	96,850	79.8
1/8/00	324	24.33	65,744	214	10.60	18,918	84,662	77.7
1/9/00	442	19.02	70,113	314	8.15	21,343	91,456	76.7
1/10/00	394	22.79	74,887	307	8.12	20,790	95,677	78.3
1/11/00	297	27.81	68,885	258	9.63	20,721	89,606	76.9
1/12/00	333	25.74	71,486	219	10.60	19,360	90,846	78.7
1/13/00	324	25.21	68,121	218	10.90	19,818	87,939	77.5
1/14/00	395	23.71	78,108	216	10.00	18,014	96,122	81.3
1/15/00	377	25.99	81,717	266	9.35	20,742	102,460	79.8
1/16/00	314	25.20	65,993	219	9.61	17,552	83,545	79.0
1/17/00	353	23.39	68,861	266	9.87	21,896	90,757	75.9
1/18/00	305	27.74	70,562	261	9.90	21,550	92,112	76.6
1/19/00	348	22.70	65,883	225	9.87	18,521	84,404	78.1
1/20/00	344	16.58	47,567	259	10.50	22,681	70,248	67.7
1/21/00	279	12.97	30,179	219	10.70	19,543	49,722	60.7

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

	Southwest Raw			West Side Raw			Total	Ratio
Date	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
1/22/00	317	16.04	42,406	214	10.40	18,562	60,968	69.6
1/23/00	413	15.39	53,010	215	9.79	17,554	70,564	75.1
1/24/00	351	13.67	40,017	218	10.20	18,545	58,562	68.3
1/25/00	338	16.78	47,301	217	10.90	19,727	67,028	70.6
1/26/00	342	15.75	44,923	228	10.40	19,776	64,699	69.4
1/27/00	340	16.28	46,164	221	11.40	21,012	67,175	68.7
1/28/00	335	15.53	43,389	217	10.80	19,546	62,935	68.9
1/29/00	322	18.02	48,392	214	10.80	19,275	67,668	71.5
1/30/00	369	16.49	50,747	222	10.30	19,070	69,818	72.7
1/31/00	394	12.25	40,253	248	9.14	18,904	59,157	68.0
2/1/00	399	21.19	70,513	224	10.70	19,989	90,502	77.9
2/2/00	330	23.72	65,282	209	10.30	17,954	83,236	78.4
2/3/00	372	21.76	67,510	200	10.30	17,180	84,690	79.7
2/4/00	335	27.02	75,491	235	12.10	23,715	99,206	76.1
2/5/00	436	19.97	72,616	254	9.45	20,019	92,634	78.4
2/6/00	323	20.77	55,951	223	9.73	18,096	74,047	75.6
2/7/00	360	24.34	73,078	224	9.60	17,934	91,013	80.3
2/8/00	331	18.82	51,953	224	10.00	18,682	70,635	73.6
2/9/00	393	20.74	67,978	251	9.67	20,243	88,220	77.1
2/10/00	397	21.09	69,829	269	8.86	19,877	89,706	77.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

Date	Southwest Raw			West Side Raw			Total	Ratio
	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
2/11/00	422	20.04	70,530	261	9.18	19,982	90,513	77.9
2/12/00	470	18.73	73,418	215	8.79	15,761	89,179	82.3
2/13/00	370	19.89	61,377	213	8.30	14,744	76,121	80.6
2/14/00	336	24.51	68,683	211	9.52	16,753	85,436	80.4
2/15/00	312	27.92	72,650	245	9.80	20,024	92,674	78.4
2/16/00	313	32.84	85,726	248	10.60	21,924	107,650	79.6
2/17/00	359	21.69	64,941	245	10.80	22,068	87,009	74.6
2/18/00	478	21.98	87,624	222	10.40	19,255	106,879	82.0
2/19/00	551	20.30	93,285	207	8.95	15,451	108,737	85.8
2/20/00	460	19.53	74,925	272	8.37	18,987	93,912	79.8
2/21/00	513	19.04	81,461	316	9.14	24,088	105,549	77.2
2/22/00	586	16.16	78,978	342	5.82	16,600	95,578	82.6
2/23/00	534	14.95	66,581	275	7.92	18,165	84,745	78.6
2/24/00	860	11.87	85,136	443	6.54	24,163	109,299	77.9
2/25/00	692	13.76	79,413	346	8.72	25,163	104,576	75.9
2/26/00	923	10.82	83,290	346	8.24	23,778	107,068	77.8
2/27/00	606	11.31	57,161	333	8.27	22,968	80,129	71.3
2/28/00	414	21.30	73,544	288	9.57	22,986	96,530	76.2
2/29/00	399	24.27	80,762	319	9.94	26,445	107,207	75.3
3/1/00	425	23.13	81,984	X*	X	X	81,984	X

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

	Southwest Raw			West Side Raw			Total	Ratio
Date	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
3/2/00	644	18.49	99,309	X	X	X	99,309	X
3/3/00	605	16.44	82,951	X	X	X	82,951	X
3/4/00	730	14.72	89,618	X	X	X	89,618	X
3/5/00	672	15.22	85,300	X	X	X	85,300	X
3/6/00	579	16.83	81,270	X	X	X	81,270	X
3/7/00	500	20.35	84,860	92	11.10	8,517	93,376	90.9
3/8/00	246	24.66	50,593	400	7.25	24,186	74,779	67.7
3/9/00	223	36.96	68,739	422	11.10	39,066	107,805	63.8
3/10/00	228	33.73	64,138	371	10.20	31,560	95,698	67.0
3/11/00	251	20.30	42,495	293	9.48	23,166	65,660	64.7
3/12/00	309	27.06	69,735	221	9.64	17,768	87,503	79.7
3/13/00	243	28.08	56,907	337	9.96	27,993	84,901	67.0
3/14/00	299	30.81	76,830	353	10.60	31,207	108,036	71.1
3/15/00	453	24.40	92,184	338	9.83	27,710	119,894	76.9
3/16/00	379	18.84	59,551	243	7.54	15,281	74,831	79.6
3/17/00	400	21.50	71,724	279	10.50	24,432	96,156	74.6
3/18/00	483	17.52	70,574	286	9.11	21,730	92,304	76.5
3/19/00	383	23.10	73,786	291	8.22	19,949	93,736	78.7
3/20/00	531	20.83	92,246	446	5.72	21,276	113,523	81.3
3/21/00	311	27.39	71,043	383	8.90	28,429	99,471	71.4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

	Southwest Raw			West Side Raw			Total	Ratio
Date	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
3/22/00	255	36.02	76,604	380	9.44	29,917	106,521	71.9
3/23/00	310	24.60	63,601	402	10.40	34,868	98,469	64.6
3/24/00	335	24.94	69,680	346	9.65	27,846	97,526	71.4
3/25/00	220	31.68	58,126	310	10.40	26,888	85,015	68.4
3/26/00	276	29.47	67,835	354	9.09	26,837	94,672	71.7
3/27/00	407	21.95	74,507	284	9.16	21,696	96,203	77.4
3/28/00	361	24.18	72,800	207	8.48	14,640	87,439	83.3
3/29/00	214	28.82	51,437	425	11.80	41,825	93,262	55.2
3/30/00	197	25.04	41,140	353	13.70	40,333	81,473	50.5
3/31/00	330	24.81	68,282	325	11.00	29,816	98,098	69.6
4/1/00	317	25.64	67,787	315	11.10	29,161	96,947	69.9
4/2/00	230	25.95	49,777	249	9.89	20,538	70,315	70.8
4/3/00	228	28.71	54,593	312	10.00	26,021	80,613	67.7
4/4/00	273	31.22	71,082	255	10.20	21,692	92,775	76.6
4/5/00	344	23.61	67,736	253	10.30	21,733	89,469	75.7
4/6/00	365	15.44	47,001	211	11.00	19,357	66,358	70.8
4/7/00	597	28.16	140,208	280	10.30	24,053	164,261	85.4
4/8/00	567	10.90	51,544	413	4.86	16,740	68,284	75.5
4/9/00	381	20.24	64,313	341	7.08	20,135	84,449	76.2
4/10/00	354	23.64	69,794	313	9.51	24,825	94,619	73.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

	Southwest Raw			West Side Raw			Total	Ratio
Date	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
4/11/00	446	19.29	71,752	250	9.31	19,411	91,163	78.7
4/12/00	432	15.87	57,178	267	9.74	21,689	78,867	72.5
4/13/00	403	17.44	58,616	271	9.45	21,358	79,975	73.3
4/14/00	352	26.21	76,944	219	10.90	19,908	96,853	79.4
4/15/00	425	22.80	80,815	195	10.80	17,564	98,379	82.1
4/16/00	439	17.64	64,585	276	10.10	23,249	87,833	73.5
4/17/00	862	7.50	53,918	340	6.62	18,772	72,690	74.2
4/18/00	685	11.78	67,298	317	7.66	20,251	87,549	76.9
4/19/00	794	9.79	64,829	419	5.45	19,045	83,874	77.3
4/20/00	856	5.45	38,908	467	2.11	8,218	47,126	82.6
4/21/00	904	7.80	58,807	462	2.53	9,748	68,555	85.8
4/22/00	664	7.43	41,146	465	4.35	16,870	58,015	70.9
4/23/00	892	4.91	36,527	530	3.86	17,062	53,589	68.2
4/24/00	707	8.19	48,291	437	5.81	21,175	69,466	69.5
4/25/00	708	10.31	60,878	444	7.18	26,587	87,465	69.6
4/26/00	608	9.83	49,845	468	8.32	32,474	82,319	60.6
4/27/00	525	13.01	56,964	402	9.08	30,442	87,407	65.2
4/28/00	484	14.35	57,925	282	7.60	17,874	75,799	76.4
4/29/00	399	20.59	68,517	251	7.83	16,391	84,907	80.7
4/30/00	398	18.80	62,403	233	8.85	17,197	79,601	78.4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

	Southwest Raw			West Side Raw			Total	Ratio
Date	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
5/1/00	496	15.65	64,738	356	7.93	23,544	88,283	73.3
5/2/00	372	20.32	63,042	268	8.52	19,043	82,086	76.8
5/3/00	439	15.01	54,956	302	9.31	23,449	78,404	70.1
5/4/00	380	14.80	46,904	274	9.05	20,681	67,585	69.4
5/5/00	392	22.24	72,709	287	9.13	21,853	94,562	76.9
5/6/00	413	20.01	68,923	231	8.72	16,799	85,722	80.4
5/7/00	330	24.29	66,851	286	8.92	21,276	88,127	75.9
5/8/00	378	23.68	74,652	289	9.28	22,367	97,019	76.9
5/9/00	858	5.56	39,786	531	3.92	17,360	57,146	69.6
5/10/00	782	8.56	55,827	401	4.17	13,946	69,773	80.0
5/11/00	804	7.94	53,241	441	6.08	22,362	75,602	70.4
5/12/00	686	10.56	60,416	396	6.91	22,821	83,238	72.6
5/13/00	839	5.39	37,715	436	5.10	18,545	56,260	67.0
5/14/00	706	6.26	36,859	596	6.82	33,900	70,759	52.1
5/15/00	502	11.55	48,356	377	8.55	26,883	75,239	64.3
5/16/00	409	11.53	39,330	396	7.73	25,529	64,859	60.6
5/17/00	472	10.87	42,790	288	8.67	20,825	63,614	67.3
5/18/00	523	14.87	64,860	386	8.18	26,333	91,194	71.1
5/19/00	616	6.80	34,935	331	8.62	23,796	58,730	59.5
5/20/00	652	10.32	56,117	472	7.68	30,232	86,349	65.0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

	Southwest Raw			West Side Raw			Total	Ratio
Date	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
5/21/00	542	9.04	40,863	510	7.72	32,836	73,700	55.4
5/22/00	410	11.76	40,212	323	8.55	23,032	63,244	63.6
5/23/00	427	13.69	48,753	181	8.58	12,952	61,704	79.0
5/24/00	585	15.95	77,818	101	8.21	6,916	84,734	91.8
5/25/00	724	12.66	76,443	X	X	X	76,443	X
5/26/00	483	14.21	57,241	201	8.84	14,819	72,060	79.4
5/27/00	334	13.35	37,187	323	8.12	21,874	59,061	63.0
5/28/00	838	10.76	75,201	424	3.74	13,225	88,426	85.0
5/29/00	818	6.69	45,640	435	5.54	20,099	65,739	69.4
5/30/00	648	9.72	52,530	395	6.86	22,599	75,129	69.9
5/31/00	700	10.49	61,241	428	6.48	23,130	84,371	72.6
6/1/00	598	8.67	43,240	388	5.57	18,024	61,264	70.6
6/2/00	632	9.68	51,022	307	6.83	17,487	68,510	74.5
6/3/00	628	10.18	53,318	518	7.76	33,524	86,842	61.4
6/4/00	378	17.51	55,201	378	8.09	25,504	80,705	68.4
6/5/00	698	8.81	51,286	449	5.58	20,895	72,181	71.1
6/6/00	310	15.84	40,953	381	7.41	23,546	64,498	63.5
6/7/00	453	14.81	55,952	363	8.66	26,217	82,170	68.1
6/8/00	563	14.12	66,299	280	8.71	20,340	86,639	76.5
6/9/00	453	11.04	41,709	376	7.65	23,989	65,699	63.5

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

	Southwest Raw			West Side Raw			Total	Ratio
Date	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
6/10/00	388	12.24	39,608	328	7.17	19,614	59,221	66.9
6/11/00	602	10.87	54,575	399	5.31	17,670	72,245	75.5
6/12/00	702	7.78	45,549	488	4.02	16,361	61,910	73.6
6/13/00	614	7.18	36,767	477	4.12	16,390	53,157	69.2
6/14/00	750	7.48	46,787	443	4.93	18,214	65,002	72.0
6/15/00	821	7.40	50,669	378	5.75	18,127	68,796	73.7
6/16/00	699	7.41	43,198	306	7.47	19,064	62,262	69.4
6/17/00	583	9.61	46,726	418	7.14	24,891	71,617	65.2
6/18/00	396	15.02	49,606	341	7.85	22,325	71,931	69.0
6/19/00	377	19.21	60,400	295	8.41	20,691	81,091	74.5
6/20/00	658	11.91	65,359	367	6.81	20,844	86,203	75.8
6/21/00	437	15.25	55,580	378	6.18	19,483	75,062	74.0
6/22/00	516	17.57	75,611	301	8.47	21,263	96,874	78.1
6/23/00	285	17.92	42,594	439	7.65	28,009	70,603	60.3
6/24/00	432	19.42	69,968	435	6.22	22,566	92,533	75.6
6/25/00	790	12.79	84,268	472	2.86	11,258	95,527	88.2
6/26/00	519	13.48	58,348	446	5.88	21,871	80,219	72.7
6/27/00	569	12.16	57,705	328	7.18	19,641	77,346	74.6
6/28/00	423	11.85	41,805	351	8.48	24,824	66,629	62.7
6/29/00	498	15.44	64,127	354	8.48	25,036	89,163	71.9

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS JANUARY 2 THROUGH JULY 31, 2000

Date	Southwest Raw Flow MGD	Southwest Raw NH_3-N mg/L	Southwest Raw NH_3-N Load lb/d	West Side Raw Flow MGD	West Side Raw NH_3-N mg/L	West Side Raw NH_3-N Load lb/d	Total NH_3-N Load lb/d	Ratio SW/Total %
6/30/00	475	14.45	57,244	230	9.25	17,743	74,987	76.3
7/1/00	356	16.06	47,683	356	8.24	24,465	72,148	66.1
7/2/00	331	15.40	42,512	294	7.81	19,150	61,662	68.9
7/3/00	846	8.26	58,280	478	9.35	37,274	95,554	61.0
7/4/00	648	6.30	34,047	545	5.48	24,908	58,955	57.8
7/5/00	473	11.87	46,825	432	6.60	23,779	70,604	66.3
7/6/00	644	11.69	62,787	283	7.84	18,504	81,291	77.2
7/7/00	552	14.37	66,155	322	8.22	22,075	88,230	75.0
7/8/00	507	12.35	52,220	237	8.47	16,742	68,962	75.7
7/9/00	427	12.22	43,518	225	8.43	15,819	59,337	73.3
7/10/00	785	6.85	44,846	476	3.84	15,244	60,090	74.6
7/11/00	689	9.57	54,992	420	5.44	19,055	74,047	74.3
7/12/00	602	13.27	66,624	407	7.31	24,813	91,437	72.9
7/13/00	554	20.00	92,407	326	8.07	21,941	114,348	80.8
7/14/00	428	15.86	56,613	344	7.70	22,091	78,704	71.9
7/15/00	550	12.85	58,943	314	7.42	19,431	78,374	75.2
7/16/00	374	11.70	36,494	260	7.88	17,087	53,581	68.1
7/17/00	343	21.40	61,217	262	8.57	18,726	79,943	76.6
7/18/00	360	17.36	52,122	232	9.18	17,762	69,884	74.6
7/19/00	361	15.47	46,576	228	9.82	18,673	65,249	71.4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

AMMONIA CONCENTRATIONS, SEWAGE FLOW RATES AND AMMONIA
LOADS AT THE STICKNEY SOUTHWEST AND WEST SIDE PLANTS
JANUARY 2 THROUGH JULY 31, 2000

	Southwest Raw			West Side Raw			Total	Ratio
Date	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	Flow MGD	NH_3-N mg/L	NH_3-N Load lb/d	NH_3-N Load lb/d	SW/Total %
7/20/00	367	17.89	54,757	225	9.76	18,315	73,072	74.9
7/21/00	379	19.52	61,700	239	9.79	19,514	81,214	76.0
7/22/00	388	17.27	55,884	263	9.52	20,881	76,766	72.8
7/23/00	366	15.87	48,442	289	9.19	22,150	70,593	68.6
7/24/00	272	21.90	49,680	338	9.89	27,879	77,559	64.1
7/25/00	331	19.89	54,907	241	9.35	18,793	73,700	74.5
7/26/00	361	24.19	72,830	248	10.20	21,097	93,927	77.5
7/27/00	436	27.42	99,706	289	9.58	23,090	122,796	81.2
7/28/00	457	15.48	59,000	315	7.77	20,413	79,413	74.3
7/29/00	455	26.69	101,281	411	5.74	19,675	120,956	83.7
7/30/00	478	11.74	46,802	320	8.45	22,551	69,353	67.5
7/31/00	497	9.81	40,662	353	6.37	18,753	59,416	68.4
Mean	470	17.59	61,832	316	8.47	21,316	82,444	73.5
Min.	197	4.91	30,179	92	2.11	6,916	47,126	50.5
Max.	923	36.96	140,208	596	13.70	41,825	164,261	91.8
Std. Dev.	166	6.85	15,930	91	1.96	5,200	15,955	6.8
CV (%)	35.3	38.9	25.8	28.7	23.1	24.4	19.4	9.2

*Data were not available.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-4

FLOW RATES AND AMMONIA CONCENTRATIONS FOR TARP PUMPBACK
AUGUST 14 THROUGH SEPTEMBER 5, 2000

Date	Flow MGD	NH_3-N mg/L	NH_3-N lb/d
8/14/00	17	ND*	ND
8/15/00	53	31.49	13,919
8/16/00	17	ND	ND
8/17/00	63	30.78	16,172
8/18/00	189	6.27	9,883
8/19/00	357	3.64	10,838
8/20/00	191	2.44	3,887
8/21/00	NF**		
8/22/00	17	4.91	696
8/23/00	33	13.35	3,674
8/24/00	39	14.21	4,622
8/25/00	17	10.55	1,496
8/26/00	67	19.95	11,148
8/27/00	NF		
8/28/00	17	8.8	1,248
8/29/00	42	14.37	5,034
8/30/00	NF		
8/31/00	6	9.9	495
9/5/00	NF		
Mean	75	13.13	6,393
Min.	6	2.44	495
Max.	357	31.49	16,172
Std. Dev.	97	9	5,348
CV (%)	130	71	84

*ND = No data.
**NF = No flow.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5

FLOW RATES AND AMMONIA CONCENTRATIONS FOR DISCHARGE
FROM THE CORN PRODUCTS CORPORATION (CPC)
AUGUST 14 THROUGH SEPTEMBER 5, 2000

	Site 1 (2AT)		Site 2 (6AT)		Total
Date	NH_3-N mg/L	FLOW* MGD	NH_3-N mg/L	FLOW** MGD	NH_3-N lb/d
8/14/00	165.92	6.50	1.01	0.191	8,996
8/15/00	231.81	6.45	1.32	0.183	12,472
8/16/00	151.49	7.28	0.04	0.274	9,198
8/17/00	112.09	6.38	0.06	0.156	5,964
8/18/00	121.82	5.93	0.05	0.198	6,025
8/19/00	154.99	6.27	0.19	0.187	8,105
8/20/00	0.09	6.57	0.09	0.187	5
8/21/00	DN***	6.6	162.19	0.19	DN
8/22/00	177.47	6.6	0.09	0.19	9,769
8/23/00	176.60	6.6	0.05	0.19	9,721
8/24/00	136.82	6.6	0.10	0.19	7,531
8/25/00	220.84	6.6	0.35	0.19	12,157
8/26/00	166.86	6.6	0.04	0.19	9,185
8/27/00	182.62	6.6	0.06	0.19	10,052
8/28/00	199.32	6.6	0.15	0.19	10,972
8/29/00	154.51	6.6	0.08	0.19	8,505
8/30/00	152.90	6.6	0.11	0.19	8,416
8/31/00	201.08	6.6	0.08	0.19	11,068
9/5/00	174.67	6.6	0.09	0.19	9,615
Mean	160.10	6.56	8.74	0.192	8,764
Min.	0.09	5.93	0.04	0.156	5
Max.	231.81	7.28	162.19	0.274	12,472
Std. Dev.	51	0	37.16	0	2,811
CV (%)	32	4	425	11	32

*A mean flow of 6.6 MGD was used for the days without records.

**A mean flow of 0.19 MGD was used for the days without records.

***Data were not available.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6

SLUDGE VOLUME INPUT AND WET CAKE WEIGHT FROM POST-DIGESTION CENTRIFUGES AND AMMONIA CONCENTRATION OF CENTRATE AUGUST 14 THROUGH SEPTEMBER 5, 2000

Date	Sludge to Centrifuges gal/d	Cake Wet Weight ton/h	Centrate Flow MGD	Centrate NH_3-N* mg/L	NH_3-N Amount lb/d
8/14/00	1,657,215	38.11	1.44	564	6,762
8/15/00	1,296,000	39.12	1.07	564	5,036
8/16/00	1,642,189	38.04	1.42	564	6,693
8/17/00	1,630,700	35.79	1.42	564	6,700
8/18/00	2,067,660	51.69	1.77	564	8,325
8/19/00	2,535,960	58.90	2.20	564	10,332
8/20/00	1,343,386	36.02	1.14	564	5,343
8/21/00	1,879,515	46.39	1.61	564	7,583
8/22/00	1,922,160	48.02	1.65	564	7,740
8/23/00	2,422,200	62.17	2.06	564	9,708
8/24/00	2,210,580	58.44	1.87	564	8,814
8/25/00	2,291,400	58.17	1.96	564	9,201
8/26/00	2,419,740	61.55	2.07	564	9,714
8/27/00	2,535,421	64.71	2.16	564	10,172
8/28/00	2,832,540	75.67	2.40	564	11,273
8/29/00	2,144,760	55.89	1.82	564	8,574
8/30/00	2,433,780	74.84	2.00	564	9,419
8/31/00	2,445,000	59.94	2.10	564	9,876
9/5/00	2,699,520	72.56	2.28	564	10,731
Mean	2,126,828	54.53	1.81		8,526
Min.	1,296,000	35.79	1.07		5,036
Max.	2,832,540	75.67	2.40		11,273
Std. Dev.	451,874	13.05	0.38		1,795
CV (%)	21.2	23.9	21.1		21.1

*The mean ammonia concentration of 564 mg/L for centrate was obtained in a separate study during September 13 through 20, 2000 (see Appendix Table AI-2), and was used here to estimate the amounts of ammonia in the centrate, as the daily concentrations of ammonia for centrate during August 14 through September 5, 2000 were not available.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-7

AMMONIA CONCENTRATIONS AND FLOW RATES OF THE OVERFLOW FROM THE SLUDGE LAGOONS AT LASMA
AUGUST 14 THROUGH SEPTEMBER 5, 2000

Date	NH_3-N Concentration mg/L	Flow* MGD	NH_3-N Load K lb/d
8/14/00	882.28	2.84	20,884
8/15/00	826.23	2.84	19,557
8/16/00	701.17	2.84	16,597
8/17/00	295.19	2.84	6,987
8/18/00	477.65	2.84	11,306
8/19/00	562.69	2.84	13,319
8/20/00	645.76	2.84	15,285
8/21/00	786.02	2.84	18,605
8/22/00	558.85	2.82	13,132
8/23/00	730.83	2.85	17,372
8/24/00	739.42	2.89	17,822
8/25/00	717.52	2.92	17,485
8/26/00	820.43	2.84	19,448
8/27/00	766.94	2.78	17,782
8/28/00	733.46	2.77	16,916
8/29/00	759.87	2.84	17,986
8/30/00	797.59	2.84	18,879
8/31/00	800.76	2.84	18,954
9/5/00	843.57	2.84	19,968
Mean	707.70	2.84	16,752
Min.	295.19	2.77	6,987
Max.	882.28	2.92	20,884
Std. Dev.	144.77		3,433
CV (%)	20.5		20.5

*A mean flow of 2.84 MGD was used for the days without records.