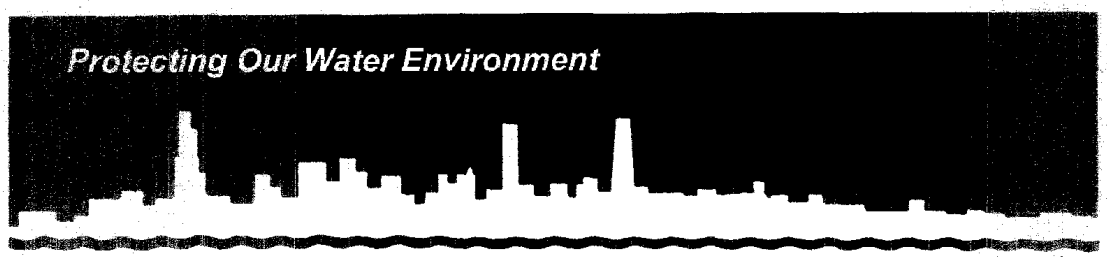

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 04-7

CHARACTERISTICS OF STORMWATER RUNOFF DISCHARGED TO THE CHICAGO WATERWAY SYSTEM FROM THREE ILLINOIS DEPARTMENT OF TRANSPORTATION PUMPING STATIONS

June 2004

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June 2004

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ACKNOWLEDGMENTS

The authors wish to acknowledge that the Industrial Waste Division (IWD) selected the IDOT pumping stations for sampling and collected all the samples. The Analytical Laboratories Division (ALD) performed sample analyses for this project.

The assistance of IWD in providing information on the selection of sampling sites, capacities of pumping stations, drainage areas, and sampling procedure for this report is deeply appreciated.

The assistance of the staff of ALD in providing electronic copies of analytical results for the IDOT pumping station discharge samples is also sincerely appreciated.

The authors wish to acknowledge the assistance of the staff of Illinois State Water Survey, particularly Ms. Nancy Westcott and Dr. James Angel, for providing hourly rainfall and daily snowfall data for this report.

The authors also wish to acknowledge the assistance of the staff of Illinois Department of Transportation, particularly Mr. Naser Gholeh, Maintenance Engineer.

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

DISCLAIMER

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

SUMMARY AND CONCLUSIONS

Summary

In order to obtain data on pollutant loadings from highway stormwater runoff to the Chicago Waterway System (CWS), a study was conducted to collect and analyze storm runoff discharged at three Illinois Department of Transportation (IDOT) pumping stations in a period from October 2002 to July 2003. The three IDOT pumping stations sampled in this study were IDOT Pumping Stations Number 3 (IDOT PS No. 3), Number 5 (IDOT PS No. 5) and Number 29 (IDOT PS No. 29). These pumping stations collect storm runoff from portions of the Edens Expressway (I-94), Eisenhower Expressway (I-290), and Dan Ryan Expressway (I-90), and discharge the runoff to the North Branch (IDOT PS No. 3) and South Branch (IDOT PS Nos. 5 and 29) of the Chicago River, respectively.

During the study period, discharges from the IDOT pumping stations were sampled in 21, 40 and 41 storm-sampling events at IDOT Pumping Stations Nos. 3, 5 and 29, respectively. These sampling events covered the discharges taking place under four different conditions, namely no rain, snowmelt, small rain (< 0.1 inches) and large rain (≥ 0.1 inches). Of the 21 storm-sampling events sampled at IDOT PS No. 3, there were 2 no rain events, 2 snowmelts, 2 small rains, and 15 large

rains. Of the 40 storm-sampling events sampled at IDOT PS No. 5, there were 4 no rain events, 9 snowmelts, 4 small rains, and 23 large rains. Of the 41 storm-sampling events sampled at IDOT PS No. 29, there were 6 no rain events, 5 snowmelts, 5 small rains, and 25 large rains.

This report presents the description of the sampling program for collecting pumping station samples, methods of data analysis, and results of the study. The data collected in the sampling phase of this study, along with the corresponding storm and snowfall data acquired from the Illinois State Water Survey (ISWS), were analyzed to examine the potential correlation between the concentrations of pollutants in the discharges and storm variables.

Conclusions

The following conclusions can be drawn from this study:

1. In the study period, the storm runoff caused by storms with greater than or equal to 0.1 inches of cumulative rainfall and discharged at the three IDOT pumping stations had average event mean concentrations (EMCs) of TSS, $CBOD_5$, TN and TP of 98.9 mg/L, 9.1 mg/L, 2.68 mg/L and 0.25 mg/L at IDOT PS No. 3, 69.3 mg/L, 10.0 mg/L, 3.32 mg/L and 0.26 mg/L at IDOT PS No. 5, and

87.3 mg/L, 8.3 mg/L, 3.31 mg/L and 0.19 mg/L at IDOT PS No. 29, respectively. Among these four stormwater constituents, TSS had the largest variation in individual EMCs and TN had the least variation in individual EMCs.

2. At the three locations sampled, the average values of EMCs of TSS, $CBOD_5$ and TP were not statistically different at the 5 percent level of significance. However, the average value of EMC of TN at IDOT PS No. 3 was significantly lower than those at the other two locations, resulting from relatively lower concentrations of $(NO_2 + NO_3)$-N at this location. The reason for this is not known.

3. Among four rain event variables, namely cumulative rainfall, rain duration, mean rain intensity, and the days since the last rain that has at least 0.1 inches of rainfall, the days since the last rain had the largest impact on the EMCs of TSS, $CBOD_5$, TN and TP at all three locations. The concentrations of these constituents in storm runoffs will be relatively high, if the days from the previous storm that has at least 0.1 inches of rainfall to the present storm are

relatively long. The correlation between the stormwater constituents and the other three rain event variables were generally weak except for a few individual pairs.

4. At all three locations sampled, the average values of EMCs of chloride and conductivity in the snow season, which took place from November 16, 2002, to April 15, 2003, were much higher than those in the non-snow season. Furthermore, the variations in individual EMCs of chloride and conductivity in the snow season were much larger than those in the non-snow season. The higher average concentrations of chloride and conductivity and larger variations in individual concentrations were likely attributable to the application of road salts during snowstorms.

INTRODUCTION

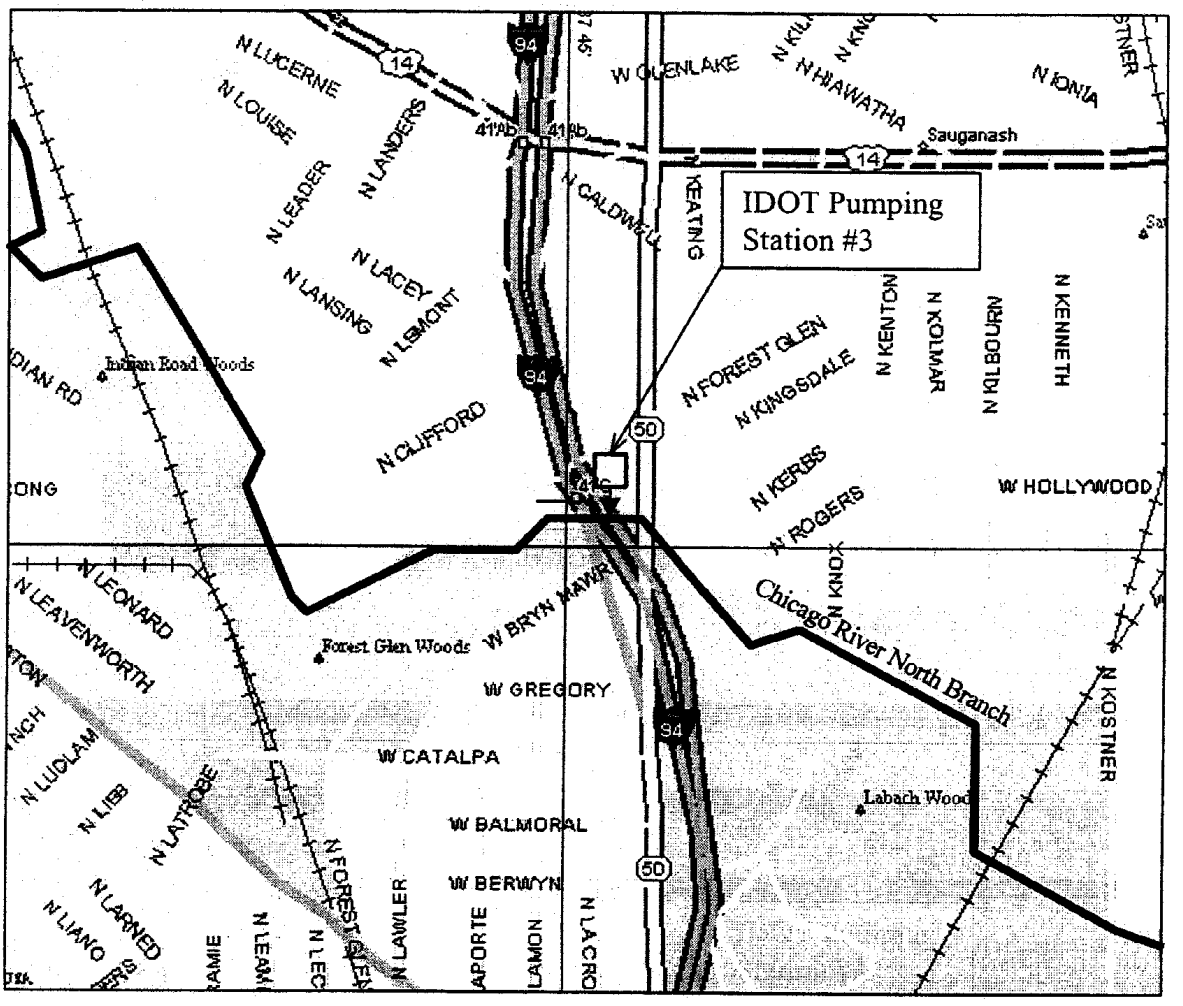
Stormwater runoff from urban highways carries pollutants from atmospheric dust, road dirt, etc., and directly discharges them into surface waters through highway drainage systems and pumping stations. In the service area of the Metropolitan Water Reclamation District of Greater Chicago (District), there are approximately 24 pumping stations operated by the Illinois Department of Transportation (IDOT) that discharge stormwater runoff from the highways in this area into the Chicago Waterway System (CWS). In order to collect data on pollutant loadings from highway stormwater runoff to the CWS, the Research and Development (R&D) Department of the District conducted a study to collect storm runoffs discharged at three IDOT pumping stations into the CWS during various storm events between October 2002 and July 2003 and analyze them for certain stormwater constituents.

The three IDOT pumping stations sampled in this study were IDOT Pumping Stations Number 3 (IDOT PS No. 3), Number 5 (IDOT PS No. 5) and Number 29 (IDOT PS No. 29). Figures 1 through 3 show the locations of these IDOT pumping stations and the receiving streams that accept the discharges from these pumping stations, respectively. IDOT PS No. 3 is located at Forest Glen Avenue, Chicago, Illinois, and is used to

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 1

LOCATION OF IDOT PUMPING STATION NO. 3



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 2

LOCATION OF IDOT PUMPING STATION NO. 5

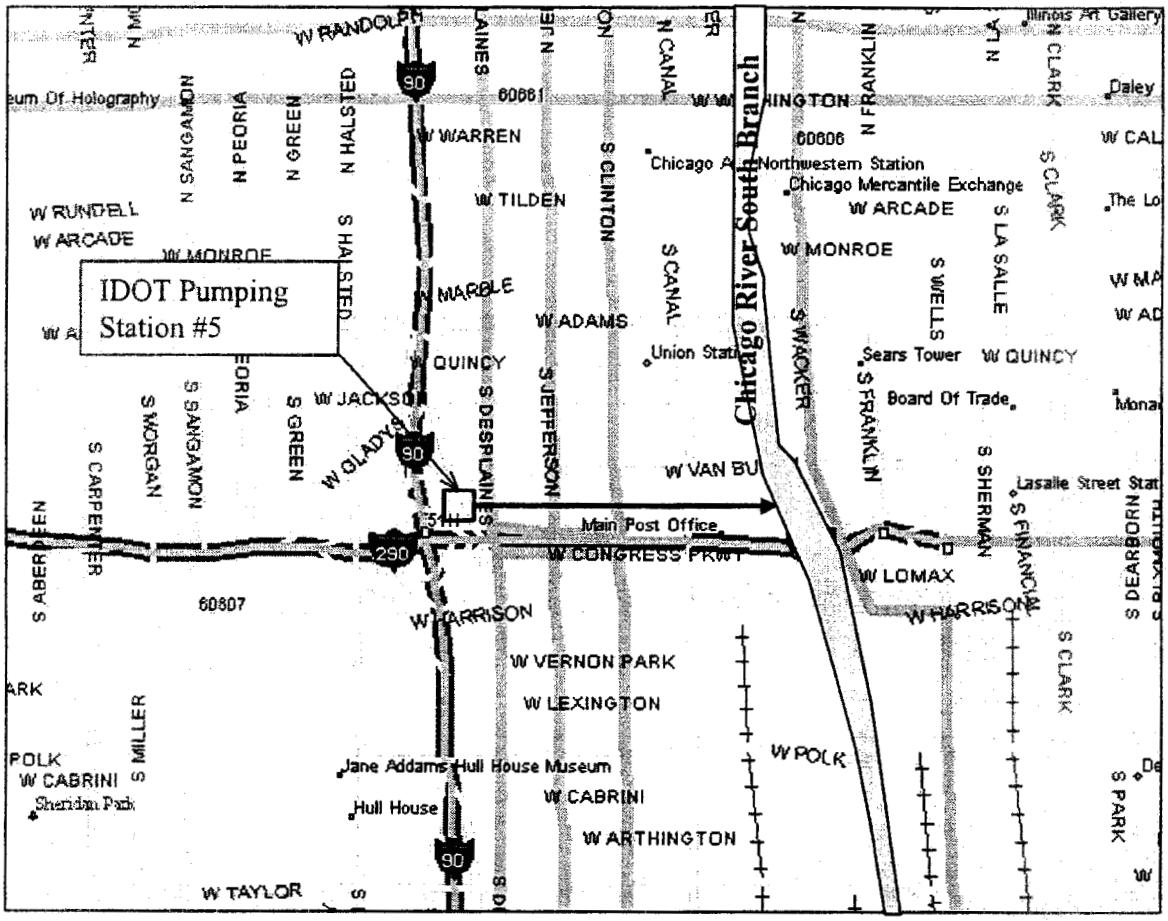


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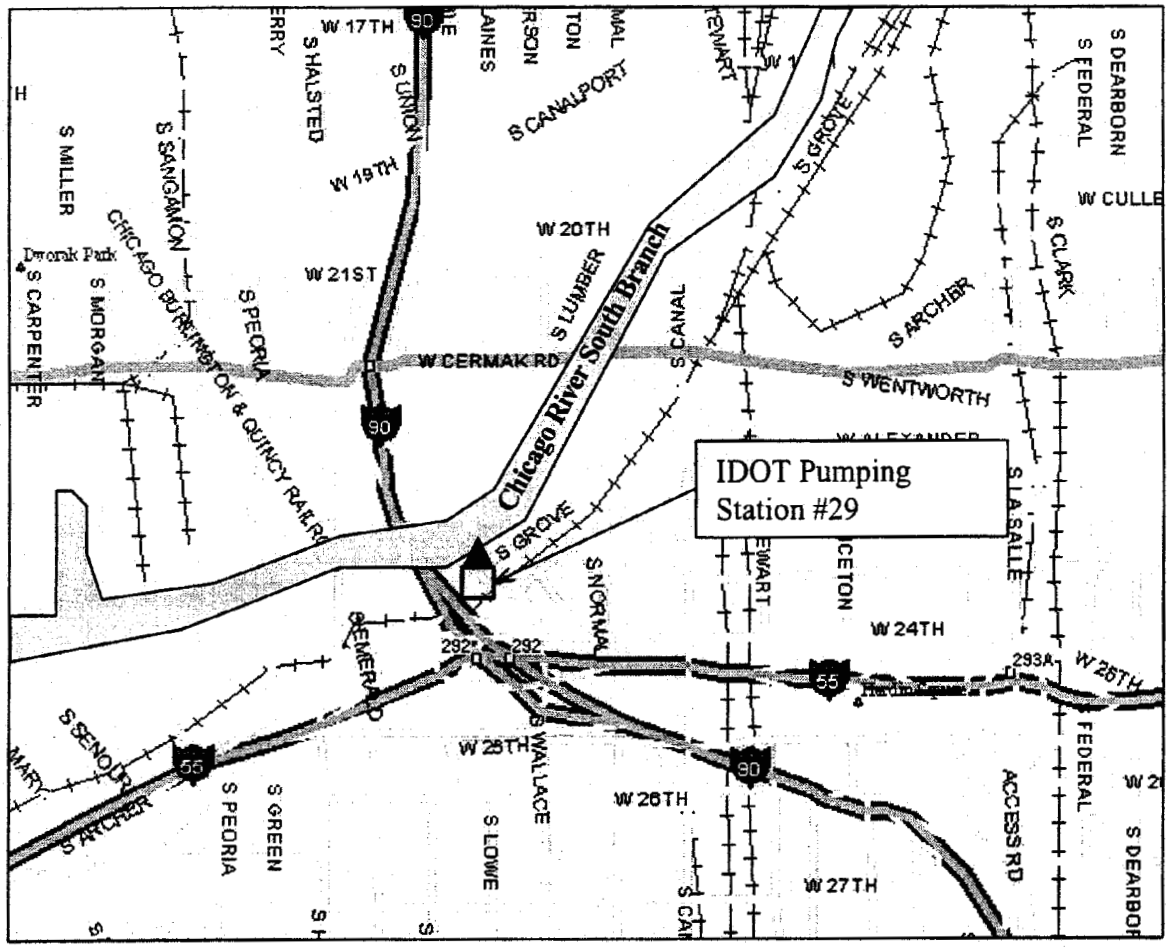
FIGURE 3

LOCATION OF IDOT PUMPING STATION NO. 29



pump the stormwater runoff collected from a portion of the Edens Expressway (I-94) to the North Branch of the Chicago River. This pumping station has four storm pumps with a rated capacity of 70,000 gallons per minute (gpm) (or 101 million gallons per day (MGD)).

IDOT PS No. 5 is located at the corner of Van Buren Street and Des Plaines Avenue, Chicago, Illinois, and is used to pump the stormwater runoff collected from a portion of Eisenhower Expressway (I-290) with a drainage area of approximately 275 acres. This pumping station has five storm pumps with an operating capacity of 38,000 gpm (54.7 MGD). The stormwater runoff pumped from this pumping station are discharged to the South Branch of the Chicago River.

IDOT PS No. 29 is located at the corner of 24th Street and Wallace Avenue, Chicago, Illinois, and is used to pump the stormwater runoff collected from a portion of the Dan Ryan Expressway (I-90) to the South Branch of the Chicago River. This pumping station has 6 storm pumps with a rated capacity of 108,000 gpm (156 MGD).

In this study, automatic samplers were used at the three sampling locations, to collect composite samples, with an aliquot taken every 15 minutes, for single sampling periods ranging from 4 to 24 hours. A discharge event which lasted for more than 24 hours at a sampling location could be captured by

two or more composite samples. All samples were preserved on site by packing the sampler trays with ice until the completion of sampling. All samples collected at each of the sampling locations were delivered to the District laboratories for sample login and analysis immediately after the completion of sampling.

The data collected in the sampling phase of this study, together with the corresponding storm data acquired from the Illinois State Water Survey (ISWS), were organized and analyzed to fulfill the objectives of this study. This report presents the description of the stormwater runoffs sampling program, methods of data analysis, discussion of results and the conclusions drawn from this study.

OBJECTIVES

The objectives of this study were:

1. To measure and examine the concentrations of common pollutants (constituents) in stormwater runoffs discharged from the three IDOT pumping stations for estimating pollutant loads to the CWS.
2. To compare the chemical characteristics of the storm runoffs discharged at the three IDOT pumping stations.
3. To find a correlation between the constituents in the stormwater runoffs and the storm variables at these locations.

METHODOLOGY

Sample Collection

Three IDOT pumping stations were selected for sampling stormwater runoffs from urban highways, after screening for site representativeness and accessibility. A sampling protocol was prepared before sample collection commenced. The procedure for sampling equipment setup, and sample collection, transportation and login was detailed in the protocol. The same procedure was followed at each sampling location.

At each sampling location, all samples were collected by an automatic sampler equipped with a discrete tray containing 24 bottles. Aliquots were taken at 15-minute intervals with 4 aliquots per bottle for a maximum period of 24 hours during a sampling event. A sampling event was defined as an event where at least four consecutive bottles contained liquid, that is, a minimum duration of four hours. Any sampling event of four or more consecutive filled bottles was considered as a separate event, and all the bottles were mixed in a single container to form a composite sample for that event. This resulted in the duration of a composite sample ranging from 4 to 24 hours, with a possibility of as many as five separate composite samples representing five separate events per day.

The automatic samplers were serviced daily during workdays, Monday through Friday, and, resources permitting, on weekends when the weather forecast indicated a sampling event was likely to occur. Each discrete tray was iced at all times during sampling duration. All composite samples were logged into a Laboratory Information Management System (LIMS) and delivered to the District analytical laboratories for analysis.

Sample Analyses

Each composite sample was analyzed for 9 constituents. These constituents include chloride (Cl), conductivity, nitrite and nitrate nitrogen [$(NO_2 + NO_3)$-N], ammonia nitrogen (NH_3-N), Total Kjeldahl Nitrogen (TKN), total phosphorus (TP), soluble phosphorus (SOL-P), total suspended solids (TSS), and carbonaceous BOD_5 ($CBOD_5$). The District's Analytical Laboratories are IEPA-accredited under the National Environmental Laboratory Accreditation Program. All the analytical methods followed for analyzing the samples for these stormwater constituents were either USEPA-approved methods or Standard Methods (1, 2).

Flow Data

Discharge flow rates at any of the three IDOT pumping stations sampled were not available for this study. Although pumping capacity of each pump and number of pumps at each

station were available, the number of pumps in operation during the sampling periods was not known. In general, the sampling duration corresponded with the discharge duration or pumping duration. However, the number of pumps in operation during a pumping event affects the discharge flow rate significantly. For example, the discharge flow rate at IDOT PS No. 3 varies from 17,500 gpm (25.2 MGD) to 70,000 gpm (101 MGD) with one to four pumps in operation, assuming that each of the four pumps has the same capacity of 17,500 gpm. Therefore, no attempt was made to estimate the discharge flow rates corresponding to the sampling events for this study.

Data Analysis

STORM DATA

The data of hourly rainfall in inches for the sampling period from October 16, 2002 to July 21, 2003 were obtained from the Illinois State Water Survey (ISWS). A raingage network operated by ISWS and the US Army Corps of Engineers for Lake Michigan diversion accounting within the Cook County area is shown in Figure 4. The data from Raingages 2 and 4 were used to calculate the rain data for IDOT PS No. 3, Raingages 6, 7, 9 and 10 for IDOT PS No. 5, and Raingages 10 and 13 for IDOT PS No. 29, respectively.

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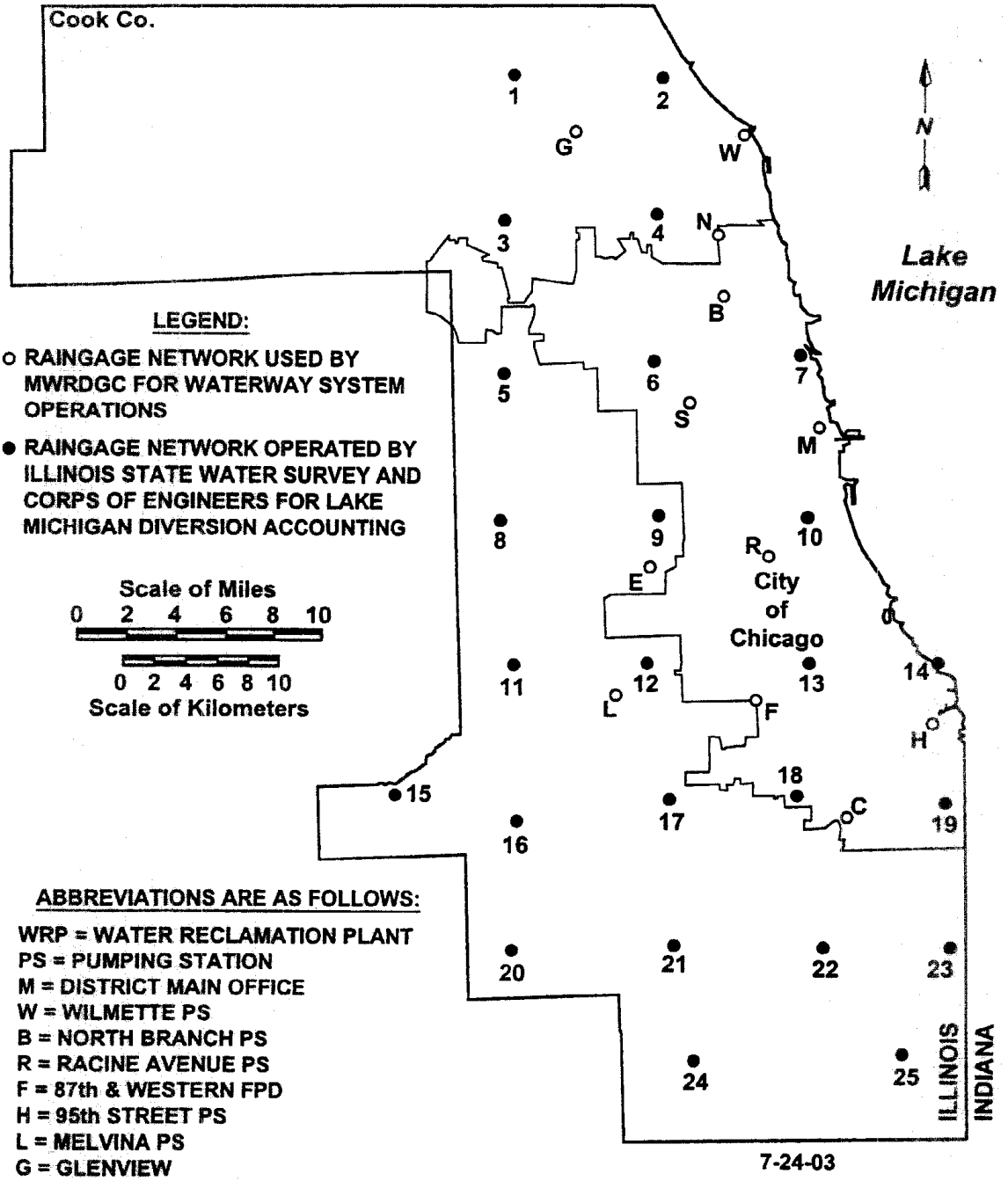
FIGURE 4

RAINGAGE LOCATIONS IN METROPOLITAN CHICAGO AREA



Four rain variables, i.e. rain duration, cumulative rainfall, rain intensity, and the days since last rain, were used in previous studies (3, 4), and were employed in this study to examine any possible correlation between constituents in rain runoff and rain variables. The values of these four rain variables for each storm-sampling event were calculated using the corresponding raingage data provided by ISWS and the methods described in the next paragraph. A storm-sampling event is defined as an event in which continuous or discrete rainfalls trigger the collection of one or more composite samples. In other words, a storm-sampling event may have included one or more sampling events, as defined in a previous section, since a storm-sampling event may have lasted as long as 76 hours while a sampling event had a maximum duration of 24 hours. The interval between sampling events for a given storm-sampling event was usually within one hour with the longest being less than and equal to 2 hours.

Rain duration (Duration) in hours was calculated using an average value of actual recorded hours that had at least 0.01 inches of rain at the raingages used for each sampling site. Rainfall in inches was calculated as a mean value of cumulative rainfalls at the corresponding raingages. Rain intensity (Intensity) in inches per hour was the average rain intensity over a storm period corresponding to a storm-sampling event.

It was derived from dividing the cumulative rainfall by the corresponding rain duration for a given storm-sampling event. The range of rain intensity was the minimum and maximum hourly rainfalls at the individual raingages included in the calculation for a IDOT pumping station sampled. The days since last rain (Last Days) were calculated using the time period between the beginning of the present rain and the ending of a preceding rain that had a continuous and cumulative rainfall of at least 0.1 inches.

The data of daily snowfall in inches for the sampling period from October 16, 2002, to May 31, 2003, were also obtained from the ISWS. There are two stations at which daily snowfall is recorded by ISWS pertaining to this study. One station is located at Chicago Botanical Garden, Illinois (Station ID: 111497), and the other at Chicago Midway Airport, Illinois (Station ID: 111577). Daily snowfall data from both stations were obtained from the ISWS and used in this study to determine if a storm runoff resulted from snowmelt.

STORM RUNOFF SAMPLING DATA

The information on storm runoffs sampled at the three IDOT pumping stations, such as sampling date and starting and ending times of each sampling event, was obtained from the sampling log sheets generated by the IWD. The concentration

values of stormwater constituents analyzed for this study were obtained from LIMS.

The sampling information was rearranged based on storm-sampling events, as defined in the previous section, and the sampling duration for each storm-sampling event was calculated based on the starting and ending times of the event. Sampling duration could be equal to or less than 24 hours, if only one sampling event was included in a storm-sampling event, and greater than 24 hours if two or more sampling events were included.

For each storm-sampling event, storm data, including rain duration, rainfall, mean rain intensity, and the days since last rain, as well as snowfall (snow), were compiled, and the values of event mean concentrations (EMCs) of the measured stormwater constituents were calculated. For the storm-sampling events that included only one sampling event, concentrations of the constituents analyzed were considered EMCs, as all storm runoff samples collected in this study were time-based composite samples. For the storm-sampling events that included two or more sampling events, EMCs of the constituents analyzed were calculated using a weighted-average method with the sampling duration of each sampling event as the weight. If the value of a constituent for a given sampling event was

missing, that sampling event was excluded in the time-weighted average calculation.

Based on the storm data, particularly rainfall and snowfall, the storm-sampling events are categorized into four groups at each sampling location. Group One contained the storm-sampling events occurring when there was no rain, either during an event or not long before the event. It is not known why the pumping stations were discharging under this type of condition. Group Two contained the storm-sampling events occurring when there was a snowfall of more than one inch either on the day of sampling or the day before sampling. Group Three included the storm-sampling events that were sampled under small rains, typically having less than 0.1 inches of cumulative rainfall. Group Four included the storm-sampling events triggered by large rains that each had a cumulative rainfall of greater than or equal to 0.1 inches.

For each group of storm-sampling events, the EMC values of the stormwater constituents monitored were pooled together for each sampling location. The number of concentration values available for calculation, minimum (Min), maximum (Max), median, mean values, standard deviation (Std Dev), and coefficient of variation (CV) were calculated in spreadsheets. If the number of concentration values available for calculation was less than three, only mean values for the group were

calculated. In this report, the value of total nitrogen (TN), which is the sum of $(NO_2 + NO_3)$-N and TKN, was calculated for each storm-sampling event, and included in the data analysis.

The average values of EMCs of all Group Four events, namely the storm-sampling events with large rains, for all constituents monitored were compared among the sampling locations. Statistical analyses were used, by comparing the mean concentrations, to examine the possible differences among the locations. Statistical analysis was also performed to find the potential correlation between the stormwater constituents measured and rain variables for each sampling location.

STATISTICAL ANALYSES

The statistical method used for comparing means is a one-way analysis of variance (ANOVA) to study the effects of location. For the one-way ANOVA, the assumption of normality for each location is verified by the Kolmogorov-Smirnov (K-S) method. If the assumption of normality holds, the assumption of equal variance due to different locations is verified by Bartlett test at 5 percent level of significance.

First, the assumptions of normality and equal variance are checked using the actual concentrations. If the assumptions of normality do not hold at each location for all parameters, the same approach is applied on the log-transformed

values of the actual concentrations to determine whether the assumptions of normality hold at each location for all parameters. Bartlett test is used to check the assumption of equal variance of two different locations for each parameter to examine whether this assumption holds for each parameter.

A parametric ANOVA is performed when the assumption of equal variance holds. Otherwise, the analysis is performed by Kruskal-Wallis (K-W) method known as nonparametric ANOVA, which makes inferences about the medians of the populations. If assumptions of normality hold for actual values at each location for all parameters, the inference due to the K-W method also applies to means of the population because the medians and the means are identical for any symmetric population, such as a normal population. Although the parametric ANOVA inference is based on log-transformed values, it also applies to the actual values since the mean of the actual value is a one-to-one function of the mean of the log values, which come from normal populations with equal standard deviations.

The correlation between each stormwater constituent monitored and each storm variable was examined using Pearson correlation coefficient (PCC). PCC has values ranging from -1.0 to +1.0. A PCC value close to either -1.0 or +1.0 for a pair of variables means that these two variables are highly correlated, whereas a PCC value close to zero from either negative

or positive sides indicates no correlation between the two variables. If one variable increases linearly with an increase in another variable, PCC value for these two variables will be close to +1.0, and if one variable decreases linearly with an increase in another variable, PCC value for these two variables will be close to -1.0. A PCC value between a stormwater constituent, such as TSS, and a storm variable, such as rainfall, for each sampling site was computed in Excel using the values of EMCs of the constituent and the corresponding storm variable obtained in the storm data analysis.

RESULTS AND DISCUSSION

During the study period from October 16, 2002 to July 21, 2003, 29, 45, and 47 composite samples were collected at IDOT pumping stations Nos. 3, 5 and 29, respectively. These samples were analyzed for nine constituents in the District Analytical Laboratories. The concentration values of nine analyzed constituents and one derived constituent, TN, for the storm runoff discharges sampled at the three IDOT pumping stations are listed in Appendix Tables AI-1 through AI-3.

Cumulative rainfalls for the individual storms sampled in the study period ranged from 0 to 2.67 inches. Discharges at the IDOT pumping stations may occur for a few days after a large storm. Also, some discharge was observed even when no recent rainfall had occurred. The source of this dry weather flow is not known. As a single sampling event for this study was set to range from 4 to 24 hours, several sampling events could have resulted from a single large storm. Figure 5 presents the hourly rainfall and sampling events taking place at IDOT PS No. 3 during the period of April 30 to May 5, 2003. Six peaks of hourly rainfall, and six sampling events, each of which is separated by vertical dotted lines in the figure, were identified during this period at this location. Based on the arrangement of sampling events in this period, two storm-

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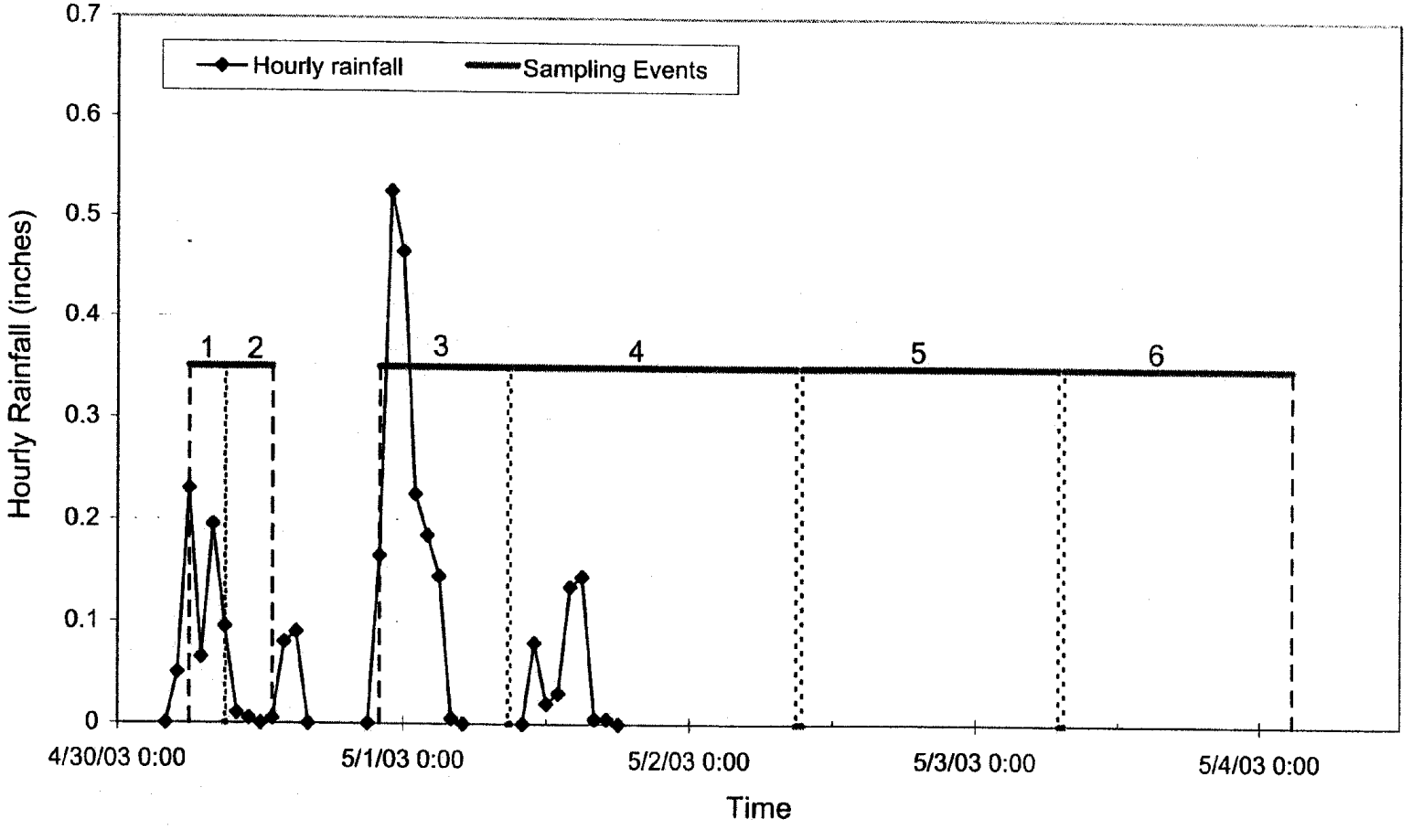
FIGURE 5

HOURLY RAINFALL AND SAMPLING EVENTS FOR IDOT PUMPING STATION NO. 3
DURING PERIOD OF APRIL 30 TO MAY 5, 2003



sampling events were determined, shown in the figure bounded by the dashed lines. The first two peaks of hourly rainfall were designated as the rains for the first storm-sampling event, whereas the third peak was excluded because it occurred after the sampling event ended. The last three peaks of hourly rainfall were assigned as the rains for the second storm-sampling event. Accordingly, the values of rain variables for each storm-sampling event were calculated using the corresponding raingage data from ISWS.

The same approach to determining storm-sampling events was used for each of the three sampling locations. After examining all sampling events at the three sampling locations, 21, 40, and 41 storm-sampling events were determined for IDOT PS Nos. 3, 5 and 29, respectively, during the study period. The rain variables for these events were calculated based on the rainfall data provided by ISWS. The summaries of storm-sampling events and the corresponding storm data for IDOT PS Nos. 3, 5 and 29 sampled in this study are presented in Tables 1 through 3, respectively.

Characteristics of Highway Storm Runoff

Concentrations of nine constituents in the storm runoffs discharged at the three IDOT pumping stations and sampled in this study were directly measured, and the concentration of

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TABLE 1

STORM RUNOFF SAMPLING AND CORRESPONDING STORM DATA FOR IDOT PUMPING STATION NO. 3

Sampling Time		Sampling Duration	No. of Composite	Storm Period		Rain Duration	Cumulative Rainfall	Mean Rain Intensity	Intensity Range	Last Days*
From	To	h	Samples	From	To	h	inch	in/h	in/h	d
12/18/02 10:50	12/19/02 00:50	14	1	12/17/02 23:30	12/18/02 20:30	21	1.05	0.050	0.01 - 0.30	15.2
03/25/03 04:10	03/25/03 09:10	5	1	03/24/03 21:00	03/25/03 03:00	6	0.15	0.025	0.01 - 0.07	5.0
04/03/03 20:00	04/04/03 08:00	12	1	04/03/03 15:00	04/04/03 06:00	15	0.82	0.055	0.01 - 0.24	5.9
04/07/03 10:55	04/07/03 21:40	11	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
04/08/03 02:55	04/08/03 09:15	7	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
04/09/03 10:45	04/09/03 14:30	4	1	04/09/03 06:30	04/09/03 10:30	4	0.31	0.076	0.01 - 0.19	0.5
04/30/03 06:00	04/30/03 14:05	8	2	04/30/03 04:00	04/30/03 15:00	11	0.74	0.067	0.01 - 0.24	20.7
04/30/03 22:05	05/04/03 02:45	76	4	04/30/04 21:00	05/01/03 16:00	12.5**	2.14	0.171	0.01 - 0.56	0.3
05/04/03 23:30	05/07/03 03:25	51	3	05/04/03 18:00	05/05/03 02:00	8	1.21	0.151	0.01 - 0.39	3.1
05/09/03 10:00	05/10/03 13:15	27	2	05/08/03 22:00	05/10/03 02:00	10**	1.45	0.145	0.01 - 0.70	3.8
05/12/03 09:10	05/12/03 22:10	12	2	05/11/03 12:00	05/11/03 22:00	10	0.17	0.017	0.01 - 0.06	0.5
05/13/03 12:00	05/13/03 22:00	10	1	no rain	no rain	0	0.00	n/a	n/a	n/a
05/14/03 19:00	05/15/03 03:00	8	1	05/14/03 09:00	05/14/03 19:00	6**	0.56	0.093	0.01 - 0.46	2.5
05/22/03 22:40	05/23/03 02:40	4	1	no rain	no rain	0	0.00	n/a	n/a	n/a
05/28/03 16:20	05/28/03 22:20	6	1	05/28/03 14:00	05/28/03 17:00	3	0.64	0.212	0.09 - 0.42	13.8
06/03/03 02:05	06/03/03 09:05	7	1	06/03/03 02:00	06/03/03 09:00	7	0.08	0.011	0.01 - 0.02	4.1
06/18/03 14:10	06/18/03 23:10	9	1	06/18/03 14:00	06/18/03 20:00	6	0.68	0.113	0.01 - 0.28	9.9
07/10/03 22:35	07/11/03 02:35	4	1	07/10/03 18:00	07/10/03 21:00	3	0.06	0.018	0.01 - 0.06	0.4
07/15/03 04:45	07/15/03 09:45	5	1	07/15/03 03:00	07/15/03 15:00	5	0.94	0.188	0.01 - 0.94	4.8
07/17/03 15:55	07/17/03 23:55	8	1	07/17/03 15:30	07/17/03 19:30	4	0.87	0.218	0.01 - 0.77	2.3
07/20/03 22:20	07/21/03 08:20	10	1	07/20/03 21:00	07/21/03 03:00	6	0.52	0.086	0.01 - 0.35	3.1

*Last Days stands for the days since last rain that had at least 0.1 inches of cumulative rainfall.

**The actual rain duration for the storm period.

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TABLE 2

STORM RUNOFF SAMPLING AND CORRESPONDING STORM DATA FOR IDOT PUMPING STATION NO. 5

Sampling Time		Sampling Duration	No. of Composite	Storm Period		Rain Duration	Cumulative Rainfall	Mean Rain Intensity	Intensity Range	Last Days*
From	To	h	Samples	From	To	h	inch	in/h	in/h	d
10/16/02 04:50	10/16/02 15:20	10	2	10/16/02 03:00	10/16/02 06:00	3	0.12	0.041	0.01 - 0.08	4.0
10/25/02 00:50	10/25/02 10:50	10	1	10/25/02 00:00	10/25/02 09:00	9	0.22	0.025	0.01 - 0.06	7.1
11/05/02 10:30	11/06/02 01:30	15	1	11/05/02 09:00	11/05/02 15:00	6	0.16	0.027	0.01 - 0.11	11.0
11/14/02 17:50	11/15/02 06:50	13	1	11/14/02 15:00	11/14/02 23:00	7	0.22	0.031	0.01 - 0.06	4.0
11/18/02 13:00	11/18/02 20:00	7	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
11/18/02 22:00	11/19/02 11:00	13	1	11/18/02 21:00	11/19/02 01:00	4	0.14	0.034	0.01 - 0.11	1.5
11/20/02	n/a	n/a	1	no rain	no rain	0	0.00	n/a	n/a	n/a
11/21/02 10:30	11/22/02 09:30	23	1	11/21/02 09:00	11/21/02 16:00	7	0.18	0.026	0.01 - 0.07	2.3
11/26/02 18:05	11/27/02 06:05	12	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
12/02/02 10:20	12/03/02 01:20	15	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
12/03/02 06:20	12/03/02 10:20	4	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
12/03/02 10:50	12/03/02 14:50	4	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
12/03/02 20:50	12/04/02 01:50	5	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
12/18/02 00:30	12/19/02 11:00	34	2	12/18/02 00:00	12/18/02 20:00	20	1.31	0.066	0.01 - 0.37	15.3
03/05/03 09:00	03/06/03 09:00	24	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
03/07/03	n/a	n/a	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
03/17/03 13:00	03/17/03 19:00	6	1	no rain	no rain	0	0.00	n/a	n/a	n/a
03/17/03 21:00	03/18/03 03:00	6	1	no rain	no rain	0	0.00	n/a	n/a	n/a
03/20/03	n/a	n/a	1	03/20/03 09:00	03/20/03 12:00	3	0.06	0.021	0.01 - 0.07	0.5
03/21/03	n/a	n/a	1	03/21/03 03:00	03/21/03 04:30	1.5	0.02	0.010	0.01 - 0.02	1.2
03/24/03 22:35	03/25/03 09:35	11	1	03/25/03 01:00	03/25/03 04:00	3	0.11	0.036	0.01 - 0.09	5.1
03/26/03	n/a	n/a	1	no rain	no rain	0	0.00	n/a	n/a	n/a
04/01/03 01:30	04/01/03 11:30	10	1	03/31/03 19:00	03/31/03 21:30	2.5	0.05	0.018	0.01 - 0.03	3.1
04/03/03 17:50	04/04/03 10:50	17	1	04/03/03 20:00	04/04/03 05:00	9	0.81	0.090	0.01 - 0.52	2.9
04/07/03 10:30	04/08/03 10:30	24	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
04/08/03 11:00	04/09/03 11:00	24	1	04/08/03 09:00	04/09/03 11:00	12**	0.19	0.016	0.01 - 0.10	3.6
04/30/03 10:00	05/02/03 09:20	47	2	04/30/03 04:00	05/01/03 16:00	23**	2.67	0.116	0.01 - 0.73	20.7
05/05/03 09:30	05/06/03 09:30	24	1	05/04/03 19:00	05/05/03 02:00	7	1.21	0.172	0.01 - 0.38	3.1
05/08/03 19:45	05/09/03 09:45	14	1	05/08/03 22:00	05/09/03 04:30	6.5	1.25	0.192	0.01 - 0.69	3.8
05/12/03 10:40	05/13/03 10:40	24	1	05/10/03 21:00	05/11/03 23:00	9**	0.70	0.078	0.01 - 0.95	0.4
05/14/03 09:50	05/15/03 05:50	20	1	05/14/03 09:00	05/14/03 14:00	5	0.22	0.044	0.01 - 0.10	2.4
05/19/03 23:35	05/21/03 10:20	35	2	05/20/03 00:00	05/20/03 05:00	5	0.26	0.052	0.01 - 0.27	5.4

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TABLE 2 (Continued)

STORM RUNOFF SAMPLING AND CORRESPONDING STORM DATA FOR IDOT PUMPING STATION NO. 5

Sampling Time		Sampling Duration	No. of Composite	Storm Period		Rain Duration	Cumulative Rainfall	Mean Rain Intensity	Intensity Range	Last Days*
From	To	h	Samples	From	To	h	inch	in/h	in/h	d
05/28/03 15:30	05/29/03 02:30	11	1	05/28/03 15:00	05/28/03 20:00	5	0.31	0.062	0.01 - 0.18	8.4
06/02/03 23:40	06/03/03 10:40	11	1	06/02/03 23:00	06/03/03 07:00	8	0.23	0.029	0.01 - 0.14	3.1
06/09/03 11:30	06/09/03 18:30	7	1	06/08/03 13:00	06/08/03 18:30	5.5	0.45	0.081	0.01 - 0.28	2.1
06/10/03 13:40	06/10/03 18:40	5	1	06/10/03 08:00	06/10/03 09:00	1	0.02	0.023	0.01 - 0.05	1.6
06/18/03 16:10	06/19/03 09:10	17	1	06/18/03 14:00	06/18/03 18:00	4	0.41	0.103	0.01 - 0.34	9.8
06/26/03 10:30	06/27/03 00:30	14	1	06/26/03 06:30	06/26/03 09:30	3	0.32	0.105	0.01 - 0.41	7.5
07/07/03 09:45	07/08/03 09:50	24	1	07/06/03 14:00	07/07/03 10:00	8.5**	0.75	0.088	0.01 - 0.79	10.2
07/08/03 10:50	07/10/03 06:00	43	2	07/08/03 10:00	07/10/03 06:00	11**	0.48	0.043	0.01 - 0.17	1.0

*Last Days stands for the days since last rain that had at least 0.1 inches of cumulative rainfall.

**The actual rain duration for the storm period.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

STORM RUNOFF SAMPLING AND CORRESPONDING STORM DATA FOR IDOT PUMPING STATION NO. 29

Sampling Time		Sampling Duration	No. of Composite	Storm Period		Rain Duration	Cumulative Rainfall	Mean Rain Intensity	Intensity Range	Last Days*
From	To	h	Samples	From	To	h	inch	in/h	in/h	d
11/05/02 09:00	11/05/02 21:00	12	1	11/05/02 07:00	11/05/02 15:00	8	0.27	0.033	0.01 - 0.11	11.0
11/06/02 05:00	11/06/02 09:00	4	1	no rain	no rain	0	0.00	n/a	n/a	n/a
11/18/02 17:00	11/18/02 21:00	4	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
11/19/02 00:00	11/19/02 09:00	9	1	11/18/02 22:30	11/19/02 01:30	3	0.10	0.033	0.01 - 0.06	1.6
11/21/02 08:50	11/22/02 06:50	22	1	11/21/02 09:00	11/21/02 17:00	8	0.23	0.029	0.01 - 0.10	2.3
12/17/02 23:20	12/19/02 08:40	33	2	12/18/02 02:00	12/18/02 20:00	18	1.00	0.055	0.01 - 0.17	15.4
03/06/03 12:55	03/06/03 23:45	11	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
03/07/03 01:55	03/07/03 06:45	5	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
03/07/03 11:35	03/08/03 02:25	15	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
03/08/03 06:35	03/08/03 10:45	4	1	n/a	n/a	n/a	snow	n/a	n/a	n/a
03/18/03 17:00	03/18/03 21:00	4	1	no rain	no rain	0	0.00	n/a	n/a	n/a
03/19/03 12:30	03/19/03 19:30	7	1	03/19/03 07:00	03/19/03 08:00	1	0.01	0.010	0.01 - 0.01	10.7
03/19/03 20:30	03/20/03 07:30	11	1	03/19/03 20:00	03/01/03 21:30	1.5	0.10	0.063	0.01 - 0.10	11.2
03/20/03 14:25	03/21/03 21:30	31	2	03/20/03 09:00	03/21/03 05:00	4**	0.18	0.044	0.01 - 0.17	0.5
03/22/03 00:30	03/22/03 04:30	4	1	no rain	no rain	0	0.00	n/a	n/a	n/a
03/22/03 05:30	03/22/03 09:30	4	1	no rain	no rain	0	0.00	n/a	n/a	n/a
03/25/03 02:15	03/25/03 10:15	8	1	03/25/03 01:00	03/25/03 04:30	3.5	0.10	0.029	0.01 - 0.07	3.8
03/28/03 11:30	03/29/03 07:30	20	1	03/28/03 11:00	03/28/03 17:30	6.5	0.23	0.035	0.01 - 0.11	3.3
04/04/03 11:40	04/05/03 11:40	24	1	04/03/03 21:00	04/04/03 18:00	15**	1.36	0.091	0.01 - 0.35	6.1
04/08/03 12:55	04/09/03 11:55	23	1	04/08/03 08:00	04/09/03 10:00	14.5**	0.26	0.018	0.01 - 0.09	3.6
04/29/03	n/a	n/a	1	no rain	no rain	0	0.00	n/a	n/a	n/a
04/29/03	n/a	n/a	1	04/29/03 19:00	04/29/03 20:00	1	0.02	0.015	0.01 - 0.02	9.5
04/30/03 11:40	05/01/03 11:40	24	1	04/30/03 03:00	05/01/03 06:00	17**	1.80	0.106	0.01 - 0.42	20.7
05/01/03 12:40	05/02/03 11:40	23	2	05/01/03 12:30	05/01/03 17:00	4.5	0.38	0.084	0.01 - 0.24	0.3
05/08/03 21:05	05/10/03 07:45	35	2	05/08/03 22:00	05/10/03 02:00	9**	1.48	0.164	0.01 - 0.68	3.9
05/10/03 21:55	05/11/03 07:55	10	1	05/10/03 21:00	05/11/03 02:00	5	0.43	0.085	0.01 - 0.40	0.8
05/14/03 10:45	05/14/03 22:45	12	1	05/14/03 08:00	05/14/03 13:00	5	0.25	0.050	0.01 - 0.12	3.3
05/20/03 00:55	05/20/03 08:55	8	1	05/19/03 22:30	05/20/03 06:00	7.5	0.45	0.059	0.01 - 0.27	5.4
05/28/03 17:00	05/29/03 06:00	13	1	05/28/03 15:00	05/28/03 20:00	5	0.22	0.043	0.01 - 0.09	8.4
05/30/03 15:30	06/01/03 08:30	17	1	05/30/03 19:00	05/31/03 08:00	4.5**	0.89	0.198	0.01 - 0.77	2.0
06/03/03 02:15	06/04/03 03:50	26	2	06/02/03 22:30	06/03/03 05:00	6.5	0.33	0.051	0.01 - 0.14	2.6
06/06/03 15:00	06/06/03 19:00	4	1	06/06/03 12:00	06/06/03 16:00	4	0.16	0.039	0.01 - 0.09	3.3

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TABLE 3 (Continued)

STORM RUNOFF SAMPLING AND CORRESPONDING STORM DATA FOR IDOT PUMPING STATION NO. 29

Sampling Time		Sampling Duration h	No. of Composite Samples	Storm Period		Rain Duration h	Cumulative Rainfall inch	Mean Rain Intensity in/h	Intensity Range in/h	Last Days* d
From	To			From	To					
06/08/03 08:30	06/09/03 07:30	23	1	06/08/03 04:00	06/08/03 18:00	6**	0.28	0.046	0.01 - 0.20	1.5
06/10/03 09:30	06/10/03 18:30	9	1	06/10/03 08:00	06/10/03 09:30	1.5	0.05	0.033	0.01 - 0.05	1.6
06/18/03 14:50	06/19/03 07:50	17	2	06/18/03 12:00	06/18/03 19:00	4.5**	0.38	0.084	0.01 - 0.19	9.8
06/28/03 15:20	06/29/03 08:20	17	1	06/28/03 16:00	06/28/03 17:00	1	0.14	0.135	0.03 - 0.24	2.3
07/07/03 08:25	07/08/03 08:25	24	1	07/07/03 06:00	07/07/03 23:00	4.5**	0.40	0.088	0.01 - 0.23	0.3
07/08/03 13:40	07/09/03 02:40	13	1	07/08/03 09:00	07/09/03 00:00	6**	0.30	0.050	0.01 - 0.12	0.3
07/09/03	n/a	n/a	1	07/09/03 12:00	07/09/03 15:00	3	0.10	0.032	0.01 -0.08	0.5
07/09/03	n/a	n/a	1	no rain	no rain	0	0.00	n/a	n/a	n/a
07/10/03	n/a	n/a	1	07/10/03 00:00	07/10/03 02:00	2	0.11	0.055	0.02 - 0.09	0.4

*Last Days stands for the days since last rain that had at least 0.1 inches of cumulative rainfall.

**The actual rain duration for the storm period.

another constituent, TN, was derived based on the concentrations of TKN and $(NO_2 + NO_3)$-N. Event mean concentrations (EMCs) of the ten constituents were determined based on whether a storm-sampling event included one, or more than one, composite samples. For a storm-sampling event containing only one composite sample, the concentrations of the constituents were considered as EMCs. For a storm-sampling event including two or more composite samples, EMCs of the constituents analyzed were calculated using a weighted-average method with the sampling duration of each composite sample as the weight.

As expected, the concentrations of chloride and conductivity in the storm runoffs discharged at these IDOT pumping stations varied seasonally with relatively high values in winter and early spring, due to the application of road salts, and low values in the remainder of the sampling period. EMCs of chloride and conductivity versus sampling times for all storm-sampling events sampled at the three IDOT pumping stations are shown, respectively, in Figures 6 through 8. As can be seen in these figures, there were elevated concentration values of chloride and conductivity between late November 2002 through the middle of April 2003. The two constituents were highly positively correlated with PCC values greater than 0.97 at all three locations.

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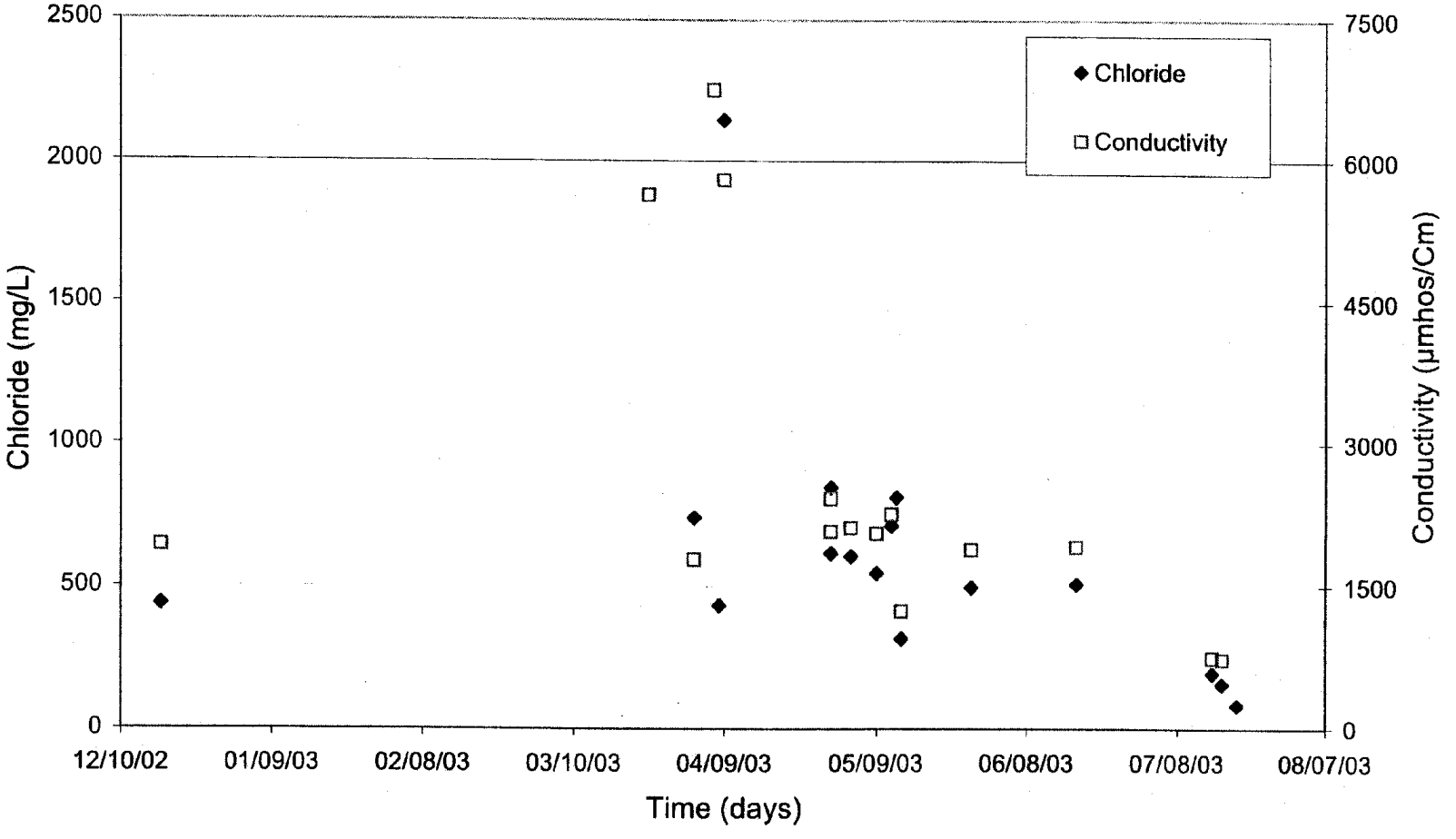
FIGURE 6

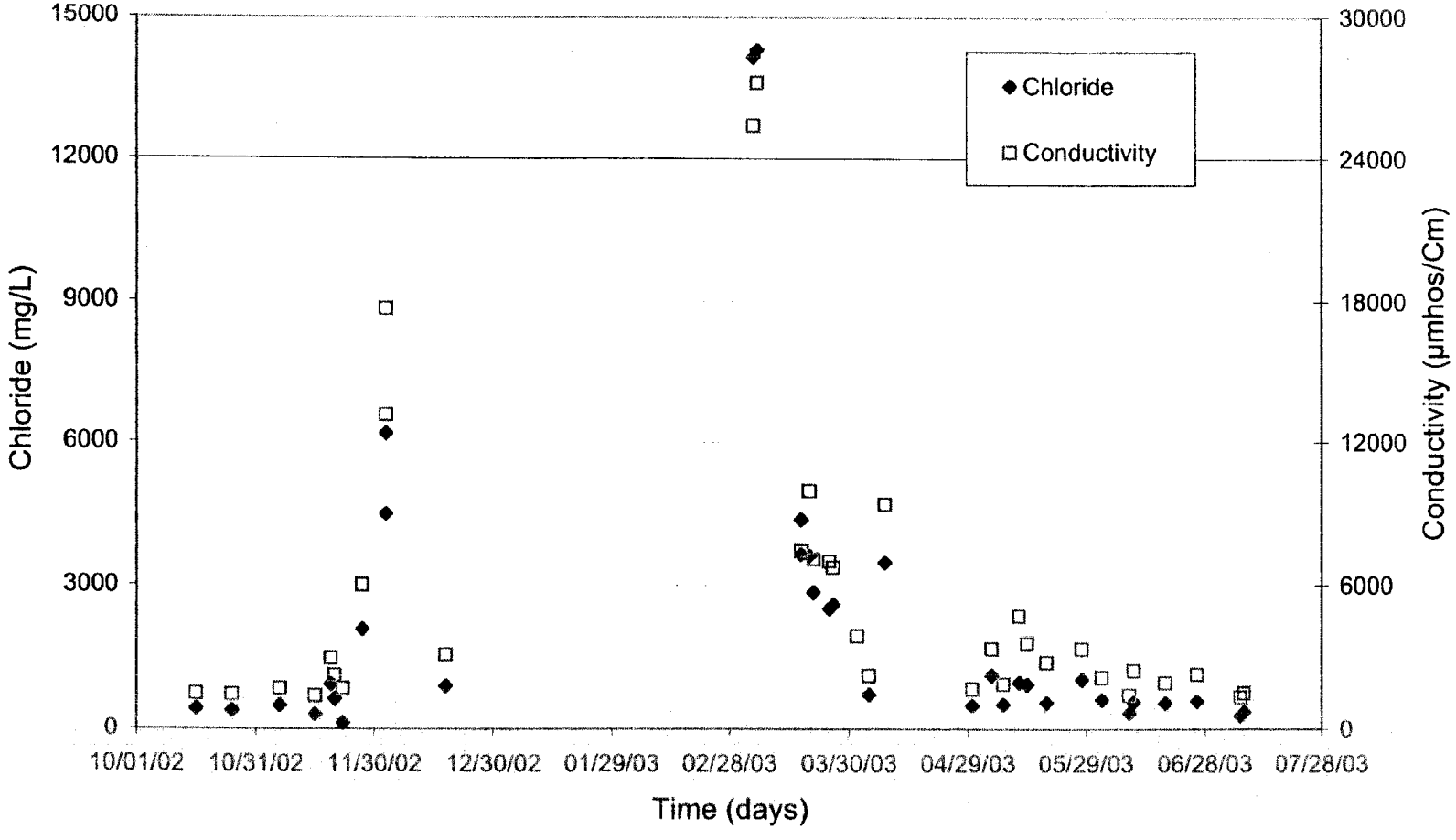
EMCs OF CHLORIDE AND CONDUCTIVITY IN STORM RUNOFF
AT IDOT PS NO. 3



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 7

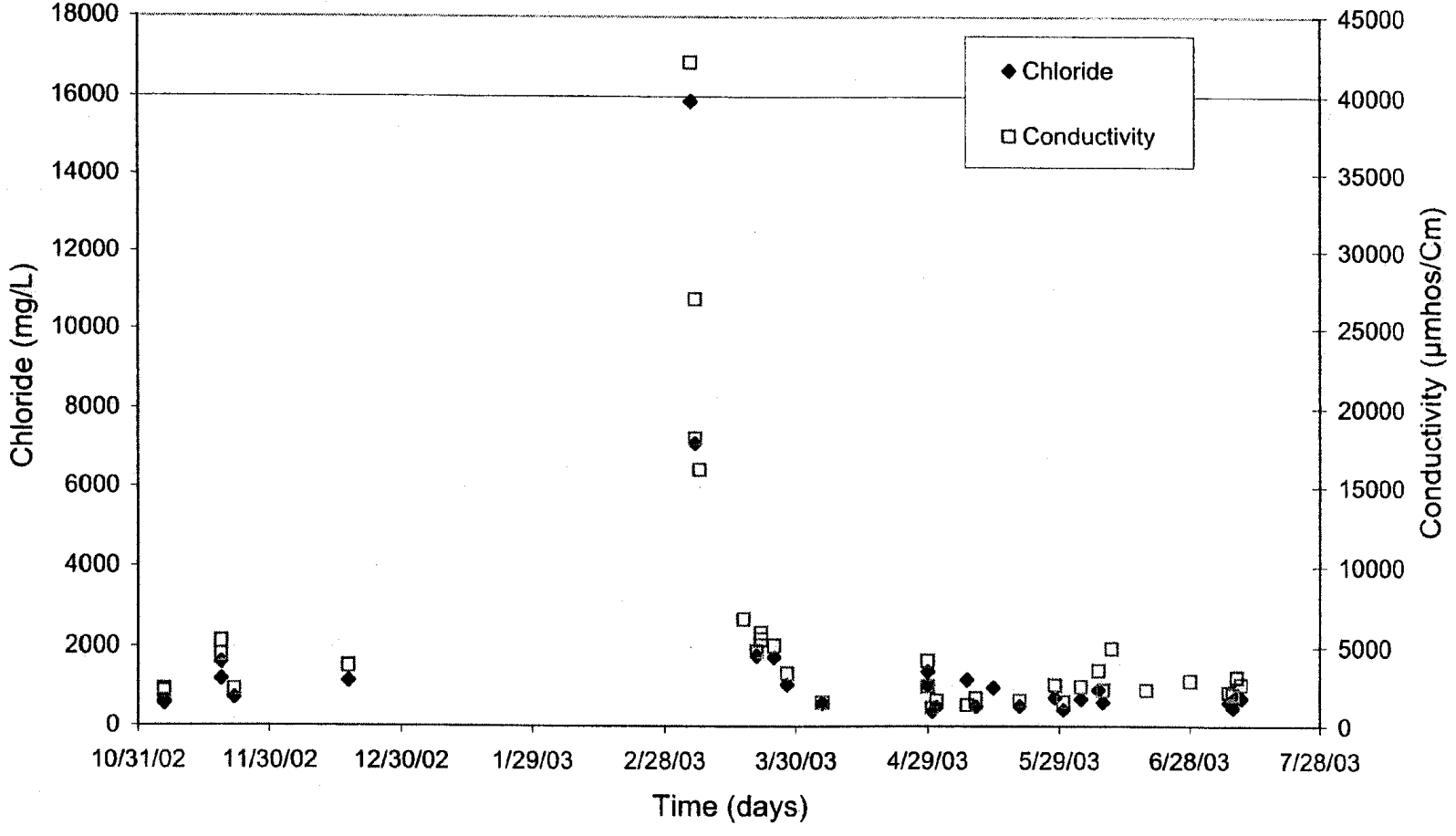
EMCs OF CHLORIDE AND CONDUCTIVITY IN STORM RUNOFF
AT IDOT PS NO. 5



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 8

EMCs OF CHLORIDE AND CONDUCTIVITY IN STORM RUNOFF
AT IDOT PS NO. 29



The mean values of EMCs of chloride and conductivity in the discharges at IDOT PS Nos. 3, 5 and 29, along with other statistical parameters, were calculated for the two different periods, i.e., snow season and non-snow season. The summary of the calculation is presented in Table 4. The elevated values of chloride and conductivity occurred mainly in the snow season from November 16, 2002, through April 15, 2003, apparently resulting from the application of road salts during snowstorms. IDOT PS No. 3 had the lowest mean values of EMCs for both chloride and conductivity during the snow season, likely because fewer samples were collected at this location in this season. The variations of individual EMCs of these two constituents at the three IDOT pumping stations sampled were similar, as evident from the similar values of coefficient of variation. However, the variations at these locations were much larger in the snow season than those at the same locations in the non-snow season. In the non-snow season, the mean values of EMCs of chloride and conductivity at the three locations were comparable, and so were the variations in individual EMCs.

The storm-sampling events at each of the three sampling locations were categorized into four different groups, namely no rain, snow, small rain (< 0.1 inches), and large rain (≥ 0.1 inches). Of the 21 storm-sampling events determined for

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TABLE 4

SUMMARY OF CHLORIDE AND CONDUCTIVITY IN HIGHWAY RUNOFF SAMPLED AT THREE IDOT PUMPING STATIONS DURING TWO DIFFERENT PERIODS

	IDOT PS No. 3		IDOT PS No. 5		IDOT PS No.29	
	Cl mg/L	Cond. µmhos/cm	Cl mg/L	Cond. µmhos/cm	Cl mg/L	Cond. µmhos/cm
----------Snow Season in 11/16/02 - 4/15/03----------						
No. of Samples	3	6	19	20	12	17
Mean	1,108	3,724	3,828	8,803	3,045	9,633
Min	438	434	126	1,317	594	1,574
Median	739	3,783	2,854	7,055	1,658	5,330
Max	2,146	6,760	14,290	27,200	15,880	42,200
Std Dev	912	2,647	3,989	7,260	4,400	10,735
CV (%)	154.8	80.0	104.2	82.5	144.5	111.4
----------Non-Snow Season in 10/16/02 - 11/15/02 and 4/16/03 - 7/21/03----------						
No. of Samples	19	16	22	21	22	24
Mean	548	1,932	580	2,180	733	2,509
Min	83	713	289	1,362	374	1,201
Median	547	1,988	512	1,927	668	2,378
Max	1,100	3,484	1,142	4,748	1,609	4,927
Std Dev	320	832	259	924	311	856
CV (%)	58.4	43.1	44.6	42.4	42.5	34.1

Note: Cl stands for chloride and Cond. for conductivity.

IDOT PS No. 3, 2, 2, 2, and 15 events occurred under no rain, snow, small rain, and large rain conditions, respectively. Of the 40 storm-sampling events determined for IDOT PS No. 5, 4, 9, 4, and 23 events occurred, respectively, under each of the four group categories. Of the 41 storm-sampling events determined for IDOT PS No. 29, 6, 5, 5, and 25 events occurred under each of the four conditions. The mean values of EMCs of the ten constituents monitored, along with other statistical values, for each group are presented in Tables 5 through 7 for IDOT PS Nos. 3, 5, and 29, respectively.

The mean values of EMCs for each of the four groups at each sampling location were similar for some constituents, but different for others. At IDOT PS No. 3, the mean EMCs for three of the four groups were based on one or two values, because only two events were sampled in each of these three groups. Therefore, other statistical values were not calculated due to lack of data, nor would a general comparison of mean EMCs for any constituent among the groups be made in this study. The mean EMCs of TSS, $CBOD_5$, TN, and TP were 98.9 mg/L, 9.1 mg/L, 2.68 mg/L and 0.25 mg/L, respectively, in the storm runoffs caused by large rains, which were categorized into the fourth group in Table 5. Of these four constituents in this group, TSS had the largest variation in individual EMCs with a CV of 96 percent, whereas TN had the lowest

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TABLE 5

SUMMARY OF EVENT MEAN CONCENTRATIONS OF CONSTITUENTS IN STORM RUNOFFS DISCHARGED AT IDOT PUMPING STATION NO. 3 IN PERIOD OF DECEMBER 18, 2002 TO JULY 21, 2003

Parameters	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
----------Sampling Events with No Rain----------										
No. of Samples	1	0	2	2	1	1	1	1	1	2
Mean	812	N/A	1.17	0.13	0.88	2.07	0.20	0.14	6.0	4.0
----------Sampling Events with Snowmelt----------										
No. of Samples	1	1	2	2	1	1	1	1	0	2
Mean	434	6,760	1.34	0.58	1.84	3.16	0.72	0.54	N/A	7.0
----------Storm-Sampling Events with Rainfall < 0.1 inches----------										
No. of Samples	0	0	1	1	1	1	1	1	0	2
Mean	N/A	N/A	1.12	0.29	0.79	1.91	0.11	0.09	N/A	5.0

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TABLE 5 (Continued)

SUMMARY OF EVENT MEAN CONCENTRATIONS OF CONSTITUENTS IN STORM RUNOFFS DISCHARGED AT IDOT PUMPING STATION NO. 3 IN PERIOD OF DECEMBER 18, 2002 TO JULY 21, 2003

Parameters	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
----------Storm-Sampling Events with Rainfall ≥ 0.1 inches----------										
No. of Samples	14	14	14	15	15	14	15	15	12	15
Mean	602	2,333	0.99	0.31	1.74	2.68	0.25	0.05	98.9	9.1
Min	83	746	0.59	0.02	0.65	1.39	0.06	0.00	16.7	3.7
Median	528	1,922	0.93	0.25	1.42	2.23	0.14	0.05	75.0	8.0
Max	2,146	5,800	1.48	0.74	4.55	5.95	0.64	0.20	339.0	17.0
Std Dev	497	1,525	0.27	0.22	1.13	1.26	0.19	0.06	95.3	4.9
CV (%)	82.5	65.4	27.4	71.4	65.1	46.9	77.3	101.9	96.4	53.5

Note: Cond. stands for conductivity and N/A for not available.

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TABLE 6

SUMMARY OF EVENT MEAN CONCENTRATIONS OF CONSTITUENTS IN STORM RUNOFFS DISCHARGED AT IDOT PUMPING STATION NO. 5 IN PERIOD OF OCTOBER 16, 2002 TO JULY 10, 2003

Parameters	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
----------Sampling Events with No Rain----------										
No. of Samples	4	4	4	4	4	4	4	4	4	4
Mean	2,819	5,990	2.21	0.22	1.18	3.38	0.21	0.10	9.0	5.3
Min	644	2,280	0.97	0.10	0.74	2.67	0.15	0.00	4.0	4.0
Median	3,126	7,100	2.37	0.23	1.13	3.48	0.18	0.06	6.0	5.5
Max	4,380	7,480	3.13	0.31	1.70	3.90	0.35	0.30	20.0	6.0
Std Dev	1,624	2,496	1.07	0.09	0.47	0.60	0.09	0.14	7.4	1.0
CV (%)	58	42	48.51	40.28	39.95	17.84	43.87	134.11	82.2	18.2
----------Sampling Events with Snowmelt----------										
No. of Samples	6	6	9	9	6	6	8	8	8	9
Mean	7,533	16,935	1.23	0.66	1.75	3.18	0.56	0.18	40.4	8.8
Min	2,095	6,020	0.73	0.09	1.12	2.10	0.11	0.00	11.0	0.0
Median	5,337	15,405	0.98	0.69	1.51	3.20	0.37	0.18	35.5	9.0
Max	14,290	27,200	2.65	1.15	2.74	4.18	1.98	0.47	78.0	18.0
Std Dev	5,337	8,171	0.59	0.30	0.64	0.89	0.60	0.16	26.0	5.2
CV (%)	71	48	47.91	45.69	36.45	28.07	108.35	92.57	64.5	59.7

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TABLE 6 (Continued)

SUMMARY OF EVENT MEAN CONCENTRATIONS OF CONSTITUENTS IN STORM RUNOFFS DISCHARGED AT IDOT PUMPING STATION NO. 5 IN PERIOD OF OCTOBER 16, 2002 TO JULY 10, 2003

Parameters	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
----------Storm-Sampling Events with Rainfall < 0.1 inches----------										
No. of Samples	3	4	4	4	4	4	4	4	4	4
Mean	2,350	5,868	2.23	0.24	1.42	3.65	0.31	0.19	38.3	8.8
Min	575	2,470	1.25	0.20	0.74	1.99	0.12	0.09	10.0	3.0
Median	2,854	5,505	2.22	0.25	1.34	3.56	0.35	0.15	39.0	10.5
Max	3,621	9,990	3.23	0.27	2.24	5.47	0.43	0.35	65.0	11.0
Std Dev	1,584	3,361	1.09	0.03	0.72	1.80	0.14	0.12	22.6	3.9
CV (%)	67	57	48.96	13.18	50.84	49.38	44.75	65.22	59.1	44.1
----------Storm-Sampling Events with Rainfall ≥ 0.1 inches----------										
No. of Samples	23	23	23	23	23	23	23	23	22	23
Mean	797	2,710	1.54	0.30	1.79	3.32	0.26	0.08	69.3	10.0
Min	126	1,364	0.95	0.07	0.62	1.86	0.06	0.00	15.0	2.0
Median	566	2,199	1.30	0.30	1.59	3.09	0.17	0.06	33.0	9.5
Max	2,950	7,010	3.66	0.88	4.52	5.90	0.90	0.42	473.6	24.0
Std Dev	672	1,573	0.59	0.20	0.97	0.99	0.22	0.09	104.7	5.1
CV (%)	84	58	38.42	67.59	54.08	29.64	86.07	106.28	151.1	51.1

Note: Cond. stands for conductivity.

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TABLE 7

SUMMARY OF EVENT MEAN CONCENTRATIONS OF CONSTITUENTS IN STORM RUNOFFS DISCHARGED AT IDOT PUMPING STATION NO. 29 IN PERIOD OF NOVEMBER 5, 2002 TO JULY 10, 2003

Parameters	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
----------Sampling Events with No Rain----------										
No. of Samples	3	6	6	6	6	6	6	3	5	5
Mean	912	4,634	1.89	0.17	0.77	2.66	0.05	0.05	25.8	7.4
Min	575	2,360	1.35	0.04	0.57	1.92	0.04	0.04	11.0	3.0
Median	768	4,830	1.93	0.16	0.71	2.72	0.06	0.05	20.0	5.0
Max	1,394	6,730	2.29	0.31	1.27	3.04	0.06	0.06	44.0	19.0
Std Dev	428	1,685	0.32	0.13	0.25	0.41	0.01	0.01	15.2	6.6
CV (%)	47	36	17.11	75.96	32.82	15.46	19.03	20.26	58.9	88.9
----------Sampling Events with Snowmelt----------										
No. of Samples	3	5	5	5	4	4	5	3	5	5
Mean	8,062	21,560	1.88	0.30	1.25	3.12	0.20	0.20	19.6	8.4
Min	1,195	4,500	1.79	0.02	0.97	2.76	0.07	0.04	9.0	5.0
Median	7,110	18,100	1.93	0.40	1.31	3.18	0.13	0.07	16.0	7.0
Max	15,880	42,200	1.96	0.45	1.41	3.36	0.55	0.49	39.0	15.0
Std Dev	7,389	14,030	0.08	0.18	0.21	0.26	0.20	0.25	11.5	3.8
CV (%)	92	65	4.23	60.65	16.49	8.18	100.66	126.05	58.9	45.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7 (Continued)

SUMMARY OF EVENT MEAN CONCENTRATIONS OF CONSTITUENTS IN STORM RUNOFFS DISCHARGED AT IDOT PUMPING STATION NO. 29 IN PERIOD OF NOVEMBER 5, 2002 TO JULY 10, 2003

Parameters	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
----------Storm-Sampling Events with Rainfall < 0.1 inches----------										
No. of Samples	2	3	4	4	4	4	4	3	3	5
Mean	929	3,536	1.76	0.24	1.64	3.40	0.23	0.06	71.7	11.6
Min	N/A	2,560	1.46	0.06	0.57	2.41	0.04	0.01	10.0	3.0
Median	N/A	3,122	1.73	0.20	1.52	3.06	0.27	0.07	12.0	13.0
Max	N/A	4,927	2.12	0.49	2.96	5.08	0.36	0.12	193.0	18.0
Std Dev	N/A	1,237	0.29	0.20	1.14	1.27	0.14	0.06	105.1	6.5
CV (%)	N/A	35	16.70	84.00	69.39	37.21	58.70	87.97	146.6	55.7
----------Storm-Sampling Events with Rainfall ≥ 0.1 inches----------										
No. of Samples	22	23	25	25	25	25	25	25	24	24
Mean	850	2,665	1.53	0.32	1.78	3.31	0.19	0.06	87.3	8.3
Min	374	1,201	0.91	0.03	0.55	2.02	0.04	0.00	14.0	2.4
Median	717	2,339	1.47	0.27	1.71	3.08	0.17	0.04	78.0	7.4
Max	1,786	5,330	2.79	1.53	4.19	5.80	0.45	0.18	288.5	16.0
Std Dev	422	1,168	0.40	0.29	0.87	0.90	0.11	0.05	62.1	3.5
CV (%)	50	44	26.23	89.91	48.79	27.05	60.02	86.49	71.1	42.4

Note: Cond. stands for conductivity, and N/A for not available.

variation with a CV of 47 percent. In the storm runoff sampled in the fourth group, TN was mostly composed of TKN (59 percent of TN), and TP was mostly composed of nonsoluble phosphorus, containing only 31 percent of SOL-P.

At IDOT PS No. 5, the mean EMCs for all the constituents monitored, along with other statistical values, were calculated for each of the four groups. The mean values of EMCs of TSS and $CBOD_5$ varied from group to group. In the runoff caused by large rains, the mean EMCs of 69.3 mg/L of TSS and 10.0 mg/L of $CBOD_5$ were the highest, whereas they were the lowest in runoff occurring in no-rain group with 9.0 mg/L of TSS and 5.3 mg/L of $CBOD_5$. The mean values of EMCs of TSS and $CBOD_5$ were 40.4 mg/L and 8.8 mg/L in the runoff caused by snowmelt, and 38.3 mg/L and 8.8 mg/L in the runoff caused by small rains. The mean values of EMCs of TN for the four groups were similar, ranging from 3.1 to 3.7 mg/L. The mean values of EMCs of TP for all groups were also similar, ranging from 0.21 to 0.31 mg/L, except for the group with snowmelt, which had a mean EMC of 0.56 mg/L. However, the makeup of TN and TP in the runoff generated under different conditions was different. In the runoff generated by large rains and snowmelt, TKN and nonsoluble phosphorus constituted a major portion of TN and TP, respectively. In contrast, in the runoff

sampled under no rain or small rains, $(NO_2 + NO_3)$-N and SOL-P were the major components of TN and TP, respectively.

The individual EMCs of some constituents varied wildly within each group, while the EMCs of other constituents did not vary much. Among the four constituents of TSS, $CBOD_5$, TN and TP, EMCs of TSS had the largest variation in all groups with CVs ranging from 59 to 151 percent, except for the group associated with snowmelt, in which TP had the largest variation with a CV of 108 percent. EMCs of TN had the lowest variation in all groups with CVs ranging from 18 to 49 percent. This indicated that TSS concentrations varied largely from sample to sample, whereas TN concentrations in different samples were similar.

As expected, EMCs of chloride and conductivity were high in the runoff caused by snowmelt and low in other groups. At IDOT PS No. 5, the mean EMCs of chloride and conductivity in runoffs occurring in no rain and small rains were relatively high in this study, compared to that in the runoff caused by large rains. This was because the most of the samples collected under no rain or small rain conditions were taken during the snow season in this study, as seen in Table 2.

At IDOT PS No. 29, the mean EMCs for all the constituents monitored, along with other statistical values, were calculated for each of the four groups, except that the other

statistical values were not calculated for chloride in the runoff cause by small rains due to insufficient data. Unlike IDOT PS No. 5, at this location, the lowest mean EMC of TSS of 19.6 mg/L was found in the runoff caused by snowmelt, and the highest mean EMC of $CBOD_5$ of 11.6 mg/L was found in the runoff cause by small rains. However, the highest mean EMC of TSS of 87.3 mg/L and the lowest mean EMC of $CBOD_5$ of 7.4 mg/L were still found in the runoff generated by large rains and under no-rain condition, respectively. The mean EMC of TSS was relatively low in the runoff caused by snowmelt with a value of 19.6 mg/L, and relatively high in the runoff caused by small rains with a value of 71.7 mg/L. The mean EMCs of TN and TP in the runoff caused by snowmelt, and small and large rains were similar, ranging from 3.1 to 3.4 mg/L and 0.19 to 0.23 mg/L, respectively. The mean EMCs of TN and TP in the runoff occurring in no-rain condition had the lowest values of 2.66 mg/L and 0.05 mg/L, respectively.

Similar to IDOT PS Nos. 3 and 5, at this location, TKN and nonsoluble phosphorus constituted a major portion of TN and TP in the runoff caused by large rains, and $(NO_2 + NO_3)$-N and SOL-P were the major components of TN and TP in the runoff occurring in no rain, respectively. Unlike IDOT PS No. 5, at IDOT PS No. 29, $(NO_2 + NO_3)$-N and SOL-P constituted a major portion of TN and TP in the runoff caused by snowmelt,

respectively, and nonsoluble phosphorus was the major component of TP in the runoff caused by small rains.

The variation in individual EMCs of TSS was still the largest in the runoff caused by small and large rains with CVs of 147 and 71 percent, respectively, among the four constituents of TSS, $CBOD_5$, TN and TP. However, individual EMCs of $CBOD_5$ and TP were the most variable constituents in the runoff sampled under no rain and snowmelt conditions with CVs of 89 and 101 percent, respectively. Similar to other two locations, the variation in individual EMCs of TN at this location was also the lowest in all groups.

The summary of statistical analysis on comparing the mean EMCs of two constituents in the runoffs caused by large rains at IDOT PS Nos. 3, 5 and 29 are presented in Table 8. The results indicated that there was no statistically significant difference in the mean values of EMCs of all constituents among these locations, except for TN and $(NO_2 + NO_3)$-N. The differences in the mean values of EMCs of TN and $(NO_2 + NO_3)$-N existed in two of three pairs of locations at 5 percent level of significance (P-value < 0.05), as seen in Table 8. IDOT PS No. 3 had the lowest mean value of EMCs of TN of 2.68 mg/L, which was significantly lower than the mean EMCs of 3.32 mg/L at IDOT PS No. 5 and 3.31 mg/L at IDOT PS No. 29. The lower mean EMC of TN at IDOT PS No. 3 resulted from lower

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TABLE 8

SUMMARY OF STATISTICAL ANALYSIS ON COMPARING MEAN EMCs AMONG THREE IDOT PUMPING STATIONS FOR STORM-SAMPLING EVENTS WITH LARGE RAINS

Constituent	Mean EMCs at IDOT PS			P-Value for Equal Mean			Comparison Among Locations
	No. 3	No. 5	No. 29	No.3 vs. No.5	No.3 vs. No.29	No.5 vs. No.29	
TSS	98.912	69.286	87.252	0.368	0.970	0.138	No Difference
$CBOD_5$	9.137	9.967	8.267	0.892	0.963	0.697	No Difference
TN	2.682	3.325	3.310	0.044	0.038	1.000	No. 3 lower
TKN	1.738	1.789	1.776	0.920	0.874	0.993	No Difference
NH_3-N	0.307	0.295	0.321	0.953	0.960	0.999	No Difference
$(NO_2 + NO_3)$-N	0.986	1.536	1.534	0.000	0.000	0.964	No. 3 lower
TP	0.246	0.257	0.190	0.968	0.799	0.578	No Difference
SOL-Phosphorus	0.055	0.085	0.056	0.617	0.776	0.133	No Difference
Chloride	601.767	797.169	849.595	0.379	0.076	0.569	No Difference
Conductivity (µmhos/cm)	2332.927	2710.244	2664.799	0.517	0.432	0.985	No Difference

Note: The unit for mean EMCs is mg/L, unless otherwise noted.
Statistical difference is determined at 5 percent level of significance ($P < 0.05$).

$(NO_2 + NO_3)$-N at this location. The mean EMC of $(NO_2 + NO_3)$-N of 0.99 mg/L at IDOT PS No. 3 was statistically significantly lower than the mean EMCs of 1.54 mg/L at IDOT PS No. 5 and 1.53 mg/L at IDOT PS No. 29. Similar comparison for the runoff sampled under the other three conditions was not made in this study, due to insufficient data.

Correlation between Constituents in Storm Runoffs and Storm Variables

To examine potential correlation between the stormwater constituents analyzed and the corresponding storm variables, Pearson correlation coefficients (PCCs) were calculated for the pairs of each of eight stormwater constituents and each of four storm variables given in Tables 1 through 3 for IDOT PS Nos. 3, 5 and 29, respectively. The calculation of PCCs was made only for the storm-sampling events that had at least 0.1 inches of cumulative rainfall (large rains) in each event. There were 15 storm-sampling events at IDOT PS No. 3, 23 events at IDOT PS No. 5, and 25 events at IDOT PS No. 29, meeting the criteria of large rains. The summary of PCCs between EMCs of eight stormwater constituents and the four corresponding storm variables for the three IDOT pumping stations sampled is presented in Table 9. PCC values of less than 0.1 and greater than -0.1 are omitted in the table, as it indicates almost no correlation between a pair of variables.

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TABLE 9

SUMMARY OF PEARSON CORRELATION COEFFICIENTS BETWEEN EMCs OF EIGHT STORMWATER CONSTITUENTS AND FOUR RAIN VARIABLES FOR THE THREE IDOT PUMPING STATIONS SAMPLED

Constituent	Rainfall	Duration	Mean Intensity	Days Since Last*
----------IDOT PS No. 3----------				
TSS	--	0.39	-0.10	0.34
$CBOD_5$	-0.20	--	--	0.58
TN	--	--	--	0.46
TKN	--	--	0.11	0.52
NH_3-N	-0.29	-0.19	0.12	0.52
(NO_2+NO_3)-N	-0.25	-0.41	-0.13	-0.15
TP	--	0.37	-0.11	0.63
SOL-P	--	0.38	-0.32	0.27
----------IDOT PS No. 5----------				
TSS	0.42	0.51	0.23	0.39
$CBOD_5$	-0.21	-0.24	-0.13	0.20
TN	0.12	0.21	--	0.47
TKN	--	--	--	0.44
NH_3-N	--	-0.16	--	0.33
(NO_2+NO_3)-N	0.22	0.39	--	--
TP	--	--	--	0.41
SOL-P	-0.19	-0.18	-0.18	--
----------IDOT PS No. 29----------				
TSS	0.37	0.54	0.11	0.39
$CBOD_5$	-0.17	--	-0.30	0.48
TN	--	--	-0.20	0.39
TKN	--	--	--	0.43
NH_3-N	--	--	--	0.42
(NO_2+NO_3)-N	-0.25	0.13	-0.46	--
TP	--	0.15	--	0.46
SOL-P	--	0.21	-0.14	0.23

*Days since the last rain that had ≥ 0.1 inch of cumulative rainfall.

The correlation between the stormwater constituents and rainfall was generally poor at all three locations. However, weak negative correlation between $CBOD_5$ and rainfall was observed at all three locations, which suggested a tendency that $CBOD_5$ could decrease with an increase in rainfall. At IDOT PS Nos. 5 and 29, moderate positive correlation between TSS and rainfall indicated that TSS could increase with an increase in rainfall. At all three locations, there was no correlation between TN and TP, and rainfall.

The correlation between the stormwater constituents and storm duration varied among the constituents at the three locations. There was no correlation between $CBOD_5$, TN and TKN, and storm duration at IDOT PS Nos. 3 and 29, but weak positive correlation between TP and storm duration. At IDOT PS No. 5, weak negative correlation between $CBOD_5$ and storm duration, and positive correlation between TN, particularly its component of $(NO_2 + NO_3)$-N, and storm duration were observed. At all three locations, moderate positive correlation between TSS and storm duration was found, which suggested that TSS could increase with an increase in storm duration.

The correlation between the stormwater constituents and mean rain intensity was generally very weak at all the locations, except for a few variations at different locations. No correlation between $CBOD_5$ and rain intensity was found at IDOT

PS No. 3, however, weak negative correlation was observed at IDOT PS Nos. 5 and 29.

Among four storm variables, the days since the last rain that had at least 0.1 inches of rainfall had the largest impact on most of the stormwater constituents monitored. Moderate positive correlation between TSS, $CBOD_5$, TN, TKN, NH_3-N and TP and the days since the last rain was found at all three locations. Figures 9 through 11 show EMCs of TSS, $CBOD_5$, TN, TKN, NH_3-N, and TP, respectively, versus the days since the last rain at IDOT PS No. 3. This suggests that the concentrations of these six constituents in storm runoffs increases as the number of days from the previous storm that had at least 0.1 inches of rainfall to the present storm increases.

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FIGURE 9

EMCs OF TSS AND $CBOD_5$ IN STORM RUNOFF CAUSED BY LARGE RAINS VERSUS DAYS SINCE LAST RAIN AT IDOT PS NO. 3

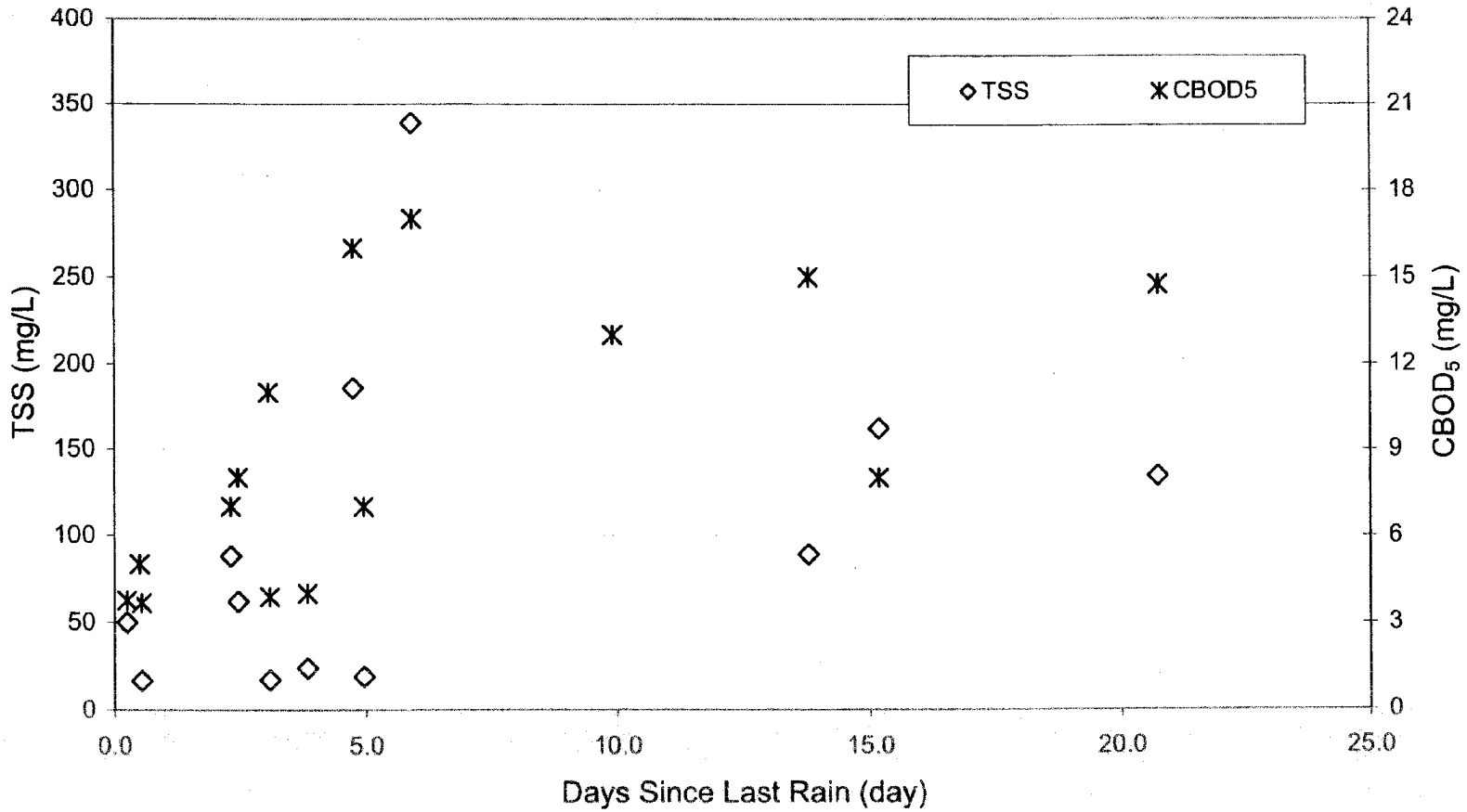

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FIGURE 10

EMCs OF TN, TKN AND NH_3-N IN STORM RUNOFF CAUSED BY LARGE RAINS VERSUS DAYS SINCE LAST RAIN AT IDOT PS NO. 3

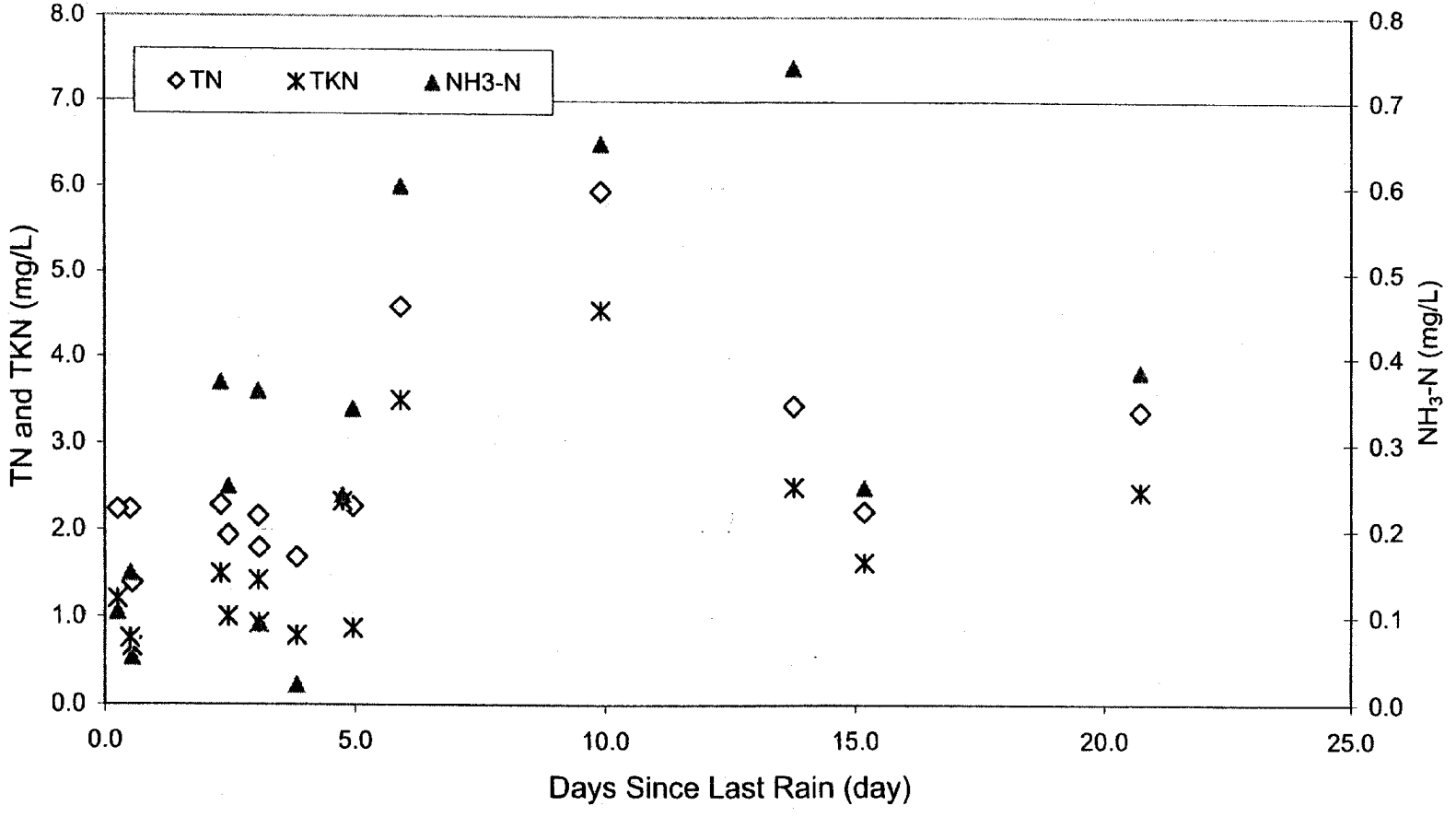

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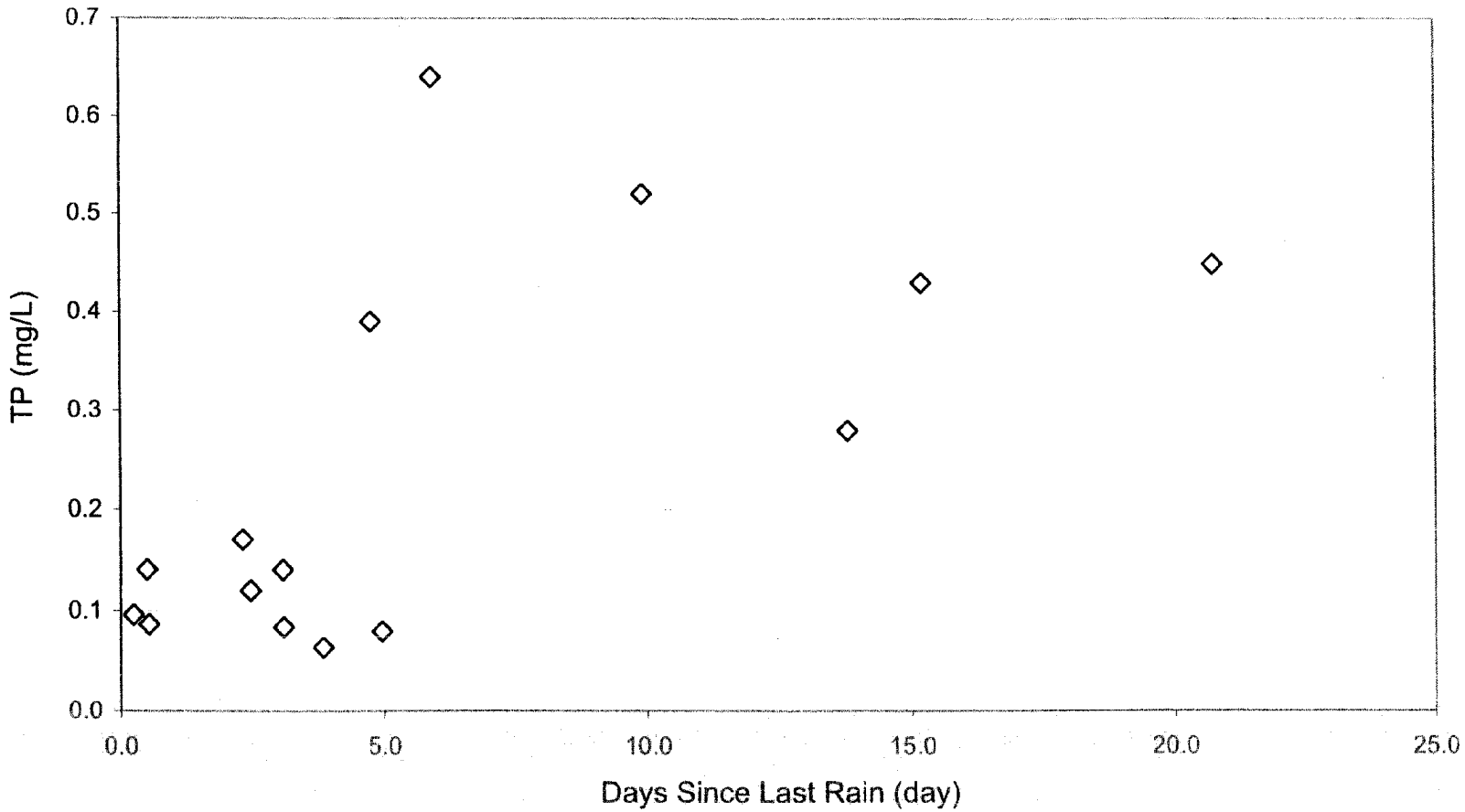
FIGURE 11

EMCs OF TP IN STORM RUNOFF CAUSED BY LARGE RAINS VERSUS DAYS SINCE LAST RAIN AT IDOT PS NO. 3



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APPENDIX

ANALYTICAL RESULTS OF STORMWATER RUNOFF DISCHARGE SAMPLES COLLECTED AT IDOT PUMPING STATION NOS. 3, 5 AND 29, RESPECTIVELY

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TABLE AI-1

CONCENTRATIONS OF CONSTITUENTS IN DISCHARGES SAMPLED AT IDOT PUMPING STATION NO. 3

Sample Date	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
12/18/02	438	1925	0.589	0.25	1.63	2.22	0.43	0.20	162	8
3/25/03	N/A	5640	1.400	0.34	0.87	2.27	0.08	0.00	19	7
4/4/03	739	1783	1.082	0.60	3.50	4.58	0.64	0.00	339	17
4/7/03	N/A	6760	1.317	0.61	1.84	3.16	0.72	0.54	N/A	8
4/8/03	N/A	434	1.370	0.55	N/A	N/A	N/A	N/A	N/A	6
4/10/03	2146	5800	1.481	0.15	0.75	2.23	0.14	0.14	N/A	5
4/30/03	1100	2760	1.028	0.49	2.14	3.17	0.48	0.17	120	11
5/1/03	594	1399	0.860	0.32	2.64	3.50	0.43	0.05	143	17
5/1/03	147	N/A	0.535	0.22	1.61	2.15	0.23	0.04	112	6
5/2/03	451	1515	0.839	0.14	1.13	1.97	0.07	0.00	74	4
5/3/03	768	2735	1.176	0.04	1.29	2.47	0.08	0.05	13	3
5/4/03	1097	3020	1.385	0.07	0.96	2.35	0.07	0.07	26	3
5/4/03	188	713	0.374	0.15	0.69	1.06	0.09	0.05	20	4
5/6/03	582	2155	0.814	0.08	0.96	1.77	0.07	0.07	16	3
5/6/03	1046	3484	1.185	0.08	1.00	2.19	0.10	0.05	17	5
5/10/03	547	2057	0.783	0.00	0.77	1.55	0.06	0.00	24	4
5/11/03	N/A	N/A	1.404	0.12	0.86	2.26	0.08	0.07	N/A	4
5/13/03	681	2230	0.674	0.05	0.62	1.29	0.08	0.06	16	3
5/13/03	643	2287	0.855	0.06	0.72	1.58	0.10	0.07	18	5
5/14/03	812	N/A	1.192	0.09	0.88	2.07	0.20	0.14	6	4
5/15/03	319	1245	0.935	0.25	1.00	1.94	0.12	0.03	62	8
5/23/03	N/A	N/A	1.150	0.16	N/A	N/A	N/A	N/A	N/A	4
5/29/03	497	1886	0.936	0.74	2.51	3.45	0.28	0.00	89	15
6/3/03	N/A	N/A	1.121	0.29	0.79	1.91	0.11	0.09	N/A	4
6/19/03	508	1918	1.398	0.65	4.55	5.95	0.52	0.05	N/A	13
7/11/03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6
7/15/03	199	765	N/A	0.24	2.33	N/A	0.39	0.07	186	16
7/18/03	160	746	0.794	0.37	1.49	2.28	0.17	0.07	88	7
7/21/03	83	N/A	0.737	0.36	1.42	2.16	0.14	0.00	N/A	11

Note: Cond. stands for conductivity, TN for total nitrogen, and TP for total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2

CONCENTRATIONS OF CONSTITUENTS IN DISCHARGES SAMPLED AT IDOT PUMPING STATION NO. 5

Sample Date	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
10/16/02	379	1,560	1.126	0.38	1.98	3.11	0.33	N/A	37	12
10/17/02	487	1,453	1.061	0.21	1.83	2.89	0.50	0.42	27	7
10/25/02	387	1,476	1.189	0.09	1.45	2.64	0.15	0.00	25	9
11/06/02	497	1,712	1.222	0.43	2.20	3.42	0.90	0.19	25	14
11/15/02	306	1,402	0.954	0.16	2.00	2.95	0.17	0.00	15	14
11/19/02	N/A	N/A	0.728	0.09	N/A	N/A	N/A	N/A	N/A	6
11/19/02	949	2,980	1.256	0.29	1.83	3.09	0.29	0.14	39	10
11/20/02	644	2,280	0.970	0.10	1.70	2.67	0.19	0.00	6	6
11/22/02	126	1,727	1.424	0.18	1.91	3.33	0.16	0.09	26	8
11/27/02	2,095	6,020	1.108	0.40	1.53	2.64	0.18	0.15	11	7
12/03/02	4,498	13,130	0.977	0.86	1.12	2.10	0.37	0.21	48	14
12/03/02	6,175	17,680	0.944	0.81	1.48	2.42	0.33	0.00	76	18
12/04/02	N/A	N/A	0.910	0.69	N/A	N/A	0.72	0.00	78	9
12/04/02	N/A	N/A	0.854	0.57	N/A	N/A	1.98	0.47	46	0
12/18/02	2,090	7,530	1.522	0.63	3.36	4.88	0.57	0.12	324	27
12/19/02	418	1,317	2.177	0.19	3.67	5.85	0.76	0.16	536	10
03/06/03	14,140	25,400	1.457	0.79	2.31	3.77	0.39	0.29	21	11
03/07/03	14,290	27,200	1.443	1.15	2.74	4.18	0.37	0.25	18	9
03/18/03	4,380	7,480	3.082	0.23	0.82	3.90	0.35	0.30	4	5
03/18/03	3,652	7,450	3.126	0.22	0.74	3.87	0.16	0.12	6	4
03/20/03	3,621	9,990	3.229	0.26	2.24	5.47	0.30	0.09	42	11
03/21/03	2,854	7,100	3.124	0.23	1.79	4.91	0.40	0.21	65	10
03/25/03	2,517	7,010	1.733	0.35	1.77	3.50	0.22	0.06	71	24
03/26/03	2,600	6,750	1.656	0.31	1.44	3.10	0.15	0.00	20	6
04/01/03	N/A	3,910	1.324	0.20	0.89	2.21	0.43	0.35	36	11
04/04/03	734	2,260	1.473	0.59	2.76	4.23	0.43	0.04	238	11
04/08/03	4,000	12,180	2.654	0.58	1.29	3.94	0.11	0.04	25	5
04/09/03	2,950	6,670	3.660	0.12	0.71	4.37	0.08	0.06	24	4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

CONCENTRATIONS OF CONSTITUENTS IN DISCHARGES SAMPLED AT IDOT PUMPING STATION NO. 5

Sample Date	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
04/30/03	432	1,362	1.283	0.48	2.16	3.44	0.25	0.05	116	7
05/01/03	566	2,060	2.229	0.23	1.05	3.28	0.07	0.03	47	6
05/05/03	1,142	3,377	2.405	0.09	0.73	3.14	0.06	0.04	34	4
05/08/03	527	1,927	1.295	0.34	1.30	2.60	0.17	0.03	162	13
05/12/03	991	4,748	1.852	0.11	0.62	2.47	0.18	0.10	15	2
05/14/03	946	3,624	1.664	0.29	1.18	2.84	0.12	0.00	37	10
05/19/03	897	2,814	1.463	0.39	2.10	3.56	0.24	0.05	140	11
05/20/03	414	N/A	0.961	0.27	1.10	2.06	0.13	0.08	21	6
05/28/03	1,057	3,374	1.241	0.88	2.80	4.04	0.22	0.04	34	17
06/02/03	632	2,199	1.197	0.34	1.26	2.46	0.11	0.10	31	8
06/09/03	345	1,454	1.011	0.09	0.85	1.86	0.08	0.07	15	5
06/10/03	575	2,470	1.249	0.27	0.74	1.99	0.12	0.10	10	3
06/18/03	561	1,972	1.381	0.63	4.52	5.90	0.66	0.18	N/A	14
06/26/03	606	2,329	1.215	0.35	2.69	3.91	0.24	0.04	48	12
07/07/03	289	1,364	1.980	0.12	0.90	2.88	0.09	0.06	22	3
07/08/03	378	1,545	1.218	0.08	1.43	2.65	0.18	0.05	25	11
07/09/03	351	1,550	1.210	0.06	0.86	2.07	0.10	0.01	11	6

Note: Cond. stands for conductivity, TN for total nitrogen, and TP for total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3

CONCENTRATIONS OF CONSTITUENTS IN DISCHARGES SAMPLED AT IDOT PUMPING STATION NO. 29

Sample Date	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
11/6/02	,616	2,190	1.857	0.56	1.54	3.40	0.13	0.00	34	14
11/6/02	,575	2,360	1.766	0.29	1.27	3.04	0.06	N/A	14	19
11/19/02	1,195	4,500	1.935	0.02	N/A	N/A	0.15	0.07	9	5
11/19/02	1,616	5,330	1.740	0.37	1.71	3.45	0.17	0.00	42	11
11/22/02	,721	2,340	1.464	0.10	2.07	3.53	0.13	0.10	74	10
12/18/02	2,374	8,850	1.665	0.53	2.89	4.56	0.44	0.13	306	18
12/19/02	,694	1,944	1.335	0.29	2.60	3.94	0.45	0.18	282	12
3/6/03	15,880	42,200	1.803	0.45	1.41	3.21	0.55	0.49	39	15
3/7/03	7,110	18,100	1.962	0.40	1.40	3.36	0.09	0.04	16	8
3/7/03	N/A	26,900	1.793	0.40	0.97	2.76	0.13	N/A	20	7
3/8/03	N/A	16,100	1.927	0.21	1.22	3.15	0.07	N/A	14	7
3/18/03	N/A	6,730	2.289	0.24	0.71	3.00	0.06	0.04	N/A	N/A
3/20/03	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	17
3/20/03	N/A	N/A	2.121	0.29	2.96	5.08	0.36	N/A	N/A	18
3/21/03	1,833	4,990	2.290	0.18	1.14	3.43	0.10	0.03	12	6
3/21/03	1,700	4,330	1.339	0.35	3.94	5.28	0.74	0.04	498	11
3/22/03	N/A	5,490	2.073	0.07	0.72	2.79	0.04	N/A	20	4
3/22/03	N/A	5,880	2.011	0.05	0.64	2.65	0.04	N/A	40	3
3/25/03	1,753	5,110	1.959	0.32	1.12	3.08	0.11	0.04	37	9
3/28/03	1,072	3,390	1.491	0.27	2.01	3.50	0.18	0.02	108	N/A
4/5/03	,594	1,574	1.716	0.47	1.90	3.62	0.18	0.04	115	7
4/9/03	N/A	N/A	2.789	0.04	0.57	3.36	0.04	0.04	N/A	4
4/29/03	1,394	4,170	1.843	0.31	0.70	2.54	0.06	0.05	44	5
4/29/03	1,062	2,560	1.463	0.49	2.21	3.67	0.28	0.07	193	13
4/30/03	,374	1,201	1.146	0.45	1.86	3.01	0.20	0.04	112	7
5/1/03	,507	1,670	1.463	0.27	1.36	2.82	0.15	0.03	69	6
5/2/03	N/A	N/A	2.246	0.11	0.93	3.18	0.01	0.03	N/A	4
5/8/03	,401	1,398	0.953	0.21	1.69	2.64	0.22	0.03	193	6

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)
CONCENTRATIONS OF CONSTITUENTS IN DISCHARGES SAMPLED AT IDOT PUMPING STATION NO. 29

Sample Date	Cl mg/L	Cond. µmhos/cm	$(NO_2 + NO_3)$-N mg/L	NH_3-N mg/L	TKN mg/L	TN mg/L	TP mg/L	SOL-P mg/L	TSS mg/L	$CBOD_5$ mg/L
5/9/03	1,609	N/A	1.937	0.14	0.93	2.87	0.04	0.03	24	6
5/10/03	,512	1,824	1.107	0.26	1.84	2.95	0.14	0.06	167	6
5/14/03	,992	N/A	1.602	0.46	1.32	2.92	0.09	0.02	65	9
5/20/03	,526	1,689	0.919	0.24	1.67	2.59	0.25	0.04	130	9
5/28/03	,745	2,666	1.435	1.53	4.03	5.47	0.41	0.18	69	16
5/30/03	,429	1,620	0.909	0.33	1.72	2.63	0.21	0.06	99	5
6/3/03	,716	2,567	1.472	0.33	2.35	3.82	0.25	0.03	81	9
6/3/03	,711	2,564	1.364	0.31	0.76	2.12	N/A	0.13	24	
6/7/03	,943	3,563	2.042	0.28	2.10	4.14	0.27	0.12	36	11
6/8/03	,625	2,331	1.115	0.24	1.49	2.61	0.25	0.13	102	7
6/10/03	N/A	4,927	1.869	0.10	0.57	2.44	0.04	0.01	10	3
6/18/03	N/A	2,314	1.755	0.46	5.15	6.91	0.56	0.04	144	15
6/19/03	N/A	2,395	1.277	0.32	2.08	3.36	0.07	0.07	12	9
6/28/03	N/A	2,928	1.306	0.22	2.13	3.44	0.15	0.03	83	9
7/7/03	,617	2,217	1.466	0.03	0.55	2.02	0.08	0.04	14	4
7/8/03	,476	2,064	1.267	0.09	1.21	2.48	0.06	0.01	19	5
7/9/03	,796	3,122	1.590	0.06	0.82	2.41	0.25	0.12	12	7
7/9/03	,768	3,175	1.345	0.04	0.57	1.92	0.05	0.06	11	6
7/10/03	,727	2,698	1.365	0.05	0.93	2.30	0.05	0.03	22	7

Note: Cond. stands for conductivity, TN for total nitrogen, and TP for total phosphorus.