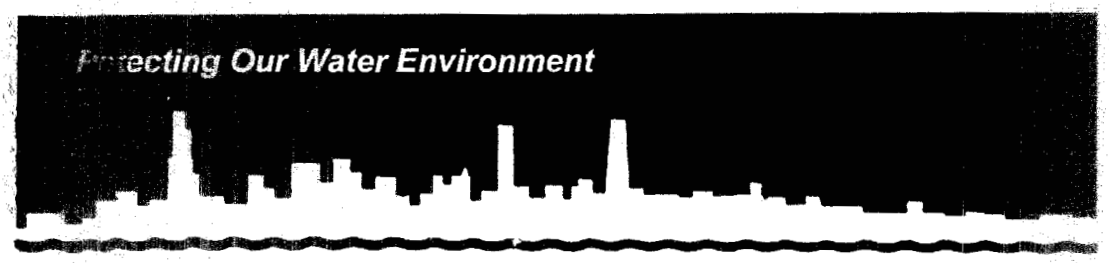

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 04-19

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

2003

ANNUAL REPORT

November 2004

Metropolitan Water Reclamation District of Greater Chicago
100 East Erie Street Chicago, IL 60611-2803 (312) 751-5600

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION
2003
ANNUAL REPORT

Research and Development Department
Richard Lanyon, Director

November 2004

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ACKNOWLEDGMENTS

This 2003 Annual Report is the result of the efforts of not only the scientists and engineers who perform the monitoring and research initiatives of the Department, but also the impressive efforts of support staff and other personnel who contribute their valuable time, energy, and know-how to the production of the report. These individuals deserve special recognition and thanks.

Special thanks are due to Laura Franklin, Rhonda Griffith, Deborah Messina, Joan Scrima, Nancy Urlacher, and Sabina Yarn for their immaculate typing, zealous adherence to Department formatting tradition, responsiveness to turnaround times, and dedication to moving the report forward.

DISCLAIMER

The mention of trade names of specific products does not constitute endorsement of them by the Metropolitan Water Reclamation District of Greater Chicago.

STRUCTURE AND RESPONSIBILITIES OF THE ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

The Environmental Monitoring and Research (EM&R) Division has 70 employees, and is comprised of seven Sections. These are illustrated in Figure 1 with a breakdown of the number of employees. The seven Sections are:

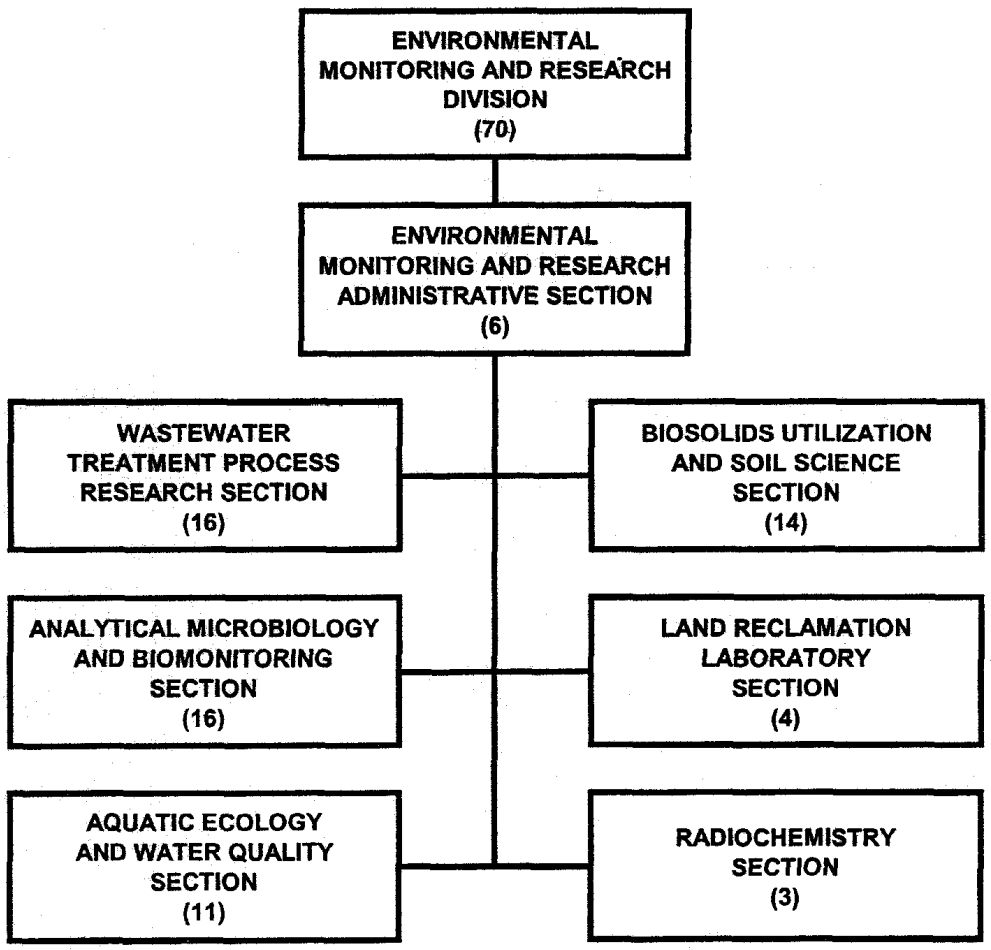
1. Administrative Section
2. Wastewater Treatment Process Research Section
3. Biosolids Utilization and Soil Science Section - Stickney
4. Land Reclamation Laboratory Section - Fulton County
5. Analytical Microbiology and Biomonitoring Section
6. Aquatic Ecology and Water Quality Section
7. Radiochemistry Section

The purpose of this report is to present the major activities and contributions of these Sections during 2003. These were to:

- Monitor the environmental quality of Lake Michigan, area rivers and canals, and the Illinois River to document the effectiveness of the

Figure 1

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION ORGANIZATION CHART (WITH THE NUMBER OF EMPLOYEES)



wastewater treatment program of the Metropolitan Water Reclamation District of Greater Chicago (District);

- Assist in the resolution of sewage treatment and solids disposal operation problems;
- Provide technical assistance to other departments and agencies with respect to issues related to wastewater treatment, combined sewer overflow management, waterways management, and solids processing, utilization, and marketing;
- Conduct applied and operations research to achieve improvement and cost reductions in District wastewater treatment, waterways management, and solids processing and biosolids utilization activities.
- Assess the impacts of new or proposed regulations on District activities.

ADMINISTRATIVE SECTION

In 2003, the EM&R Division was reorganized, with the Toxic Substances Section transferred to the Analytical Laboratories Division and the Experimental Design and Statistical Evaluation Section merged with the EM&R Division Administrative Section.

The Administrative Section now consists of the Assistant Director of Research and Development, one Research Scientist IV, two Statisticians, and a clerical support staff. Its purpose is to oversee and coordinate the work of the Sections comprising the EM&R Division.

In addition to the overall administrative and supervisory functions performed by the Administrative Section, the Experimental Design and Statistical Evaluation Group, which is part of the Administrative Section, provided statistical support to the rest of the EM&R Division. This statistical work will be discussed in more detail later in this report.

WASTEWATER TREATMENT PROCESS RESEARCH SECTION

The Wastewater Treatment Process Research Section is responsible for conducting basic, applied, and problem solving research with regard to various wastewater and sludge treatment processes currently utilized by the District. Technical assistance is provided to the Maintenance and Operations (M&O) Department for solving water reclamation plant (WRP) operating problems. This Section also investigates innovative treatment processes for future use.

The work of the Wastewater Treatment Process Research Section originates from several sources. Current operations may be investigated as the result of a WRP problem, or interest in arriving at new knowledge concerning certain aspects of a waste treatment process. Studies of future operations are concerned with maximizing the efficiency of an existing process at the lowest cost, or the development of new processes. Investigations may take the form of surveys, literature reviews, laboratory bench testing, pilot plant studies, full-scale testing, special analyses, or a combination or progression of any or all of the above. Plans and specifications are also reviewed at the request of the Engineering Department for the purpose of optimizing process design criteria.

In 2003, the Section was primarily concerned with studies relating to odor monitoring and control, sludge treatment technologies, oxygen transfer efficiency, ammonia loads to the Stickney Water Reclamation Plant (WRP), settling and chemical characteristics of combined sewer overflows, reevaluation of pretreatment program local limits, participation in the Stickney and Calumet WRP Master Plans, and the operation of the Tunnel and Reservoir Plan (TARP) System. The main projects performed by the Section are summarized below.

Polymer Testing Program for the District Centrifuge Complexes

In April-May 2003 and August 2003, winter polymer testing and summer polymer testing was carried out at the Stickney WRP for the selection and purchase of polymers used in the centrifugal dewatering of anaerobically digested sludge. The testing procedure is performed twice at Stickney, once in summer and once in winter, as the change in sludge characteristics during these seasons require different polymers at this WRP.

Polymer testing was also carried out for centrifugal dewatering at the Calumet WRP during June 2003 and July 2003. At a request of Calumet operating staff, a total of ten polymers were tested with carbon dioxide as a preconditioner

during June 2003, and with ferric chloride as a preconditioner during July 2003. The purpose of testing with both preconditioners was to evaluate whether carbon dioxide preconditioner could be a better choice than the existing preconditioner, i.e. ferric chloride.

Contract documents were prepared and issued by the District for the solicitation and submittal of polymers for testing at the Stickney WRP and the Calumet WRP, with the objective of selecting suitable polymers meeting the centrifuge performance criteria described therein at the lowest cost. This includes polymer cost, sludge transportation cost, and air-drying cost.

The polymer selection procedure consisted of testing a maximum of two polymers from any given vendor on a full-scale centrifuge. The polymer that passes the test performance criteria as described in the bid documents, and has the lowest cost for conditioning per unit mass of sludge is the polymer of choice for purchase. A summary of the relevant information about the winter and summer tests conducted at the Stickney WRP is presented in Tables 1 and 2, respectively. The Calumet WRP test summary is presented in Tables 3 and 4.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 1

CENTRIFUGE COMPLEX WINTER POLYMER TEST RESULTS
AT THE STICKNEY WRP - APRIL-MAY 2003

Number of Vendors Involved in Tests	5
Number of Polymers Submitted for Testing	10
Number of Polymers Qualified for Bidding	10
Polymer Selected	Polydyne CE 347
Polymer Dosage, lbs/dry ton	326.7

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 2

CENTRIFUGE COMPLEX SUMMER POLYMER TEST RESULTS
AT THE STICKNEY WRP - AUGUST 2003

Number of Vendors Involved in Tests	5
Number of Polymers Submitted for Testing	10
Number of Polymers Qualified for Bidding	10
Polymer Selected	Polydyne CE 386
Polymer Dosage, lbs/dry ton	351.5

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

POLYMER TEST RESULTS AT THE CALUMET WRP CENTRIFUGE COMPLEX USING CO_2 AS A PRECONDITIONER - JUNE 2003

Number of Vendors Involved in Tests	5
Number of Polymers Submitted for Testing	10
Number of Polymers Qualified for Bidding	8
Polymer Selected	N/A
Polymer Dosage, lbs/dry ton	N/A

N/A = Not applicable.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

POLYMER TEST RESULTS AT THE CALUMET WRP CENTRIFUGE COMPLEX USING $FeCl_3$ AS A PRECONDITIONER - JULY 2003

Number of Vendors Involved in Tests	5
Number of Polymers Submitted for Testing	10
Number of Polymers Qualified for Bidding	10
Polymer Selected	Ondeo-Nalco 2100 C
Polymer Dosage, lbs/dry ton	147.1

Polymer Testing Program for Gravity Concentration Tanks at the Calumet WRP

In August 2003, bench-scale polymer testing was carried out at the Lue-Hing Research and Development Complex for the selection and purchase of polymers used in the gravity concentration tanks to thicken the primary and waste-activated sludge at the Calumet WRP. Documents were issued by the District for the solicitation and submittal of polymers for testing at the Lue-Hing Research and Development Complex at the Stickney WRP with the objective of selecting suitable polymers meeting the gravity concentration tanks performance criteria described therein at the lowest cost.

The polymer selection procedure consisted of testing a maximum of three polymers from any given vendor on a bench-scale test to obtain a capillary suction time (CST) of ten seconds. The polymer that passed the test performance criteria (the CST requirement of 10 seconds as described in the bid documents) were subjected to bench-scale settling tests at "optimum dose." The polymers were then ranked based on their performance. Thus, the polymers that met the criteria and had the lowest cost for concentrating per unit mass of sludge became the polymer of choice for purchase. A summary of the relevant information about the tests conducted during August

2003 for the Calumet WRP gravity concentration tanks WRP is presented in Table 5.

Polymer Testing Program for Gravity Belt Thickeners at the Hanover Park WRP

In February-March 2003, polymer testing was carried out at the Hanover Park WRP for the selection and purchase of polymers used in the gravity belt thickening of primary and waste-activated sludge. Documents were issued by the District for the solicitation and submittal of polymers for testing at the Hanover Park WRP, with the objective of selecting suitable polymers meeting the gravity belt thickener performance criteria described therein at the lowest cost.

The polymer selection procedure consisted of testing a maximum of two polymers from any given vendor on a full-scale gravity belt thickener to obtain a cake solids of 6.0 percent (criterion upgraded from 5.5 to 6.0 percent this year). The polymer that passed the test performance criteria as described in the bid documents and had the lowest cost for conditioning per unit mass of sludge became the polymer of choice for purchase. A summary of the relevant information about the tests conducted during February-March 2003 at the Hanover Park WRP is presented in Table 6.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

POLYMER TEST RESULTS FOR CALUMET WRP
GRAVITY CONCENTRATION TANKS - AUGUST 2003

Number of Vendors Involved in Tests	4
Number of Polymers Submitted for Testing	11
Number of Polymers Qualified for Bidding	7
Polymer Selected	Ondeo-Nalco 2100 B
Polymer Dosage, lbs/dry ton	65.87

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6

GRAVITY BELT THICKENER POLYMER TEST RESULTS
AT THE HANOVER PARK WRP - FEBRUARY-MARCH 2003

Number of Vendors Involved in Tests	4
Number of Polymers Submitted for Testing	8
Number of Polymers Qualified for Bidding	7
Polymer Selected	Polydyne CE 323
Polymer Dosage, lbs/dry ton	3.72

Summer/Winter Polymer Testing Program for the Stickney Centrifuge Complex

In May 2003 and November 2003, full-scale polymer testing was carried out at the Stickney WRP for changing of polymers used in the centrifugal dewatering of anaerobically digested sludge. The May 2003 tests had to be canceled because the centrifuge machine malfunctioned in the midst of testing. The testing procedure is performed twice at Stickney, once in summer and once in winter, as the change in sludge characteristics during these seasons require different polymers at this WRP.

Full-Scale Polymer-Enhanced Lagoon Dewatering of Digested Sludge

PILOT-SCALE STUDY BACKGROUND AND OBJECTIVES

The increasing use of centrifuges for dewatering operations in recent years at the Stickney WRP, the largest of seven owned and operated WRPs of the District, and a loss of all but two lagoons (Lagoons 24 and 25) at the Lawndale Avenue Solids Management Area (LASMA) for emergency liquid sludge storage has raised concern in the District's Maintenance and Operation (M&O) Department regarding the reduced lagoon capacity on-hand. If an emergency arose in which the sludge could not be centrifuged, the M&O Department would not be able to

handle all of the Stickney WRP liquid digested sludge using a traditional lagoon storage treatment due to a reduced lagoon capacity arising from changes in the overall site plan. In the near future, only a one-month emergency storage capacity (approximately 552,000 cubic yards) may be available.

One of the ways by which the lagoon capacity may be increased is by using cationic polymer to enhance settling and dewatering. At the request of the M&O staff at the Stickney WRP, the R&D Department undertook a pilot-scale study in the year of 2001 and concluded in the year of 2002. The study evaluated the addition of cationic emulsion polymer to improve the settling and dewatering of anaerobically digested sludge in the lagoons. The objective of the study was to investigate whether the application of cationic polymer would improve dewatering and settling of anaerobically digested sludge, and thereby increase the sludge processing and storage capacity of two existing storage lagoons. The effect of polymer addition on odors, as measured by the hydrogen sulfide concentrations, was also a concern and hence was investigated as a secondary objective of the study.

SUMMARY OF PILOT-SCALE STUDY

The pilot-scale study clearly showed that the addition of cationic emulsion polymer appreciably improved the settling and dewatering performance of the anaerobically digested sludge. Polymer addition at approximately 30 lbs per dry ton of solids increased the amount of sludge processed by approximately 26 to 40 percent with a much better separated water quality and a drier cake solids. The specific selection of polymer would be based upon cost considerations.

Also, the addition of polymer separated water from the sludge much quicker than that of the control lagoon. Regardless of which polymer was used, its addition caused the solids layer to remain floating at the top of the separated water over entire test period. The control lagoon did not exhibit the phenomenon of floating solids.

No difference in odors was observed between polymer fed lagoons and the control lagoon. Hydrogen sulfide concentrations measured above the lagoons showed no significant difference among all three lagoons. This indicates that polymer addition did not contribute to odor as measured by hydrogen sulfide concentrations.

Thus, the results of the study showed that the addition of cationic emulsion polymer would appreciably improve the

dewatering of digested sludge and thereby increase the lagoon's sludge processing and emergency storage capacity without increasing objectionable odor levels. It is estimated that 26 to 40 percent more sludge could be processed in the full size lagoons using polymer treatment. This increased storage capacity could prove critical during a catastrophic failure of the Stickney WRP's centrifuge dewatering facility.

FULL-SCALE STUDY

With the success of pilot-scale study, the operating staff of Stickney WRP decided to verify the pilot-scale results in a full-scale test with the polymers used in the pilot-scale studies and determine whether a full-scale operation was workable in lagoon no. 25. During 2003, R&D Department staff conducted bench-scale CST, floc-strength, and settling tests to determine the maximum distance that the polymer could be injected without deteriorating performance in lagoon. The test results show that a chosen site of Vulcan scale-house that is approximately 1.81 miles away from lagoon no. 25 could work for injecting polymer in the full-scale system. Also, provided was the guidance on miscellaneous operational challenges that might be faced during full-scale study.

Odor Monitoring Programs

As part of the District's continuing odor surveillance program, the EM&R Division conducts odor monitoring at the Harlem Avenue Solids Management Area (HASMA), Vulcan, the Lawndale Avenue Solids Management Area (LASMA), and Marathon air drying sites. A similar odor monitoring program was initiated in the spring of 2001 at the Stony Island and the 119th and Ridgeland Avenue Solids Management Area (RASMA) drying areas. The programs are a part of the NPDES permits for the solids management areas. Odor monitoring is also conducted at the Calumet WRP, the John E. Egan WRP, the Stickney WRP, the James C. Kirie WRP, and the North Side WRP.

Each location uses a similar protocol for monitoring odors. R&D personnel (and at some WRPs M&O Department personnel) visit various stations at each site on a regular basis. Frequency can range from once per week (as with the John E. Egan WRP), or daily (as with the Kirie WRP), depending on the program. The odor monitoring personnel make subjective observations regarding the character and intensity of odors at each of the stations. The odor intensities are ranked on a scale from 0, no odor, to 5, very strong odor. These data are tabulated monthly.

The objective of all the programs is to collect and maintain a database of odor levels within and around each WRP, and associated sludge processing areas. The data are used to study the trends in odor levels associated with WRP operations, and to relate odor levels to changing conditions within the WRP, such as installation of odor control equipment.

Since several residential areas surround the WRPs in the program, the odor monitoring activities also provide early warning of odorous conditions that develop within the WRPs, and to allow control of them before they come to the notice of the residents. Any citizen calls regarding odors at any of the WRPs in the program are immediately investigated by M&O Department personnel, and the corrective action is taken at the WRP if the complaint resulted from odor emissions from the WRP. Citizen odor calls for all WRPs are summarized in Table 7.

ODOR MONITORING AT THE HASMA, VULCAN, LASMA, AND MARATHON SLUDGE PROCESSING SITES

This odor monitoring program was initiated in 1990. Anaerobically digested sludge lagooned for one and one-half years and/or centrifuge cake is dried on paved drying cells to a solids content greater than 60 percent. The sludge drying process is enhanced by agitation using auger-equipped

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7

CITIZEN ODOR CALLS REGARDING DISTRICT WRPs OR SOLIDS DRYING SITES (SDS) DURING 2003

	Total Number of Calls	Number of Calls Confirmed
HASMA, Vulcan, LASMA, Marathon Sites	1	1
Ridgeland SDS	0	0
Stony Island SDS	0	0
Calumet WRP	0	0
John E. Egan WRP	1	0
Stickney WRP	3	0
James C. Kirie WRP	0	0
North Side WRP	0	0

tractors. Experience has indicated that agitation is important for drying the sludge in a low odor manner.

R&D personnel visited 16 stations throughout the three solids drying areas (HASMA, Vulcan, and Marathon) and the lagoon area (LASMA) at least three times a week. During 2003 additional monitoring locations were added at Vulcan and Marathon. Figure 2 summarizes the observations of odor monitoring personnel during 2003.

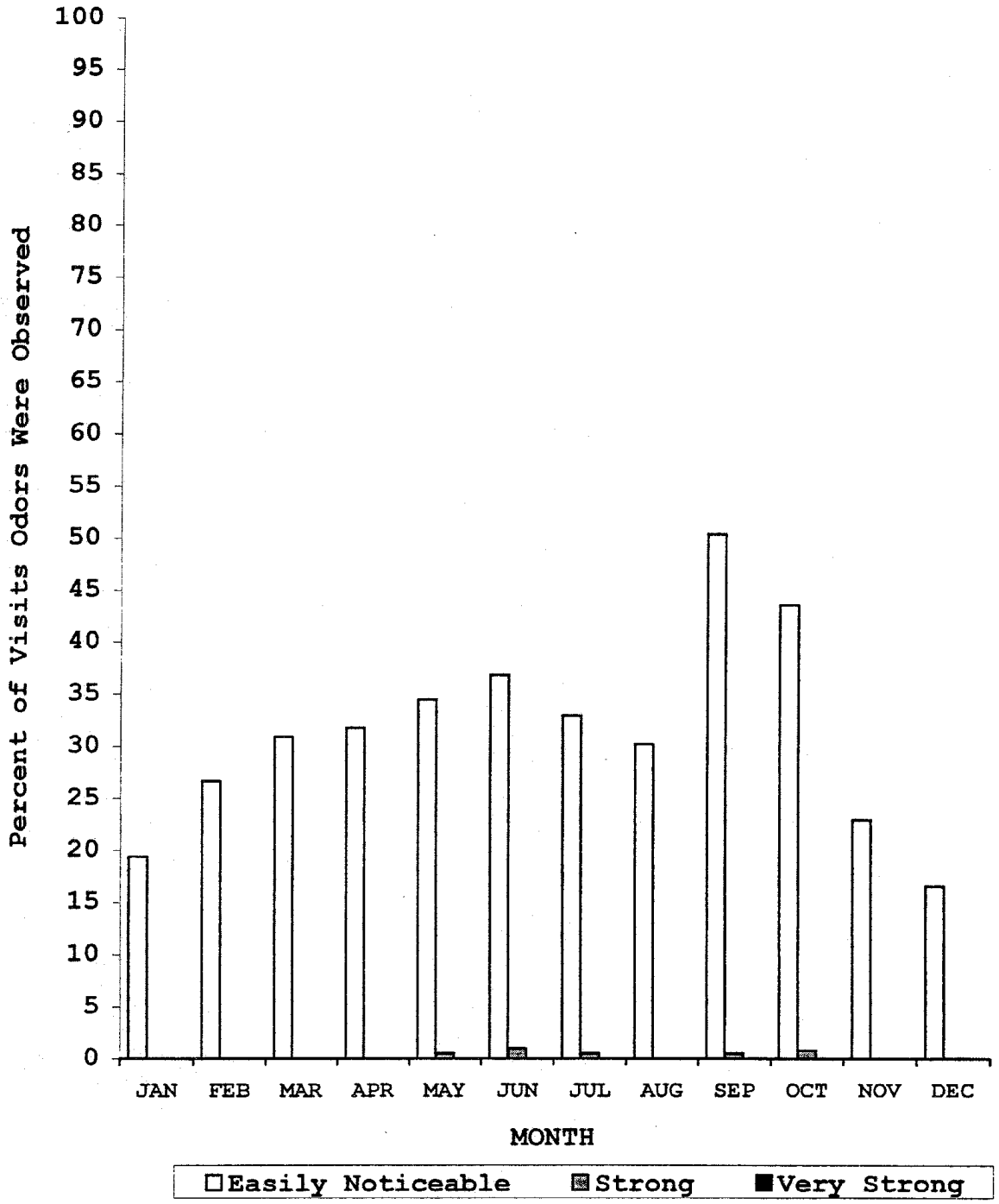
For each month, average odor intensity data from the 13 stations were calculated. The percentage of visits at which easily noticeable, strong, and very strong odors were observed was plotted by month. Although there were peaks of easily noticeable odor observations, ranging from 16 to 50 percent, during the year, there were no very strong odor observations. The strong odor observations were less than 1.0 percent of the total observations during any month throughout the year.

The best indication of the District's success in processing sludge is the number of odor complaints received from citizens in the vicinity of the processing operation. There was only one call received from citizens in regards to odors from these sludge processing facilities in 2003, as shown in Table 7.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 2

ODOR OBSERVANCE ON DISTRICT PROPERTY AT HASMA, LASMA, VULCAN, AND MARATHON SITES - 2003



ODOR MONITORING AT THE CALUMET WRP

The Calumet WRP odor monitoring program which was initiated in March 1992 is a cooperative effort of the R&D and M&O Departments. The Calumet odor monitoring program involves the daily visitation of 22 stations around the WRP and sludge processing areas.

Figures 3 and 4 summarize the observations of easily noticeable, strong, and very strong odors made during 2003 in terms of frequency of occurrence for the Calumet WRP and the Calumet Drying Areas, respectively. The odors were at generally low levels in 2003, with no very strong odors being observed at either the Calumet WRP or Drying Areas. Only a few instances of a strong odor were observed, in September, October, and December at the Calumet WRP. Easily noticeable odor observations varied between 11 and 21 percent of the monthly observations at the Calumet WRP and between 5 and 22 percent at the Drying Areas. No odor complaints were reported from the public regarding these facilities during 2003, as shown in Table 7.

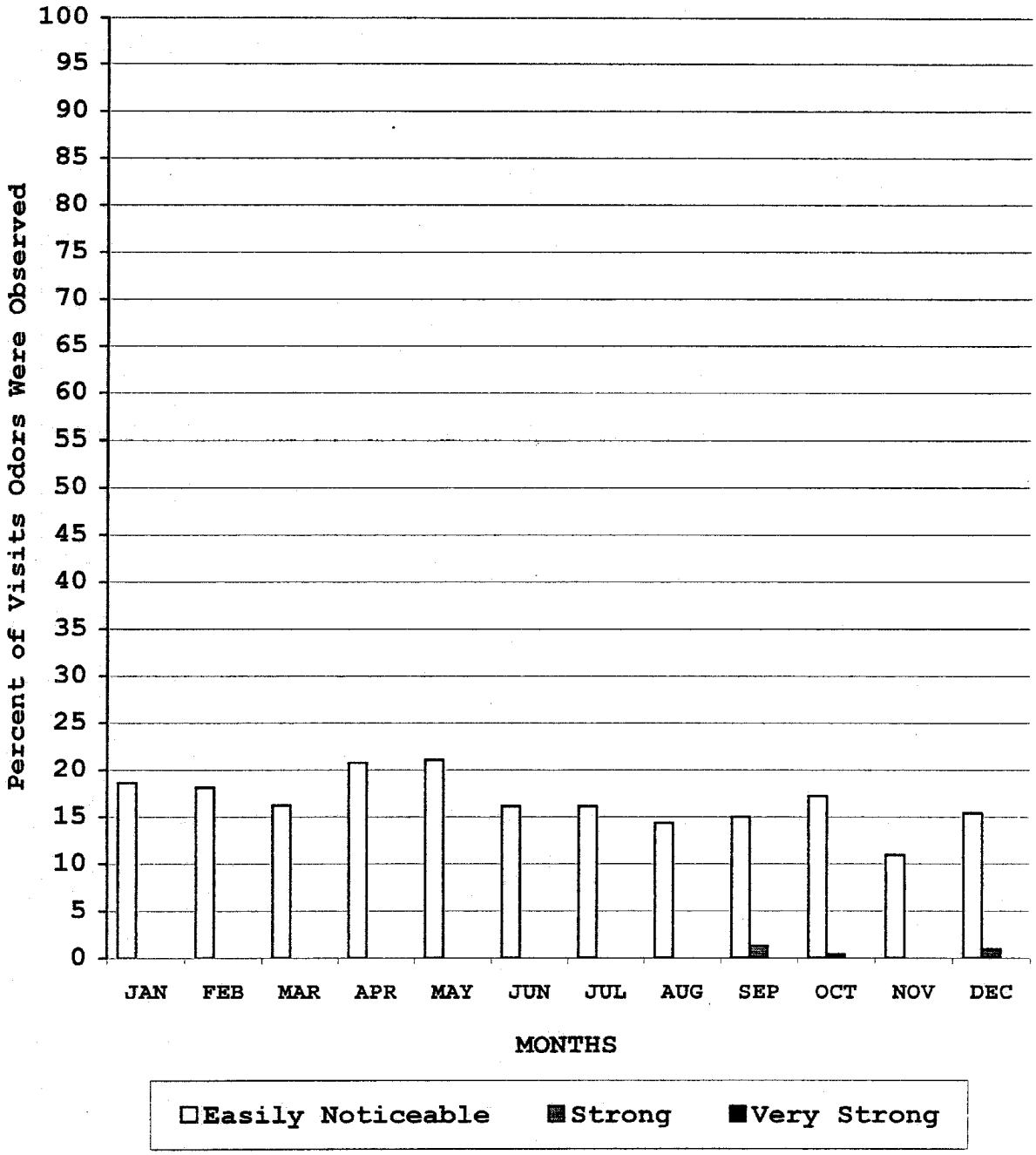
ODOR MONITORING AT THE STONY ISLAND SOLIDS MANAGEMENT AREA

The odor monitoring program at the Stony Island Solids Management Area was started in June of 2001. R&D Department

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 3

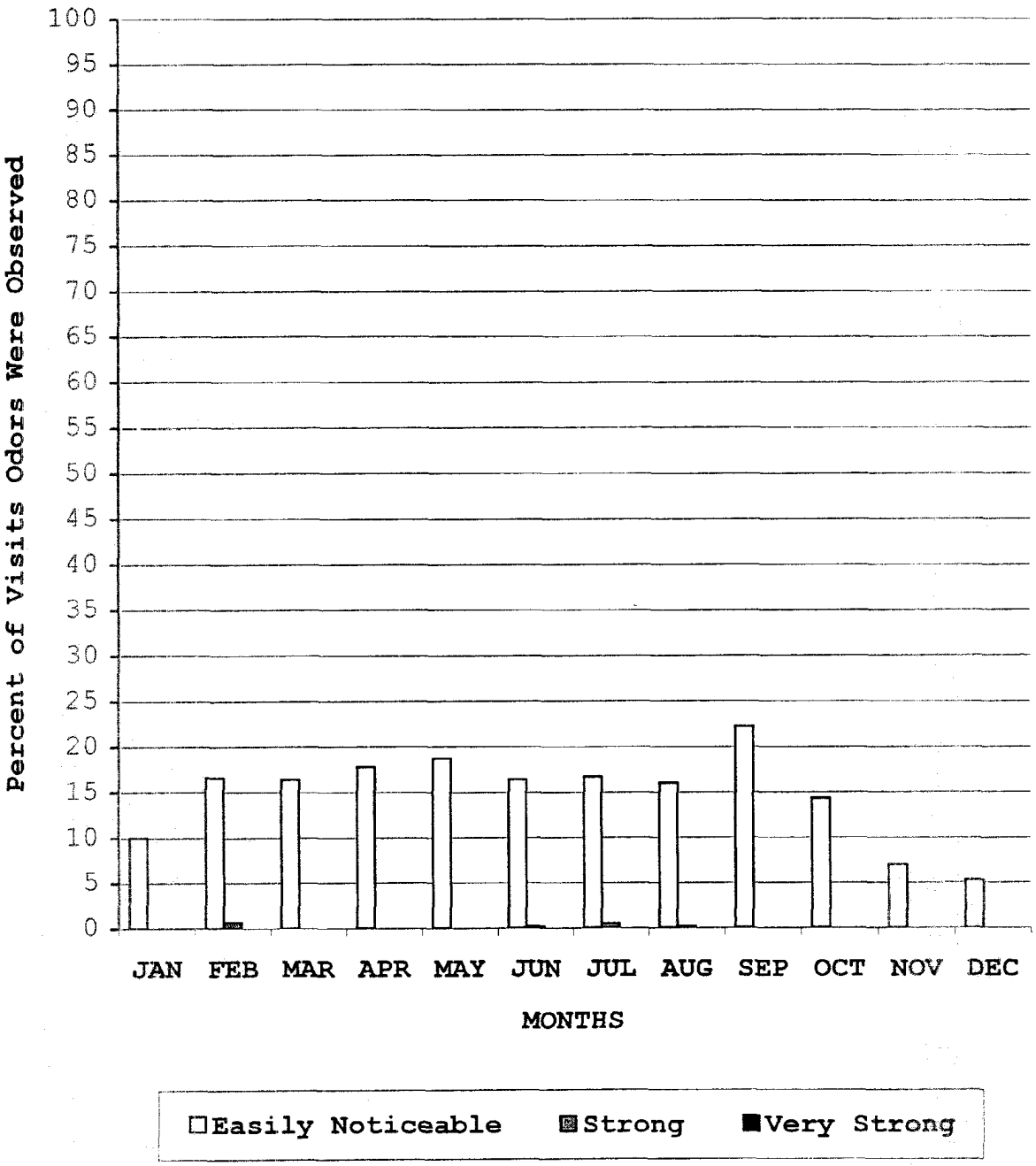
ODOR OBSERVANCES AT CALUMET WRP - 2003



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 4

ODOR OBSERVANCES AT CALUMET
SLUDGE DRYING AREAS - 2003



personnel visit four stations located around the boundary of the drying cells at least once per week.

Figure 5 summarizes the observations of easily noticeable, strong, and very strong odors made during 2003 in terms of frequency of occurrence. There were no very strong odor observations and the monthly strong odors varied between 0 and 12.5 percent of total observations in 2003. There were no confirmed odor complaints, as shown in Table 7.

ODOR MONITORING AT THE RIDGELAND SOLIDS MANAGEMENT AREA

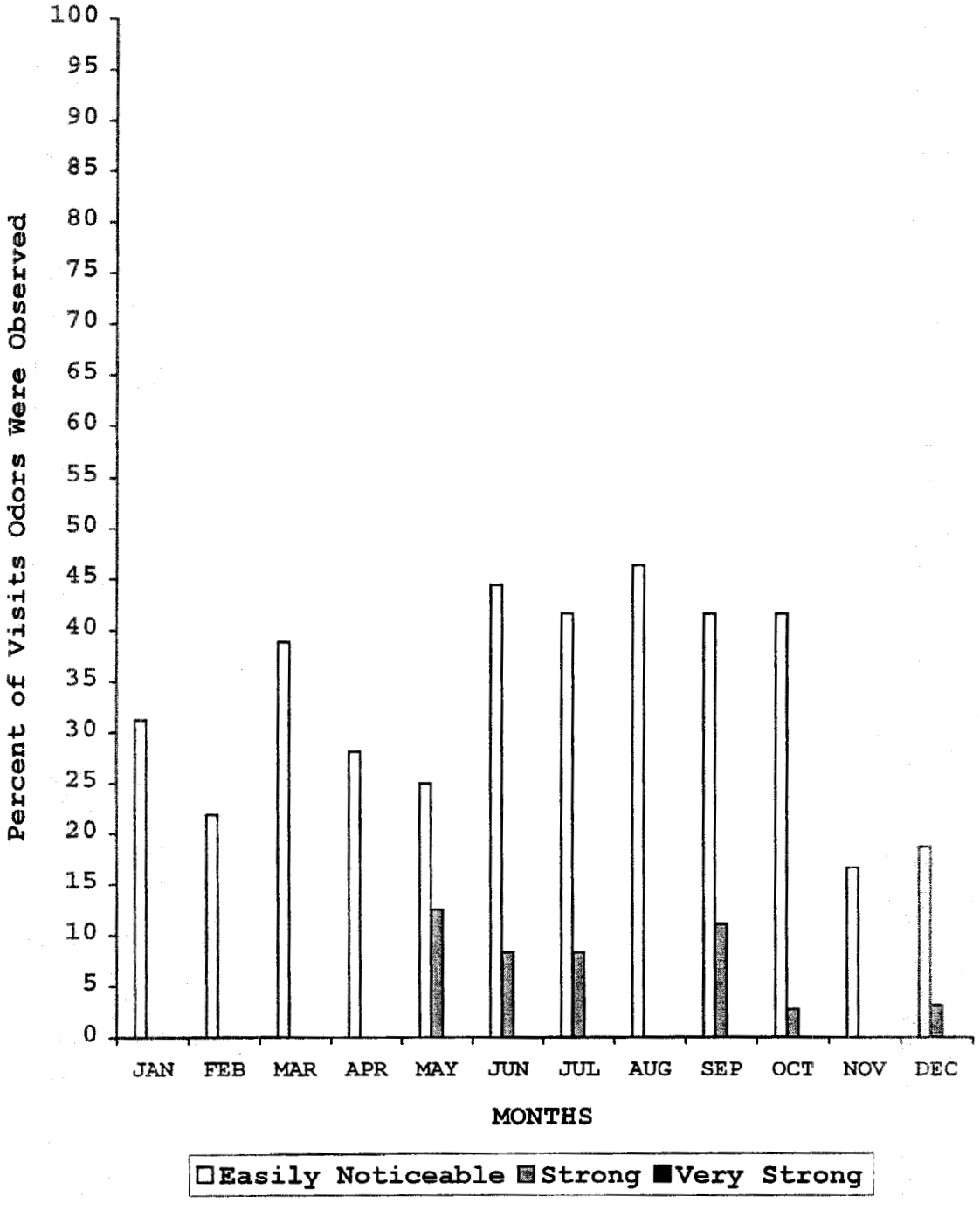
The odor monitoring program at the Ridgeland Solids Management Area was started in May of 2001. R&D Department personnel visit four stations located around the boundary of the drying cells one to two days per week.

A monthly summary of the observations of easily noticeable, strong, and very strong odors made during 2003 is presented in Figure 6 expressed as frequency of occurrence. No very strong or strong odors were observed. Easily noticeable odors were observed only during the drying period of April through November 2003, varying from 0 to 50 percent of the time. No calls were received regarding odors at Ridgeland in 2003 (Table 7).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 5

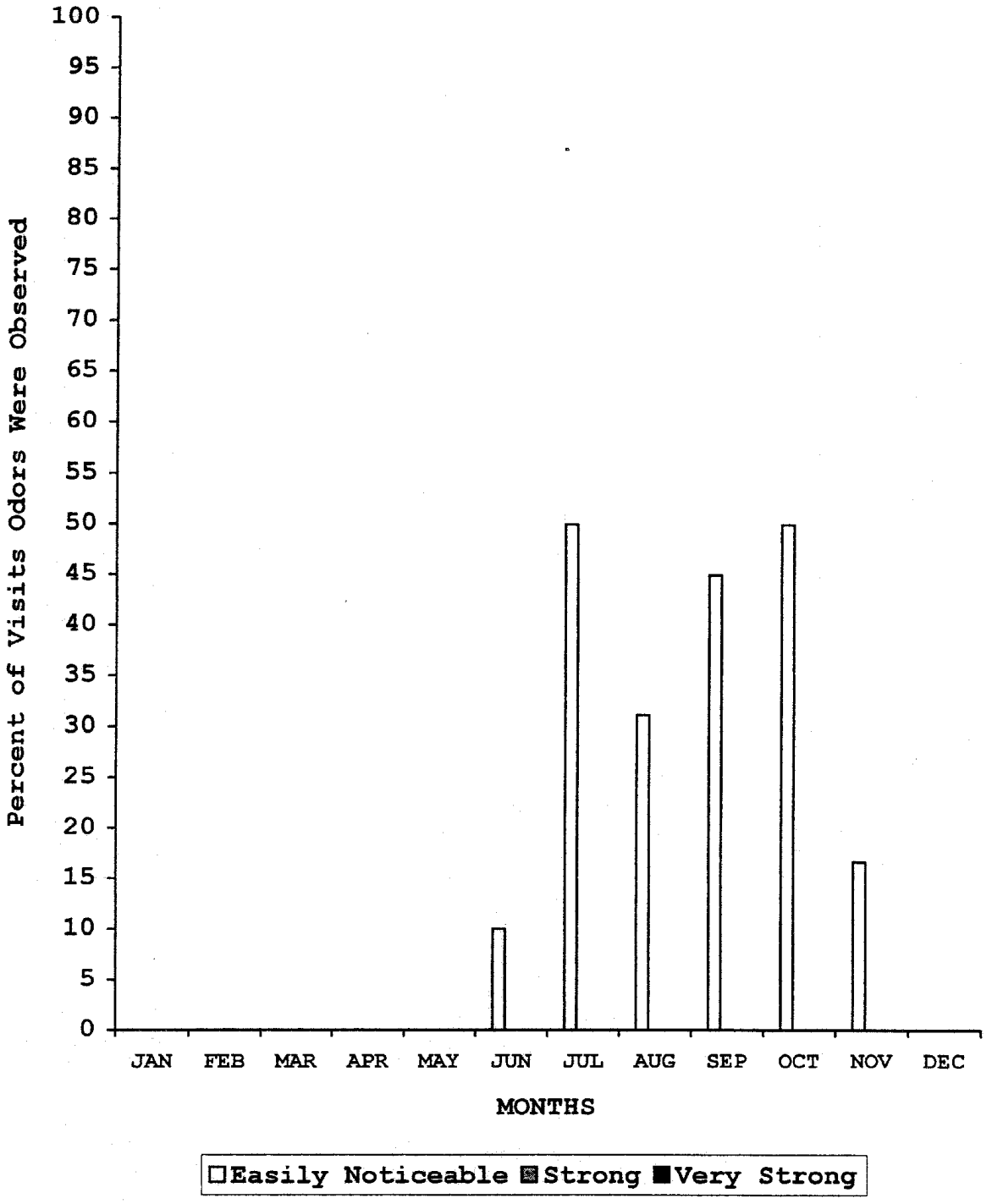
ODOR OBSERVANCES AT STONY ISLAND - 2003



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 6

ODOR OBSERVANCES AT RIDGELAND - 2003



ODOR MONITORING AT THE JOHN E. EGAN WRP

The John E. Egan WRP odor monitoring program initiated in October 1993 is also a joint effort between the R&D and M&O Departments. Seven stations within the WRP boundaries are visited at least once a week by M&O and R&D personnel. For each month, average odor intensity data from the seven stations were calculated. The percentage of observations at which easily noticeable, strong, and very strong odors were observed during 2003 was plotted by month and is presented in Figure 7. Odor of an easily noticeable intensity was observed from approximately 0 to 21 percent of the monthly observations made at the John E. Egan WRP. No very strong odors were observed, and only a few strong odors were observed in June 2003. Only one unverified odor call from the public was reported regarding this WRP during 2003, as shown in Table 7.

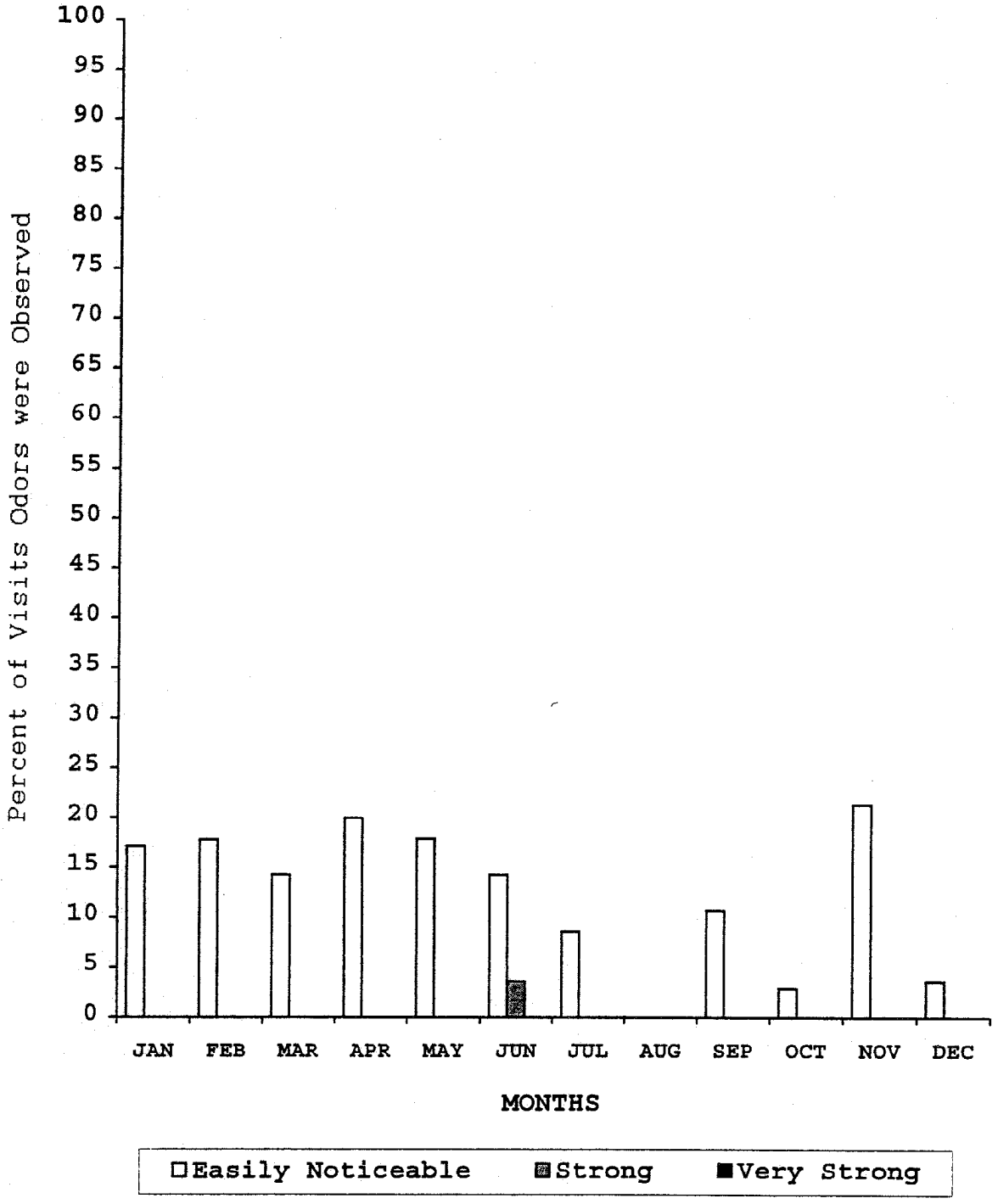
ODOR MONITORING AT THE STICKNEY WRP

The Stickney WRP odor monitoring program initiated in May 1991 is a cooperative effort between the R&D and M&O Departments. Either R&D or M&O personnel visit each of the 19 established stations within and around the Stickney WRP on five days each week.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 7

ODOR OBSERVANCES AT JOHN E. EGAN WRP - 2003



The 19 stations are located at treatment process operation sites where potentially odorous activities, such as sludge dewatering and anaerobic digestion, take place. Also included are locations along the perimeter of the WRP where odors might be detected by the public.

Figure 8 summarizes the observations of odor monitoring personnel during 2003. For each month, average intensity data from the 19 stations were plotted. The percentage of visits at which easily noticeable, strong, and very strong odors were observed and plotted by month in Figure 8. Easily noticeable odors were observed less than 33 percent of the time during any month of the year. No very strong odors were observed. Strong odor observations varied from 0.3 to 1.3 percent of the total observations throughout the year.

At this WRP, three citizen calls about odors were received during 2003, as shown in Table 7. Investigation by District personnel indicated that the reported odors were not verified as originating from the Stickney WRP.

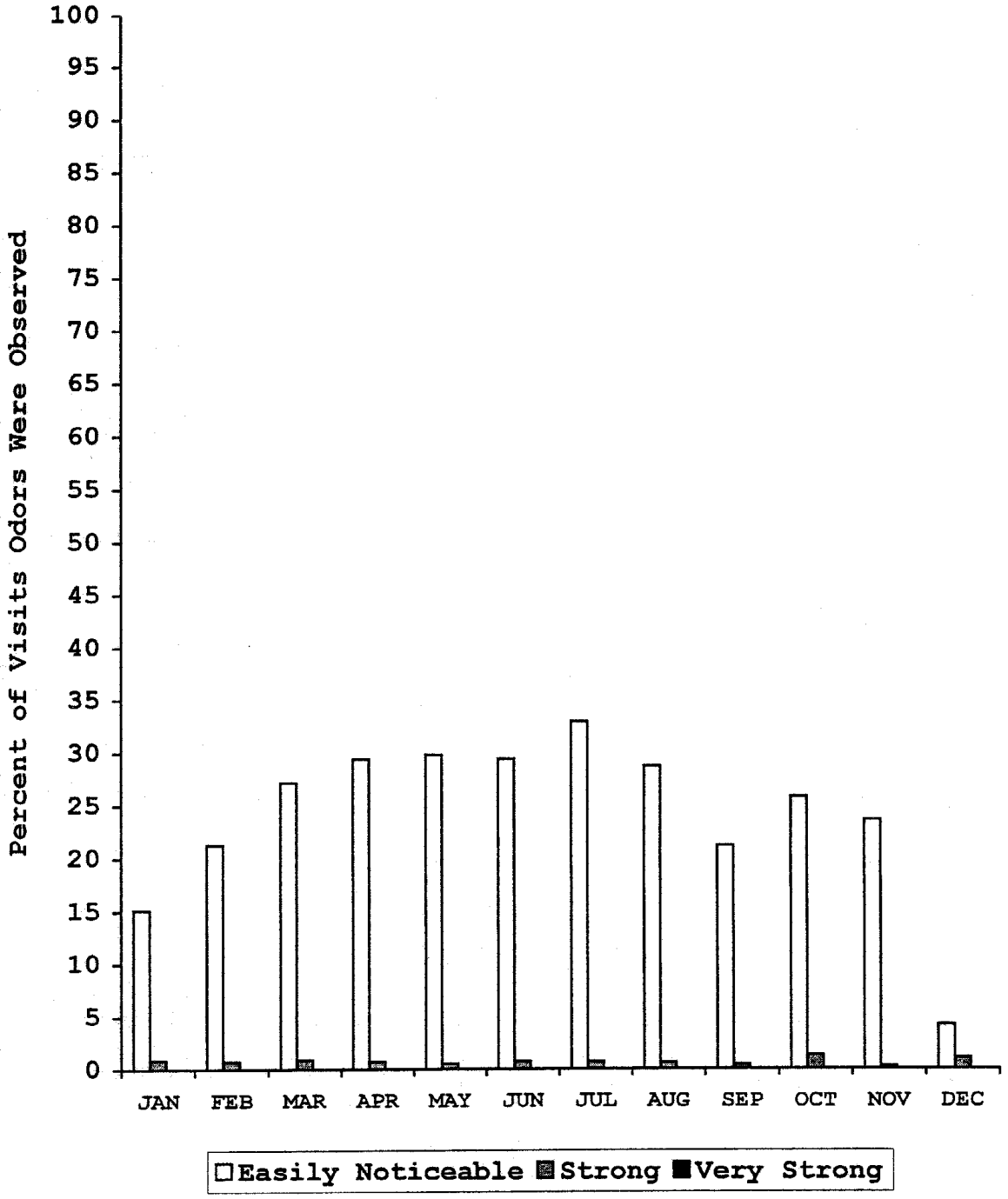
ODOR MONITORING AT THE JAMES C. KIRIE WRP

The James C. Kirie WRP odor monitoring program is a joint effort between the R&D and M&O Departments, and was initiated in September 1996. The program includes monitoring of 15

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 8

ODOR OBSERVANCES AT STICKNEY WRP - 2003



locations within the WRP boundaries and two locations in the nearby community. R&D Department personnel monitor once a week, and during the summer months M&O Department personnel monitor three times a day.

Figure 9 summarizes the observations of odor monitoring personnel during 2003 in terms of easily noticeable or greater. As may be noted from the figure, there were no very strong odors and only one strong odor in November. Easily noticeable odors were detected in less than one percent of the observations during the summer months. No odor complaints were received from the public regarding this facility during 2003, as shown in Table 7.

ODOR MONITORING AT THE NORTH SIDE WRP

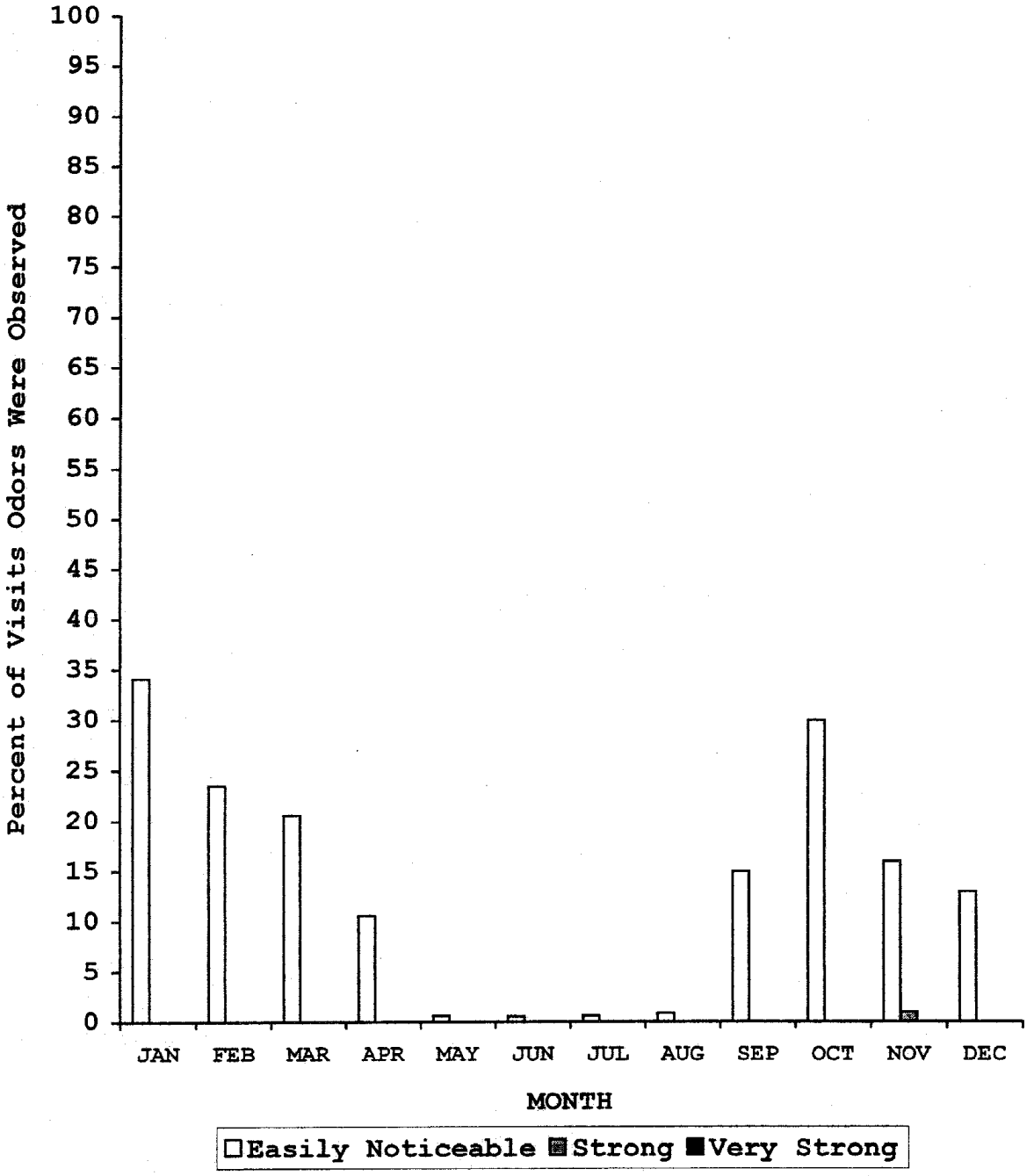
The North Side WRP is located in close proximity to residences and several light industrial facilities. There is little buffer between the WRP, residences, and industrial facilities, particularly along the Howard Street boundary of the WRP.

R&D personnel visited 13 stations within and around WRP boundaries at least once a week. Figure 10 summarizes the observations of odor monitoring personnel from January through December 2003. For each month, average odor intensity data

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 9

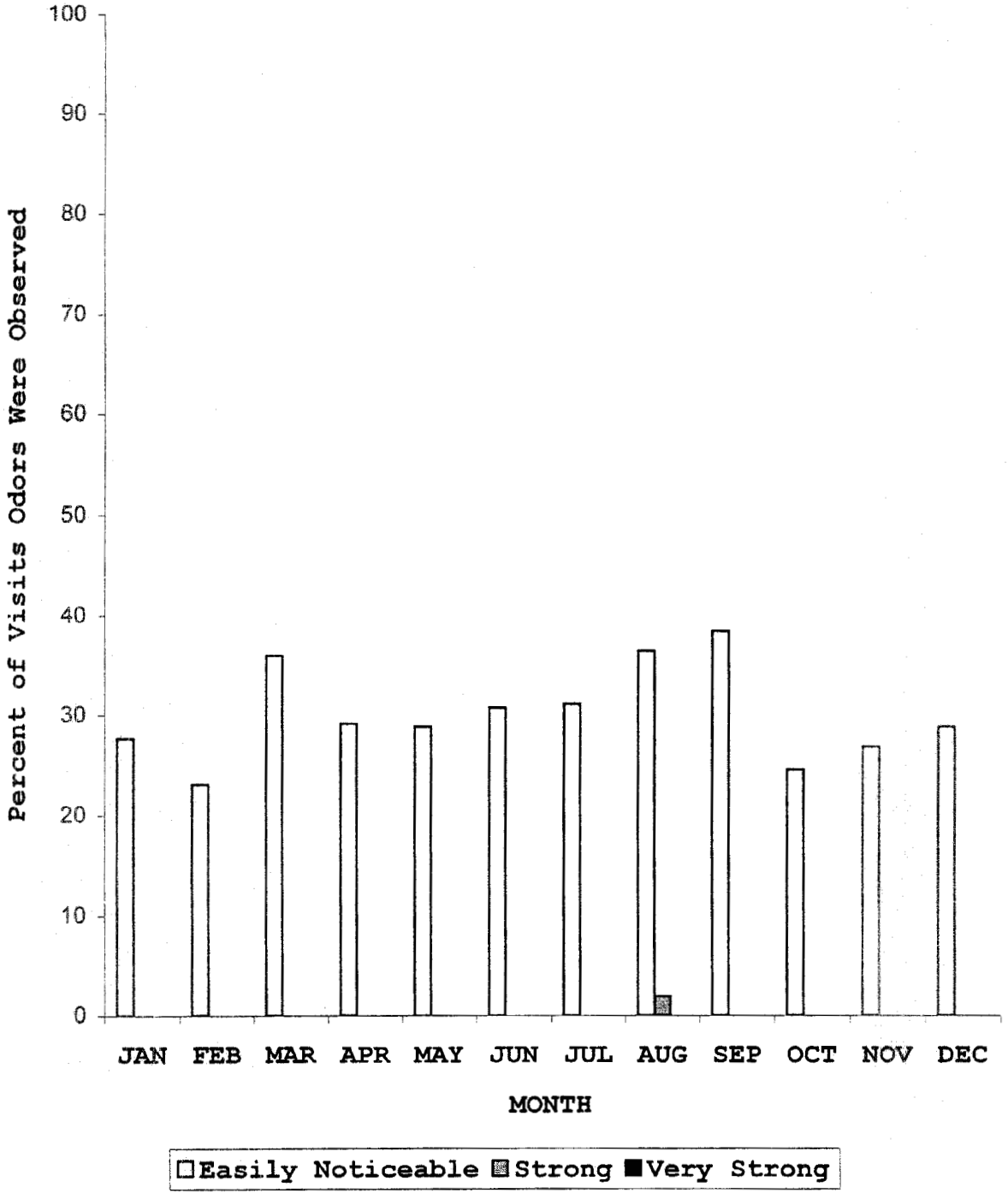
ODOR OBSERVANCES AT JAMES C. KIRIE WRP - 2003



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 10

ODOR OBSERVANCES AT NORTH SIDE WRP



from the 13 stations that were monitored was calculated and plotted. The percentage of observations at which easily noticeable, strong, and very strong odors were observed was plotted by month. No very strong odors were observed during the year, and a couple of strong odors were observed in the month of August 2003. The easily noticeable odors ranged from 25 to 38 percent of the monthly observations.

There were no citizen odor complaints reported by the M&O Department during 2003, as shown in Table 7.

Estimation of Emission of Hazardous Air Pollutants (HAPs)

Under Section 112 of Title I of the Clean Air Act, a publicly owned treatment works (POTW) is considered a major source of HAPs if it emits or has the potential to emit 10 tons per year or more of any HAP or 25 tons per year or more of any combination of HAPs.

Samples of the influent sewage to each of the District's WRPs are collected twice a year and analyzed by the Toxic Substances Section of the Analytical Laboratory Division for 65 of the HAP compounds of concern to POTWs. Estimates of the emissions of these HAPs from the wastewater treatment process units (grit chamber, primary settling tanks, aeration tanks, and secondary settling tanks) are made using the Bay Area

Sewage Toxics Emissions (BASTE) computer model developed by CH2M Hill. The average concentration of each HAP detected in the influent sewage was used as an input to the model along with the annual average operating conditions. The physical properties of the individual compounds were taken from the United States Environmental Protection Agency (USEPA) database.

During 2003, influent samples were collected in January and July. The average influent concentrations found are presented in Table 8 for the three major District WRPs. The estimated emissions of individual HAPs for the three major District WRPs are summarized in Table 9.

All of the individual HAP emissions were less than the 10 tons/year criterion. Toluene, acetaldehyde, and dichloromethane were the predominant compounds found at the Stickney WRP. The Calumet WRP had the most compounds detected, but the emissions were very low, with all less than 0.4 ton/year. The total measured HAP emissions were substantially less than the 25 ton/year threshold at each of the three WRPs. Thus, the wastewater treatment process units at the District's WRPs are not a major source of HAPs.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 8

INFLUENT HAZARDOUS AIR POLLUTANT CONCENTRATIONS AT THE DISTRICT'S MAJOR WATER RECLAMATION PLANTS IN 2003

HAP Organic Compound	Concentrations in µg/L[1]		
	Stickney	Calumet	North Side
Dichloromethane	10	8	6
Chloroform	3	2	4
Trichloroethane	NF	1	2
Benzene	NF	7	NF
Tetrachloroethene	NF	4	4
Toluene	28	8	6
Ethylbenzene	NF	1	NF
Carbon disulfide	NF	6	1
Methyl ethyl ketone	8	18	NF
Styrene	5	12	NF
Xylene (total)	NF	3	NF
Cresol (total)	NF	15	11
Acetophenone	NF	19	NF
Cumene	NF	9	NF
Acetaldehyde	92	38	NF

[1]Average results of the two influent samples collected in January and July 2003.
NF = Not found.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9

HAZARDOUS AIR POLLUTANT EMISSIONS FROM DISTRICT'S MAJOR WATER RECLAMATION PLANTS IN 2003[1]

HAP Organic Compound	Stickney (tons/yr)	Calumet (tons/yr)	North Side (tons/yr)
Dichloromethane	1.32	0.29	0.27
Chloroform	0.35	0.07	0.15
Trichloroethane	0	0.05	0.08
Benzene	0	0.22	0
Tetrachloroethene	0	0.37	0.43
Toluene	2.63	0.21	0.19
Ethylbenzene	0	0.03	0
Carbon disulfide	0	0.33	0.07
Methyl ethyl ketone	0.09	0.07	0
Styrene	0.37	0.25	0
Xylene (total)	0	0.09	0
Cresol (total)	0	0.02	0.01
Acetophenone	0	0.02	0
Cumene	0	0.25	0
Acetaldehyde	2.44	0.34	0
Total	7.20	2.61	1.20

[1]Emissions estimated using the BASTE model.

Monitoring of Organic Priority Pollutants in District WRPs

In compliance with NPDES permit requirements, the District analyzes the raw sewage, final effluent, and sludges from its seven WRPs for organic priority pollutants. The levels of 111 organic priority pollutants are determined following USEPA 600 Series Methods. The analyses are done by the Toxic Substances Section of the Analytical Laboratory Division.

Tables 10, 11, and 12 present the average concentrations of the compounds found in District raw sewage, final effluent, and sludge samples, respectively. The data represent two sets of samples taken in February and July 2003.

The noticeable higher values of purgeable compounds or VOCs observed in the raw sewage were for chloroform, toluene, and trichloroethylene in concentrations of 75.5 µg/L, 43 µg/L, and 20.5 µg/L at the Lemont, Stickney - Southwest, and Stickney - West Side WRPs, respectively.

The highest values of purgeable compounds found in the final effluent were for chloroform in concentrations of 27.0 µg/L and 7.5 µg/L at the Lemont and Hanover Park WRPs, respectively, and toluene in concentration of 24.5 µg/L at the Egan WRP.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 10

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT RAW SEWAGE - 2003

Type of Compound	Reporting Limit (µg/L)	Average Values in µg/L (ppb)[1]							
								Stickney[2]	
		Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Southwest	West Side
Purgeables									
Acrylonitrile	2	ND	2	ND	ND	ND	ND	ND	ND
Benzene	2	7	2	ND	ND	ND	ND	ND	ND
Chloroform	2	2.5	9.5	6.5	5	75.5	4	3	3.5
Dichlorobromomethane	2	ND	ND	1	ND	ND	ND	ND	ND
Ethyl Benzene	2	1	ND	ND	ND	ND	ND	ND	ND
Methyl chloride	3	ND	ND	4	ND	ND	ND	ND	ND
Methylene chloride	2	7.5	3	3.5	15.5	7	6	10.5	10
Tetrachloroethylene	2	3.5	ND	1	2	3.5	3.5	0	10.5
Toluene	2	7.5	3.5	7.5	7	8.5	6	43	12.5
Trichloroethylene	2	1	ND	ND	ND	ND	1.5	0	20.5
Trichlorofluoromethane	4	ND	ND	1	ND	ND	ND	ND	ND
Acid Extractables									
Phenol	4	21	ND	3	3	2.5	ND	ND	ND
Base/Neutral Extractables									
Benzo (a) pyrene	2	ND	1	ND	ND	ND	ND	ND	ND
Bis (2-ethylhexyl)phthalate	50	25	ND	ND	ND	ND	ND	ND	ND
Butylbenzyl phthalate	4	ND	ND	ND	4	ND	13.5	ND	ND
Chrysene	2	1	ND	ND	ND	ND	ND	ND	ND
Diethyl phthalate	6	3.5	ND	11	4	3.5	3	ND	ND
Phenanthrene	2	1	1.5	ND	ND	ND	ND	ND	ND
Pyrene	2	ND	1.5	ND	ND	ND	ND	ND	ND

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 10 (Continued)

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT RAW SEWAGE - 2003

Type of Compound	Reporting Limit (µg/L)	Average Values in µg/L (ppb)[1]							
								Stickney[2]	
		Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Southwest	West Side
Pesticides & PCBs									
None Found									

[1]Average results of two samples from February and July.
[2]Stickney WRP receives two influent raw sewages.
ND = Not detected.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 11

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT FINAL EFFLUENT - 2003

Type of Compound	Reporting Limit (µg/L)	Average Values in µg/L (ppb)[1]						
		Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Stickney
Purgeables								
Chloroform	2	ND	4.5	7.5	1	27	ND	ND
Chlorodibromomethane	2	ND	2	1.5	ND	ND	ND	ND
Methylene chloride	2	4	1.5	1.5	2.5	4	2	5
Toluene	2	ND	24.5	ND	ND	ND	ND	ND
Dichlorobromomethane	1	ND	ND	3.5	ND	ND	ND	ND
Acid Extractables								
None Found								
Base/Neutral Extractables								
None Found								
Pesticides & PCBs								
None Found								

[1]Average results of two samples from February and July.
ND = Not detected.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 12

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT SLUDGES - 2003

Type of Compound	Average Values in mg/Kg (ppm)[1]						
	Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Stickney
Average Total Solids	2.60%	2.33%	1.72%	0.83%	0.75%	0.97%	2.85%
Purgeables							
Chloroform	ND	ND	ND	ND	1.17	0.1	ND
Methylene Chloride	ND	ND	ND	0.42	ND	0.46	0.2
Tetrachloroethylene	ND	ND	ND	ND	0.2	0.15	ND
Toluene	0.46	1.05	26.51	ND	ND	11.34	2.96
Trichloroethylene	ND	ND	ND	ND	ND	0.1	ND
Acid Extractables							
None found							
Base/Neutral Extractables							
Benzo(a)pyrene	2.25	1.84	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	2.9	2.32	ND	ND	ND	ND	ND
Benzo(ghi)perylene	2.85	ND	ND	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	68.6	ND	ND	ND	ND	ND	ND
Chrysene	3	ND	ND	ND	ND	ND	2.68
Di-n-butyl phthalate	ND	ND	ND	34.7	ND	ND	ND
Fluoranthene	4.92	2.96	ND	2.77	ND	ND	4.39
Phenanthrene	2.44	3	ND	ND	ND	ND	2.54
Pyrene	4.15	ND	ND	ND	ND	ND	4.74

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 12 (Continued)

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT SLUDGES - 2003

Type of Compound	Average Values in mg/Kg (ppm)[1]						
	Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Stickney
Pesticides & PCBs							
4,4'-DDT	ND	ND	ND	ND	ND	ND	0.05

[1]Average results of two samples based on solids content from February and July.
ND = None detected.

The highest values of purgeable compounds in the sludge samples were for toluene in concentrations of 26.51, 11.34, and 2.96 mg/Kg dry weight (based on the solids content) at the Hanover Park, North Side, and Stickney WRPs, respectively.

The noticeably high values of base/neutral/acid extractable (BNA) compounds in the raw sewage were bis(2-ethylhexyl) phthalate, phenol, butylbenzene phthalate, and diethyl phthalate in a concentration of 25 µg/L, 21 µg/L, 13.5 µg/L and 11 µg/L at the Calumet WRP. No BNA compound was detected in the final effluent of all seven WRPs.

The highest values of BNA compounds detected in the sludge were bis(2-ethylhexyl)phthalate and di-n-butyl phthalate in concentrations of 68.6 mg/Kg and 34.7 mg/Kg at the Calumet and Kirie WRPs, respectively.

No PCBs were found in any final effluent or sludge samples. The only pesticide compound detected in the sludge sample was 4,4'-DDT at a concentration of 0.05 mg/Kg at the Stickney WRP.

The frequency of occurrence of the compounds detected in all WRP samples (raw sewage, final effluent, and sludges) are summarized as follows:

1. Only five of the 111 listed organic priority pollutants were detected in the final effluent

samples: five of the 30 purgeable compounds, none of the 57 BNA extractable compounds, and none of the 24 pesticides and PCBs.

2. Most of the organic priority pollutant compounds found in the raw sewage samples were completely removed by the treatment process, and were not detected in the effluents. They include benzene, ethyl benzene, methyl chloride, tetrachloroethylene, trichloroethylene, phenol, benzo(a) pyrene, bis(2-ethylhexyl)phthalate, butylbenzyl phthalate, diethyl phthalate, chrysene, and phenanthrene.

3. Other compounds (chloroform, toluene, and methylene chloride) showed partial removals; i.e., lower frequency of occurrence or lower concentrations in effluent than in raw sewage samples. An example is chloroform which was present in the raw sewage of all the WRPs, but only present in the effluent of four WRPs. Chlorodibromomethane and dichlorobromomethane could be the byproducts from the disinfection process as well, since they were only present in the final effluents of two WRPs.

Monitoring of Nonlisted Organic Compounds in District WRPs

In addition to the listed organic compounds (priority pollutants), the concentrations of nonlisted organic compounds were determined in the raw sewage, final effluent, and sludges at District WRPs. These compounds were detected in the samples taken in February and July 2003. Table 13 shows the frequency of occurrence of nonlisted organic compounds in District WRP samples during 2003.

The nonlisted purgeable compounds found were solvents, hydrocarbons, and products from anaerobic biological degradation. No nonlisted purgeable compounds occurred in District WRP effluents, whereas 10 compounds occurred 57 times in raw sewage samples. This indicates 100 percent removal efficiencies for these compounds during the treatment process.

Sixty-eight nonlisted BNA compounds were found in District WRP influent samples during 2003. The majority of these compounds come from human and animal wastes, industrial waste, and gasoline and/or oil derivatives. Two compounds occurred two times in the effluents, whereas 66 compounds occurred 307 times in the raw sewage, indicating excellent removal efficiencies of many of these compounds during the wastewater treatment process.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 13

FREQUENCY OF NONLISTED ORGANIC COMPOUNDS IN DISTRICT WRP SAMPLES - 2003

Type of Compound	Raw Sewage 16 Samples[1]		Effluent 14 Samples[1]		Sludge 14 Samples[1]	
	Times Found	Percent	Times Found	Percent	Times Found	Percent
Nonlisted Purgeables						
Acetone	16	100	0	0	12	86
Dimethyl sulfide	0	0	0	0	1	7
Carbon disulfide	4	25	0	0	0	0
Tetrahydrofuran	0	0	0	0	1	7
Diethyl ether	2	13	0	0	0	0
2-Butanone (MEK)	8	50	0	0	0	0
Acetaldehyde	4	25	0	0	0	0
Propionaldehyde	2	13	0	0	0	0
2-Methyl-2-pentanone (MIBK)	2	13	0	0	0	0
Isopropylbenzene (Cumene)	0	0	0	0	1	7
Styrene	3	19	0	0	0	0
α-Methylstyrene	2	13	0	0	0	0
Limonene	14	88	0	0	6	43
4-Isopropyltoluene	0	0	0	0	1	7
	0	0	0	0	0	0
Nonlisted Base/Neutral and Acid Extractables	0	0	0	0	0	0
Ethylene glycol butyl ether	11	69	0	0	0	0
Benzyl alcohol	12	75	0	0	0	0
Acetophenone	2	13	0	0	0	0
m-and/or p-Cresol	6	38	0	0	2	14
Benzoic acid	7	44	0	0	1	7
Diethylene glycol butyl ether	4	25	0	0	0	0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 13 (Continued)

FREQUENCY OF NONLISTED ORGANIC COMPOUNDS IN DISTRICT WRP SAMPLES - 2003

Type of Compound	Raw Sewage 16 Samples[1]		Effluent 14 Samples[1]		Sludge 14 Samples[1]	
	Times Found	Percent	Times Found	Percent	Times Found	Percent
Nonlisted Base/Neutral/Acid Extractables (Continued)						
Phenylacetic acid	7	44	0	0	4	29
Tridecane	2	13	0	0	0	0
Decanoic acid	6	38	0	0	0	0
Tetradecane	4	25	0	0	0	0
N, N-Dimethyl-1-dodecanamine	8	50	0	0	2	14
Pentadecane	4	25	0	0	1	7
Dodecanol	9	56	0	0	1	7
Dodecanoic acid	15	94	0	0	3	21
Hexadecane	2	13	0	0	0	0
Tetradecanoic acid	10	63	0	0	6	43
Pentachloronitrobenzene	2	13	0	0	0	0
Octadecane	2	13	0	0	0	0
Caffeine	14	88	0	0	0	0
Pentadecanoic acid	11	69	0	0	4	29
cis-9-Hexadecenoic acid	4	25	0	0	0	0
Hexadecanol	8	50	0	0	0	0
Hexadecanoic acid	16	100	0	0	13	93
Heptadecanoic acid	6	38	0	0	0	0
z-9-Octadecanoic acid	16	100	0	0	11	79
Octadecanoic acid	15	94	0	0	12	86
Dioctyl adipate	0	0	0	0	1	7
(1-Methyl ethenyl) benzene	2	13	0	0	0	0
Cholest-5-en-3-ol	2	13	0	0	0	0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 13 (Continued)

FREQUENCY OF NONLISTED ORGANIC COMPOUNDS IN DISTRICT WRP SAMPLES - 2003

Type of Compound	Raw Sewage 16 Samples[1]		Effluent 14 Samples[1]		Sludge 14 Samples[1]	
	Times Found	Percent	Times Found	Percent	Times Found	Percent
Nonlisted Base/Neutral/Acid Extractables (Continued)						
α-α-Dimethyl-benzenemethanol	2	13	0	0	0	0
2-Phenoxyethanol	2	13	0	0	0	0
4-Hydroxy-4-methyl-2-pentanone	0	0	0	0	12	86
(1-ButylHeptyl)-benzene	0	0	0	0	1	7
4-(1,1,3,3-Tetramethylbutyl)-phenol	0	0	0	0	1	7
2-Methyl propanoic acid	0	0	0	0	3	21
Butanoic acid	2	13	0	0	2	14
3- Methyl butanoic acid	2	13	0	0	1	7
2-Methyl butanoic acid	2	13	0	0	2	14
Pantanoic acid	2	13	0	0	1	7
1-Phenylpropanoic acid	4	25	0	0	2	14
Tetradecanol	4	25	0	0	1	7
Propanoic acid	2	13	0	0	2	14
4-Methyl-pentanoic aid	0	0	0	0	1	7
Tridecanol	6	38	0	0	0	0
1-Hexadecane	2	13	0	0	0	0
Z-7-Hexadecanoic acid, methyl ester	0	0	0	0	1	7
Hexadecanoic acid, methyl ester	0	0	0	0	1	7
2,6, 10,14,18,22-Tetracosahexaene	7	44	0	0	6	43
Phenylethylalcohol	2	13	0	0	0	0
2-Ethyl-hexanoic acid	2	13	0	0	0	0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 13 (Continued)

FREQUENCY OF NONLISTED ORGANIC COMPOUNDS IN DISTRICT WRP SAMPLES - 2003

Type of Compound	Raw Sewage 16 Samples[1]		Effluent 14 Samples[1]		Sludge 14 Samples[1]	
	Times Found	Percent	Times Found	Percent	Times Found	Percent
Nonlisted Base/Neutral/Acid Extractables (Continued)						
Decamethylcyclopentasiloxane	0	0	0	0	2	14
(+-)-15-Hexadecanolide	2	13	0	0	1	7
m-Toluamide	2	13	0	0	0	0
9,12-Octadecadienoic acid	4	25	0	0	0	0
Linoleic acid	2	13	0	0	0	0
(z)-9-Hexadecanoic acid methyl ester	0	0	0	0	2	14
9-Hexadecanoic acid	0	0	0	0	2	14
Pentanedioic acid, dimethyl ester	2	13	0	0	0	0
Diphenylmethanone	2	13	0	0	0	0
2-(Dodecyloxy)-ethanol	3	19	0	0	0	0
Coprostan-3-one	0	0	0	0	1	7
Octanoic acid	2	13	0	0	1	7
Hexanedioic acid, bis (2-ethylhexyl)ester	0	0	0	0	1	7
Vitamin E	0	0	0	0	1	7
1-Octadecene	2	13	0	0	0	0
1-Tetradecene	2	13	0	0	0	0
Pentadecanol	2	13	0	0	0	0
1-H-Indole	2	13	0	0	0	0
1-Phenylpropanoic acid	2	13	0	0	0	0
1-Tridecene	2	13	0	0	0	0
12-methyl-tetradecanoic acid	2	13	0	0	0	0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 13 (Continued)

FREQUENCY OF NONLISTED ORGANIC COMPOUNDS IN DISTRICT WRP SAMPLES - 2003

Type of Compound	Raw Sewage 16 Samples[1]		Effluent 14 Samples[1]		Sludge 14 Samples[1]	
	Times Found	Percent	Times Found	Percent	Times Found	Percent
Nonlisted Base/Neutral/Acid Extractables (Continued)						
2-Ethyl-3 methylcyclopentene	0	0	0	0	1	7
1-Methyl-2-pyrrolidone	2	13	0	0	0	0
1-Hexadecene	6	38	0	0	0	0
Oleic Acid, Propyl Ester	2	13	0	0	0	0
Oleic acid, eicosyl ester	2	13	0	0	0	0
Decamethylcyclopentasiloxane	2	13	0	0	0	0
N,N-diethyl-3-methyl-benzamide	2	13	0	0	0	0
Tridecanoic acid	2	13	0	0	0	0
Tetradecanoic acid	0	0	0	0	2	14
2-Methyl-Butyric acid	0	0	0	0	1	7
4-Methyl-pentanoic aid	0	0	0	0	1	7
1-hexadecene	2	13	1	6	0	0
Bis(2-ethylhexyl)adipate	0	0	1	6	0	0
Dihydrocholestrol	2	13	0	0	0	0
Cholest-5-en-3-01	2	13	0	0	0	0
Dipropylene glycol methylene	2	13	0	0	0	0

[1]Represents two sampling cycles (February and July 2003) for each of the seven WRPs (n = 14), with the Stickney WRP having two influents (n = 16 for raw sewage).

Characteristics of Stormwater Runoff from Two Storm Sewers

To collect data on pollutant loading due to urban stormwater runoff to the Chicago Waterway System (CWS), the stormwater runoff from two storm sewers in Evanston and Crestwood, Illinois, was sampled by the Industrial Waste Division (IWD) of the Research and Development (R&D) Department between August 2002 and May 2003. The information collected through this sampling program was provided to the Wastewater Treatment Research Section of the EM&R Division for data analyses and report preparation. As a result, an R&D Department report (Report No. 03-25) was completed and published in 2003. A brief summary and major findings of the report are described in the following paragraphs.

The storm sewer at Evanston, Illinois, is a storm relief sewer with a diameter of 60 inches, and serves an area of approximately 300 acres, which is also served by combined sewers for sanitary wastewater. This area is predominantly residential and commercial. Stormwater runoff through this storm sewer discharges into the North Shore Channel of the CWS. The other storm sewer system at Crestwood, Illinois, includes a sewer line with a diameter of 54 inches and some open storm ditches, and serves a separate sewered area of approximately 160 acres, which is predominantly residential. The stormwater

runoff from this system discharges into the Calumet-Sag Channel of the CWS.

Stormwater runoff samples were collected every 15 minutes in the first 2 hours, every 30 minutes in the next 4 hours and every 60 minutes thereafter in seven storm events at each of the two sampling locations. The number of grab samples taken in a storm-sampling event ranged from 10 to 23 at the Evanston location and 16 to 23 at the Crestwood location. Each sample was analyzed for 12 constituents, including BOD_5, carbonaceous BOD_5 ($CBOD_5$), total suspended solids (TSS), volatile suspended solids (VSS), nitrite nitrogen (NO_2-N), nitrite plus nitrate nitrogen [(NO_2 + NO_3)-N], ammonia nitrogen (NH_3-N), total Kjeldahl nitrogen (TKN), total phosphorus (TP), conductivity, alkalinity, and chloride. Total nitrogen (TN) was calculated in the data analysis as the sum of TKN and (NO_2 + NO_3)-N.

Concentrations of individual grab samples collected at either of the Evanston and Crestwood storm sewers in a storm-sampling event varied widely with TSS having the largest variation among the four major pollutants of BOD_5, TSS, TN, and TP. No unique pattern of concentration profiles within a storm event was observed for any stormwater constituent at either sampling location.

The Event Mean Concentrations (EMCs) of BOD_5, TSS, TN and TP, calculated using arithmetic average method, ranged from 9.4 to 31.5 mg/L, 49 to 317 mg/L, 1.87 to 4.61 mg/L and 0.14 to 0.58 mg/L, respectively, at the Evanston location, and 4.4 to 20.0 mg/L, 33 to 334 mg/L, 1.57 to 4.19 mg/L and 0.23 to 0.81 mg/L at the Crestwood location. Comparing the average values of seven EMCs for these four major stormwater constituents between the two storm sewers, no statistically significant difference in TSS, TN and TP was found at a 90 percent confidence level (P-value > 0.1). However, the average value of seven EMCs of BOD_5 was statistically higher at the Evanston storm sewer than that at the Crestwood storm sewer (P-value < 0.1).

The corresponding rainfall in a storm-sampling event ranged from 0.31 to 1.16 inches at the Evanston location and 0.41 to 1.81 inches at the Crestwood location. A multiple linear regression analysis on EMCs of the four major stormwater pollutants and four storm variables, i.e. rainfall amount, rain duration, mean intensity and the days since the last rain that has at least 0.1 inches of rainfall, was performed. The results revealed that rainfall amount was generally the most important storm variable that inversely influenced EMCs of the four major pollutants, while the days since the last rain also

had positive impact on EMCs of BOD_5 at the Evanston storm sewer. However, the days since the last rain was the most important storm variable that positively influenced EMCs of the four major pollutants, while rainfall amount also had positive impact on TP at the Crestwood storm sewer.

Characteristics of Stormwater Runoff from Three IDOT Pumping Stations

A stormwater runoff sampling program was developed by the IWD of the R&D Department to collect data on pollutant loading from highway stormwater runoff to the CWS. This program was implemented to sample the storm runoff discharged at three Illinois Department of Transportation (IDOT) pumping stations between October 2002 and July 2003. Time composite samples with aliquots taken every 15 minutes were collected at the three IDOT pumping stations during various storm events. Each sample collected was analyzed for 9 constituents, including $CBOD_5$, TSS, several forms of nitrogen and phosphorus, chloride and conductivity.

The information collected through this sampling program was provided to the Wastewater Treatment Research Section of the EM&R Division for data analyses and report preparation. Data preparation and analyses started in 2003, but were not completed by the end of 2003. The efforts of conducting data

analyses for this sampling program will continue, and the report preparation is expected to be complete in 2004.

Additional Digestion Tests for Calumet WRP

The purpose of this project was to monitor whether the requirements for vector attraction reduction could be met through sludge anaerobic digestion at the Calumet WRP, using Option 2 in Section 503.33(b) of the 40 CFR Part 503 Regulation. Option 2 states that vector attraction reduction is demonstrated if, after anaerobic digestion of the biosolids, the volatile solids in the biosolids are reduced by less than 17 percent in an additional 40-day bench-scale anaerobic digestion at a temperature between 30° and 37°C. The main reason of employing Option 2 and conducting laboratory bench-scale additional digestion tests is that volatile solids reduction of 38 percent cannot be consistently achieved at the Calumet WRP through its two-step anaerobic digestion.

Additional digestion tests for the Calumet WRP started in March 2003 as a routine monitoring program in the Wastewater Treatment Research Section of the EM&R Division for the biosolids program at the Calumet WRP. These tests were conducted once or twice a month in the R&D Department wastewater treatment research laboratory at the Stickney WRP. The test

procedure proposed in Appendix D of the White House Document by USEPA (EPA/625/R-92/013, Revised October 1999) was generally followed in each test. The digester draw sample used in the additional digestion tests was a mixture of the digester draw from the four second step digesters, and was collected by the personnel at the Calumet WRP. A test was set up soon after the R&D Department laboratory at the Stickney WRP received a digester draw sample. Fifteen replicates of 50-mL digester draw in a 125-mL flask were prepared. On Day 0, five replicates were randomly selected and sent to ALD for determining the contents of total and volatile solids, and the remaining ten were incubated in a shaking incubator at a temperature of 35.5°C (about 96°F). On Day 20 and 40, five replicates each were taken out of the incubator, and sent to ALD for analysis for total and volatile solids. The mean values of five replicates were used in data analysis.

Twelve tests were conducted in 2003. The total and volatile solids contents of the Calumet digester draw samples used in the twelve additional digestion tests ranged from 1.87 to 3.77 percent with an average of 2.70 percent and from 40.2 to 64.4 percent with an average of 50.9 percent, respectively. These values were comparable to the plant daily monitoring values for the digester draw, which were from 1.80 to 4.29

percent with an average of 2.71 percent for total solids and from 40.4 to 66.6 percent with an average of 51.7 percent for total volatile solids, during the same period. This indicated that the digester draw samples collected for the additional digestion tests could represent well the actual digester draw at the WRP. The standard errors of the mean values calculated from the replicates were relatively small in these tests, ranging from 0.10 to 1.46 percent with average of 0.34 percent for total solids analysis and from 0.07 to 1.43 percent with an average of 0.30 percent for total volatile solids.

The volatile solids reduction through an addition digestion test was calculated using both Van Kleeck equation and mass balance method. The 40-day additional volatile solids reduction from the twelve additional digestion tests conducted in 2003 for the Calumet WRP is presented in Table 14. The additional volatile solids reduction, calculated using both methods, in any of the twelve tests was less than 17 percent, as can be seen in the table. This indicates that the requirement for vector attraction reduction for the biosolids produced at the Calumet WRP can consistently be met by using Option 2 of the Part 503 Regulation. These test results were provided to be included in the annual Part 503 report to USEPA for 2003.

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TABLE 14

SUMMARY OF TEST RESULTS FROM THE ADDITIONAL DIGESTION TESTS CONDUCTED IN 2003 FOR THE CALUMET WRP

Test Date	Before Test		After Test		Volatile Solids Reduction (%)	
	TS (%)	%VTS (%)	TS (%)	%VTS (%)	By Equation*	By Mass
3/21/03	1.92	64.4	1.75	61.0	13.6	14.0
4/18/03	2.25	57.9	2.14	55.4	10.0	9.0
5/9/03	2.36	57.5	2.23	54.8	10.4	9.7
5/23/03	2.73	55.3	2.50	51.0	15.8	15.4
6/13/03	2.96	48.6	2.82	44.4	15.5	12.8
7/11/03	2.89	49.8	2.85	47.4	9.5	6.4
8/8/03	3.77	40.2	3.65	39.9	1.4	4.0
8/29/03	3.75	40.8	3.62	37.9	11.4	10.4
9/12/03	3.15	43.0	3.03	40.9	8.5	8.6
10/10/03	2.45	45.9	2.35	43.6	9.2	9.3
11/13/03	1.87	53.2	1.76	50.4	10.7	11.1
12/19/03	2.32	53.6	2.13	49.6	15.0	14.9

*The Van Kleeck Equation was used in calculations.

Unsteady Flow Water Quality Model for the CWS

The development of a water quality model for unsteady flow in the Chicago Waterway System (CWS) was contracted to Marquette University. The Wastewater Treatment Research Section of the EM&R Division has been involved in this project as a member of the liaison committee for developing the model. Four project progress meetings regarding the calibration and verification of hydraulic portion of the model and preliminary calibration of water quality portion were held and attended in 2003. The draft report on the development of hydraulic data compilation and model calibration from Marquette University was reviewed in 2003.

Evaluation of Technologies for Producing Class A Biosolids

As a member of the District Interdepartmental Task Force on producing Class A biosolids, section staff attended numerous Task Force meetings in an effort to evaluate technologies to produce Class A biosolids with the existing anaerobic digesters at the District WRPs. Data collection and analyses for using two-stage thermophilic anaerobic digestion and two-stage thermophilic and mesophilic anaerobic digestion processes at the District's Egan, Calumet, and Stickney WRPs were conducted and provided to the Task Force for evaluation.

Laboratory bench tests on heating sludge in stainless steel pipes for examining the potential of sludge fouling on pipe walls were performed. A matrix of six processes, including BioPasteur™ pre-pasteurization, BioPass pre-pasteurization, Cambi™ thermal hydrolysis, heat drying, two-stage thermophilic digestion and two-stage thermophilic-mesophilic digestion, were evaluated thoroughly by the Task Force. The evaluation results were presented to the General Superintendent later in 2003.

Evaluation of Technologies for Nutrient Removal

As a member of the District's Interdepartmental Task Force on Nutrient Removal Strategies, section staff participated in the Task Force's various activities. In 2003, upon a request by the General Superintendent, the Task Force was focusing on cost estimates and related information for the scenarios of only needing to remove phosphorus from District WRP effluents. A nationwide survey on the processes used by other water reclamation districts to remove phosphorus was conducted. Efforts were made to collect information for performing cost estimation and to review the cost estimates prepared by the Engineering Department.

Hydrogen Sulfide Monitoring Stations

Two hydrogen sulfide monitoring stations are operating at the Calumet WRP. The stations monitor and record hydrogen sulfide concentrations that may be emitted from the WRP and sludge lagoons. The stations consist of two hydrogen sulfide analyzers in a temperature controlled shelter. Both analyzers measure hydrogen sulfide in the very low part per billion range. The odor threshold for the human nose is about 25 ppb. The stations detect hydrogen sulfide before it is noticeable to nearby residents. Hydrogen sulfide is used as an indicator, since many odors from wastewater reclamation plants have a hydrogen sulfide component.

The continuously run hydrogen sulfide analyzers are compared against each other in order to determine the most reliable method to detect hydrogen sulfide in the low part per billion range. The two analyzers work on different principals. The Single Point Monitor (SPM) uses a calibrated lead acetate tape with a colorimeter to indicate the hydrogen sulfide level. The SPM is setup with a software key with corresponding precalibrated lead acetate tape. The setup has a range of zero to ninety parts per billion. It samples for fifteen minutes then reports the result. The SPM analyzer uses a communication port to record to a printer, and an

analog output to record to a data logger. The second analyzer, Advanced Pollution Instrument Model 101A, (API) uses pulsed fluorescence to determine the hydrogen sulfide level. The API analyzer is a sulfur dioxide analyzer which was converted to a hydrogen sulfide analyzer using a catalytic converter and scrubber. In order to compare the two analyzers fairly, the range on the API and the SPM are set up the same. The same type of analog output to the datalogger for both instruments is used. The datalogger has a memory card to store the results until they are downloaded to the data collector.

The two hydrogen sulfide monitoring stations were set up in October of 2002. The north station is north of the Calumet WRP lagoons and the south station is outside of the plant fence line near 130th Street. Figure 11 shows the location of both the north and south monitoring stations. The locations were chosen to pick up hydrogen sulfide before it moves across 130th Street to the residential neighborhood. Each station consists of a six by six shelter which is temperature controlled. A small window type air conditioner with a thermostat control is used to maintain the instruments within their operating range. The operating range is five to forty degrees Celsius. Electric baseboard heat is used in the winter. Each station has one SPM and one API analyzer, as well as the

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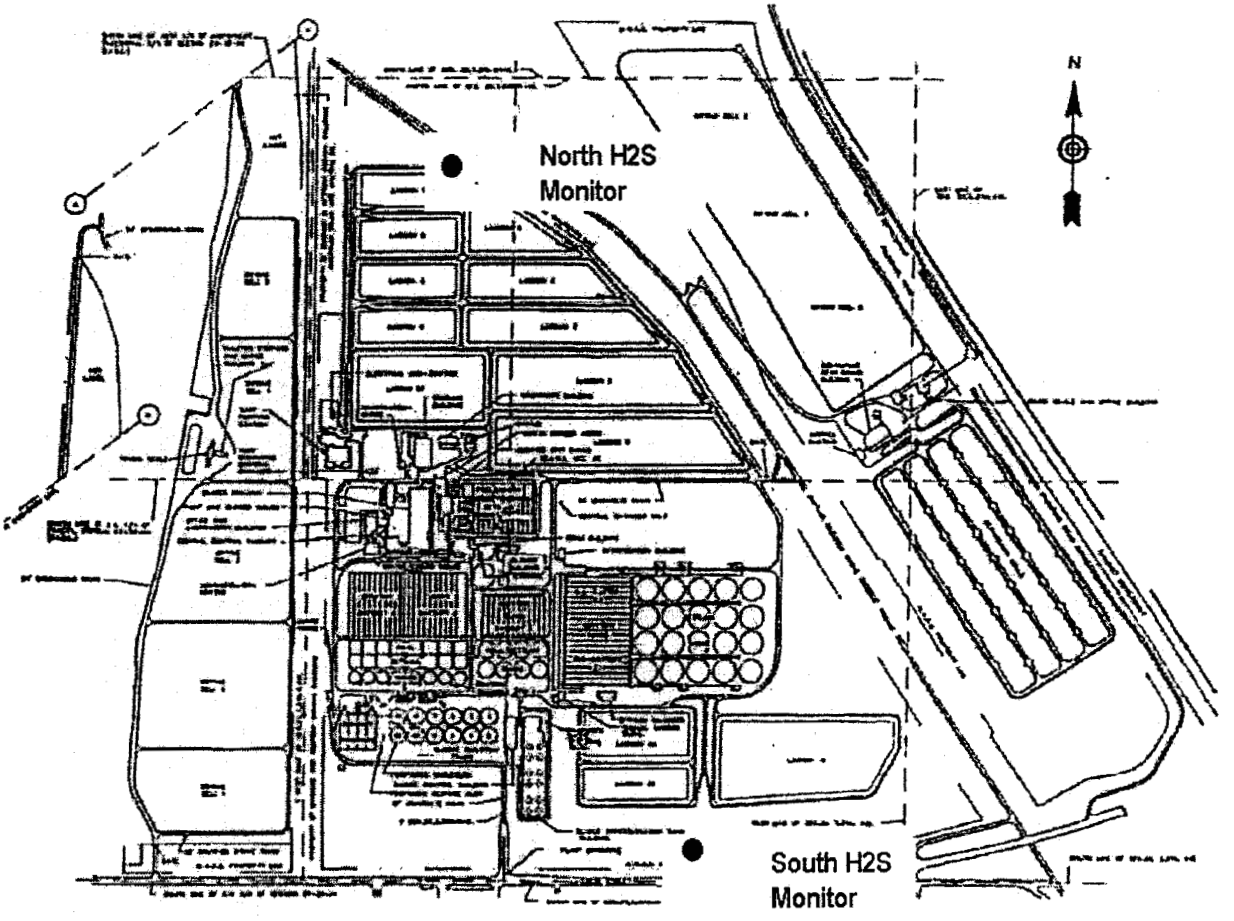
FIGURE 11

CALUMET WRP HYDROGEN SULFIDE MONITORING LOCATIONS



datalogger connected to both. The logger has six channels. One is used as an indication of fault for the SPM. Two channels are used to compare the temperature inside and outside, monitoring the performance of the heating and cooling units. The intake lines have been modified to prevent water intake during heavy rainstorms.

The comparison of the two types of low level hydrogen sulfide analyzers show good agreement between the two. An example is the north Calumet location data for May 10, 2003. The SPM data, shown in Figure 12, correlates well with the API data, shown in Figure 13. The square shape of the SPM data is due to the fifteen minute averaging. The API, on the other hand, does not average the concentration over time. The instantaneous data collection of the API accounts for the higher peaks in Figure 13. Comparison over a longer time frame shows good comparison, as well. Figure 14 and Figure 15 compare the SPM and API data collected from April 25, 2003, through June 16, 2003. The large apparent spike in Figure 14, beginning April 30, 2003, is the instrument in a fault state. The fault ended on May 2, 2003. The fault was verified with the datalogger fault channel. The nature of the fault is not recorded. The likely causes for a fault that corrects itself is dampness or flow problem. Similar to the May 10, 2003, data,

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FIGURE 12

HYDROGEN SULFIDE CONCENTRATION AT CALUMET WRP SOUTH LOCATION
MONITORED WITH SPM, MAY 10, 2003

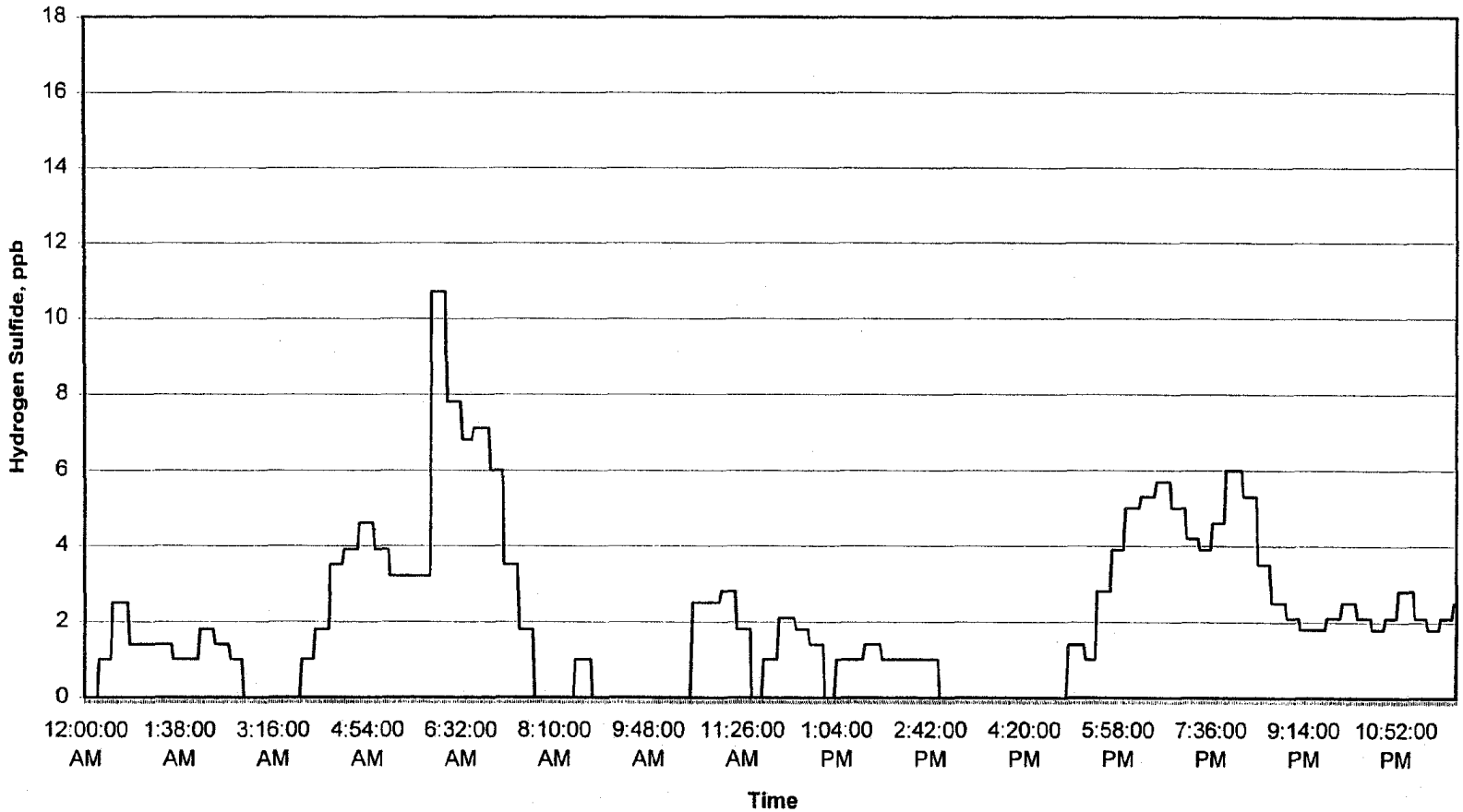

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FIGURE 13

HYDROGEN SULFIDE CONCENTRATION AT CALUMET WRP
SOUTH LOCATION MONITORED WITH ADVANCED POLLUTION INSTRUMENT
MODEL 101A, MAY 10, 2003

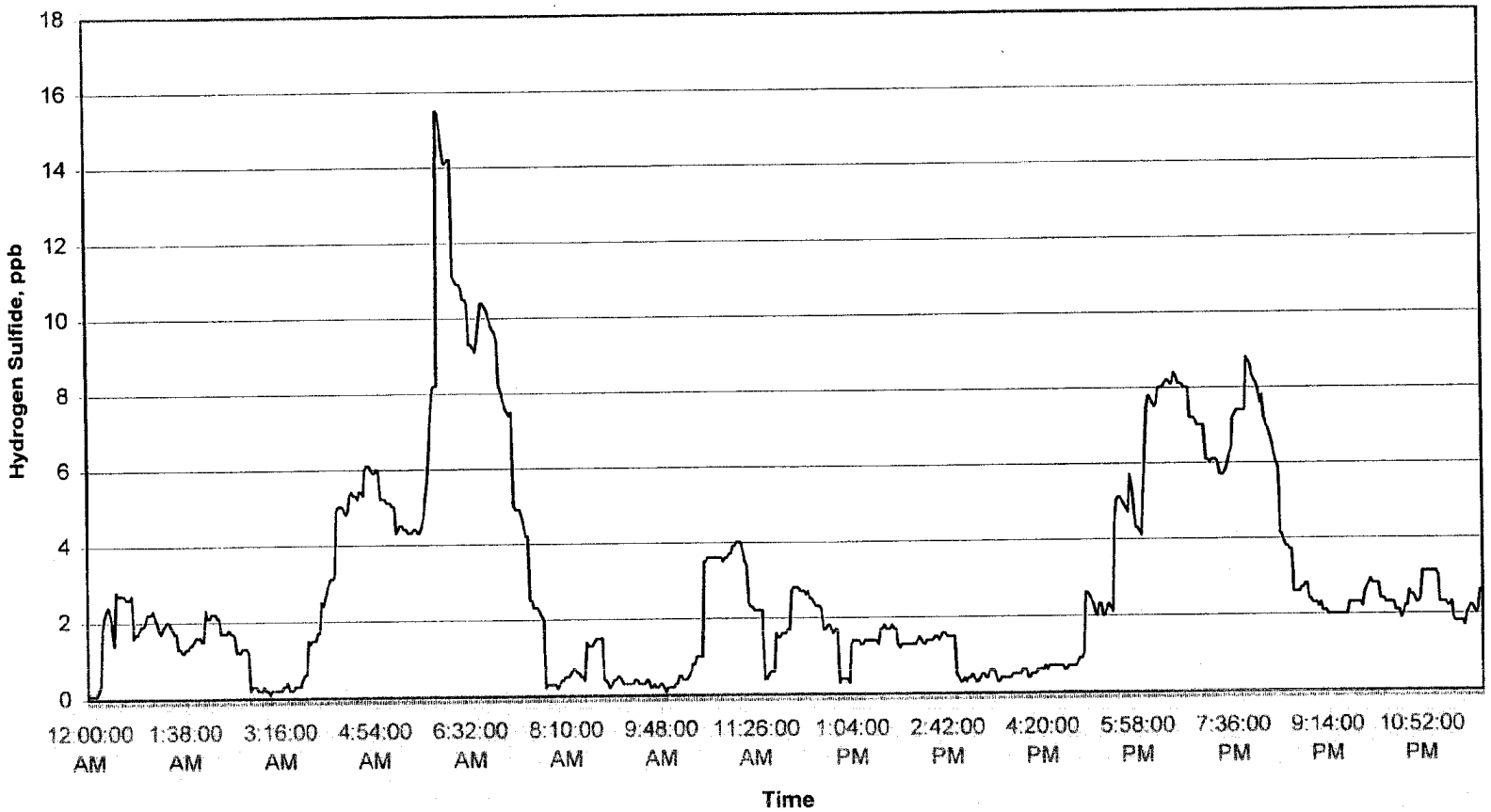

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FIGURE 14

HYDROGEN SULFIDE CONCENTRATION AT CALUMET WRP SOUTH LOCATION
MEASURED BY SPM
APRIL 25, 2003 THROUGH JUNE 16, 2003

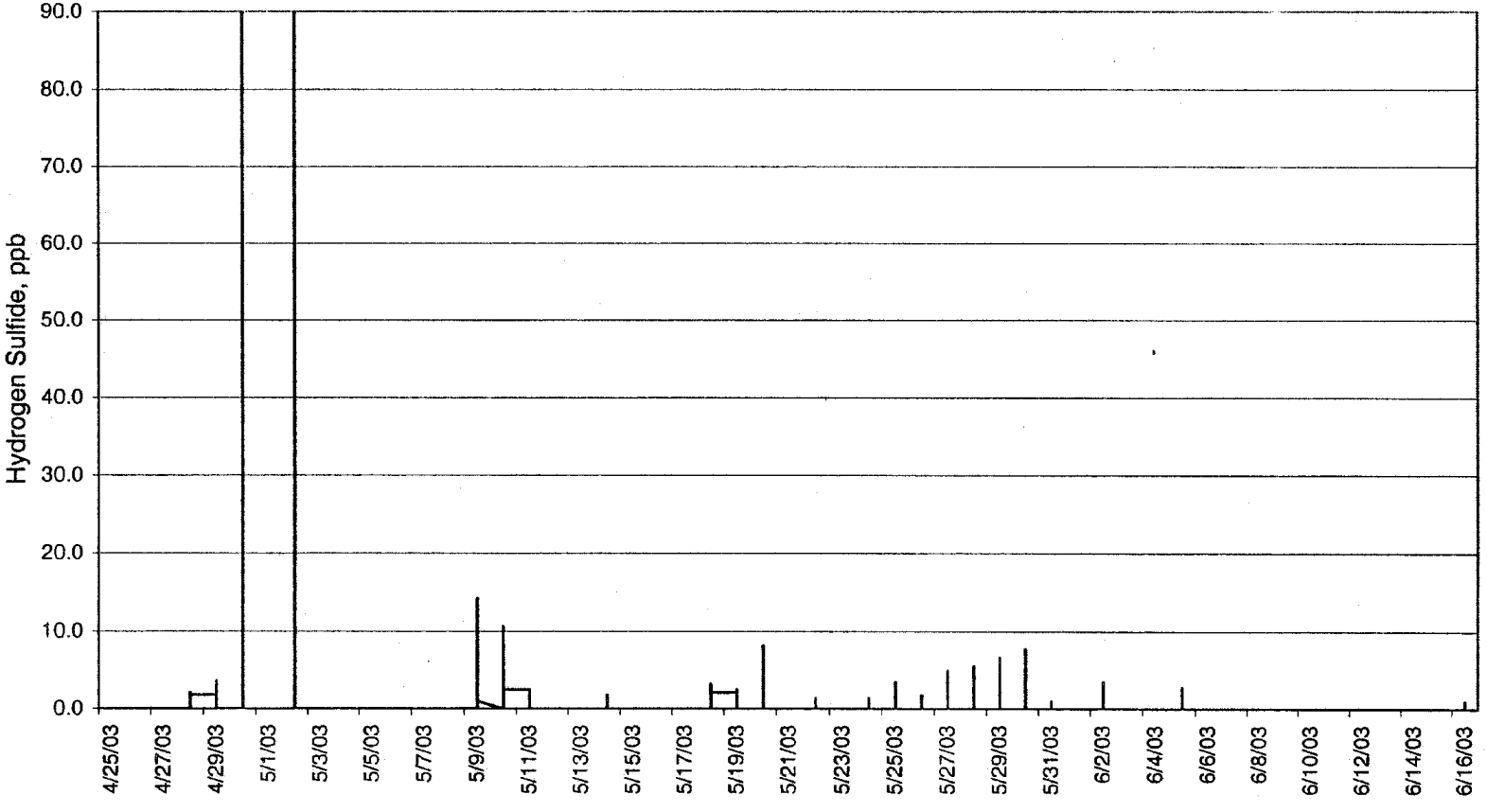

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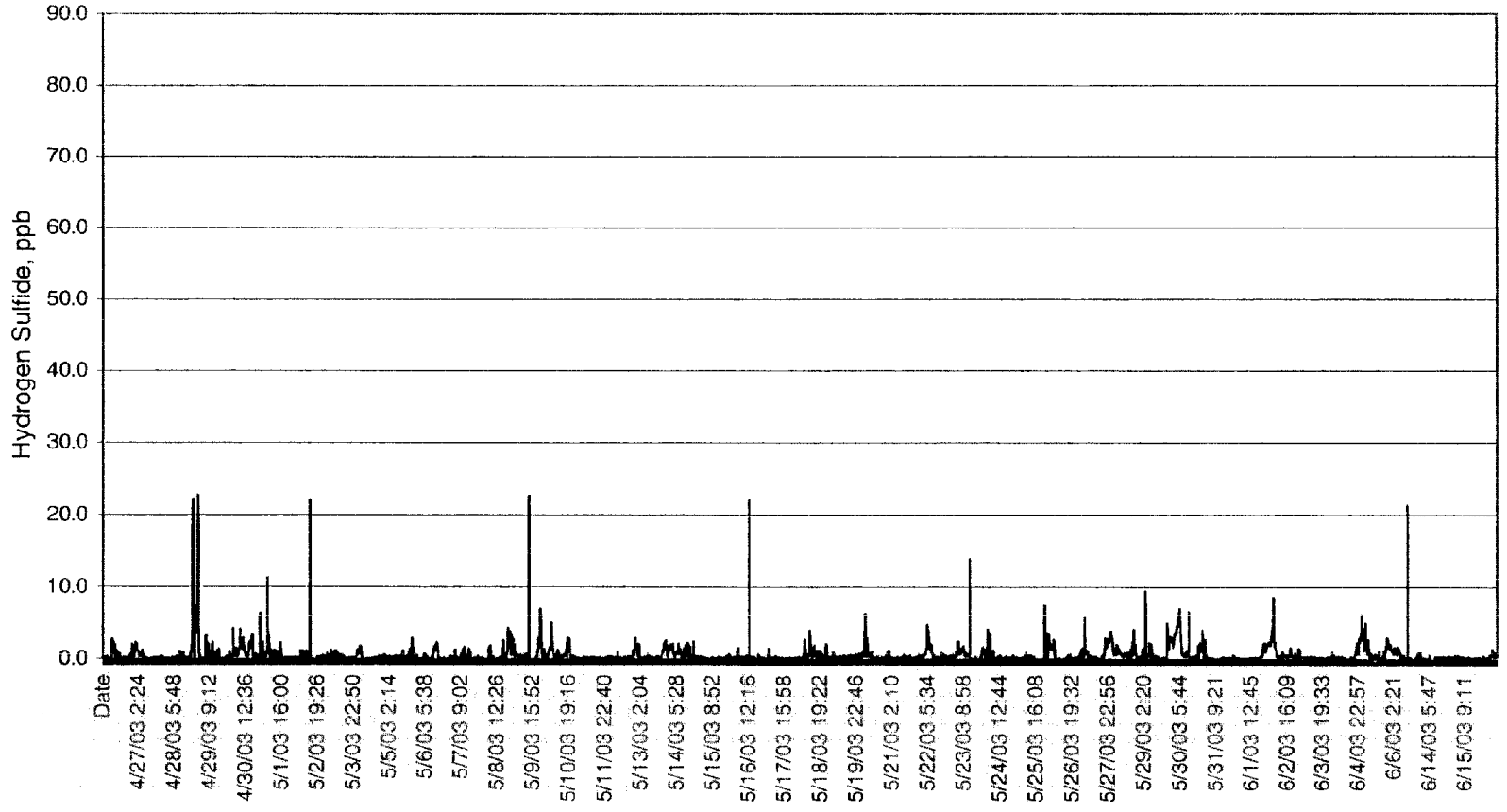
FIGURE 15

HYDROGEN SULFIDE CONCENTRATION AT CALUMET WRP SOUTH LOCATION
MEASURED BY ADVANCED POLLUTION INSTRUMENT MODEL 101A
APRIL 25, 2003 THROUGH JUNE 16, 2003



the API indicates higher spikes, due to instantaneous data collection. There are no peaks above 25 ppb.

The ambient low level hydrogen sulfide concentration is measured equally well with either instrument. The SPM is more rugged and easier to set up and operate. The SPM requires the lead acetate tape to be changed monthly. The API takes considerably more time to maintain. The API requires a weekly zero and calibration check.

Overall the two hydrogen sulfide analyzers perform well and are in good agreement with each other. The SPM is preferred because of ease of maintenance. The analyzers will continue to run for further evaluation of low level hydrogen sulfide near the Calumet WRP.

Re-Evaluation of Local Pretreatment Limits

The EM&R Division, working with the Industrial Waste Division, re-evaluated pretreatment program local limits for the District's local service area. Local limits are intended to prevent site-specific plant passthrough and interference, caused by industrial discharge. The method required site specific WRP and environmental criteria to determine the limit for each pollutant at each WRP. A mass balance approach was used to convert standards into allowable headwork loadings at

each District WRP. The District operates seven activated sludge WRPs. Four of the seven also have anaerobic sludge digestion facilities.

The local limits are intended to protect water quality, sludge quality, biological integrity of WRPs, worker safety, collection system and air emissions. Each of the seven District WRPs was evaluated individually. One of the objectives was to maintain one limit throughout the District service area. The most stringent limit for each pollutant was used as the limiting concentration for that particular pollutant. The pollutants of concern were identified for each WRP. The data collection strategy, as well as an analysis of data quality was detailed in the final report. The District took into account site-specific conditions including National Pollutant Discharge Elimination System (NPDES) compliance, receiving water quality, sludge quality, worker health and safety, and potential biological inhibition. The technically based local limits were based on the Guidance Manual for the Development and Implementation of Local Discharge Limitations Under the Pretreatment Program (1987 Guidance) methodology using maximum allowable headworks loading (MAHL). The historical influent loading data was evaluated and compared to the MAHL. In each case, the pollutant of concern, technically based

determinations, and the historical data was evaluated. If there was sufficient need for a limit based on the initial screening, further calculations were used to determine the local limit concentration required to meet the standards. The calculated limit concentrations were compared to the current District pretreatment local limits. A uniform allocation method was used within each of the seven service areas.

The necessary data, including sampling and analysis, was conducted on a routine basis. The site-specific data were used to determine influent and effluent loading; the evaluation was conducted using year 2000 data. The data analysis was used to identify the presence of individual pollutants, determine current influent loadings, calculate pollutant removal efficiencies, and evaluate site-specific inhibition thresholds. The pollutant removal efficiency method was based on the 1987 Guidance mean value method. At each WRP the flow and pollutant concentration was monitored for both influent and effluent. The removal efficiency was determined by Equation 1.

Equation 1: Mean Removal Efficiency

$$R_{WRP} = \frac{L_{INF} - L_{EFF}}{L_{INF}}$$

where,

R_{WRP} = Removal Efficiency Across the WRP, as a Decimal

L_{INF} = Average Influent Load, lbs/day

L_{EFF} = Average Effluent Load, lbs/day

Frequently, the measured influent and effluent concentrations were near, or even less than, the method detection limit. Consequently, computed removal efficiencies were erratic. Where adequate data were lacking to establish reliable percentage removal, an estimated removal efficiency was used. In the cases where there were less than thirty percent of samples with pollution concentrations at the detectable level, an estimated removal efficiency was used. The combined average removal efficiency from the other District WRPs was used as an estimate. This was a close estimate, since all of the District WRPs have similar operations and the same climate. In the cases where there were not enough data for any removal efficiency determination, the literature values from the 1987 Guidance were used. Table 15 summarizes the removal efficiencies for each WRP. The removal across primary treatment (R_{PRI}) was estimated to be the same as mean literature values in the 1987 Guidance.

A mass balance approach was used to correlate limiting criteria into allowable headwork loadings. This approach

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TABLE 15

REMOVAL EFFICIENCIES FOR POLLUTANTS THROUGH SECONDARY TREATMENT AT DISTRICT WRPs

Pollutant	District WRP						
	Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Stickney
Arsenic	0.05*	0.06	0.06	0.01	0.05*	0.07	0.05*
Cadmium	0.59*	0.59*	0.59*	0.59*	0.59*	0.59	0.59*
Chromium, total	0.94*	0.94*	0.94*	0.94*	0.94*	1.00	0.89
Hexavalent chromium	0.76*	0.76	0.76*	0.76*	0.76*	0.76*	0.76*
Copper	0.79	0.90	0.91	0.94	0.93	0.87	0.87
Lead	0.96*	0.96*	0.96*	0.96*	0.96*	0.96	0.96*
Iron, total	0.95*	0.95*	0.95*	0.95*	0.95*	0.94	0.96
Fluoride	0.04*	0.04	0.03	0.02	0.04*	0.03	0.09
Mercury	0.92*	0.92*	0.97	0.78	0.99	0.92*	0.92*
Nickel	0.52*	0.53	0.64	0.50	0.52*	0.40	0.52*
Selenium	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Silver	0.92*	0.93	0.92	0.96	0.92*	0.88	0.92*
Zinc	0.75	0.67	0.68	0.62	0.83	0.62	0.83
Ammonia	0.98	0.99	0.96	0.97	0.92	0.96	0.95
Cyanide	0.93	0.50	0.41	0.61	0.67	0.60	0.69
Phenol	0.99	0.99	0.99	0.99	0.97	0.98	0.99
FOG	0.91	0.91*	0.91*	0.91*	0.91	0.93	0.91*

*The value is the average removal efficiency for the WRPs which had at least 30% of the samples with pollutant concentrations above the detection limit.

traces the routes of each pollutant through the treatment process, taking into account pollutant removals in upstream processes. For each pollutant, the smallest of the allowable headwork loadings derived from the criteria was selected as the pollutant's maximum allowable headworks loading. This ensures that the actual headwork loading was consistently below the maximum, and compliance with all applicable standards was achieved.

A preliminary screening evaluation was used to determine if further evaluation was needed. The screening was performed on each pollutant of concern, at each WRP and evaluated as effluent, sludge, or biological criteria. The pollutants of concern were determined from regulatory criteria, historical performance, and biological process inhibition. The regulatory criteria consisted of water quality, sludge quality, and biological inhibition criteria.

The effluent criteria were determined by state water quality standards and NPDES Permits. Equation 2 determines the allowable headworks loading based on the NPDES permits. Equation 3 determines the allowable headworks loading based on state water quality standards.

Equation 2: AHL Based on NPDES Permit Limits

$$AHL = \frac{C_{NPDES}\, Q_{WRP} 8.34}{1 - R_{WRP}}$$

Equation 3: AHL Based on State Water Quality Standards

$$AHL = \frac{\left[C_{WATERQUAL}(Q_{WRP} + Q_{STREAM}) - C_{STREAM}Q_{STREAM}\right]8.34}{1 - R_{WRP}}$$

where,

AHL= Allowable Headworks Loading, lbs/day

C_{NPDES} = Effluent NPDES Concentration Limit, mg/L

$C_{WATERQUAL}$ = Water Quality Standard Concentration, mg/L

C_{STREAM} = Receiving Stream Concentration, mg/L

Q_{WRP}= Treatment WRP Flow, MGD

Q_{STREAM}= Receiving Stream Flow, MGD

R_{WRP} = Removal Efficiency Across WRP, as a Decimal

8.34 = Unit Conversion Factor

Comparison of the effluent standards and loading characteristics indicated several pollutants for further evaluation. The criteria for screening was based on the average and maximum influent concentrations compared to the maximum allowable headworks loadings determined from each site. The maximum allowable headworks loading was the most stringent at each site for each pollutant. In the event further evaluation was needed the maximum allowable headworks was used to back

calculate the local limit concentration allowed for each site, as shown in Equation 4 and Equation 5.

Equation 4: $L_{MAIL} = MAHL(1 - SF) - L_{DOM}$

Equation 5: $C_{LOCAL\_LIMIT} = \frac{L_{MAIL}}{(QIND)(8.34)}$

where,

L_{MAIL} = Maximum Allowable Industrial Load, lbs/day

MAHL = Maximum Allowable Headworks Load, lbs/day

SF = Safety Factor

L_{DOM} = Domestic or Background Load, lbs/day

Q_{IND} = Industrial Flow, MGD

$C_{LOCAL\_LIMIT} = \frac{L_{MAIL}}{(QIND)(8.34)}$ Maximum Concentration Allowed in Industrial Discharge, mg/L

The results indicated a closer look at both silver and fluoride. The Industrial Waste Division is conducting an in depth study at this time.

Ammonia, cyanide and total chromium required additional consideration. The federal chromium criteria use the measurement of total chromium. The District determined total chromium in their routine data analysis. The State of Illinois uses the trivalent chromium standard. The District total chromium concentration was used to meet the trivalent chromium

state standards. This was a reasonable assumption since the trivalent species was the most prevalent of the chromium species. The ammonia and cyanide evaluations considered chemical subspecies of un-ionized ammonia and WAD cyanide using stoichiometric ratios.

The sludge criteria used the Part 503 sludge concentration values to determine the allowable headworks loadings, as shown in Equation 6. The District sludge contained metal concentrations well below the federal limits in all cases. The federal sludge quality standards and the actual maximum concentration of the metal at each of the sludge processing facilities is shown in Table 16. In each case the maximum metal concentrations were well below the federal criteria. The evaluation of sludge criteria suggested no further restrictions on metals based on the historical data. The evaluation determined the District is not at risk of overloading metals in the sludge.

Equation 6: $$AHL = \frac{C_{SLUDGE} Q_{SLUDGE} \left(PS/100\right) G_{SLUDGE} 8.34}{R_{WRP}}$$

C_{SLUDGE} = Sludge Quality Standard Concentration, mg/Kg

Q_{SLUDGE} = Sludge to Disposal Flow, MGD

PS = Percent Solids of Sludge

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TABLE 16

FEDERAL SLUDGE QUALITY STANDARDS AND MAXIMUM LEVELS, YEAR 2000

Pollutant	Standard	Calumet WRP	Egan and Kirie WRPs*	Hanover Park WRP	Stickney North Side Lemont WRPs*
	mg/Kg				
Arsenic	41	10	4	4	6
Cadmium	39	7	6	3	6
Copper	1,500	416	923	925	471
Lead	300	135	54	103	187
Mercury	17	1	1	3	1
Molybdenum	75	16	26	16	20
Nickel	420	39	102	57	66
Selenium	100	21	5	6	4
Zinc	2,800	1,406	913	709	998

*Sludges combined before final processing.

G_{SLUDGE} = Specific Gravity of Sludge ≅ 1 kg/L

The biological criteria were based on both carbonaceous and nitrogenous upset in the activated sludge process and disruption of the anaerobic digesters. The allowable headworks determination for each type of biological upset is shown in Equation 7 and Equation 8. There has not been an upset at the District facilities with the current local limits. It was not necessary to further limit pollutants to prevent biological upsets.

Equation 7: AHL Based on Activated Sludge Inhibition Criteria

$$AHL = \frac{C_{AS/INHIBIT} Q_{WRP} 8.34}{1 - R_{PRI}}$$

Equation 8: AHL Based on Anaerobic Digestion Inhibition Criteria for Conservative Pollutants.

$$AHL = \frac{C_{DIG/INHIBIT}\ Q_{DIGESTER} 8.34}{R_{WRP}}$$

$C_{AS/INHIBIT}$ =Activated Sludge Inhibition Concentration, mg/L

$C_{DIG/INHIBIT}$ =Anaerobic Digester Inhibition Concentration, mg/L

$Q_{DIGESTER}$ = Sludge to Digester Flow, MGD

R_{PRI} = Removal Efficiencies Across Primary, as a Decimal

In summary, the screening of the pollutants of concern at the seven District WRPs resulted in a more detailed look at the effluent criteria, specifically for copper, zinc, silver, fluoride, and cyanide. The analysis of copper, zinc, and cyanide resulted in local limits concentrations the same or above the current levels. The no backsliding policy was used to maintain the current limits in the cases where the calculated limit is higher than the current limits. Fluoride and silver are not currently limited. The recommendation was to maintain the current status. The IWD is investigating the fluoride and silver loading in the Egan and Hanover service area to determine what, if any, measures need to be taken to protect the water quality. Table 17 summarizes the current and recommended local limits. The completed draft was submitted to the Illinois Environmental Protection Agency (IEPA) in April 2003.

Weller Creek Odor Study

At the request of the Kirie WRP staff, a study to determine the cause of odors at Weller Creek near Central Road was initiated (see Figure 16). The site was visited on March 28, 2003. It appears that the sediments and the standing water at the head of Weller Creek are a significant source of odors

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TABLE 17

SUMMARY OF RECOMMENDATIONS

Pollutant	Current Limit (mg/L)	Recommended Limit (mg/L)
Arsenic	None	None
Cadmium	2.0	2.0
Chromium, total	25.0	25.0
Chromium, hexavalent	10.0	10.0
Copper	3.0	3.0
Lead	0.5	0.5
Iron	250.0	250.0
Fluoride	None	None*
Mercury	0.005	0.005
Molybdenum	None	None
Nickel	10.0	10.0
Selenium	None	None
Silver	None	None*
Zinc	15.0	15.0
Ammonia	None	None
Cyanide	5.0	5.0
Phenol	None	None
FOG	250.0	250.0

*Study of these pollutants currently in progress.

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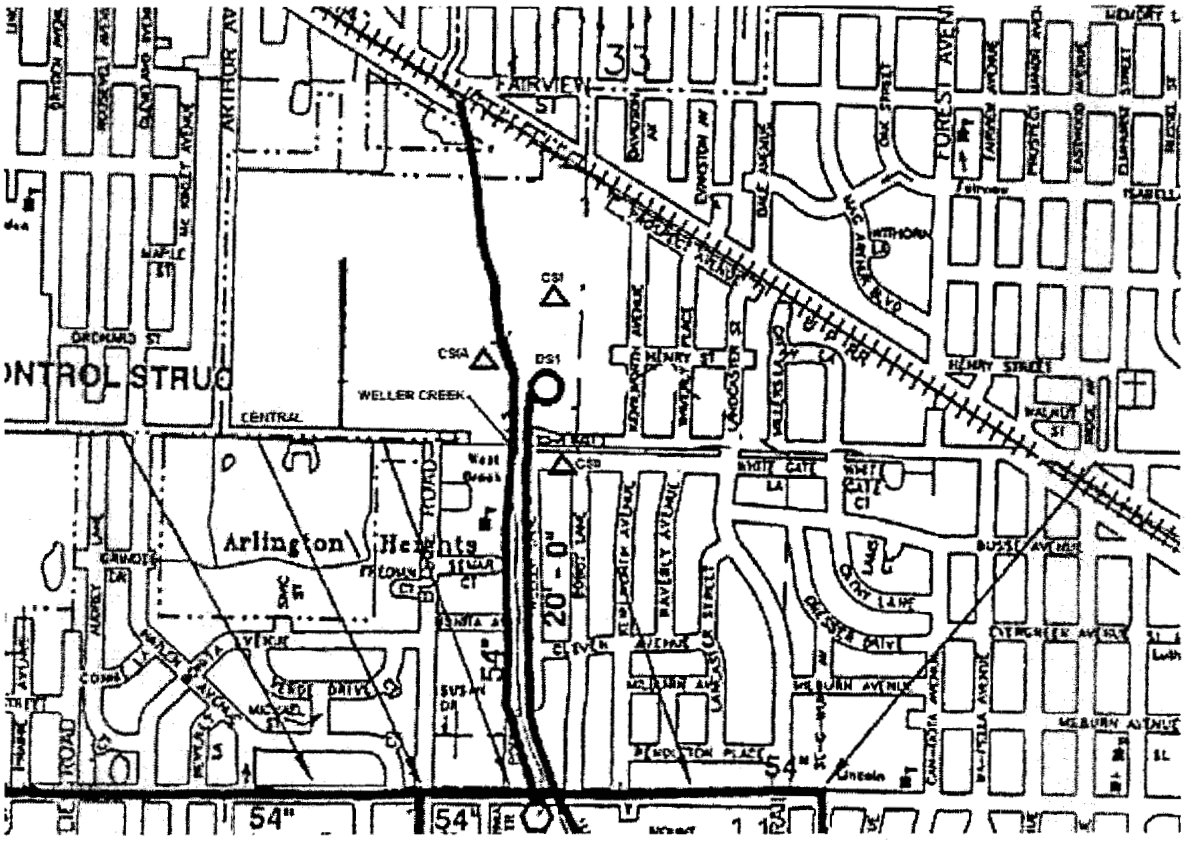
FIGURE 16

WELLER CREEK AREA



emanating from this site. Removing the deposits may substantially reduce the odor problem in the area. The creek bed could be graded to eliminate the occurrence of nuisance odors due to standing water.

However, to confirm whether the deposits are the only cause of the odors in this area an odor study was initiated.

The study intends to determine the origin of the odors in the area, Central Road and Busse Road, Mt. Prospect, Illinois. Once the origins of the odors are determined, odor control options will be evaluated.

The hydrogen sulfide concentration in the air is monitored in the study area. The hydrogen sulfide concentration is measured in five locations each week. The Arizona Instrument Jerome 631-X (Jerome) is used to measure the concentration of hydrogen sulfide in air. The Jerome has a detection limit of 3 ppb for hydrogen sulfide. The five locations are Control Structure I (CSI), Control Structure 1A (CS1A), Control Structure II (CSII), Drop Shaft 1 (DS1), and the residential area. CSI, CS1A and DS1 are located north of Central Road. CSII and the residential area are on the south side of Central Road, see Figure 16. The weather conditions, as well as any noticeable odors are logged each week.

The odor evaluation and hydrogen sulfide concentration at the monitoring locations is used to pinpoint one or more sources of odor. Factors which affect odor generation from sewers will be compared with the air monitoring results. The temperature, rainfall, and duration of dry spells are considered. The study began in May 2003 and continued through October 2003.

The hydrogen sulfide concentration data and odor evaluations were collected and evaluated. Sampling was done for 16 days. Twelve of the days had no odor, two of the days had a slight odor, and two of the days had a strong odor. Of the sixteen days sampled seven had precipitation on the sampling day or preceding day. Odor is not expected on days with precipitation. Strong odor was present at all monitoring points on August 22, 2003. On September 5, 2003, a strong odor was present at the Drop Shaft 1 vent. The hydrogen sulfide concentrations did not correlate with the odor evaluations. The study will resume in the warm weather months of 2004.

Odor Control Studies for Upper Des Plaines 14 Waste Stream

A comparison between the waste streams in the Upper Des Plaines collection sewer 14 (UDP14), and Upper Des Plaines collection sewer 22 (UDP22) was conducted to determine the

source of odor problems in the vicinity of Drop Shaft 5(DS5). The results showed a higher component of food industry waste in UDP14. The food industry waste had increased BOD_5, FOG, and hydrogen sulfide. The high BOD_5 at the northernmost end of the study led to an additional study of the feeder sewers. The studies confirmed the presence of hydrogen sulfide in the wastewater. The studies indicated there was not a specific point source of the sulfides or sulfates. The characteristics of the waste and the environment in the sewers both contribute to the production of hydrogen sulfides, which are believed to be a component of the offending odor.

In the collection system, H_2S is produced when bacteria consume sulfate oxygen for organic processes. Sulfate reducing bacteria grow in a "slime layer" that coats the sewer's wetted perimeter. These bacteria use oxygen in the most readily available form: first, from the elemental oxygen; then nitrate oxygen, then sulfate oxygen. As nitrate is not usually available in wastewater, bacteria will consume sulfate oxygen after depleting the dissolved oxygen, leaving bisulfide ions to combine with hydrogen to form aqueous hydrogen sulfide ($H_2S(aq)$). At pH 7, the bisulfide ion and $H_2S(aq)$ are equally proportionate. pH, Henry's Law, and the turbulence of the waste stream govern the rate at which $H_2S(aq)$ is transferred

into atmospheric H_2S. Factors which increase the rate of H_2S transfer are higher temperatures, lower pH and increased turbulence.

An H_2S monitor is located in the airspace of a manhole of the waste stream, manhole C. Manhole C is located directly upstream of DS5. An area location map is shown in Figure 17. Monitoring of the site began in May 2002. The data was collected through the end of 2003.

Chemical Dosing for Odor Control at DS5

The study consisted of two trials for controlling odors at DS5: 1) ferric chloride and 2) calcium nitrate. M&O determined a location for a dosing station upstream of DS5 on UDP14. The dosing station was constructed on Kensington Road, east of Wolf Road, see Figure 17.

FERRIC CHLORIDE

In the first trial, ferric chloride was dosed into UDP14 to mitigate odors. Ferric chloride solution (35 percent ferric chloride) was added to the waste stream to decrease the $H_2S(aq)$ concentration; leading to decreased atmospheric H_2S in the vicinity of DS5. The ferric chloride mechanism utilizes both oxidation and precipitation to remove $H_2S(aq)$ from the waste stream. The dosing station went into operation on

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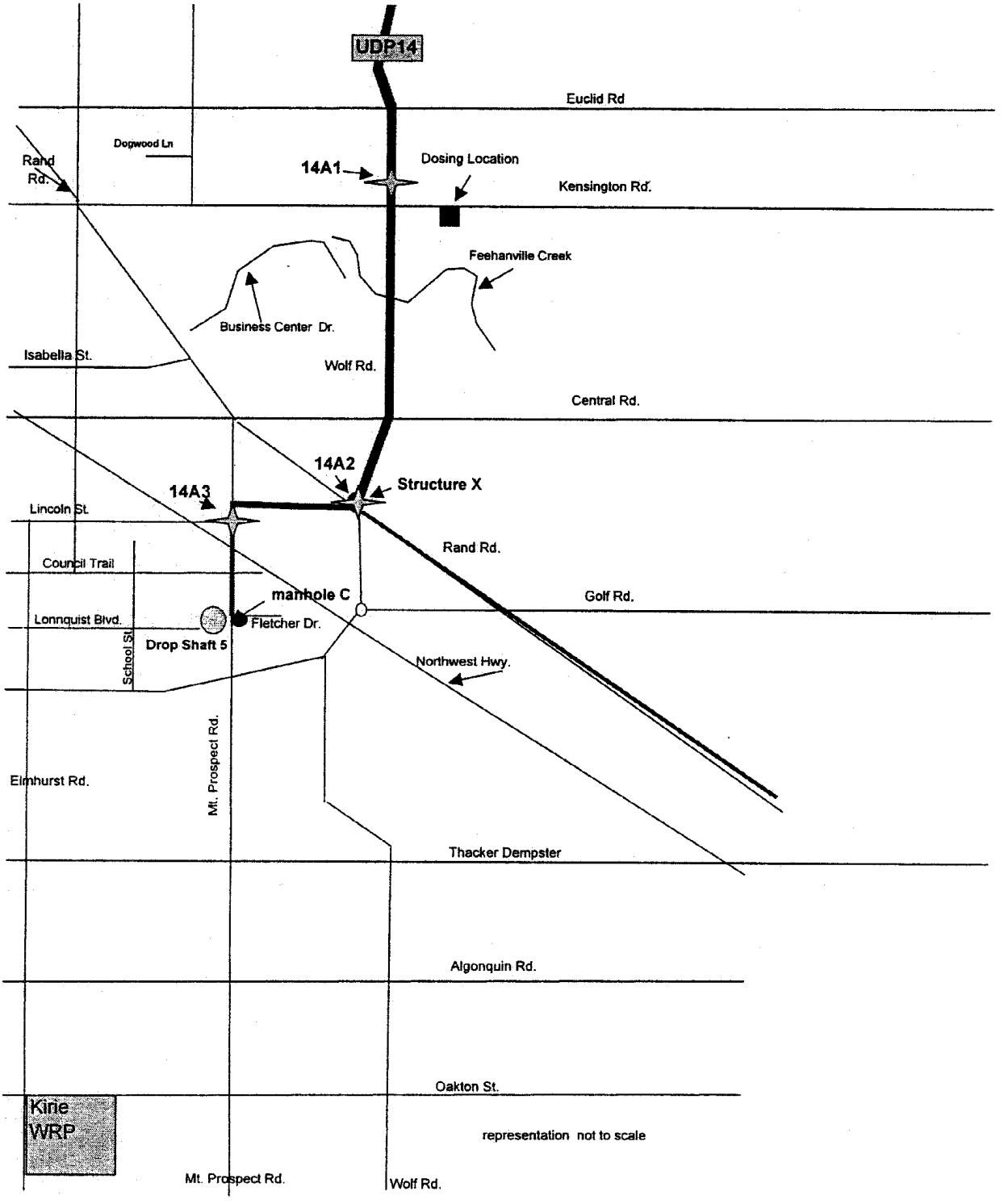
FIGURE 17

AREA LOCATION MAP



February 18, 2003. The ferric chloride solution was dosed through July 28, 2003.

The effect of the June and July 2003 ferric chloride dosing is shown in Figure 18. The H_2S concentrations in July 2003 is substantially below the undosed baseline concentrations for July 2002 (Figure 19). The ferric chloride was effective at reducing high peak H_2S concentrations seen prior to 2003. The ferric chloride was effective at reducing the peak H_2S concentration below 100 ppm. The response to increasing the ferric chloride dose indicates the $H_2S(aq)$ is being removed from the waste stream.

During the ferric chloride trial there were five verified odor complaints attributed to DS5. The dates of the complaints were; June 21, 2003, June 22, 2003, June 24, 2003, and July 19, 2003. The respective daily maximum H_2S concentrations in the manhole atmosphere were; 73 ppm, 40 ppm, 53 ppm, and 42 ppm. All of the daily maximum H_2S concentrations were below 100 ppm, four of the five were below 50 ppm. Therefore, it was concluded that increasingly higher doses of ferric chloride would be needed to reduce the ambient H_2S concentration to lower levels.

Problems developed because of additional sludge production due to ferric sulfate precipitation. It was suspected

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FIGURE 18

DAILY PEAK HYDROGEN SULFIDE CONCENTRATION IN SEWER HEADSPACE IN 2003

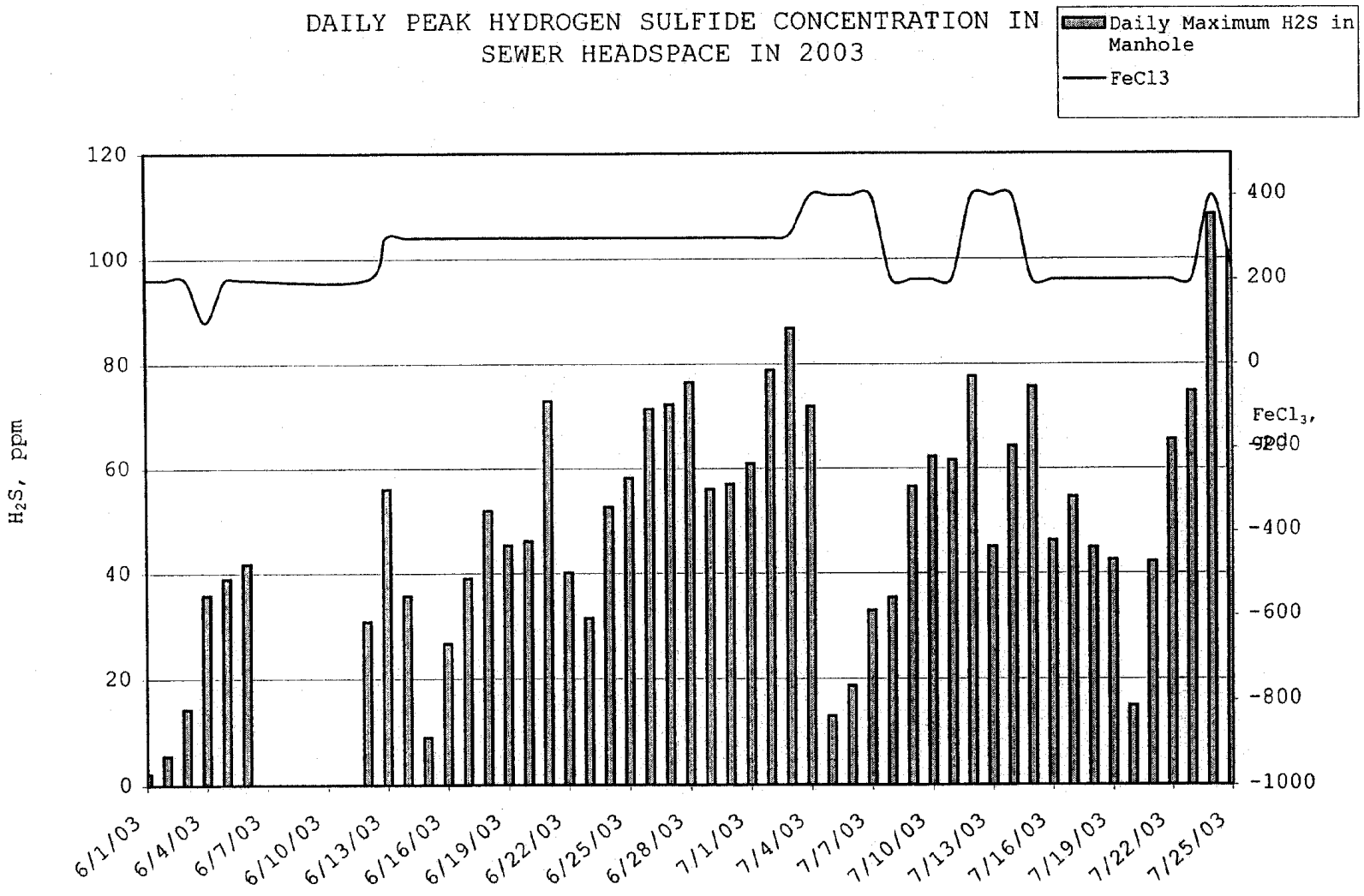

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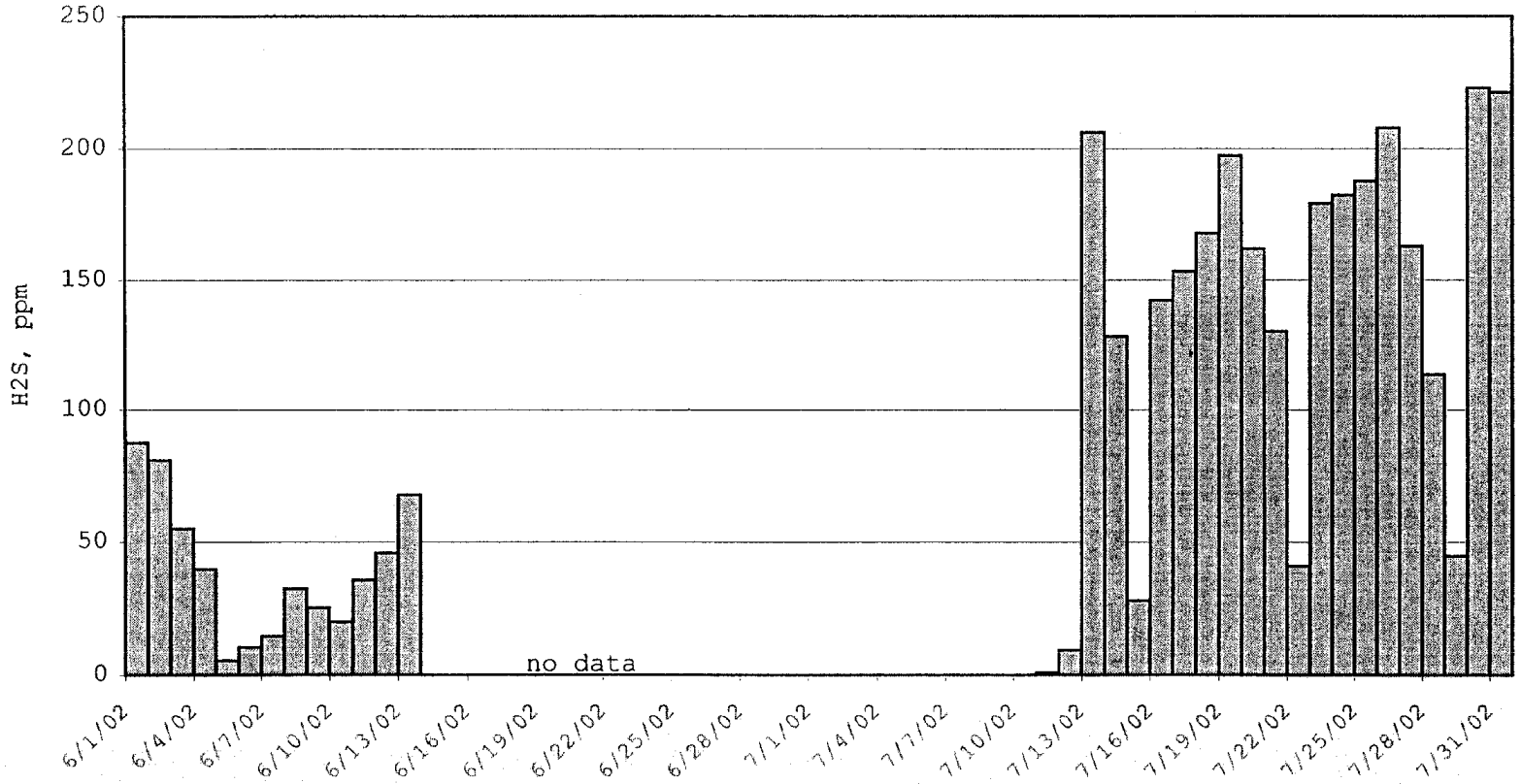
FIGURE 19

DAILY PEAK HYDROGEN SULFIDE CONCENTRATION
IN SEWER HEADSPACE IN 2002



that these deposits were responsible for odor complaints from the residents in the area. The UDP14 flow was diverted to the North Side WRP to allow the flushing of the sewer between Structure X and DS5, see Figure 17. Therefore, it was decided to try calcium nitrate which does not accumulate chemical deposits.

CALCIUM NITRATE

In the second trial, U. S. Filter's Bioxide® was used as a source of calcium nitrate. The chemical dosing station was located on Kensington Road east of Wolf Road, see Figure 17. Bioxide (4.52 lb NO_3/gal) was added to the waste stream to decrease the H_2S(aq) concentration. The Bioxide solution prevents the formation of H_2S(aq) in the waste stream by supplying readily available nitrate oxygen to be reduced in place of the sulfate oxygen. Bioxide also removes H_2S(aq) already present in the waste stream through oxidation.

The Bioxide dosing began September 18, 2003, and continued until October 28, 2003. Four weeks of Bioxide dosing and the resulting H_2S concentrations beginning October 1, 2003, are shown in Figure 20. The headspace temperature ranged from 64°F through 67°F during the first three weeks. The headspace temperature ranged from 62°F through 64° during the fourth

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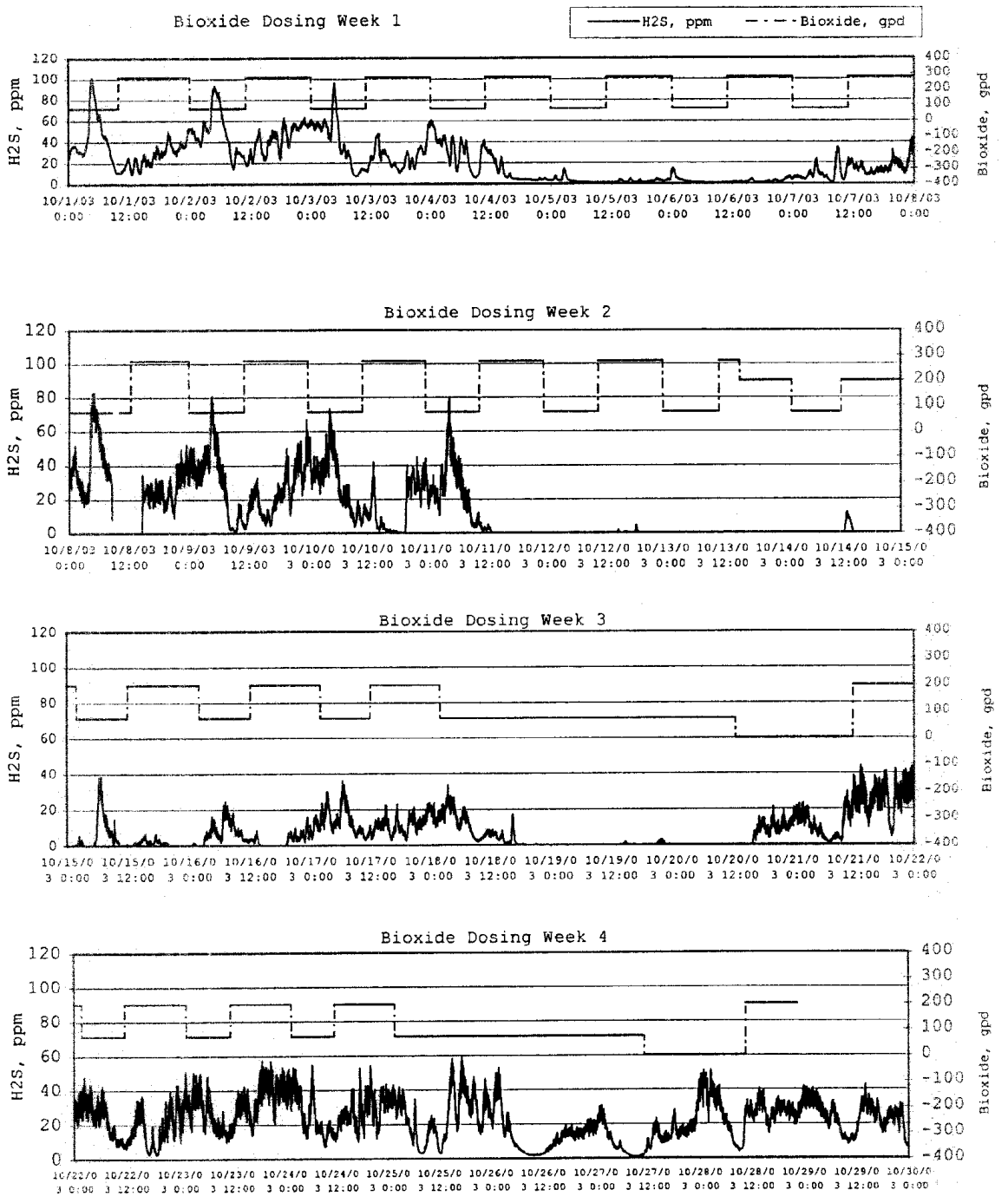
FIGURE 20

HYDROGEN SULFIDE CONCENTRATION IN SEWER HEADSPACE DURING BIOXIDE DOSING TRIAL



week. Three dosing schedules were evaluated. The first dosing schedule, from Wednesday, October 1, 2003, through Monday, October 13, 2003, dosed Bioxide: 278 gpd (11 AM until midnight), 76 gpd (midnight until 11 AM). The dosing schedule was effective at reducing the daily H_2S concentration peaks below 100 ppm for all days. The H_2S concentration peaks on Saturday, Sunday, and Monday were below 20 ppm. The low levels of H_2S on these days indicates the effectiveness of Bioxide to decrease the H_2S concentration. The H_2S concentration dry weather weekly trend was interrupted by two rain events; October 3, 2003, (0.27 inches) and October 14, 2003 (1.05 inches). The lowered H_2S concentration peaks on October 4, 2003, are a result of the October 3, 2003, rain event. The large flushing rain event of October 14, 2003, resulted in H_2S concentration peaks decreased by about 50 percent for four days. The dosage for Saturday, Sunday, and Monday was decreased in the second dosing schedule.

The second dosing schedule, from Tuesday, October 14, 2003, through Saturday, October 25, 2003, split the week into two categories; high peak days (Tuesday, Wednesday, Thursday, and Friday) and low peak days (Saturday, Sunday, and Monday). The second Bioxide dose was as follows:

1. High peak day dose 200 gpd (noon-2 AM), and 75 gpd (2 AM-noon).
2. Low peak day dose: 75 gpd.

The second Bioxide dose schedule reduced the high peak day's H_2S concentration peaks below 60 ppm. The low peak day's H_2S concentration peaks were below 25 ppm.

The third schedule was the same as the second on high peak days except it did not dose on the low peak days. This schedule was used Saturday, October 25, 2003, through Tuesday, October 28, 2003. This schedule resulted in an elevation of H_2S peak concentrations on the low peak days.

A summary of the schedules and resulting maximum H_2S concentrations is shown in Table 18. To maintain the peak H_2S concentration below 25 ppm a higher dose is needed on high peak days. The low peak days appear to require between 0 gpd and 75 gpd of Bioxide to maintain the H_2S concentration below 25 ppm.

From the trial it was evident that no chemical deposits resulted from the application of Bioxide to mitigate H_2S in the headspace of the sewer. Bioxide dosing is effective to reduce the H_2S concentrations in the sewer headspace near DS5. The trial was conducted in the headspace temperature range seen in July, and October, see Figure 21. The August and

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TABLE 18

BIOXIDE DOSING SCHEDULES AND RESULTING PEAK HYDROGEN SULFIDE CONCENTRATIONS

Schedule	Bioxide Dose, gpd		Daily Average Dose, gpd	Max Peak H_2S, ppm
	Afternoon & Evening	Mornings		
High Peak Days[1] (Tue-Fri)				
1	278	76	186	100
2	200	75	148	60
3	200	75	148	60
Low Peak Days[2] (Sat-Mon)				
1	278	76	186	20
2	75	75	75	25
3	0	0	0	50

[1]High peak days: Tuesday, Wednesday, Thursday, and Friday.
[2]Low peak days: Saturday, Sunday, and Monday.

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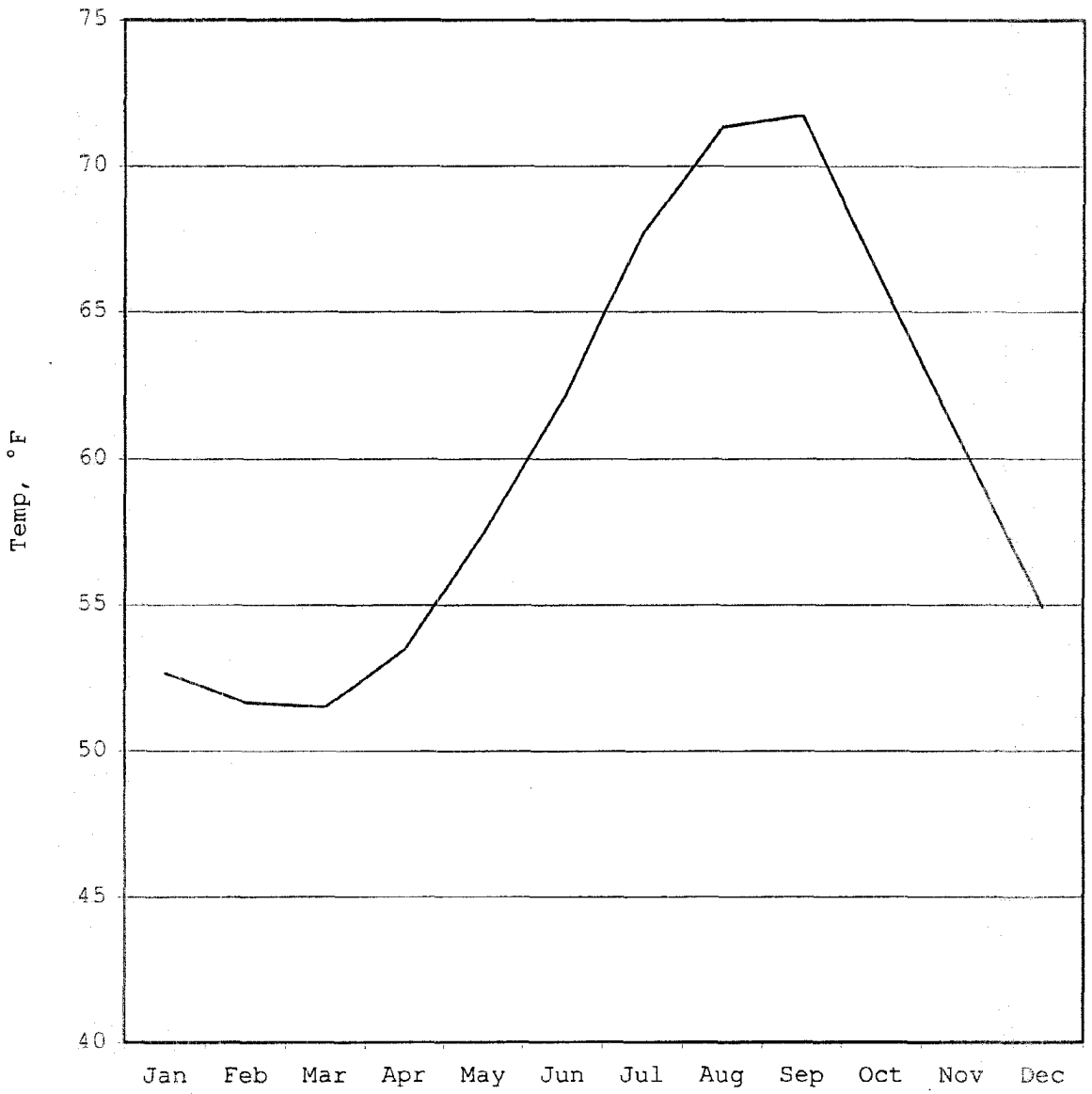
FIGURE 21

ANNUAL TEMPERATURE VARIATIONS OF MANHOLE C
HEADSPACE



September headspace temperatures are higher, requiring additional Bioxide to remove $H_2S(aq)$ formed upstream. The higher temperatures will increase biological metabolism, requiring an increased Bioxide dose. May and June, similarly will have decreased Bioxide dosage needs. The October trial is a fair indicator of dosage effectiveness.

The dosing schedule should be further fine tuned to reduce the H_2S peaks to levels which correlate with no odor complaints in the DS5 vicinity. This target level will determine the dosage needed. The above data suggests a daily peak H_2S concentration not to exceed 25 ppm. In addition to the low peak days and high peak days, nighttime and daytime peaks could be factored into the tuning process to obtain the maximum effectiveness with the minimum cost. The incorporation of UDP14 flow variations would further fine tune the dosing schedule.

Along with the airspace study to evaluate the odor control chemical dosing program, wastewater samples were analyzed for nitrate concentration. Three sampling sites were sampled three times per week. As shown in Figure 17, Station 14A1 (District manhole south of parking lot exit lane at River Trails Middle School, 1000 N. Wolf Road, Mt. Prospect, Illinois) is upstream of the dosing station. Station 14A2

(District manhole at southwest corner of Rand and Wolf Roads, Des Plaines, Illinois) and 14A3 (District manhole in lawn of DiMucci Park, 25 feet east of Mt. Prospect Road, at Princeton Street, Des Plaines, Illinois) are downstream. The nitrate concentration was evaluated. The residual nitrate concentration in the wastewater is an indication of availability of oxygen for bacteria without requiring oxygen from sulfate ions. The data is shown in Table 19. The Bioxide evaluation will continue in 2004.

O'Hare CUP Reservoir Fill Event Experiment

The objective of this project is to provide research assistance, by the District and/or its subcontractors, to the U. S. Army Corps of Engineers (ACOE) to support the design of full scale aeration and wash down systems for the McCook and Thornton Reservoirs. Since the McCook and Thornton Reservoirs will eventually contain combined sewer overflows (CSOs), an assessment of the impact of CSO storage on ambient air quality was conducted. Meetings are held regularly between the District and ACOE to review the progress of the project.

A full-scale experiment was conducted from May 1, 2003, to May 21, 2003, at O'Hare CUP Reservoir to study the potential for odor formation during storage of CSOs without

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TABLE 19

NITRATE CONCENTRATION IN UDP14

Date	Location		
	14A-1	14A-2	14A-3
	----------Nitrate, ppm----------		
9/16/03	0.00	0.01	0.00
9/17/03	0.02	0.01	0.03
9/18/03	0.02	0.08	0.05
9/23/03	0.00	0.00	0.00
9/24/03	0.00	0.00	0.00
9/25/03	0.00	0.00	0.00
9/3/03	0.01	0.00	0.00
10/1/03	0.03	0.01	0.02
10/2/03	*	0.00	*
10/7/03	0.00	0.00	0.00
10/8/03	0.00	0.00	0.00
10/9/03	0.00	0.00	0.00
10/14/03	0.27	0.41	0.02
10/15/03	0.00	0.00	0.00
10/16/03	0.00	0.00	0.00
10/21/03	0.00	0.00	0.00
10/22/03	0.00	0.23	0.00
10/23/03	0.00	0.00	0.00
10/28/03	0.01	0.00	0.00
10/29/03	0.00	0.03	0.00
10/30/03	0.00	0.01	0.00
11/5/03	0.70	2.20	1.71
11/6/03	0.01	0.01	0.00

*No sample.

mechanical aeration. This was a follow-up experiment to the two similar full-scale experiments that were conducted from May 12 to June 12, and August 13 to September 3 in 2002. As in the two experiments conducted in 2002 the objective of this experiment was also to collect information and data for use in the evaluation and design of aeration systems of the future McCook and Thornton Reservoirs.

The experimental plan dated April 19, 2002 for the O'Hare CUP Reservoir was followed in this experiment. The experimental plan calls for two scenarios, one a Manmade Fill Event, and the other a Natural Fill Event. The fill event covered in this report was a Natural Fill Event.

The O'Hare CUP Reservoir experimental plan was put into effect following the Natural Fill Event that occurred on May 1, 2003. The O'Hare CUP Reservoir began filling with CSO at 0505 hours (military time) May 1, 2003, and became static at 0100 hours (military time) on May 2, 2003. A total of 72 million gallons of CSO was captured in the reservoir. Approximately 1.39 inches of rain was recorded on May 1 for this storm event. On May 4 the reservoir was drained to 60 million gallons in anticipation of additional rainfall. On May 5, 2003, the reservoir began filing again at 1030 hours (military time) adding a little over one million gallons of CSO to the

60 million gallons of CSO that was already in the reservoir. Approximately 1.10 inches of rain fell on May 4 and 0.25 inches of rain fell on May 5.

Due to the decreasing volume of CSO in the reservoir, bottom solids at the western end of the reservoir were exposed to air increasing the potential for odors in the reservoir. Because of this condition a decision was made on May 20 to terminate the experiment and drain the reservoir. Draining of the reservoir was initiated on May 21. The aerators were not turned on for this experiment.

CUP FILL EVENT SAMPLING

Hourly samples were collected from CSO entering the reservoir during the fill event using an automatic sampler until the reservoir went static. These samples were analyzed for BOD_5, TSS, NO_2-N, NO_3-N, and NH_3-N.

Stored CSO samples were collected from the reservoir using a remote controlled boat at three locations and at different depths. These samples were analyzed for BOD_5, NH_4-N, TSS and VSS. Stored CSO was also sampled for dissolved oxygen and temperature at the same locations and depths. Samples were also collected for chlorophyll and sulfide analysis.

ODOR MONITORING

H_2S measurements and qualitative odor monitoring were performed by R&D Department personnel from various locations around the reservoir during the fill event. The locations of odor monitoring sites are shown in Figure 22. R&D Department personnel then patrolled the area to check for odors. No strong odors were detected and H_2S readings ranged between 0 and 14 ppb, well below the threshold odor concentration of 25 ppb as can be seen in Table 20. Odor frequency was perceived as infrequent and odor intensity was perceived as low as can be seen in Table 21.

DISSOLVED OXYGEN ANALYSIS

One unexpected aspect of the study was the large amount of phytoplankton observed giving the CSO a greenish tint. The phytoplankton was assumed to be responsible for some very high dissolved oxygen (DO) readings. Tables 22 and 23 show concentrations of DO and temperature, and phytoplankton, respectively. It may be possible that the phytoplankton may produce enough DO to maintain a DO concentration of 2.0 mg/L in the CSO in the reservoir. In Table 22, the terms ES, MS, and WS represent east south, middle south, and west south locations at the reservoir and next to these locations numerals 5, 10,

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FIGURE 22

LOCATIONS OF SEDIMENT DEPTH MEASUREMENTS AT THE BOTTOM OF THE RESERVOIR
AND THE SIX PANS INSTALLED FOR THE EXPERIMENT
SAMPLES COLLECTED ON MAY 21, 2003

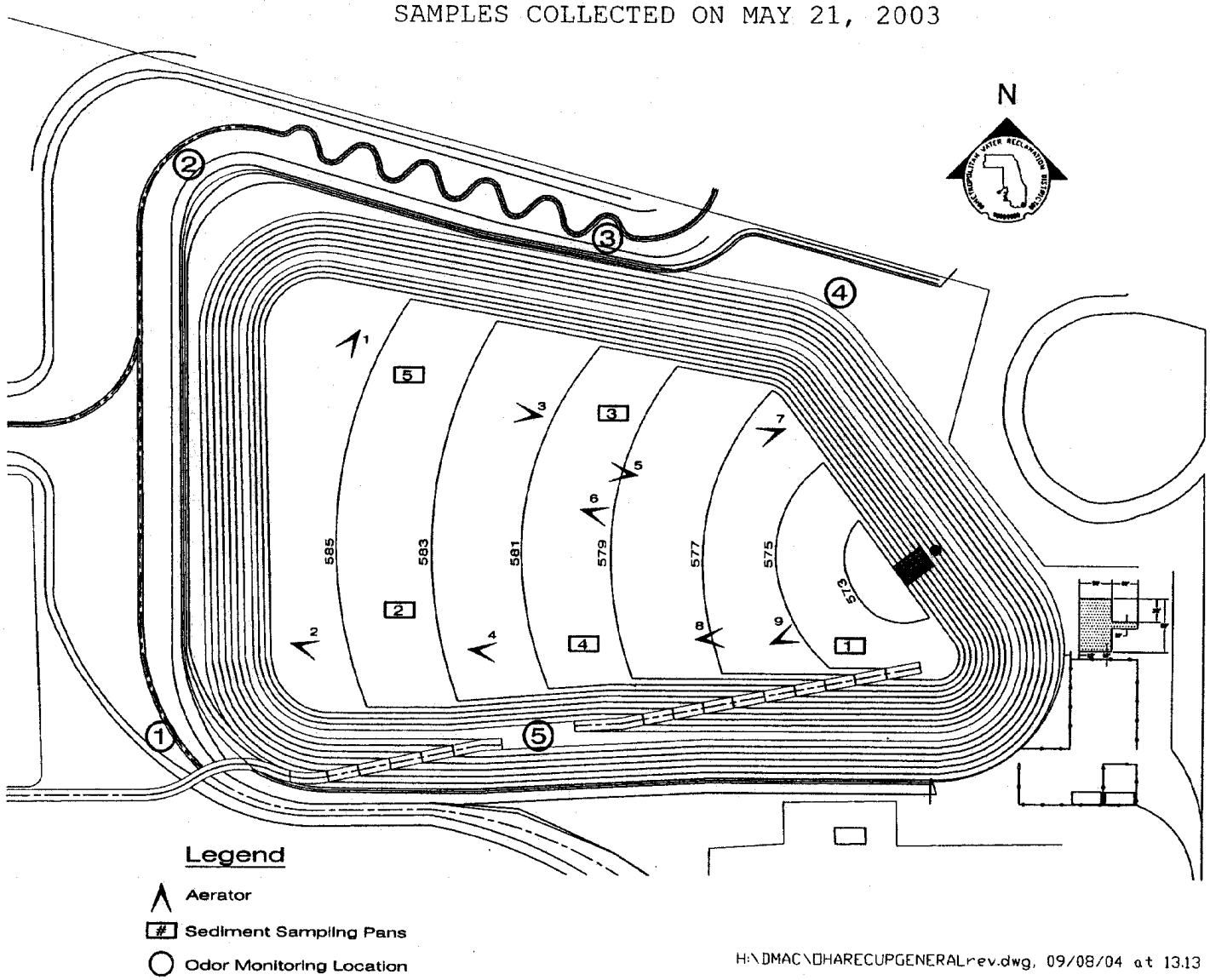

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TABLE 20

HYDROGEN SULFIDE MONITORING DATA IN PARTS PER BILLION (ppb) AROUND THE O'HARE CUP RESERVOIR DURING THE MAY 1, 2003, THROUGH MAY 21, 2003, FILL EVENT EXPERIMENT

Date	Location 1	Location 2	Location 3	Location 4	Location 5
5/2/03	7	7	7	9	7
5/3/03	14	13	12	11	10
5/4/03	10	8	8	11	9
5/5/03	2	2	1	1	2
5/6/03	9	8	9	10	9
5/7/03	7	7	4	8	7
5/8/03	8	8	10	9	8
5/9/03	7	9	11	10	11
5/10/03	6	7	8	9	9
5/11/03	NA	NA	NA	NA	NA
5/12/03	11	10	10	10	8
5/13/03	9	12	11	12	13
5/14/03	12	14	10	10	12
5/15/03	12	10	9	10	10
5/16/03	10	10	10	9	11
5/17/03	12	9	12	12	14
5/18/03	7	7	9	10	11
5/19/03	4	4	4	5	5
5/20/03	10	12	10	11	13
5/21/03*	5	6	5	4	5
5/21/03**	3	5	3	2	5
Min	2	2	1	1	2
Mean	8	8	8	9	9
Max	14	14	12	12	14

NA = Readings not taken due to meter malfunction.
*Readings taken before reservoir was drained.
**Readings taken after reservoir was drained.

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TABLE 21

QUALITATIVE ODOR INTENSITY MONITORING AROUND THE O'HARE CUP RESERVOIR
DURING THE MAY 1, 2003, THROUGH MAY 21, 2003, FILL EVENT EXPERIMENT

Location No.**	Total Number of Observations	Number of Times Odor Perceived with Varying Intensity*					
		No Odor	Very Faint	Faint	Noticeable	Strong	Very Strong
1	21	15	3	2	1	0	0
2	21	19	0	2	0	0	0
3	21	19	2	0	0	0	0
4	21	19	1	1	0	0	0
5	21	17	3	1	0	0	0
Total Number of Readings	105	89	9	6	1	0	0

*A subjective odor intensity as interpreted by the person doing the monitoring.
**See Figure 22.

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TABLE 22

DISSOLVED OXYGEN AND TEMPERATURE READINGS AT SEVERAL LOCATIONS AND VARIOUS DEPTHS DURING THE O'HARE CUP RESERVOIR MAY 1, 2003, THROUGH MAY 21, 2003, FILL EVENT EXPERIMENT

	ES1/5		ES1/10		ES1/15		MS2/5		MS2/10		WS3/5	
Date	DO mg/L	Temp. °C	DO mg/L	Temp. °C	DO mg/L	Temp. °C	DO mg/L	Temp. °C	DO mg/L	Temp. °C	DO mg/L	Temp. °C
5/2/03	1.10	12.2	0.40	12.3	0.60	12.6	0.60	12.6	3.90	12.1	1.00	13.1
5/3/03	*	*	*	*	*	*	*	*	*	*	*	*
5/4/03	*	*	*	*	*	*	*	*	*	*	*	*
5/5/03	**	**	**	**	**	**	**	**	**	**	**	**
5/6/03	0.10	14.4	0.10	14.8	0.10	14.9	21.10	17.7	11.90	15.9	3.90	16.3
5/7/03	9.70	15.8	0.20	13.2	0.00	13.9	0.10	15.6	10.10	14.2	0.20	16.0
5/8/03	1.90	15.7	0.00	13.1	0.10	13.4	3.70	15.6	2.50	15.0	7.60	15.8
5/9/03	9.70	15.5	0.00	13.6	0.00	14.2	4.10	15.6	4.90	14.6	4.20	15.7
5/10/03	2.40	15.0	0.00	13.5	0.20	14.1	2.50	15.4	0.10	15.0	2.70	17.5
5/11/03	7.40	17.1	5.10	16.7	0.30	14.1	4.10	16.1	2.90	15.3	1.60	15.1
5/12/03	9.80	22.5	7.50	14.6	7.20	14.5	11.80	15.5	10.10	15.5	10.00	15.5
5/13/03	10.20	15.4	9.10	15.2	8.30	15.3	10.40	15.3	8.70	15.2	11.00	15.4
5/14/03	8.30	15.5	7.30	15.1	6.20	15.5	11.40	15.7	17.80	16.1	17.70	16.2
5/15/03	10.70	15.1	6.10	14.9	5..7	14.9	20.30	15.1	12.10	15.0	17.20	15.1
5/16/03	9.80	15.1	6.90	15.1	7.40	15.0	8.70	15.0	7.30	14.9	12.7	16.0
5/19/03	7.10	15.6	8.70	14.9	1.40	15.8	8.60	16.8	8.40	16.4	10.30	18.4
5/20/03	16.90	19.5	6.50	15.5	1.60	15.9	12.0	19.6	8.60	16.7	13.30	19.0
5/21/03	12.00	18.5	2.90	15.6	1.80	17.4	16.30	18.6	4.70	18.1	18.80	18.2
Min.	0.10	12.20	0.00	12.30	0.00	12.60	0.10	12.60	0.10	12.10	0.20	13.10
Mean	7.81	15.74	4.05	14.54	2.51	14.77	8.84	16.01	7.60	15.33	8.54	16.22
Max.	16.90	19.50	9.10	16.70	8.30	17.40	21.10	19.60	17.80	18.10	18.80	19.00

*Data not recorded due to faulty probe.
**Reservoir began filling again, no readings were taken that day.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 23

RESULTS OF CHLOROPHYLL *a* IN µg/L FROM SAMPLES COLLECTED AT A DEPTH OF 5 FEET IN THE O'HARE CUP RESERVOIR DURING THE MAY 1, 2003, THROUGH MAY 21, 2003, FILL EVENT EXPERIMENT

Date	East	Center	West
5/6/03	0.690	0.000	3.276
5/15/03	167.182	161.680	225.256
5/21/03	84.628	98.316	394.652

and 15 indicate depths in feet at which a particular sample was taken.

SEDIMENT MEASUREMENTS

Bottom sediments were collected on May 21, 2003, from four different locations after the reservoir was drained and the depths of the sediments were measured. The locations of the of the depth measurements of sediment deposits are shown in Figure 22. The data on sediment deposit depths along with total solids (TS) and total volatile solids (TVS) concentrations are given in Table 24.

The depth of sediments varied from 0.06 inch to 0.94 inch with a mean value of 0.45 inch. The mean TS concentration of the sediment was 6.27 percent and 43.64 percent volatile solids. The mean sediment depth for this fill event was on the low end of projected estimates for a comparable size fill event. Because of the small amount of sediment on the bottom of the reservoir, only four sampling sites were used. At the other areas of the reservoir there was insufficient amount of bottom sediments for collection of samples.

Another set of sediment depth measurements was collected from six pans specially installed for this experiment at the bottom of this reservoir. The locations of the pans are shown

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 24

SEDIMENT DEPTH AND SOLIDS RESULTS FROM THE BOTTOM AFTER DRAINING THE RESERVOIR DURING THE O'HARE CUP RESERVOIR MAY 1, 2003, THROUGH MAY 21, 2003, FILL EVENT EXPERIMENT RESULTS FROM MAY 21, 2003, MEASUREMENTS

Site[1]	Depth Inches	Total Solids (TS) Percent	Total Volatile Solids (TVS) Percent
1	0.19	8.27	39.39
2	0.06	7.62	39.35
3	0.63	1.63	39.51
4	0.94	7.54	56.31
Min.	0.06	1.63	39.35
Mean	0.45	6.27	43.64
Max.	0.94	8.27	56.31

Note: Dry Density of combined sediments is 1.28 g/mL.
[1]See Figure 22.

in Figure 22 and the results of depth measurements are shown in Table 25. The depths of the sediments in the pans varied from 0.03 inch to 0.06 inch with a mean value of 0.04 inch. The purpose of the sediment pans was to compare the results of sediment deposits in stationary containers such as the pans (13 1/2" L x 10" W x 10" D) with that of freely moving sediments in the rest of the reservoir.

The mean depth of sediment deposits in pans is significantly lower (0.04 inch) compared to the mean deposit of 0.47 inch in the reservoir. This difference cannot be explained.

CONCLUSIONS

The main conclusions of this report are:

1. Based on the results of the full-scale experiment conducted at the O'Hare CUP Reservoir from May 1, 2003, to May 21, 2003, it can be concluded that the future McCook and Thornton Reservoirs may not require maintenance of 2.0 mg/L DO throughout the reservoir as provided in the proposed design in order to ensure a reasonably odor free environment in the vicinity of these two reservoirs during the storage of CSOs. This finding is consistent with the conclusions drawn

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 25

SEDIMENT DEPTH AND SOLIDS RESULTS FROM THE SEDIMENT PANS INSTALLED AT THE BOTTOM OF THE RESERVOIR DURING THE O'HARE CUP RESERVOIR MAY 1, 2003, THROUGH MAY 21, 2003, FILL EVENT EXPERIMENT RESULTS FROM MAY 21, 2003, MEASUREMENTS

Site[1]	Depth Inches	Total Solids (TS) Percent	Total Volatile Solids (TVS) Percent
1	0.06	4.46	40.29
2	0.06	3.77	41.64
3	0.03	2.48	40.23
4	0.03	1.87	41.23
5	0.03	6.63	43.51
6	0.03	3.60	41.22
Min.	0.03	1.87	40.23
Mean	0.04	3.80	41.35
Max.	0.06	6.63	43.51

[1]See Figure 22.

from the previous experiments conducted at the O'Hare CUP Reservoir on May 12, June 12 and August 13 to September 3 in 2002.

2. During the 19-day holding period of CSOs, without any aeration, no significant odors emanated from the reservoir even though dissolved oxygen concentrations at the beginning of the fill event were very low.

3. The depth of the sediment deposits at the bottom of the reservoir found during this experiment were lower than sediment depths measured in the 2002 fill events. This finding again confirms the conclusions drawn in the previous reports that the actual sediment deposits for a comparable size fill event in the McCook and Thornton Reservoirs would be lower than the projected estimates of the sediment deposits for these two reservoirs.

Tunnel and Reservoir Plan (TARP) Groundwater Monitoring Program

The District's TARP Groundwater Monitoring Program was implemented in 1976 to assess the impact of TARP on groundwater quality and quantity. The TARP tunnels were constructed

100 to 350 feet underground, and function as a part of a region-wide pollution and flood control system, capturing and temporarily storing CSOs. The CSOs, which are a mixture of raw sewage and storm runoff, are subsequently treated at District WRPs.

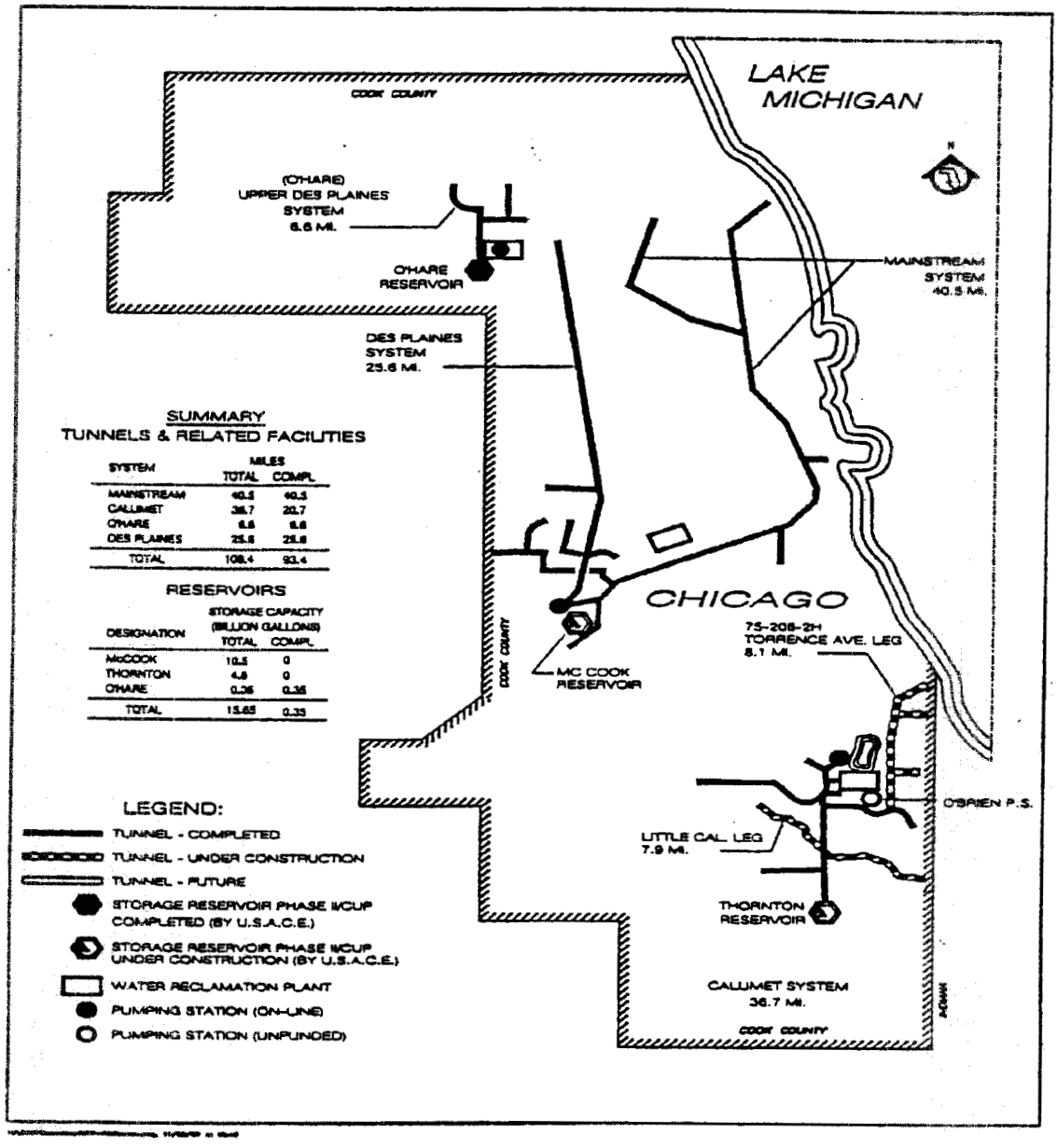
During normal dry weather conditions, a small amount of groundwater infiltrates the tunnels due to a naturally higher pressure gradient favoring the groundwater table. However, during a major storm, the tunnels may become full with CSOs, producing an internal pressure that causes exfiltration of small amounts of CSOs into the surrounding groundwater. After the storm subsides and the TARP tunnels have been dewatered, infiltration occurs, and small amounts of the surrounding groundwater are drawn into the tunnel. Groundwater monitoring wells have been installed to verify the infiltration/exfiltration process, which may occur in strategic locations of the TARP tunnel operation, and that the TARP system is not adversely affecting the local groundwater.

The TARP groundwater monitoring program currently includes 128 monitoring wells and 34 observation wells in the Calumet, Mainstream, Des Plaines, Upper Des Plaines, and Chicagoland Underflow Plan (CUP) Reservoir systems (Figure 23). Of the 128 water quality monitoring wells, 119 are currently

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 23

LOCATION OF TARP TUNNELS



being monitored. The remaining nine wells (QM-51, QM-52, QM-54, QM-55, QM-57, QM-59, QM-60, QM-66, and QC-8.1), are not required to be monitored. Four of the 119 monitoring wells are located around the perimeter of the O'Hare Reservoir, and another four monitoring wells are located on the perimeter of the Thornton Transitional Reservoir which anchors the Calumet TARP system. The Little Calumet leg of the Calumet TARP system (QC-29 through QC-37) has not been completed yet, but it is expected to go on line in spring or summer of 2004. The remaining TARP wells are located alongside of the 101.5 miles completed portion of the TARP tunnel system.

The IEPA gave the District permission to monitor 15 Mainstream TARP System Wells (QM-53, QM-56, QM-58, QM-68, and QM-70 through QM-82 excluding wells QM-72 and QM-81) at a reduced rate of twice times per year from six times per year. The same reduced sampling frequency was also granted for nine Calumet TARP system wells (QC-2.2, QC-9, QC-11 through QC-15, QC-17, and QC-18), and eleven Des Plaines TARP system wells (QD-34, QD-39 through QD-45, and QD-47 through QD-49). Also the IEPA gave the District permission to reduce monitoring of the Mainstream observation wells (OM-1 through OM-23) from once every two weeks to once every two months.

The water quality wells are sampled for the following parameters: ammonia nitrogen, electrical conductivity, chloride, fecal coliform bacteria, hardness, pH, sulfate, temperature, total organic carbon, and total dissolved solids. Water level elevation is measured at all TARP wells. Data collected from the TARP wells are submitted annually to the IEPA.

The overall results obtained from regularly monitoring and sampling TARP wells indicate that operation of TARP tunnels and reservoirs has had no adverse effect on local groundwater system.

Thornton Transitional Flood Control Reservoir Preoperational Background Water Quality Report

According to the Scope of Work (SOW) specified by the IEPA, for twelve months prior to the Thornton Reservoir going on-line, samples shall be collected approximately every two months from the groundwater monitoring wells for background data collection. These samples shall be analyzed for parameters listed in Table I of the IEPA's SOW and used to determine the upper 95 percent confidence limit for each parameter. The parameters from Table I of the IEPA's SOW are reproduced in Table 26.

After the Thornton Reservoir goes on-line event based monitoring shall be conducted for the indicator parameters in

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 26

GROUNDWATER QUALITY STANDARDS FOR CLASS I:
POTABLE RESOURCE GROUNDWATER

Inorganic Chemical Constituents

Arsenic
Barium
Cadmium
Chloride
Chromium
Copper
Cyanide
Fluoride
Iron
Lead
Manganese
Mercury
Nitrate as N
Radium-226
Radium-228
Selenium
Silver
Sulfate
Total Dissolved Solids (TDS)
pH

Organic Chemical Constituents

Alachlor
Aldicarb
Atrazine
Carbofuran
Carbon Tetrachloride*
Chlordane*
Endrin
Heptachlor*
Heptachlor Epoxide*
Lindane (Gamma-Hexachlorocyclohexane)
2,4,D
Ortho-Dichlorobenzene
Para-Dichlorobenzene
1,2 Dichloroethane*
1,1 Dichloroethylene
Trans 1,2-Dichloroethylene
1,2 Dichloropropane*
Ethylbenzene
Methoxychlor
Monochlorobenzene
Pentachlorophenol*
Polychlorinated Biphenyls (PCBs) (as decachloro-biphenyl)*
Styrene
2,4,5-TP (Silvex)
Tetrachloroethylene*
Toluene
Toxaphene*
1,1,1-Trichloroethane
Trichloroethylene*
Vinyl Chloride*
Xylenes

Complex Organic Chemical Mixtures

Benzene*
BETX

*Denotes a carcinogen.

Table II from the IEPA's SOW on a weekly basis while floodwater is stored in the Thornton Reservoir. The parameters from Table II of the IEPA's SOW are reproduced in Table 27. This will include grab sampling of floodwater stored in the Thornton Reservoir, in addition to samples collected from the groundwater monitoring wells.

During the storage of floodwater in the Thornton Reservoir, if an analysis of samples collected from the groundwater monitoring wells shows an increase above the 95 percent confidence limit of any of the indicator parameters in Table 27, the parameters list shall be expanded to include all the parameters in Table 26 and weekly sampling shall continue until the concentrations of all parameters in Table 26 are below the 95 percent confidence limit.

The Preoperational Background Water Quality Report on the Thornton Transitional Flood Control Reservoir was prepared and submitted to the IEPA in December 2003 (R&D Department Report No. 03-23).

Thornton Transitional Flood Control Reservoir Fill Events for 2003

According to the IEPA's Scope of Work (SOW) after the reservoir goes on line, event based sampling shall be conducted for the indicator parameters, specified in the IEPA's

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 27

CONSTITUENTS COMMONLY FOUND IN STORMWATER
FROM TABLE II OF THE IEPA'S SCOPE OF WORK

Arsenic	Ammonia
Boron	Barium
Copper	Cadmium
Fecal Coliform	Chromium
Iron	Cyanide
Lead	Fluoride
Mercury	Manganese
Phenols	Nickel
Sulfate	Temperature
Total Dissolved Solids	Nitrate

Biochemical Oxygen Demand (5-day and 21-day)

SOW Table II reproduced here as Table 24, on a weekly basis while floodwater is stored in the reservoir. This will include floodwater stored in the reservoir in addition to samples collected from the groundwater quality monitoring wells (QT-1 through QT-4). A report is prepared to fulfill the IEPA requirements for the Thornton Transitional Flood Control Reservoir fill events that took place during 2003.

There were a total of three fill events at the Thornton Transitional Flood Control Reservoir during 2003. The events took place on July 21, July 27 and November 18, 2003.

The first fill event took place on July 21, 2003. This fill event resulted in only a small amount of water in the Thornton Reservoir. The second fill event took place on July 27, 2003, while there was water still in the Thornton Reservoir from the first fill event. On September 4, 2003, IWD personnel reported that the Thornton Reservoir was empty at which time sampling at both the Thornton Reservoir and water quality monitoring wells was discontinued.

The third fill event took place on November 18, 2003. The maximum depth in the Thornton Reservoir was estimated to between five and six feet. On December 2, 2003, the Thornton Reservoir was reported dry by IWD personnel.

In all three fill events samples were collected from the Thornton Reservoir and the four water quality monitoring wells (QT-1, QT-2, QT-3, and QT-4) surrounding the Thornton Reservoir.

A separate report for the three fill events experienced at the Thornton Transitional Flood Control Reservoir during 2003 is under preparation and will be published as an R&D Department report.

BIOSOLIDS UTILIZATION AND SOIL SCIENCE SECTION

The Biosolids Utilization and Soil Science Section is responsible for determining, through monitoring and research activities, the environmental impact of the District's biosolids applications on agricultural fields, disturbed lands, and landfill sites. The environmental monitoring component of the program includes the sampling and analyses of waters, soils, plants, and biosolids at land application sites and landfills receiving biosolids. The research component consists of an in-depth examination of the selected environmental and biosolids parameters related to the application of biosolids to agricultural fields, disturbed lands, and their utilization in landfills and for landscaping.

Fulton County Environmental Monitoring

The Fulton County Land Reclamation Site is a large tract of land, 6122.5 hectares (15,264.5 acres), owned by the District in Fulton County, Illinois. The site is used to recycle biosolids for the purpose of reclaiming mine soil and fertilizing agricultural crops. To satisfy the permit requirements of the IEPA for operation of the site, the District established an environmental monitoring program to ensure that the land application of biosolids would not adversely affect surface waters, groundwaters, soils, and

crops. The Land Reclamation Laboratory is responsible for collecting and analyzing environmental monitoring samples from the Fulton County Site. Monthly reports are generated that summarize the monitoring data required to demonstrate compliance with the IEPA, and USEPA regulations for land application of biosolids.

OVERVIEW

In 2003, the monitoring activities at the Fulton County site decreased in quantity from those in 2002 due to IEPA reductions in surface water protection sites (from 14 to 2) and a reduction to quarterly, instead of monthly, sampling of the St. David, Morgan Mine, and United Electric Company coal refuse piles. Also, monitoring was only required of biosolids-amended fields that were bermed. No supernatant or dewatered liquid fertilizer from Holding Basin 1 were applied to Fulton County fields during 2003. Air-dried, anaerobically digested biosolids from the District's Calumet WRP were trucked to the Fulton County site in 2003 and land-applied.

The water monitoring included:

- quarterly sampling of 20 groundwater monitoring wells;

- sampling of surface waters from 10 streams, 8 reservoirs, and 2 surface water protection sites in the supernatant application area three times per year between April and November;
- sampling of 40 field runoff retention basins as needed;
- sampling of 19 lysimeters and three drainage tiles at the St. David Coal Refuse Pile quarterly;
- sampling of three lysimeters at the Morgan Mine Coal Refuse Pile quarterly; and
- sampling of 10 lysimeters at the United Electric Company (UEC) Coal Refuse Pile quarterly.

Water monitoring also included sampling of the discharges from the Acid-Mine Lake receiving drainage from the UEC Coal Refuse Pile for monthly and quarterly reports.

GENERAL APPLICATION FIELDS

Soil samples were collected from 73 fields in 2002 and 46 fields in 2003 for chemical analysis. Plant tissue samples were collected from 26 hay fields, 37 soybean fields, and 9 cornfields in 2002 and 23 hay fields, 29 soybean fields, 28 cornfields, 3 sudax fields, and 1 wheat field in 2003. Chemical analyses were performed on these samples during 2003.

Climatological conditions were monitored at the project weather station.

Biosolids have been applied to fields at the Fulton County site since 1972. Tables 28 and 29 show the concentrations of all measured parameters found in field soils (0- to 15-cm depth), which received different cumulative rates of biosolids, and were sampled in 2002 and 2003, respectively. The crops planted on these fields and yields for 2002 and 2003 are shown in Tables 30 and 31, respectively.

Plant tissue samples (grain, leaf, and/or stover) are collected annually from fields leased to local farmers at the Fulton County site. Analyses for the total concentrations of metals found in the 2002 corn grain, corn leaf, hay, and soybean grain, are shown in Tables 32 through 35, respectively. Analyses for the total concentrations of metals found in the 2003 corn grain, corn leaf, hay, soybean grain, sudax, and wheat grain are shown in Tables 36 through 41, respectively.

ACID-MINE LAKE

As part of the purchasing agreements for the parcels of land comprising the Fulton County Land Reclamation Project, the District also took ownership of the old UEC Cuba Mine No. 9 site, which included an impoundment that collected surface water from exposed gob and coal fines areas. This Acid-Mine

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2002[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2-N+ NO_3-N[3]	Zn[5]	Cd[5]	Cu[5]	Cr[5]	Ni[5]	Pb[5]
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
1	1,643	734	6.8	0.29	6.52	5,896	10,071	6.6	16	1,193	72	582	924	140	291
2	1,816	810	6.9	0.24	5.79	5,288	10,689	4.8	11	1,110	64	508	799	130	269
3	1,722	769	6.9	0.22	6.65	6,214	8,267	6.9	17	864	46	411	615	101	200
4	1,522	680	6.9	0.20	5.59	4,840	8,039	4.6	14	930	52	442	675	113	215
5	1,469	656	6.9	0.22	6.38	5,403	8,811	4.8	14	903	50	429	658	110	210
6	614	274	7.5	0.15	2.95	2,561	2,435	2.8	3.4	290	16	126	213	50	66
7E	1,494	667	7.0	0.16	5.38	4,354	7,027	3.7	11	927	59	457	734	120	227
7W	1,494	667	7.5	0.15	2.82	1,929	2,985	2.6	5.7	389	23	174	291	60	92
8	1,320	589	6.9	0.19	5.42	3,904	8,446	4.4	17	967	60	468	758	118	238
9	1,519	678	7.2	0.17	5.95	4,427	7,287	5.0	12	835	45	379	578	98	185
10	1,073	479	6.8	0.14	5.26	4,473	8,838	4.4	15	1,134	75	546	931	128	294

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2002[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N^3	NO_2-N+ NO_3-N^3	Zn^5	Cd^5	Cu^5	Cr^5	Ni^5	Pb^5
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
11	1,485	663	7.1	0.16	5.14	4,427	7,876	3.7	13	1,056	66	474	806	130	267
12	1,398	624	7.3	0.16	4.74	3,545	6,747	3.6	9.0	828	50	370	614	101	200
13	1,269	566	7.0	0.14	5.34	4,385	8,496	4.8	8.5	1,082	68	498	824	119	266
14	1,387	619	6.9	0.25	5.51	4,761	9,521	7.2	13	973	56	435	698	110	233
15	1,360	607	6.9	0.34	5.01	4,006	7,568	6.0	12	920	51	394	635	98	218
16E	1,510	674	7.0	0.16	4.28	3,728	6,318	4.3	11	759	46	344	576	89	186
16W	1,510	674	7.1	0.14	4.26	3,816	7,836	4.8	13	866	54	396	658	100	216
17	1,631	728	7.1	0.17	6.17	5,887	10,036	5.0	14	1,103	63	517	789	124	251
18[4]	1	0.5	7.7	0.22	1.48	1,207	505	3.2	6.6	73	1.1	18	23	24	14
19	644	287	7.0	0.10	3.29	2,517	3,777	3.6	8.0	526	33	240	448	59	147
20	531	237	6.8	0.11	4.71	3,619	5,730	5.6	11	758	49	354	627	85	200

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2002[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2-N+ NO_3-N[3]	Zn[5]	Cd[5]	Cu[5]	Cr[5]	Ni[5]	Pb[5]
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
21	618	276	6.9	0.12	3.63	2,824	5,077	6.2	10	745	48	332	605	81	198
22	455	203	6.9	0.13	4.34	3,570	6,511	6.0	10	889	59	417	749	98	242
23	473	211	6.9	0.12	3.82	3,442	5,153	6.1	8.2	724	46	329	589	84	191
24	1	0.5	7.8	0.15	1.20	1,252	447	2.3	6.2	64	1.2	19	27	28	12
25	869	388	6.9	1.12	5.92	4,414	6,560	4.5	18	887	47	360	603	90	216
26	1,086	485	7.2	0.40	4.79	3,907	6,372	4.5	18	807	46	336	570	93	192
27	847	378	7.1	0.14	4.73	3,893	7,146	5.4	8.6	906	57	400	699	99	228
28	903	403	7.2	0.17	5.12	4,416	7,407	5.5	12	961	60	457	750	121	235
29[4]	1	0.5	7.9	0.14	1.20	1,139	560	3.4	4.3	75	1.2	16	24	26	13
30	1,169	522	7.2	0.20	5.69	5,010	8,202	5.2	25	962	52	410	649	109	213
31	557	249	7.0	0.11	3.32	2,944	5,041	5.2	9.4	711	45	319	559	87	176

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2002[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N^3	NO_2-N+ NO_3-N^3	Zn^5	Cd^5	Cu^5	Cr^5	Ni^5	Pb^5
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
32	476	213	7.3	0.16	4.60	3,845	5,996	5.6	8.8	748	43	318	536	96	173
33	986	440	7.3	0.23	6.19	5,222	8,932	6.2	17	1,017	59	475	748	120	229
34	566	253	7.0	0.14	3.64	3,110	5,654	4.4	11	733	47	340	598	85	188
35	1,048	468	7.1	0.20	4.98	4,591	8,197	6.3	14	865	50	376	623	90	201
36	1,083	483	6.9	0.19	4.81	4,125	8,084	5.8	12	966	58	428	722	101	225
37	801	358	7.0	0.19	4.52	3,788	6,982	5.7	13	808	49	359	615	92	190
38A	9	4	7.4	1.18	1.14	960	942	1.4	2.1	136	1.7	23	33	43	24
38C	9	4	7.9	0.23	1.12	1,121	606	1.6	5.6	76	1.4	18	29	30	15
39	559	249	6.9	0.69	4.11	3,909	5,203	8.4	25	638	32	266	411	76	137
40	497	222	6.8	0.27	4.25	3,362	5,490	9.0	67	718	46	334	579	90	180
41	870	388	7.0	0.48	5.45	4,808	7,120	6.8	21	688	30	275	385	69	138

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2002[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N^3	NO_2-N+ NO_3-N^3	Zn[5]	Cd[5]	Cu[5]	Cr[5]	Ni[5]	Pb[5]
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
42	782	349	7.0	0.28	4.38	3,854	7,157	3.6	18	875	54	392	665	99	208
43	908	405	6.9	0.48	5.47	5,096	7,924	6.8	28	770	39	330	496	79	168
44	715	319	6.9	0.36	4.62	3,765	5,812	5.5	16	761	45	339	562	91	176
45	746	333	7.1	0.45	4.81	4,149	6,809	4.2	18	723	38	318	472	78	155
47	1,029	459	6.6	0.82	7.17	5,976	9,975	7.4	52	1,186	60	490	750	114	245
50[4]	7	3	7.1	0.49	1.27	1,422	453	2.8	88	52	1.1	15	25	25	11
51	46	20	7.4	0.17	1.40	1,276	891	4.4	3.0	111	3.3	33	52	24	30
52[4]	9	4	6.7	0.25	1.13	1,193	456	2.8	24	67	1.2	17	27	28	12
53	5	2	7.6	0.43	2.05	1,815	496	2.2	2.2	55	1.1	19	25	27	11
54	14	6	7.4	0.46	1.86	1,757	635	2.1	60	85	1.4	25	28	40	16
55	9	4	6.5	0.63	1.96	1,881	586	3.6	115	77	1.5	22	26	38	18

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2002[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N^3	NO_2-N+ NO_3-N^3	Zn^5	Cd^5	Cu^5	Cr^5	Ni^5	Pb^5
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
56	13	6	7.6	0.58	1.71	1,626	544	2.4	66	63	1.2	20	25	36	15
57	3	1	7.7	0.20	1.49	1,416	520	1.5	2.0	54	1.1	21	24	29	7.6
58	5	2	7.9	0.23	1.53	1,716	493	0.15	5.5	57	1.0	20	23	30	6.9
59	2	1	6.4	0.36	1.43	1,325	395	11	48	50	0.73	10	18	15	16
60	3	1	7.8	0.20	1.51	1,403	443	0.80	7.6	52	1.0	17	22	25	9.8
61	2	1	7.8	0.56	1.41	1,329	451	1.2	6.3	59	1.2	21	28	34	10
62	5	2	7.5	0.18	1.49	1,311	455	1.6	3.8	59	1.2	19	29	31	11
63	22	10	7.5	0.26	1.86	1,631	477	2.6	11	61	1.2	19	30	33	10
64	2	1	7.7	0.51	1.48	1,151	562	2.4	3.6	91	1.4	20	29	40	17
65[4]	0.4	0.2	7.6	0.89	1.27	1,004	545	2.8	5.4	88	1.5	22	29	43	15
73[4]	0	0	7.8	0.21	1.29	1,108	466	2.7	6.3	66	1.4	16	30	28	12

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2002[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N^3	NO_2-N+ NO_3-N^3	Zn^5	Cd^5	Cu^5	Cr^5	Ni^5	Pb^5
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
75	336	150	7.0	0.16	1.81	1,379	1,882	2.4	34	292	11	118	229	46	76
76[4]	0	0	7.2	0.16	1.09	804	361	1.8	7.6	50	1.0	12	25	25	9.8
80[4]	0	0	5.1	0.11	1.14	970	355	7.1	20	49	0.68	5.5	17	17	15
81[4]	0	0	6.1	0.12	2.15	1,603	401	3.0	18	47	0.63	6.5	17	16	14
82[4]	0	0	5.6	0.17	1.09	992	377	3.2	17	50	0.77	6.8	19	16	16
83[4]	0	0	6.3	0.17	1.58	1,330	391	3.2	19	54	0.79	5.4	15	13	20
84[4]	0	0	7.7	0.12	1.15	1,106	420	2.5	12	80	1.2	15	26	26	13

[1]Sampling depth 0-15 cm.
[2]Through 2002.
[3]1-M KCl-extractable.
[4]Only commercial fertilizer was applied to this field.
[5]These metals extracted with concentrated HNO_3.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 29

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR BERMED BIOSOLIDS APPLICATION FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2003[1]

Field Number	Cumulative Biosolids Applied[2]		PH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N^3	NO_2-N+ NO_3-N^3	Zn^6	Cd^6	Cu^6	Cr^6	Ni^6	Pb^6
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
1	1,643	734	6.9	0.20	7.32	4,365	8,805	5.7	16	904	56	450	694	106	217
2	1,816	810	6.6	0.68	6.99	5,316	10,884	2.8	138	906	51	418	618	98	209
3	1,722	769	6.9	0.11	7.70	5,554	8,449	5.4	14	848	48	415	622	91	201
4	1,522	680	6.7	0.44	6.56	5,551	8,685	6.0	124	816	45	392	580	92	186
5	1,562	698	6.8	0.24	6.81	4,954	8,623	4.6	30	802	44	399	565	90	180
6	614	274	7.4	0.11	2.98	2,343	3,112	1.4	2.7	298	18	136	222	47	69
7E	1,494	667	6.7	0.91	5.90	4,959	7,724	3.4	175	851	53	425	657	97	203
7W	1,494	667	7.1	0.27	3.90	2,989	3,684	4.4	124	372	20	169	255	49	83
8	1,320	589	6.7	0.36	5.68	4,684	8,571	2.6	132	801	48	402	596	89	189
9	1,602	716	7.0	0.15	6.12	4,448	7,463	0.45	17	712	39	351	509	81	157
10	1,073	479	6.5	0.16	6.81	5,110	10,698	5.0	25	1,154	78	622	975	122	293

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 29 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR BERMED BIOSOLIDS APPLICATION FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2003[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2-N+ NO_3-N[3]	Zn[6]	Cd[6]	Cu[6]	Cr[6]	Ni[6]	Pb[6]
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
11	1,485	663	6.9	0.14	5.74	4,307	7,580	15	60	888	56	431	691	103	226
12	1,398	624	7.0	0.29	5.41	4,059	7,521	25	88	813	51	402	618	93	198
13	1,269	566	7.0	0.12	5.63	4,036	8,384	2.3	7.6	898	58	432	693	95	223
14	1,387	619	6.9	0.17	5.45	3,786	7,510	3.1	8.0	834	50	393	631	91	205
15	1,360	607	7.0	0.23	5.36	4,130	7,854	3.0	24	932	48	384	581	86	194
16E	1,510	674	6.9	0.16	4.68	3,574	6,353	18	51	720	46	347	565	82	181
16W	1,510	674	7.0	0.18	4.44	3,669	6,702	12	53	730	46	353	565	81	181
17	1,722	770	7.0	0.20	6.41	5,545	10,957	4.4	26	1,035	61	514	736	114	240
19	644	287	6.7	0.19	3.62	2,935	5,091	3.6	71	598	40	289	523	62	165
20	531	237	6.8	0.14	4.80	3,710	5,976	4.2	17	689	46	335	573	74	180
21	618	276	6.9	0.17	3.01	2,662	4,177	4.8	58	546	36	248	439	60	142

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 29 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR BERMED BIOSOLIDS APPLICATION FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2003[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N^3	NO_2-N+ NO_3-N^3	Zn^6	Cd^6	Cu^6	Cr^6	Ni^6	Pb^6
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
22	455	203	6.8	0.79	3.96	3,181	5,722	4.5	61	682	46	333	575	73	184
23	473	211	6.8	0.18	3.59	2,918	4,501	5.2	56	588	39	279	481	67	154
25	869	388	7.0	0.69	6.17	4,432	7,234	3.2	14	842	46	362	574	85	200
26	1,086	485	7.1	0.44	5.17	3,849	6,914	2.9	12	811	49	374	588	92	192
27	847	378	6.7	1.21	5.44	5,171	8,505	183	251	826	48	371	582	84	198
28	903	403	7.1	0.35	5.70	4,624	7,493	2.8	62	846	52	419	644	103	203
30	1,169	522	7.2	0.29	5.00	4,747	7,626	2.6	14	756	38	327	471	81	160
31	557	249	6.9	0.15	2.81	2,846	4,814	4.0	12	610	40	285	483	71	151
32	476	213	7.1	0.15	3.95	3,654	6,271	2.4	1.8	705	42	320	520	85	165
33	986	440	7.0	0.17	5.77	5,170	10,153	4.3	3.5	1,062	64	532	804	118	244
34	566	253	6.8	0.17	3.26	3,093	5,789	3.2	22	680	45	321	558	77	174

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 29 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR BERMED BIOSOLIDS APPLICATION FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2003[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N^3	NO_2-N+ NO_3-N^3	Zn^6	Cd^6	Cu^6	Cr^6	Ni^6	Pb^6
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
35	1,048	468	6.7	0.53	4.36	4,268	7,287	8.0	131	750	44	343	560	76	181
36	1,083	483	6.8	0.33	4.26	4,055	6,624	5.8	73	735	44	340	557	77	176
37	801	358	6.8	0.41	3.86	3,634	5,654	5.8	88	694	42	318	524	76	162
39	559	249	7.1	0.37	3.24	3,790	5,391	3.6	36	576	31	258	402	68	127
40	497	222	6.7	0.16	3.94	3,728	6,321	3.8	23	726	48	353	594	83	182
41	870	388	7.0	0.44	5.31	5,499	7,837	5.2	55	663	29	280	374	63	135
42	858	384	7.0	0.22	4.04	3,993	7,567	3.2	19	855	55	403	662	93	206
43	908	405	6.9	0.57	4.77	4,905	7,877	6.7	57	754	41	346	516	77	170
44	715	319	6.9	0.29	3.98	3,981	6,659	3.5	28	712	44	347	548	84	168
45	1659	741	7.0	0.29	4.32	4,158	6,953	2.9	16	691	41	337	514	77	159
47	1029	459	6.6	0.49	5.62	4,959	8,377	5.6	40	995	54	437	686	101	218

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 29 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS FOR BERMED BIOSOLIDS APPLICATION FIELDS AT THE FULTON COUNTY RECLAMATION SITE SAMPLED IN 2003[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N^3	NO_2-N+ NO_3-N^3	Zn^6	Cd^6	Cu^6	Cr^6	Ni^6	Pb^6
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	Tons/acre													
63-8[4]	22	10	7.3	0.17	4.38	2,011	485	5.7	5.9	53	1.1	18	25	26	10
83[4,5]	0	0	6.0	0.12	1.10	1,225	422	3.8	12	48	0.76	7.0	14	12	16

[1]Sampling depth 0-15 cm.
[2]Through 2003.
[3]1-M KCl-extractable.
[4]Fields included because of P-study.
[5]Only commercial fertilizer was applied to this field.
[6]These metals extracted with concentrated HNO^3.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 30

2002 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	Bu/acre	bu/acre
		Mg/ha	Tons/acre			
5	MS	1,469	656		47	
9	MS	1,519	678		47	
11	MS	1,485	663		29	
12	MS	1,398	624		31	
16E	1/4 MS	1,510	674		39	
16W	1/4 MS	1,510	674		37	
17	MS	1,631	728		47	
18	1/2 MS	1	0.5		36	
19	PL	644	287		65	
20	PL	531	237	175		

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 30 (Continued)

2002 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	Bu/acre	bu/acre
		Mg/ha	Tons/acre			
21	PL	618	276		65	
22	PL	455	203		65	
23	PL	473	211		65	
24	MS	1	0.5		24	
25	PL	869	388		30	
26	PL	1,086	485		32	
30	MS	1,169	522		37	
31	PL	557	249		71	
34	PL	566	253		68	
38A	MS	9	4		15	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 30 (Continued)

2002 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	Bu/acre	bu/acre
		Mg/ha	Tons/acre			
38C	MS	9	4		32	
39	MS	559	249		30	
40	1/5 MS	497	222	140		
41	MS	870	388		35	
42	MS	782	349		38	
43	MS	908	405		30	
44	MS	715	319		33	
45	3/4 MS	746	333		45	
47	MS	1,029	459		30	
50	7/8 MS	7	3	121		

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 30 (Continued)

2002 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	Bu/acre	bu/acre
		Mg/ha	Tons/acre			
51	1/4 MS	46	20		25	
52	MS	9	4	121		
54	MS	14	6	118		
55	MS	9	4	118		
56	MS	13	6	118		
59	PL	2	1	110		
60	MS	3	1		32	
61	MS	2	1		32	
63-1-1	MS	22	10		32	
64	MS	2	1		32	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 30 (Continued)

2002 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	Bu/acre	bu/acre
		Mg/ha	Tons/acre			
65	MS	0.4	0.2		32	
75	MS	336	150	75		
80	MS	0	0		45	
82	MS	0	0		45	
83	MS	0	0		39	
84	MS	0	0		39	

[1]MS = mine-spoil; fractions appearing before MS indicate the proportion of the field that consists of mine-spoil with the remainder of the surface being placed land. PL = placed land indicating that the field has not been strip mined.
[2]Through 2002.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 31

2003 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------				
		Mg/ha	tons/acre	bu/acre	bu/acre	bu/acre
2	MS	1,816	810		41	
3	MS	1,722	769		13	
4	MS	1,522	680		41	
7E	MS	1,494	667	140		
7W	MS	1,494	667	140		
8	MS	1,320	589	140		
11	MS	1,486	663	120		
12	MS	1,397	624	120		
13	MS	1,269	566		16	
14	MS	1,387	619		18	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 31 (Continued)

2003 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	bu/acre	bu/acre
		Mg/ha	Tons/acre			
15	MS	1,360	607		17	
16E	1/4 MS	1,510	674	160		
16W	1/4 MS	1,510	674	160		
18	1/2 MS	1	0.5	160	37	
19	PL	644	287	160		
20	PL	531	237		46	
21	PL	618	276	160		
22	PL	455	203	160		
23	PL	473	211	160		
24	MS	1	0.5	110		

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 31 (Continued)

2003 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	bu/acre	bu/acre
		Mg/ha	Tons/acre			
25	MS	869	388		20	
26	MS	1,087	485		18	
27	2/3 MS	847	378	115		
28	MS	903	403	117		
29	MS	1	0.5		14	
30	MS	1,169	522		28	
31	PL	557	249	158		
34	PL	566	253	161		
35	PL	1,048	468	150		
36	PL	1,083	483	150		

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 31 (Continued)

2003 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	bu/acre	bu/acre
		Mg/ha	Tons/acre			
37	PL	801	358		40	
38A	MS	9	4		15	
38C	MS	9	4		29	
39	MS	559	249		30	
40	1/2 MS	497	222		44	
41	MS	870	388		22	
43	MS	908	405		18	
44	MS	715	319		19	
47	MS	1,029	459		16	
50	5/6 MS	7	3		21	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 31 (Continued)

2003 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	bu/acre	bu/acre
		Mg/ha	Tons/acre			
51	1/4 MS	46	20		25	
52	MS	9	4		20	
54	MS	14	6		37	
55	MS	9	4		32	
56	MS	13	6		37	
59	PL	2	1		33	
60	MS	3	1	18		
61	MS	2	1	18		
63-1-1	MS	22	10	18		
63-8	MS	22	10			45

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 31 (Continued)

2003 FULTON COUNTY CROP YIELD DATA

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn	Soybeans	Wheat
		------Dry Solids------		bu/acre	bu/acre	bu/acre
		Mg/ha	Tons/acre			
64	MS	2	1	18		
65	MS	0.4	0.2	18		
75	MS	336	150		25	
80	PL	0	0	111		
82	PL	0	0	146		
83	PL	0	0	155		
84	MS	0	0	150		

[1] MS = mine-spoil; fractions appearing before MS indicate the proportion of the field that consists of mine-spoil with the remainder of the surface being placed land. PL = placed land indicating that the field has not been strip mined.

[2] Through 2003

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 32

MEAN CONCENTRATIONS OF METALS IN CORN GRAIN SAMPLES COLLECTED FROM THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
20	24	<0.01	1.0	0.10	0.42	<0.10	3,904	36	1,439
40	31	0.07	2.4	0.13	0.84	<0.10	4,279	43	1,241
50	27	<0.01	3.0	0.12	0.20	<0.10	3,690	32	1,254
52	26	<0.01	1.8	0.10	0.14	<0.10	3,629	45	1,269
54	28	<0.01	1.1	0.11	0.48	0.10	3,966	32	1,414
55	31	<0.01	1.2	0.14	0.70	<0.10	3,855	33	1,386
56	28	<0.01	1.2	0.26	0.68	<0.10	3,947	33	1,396
59	25	<0.01	1.8	0.21	0.55	<0.10	4,151	48	1,265
75	28	<0.01	1.3	0.10	0.27	<0.10	3,645	38	1,330

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 33

MEAN CONCENTRATIONS OF METALS IN CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
20-1	70	3.7	9.6	0.38	0.32	<0.20	17,520	7,174	3,309
20-2	124	5.1	22	0.56	1.0	<0.20	18,390	7,037	3,074
40-1	118	9.5	16	0.46	0.48	<0.20	18,100	5,158	2,196
40-2	92	6.9	16	0.24	0.12	<0.20	16,870	7,209	2,857
50-1	197	11	28	0.37	0.44	<0.20	16,550	8,039	3,757
50-2	151	8.3	23	0.48	0.19	<0.20	20,110	7,277	3,621
52-1	110	5.6	19	0.35	0.24	<0.20	20,320	6,879	2,604
52-2	117	3.1	15	0.44	0.30	<0.20	24,630	6,309	2,692
54-1	123	7.4	16	0.42	0.63	<0.20	20,600	5,913	3,433
54-2	171	8.9	18	0.72	0.46	<0.20	21,990	5,745	2,870

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 33 (Continued)

MEAN CONCENTRATIONS OF METALS IN CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
55-1	21	0.10	7.8	0.18	0.06	<0.20	14,920	6,152	3,838
55-2	19	0.14	7.8	0.22	0.21	<0.20	11,090	7,116	5,881
56-1	92	6.7	11	0.36	0.44	<0.20	18,020	6,241	3,228
56-2	57	3.7	11	0.36	0.25	<0.20	11,790	6,376	6,008
59-1	64	5.1	9.6	0.31	0.24	<0.20	18,830	5,753	2,373
59-2	67	6.3	10	0.27	0.20	<0.20	14,720	6,759	4,268
75-1	79	6.5	11	0.32	0.35	<0.20	20,890	5,057	2,336
75-2	78	5.6	12	0.28	0.30	<0.20	15,620	5,967	4,338

[1] Fields are broken down into two sections each for leaf sampling.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 34

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
10-1	1	102	4.45	8.4	2.6	7.1	<0.10	27,682	8,194	1,862
10-2	1	106	4.83	10	0.38	5.0	<0.10	27,007	4,563	1,981
15[1]	1	88	4.64	7.3	0.21	0.62	<0.10	15,641	2,554	2,797
29-1	1	16	<0.01	7.3	0.10	0.83	<0.10	20,958	9,037	2,311
29-2	1	19	<0.01	7.2	0.09	0.40	<0.10	19,122	8,705	2,370
62-1	1	14	<0.01	3.5	0.13	0.29	<0.10	15,290	3,628	1,393
62-2	1	14	<0.01	5.8	0.11	0.50	<0.10	14,677	9,437	2,296
63-1-2	1	20	<0.01	6.1	0.32	0.60	<0.10	14,502	6,982	2,650
63-2-1	1	20	<0.01	5.4	0.11	0.33	<0.10	14,315	4,900	2,309
63-2-2	1	13	<0.01	4.2	0.10	0.32	<0.10	13,411	4,114	1,876

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 34 (Continued)

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED
AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
63-3-1	1	18	0.04	6.1	0.10	0.92	<0.10	16,692	6,267	1,720
63-3-2	1	21	0.02	6.6	0.11	0.88	<0.10	19,001	7,187	1,601
63-4-1	1	20	<0.01	6.0	0.13	0.96	<0.10	13,798	7,391	1,956
63-4-2	1	15	<0.01	6.5	0.13	0.60	<0.10	19,114	7,659	1,837
63-5-1	1	19	<0.01	7.3	0.12	1.3	<0.10	20,454	10,192	2,059
63-5-2	1	26	<0.01	8.6	0.38	0.62	<0.10	23,439	7,214	2,043
63-6-1	1	13	<0.01	6.3	0.13	0.63	<0.10	15,574	8,984	2,723
63-6-2	1	17	<0.01	6.2	0.14	0.74	<0.10	19,678	7,204	2,273
63-7-1	1	14	<0.01	6.1	0.21	0.52	<0.10	18,690	8,979	2,243
63-7-2	1	12	<0.01	5.1	0.10	0.44	<0.10	15,149	5,272	1,703

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 34 (Continued)

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED
AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
63-8-1	1	18	<0.01	7.4	0.06	0.84	<0.10	26,771	9,280	2,470
63-8-2	1	14	<0.01	4.7	<0.04	0.29	<0.10	15,807	5,774	1,780
73-1	1	18	<0.01	6.0	<0.04	0.82	<0.10	16,651	6,825	1,727
73-2	1	18	<0.01	6.3	0.38	0.94	<0.10	17,710	9,741	1,780
76-1	1	20	<0.01	7.2	0.12	0.97	<0.10	12,536	10,263	2,989
76-2	1	18	<0.01	7.4	0.11	0.86	<0.10	14,195	10,856	2,494
10-1	2	91	4.1	11	4.2	11	0.65	19,476	12,135	4,421
10-2	2	143	7.6	18	7.8	9.3	2.00	29,035	6,285	3,700
62-1	2	17	<0.01	9.1	0.14	0.87	<0.10	18,955	13,600	2,969
62-2	2	18	<0.01	9.9	0.14	0.78	<0.10	16,323	13,491	3,520

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 34 (Continued)

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED
AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
63-2-1	2	26	<0.01	10	0.14	0.84	<0.10	21,907	9,790	3,159
63-2-2	2	23	<0.01	11	0.13	0.72	<0.10	20,108	9,317	2,454
63-4-2	2	17	<0.01	9.4	0.15	0.98	<0.10	19,010	13,050	2,976
63-6-1	2	19	<0.01	8.7	0.16	0.67	<0.10	17,616	9,097	2,833
63-6-2	2	23	<0.01	8.4	0.78	0.90	<0.10	10,027	10,635	2,752
63-7-1	2	15	<0.01	4.2	0.19	0.32	<0.10	20,260	4,560	1,907
63-7-2	2	24	<0.01	7.8	0.17	0.68	<0.10	23,124	8,149	1,682
63-8-1[2]	2	34	<0.01	4.8	0.25	0.38	<0.10	11,841	4,397	3,347
63-8-2[2]	2	34	<0.01	3.4	0.19	0.24	<0.10	8,766	4,240	3,244
73-1	2	27	0.02	9.8	0.23	0.95	<0.10	20,787	8,434	2,680

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 34 (Continued)

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED
AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
73-2	2	23	0.02	8.8	0.33	0.62	<0.10	27,121	10,098	2,386
76-1	2	21	<0.01	11	0.19	0.91	<0.10	18,744	13,555	3,522
76-2	2	21	<0.01	9.7	0.18	1.1	<0.10	20,256	12,484	3,563
10-1	3	95	4.7	11	3.8	11	0.40	30,885	11,054	3,647
63-6-1	3	21	<0.01	9.6	0.25	0.76	<0.10	23,470	9,952	3,541
63-6-2	3	22	<0.01	9.6	0.16	1.1	<0.10	22,145	9,756	3,672
63-7-1	3	23	<0.01	7.6	0.18	0.72	<0.10	23,616	7,956	2,710

[1] Sudax hay.
[2] Soybean hay.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 35

MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLED AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
5	65	1.1	13	0.27	10	<0.10	21,407	3,651	3,073
9	64	1.1	14	0.42	12	<0.10	21,132	3,268	3,009
11	67	1.5	15	0.24	13	<0.10	21,848	2,583	2,932
12	66	1.5	14	0.21	12	<0.10	22,029	2,583	2,916
16E	77	2.2	15	0.20	15	<0.10	20,560	2,838	2,997
16W	76	1.6	13	0.18	16	<0.10	19,420	3,161	2,950
17	63	1.1	14	0.26	12	<0.10	21,108	3,310	3,003
18	45	<0.01	14	0.24	12	<0.10	19,152	2,990	2,522
19	63	1.2	14	0.25	14	<0.10	20,137	2,409	2,825
21	58	0.68	14	0.22	13	<0.10	18,415	2,724	2,846

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 35 (Continued)

MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLED AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
22	83	2.1	13	0.24	15	<0.10	19,607	2,569	2,820
23	633	1.8	13	0.22	16	<0.10	20,297	2,643	2,889
24	53	<0.01	21	0.18	3.5	<0.10	19,152	2,727	2,832
25	68	1.5	16	0.46	9.4	<0.10	21,386	2,431	2,852
26	73	2.2	17	0.23	12	<0.10	22,608	2,616	2,971
30	66	0.68	18	0.22	6.4	<0.10	21,489	2,808	3,167
31	62	1.5	14	0.38	20	<0.10	21,380	3,021	3,213
34	65	1.7	13	0.58	12	<0.10	20,619	3,084	3,047
38A	71	1.9	17	0.31	11	<0.10	22,854	2,729	2,924
38C	630	0.04	20	0.30	5.2	<0.10	20,640	2,946	2,836

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 35 (Continued)

MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLED AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
39	69	1.03	16	0.26	7.3	<0.10	21,996	3,190	3,453
41	69	0.74	14	0.25	6.1	<0.10	21,929	3,223	3,596
42	64	1.26	12	0.25	8.8	<0.10	21,539	3,072	3,329
43	72	0.99	17	0.25	6.9	<0.10	21,874	3,121	3,366
44	71	1.11	16	0.22	7.3	<0.10	21,619	3,068	3,484
45	64	0.53	14	0.30	4.2	<0.10	20,370	2,867	3,111
47	67	0.59	13	0.22	8.9	<0.10	20,537	3,173	3,223
51	48	<0.01	15	0.24	5.3	<0.10	19,745	2,999	2,880
60	48	<0.01	18	0.17	3.6	<0.10	20,093	3,174	2,719
61	55	<0.01	17	0.24	4.9	<0.10	20,140	3,609	2,721

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 35 (Continued)

MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLED AT THE FULTON COUNTY RECLAMATION SITE IN 2002

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
63-1-1[1]	50	<0.01	15	0.16	2.6	<0.10	18,799	3,654	2,628
64	56	<0.01	19	0.21	5.6	<0.10	20,506	3,438	2,832
65	52	<0.01	16	0.21	11	<0.10	21,241	3,517	2,764
80	51	<0.01	16	0.28	8.5	<0.10	19,877	3,261	2,767
82	51	<0.01	16	0.28	8.9	<0.10	20,350	2,619	2,825
83	52	<0.01	17	0.26	7.8	<0.10	20,089	3,348	2,771
84	49	<0.01	16	0.19	2.3	<0.10	19,402	3,106	2,757

[1] Only this section of this field was planted in soybeans.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 36

MEAN CONCENTRATIONS OF METALS IN CORN GRAIN SAMPLED AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
7E	39	0.09	2.6	0.10	0.78	<0.10	4,414	48	1,255
7W	30	<0.01	2.0	0.09	0.27	<0.10	4,150	41	1,247
8	39	0.07	2.3	0.11	0.66	<0.10	4,590	42	1,435
11	29	<0.01	1.5	0.10	0.42	<0.10	4,186	56	1,350
12	29	0.02	1.7	0.09	0.58	<0.10	4,293	54	1,332
16E	31	0.07	1.2	0.07	1.2	<0.10	3,964	42	1,233
16W	32	0.05	1.2	0.07	1.2	<0.10	3,947	43	1,270
18	25	<0.01	2.4	0.09	0.41	<0.10	4,229	56	1,187
19	27	0.02	1.6	0.14	0.69	<0.10	3,555	37	1,090
21	26	<0.01	1.6	0.35	0.65	<0.10	3,951	36	1,255

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 36 (Continued)

MEAN CONCENTRATIONS OF METALS IN CORN GRAIN SAMPLED
AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
22	24	<0.01	2.0	0.29	0.74	<0.10	3,675	52	1,067
23	25	0.04	1.8	0.33	0.87	<0.10	3,742	38	1,075
24	24	<0.01	1.8	0.11	0.30	<0.10	4,349	44	1,291
27	33	0.04	3.1	0.32	0.34	<0.10	3,875	54	1,165
28	30	<0.01	2.6	0.20	0.30	<0.10	3,911	46	1,072
31	23	<0.01	1.5	0.08	0.43	<0.10	3,565	36	1,083
34	25	<0.01	1.9	0.07	0.52	<0.10	4,232	41	1,290
35	34	0.04	2.1	0.61	1.2	<0.10	3,841	47	1,208
36	30	0.03	2.1	0.70	0.90	0.015	3,846	48	1,240
60	24	<0.01	2.4	0.07	0.30	<0.10	3,386	40	994

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 36 (Continued)

MEAN CONCENTRATIONS OF METALS IN CORN GRAIN SAMPLED
AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
61	25	<0.01	2.1	<0.04	0.26	<0.10	3,950	38	1,285
63-1-1[1]	26	<0.01	2.9	<0.04	0.33	<0.10	3,751	34	1,096
64	32	<0.01	3.2	<0.04	0.43	<0.10	4,359	54	1,224
65	24	<0.01	2.2	<0.04	0.41	<0.10	3,980	51	1,062
80	24	<0.01	2.7	<0.04	1.0	<0.10	4,153	42	1,169
82	22	<0.01	2.2	<0.04	0.45	<0.10	3,623	32	1,083
83	21	<0.01	2.2	0.05	0.56	<0.10	3,596	36	1,015
84	21	<0.01	1.9	0.06	0.34	<0.10	3,915	45	1,152

[1] Only this section of this field was planted in corn.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 37

MEAN CONCENTRATIONS OF METALS IN CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
7E	185	8.3	15	15	0.48	<0.20	23,818	7,169	3,828
7W	93	2.5	11	11	0.12	<0.20	18,172	7,935	4,847
8	106	3.9	12	12	0.24	<0.20	20,680	7,127	4,758
11	114	8.9	16	16	0.33	<0.20	19,771	6,318	2,742
12	125	5.1	15	15	0.30	<0.20	17,066	7,477	5,485
16E	103	6.2	11	11	0.31	<0.20	16,415	7,710	5,670
16W	70	2.9	11	11	0.22	<0.20	15,722	7,227	5,608
18	45	0.06	8.1	8.1	0.10	<0.20	18,688	5,751	4,781
19-1	67	3.6	11	11	0.40	<0.20	20,013	4,719	3,385
19-2	41	2.4	10	10	0.18	<0.20	14,090	5,064	5,721

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 37 (Continued)

MEAN CONCENTRATIONS OF METALS IN CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
21-1	61	2.6	13	13	0.32	<0.20	21,226	4,637	3,937
21-2	70	3.1	11	11	0.56	<0.20	17,721	5,366	4,200
22-1	61	3.2	12	12	0.31	<0.20	16,972	5,324	5,294
22-2	62	2.8	11	11	0.38	<0.20	16,420	5,420	4,482
23-1	61	4.4	12	12	0.15	<0.20	6,145	7,178	11,445
23-2	73	6.6	11	11	0.23	<0.20	9,828	6,361	7,973
24	32	<0.02	11	11	<0.07	<0.20	9,929	6,071	8,735
27	157	8.4	16	16	0.40	<0.20	19,546	6,791	3,706
28	98	3.1	15	15	0.24	<0.20	21,680	5,672	3,173
31-1	33	1.2	8.8	8.8	0.11	<0.20	12,508	5,051	5,441

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 37 (Continued)

MEAN CONCENTRATIONS OF METALS IN CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
31-2	78	6.1	12	11	0.44	<0.20	10,603	6,615	7,058
34-1	26	<0.02	10	9.6	0.16	<0.20	11,602	3,943	5,382
34-2	74	4.2	12	12	0.49	<0.20	21,614	4,594	4,319
35	119	6.7	14	14	0.43	<0.20	21,793	4,369	2,914
36	72	5.3	11	11	0.35	<0.20	22,436	3,652	3,359
60	28	<0.02	14	14	0.23	<0.20	12,539	7,045	6,814
61	32	<0.02	11	11	0.14	<0.20	16,051	5,857	5,439
63-1-1[2]	30	<0.02	10	10	0.15	<0.20	16,225	5,323	4,616
64	60	<0.02	12	12	0.16	<0.20	15,294	7,085	4,872
65	45	0.04	11	11	0.15	<0.20	15,163	6,737	5,018

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 37 (Continued)

MEAN CONCENTRATIONS OF METALS IN CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
80	30	0.05	11	11	0.30	<0.20	17,430	3,306	2,794
82	30	0.03	10	10	0.15	<0.20	18,527	4,529	3,384
83-1[3]	30	0.04	12	12	0.21	<0.20	14,706	5,430	5,296
83-2[3]	22	<0.02	7.4	7.4	0.17	<0.20	13,902	5,486	5,385
84	24	<0.02	10	10	0.21	<0.20	15,954	5,271	6,135

[1] These fields are broken down into two sections each for special leaf sampling.
[2] Only section 63-1-1 of FLD 63 was planted in corn.
[3] These P-Study fields are broken down into two sections for special leaf sampling.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
10-1	1	75	3.2	9.0	3.2	8.0	0.30	22,477	7,318	1,645
10-2	1	96	2.6	7.8	0.62	2.6	<0.10	15,822	3,426	1,459
62-1	1	11	<0.01	6.2	0.19	0.73	<0.10	14,315	9,921	2,486
62-2	1	12	<0.01	7.0	0.17	0.75	<0.10	13,326	13,321	2,973
63-1-2	1	14	<0.01	4.0	0.17	0.44	<0.10	16,304	5,468	2,001
63-2-1	1	16	<0.01	8.0	0.17	0.66	<0.10	14,120	11,600	2,505
63-2-2	1	17	<0.01	7.8	0.17	0.57	<0.10	13,439	11,849	2,755
63-3-1	1	14	<0.01	5.2	0.14	0.98	<0.10	16,561	6,838	1,992
63-3-2	1	15	<0.01	6.4	0.13	0.93	<0.10	16,786	6,817	2,077
63-4-1	1	12	<0.01	5.78	0.13	0.46	<0.10	17,030	6,524	2,067

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38 (Continued)

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED
AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
63-4-2	1	13	<0.01	4.7	0.18	0.18	<0.10	15,455	8,080	2,171
63-5-1	1	10	0.02	5.2	0.13	0.13	<0.10	13,423	7,353	1,728
63-5-2	1	14	<0.01	2.2	0.12	0.12	<0.10	10,589	2,400	970
63-6-1	1	12	<0.01	5.6	0.16	0.17	<0.10	16,996	9,554	3,131
63-6-2	1	14	<0.01	5.5	0.16	0.16	<0.10	15,938	10,080	2,954
63-7-1	1	13	<0.01	5.5	0.14	0.14	<0.10	15,083	10,080	2,216
63-7-2	1	14	<0.01	6.4	0.14	0.14	<0.10	16,066	13,003	2,273
63-8-1	1	18	0.02	6.3	0.15	0.15	<0.10	18,276	8,627	2,077
63-8-2	1	20	<0.01	6.9	0.14	0.14	<0.10	13,517	10,134	2,052
73-1	1	18	<0.01	7.0	0.15	0.15	<0.10	16,191	12,466	2,732

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38 (Continued)

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED
AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
73-2	1	20	<0.01	6.5	0.18	0.62	<0.10	20,154	11,579	2,278
76-1	1	14	<0.01	6.1	0.11	0.32	<0.10	13,824	6,537	2,126
76-2	1	16	<0.01	7.3	0.10	0.41	<0.10	14,618	7,438	2,294
10-1	2	67	3.0	9.0	2.1	8.3	<0.10	19,804	9,678	2,025
10-2	2	72	3.1	9.6	2.0	6.0	<0.10	22,007	7,532	2,675
62-1	2	19	<0.01	7.8	0.13	0.91	<0.10	18,435	8,693	2,137
62-2	2	17	<0.01	7.6	0.12	0.80	<0.10	15,993	9,607	2,251
63-1-2	2	15	<0.01	7.5	0.12	0.69	<0.10	18,376	9,875	2,586
63-2-1	2	21	<0.01	8.2	0.10	0.59	<0.10	19,298	8,760	2,440
63-2-2	2	18	<0.01	8.2	0.12	0.56	<0.10	18,197	8,003	2,049

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38 (Continued)

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED
AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
63-4-1	2	15	<0.01	7.5	0.14	0.67	<0.10	17,903	9,087	1,999
63-4-2	2	14	<0.01	8.1	0.14	0.68	<0.10	15,542	10,045	2,370
63-5-2	2	14	<0.01	6.9	0.13	0.60	<0.10	17,023	9,561	2,234
63-6-1	2	14	<0.01	7.4	0.12	0.50	<0.10	12,946	11,918	2,861
63-6-2	2	15	<0.01	8.5	0.15	0.85	<0.10	13,619	12,715	3,054
63-7-1	2	15	<0.01	7.2	0.18	0.75	<0.10	12,827	8,758	2,413
63-7-2	2	14	<0.01	7.0	0.14	0.59	<0.10	12,251	8,491	2,186
73-1	2	22	<0.01	7.8	0.13	1.1	<0.10	18,166	8,678	2,432
73-2	2	19	0.02	7.9	0.17	0.44	<0.10	17,907	9,177	2,268
76-1	2	17	<0.01	8.4	0.13	0.50	<0.10	13,662	8,317	2,427

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38 (Continued)

MEAN CONCENTRATIONS OF METALS IN HAY SAMPLES COLLECTED
AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
76-2	2	12	<0.01	6.8	0.11	0.30	<0.10	14,222	5,390	1,775
10-1	3	102	5.1	21	18	13	4.5	21,337	11,685	3,559
62-1	3	24	<0.01	10	0.20	0.86	<0.10	21,692	11,571	3,008
63-2-1	3	23	<0.01	11	0.16	0.91	<0.10	21,692	12,374	3,323
63-2-2	3	19	<0.01	10	0.16	0.70	<0.10	22,558	10,992	3,247
63-6-1	3	17	<0.01	8.6	0.23	0.87	<0.10	16,683	11,861	3,209
63-6-2	3	15	<0.01	9.7	0.16	0.63	<0.10	12,976	15,288	3,895
73-1	3	27	<0.01	9.9	0.19	1.5	<0.10	21,261	12,157	3,374
73-2	3	28	<0.01	9.1	0.17	0.86	<0.10	24,208	11,148	3,160

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 39

MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLED AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
2	68	0.97	13	0.37	11	<0.10	21,276	2,062	2,755
3	58	0.91	15	0.22	8.1	<0.10	20,704	2,925	3,043
4	60	0.61	14	0.20	9.0	<0.10	20,488	2,626	2,750
13	58	0.76	12	0.22	11	<0.10	19,584	2,495	2,813
14	61	0.86	12	0.22	10	<0.10	19,771	2,738	2,925
15	53	0.43	12	0.21	4.1	<0.10	19,161	3,073	2,885
18	37	<0.01	12	0.19	4.3	<0.10	18,574	2,721	2,559
20	40	<0.01	12	0.23	4.9	<0.10	18,687	2,764	2,405
25	56	0.02	17	0.19	3.9	<0.10	20,447	2,774	2,605
26	60	1.3	12	0.21	5.1	<0.10	19,509	3,031	2,756

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 39 (Continued)

MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLED AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
29	53	0.43	12	0.29	4.3	<0.10	19,284	3,104	2,849
30	62	1.0	12	0.19	5.3	<0.10	21,212	2,384	2,795
37	40	<0.01	13	0.22	5.0	<0.10	19,145	2,800	2,421
38A	54	<0.01	16	0.15	3.5	<0.10	19,426	2,667	2,426
38C	50	<0.01	17	0.18	3.2	<0.10	17,591	2,841	2,630
39	55	0.36	12	0.16	5.6	<0.10	19,473	2,918	2,798
40	54	0.65	8.6	0.19	13	<0.10	20,185	2,692	2,783
41	57	0.73	13	0.17	6.2	<0.10	21,942	2,531	2,921
43	59	0.70	15	0.19	9.7	<0.10	21,099	2,887	2,859
44	54	0.46	13	0.17	5.1	<0.10	21,914	2,596	2,749

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 39 (Continued)

MEAN CONCENTRATIONS OF METALS IN SOYBEAN GRAIN SAMPLED
AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
47	57	0.37	14	0.18	8.3	<0.10	22,025	2,704	2,821
50	46	<0.01	20	0.17	3.7	<0.10	22,032	2,952	2,887
51	46	0.13	14	0.32	6.3	<0.10	20,455	2,808	2,677
52	49	<0.01	20	0.17	3.9	<0.10	21,917	2,661	2,787
54	45	<0.01	17	0.24	4.5	<0.10	21,034	3,174	2,631
55	46	<0.01	18	0.29	4.7	<0.10	21,414	3,143	2,671
56	44	<0.01	17	0.23	4.8	<0.10	20,870	2,963	2,548
59	44	0.07	14	0.26	5.7	<0.10	19,922	2,835	2,627
75	44	<0.01	14	0.26	6.1	<0.10	19,250	2,889	2,502

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 40

MEAN CONCENTRATIONS OF METALS IN SUDAX SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/kg								
1	1	118	14	6.4	0.18	1.1	<0.10	27,003	3,675	2,898
32	1	74	6.6	5.6	0.29	0.53	<0.10	16,027	3,768	2,525
33	1	116	11	10	1.7	1.2	<0.10	14,148	3,385	2,762

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 41

MEAN CONCENTRATIONS OF METALS IN WHEAT GRAIN SAMPLES COLLECTED FROM THE FULTON COUNTY RECLAMATION SITE IN 2003

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/kg								
63-8	38	<0.01	6.0	0.12	0.19	<0.10	4,843	403	1,628

Lake originally had a pH that ranged from 1.8 to 2.0. After the UEC property was reclaimed with applications of lime, clay, and biosolids, the lake pH has been elevated to its current level which ranges between 6.0 and 8.0 and requires no treatment when discharged. The only parameters currently required to be monitored are pH and settleable solids.

ST. DAVID, MORGAN MINE, AND UNITED ELECTRIC COAL REFUSE RECLAMATION SITES

In 1987, the District initiated an experiment on a coal refuse pile at St. David, Illinois, to determine the rates of anaerobically digested biosolids, agricultural lime, and clay necessary for long-term reclamation of coal refuse material (Table 42). The experiment was initiated with the approval of the IEPA.

In 2000, plot 1 was totally reclaimed by applying 1,000 dry tons biosolids/acre and 80 tons limestone/acre. This served as the control plot and was no longer used after the original experiment ended in 1996. The portions of plot 2 next to plot 1 that had eroded were also reclaimed in the same manner.

Data generated by this reclamation work were used to establish the reclamation protocols for the remainder of the St. David coal refuse pile. The reclamation of the Morgan Mine and UEC Cuba Mine No. 9 coal refuse pile properties also followed this protocol in 1991 and 1990, respectively, in Fulton

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 42

AMENDMENTS USED IN RECLAMATION OF COAL REFUSE AT ST. DAVID, ILLINOIS

Plot Number	Treatment Composition[1]					
	Biosolids		Lime[2]		Clay[2]	
	Mg/ha	tons/acre	Mg/ha	tons/acre	cm	Inches
1	0	0	0	0	0	0
2	784	350	0	0	0	0
3	784	350	179	80	0	0
4	784	350	179	80	10.2	4
5	1,568	700	0	0	0	0
6	1,568	700	179	80	0	0
7	1,568	700	179	80	10.2	4
8	2,240	1,000	0	0	0	0
9	2,800	1,250	0	0	0	0
10	3,360	1,500	0	0	0	0

[1] Application rates for biosolids and lime are on a dry weight basis.
[2] Applied only when required in the plan.

County. The final reclamation of these coal refuse piles consisted of applying 1,000 dry tons biosolids/acre and 70 tons limestone/acre. This work also formed the basis for the demonstration and research plots recently established at the USX property on Chicago's southern lakefront.

Water was collected from the coal refuse pile lysimeters on a quarterly basis in 2003. Yearly means of four selected chemical parameters for 1999 through 2003 are presented in Tables 43 through 45 for the lysimeters from these three reclaimed areas.

HYBRID SEED DATABASE

The Land Reclamation and Soil Science Section is conducting a program to obtain hybrid seed information from each farmer for plantings in 2001 and beyond. These data will be correlated with biosolids application and yield data to produce recommendations leading to increased productivity for not only the Fulton County site, but farms in the Chicagoland area that are receiving biosolids from the District's water reclamation plants.

MISCELLANEOUS INITIATIVES

During the year 2003, various alfalfa fields were monitored throughout the growing and harvesting seasons for signs of disease or insect infestations that would reduce crop

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 43

YEARLY MEAN CONCENTRATIONS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE ST. DAVID, ILLINOIS, COAL REFUSE PILE RECLAMATION SITE 1999 - 2003

Chemical Parameters	Year	Plot Number									
		1	2	3	4	5	6	7	8	9	10
pH	1999	2.2	7.2	7.4	7.3	7.5	7.5	7.6	7.2	7.1	6.7
	2000	NA[1]	7.2	7.3	7.1	7.4	7.5	NA	6.8	7.1	NA
	2001	4.8	7.0	6.9	7.2	7.3	7.2	7.1	6.7	6.7	6.6
	2002	7.1	7.0	7.0	7.2	7.2	7.1	6.8	6.8	7.0	6.9
	2003[2]	7.1	7.6	7.2	7.3	7.4	7.8	NA	7.6	7.6	NA
		mg/L									
$SO_4^=$	1999	31250	1788	1284	1631	1495	1681	1557	1147	1639	1899
	2000	NA	2082	1622	1621	1579	2119	NA	865	2071	NA
	2001	13323	1823	1155	1511	1414	1841	1421	1120	1864	1758
	2002	5040	1628	1598	1828	1351	1988	1430	1024	1745	1932
	2003	2105	2098	1140	1540	1407	1794	NA	578	1909	NA
NH_4-N	1999	0.76	0.23	0.16	0.12	0.16	0.17	0.25	0.19	0.22	0.71
	2000	NA	0.22	0.15	0.21	0.16	0.14	NA	0.49	0.27	NA
	2001	1.88	0.24	0.23	0.19	0.24	0.19	0.34	0.31	0.30	0.40
	2002	0.45	0.15	0.14	0.11	0.07	0.13	0.51	0.15	0.21	0.17
	2003	0.12	0.04	0.03	0.06	0.11	0.04	NA	<0.01	0.03	NA
NO_2+NO_3-N	1999	1.48	1.62	0.17	2.54	7.97	0.60	18.0	3.60	57.4	49.1
	2000	NA	2.55	2.18	3.31	6.44	0.33	NA	9.54	56.1	NA
	2001	355	1.68	1.09	2.44	6.39	1.41	30.8	2.44	64.3	50.2
	2002	270	1.72	0.73	2.69	4.09	1.02	18.8	3.80	64.9	41.9
	2003	94.3	1.56	1.20	3.00	4.30	1.44	NA	3.13	85.3	NA

[1] NA = Samples are not available due to insufficient precipitation.
[2] In 2003 lysimeters were sampled quarterly, rather than monthly.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 44

YEARLY MEAN CONCENTRATIONS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE MORGAN MINE COAL REFUSE RECLAMATION SITE 1999 - 2003

Chemical Parameters	Year	Lysimeter Number 1	2	3
pH	1999	7.1	6.8	6.3
	2000	6.9	6.9	6.5
	2001	6.8	6.8	6.4
	2002	6.9	6.9	6.6
	2003[1]	6.8	6.9	6.7
		----------mg/L----------		
$SO_4^=$	1999	1,655	1,973	1,958
	2000	1,754	1,807	3,502
	2001	1,569	1,924	3,018
	2002	1,621	2,019	2,520
	2003	1,727	1,866	2,623
NH_4-N	1999	1.64	1.92	2.53
	2000	1.33	0.78	3.02
	2001	0.98	0.96	2.29
	2002	0.96	1.68	0.98
	2003	1.36	4.79	1.14
NO_2+NO_3-N	1999	2.18	1.78	85.4
	2000	7.65	3.34	302
	2001	6.96	3.72	138
	2002	3.35	3.97	38.2
	2003	2.34	3.63	43.1

[1] In 2003 lysimeters were sampled quarterly, rather than monthly.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 45

YEARLY MEAN CONCENTRATIONS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE UNITED ELECTRIC COAL REFUSE PILE RECLAMATION SITE 1999 - 2003

Chemical Parameters	Year	Lysimeter Number 1	2	3	4	5	6	7	8	9	10
pH	1999	7.2	7.2	7.3	7.1	7.1	7.1	7.4	7.0	7.4	NA
	2000	NA[1]	6.9	7.4	7.0	7.2	7.3	7.3	7.0	7.3	NA
	2001	NA	7.0	7.3	7.1	7.2	4.8	7.3	7.2	7.2	NA
	2002	NA	7.2	7.4	7.2	7.4	4.8	7.4	7.0	7.3	NA
	2003[2]	NA	7.2	7.4	7.1	7.3	6.6	7.4	7.1	7.3	NA
		mg/L									
$SO_4^=$	1999	95	927	1859	2116	2158	1749	1915	2874	2762	NA
	2000	NA	1582	1930	2139	2283	2229	1956	2951	3059	NA
	2001	NA	987	1684	2189	2077	1677	1606	3424	2873	NA
	2002	NA	978	1675	2323	2057	1541	1929	4076	3140	NA
	2003	NA	1439	1751	2089	2063	1415	1736	3772	2722	NA
NH_4-N	1999	0.20	0.43	0.52	0.47	0.40	0.34	0.60	14.3	0.40	NA
	2000	NA	0.61	0.48	0.43	0.30	0.83	0.73	25.0	0.36	NA
	2001	NA	0.39	0.50	0.44	0.33	0.66	0.29	22.2	0.37	NA
	2002	NA	0.31	0.43	0.47	0.34	0.64	0.27	11.9	0.38	NA
	2003	NA	0.25	0.40	0.45	0.37	0.36	0.20	9.10	0.36	NA
NO_2+NO_3-N	1999	109	14.3	43.1	13.1	5.40	23.8	2.40	2.30	1.60	NA
	2000	NA	133	111	38.2	5.60	81.8	35.5	0.40	7.70	NA
	2001	NA	47.4	84.0	47.6	11.8	36.5	76.2	5.00	1.20	NA
	2002	NA	31.6	32.7	17.5	3.47	14.2	32.7	2.83	1.46	NA
	2003	NA	47.6	26.9	25.9	3.46	22.5	15.4	3.54	1.53	NA

[1] NA = Samples are not available due to low precipitation.
[2] In 2003 lysimeters were sampled quarterly, rather than monthly.

yields, and thus, decrease the value of the product to the District's land renters.

The vast accumulation of data from the inception of the Project in 1971 to the current time continued to be placed into various databases for easier access by District personnel and other agencies.

In the fall of 2003, preliminary work was begun to establish cooperative studies between the District, the IEPA, and researchers from the University of Florida and Pennsylvania State University dealing with the potential for phosphorus runoff from biosolids-amended land. The Fulton County Land Reclamation Laboratory Section is providing support for these efforts which are discussed in more detail later in this report. These studies will run through 2008 at the Fulton County Site, as well as the greenhouse and research facilities at the Cecil Lue-Hing Research and Development Complex at the Stickney Water Reclamation Plant.

CORN FERTILITY EXPERIMENT ON CALCAREOUS MINE-SPOIL

Since 1973, the District has had a corn fertility experiment on calcareous mine-spoil at the Fulton County site. The purpose of this experiment was to evaluate the effect of long-term applications of anaerobically digested biosolids on crop yields, crop chemical composition, and mine-spoil chemical

composition. The experiment was designed to simulate biosolids application to fields at the site at agronomic and reclamation rates, and to provide information that can be used for management of biosolids and crops.

This is the longest running continuous biosolids research experiment in the country. Data on the metals uptake in corn tissues from these plots were used in the risk assessments conducted by the USEPA prior to the final promulgation of its 40 CFR Part 503 biosolids regulations in 1993. All 30 years of soil and plant tissue samples are available in the sample repository at the Fulton County R&D Laboratory.

There are four treatments of biosolids or commercial fertilizer applied to the corn fertility plots each year. The amounts of biosolids or commercial fertilizer added annually for each treatment are listed in Table 46, along with the cumulative totals of biosolids applied per plot through 2003. Table 47 shows a four-year comparison (2000-2003) of soil data from the experimental plots.

The corn hybrid planted in 1997 through 2001 was Pioneer 3394. During the year 2001, a new herbicide-ready genetically modified corn hybrid (Pioneer 33P69) was planted in a side-by-side study with the previous Pioneer 3394 hybrid. Pioneer 3394 is to be replaced because its parent seed stock is being eliminated from production. Table 48 compares the

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TABLE 46

FULTON COUNTY RESEARCH AND DEVELOPMENT LABORATORY
2003 UICF BIOSOLIDS APPLICATION RATES[1]

TREATMENT	LOADING RATE			
	ANNUAL		CUMULATIVE	
	Dry Solids Applied			
	Mg/ha	tons/acre	Mg/ha	tons/acre
Control	0.0	0.0	0.0	0.0
¼ Max	16.8	7.5	505	226
½ Max	33.6	15.0	1010	451
MAX	67.2	30.0	2018	901

[1] Control Plots receive 336-224-112 kg/ha of N-P-K annually and biosolids-amended plots receive 112 Kg/ha of K annually.

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TABLE 47

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS AND METALS IN SURFACE SOIL[1] FROM THE CORN FERTILITY EXPERIMENTAL PLOTS[2] AT THE FULTON COUNTY RECLAMATION SITE FOR 2000 - 2003

				Organic	------0.1N HCl Extracted-----						-Concentrated HNO_3 Extracted-							
Plot	Year	pH	EC	Carbon	Zn	Cd	Cu	Cr	Ni	Pb	Zn	Cd	Cu	Cr	Ni	Pb	TKN	Tot-P
			dS/m	%	mg/kg													
Control	2000	7.6	0.265	1.04	147	28	55	25	13	29	193	10	86	151	46	48	1,278	2,538
	2001	7.4	0.398	1.28	142	11	59	20	14	29	188	10	82	146	45	46	1,249	2,535
	2002	7.2	0.433	1.18	132	10	57	18	12	29	162	9.5	75	124	36	39	1,374	2,690
	2003	7.2	0.500	1.01	123	9.7	52	16	12	23	174	10	84	137	41	41	1,170	2,665
1/4	2000	7.6	0.205	1.71	277	20	121	38	19	50	352	19	159	264	60	81	1,776	3,032
	2001	7.6	0.223	1.75	235	17	103	32	17	45	315	17	141	232	56	72	1,494	2,749
	2002	7.6	0.213	1.92	249	18	108	33	16	44	287	16	129	208	45	64	1,817	3,019
	2003	7.6	0.185	1.62	219	16	96	29	16	39	298	17	151	220	49	66	1,701	2,781
1/2	2000	7.5	0.205	2.64	466	32	197	65	29	68	558	31	257	413	80	126	2,516	4,499
	2001	7.6	0.238	2.80	430	30	179	56	27	64	530	30	241	388	77	120	2,349	4,355
	2002	7.4	0.203	3.05	446	31	185	57	25	58	461	26	210	324	60	99	2,786	4,921
	2003	7.4	0.300	2.74	410	27	166	49	24	50	495	28	241	350	64	106	2,823	5,121
Max	2000	7.4	0.198	4.01	742	49	297	90	43	78	793	45	375	596	101	182	3,674	7,033
	2001	7.4	0.293	3.97	693	46	279	84	41	76	808	46	384	610	101	185	3,548	6,645
	2002	7.1	0.280	5.08	766	50	308	90	41	66	761	43	360	639	84	162	3,618	8,242
	2003	7.1	0.313	4.46	698	44	275	77	38	54	807	44	389	653	88	169	3,735	9,669

[1] Sampling depth 0-15 cm.

[2] Control = No biosolids application - inorganic fertilizer, 1/4-maximum = biosolids loading rate of 16.8 Mg/ha/yr, 1/2-maximum = biosolids loading rate of 33.6 Mg/ha/yr, maximum = biosolids loading rate of 67.2 Mg/ha/yr.

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TABLE 48

MEAN CONCENTRATIONS OF TKN, PHOSPHORUS, AND METALS IN CORN GRAIN FROM THE CORN FERTILITY EXPERIMENTAL PLOTS[1] AT THE FULTON COUNTY RECLAMATION SITE FOR HYBRID 3394 FROM 1998-2001 AND HYBRID 33P69 FROM 2001-2003

	Control		1/4-Maximum		1/2-Maximum		Maximum	
	3394	33P69	3394	33P69	3394	33P69	3394	33P69
Analyte[2]	1998-2001	2001-2003	1998-2001	2001-2003	1998-2001	2001-2003	1998-2001	2001-2003
	mg/kg							
TKN	12,633	15,696	10,437	12,532	10,800	13,253	11,629	14,634
Tot.-P	2,821	3,163	3,014	3,268	2,938	3,177	2,823	3,078
Zn	21.7	23.8	26.5	26.4	25.0	26.2	25.3	27.6
Cd	0.018	<0.010	0.024	<0.010	0.014	<0.010	0.016	<0.010
Cu	1.69	1.57	1.65	1.26	1.55	1.49	1.71	1.63
Cr	1.69	0.182	1.14	0.145	1.16	0.134	2.57	0.137
Ni	1.29	0.775	1.86	1.76	1.50	1.50	2.01	1.08
Pb	0.106	<0.100	0.119	<0.100	0.119	<0.100	0.116	<0.100
K	3,485	3,704	3,598	3,864	3,596	3,767	3,568	3,659
Ca	63.4	41.5	72.5	41.5	62.6	46.3	73.5	46.8
Mg	1,160	1,286	1,237	1,351	1,217	1,284	1,160	1,239

[1]Control = No biosolids application - inorganic fertilizer, 1/4-maximum = biosolids loading rate of 16.8 Mg/ha/yr, 1/2-maximum = biosolids loading rate of 33.6 Mg/ha/yr, maximum = biosolids loading rate of 67.2 Mg/ha/yr.

[2]Tissue digested with $HNO_3/HClO_4$ for metals, TKN is Total Kjeldahl-N, and Tot.-P is Total Phosphorus.

grain nutrient and metal concentrations from hybrid 3394 from 1998 through 2001 with the values for the same tissue samples from hybrid 33P69 in 2001 through 2003 for the four treatments. From 2002 onward, only the 33P69 hybrid is being planted in the research plots. Table 49 shows the comparison of the grain yields for the new hybrid for 2001 through 2003.

Hanover Park Fischer Farm

The Hanover Park Fischer Farm is a 48-hectare (120 acres) tract of land, which utilizes all of the biosolids produced by the Hanover Park WRP. The farm, located on the south side of the WRP grounds, has 18 gently sloping fields, each surrounded by a berm to control surface runoff. An underground tile drain system collects surface and subsurface drainage which is returned to the Hanover Park WRP for treatment.

Anaerobically digested biosolids are applied by injection from tank trucks. The IEPA operating permit (Permit No. 1997-SC-3840) for the site limits the annual biosolids application rate to 56 dry Mg/ha (25 dry tons/acre). The crop plan for 2003 included the cultivation of corn in 12 biosolids-treated fields.

Groundwater monitoring is required by the IEPA operating permit. Fields and monitoring locations at the Fischer Farm are shown in Figure 24. Four monitoring wells (W-5, W-6, W-7,

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TABLE 49

AVERAGE CORN GRAIN AND CORN STOVER YIELDS FOR HYBRID 33P69 GROWN AT THE CORN FERTILITY EXPERIMENTAL PLOTS FROM 2001[1] - 2003

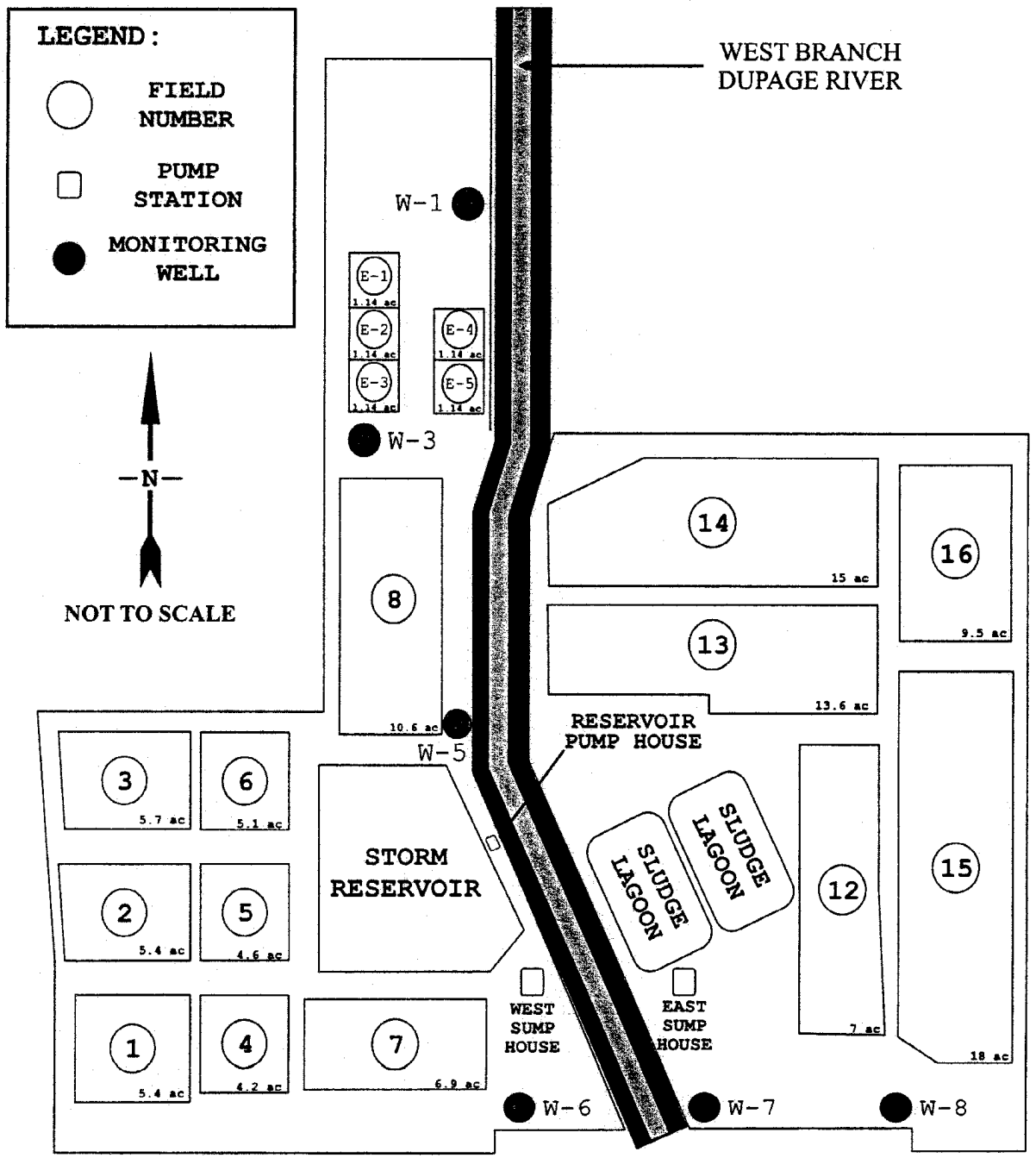
Harvested Tissue	Units	Control[1]			1/4-Maximum			1/2-Maximum			Maximum		
		2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
Grain	Bu/acre	99	48	22	49	25	21	77	40	40	109	52	51
	Mg/ha	6.2	3.0	1.4	3.0	1.6	1.3	4.8	2.5	2.5	6.8	3.2	3.2
Stover	Tons/acre	1.8	1.3	1.2	0.9	0.9	0.9	1.1	1.0	1.5	1.6	1.2	1.6
	Mg/ha	4.1	3.0	2.7	2.0	2.1	2.0	2.6	2.2	3.4	3.7	2.8	3.6

[1] Control = No biosolids application - inorganic fertilizer, 1/4-maximum = biosolids loading rate of 16.8 Mg/ha/yr, 1/2-maximum = biosolids loading rate of 33.6 Mg/ha/yr, maximum = biosolids loading rate of 67.2 Mg/ha/yr.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 24

LOCATION OF THE FISCHER FARM FIELDS AND WELLS
AT THE HANOVER PARK WRP



and W-8) on the farm have been sampled twice monthly since biosolids applications began in 1979. The analytical data for groundwater sampled from these wells were submitted to the IEPA in the quarterly monitoring reports of 2003.

In June 1988, the six-acre area used for an experimental corn plot in the 1970s was divided into five fields. Two shallow wells (W-1 and W-3) located next to these experimental fields have been sampled twice per month since 1988 to monitor the chemical composition of the groundwater. The analytical data for these samples were submitted to the IEPA in quarterly monitoring reports during 2003.

Groundwater Quality Monitoring at the John E. Egan WRP Solids Drying Facility

In 1986, paved solids drying areas were constructed at the John E. Egan WRP facility. This area was designed to produce biosolids air-dried to a solids content of ≥60%. This substantially reduces the volume of biosolids processed, and results in a material which can be distributed locally for landscaping purposes. However, the Egan WRP now has a thriving program of applying fresh centrifuge cake to farmland via a contractor and the Egan drying site is not being used. The IEPA operating permit (Permit No. 2000-AO-1383-1) for this drying facility requires groundwater monitoring. In October 1986, lysimeters were installed at the John E. Egan WRP for

sampling groundwater immediately below the drying site. During 2003, groundwater samples were collected until the month of June. However, from June 12, 2003 sampling was discontinued following the IEPA's approval of a request from the District to discontinue monitoring. The concentrations of 28 parameters were measured in the Egan lysimeter samples during the first six months of 2003, and were submitted to the IEPA in quarterly monitoring reports. There was no significant change in groundwater quality within the last year.

Groundwater Quality Monitoring at the Calumet WRP Solids Drying Facilities

In 1986, a paved solids drying area, the Calumet West Solids Drying facility, was constructed at the Calumet WRP. In November 1990, a second paved solids drying area, the Calumet East Solids Drying Facility, was put into service at the Calumet WRP. These areas were designed to produce biosolids air-dried to a solids content of ≥60%. This substantially reduces the volume of biosolids processed, and results in a material which can be distributed locally for landscaping purposes. The Calumet East and West solids drying facilities have been continuously operated for drying biosolids material every year since their installation.

The IEPA operating permit (Permit No. 2000-AO-1382) for these facilities requires groundwater monitoring. Lysimeters

were installed at the Calumet West drying facility in October 1986 for sampling groundwater immediately below the drying site. In November 1990, lysimeters were installed at the Calumet East drying facility. The locations of lysimeters are presented in Figures 25 and 26, respectively.

During 2003, samples were taken once per month at both Calumet drying sites. Analytical data for water samples taken in 2003 from the three lysimeters at the Calumet West and from the six lysimeters at the Calumet East drying sites were submitted to the IEPA in the respective quarterly reports. There are indications that the shallow groundwater at these two sites is highly mineralized, and the principal constituents are Ca, Mg, K, Na, SO_4, and alkalinity.

Groundwater Quality Monitoring at LASMA

In 1983, the District began biosolids drying operations at LASMA. This involves spreading either dewatered lagoon biosolids or lagoon-aged, centrifuged, digested biosolids 45-60 cm (18-24 inches) deep on specially designed flat areas, and turning the biosolids over daily to enhance drying until the solids content is ≥60%. In 1983, the biosolids drying operations were performed on clay surfaces. These drying surfaces were paved with asphalt in 1984, and biosolids drying operations resumed in August 1984.

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FIGURE 25

LOCATION OF THE LYSIMETERS AT THE CALUMET EAST SOLIDS DRYING FACILITY

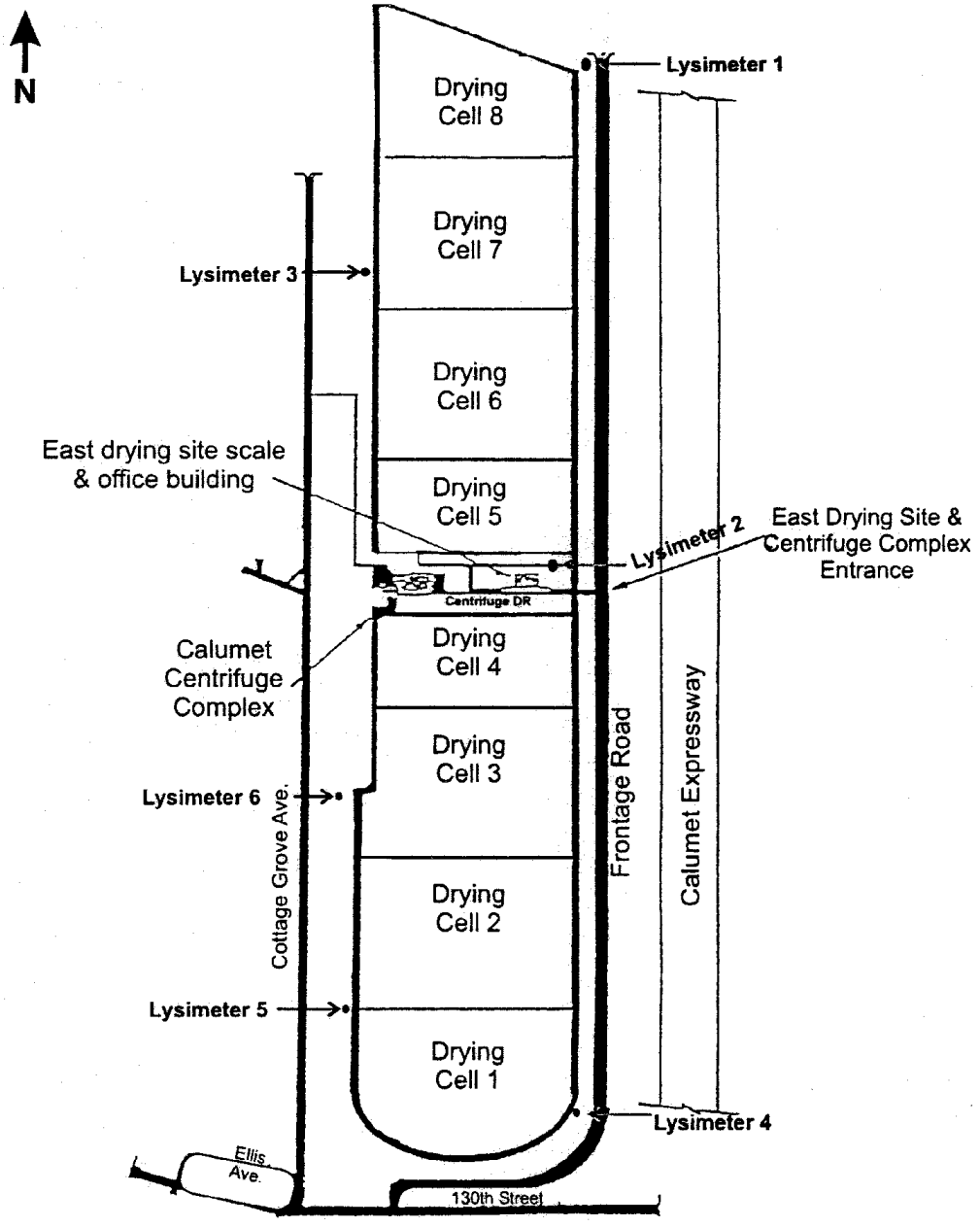

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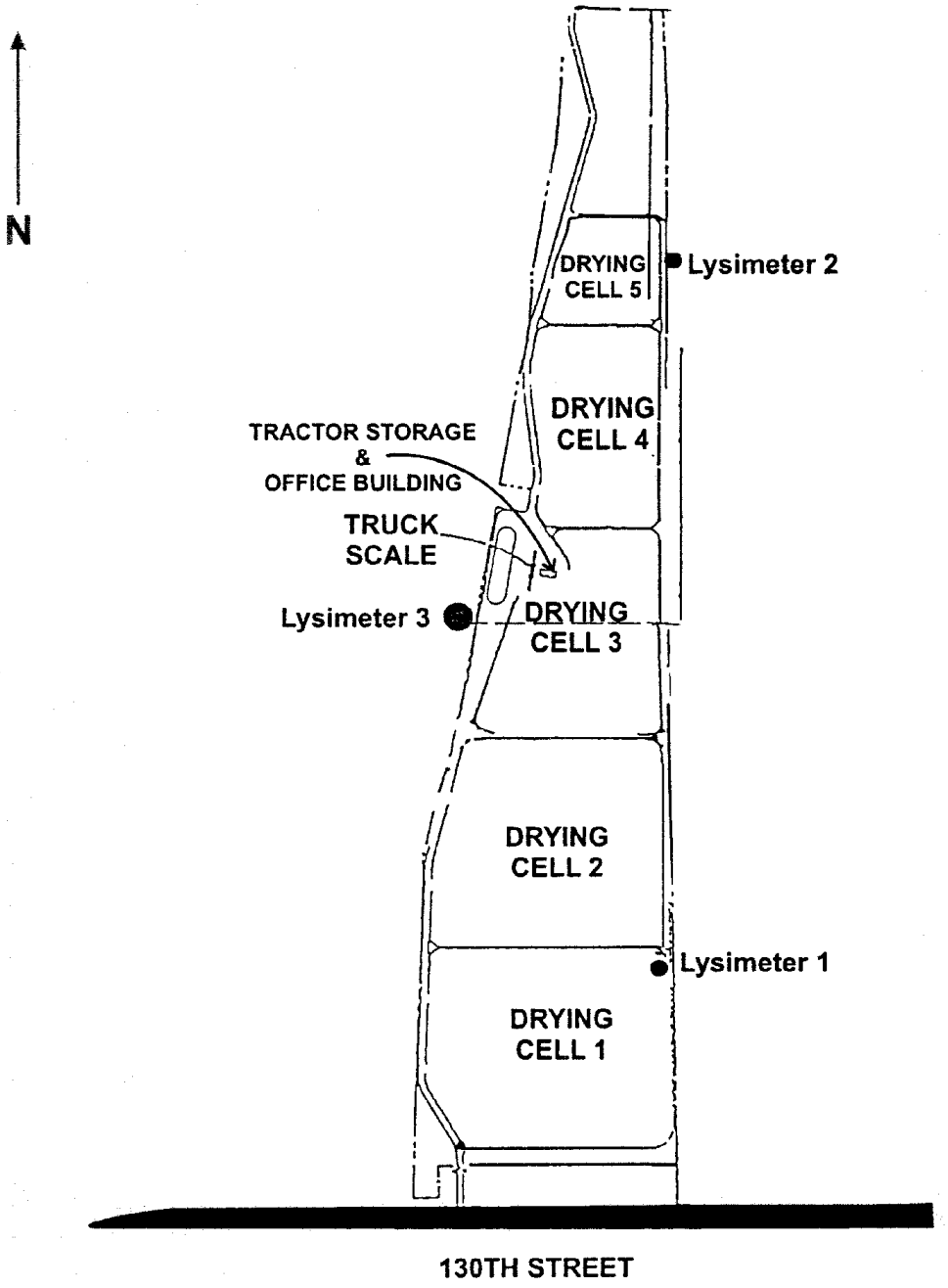
FIGURE 26

LOCATION OF THE LYSIMETERS AT THE CALUMET WEST SOLIDS DRYING FACILITY



The IEPA operating permit for this site requires groundwater monitoring. Five wells were drilled into the limestone aquifer underlying the site, and were sampled every two weeks, beginning in spring 1983. After one year of biweekly sampling, a quarterly sampling schedule was instituted.

In July 1984, three functional lysimeters (L-1, L-3, and L-4) were installed for biweekly sampling of groundwater immediately above the limestone bedrock, which is located 6-12 m (20-40 ft) below the surface in this area. In early 1985, six more lysimeters (L-2, L-5, L-6, L-7, L-8, and L-9) were installed at the site. By April 1985, a total of nine lysimeters were installed at LASMA as required by the IEPA operating permit. A site plan of lysimeters and monitoring wells at LASMA is attached (Figure 27).

A total of 30 parameters require monitoring according to the permit governing the LASMA wells. The analytical data for quarterly samples taken in 2003 from the five wells were presented in quarterly monitoring reports submitted to the IEPA. The water quality is typical of limestone aquifers. Calcium, Mg, and Na are the major cations, and HCO_3 (alkalinity expressed as $CaCO_3$) and SO_4 are the major anions. There is no indication that biosolids constituents have entered the aquifer underlying the site.

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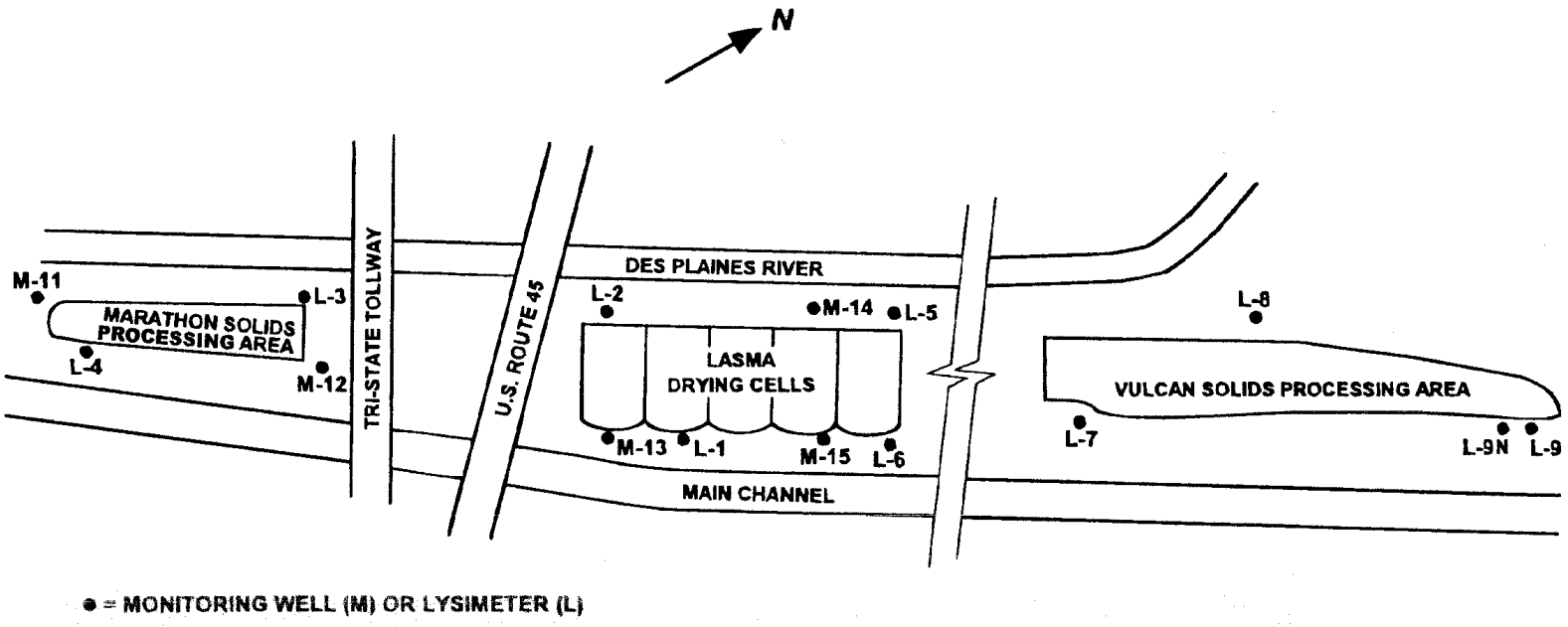
FIGURE 27

LOCATION OF THE MONITORING WELLS AND LYSIMETERS AT LASMA



The operating permit for LASMA requires monthly monitoring of 28 parameters in lysimeter samples. The analytical results for lysimeter samples were submitted to the IEPA in quarterly monitoring reports. Lysimeter water is highly mineralized and is affected by the fill material in which the lysimeters are located. The lysimeters are located in a marshland covered with imported fill.

Groundwater Quality Monitoring at RASMA

The solids drying area at RASMA was originally constructed with a clay base. Drying on a clay surface was in progress as early as 1987, until the area was paved with asphalt in 1992 and 1993. Drying operations on asphalt began in June 1993. Lysimeter locations at the RASMA site are shown in Figure 28.

The IEPA operating permit for this site requires groundwater monitoring. Four lysimeters, approximately 20 feet deep, were installed for biweekly groundwater sampling, which began in September 1993. Three of the four lysimeters rarely yielded water samples. The installation contractor inspected and tested the lysimeters in June 1994, and found no problems with the lysimeters themselves. The contractor determined that, due to soil conditions, there was little free water available at the depths at which these three lysimeters were

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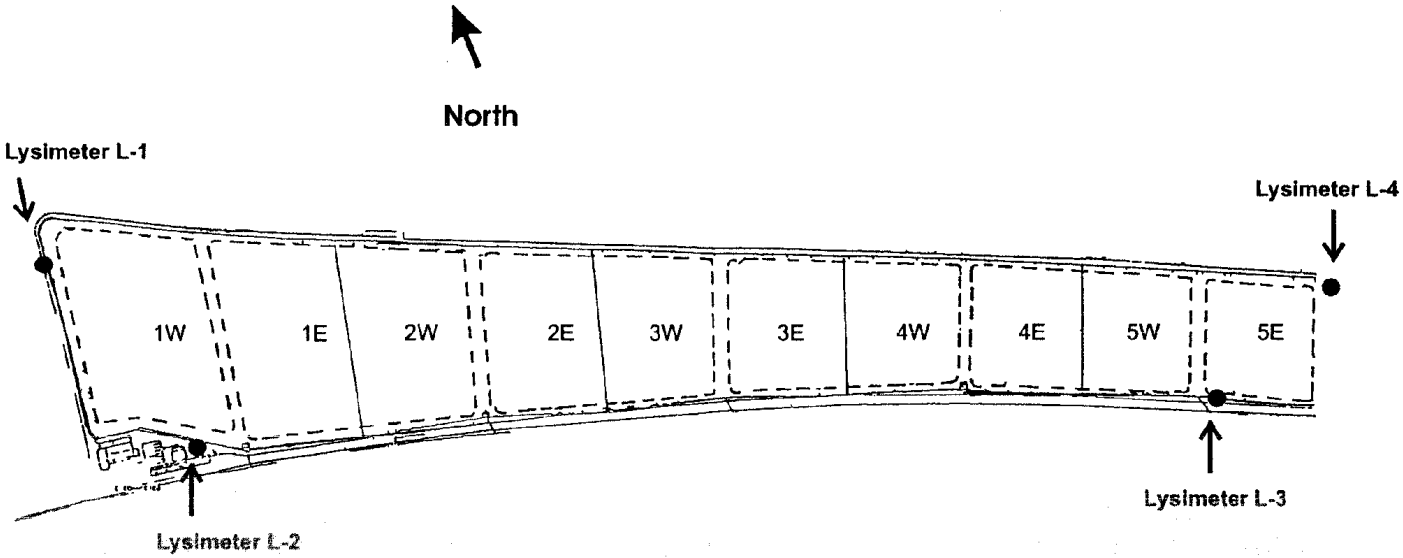
FIGURE 28

LOCATION OF THE LYSIMETERS AT RASMA



installed. The lysimeters were also inspected in 1999 and 2002. In December 2003, the contractor performed several soil borings in the vicinity of these three devices, and confirmed that they were inadvertently positioned in areas that were not conducive to moisture uptake. A budget request has been submitted for the replacement of these devices.

The current IEPA operating permit requires biweekly monitoring of 25 groundwater parameters. Analytical results for lysimeters sampled in 2003 were submitted to IEPA in quarterly monitoring reports. Within the last year, there was no significant change in the water quality. The shallow groundwater at this site is highly mineralized, and the principal dissolved constituents are Ca, Mg, Na, SO_4, Cl, and HCO_3 (alkalinity).

Groundwater Quality Monitoring at HASMA

In 1990, the District began biosolids drying operations at HASMA. Dewatered lagoon biosolids or centrifuged digested biosolids are agitated on this paved area to enhance drying to a solids content of ≥60%.

The IEPA operating permit for this site requires biweekly groundwater monitoring. Three lysimeters were initially installed for groundwater sampling immediately below the drying site. In 1996 a new lysimeter, designated L-1N, was installed. A detailed site plan of lysimeter locations at HASMA is given

in Figure 29. Analytical data for water sampled from the four lysimeters in 2003 were presented in quarterly reports submitted to the IEPA.

The NH_4-N at this site has been high from the time of lysimeter installation, and has been decreasing with time. Biosolids processing at this site is not considered a contributing factor. The District is planning to install another lysimeter at the HASMA site in 2004 and 2005. The proposed location for this new lysimeter will be south of the site on this property and in closer proximity to L-1.

Groundwater Quality Monitoring at the 122nd and Stony Island Solids Management Area

In 1991, the solids drying facility at 122nd Street and Stony Island Avenue was paved to facilitate biosolids drying. From 1980 through 1991, drying was done on a clay surface. This drying facility is used to process biosolids for final distribution. In 2003, the site was used to dewater centrifuged digested biosolids from the Stickney WRP. The dried biosolids were utilized in landfills as daily and final cover to enhance vegetative growth.

The IEPA operating permit for this drying facility requires groundwater monitoring. Four lysimeters were installed in September 1991 for sampling groundwater immediately below the drying site. Figure 30 shows the location of lysimeters

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FIGURE 29

LOCATION OF THE LYSIMETERS AT HASMA

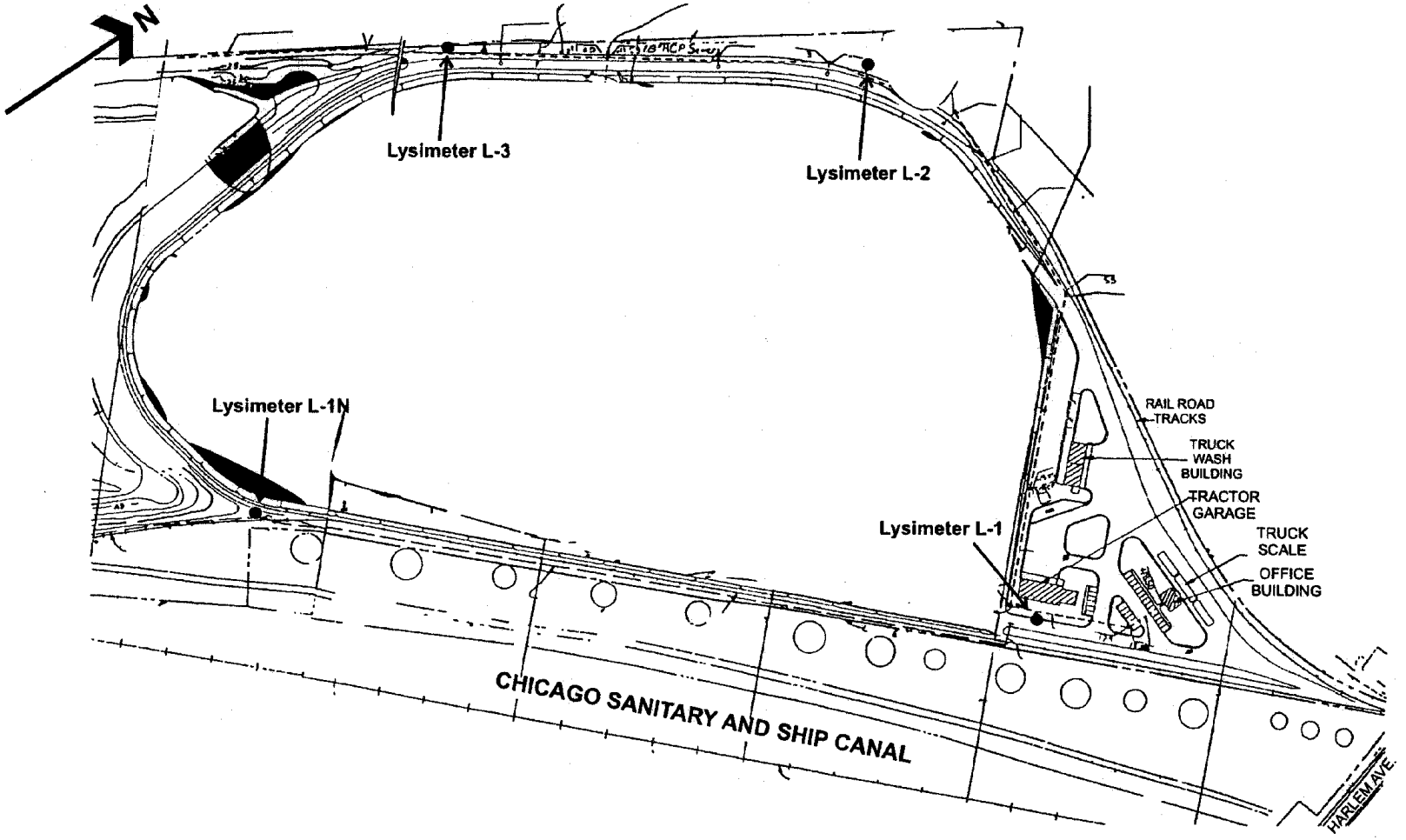

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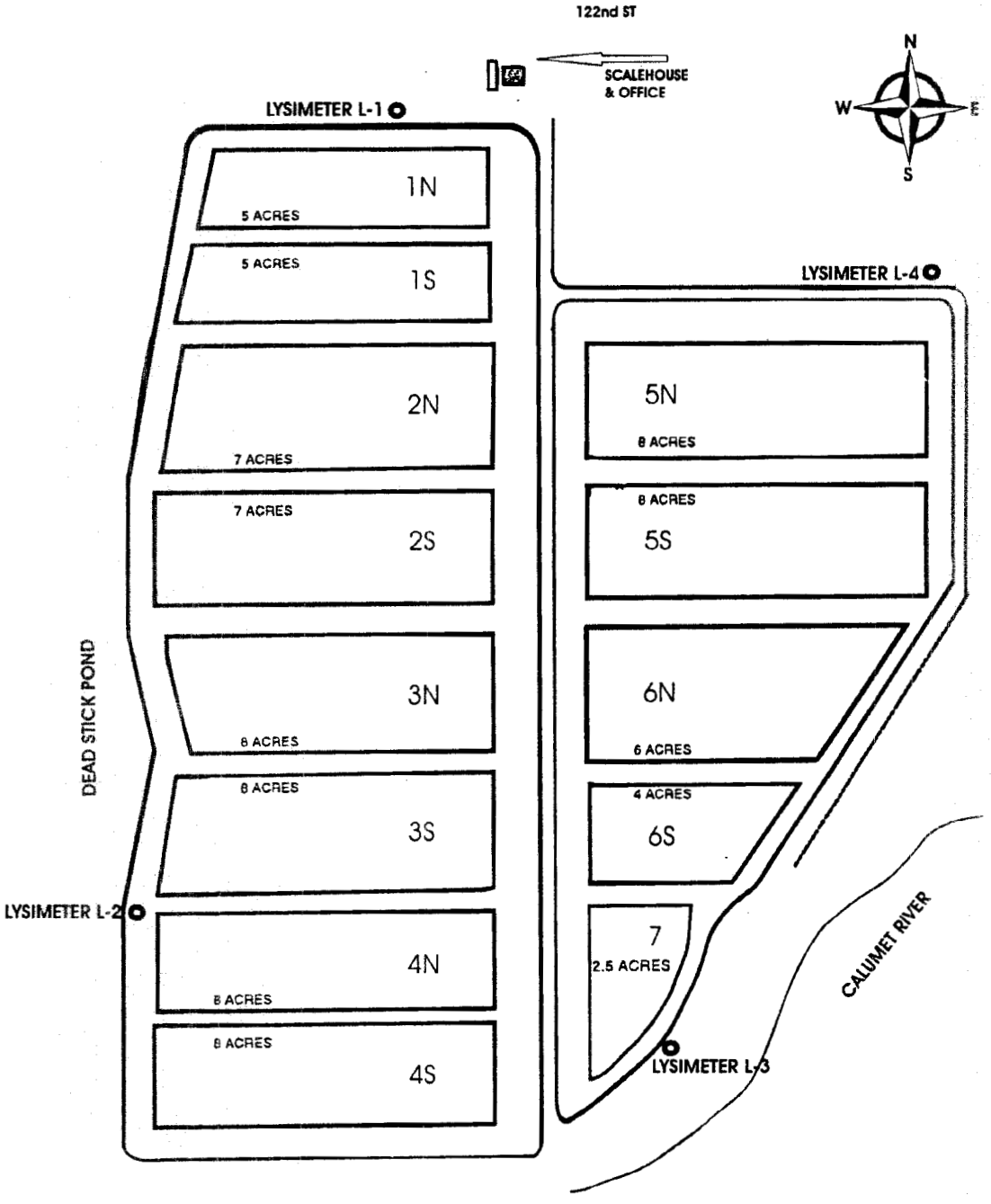
FIGURE 30

LOCATION OF THE LYSIMETERS AT THE STONY ISLAND AVENUE SOLIDS MANAGEMENT AREA



at the Stony Island drying site. Analytical results for water sampled monthly during 2003 from the four lysimeters at this drying facility were submitted to the IEPA in quarterly monitoring reports. Groundwater quality remained relatively constant within the last year.

USX Research and Demonstration Project

Formerly referred to as U. S. Steel Southworks, the USX site is a 570-acre brownfield located near 86th Street and South Shore Drive. At one time, the site housed one of the largest steel mills in the world. The steel mill ceased operation over 20 years ago and has since been demolished, and all buildings and structures on the site have been razed. The site is now characterized by soils composed of slag; a by-product of steel and iron manufacture, and the rubble and foundations resulting from the demolition of all of the structures once covering the site. The slag and rubble fill is poorly suited for the growth of any vegetation. Currently, the Solo Cup Company is in the process of constructing a new factory at the site and would like to create some green space. The City of Chicago and the Chicago Park District are planning to create a 120-acre of lakefront park on the parcel. In order to establish any kind of vegetation at the site the slag has to be either capped or reclaimed.

A research and demonstration project was designed and conducted to test the effectiveness of soil, biosolids, and soil amended with biosolids for establishing suitable vegetation on the slag materials, and to determine the impacts of these treatments on groundwater and lake water quality. The suitable vegetation included turf and tree species commonly used in city parks and other public areas. The project was originally intended to last for two years but it later was extended for an additional year. The project was concluded in December 2003. Cooperative organizations in this effort were:

- the Biosolids Utilization and Soil Sciences Section (District);
- the Analytical Laboratories Division (District);
- the City of Chicago; and
- the Chicago Park District.

The data generated from this project will be helpful in determining the most appropriate biosolids loading rates for reclaiming slag at the USX site and other similar sites on the city's southeast side.

PLOTS AND AMENDMENT TREATMENTS

The research and demonstration project was designed to test the effectiveness of four amendments: 100 percent soil, a 25 percent biosolids and 75 percent soil mixture, a 50 percent

biosolids and 50 percent soil mixture, and 100 percent biosolids. The demonstration consisted of two plots for each amendment. For each amendment, the west plot consisted of the amendment being placed directly onto the slag, while the east plot received a six-inch layer of silty clay loam prior to the placement of amendments. Details of the plot layout are given in Figure 31. The purpose of the silty clay loam layer was to simulate the clay textured B horizon that occurs in most natural soil profiles. This soil horizon was expected to minimize percolation of water from the nutrient-rich amendments into the porous slag, thereby retaining more moisture and nutrients in the plant's root zone.

In June of 2000, the amendments were placed on each of the eight plots to a depth of one foot where turf was to be established, and four feet where trees were to be established. The area of each plot that received the one-foot thick amendment application was divided into four subplots for testing different turfgrass mixes.

SOIL SAMPLING AND ANALYSIS

Soil samples were collected from the one-foot thick amendments of each of the eight plots in April and October 2003. The soil was sampled by compositing several cores at the 0- to 6-inch depth. In April 2003, the soil samples were

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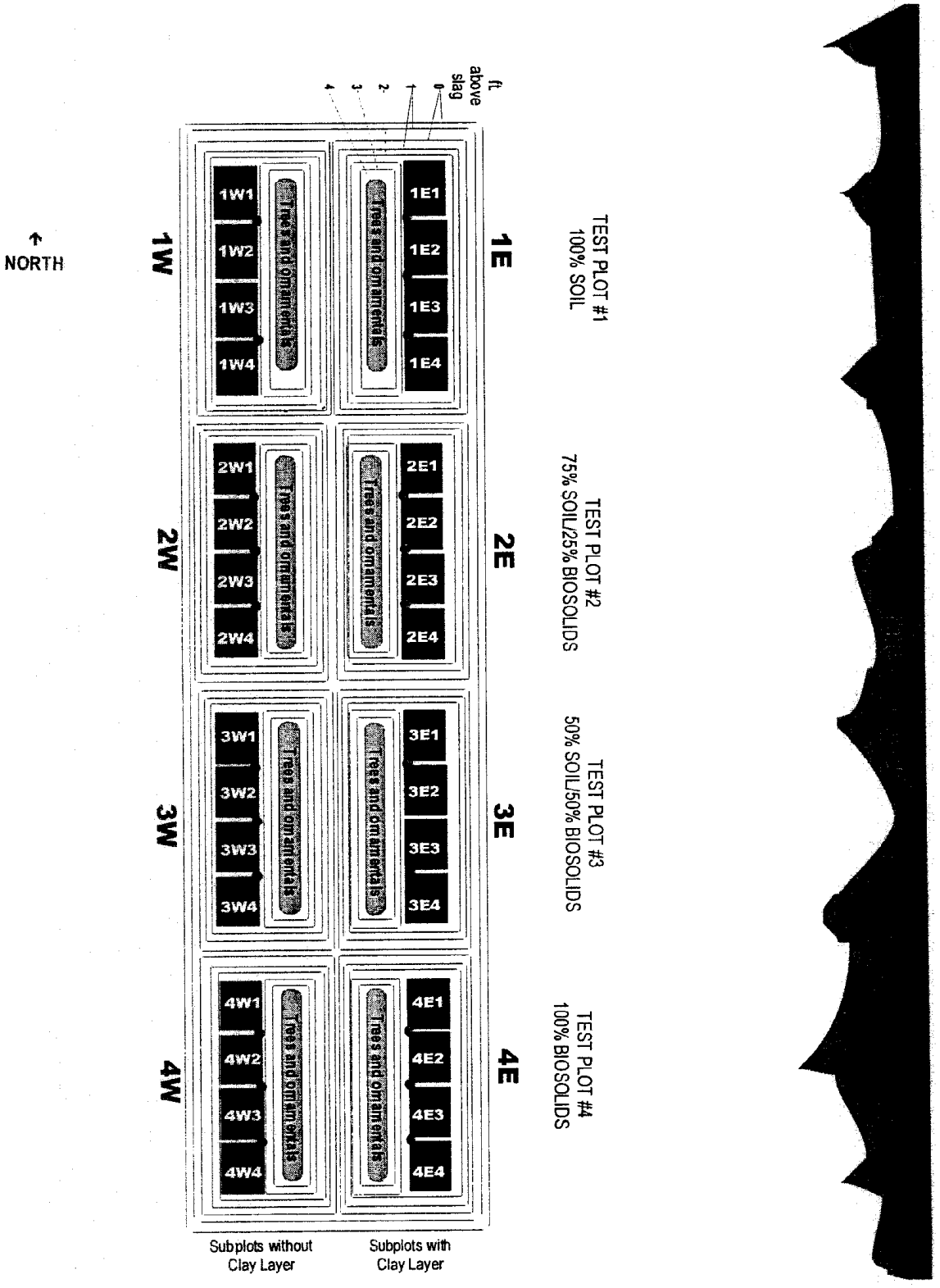
FIGURE 31

USX SITE SCHEMATIC OF PLOTS, SUBPLOTS, AND SUB-SUBPLOTS



collected as composites of each of the eight amendment plots and in October, samples were collected as composites of each of the thirty-two turfgrass testing subplots. The samples were air-dried and analyzed for chemical constituents.

The annual mean concentrations of nutrients and trace metals in the surface (0- to 6-inch depth) soil samples are presented in Tables 50 and 51 , respectively.

LYSIMETERS, WELLS, AND LAKE SAMPLING AND ANALYSIS

Prior to the application of the amendments, one well and two lysimeters were installed in each plot and at a remote site for the purpose of groundwater monitoring (Figure 32). Due to difficult drilling conditions, wells could not be installed in plots 1W and 3E. Where drilling conditions permitted, wells were installed in the slag at the water table 20 - 25 feet below the slag surface, which is the static water level of Lake Michigan. Two lysimeters were installed in each plot and at the remote site at depths of 5 and 10 feet below the surface of the slag. Additionally, three sampling locations were designated in Lake Michigan at points approximately 50 feet off shore, which corresponded with the north end, midpoint, and south end of the research plots. Waters from the wells, lysimeters, and sampling locations on Lake Michigan were sampled and analyzed monthly from January

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TABLE 50

MEAN CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN SURFACE SOIL (0-6 INCH DEPTH) OF THE USX PLOTS IN 2003[1]

Plot[2]	pH[3]	EC[3]	Available P	TKN[4]	NH_4-N[3]	NO_3-N[3]	SO_4-S[3]	Organic Carbon
		dS/m	mg/kg					%
1 East	7.6	0.2	15	1,877	0.1	1.2	15	4.2
2 East	7.1	0.3	252	5,775	0.2	12.3	34	8.9
3 East	7.6	0.5	219	7,463	0.3	15.8	47	17.6
4 East	6.4	1.4	557	12,413	4.0	136.8	325	24.0
1 West	7.7	0.4	18	2,114	0.5	1.9	20	4.2
2 West	7.6	0.4	234	6,011	0.4	17.3	18	9.0
3 West	7.3	0.4	263	8,178	0.4	27.6	20	18.9
4 West	6.5	1.3	544	12,108	4.0	84.7	341	24.2

[1] Values are the mean of values for four subplots during spring and fall samplings.
[2] Plot designations 1, 2, 3, and 4 represent amendments of 0, 25, 50, and 100 percent biosolids, respectively.
[3] Concentrations in 1:2 (soil:water) extract.
[4] TKN = Total Kjeldahl nitrogen.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 51

MEAN TOTAL CONCENTRATIONS OF METALS IN SURFACE SOIL (0-6 INCH DEPTH) OF THE USX PLOTS IN 2003[1]

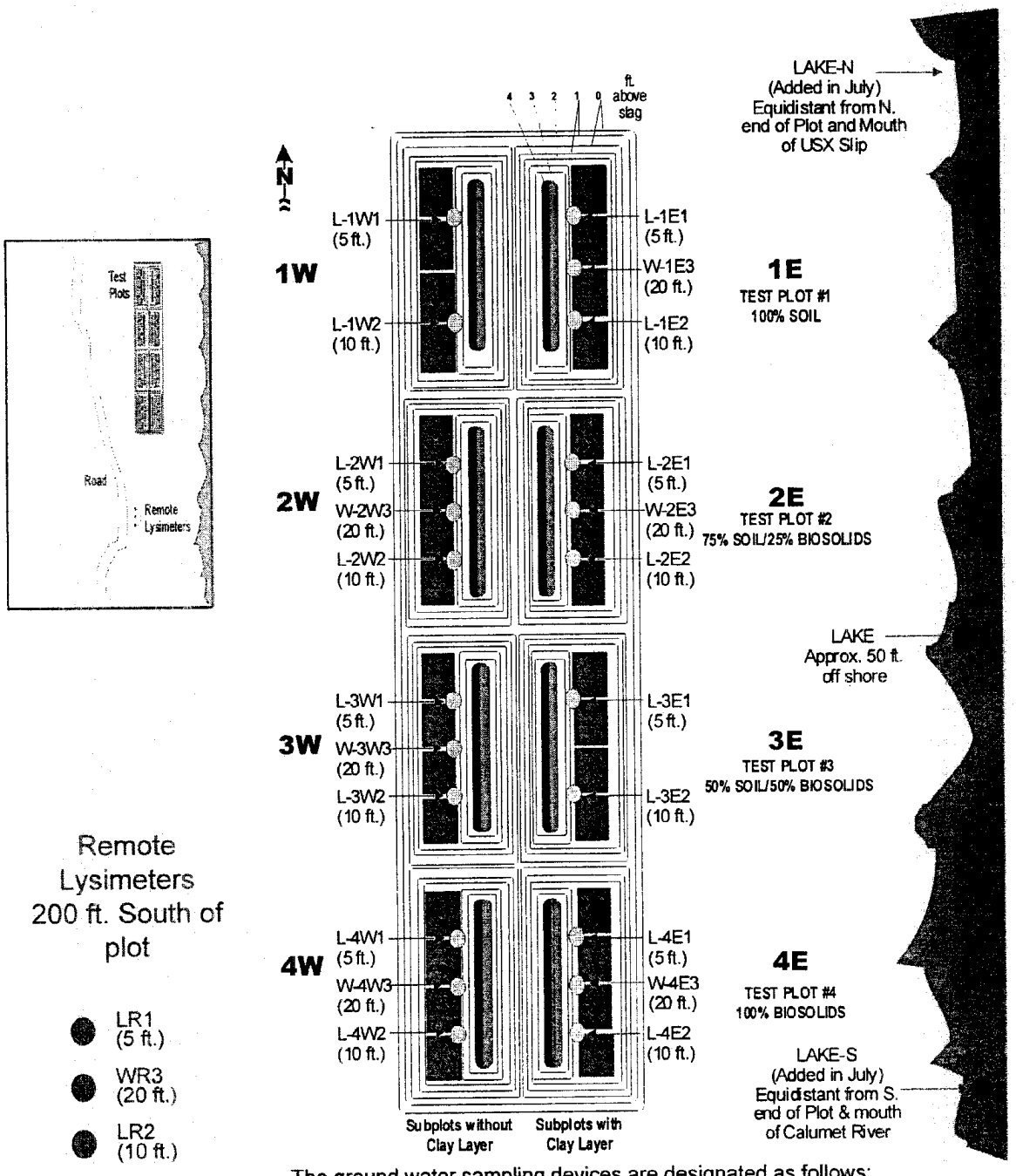
Plot[2]	Zn	Cd	Cu	Cr	Ni	Pb	Mn	Fe	Mo
	mg/kg								
1 East	62	1.1	21	31	20	27	482	15,631	0.8
2 East	461	4.7	132	96	29	60	554	20,409	3.2
3 East	503	5.4	157	343	39	63	2,972	25,467	6.5
4 East	1,332	11.8	392	173	35	145	394	22,531	11.2
1 West	71	1.2	26	97	26	26	948	15,060	1.4
2 West	359	3.9	106	228	34	51	1,863	23,181	4.4
3 West	574	5.8	168	234	32	73	1,444	22,372	5.3
4 West	1,288	11.8	377	202	34	142	679	22,250	10.1

[1] Values are the mean of values for four subplots during fall sampling.
[2] Plot designations 1, 2, 3, and 4 represent amendments of 0, 25, 50, and 100 percent biosolids, respectively.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 32

A SCHEMATIC OF USX BIOSOLIDS DEMONSTRATION PLOTS
WITH LOCATIONS OF SAMPLING DEVICES



The ground water sampling devices are designated as follows:
Last number 1 & 2 are lysimeters and 3 is observation well.

through June and bimonthly from August through December 2003. The legend for coding the groundwater monitoring and lake sampling locations is shown in Figure 32. Mean annual concentrations of various parameters analyzed for the water samples are presented by sampling location in Table 52.

Quarterly water sampling and analyses for 111 organic priority pollutants were conducted in March, June, September, and November of 2003. Because of the small sample volumes obtained from the lysimeters, the water samples for organic priority pollutant analyses were composited as follows: the 5-foot lysimeters from plots 1E and 1W (topsoil amendment) and the remote site; the 5-foot lysimeters plots 3E and 3W (50 percent biosolids/50 percent topsoil), and plots 4E and 4W (100 percent biosolids); the 10-foot lysimeters from plots 1E and 1W and the remote site; the 10-foot lysimeters from plots 3E, 3W, 4E, and 4W; the wells from plot 1E and the remote site; and the wells from plots 3W, 4E, and 4W.

The maximum levels of organic priority pollutants found in the composite samples are presented in Table 53.

PLANT TISSUE SAMPLING AND ANALYSIS

The project was designed to evaluate the performance of four turf blends and eleven tree species grown on the slag material capped with topsoil and mixtures of topsoil and

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 52

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE FROM JANUARY THROUGH DECEMBER 2003

Parameter	Units	Sample Point Identification[2]					
		L1E1 @5′	L1E2 @10′	W1E3 @20′	L2E1 @5′	L2E2 @10′	W2E3 @20′
pH		7.7	7.9	7.4	7.9	7.6	7.3
EC	mS/m	129	123	119	128	193	135
Total Dissolved Solids	mg/L	1,352	NA	1,070	1,473	2.544	1,053
Cl^-	"	29.4	NA	33.9	17.7	20.5	65.7
$SO_4^=$	"	373	NA	324	384	783	286
TKN	"	1.20	1.03	0.29	3.01	2.18	0.35
NH_3-N	"	0.16	0.94	0.10	0.10	0.10	0.16
NO_2-N	"	0.117	2.640	0.026	0.040	0.035	0.012
NO_3-N	"	4.26	1.67	0.28	23.00	19.03	0.37
Total P	"	NA	NA	0.06	0.32	0.11	0.06
Alkalinity as $CaCO_3$	"	628	NA	439	500	565	404
Hardness	"	904	NA	658	964	1,553	553
As	µg/L	<4	NA	<2	<4	<4	<2
Cd	"	<0.6	NA	<0.3	<0.6	<0.6	<0.3
Cr	"	18.3	NA	2.8	6.0	6.0	2.5
Cu	"	24.5	NA	4.0	44.0	64.0	2.0
Hg	µg/L	0.69	NA	0.22	0.45	0.15	0.05
Mn	"	114	NA	881	337	169	1,387
Ni	"	8.0	NA	3.0	7.0	13.0	2.0
Pb	"	12.0	NA	4.9	10.3	12.0	4.8
Sb	"	12.0	NA	9.4	13.2	21.6	7.7
Zn	"	422	NA	177	113	149	192
Fecal Coliform	#/100mL	<1	<1	12	<1	<1	<1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 52 (Continued)

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE FROM JANUARY THROUGH DECEMBER 2003

Parameter	Units	Sample Point Identification[2]				
		L3E1 @5'	L3E2 @10'	L4E1 @5'	L4E2 @10'	W4E3 @20'
pH		7.8	7.5	9.0	7.8	7.5
EC	mS/m	169	222	149	229	125
Total Dissolved Solids	mg/L	1,671	2,906	1,716	3,120	1,026
Cl^-	"	NA	30.4	133.6	36.7	49.8
$SO_4^=$	"	568	1,047	248	1,208	450
TKN	"	3.82	3.90	60.28	2.20	1.15
NH_3-N	"	0.08	0.97	37.07	0.35	0.90
NO_2-N	"	0.036	0.997	32.463	0.139	0.016
NO_3-N	"	23.4	16.96	7.95	28.03	0.10
Total P	"	0.10	0.09	0.20	0.08	0.05
Alkalinity as $CaCO_3$	"	521	526	351	463	143
Hardness	"	1,202	1,523	184	1,566	457
As	µg/L	<4	<4	<4	<4	<2
Cd	"	<0.6	<0.6	<0.6	<0.6	<0.3
Cr	"	6.4	5.0	2.7	4.0	2.5
Cu	"	56	68	17	14	NA
Hg	µg/L	0.15	0.11	0.70	0.14	0.17
Mn	"	949	761	26	207	1,367
Ni	"	9.7	8.5	25.5	14.0	4.2
Pb	"	31.7	19.6	6.2	14.7	4.6
Sb	"	15.2	18.0	13.0	24.7	8.2
Zn	"	138	131	15	125	61
Fecal Coliform	#/100mL	<1	<1	<1	<1	6

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 52 (Continued)

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE FROM JANUARY THROUGH DECEMBER 2003

Parameter	Units	Sample Point Identification[2] L1W1 @5'	L1W2 @10'	L2W1 @5'	L2W2 @10'	W2W3 @20'
pH		7.1	734	736	7.9	7.3
EC	mS/m	145	260	154	219	111
Total Dissolved Solids	mg/L	NA	3,324	1,336	,2918	868
Cl^-	"	NA	15	24	20	60
$SO_4^=$	"	NA	1,517	251	745	251
TKN	"	NA	1.11	2.77	3.64	0.52
NH_3-N	"	NA	0.26	0.10	0.11	0.33
NO_2-N	"	NA	0.79	0.07	0.16	0.01
NO_3-N	"	NA	16.3	12.8	25.2	0.345
Total P	"	NA	0.09	NA	0.09	0.10
Alkalinity as $CaCO_3$	"	NA	397	604	896	317
Hardness	"	NA	1,776	695	1,715	442
As	µg/L	NA	<4	<4	<4	<2
Cd	"	NA	0.6	<0.6	<0.6	<0.3
Cr	"	NA	5.6	5.2	6.3	1.7
Cu	"	NA	14	38	30	3.0
Hg	µg/L	NA	0.46	0.12	0.15	0.06
Mn	"	NA	358	69	179	365
Ni	"	NA	6.7	7.0	7.7	2.0
Pb	"	NA	13.2	12.0	11.7	4.6
Sb	"	NA	26.5	11.8	20.0	7.0
Zn	"	NA	1,253	370	216	111
Fecal Coliform	#/100mL	NA	<1	<1	<1	<1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 52 (Continued)

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE FROM JANUARY THROUGH DECEMBER 2003

Parameter	Units	Sample Point Identification[2]					
		L3W1 @5′	L3W2 @10′	W3W3 @20′	L4W1 @5′	L4W2 @10′	W4W3 @20′
pH		7.7	7.5	7.4	8.0	7.4	7.4
EC	mS/m	195	237	132	265	221	137
Total Dissolved Solids	mg/L	1,816	2,316	1,039	2,848	3,040	1,114
Cl^-	"	44.8	22.5	41.7	27.8	74.8	37.6
$SO_4^=$	"	490	1,052	336	1,213	966	397
TKN	"	2.02	2.78	0.54	7.12	28.93	1.13
NH_3-N	"	0.14	0.37	0.42	0.08	16.19	0.88
NO_2-N	"	0.021	1.661	0.085	NA	40.93	0.045
NO_3-N	"	106	28.61	0.54	14.61	60.37	0.43
Total P	"	0.08	0.09	0.07	0.68	0.24	0.06
Alkalinity as $CaCO_3$	"	461	240	372	570	210	335
Hardness	"	1,259	1,202	595	1,804	1,364	644
As	µg/L	<4	<4	<2	<4	<4	<2
Cd	"	<0.6	<0.6	<0.3	<0.6	<0.6	0.5
Cr	"	5.6	5.2	2.2	8.0	3.6	2.8
Cu	"	34	139	<2	<2	384	<2
Hg	µg/L	0.08	0.10	0.06	0.08	0.31	0.09
Mn	"	114	490	1,337	2,577	294	2,004
Ni	"	6.0	5.6	NA	22.0	33.2	4.3
Pb	"	11.2	38.0	5.0	16.0	34.0	5.3
Sb	"	21.0	19.5	8.3	NA	14.8	9.1
Zn	"	251	98	98	16	318	152
Fecal Coliform	#/100mL	<1	<1	<1	<1	<1	1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 52 (Continued)

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE FROM JANUARY THROUGH DECEMBER 2003

Parameter	Units	Sample Point Identification[2]					
		LR1 @5′	LR2 @10′	WR3 @20′	LAKE-N	LAKE	LAKE-S
pH		7.6	7.5	7.1	7.7	7.7	7.7
EC	mS/m	76.4	129.7	130.8	27.9	36.1	30.8
Total Dissolved Solids	mg/L	NA	1,320	985	203	201	198
Cl^-	"	30.1	22.2	33.1	32.5	12.2	12.8
$SO_4^=$	"	NA	317	396	28	29	28
TKN	"	6.90	0.50	0.40	0.21	0.19	0.21
NH_3-N	"	0.54	0.16	0.29	0.03	0.03	0.03
NO_2-N	"	0.301	0.371	0.019	0.002	0.002	0.003
NO_3-N	"	2.26	3.17	0.27	0.31	0.32	0.57
Total P	"	0.11	0.14	0.14	0.04	0.05	0.03
Alkalinity as $CaCO_3$	"	423	687	374	146	103	103
Hardness	"	515	760	637	135	134	135
As	µg/L	<4	<4	<2	<2	<2	<2
Cd	"	0.8	<0.6	0.4	<0.6	0.3	<0.6
Cr	"	13.3	3.5	2.1	1.0	1.0	1.0
Cu	"	28	239	<2	<2	2	2
Hg	µg/L	0.16	0.18	0.10	0.04	0.05	0.04
Mn	"	9	156	1,099	12	14	39
Ni	"	23.0	82.0	<2	3.5	<2	<2
Pb	"	18.7	31.5	5.6	1.7	2.5	1.7
Sb	"	8.0	19.0	9.7	4.3	3.0	4.3
Zn	"	320	355	184	19	13	12

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 52 (Continued)

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE FROM JANUARY THROUGH DECEMBER 2003

Parameter	Units	Sample Point Identification[2]					
		LR1 @5′	LR2 @10′	WR3 @20′	LAKE-N	LAKE	LAKE-S
Fecal Coliform	#/100mL	<1	<1	<1	5	4	8

[1] The method detection limit (MDL) was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.

[2] Lysimeters were installed at 5- and 10-ft depths and observation wells were installed at 20-ft depth. Remote lysimeters and well were situated were installed at 20-ft depth. Remote lysimeters and well were situated 200-ft south of the plots and are labeled as LR and WR, respectively. Lake sampling locations are labeled as Lake-N, Lake, and Lake-S.

NA = No analysis; insufficient sample volume.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 53

MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING QUARTERLY SAMPLING IN 2003

Compound	Reporting Limit µg/L (ppb)	Values Found in µg/L (ppb)	Composite Source
Volatile Organic Compounds			
Acrolein	33	--	
Acrylonitrile	2	--	
Benzene	2	--	
Bromoform	2	--	
Carbon tetrachloride	2	--	
Chlorobenzene	2	--	
Chlorodibromomethane	2	--	
Chloroethane	4	--	
2-Chloroethylvinyl ether	2	--	
Chloroform	2	--	
Dichlorobromomethane	2	--	
1,1-Dichloroethane	2	--	
1,2-Dichloroethane	2	--	
1,1-Dichloroethylene	3	--	
1,2-Dichloropropane	2	--	
1,3-Dichloropropene	2	--	
Ethyl benzene	2	--	
Methyl bromide	3	--	
Methyl chloride	3	--	
Methylene chloride	2	--	
1,1,2,2 Tetrachloroethane	3	--	
Tetrachloroethylene	2	--	
Toluene	2	--	
1,2-trans Dichloroethylene	2	--	
1,1,1-Trichloroethane	2		
1,1,2-Trichloroethane	2	--	
Trichloroethylene	2	--	
Vinyl chloride	3	--	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 53 (Continued)

MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING QUARTERLY SAMPLING IN 2003

Compound	Reporting Limit µg/L (ppb)	Values Found in µg/L (ppb)	Composite Source
Trichlorofluoromethane	4	--	
Acid Extractable Compounds*			
2-Chlorophenol	7	--	
2,4-Dichlorophenol	4	--	
2,4-Dimethylphenol	3	--	
4,6-Dinitro-o-cresol	29	--	
2,4-Dinitrophenol	28	--	
2-Nitrophenol	4	--	
4-Nitrophenol	22	--	
Parachlorometacresol	4	--	
Pentachlorophenol	15	--	
Phenol	4	167	L13E3W4E4W
2,4,6-Trichlorophenol	6	--	
Base/Neutral Extractable Compounds*			
Acenaphthene	4	--	
Acenaphthylene	5	--	
Anthracene	3	--	
Benzidine	26	--	
Benzo(a)anthracene	3	--	
Benzo(a)pyrene	2	--	
3,4-Benzofluoranthene	2	--	
Benzo(ghi)perylene	2	--	
Benzo(k)fluoranthene	2	--	
Bis(2-chloroethoxy)methane	6	--	
Bis(2-chloroethyl)ether	6	--	
Bis(2-chloroisopropyl)ether	6	--	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 53 (Continued)

MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING QUARTERLY SAMPLING IN 2003

Compound	Reporting Limit µg/L (ppb)	Values Found in µg/L (ppb)	Composite Source
Bis(2-ethylhexyl)phthalate	50	--	
4-Bromophenyl phenyl ether	4	--	
Butylbenzyl phthalate	4	--	
2-Chloronaphthalene	4	--	
4-Chlorophenyl phenyl ether	4	--	
Chrysene	2	--	
Dibenzo(a,h)anthracene	2	--	
1,2-Dichlorobenzene	4	--	
1,3-Dichlorobenzene	4	--	
1,4-Dichlorobenzene	4	--	
3,3'-Dichlorobenzidine	11	--	
Diethyl phthalate	6	--	
Dimethyl phthalate	4	--	
Di-n-butyl phthalate	5	--	
2,4-Dinitrotoluene	4	--	
2,6-Dinitrotoluene	4	--	
Di-n-octyl phthalate	6	--	
1,2-Diphenylhydrazine	4	--	
Fluoranthene	2	--	
Fluorene	4	--	
Hexachlorobenzene	4	--	
Hexachlorobutadiene	5	--	
Hexachlorocyclopentadiene	50	--	
Hexachloroethane	4	--	
Indeno(1,2,3-cd)pyrene	2	--	
Isophorone	6	--	
Naphthalene	5	--	
Nitrobenzene	8	--	
N-Nitrosodimethylamine	5	--	
N-Nitrosodi-n-propylamine	6	--	
N-Nitrosodiphenylamine	4	--	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 53 (Continued)

MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING QUARTERLY SAMPLING IN 2003

Compound	Reporting Limit µg/L (ppb)	Values Found in µg/L (ppb)	Composite Source
Phenanthrene	2	--	
Pyrene	2	--	
1,2,4-Trichlorobenzene	4	--	
Pesticides & PCBs			
Aldrin	0.03	--	
a-BHC-alpha	0.03	--	
b-BHC-beta	0.03	--	
BHC-gamma	0.03	--	
BHC-delta	0.03	--	
Chlordane	0.3	--	
4,4'-DDT	0.03	--	
4,4'-DDE	0.03	--	
4,4'-DDD	0.03	--	
Dieldrin	0.03	--	
a-Endosulfan-alpha	0.03	--	
b-Endosulfan-beta	0.03	--	
Endosulfan sulfate	0.03	--	
Endrin	0.06	--	
Endrin aldehyde	0.03	--	
Heptachlor	0.03		
Heptachlor epoxide	0.03	--	
PCB-1242	0.3	--	
PCB-1254	0.3	--	
PCB-1221	0.6	--	
PCB-1232	0.4	--	
PCB-1248	0.3	--	
PCB-1260	0.3	--	
PCB-1016	0.3	--	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 53 (Continued)

MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING QUARTERLY SAMPLING IN 2003

Compound	Reporting Limit µg/L (ppb)	Values Found in µg/L (ppb)	Composite Source
(Total PCB)	(0.3)	--	
Toxaphene	1.0	--	

-- Not found, below reporting limit.
* Reporting limits are 10 times higher than listed due to a dilution of 1:10.
L13E3W4E4W = Composite sample of the 5-ft lysimeters from 3E, 3W, 4E, and 4W plots.

biosolids (100% topsoil, 75% topsoil and 25% biosolids mixture, 50% topsoil and 50% biosolids mixture, and 100% biosolids). Each plot receiving these amendments was further divided into four subplots for testing the performance of four turf blends commonly used in the city parks. Similarly, the performance of five species of shade trees and six species of ornamental trees commonly used in the city parks and landscape was evaluated in the plots receiving the above mentioned amendments. Details of the plot layout are given in Figure 32 and the details of the turf blends and tree species evaluated are given in Table 54.

Tissue samples of turf blends were collected from all the thirty-two subplots, and the samples were analyzed for Zn, Cu, Cr, Cd, Ni, Pb, Mo, Fe, Ca, Na, K, Mg, Mn, N, and P to determine the effect of various amendments on the uptake of common plant nutrients and trace elements. The mean annual concentrations of all the chemical constituents analyzed in the tissue samples of the turf grasses are presented in Table 55.

Tissue samples of trees were collected from all the tree species by plucking approximately 20-40 leaves from each tree. The samples were analyzed for nutrients and trace elements to determine the uptake of the chemical constituents from various amendments, i.e., the mixtures of biosolids and topsoil applied to the demonstration plots. The mean concentrations of

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 54

USX DEMONSTRATION PLOT PLANT SCHEDULE

Grass Seed Mixtures

Name	Acronym	Composition
Metropolitan Water Reclamation District of Greater Chicago	MWRDGC	70% Tall Fescue 30% Kentucky Bluegrass
Standard Chicago Park District Turf Blend	SCPD	70% Kentucky Bluegrass 15% Creeping Red Fescue 10% Perennial Rye 5% Redtop
Illinois Department of Transportation	IDOT 1B	75% Tall Fescue 15% Perennial Rye 10% Creeping Red Fescue
Variation of Illinois Department of Transportation Lawn Mixture	VIDOT1	50% Perennial Rye 30% Kentucky Bluegrass 20% Creeping Red Fescue

Woody Plant Material

Botanical Name	Common Name	Size	Classification
Acer ginnala	Amur Maple	6' clump	Ornamental Tree
Acer x freemanii "Marmo"	Marmo Hybrid Maple	2" cal	Shade Tree
Amelanchier x grandiflora	Apple Serviceberry	4'-5' clump	Ornamental Tree
Crataegus crusgalli inermis	Thornless Cockspur Hawthorn	1 3/4" cal	Ornamental Tree
Fraxinus americana "Autumn Purple"	Autumn Purple Ash	2" cal	Shade Tree
Glenditsia triacanthos inermis "Skyline"	Skyline Honey Locust	2" cal	Shade Tree
Malus "Donald Wyman"	Donald Wyman Crab	4'-5' clump	Ornamental Tree
Malus zumi calocarpa	Zumi Crabapple	4'-5' clump	Ornamental Tree
Populus deltoides "Siouxland"	Siouxland Cottonless Cottonwood	2" cal	Shade Tree
Quercus rubra	Red Oak	1 1/2" cal	Shade Tree
Ulmus x "Homestead"	Homestead Hybrid Elm	2" cal	Shade Tree

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TABLE 55

MEAN ANNUAL CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN TISSUE SAMPLES OF TURF GRASSES GROWN IN THE USX PLOTS IN 2003[1]

Parameter	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
	1 East	1 West	2 East	2 West	3 East	3 West	4 East	4 West
	mg/kg							
Zn	43.7	47.9	39.9	64.9	48.1	76.0	47.9	85.1
Cd	0.16	0.06	0.13	0.41	0.04	0.60	0.02	0.25
Cu	11.4	14.5	10.0	17.6	15.4	20.4	14.4	18.0
Cr	0.47	0.38	0.42	0.60	0.20	0.82	0.21	0.42
Ni	1.78	2.34	1.65	3.33	1.69	6.30	1.88	5.00
Pb	2.04	0.60	1.72	2.01	1.48	2.15	1.89	1.51
K	23,193	28,835	22,928	30,774	27,525	31,585	28,324	31,116
Na	59	91	62	217	105	96	98	203
Ca	5,580	4,706	5,850	4,998	4,403	4,450	4,456	5,235
Mg	3,276	3,143	3,124	3,547	3,133	3,613	3,102	4,110
Mn	45	26	51	33	25	91	26	87
Fe	108	96	109	148	94	226	84	159
Mo	10.5	5.0	8.4	5.1	5.7	4.1	6.3	5.0
TKN[2]	26,266	26,167	42,499	44,085	45,852	38,752	45,495	39,631
TP[3]	5,252	4,645	4,657	3,946	4,208	4,030	4,407	4,294

[1]Values are the mean of values for composite tissue samples of all the four turf blends evaluated at the USX site.
[2]TKN = Total Kjeldahl nitrogen.
[3]TP = Total phosphorus.

chemical constituents in the leaves of shade tree species and ornamental tree species evaluated are presented in Tables 56 and 57, respectively

We are in the process of preparing a final report on the USX Research and Demonstration Project. A detailed discussion and interpretation of the soil fertility, concentration of nutrients and trace elements in plant tissues, and the water quality data collected for the entire duration of the project will be presented in the final report.

Biosolids Stockpile Salinity Study

Beginning in the mid 1990s, the District increased the emphasis on local marketing of biosolids to increase the awareness of the cost-effectiveness of using biosolids for urban land reclamation. Locally, biosolids are often applied to soils at high rates as a soil conditioner or as a topsoil substitute. The relatively high salinity of biosolids compared to natural soils can potentially limit the use of biosolids for successful establishment of a wide range of vegetation.

In the stockpile salinity survey, biosolids that were completely processed and stockpiled at the solids management areas (SMAs) before distribution were sampled and analyzed for pH, EC, NO_3-N, and NH_3-N in 1:2 (biosolids:water ratio) extracts. In 2003, a total of 80 biosolids samples from

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TABLE 56

MEAN CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF SHADE TREES GROWN IN THE USX PLOTS IN 2003[1]

Parameter	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
	1 East	1 West	2 East	2 West	3 East	3 West	4 East	4 West
	mg/kg							
Zn	88.6	79.5	86.1	70.9	94.9	98.2	99.7	109.5
Cd	1.55	0.92	1.23	0.79	1.22	1.31	1.38	1.75
Cu	9.9	10.1	5.0	4.5	4.6	5.0	5.0	5.3
Cr	0.53	0.61	0.56	0.73	0.91	0.82	0.67	0.78
Ni	3.10	1.01	0.91	0.88	1.13	1.05	1.52	1.57
Pb	1.19	1.54	0.93	1.53	0.76	0.79	1.06	1.90
Na	32	31	50	56	60	46	53	47
K	10,518	11,048	10,732	10,102	11,732	11,857	11,339	10,383
Ca	15,884	18,287	15,441	17,195	17,491	16,454	16,984	17,388
Mg	3,448	3,842	3,090	3,605	3,980	3,673	3,360	3,767
Mn	40	45	68	47	147	104	198	237
Fe	138	166	148	173	180	175	155	164
Mo	1.1	1.3	1.8	1.0	1.2	1.2	1.2	1.1
TKN[2]	23,602	25,570	27,624	27,037	25,084	27,351	26,803	26,192
TP[3]	1,182	1,836	2,129	1,976	2,444	2,957	4,062	4,011

[1]Values are the mean of values for six shade tree species evaluated at the USX site.
[2]TKN = Total Kjeldahl nitrogen.
[3]TP = Total phosphorus.

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TABLE 57

MEAN CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF ORNAMENTAL TREES GROWN IN THE USX PLOTS IN 2003[1]

Parameter	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
	1 East	1 West	2 East	2 West	3 East	3 West	4 East	4 West
	mg/kg							
Zn	23.5	28.3	31.9	25.2	35.9	28.0	45.0	39.7
Cd	0.02	0.04	0.13	0.07	0.14	0.09	0.21	0.25
Cu	5.8	4.9	1.6	1.2	4.4	4.5	6.2	5.7
Cr	0.64	0.55	0.75	0.79	0.90	1.89	1.08	0.81
Ni	1.07	1.13	1.15	0.59	2.57	1.98	2.49	1.78
Pb	0.90	2.16	1.71	0.74	0.91	2.45	0.99	0.59
Na	26	21	20	46	29	26	22	45
K	9,426	8,930	10,669	10,487	7,224	8,770	8,572	8,883
Ca	19,687	19,292	17,508	16,832	19,753	15,781	19,269	17,863
Mg	3,743	3,517	3,460	3,588	5,154	6,797	7,749	4,580
Mn	31	31	78	34	128	129	148	210
Fe	162	132	128	132	161	137	205	143
Mo	0.77	0.92	1.26	1.29	1.63	1.60	1.67	2.15
TKN[2]	21,879	21,051	24,021	23,650	23,040	22,336	24,209	23,907
TP[3]	2,353	2,433	2,044	1,814	1,853	1,932	3,110	3,137

[1]Values are the mean of values for five ornamental tree species evaluated at the USX site.
[2]TKN = Total Kjeldahl nitrogen.
[3]TP = Total phosphorus.

stockpiles at the Calumet, HASMA, Marathon, RASMA, and Stony Island SMAs were collected and analyzed.

A summary of the pH, EC, NO_3-N, and NH_4-N in biosolids stockpiles sampled at the District's SMAs in 2003 is presented in Table 58. In 2003, the pH in the 1:2 biosolids:water extract ranged from 5.9 to 7.4 (Stony Island).

The EC in the 1:2 biosolids:water extracts varied widely between the SMAs. The EC levels ranged from 1.7 mS/cm (Stony Island) to 8.3 mS/cm (Calumet).

The NO_3-N and NH_3-N concentrations in the 1:2 biosolids:water extract varied widely between the SMAs. The NO_3-N concentrations were usually much lower than NH_3-N concentrations. The NO_3-N concentrations ranged from 0.3 (Calumet) to 678 mg/L (HASMA), and NH_3-N concentrations ranged from 1.0 (Calumet) to 1,253 mg/L (Calumet).

The data show that the salinity, NO_3-N and NH_3-N levels in biosolids produced at the SMAs varied widely during 2003.

Improvement of Rootzone Nutrient Supply with Biosolids as a Soil Amendment for Golf Courses

Application of organic soil amendments is becoming popular as a method of maintaining the nutrition of turfgrass on golf courses. The United States Golf Association has recommended the use of peats as an amendment for rootzones to enhance their nutrient reserve. More recently, composts are being tested as

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TABLE 58

SUMMARY OF pH, EC, NO_3-N, AND NH_3-N, IN 1:2 (SAMPLE:WATER) EXTRACTS OF BIOSOLIDS STOCKPILES SAMPLED DURING 2003

SMA	pH			EC (dS/m)			NO_3-N (mg/L)			NH_3-N (mg/L)		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Calumet	6.1	7.0	6.6	3.2	8.3	5.4	0.3	333	38	1.0	1,253	453
HASMA	6.1	6.9	6.3	5.2	8.2	6.1	2.0	678	405	70	997	289
Marathon	7.0	7.2	7.1	2.3	3.8	3.2	2.3	21	12	151	531	270
RASMA	6.1	7.0	6.5	4.5	5.8	5.1	8.4	200	71	291	483	386
Stony Is.	5.9	7.4	6.6	1.7	7.3	4.6	0.8	210	65	138	977	343

basal materials in golf courses. Because of its high organic matter and nutrient content, biosolids are a suitable alternative to peats as a soil amendment for turf establishment.

In 1997, the District began a project at the North Shore Country Club located in the northern Chicago suburb of Glenview, to test the use of biosolids as an alternative to peats and compost amendments to improve the nutrient supply in the rootzone of turfgrass grown on golf course greens. In July 2003, three soil samples were collected in the rootzone (0 to 12 inches) of each of six treatments that were established as amendments to the 0 to 12-inch layer on a volume percentage basis. The treatments were sand (control), Sphagnum peat (15%), Dakota reed sedge peat (10%), yard-waste compost (10%), biosolids (10%), 1:1 biosolids:yard-waste compost mixture (5%). The freshly sampled soil was analyzed for potentially mineralizable N (PMN) using anaerobic incubation for one week. The PMN is designated as the pool of N stored mainly in the labile fraction of soil organic matter, which can become readily plant available as inorganic N through mineralization. Organic carbon (SOC) content and Bray P1 available P were determined also on the air-dried soil.

The SOC, PMN, and available P in the six treatments are presented in Table 59. The two peats increased SOC and PMN, but not available P, compared to the unamended control. The

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TABLE 59

SOIL ORGANIC CARBON (SOC), POTENTIALLY MINERALIZABLE N (PMN) AND AVAILABLE PHOSPHORUS (MEAN ± SE) IN SAND ROOTZONE OF TURFGRASS GROWN ON AN EXPERIMENTAL GREEN AT THE NORTH SHORE COUNTRY CLUB AS AFFECTED BY VARIOUS ROOTZONE AMENDMENTS

Amendments	SOC (%)	PMN (mg/kg)	Available P (mg/kg)
None	0.07 ± 0.01	2.5 ± 0.69	14.6 ± 1.5
Dakota peat	0.32 ± 0.02	4.2 ± 0.87	9.3 ± 0.7
Sphagnum peat	0.2 ± 0.05	4.6 ± 0.29	11.0 ± 1.0
Compost	0.35 ± 0.02	3.4 ± 0.34	31.4 ± 1.7
Biosolids	0.66 ± 0.03	11.7 ± 0.52	353 ± 5.6
Biosolids + Compost	0.55 ± 0.05	7.1 ± 0.35	190 ± 5.4
LSD (0.05)	0.13	1.8	11.4

compost amendment increased the rootzone SOC available P, but not PMN. The biosolids and biosolids plus compost amendments increased the rootzone SOC, PMN, and available P, compared to the other treatments. Our first-year data from this study clearly indicate that biosolids are potentially superior to peats and composts as an amendment to improve nutrient supply in turfgrass rootzone on golf courses. We are conducting additional work to confirm the above findings.

BENEFICIAL EFFECTS OF BIOSOLIDS ON TURF AT THE HICKORY HILLS COUNTRY CLUB

Hickory Hills Country Club located in Hickory Hills, Illinois has been using District biosolids annually since 1997 to top dress fairways and make improvements to the golf course. A research study was established on the golf course in the fall of 2002 to evaluate the performance of several species of turf on a Markham silt loam soil treated with two levels of biosolids, under two shade regimes.

Three turf species (Kentucky bluegrass, cvs. Arcadia and SR 2100, perennial ryegrass cv. SR 4500, and creeping red fescue) were planted in individual plots established on soil that received 0 (Control), 280 (low), and 560 (high) tons/ acre of air-dried biosolids. One set of plots was established in a shaded area, and an identical set in a no-shade area. The shaded area received some sunlight during the morning but was

completely shaded for the rest of the day. The no-shade area received direct sunlight throughout the day. The growth and performance of the turfgrass were evaluated visually.

Observations from 2003 showed that the performance of the turf species was variable. Both Kentucky bluegrass cultivars performed best in the shaded plot at the high level (560 tons/ acre) of applied biosolids. These cultivars, especially Arcadia, also produced fairly good growth under both shade and no-shade regimes at all levels of biosolids.

The performance of the perennial ryegrass was slightly lower than that of the Kentucky bluegrass cultivars. The ryegrass seemed to perform better under both shaded and unshaded conditions in the low- rather than the high-biosolids soil. The growth of this species appeared to be suppressed under a combination of full sunlight and high biosolids, but it was still better than in the control soil.

In the shaded area, the stand of creeping red fescue in the control (no biosolids) plots was very thin, patchy, and chlorotic. Etiolation (weak, spindly growth under limited light) was clearly evident under maximum shade below the large trees. However, this species performed best under shade in the low-biosolids treatment, and fairly well in full sunlight in the high-biosolids treatment. It was clearly evident that

a combination of full shade and high biosolids is undesirable for creeping red fescue.

This study is still in progress, and evaluation of the performance of the turf species will continue in 2004.

Nickel Phytotoxicity Study

The USEPA Part 503 regulations, which govern the land application of biosolids, set limits on trace element concentrations and loading rates based on a comprehensive risk assessment. The limits for zinc, nickel, and copper were based on the risk of phytotoxicity resulting from land application of biosolids. The District began a study to evaluate the phytotoxicity thresholds for these metals used in the risk assessment and the level of protection the Part 503 Rule provides to human health and the environment.

During 2003, a preliminary study was conducted to determine the range of soil Ni loadings that could be used to evaluate Ni phytotoxicity in lettuce, a bean, and a turfgrass (perennial ryegrass). Each crop was grown for 6 to 8 weeks in 15-kg pots of a Watseka loamy sand treated with various levels of Ni applied as soluble nickel sulfate. The ranges of Ni application rates were determined as 0 to 50 mg/kg for beans and lettuce and 0 to 250 mg/kg for the perennial ryegrass.

The results indicate that Ni has a profound effect on the germination of seeds and root development. In the more sensitive lettuce and bean crops, germination was delayed by as much as two weeks by Ni concentrations exceeding 30 mg/kg. For the perennial ryegrass, germination rates were reduced by Ni rates above 75 mg/kg.

The dry matter yields of the crops, presented in Table 60, were highest in the control and declined with increasing Ni application rate. Dry matter yields in the control of the lettuce and bean were similar, but the effect of Ni rate on yield reduction appeared to be more pronounced in the bean than in the lettuce. The results of this screening indicate that similar ranges of Ni loading rates could be used in further evaluating Ni phytotoxicity of these crops in the greenhouse.

Additional studies are in progress to further evaluate Ni phytotoxicity, utilizing a wider range of test crops to allow for more comprehensive data acquisition and analysis.

Effect of Biosolids Source and Processing on P Supplying Potential and Soil Test P in Biosolids-Amended Soils

Over-application of P associated with use of inorganic P fertilizers and land application of biosolids, manures, and other soil amendments can lead to excessive levels of P in soils and can potentially contaminate surface waters.

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TABLE 60

DRY MATTER YIELDS OF THREE CROP SPECIES GROWN IN NICKEL-TREATED WATSEKA LOAMY SAND

Crop	Ni Rate	Dry Matter Yield	Relative Dry Matter Yield[1]
	Mg Ni/kg Soil	g/pot	%
Lettuce	0	5.80	100
	5	5.12	88
	10	4.54	78
	15	4.48	77
	20	4.40	76
	25	3.66	63
	30	3.22	56
	40	1.32	23
	50	0.58	10
Bean	0	5.43	100
	5	4.72	87
	10	3.92	72
	15	4.05	75
	20	1.96	36
	25	1.49	27
	30	1.10	20
	40	0.63	12
	50	0.53	10
Perennial	10	11.6	98
	30	11.7	99
	50	6.77	57
	75	5.07	43
	100	0.38	3.2
	250	0.05	0.4

[1] Relative dry matter yield = dry matter yield in treated pot/yield in control pot x 100

The ability of biosolids-amended soil to release P into a water soluble form, which is vulnerable to losses through surface runoff and leaching, is controlled by properties of the soil and biosolids. The process through which biosolids are generated influences their characteristics.

Many states are implementing rules to govern land application of biosolids and other materials based on their P content and potential of environmental impacts. Information on how the various biosolids products generated at the District affect the release of soluble P in biosolids-amended soil will help to better utilize the biosolids P fertilizer value and minimize the potential for environmental impacts associated with land application. In 2003 a study was conducted to compare phosphorus solubility and extractability in soils amended with District biosolids generated from the Calumet and Stickney water reclamation plants (WRP) and commercial inorganic fertilizer.

A total of 15 samples of biosolids generated from the Calumet and Stickney WRPs' low solids (LS) and high solids (HS) processing trains were collected and air-dried. Samples of 100 g of Drummer silt loam and Watseka loamy sand soils were amended with treatments of two total P rates of the biosolids and triple superphoshosphate (TSP) fertilizer. The P rates were 400 and 2,000 mg P/kg soil. The 400 mg P/kg rate

is equivalent to the average P loading associated with 280 kg N/ha provided via biosolids which is the typical agronomic nitrogen (N) rate for a corn crop used in the District's biosolids farmland application program. The 2,000 mg P/kg loading rate was used to simulate five annual applications of the agronomic rate. The amended 100-g soil samples were placed in Ziploc plastic bags, moistened to approximately 80% of field water holding capacity, then incubated for six weeks. After incubation, the amended soils were air-dried then sieved through a 2-mm sieve. The amount of water soluble P that can be potentially released from the amended soil was determined in the Drummer amended soil only. This was done by conducting successive extractions of 0.5-g samples of the amended soil in 0.005 M $CaCl_2$ solution until the P concentration in solution was near zero. The cumulative amount of the added P released was calculated as the sum of the P extracted in each of the successive extractions. The amended Drummer and Watseka soil were analyzed for Bray P1 available P.

The fraction of the P added that was released as water soluble P, presented in Table 61, varied widely in the biosolids-amended soil (8.2 to 28%) and was much lower than in the TSP-amended soil (84.2 to 93.8%). There were no marked differences among the biosolids attributable to source WRP or solids processing train. For all the treatments, the fraction

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TABLE 61

FRACTION OF ADDED P RELEASED (MEAN AND RANGE) AS WATER SOLUBLE P IN DRUMMER SILTY CLAY LOAM SOIL AMENDED WITH TWO TOTAL P RATES ADDED AS TRIPLE SUPERPHOSPHATE FERTILIZER AND BIOSOLIDS GENERATED FROM CALUMET AND STICKNEY WRPS

Source	SPT[1]	P Loading Rate (mg P/kg) 400	2,000
		------ Fraction of P Released (%)[2] ------	
TSP[3]		93.8	84.2
CWRP	HS	15 (10 - 28)	8.3 (6.3 - 13)
	LS	19 (15 - 24)	11 (9.0 - 13)
SWRP	HS	17 (15 - 22)	9.4 (8.2 - 11)
	LS	19 (14 - 21)	12 (12 - 13)

[1] Solids processing train. HS = high solids, LS = low solids.
[2] Fraction = P released/P added x 100.
[3] TSP = Triple superphosphate fertilizer.

of added P released was higher at the 400 mg P/kg rate than at the 2,000 mg P/kg rate.

The increase in the Bray P1 available P in the biosolids-amended Drummer and Watseka soil is presented in Table 62. The increase in Bray P1 available P was much higher in the TSP-amended soils than in the biosolids-amended soils. The increase varied among the biosolids and for both WRPs, it tended to be higher in the biosolids generated through the LS than through the HS processing trains. These data show that the increase in potentially water soluble P, which can be vulnerable to P runoff and leaching, is much higher for soils treated with commercial fertilizer than for soils treated with biosolids.

Water Soluble P and Available Soil Test P in Calcareous Mine-spoil Soil During Long-Term Continuous Biosolids Application

Over application of phosphorus (P) from land application of biosolids, fertilizers, and other soil amendments can contaminate water bodies through surface runoff and leaching. Many states are implementing rules to stipulate land application rates of biosolids and other amendments based the P content of these materials. The District can use data on the long-term fate of land-applied biosolids P to minimize the potential for

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TABLE 62

INCREASE IN BRAY P1 AVAILABLE P (MEAN AND RANGE) IN DRUMMER SILTY CLAY LOAM AND WATSEKA LOAMY FINE SAND SOILS AMENDED WITH TWO TOTAL P RATES ADDED AS TRIPLE SUPERPHOSPHATE FERTILIZER AND BIOSOLIDS GENERATED FROM CALUMET AND STICKNEY WRPs

Source	SPT[1]	No. of Samples	400 mg P/kg added		2,000 mg P/kg added	
			Drummer	Watseka	Drummer	Watseka
			Increase in Bray P1 P (mg P/kg soil)[2]			
TSP[3]			254	324	1,234	1,384
CWRP	HS	4	41 (32 - 49)	86 (65 - 101)	120 (68 - 160)	112 (73 - 152)
	LS	2	55 (47 - 62)	98 (85 - 111)	146 (89 - 202)	175 (136 - 215)
SWRP	HS	5	51 (34 - 59)	119 (98 - 136)	149 (87 - 200)	159 (102 - 202)
	LS	4	57 (44 - 74)	127 (118 - 132)	160 (116 - 212)	181 (114 - 279)

[1] HS = high solids, LS = low solids.
[2] Change in Bray P1 P = Bray P1 P in treated minus untreated.
[3] TSP = Triple superphosphate fertilizer.

negative impacts of future P-based land application rules on the District's biosolids management program.

In 2003, archived soil samples from the District's UICF field study conducted at Fulton County were analyzed to compare the effect of long-term continuous application of biosolids and commercial inorganic fertilizer on the leaching of the applied P and the build up of plant available (soil test) P. The UICF field study began in 1973 and consists of sixteen plots in which annual treatments of a control, which receives 336-224-112 kg/ha/yr of $N-P_2O_5-K_2O$ and three biosolids application rates of 17, 34, and 67 Mg/ha/yr (dry weight basis). During the 1973 to 2003 period, the mean annual P loading rates for the treatments were 98, 435, 870, and 1,740 kg P/ha/yr for the control and for the 17, 34, and 67 Mg/ha/yr biosolids rates, respectively. Every year, corn is grown on the plots and soil samples are collected in 15-cm depth increments before application of the treatments.

Soil samples for all depth increments collected before application of treatments in 1973 through 1978, and at five-year intervals after then until 2003 were selected from the archive for analysis. The samples for all soil depths were analyzed for water soluble P (1:25 soil:water extraction ratio) and the surface 0 to 15-cm depth samples were analyzed for Bray P1 P.

The concentrations of water soluble P in treatments during the five-year intervals from 1973 to 2003 are presented in Table 63. In all the treatments, the water soluble P concentrations increased with time mostly in the 0 to 15-cm depth, where the treatments are incorporated. Below this depth, there were only slight increases in water soluble P with time, indicating that most of the applied P accumulated at the depth of incorporation with very little P leaching. Although the mean annual P loading rates were much higher in the biosolids treatments (435 to 1,740 kg P/ha/yr) than in the fertilizer control (98 kg P/ha/yr), water soluble P concentrations in the 0 to 15-cm soil depth were always highest in the fertilizer control.

The effect of cumulative P loading rate associated with the biosolids treatments on Bray P1 available P in the 0 to 15-cm soil depth is presented in Figure 33. The slopes of the regression lines for the treatments show that the increase in Bray P1 available P per unit of applied P for the fertilizer control was more than six times higher than the increases for the biosolids treatments. These data show that P associated with long-term continuous biosolids application tend to accumulate mostly at the surface where it is incorporated and results in very little P leaching. The data show also that increases in soil water soluble P and soil test P is much

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TABLE 63

WATER SOLUBLE P AT FIVE-YEAR INTERVALS IN A CALCAREOUS MINE-SPOIL SOIL RECEIVING ANNUAL TREATMENTS OF A FERTILIZER CONTROL AND THREE RATES OF BIOSOLIDS FROM 1973 TO 2003

Depth (cm)[2]	Biosolids Rate (Mg/ha)[1] 0 (Control)	17	34	67
		1973		
0 - 15	0.88	0.94	1.20	1.17
15 - 30	1.15	0.81	0.93	1.00
30 - 45	0.90	0.60	0.71	1.10
60 - 75	0.79	0.72	0.86	1.09
		1978		
0 - 15	7.49	4.17	7.53	9.03
15 - 30	0.93	0.59	0.66	1.22
30 - 45	1.20	0.56	0.71	0.80
60 - 75	0.94	0.84	1.09	1.22
		1983		
0 - 15	14.86	10.39	14.53	19.25
15 - 30	0.87	1.46	1.72	2.48
30 - 45	0.51	0.62	0.96	0.71
60 - 75	0.56	0.68	0.68	0.50
		1988		
0 - 15	29.50	14.00	18.87	20.86
15 - 30	2.00	2.06	2.58	3.27
30 - 45	1.26	0.98	1.35	1.50
60 - 75	1.01	0.96	1.16	1.43

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TABLE 63 (Continued)

WATER SOLUBLE P AT FIVE-YEAR INTERVALS IN A CALCAREOUS MINE-SPOIL SOIL RECEIVING ANNUAL TREATMENTS OF A FERTILIZER CONTROL AND THREE RATES OF BIOSOLIDS FROM 1973 TO 2003

Depth (cm)[2]	Biosolids Rate (Mg/ha)[1]			
	0 (Control)	17	34	67
		1993		
0 - 15	41.30	24.02	33.26	39.76
15 - 30	6.83	3.11	5.83	19.74
30 - 45	2.89	1.89	1.73	2.32
60 - 75	1.91	0.83	1.34	1.25
		1998		
0 - 15	56.42	23.60	41.63	38.51
15 - 30	2.49	3.89	2.99	16.49
30 - 45	2.23	1.38	2.93	2.72
60 - 75	2.54	1.89	1.90	1.76
		2003		
0 - 15	53.99	32.23	41.43	45.84
15 - 30	8.36	6.49	7.22	19.06
30 - 45	5.46	3.71	2.68	6.46
45 - 60	5.29	3.00	3.91	4.95
60 - 75	4.24	1.80	2.70	3.39
75 - 90	3.55	2.72	3.24	3.40

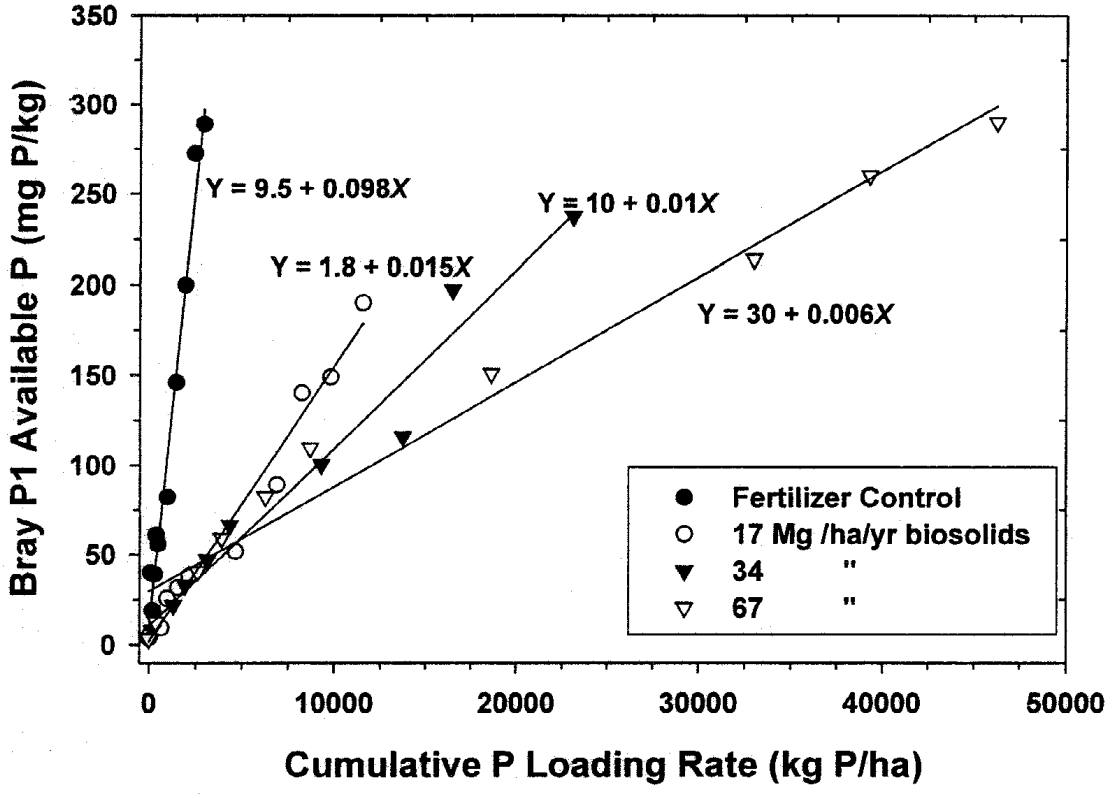
1 The control treatment received 336-224-112 kg/ha/yr of N-P_2O_5-K_2O fertilizer and biosolids treatments received 112 kg K_2O/ha/yr.

2 The 45 to 60-cm depth was sampled only in 2003.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 33

BRAY P1 AVAILABLE P VS. P LOADING ASSOCIATED WITH LONG-TERM CONTINUOUS APPLICATION OF A FERTILIZER CONTROL AND THREE RATES OF BIOSOLIDS IN THE 0 TO 15-CM DEPTH OF A CALCAREOUS MINE-SPOIL SOIL



lower for biosolids than for commercial inorganic fertilizer, and for equal cumulative P loading, soil test P increases as annual biosolids loading rate decreases.

Technical Support for Biosolids Management

The Biosolids Utilization and Soil Science Section provides technical support for biosolids management to both the M&O Department and the biosolids users. This ensures full regulatory compliance of these projects and enhances the successful and safe use of the District's biosolids. The Section is also charged with conducting and communicating the results of applied research on the beneficial use of the District's biosolids. This research is conducted to provide agronomic information, assess the environmental impacts of their use, and promote these practices. The Section's support for biosolids management consists of the following:

1. Monitoring of air-dried biosolids products for compliance with USEPA and IEPA standards.
2. Collecting samples for internal studies and external requirements.
3. Reporting relevant data and information to contractors, biosolids users, IEPA, and USEPA.

4. Providing oversight support for District contracts for application of Class B biosolids cake to farmland.

5. Educating biosolids users to ensure compliance with state and federal regulations governing biosolids use, and to provide technical information related to specific planned uses of biosolids.

6. Documenting biosolids use at major projects to produce case studies to promote future use of biosolids.

7. Initiating and documenting demonstration scale projects using biosolids to increase public acceptance and promote future projects.

8. Providing surveillance and documentation of management practices at local biosolids use projects.

9. Maintaining year-round demonstrations of biosolids as a topsoil substitute in the Lue-Hing R&D Complex Greenhouse and hosting tours to educate potential biosolids users and promote local marketing.

10. Conducting applied research on agronomic and environmental aspects of biosolids use as a

fertilizer, soil conditioner and topsoil substitute.

11. Presenting information at local and national scientific conferences, and at meetings with potential biosolids users, promoting the beneficial use of the District's biosolids.
12. Interacting with state and federal regulators to defend the District's biosolids management activities, review and comment on development of new regulations, and obtain permitting or approval for new biosolids projects.

In 2003, the Section provided technical support, in the form of one or more of the activities listed above for several biosolids projects and potential users. Examples of biosolids projects conducted by, or supported by, the Section in 2003 include:

1. Rehabilitation of fairways using biosolids as a soil conditioner and topsoil substitute at the Hickory Hills, Longwood, and Cinder Ridge Golf Courses.
2. Development of athletic fields using biosolids as a soil conditioner by High School District 230 at Amos Alonzo Stagg High School, at St.

Rita High School, and at St. John the Baptist Missionary Church in Homer Township.

3. Use of biosolids as a topsoil substitute and soil conditioner for maintenance of nursery and sod at Land of Lincoln Tree Farm Nursery and Greener Gardens Sod Farm.

4. Use of biosolids as a topsoil substitute and soil conditioner for maintenance of park and recreational land in the Village of Blue Island.

5. Use of biosolids as a topsoil substitute and soil conditioner to establish native vegetation for erosion control on the cap of a landscape berm built by the District in Willow Springs.

6. Use of biosolids as a topsoil substitute and soil conditioner to establish a landscape berm supporting shrubs and ornamental vegetation at Eden Place Nature Center an initiative of the Fuller Park Community Development Project.

7. Use of biosolids, as a topsoil substitute, in the final protective layer at various landfills.

8. Completion of detailed plans for the establishment of plots to demonstrate the beneficial use of Class B biosolids on farmland.
9. Initiation of collaboration with University of Florida, Pennsylvania State University, and IEPA to develop a comprehensive project to evaluate the environmental impacts of phosphorus in land applied biosolids.
10. Continuation of greenhouse studies to assess the risk of metal phytotoxicity.
11. Initiation of collaborative research with North Shore Country Club to assess the effectiveness of biosolids as a substitute for peat and other soil amendments typically utilized in construction of golf course greens and fairways.
12. Conduct of the USX Slag Reclamation Research and Demonstration study to promote biosolids use in establishment of public parks at brownfield sites.

ANALYTICAL MICROBIOLOGY AND BIOMONITORING SECTION

The Analytical Microbiology and Biomonitoring Section is composed of four professional and 12 technical personnel. The Section is organized into four groups, which perform specific monitoring or research activities. The four groups are:

I. Analytical Microbiology

II. Virology

III. Parasitology

IV. Biomonitoring

Section personnel are often involved in studies of wastewater treatment, biosolids assessment, and environmental monitoring which require the application of specific microbiological disciplines and expertise. The areas of study in which the Section personnel can be involved during the course of a given year include, but are not limited to:

- public health risk assessment;
- ecological risk assessment;
- water quality monitoring;
- ecotoxicology and biomonitoring;
- bioassay methodology;
- microbial processes;

- enumeration of viral, microbial, and parasitic indicators;
- enumeration of specific pathogens; and
- the microbiology of specific wastewater or biosolids treatment options.

In 2003, personnel in the Section participated in a variety of monitoring and research activities. Listed below are the most important of these activities and the group which had the most direct participation.

I. Analytical Microbiology Group Activities

a. Water Reclamation Plant (WRP) Quality Control. Monitoring WRP effluents for the presence and density of fecal coliforms (FC) for disinfection control.

b. Bypasses to Lake Michigan. Monitoring the Lake Michigan shoreline and Chicago area beaches for the presence and density of FC and *Escherichia coli* (EC), following diversion of storm water and combined sewage to the lake.

c. Chicago Area Waterways. Monitoring District waterways in Cook County upstream

and downstream of the Calumet, North Side, Stickney, and Lemont WRPs.

d. Groundwater Monitoring Wells. Monitoring FC presence and density in groundwater monitoring wells near TARP tunnels, as required by Illinois Environmental Protection Agency (IEPA) operational permits.

e. Land Reclamation. Monitoring the presence and density of FC in groundwater monitoring wells around biosolids handling sites in Cook County.

f. Part 503 Compliance Monitoring. Analysis of biosolids for FC.

g. Potable Water Analysis. Monitoring drinking water at District WRPs, and other locations.

h. Reviews. Review research reports and proposed regulations to determine the impact on District operations.

II. Virology Group Activities

a. Part 503 Compliance Monitoring. Analysis of biosolids for enteric viruses.

b. Process Certification for Class A Biosolids. Analysis of biosolids for enteric viruses to demonstrate that the District's codified treatment processes consistently produce Class A biosolids as defined in the Part 503 Regulations.

c. Monitoring of Biosolids for Somatic and Male-specific RNA (FRNA) Phages. Research on the use of FRNA phages as indicators for enteric viruses in biosolids.

d. Reviews. Review research reports and proposed regulations for any impact on District operations.

III. Parasitology Group Activities

a. Part 503 Compliance Monitoring. Analysis of biosolids for viable *Ascaris* ova.

b. Process Certification for Class A Biosolids. Analysis of biosolids for viable *Ascaris* ova to demonstrate that the District's codified treatment processes consistently produce Class A biosolids as defined in the Part 503 Regulations.

c. Reviews. Review research reports and proposed regulations for any impact on District operations.

IV. Biomonitoring Group Activities

a. Whole Effluent Toxicity (WET) Testing for National Pollutant Discharge Elimination System (NPDES) Permits. Use of fathead minnows and daphnids to assess acute and chronic toxicity of effluents from District WRPs.

b. Chronic Whole Effluent Toxicity (WET) Testing of Effluents from the Stickney, Calumet, and North Side WRPs. Joint study involving the District, USEPA, and IEPA.

c. Reviews. Review research reports and proposed regulations for any impact on District operations.

Analytical Microbiology Group Activities

The Analytical Microbiology Laboratory is certified by the Illinois Department of Public Health (IDPH) for the bacterial analysis of water. The Laboratory has held this certification since 1979. The Analytical Microbiology Group is responsible for all bacterial population density analyses used for the WRP

effluent monitoring required by NPDES permits. Monitoring the densities of FC bacteria in effluents of the District's WRPs was begun in 1972, when first required by NPDES permits, and continues to the present. Monitoring of the Chicago beaches is conducted when river reversals to Lake Michigan occur after large amounts of rainfall. The Analytical Microbiology Group also conducts microbiological analyses in support of other Sections.

Table 64 summarizes the number and type of analyses performed by the Analytical Microbiology Group in 2003. Bacterial analyses for total coliforms (TC), FC, *and* EC are used by the District as indicators of the sanitary quality of water. The heterotrophic plate count (HPC) is a procedure for estimating the number of viable heterotrophic bacteria in water. Bacteria were identified to species (ID-CONF) using specific biochemical metabolic characteristics.

CERTIFICATION BY THE IDPH

The Analytical Microbiology Group is certified by the IDPH, Registry #17508, for the following laboratory examinations:

- HPC for water;
- TC with EC broth verification examination of water

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TABLE 64

ANALYTICAL MICROBIOLOGY GROUP SAMPLES AND ANALYSES
2002 THROUGH 2003

Year	Samples	Analysis or Test Performed[1]										
		TC	FC	FS	PA	SAL	HPC	EC	ENT	IQC	ID-CONF	Total
2002	2,954	52	2,991[a]	0	0	0	51	692	0	7,624	242	11,652
2003	2,612	37	2,525	0	0	2	43	316	0	7,667	358	10,952

[1]TC = Total Coliform; FC = Fecal Coliform; FS = Fecal Streptococcus; PA = Pseudomonas aeruginosa; SAL = Salmonella sp.; SPC - Heterotrophic Plate Count; EC = Escherichia coli; ENT = Enterococcus sp.; IQC = Internal Quality Control testing (reported as the number of procedures performed); ID-CONF = Organism Identification using specific biochemical metabolic characteristics.

[a]Some samples were analyzed for FC with two different methods for research and quality assurance purposes. This explains why the number of FC analyses is greater than the number of samples.

from public water supplies and their sources [membrane filtration, (MF), and multiple tube fermentation, (MTF)];

- FC examination of water from public water sources (MF and MTF);
- TC and EC examination of samples of water from public water supplies and their sources (MMO-MUG).

The Analytical Microbiology Group's facilities, equipment, and procedures were the subject of the biennial on-site evaluation for certification by the IDPH on November 13, 2002, and were found to be in general compliance with the provisions of 18th Edition of *Standard Methods for the Examination of Water and Wastewater* (SM 18th ed.), and the Illinois Rules for Certification and Operation of Environmental Laboratories, Title 77, Part 465, with no deviations. The Group collects and analyzes potable water samples from District facilities as required.

NPDES COMPLIANCE MONITORING

Fecal coliform data are made available to the Hanover Park, James C. Kirie, and John E. Egan WRPs within 24 hours of sample collections. These data are used as a guide in maintaining proper chlorination at these District WRPs, and for

reporting compliance with NPDES permit regulations. All District WRPs with NPDES disinfection requirements have a seasonal exemption from November 1 through April 30 of each year and are not subject to any effluent disinfection requirements during this period.

NPDES permits also require additional monitoring when increased flows caused by storms exceed the design (treatment) capacities of the WRPs. These storms can cause the WRPs to divert a portion of the influent, which is then given minimal treatment, before being delivered to the receiving stream. These storm related excess flow discharges (WRP bypasses) must be monitored for the FC bacteria levels. During 2003 the Analytical Microbiology Group performed analyses for FC bacteria on storm related excess flow discharges from the Hanover Park (one sample) and Egan WRPs (two samples). In compliance with the NPDES permits the Analytical Microbiology Group also performed analyses for FC bacteria on five samples from retention ponds and eight samples from the CS tanks at the Hanover Park WRP. Results were reported to WRP personnel as soon as data were available.

PART 503 COMPLIANCE MONITORING

In 2003 the Analytical Microbiology Group performed MPN analyses for FC bacteria on 68 samples of biosolids to

determine if they met the Class A pathogen requirement of less than 1000 FC MPN/g (dry weight) specified in the Part 503 Regulations for the Disposal of Sewage Sludge. The results were reported to M&O personnel responsible for the District's Controlled Solids Distribution Program at the solids management areas. The District has more distribution options for biosolids demonstrated to be Class A than for non-Class A biosolids.

MONITORING OF CLASS B BIOSOLIDS AT THE JOHN E. EGAN WRP

In the District, Class B biosolids are generated with an anaerobic digestion process. Anaerobic digestion is listed in Appendix B of the Part 503 Regulations as a Process to Significantly Reduce Pathogens (PSRP). The John E. Egan WRP normally operates a 2-stage digestion system using four digesters. In 2002 and 2003 the John E. Egan WRP operated only two digesters because of construction. Therefore, the FC density in John E. Egan WRP biosolids were monitored, even though there is normally no pathogen monitoring requirement for Class B biosolids produced by a PSRP. The Analytical Microbiology Group performed MPN analyses for FC bacteria on 105 samples of John E. Egan WRP digester draw during the construction period. The FC density in these samples ranged from 3,700 to 722,800 FC MPN/g dry weight, and the geometric mean for all 105

samples was 45,284 FC MPN/g dry weight. Sampling began in April of 2002 and continued through April 2003, with at least seven samples collected per month. All samples met the pathogen limits for Class B biosolids (FC < 2 x 10^6 FC/g dry weight).

SUPPORT OF OTHER SECTIONS

The Analytical Microbiology Group supported a variety of Environmental Monitoring and Research and Industrial Waste Division programs in 2003. These are effluent analysis, land reclamation, sludge indicator organism densities, District waterway surveys, Lake Michigan monitoring, major treatment facility monitoring, TARP, research support, industrial waste surveys, the Illinois waterway survey, emergency response, combined sewer overflows, and other miscellaneous samples. Table 65 is a summary of the major programs receiving support from 2002 through 2003, and the number of analyses performed for each program.

Virology Group Activities

In 2003 the Virology Group analyzed 23 biosolids samples for site-specific Processes to Further Reduce Pathogens (PFRP) equivalency monitoring and for compliance with the Part 503 sludge disposal regulations. Enteric virus densities in all

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TABLE 65

INDICATOR BACTERIA ANALYSES PERFORMED BY THE ANALYTICAL MICROBIOLOGY GROUP FOR VARIOUS DISTRICT PROGRAMS 2001 THROUGH 2003

Program	Total Coliform			Fecal Coliform			*Escherichia coli*		
	2001	2002	2003	2001	2002	2003	2001	2002	2003
Effluent Analysis	11	11	12	808	792	716	228	315	64
Land Reclamation	-[a]	-	-	451	461	309	-	-	-
Sludge Indicator Organism Density	-	-	-	38	122	100	-	-	-
Ambient Water Quality	-	-	-	953	711	637	165	241	237
Industrial Waste Surveys[1]	-	-	-	12	8	7	2	-	-
Research -Support	-	-	-	34	91	-	-	98	-
Lake Michigan Monitoring[2]	-	-	-	198	85	75	100	40	15
Illinois Waterway	-	-	-	245	-	-	-	-	-
TARP	-	-	-	707	759	681	-	-	-
Emergency Response	-	-	-	-	-	-	-	-	-
Combined Sewer Overflow	-	-	-	-	-	-	-	-	-
Other[3]	23	52	25	-	-	-	-	-	-
Total	34	63	37	3,446	3,029	2,525	495	694	316

[a] No samples analyzed.
[1] Unscheduled sampling to detect pollution.
[2] Includes festivals and District bypasses to Lake Michigan.
[3] Includes drinking water.

samples of biosolids produced by the District's codified process were determined to be below the detectable limit, which is less than one plaque forming unit (PFU) per four grams total solids (dry weight basis). Positive recovery studies were performed on these samples for quality assurance purposes. The mean recovery of spiked viruses was 73.5 percent. Recoveries ranged from 50.4 to 112.2 percent and were dependent upon the sample spiked. (Recoveries of greater than 100 percent could be explained by aggregation and de-aggregation of virus particles in suspension.) Results of these analyses are shown in Table 66.

The analytical method used by the District for determining the density of enteric viruses in biosolids was published and approved by the USEPA (Appendix H, EPA/625/R-92/013). The analytical method for enteric viruses involves the elution of viruses from solids, concentration of the eluates, and an assay for plaque-forming viruses using BGM-K cells.

MONITORING OF BIOSOLIDS FOR FRNA PHAGES AND ENTERIC VIRUSES

The USEPA FRNA coliphage method was modified and adapted in the District to determine FRNA coliphage concentrations in raw wastewater, digester feed, digester draw, centrifuge cake, and air-dried biosolids. Research is currently being conducted to evaluate the usefulness of FRNA phages as an

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TABLE 66

VIROLOGICAL ANALYSIS OF BIOSOLIDS FOR DISPOSAL IN 2003[1]

Drying Area	Number Samples That Meet Class A[2]/Number of Samples Collected	PFU/4 g dry wt Range[3,4]	Percent Recovery of Seeded Viruses[5] Range
Calumet	14/14	<0.7844 - <0.8047	50.4 - 112.2
LASMA[6]	1/1	<0.7937	70.0
HASMA[7]	6/6	<0.7952 - <0.8048	50.9 - 108.8
Marathon	2/2	<0.8002 - <0.8079	71.5 - 95.1

[1]Results of analyses performed in the District's Virology Laboratory for site-specific PFRP equivalency monitoring and other monitoring.
[2]Enteric virus densities must be less than one per 4 g total solids (dry weight) in order to meet the Class A pathogen requirement (EPA/625/r-92/013, Revised 2003).
[3]Confirmed plaque forming units/4 g.
[4]Failure to detect viruses in sludge eluates is recorded as less than (<) the limit of test sensitivity.
[5]Positive recovery controls: percent recovery of 400 plaque forming units of poliovirus 1 Sabin seeded into a 4 g aliquot of sample. A positive recovery control was performed for each sample analyzed.
[6]Lawndale Avenue Sludge Management Area.
[7]Harlem Avenue Sludge Management Area.

alternative indicator for the presence of enteric viruses in biosolids. Data collected to date suggest that FRNA coliphages are a good alternate indicator for predicting the presence or absence of enteric viruses in biosolids, specifically, and for assessing the efficiency of wastewater sludge treatment, in general. Mean concentrations of FRNA coliphages and enteric viruses in Stickney and Calumet WRP sludge processing operation sites are shown in Figures 34 and 35, respectively.

Parasitology Group Activities

In 2003 the Parasitology Group analyzed 23 biosolids samples for site-specific Processes to Further Reduce Pathogens (PFRP) equivalency monitoring and for compliance with the Part 503 sludge disposal regulations. *Ascaris* densities in all samples of biosolids produced by the District's codified process were determined to be below the detectable limit which is less than one viable *Ascaris* ovum per four grams total solids (dry weight basis). Results of these analyses are shown in Table 67. Positive recovery studies were performed on these samples for quality assurance purposes. The average recovery of spiked *Ascaris* eggs was 77.95 percent (four samples). These data are shown in Table 68. Since 1996 when the District began monitoring the levels of FC bacteria (see Analytical

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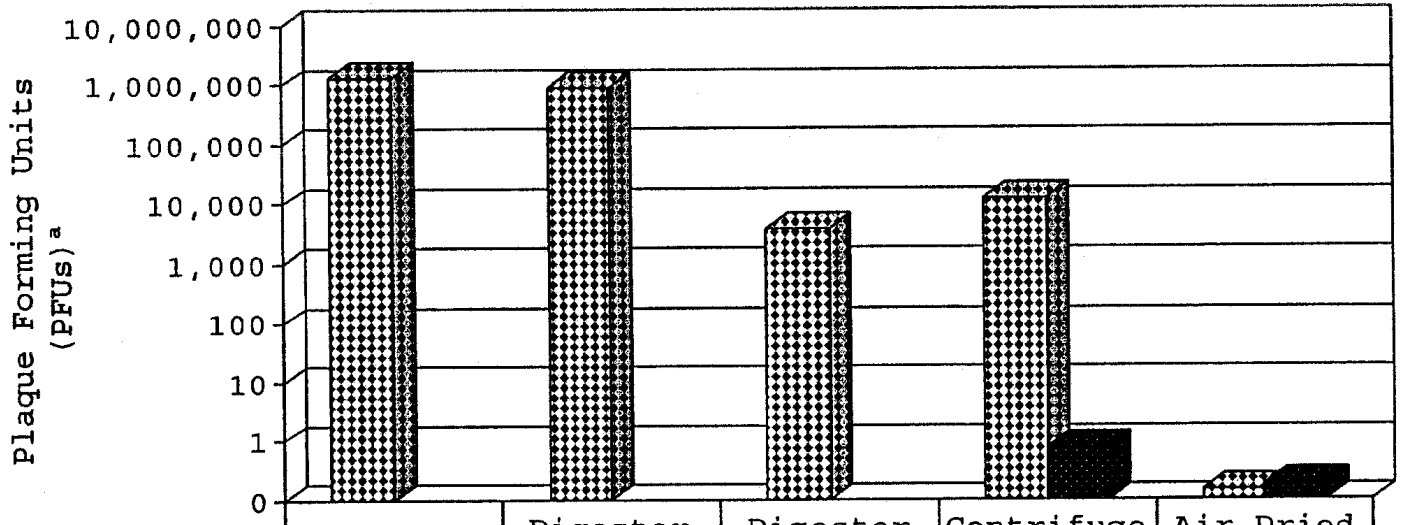
FIGURE 34

MEAN CONCENTRATIONS OF FRNA COLIPHAGES (FRNA) AND ENTERIC VIRUSES (EV) IN STICKNEY WRP SLUDGE PROCESSING OPERATION SITES



	Raw Sewage	Digester Feed	Digester Draw	Centrifuge Cake	Air Dried Biosolids
FRNA [a] PFU/g[b]	1,300,000	900,000	3,900	12,000	< 0.1439
EV [a] PFU/4g[b]	NT[c]	NT[c]	NT[c]	0.7427	< 0.1931

[a] Plaque Forming Units (PFUs): FRNA = PFU/g and EV = PFU/4g

[b] Dry weight

[c] Not Tested

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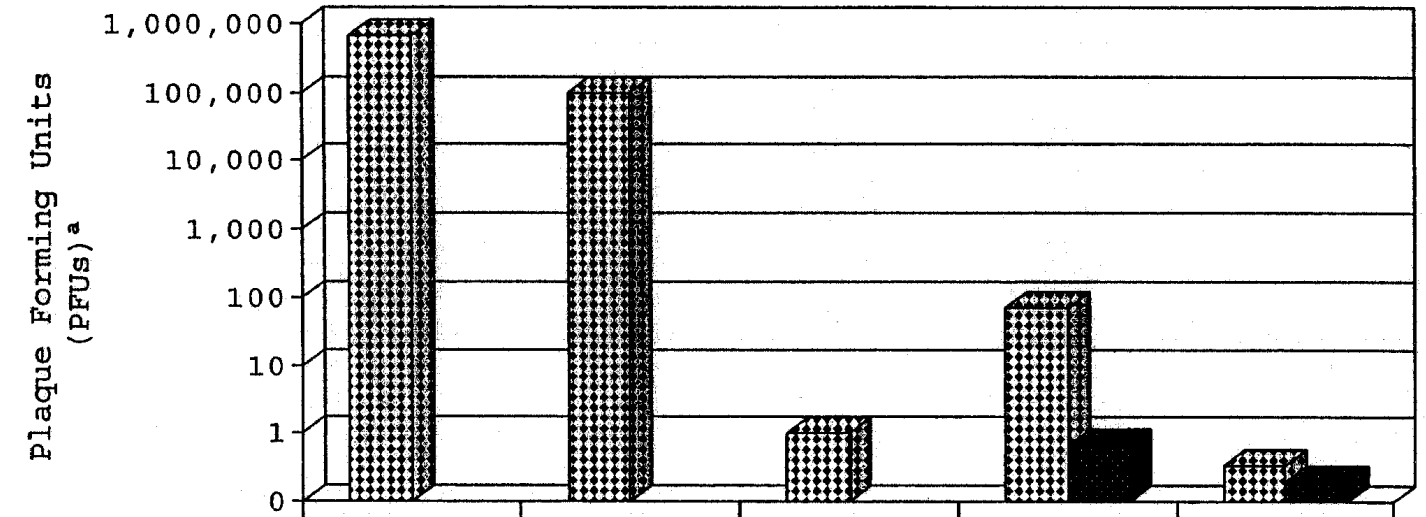
FIGURE 35

MEAN CONCENTRATIONS OF FRNA COLIPHAGES (FRNA) AND ENTERIC VIRUSES (EV) IN CALUMET WRP SLUDGE PROCESSING OPERATION SITES



	Raw Sewage	Digester Feed	Digester Draw	Centrifuge Cake	Air Dried Biosolids
FRNA [a] PFU/g[b]	650,000	98,000	< 1	70	< 0.3398
EV [a] PFU/4g[b]	NT[c]	NT[c]	NT[c]	0.685	< 0.199

[a] Plaque Forming Units (PFUs): FRNA = PFU/g and EV = PFU/4g
[b] Dry weight
[c] Not Tested

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TABLE 67

ASCARIS ANALYSIS OF BIOSOLIDS FOR DISPOSAL IN 2003[1]

Sample Source	Total Number of Samples Collected	Total Number of Samples that Meet Class A Pathogen Requirement[2]	Range of Total Viable *Ascaris* per 4 gram Dry Weight
Calumet	14	14	< 0.0133 - < 0.0800
LASMA[3]	1	1	0.0800
HASMA[4]	6	6	< 0.0133 - < 0.0800
Marathon	2	2	< 0.0800 - 0.0800

[1]Test Method for Detecting, Enumerating, and Determining the Viability of *Ascaris* Ova in Sludge, Appendix I, Environmental Regulations and Technology, EPA/625/R-92/013, Revised 2003.
[2]Viable Helminth ova must be less than 1 viable *Ascaris* ovum per 4 g total solids (Dry Weight) in order to meet the Class A pathogen requirement (EPA/625/R-2/013,2003).
[3]Lawndale Avenue Sludge Management Area.
[4]Harlem Avenue Sludge Management Area.

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TABLE 68

PERCENT RECOVERIES OF "SPIKED *Ascaris suum*" OVA FROM BIOSOLIDS SAMPLES[1] IN 2003

% Total Solids	Sample Weight Analyzed (g)	Estimated Ova Spiked	Percent Total Ova Recovered[2]
18.33	50	5,780	58.56
62.17	50	5,780	87.32
64.90	50	584	89.90
64.90	50	5,840	76.01

[1]Test Method for Detecting, Enumerating, and Determining the Viability of *Ascaris* Ova in Sludge, Appendix I, Environmental Regulations and Technology, EPA/625/R-92/013, Revised 2003.

[2]Percent total ova recovered (viable and non-viable).

Microbiology Group Activities above), enteric viruses (see Virology Group Activities above), and viable *Ascaris* in its dried biosolids product for compliance with the Class A biosolids criteria in the Part 503 sludge disposal regulations, all biosolids produced by the District's codified process have been in compliance with the Class A criteria for shipment and use under the District's Controlled Solids Distribution Program.

The analytical method used in the District for enumerating *Ascaris* ova in sludge was published and approved by the USEPA (Appendix I, EPA/625/R-92/013). The *Ascaris* method employs a combination of sieving, flotation, centrifugation, incubation and microscopic analysis to extract and enumerate viable *Ascaris* ova.

MICROSCOPIC IMAGE ANALYSIS

The District uses microscopic image analysis (MIA) as an aid to monitoring viable *Ascaris* ova in biosolids. The MIA system, mounted on a Nikon Eclipse E600 phase contrast microscope, includes a digital camera with a video image acquisition mode to transmit microscopic images from slides to a computer workstation (Figure 36). Digital images are stored and analyzed using the MetaMorph™ imaging system. The MIA system has proven itself to be a useful tool for the verification and

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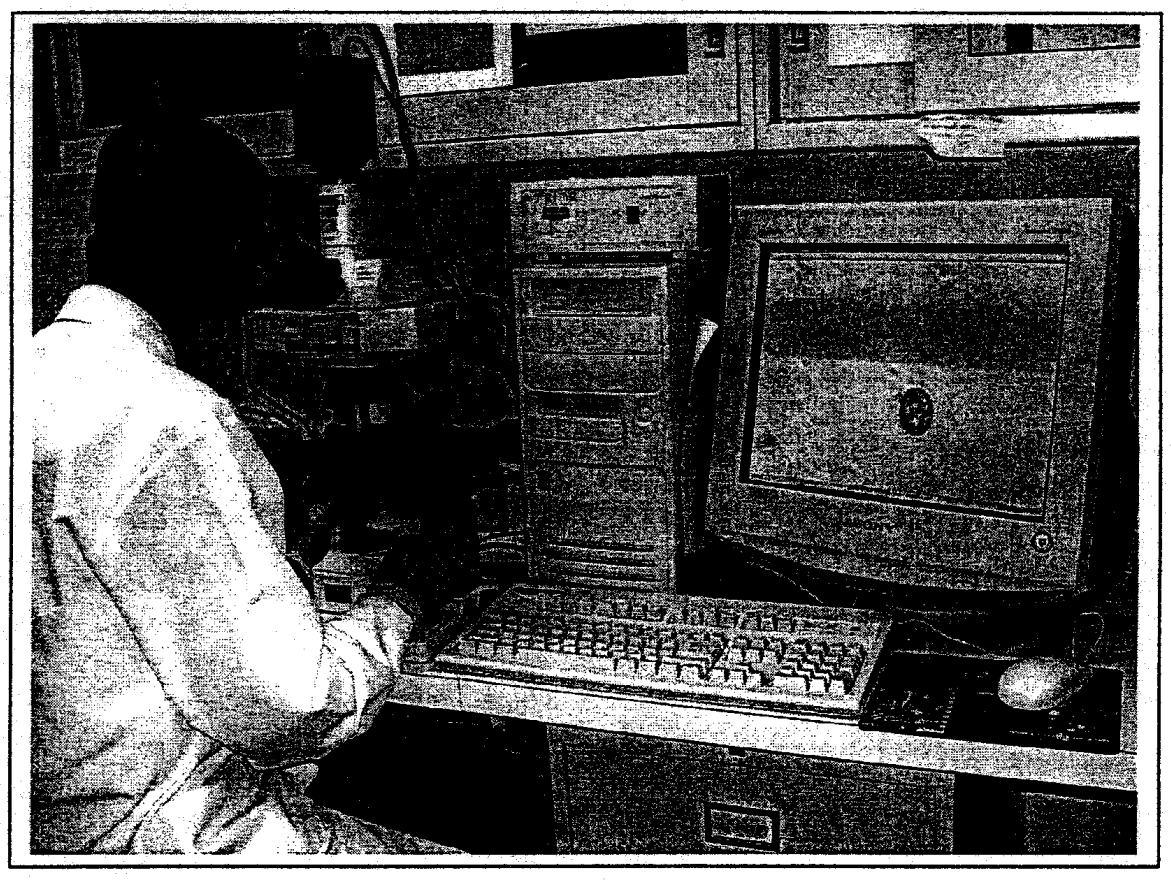
FIGURE 36

MICROSCOPIC IMAGE ANALYSIS SYSTEM (MIA)



Nikon E600 Research Phase Contrast Microscope with a Digital Snap Video Camera Transmitting Microscopic Images from Slide to a Computer Workstation with a Metamorph Software Program.

monitoring of biosolids for Part 503 compliance. For each digital image the following information is automatically stored in a computer file by the imaging software: 1) length of the ovum; 2) width of the ovum; 3) date and time the image was recorded; 4) sample identification number. A series of video digital images is recorded for each ovum examined when larval movement is observed in order to document viable *Ascaris* ova.

In 2003 a study was initiated to determine the feasibility of automating the MIA system for routine monitoring of biosolids for viable *Ascaris* ova. The objectives of this study include optimization of the following MetaMorph image parameters: radial dispersion, pixel area, shape factor, optical density, and area. Viability staining will also be studied. Preliminary data collected in 2003 are promising and indicate that automating the MIA system for routine monitoring may be possible.

Biomonitoring Group Activities

NPDES COMPLIANCE BIOMONITORING

In 2003 acute whole effluent toxicity (WET tests) with fish (*Pimephales promelas)* and daphnids (*Ceriodaphnia dubia)* were conducted on effluent samples from the James C. Kirie WRP for NPDES Permit compliance. No acute toxicity was observed.

Chronic WET tests were also conducted on effluent samples from the Hanover Park WRP for NPDES Permit compliance. No chronic toxicity was observed. These data are shown in Table 69. Biomonitoring reports for the Hanover Park and James C. Kirie WRPs were submitted to the IEPA in compliance with the respective NPDES permits.

CHRONIC WET ASSESSMENT

In July 2002, the District entered into a cooperative agreement with the IEPA and the USEPA-Region 5 to investigate chronic whole effluent toxicity at the Calumet, North Side, and Stickney WRPs. The objective of the WET assessment is to determine whether the effluents from the Calumet, North Side, and Stickney WRPs exhibit any chronic toxicity.

The agreement specifies that the District's Biomonitoring Laboratory and the USEPA's Central Regional Laboratory will each perform chronic toxicity testing on both *Pimephales promelas* and *Ceriodaphnia dubia* with sample collection and analytical laboratory procedures as agreed to by Technical Coordination Group (TCG) composed of representatives of each of the three parties. The TCG met and reached agreement on field sample collection methodology, culturing of test organisms, and laboratory toxicity testing procedures. The TCG also reached agreement on criteria for initial interpretation of

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 69

RESULTS OF WHOLE EFFLUENT TOXICITY (WET) TESTS CONDUCTED ON WATER RECLAMATION PLANT EFFLUENTS FOR NPDES PERMIT COMPLIANCE DURING 2003

Effluent Tested	Date(s) Collected	WET Test[1]	Result[2]
James C. Kirie WRP	5/27/03	Acute *P.promelas* (Survival)	NTE
		Acute *C.dubia* (Survival)	NTE
Hanover Park WRP	6/2-7/03	Chronic *P.promelas* (Survival)	NTE
		(Growth)	NTE
		Chronic *C.dubia* (Survival)	NTE
		(Reproduction)	NTE

[1]WET Tests: Acute *Pimephales promelas* (Survival) and Acute *Ceriodaphnia dubia* (Survival), EPA 600/4-90/027F, (Fourth Edition), 1993; Chronic *Pimephales promelas* (Survival, Growth) and Chronic *Ceriodaphnia dubia* (Survival, Reproduction), EPA 821/R-02/013, (Fourth Edition), 2002.

[2]Results: NTE = no toxic effect.

chronic WET test results. When the testing is completed in 2004, the TCG shall prepare a joint final report on the results of the chronic WET tests conducted under the Agreement. Results of tests conducted in 2003 are shown in Tables 70, 71, and 72.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 70

RESULTS OF CHRONIC WHOLE EFFLUENT TOXICITY (WET) ASSESSMENT[1]
CONDUCTED IN THE FIRST QUARTER, 2003

Effluent Tested	Dates Collected	Chronic *P.promelas*				Chronic *C.dubia*			
		NOEC[2] Survival		NOEC Growth		NOEC Survival		NOEC Reproduction	
		D[3]	EPA[4]	D	EPA	D	EPA	D	EPA
North Side WRP	1/6-11/03	100	NT[5]	100	NT	100	NT	100	NT
Calumet WRP	1/27-2/1/03	100	NT	100	NT	100	NT	100	NT
Stickney WRP	2/24-3/1/03	100	100	100	100	100	100	100	100
North Side WRP	3/10-15/03	100	NT	100	NT	100	NT	100	NT
Stickney WRP	3/24-29/03	100	NT	100	NT	100	NT	100	NT

[1]WET tests: Chronic *Pimephales promelas* (Survival, Growth) and Chronic *Ceriodaphnia dubia* (Survival, Reproduction), EPA-821-R-02-013, (Fourth Edition), 2002.
[2]NOEC = no observable effect concentration; an NOEC of 100 indicates no significant toxicity.
[3]Results obtained in the District's Biomonitoring Laboratory.
[4]Results obtained in the USEPA Central Regional Laboratory, Region 5.
[5]No test.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 71

RESULTS OF CHRONIC WHOLE EFFLUENT TOXICITY (WET) ASSESSMENT[1]
CONDUCTED IN THE SECOND QUARTER, 2003

Effluent Tested	Dates Collected	Chronic *P.promelas*				Chronic *C.dubia*			
		NOEC[2] Survival		NOEC Growth		NOEC Survival		NOEC Reproduction	
		D[3]	EPA[4]	D	EPA	D	EPA	D	EPA
Calumet WRP	4/7-12/03	100	100	100	NT	100	100	100	100
North Side WRP	4/21-26/03	100	NT[5]	100	NT	100	NT	100	NT
Stickney WRP	5/12-17/03	100	NT	100	NT	100	NT	100	NT
Calumet WRP	6/16-21/03	100	NT	100	NT	100	NT	100	NT

[1]WET tests: Chronic *Pimephales promelas* (Survival, Growth) and Chronic *Ceriodaphnia dubia* (Survival, Reproduction), EPA-821-R-02-013, (Fourth Edition), 2002.
[2]NOEC = no observable effect concentration; an NOEC of 100 indicates no significant toxicity.
[3]Results obtained in the District's Biomonitoring Laboratory.
[4]Results obtained in the USEPA Central Regional Laboratory, Region 5.
[5]No test.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 72

RESULTS OF CHRONIC WHOLE EFFLUENT TOXICITY (WET) ASSESSMENT[1]
CONDUCTED IN THE THIRD QUARTER, 2003

Effluent Tested	Dates Collected	Chronic *P.promelas*				Chronic *C.dubia*			
		NOEC[2] Survival		NOEC Growth		NOEC Survival		NOEC Reproduction	
		D[3]	EPA[4]	D	EPA	D	EPA	D	EPA
North Side WRP	7/21-26/03	100	NT[5]	100	NT	75	NT	75	NT
Stickney WRP	8/18-23/03	100	NT	100	NT	100	NT	100	NT
Calumet WRP	9/1-6/03	100	NT	100	NT	100	NT	100	NT
North Side WRP	9/15-20/03	100	100	100	100	100	NT	100	NT
Calumet WRP	9/29-10/4/03	100	NT	100	NT	100	NT	100	NT

[1]WET tests: Chronic *Pimephales promelas* (Survival, Growth) and Chronic *Ceriodaphnia dubia* (Survival, Reproduction), EPA-821-R-02-013, (Fourth Edition), 2002.
[2]NOEC = no observable effect concentration; an NOEC of 100 indicates no significant toxicity.
[3]Results obtained in the District's Biomonitoring Laboratory.
[4]Results obtained in the USEPA Central Regional Laboratory, Region 5.
[5]No test.

AQUATIC ECOLOGY AND WATER QUALITY SECTION

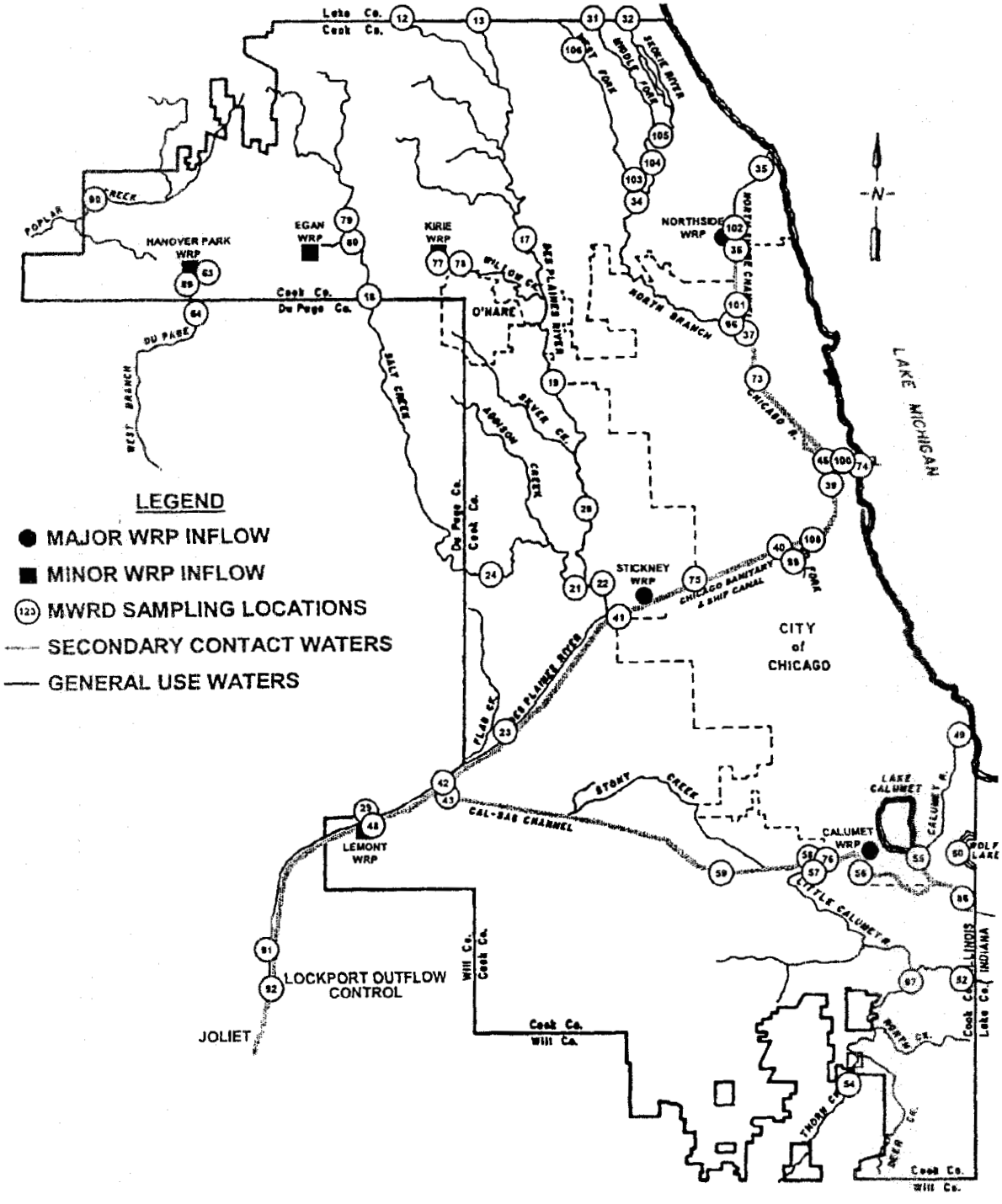
The Aquatic Ecology and Water Quality Section is primarily responsible for assessing the water and sediment quality in both shallow water and deep-draft waterways in the District's service area. The monitoring program, which runs in conjunction with the Ambient Water Quality Monitoring (AWQM) Program, includes the study of the benthic invertebrate and fish communities, characterization of the physical habitat, and assessment of sediment toxicity and sediment chemistry. The primary objective of the monitoring program is to provide scientific data to the District and the Illinois Environmental Protection Agency (IEPA) regarding the biological condition of the Chicagoland waterways. The IEPA uses the data to assess the biological integrity, physical habitat, and sediment quality in waterways in the District's service area. These assessments are summarized in the IEPA's 305(b) use assessment report. Results from the 305(b) report are used by IEPA to prepare a list of impaired waters through the 303(d) listing process.

The biological portion of the AWQM program began in 2001 and is conducted from June through September at 59 stations on the Chicago Waterway System (Figure 37). Fifteen of the 59

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 37

AMBIENT WATER QUALITY MONITORING LOCATIONS



sampling stations are assessed annually, with the remaining 44 stations assessed once every four years.

Additional water and sediment quality monitoring is conducted outside of the District's service area in the lower Des Plaines River and the Illinois River. Special water quality surveys are also conducted to provide technical assistance for the Maintenance and Operations and Engineering Departments.

Fish Monitoring in 2003

During July through September of 2003, fish were collected by electrofishing and seining at 29 biological monitoring stations on Chicago area waterways. Three thousand one hundred and eighty-one fish composed of 42 species were identified, weighed, and measured for length. The fish were also examined for parasites and disease.

Data from these collections are shown in Table 73 for the deep-draft waterways, and in Table 74 for the shallow waterways. The most abundant fish species (those comprising a 3 percent or greater portion of the total catch) in the deep-draft waterways included gizzard shad, carp, bluntnose minnows, largemouth bass, pumpkinseed, emerald shiner, and bluegill. In the shallow waterways, green sunfish, bluegill,

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 73

FISH COLLECTED FROM DEEP-DRAFT WATERWAYS DURING 2003

Fish Species or Hybrid (X)	North Shore Channel Touhy Avenue	North Branch Chicago River[1,2]	Bubbly Creek[3]	Chicago Sanitary and Ship Canal[4]	Calumet River[5]	Little Calumet River[1,6]	Calumet-Sag Channel[7]	Grand Calumet River[1] Burnham Avenue
Alewife	6	1	0	0	0	0	0	0
Gizzard shad	268	34	118	161	176	350	379	0
Rainbow trout	0	0	0	0	0	0	1	0
Coho salmon	0	0	1	0	0	0	0	0
Goldfish	2	0	0	4	0	0	2	0
Carp	27	23	38	73	22	75	85	0
Carp x Goldfish Hybrid	1	0	10	2	0	0	0	0
Golden shiner	9	0	0	2	0	19	1	0
Emerald shiner	0	0	0	1	14	65	22	0
Spottail shiner	0	0	0	0	0	1	1	0
Spotfin shiner	0	0	0	4	0	0	2	0
Bluntnose minnow	0	1	0	114	106	23	36	0
Fathead minnow	0	0	0	0	0	0	2	0
Creek chub	0	0	0	0	0	0	1	0
White sucker	1	0	0	0	18	3	4	0
River carpsucker	0	0	0	0	1	0	0	0
Black buffalo	0	0	0	0	4	0	0	0
Black bullhead	0	0	0	0	0	0	1	0
Yellow bullhead	1	0	0	8	0	4	7	0
Channel catfish	0	0	0	1	0	1	11	0
Blackstripe topminnow	1	1	0	0	0	0	0	0
Mosquitofish	0	0	0	1	0	0	0	0
White bass	0	0	0	0	0	1	0	0
White perch	0	3	0	0	2	14	14	0
Yellow bass	0	0	0	0	1	0	3	0
Striped bass	0	0	0	0	0	0	1	0
Rock bass	0	0	0	0	7	0	0	0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 73 (Continued)

FISH COLLECTED FROM DEEP-DRAFT WATERWAYS DURING 2003

Fish Species or Hybrid (X)	North Shore Channel Touhy Avenue	North Branch Chicago River[1,2]	Bubbly Creek[3]	Chicago Sanitary and Ship Canal[4]	Calumet River[5]	Little Calumet River[1,6]	Calumet-Sag Channel[7]	Grand Calumet River[1] Burnham Avenue
Green sunfish	1	6	4	10	2	7	26	0
Pumpkinseed	1	1	31	48	16	10	4	0
Bluegill	7	3	15	1	31	16	17	0
Smallmouth bass	0	0	0	0	23	0	2	0
Largemouth bass	8	0	4	0	25	76	57	0
White crappie	0	0	0	0	0	12	0	0
Black crappie	2	0	0	0	0	5	0	0
Green sunfish x Bluegill Hybrid	0	0	0	0	0	1	1	0
Freshwater drum	0	0	0	0	0	1	3	0
Round goby	0	0	0	0	0	0	2	0
Total Number	335	73	221	430	448	684	685	0
Total Species	13	9	7	13	15	18	25	0

[1]Includes some shallow portions.
[2]Albany Avenue and Grand Avenue.
[3]Interstate Highway 55, 35th Street, and Racine Avenue Pumping Station.
[4]Cicero Avenue, Harlem Avenue, and 16th Street, Lockport.
[5]Ewing Avenue and 130th Street.
[6]Indiana Avenue, Halsted Street, Wentworth Avenue, and Ashland Avenue.
[7]Ashland Avenue, Cicero Avenue, and Route 83.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 74

FISH COLLECTED FROM SHALLOW WATER STREAMS DURING 2003

Fish Species or Hybrid (X)	Salt Creek Devon Avenue	West Branch DuPage River Lake Street	Des Plaines River[1]	Higgins Creek Wille Road	Thorn Creek[2]	Wolf Lake Drain[3]
Gizzard shad	0	0	0	0	1	0
Grass pickerel	0	0	1	0	0	0
Carp	3	7	3	0	1	0
Spotfin shiner	1	0	40	0	0	0
Sand shiner	0	1	0	0	0	0
Bluntnose minnow	0	0	6	0	0	0
Creek chub	0	0	0	0	9	0
White sucker	3	1	0	0	2	0
Black bullhead	0	0	1	0	0	0
Yellow bullhead	1	1	1	0	0	0
Channel catfish	0	0	1	0	0	0
Pirate perch	0	0	1	0	0	0
Blackstripe topminnow	0	0	31	0	0	0
Rock bass	0	0	1	0	0	0
Green sunfish	11	33	63	0	10	2
Pumpkinseed	0	0	0	0	0	2
Orangespotted sunfish	0	1	1	0	0	0
Bluegill	4	25	16	1	1	3
Longear sunfish	0	0	0	0	0	7
Smallmouth bass	0	0	0	0	0	1
Largemouth bass	0	0	1	0	0	0
Black crappie	0	1	0	0	0	0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 74 (Continued)

FISH COLLECTED FROM SHALLOW WATER STREAMS DURING 2003

Fish Species or Hybrid (X)	Salt Creek Devon Avenue	West Branch DuPage River Lake Street	Des Plaines River[1]	Higgins Creek Wille Road	Thorn Creek[2]	Wolf Lake Drain[3]
Johnny darter	0	0	3	0	0	0
Blackside darter	0	0	1	0	0	0
Round goby	0	0	0	0	0	1
Total Fish	23	70	171	1	24	16
Total Fish Species	6	8	16	2	6	6

[1]Lake-Cook Road, Ogden Avenue, and Material Service Road
[2]Joe Orr Road and 170th Street.
[3]Burnham Avenue.

spotfin shiner, blackstripe topminnow, and carp were the most abundant.

Benthic Invertebrate Monitoring - 2001–2002 Results

As part of the biological portion of the AWQM Program, benthic invertebrates were collected using Hester-Dendy artificial substrate samplers and ponar dredges at deep draft and shallow water biological monitoring stations on Chicago area waterways in 2001 and 2002. Taxonomic identification of the benthic invertebrates was performed by a consultant and the results were published in Research and Development Department Report Number 04-4.

As shown in Table 75, a total of 101 taxonomic groups (taxa) of benthic invertebrates were identified during 2001 and 90 taxa in 2002. The taxa richness, or the number of distinct taxa, represents the diversity of the benthic community. The number of Ephemeroptera (mayflies) + Plecoptera (stoneflies) + Trichoptera (caddisflies), known as EPT taxa, represent a subset of the total taxa, and are composed of environmentally sensitive benthic invertebrate groups. A total of 20 EPT taxa were identified in 2001 and 19 EPT taxa in 2002.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 75

LIST OF BENTHIC INVERTEBRATE TAXA FOUND IN HESTER-DENDY AND PONAR SAMPLES FROM SEVERAL CHICAGO METROPOLITAN AREA WATERWAYS DURING 2001 AND 2002

Taxa	Sample Device and Year			
	Hester-Dendy 2001	Ponar 2001	Hester-Dendy 2002	Ponar 2002
COELENTERATA (Hydroids)				
Hydra	X	X	X	X
PLATYHELMINTHES (Flat worms)				
Turbellaria	X	X	X	X
ENTOPROCTA (Moss Animalcules)				
Urnatella gracilis		X		
ECTOPROCTA (Bryozoans)				
Plumatella	X	X	X	X
ANNELLIDA				
Oligochaeta (Aquatic Worms)	X	X	X	X
Hirudinea (Leeches)				
Glossiphoniidae[1]			X	X
Helobdella[1]	X			
Helobdella stagnalis	X	X	X	X
Helobdella triserialis	X	X	X	
Placobdella			X	
Erpobdella punctata punctata	X	X		X
Mooreobdella microstoma	X	X	X	X
CRUSTACEA				
Ostracoda (Seed Shrimp)		X		
Isopoda (Sow Bugs)				
Caecidotea	X	X	X	X
Amphipoda (Side Swimmers)				
Gammarus[1]				X
Gammarus fasciatus	X	X	X	X
Decapoda (Crayfish)				
Orconectes immunis		X		
Orconectes virilis	X			X
ARACHNOIDEA				
Hydracarina (Water Mites)	X	X		
INSECTA				
Ephemeroptera (Mayflies)				
Isonychia	X		X	
Baetis intercalaris	X	X	X	X
Pseudocloeon ephippiatum	X			

TABLE 75 (Continued)

LIST OF BENTHIC INVERTEBRATE TAXA FOUND IN HESTER-DENDY AND PONAR SAMPLES FROM SEVERAL CHICAGO METROPOLITAN AREA WATERWAYS DURING 2001 AND 2002

Taxa	Sample Device and Year			
	Hester-Dendy 2001	Ponar 2001	Hester-Dendy 2002	Ponar 2002
Heptageniidae[1]	X	X		
Heptagenia	X		X	
Leucrocuta	X		X	
Stenacron	X		X	
Stenonema	X[1]	X		
Stenonema integrum	X		X	
Stenonema terminatum	X		X	
Tricorythodes	X	X	X	X
Caenis		X		
Hexagenia bilineata				X
Odonata (Damselflies and Dragonflies)				
Calopteryx	X			
Argia	X		X	
Enallagma	X	X	X	
Somatochlora			X	
Stylurus		X		
Hemiptera (True Bugs)				
Trepobates			X	
Corixidae			X	X
Palmacorixa		X		
Trichoptera (Caddisflies)				
Cyrnellus fraternus	X	X	X	
Hydropsychidae[1]				X
Ceratopsyche morosa	X		X	
Cheumatopsyche	X	X	X	X
Hydropsyche	X		X	
Hydropsyche betteni	X	X	X	
Hydropsyche orris	X		X	
Hydropsyche simulans	X		X	
Hydropsyche bidens	X		X	
Potamyia flava	X	X	X	X
Hydroptila	X		X	
Lepidoptera (Aquatic Moths)				
Petrophila	X		X	
Coleoptera (Beetles)				
Copelatus			X	
Laccophilus maculosus			X	
Dubiraphia	X	X		X

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 75 (Continued)

LIST OF BENTHIC INVERTEBRATE TAXA FOUND IN HESTER-DENDY AND PONAR SAMPLES FROM SEVERAL CHICAGO METROPOLITAN AREA WATERWAYS DURING 2001 AND 2002

Taxa	Sample Device and Year			
	Hester-Dendy 2001	Ponar 2001	Hester-Dendy 2002	Ponar 2002
Macronychus glabratus	X	X	X	
Stenelmis[1]	X	X		X
Stenelmis crenata grp.	X	X	X	X
Tropisternus			X	
Berosus	X	X		
Diptera (True Flies)				
Bezzia		X		
Chaoborus	X	X		
Hemerodromia	X			
Simulium	X	X		
Tipula			X	
Chironomidae (Midges)[1]	X	X	X	X
Ablabesmyia janta	X		X	X
Ablabesmyia mallochi	X	X	X	X
Clinotanypus		X		
Coelotanypus				X
Natarsia sp. A		X		
Nilotanypus fimbriatus	X		X	
Procladius (Holotanypus)	X	X	X	X
Tanypus		X		
Thienemannimyia grp.	X	X	X	X
Corynoneura	X	X		
Cricotopus tremulus grp.	X		X	X
Cricotopus bicinctus grp.	X	X	X	X
Chironomidae (cont.)				
Cricotopus trifascia grp.		X	X	
Cricotopus sylvestris grp.	X	X	X	X
Heterotrissocladius			X	
Nanocladius[1]		X		
Nanocladius distinctus	X	X	X	X
Nanocladius crassicornus/rectinervis	X	X	X	
Rheocricotopus robacki	X		X	
Thienemanniella xena	X		X	
Thienemanniella similis	X	X		
Chironomus	X	X	X	X
Cladopelma		X	X	
Cryptochironomus	X	X	X	X
Dicrotendipes neomodestus	X	X	X	X

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 75 (Continued)

LIST OF BENTHIC INVERTEBRATE TAXA FOUND IN HESTER-DENDY AND PONAR SAMPLES FROM SEVERAL CHICAGO METROPOLITAN AREA WATERWAYS DURING 2001 AND 2002

Taxa	Sample Device and Year			
	Hester-Dendy 2001	Ponar 2001	Hester-Dendy 2002	Ponar 2002
Chironomidae (Cont.)[1]	X	X	X	X
Dicrotendipes simpsoni	X	X	X	X
Endochironomus nigricans	X			
Glyptotendipes	X	X	X	X
Microchironomus		X	X	
Microtendipes		X		X
Parachironomus	X	X	X	X
Paracladopelma	X	X		X
Phaenopsectra	X			
Polypedilum fallax grp.	X	X	X	
Polypedilum flavum	X	X	X	X
Polypedilum halterale grp.	X	X	X	X
Polypedilum illinoense	X	X	X	X
Polypedilum scalaenum grp.	X	X	X	X
Stenochironomus	X	X	X	
Xenochironomus xenolabis			X	
Cladotanytarsus mancus grp.	X	X	X	
Cladotanytarsus vanderwulpi grp.	X			
Micropsectra			X	
Paratanytarsus	X		X	X
Rheotanytarsus	X	X	X	
Tanytarsus			X	X
Tanytarsus glabrescens grp.			X	
Tanytarsus guerlus grp.	X	X	X	
GASTROPODA (Snails)				
Amnicola		X		X
Pleuroceridae	X	X		
Ferrissia	X		X	X
Menetus dilatatus	X	X	X	
Physella	X	X	X	
PELECYPODA (Mussels and Clams)[1]	X			
Corbicula fluminea	X	X	X	X
Musculium		X[1]	X	
Musculium transversum	X	X		X

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 75 (Continued)

LIST OF BENTHIC INVERTEBRATE TAXA FOUND IN HESTER-DENDY AND PONAR SAMPLES FROM SEVERAL CHICAGO METROPOLITAN AREA WATERWAYS DURING 2001 AND 2002

Taxa	Sample Device and Year			
	Hester-Dendy 2001	Ponar 2001	Hester-Dendy 2002	Ponar 2002
Pisidium	X	X[1]		
Pisidium compressum		X		
Pisidium nitidum				X
Sphaerium simile		X		
Lasmigona complanata		X		
Dreissena polymorpha	X	X	X	X
Total Richness by Sample Type	83	74	81	50
Ept Richness by Sample Type	19	8	18	5
Total Richness by Year	101		90	
Ept Richness by Year	20		19	

[1]Not counted as a discreet taxa.

Illinois Waterway Monitoring

WATER QUALITY

In 1984, the Research and Development Department established a long-term water and sediment monitoring program along the Illinois Waterway from the Lockport Lock to the Peoria Lock, a distance of approximately 133 miles. The purpose of the monitoring program was to assess the chemical and microbiological quality of the water and to characterize the chemical quality of the sediments.

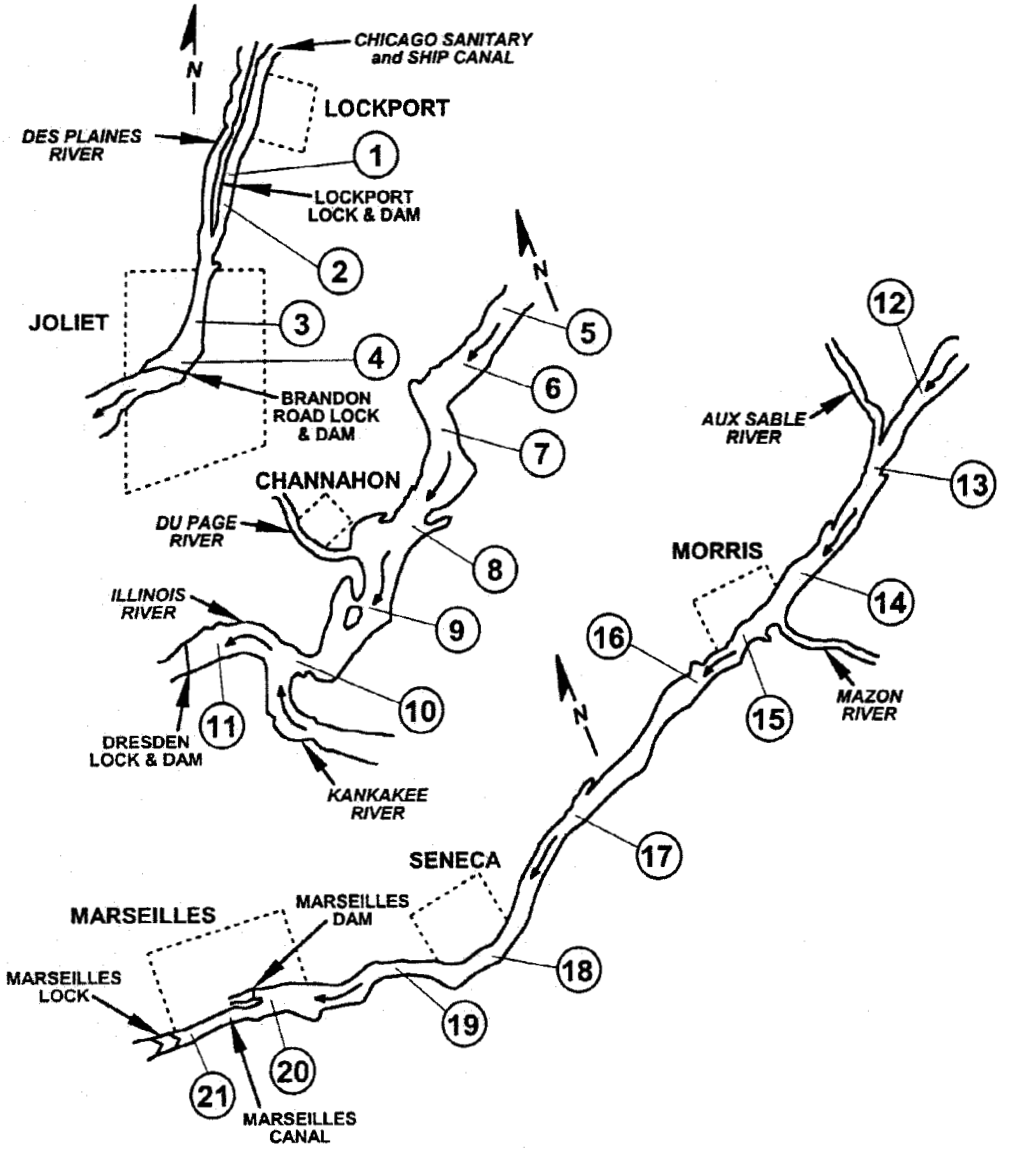
Historically, water samples were collected annually during May, August, and October from each of the 49 sampling stations (Figures 38 and 39). During October, sediment samples were collected at 14 selected stations. Similar monitoring studies were conducted during 2003.

The mean dissolved oxygen (DO) concentrations along the six navigational pools (Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, and Peoria) during May, August, and October of 2003 are presented in Figure 40. During 2003, the mean DO concentration increased substantially along the Illinois Waterway from the Lockport Pool (4.7 mg/L) to the lower Peoria Pool (8.2 mg/L). The increase in DO along the waterway may be attributable to re-aeration at the Brandon

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 38

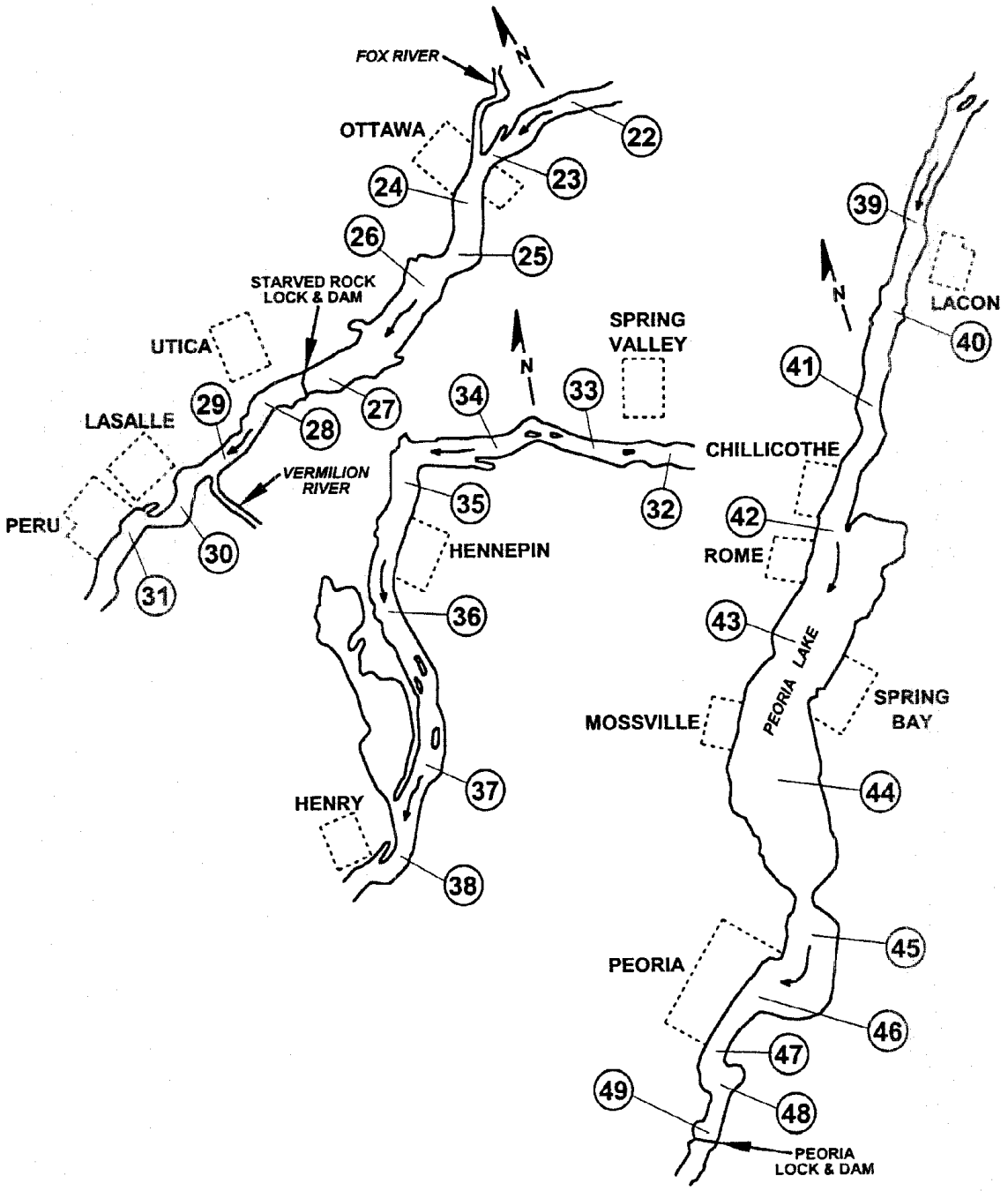
MAP OF THE ILLINOIS WATERWAY FROM LOCKPORT TO MARSEILLES
SHOWING SAMPLING STATIONS 1 TO 21



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 39

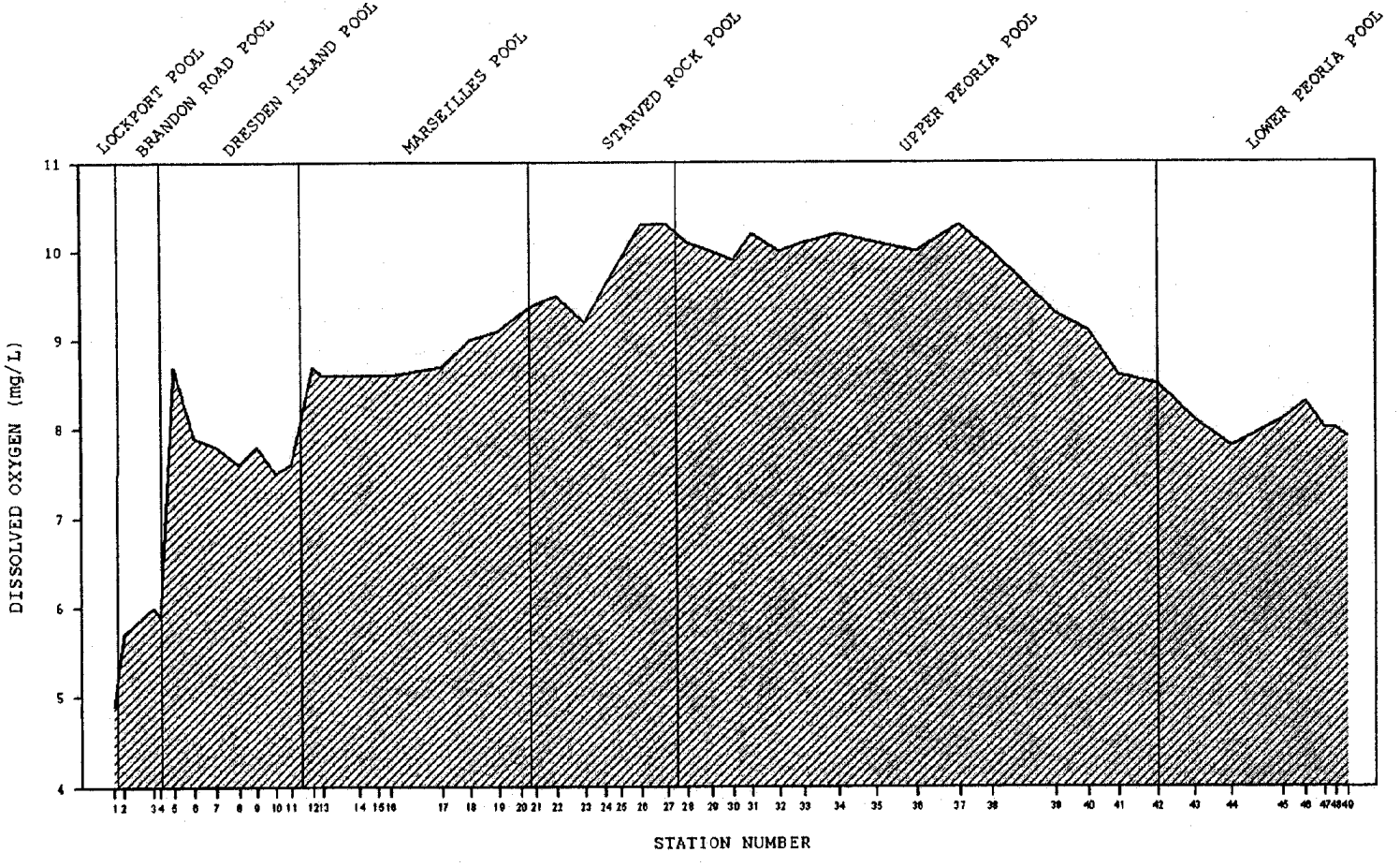
MAP OF THE ILLINOIS WATERWAY FROM OTTAWA TO PEORIA
SHOWING SAMPLING STATIONS 22 TO 49



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 40

MEAN DISSOLVED OXYGEN CONCENTRATION AT 49 STATIONS ALONG THE ILLINOIS WATERWAY FROM THE LOCKPORT LOCK TO THE PEORIA LOCK DURING MAY, AUGUST, AND OCTOBER 2003



Road, Dresden Island, and Marseilles navigational dams and due to photosynthesis.

Figure 41 displays the mean concentrations of ammonia nitrogen measured along the Illinois Waterway in 2003. Ammonia nitrogen levels fall off rapidly throughout the Brandon Road Pool and continue to decrease steadily until the upper Peoria Pool. Mean ammonia nitrogen concentration decreased from 0.48 mg/L in the Lockport Pool to 0.09 mg/L in the lower Peoria Pool. Nutrient uptake by algae and aquatic vegetation resulting in primary production, instream nitrification, and dilution from the Kankakee River and other tributaries may account for the decrease in ammonia nitrogen.

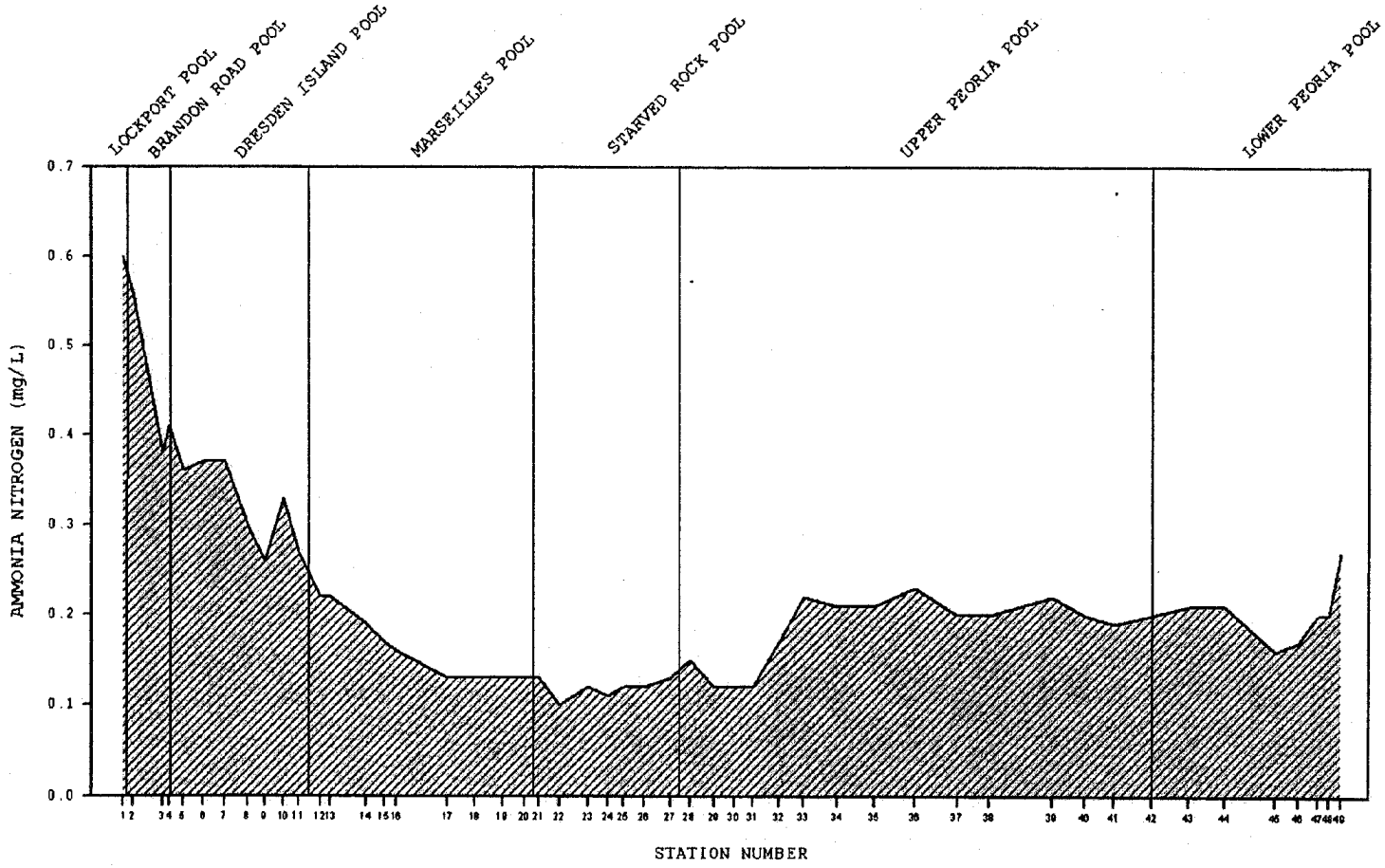
There was a considerable amount of variation in the mean total nitrogen (TN) concentrations along the Illinois Waterway during the three monitoring periods in 2003 as evidenced by Figure 42. However, the mean concentration of TN decreased overall between the Lockport Pool (6.58 mg/L) and the lower Peoria Pool (5.28 mg/L). The decrease in TN may be a result of nutrient uptake by aquatic plants, in-stream nitrification/ denitrification, and dilution from tributaries.

Figure 43 shows the mean concentrations of total phosphorus (TP) measured in 2003 during the three monitoring periods. There is a fairly uniform decline in the mean concentration of

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 41

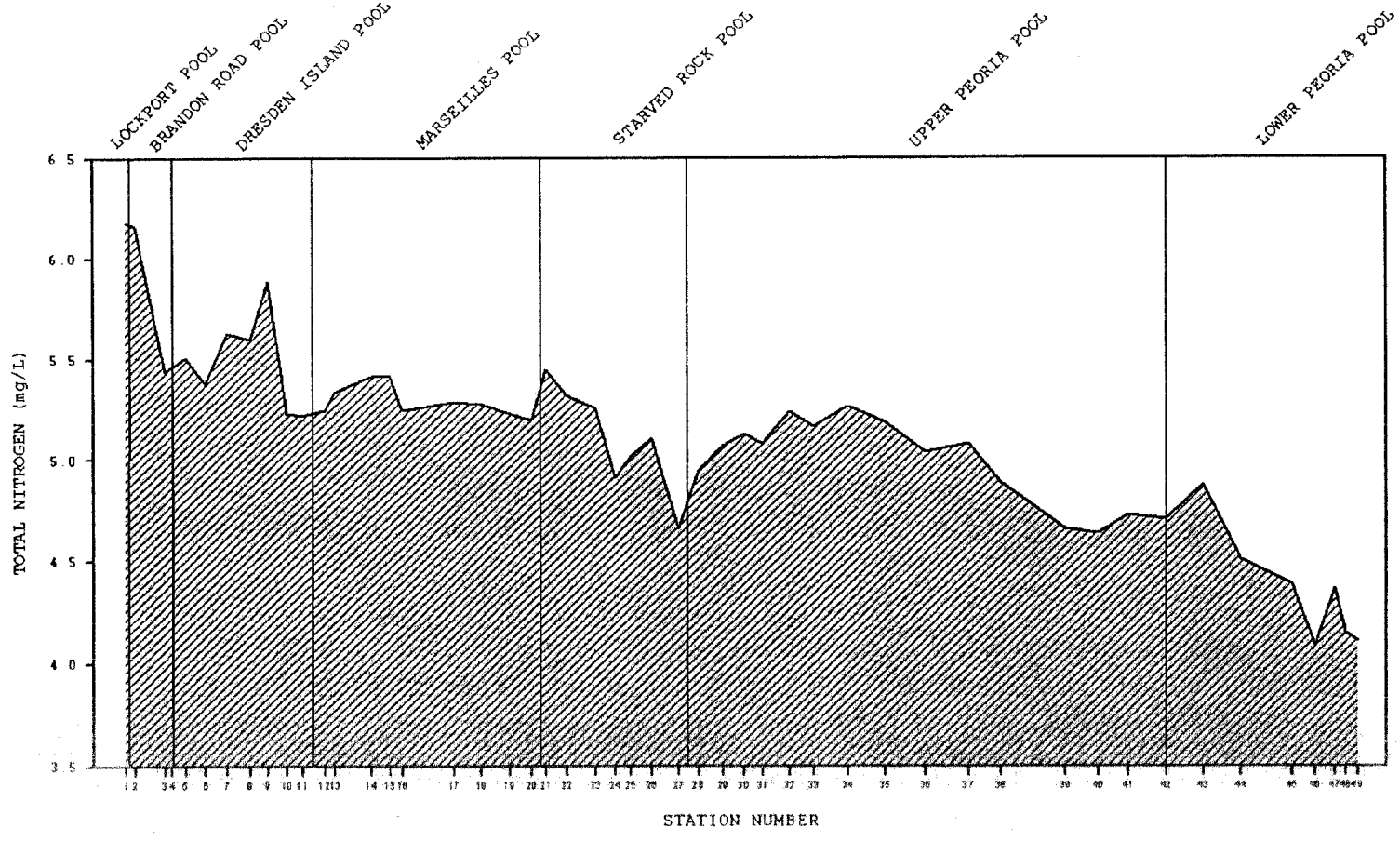
MEAN AMMONIA NITROGEN CONCENTRATION AT 49 STATIONS ALONG THE ILLINOIS WATERWAY FROM THE LOCKPORT LOCK TO THE PEORIA LOCK DURING MAY, AUGUST, AND OCTOBER 2003



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 42

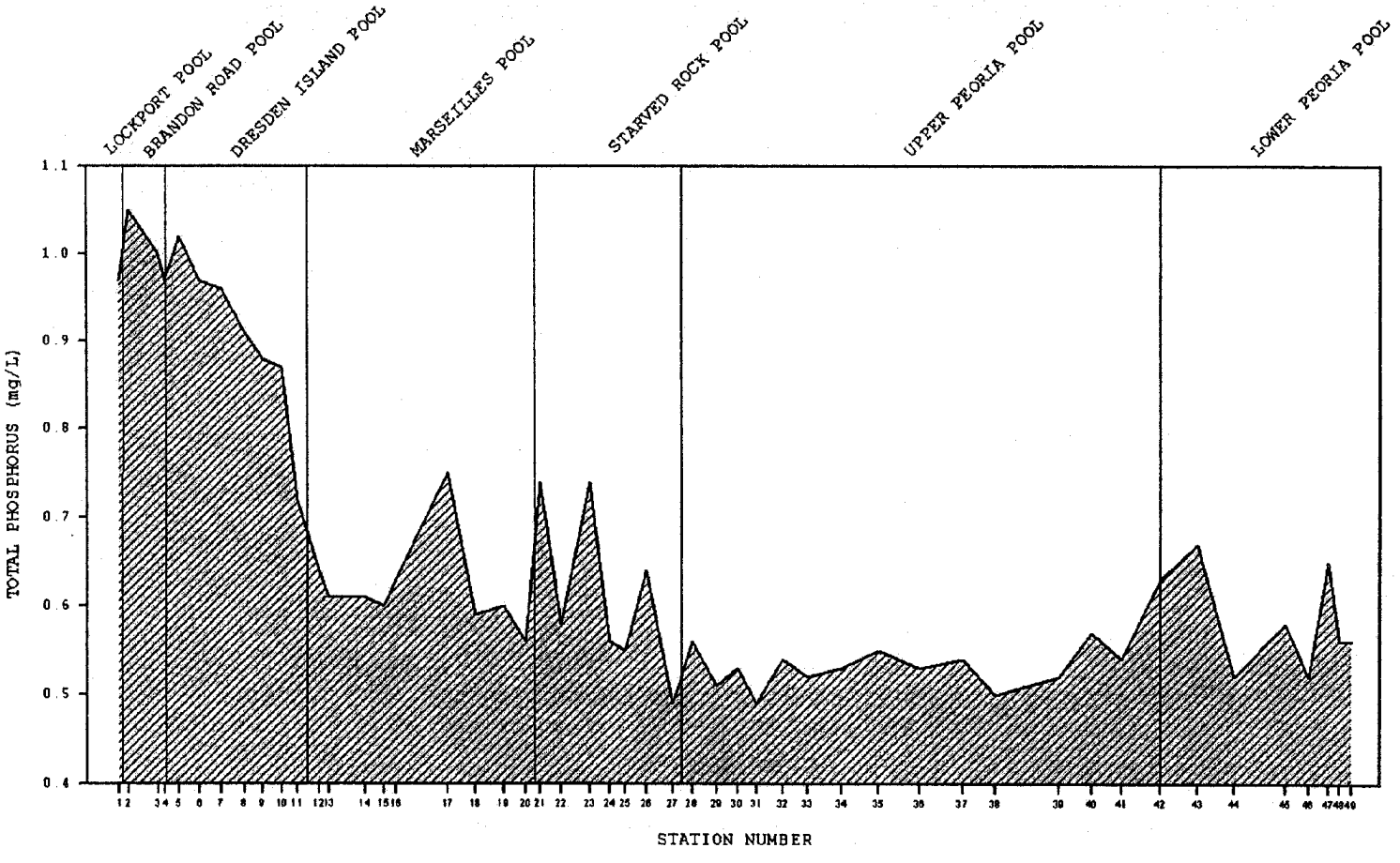
MEAN TOTAL NITROGEN CONCENTRATION AT 49 STATIONS ALONG THE ILLINOIS WATERWAY FROM THE LOCKPORT LOCK TO THE PEORIA LOCK DURING MAY, AUGUST, AND OCTOBER 2003



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 43

MEAN TOTAL PHOSPHORUS CONCENTRATION AT 49 STATIONS ALONG THE ILLINOIS WATERWAY FROM THE LOCKPORT LOCK TO THE PEORIA LOCK DURING MAY, AUGUST, AND OCTOBER 2003



TP from the Lockport Pool (1.05 mg/L) to the lower Peoria Pool (0.54 mg/L). The decrease in TP may be explained by nutrient uptake from biological production and sedimentation of particulate phosphorus.

Fecal coliform (FC) levels fell substantially along the Illinois Waterway, especially throughout the Dresden Island Pool. Geometric mean FC values decreased from 67 cfu/100 ml in the Lockport Pool to 19 cfu/100 ml in the lower Peoria Pool as shown in Figure 44.

SEDIMENT QUALITY

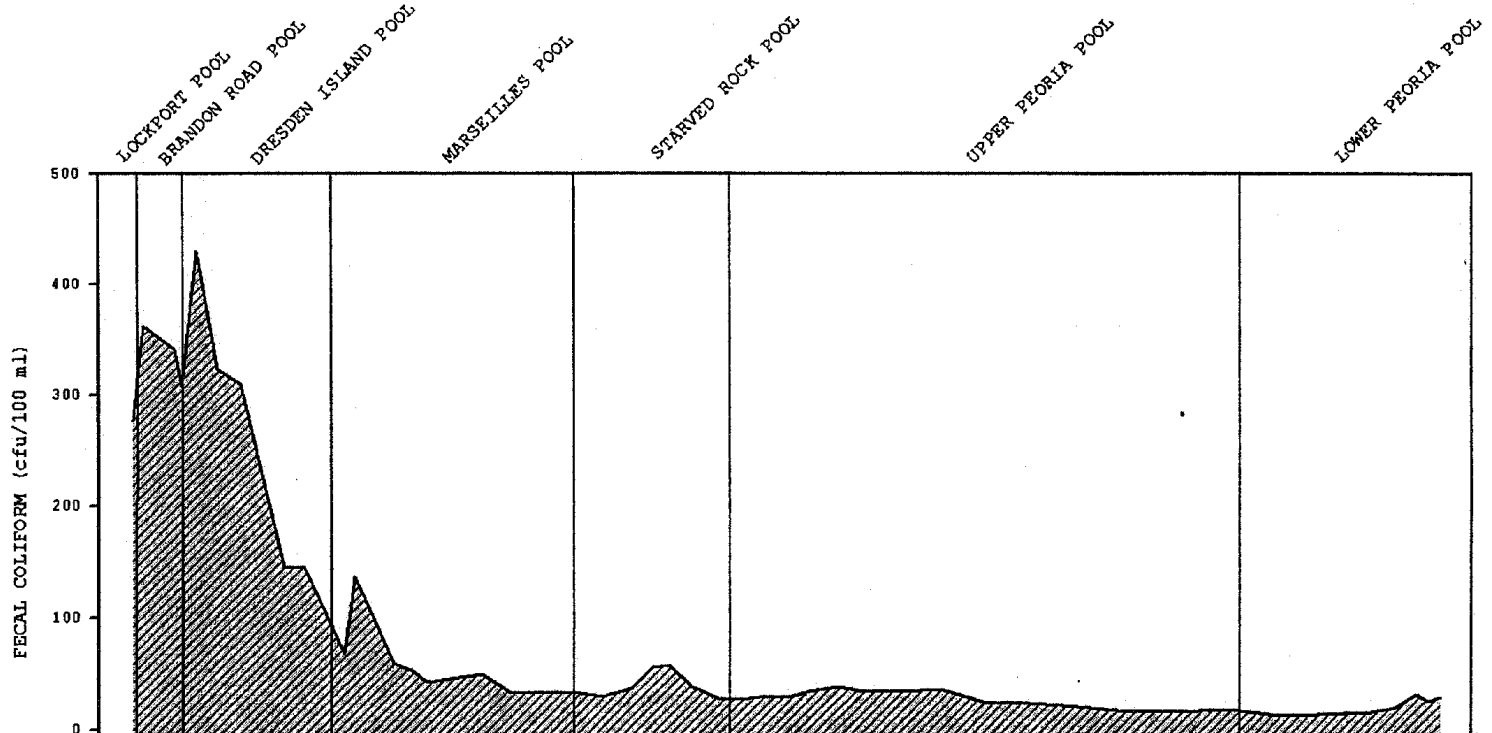
Sediment quality can considerably impact water quality, benthic community structure, food chain dynamics, and other aspects of freshwater ecosystems. Since sediment acts as a reservoir for persistent or bioaccumulative contaminants, sediment data reflects a long-term record of quality. Sediment chemistry results are presented in Table 76. Trace metal data from the sediments along the Illinois Waterway are shown in Table 77.

Total solids (TS) in the sediment varied widely along the Illinois Waterway during the 2003 monitoring periods, while there was a decrease in the mean concentration of total

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 44

GEOMETRIC MEAN FECAL COLIFORM CONCENTRATION AT 49 STATIONS ALONG THE ILLINOIS WATERWAY FROM THE LOCKPORT LOCK TO THE PEORIA LOCK DURING MAY, AUGUST, AND OCTOBER 2003



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 76

CHEMICAL CHARACTERISTICS OF SEDIMENT COLLECTED FROM THE LOCKPORT, BRANDON ROAD, DRESDEN ISLAND, MARSEILLES, STARVED ROCK, AND PEORIA POOLS OF THE ILLINOIS WATERWAY, OCTOBER 2003

Station Number	Navigational Pool	Constituents (Expressed on a dry weight basis)							
		Total Solids (%)	Total Volatile Solids (%)	Ammonia Nitrogen (mg/kg)	Total Kjeldahl Nitrogen (mg/kg)	Nitrite plus Nitrate Nitrogen (mg/kg)	Total Phos-phorus (mg/kg)	Total Cyanides (mg/kg)	Phenols (mg/kg)
1	Lockport	37.3	11	100	1,614	2.3	2,476	0.819	0.061
2	Brandon Road	33.6	12	46	1,286	4.7	1,650	1.413	0.057
5	Dresden Island	64.8	5	7	498	1.8	595	0.267	0.045
8	Dresden Island	69.7	5	7	295	1.4	373	0.284	0.029
12	Marseilles	85.8	1	1	7	2.6	8	0.041	0.028
18	Marseilles	79.4	1	2	30	1.3	25	0.043	0.024
23	Starved Rock	81.5	1	1	5	0.9	5	0.025	0.020
28	Peoria	75.7	1	2	29	1.9	20	0.019	0.032
32	Peoria	81.5	2	1	11	1.4	14	0.024	0.043
35	Peoria	71.7	2	6	172	1.9	138	0.049	0.043
38	Peoria	56.5	6	18	417	2.7	333	0.082	0.047

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 76 (Continued)

CHEMICAL CHARACTERISTICS OF SEDIMENT COLLECTED FROM THE LOCKPORT, BRANDON ROAD, DRESDEN ISLAND, MARSEILLES, STARVED ROCK, AND PEORIA POOLS OF THE ILLINOIS WATERWAY, OCTOBER 2003

Station Number	Navigational Pool	Constituents (Expressed on a dry weight basis)							
		Total Solids (%)	Total Volatile Solids (%)	Ammonia Nitrogen (mg/kg)	Total Kjeldahl Nitrogen (mg/kg)	Nitrite plus Nitrate Nitrogen (mg/kg)	Total Phos-phorus (mg/kg)	Total Cyanides (mg/kg)	Phenols (mg/kg)
41	Peoria	43.7	7	16	899	0.7	449	0.111	0.027
44	Peoria	48.8	8	20	474	2.3	245	0.630	0.043
48	Peoria	71.8	2	9	369	2.3	165	0.150	0.023

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 77

TRACE METALS IN SEDIMENTS COLLECTED FROM THE LOCKPORT, BRANDON ROAD, DRESDEN ISLAND, MARSEILLES, STARVED ROCK, AND PEORIA POOLS OF THE ILLINOIS WATERWAY, OCTOBER 2003

Station Number	Navigational Pool	Arsenic	Cadmium	Chromium	Copper	Iron	Lead
		(mg/kg dry weight)					
1	Lockport	2	9.3	137	166	29,517	181
2	Brandon Road	1	23.6	234	233	28,917	258
5	Dresden Island	<1	1.8	37	92	15,471	78
8	Dresden Island	<1	1.5	30	20	12,926	34
12	Marseilles	<1	0.3	5	1	5,700	8
18	Marseilles	<1	0.1	5	<1	4,066	7
23	Starved Rock	<1	0.6	6	1	4,702	8
28	Peoria	<1	0.2	7	<1	4,531	11
32	Peoria	<1	0.1	19	2	5,580	6
35	Peoria	<1	0.7	11	7	7,712	16
38	Peoria	<1	0.4	22	14	31,702	21
41	Peoria	<1	2.3	40	31	19,123	31
44	Peoria	<1	1.6	41	36	27,299	45
48	Peoria	<1	0.9	19	12	12,974	23

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 77 (Continued)

TRACE METALS IN SEDIMENTS COLLECTED FROM THE LOCKPORT, BRANDON ROAD, DRESDEN ISLAND, MARSEILLES, STARVED ROCK, AND PEORIA POOLS OF THE ILLINOIS WATERWAY, OCTOBER 2003

Station Number	Navigational Pool	Manganese	Mercury	Nickel	Silver	Zinc
		(mg/kg dry weight)				
1	Lockport	493	0.6304	42	7.4	812
2	Brandon Road	465	1.7754	83	3.5	1,124
5	Dresden Island	333	0.1183	23	<0.1	206
8	Dresden Island	290	0.1948	30	<0.1	201
12	Marseilles	109	0.0157	5	0.2	33
18	Marseilles	145	0.0263	5	<0.1	29
23	Starved Rock	119	0.0135	7	<0.1	27
28	Peoria	125	0.0169	6	<0.1	25
32	Peoria	157	0.0094	13	<0.1	158
35	Peoria	190	0.0988	9	<0.1	75
38	Peoria	437	0.0541	21	<0.1	100
41	Peoria	548	0.1544	24	<0.1	178
44	Peoria	671	0.4476	31	<0.1	229
48	Peoria	364	0.1129	14	<0.1	88

volatile solids (TVS) from the Lockport Pool (13 percent) to the lower Peoria Pool (8 percent).

Mean ammonia nitrogen concentrations decreased markedly from 254 mg/kg in the Lockport Pool to a mean of 23 mg/kg in the lower Peoria Pool.

While the concentrations of the 13 trace metals measured in the sediment were quite variable among the 14 sampling stations, significantly higher levels of chromium, copper, lead, mercury, nickel, and zinc were detected in the Lockport and Brandon Road Pools compared to the Dresden Island, Marseilles, Starved Rock, and Peoria Pools.

Continuous Monitoring of Dissolved Oxygen

In order to gain a better understanding of the oxygen dynamics in Chicago area deep-draft waterways, the R&D Department developed a comprehensive continuous dissolved oxygen (DO) monitoring program beginning in August 1998 in the Chicago Waterway System, and in July 2001 in the Calumet Waterway System.

Dissolved oxygen was measured hourly using remote (*in-situ*) water quality monitors deployed in protective stainless steel housing enclosures. In the Chicago Waterway System, the monitors were located at 21 stations on the North Shore

Channel, North Branch of the Chicago River, Chicago River, South Branch of the Chicago River, Bubbly Creek, and the Chicago Sanitary and Ship Canal. In the Calumet Waterway System, the monitors were located at 13 stations on the Calumet River, Grand Calumet River, Little Calumet River, and the Calumet-Sag Channel.

The number and percent of DO values measured with the monitors during the period from January through December of 2003 that were above the Illinois Pollution Control Board's (IPCB) DO standards are presented in Tables 78 and 79.

During 2003, the stations that recorded the lowest percentage of DO values meeting the IPCB DO standards were Linden (73 percent), Simpson (64 percent), and Main (76 percent) Streets on the North Shore Channel, 36th Street (60 percent) and I-55 (78 percent) on Bubbly Creek, Route 83 (79 percent) on the Chicago Sanitary and Ship Canal, Torrence Avenue on the Grand Calumet River (78 percent), and Ashland Avenue (68 percent) on the Little Calumet River. Overall, 247,470 of 272,336 DO measurements (91 percent) met the IPCB's DO water quality standards in the Chicago and Calumet Waterway Systems.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 78

NUMBER AND PERCENT OF DISSOLVED OXYGEN VALUES ABOVE THE ILLINOIS POLLUTION CONTROL BOARD'S WATER QUALITY STANDARDS IN THE CHICAGO WATERWAY SYSTEM DURING JANUARY THROUGH DECEMBER 2003[1]

Monitoring Location	DO Standard (mg/L)	Number of DO Values	Number of DO Values Above IPCB Standard	Percent of DO Values Above IPCB Standard
		North Shore Channel		
Linden Street	5.0	8,350	6,059	73
Simpson Street	5.0	7,373	4,723	64
Main Street	5.0	8,525	6,492	76
		North Branch Chicago River		
Addison Street	4.0	8,326	8,319	>99
Fullerton Avenue	4.0	8,093	7,726	95
Division Street	4.0	8,550	8,452	99
Kinzie Street	4.0	8,589	8,264	96
		Chicago River		
Controlling Works	5.0	8,629	8,629	100
Michigan Avenue	5.0	8,191	8,191	100
Clark Street	5.0	8,588	8,562	>99
		South Branch Chicago River		
Jackson Boulevard	4.0	8,565	8,491	99
Loomis Street	4.0	5,757	5,628	98
		Bubbly Creek		
36th Street	4.0	7,755	4,680	60
I-55	4.0	8,112	6,343	78

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 78 (Continued)

NUMBER AND PERCENT OF DISSOLVED OXYGEN VALUES ABOVE THE ILLINOIS POLLUTION CONTROL BOARD'S WATER QUALITY STANDARDS IN THE CHICAGO WATERWAY SYSTEM DURING JANUARY THROUGH DECEMBER 2003[1]

Monitoring Location	DO Standard (mg/L)	Number of DO Values	Number of DO Values Above IPCB Standard	Percent of DO Values Above IPCB Standard
		Chicago Sanitary and Ship Canal		
Cicero Avenue	4.0	8,076	6,520	81
B&O Central RR	4.0	8,031	7,965	99
Route 83	4.0	7,915	6,260	79
River Mile 302.6	4.0	8,062	7,479	93
Romeoville Road	4.0	8,419	7,251	86
Lockport Powerhouse	4.0	8,406	6,763	80
		Des Plaines River		
Jefferson Street	4.0	8,083	7,858	97

[1] Dissolved oxygen was measured hourly using a continuous water quality monitor.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 79

NUMBER AND PERCENT OF DISSOLVED OXYGEN VALUES ABOVE THE ILLINOIS POLLUTION CONTROL BOARD'S WATER QUALITY STANDARDS IN THE CALUMET WATERWAY SYSTEM DURING JANUARY THROUGH DECEMBER 2003[1]

Monitoring Location	DO Standard (mg/L)	Number of DO Values	Number of DO Values Above IPCB Standard	Percent of DO Values Above IPCB Standard
		Calumet River		
130th Street	5.0	7,793	7,622	98
		Grand Calumet River		
Torrence Avenue	4.0	6,434	5,014	78
		Little Calumet River		
Conrail RR	4.0	6,885	6,775	98
C&W Indiana RR	4.0	8,617	8,308	96
Halsted Street	4.0	8,250	8,083	98
Ashland Avenue	5.0	8,226	5,597	68
		Calumet-Sag Channel		
Division Street	3.0	8,399	8,388	>99
Kedzie Avenue	3.0	7,780	7,773	>99
Cicero Avenue	3.0	8,438	8,434	>99
River Mile 311.7	3.0	7,962	7,947	>99
Southwest Highway	3.0	8,059	7,979	99
104th Avenue	3.0	7,998	7,882	99
Route 83	3.0	7,100	7,013	99

[1]Dissolved oxygen was measured hourly using a continuous water quality monitor.

Bubbly Creek Demonstration Project

Bubbly Creek is the name commonly given to the South Fork of the South Branch of the Chicago River. Once the recipient of raw sewage and industrial waste, the creek now serves only to convey combined sewer overflow (CSO) and stormwater a few days each year to the South Branch. The District's Racine Avenue Pumping Station (RAPS) is the principal source of CSO. The city of Chicago owns several other CSO outfalls. In addition, storm water runoff enters directly from adjoining property. Due to the periodic CSOs and the frequent appearance of floating debris, water quality in Bubbly Creek is generally considered to be poor. Recently, redevelopment of industrial properties for residential use brought the condition of Bubbly Creek to the forefront. A demonstration project in 2002 assessed the impact on DO of the creation of artificial flow in Bubbly Creek. Flow was created by continuously diverting Bubbly Creek water through a sluice gate at RAPS to the Stickney WRP by means of the intercepting sewer system. The 2002 demonstration project lasted for 105 days from June 20 to October 20. Cost to the District for treatment of the additional Bubbly Creek flow (2.5 billion gallons) at the Stickney WRP was $625,000 during this demonstration project.

During 2003, another demonstration project was conducted from May 1 to October 31, and incorporated a wider range of flows into the experimental plan. Instead of evaluating the effect of relatively low continuous flow on Bubbly Creek water quality, a more controlled test was designed to evaluate the effects of 38 million gallons per day (mgd) and 75 mgd flow rates under wet and dry weather conditions. Bubbly Creek flow was maintained at 38 mgd for six days or 75 mgd for five days during each demonstration event. During the 2003 project approximately 2.1 billion gallons of water from Bubbly Creek were diverted to the Stickney WRP. Total cost to the District for treating this additional flow at the Stickney WRP was $525,000. Eight rainstorms occurred during the demonstration project, slightly more than would be expected in an average year. Continuous in-situ monitoring of DO was used to assess the impact of the artificially created flow during both dry weather and wet weather periods.

Conclusions of the 2003 Bubbly Creek Demonstration Project were as follows:

1. Artificial flow creation in Bubbly Creek appeared to reduce diel DO range and provided more stable DO conditions in dry weather and wet weather situations.
2. Under dry weather conditions with no artificial flow, Bubbly Creek mimicked conditions in a

eutrophic lake, where photosynthetic activity can cause dissolved oxygen levels to rise above saturation levels (16 mg/L) during the day and fall to near 0 mg/L at night.

3. During most of the demonstration events, low DO at Interstate Highway 55 (I-55) and 36th Street increased almost immediately after 38 mgd and 75 mgd flows were started.
4. During the 38 mgd dry weather demonstration event, DO at I-55 and 36th Street met the IPCB standards over 80 percent of the time, and DO values never fell below 1.0 mg/L.
5. During the two 75 mgd dry weather demonstration events, DO levels at I-55 and 36th Street met IPCB standards over 90 percent of the time. DO levels never fell below 1.0 mg/L.
6. During the two 38 mgd wet weather demonstration events DO levels at I-55 met IPCB standards over 70 percent of the time, but DO levels at 36th Street met IPCB standards less than 5 percent of the time. For short periods of time DO values of 0.0 mg/L were observed. During these two tests recovery of DO levels was observed over a

period ranging from 10 hours to 48 hours after initiation of flow diversion to the Stickney WRP. This was 3 to 4 days after the discharge of CSOs from RAPS ended, as there was a lag before the Stickney WRP could start accepting Bubbly Creek flows after a rain.

7. During the two 75 mgd wet weather demonstration events DO levels at I-55 met IPCB standards over 80 percent of the time. However, for short periods of time, DO values of 0.0 mg/L were observed at I-55. For the 36th Street location, contradictory results were found. During one test, DO levels met IPCB standards 81.7 percent of the time, while during the second test, DO levels never met IPCB standards. Many DO readings of 0.0 mg/L were observed during this second test. Not enough information was available to determine the cause of these contradictory results. During these two tests recovery of DO levels was observed over a period ranging from 12 hours to 27 hours after initiation of flow diversion to the Stickney WRP. This was 28 hours to 4 days after the discharge of CSOs from

RAPS ended, as there was a lag before the Stickney WRP could start accepting Bubbly Creek flows after a rain.

8. Periods of low DO following CSO discharges to Bubbly Creek, which can range from 1-2 weeks in length when there is zero flow being induced, can be reduced to as little as 1-2 days by initiating the artificial flows used during this study.

9. Diversion of Bubbly Creek water to the Stickney WRP cannot be used as a tool to meet IPCB DO standards in wet weather because capacity to accept wet weather flows may be limited. In addition, operational costs to treat the river water are substantial.

RADIOCHEMISTRY SECTION

The Radiochemistry Section is responsible for the radiological monitoring of waters, wastewaters, sludges, and biosolids, and the maintenance of radiation safety at the District. It also performs special tasks involving the use of ionizing radiation and radioisotopes.

The Radiochemistry Laboratory is certified by the Illinois Department of Nuclear Safety, now the Illinois Emergency Management Agency (IEMA), Division of Nuclear Safety (DNS). The laboratory is approved for the examination of gross alpha/beta, tritium, and photon emitting radionuclides in public water supplies.

The Radiochemistry Section participates in the ambient water quality monitoring program of the Chicago Waterways System. The radiological monitoring of area waterways under the jurisdiction of the District includes the Calumet, Chicago, and Des Plaines River systems.

The radiological monitoring of raw and treated wastewaters from the District's seven WRPs was initiated in 1967 as the State of Illinois Sanitary Water Board developed effluent criteria (Technical Release 20-22, April 1, 1967). Although the present NPDES permits from the IEPA do not include limits

for radioactivity in the District's effluents, monitoring continued into 2003 since there are radioactivity water quality standards for the General Use waters.

Since 1978, the Section has conducted radiological monitoring of biosolids from both the LASMA and HASMA drying sites. Beginning in 1993, biosolids sampling was greatly increased to include anaerobically digested sludges from District WRPs and air-dried biosolids ready for final utilization from the Stickney and Calumet solids management areas.

The Section also maintains the radioactive material license issued to the District by the IEMA-DNS, assuring that the activities are conducted according to the license conditions and regulations.

The Section participates in the Environmental Resource Associates (ERA) RadChem Proficiency Testing (PT) program as required by the IEMA-DNS for maintaining laboratory certification. Water samples were analyzed for gross alpha, gross beta, barium-133, cesium-134, cesium-137, cobalt-60, zinc-65, and tritium radioactivity.

The Section continued to participate in the U.S. Department of Energy (USDOE), Environmental Laboratory's Quality Assessment Program. Water samples were analyzed for gross alpha, gross beta, tritium, cobalt-60, and cesium-137

radioactivity. Soil samples were analyzed for potassium-40, cesium-137, bismuth-212, lead-212, bismuth-214, lead-214, and actinium-228 radioactivity.

Radiation Safety

The Radiochemistry Section continues to maintain a radiation safety program for the District. The program includes:

- keeping up-to-date the IEMA-DNS radioactive material license;
- low-level radioactive waste management;
- personnel monitoring for radiation exposure;
- operational checks of radiation survey meters;
- radiation survey of the Radiochemistry Laboratory working areas;
- leak testing of the radioactive sealed sources; and
- physical inventory of licensed radioactive materials;

The District possesses a radioactive material license from the IEMA-DNS. The radiation protection program is conducted in accordance with the license conditions. Appropriate amendments were requested in 2003 to make the necessary changes in the license to keep it up-to-date.

The Illinois Low-Level Radioactive Waste Management Act requires all generators and brokers of low-level radioactive waste (LLRW) in Illinois to file an annual survey form with the IEMA-DNS. In 2003, the relevant forms were received from the IEMA-DNS, completed, and returned to the IEMA-DNS.

The monitoring of District employees for radiation exposure was carried out using dosimeter badges and finger ring dosimeters. The dosimeters are worn by laboratory personnel, and users of moisture/density gauges. A total of 238 dosimeters were analyzed in 2003. No employee of the District was exposed to an overdose of radiation.

The operational checks of radiation survey meters were carried out on each day that radioactive materials were used or at least once a month. A record was maintained for the operational checks of radiation survey instruments.

The Radiochemistry Laboratory is regularly surveyed for radiation contamination. A total of 120 wipe tests were performed in 2003. No contamination was found in any work area.

As per IEMA-DNS regulations, radioactive sealed sources are tested for leakage or contamination at intervals not to exceed six months. All of the radioactive sealed sources used by the District personnel were tested for leakage twice in 2003.

Nickel-63 sources constitute a part of the electron capture detectors of gas chromatographs used by the R&D Department. Leak tests were performed on the following detectors in March and September 2003:

Varian A-12876	Varian A-12877
Hewlett-Packard U-1440	Hewlett-Packard U-1451
Finnigan 5678	Finnigan 5680

No leaks were detected in any detectors used by the District.

Two leak tests each were performed in 2003 on the APD2000 CW Detector, and an XRF Paint Analyzer, owned by the Safety Section of General Administration. The APD2000 CW detector is equipped with a nickel-63 sealed source and the XRF Paint Analyzer is equipped with a Cobalt-57 sealed source. No leaks were detected in the detectors.

Leak tests were also performed on four Troxler surface moisture/density gauges used by the Construction Division of the Engineering Department. A total of 16 leak tests were performed in 2003. No leaks were detected in any of these gauges.

A physical inventory for each radioactive sealed source possessed by the District was carried out twice in the year

2003. A record of this inventory was maintained as per license conditions.

Certification by the IEMA-DNS

The Radiochemistry Laboratory was certified by the Illinois Department of Nuclear Safety, now the IEMA-DNS on October 2, 2001 and has maintained its certification status. The laboratory is approved for the examination of gross alpha/beta, tritium, and photon emitting radionuclides in public water supplies.

Participation in the ERA Proficiency Testing Program

The Radiochemistry Section participated in the ERA RadChem PT program, along with other certified laboratories. The participation in the PT study is an IEMA-DNS requirement to maintain laboratory certification.

The participating laboratories receive, for analysis, water samples from ERA. The known radioactivity concentrations and the participant's experimental results are published in the ERA's report.

During 2003, the Radiochemistry Section analyzed five PT water samples for gross alpha and gross beta; four for cobalt-60, cesium-134, and cesium-137; and two samples for barium 133, zinc-65 and tritium radioactivity. The analyses of all

the samples were reported to the ERA. Acceptable results were obtained on all the samples.

Participation in the USDOE Environmental Laboratory Quality Assessment Program

The Radiochemistry Section continues to participate in the USDOE Environmental Laboratory Quality Assessment Program, along with other participating laboratories (regional, state, national, nuclear, commercial, and international). The purpose of this participation is to maintain a good quality control program, and document the precision and accuracy of the methods used.

The participating laboratories receive, for analysis, water and soil samples from the USDOE Environmental Laboratory, New York, New York. The known radioactivity concentrations and the participants' experimental results are published in a USDOE report.

During 2003, the Radiochemistry Section analyzed two Quality Assessment water samples for tritium, gross alpha, gross beta, cobalt-60, cesium-134, and cesium-137 radioactivity. The Section also analyzed two soil samples for potassium-40, cesium-137, bismuth-212, lead-212, bismuth-214, lead-214, and actinium-228 radioactivity. The analyses of all the samples were reported to the USDOE, and the results

were published in an USDOE report. Acceptable results were obtained on all these samples.

Levels of Radioactivity in Raw and Treated Wastewaters

Radiological monitoring of raw wastewaters and final effluents from the District's seven WRPs continued in 2003. Data from the monitoring serves as a measure of present-day radioactivity levels in comparison to levels in past years. The IPCB has established General Use water quality standards for radioactivity in the waters of the State. According to IPCB regulations (Title 35, Chapter 1, Section 302.207) gross beta concentration shall not exceed 100 pCi/L, and the concentration of radium-226 and strontium-90 shall not exceed 1 and 2 pCi/L of water, respectively, in General Use waters. There are no IPCB or USEPA radioactivity standards for raw sewage or final effluents. However, the District uses the IPCB General Use Waters limits for gross beta concentration as the standard for monitoring effluents.

The radioactivity analysis was conducted on 24-hour composite samples of raw sewage and final effluent. The samples were processed using USEPA, Environmental Monitoring and Support Laboratory procedures, March 1979, and counted for gross alpha and gross beta radioactivity on a Tennelec

LB5100 alpha/beta gas proportional counter. The gas proportional counter was calibrated for alpha efficiency using thorium-230, and for beta efficiency using cesium-137 standard obtained from the North American Scientific, California.

For calculation purposes, less than lower limit of detection (LLD) values were considered as real numbers, i.e., <1 pCi/L was considered as 1. Average radioactivity was calculated by adding the monthly activity and dividing the sum by the number of observations. In a set of data points with a combination of real numbers and LLD values, if any value in the individual data set with the less than symbol was higher than the average value, then the average value was reported with the less than symbol (<). If all the values in the individual data set with the less than symbol were lower than the average values, then the average value was reported without the less than symbol.

In a set of data points with a combination of real numbers and LLD values, the highest real number was considered as the maximum value. The lowest real number was considered as the minimum value if the number was lower than the lowest LLD value of the data set, otherwise LLD value was reported as the minimum value.

Table 80 presents the 2003 yearly averages of gross alpha radioactivity for the raw sewage and final effluent from the

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 80

AVERAGE GROSS ALPHA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WRPs - 2003

WRP Type of Sample	Gross Alpha Radioactivity (pCi/L)
Stickney	
Raw (West Side)	<3.9
Raw (Southwest)	<6.1
Secondary - Final Effluent	<3.5
Calumet	
Raw	<4.3
Secondary - Final Effluent	<3.8
North Side	
Raw	<3.6
Secondary - Final Effluent	<3.4
Hanover Park	
Raw	<4.1
Tertiary - Final Effluent	<3.5
John E. Egan	
Raw	<4.2
Tertiary - Final Effluent	<3.6
Lemont	
Raw	16.4
Secondary - Final Effluent	<9.3
James C. Kirie	
Raw	<4.2
Tertiary - Final Effluent	<3.7

< = Less than LLD.

District's seven WRPs. With the exception of the Lemont WRP, average raw sewage gross alpha radioactivity at all the WRPs was less than the LLD (3.6 to 6.1 pCi/L). The gross alpha radioactivity at the Lemont WRP was 16.4 pCi/L. This level of radioactivity in Lemont raw sewage has been observed since the village of Lemont began a water treatment process for the removal of radium from their water supply in 1989, as the backwash water from the system is discharged into the Lemont WRP. However, this backwash from the Lemont drinking water system does not pose a threat to the District's compliance status. The gross alpha radioactivity in the final effluent at all the WRPs was less than the LLD (3.4 to 9.3 pCi/L).

Table 81 presents the 2003 yearly averages for gross beta radioactivity in raw sewage and final effluent from the District's seven WRPs. The Lemont WRP has the highest average raw sewage and final effluent gross beta radioactivity levels, 26.4 and 18.4 pCi/L, respectively. At the remaining six WRPs, the average raw sewage gross beta radioactivity ranged from 10.0 to 20.5 pCi/L, and the average final effluent gross beta radioactivity ranged from 7.7 to 11.8 pCi/L.

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TABLE 81

AVERAGE GROSS BETA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WRPs - 2003

WRP Type of Sample	Gross Beta Radioactivity (pCi/L)
Stickney	
Raw (West Side)	12.7
Raw (Southwest)	20.5
Secondary - Final Effluent	7.8
Calumet	
Raw	15.1
Secondary - Final Effluent	9.9
North Side	
Raw	10.0
Secondary - Final Effluent	7.7
Hanover Park	
Raw	13.5
Tertiary - Final Effluent	10.7
John E. Egan	
Raw	14.0
Tertiary - Final Effluent	10.7
Lemont	
Raw	26.4
Secondary - Final Effluent	18.4
James C. Kirie	
Raw	16.1
Tertiary - Final Effluent	11.8

Levels of Radioactivity in Sludges and Biosolids

In 1993, the Radiochemistry Section revised and expanded its monitoring program of District sludges in response to the increased emphasis on monitoring biosolids quality brought about by adoption of the USEPA's Part 503 Sewage Sludge Regulations. Although there are no standards for radioactivity in these regulations, it was felt that the District should expand its database on the radiological characteristics of its sludges and biosolids.

During 2003, sludge or biosolids samples were collected monthly at all WRPs. Biosolids samples were also collected monthly from the eight solids drying sites of the District from May through September.

Sludge and biosolids samples were processed according to the *Standard Methods* (20th Edition, 1998) procedures, and counted for gross alpha and gross beta radioactivity using a Tennelec LB5100 alpha/beta counting system. The instrument was calibrated with a thorium-230 standard for gross alpha, and a cesium-137 standard for gross beta radioactivity determinations. The results, in pCi/g of dry weight (DW), were averaged and are tabulated in Tables 82 and 83.

In Table 82, the average gross alpha radioactivity of WRP anaerobically digested sludge from the Calumet, John E. Egan,

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TABLE 82

GROSS ALPHA AND GROSS BETA RADIOACTIVITY OF WRP SLUDGES - 2003

WRP Type of Sample	No. of Samples	Gross Alpha (pCi/g DW) Average	Minimum	Maximum	Gross Beta (pCi/g DW) Average	Minimum	Maximum
Calumet Digester Draw	12	12.4	7.0	16.2	23.7	17.2	29.1
John E. Egan Digester Draw	12	9.7	6.6	13.4	18.6	14.3	23.8
Lemont[1] Activated Sludge	12	86.5	38.3	128.4	61.1	26.1	79.2
Hanover Park Digester Draw	12	7.1	4.8	9.3	12.0	8.5	16.4
James C. Kirie[1] Activated Sludge	12	7.2	3.4	11.0	13.5	7.4	21.7
North Side[1] Activated Sludge	12	6.2	4.0	10.0	13.3	7.4	17.9
Stickney Digester Draw	12	11.7	8.0	15.4	24.8	20.0	30.9

[1]No digesters at this WRP.

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TABLE 83

GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN DISTRICT BIOSOLIDS - 2003

Drying Site Location	No. of Samples	Gross Alpha (pCi/g DW)			Gross Beta (pCi/g DW)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
LASMA	5	15.7	12.5	18.5	26.8	23.7	30.3
Calumet East	5	16.2	13.4	17.7	25.3	20.6	30.1
Calumet West	5	17.0	15.1	20.9	26.6	23.7	30.1
HASMA	5	16.8	13.2	19.6	25.0	22.2	29.2
Marathon	4	15.4	11.6	19.5	25.6	23.9	28.8
Stony Island	5	14.6	13.8	16.4	23.3	20.2	25.8
Vulcan	5	15.8	14.2	17.5	25.0	22.4	30.1
RASMA	2	16.6	14.8	18.5	26.5	26.2	26.9

Hanover Park, and Stickney WRPs and activated sludge from the Lemont, North Side, and James C. Kirie WRPs ranged from a low of 6.2 pCi/g DW at the North Side WRP to a high of 86.5 pCi/g DW at the Lemont WRP. The average gross beta radioactivity of these sludges ranged from a low of 12.0 pCi/g DW at the Hanover Park WRP to a high of 61.1 pCi/g DW at the Lemont WRP.

Table 83 presents the gross alpha and gross beta data for air-dried biosolids from the District's solids management areas. The average gross alpha radioactivity ranged from a low of 14.6 pCi/g DW for the Stony Island drying site to a high of 17.0 pCi/g DW for the Calumet West drying site. The average gross beta radioactivity ranged from a low of 23.3 pCi/g DW for the Stony Island drying site to a high of 26.8 pCi/g DW for the LASMA drying site.

Sludge and biosolids samples were also processed for the determination of gamma-emitting radionuclides. The samples were dried on hot plates. The dried samples were ground and passed through a 30-mesh sieve. The samples were packed in three-ounce canisters and sealed with a vinyl electrical tape to avoid loss of the gaseous progeny of uranium and thorium. The samples were stored for at least 30-days for radium-radon to reach equilibrium before counting. The samples were analyzed by a gamma spectroscopy system

equipped with a high-purity germanium detector and Genie-2000 Spectroscopy software analysis package from Canberra Industries.

Eleven specific radionuclides, with a potential for re-concentration in sludge, were analyzed. Only three of them were detected at measurable levels. The radium-226 activity concentration was calculated from 186 Kev photopeak, cesium-137 radioactivity concentration was calculated from 661.6 Kev photopeak, and potassium-40 radioactivity from 1461 Kev photopeak. Two of these three radionuclides, radium-226 and potassium-40 are of natural origin. The third radionuclide, cesium-137, is man-made and may have arisen from fallout of nuclear weapons testing in the middle of the 20th century.

Table 84 presents the potassium-40, radium-226, and cesium-137 concentrations in the District's sewage sludge and biosolids. The average potassium-40 radioactivity ranged from 5.0 pCi/g DW at Hanover Park WRP to 10.3 pCi/g DW at Stickney WRP. The average radium-226 radioactivity ranged from 3.3 pCi/g DW at Stickney WRP to 58.0 pCi/g DW at Lemont WRP. The average cesium-137 radioactivity ranged from non-detectable levels at Egan, Hanover Park, and Lemont WRPs to 0.07 pCi/g DW at Calumet WRP.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 84

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WRP SLUDGE - 2003

Sample Location WRP	No. of Samples	Potassium-40 (pCi/g DW)			Radium-226 (pCi/g DW)			Cesium-137 (pCi/g DW)		
		Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.
Calumet	4	8.8	7.7	9.6	4.2	3.6	4.8	0.07	ND	0.10
John E. Egan	3	7.4	6.9	8.4	4.0	3.7	4.5	ND	ND	ND
Hanover Park	4	5.0	4.5	5.3	3.4	3.1	3.6	ND	ND	ND
Stickney	4	10.3	9.0	11.5	3.3	3.2	3.3	0.06	ND	0.08
Lemont	4	7.2	6.0	7.9	58.0	46.3	76.0	ND	ND	ND

ND - Not Detected

Table 85 presents the potassium-40, radium-226, and cesium-137 concentrations in the District's biosolids from the solids management areas. The average potassium-40 radioactivity ranges from 8.9 pCi/g DW at Stony Island to 11.8 pCi/g DW at Calumet West drying site. The average radium-226 radioactivity in the biosolids ranged from 3.8 pCi/g DW at RASMA, Stony Island, and Marathon to 4.6 pCi/g DW at Calumet West drying site. The average cesium-137 radioactivity ranged from 0.07 pCi/g DW at Calumet East, Calumet West, and Stony Island to 0.09 pCi/g DW at HASMA and LASMA drying sites.

Radiological Monitoring of the Chicago Waterways

Radiological monitoring is a part of the overall monitoring program of the water quality within the District's waterways. Radiological monitoring involves the determination of gross alpha and gross beta radioactivity of samples collected from the waterways. The program includes the Calumet, Chicago, and Des Plaines River systems comprising 170 miles (273.6 km) of waterways. There were sixteen sampling locations on the Chicago River, nine on the Calumet River, and nineteen on the Des Plaines River. Each location was sampled once per month.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 85

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN DISTRICT BIOSOLIDS - 2003

Sample Location	No. of Samples	Potassium-40 (pCi/g DW)			Radium-226 (pCi/g DW)			Cesium-137 (pCi/g DW)		
		Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.
Calumet East	5	11.4	6.9	16.8	4.4	3.9	5.5	0.07	0.07	0.08
Calumet West	5	11.8	7.8	14.0	4.6	3.9	5.6	0.07	0.06	0.09
RASMA	2	10.4	9.9	10.9	3.8	3.7	3.9	0.08	0.08	0.08
Stony Island	5	8.9	8.1	9.5	3.8	3.6	4.2	0.07	0.06	0.09
HASMA	5	10.0	8.6	11.2	3.9	3.8	4.1	0.09	0.07	0.10
LASMA	5	10.4	9.5	11.8	4.0	3.5	4.5	0.09	0.07	0.10
Marathon	4	11.0	9.9	11.6	3.8	3.6	4.1	0.08	0.07	0.10
Vulcan	5	9.9	9.2	10.6	4.0	3.7	4.2	0.08	0.07	0.10

The waterways samples were processed using USEPA, Environmental Monitoring and Support Laboratory procedures, March 1979, and the gross alpha and beta radioactivity was counted using a Tennelec LB5100 gas proportional counter.

Table 86 presents the 2003 average values for gross alpha and gross beta radioactivity for the Chicago waterways at each of the 44 sampling locations. The average gross alpha radioactivity in the water samples was found to be less than the detection limits (3.1 to 6.4 pCi/L). The average gross beta radioactivity ranged from less than 4.1 to 15.5 pCi/L.

The concentrations of radioactivity in all samples analyzed were well within the USEPA Drinking Water Standards of 15 pCi/L for gross alpha (excluding radon and uranium), and 50 pCi/L (screening level) for gross beta particle activity minus the naturally occurring potassium-40 beta particle activity.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 86

AVERAGE GROSS ALPHA AND GROSS BETA
RADIOACTIVITY FOR THE CHICAGO WATERWAYS - 2003

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Lake-Cook Rd., Des Plaines	<4.0	10.7
Oakton Street, Des Plaines	<4.1	10.6
Belmont Ave., Des Plaines	<4.2	10.6
Roosevelt Road, Des Plaines	<4.2	10.2
Ogden Avenue, Des Plaines	<4.2	9.4
Willow Springs Rd., Des Plaines	<4.2	9.3
Stephen Street, Des Plaines	<4.3	10.2
Lake-Cook Rd., Buffalo Creek	<4.7	8.4
Elmhurst Rd., Higgins Creek	<4.5	9.8
Wille Rd., Higgins Creek	<4.0	13.2
Higgins Rd., Salt Creek	<4.6	8.4
Arlington Heights Rd., Salt Creek	<4.3	9.5
Devon Ave., Salt Creek	<4.3	10.5
Wolf Rd., Salt Creek	<4.3	10.4
Brookfield Ave., Salt Creek	<4.3	9.4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 86 (Continued)

AVERAGE GROSS ALPHA AND GROSS BETA
RADIOACTIVITY FOR THE CHICAGO WATERWAYS - 2003

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Material Service Bridge, Des Plaines	<4.2	10.5
Route 19, Popular Creek	<3.9	6.8
Walnut Lane, W. Br. Dupage River	<3.8	10.5
Lake St., W. Br. Dupage River	<3.7	10.6
Central St., N. Shore Channel	<3.4	4.8
Oakton St., N. Shore Channel	<3.6	6.2
Touhy Avenue, N. Shore Channel	<3.5	7.6
Dundee Rd., W. Fork N. Branch	<3.8	8.9
Golf Rd., W. Fork N. Branch	<4.8	10.3
Lake-Cook Rd., Middle Fork, N. Branch	<4.5	7.4
Glenview Rd., Middle Fork, N. Branch	<4.5	8.9
Lake-Cook Rd., Skokie River	<4.3	7.4
Frontage Rd., Skokie River	<3.9	9.9
Dempster St., N. Br. Chicago River	<4.9	10.2

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 86 (Continued)

AVERAGE GROSS ALPHA AND GROSS BETA
RADIOACTIVITY FOR THE CHICAGO WATERWAYS - 2003

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Albany Ave., N. Br. Chicago River	<4.2	9.1
Lake Shore Dr., Chicago River	<3.1	4.7
Wells St., Chicago River	<3.4	6.2
Cicero Ave., Chicago Sanitary & Ship Canal	<3.6	7.8
Harlem Ave., Chicago Sanitary & Ship Canal	<3.5	8.1
Lockport, Chicago Sanitary and Ship Canal	<3.6	9.0
Ewing Ave., Calumet River	<3.2	<4.1
130th St., Calumet River	<3.5	5.8
Burnham Ave., Wolf Lake	<3.1	4.7
Indiana Ave., Little Calumet River	<3.8	7.1
Halsted St., Little Calumet River	<4.1	10.0
Wentworth Ave., Little Calumet River	<4.5	12.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 86 (Continued)

AVERAGE GROSS ALPHA AND GROSS BETA
RADIOACTIVITY FOR THE CHICAGO WATERWAYS - 2003

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Ashland Ave., Little Calumet River	<4.5	10.6
Joe Orr Road, Thorn Creek	<6.4	15.5
170th St., Thorn Creek	<5.9	12.5

< = Less than LLD.

EXPERIMENTAL DESIGN AND STATISTICAL EVALUATION SECTION

The Experimental Design and Statistical Evaluation Section is responsible for providing assistance in the design of laboratory and full-scale experiments, collection of appropriate data, development of guidelines for data collection methods, and statistical analyses. Since 1999, Section personnel have been performing these tasks using PC computing media. They also developed programs to interconnect Visual Basic Program with SAS, Access, Excel, Outlook, and PowerPoint software programs. This has enabled the Section to produce reports, tables, and texts in suitable designs, and to respond to many requests in a shorter period of time.

Statistical and Computing Support

During 2003, a Biostatistician and an Associate Statistician provided statistical and computing support to various projects. The following is a description of some of the activities.

1. Statistical support was provided to USEPA-Region 5 Biosolids Survey for assessment of the accuracy of Publicly Owned Treatment Works (POTWs) self reported 40 CFR Part 503 regulated metals data. The project was completed in August 2003.

2. Statistical support was provided to the Analytical Microbiology & Biomonitoring Section to study the trend in average fecal coliform (FC) concentrations in the Des Plaines River and the Chicago Sanitary and Ship Canal at Lockport for the 2000-2001 period. The project was completed in September 2003.
3. Statistical support was provided to the Analytical Microbiology & Biomonitoring Section to study E.coli or FC concentration at different beaches of 6 Park Districts, and to develop models of E.coli or FC concentrations on the basis of their past concentrations and rain events. The project was completed in May 2003.
4. Statistical support was provided to the Biosolids Utilization and Soil Science Section in analyzing the concentrations of metals in street dust collected from the drainage basins of the Stickney and Calumet WRPs. Statistical analyses were done to determine if there exists any significant differences in the mean concentrations of metals in the street dust from main streets, side streets, alleys, or the periphery of auto

junkyards or scrap metal yards and surface soils. The project was completed in September 2003.

5. Statistical support was provided to the Wastewater Treatment Process Research Section to study the characteristics of stormwater runoff at two storm sewers in Evanston and Crestwood, Illinois. The project was completed in November 2003.
6. Statistical support was provided to the Analytical Microbiology & Biomonitoring Section to study on the estimation of the E.coli to FC ratio in wastewater effluents and ambient waters of the District. The statistical analyses for the project were completed in November 2003.
7. Statistical support was provided to the Biosolids Utilization and Soil Science Section on the study of corn yields and nutrient composition during long-term biosolids applications to calcareous strip-mine soil. All statistical analyses including stability analyses were completed. The final report of the project in underway.

8. Statistical support was also provided to the Wastewater Treatment Process Research Section on centrifuge performance analyses to determine effects of polymer dose (lbs/DT), on cake total solids content under typical sludge throughput (DT/Day) conditions.

Water Quality Data

Each year, the Section prepares an annual report describing the water quality of the streams and canals within the District's jurisdiction for the preceding year. Surface water quality data for 2003 were evaluated regarding compliance with water quality standards set by the Illinois Pollution Control Board (IPCB). In 2003, 64 water quality parameters (biochemical oxygen demand; carbonaceous biochemical oxygen demand; dissolved oxygen; temperature; pH; alkalinity (total); chloride; turbidity; total Kjeldahl nitrogen; ammonium nitrogen; un-ionized ammonia; organic nitrogen; nitrite plus nitrate nitrogen; total solids; total suspended solids; volatile suspended solids; total dissolved solids; phenols; sulfate; fats, oils, and greases; total phosphorus; total cyanide; weak acid dissociable [WAD] cyanide; fluoride; total organic carbon; FC; escherichia coli; total calcium; soluble

calcium; total magnesium; soluble magnesium; hardness; gross alpha radioactivity; gross beta radioactivity; chlorophyll a; total silver; soluble silver; total arsenic; soluble arsenic; total barium; soluble barium; total boron; soluble boron; total cadmium; soluble cadmium; total copper; soluble copper; total chromium; soluble chromium; total hexavalent chromium; total iron; soluble iron; total lead; soluble lead; total nickel; soluble nickel; total manganese; soluble manganese; total mercury; soluble mercury; total zinc; soluble zinc; total selenium; and soluble selenium) were assayed.

COMPLIANCE OF GENERAL USE WATERS

In 2003, 28 water quality parameters (dissolved oxygen; temperature; pH; chloride; ammonium nitrogen; un-ionized ammonia; total dissolved solids; phenols; sulfate; WAD cyanide; fluoride; FC; gross beta radioactivity; total silver; total arsenic; total barium; total boron; total cadmium; total copper; total chromium; total iron; soluble iron; total lead; total nickel; total manganese; total mercury; total zinc; and total selenium) had an IPCB General Use Standard.

Seventeen parameters (temperature; ammonium nitrogen; un-ionized ammonia; phenols; WAD cyanide; gross beta activity; and 11 metals (total arsenic; total barium; total boron; total

cadmium; total chromium [trivalent and hexavalent]; soluble iron; total lead; total nickel; total mercury; total zinc; and total selenium) were in total compliance with General Use Water Standards in all river systems. Ten of the remaining 11 parameters (dissolved oxygen, pH; chloride; total dissolved solids; sulfate; fluoride; total silver; total copper; total iron; and total manganese) had compliance greater than 74.0 percent in all river systems. Fecal coliform had the lowest compliance with General Use Standards which ranged from 37.9 percent to 64.1 percent in all river systems.

COMPLIANCE OF SECONDARY CONTACT WATERS

Twenty-three water quality parameters (dissolved oxygen; temperature; pH; un-ionized ammonia; total dissolved solids; phenols; fats, oils, and greases; total cyanide; fluoride; total silver; total arsenic; total barium; total cadmium; total copper; total chromium; total iron; soluble iron; total lead; total nickel; total manganese; total mercury; total zinc; and total selenium) had IPCB water quality standards established for Secondary Contact Waters.

Among the 23 water quality parameters listed above, twenty parameters (temperature; pH; total dissolved solids; phenols; fats, oils, and greases; total cyanide; fluoride;

total silver; total arsenic; total barium; total cadmium; total copper; total chromium; soluble iron; total lead; total nickel; total manganese; total mercury; total zinc; and total selenium) were in complete compliance with the IPCB's Secondary Contact Standards in all river systems. The compliance rates of the 3 remaining parameters (dissolved oxygen; unionized ammonia; and total iron) varied from 89.4 percent to 99.5 percent in the Chicago and the Calumet River system, respectively.

APPENDIX I

MEETINGS AND SEMINARS 2003

MEETINGS AND SEMINARS 2003
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

1. Aquatic Nuisance Species Dispersal Barrier Meeting, Chicago, Illinois, January 2003.

2. Illinois Water Environment Association, Government Affairs in Water Pollution Control Seminar, Lisle, Illinois, January 2003.

3. Midwest Water Analysts Association, Winter Expo 2003, Kenosha, Wisconsin, January 2003.

4. United States Department of Agriculture, CSRS Regional Research Committee W-170 Annual Meeting, Las Vegas, Nevada, January 2003.

5. United States Environmental Protection Agency, Workshop to Develop a Protocol for Reliable Genetic Methods for the Detection of Viruses for Use in EPA's Water Programs, Cincinnati, Ohio, January 2003.

6. Pennsylvania State University, Wastewater Biology Courses, Champaign, Illinois, February 2003.

7. United States Environmental Protection Agency, Nutrient Standards Workgroup Meeting, Springfield, Illinois, February 2003.

8. United States Environmental Protection Agency, Region V, 2003 Midwest Surface Water Monitoring and Standards Meeting, Chicago, Illinois, February 2003.

9. United States Geological Survey, Office of Employee Development, Aquatic Chemistry, Denver, Colorado, February 2003.

10. Water Environment Federation/AWWA/CWEA Joint Residuals and Biosolids Management Conference and Exhibition, Baltimore, Maryland, February 2003.

11. Asian Carp Rapid Response Planning Team Meeting, Chicago, Illinois, March 2003.

12. Illinois Chapter of American Fisheries Annual Meeting, Whittington, Illinois, March 2003.

13. Illinois Environmental Protection Agency, Water Quality Standards for Radium Meeting, Springfield, Illinois, March 2003.

14. Illinois Water Environment Association, 24th Annual Conference, Rockford, Illinois, March 2003.

15. Interagency Task Force on *E. coli*, NIPRC Office, Portage, Indiana, March 2003.

16. United States Geological Survey, Office of Employee Development, Sediment Data-Collection Techniques, Vancouver, Washington, March 2003.

17. Asian Carp Rapid Response Planning Team Meeting, Chicago, Illinois, April 2003.

18. Central States Water Environment Association, 8th Annual Education Seminar, Madison, Wisconsin, April 2003.

19. Evergreen Park Environmental Fair, Evergreen Park, Illinois, April 2003.

20. Midwest Water Analysts Association and the Northern Illinois Water Analysts Association, Joint Meeting, Chicago, Illinois, April 2003.

21. United States Environmental Protection Agency, 26th Annual Conference on the Analysis of Pollutants in the Environment, Chicago, Illinois, April 2003.

22. Water Environment Research Foundation, PSC Meeting, Lewisburg, Pennsylvania, April 2003.

23. Aquatic Invasive Species Summit, Chicago, Illinois, May 2003.

24. Asian Carp Rapid Response Planning Team Meeting, Chicago, Illinois, May 2003.

MEETINGS AND SEMINARS 2003
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

25. City of Chicago and the United States Fish and Wildlife Service, Aquatic Invasive Species Summit, Chicago, Illinois, May 2003.

26. Illinois Environmental Protection Agency, Nutrient Criteria Workgroup Meeting, Springfield, Illinois, May 2003.

27. North American Benthological Society Annual Meeting, Athens, Georgia, May 2003.

28. Interagency Task Force on *E. coli*, NIPRC Office, Portage, Indiana, June 2003.

29. International Association for Great Lakes Research, Annual Conference, Chicago, Illinois, June 2003.

30. Aquatic Nuisance Species Dispersal Barrier Meeting, Chicago, Illinois, July 2003.

31. Asian Carp Rapid Response Planning Team Meeting, Chicago, Illinois, July 2003.

32. Association of Metropolitan Sewerage Agencies and Environmental Protection Agency, Water9 Model Evaluation Meeting, Research Triangle Park, North Carolina, July 2003.

33. Illinois Water Environment Association, Plant Operations Seminar, Bloomington, Illinois, July 2003.

34. United States Environmental Protection Agency, Water Quality Trading Program Workshop, Chicago, Illinois, July 2003.

35. Water Environment Research Foundation, Biosolids Research Summit, Alexandria, Virginia, July 2003.

36. United States Geological Survey, Streamgage Cooperators Meeting, Peoria, Illinois, August 2003.

37. American Society for Microbiology, 43rd Annual Meeting on Infectious Diseases, Chicago, Illinois, September 2003.

MEETINGS AND SEMINARS 2003
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

38. Asian Carp Rapid Response Planning Team Meeting, Chicago, Illinois, September 2003.

39. Illinois River Coordinating Council Meeting, Chicago, Illinois, September 2003.

40. International Ion Chromatography Symposium, San Diego, California, September 2003.

41. Wildlife Habitat Council, Restoring Greenspace 2003 Conference, Merrillville, Indiana, September 2003.

42. Asian Carp Rapid Response Planning Team Meeting, Chicago, Illinois, October 2003.

43. Great Lakes Beach Association, 3rd Annual Meeting, Lake Michigan: State of the Lake '03 Conference, Muskegon, Michigan, October 2003.

44. Interagency Task Force on *E. coli*, NIPRC Office, Portage, Indiana, October 2003.

45. Midwest Water Analysts Association, 2003 Fall Meeting, Sheboygan, Wisconsin, October 2003.

46. QIAGEN Gene Expression Seminar, Chicago, Illinois, October 2003.

47. Radiobioassay and Radiochemical Measurement Conference, Jackson Hole, Wyoming, October 2003.

48. Water Environmental Federation, 76th Annual Conference, Los Angeles, California, October 2003.

49. American Society of Agronomy Annual Meeting, Denver, Colorado, November 2003.

50. Illinois Department of Public Health, Annual Environmental Laboratory Seminar, Springfield, Illinois, November 2003.

51. Illinois Scientific Surveys Conference, Chicago, Illinois, November 2003.

MEETINGS AND SEMINARS 2003
ENVIRONMENTAL MONITORING & RESEARCH DIVISION

52. Illinois Water Environment Association, Hazardous Waste and Industrial Pretreatment Annual Committee Meeting, Lombard, Illinois, November 2003

53. United States Environmental Protection Agency, Regional Technical Advisory Group Meeting, Chicago, Illinois, November 2003.

54. Water Environment Federation, TMDL 2003 Conference, Chicago, Illinois, November 2003.

55. Asian Carp Rapid Response Planning Team Meeting, Chicago, Illinois, December 2003.

56. Water Environment Research Foundation, Workshop on Developing Better Microbial Indicators, San Antonio, Texas, December 2003.

APPENDIX II

PRESENTATIONS 2003

PRESENTATIONS 2003
ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

1. "Ambient Hydrogen Sulfide Monitoring." Presented at the Midwest Water Analysts Association, Winter Expo 2003, Kenosha, Wisconsin, by Doris Bernstein, January 2003. PP

2. "Quality of Runoff Water from Biosolids-Amended Soils: 30 Years of Monitoring at Fulton County." Presented at the Midwest Water Analysts Association, Winter Expo 2003, Kenosha, Wisconsin, by Lakhwinder S. Hundal, Thomas C. Granato, Richard I. Pietz, and Carl R. Carlson, January 2003. PS

3. "The Impact of Zion Nuclear Power Plant Operation on Lake Michigan Water Quality." Presented at the Midwest Water Analysts Association, Winter Expo 2003, Kenosha, Wisconsin, by Abdul Khalique, Richard Pietz, Bernard Sawyer, and Richard Lanyon, January 2003. PP

4. "Biosolids Source and Processing Effects on Inorganic Forms and Release of Biosolids Phosphorus." Presented at the United States Department of Agriculture, CSRS Regional Research Committee W-170 Annual Meeting, Las Vegas, Nevada, by Albert E. Cox, Thomas C. Granato, and Richard I. Pietz, January 2003. PP

5. "Update of Biosolids Research Activities at the Metropolitan Water Reclamation District of Greater Chicago." Presented at the United States Department of Agriculture, CSRS Regional Research Committee W-170 Annual Meeting, Las Vegas, Nevada, by Thomas C. Granato, January 2003. PP

6. "Biosolids Regulations: An Update of Activities by the United States Environmental Protection Agency and the Nuclear Regulatory Commission." Presented at the Illinois Water Environment Association, 24th Annual Conference, Rockford, Illinois, by Thomas C. Granato, March 2003. PP

7. "Comparison of Fecal Coliform Concentrations and Trends in Two Urban Rivers: The Chicago Sanitary and Ship Canal and the Des Plaines River." Presented at the

Illinois Water Environment Association, 24th Annual Conference, Rockford, Illinois, by Geeta Rijal, March 2003. PP

8. "Pilot-Scale Polymer-Enhanced Lagoon Dewatering of Digested Sludge." Presented at the Water Environment Federation, 76th Annual Conference, Los Angeles, California, by Kamlesh Patel, David T. Lordi, Bernard Sawyer, and Richard Lanyon, October 2003. PS

9. "Protecting Lake Michigan Water Quality; Addressing Beach Issues in 2003." Presented at the Great Lakes Beach Association, 3rd Annual Meeting, Lake Michigan: State of the Lake '03 Conference, Muskegon, Michigan, by James Zmuda, October 2003. PS

10. "Radioactivity in Biosolids-Amended Soil and Uptake of Radioactivity by Crops." Presented at the Radiobioassay and Radiochemical Measurement Conference, Jackson Hole, Wyoming, by Abdul Khalique, Albert Cox, Thomas C. Granato, and Richard I. Pietz, October 2003. PP

11. "E.coli to Fecal Coliform Ratios in Wastewater, Chicago Area Rivers, and Lake Michigan." Presented at the Illinois Department of Public Health, Annual Environmental Laboratory Seminar, Springfield, Illinois, by Rick Gore, November 2003. PP

12. "Soil Phosphorus Status During Thirty Years of Annual Biosolids Application." Presented at the American Society of Agronomy Annual Meeting, Denver, Colorado, by Albert E. Cox, Thomas C. Granato, Richard I. Pietz, and Carl R. Carlson, November 2003. PS

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*P = Available as a paper
B = Available as both a paper and PowerPoint Presentation
PP = Available as PowerPoint Presentation
PS = Poster Presentation

APPENDIX III

PAPERS PUBLISHED 2003

PAPERS PUBLISHED 2003
ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

1. Lanyon, R., I. Polls, and M. Sopcak, "Continuous Monitoring Prevents Data Problems." Water Environment Laboratory Solutions, Vol. 10, No. 4, pp. 6-9. 2003.

2. Patel, K., D.T. Lordi, B. Sawyer, and R. Lanyon, "Pilot-Scale Polymer-Enhanced Lagoon Dewatering of Digested Sludge." Proceedings of the Water Environment Federation, 76th Annual Conference, Los Angeles, California, 2003.

APPENDIX IV

RESEARCH AND DEVELOPMENT DEPARTMENT
2003 SEMINAR SERIES

RESEARCH AND DEVELOPMENT DEPARTMENT
2003 SEMINAR SERIES

Date	Subject
Friday **January 31, 2003**	***Overview of Chicago Waterways System Use Attainability Analysis (UAA)*** Mr. Rob Sulski, Environmental Engineer Illinois Environmental Protection Agency Des Plaines, Illinois
Friday **February 28, 2003**	***Future Trends in Wastewater Treatment*** Dr. Glen Daigger, Kappe Lecturer Denver, Colorado
Friday **March 28, 2003**	***Regulatory Issues Regarding Phosphorus in Biosolids*** Professor George O'Connor University of Florida Gainesville, Florida
Friday **April 25, 2003**	***An Update on the Nu Earth Vegetable Garden*** Dr. Albert Cox, Soil Scientist Dr. Thomas Granato, Soil Scientist Research and Development Department Metropolitan Water Reclamation District of Greater Chicago (District), Cicero, Illinois
Friday **May 30, 2003**	***The Future of the Total Maximum Daily Load (TMDL) Program*** Professor Kenneth Reckhow Duke University Durham, North Carolina
Friday **June 27, 2003**	***Nitrogen Removal Using Membrane-Biofilm Reactors*** Professor Bruce Rittmann Northwestern University Evanston, Illinois
Friday **July 25, 2003**	***Volatile Organic Compound (VOC) Emissions from Sewers*** Professor Richard Corsi University of Texas Austin, Texas

RESEARCH AND DEVELOPMENT DEPARTMENT
2003 SEMINAR SERIES

Date	Subject
Friday **August 29, 2003**	***E. Coli/Fecal Coliform Ratios in Wastewater, Rivers, and Lake Michigan*** Mr. Richard Gore, Microbiologist Research and Development Department District, Cicero, Illinois
Friday **September 26, 2003**	***Radioactivity in Biosolids Amended Soils and Uptake by Corn*** Dr. Abdul Khalique, Radiation Chemist Research and Development Department District, Cicero, Illinois
Friday **October 31, 2003**	***Chlorophyll a Levels in the District's Waterways*** Ms. Jennifer Wasik, Biologist Research and Development Department District, Cicero, Illinois
Friday **November 21, 2003**	***An Update on Odor Monitoring and Odor Control at the District*** Ms. Doris Bernstein, Research Scientist Dr. Ali Oskouie, Research Scientist Dr. David Lordi, Research Scientist Research and Development Department District, Cicero, Illinois

LOCATION:
Stickney Water Reclamation Plant
Lue-Hing Research and Development Complex
6001 West Pershing Road, Cicero, Illinois 60804-4112

TIME: 10:00 A.M.

FOR INFORMATION CONTACT:
Mr. Bernard Sawyer, Assistant Director Research & Development
Environmental Monitoring and Research Division (708) 588-4059

APPENDIX V

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION EMPLOYEES 2003

Environmental Monitoring and Research Division

Sec. 121 – Administration
Sawyer, Bernard, Assistant Director of R&D
Messina, Deborah, Secretary

Pietz, Richard, Research Scientist 4
Urlacher, Nancy, Administrative Assistant

Abedin, Zainul, Biostatistician
Emery, David, Associate Statistician

Sec. 122 – Wastewater Treatment Research
Jain, Jain, Research Scientist 3
Lordi, David, Research Scientist 3
Franklin, Laura, Prin. Office Support Specialist
Patel, Kamlesh, Research Scientist 2
Zhang, Heng, Research Scientist 2
Bernstein, Doris, Research Scientist 1
Kaschak, John, Research Scientist 1
MacDonald, Dale, Research Scientist 1
Oskouie, Ali, Research Scientist 1
Haizel, Anthony, Laboratory Tech 2
Rohe, Donald, Laboratory Tech 2
Bodnar, Robert, Laboratory Tech 1
Byrnes, Marc, Laboratory Tech 1
Pierson, Rodney, Laboratory Tech 1
Rahman, Shafiq, Laboratory Tech 1
Saric, Ronald, Laboratory Tech 1

Sec. 123 – Land Reclam. & Soil Science
Granato, Thomas, Soil Scientist 3
Yarn, Sabina, Prin. Office Support Specialist
Cox, Albert, Soil Scientist 2
Hundal, Lakhwinder, Soil Scientist 2
Lindo, Pauline, Soil Scientist 1
Tian, Guanglong, Soil Scientist 1
Dennison, Odona, Sanitary Chemist 1
Patel, Minaxi, Sanitary Chemist 1
Stefanich, Tricia, Laboratory Tech 2
Tate, Tiffany, Laboratory Tech 2
Reddy, Thota, Laboratory Tech 1
Shingles, Craig, Laboratory Tech 1
Conwell, Heather, Laboratory Assistant
Patel, Upendra, Laboratory Assistant

Sec. 124 – Analytical Microbiology & Biomon.
Zmuda, James, Microbiologist 4
Vacant, Prin. Office Support Specialist
Rijal, Geeta, Microbiologist 3
Gore, Richard, Microbiologist 2
Yamanaka, Jon, Biologist 1
Billett, George, Laboratory Tech 2
Jackowski, Kathleen, Laboratory Tech 2
Maka, Andrea, Laboratory Tech 2
Vacant, Laboratory Tech 2
Shukla, Hemangini, Laboratory Tech 2
Hussaini, Syed, Laboratory Tech 1
Kaehn, James, Laboratory Tech 1
Mangkorn, Damrong, Laboratory Tech 1
Roberts, David, Laboratory Tech 1
Burke, Michael, Laboratory Assistant
Vacant, Laboratory Assistant

Sec. 125 – Land Reclam. & Soil Science (FC)
Carlson, Jr., Carl, Sanitary Chemist 2
Boucek, Jr., Emil, Field and Lab Tech
DeWees, Josh, Field and Lab Tech
Swango, Rosalie, Field and Lab Tech

Sec. 126 – Aquatic Ecology & Water Quality
Dennison, Sam, Acting Biologist 4
Scrima, Joan, Prin. Office Support Specialist
Sopcak, Michael, Acting Biologist 3
Wasik, Jennifer, Acting Biologist 2
Hartford, Mary Lynn, Acting Biologist 1
Vacant, Laboratory Tech 2
Minarik, Thomas, Laboratory Tech 2
Schackart, Richard, Laboratory Tech 2
Szafoni, John, Laboratory Tech 2
Gallagher, Dustin, Laboratory Tech 1
Vick, Justin, Laboratory Tech 1

Sec. 128 – Radiochemistry
Khalique, Abdul, Radiation Chemist
Abdussalam, Tasneem, Sanitary Chemist 1
Robinson, Harold, Laboratory Tech 1

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