Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 02-15

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

2001

ANNUAL REPORT

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Debbie

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ENVIRONMENTAL MONITORING AND RESEARCH DIVISION
2001
ANNUAL REPORT

Research and Development Department
Richard Lanyon, Director

December 2002

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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 83 employees and is comprised of nine Sections. These are illustrated in Figure 1 with a breakdown of the number of employees. The nine sections are:

1. Administrative Section
2. Wastewater Treatment Research Section
3. Land Reclamation and Soil Science Section - Stickney
4. Land Reclamation and Soil Science Section - Fulton County
5. Analytical Microbiology and Biomonitoring Section
6. Aquatic Ecology and Water Quality Section
7. Toxic Substances Section
8. Radiochemistry Section
9. Experimental Design and Statistical Evaluation Section

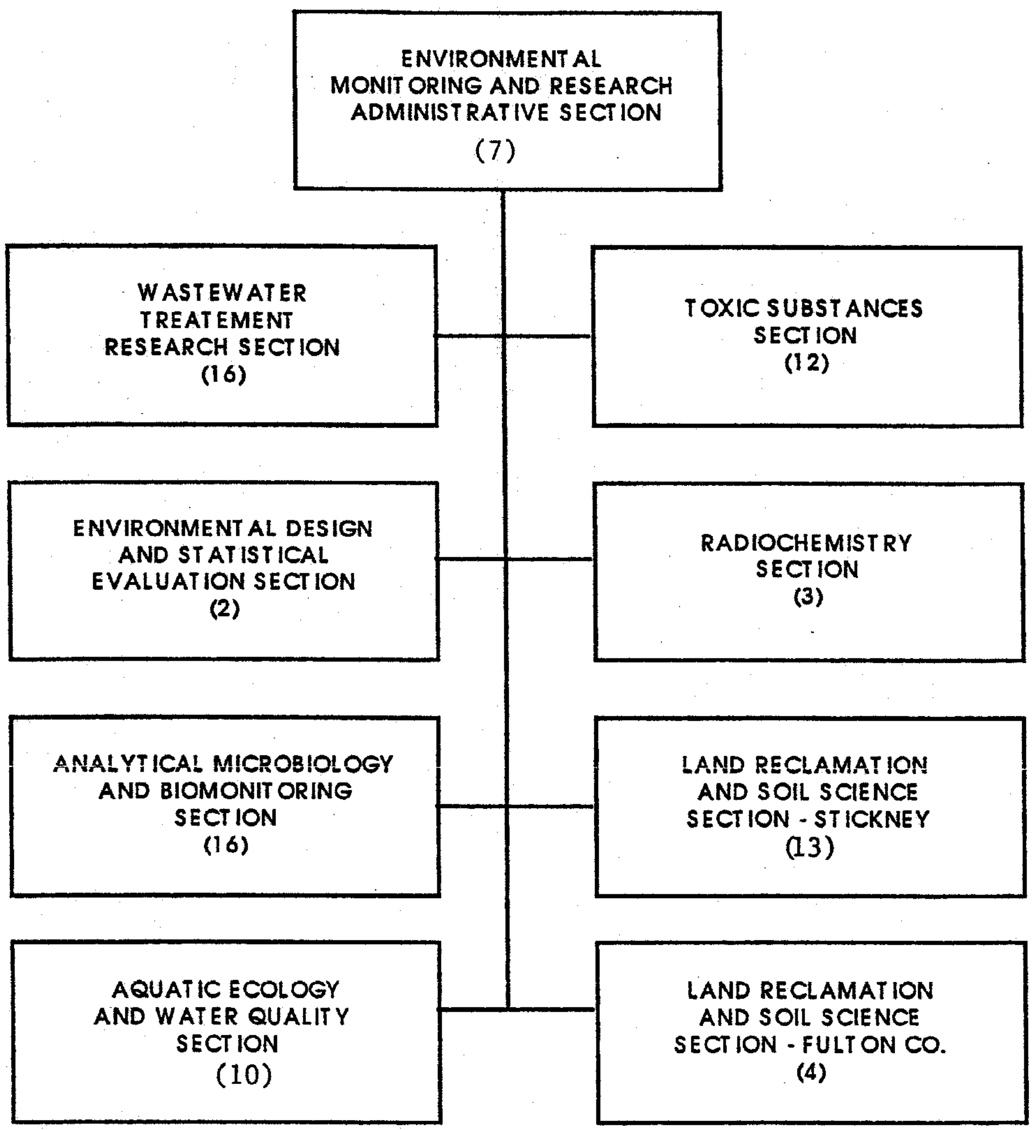
The purpose of this report is to present the major activities and contributions of these sections during 2001. These were to:

- monitor the environmental quality of Lake Michigan, area rivers and canals, and the

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 1

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



Illinois River to document the effectiveness of the wastewater treatment program of the Metropolitan Water Reclamation District of Greater Chicago (District);

- assist in the resolution of sewage treatment and solids disposal operations problems where identified;
- provide technical assistance to other departments and agencies with respect to issues related to wastewater treatment, 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 activities; and
- assess the impact of new or proposed regulations on District activities.

ADMINISTRATIVE SECTION

This Section consists of the Assistant Director of Research and Development, two Research Scientists (Level IV), and a clerical support staff. Its purpose is to oversee and coordinate the work of the sections comprising the EM&R Division.

WASTEWATER TREATMENT RESEARCH SECTION

The Wastewater Treatment 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 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 2001, the section was primarily concerned with studies relating to odor monitoring and control, sludge treatment technologies, oxygen transfer efficiency, ammonia loads to the Stickney WRP, settling and chemical characteristics of combined sewer overflows, reevaluation of pretreatment program local limits, 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 March-April 2001 and July-August 2001, 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 sludge conditions during these seasons require different polymers at this WRP. Polymer testing was also carried out for centrifugal dewatering at the Calumet WRP during June 2001.

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 Table 3.

Polymer Testing Program for Gravity Concentration Tanks at the Calumet WRP

In July 2001, 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.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 1

CENTRIFUGE COMPLEX WINTER POLYMER TEST RESULTS
AT THE STICKNEY WRP - MARCH-APRIL 2001

Number of Vendors Involved in Tests	4
Number of Polymers Submitted for Testing	8
Number of Polymers Qualified for Bidding	7
Polymer Selected	Polydyne NW198
Polymer Dosage, lbs/dry ton	428.1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 2

CENTRIFUGE COMPLEX SUMMER POLYMER TEST RESULTS
AT THE STICKNEY WRP - JULY-AUGUST 2001

Number of Vendors Involved in Tests	5
Number of Polymers Submitted for Testing	8
Number of Polymers Qualified for Bidding	7
Polymer Selected	Polydyne CE045
Polymer Dosage, lbs/dry ton	212.2

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

CENTRIFUGE COMPLEX POLYMER TEST RESULTS
AT THE CALUMET WRP - JUNE 2001

Number of Vendors Involved in Tests	4
Number of Polymers Submitted for Testing	8
Number of Polymers Qualified for Bidding	8
Polymer Selected	Polydyne CE002

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 CST requirement of 10 seconds as described in the bid documents) the test performance criteria 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 July 2001 for the Calumet WRP gravity concentration tanks WRP is presented in Table 4.

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

In May 2001, 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 5.5 percent. The polymer that passed the test performance criteria (as

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TABLE 4

POLYMER TEST RESULTS FOR CALUMET WRP
GRAVITY CONCENTRATION TANKS - JULY 2001

Number of Vendors Involved in Tests	4
Number of Polymers Submitted for Testing	10
Number of Polymers Qualified for Bidding	6
Polymer Selected	Zetag 7816
Polymer Dosage, lbs/dry ton	18.7

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 May 2001 at the Hanover Park WRP is presented in Table 5.

Odor Monitoring Programs

As part of the District's continuing odor surveillance program, the EM&R Division conducts odor monitoring at the Harlem Avenue Sludge Management Area (HASMA), Vulcan, the Lawndale Avenue Sludge 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 Sludge Management Area (RASMA) drying areas. The programs are a part of the NPDES permits for the sludge 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 process to monitor odors. R&D personnel (and in some cases M&O Department personnel) visit various stations at each site on a regular basis. Frequency can range from once per week (as with the North Side WRP), or daily (as with the Kirie WRP), depending on the program. The odor monitoring personnel make subjective

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TABLE 5

GRAVITY BELT THICKENER POLYMER TEST RESULTS
AT THE HANOVER PARK WRP - MAY 2001

Number of Vendors Involved in Tests	1
Number of Polymers Submitted for Testing	2
Number of Polymers Qualified for Bidding	2
Polymer Selected	Polydyne C6277
Polymer Dosage, lbs/dry ton	3.16

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 conditions unrelated to WRP operations or 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 are designed to 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, 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 6.

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

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TABLE 6

CITIZEN ODOR CALLS REGARDING DISTRICT WRPs OR SLUDGE DRYING SITES (SDS) - 2001

	Total Number of Calls Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
HASMA, Vulcan, LASMA, Marathon Sites	0	0	0	0	0	0	0	1	0	0	0	0
Ridgeland SDS	0	0	0	0	0	0	0	1	0	0	0	0
Stony Island SDS	0	0	0	0	0	0	0	0	0	0	0	0
Calumet WRP	0	0	0	0	0	0	0	0	0	0	0	0
John E. Egan WRP	0	0	0	0	0	0	0	0	0	0	0	0
Stickney WRP	0	0	0	0	3	1	1	0	0	0	0	0
James C. Kirie WRP	0	0	0	0	0	0	0	0	0	0	0	0
North Side WRP	0	0	0	0	0	0	0	0	0	0	0	0
Total Calls	0	0	0	0	3	1	1	2	0	0	0	0
Number Confirmed	0	0	0	0	0	0	0	0	0	0	0	0

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

R&D personnel visited 13 stations throughout the three sludge drying areas (HASMA, Vulcan, and Marathon) and the lagoon area (LASMA) at least three times a week. Figure 2 summarizes the observations of odor monitoring personnel during 2001.

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 during the year, there were no very strong odor observations and the strong odor observations were less than two percent of the total observations 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. The one call received from citizens in regard to odors from the sludge processing facilities in 2001 was not able to be confirmed, as shown in Table 6.

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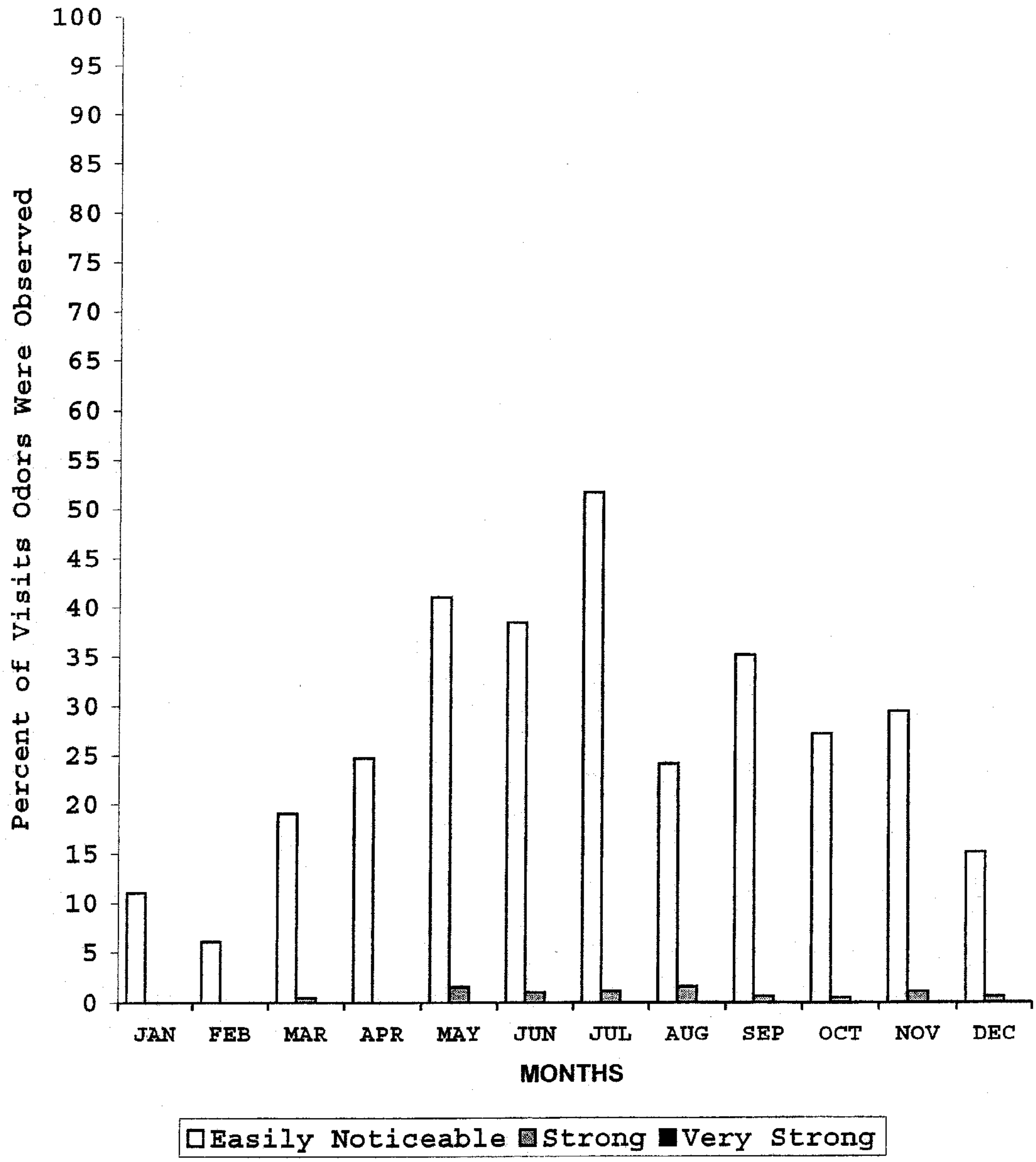
FIGURE 2

ODOR OBSERVANCES AT HASMA, LASMA, VULCAN AND MARATHON SITES - 2001



ODOR MONITORING AT THE CALUMET WRP

The Calumet WRP odor monitoring program 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.

Figure 3 summarizes the observations of easily noticeable, strong, and very strong odors made during 2001 in terms of frequency of occurrence. The odors were at generally low levels in 2001, with no very strong odors being observed and only a few instances of a strong odor. No odor complaints were reported from the public regarding these facilities during 2001, as shown in Table 6.

ODOR MONITORING AT THE STONY ISLAND SLUDGE MANAGEMENT AREA

The odor monitoring program at the Stony Island Sludge Management Area was started in June of 2001. R&D Department personnel visit four stations located around the boundary of the drying cells at least once per week.

Figure 4 summarizes the observations of easily noticeable, strong, and very strong odors made during 2001 in terms of frequency of occurrence. There were no very strong odor observations and only one strong odor observation in 2001, as shown in Table 6.

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FIGURE 3

ODOR OBSERVANCES AT CALUMET WRP - 2001

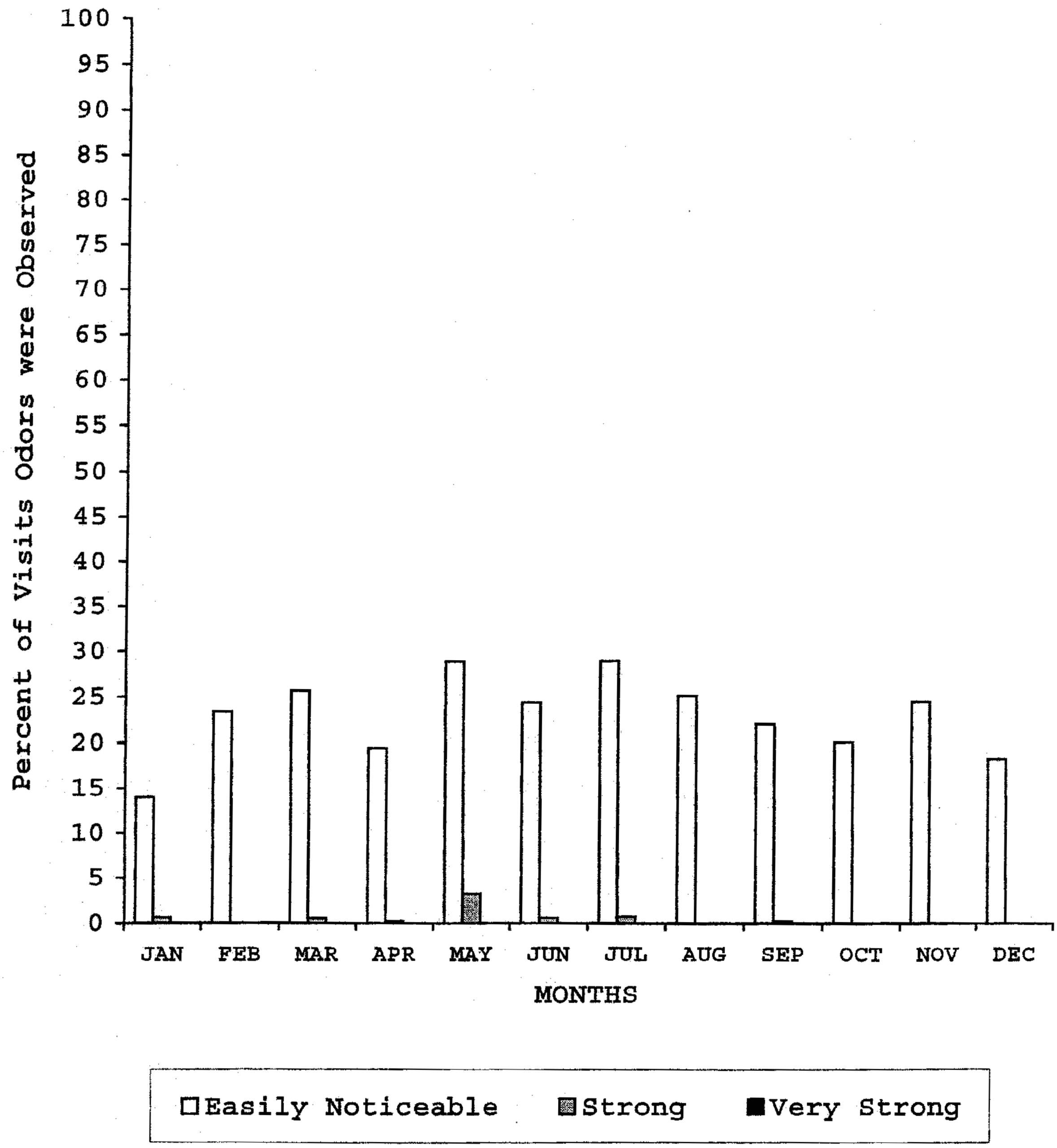

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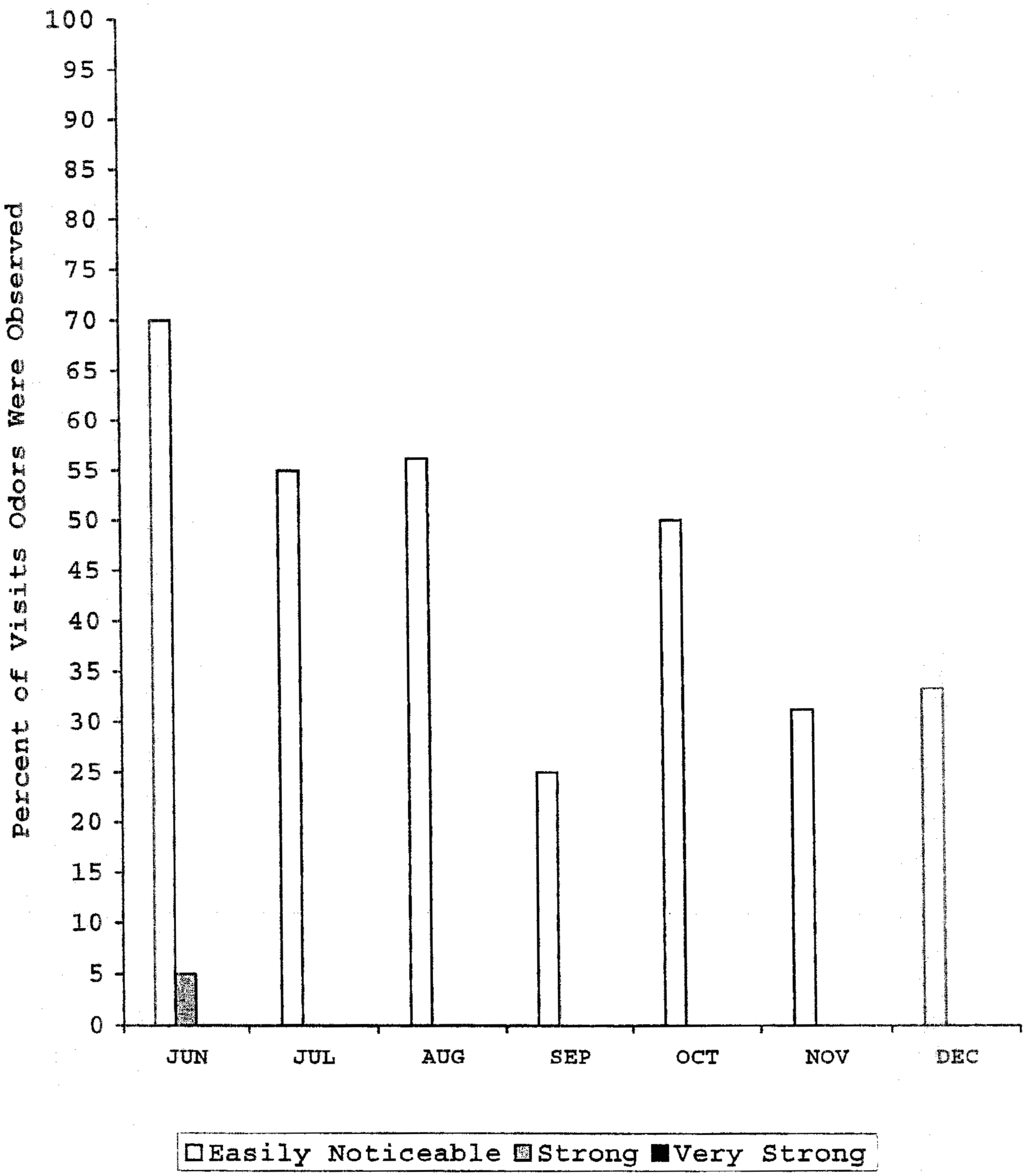
FIGURE 4

ODOR OBSERVANCES AT STONY ISLAND - 2001



ODOR MONITORING AT THE RIDGELAND SLUDGE MANAGEMENT AREA

The odor monitoring program at the Ridgeland Sludge 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 2001 is presented in Figure 5 expressed as frequency of occurrence. No very strong odors were observed. A few strong odors were observed in May and June. One call was received regarding odors at Ridgeland in 2001 (Table 6). On a follow-up investigation, this was not confirmed.

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 2001 was plotted by month and is presented in Figure 6. Odor of an easily noticeable intensity was observed generally less than 20 percent of the monthly observations

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FIGURE 5

ODOR OBSERVANCES AT RIDGELAND - 2001

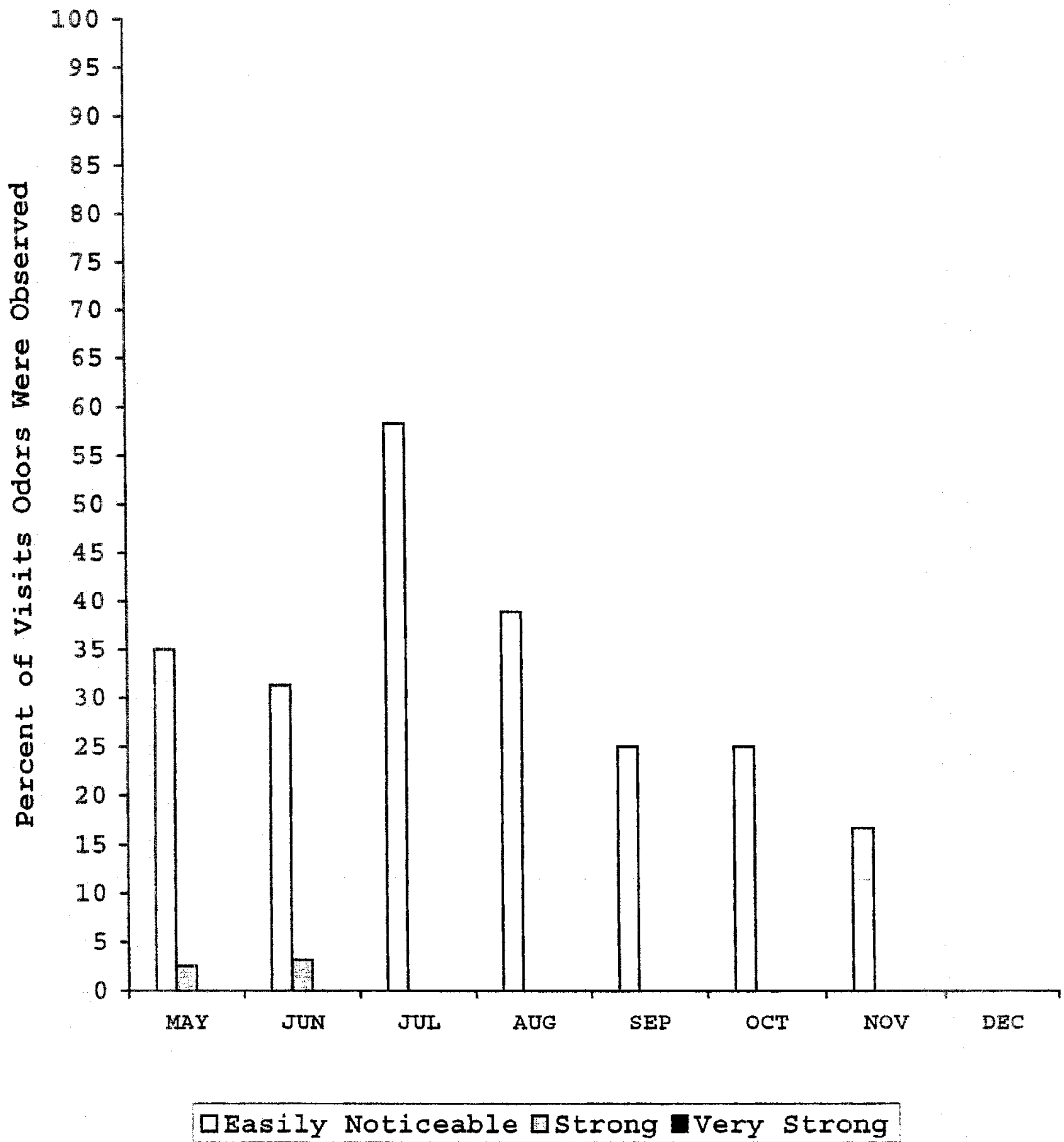

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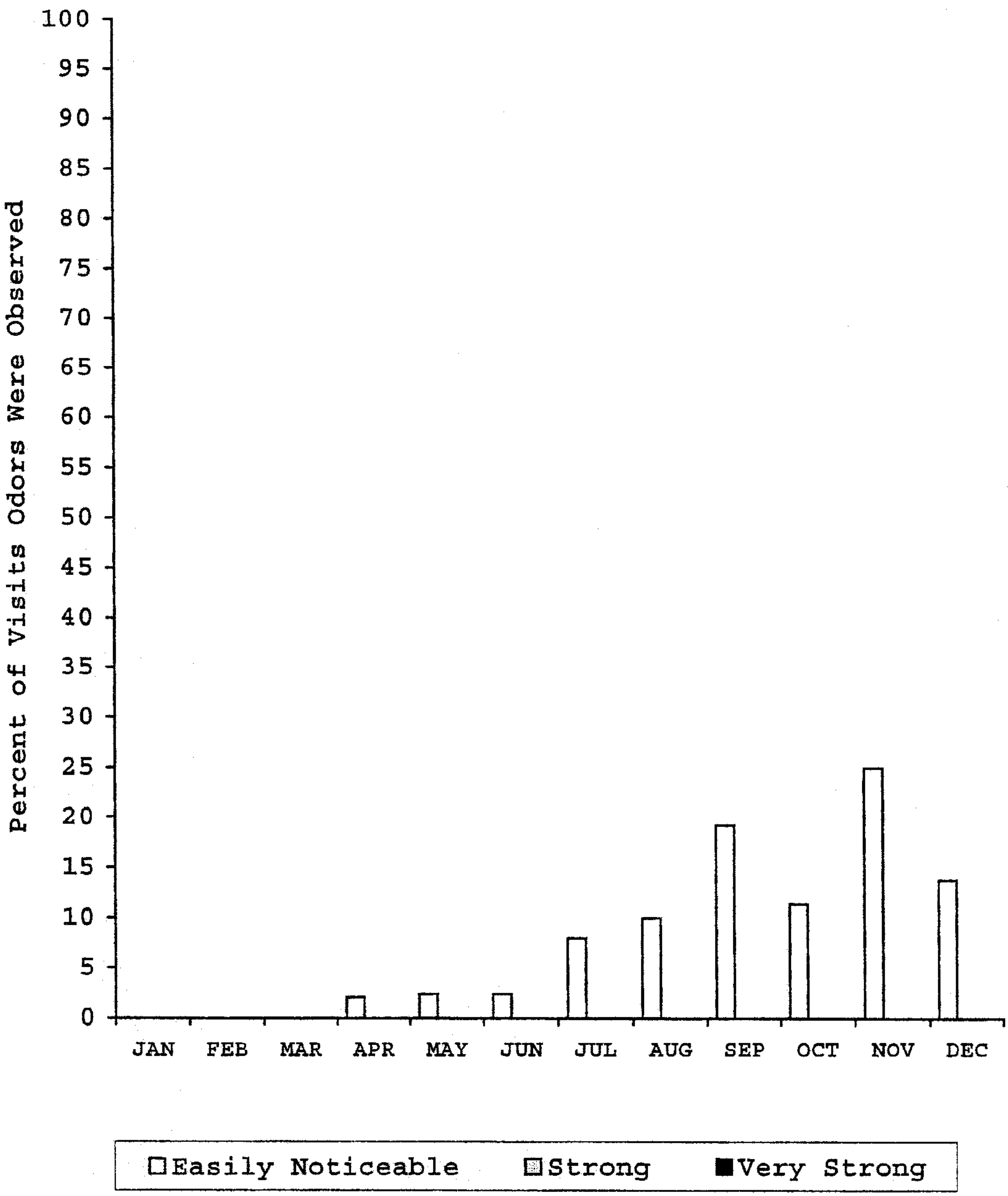
FIGURE 6

ODOR OBSERVANCES AT JOHN E. EGAN WRP - 2001



made at the John E. Egan WRP. No very strong odors were observed. No odor complaints from the public were reported regarding this WRP during 2001, as shown in Table 6.

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. On alternate days (during five days of the week), either R&D or M&O personnel visit each of the 19 established stations within and around the Stickney WRP.

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 7 summarizes the observations of odor monitoring personnel during 2001. 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. As can be seen from Figure 7, easily noticeable odors were observed less than 25 percent of the time for most part of the year. No very strong odors were observed.

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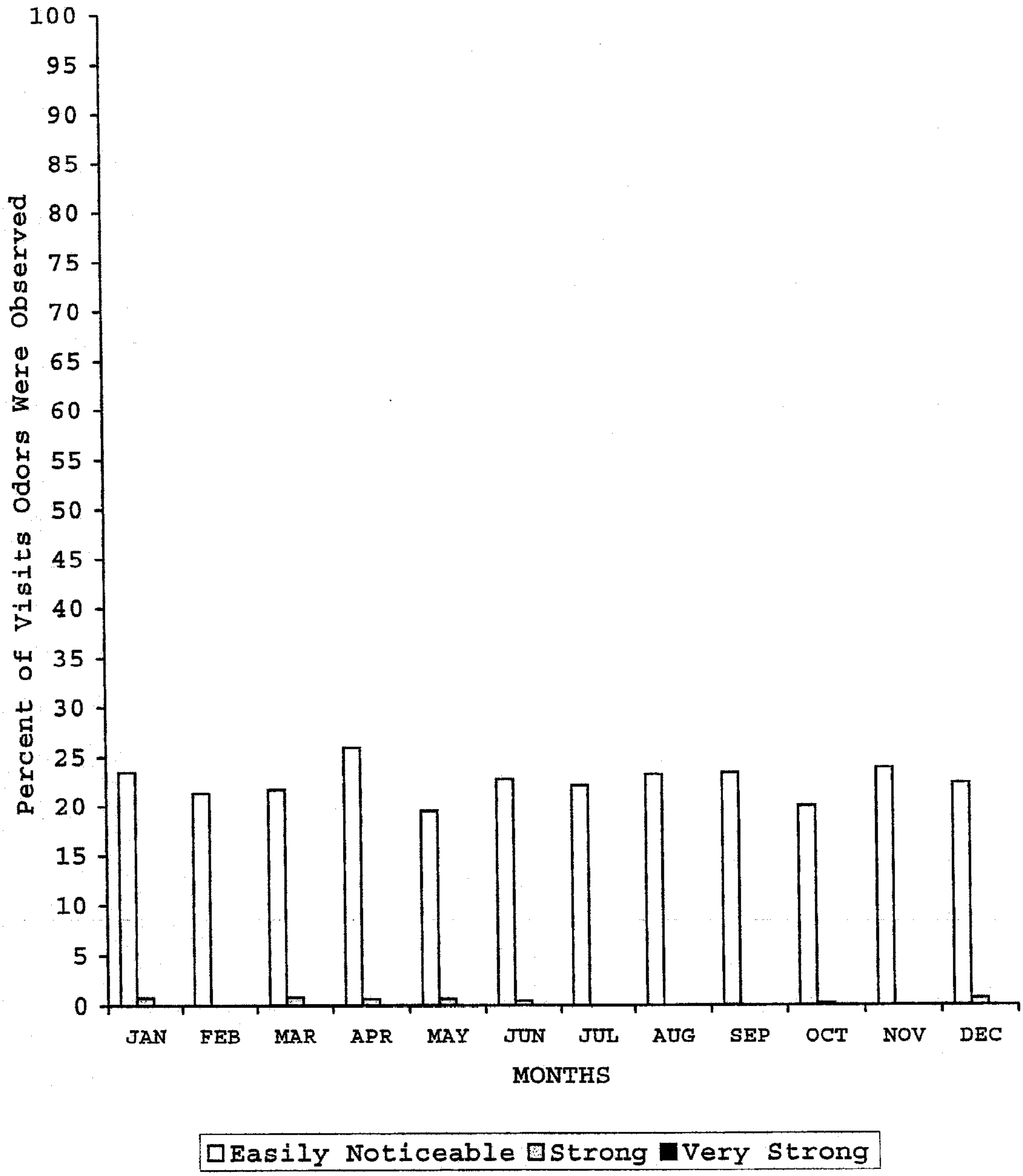
FIGURE 7

ODOR OBSERVANCES AT STICKNEY WRP - 2001



At this WRP, five citizen calls about odors were received during 2001, as shown in Table 6. Investigation by District personnel indicated that the reported odors were not 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 locations within the WRP boundaries and two locations in the nearby community.

Figure 8 summarizes the observations of odor monitoring personnel during 2001 in terms of easily noticeable or greater. As may be noted from the figure, the incidence of odors within the WRP was very low, with odors detected in less than two percent of the observations during most of the year. No odor complaints were received from the public regarding this facility during 2001, as shown in Table 6.

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.

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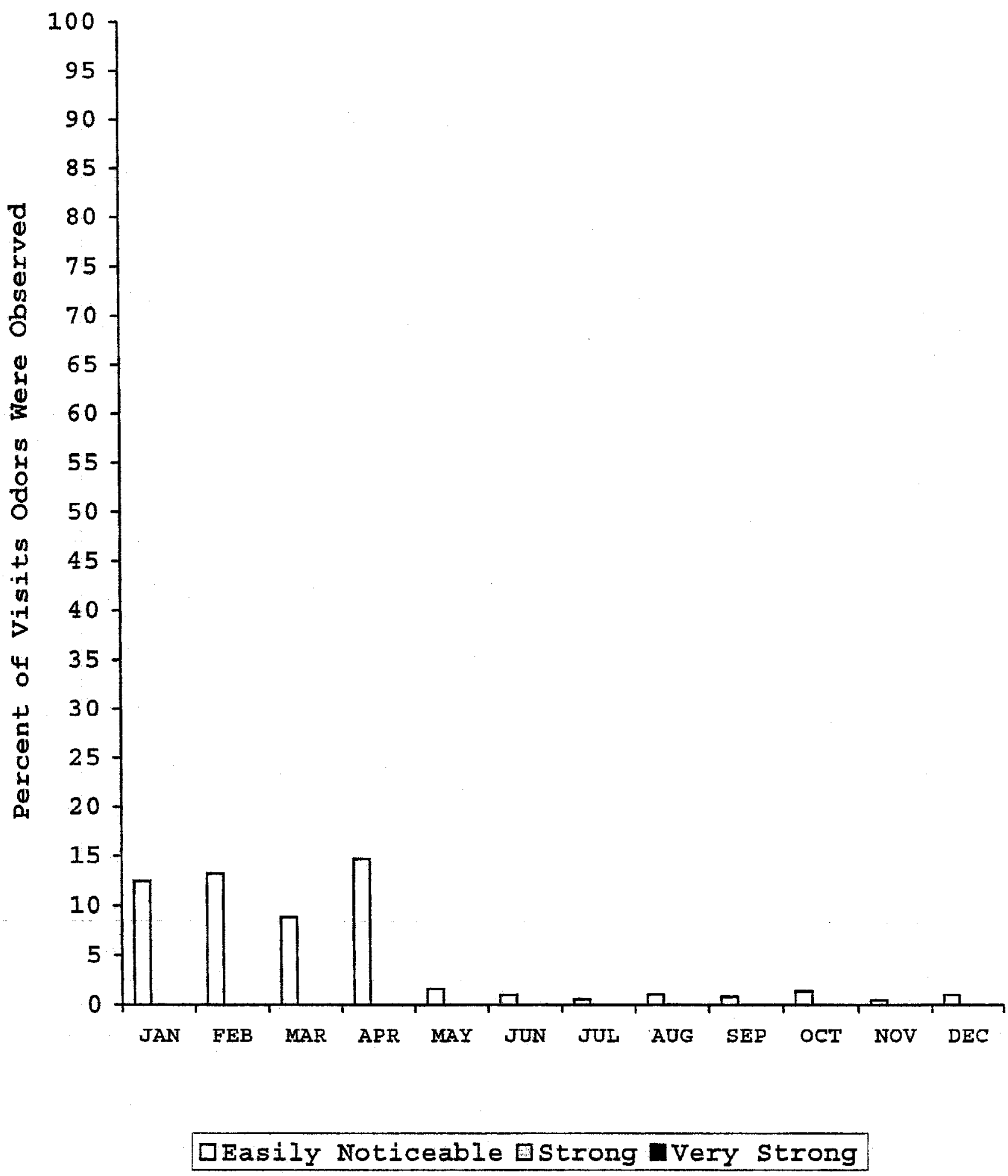
FIGURE 8

ODOR OBSERVANCES AT JAMES C. KIRIE WRP - 2001



R&D personnel visited 13 stations within and around WRP boundaries at least once a week. Figure 9 summarizes the observations of odor monitoring personnel from January through December 2001. For each month, average odor intensity data 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, and only one strong observation was noted during the year.

There were no citizen odor complaints reported by the M&O Department during 2001, as shown in Table 6.

Odor Monitoring Studies of Aged and Unaged Centrifuge Cake

The results of an earlier study conducted by the R&D Department from 1990 through 1994 indicated that centrifuge cake aged for three years in a lagoon consistently yielded low odor intensities as indicated by ED_{50} values below 300. The ED_{50} value is a measure of the odor potential of the centrifuge cake. An ED_{50} value of 300 has been designated as the upper limit for District sludges used for land application in odor-sensitive areas. However, because the District plans to air-dry centrifuge cake at LASMA after only 1 1/2 years in the lagoons, additional odor monitoring was requested by the M&O Department. In addition, centrifuge cake which was not aged at

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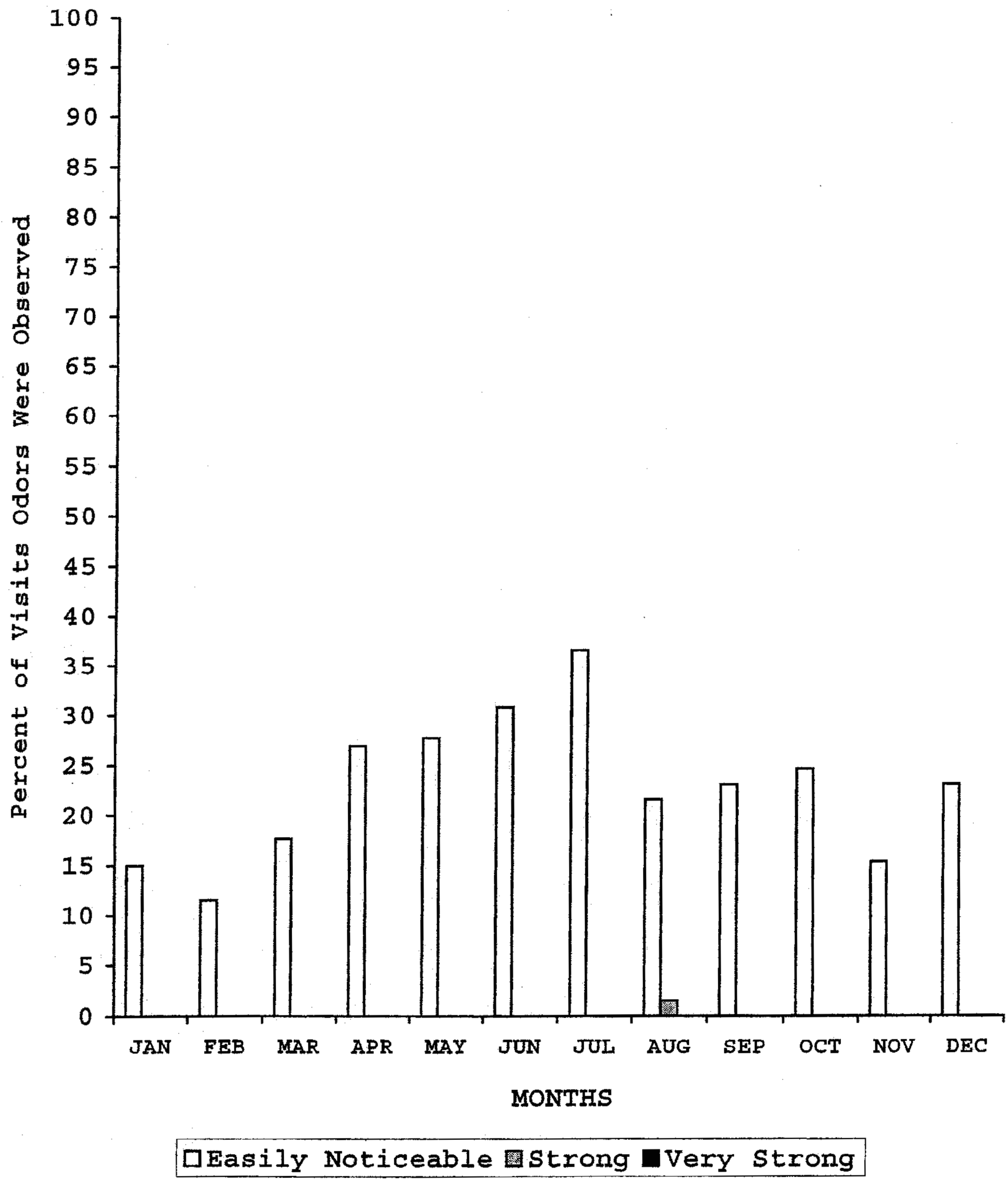
FIGURE 9

ODOR OBSERVANCES AT NORTH SIDE WRP - 2001



all in lagoons was also monitored in order to provide a comparison of the two cakes under the same weather and air-drying conditions.

Unaged or 24-hour cake and (1 1/2 year) lagoon-aged centrifuge cake (aged cake) were applied to the drying cells at Stony Island during the spring and summer seasons. Three random samples of the cake from each of the drying cells studied were collected once a week during each drying cycle. Portions of the cake samples were analyzed for total solids (TS), total volatile solids (TVS), total Kjeldahl nitrogen (TKN), and ammonium nitrogen (NH_4-N) to characterize the sludge. The odor potential of the headspace air over the cake sample contained in an enclosed container was determined by an odor panel using a forced-choice triangle olfactometry procedure and expressed as an ED_{50} value.

Statistical comparisons of the ED_{50} values of the unaged cake and the aged cake were carried out. Although no statistical differences were found between the two types of cake, the unaged cake ED_{50} showed a much greater variability in comparison to the variability of aged cake data. The majority of the samples of both unaged and aged cake had ED_{50} values of less than 200. The ED_{50} values decreased as the cakes were dried.

Air-drying of centrifuge cake that is lagooned less than 18 months most likely would not produce any greater potential for odors during the drying process than 18-month lagoon-aged cake. However, an 18-month lagoon-aging period for centrifuge cake is required for the Class A Process to Further Reduce Pathogens codified operation, and for the use of the centrifuge cake as final landfill cover under Illinois Pollution Control Board AS95-4. The results of this study were published as R&D Department Report No. 02-2, "Evaluation of Odor Potential of Centrifuge Cake During Air-Drying Operations."

Ambient Air Sampling

A project was initiated in 2001 to determine possible volatile organic compounds which may be found in the ambient air in and around the various District WRPs and Sludge Management Areas. This project is a joint effort of the Wastewater Treatment Research Section and the Toxic Substances Section. Ambient air samples were collected using evacuated six-liter Summa canisters. The samples were analyzed for compounds by means of a preconcentrator utilizing liquid nitrogen, followed by separation and detection with a gas chromatograph/mass spectrometer. A total of 24 samples were collected at the Stickney and Calumet WRPs and at several of the Sludge Management Areas during August and October 2001.

The results of analyses are presented in Tables 7 and 8 for the Stickney WRP and Calumet WRP, respectively. Only those compounds for which there was at least one measurable value are presented. Fourteen compounds were found in the Stickney WRP air samples, and 22 compounds were found in the Calumet WRP samples. Acetone and ethanol were the most ubiquitous compounds, showing up in 12 and 11 of the WRP air samples with a range of 3.78 to 11.46 and 2.88 to 22.3 parts per billion by volume (ppbv), respectively. Other predominant compounds were toluene, ranging from 0.52 to 9.23 ppbv, dimethylsulfide, ranging from 0.52 to 120 ppbv, and limonene, ranging from 0.48 to 1.93 ppbv. The greatest number of compounds were found in the Calumet TARP Pump Station sample, with 16 different compounds being identified. Most of them are commonly found in fuels.

The results for the air samples from the Stickney Sludge Management Areas are presented in Table 9, and for the Calumet and Stony Island Sludge Management Areas in Table 10. Not including the TARP drop shaft only 10 compounds were found at these Sludge Management Areas. Again the most prevalent compounds were acetone and ethanol, ranging from 1.47 to 9.86 ppbv and 2.31 to 14.25 ppbv, respectively. The TARP Drop Shaft at the Vulcan Drying Areas had the largest number of compounds, with 23 compounds identified.

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TABLE 7

VOLATILE ORGANIC COMPOUNDS (ppbv) IN AMBIENT AIR SAMPLES AT STICKNEY WRP - AUGUST 2001

Compound	MDL (ppbv)	Reporting Limit (3X MDL)	Stickney Coarse Screen Room	Stickney Aerated Grit Tanks	Stickney Imhoff Tanks	Stickney Pre-digestion Centrifuge	Stickney Post-digestion Centrifuge	Stickney Sludge Concentration Building
Propene	ND	ND	--	--	--	--	1.24	--
Dichlorodifluoromethane	0.12	0.36	--	--	--	--	--	0.41
Ethanol[1]	ND	ND	5.84	22.31	5.20	5.46	--	3.91
Acetone[2]	ND	ND	7.35	8.13	7.57	7.52	11.46	6.32
Isopropanol	ND	ND	--	4.51	--	--	--	--
Methylene chloride	0.19	0.57	--	--	--	--	0.70	--
Carbon disulfide[3]	ND	ND	0.84	0.71	--	--	0.95	--
2-Butanone	ND	ND	0.47	0.43	--	--	0.76	--
Chloroform	0.11	0.33	--	0.42	--	--	--	--
Toluene	0.17	0.51	8.26	5.22	0.52	4.52	4.56	7.93
Isobutane[4]	ND	ND	--	--	--	1.00	0.62	--
Dimethylsulfide[5]	ND	ND	25.85	119.92	0.67	2.28	--	18.35
Dimethyldisulfide[5]	ND	ND	2.64	--	--	2.26	--	3.06
Limonene[5]	ND	ND	1.31	1.93	--	0.52	--	1.59

ND = Not Determined.
-- Not found, below Reporting Limit.
[1]Found in canister blanks at 0.00 and 0.40 ppb.
[2]Found in canister blanks at 2.00 and 1.04 ppb.
[3]Found in canister blanks at 0.07 and 0.89 ppb.
[4]Estimated assuming same total ion response as 1,3-butadiene.
[5]Estimated concentrations based on purge and trap data of exact compounds and internal standards.

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TABLE 8

VOLATILE ORGANIC COMPOUNDS (ppbv) IN AMBIENT AIR SAMPLES AT CALUMET WRP - OCTOBER 2001

Compound	MDL (ppbv)	Reporting Limit (3X MDL)	Calumet Between A & B Batts.	Calumet Sludge Conc. Bldg.	Calumet Aerated Grit	TARP Pump	Calumet East Pre Tanks	Calumet Fine Screen 31	Calumet Centrifuge Building
Propene	ND	ND	0.47	--	--	1.42	--	0.71	--
Ethanol[1]	ND	ND	4.94	5.25	--	14.2	3.78	13.9	6.10
Acetone[1]	ND	ND	6.14	4.36	--	6.75	6.93	11.3	2.88
Carbon disulfide[1]	ND	ND	--	0.64	--	0.53	1.78	1.68	--
2-Butanone	ND	ND	--	--	--	1.21	--	--	--
Hexane	ND	ND	--	--	--	--	--	0.51	--
Benzene	0.11	0.33	--	--	--	--	1.08	1.28	--
Heptane	ND	ND	--	--	--	--	--	0.73	--
4-Methyl-2-Pentanone	ND	ND	--	--	--	1.40	--	--	--
Toluene	0.17	0.51	--	9.23	--	3.43	1.54	2.97	--
Tetrachloroethene	0.16	0.48	--	--	--	--	--	0.51	--
Ethylbenzene	0.17	0.51	--	--	--	2.51	--	--	--
m & p-Xylenes	0.17	0.51	--	--	--	5.36	--	0.56	--
o-Xylene	0.16	0.48	--	--	--	2.83	--	--	--
1,2,4-Trimethylbenzene	0.17	0.51	--	--	--	0.98	--	--	--
1,4-Dichlorobenzene	0.16	0.48	--	--	--	17.9	--	--	--
Isobutane[2]	ND	ND	--	--	--	45.1	--	1.79	--
1,1-Dichloro-1-fluoroethane[3]	ND	ND	--	--	--	--	--	140	--
Dimethylsulfide[4]	ND	ND	--	0.45	--	--	--	0.59	--
Limonene[4]	ND	ND	--	--	--	0.66	0.48	0.78	--

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TABLE 8 (Continued)

VOLATILE ORGANIC COMPOUNDS (ppbv) IN AMBIENT AIR SAMPLES AT CALUMET WRP - OCTOBER 2001

Compound	MDL (ppbv)	Reporting Limit (3X MDL)	Calumet Between A & B Batts.	Calumet Sludge Conc. Bldg.	Calumet Aerated Grit	TARP Pump	Calumet East Pre Tanks	Calumet Fine Screen 31	Calumet Centrifuge Building
Decane[5]	ND	ND	--	--	--	98.7	--	--	--
Undecane[5]	ND	ND	--	--	--	72.8	--	--	--

ND = Not determined.
-- Not found, below Reporting Limit.
[1]Found in canister blanks. Ethanol at 6.50 & 6.72 ppb, Acetone at 10.2 & 5.58 ppb, and Carbon disulfide at 0.80 & 0.36 ppb.
[2]Estimated concentration assuming same total ion response as 1,3-butadiene.
[3]Estimated concentration assuming base ion gives 20% less response than equivalent base ion of 1,1,1-trichloroethane. Real value probably higher due to nonlinearity.
[4]Estimated concentrations based on purge and trap data of exact compounds and internal standards.
[5]Estimated concentration assuming response relative to dichlorobenzenes (3 isomers averaged) is the same in air analysis as it is in semivolatile analysis, where actual data was obtained. Real values probably higher due to nonlinearity. Branched hydrocarbons near in volatility contributed at least 6 more peaks for about 100 ppb extra.

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TABLE 9

VOLATILE ORGANIC COMPOUNDS (ppbv) IN AMBIENT AIR SAMPLES AT SLUDGE MANAGEMENT AREAS - AUGUST 2001

Compound	MDL (ppbv)	Reporting Limit (3X MDL)	LASMA 5W	HASMA 2W	Marathon	Vulcan West of Fence	LASMA Lagoon 16	Vulcan TARP Drop Shaft
Propene	ND	ND	--	1.33	--	--	--	4.81
Dichlorodifluoromethane	0.12	0.36	--	0.38	0.45	--	0.36	0.44
Vinyl chloride	0.13	0.39	--	--	--	--	--	2.99
Ethanol[1]	ND	ND	--	4.03	2.31	4.22	14.25	9.10
Acetone[2]	ND	ND	1.47	6.02	5.75	5.70	6.11	13.21
Isopropanol	ND	ND	--	7.97	--	4.97	--	--
Methylene chloride	0.19	0.57	--	--	--	--	--	1.61
Carbon disulfide[3]	ND	ND	--	0.56	--	0.9	0.77	0.60
1,1-Dichloroethane	0.10	0.30	--	--	--	--	--	0.52
2-Butanone	ND	ND	--	--	--	--	--	0.52
cis-1,2-Dichloroethene	0.10	0.30	--	--	--	--	--	7.64
Chloroform	0.11	0.33	--	--	--	--	--	4.05
1,1,1-Trichloroethane	0.11	0.33	--	--	--	--	--	0.92
Bromodichloromethane	ND	ND	--	--	--	--	--	0.42
Trichloroethene	0.10	0.30	--	--	--	--	--	2.25
Toluene	0.17	0.51	--	2.21	--	--	--	6.59
2-Hexanone	ND	ND	--	--	--	--	--	0.65
Tetrachloroethene	0.16	0.48	--	--	--	--	--	3.38
1,2,4-Trimethylbenzene	0.17	0.51	--	--	--	--	--	0.72
1,4-Dichlorobenzene	0.16	0.48	--	--	--	--	--	1.16
Isobutane[4]	ND	ND	--	--	--	--	0.60	4.76
Dimethylsulfide[5]	ND	ND	--	--	--	--	--	1.66

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TABLE 9 (Continued)

VOLATILE ORGANIC COMPOUNDS (ppbv) IN AMBIENT AIR SAMPLES AT SLUDGE MANAGEMENT AREAS - AUGUST 2001

Compound	MDL (ppbv)	Reporting Limit (3X MDL)	LASMA 5W	HASMA 2W	Marathon	Vulcan West of Fence	LASMA Lagoon 16	Vulcan TARP Drop Shaft
Dimethyldisulfide[5]	ND	ND	--	--	--	--	--	0.41
Limonene[5]	ND	ND	--	--	--	--	--	14.13

ND = Not Determined.
-- Not found, below Reporting Limit.
[1]Found in canister blanks at 0.00 and 0.40 ppb.
[2]Found in canister blanks at 2.00 and 1.04 ppb.
[3]Found in canister blanks at 0.07 and 0.89 ppb.
[4]Estimated assuming same total ion response as 1,3-butadiene.
[5]Estimated concentrations based on purge and trap data of exact compounds and internal standards.

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TABLE 10

VOLATILE ORGANIC COMPOUNDS (ppbv) IN AMBIENT AIR SAMPLES AT CALUMET AND STONY ISLAND SLUDGE MANAGEMENT AREAS
OCTOBER 2001

Compound	MDL (ppbv)	Reporting Limit (3X MDL)	Calumet Cell 1 East	Calumet Cell 7 East	Calumet Cell 2 West	Stony Island Wet Sludge South Cell 5 by Split	Stony Island X - South S1
Propene	ND	ND	0.50	--	0.46	--	--
Ethanol[1]	ND	ND	7.08	4.47	5.48	9.86	9.48
Acetone[1]	ND	ND	4.48	2.75	7.37	4.31	4.64
2-Butanone	ND	ND	--	--	--	--	3.91
Benzene	0.11	0.33	--	--	--	--	0.37
1,2,4-Trichlorobenzene	0.17	0.51	--	--	0.69	--	--
Hexachlorobutadiene	0.16	0.48	--	--	0.48	--	--
Isobutane[2]	ND	ND	--	--	0.76	--	--

ND = Not determined.
-- Not found, below Reporting Limit.
[1]Found in canister blanks. Ethanol at 6.50 & 6.72 ppb, Acetone at 10.2 & 5.58 ppb, and Carbon disulfide at 0.80 & 0.36 ppb.
[2]Estimated concentration assuming same total ion response as 1,3-butadiene.

This project will be expanded in 2002 to include other locations and repeat sampling at present locations.

Polymer-Enhanced Settling of Anaerobically Digested Sludge in Pilot Lagoons

The increasing use of centrifuge machines for dewatering digested sludge at the Stickney WRP and the reduction of the number of lagoons available for dewatering if the centrifuges are not operable has caused a concern to the M&O Department regarding sufficient lagoon capacity for emergency use. One way by which the lagoon capacity may be increased is by using a cationic polymer to enhance settling and dewatering. The M&O Department requested that the R&D Department undertake a study to evaluate the effectiveness of the addition of a polymer to enhance the settling and dewatering of anaerobically digested sludge in the lagoons.

During 2001, the M&O Department trade personnel fabricated three pilot-scale lagoons at Stickney shops and installed them with necessary piping and plumbing fixtures in the lower gallery by digested sludge holding tanks 9 and 10. A schematic of a typical set-up is shown in Figure 10 in which polymer fed tanks are located at each end while control tank is in the middle.

The pilot lagoons were fabricated using steel sheets in the sizes of 4′ X 8′ X 0.25". Two sight-glass windows, one in

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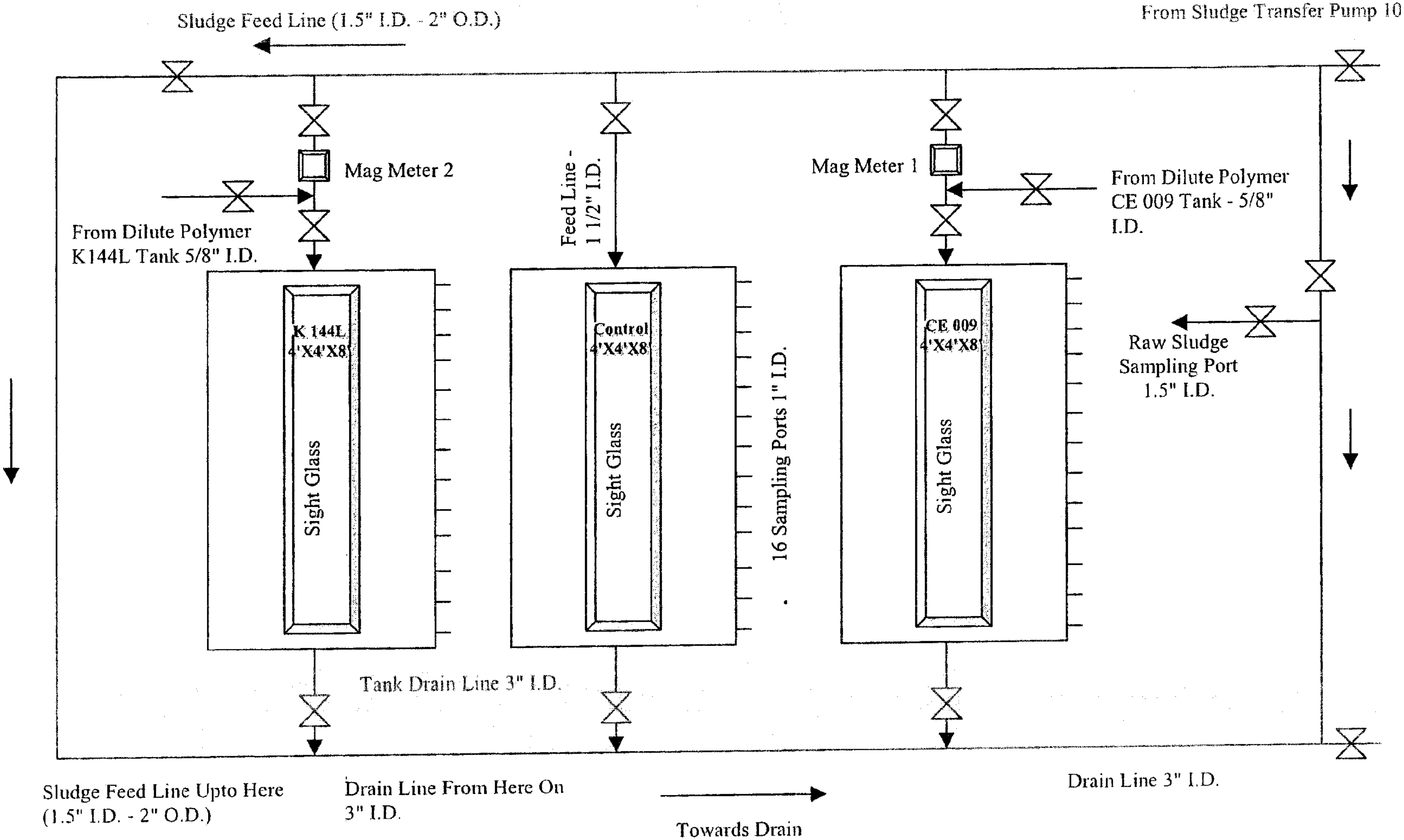
FIGURE 10

SCHEMATIC OF PILOT LAGOONS



the front and the other in the rear of each tank are installed for observations along the depth. The dimensions of all three tanks are approximately 4′ X 4′ X 8′, having a capacity of approximately 958 gallons plus a freeboard volume of approximately 60 gallons. A minor variation in tank dimensions during fabrication job resulted in a slight difference in volume of all three tanks.

After fabrication and installation, the volumetric capacities of all three tanks were individually calibrated with a magnetic flow meter (Foxboro 8000 series). Magnetic flow meter results was also verified by a bucket and stopwatch method prior to calibrating tanks and marking graduations in increment of 5 gallons.

Each tank has 16 sampling ports (of 1" in outer diameter), every six inches apart center to center. Inlet pipe (1 1/2" outer diameter) to each tank is from the top of a tank going all the way up to a few inches above from the bottom of a tank. A drainage line (4" outer diameter) on the bottom of each tank is also provided for cleaning the tank by draining and flushing out the material and/or by back-flushing the sticky material with clean water and then draining out. For flexibility in control, all sampling ports, inlet and drainage lines are provided with control valves.

A sludge line (1 1/2" outer diameter) from sludge transfer pump number 10 feeds all three tanks. This pump transfers the digested sludge stored in holding tank 10 to the post centrifuge complex for dewatering. It should be noticed that the sludge used for this study does not contain carbon dioxide that is injected to prevent struvite deposition at Stickney WRP.

The sludge line feeding the polymer fed tanks receives dilute polymer solution. A vigorous mixing of dilute polymer-sludge mixture takes place in the feed pipe resulting in a conditioned sludge feed to the tank.

The sludge feed to the polymer fed tanks is measured by a magnetic flow meter while the dilute polymer input to the sludge line is measured by a draw down in the polymer preparation tank. Magnetic flow meter is installed such that it measures only sludge flow to only one polymer fed tank at a time. Sludge in the control tank is measured from the graduations marked on the tank.

Raw polymer is drawn into a graduated cylinder from a 55-gallon drum using a hand pump and is mixed in a 55-gallon graduated (and factory calibrated, Nalge Company) polymer preparation tank. City water and raw polymer is mixed to prepare a desired strength of a dilute polymer solution. A hand drill is used to mix the polymer solution. A progressive cavity pump (manufactured by Dayton Electric Manufacturing Company, Chicago, USA) pumps dilute polymer into a sludge line via (5/8" internal diameter) tubing.

All three tanks and associated plumbing were leak-tested with clean water and then with sludge.

A preliminary laboratory testing was conducted to select two polymers for the pilot-lagoon tests. Nine emulsion polymers were supplied by two vendors which were formulated for settling and dewatering of anaerobically digested sludge. The laboratory tests include both CST and settling tests and a determination of the applicable dosage of the two polymers selected to be used in the pilot study.

A series of pilot-lagoon studies are planned to be carried out in 2002.

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 the regionwide pollution and flood control system capturing and temporarily storing combined sewer overflows (CSOs). The CSOs, which are mixtures of raw sewage and stormwater runoff, are subsequently treated at District WRPs.

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

There are a total of 115 water quality monitoring wells, and 34 observation wells in the Calumet, Mainstream, Des Plaines, Upper Des Plaines, and Chicagoland Underflow Plan (CUP) Reservoir systems (Figure 11). Of these 115 wells, 106 are currently 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 106 monitoring wells are located on the perimeter of the O'Hare Reservoir. The other TARP wells are located alongside the 93.4 miles of completed TARP tunnels.

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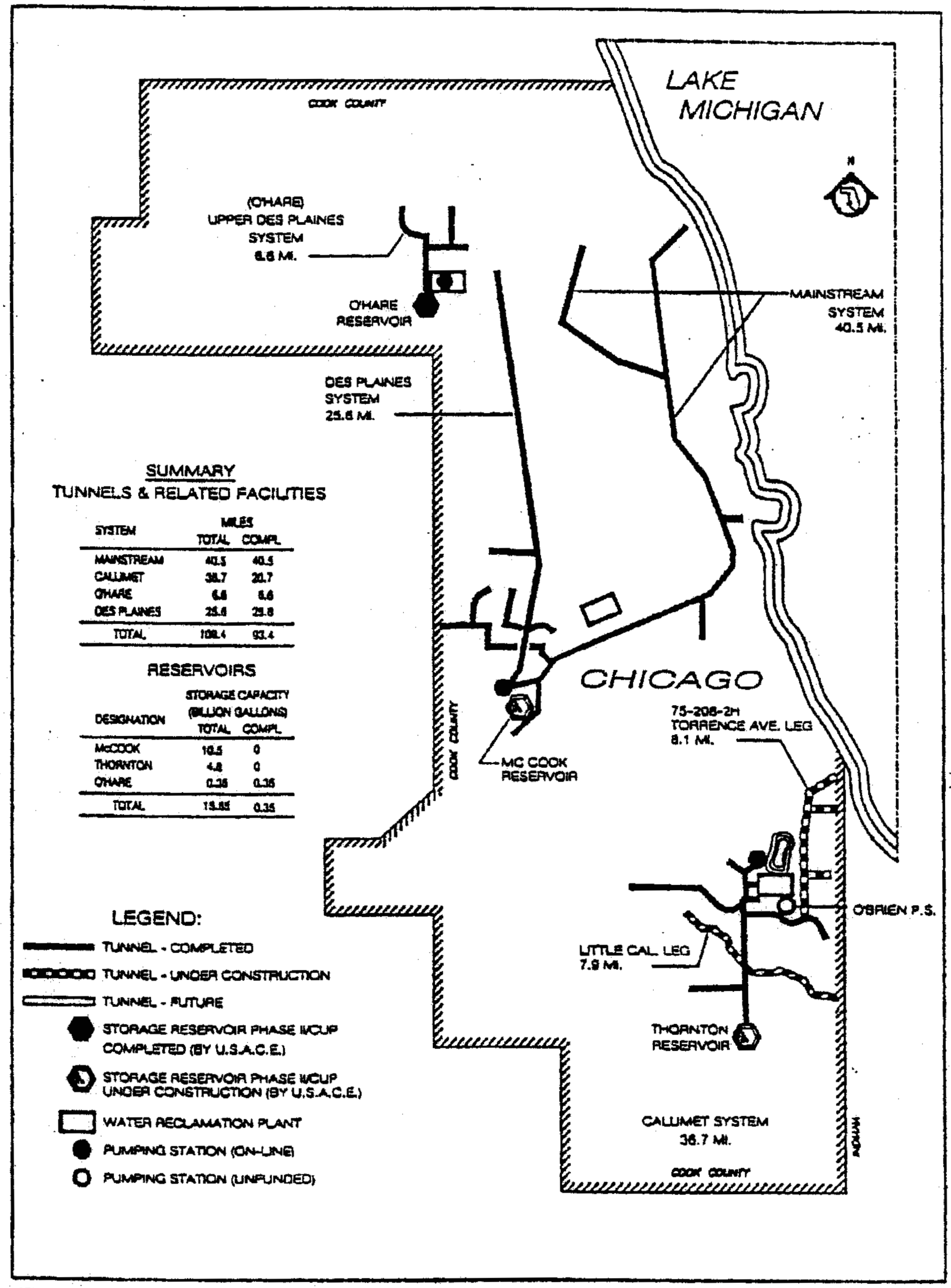
FIGURE 11

LOCATION OF TARP TUNNELS



The Illinois Environmental Protection Agency (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 per year, which was originally at 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). The monitoring frequency of the Mainstream observation wells (OM-1 through OM-23) has been reduced from once every two weeks to once every two months.

The water quality monitoring wells are sampled for the following parameters: ammonia (NH_4-N), conductivity, chloride, fecal coliform concentration, hardness, pH, sulfate, temperature, total organic carbon, and total dissolved solids. Data collected from sampling TARP wells are submitted annually to the IEPA.

The overall results obtained from regularly monitoring the TARP wells indicate that operation of the TARP tunnels has no adverse effect on the local groundwater quality.

Oxygen Transfer Efficiency of Diffuser Plates

This project was a follow-up study. The main objective of this study was to evaluate the changes of oxygen transfer efficiency (OTE) of the diffuser plates at the North Side WRP in the selected tanks of Batteries B and D after the 1999 and earlier tests. Field tests using an off-gas analyzer and off-gas hoods were conducted during the summer and fall of 2001. Data collections were completed in 2001, and data analysis and report preparation will be performed in 2002.

The scope of this project included conducting off-gas tests (1) in one aeration tank, B6 West, in Battery B, where the diffuser plates were steam and hot water cleaned in 1999 and OTEs were measured in 1999; (2) in aeration tanks D1 and D3, where OTEs were measured at 1/4 and 1/2 locations in 1990; and (3) in aeration tanks D5, D6 and D7, where OTEs were measured in 1995 and 1999.

The positions of off-gas hoods in different aeration tanks tested were different in this study, due to the difference in tank configuration and targets of measurements. In B6 West, the aeration tank is a narrow bay with a tank width of 17 feet. To catch the largest portion of the off gas emitting from a spiral-type of aeration tanks at a test station, two hood positions, next to each other in a lateral direction, were employed at each test station. A total of five test stations, two each at the 1/4 and 1/2 locations and one at the 3/4 location, were selected for this study. The two stations each at the 1/4 and 1/2 locations were adjacent to each other in longitudinal direction to examine the possible spatial variation of OTE. In D1 and D3, the exact off-gas hood locations in the 1990 study were unknown. As D1 and D3 have a tank width of 34 feet and a spiral-type of aeration system, three lateral hood positions with the first one being one foot away from the wall of the diffuser-side walkway were used at each of the test stations. According to the 1990 study, two test stations, one at the 1/4 location and the other at 1/2, were set up for each tank. The same two test stations were also adopted in this study. In D5, D6 and D7, as in the 1995 and 1999 studies, only one off-gas hood position, two feet away from the wall of diffuser-side walkway, was used at each of the test stations. Two test stations in each aeration tank were set up identical to D1 and D3, one at 1/4 and the other at 1/2.

The off-gas tests were conducted under controlled conditions, except for a few occasions when the plant received wet weather flows. At the North Side WRP, air flow to each aeration tank can be set and controlled, but the sewage flow can only be measured and adjusted for the entire battery. During the off-gas tests, sewage flow to the test battery was adjusted to 50 million gallons per day (MGD) whenever the plant operation conditions permitted. The air flow to each test tank was set at 2100 standard cubic feet per minute (scfm) for Battery B and at 2800 scfm for Battery D.

To account for the variation of sewage characteristics, off-gas tests were repeated at the same test locations on different days. In Tank B6 West, off-gas tests were performed seven times at almost every test station on seven different days. In Tanks D1, D3, D5, D6 and D7, off-gas tests were conducted at least five times at each test station.

Research Services to the Army Corps of Engineers (ACOE) to Support the Design of the Aeration and Wash Down Systems for the McCook Reservoir

The objective of this project is to provide research assistance, by the District and/or its subcontractors, to the ACOE to support the design of full scale aeration and wash down systems for the McCook Reservoir. Since the McCook Reservoir will eventually contain CSOs, an assessment of the potential for odors, and the impact of the reservoir contents on the ambient air quality was conducted.

The McCook Reservoir will provide storage for CSOs from the Mainstream and Des Plaines TARP tunnel systems to reduce flood damage and minimize the release of untreated CSOs to area waterways. The Mainstream and Des Plaines TARP tunnels, constructed and operated by the District, will transport the CSOs to McCook Reservoir when flows exceed the capacity of the Stickney and North Side WRPs. Provision(s), which are not defined as yet, will be made in the design of the McCook Reservoir to minimize odor formation between and during fill events in the reservoir. A wash down system will be designed to remove solids and debris from the walls and floor of the reservoir between storm events to minimize odors, maintain air quality, and comply with the applicable air pollution regulations.

A literature investigation was undertaken to determine the technical, economic, and physical feasibility of incorporating the candidate systems into the design of the total aeration system. Two reports were prepared. They are: *Possible Aeration Systems and Washdown Procedures for Use with the Proposed McCook Reservoir, Part I: Comparison of U-Tube, Cryogenic Oxygen, and Diffused Air Technology Alternatives for Aeration of Deep Reservoirs and Reservoirs with Large Depth Variations - A Literature Search and Review,* and *Literature Search of Possible Aeration Systems and Washdown Procedures for Use with the Proposed McCook Reservoir, Part II: Comparison of Washdown Procedures for Deep Reservoirs and Reservoirs with Large Depth Variations - A Literature Search and Review.*

These reports were reviewed by the ACOE, Chicago Office, and were accepted after minor changes.

The ACOE, Chicago Office, is conducting pilot-plant studies through its consultant Dr. Marcelo Garcia, a professor at the University of Illinois at Urbana-Champaign, Illinois, to support the design for aeration and washdown systems for the McCook Reservoir. In addition, the ACOE is planning to conduct full-scale tests for aeration in deep waters to develop data for the design of McCook Reservoir. Meetings are held regularly between District and ACOE staffs to review the progress of the project.

EVALUATION OF SETTLING CHARACTERISTICS OF CSOS

In order to provide technical assistance to the ACOE Chicago District in the design of the McCook Reservoir, a study was conducted to evaluate the settling characteristics of CSOs under quiescent conditions. The study was initiated in 2000.

The settling tests were conducted under static conditions in two identical clear PVC columns, which were 10 feet tall with a diameter of 6 inches and a volume of nearly 15 gallons. The columns were installed in the pilot plant room of the Wastewater Treatment Research Laboratory.

Two types of CSOs were tested in this study. One was the TARP pumpback, which is collected in the Mainstream Deep

Tunnel during the occurrence of a significant rainfall and is returned to the Stickney WRP for treatment after the rain. The other was the Racine Avenue Pump Station (RAPS) overflow, which is the CSO pumped to the Chicago waterways during an excessive rainfall event after the Deep Tunnel is filled. Raw sewage to the Stickney WRP West Side was also used in the settling tests for the purpose of comparison. The grab samples from TARP pumpback and the raw sewage (Stickney West Side) were used for the column settling studies in the year 2000. The second type of CSO, namely overflow from the RAPS, was used in the column settling studies conducted in the year 2001.

The characteristics of the CSOs and wastewater used in the static settling tests are presented in Table 11. The results of the static settling tests are shown in Figures 12, 13, 14, 15, 16, and 17 for the various wastewaters. These results were sent to ACOE Chicago District and to Prof. Marcelo Garcia, consultant to ACOE.

Investigation of Ammonia and Organic Nitrogen Sources Contributing to the Stickney WRP

The proposed reissued NPDES permit for the Stickney WRP requires ammonia-nitrogen (ammonia) in the final effluent not to exceed a maximum daily concentration of 8 mg/L in winter and 5 mg/L in summer, in addition to continuation of the

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TABLE 11

SUMMARY OF COMBINED SEWER OVERFLOWS AND WASTEWATER USED FOR STATIC SETTLING TESTS
NOVEMBER 2000 THROUGH FEBRUARY 2001

Samples		Rainfall (inch)	SS (mg/L)	VSS (mg/L)	BOD_5 (mg/L)	pH
11/14/00	TARP Pumpback[1]	0.23	102	59	84	6.9
11/16/00	TARP Pumpback	0.00	138	82	120	6.7
02/09/01	Racine Overflow[2]	1.04	269	116	75	7.4
11/15/00	Stickney WRP West Side Raw	0.00	147	91	146	NA[3]
11/21/00	Stickney WRP West Side Raw	0.00	93	NA	101	7.0
11/22/00	Stickney WRP West Side Raw	0.00	208	NA	167	6.9

[1]Rainfall occurred on 11/13/2000, but stopped on 11/14/2000.
[2]This stands for Racine Avenue Pumping Station Overflow, and rainfall began on 02/08/2001 and continued on 02/09/2001.
[3]No analysis.

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FIGURE 12

STATIC SETTLING TEST RESULTS FOR STICKNEY TARP PUMPBACK
(SS=102 mg/L, VSS=59 mg/L, pH=6.9)

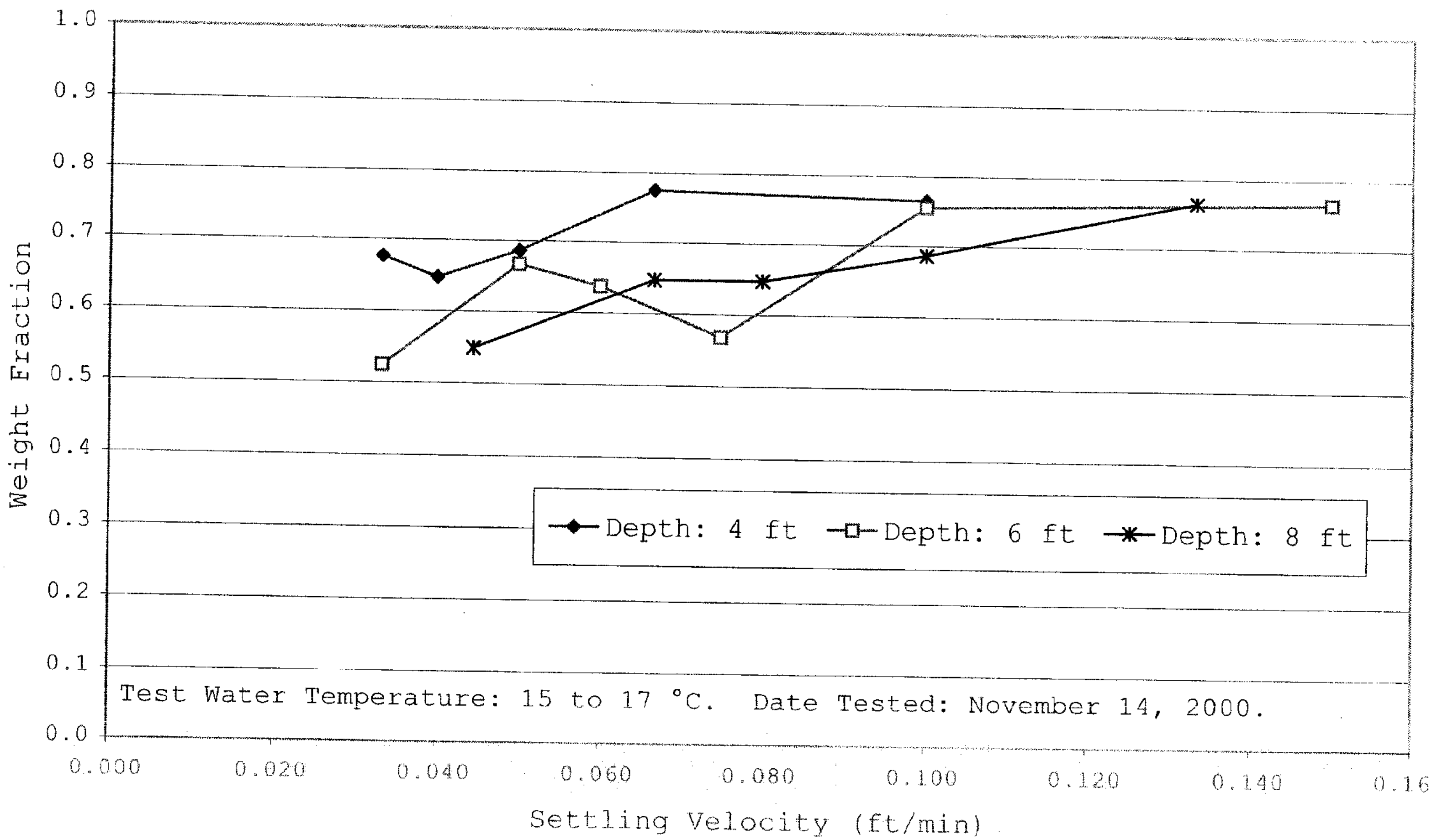

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FIGURE 13

STATIC SETTLING TEST RESULTS FOR STICKNEY TARP PUMPBACK
(SS=138 mg/L, VSS=82 mg/L, pH=6.7)

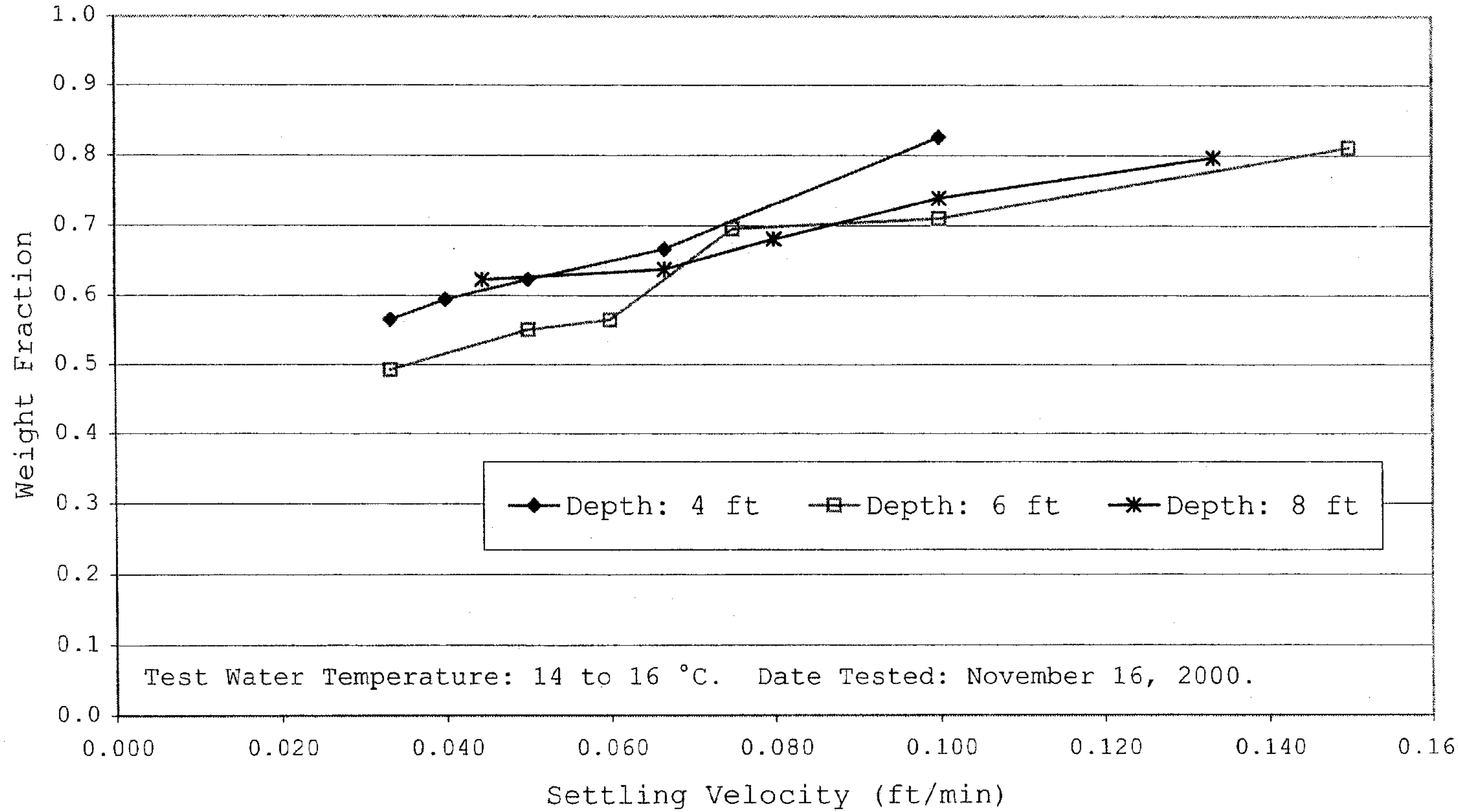

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FIGURE 14

STATIC SETTLING TEST RESULTS FOR RACINE AVENUE
PUMPING STATION OVERFLOW
(SS=268 mg/L, VSS=116 mg/L, pH=7.4)

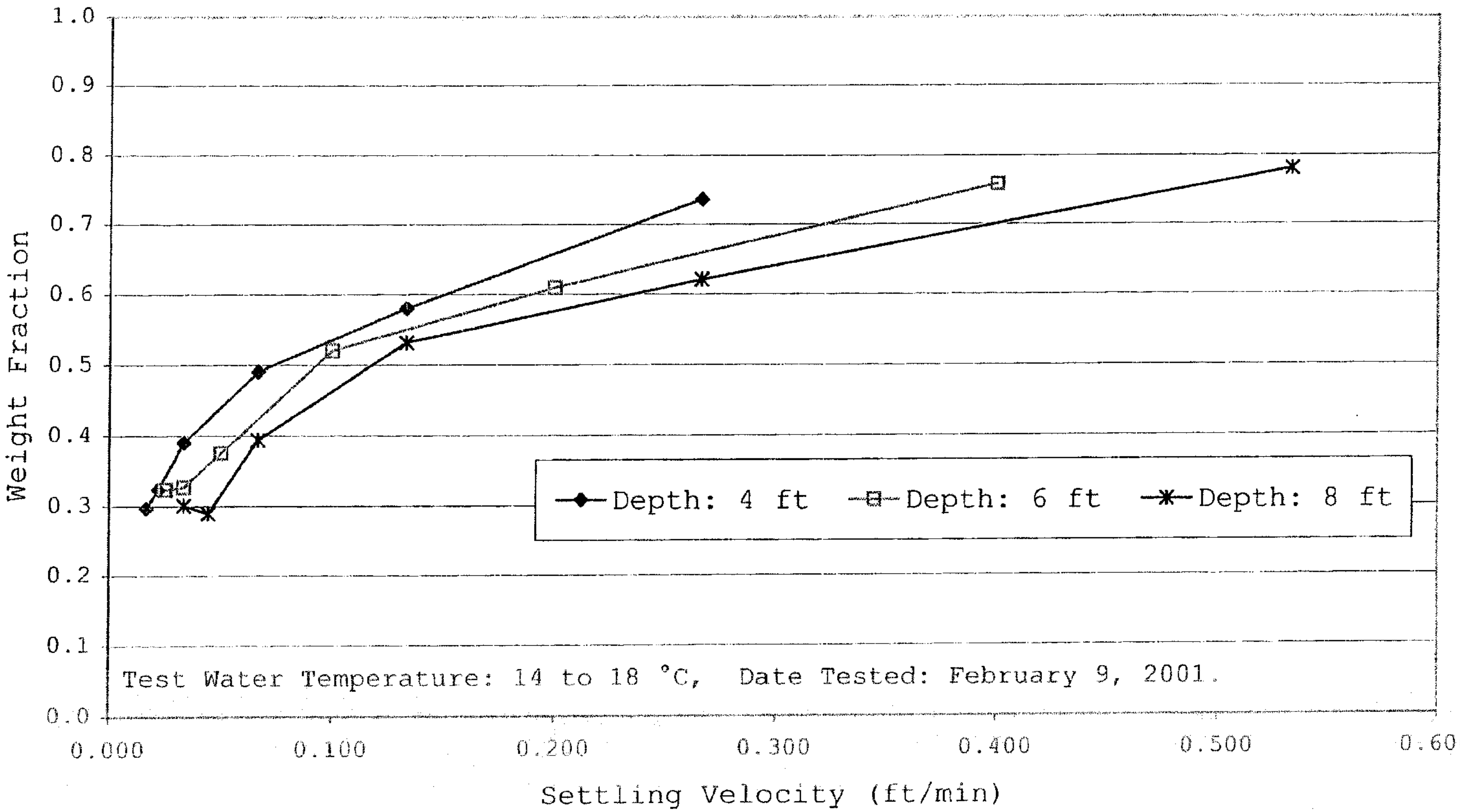

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FIGURE 15

STATIC SETTLING TEST RESULTS FOR STICKNEY WRP WEST SIDE RAW SEWAGE
(SS=147 mg/L, VSS=91 mg/L)

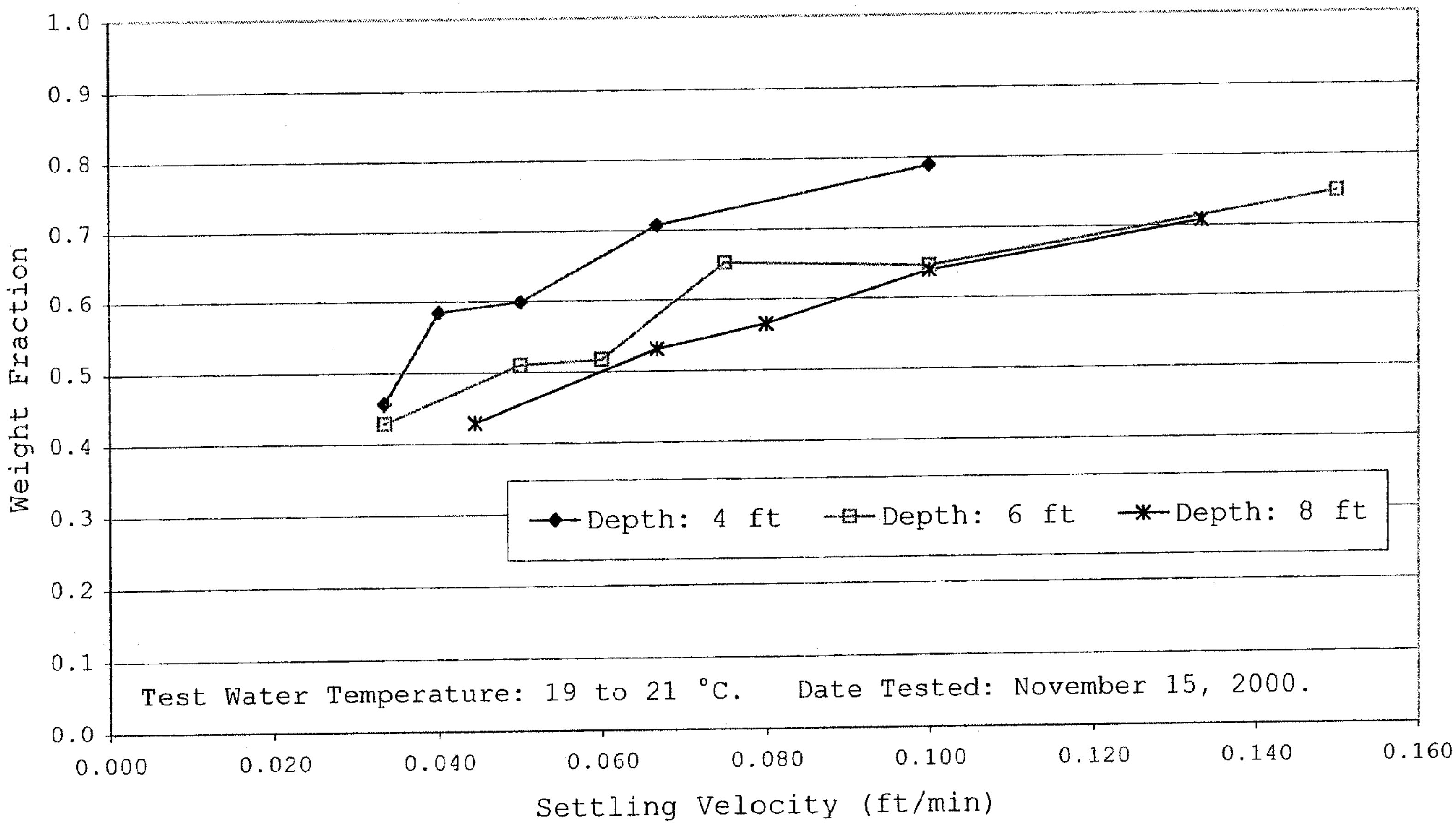

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FIGURE 16

STATIC SETTLING TEST RESULTS FOR STICKNEY WRP WEST SIDE RAW SEWAGE
(SS=93 mg/L, pH=7)

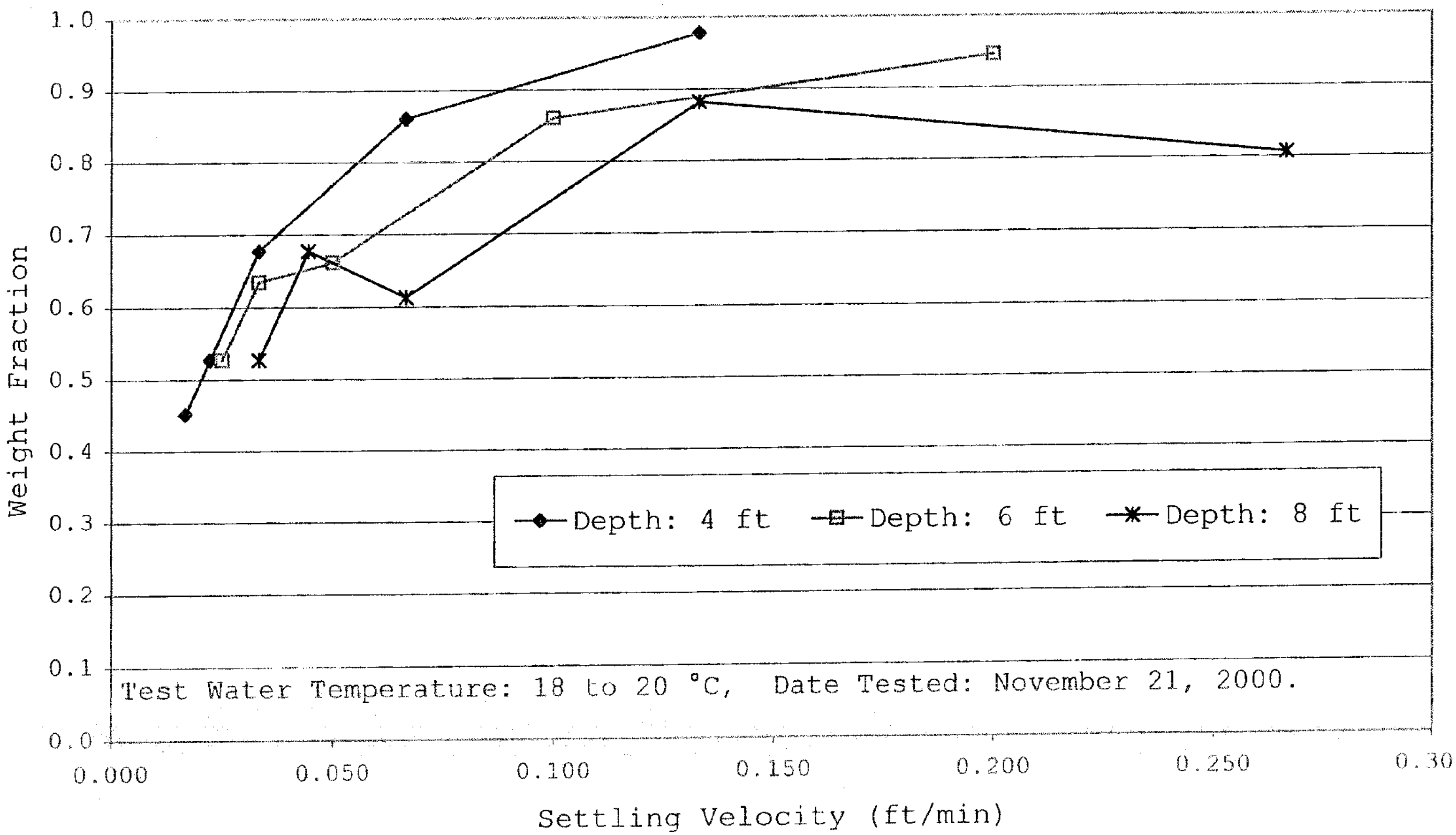

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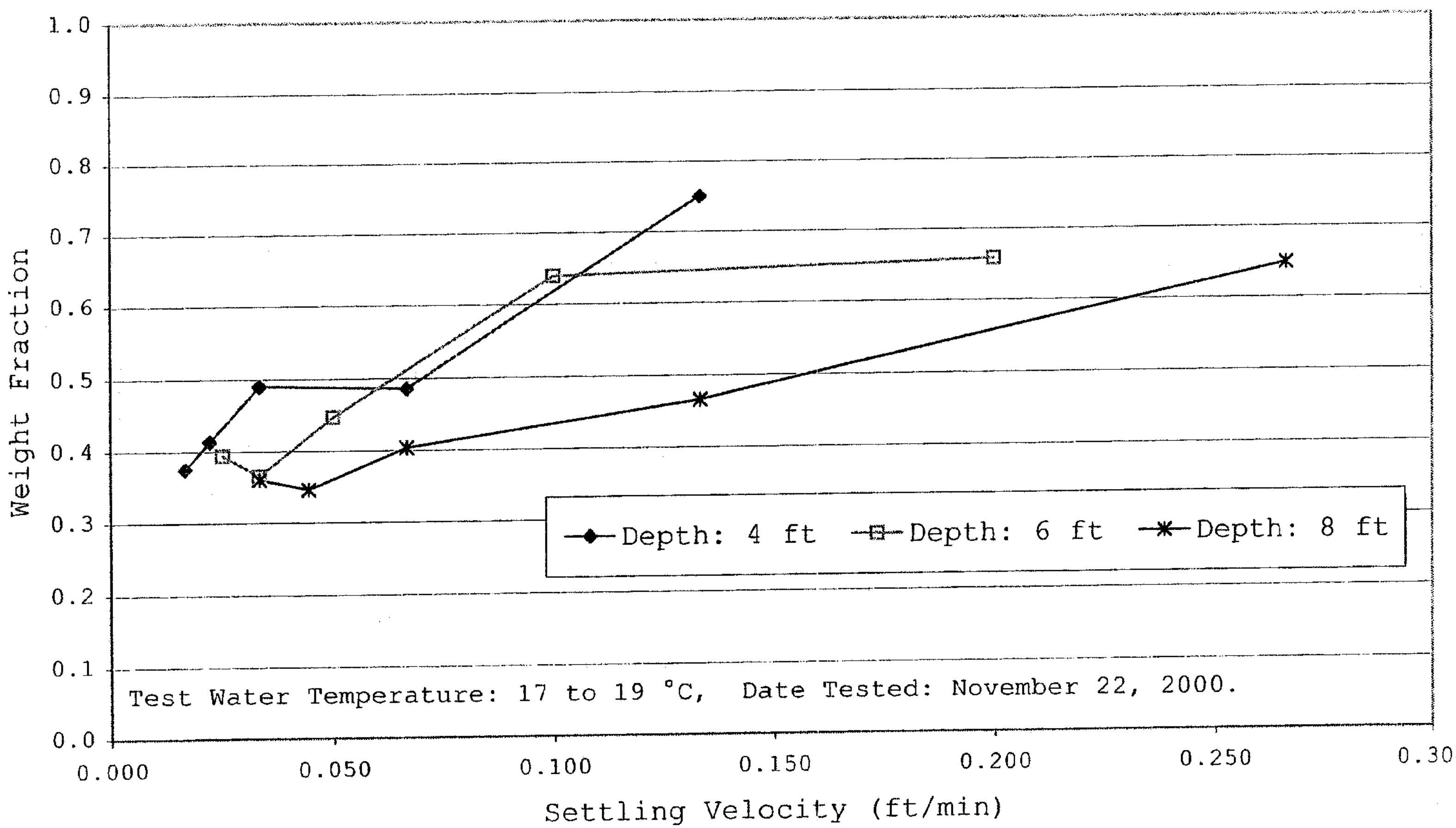
FIGURE 17

STATIC SETTLING TEST RESULTS FOR STICKNEY WRP WEST SIDE RAW SEWAGE
(SS=208 mg/L, pH=6.9)



monthly average concentration limit contained in the current expired permit. In the current expired NPDES permit, the ammonia limit is seasonal and set at a maximum monthly average concentration of 2.5 mg/L (April-October) and 4.0 mg/L (November-March). Twice in the year 2000, on April 7 and again on July 22, the daily ammonia concentration in the final effluent of the Stickney WRP exceeded 5 mg/L.

As a result of these two incidents, the M&O Department expressed a concern and requested the R&D Department to identify major sources contributing ammonia to the Stickney WRP and to determine the likely cause(s) of ammonia spikes (i.e., exceedence of the proposed daily ammonia limits) in the final effluent of the Stickney WRP on April 7 and July 22, 2000. In response to this request from the M&O Department, the R&D Department conducted a study in 2000, in which field sampling collection was performed during August 14 through September 5, 2000. The purpose of this study was to identify main sources contributing ammonia to the Stickney WRP with the purpose of determining possible cause(s) of ammonia spikes that occurred twice in the year 2000 in the final effluent of the Stickney WRP. The findings of this study were published as R&D Department Report No. 01-3 dated February 2001.

The above mentioned study identified four major ammonia and organic nitrogen contributing sources to the Stickney WRP in addition to the regular domestic loading (domestic source), which is considered normal background ammonia and organic nitrogen load. The four major ammonia and organic nitrogen contributing sources identified are TARP pumpback, discharge from Corn Products International (CPI), centrate from the post-digestion centrifuge (Post-DC), and overflow from the sludge lagoons in the Lawndale Solids Management Area (LASMA).

In the 2000 study, loading of ammonia to the Stickney WRP was determined on a daily basis but insufficient data were collected to determine variations of the ammonia loading which could be responsible for spikes of ammonia exceeding proposed daily maximum ammonia limit in the final effluent. Therefore, another study was conducted in 2001 to determine hourly fluctuations in ammonia and organic nitrogen loadings from the four identified sources to the Stickney WRP.

In the 2001 study, site visits were conducted to identify and locate proper sampling sites at the CPI and Stickney WRP facilities prior to the collection of field samples. As a result of these visits, ten locations were selected to collect samples for the determination of ammonia and organic nitrogen contributing sources. A list of these ten locations is given below:

1 Corn Products International at 2AT (CPI).

2 LASMA East Manhole (LASMA East).

3 LASMA West Manhole (LASMA West).

4 Interceptor SW-12 upstream of CPI (SW-12).

5 Centrate from Stickney Post-digestion Centrifuge (Post-DC).

6 TARP Pumpback to Stickney WRP (TARP).

7 Southwest Raw Sewage (SW RAW).

8 Southwest Preliminary Effluent (SW PREF).

9 West Side Raw Sewage (WS RAW).

10 West Side Imhoff Effluent (WS IMEF).

Figure 18, a schematic diagram, shows the sampling locations selected for this study. In LASMA area, two sampling sites were set up to collect, (1) the overflow from sludge storing lagoons escaping directly to the interceptor, and (2) the overflow from the LASMA dry cells and from a desilting basin at the Marathon Solids Drying Area, which is located west of LASMA. To monitor the background concentrations before a major discharge from CPI, one sampling station was set up on interceptor SW-12 upstream of CPI. For centrate from the Stickney post-digestion centrifuges, three individual centrifuges were sampled and then the three samples were composited. Raw sewage entering the Stickney West Side and Southwest plants and the effluents of Imhoff tanks at the West Side plant and the preliminary settling tanks at the Southwest plant were monitored in this study in order to examine the

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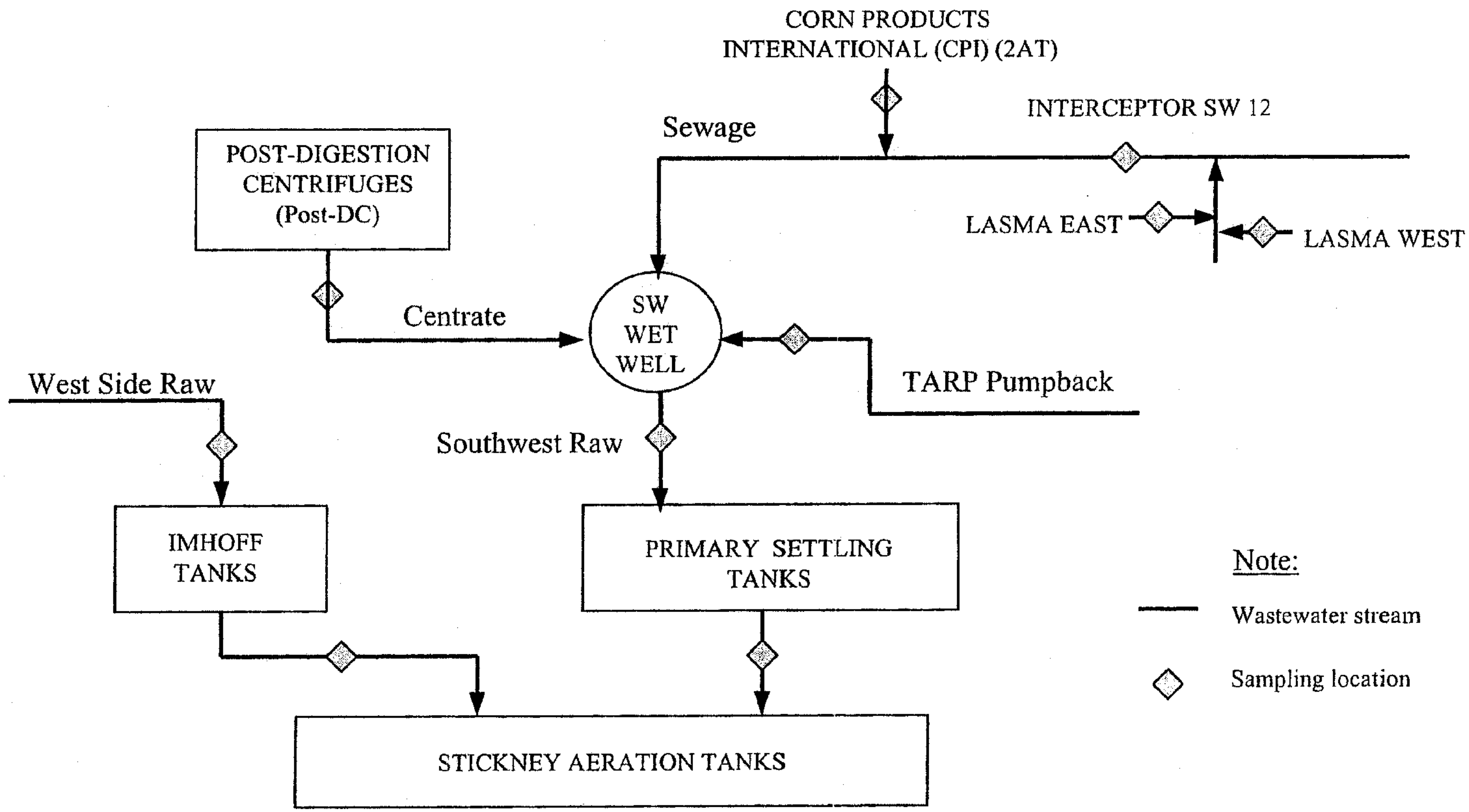
FIGURE 18

SCHEMATIC DIAGRAM OF SAMPLING LOCATIONS FOR THE STICKNEY WRP AMMONIA STUDY IN 2001



changes in concentrations of organic nitrogen (obtained by subtracting ammonia concentration value from TKN concentration value) and ammonia through primary settling of the sewage.

The sample collection was carried out during the period of September 17 through October 15, 2001. Auto-samplers were employed at each sampling site to collect an aliquot every 15 minutes. Eight aliquots were put into one sampling bottle to form a two-hour composite sample. A total of 3,203 samples was collected from the ten sampling locations during the study. Each sample was analyzed for ammonia and TKN.

The quantity of ammonia and TKN at each monitored location in the given time period was calculated based on the concentrations and the corresponding flow rates. The data of wastewater flow rates at the ten sampling locations were gathered in several ways. At CPI, the flow rate data from the totalizer that records daily total discharge and strip charts that record instant discharge for the study period were obtained from CPI. The measurement of flow rates at LASMA East and LASMA West sampling sites and interceptor SW-12 was contracted to Elan Industries, Inc. The discharge rates of centrate at the Post-DC were estimated based on the solids contents of centrifuge feed, sludge cake and centrate, and the feeding rates of digester draw to the working centrifuges. The flow rates for TARP pumpback, and raw sewage to, and primary effluents from, the Stickney West Side and Southwest plants were obtained from the pumping records of the M&O Department.

The analyses of samples collected and collection of pertinent flow data for this study were completed in 2001. The data analysis and report preparation will be performed in the year 2002.

Reevaluation of Local Pretreatment Program Limits

The EM&R Division, working with the Industrial Waste Division (IWD), is evaluating technology-based pollutant limits for the District's local service area. Local limits are intended to prevent site-specific plant passthrough and interference. This method requires site specific treatment plant and environmental criteria to determine the limit for each pollutant at each plant. A mass balance approach is used to convert criteria into allowable headwork loadings. This approach traces the routes of each pollutant through the treatment process, taking into account pollutant removals in upstream processes. The initial evaluation consisted of 1999 data for two of the District plants, Hanover Park and Lemont. In 2001 all of the plants were evaluated using 1999 data.

For each pollutant, the most stringent of the allowable headwork loadings derived from the criteria is selected as the pollutant's maximum allowable headwork loading. This ensures that the actual headwork loading is consistently below the maximum, and compliance with all applicable criteria is achieved. The criteria considered are NPDES permits, state water quality standards, biological inhibition thresholds, and federal Part 503 regulation limits.

The limits are calculated using removal efficiencies for each pollutant using the method of computing the average removal of a parameter. The Lemont influent concentrations were used as the background level. The initial assumption was that the Lemont WRP influent had no industrial component, therefore, was equivalent to the nonindustrial or domestic background level. The USEPA biological inhibition threshold values were used for the calculation of local limits.

This methodology proved to be problematic. The limits derived using the USEPA guidance procedure for copper and zinc were below zero at Calumet, Hanover, Kirie, Egan, Stickney and North Side WRPs. The use of the Lemont influent concentrations as the background level for toxic pollutants caused the maximum industrial loading of copper and zinc to be unrealistically low. According to the methodology, the background load is deducted from the total allowable load; resulting in the maximum allowable industrial load for each pollutant. The Lemont water source is not representative of the District service area. The Lemont area water is primarily well water, and therefore has higher concentrations of zinc and copper. The City of Chicago supplies most of the District service area with Lake Michigan water, which is much lower in both copper and zinc.

The other pollutants of concern had industrial limits approaching zero using the methodology. The extremely low limits derived from this methodology are unrealistically stringent. The current limits, contained in Appendix B of the Sewage and Waste Control Ordinance, have a proven record of protecting the WRPs from passthrough and interference. Most of the overly stringent limits are derived from the biological inhibition criteria or the Part 503 sludge criteria. Considering the proven District record, the methodology was evaluated in more detail.

The detailed evaluation consisted of four components.

1. A review of the 1999 flow and pollutant data to determine if any of the values used in the original calculations represent outliers based on a comparison to the previous values for five years.

2. The use of City of Chicago water supply concentrations to represent domestic background concentrations for all calculations.

3. A review of District process train data to determine actual inhibition biological levels.
4. Recalculation of recommended spreadsheets using average values from the five-year period, 1995 through 1999.

The comparison of 1999 data to the five years of data showed very little difference in the flow and pollutant data. The average values are almost identical for the five year versus the one year data. The spreadsheets were rerun using the average values from the five year period, 1995 through 1999, rather than only the 1999 data. The five year theoretical calculations are not significantly different from the 1999 data.

The City of Chicago water supply concentrations are used to represent domestic background concentrations instead of using Lemont WRP influent concentrations. The difference in the results are significant. The technically based local limit evaluation using the City of Chicago water supply as background resulted in the copper and zinc limits with a more reasonable value.

The District process train data was reviewed to determine actual inhibition levels in the various processes within the District. The original calculations are based on literature values of biological inhibition. The theoretical calculations resulted in limits many times less than the current limits. The limits were exceedingly stringent, considering the full scale operation of the plants did not experience biological inhibition. The activated sludge processes were evaluated to determine if any indication of upset had occurred. The maximum influent concentration, for each plant, of each toxin was found using the 1999 data. The days with the highest concentration of toxin were investigated for signs of upset. Operational parameters, $CBOD_5$ and NH_3, were compared to the monthly averages. The evaluation of each of the toxins, at all seven plants, did not reveal one instance of biological upset. The anaerobic digestion inhibition was similarly evaluated with volatile acid production data. The process train data investigation strongly suggests the current limits adequately protect the District plants. The exclusion of the biological inhibition criteria in the determination of the local limits results in a better representation of the limits with respect to the actual performance of the District WRPs.

The year 2000 data will be evaluated using a more accurate and practical method. The mass-balance calculations will be used with the same spreadsheet calculations. The more realistic approach involves not limiting a pollutant which is not detectable in our wastewater influent. In the original method, the pollutant would have a very stringent limit due to default values utilized by the recommended spreadsheets, rather than a more rational limit, based on the full scale operation data of seven plants. The practical evaluation of all seven plants, as well as the draft version of the report is expected to be completed sometime in the year 2002.

Studies Related to Odors Emanating from Drop Shaft No. 5 in the James C. Kirie WRP Service Area

This study was undertaken at the request of the M&O Department to determine the cause(s) of odors emanating from Drop Shaft No. 5 located near the intersection of Mt. Prospect Road and Fletcher Drive in the James C. Kirie WRP service area.

In a meeting held on November 15, 2000, in which representatives from the R&D, Engineering, and M&O Departments participated, the general consensus of the participants was that the odors at Drop Shaft No. 5 emanate from Upper Des Plaines (UDP) 14 interceptor. The main basis of this consensus was that when the flow from UDP14 is bypassed to the North Side WRP, the H_2S reading in the drop shaft is reduced by a couple orders of magnitude. It was also noted that the high H_2S appears to be unique to Drop Shaft No. 5 only, and similar problems have not been reported at other structures.

The EM&R Division with the assistance of the IWD conducted two studies, one in February 2001, and the second in

May 2001. The purpose of the February study was to compare the wastewater characteristics along the length of UDP14, which is suspected to carry wastewater responsible for formation of H_2S and other odorous gases emanating at Drop Shaft No. 5 with that of UDP22, which runs parallel to UDP14, but does not appear to generate sulfides or other odorous gases. The February study concluded that UDP14 carries substantial BOD_5 load in the wastewater and perhaps was mainly responsible for odors emanating at Drop Shaft No. 5. A follow-up study to the one conducted in February 2001 was conducted in May 2001 upstream of location 26X on UDP14. The objective of this study was to determine if there was another major source of BOD_5 in the upstream segment, including its tributaries, which contributes to high BOD_5 and thus indirectly becomes a source of odors at Drop Shaft No. 5. These two studies are described below.

FEBRUARY 2001 ODOR STUDIES FOR UDP14 WASTE STREAM

A comparison of the waste streams between UDP14 and UDP22 was conducted to determine the source of odor problems in the vicinity of Drop Shaft No. 5. The chemical characteristics of the waste streams were evaluated. The results showed a higher component of food industry waste in UDP14. The food industry waste had a high BOD_5, FOG, and sulfides. 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 sulfide in the wastewater. The studies indicated that 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 sulfides.

The initial sample collection phase of the interceptor comparison project relative to odor in the area of Drop Shaft No. 5 in the Kirie WRP service area was completed in February of 2001. Figure 19 shows the sampling locations. UDP14 was evaluated at five points, the northernmost at Palwaukee Airport and the southernmost near the Wolf Road and Rand Road intersection. UDP22 was sampled at three points, the northernmost near the Wheeling Road and Hintz Road intersection and the southernmost near the Business Center Drive and Rand Road intersection. One point on 11A was also sampled, near the Berkshire Lane and School Street intersection. The samples were taken by the IWD three times a week for four consecutive weeks. The first samples were collected on February 6, 2001.

IWD measured the wastewater temperature and the H_2S in the air at both the rim and the invert for each sample. IWD reported the weather conditions and the emergence of any odors in the Mt. Prospect Road and Fletcher Drive area on the sampling days. The collected samples were analyzed for the

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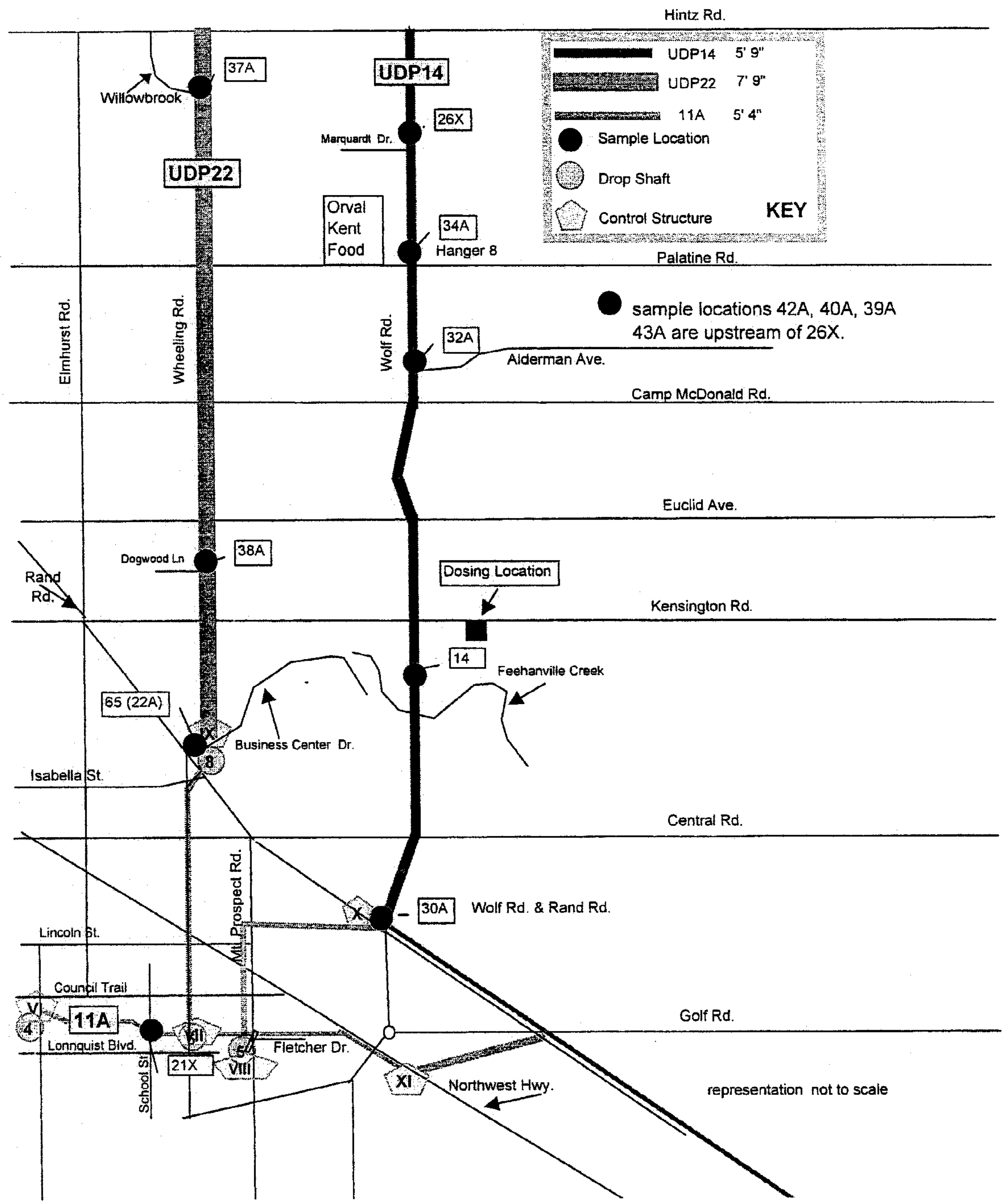
FIGURE 19

DROP SHAFT NO. 5 ODOR STUDY



following parameters: BOD_5, suspended solids, volatile suspended solids, FOG, ammonia, sulfate, sulfide, pH, conductivity and oxidation reduction potential. Table 12 represents the average of the twelve samples at each location for each parameter.

The evaluation of the data indicates there are differences in the characteristics in the waste streams of UDP14 and UDP22. The northernmost sample point on UDP14 (26X, Wolf at Hanger Bay 8, Palwaukee Airport) has an average BOD_5 of 349 mg/L. The northermost point in UDP22 (37A, Wheeling Road and Willowbrook, Wheeling) has a more typical municipal wastewater BOD_5 average of 154 mg/L. UDP14 serves a more industrial area with a number of food processors. In addition to an already elevated BOD_5 in UDP14, there is a large increase of BOD_5 at sample point 32A, and the average value is 768 mg/L. The heavy loading at this point is attributed to discharges from Orval Kent Food Company located at 120 W. Palatine Road, Wheeling. In contrast, the sampled segments of UDP22 have a consistent BOD_5 with an average of 145 mg/L. The data from interceptor 11A indicates that it is not contributing to the odor problem in the Mt. Prospect Road and Fletcher Drive area.

The comparison of dissolved sulfide indicates a difference in the waste streams of UDP14 and UDP22. UDP14 has an overall average sulfide concentration of 0.07 mg/L. In

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TABLE 12

COMPARISON OF WASTE STREAMS FROM UDP14, UDP22, AND 11A
FEBRUARY 2001

Interceptor/ Location	ORP (mv)	Temp. (°C)	H_2S at invert (ppm in air)	H_2S at rim (ppm in air)	BOD_5 (mg/L)	SS (mg/L)	VSS (mg/L)	NH_3 (mg/L)	SO_4 (mg/L)	Sulfide (mg/L)	pH	Conduc- tivity (mho)	FOG (mg/L)
UDP14/26X	54	11.67	0.00	0.00	349	274	202	17.40	97.01	0.07	7.47	1486	67
UDP14/34A	34	11.67	0.00	0.00	304	245	180	17.09	90.50	0.05	7.48	1424	63
UDP14/32A	39	11.92	0.17	0.00	768	330	271	14.14	99.21	0.06	7.34	1311	100
UDP14/14	71	11.58	0.08	0.00	409	246	209	14.94	92.79	0.05	7.34	1357	71
UDP14/30A	13	12.17	0.58	0.17	341	244	184	14.92	101.17	0.11	7.43	1365	44
UDP22/37A	61	11.67	0.00	0.00	154	147	118	15.64	68.04	0.01	7.78	1255	34
UDP22/38A	53	11.58	0.00	0.00	142	150	121	17.31	72.24	0.02	7.78	1311	42
UDP22/65	66	11.25	0.00	0.00	139	164	138	17.69	75.98	0.02	7.74	1344	23
11A/21X	52	12.08	0.00	0.00	183	337	246	28.83	98.59	0.00	7.64	1548	28

The data represents the average of all samples taken at each location.

contrast, UDP22 has an overall average sulfide concentration of 0.02 mg/L. Interceptor 11A has an average of 0.003 mg/L sulfide. The sulfide concentrations are tabulated in Table 13. The sulfide concentrations in UDP14 ranged from zero to 0.44 mg/L. On two sampling days, 2/8/01 and 2/22/01, there were slight odors near the bridge in the Mt. Prospect Road and Fletcher Drive vicinity. The average sulfide concentration from UDP14 on the days the odor was present was 0.16 mg/L and 0.11 mg/L, respectively. On five days or 42 percent of the time, UDP14 had an average sulfide concentration above 0.10 mg/L. In contrast, UDP22 ranged from zero to 0.09 mg/L sulfide in the waste stream.

The more industrial nature of UDP14 indicates this waste stream is a contributing factor to the odor problems in the Mt. Prospect Road and Fletcher Drive area. UDP14 has elevated levels of sulfide, BOD_5, FOG, suspended solids, and volatile suspended solid compared to UDP22 and 11A.

MAY 2001 ODOR STUDIES UPSTREAM OF LOCATION 26X ON UDP14

A follow-up study was conducted upstream of UDP14, in May of 2001. The objective of this study is to determine if there is another major source of BOD_5 in the upstream segment, including its tributaries, which contributes to high BOD_5 and

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TABLE 13

DISSOLVED SULFIDE CONCENTRATION IN WASTE STREAMS FROM UDP14, UDP22, AND 11A
FEBRUARY 2001

Interceptor/ Location	Sulfide (mg/L)											
	2/6	2/7	2/8	2/13	2/14	2/15	2/20	2/21	2/22	2/26	2/27	2/28
UDP14/26X	0.29	0.05	0.04	0	0	0	0.01	0.18	0.17	0.02	0	0.04
UDP14/34A	0	0.08	0.05	0	0	0	0.03	0.05	0.1	0.09	0.07	0.11
UDP14/32A	0.2	0.03	0.11	0	0	0.07	0	0.12	0.05	0.09	0.01	0.05
UDP14/14	0	0.27	0.25	0	0	0.02	0	0	0.1	0	0	0
UDP14/30A	0.12	0.44	0.35	0.01	0.02	0.08	0	0.16	0.13	0	0	0
UDP22/37A	0	0	0	0	0	0	0	0.01	0	0.02	0.07	0
UDP22/38A	0.06	0	0	0	0	0	0	0	0.09	0.07	0	0
UDP22/65	0.08	0.03	0	0	0	0	0.09	0	0.02	0	0	0
11A/21X	0	0	0	0	0	0	0	0	0.04	0	0	0

thus indirectly becoming a source of odors at Drop Shaft No. 5.

In all, seven sample locations were selected for this follow-up study.

1. 16X - Northgate Parkway, evaluates the waste stream contributed from J. W. Allen & Co. as well as the Northgate Industrial Park.
2. 43A - Jeffery Avenue at the south edge of Heritage Park, isolates the area north of Heritage Park and west of the Wheeling Drainage Ditch, it also includes the waste stream from 16X.
3. 42A - Meadowbrook Lane, isolates the area east of the Wheeling Drainage Ditch including the Wheeling restaurant district on Milwaukee Avenue.
4. 40A - Waltz Drive, collects discharge from Stiglmeier Sausage Co. as well as from all waste streams north, including the waste streams from 16X, 43A, and 42A.
5. 41A - Hintz Road west of the railroad tracks, isolates the discharges from HV Manufacturing and Feed Flavors.

6. 39A - Chaddick Drive and Hintz Road, collects discharge from Nedlog Corporation, and other flow from the south end of Chaddick Drive.
7. 26X - Wolf Road north of Larkin Drive, collects discharge from Bon Ton Poultry as well as all other waste streams evaluated, i.e. 16X, 43A, 42A, 40A, 41A, and 39A.

The samples were collected by IWD at all seven locations three times a week for four consecutive weeks. The first sampling day was May 1, 2001. IWD measured the wastewater temperature and the H_2S in the air at both the rim and the invert for each sample. The collected samples were analyzed for the following parameters: BOD_5, suspended solids, volatile suspended solids, FOG, ammonia, sulfate, sulfide, pH, conductivity and oxidation reduction potential. Table 14 represents the average of the twelve samples, at each location, for each parameter.

The six sample points upstream of 26X isolate and separate the various discharges, which include several food processing plants. The findings are as follows:

1. 16X has an average BOD_5 of 1303 mg/L. This is the highest average BOD_5 found during the May 2001 study. This location also has the highest average FOG, sulfates, volatile suspended

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TABLE 14

DROP SHAFT NO. 5 ODOR STUDY
COMPARISON OF WASTE STREAMS UPSTREAM OF UDP14/26X
MAY 2001

Location	ORP (mv)	Temp. (°C)	H_2S at Invert (ppm in air)	H_2S at Rim (ppm in air)	BOD_5 (mg/L)	SS (mg/L)	VSS (mg/L)	NH_3 (mg/L)	SO_4 (mg/L)	Sulfide (mg/L)	pH	Cond. (mho)	FOG (mg/L)
16X	39	19	0.25	0.00	1303	402	368	13.11	21.86	0.02	6.94	945	127
43A	22	18	0.00	0.00	268	224	193	20.67	90.13	0.13	7.48	1069	58
42A	6	19	0.17	0.08	192	152	125	16.69	72.75	0.19	7.71	1401	39
40A	12	19	0.00	0.00	207	267	201	20.16	76.94	0.18	7.52	1159	40
41A	31	20	0.00	0.00	336	475	308	13.83	52.97	0.02	7.92	871	45
39A	28	17	0.00	0.00	250	364	313	33.77	55.48	0.05	8.48	1042	32
26X	4	19	0.00	0.00	355	387	279	20.86	78.18	0.10	7.47	1208	53

The data represents the average of all samples taken at each location.

solids, and H_2S (H_2S in air measured at the invert of the sewer). The average dissolved sulfide is one of the two lowest in the study. This sample includes discharges from J. W. Allen & Co. The food processor was sampled by IWD in September of 2000 and found to have, on average, a flow of 31,790 gpd and a BOD_5 of 10,395 mg/L.

2. 43A has an average BOD_5 of 268 mg/L. This location is downstream of 16X. The large decrease in concentration between 16X and 43A indicates the BOD_5 discharge from J. W. Allen & Co. has been diluted in the sewer.

3. 42A has an average BOD_5 of 192 mg/L. This location has the highest dissolved sulfide concentration in the waste stream as well as the highest H_2S in air measured at the rim. This sample includes discharges from the Wheeling restaurant district. The restaurant district has not been previously sampled by IWD. The BOD_5 values of the wastes discharged from the individual restaurants are not available.

4. 40A has an average BOD_5 of 207 mg/L. This sample is the discharge from Stiglmeier Sausage Co. The meat processor was sampled by IWD in October

of 1995 and found to have, on average, a flow of 4,250 gpd and a BOD_5 of 291 mg/L. This waste stream includes the waste streams from 42A, 43A, and 16X.

5. 41A has an average BOD_5 of 336 mg/L. This sample includes discharge from HV Manufacturing and Feed Flavors. HV Manufacturing was sampled by IWD in June of 2000 and found to have, on average, a flow of 143,700 gpd and a BOD_5 of 432 mg/L. Feed Flavors was sampled by IWD in April of 1998 and found to have, on average, a flow of 1,375 gpd and a BOD_5 of 1,988 mg/L.
6. 39A has an average BOD_5 of 250 mg/L. This sample includes discharge from Nedlog Corporation. The food processor was sampled by IWD in April of 2000 and found to have, on average, a flow of 3,800 gpd and a BOD_5 of 2,734 mg/L.
7. 26X has an average BOD_5 of 355 mg/L. The elevated BOD_5 is attributed to Bon Ton Poultry. The poultry processor was sampled by IWD in May of 1999 and found, on average, to have a flow of 5,000 gpd and a BOD_5 of 958 mg/L.

Sample location 26X is the northernmost sample of the February study, and the southernmost of the May study. This location was resampled to assess consistency in the wastewater characteristics between the two studies. Table 15 compares the February and May results at 26X. The results of the February and May studies indicate reliability of the results. The BOD_5, on average, for February and May is 349 mg/L and 355 mg/L, respectively.

The evaluation of the individual dissolved sulfide results for each sample, Table 16, reveals low levels of dissolved sulfide at location 16X. This sampling site had no dissolved sulfide 75 percent of the time. Sample sites 43A, 42A, 40A, and 26X had a dissolved sulfide concentration at least ninety percent of the time. The single highest dissolved sulfide concentration, 0.59 mg/L, occurred in the waste stream isolating the restaurant district, location 42A.

The evaluation of the waste stream is consistent with the IWD data. The high BOD_5 results observed at 16X, 41A, and 26X are extremely likely due to discharges with high BOD_5 values from food processors. The remaining sample locations, 39A, 40A, 42A, and 43A have average BOD_5 values between 192 mg/L and 268 mg/L. The high BOD_5 of the waste stream of UDP14 is extremely likely due to the discharges from food processors on the line. Although there is a high BOD_5, suspended solids, and sulfate in this interceptor there does not appear to be

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TABLE 15

DROP SHAFT NO. 5 ODOR STUDY
COMPARISON OF WASTE STREAMS AT SAMPLE LOCATION UDP14/26X
MAY 2001 VS. FEBRUARY 2001

Month	ORP (mv)	Temp. (°C)	H_2S at Invert (ppm in air)	H_2S at Rim (ppm in air)	BOD_5 (mg/L)	SS (mg/L)	VSS (mg/L)	NH_3 (mg/L)	SO_4 (mg/L)	Sulfide (mg/L)	pH	Cond. (mho)	FOG (mg/L)
February	54.4	12	0.00	0.00	349	274	202	17.40	88.93	0.07	7.47	1115	68
May	-4.25	19	0.00	0.00	355	387	279	20.86	78.18	0.10	7.47	1208	53

The data represents the average of all samples taken during the study period.

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TABLE 16

DROP SHAFT NO. 5 ODOR STUDY
DISSOLVED SULFIDE CONCENTRATION IN WASTE STREAMS UPSTREAM OF UDP14/26X
MAY 2001

Interceptor Location	Sulfide (mg/L)											
	5/1	5/2	5/3	5/8	5/9	5/10	5/15	5/16	5/17	5/22	5/23	5/24
16X	0	0	0	0	0	0	0	0.03	0	0	0.08	0.10
43A	0.21	0.09	0.18	0.17	0.14	0	0.05	0.11	0.07	0.18	0.23	0.10
42A	0.14	0.01	0.13	0.19	0.26	0.12	0.18	0.22	0.09	0.59	0.24	0.14
40A	0.15	0.21	0.16	0.12	0.11	0.05	0.09	0.26	0.13	0.26	0.49	0.08
41A	0	0.02	0.03	0	0	0.01	0	0.03	0	0	0.1	0
39A	0.04	0.02	0	0	0.02	0.08	0	0	0.27	0.10	0.07	0
26X	0.15	0.10	0.09	0.12	0.12	0.16	0.11	0.12	0.01	0.17	0.08	0

one particular source, but a compilation of the discharges of many food processors entering this line.

The two studies indicate that the addition of a chemical to control odors at Drop Shaft No. 5 is warranted. The choice of a location is dependent on the availability of a dosing site. The dosing location should provide sufficient contact time for the chemical to react effectively to mitigate the odors emanating at Drop Shaft No. 5.

Ferric chloride solution will be used to precipitate the sulfides in the waste stream. The reduction of the sulfides will alleviate the odor at Drop Shaft No. 5. A location was identified upstream of Drop Shaft No. 5 on UDP14 to construct a dosing station. The dosing station will be constructed by M&O. Based on the studies conducted, as well as previous studies, the calculated starting point dosage of ferric chloride was determined to treat the Drop Shaft No. 5 odors. The dosing station is planned to be in operation by 2002. R&D will conduct analytical studies to measure the effectiveness of the odor treatment.

Vector Attraction Reduction Study for the Calumet and Stickney WRPs

Presently the anaerobic digestion of sludges produced at the Stickney and Calumet WRPs does not reduce volatile solids consistently at or above 38 percent to meet the requirements for vector attraction reduction of biosolids as defined in 40 CFR Part 503 regulations. Therefore, a study was undertaken to determine whether the requirements of the Part 503 regulation for vector attraction reduction under Option 2 in Section 503.32(b) of the 40 CFR Part 503 regulation could be met in the sludge treatment processes at the Stickney and Calumet WRPs. This option 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 days bench-scale anaerobic digestion at a temperature between 30° and 37°C.

This study consists of a series of bench-scale anaerobic digestion tests. The bench-scale tests are being conducted using 125-mL flasks as bench digesters placed in two water baths, which are used to maintain the digestion temperature. Following a USEPA guideline, in each bench-scale test, fifteen 125-mL flasks are used and each flask receives 50 mL of digester draw sample. After all fifteen flasks are filled with samples, five are randomly selected for determining the contents of total solids (TS) and total volatile solids (TVS). The remaining ten are purged with nitrogen gas and sealed with the rubber stoppers that have a tubing through each stopper for gas release. Then, these ten flasks are placed into a water bath with temperature set at approximately 35°C. The tubing from each flask is submerged in the water to prevent entry of air. Each flask is shaken twice every working day to assure adequate mixing. After 20 days, five flasks are withdrawn from the water batch for analyzing the contents of TS and TVS. After 40 days, the remaining five are taken for TS and TVS measurements. As per the USEPA guideline, the entire 50 mL sample is used to determine TS and TVS contents of the sample.

The digester draw samples to be tested were collected by the M&O personnel at the Stickney and Calumet WRPs. The Stickney samples were composed of 24 individual digester draw samples, one from each digester. These 24 individual digester draw samples were mixed to form a composite digester draw sample for the bench-scale anaerobic digestion test. Similarly, a composite sample from the four second-stage digesters at the Calumet WRP is collected and used in this study.

A bench-scale anaerobic digestion trial test was first tried in the Wastewater Treatment Research Laboratory in August 2001. After a successful trial test, it was decided that the bench-scale tests would be conducted once a month for digester draw from each of the Calumet and Stickney WRPs. These tests were formally started in October 2001. Three sets of tests for each of Calumet and Stickney WRPs were set up in 2001. The results of the bench-scale digestion tests conducted in 2001 are presented in Tables 17 through 20. The results indicate that the requirement of less than 17 percent volatile solids reduction in additional 40 days bench-scale anaerobic digestion can be met at CWRP and SWRP in the period tested. The tests were planned to be conducted for one year and to be continued until October 2002.

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TABLE 17

BATCH DIGESTION TESTS FOR CALUMET DIGESTER DRAW DURING THE PERIOD 10/24/01 THROUGH 12/03/01
VECTOR ATTRACTION REDUCTION STUDY

Sample	Before Test			After 20 Days of Test			After 40 Days of Test			20 Day VS Reduction (%)		40 Day VS Reduction (%)	
	TS mg/L	TVS mg/L	TVS % of TS	TS mg/L	TVS mg/L	TVS % of TS	TS mg/L	TVS mg/L	TVS % of TS	by Equation	by Mass Balance	by Equation	by Mass Balance
1	18,108	10,038	55.4	17,604	9,374	53.2	17,138	8,686	50.7				
2	17,884	9,978	55.8	17,470	9,264	53.0	17,092	8,722	51.0				
3	18,034	10,078	55.9	17,260	9,096	52.7	16,840	8,688	51.6				
4	17,846	9,870	55.3	17,608	9,344	53.1	16,928	8,692	51.3				
5	17,700	10,054	56.8	17,524	9,308	53.1	16,554	8,524	51.5				
Mean	17,914	10,004	55.8	17,493	9,277	53.0	16,910	8,662	51.2	10.7	7.3	16.9	13.4
Std. Dev.	161	83	0.587	143	109	0.204	233	79	0.372				
CV (%)	0.9	0.8	1.1	0.8	1.2	0.4	1.4	0.9	0.7				

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TABLE 18

BATCH DIGESTION TESTS FOR CALUMET DIGESTER DRAW DURING THE PERIOD 11/21/01 THROUGH 12/31/01
VECTOR ATTRACTION REDUCTION STUDY

	Before Test			After 20 Days of Test			After 40 Days of Test			20 Day VS Reduction (%)		40 Day VS Reduction (%)	
Sample	TS mg/L	TVS mg/L	TVS % of TS	TS mg/L	TVS mg/L	TVS % of TS	TS mg/L	TVS mg/L	TVS % of TS	by Equation	by Mass Balance	by Equation	by Mass Balance
1	21,494	11,758	54.7	20,508	10,494	51.2	20,178	10,214	50.6				
2	21,312	11,622	54.5	20,482	10,396	50.8	20,112	10,194	50.7				
3	21,088	11,440	54.2	20,464	10,464	51.1	19,974	9,988	50.0				
4	21,262	11,588	54.5	20,452	10,422	51.0	20,084	10,076	50.2				
5	21,284	11,578	54.4	20,242	10,354	51.2	20,200	10,178	50.4				
Mean	21,288	11,597	54.5	20,430	10,426	51.0	20,110	10,130	50.4	12.9	10.1	15.2	12.7
Std. Dev.	145	114	0.168	107	55	0.177	89	96	0.290				
CV (%)	0.7	1.0	0.3	0.5	0.5	0.3	0.4	0.9	0.6				

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TABLE 19

BATCH DIGESTION TESTS FOR STICKNEY DIGESTER DRAW DURING THE PERIOD 10/17/01 THROUGH 11/26/01
VECTOR ATTRACTION REDUCTION STUDY

	Before Test			After 20 Days of Test			After 40 Days of Test			20 Day VS Reduction (%)		40 Day VS Reduction (%)	
Sample	TS mg/L	TVS mg/L	TVS % of TS	TS mg/L	TVS mg/L	TVS % of TS	TS mg/L	TVS mg/L	TVS % of TS	by Equation	by Mass Balance	by Equation	by Mass Balance
1	37,938	17,708	46.7	35,734	15,814	44.3	36,258	15,840	43.7				
2	39,500	18,750	47.5	36,274	15,992	44.1	35,874	15,660	43.7				
3	38,982	18,334	47.0	36,064	15,848	43.9	35,684	15,526	43.5				
4	38,952	18,596	47.7	36,856	16,140	43.8	35,188	15,434	43.9				
5	38,788	18,412	47.5	36,598	16,088	44.0	35,822	15,730	43.9				
Mean	38,832	18,360	47.3	36,305	15,976	44.0	35,765	15,638	43.7	12.4	13.0	13.4	14.8
Std. Dev.	567	399	0.421	440	143	0.173	387	161	0.163				
CV (%)	1.5	2.2	0.9	1.2	0.9	0.4	1.1	1.0	0.4				

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 20

BATCH DIGESTION TESTS FOR STICKNEY DIGESTER DRAW DURING THE PERIOD 11/16/01 THROUGH 12/26/01
VECTOR ATTRACTION REDUCTION STUDY

	Before Test			After 20 Days of Test			After 40 Days of Test			20 Day VS Reduction (%)		40 Day VS Reduction (%)	
Sample	TS mg/L	TVS mg/L	TVS % of TS	TS mg/L	TVS mg/L	TVS % of TS	TS mg/L	TVS mg/L	TVS % of TS	by Equation	by Mass Balance	by Equation	by Mass Balance
1	38,040	17,780	46.7	35,662	15,756	44.2	34,450	14,882	43.2				
2	37,796	17,600	46.6	35,544	15,612	43.9	34,876	15,036	43.1				
3	37,976	17,696	46.6	36,500	16,056	44.0	34,210	14,794	43.2				
4	37,526	17,398	46.4	36,520	15,890	43.5	35,612	15,372	43.2				
5	37,804	17,464	46.2	35,830	15,776	44.0	34,858	15,048	43.2				
Mean	37,828	17,588	46.5	36,011	15,818	43.9	34,801	15,026	43.2	9.8	10.1	12.5	14.6
Std. Dev.	200	158	0.214	467	166	0.251	534	221	0.048				
CV (%)	0.5	0.9	0.5	1.3	1.0	0.6	1.5	1.5	0.1				

LAND RECLAMATION AND SOIL SCIENCE SECTION

The Land Reclamation 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, biosolids, and plants at land application sites, landfills, and solids drying facilities 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 Prairie Plan Environmental Monitoring

The Prairie Plan 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 and Soil

Science Section is responsible for preparing monthly reports that summarize the monitoring data required to demonstrate compliance with the IEPA, and USEPA regulations for land application of biosolids.

ENVIRONMENTAL MONITORING

In 2001, the monitoring activities at the Fulton County site remained similar in quantity and nature to those conducted in 2000. No supernatant or dewatered liquid fertilizer from Holding Basin 1 were applied to Fulton County fields during 2001. Air-dried, anaerobically digested biosolids from the District's Calumet WRP were trucked to the Fulton County site in 2001 and land-applied.

The water monitoring included:

- quarterly sampling of 20 groundwater monitoring wells; and sampling of 15 lysimeters in the supernatant application area. (The lysimeter monitoring ended in June 2001 after the section successfully petitioned the IEPA for its elimination);
- sampling of surface waters from 10 streams, 8 reservoirs, and 14 sites in the supernatant application area three times per year between April and November;

- sampling of 60 field runoff retention basins as needed;
- sampling of 19 lysimeters and three drainage tiles at the St. David Coal Refuse Pile monthly;
- sampling of three lysimeters at the Morgan Mine Coal Refuse Pile monthly; and
- sampling of ten lysimeters at the United Electric Coal (UEC) Refuse Pile monthly.

Water monitoring also included sampling of the discharges from the acidic mine lake receiving drainage from the UEC Refuse Pile for monthly and quarterly reports.

Soil samples were collected from 73 fields for chemical analysis, and plant samples were collected from 21 hay fields, 33 soybean fields, 2 wheat fields, and 19 corn fields for chemical analysis in 2001. Climatological conditions were monitored at the project weather station.

Biosolids have been applied to fields at the Fulton County site since 1972. Table 21 shows the concentrations of all measured parameters found in field soils (0- to 15-cm deep), which received different cumulative rates of biosolids, and were sampled in 2000 and analyzed in 2001. The concentrations generally increased with higher biosolids loading rates.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS, AND METALS FOR FIELDS SAMPLED IN 2000 AT THE FULTON COUNTY RECLAMATION SITE[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2+ NO_3-N[3]	Zn	Cd	Cu	Cr	Ni	Pb
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	tons/acre													
1	1,546	690	7.0	0.23	5.31	4,397	8,246	5.0	16.2	1,030	55.8	429	756	110	213
2	1,726	770	7.1	0.46	4.73	4,230	9,321	5.5	39.7	1,115	58.7	421	750	112	234
3	1,722	769	7.0	0.24	5.76	5,151	7,851	8.8	17.5	1,043	54.5	430	750	109	217
4	1,437	642	7.1	0.35	5.23	4,813	8,057	5.5	21.9	859	43.1	346	606	97	177
5	1,469	656	7.1	0.81	5.57	4,962	8,623	9.9	94.4	1,019	47.4	404	653	98	188
6	614	274	8.0	0.17	2.26	2,084	2,194	1.0	0.9	287	14.1	115	195	47	50
7E	1,394	622	7.4	0.18	4.40	4,213	7,698	4.4	13.2	1,070	61.7	450	809	116	230
7W	1,394	622	7.7	0.17	2.19	2,023	2,766	4.8	15.1	398	21.2	153	285	51	79
8	1,222	546	7.1	0.20	4.23	3,907	8,568	4.1	12.9	1,114	62.2	461	840	112	244
9	1,519	678	6.9	0.14	5.17	5,083	8,729	7.4	136	1,006	49.1	398	657	102	188
10	1,073	479	6.8	0.26	5.41	5,089	10,299	7.3	16.6	1,438	84.2	613	1,112	139	323

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS, AND METALS FOR FIELDS SAMPLED IN 2000 AT THE FULTON COUNTY RECLAMATION SITE[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2+ NO_3-N[3]	Zn	Cd	Cu	Cr	Ni	Pb
	----Dry Solids----			(dS/m)	(%)	----mg/kg----									
	Mg/ha	tons/acre													
11	1,485	663	7.1	0.32	4.39	3,801	7,528	3.7	10.1	1,015	56.3	396	734	110	223
12	1,398	624	7.4	0.22	3.74	3,015	6,462	3.6	4.5	970	53.3	377	702	107	200
13	1,163	519	7.1	0.26	3.96	3,824	7,481	5.8	14.7	1,106	63.7	441	828	104	238
14	1,279	571	7.3	0.24	3.74	3,179	6,690	4.4	5.4	852	47.1	345	629	91	180
15	1,260	563	7.4	0.21	3.44	3,370	6,874	4.4	17.6	1,006	50.1	377	682	95	201
16E	1,510	674	7.2	0.22	3.71	3,394	6,519	8.0	18.6	946	52.7	382	691	97	206
16W	1,510	674	7.2	0.24	3.35	3,405	7,106	8.2	16.6	848	47.3	363	626	88	178
17	1,631	728	7.0	0.14	5.71	4,208	9,936	9.2	178	1,200	61.5	515	810	119	247
18[4]	1.0	0.5	7.8	0.24	1.25	1,685	510	2.6	3.8	65	0.8	18	24	18	3
19	644	287	7.2	0.17	2.62	2,675	4,298	2.9	12.4	644	36.5	273	507	64	156
20	531	237	7.1	0.25	4.00	3,517	6,030	6.7	23.5	779	45.3	343	585	78	175

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS, AND METALS FOR FIELDS SAMPLED IN 2000 AT THE FULTON COUNTY RECLAMATION SITE[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2+ NO_3-N[3]	Zn	Cd	Cu	Cr	Ni	Pb
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	tons/acre													
21	618	276	7.2	0.19	2.46	2,437	3,944	4.2	13.8	555	32.0	223	403	60	125
22	455	203	7.3	0.21	3.34	3,262	5,690	4.8	16.1	787	45.3	330	579	77	179
23	473	211	7.2	0.20	3.26	2,951	4,812	4.3	12.8	700	40.2	292	541	71	160
24	1.1	0.5	7.9	0.18	0.79	1,059	524	2.4	3.3	73	1.7	25	34	23	2
25	869	388	7.3	0.29	5.09	4,429	7,365	3.8	12.0	990	51.5	382	663	103	220
26	1,086	485	7.4	0.42	4.02	3,662	6,567	2.8	9.6	808	44.7	306	542	88	168
27	755	337	7.3	0.49	3.95	3,405	7,052	3.0	23.6	952	54.0	367	675	98	208
28	802	358	7.5	0.22	4.71	4,095	8,125	3.0	15.2	1,092	61.1	436	770	121	234
29[4]	1.1	0.5	8.1	0.22	0.81	841	528	2.8	3.7	73	0.7	17	24	29	12
30	1,169	522	7.5	0.40	4.62	4,009	7,192	4.3	20.3	959	45.6	356	594	100	181
31	557	249	7.2	0.15	2.72	2,891	5,785	3.8	13.2	788	47.7	315	595	85	179

TABLE 21 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS, AND METALS FOR FIELDS SAMPLED IN 2000 AT THE FULTON COUNTY RECLAMATION SITE[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2+ NO_3-N[3]	Zn	Cd	Cu	Cr	Ni	Pb
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	tons/acre													
32	388	173	7.5	0.18	3.32	2,960	5,675	2.0	9.2	798	42.9	310	561	95	163
33	903	403	7.4	0.29	5.27	4,612	9,497	4.0	19.4	1,217	67.4	480	823	131	237
34	566	253	7.3	0.19	3.06	2,630	5,680	2.2	17.2	750	44.4	297	571	80	168
35	1,008	450	6.9	0.38	4.16	3,287	6,938	9.6	50.0	870	46.8	337	616	85	185
36	1,048	468	6.9	0.26	3.71	3,317	6,496	6.7	33.9	811	44.3	318	565	83	169
37	768	343	6.8	0.43	3.56	2,748	4,877	12.0	40.3	774	42.6	314	540	86	156
38A	9.4	4.2	7.4	1.70	1.36	945	855	0.5	0.4	142	1.8	27	28	47	18
38C	9.4	4.2	8.0	0.18	1.27	1,039	620	1.6	1.5	77	0.8	17	21	28	14
39	441	197	7.7	0.20	2.38	2,162	3,650	13.7	7.4	598	34.1	240	428	76	129
40	497	222	7.1	0.19	4.01	3,434	6,793	11.4	17.5	881	51.2	372	660	97	195
41	759	339	7.4	0.24	4.15	3,763	6,157	5.8	8.4	725	30.8	275	449	73	123

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS, AND METALS FOR FIELDS SAMPLED IN 2000 AT THE FULTON COUNTY RECLAMATION SITE[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2+ NO_3-N[3]	Zn	Cd	Cu	Cr	Ni	Pb
	----Dry Solids----			(dS/m)	(%)	----------mg/kg----------									
	Mg/ha	tons/acre													
42	782	349	7.2	0.23	3.65	3,232	6,653	5.0	15.9	1,055	57.3	446	792	111	215
43	793	354	7.3	0.28	3.91	3,048	6,455	6.1	10.1	823	39.8	321	562	84	159
44	598	267	7.2	0.23	3.67	3,082	6,775	18.0	15.9	913	48.0	374	658	103	178
45	746	333	7.1	0.95	4.00	3,628	6,860	8.2	106	821	36.3	322	522	77	145
47	903	403	7.1	0.44	5.19	4,292	9,025	46.7	30.4	1,240	60.9	488	878	116	242
50[4]	6.7	3.0	7.4	0.17	1.07	1,390	626	3.0	4.5	53	<0.2	15	23	21	<1
51	45.7	20.4	7.4	0.19	1.11	1,330	802	4.9	3.7	118	2.5	33	49	25	25
52[4]	9.2	4.1	7.3	0.20	0.89	1,231	542	2.7	9.4	53	1.3	18	24	24	<1
53	5.2	2.3	7.8	0.25	1.55	1,646	487	5.2	2.3	54	0.7	18	21	26	<1
54	14.3	6.4	7.7	0.30	1.78	1,659	672	4.0	6.7	90	1.0	26	24	36	15
55	9.4	4.2	7.3	0.31	1.56	1,535	631	4.3	5.9	82	1.1	23	23	38	14

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS, AND METALS FOR FIELDS SAMPLED IN 2000 AT THE FULTON COUNTY RECLAMATION SITE[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2+ NO_3-N[3]	Zn	Cd	Cu	Cr	Ni	Pb
	----Dry Solids----			(dS/m)	(%)	---------------------------mg/kg---------------------------									
	Mg/ha	tons/acre													
56	13.2	5.9	7.7	0.25	1.35	1,126	617	2.8	4.5	69	1.3	23	24	34	15
57	2.9	1.3	7.6	0.22	1.56	1,671	551	5.1	1.0	59	1.0	27	21	28	<1
58	5.4	2.4	7.9	0.26	1.71	1,595	510	4.3	1.2	57	0.9	20	22	28	<1
59	2.5	1.1	6.8	0.15	1.13	1,112	395	7.2	5.1	50	0.5	11	18	15	1
60	3.1	1.4	7.8	0.25	1.49	1,579	509	2.1	9.5	54	0.8	19	21	24	<1
61	2.2	1.0	7.8	0.84	1.35	1,272	483	2.1	7.1	138	1.6	21	24	31	<1
62	5.4	2.4	7.6	0.28	1.52	1,518	495	4.2	1.3	54	0.8	17	22	24	<1
63	21.5	9.6	7.5	0.28	1.70	1,784	506	3.7	5.1	54	0.9	19	21	27	<1
64	2.2	1.0	7.9	0.28	1.25	1,418	622	2.7	4.8	126	1.5	22	24	37	18
65[4]	0.4	0.2	7.7	0.80	1.21	1,124	660	3.9	6.4	86	1.2	25	23	36	14
73[4]	0	0	7.8	0.38	1.03	1,189	553	4.7	4.2	76	1.2	19	23	26	11

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21 (Continued)

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS, AND METALS FOR FIELDS SAMPLED IN 2000 AT THE FULTON COUNTY RECLAMATION SITE[1]

Field Number	Cumulative Biosolids Applied[2]		pH	EC	Organic Carbon	TKN	Tot.-P	NH_3-N[3]	NO_2+ NO_3-N[3]	Zn	Cd	Cu	Cr	Ni	Pb
	----Dry Solids----			(dS/m)	(%)	----mg/kg----									
	Mg/ha	tons/acre													
75	336	150	7.5	0.20	1.36	1,253	1,931	3.2	8.5	253	14.3	98	173	39	60
76[4]	0	0	7.7	0.20	0.61	607	382	2.9	3.3	54	0.6	15	21	19	<1
80[4]	0	0	5.6	0.07	0.93	900	364	4.8	1.2	46	0.5	9	14	14	6
81[4]	0	0	6.2	0.14	1.74	1,297	380	5.8	0.5	43	0.4	7	14	13	13
82[4]	0	0	6.0	0.10	1.05	959	373	4.2	2.8	49	0.8	9	15	13	6
83[4]	0	0	6.5	0.11	1.43	1,065	465	4.3	1.6	62	0.8	9	13	14	13
84[4]	0	0	7.7	0.15	0.90	861	425	3.8	1.3	71	1.0	20	22	24	12

[1]Sampling depth 0-15 cm.
[2]Through 2000.
[3]1M KCl-extractable.
[4]Only commercial fertilizer was applied to this field.

Plant tissue samples (grain, leaf, and/or stover) are collected annually from fields leased to local farmers at the Fulton County site. Table 22 shows the total concentrations of metals found in 2000 corn grain collected from fields with different cumulative loading rates of biosolids. No clear pattern of metal uptake by the grain tissue for any of the parameters was apparent with higher cumulative biosolids loading rates.

Table 23 shows the total concentrations of metals found in 2000 corn leaf tissue samples from the same cornfields. Zinc and cadmium concentrations in the leaf tissue were influenced by cumulative biosolids applied to each field. The concentrations of K, Ca, and Mg vary with the applications of commercial fertilizer and/or lime on some fields. The concentrations of all other elements, however, remain fairly constant despite the cumulative amount of biosolids applied to each field.

Table 24 displays the total concentrations of metals found in 2000 soybean grain samples. Generally, the metal concentrations in the soybean grain were relatively insensitive to the varying cumulative amounts of biosolids applied over time.

Table 25 shows the total concentrations of metals in 2000 hay samples. The fields are divided into different sections,

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 22

MEAN CONCENTRATIONS OF METALS IN 2000 CORN GRAIN SAMPLES COLLECTED FROM THE FULTON COUNTY RECLAMATION SITE

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/Kg								
1	29.6	0.10	2.40	0.30	1.15	<0.10	3,743	43.8	1,153
7E	28.6	0.15	1.98	0.25	1.08	<0.10	3,299	37.2	1,000
7W	18.7	<0.02	1.15	0.25	0.35	<0.10	3,359	38.8	865
8	24.1	<0.02	1.45	0.20	0.60	<0.10	3,356	32.5	1,082
13	25.9	0.10	1.72	0.20	0.88	<0.10	3,521	36.0	962
14	26.4	0.10	1.60	0.18	0.90	<0.10	3,459	36.5	1,028
35	36.0	0.18	2.45	1.15	1.10	<0.10	3,531	68.5	1,068
36	31.9	0.10	2.12	0.70	0.68	<0.10	3,528	61.0	1,031
37	32.5	0.10	2.22	0.78	0.68	<0.10	3,540	56.0	1,020
39	27.9	0.10	1.85	0.22	0.62	<0.10	3,160	41.0	1,150

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 22 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 CORN GRAIN SAMPLES COLLECTED FROM THE FULTON COUNTY RECLAMATION SITE

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/Kg								
40	28.4	0.05	1.68	0.35	0.42	<0.10	3,574	43.0	1,096
41	36.4	0.10	1.72	0.22	0.52	<0.10	3,353	40.0	1,162
44	30.1	0.04	1.88	0.35	0.48	<0.10	3,706	71.2	1,163
47	29.2	0.04	2.25	0.41	0.55	<0.10	3,483	68.2	1,053
50	21.2	<0.02	1.50	0.22	0.30	<0.10	3,671	52.8	970
52	20.6	<0.02	1.58	0.48	0.90	<0.10	3,756	66.8	985
59-2	18.5	<0.02	1.38	0.14	0.35	<0.10	3,423	66.5	943

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 23

MEAN CONCENTRATIONS OF METALS IN 2000 CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/Kg								
1-1	59.7	6.60	12.3	0.10	<0.30	<0.20	22,430	4,174	2,991
1-2	51.2	2.65	12.7	0.70	<0.30	<0.20	21,490	4,243	2,460
7E-1	59.2	5.80	11.6	0.60	<0.30	<0.20	19,310	4,350	3,033
7E-2	50.9	3.30	11.8	0.25	<0.30	<0.20	15,120	4,761	4,387
7W-1	45.8	3.35	11.2	0.15	<0.30	<0.20	18,360	4,582	2,898
7W-2	26.8	0.70	10.4	0.15	<0.30	<0.20	14,490	5,188	4,144
8-1	42.7	5.00	11.0	0.15	<0.30	<0.20	21,820	3,979	2,652
8-2	99.5	8.00	15.9	0.20	<0.30	<0.20	21,480	4,658	2,384
13-1	67.8	5.35	14.3	0.25	<0.30	<0.20	18,070	5,010	4,050
13-2	73.6	7.30	12.8	0.15	<0.30	<0.20	20,640	4,023	2,994

TABLE 23 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	----------	----------	----------	----------	mg/Kg	----------	----------	----------	----------
14-1	70.3	5.25	13.0	0.10	<0.30	<0.20	15,180	5,496	4,113
14-2	75.5	5.45	14.8	0.15	<0.30	<0.20	16,840	5,100	4,098
35-1	121	3.70	13.2	0.15	<0.30	<0.20	18,090	5,823	3,402
35-2	103	5.05	11.1	0.20	<0.30	<0.20	19,940	4,850	3,101
36-1	103	4.10	11.8	0.20	<0.30	<0.20	17,000	5,635	3,627
36-2	52.0	3.60	9.0	0.60	<0.30	<0.20	9,641	7,575	5,506
37-1	83.8	3.25	10.2	0.15	<0.30	<0.20	17,500	4,641	3,865
37-2	53.5	3.85	9.2	0.25	<0.30	<0.20	9,577	7,473	5,715
39-1	48.6	5.40	9.0	1.20	<0.30	<0.20	19,660	3,539	2,730

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 23 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/Kg								
39-2	61.6	7.05	8.2	0.10	<0.30	<0.20	19,740	3,761	2,133
40-1	47.6	4.35	9.4	0.20	<0.30	<0.20	13,950	4,937	5,006
40-2	68.9	5.75	9.8	0.15	<0.30	<0.20	13,680	5,883	5,499
41-1	96.2	8.35	12.6	0.10	<0.30	<0.20	19,850	4,363	2,171
41-2	55.1	3.10	9.2	0.10	<0.30	<0.20	19,080	3,480	1,932
44-1	73.6	2.50	9.8	0.20	<0.30	<0.20	21,220	4,271	2,532
44-2	72.6	2.95	12.0	0.20	<0.30	<0.20	5,558	20,230	4,385
47-1	113	3.15	12.4	0.10	<0.30	<0.20	3,855	24,490	2,429
47-2	79.8	6.10	11.1	0.20	<0.30	<0.20	4,044	23,470	1,757
50-1	22.0	<0.04	12.0	0.20	<0.30	<0.20	4,858	23,150	3,316

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 23 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 CORN LEAF SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE

Field[1] Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/Kg								
50-2	23.5	0.20	12.3	<0.04	<0.30	<0.20	5,287	22,200	2,628
52-1	16.6	0.10	12.3	0.10	<0.30	<0.20	6,525	15,520	5,546
52-2	22.6	0.20	9.8	0.15	<0.30	<0.20	4,513	25,940	2,612
59-2	70.0	2.85	10.8	0.15	<0.30	<0.20	4,800	23,420	2,752

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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 24

MEAN CONCENTRATIONS OF METALS IN 2000 SOYBEANS SAMPLED AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/Kg								
2	51.8	0.62	13.6	0.20	<0.15	<0.10	20,900	2,559	2,536
4	54.2	1.03	12.4	0.15	<0.15	<0.10	21,880	2,873	2,643
5	54.6	0.42	12.0	1.00	<0.15	<0.10	20,180	1,940	2,496
9	57.4	0.55	12.2	0.10	<0.15	<0.10	21,320	2,064	2,631
15	59.7	1.33	11.7	0.65	<0.15	<0.10	19,920	2,691	2,977
17	60.0	0.82	12.9	0.10	<0.15	<0.10	20,780	1,995	2,561
18	45.5	<0.02	15.2	0.05	<0.15	<0.10	20,970	3,217	2,744
19	55.8	0.68	10.8	0.15	<0.15	<0.10	21,030	2,400	2,954
20	44.2	0.20	12.4	0.10	<0.15	<0.10	19,100	2,662	2,693
21	49.4	0.15	15.1	0.15	<0.15	<0.10	18,360	2,555	2,715

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 24 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 SOYBEANS SAMPLED
AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/Kg								
22	50.3	0.45	11.2	0.10	<0.15	<0.10	18,020	2,686	2,772
23	50.9	0.45	11.2	0.08	<0.15	<0.10	18,490	2,527	2,915
24	46.6	<0.02	17.6	0.05	<0.15	<0.10	18,710	2,718	2,957
27	56.2	0.72	12.2	0.08	<0.15	<0.10	19,440	2,352	2,525
28	54.4	0.70	12.0	0.05	<0.15	<0.10	20,160	2,130	2,469
29	45.4	<0.02	13.9	0.05	<0.15	<0.10	20,040	2,886	2,994
31	55.0	0.95	11.2	0.15	<0.15	<0.10	21,020	2,680	2,684
32	56.1	0.80	12.2	0.68	<0.15	<0.10	20,440	2,820	2,554
33	62.5	1.15	12.5	1.98	<0.15	<0.10	20,620	2,573	2,533
34	54.8	0.82	9.0	<0.02	<0.15	<0.10	18,440	2,544	2,781

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 24 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 SOYBEANS SAMPLED AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/Kg								
38-A	48.4	<0.02	17.1	<0.02	<0.15	<0.10	18,980	3,143	2,597
38-C	49.0	<0.02	17.5	<0.02	<0.15	<0.10	18,970	3,134	2,466
43	45.0	<0.02	13.5	<0.02	<0.15	<0.10	18,930	3,116	2,987
45	43.6	<0.02	15.5	<0.02	<0.15	<0.10	19,500	2,763	2,453
51	47.1	<0.02	17.7	<0.02	<0.15	<0.10	19,990	3,246	2,570
54	43.4	<0.02	16.6	<0.02	<0.15	<0.10	18,690	2,970	2,328
55	45.2	<0.02	16.8	<0.02	<0.15	<0.10	19,640	2,986	2,455
56	45.5	<0.02	17.0	<0.02	<0.15	<0.10	18,420	2,888	2,315
59-1	36.5	<0.02	11.8	<0.02	<0.15	<0.10	17,520	3,295	2,637
60	45.9	<0.02	18.4	<0.02	<0.15	<0.10	19,350	3,778	2,832

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 24 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 SOYBEANS SAMPLED AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
	mg/Kg								
61	48.5	<0.02	16.2	<0.02	<0.15	<0.10	18,760	2,593	2,336
63-1-1	47.4	<0.02	16.8	<0.02	<0.15	<0.10	19,340	3,019	2,503
64	50.1	<0.02	16.0	<0.02	<0.15	<0.10	19,340	2,635	2,270
65	46.4	<0.02	16.2	<0.02	<0.15	<0.10	18,040	2,691	2,205
75	45.4	<0.02	17.9	<0.02	<0.15	<0.10	18,960	2,943	2,372

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 25

MEAN CONCENTRATIONS OF METALS IN 2000 HAY SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/Kg								
10-2	1	75.7	2.78	7.48	1.03	<0.15	<0.10	20,470	11,320	1,778
62-1	1	16.8	<0.02	4.35	0.18	<0.15	<0.10	14,400	6,352	1,858
62-2	1	16.4	<0.02	3.95	0.18	<0.15	<0.10	11,840	5,365	1,901
63-1-2	1	17.6	<0.02	4.60	0.05	<0.15	<0.10	14,250	3,969	1,764
63-2-1	1	17.3	<0.02	7.08	0.28	<0.15	<0.10	14,620	7,972	2,398
63-2-2	1	18.2	<0.02	6.68	0.10	<0.15	<0.10	12,660	6,975	2,175
63-3-1	1	18.3	<0.02	3.83	0.12	<0.15	<0.10	13,570	3,643	1,615
63-3-2	1	16.0	<0.02	4.40	0.10	<0.15	<0.10	17,080	4,363	2,064
63-4-1	1	17.5	<0.02	6.40	0.05	<0.15	<0.10	19,450	6,882	2,140
63-4-2	1	14.3	<0.02	7.28	0.08	<0.15	<0.10	15,720	12,180	2,571

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 25 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 HAY SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/Kg								
63-5-1	1	13.2	<0.02	6.35	0.10	<0.15	<0.10	15,820	9,620	1,771
63-5-2	1	19.4	<0.02	4.75	0.10	<0.15	<0.10	15,500	5,615	2,082
63-6-1	1	14.2	<0.02	6.20	0.08	<0.15	<0.10	14,570	9,922	2,161
63-6-2	1	14.3	<0.02	3.73	0.08	<0.15	<0.10	11,270	4,028	1,554
63-7-1	1	15.7	<0.02	4.28	<0.02	<0.15	<0.10	16,210	4,282	2,024
63-7-2	1	19.4	<0.02	4.90	0.12	<0.15	<0.10	19,730	5,190	2,022
73-1	1	25.8	<0.02	7.18	0.10	<0.15	<0.10	16,460	11,060	2,309
73-2	1	21.0	<0.02	5.70	0.05	<0.15	<0.10	18,540	8,250	1,862
76-1	1	22.5	<0.02	6.28	0.02	<0.15	<0.10	13,330	6,050	1,775
76-2	1	16.0	<0.02	7.53	<0.02	<0.15	<0.10	12,730	7,213	2,005

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 25 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 HAY SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/Kg								
62-1	2	12.2	<0.02	6.33	<0.02	<0.15	<0.10	14,800	12,490	2,421
62-2	2	18.4	<0.02	8.70	<0.02	<0.15	<0.10	19,730	9,188	2,806
63-1-2	2	15.0	<0.02	8.08	<0.02	<0.15	<0.10	17,820	7,690	2,016
63-2-1	2	19.0	<0.02	8.33	<0.02	<0.15	<0.10	19,560	10,060	2,202
63-2-2	2	20.3	<0.02	8.93	<0.02	<0.15	<0.10	21,360	10,990	2,600
63-3-2	2	22.2	<0.02	9.58	<0.02	<0.15	<0.10	18,430	10,540	2,127
63-4-1	2	13.6	<0.02	6.35	<0.02	<0.15	<0.10	16,220	9,815	2,259
63-4-2	2	12.3	<0.02	7.05	<0.02	<0.15	<0.10	13,300	9,213	1,914
63-6-1	2	21.0	<0.02	7.18	<0.02	<0.15	<0.10	23,170	4,909	2,158
63-6-2	2	20.7	<0.02	8.33	<0.02	<0.15	<0.10	20,100	8,173	2,306

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 25 (Continued)

MEAN CONCENTRATIONS OF METALS IN 2000 HAY SAMPLES COLLECTED AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Cutting	Zn	Cd	Cu	Cr	Ni	Pb	K	Ca	Mg
		mg/Kg								
63-7-1	2	15.8	<0.02	8.23	<0.02	<0.15	<0.10	10,640	13,730	2,758
63-7-2	2	19.0	<0.02	8.50	<0.02	<0.15	<0.10	19,840	12,190	2,427
73-1	2	52.4	<0.10	5.83	<0.15	<0.15	<0.10	22,820	4,609	3,640
73-2	2	45.8	<0.10	7.10	<0.18	<0.15	<0.10	21,450	5,276	2,086
76-1	2	22.0	<0.02	10.1	<0.02	<0.15	<0.10	19,610	11,770	2,770
76-2	2	22.5	<0.02	10.4	<0.02	<0.15	<0.10	20,000	10,960	2,816
63-2-1	3	18.7	<0.02	10.4	<0.02	<0.15	<0.10	17,560	10,530	2,720
63-2-2	3	21.8	<0.02	10.3	<0.02	<0.15	<0.10	19,230	10,360	2,422

and there are multiple samplings (cutting) of the hay throughout the year. The metal concentrations reflect the varying cumulative amounts of biosolids applied over time.

Tables 26 and 27 show the grain yields for corn and soybean fields, respectively, in 2000. Table 26 shows that corn grain yields were generally higher on placed land fields (35, 36, 37, and 59-2) (i.e. fields not strip mined) and mine spoil fields with cumulative biosolids loading rates up to 900 Mg/ha (403 tons/acre) (39, 40, 41, 44, 47, 50, and 52) than on the mine spoil fields with heavier cumulative loading rates (1, 7E, 7W, 8, 13, and 14). Farming practices cannot be ignored as another reason for these differences. For soybeans, Table 27, yields do not appear to be strongly related to biosolids loading rates or soil types.

HYBRID SEED INFORMATION COMPONENT

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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 26

2000 CORN GRAIN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn Grain Yield
		-----Dry Solids-----		bu/acre
		Mg/ha	tons/acre	
1	MS	1,546	690	100
7E	MS	1,394	622	100
7W	MS	1,394	622	100
8	MS	1,222	546	100
13	MS	1,163	519	100
14	MS	1,279	571	100
35	PL	1,008	450	120
36	PL	1,048	468	120
37	PL	768	343	120
39	MS	441	197	141
40	1/5 MS	497	222	158
41	MS	759	339	142
44	MS	598	267	140
47	MS	903	403	141
50	7/8 MS	6.7	3.0	130

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 26 (Continued)

2000 CORN GRAIN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Corn Grain Yield
		-----Dry Solids-----		bu/acre
		Mg/ha	tons/acre	
52	MS	9.2	4.1	130
59-2	PL	2.5	1.1	131.5

[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 or part of the field that has not been strip mined.
[2]Through 2000.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 27

2000 SOYBEAN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Soybean Yield
		-----Dry Solids-----		bu/acre
		Mg/ha	tons/acre	
2	MS	1,726	770	35
4	MS	1,437	642	39
5	MS	1,469	656	41
9	MS	1,519	678	45
15	MS	1,260	563	40
17	MS	1,631	728	45
18	1/2 MS	1.0	0.5	40
19	PL	644	287	45
20	PL	531	237	45
21	PL	618	276	45
22	PL	455	203	44
23	PL	473	211	45
24	MS	1.1	0.5	24
27	2/3 MS	755	337	33
28	PL	802	358	28

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 27 (Continued)

2000 SOYBEAN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Soybean Yield
		-----Dry Solids-----		bu/acre
		Mg/ha	tons/acre	
29	MS	1.1	0.5	13
31	PL	557	249	50
32	MS	388	173	50
33	MS	903	403	50
34	PL	566	253	50
38-A	MS	9.4	4.2	12
38-C	MS	9.4	4.2	25
43	MS	793	354	14
45	3/4 MS	746	333	35
51	1/4 MS	45.7	20.4	36
54	MS	14.3	6.4	32
55	MS	9.4	4.2	30
56	MS	13.2	5.9	30
59-1	PL	2.5	1.1	40
60	MS	3.1	1.4	36

TABLE 27 (Continued)

2000 SOYBEAN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

Field Number	Soil Type[1]	Cumulative Biosolids Applied[2]		Soybean Yield
		-----Dry Solids-----		bu/acre
		Mg/ha	tons/acre	
61	MS	2.2	1.0	36
63-1-1	MS	21.5	9.6	36
64	MS	2.2	1.0	30
65	MS	0.4	0.2	30
75	MS	336	150	36

[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 or part of the field that has not been strip mined.
[2]Through 2000.

MISCELLANEOUS INITIATIVES

During the year 2001, Fulton County R&D Laboratory staff assisted the USDA and USEPA in Beltsville, Maryland and Cincinnati, Ohio, respectively, by collecting 140 3-gallon buckets of soil from selected fields at the site which were sent to the USDA and USEPA laboratories for analyses. This project is examining the long term phytoavailability of metals in biosolids amended soils.

Various alfalfa fields were monitored throughout the growing and harvesting seasons for signs of disease or insect infestations that would reduce crop yields, and decrease the value of the product to the District's land renters.

The large amount of data accumulated from the inception of the project in 1971 to the present continued to be placed into various databases for easier access by District personnel and other agencies. Also, preparations were made to generate the data required to request further reductions in monitoring at the site. A request was submitted to IEPA for reduction in monitoring of lysimeters at the site. In 2001, the IEPA issued the District a supplemental permit eliminating the requirement to monitor lysimeters at the Fulton County Land Reclamation Project.

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 United Electric Company (UEC) Cuba Mine No. 9 site, which included an impoundment that collected surface water from exposed gob and coal fines areas. This Acid-Mine 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.

Corn Fertility Experiment on Calcareous Mine Spoil

Since 1973, the District has been involved in a corn fertility experiment with the University of Illinois, using the calcareous mine spoil at the Fulton County site. The purpose of this experiment has been 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, and to provide information that can be used for management of biosolids and crops.

This is the longest running continuous biosolids research initiative 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 28 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 made on the Fulton County plots each year. The amounts of biosolids or commercial fertilizer added annually for each treatment are listed in Table 28, along with the cumulative totals of biosolids applied per plot through 2001. Check plots receive a commercial fertilizer mix comprised of 336 Kg/ha nitrogen (N), 224 Kg/ha phosphorus (P), and 112 Kg/ha potassium (K) annually. Biosolids-amended plots receive 112 Kg/ha of potassium annually.

Table 29 shows a three-year comparison (1998-2000) of soil data from the experimental plots. While the values for all parameters except pH and EC tend to increase with the different biosolids applications, the values within each separate treatment tend to remain similar. For the tissue samples (Table 30 - corn grain, Table 31 - corn leaf, and Table 32 - corn

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28

BIOSOLIDS APPLICATION RATES FOR 2001 AT THE FULTON COUNTY CORN FERTILITY PLOT EXPERIMENT[1]

PLOT	ANNUAL		CUMULATIVE	
	Dry Solids			
	Mg/ha	(tons/acre)	Mg/ha	(tons/acre)
Check	0.0	(0.0)	0.0	(0.0)
1/4	16.8	(7.5)	471.5	(210.5)
1/2	33.6	(15.0)	943.0	(421.0)
MAX	67.2	(30.0)	1883.8	(841.0)

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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 29

MEAN pH, ELECTRICAL CONDUCTIVITY (EC), AND CONCENTRATIONS OF ORGANIC CARBON, NUTRIENTS, AND METALS IN SURFACE SOIL[1] FROM UICF EXPERIMENTAL PLOTS AT THE FULTON COUNTY RECLAMATION SITE FOR 1998 - 2000

Treat-				Organic	0.1N HCl Extracted						Concentrated HNO_3 Extracted							
ment[2]	Year	pH	EC	Carbon	Zn	Cd	Cu	Cr	Ni	Pb	Zn	Cd	Cu	Cr	Ni	Pb	TKN	Tot-P
			dS/m	%	mg/kg													
Check	1998	7.4	0.270	0.80	97	6.8	38	13.5	10.8	21.0	162	9.0	65	110	42.5	33.8	1,029	2,512
	1999	7.3	0.553	0.96	118	8.5	46	15.8	11.2	23.2	158	8.8	67	110	39.0	35.2	1,226	2,384
	2000	7.6	0.265	1.04	147	28.4	55	24.9	12.7	28.8	193	10.5	86	151	46.2	48.5	1,278	2,538
¼	1998	7.6	0.225	1.36	203	14.3	81	25.0	16.5	37.3	299	15.8	119	203	52.0	64.8	1,387	2,857
	1999	7.7	0.440	1.28	202	14.5	83	27.0	16.3	38.0	255	13.3	108	171	47.5	53.5	1,225	2,080
	2000	7.6	0.205	1.71	277	20.3	121	37.9	19.4	50.3	352	19.3	159	264	59.8	81.0	1,776	3,032
½	1998	7.5	0.253	1.82	327	21.8	128	39.8	23.3	49.5	444	23.8	182	298	63.8	90.8	1,923	3,749
	1999	7.6	0.300	1.92	375	25.8	137	45.0	26.0	54.3	405	21.5	174	280	60.3	84.8	1,917	3,246
	2000	7.5	0.205	2.64	466	32.2	197	64.6	29.3	67.8	558	31.0	257	413	79.5	126	2,516	4,499
Max	1998	7.2	0.255	3.60	675	41.8	247	74.5	41.5	67.0	844	44.8	343	567	97.8	178	3,474	6,367
	1999	7.4	0.268	3.59	679	43.0	247	75.5	40.0	71.3	706	37.0	304	488	85.8	150	3,268	4,380
	2000	7.4	0.198	4.01	742	49.1	297	89.9	42.7	78.1	793	45.3	375	596	101	182	3,674	7,033

[1]Sampling depth 0-15 cm.

[2]Check = no biosolids application - inorganic fertilizer, ¼ = one-quarter maximum biosolids loading rate or 16.8 mg/ha/year, ½ = one-half maximum biosolids loading rate or 33.6 mg/ha/year, Max = maximum biosolids loading rate or 67.2 mg/ha/year.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 30

MEAN CONCENTRATIONS OF TKN, PHOSPHORUS, AND METALS IN CORN GRAIN FROM THE UICF EXPERIMENTAL PLOTS[1] AT THE FULTON COUNTY RECLAMATION SITE FOR 1998-2000

	Control			1/4			1/2			Max		
Analyte[2]	1998	1999	2000	1998	1999	2000	1998	1999	2000	1998	1999	2000
	mg/kg											
TKN	10,580	10,550	14,560	9,284	8,888	12,380	10,680	8,129	13,130	10,820	9,093	13,690
Tot-P	2,710	2,697	2,825	3,501	2,743	2,903	3,479	2,646	2,937	3,077	2,828	2,821
Zn	18.9	22.4	22.6	25.1	25.8	28.8	23.5	24.5	27.6	23.9	24.5	27.7
Cd	<1	<0.02	0.03	<1	<0.02	0.05	<1	<0.02	0.04*	<1	<0.02	0.04
Cu	2.08	1.33	1.81	2.41	1.05	1.73	1.86*	0.98	1.93	2.06*	1.16	2.03
Cr	<1	0.43*	4.02	<1	0.63*	0.91	<1	0.16*	1.20	<1	0.21*	4.84
Ni	1.08*	0.62	1.77	1.09	1.91	2.06	1.21	0.37	1.37	1.09	1.24	1.42
Pb	0.425	<0.1	<0.1	0.475	<0.1	<0.1	0.475	<0.1	<0.1	0.463	<0.1	<0.1
K	3,139	3,418	3,627	3,536	3,324	3,662	3,427	3,347	3,858	3,357	3,473	3,833
Ca	30.4	39.1	NA	32.0	49.3	NA	31.3	46.0	NA	28.0	41.4	NA
Mg	1,051	1,126	1,194	1,163	1,195	1,328	1,118	1,197	1,345	979	1,153	1,310

[1]Check = no biosolids application - inorganic fertilizer, ¼ = one-quarter maximum biosolids loading rate or 16.8 mg/ha/year, ½ = one-half maximum biosolids loading rate or 33.6 mg/ha/year, Max = maximum biosolids loading rate or 67.2 mg/ha/year.
[2]Tissue digested with $HNO_3/HClO_4$ for metals, and TKN is total Kjeldahl N and Tot-P is total P.
NA = data not presently available.
*Mean was calculated assuming values below detectable limits were zero.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 31

MEAN CONCENTRATIONS OF TKN, PHOSPHORUS, AND METALS IN CORN LEAF TISSUE FROM THE UICF EXPERIMENTAL PLOTS[1] AT THE FULTON COUNTY RECLAMATION SITE FOR 1998-2000

	Control			1/4			1/2			Max		
Analyte[2]	1998	1999	2000	1998	1999	2000	1998	1999	2000	1998	1999	2000
	mg/kg											
TKN	16,630	23,960	26,730	13,330	12,360	17,380	15,860	15,030	21,790	23,810	19,310	19,560
Tot-P	3,089	2,507	2,932	4,309	3,323	5,804	3,651	2,788	5,134	4,153	2,673	3,101
Zn	20.5	30.3	32.9	35.4	21.7	57.6	38.5	20.9	42.8	49.7	34.6	40.8
Cd	<1	2.71	1.75	1.75*	1.75	1.29	2.00	1.21	1.24	1.25*	2.19	1.03
Cu	5.88	8.76	10.8	5.50	4.61	6.93	6.25	5.21	9.01	7.38	6.99	8.39
Cr	<1	0.11*	0.25	<1	0.11*	0.41	<1	0.05*	0.56	<1	0.02*	0.22
Ni	0.08	0.19*	0.16	0.13	0.30	0.36	0.14	0.23	0.40	1.25*	0.26	0.37
Pb	0.32	<0.2	<0.10	0.42	0.23	0.22	0.42	<0.2	0.19	0.68	<0.02	0.17
K	18,550	20,110	17,450	17,830	21,130	19,380	18,050	19,710	19,040	18,260	20,810	21,890
Ca	2,597	3,548	4,871	3,229	2,658	3,623	3,513	3,084	3,825	4,616	3,236	3,971
Mg	1,723	1,874	2,166	2,287	2,228	3,655	2,066	2,262	3,369	2,123	2,239	2,613

[1]Check = no biosolids application - inorganic fertilizer, ¼ = one-quarter maximum biosolids loading rate or 16.8 mg/ha/year, ½ = one-half maximum biosolids loading rate or 33.6 mg/ha/year, Max = maximum biosolids loading rate or 67.2 mg/ha/year.
[2]Tissue digested with $HNO_3/HClO_4$ for metals, and TKN is total Kjeldahl N and tot-P is total P.
*Mean was calculated assuming values below detectable limits were zero.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 32

MEAN CONCENTRATIONS OF TKN, PHOSPHORUS, AND METALS IN CORN STOVER TISSUE FROM THE UICF EXPERIMENTAL PLOTS[1] AT THE FULTON COUNTY RECLAMATION SITE FOR 1998-2000

	Control			1/4			1/2			Max		
Analyte[2]	1998	1999	2000	1998	1999	2000	1998	1999	2000	1998	1999	2000
	mg/kg											
TKN	4,669	8,920	5,955	5,341	6,335	6,695	5,797	6,544	6,261	5,594	7,447	6,454
Tot-P	980	1,047	994	2,306	3,854	4,330	2,202	3,005	3,167	967	1,160	2,234
Zn	35.0	32.2	28.6	149	138	159	147	109	108	127	95.2	78.1
Cd	<1	1.98	1.16	2.63	2.01	2.40	2.91	2.16	2,07	2.68	2.25	2.12
Cu	4.75	6.58	3.54	5.88	4.63	6.82	7.88	6.45	6.77	5.38	6.03	7.97
Cr	<1	<0.02	0.78	<1	0.46*	1.99	1*	0.81*	2.03	<1	<0.02	1.73
Ni	0.29	0.21	0.71	0.65	1.33	2.18	0.94	0.74	1.54	0.41	0.46	2.01
Pb	0.80	0.28*	0.89*	1.55	0.89	0.98*	2.65	0.60*	0.94*	1.13	0.25*	1.56*
K	11,760	13,740	14,830	8,986	15,490	12,100	10,830	19,780	14,920	9,998	16,330	12,590
Ca	1,877	2,169	2,113	1,847	1,470	2,694	1,891	1,709	2,107	1,978	1,608	3,351
Mg	1,875	1,529	1,649	2,371	2,588	3,378	2,341	2,386	2,300	1,684	1,702	2,523

[1]Check = no biosolids application - inorganic fertilizer, ¼ = one-quarter maximum biosolids loading rate or 16.8 mg/ha/year, ½ = one-half maximum biosolids loading rate or 33.6 mg/ha/year, Max = maximum biosolids loading rate or 67.2 Mg/ha/year.
[2]Tissue digested with $HNO_3/HClO_4$ for metals, and TKN is total Kjeldahl N and Tot-P is total P.
*Mean was calculated assuming values below detectable limits were zero.

stover) except for Cr, the parameters do not vary much either by year or treatment.

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 33 shows the grain and stover yields for both hybrids in 2001 for the four treatments. The data reveal no significant differences between hybrids. Therefore, from 2002 onward only the 33P69 hybrid will be planted in the research plots.

Research and Environmental Monitoring at the St. David, Illinois Coal Refuse Reclamation Site

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. The experiment was initiated with the approval of the IEPA.

Ten treatments were established on the west lobe and side slopes of a coal refuse pile at St. David, Illinois (Table 34). Each of the ten treatment plots was approximately 0.405 ha (1 acre). In establishing the treatments, a specific

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 33

AVERAGE CORN GRAIN AND STOVER YIELDS FOR HYBRIDS 3394 AND 33P69
GROWN ON THE FULTON COUNTY CORN FERTILITY PLOTS IN 2001

Harvested Tissue	Units	Max		Half		Quarter		Control	
		3394[1]	33P69[2]	3394	33P69	3394	33P69	3394	33P69
Grain	Bu/acre	103	109	65	77	37	49	97	99
	Mg/ha	6.5	6.8	4.1	4.8	2.3	3.0	6.1	6.2
Stover	Tons/acre	1.9	1.6	1.3	1.1	1.0	0.9	1.7	1.8
	Mg/ha	4.3	3.7	2.8	2.6	2.3	2.0	3.7	4.1

[1] Current corn hybrid being replaced.
[2] Herbicide-ready genetically modified corn hybrid.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 34

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.

sequence of operations was used, and these operations were conducted in four phases. The first phase consisted of preliminary grading to fill existing erosion gullies on the surface, and removing the old nonfunctioning terraces from the side slopes of the coal refuse pile. When this was completed, lysimeters were installed in each treatment.

The second phase of operations consisted of applying the amendments. Agricultural limestone was applied to those treatments requiring it, then anaerobically digested municipal biosolids were applied in 10.2-cm (4-inch) layers using a scraper. These biosolids were from the District's Stickney WRP. A chisel plow was used to incorporate the applied biosolids. After the last layer of biosolids was applied, 10.2-cm (4-inches) of clay was applied to those treatments requiring it, and then incorporated by chisel plow mixing.

The third phase of operations consisted of planting the vegetative cover. The amended surface of the coal refuse pile was disked with an agricultural disk transverse to the slopes. The planted vegetative cover consisted of broadcast seeding of cereal rye at a rate of 121 Kg/ha (108 lb/acre), followed by broadcast seeding of alfalfa and alsike clover at a rate of 22.4 Kg/ha (20 lb/acre). Next, bromegrass and tall fescue were drill seeded at a rate of 11.2 Kg/ha (10 lb/acre).

The final phase of operations consisted of mulching each treatment after planting the vegetative cover. Those areas on each treatment which were flatter, and had an average slope of ten percent or less, received a mulching of straw or old hay at the rate of 136 bales/ha (55 bales/acre). Portions of each treatment with slopes greater than ten percent were covered with a biodegradable paper fabric, and held in place with 10.2-cm (4-inch) staples.

Lysimeters were installed in the middle of the upper slope of each treatment to collect monthly samples, as specified in the site permit from the IEPA. The lysimeter for each treatment consisted of a 3.04-m x 5.1-cm (10-ft x 2-inch) diameter PVC pipe placed in a lateral trench at a depth of 1.22-m (4-ft) in the coal refuse material prior to application of any amendments. The PVC pipe, used as a lateral drain, had 0.32-cm diameter holes (0.125-inch) drilled in three rows on the top and down both sides to allow water to flow into the pipe. The lateral drain was placed on top of a polyethylene sheet underlain by sand. The drainpipe was placed in the center of a polyethylene sheet, which was laid upward at an angle of about 30° on each side of the pipe. Pea gravel was placed directly over the pipe, 0.304-m (1-ft). The remainder of the trench was back filled with coal refuse material. Water collected by the lateral drain moved to a 25.4-cm (10-inch) vertical PVC standpipe placed adjacent to the trench. The bottom of the standpipe was placed at a minimum of 1.82-m (6-ft) below grade. Monthly water samples were collected by placing a plastic bucket, 15.2-cm x 30.5-cm (6-inch x 12-inch), in the standpipe below the outlet of the lateral drain to collect percolating water. The vertical standpipe had a plastic cover placed over the top to prevent any rainfall or contamination from entering the collection container.

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 property also followed this protocol in 1991 and 1990, respectively, in Fulton 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 lysimeters on a monthly basis. Yearly means of four selected chemical parameters for 1997 through 2001 are presented in Table 35. These are pH, sulfate (SO_4), ammonium nitrogen (NH_4-N), and nitrite + nitrate nitrogen (NO_2+NO_3-N). The mean pH values ranged from 4.8 to 7.3 in 2001. These mean pH values are typical of what has been observed for the past four years.

The highest mean sulfate concentration of 37,417 mg/L occurred in the lysimeter water from control plot 1 in 1998 which was prior to the reclamation of this plot in 2000. Mean sulfate concentrations ranged from 1,120 to 13,323 mg/L in 2001. The mean NH_4-N concentrations ranged from 0.19 to 1.88 mg/L in 2001, and the mean NO_2+NO_3-N concentrations ranged from 1.09 to 355 mg/L in 2001 (Table 35). The highest mean NH_4-N and NO_3+NO_2-N concentrations occurred in plot 1, which was reclaimed with 1,000 tons/acre of biosolids and 80 tons/acre of limestone in 2000.

Environmental Monitoring at the Morgan Mine and United Electric Coal Refuse Pile Reclamation Site

The reclamation of the Morgan Mine and UEC Cuba Mine No. 9 coal refuse piles were based on the same general biosolids, lime, and clay loading rates, plant species seedings, and lysimeter/surface monitoring procedures as the St. David coal refuse reclamation site. The IEPA has imposed the same

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 35

YEARLY MEAN CONCENTRATIONS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE ST. DAVID, ILLINOIS, COAL REFUSE PILE RECLAMATION SITE 1997 - 2001

Chemical Parameters	Year	Plot Number 1	2	3	4	5	6	7	8	9	10
pH	1997	NA	6.6	7.1	7.2	7.2	7.1	7.5	7.1	6.9	6.5
	1998	2.4	6.7	7.1	7.1	7.0	7.2	7.1	7.1	6.9	6.9
	1999	2.2	7.2	7.4	7.3	7.5	7.5	7.6	7.2	7.1	6.7
	2000	NA	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
		mg/L									
$SO_4^=$	1997	NA	2146	1574	1687	1506	1593	1434	1227	1668	2354
	1998	37417	1834	1265	1675	1446	2031	1425	1062	1790	1770
	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
NH_4-N	1997	NA	0.17	0.12	0.19	0.14	0.11	0.39	0.35	0.21	2.65
	1998	0.80	0.19	0.15	0.12	0.20	0.16	0.17	0.58	0.29	0.36
	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
NO_2+NO_3-N	1997	NA	1.50	1.80	2.65	9.23	0.56	11.5	3.44	52.7	42.2
	1998	5.99	1.44	0.82	2.19	8.61	0.67	16.3	5.27	60.7	42.3
	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

NA = Samples are not available due to insufficient precipitation.

monitoring requirements at the Morgan Mine and UEC sites as at the St. David site except that the soil did not have to be sampled.

Water was collected from lysimeters on a monthly basis. Yearly means of selected chemical parameters for 1997 through 2001 are presented in Table 36 for UEC and Table 37 for Morgan Mine. The mean pH of water collected from the UEC lysimeters in 2001 ranged from 4.8 to 7.3 and from 6.4 to 6.8 for the Morgan Mine lysimeters.

In 2001, mean sulfate concentrations in all the UEC lysimeters ranged between 987 mg/L and 3,424 mg/L (Table 36), and in the Morgan Mine lysimeters they ranged from 1,569 mg/L to 3,018 mg/L (Table 37). For the nitrogen species, the mean NH_4-N concentrations ranged from 0.29 to 22.2 mg/L and 0.96 to 2.29 mg/L for the UEC and Morgan Mine lysimeters, respectively, in 2001. The mean NO_2+NO_3-N concentrations ranged from 1.20 to 84.0 mg/L for UEC and from 3.72 to 138 mg/L for Morgan Mine during 2001 (Tables 36 and 37).

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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 36

YEARLY MEAN CONCENTRATIONS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE UNITED ELECTRIC COAL REFUSE PILE RECLAMATION SITE 1997 - 2001

Chemical Parameters	Year	Lysimeter Number 1	2	3	4	5	6	7	8	9	10
pH	1997	6.0	6.8	7.0	7.0	7.0	6.1	7.1	6.9	7.4	NA
	1998	7.1	7.1	7.2	7.0	7.0	6.5	7.3	7.1	7.3	NA
	1999	7.2	7.2	7.3	7.1	7.1	7.1	7.4	7.0	7.4	NA
	2000	NA	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
	mg/L										
$SO_4^{=}$	1997	178	1677	1937	2217	2443	2631	1891	2552	2391	NA
	1998	545	922	1824	2228	2302	1967	1939	2812	2853	NA
	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
NH_4-N	1997	4.02	0.62	1.72	0.37	0.38	0.45	0.84	19.5	3.49	NA
	1998	1.13	0.66	0.75	0.43	0.40	0.51	0.38	23.5	0.40	NA
	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
NO_2+NO_3-N	1997	17.4	77.4	169	68.6	11.0	40.5	24.6	2.30	10.1	NA
	1998	111	35.4	73.4	39.2	9.50	22.8	13.7	2.60	3.60	NA
	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

NA = Samples are not available due to low precipitation.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 37

YEARLY MEAN CONCENTRATIONS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE MORGAN MINE COAL REFUSE RECLAMATION SITE 1997 - 2001

Chemical Parameters	Year	Lysimeter Number		
		1	2	3
pH	1997	6.8	6.7	3.0
	1998	7.0	6.7	5.6
	1999	7.1	6.8	6.3
	2000	6.9	6.9	6.5
	2001	6.8	6.8	6.4
		---------------mg/L---------------		
$SO_4^=$	1997	1,571	1,704	3,030
	1998	1,701	1,747	2,079
	1999	1,655	1,973	1,958
	2000	1,754	1,807	3,502
	2001	1,569	1,924	3,018
NH_4-N	1997	6.52	1.14	3.71
	1998	2.43	0.79	3.22
	1999	1.64	1.92	2.53
	2000	1.33	0.78	3.02
	2001	0.98	0.96	2.29
NO_2+NO_3-N	1997	2.27	1.13	55.9
	1998	2.33	1.07	76.4
	1999	2.18	1.78	85.4
	2000	7.65	3.34	302
	2001	6.96	3.72	138

by a berm to control surface runoff. An underdrain tile 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 2001 included the use of 13 fields for biosolids application which produced corn.

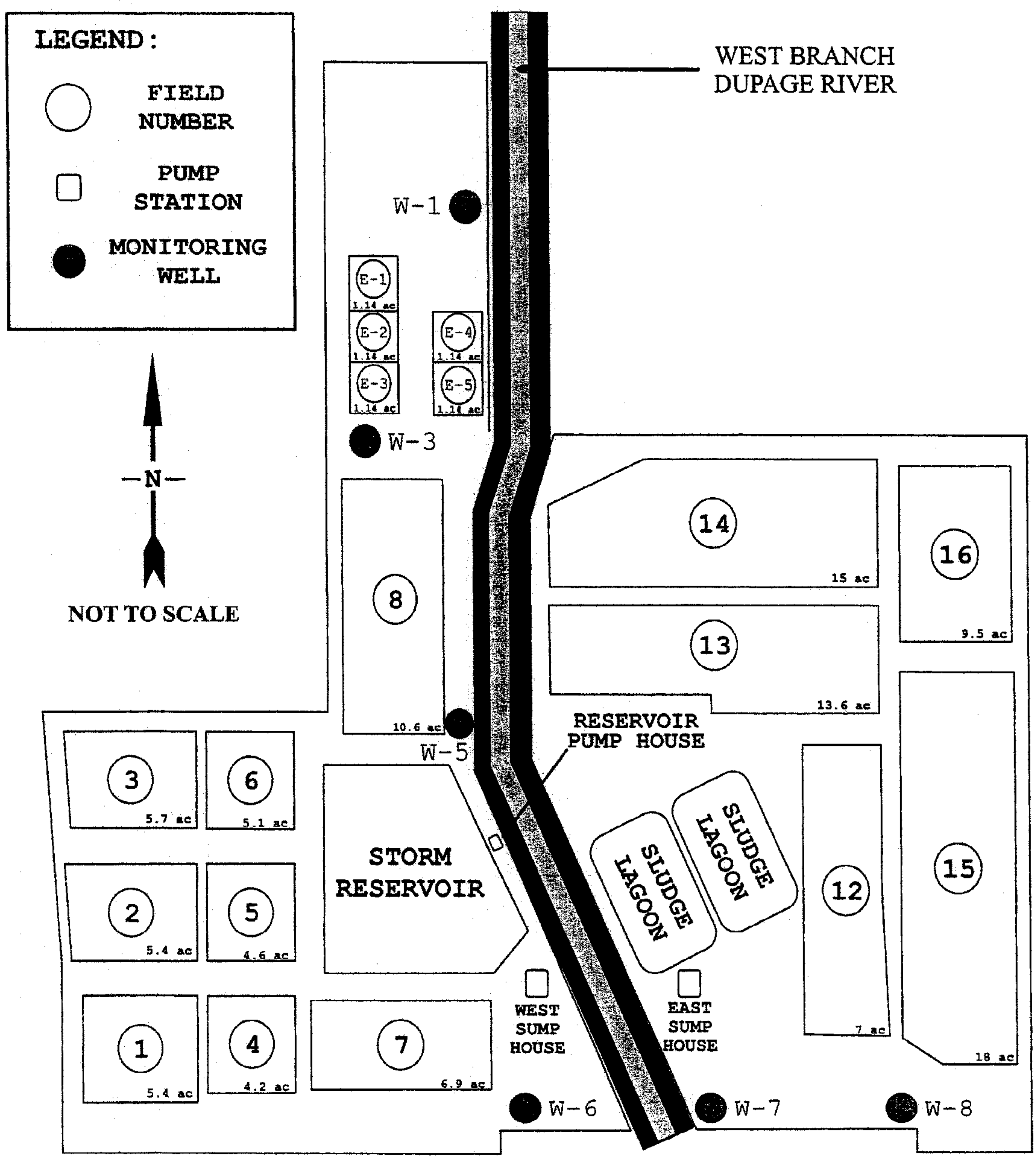
Groundwater monitoring is required by the IEPA operating permit. Fields and monitoring locations at the Fischer Farm are shown on Figure 20. Four monitoring wells (W-5, W-6, W-7, and W-8) on the farm have been sampled twice monthly since biosolids applications began in 1979. The annual mean chemical composition of groundwater from these wells for 1979 and 2001 are compared in Table 38.

This comparison is used to determine any impact on groundwater quality from continuous biosolids application since 1979. In many respects, the groundwater quality in 2001 had improved over that of 1979, as shown by the reduced levels of TKN, total P, Cl, Fe, and EC. Overall, twenty-two years of biosolids application has not adversely affected the groundwater quality at the Hanover Park Fischer Farm.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 20

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



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38

HANOVER PARK WRP FISCHER FARM AVERAGE[1] ANNUAL WELL WATER ANALYSIS FOR 1979 AND 2001

Parameter	Units	1979[2]	2001[3]
pH		7.0	7.8
EC	mS/m	102	75
Total P	mg/L	0.2	0.11
Cl^-	"	61	22
$SO_4^=$	"	122	106
TKN	"	5.4	2.2
NH_4-N	"	0.1	1.51
NO_2+NO_3-N	"	0.3	0.790
Alkalinity as $CaCO_3$	"	386	291
Zn	"	0.2	0.8685
Cd	"	<0.02	0.0009
Cu	"	<0.02	0.0163
Cr	"	<0.02	0.0012
Ni	"	<0.1	0.0035
Mn	"	0.80	0.0648
Fe	"	122	4.18
FC[4]	per 100 mL	2.6	75.6

[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]Four wells sampled April-October 1979 twice per month.
[3]Four wells sampled January-December 2001 twice per month.
[4]Geometric mean.

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 a month since 1988 to monitor the chemical composition of the groundwater. The annual mean analysis of water from these wells for 2001 is shown in Table 39.

In November of 2000, the District met with the IEPA to discuss monitoring issues relating to elevated levels of some parameters in lysimeter and well samples collected at biosolids drying and application sites. One issue discussed was the increase of NH_4-N at the Hanover Park Fischer Farm well 7. Table 40 shows the mean, minimum, and maximum values of NH_4-N in well 7 from 1991 through 2001. There was an increase in NH_4-N in 1999 which continued through 2000. In 2001, the NH_4-N concentrations showed a decreasing trend. The District will continue to monitor the wells and identify and control the source of NH_4-N affecting well 7. The increase in NH_4-N may be due to ponding of water on Field 12 near well 7, or from leakage of the underground drain tile feeding the East sump house at the site, which is in close proximity to well 7.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 39

HANOVER PARK WRP FISCHER FARM AVERAGE[1] ANNUAL
WELL WATER ANALYSIS - 2001[2]

Parameter	Units	Concentration
pH		7.7
EC	mS/m	162.
Total P	mg/L	0.14
Cl^-	"	252.
$SO_4^=$	"	171.
TKN	"	1.09
NH_4-N	"	0.40
NO_2+NO_3-N	"	0.287
Alkalinity as $CaCO_3$	"	308.
Zn	"	0.173
Cd	"	0.0010
Cu	"	0.011
Cr	"	0.0066
Ni	"	0.002
Mn	"	0.1835
Fe	"	12.5
FC[3]	per 100 mL	14.4

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
[2]Based on biweekly sampling of two wells located by the previous experimental corn plot.
[3]Geometric mean.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 40

MEAN, MINIMUM, AND MAXIMUM CONCENTRATIONS OF NH_4-N IN WATER FROM HANOVER PARK FISCHER FARM WELL 7
1991 - 2001

Year	NH_4-N		
	Mean	Minimum	Maximum
1991	0.28	0.10	0.80
1992	0.10	0.00	0.20
1993	0.34	0.07	1.10
1994	0.48	0.16	0.86
1995	0.24	0.13	0.39
1996	0.28	0.13	0.45
1997	0.31	0.13	0.43
1998	0.68	0.18	2.10
1999	8.99	0.18	20.1
2000	26.3	5.42	37.8
2001	5.68	0.05	14.3

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

In 1986, paved solids drying areas were constructed at the John E. Egan WRP facility. This area was designed to handle biosolids production at the Egan WRP by air-drying the biosolids to greater than 60 percent solids content. This substantially reduces the volume of biosolids produced, and results in a material which can be distributed locally for landscaping purposes. The Egan drying site is seldom used for biosolids applications.

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 2001, samples were taken twice per month at the Egan drying site.

Table 41 presents the analysis of water from the two lysimeters at the John E. Egan WRP. The table shows the average concentrations for the year for 28 parameters. The south lysimeter displays a noticeable increase in NO_2 + NO_3-N and K values when compared to the north lysimeter. The Egan WRP had leaking process water lines repaired near the proximity of the south lysimeter. This may have contributed to the elevated concentrations in these parameters at the south lysimeter.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 41

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LYSIMETERS AT THE JOHN E. EGAN SOLIDS DRYING FACILITY - 2001

Parameter	Units	Lysimeter Location[2] North	Lysimeter Location[2] South
pH		7.3	7.4
EC	mS/m	127	128
Total Dissolved Solids	mg/L	1,253	1,077
Total Dissolved Organic C	"	5	5
Cl^-	"	63	100
$SO_4^=$	"	261	255
TKN	"	<0.4	0.5
NH_4-N	"	0.04	0.03
Total P		0.08	0.09
NO_2+NO_3-N	"	0.48	10.4
Alkalinity as $CaCO_3$	"	605	281
Al	"	0.02	0.02
As	"	0.030	0.027
B	"	0.19	0.18
Ca	"	195	159
Cd	"	0.0005	0.0006
Cr	"	0.0008	<0.0005
Cu	"	0.003	0.005
Fe	"	0.568	0.03
Hg	µg/L	0.05	0.05
K	mg/L	1.91	9.02
Mg	"	98.8	54.1
Mn	"	0.0447	0.0744
Na	"	35.6	64.5
Ni	"	0.003	0.006
Pb	"	0.003	0.003
Se	"	0.004	0.003
Zn	"	0.007	0.009

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
[2]Lysimeter depths: North, 20 feet; South, 21 feet.

The data indicate that the shallow groundwater at the site is highly mineralized. The principal constituents are Ca, Mg, K, Na, SO_4, and alkalinity.

Groundwater Quality Monitoring at the Calumet WRP Solids Drying Facilities

In 1986, paved solids drying areas were constructed at the Calumet WRP, the West Solids Drying facility. In November 1990, a second paved solids drying area was put into service at the Calumet WRP, the Calumet East Solids Drying Facility. These areas were designated to handle biosolids production at the Calumet WRP by air-drying the biosolids to greater than 60 percent solids content. This substantially reduces the volume of biosolids produced, 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, receiving biosolids applications for drying every year since their installation.

The IEPA operating permit (Permit No. 2000-AO-1382) for these drying 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. During 2001, samples were taken once per month at both of the Calumet drying sites.

Table 42 presents the analysis of water samples taken in 2001 from the three lysimeters at the Calumet West drying facility, and Figure 21 shows the location of the lysimeters at the site. Table 43 presents the analysis of water samples taken in 2001 from the six lysimeters at the Calumet East drying facility, and Figure 22 shows the location of the lysimeters at the site. The data indicate 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 centrifuged digested biosolids 45- to 60-cm (18- to 24-inches) deep on specially designed flat areas, and turning the biosolids over daily to enhance drying until the solids content is greater than 60 percent. The 1983 biosolids drying operations were performed on clay surfaces. These drying surfaces were paved with asphalt in 1984, and biosolids drying operations resumed on August 31, 1984.

The IEPA operating permit for this site requires groundwater monitoring. Five wells were drilled into the limestone

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 42

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LYSIMETERS AT THE CALUMET WEST SOLIDS DRYING FACILITY - 2001

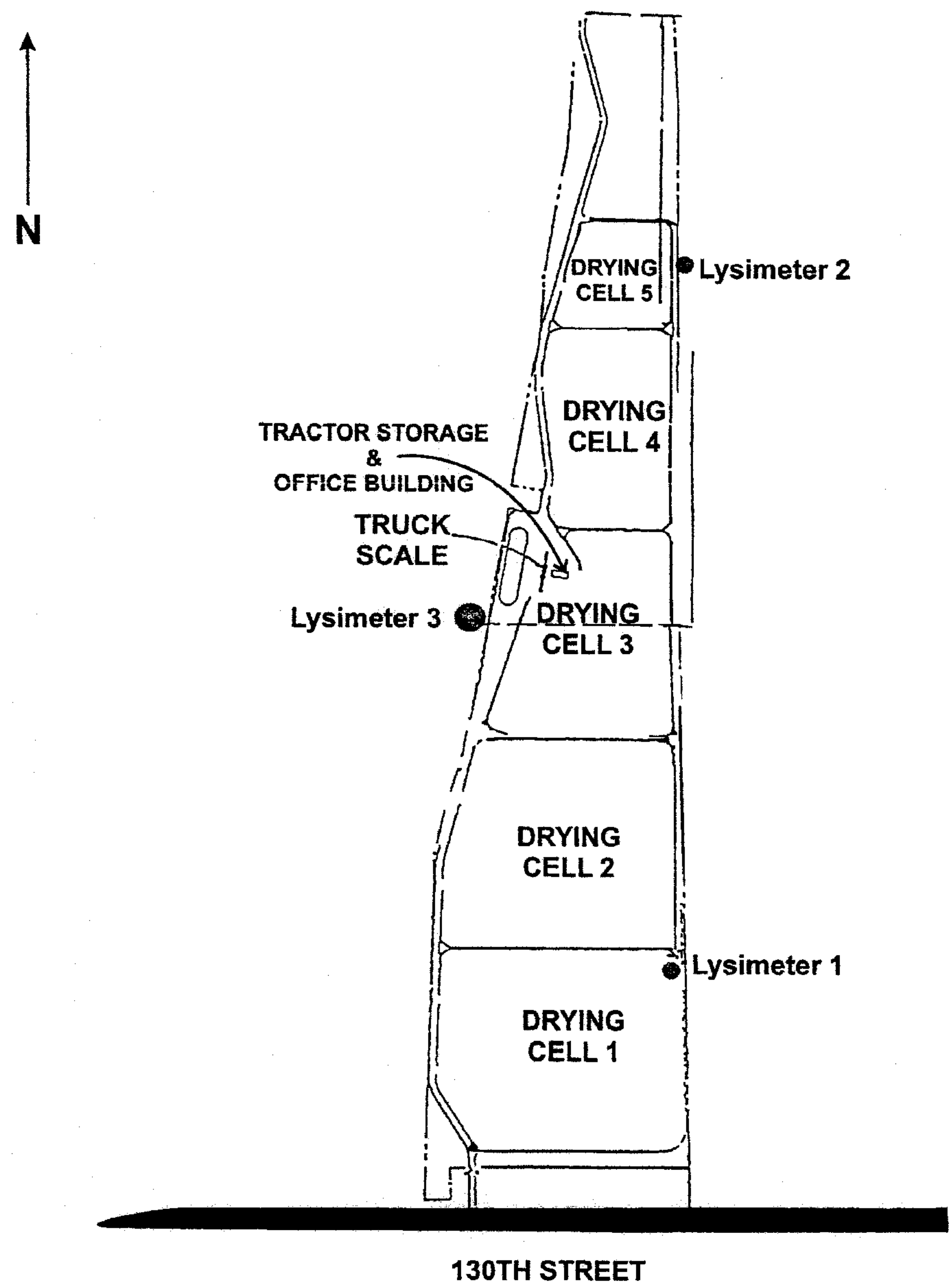
Parameter	Units	Lysimeter[2] 1	2	3
pH		7.3	7.2	7.3
EC	mS/m	265	310	318
Total Dissolved Solids	mg/L	2,451	3,267	3,304
Total Dissolved Organic C	"	10	10	9
Cl^-	"	126	34	27
$SO_4^=$	"	1,224	1,732	1,740
TKN-N	"	0.51	0.62	0.52
NH_4-N	"	0.24	0.20	0.22
Total P	"	0.10	0.10	0.09
NO_2+NO_3-N	"	1.57	0.925	0.371
Alkalinity as $CaCO_3$	"	142	170	120
Al	"	0.11	0.11	0.11
Ca	"	269	342	370
Cd	"	<0.007	<0.007	<0.007
Cr	"	0.006	0.007	0.006
Cu	"	0.020	0.026	0.017
Fe	"	0.89	0.51	2.55
Hg	µg/L	0.07	0.06	0.06
K	mg/L	8.3	10.4	6.8
Mg	"	129	186	187
Mn	"	0.084	0.168	0.437
Na	"	219	206	221
Ni	"	<0.03	0.03	<0.03
Pb	"	<0.06	<0.06	<0.06
Zn	"	0.025	0.040	0.026

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
[2]Lysimeter depths: No. 1, 20 feet; No. 2, 21 feet; No. 3, 21 feet.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 21

LOCATION OF THE LYSIMETERS AT THE CALUMET WEST SOLIDS DRYING FACILITY



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 43

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LYSIMETERS AT THE CALUMET EAST SOLIDS DRYING FACILITY - 2001

Parameter	Units	Lysimeter[2] 1	2	3
pH		7.3	7.4	7.3
EC	mS/m	431	382	242
Total Dissolved Solids	mg/L	4,809	4,253	2,206
Total Dissolved Organic C	"	19	22	17
Cl^-	"	202	178	78
$SO_4^=$	"	2,369	1,955	895
TKN-N	"	0.72	1.54	0.65
NH_4-N	"	0.12	0.46	0.07
Total P	"	0.18	0.18	0.09
NO_2+NO_3-N	"	0.551	3.81	1.01
Alkalinity as $CaCO_3$	"	541	480	507
Al	"	0.23	0.25	0.10
Ca	"	548	547	267
Cd	"	<0.007	<0.007	<0.007
Cr	"	0.013	0.012	0.006
Cu	"	0.215	0.067	0.018
Fe	"	0.21	0.19	0.08
Hg	µg/L	0.09	0.19	0.06
K	mg/L	9.6	6.4	3.0
Mg	"	333	265	178
Mn	"	0.057	0.047	0.013
Na	"	201	146	78.3
Ni	"	<0.03	<0.03	<0.03
Pb	"	<0.06	<0.06	<0.06
Zn	"	0.290	0.284	0.097

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 43 (Continued)

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LYSIMETERS AT THE CALUMET EAST SOLIDS DRYING FACILITY - 2001

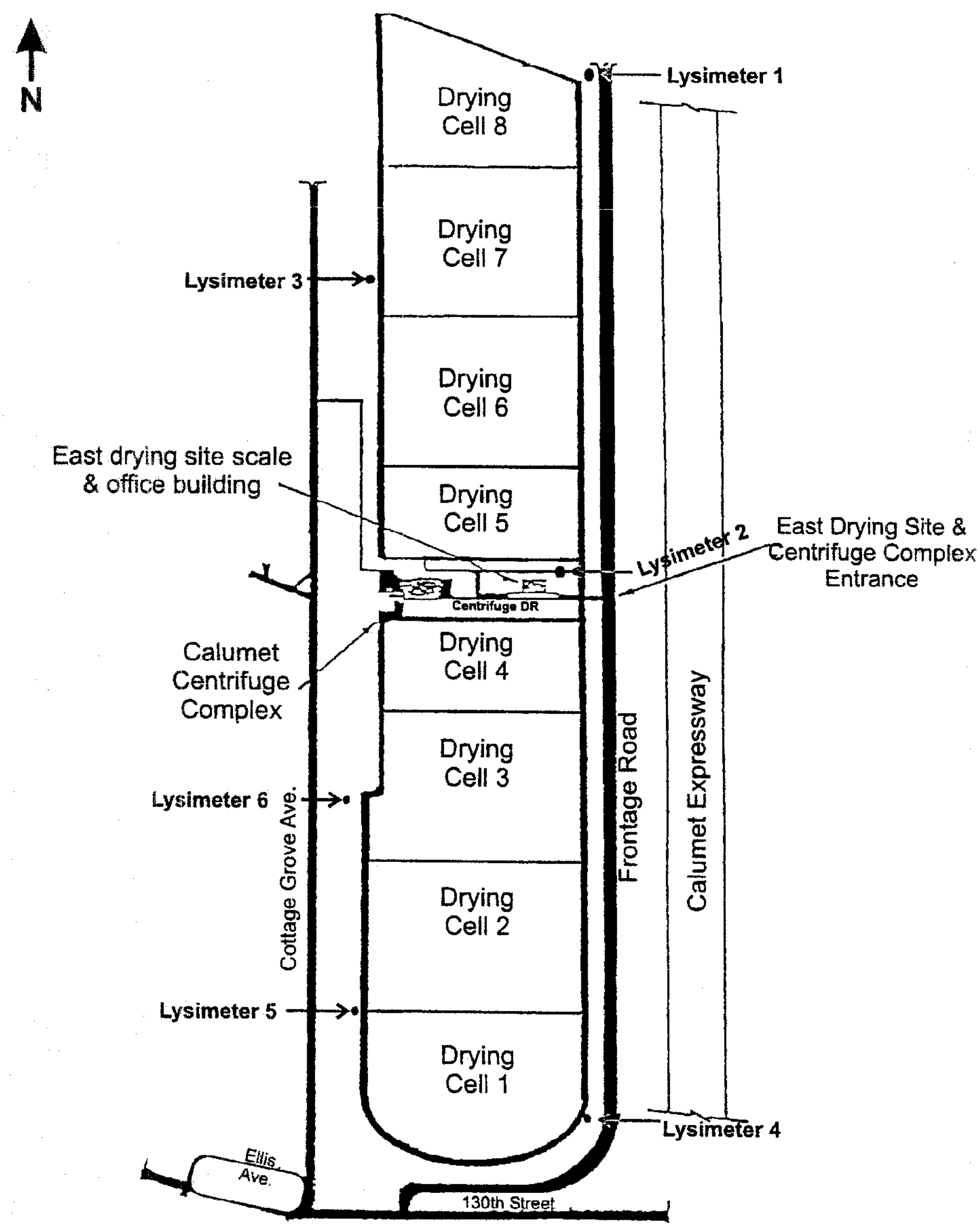
Parameter	Units	Lysimeter[2] 4	5	6
pH		7.3	7.5	7.6
EC	mS/m	342	204	161
Total Dissolved Solids	mg/L	4,128	1,699	1,418
Total Dissolved Organic C	"	12	10	10
Cl^-	"	397	198	28
$SO_4^=$	"	1,534	539	612
TKN-N	"	1.29	0.70	0.61
NH_4-N	"	0.58	0.41	0.28
Total P	"	0.09	0.08	0.10
NO_2+NO_3-N	"	0.253	0.385	0.508
Alkalinity as $CaCO_3$	"	380	241	255
Al	"	0.12	0.10	0.11
Ca	"	443	197	194
Cd	"	<0.007	<0.007	<0.007
Cr	"	0.009	0.005	0.005
Cu	"	0.016	0.015	0.018
Fe	"	10.2	1.74	0.79
Hg	µg/L	0.05	0.05	0.05
K	mg/L	6.6	4.0	4.3
Mg	"	278	98.6	103
Mn	"	0.092	0.050	0.047
Na	"	142	89.8	93.8
Ni	"	<0.03	<0.03	0.03
Pb	"	<0.06	0.06	<0.06
Zn	"	0.054	0.029	0.033

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
[2]Lysimeter depths: Nos. 1, 2, and 3, 28 feet; Nos. 4, 5, and 6, 22 feet.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 22

LOCATION OF THE LYSIMETERS AT THE CALUMET EAST SOLIDS DRYING FACILITY



aquifer underlying the site, and were sampled every two weeks, beginning in spring 1983. After one year of biweekly sampling, a quarterly sampling frequency was instituted.

In July 1984, three functional lysimeters (L-1, L-3, and L-4) were installed for sampling groundwater (every two weeks) 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. Lysimeter and monitoring well locations at the LASMA site are shown in Figure 23.

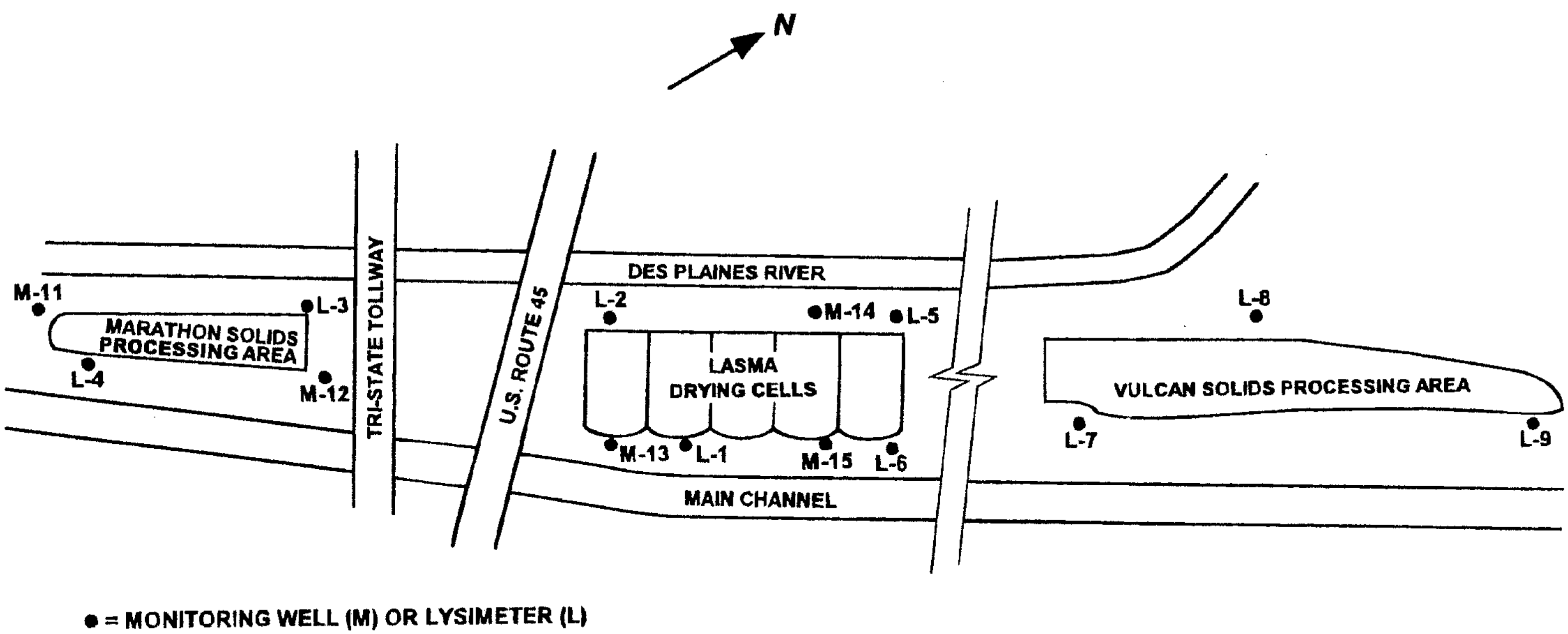
In all, 30 parameters are required to be monitored as per the permit on the LASMA wells. The average monitoring results for the five wells for quarterly samples taken in 2001 are presented in Table 44. The water quality is typical of limestone aquifers. Calcium, Mg, and Na are the major cations, and bicarbonate (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.

The operating permit for LASMA required monthly lysimeter monitoring in 2001 for 28 parameters. The average lysimeter monitoring results are presented in Table 45. Lysimeter water is highly mineralized and is affected by the fill material in

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 23

LOCATION OF THE MONITORING WELLS AND LYSIMETERS AT LASMA



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 44

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LASMA MONITORING WELLS - 2001

Parameter	Units	Monitoring Well Number[2]				
		M-11	M-12	M-13	M-14	M-15
pH		7.8	7.8	7.7	7.8	7.5
EC	mS/m	79	102	115	66	137
Total Dissolved Solids	mg/L	880	867	1,385	1,445	1,673
Total Dissolved Organic C	"	12	13	10	14	12
Cl^-	"	12	15	74	11	9
$SO_4^=$	"	194	358	618	124	746
TKN		1.42	0.52	0.54	0.34	0.70
NH_4-N	"	1.24	0.33	0.41	0.28	0.52
NO_2+NO_3-N	"	0.117	0.030	0.013	0.327	0.014
Total P	"	0.08	0.10	0.08	0.09	0.08
Alkalinity as $CaCO_3$	"	438	299	323	294	355
Al	"	0.12	0.11	0.09	0.11	0.09
As	"	<0.08	<0.08	0.08	<0.08	<0.08
B	"	1.27	1.69	1.50	1.29	1.19
Ca	"	95.2	82.6	166	74.5	230
Cd	"	<0.007	<0.007	<0.007	<0.007	<0.007
Cr	"	0.007	0.005	<0.011	<0.006	0.012
Cu	"	0.008	0.007	0.009	0.009	0.010
Fe	"	0.09	0.06	0.21	0.05	0.54
Hg	µg/L	<0.04	<0.04	0.04	0.04	<0.04
K	mg/L	9.0	10.4	10.5	8.8	11.0
Mg	"	47.7	40.3	82.9	43.6	109
Mn	"	0.006	0.003	0.009	0.002	0.018
Na	"	59.6	147	94.8	47.8	65.4
Ni	"	<0.03	<0.03	0.04	0.03	0.04
Pb	"	<0.06	<0.06	<0.06	<0.06	<0.06

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 44 (Continued)

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LASMA MONITORING WELLS - 2001

Parameter	Units	Monitoring Well Number[2]				
		M-11	M-12	M-13	M-14	M-15
Se	"	<0.2	<0.2	<0.2	<0.2	<0.2
Zn	"	1.20	0.300	1.36	0.378	2.38
FC	#/100mL	<1	<1	<1	<1	<1
Static Water Elevation	Feet	581.0	579.8	583.3	586.0	578.5

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
[2]Well depths: No. 11, 160 feet; No. 12, 100 feet; No. 13, 180 feet; No. 14, 100 feet; No. 15, 100 feet.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 45

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LASMA LYSIMETERS - 2001

Parameter	Units	Lysimeter No.[2] L-1	L-2	L-3	L-4	L-5
pH		7.4	7.3	7.5	7.3	7.6
EC	mS/m	193	299	148	404	179
Total Dissolved Solids	mg/L	1,446	2,329	885	4,325	1,311
Total Dissolved Organic C	"	16	16	16	34	9
Cl^-	"	53	376	172	65	29
$SO_4^=$	"	525	557	67	1,871	516
TKN	"	5.51	0.54	5.09	17.5	0.22
NH_4-N	"	4.27	0.053	3.98	11.9	0.049
NO_2+NO_3-N	"	0.289	0.445	2.12	0.207	0.342
Total P	"	0.09	0.10	2.19	1.46	0.09
Alkalinity as $CaCO_3$	"	473	407	367	1,036	274
Al	"	0.13	0.13	0.13	0.15	0.11
As	"	<0.08	<0.08	0.08	0.09	0.08
B	"	0.47	0.24	0.23	0.22	0.70
Ca	"	229	248	155	597	208
Cd	"	<0.007	<0.007	<0.007	<0.007	<0.007
Cr	"	0.007	0.009	0.007	0.010	0.006
Cu	"	0.018	0.034	0.015	0.014	0.018
Fe	"	4.15	0.24	3.08	19.7	3.27
Hg	µg/L	0.23	0.19	0.07	0.08	0.32
K	mg/L	6.3	3.7	4.2	7.7	4.2
Mg	"	102	123	68.8	282	126
Mn	"	0.076	0.016	0.158	0.993	0.137
Na	"	57.1	216	98.4	33.0	46.2
Ni	"	0.03	0.04	0.03	0.03	<0.03
Pb	"	<0.06	0.08	<0.06	0.06	<0.06
Se	"	<0.2	<0.2	0.2	0.2	<0.2
Zn	"	0.019	0.025	0.017	0.015	0.017

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 45 (Continued)

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LASMA LYSIMETERS - 2001

Parameter	Units	Lysimeter No.[2]			
		L-6	L-7	L-8	L-9
pH		7.6	7.7	NA	7.5
EC	mS/m	206	348	NA	216
Total Dissolved Solids	mg/L	1,936	NA	NA	1,849
Total Dissolved Organic C	"	20	NA	NA	21
Cl^-	"	78	NA	NA	110
$SO_4^=$	"	NA	NA	NA	502
TKN	"	0.94	NA	NA	1.42
NH_4-N	"	0.438	14.9	NA	0.474
NO_2+NO_3-N	"	0.155	<0.005	NA	1.87
Total P	"	0.25	NA	NA	0.09
Alkalinity as CaCO3	"	377	NA	NA	474
Al	"	0.62	NA	NA	0.14
As	"	<0.08	NA	NA	0.08
B	"	0.302	NA	NA	0.397
Ca	"	274	NA	NA	249
Cd	"	<0.007	NA	NA	<0.007
Cr	"	0.010	NA	NA	0.007
Cu	"	0.050	NA	NA	0.018
Fe	"	0.36	NA	NA	0.07
Hg	µg/L	0.08	NA	NA	5.75
K	mg/L	7.6	NA	NA	3.3
Mg	"	128	NA	NA	128
Mn	"	0.014	NA	NA	0.239
Na	"	61.6	NA	NA	57.4
Ni	mg/L	<0.03	NA	NA	0.03
Pb	"	<0.06	NA	NA	<0.06

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 45 (Continued)

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LASMA LYSIMETERS - 2001

Parameter	Units	Lysimeter No.[2] L-6	L-7	L-8	L-9
Se	"	<0.2	NA	NA	0.2
Zn	"	0.020	NA	NA	0.014

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
[2]Lysimeter depths: No. 1, 41 feet; No. 2, 29.5 feet; No. 3, 30 feet; No. 4, 26 feet; No. 5, 38 feet; No. 6, 31 feet; No. 7, 15 feet; No. 8, 25 feet; No. 9, 18 feet.
NA = No analysis.

which the lysimeters are located. The lysimeters are located in a marshland covered with imported fill.

In November 2000, a meeting was held with the IEPA regarding the LASMA site. Reports were discussed of elevated concentrations of NH_4-N in lysimeter L-4, Hg concentrations in lysimeter L-9, and B and Zn values in the monitoring well water samples in relation to the surrounding water bodies.

The NH_4-N concentrations in lysimeter L-4 from 1984 through 2001 are shown in Table 46. The mean NH_4-N concentration in this lysimeter has been lower from 1995 to 2001, than it was in 1984 when the lysimeter was installed, indicating that biosolids have had no long term impact on groundwater at this site.

The Hg levels in lysimeter L-9 are presented from 1984 through 2001 in Table 47. There was an increase in the mean Hg concentration starting in 1991 and an investigation found that the Hg contamination increase was due to the use of a particular air pump to collect groundwater in 1991. Other lysimeters were also affected by the use of this air pump in 1991, and the levels dropped, with the exception of L-9, after purging all of the lysimeters with deionized water. The District will continue to monitor L-9 until an uncontaminated replacement lysimeter is installed in close proximity to L-9 for

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 46

MEAN, MINIMUM, AND MAXIMUM NH_4-N CONCENTRATIONS IN WATER FROM LASMA LYSIMETER L-4 1984 - 2001

Year	NH_4-N		
	Mean	Minimum	Maximum
	---------------------mg/L---------------------		
1984	13.8	NA	NA
1985	14.1	NA	NA
1986	13.2	NA	NA
1987	15.2	NA	NA
1988	14.9	NA	NA
1989	14.5	NA	NA
1990	16.1	10.4	19.4
1991	15.0	13.0	17.5
1992	17.2	15.2	20.7
1993	16.9	13.3	20.0
1994	13.8	8.2	17.1
1995	9.7	4.8	15.2
1996	9.7	7.6	14.0
1997	8.0	6.2	10.3
1998	7.8	5.7	9.9
1999	9.4	8.0	14.0
2000	10.5	0.1	17.6
2001	11.0	5.9	14.2

NA = No analysis.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 47

MEAN, MINIMUM, AND MAXIMUM MERCURY CONCENTRATIONS IN WATER FROM LASMA LYSIMETER L-9
1984 - 2001

Year	Hg		
	Mean	Minimum	Maximum
	----------μg/L----------		
1984	NA	NA	NA
1985	0.1	NA	NA
1986	0.2	NA	NA
1987	0.2	NA	NA
1988	0.2	NA	NA
1989	0.2	NA	NA
1990	0.15	0.10	0.80
1991	2.40	0.00	18.4
1992	12.1	4.20	40.8
1993	8.03	0.00	30.4
1994	4.88	1.30	8.30
1995	4.07	0.00	8.20
1996	4.88	0.00	8.70
1997	4.91	0.00	8.67
1998	5.78	2.07	8.83
1999	7.13	4.98	10.8
2000	5.42	1.74	8.57
2001	5.75	1.17	12.8

NA = No analysis.

additional monitoring at the site. This replacement lysimeter is scheduled to be installed in 2002.

The IEPA also expressed an interest in the B and Zn levels in the monitoring wells at LASMA. Table 48 presents the mean B concentrations from 1983 through 2001. The concentrations in each well have not varied significantly throughout this period. Table 49 shows the mean Zn concentrations from April 1999 through October 2001. The mean Zn concentrations have remained consistently low and are not increasing. After a review of the data submitted, the IEPA was satisfied that biosolids have not had any long-term impacts on these parameters at LASMA.

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 drying area was paved with asphalt in 1992 and 1993. Drying operations on asphalt began on June 29, 1993. Lysimeter locations at the RASMA site are shown in Figure 24.

The IEPA operating permit for this site requires groundwater monitoring. Four lysimeters, approximately 20 feet deep, were installed for sampling groundwater every two weeks, which began in September 1993. Three of the four lysimeters

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 48

MEAN BORON CONCENTRATIONS IN WATER FROM LASMA WELLS
1983 - 2001

Year	Monitoring Well No.				
	M-11	M-12	M-13	M-14	M-15
	mg/L				
1983	1.30	1.60	1.40	1.10	1.00
1984	1.20	1.50	1.40	1.20	1.10
1985	1.20	1.40	1.30	1.10	1.00
1986	1.30	1.60	1.50	1.00	1.10
1987	1.30	1.70	1.40	1.10	1.10
1988	1.10	1.30	1.30	1.10	0.90
1989	1.20	1.60	1.50	1.20	1.10
1990	1.28	1.67	1.45	1.24	1.13
1991	1.32	1.72	1.51	1.31	1.14
1992	1.25	1.68	1.45	1.22	1.08
1993	1.15	1.54	1.23	1.03	0.92
1994	1.21	1.59	1.33	1.16	1.03
1995	1.64	2.12	1.87	1.61	1.41
1996	1.39	1.83	1.59	1.36	1.23
1997	1.32	1.76	1.52	1.31	1.20
1998	1.37	1.79	1.53	1.32	1.18
1999	1.38	1.83	1.52	1.32	1.19
2000	1.30	1.80	1.53	1.33	1.18
2001	1.26	1.72	1.51	1.30	1.19

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 49

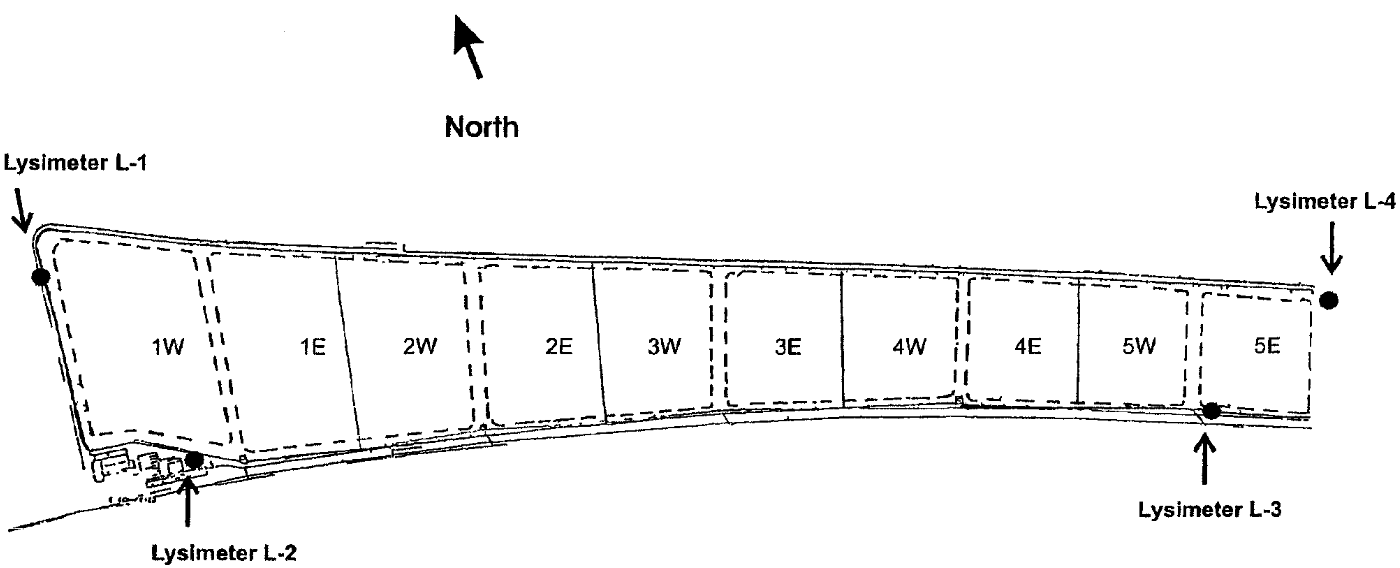
MEAN ZINC CONCENTRATIONS IN WATER FROM LASMA WELLS
APRIL 1999 - OCTOBER 2001

Date	Monitoring Well No.				
	M-11	M-12	M-13	M-14	M-15
4/7/99	1.16	0.196	1.06	0.523	1.95
7/14/99	2.57	0.880	1.49	0.700	1.17
10/6/99	3.38	1.51	1.30	1.09	3.23
1/20/00	0.790	0.950	1.12	0.480	2.18
4/5/00	1.85	0.610	0.820	0.710	2.79
7/6/00	0.033	0.431	0.358	0.362	1.67
10/18/00	1.59	0.300	0.270	0.330	0.85
1/10/01	0.331	0.060	2.95	0.211	2.82
4/12/01	1.99	0.340	0.330	0.260	0.60
7/30/01	1.29	0.640	1.70	0.720	4.58
10/24/01	1.19	0.160	0.440	0.320	1.52

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 24

LOCATION OF THE LYSIMETERS AT RASMA



rarely yielded water. 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 the three lysimeters were installed. This also held true for inspections of the lysimeters in 1999.

The current IEPA operating permit requires biweekly groundwater monitoring of 25 parameters. Table 50 presents a summary of the analysis of lysimeter water for 2001. The average concentrations presented show that the shallow groundwater at this site is highly mineralized. 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 evaporation until the solids content reaches 60 percent or greater.

The IEPA operating permit for this site requires biweekly groundwater monitoring. Three lysimeters were initially installed for sampling the groundwater immediately below the drying site. In 1996 a new lysimeter, designated L-1N, was installed. Lysimeter locations at the HASMA site are shown in Figure 25. Table 51 presents the analysis of water sampled

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 50

MEAN[1] ANALYSIS OF WATER FROM RASMA LYSIMETERS - 2001

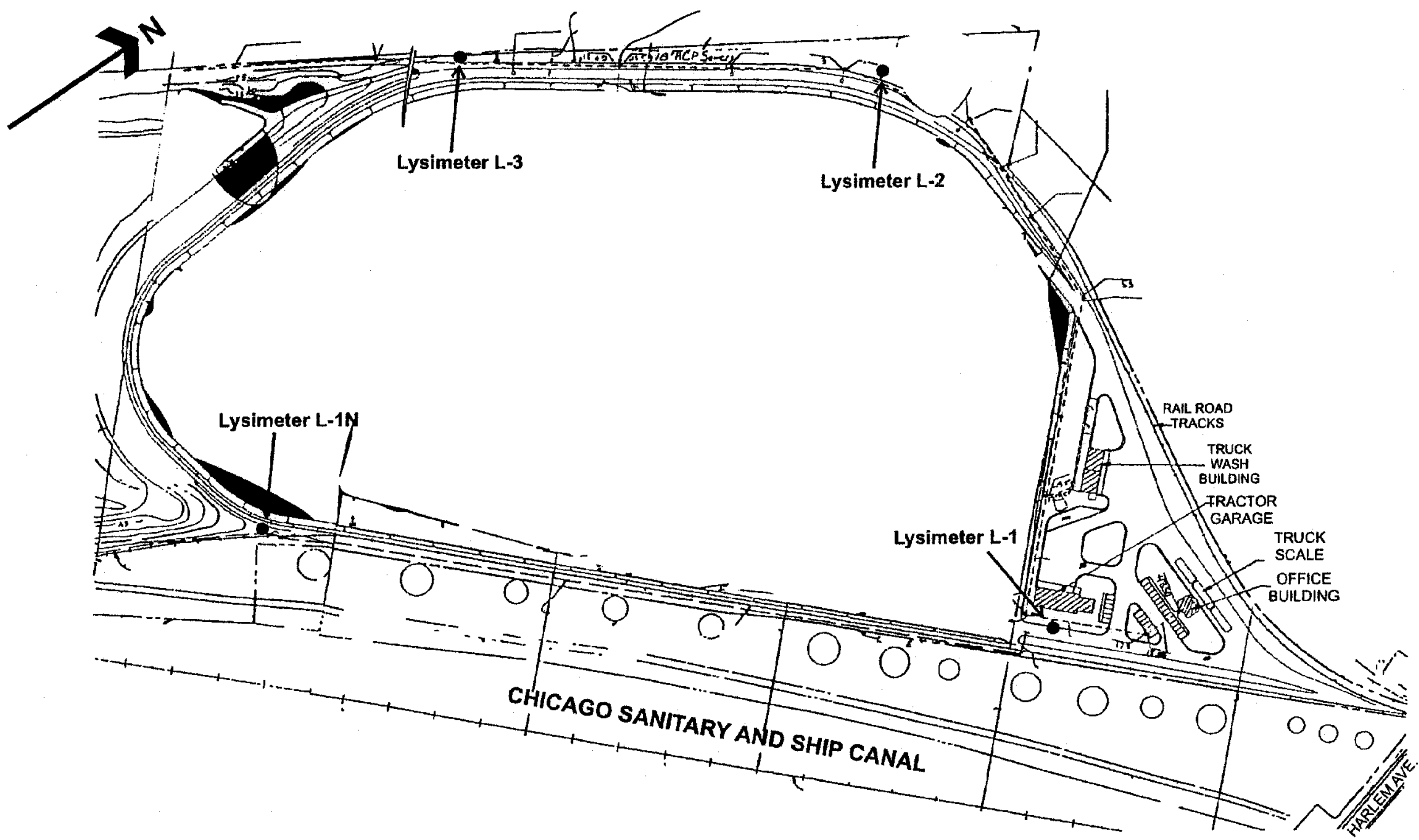
Parameter	Units	Lysimeter No. L-1	L-2	L-3	L-4
pH		7.4	7.6	7.4	7.5
EC	mS/m	269	NA	423	193
Total Dissolved Solids	mg/L	3,416	NA	NA	1,507
Total Dissolved Organic C	"	NA	NA	NA	16
Cl^-	"	96	NA	NA	247
$SO_4^=$	"	NA	NA	NA	312
TKN	"	1.67	NA	NA	0.97
NH_4-N	"	0.425	NA	NA	0.325
NO_2+NO_3-N	"	1.46	NA	NA	0.494
Total P	"	0.270	NA	NA	0.090
Alkalinity as $CaCO_3$	"	478	NA	NA	295
Al	"	NA	NA	NA	0.16
Ca	"	NA	NA	NA	229
Cd	"	NA	NA	NA	<0.007
Cr	"	NA	NA	NA	0.006
Cu	"	NA	NA	NA	0.017
Fe	"	NA	NA	NA	0.11
Hg	µg/L	NA	NA	NA	0.04
K	mg/L	NA	NA	NA	4.0
Mg	"	NA	NA	NA	72.0
Mn	"	NA	NA	NA	0.212
Na	"	NA	NA	NA	102
Ni	"	NA	NA	NA	0.04
Pb	"	NA	NA	NA	0.06
Zn	"	NA	NA	NA	0.031

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
NA = No analysis.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 25

LOCATION OF THE LYSIMETERS AT HASMA



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 51

MEAN[1] ANALYSIS OF WATER SAMPLES FROM HASMA LYSIMETERS - 2001

Parameter	Units	Lysimeter No.[2] L-1	L-1N	L-2	L-3
pH		7.1	7.4	7.2	7.3
EC	mS/m	390	180	203	228
Total Dissolved Solids	mg/L	3,678	1,396	1,616	1,921
Total Dissolved Organic C	"	67	39	12	15
Cl^-	"	93	48	151	101
$SO_4^=$	"	1,710	49	457	307
TKN	"	175	10.2	7.24	0.763
NH_4-N	"	144	7.89	5.91	0.153
NO_2+NO_3-N	"	12.5	1.76	0.62	0.41
Total P	"	0.11	0.18	0.09	0.09
Alkalinity as $CaCO_3$	"	1,022	1,065	416	1,066
Al	"	0.13	0.27	0.11	0.10
Ca	"	436	251	268	362
Cd	"	<0.007	<0.007	<0.007	<0.007
Cr	"	0.007	0.010	0.006	0.006
Cu	"	0.033	0.230	0.016	0.016
Fe	"	0.08	0.55	0.04	0.24
Hg	µg/L	0.05	0.10	0.05	0.05
K	mg/L	18.0	3.3	1.4	1.8
Mg	"	261	146	78.1	157
Mn	"	0.664	0.318	0.103	0.662
Na	"	78.1	51.3	57.4	45.9
Ni	"	0.03	0.10	0.03	0.03
Pb	"	0.06	<0.06	<0.06	<0.06
Zn	"	0.290	0.225	0.050	0.071

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
[2]Lysimeter depths: No. 1, 14 feet, No. 2, 14 feet; No. 3, 16 feet.

from the four lysimeters in 2001. The data indicate that the shallow groundwater at this site is highly mineralized. The principal constituents are Ca, Mg, Na, SO_4, and Cl. Lysimeter L-1 has had a high background NH_4-N content and lysimeter L-1N produced water of quality similar to the other HASMA lysimeters. The elevated NH_4-N values at lysimeter L-1 were of concern to the IEPA. Table 52 shows the yearly mean, minimum, and maximum NH_4-N values from 1990 to 2001. These data were presented to the IEPA. The NH_4-N values have been historically high at this site and have been decreasing with time. The NH_4-N level was high from the time of lysimeter installation and was not due to biosolids drying at the site. The District was planning to install another lysimeter at the HASMA site in 2001, but this was delayed. The lysimeter will not be installed until a full environmental audit has been completed on the property adjacent to the south end of the site, which the District is recovering from lease. 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 and Stony Island was paved to facilitate biosolids drying. From 1980 through 1991, drying was done on a clay surface. This drying

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 52

YEARLY NH_4-N CONCENTRATIONS IN HASMA LYSIMETER L-1
1990 - 2001

Year	NH_4-N Mean	Minimum	Maximum
	----------mg/L----------		
1990	288	84.8	368
1991	292	249	450
1992	258	192	490
1993	244	211	302
1994	232	207	257
1995	202	2.22	485
1996	209	171	400
1997	212	158	279
1998	189	134	243
1999	173	88.1	200
2000	139	27.5	162
2001	144	112	182

facility is used to process biosolids for final distribution. In 2001, the site was used to dewater centrifuged digested biosolids from the Stickney WRP. These biosolids were utilized in landfills as daily and final vegetative cover.

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 26 shows the location of the lysimeters at the Stony Island drying site. Table 53 presents the average values for the analysis of water from the four lysimeters at the Stony Island drying facility for samples taken at monthly intervals in 2001. The lysimeter water is highly mineralized.

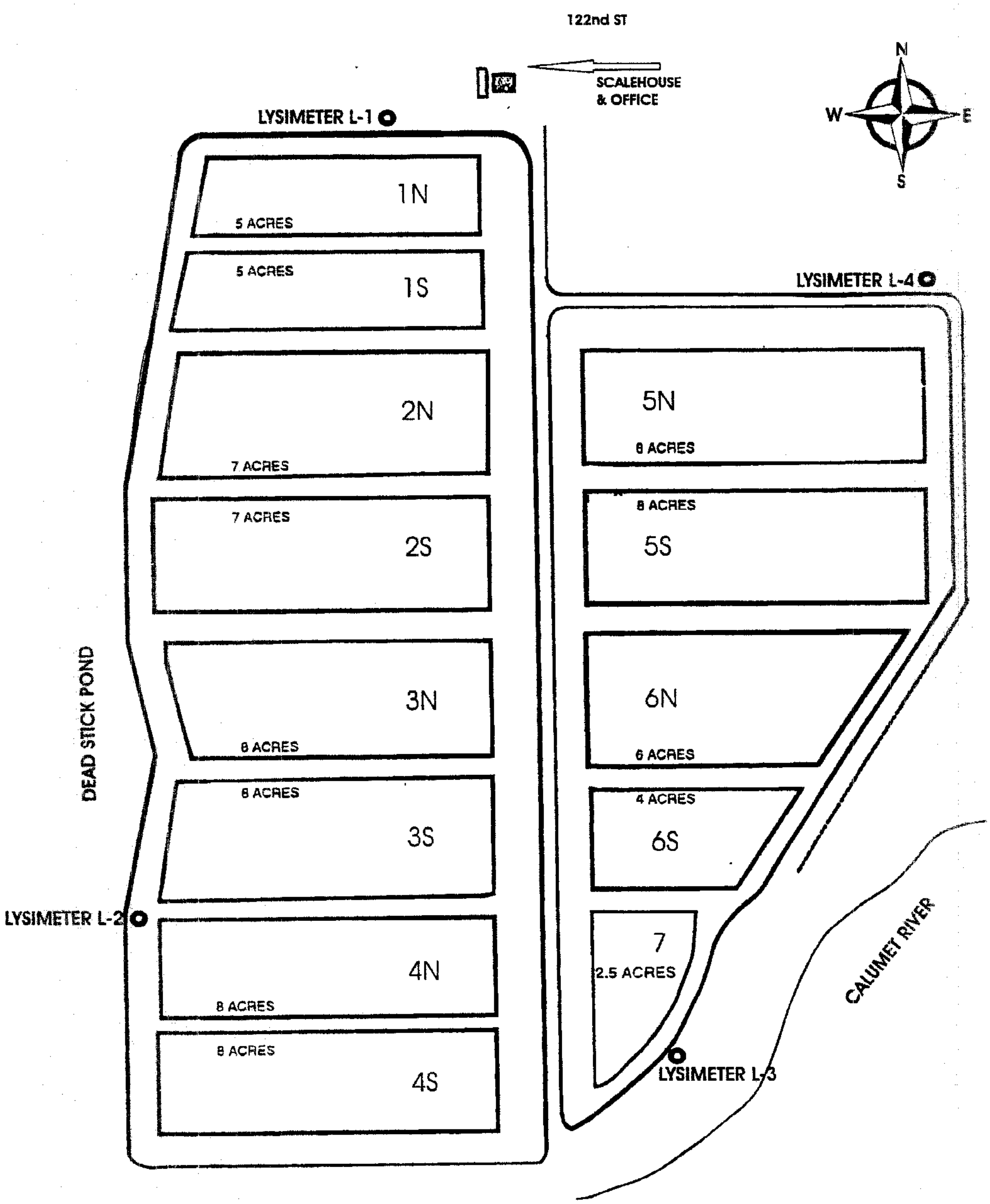
Table 54 includes the annual mean NH_4-N concentrations, in all four lysimeters from 1991 to 2001. Lysimeter L-1 showed a continual increase in the NH_4-N concentrations starting in 1996, while NH_4-N levels in lysimeters 2, 3, and 4 remained stable. The IEPA questioned the high levels of NH_4-N at L-1.

Investigators examined whether the NH_4-N in water from L-1 was originating from the drying site. Table 55 shows the annual means of NH_4-N, NO_2+NO_3-N, K, Na, and Cl of L-1 from 1991 through 2001. As the NH_4-N concentrations increased, so did the K, Cl, and Na concentrations. The NO_2+NO_3-N concentrations

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 26

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



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 53

MEAN[1] ANALYSIS OF WATER FROM STONY ISLAND LYSIMETERS - 2001

Parameter	Units	Lysimeter Number L-1	L-2	L-3	L-4
pH		7.3	7.3	7.3	7.3
EC	mS/m	322	268	299	220
Total Dissolved Solids	mg/L	2,365	1,903	2,720	1,454
Total Dissolved Organic C	"	47	34	54	31
Cl^-	"	288	419	57	307
$SO_4^=$	"	374	372	799	138
TKN	"	44.9	7.87	8.29	5.88
NH_4-N	"	37.5	5.19	4.27	3.60
NO2+NO3-N	"	1.00	0.127	0.189	0.125
Total P	"	0.12	0.77	0.10	0.09
Alkalinity as $CaCO_3$	"	1,199	435	1,144	579
Al	"	0.12	0.13	0.11	0.11
B	"	9.36	1.28	0.54	1.19
Ca	"	290	165	521	198
Cd	"	<0.007	<0.007	<0.007	<0.007
Cr	"	0.009	0.008	0.006	0.006
Cu	"	0.016	0.018	0.027	0.016
Fe	"	13.8	5.78	18.2	4.01
Hg	µg/L	0.11	0.09	0.05	0.05
K	mg/L	30.8	50.8	5.6	6.0
Mg	"	168	100	168	94.7
Mn	"	0.415	0.602	0.606	0.213
Na	"	233	279	53.3	196
Ni	"	<0.03	0.04	0.03	<0.03
Pb	"	<0.06	<0.06	0.06	<0.06
Zn	"	0.038	0.022	0.023	0.063

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 54

YEARLY MEAN NH_4-N CONCENTRATIONS FROM ALL STONY ISLAND LYSIMETERS 1991 - 2001

Year	Lysimeter Number L-1	L-2	L-3	L-4
	mg/L			
1991	0.80	6.80	4.60	3.70
1992	0.89	5.70	4.58	3.25
1993	1.18	5.47	4.35	3.73
1994	1.41	5.37	4.54	4.24
1995	1.02	4.14	4.05	5.52
1996	3.86	5.18	3.70	5.52
1997	23.3	7.30	3.75	6.94
1998	32.4	7.23	3.20	6.17
1999	42.5	7.98	3.82	5.92
2000	44.7	8.76	3.73	4.33
2001	37.5	5.19	4.27	3.60

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 55

YEARLY MEAN CONCENTRATIONS OF NH_4-N, NO_2+NO_3-N, K, Na, AND Cl
FROM STONY ISLAND LYSIMETER L-1
1991 - 2001

Parameter	Units	Year										
		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
NH_4-N	mg/L	0.80	0.89	1.18	1.41	1.02	3.86	23.3	32.4	42.5	44.7	37.5
NO_2+NO_3-N	"	0.05	0.11	0.24	0.12	0.06	0.08	0.07	0.06	0.16	0.11	1.00
K	"	2.00	1.54	1.34	2.86	3.70	4.00	11.8	13.7	25.3	29.4	30.8
Cl^-	"	45.0	40.4	104	319	529	461	409	367	356	300	288
Na	"	53.0	58.8	75.1	227	511	382	343	299	293	251	233

did not show a marked increase and remained stable, ranging from 0.05 to 1.00 mg/L from 1991 through 2001. Higher levels of NO_2+NO_3-N would be expected had there been contamination from the biosolids, since NO_2+NO_3-N moves readily through the soil profile and would be detected in the groundwater. This led investigators to believe that the high levels of NH_4-N in the groundwater were due to another source.

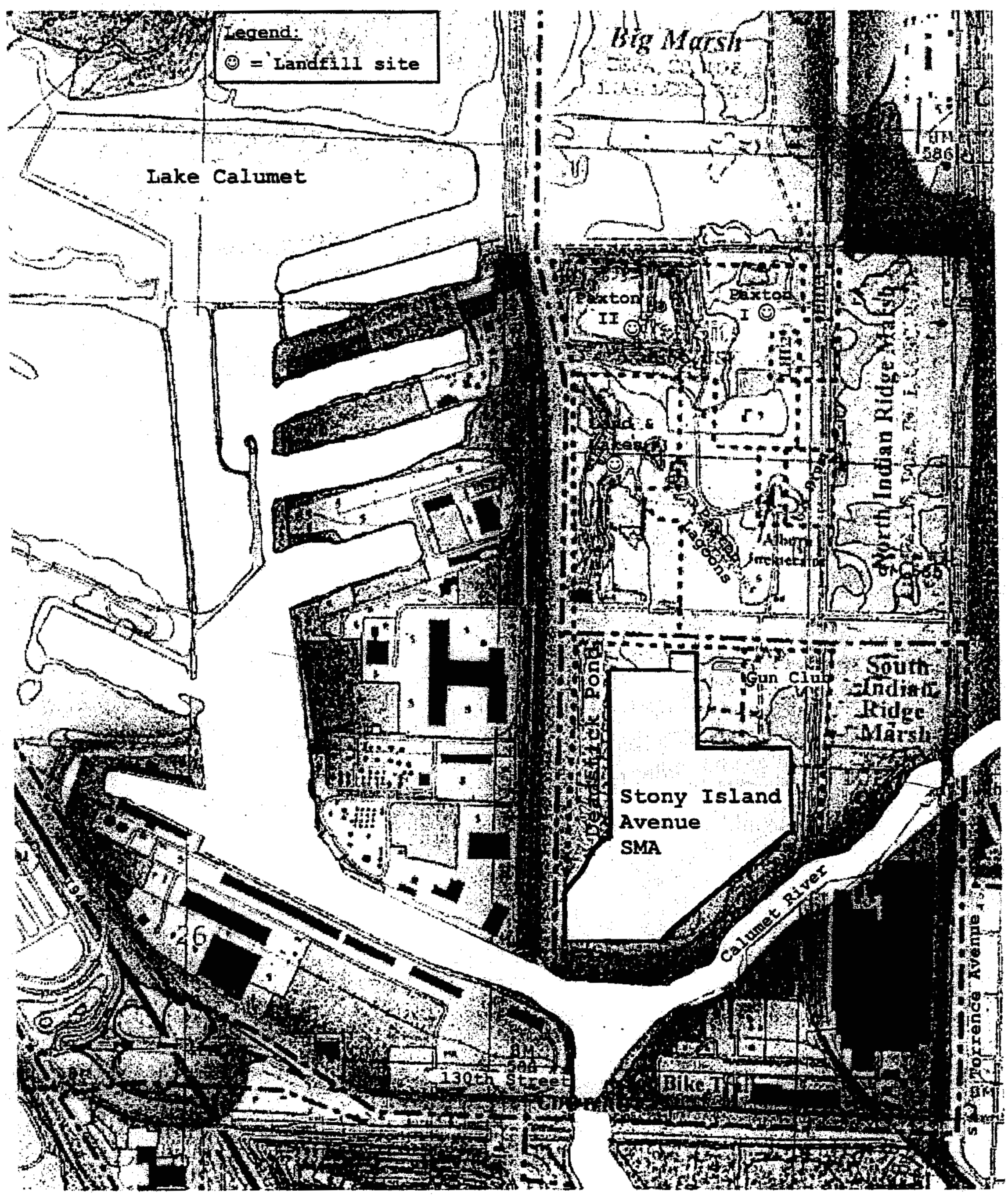
The soil profile and geological survey maps of the Lake Calumet region where the Stony Island site is located were studied to explain the high levels of NH_4-N. This investigation revealed that groundwater migrates from the landfill cluster site north of 122nd Street southward toward the Stony Island site. Lysimeter 1 would be the first lysimeter at the Stony Island site to collect any chemicals migrating to the groundwater from the landfill cluster site to the north. Figure 27 shows a map of the region and the relationship of the landfill areas just north of the Stony Island site. Figure 28 is a contour map which shows the groundwater elevations in feet for the Lake Calumet region.

The concentrations of Na and Cl increased in groundwater from lysimeter 1 from 1993 to 1995, and then gradually decreased from 1995 to 2001 (Table 55). The concentration of K followed the same increasing trend as NH_4-N, due to the

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 27

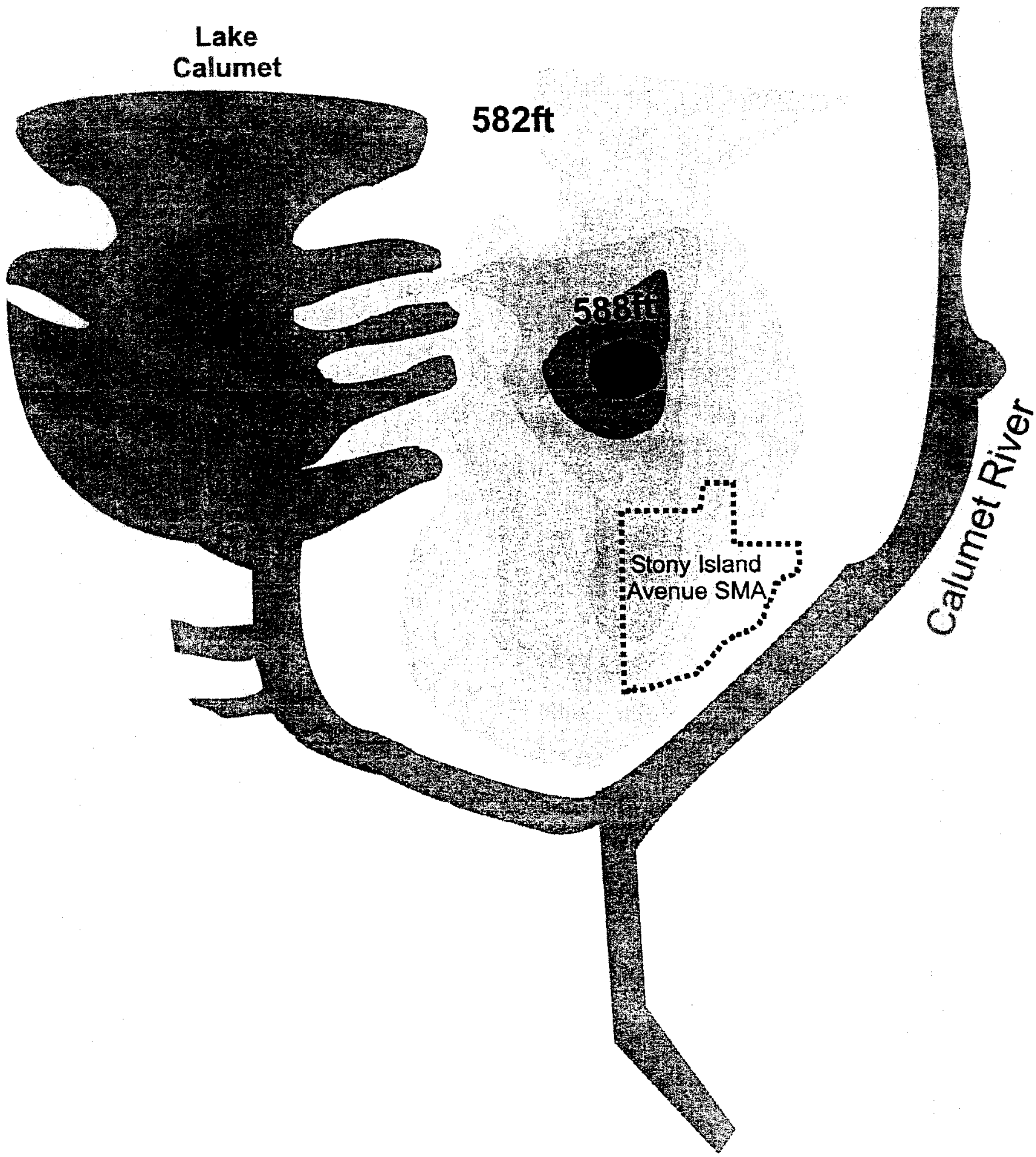
MAP OF LAKE CALUMET REGION LANDFILL SITES AND STONY ISLAND AVENUE SOLIDS MANAGEMENT AREA



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 28

GROUNDWATER ELEVATION LEVELS IN THE LAKE CALUMET REGION



similar ionic radius and groundwater migration rates of the two locations.

The IEPA suggested testing for B, a common tracer of landfill contamination, in the Stony Island lysimeters. Boron analysis was added to the permit, and was monitored along with the other required parameters in 2001. Table 53 shows the mean boron concentrations obtained from the four lysimeters. The boron levels in Lysimeter L-1 were much higher than those boron levels in Lysimeters L-2, L-3, and L-4, which supports the possibility of groundwater contamination originating from the landfill.

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 approximately 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, there are no specific plans for rehabilitation of the site; however, the Chicago Park District hopes to create a lakefront park of about 120 acres on the parcel.

This research and demonstration project was designed to test the effectiveness of soil, biosolids, and soil amended with biosolids for establishment of suitable vegetation, and to determine the impacts of these treatments on groundwater and lake water quality. Suitable vegetation includes turf and tree species commonly used in city parks and other public areas. The duration of this research and demonstration project was originally planned to last two years, but may last longer depending upon the speed of development of adjacent land parcels. Cooperative organizations in this effort include:

- the Land Reclamation and Soil Sciences Section (District);
- the Toxic Substances Section (District);
- the City of Chicago; and
- the Chicago Park District.

If the project is successful, it will create opportunities for use of biosolids in the development of a 120-acre park at the site, as well as the rehabilitation of similar sites on the city's southeast side.

The progress of the project is described under the following sections, namely, (1) plots and amendment treatments, (2) monthly well, lysimeter, and lake monitoring, (3) uptake of nutrients and trace elements by turf grass, and (4) uptake of nutrients and trace elements by trees.

PLOTS AND AMENDMENT TREATMENTS

This project was designed to test the effectiveness of four amendments including soil, a 25 percent biosolids and 75 percent soil mixture, a 50 percent biosolids and 50 percent soil mixture, and biosolids. The demonstration consists of eight plots, i.e., two plots for each of the four amendments. For each amendment, the west amendment plot consists of the amendment being placed directly onto the slag, while the east amendment plot received a six-inch layer of silty clay loam prior to the placement of amendments <u>Figure 29</u>. 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 acts to minimize leaching of water from the nutrient-rich amendments into the porous slag, thereby retaining more moisture and nutrients in the root zone of plants.

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

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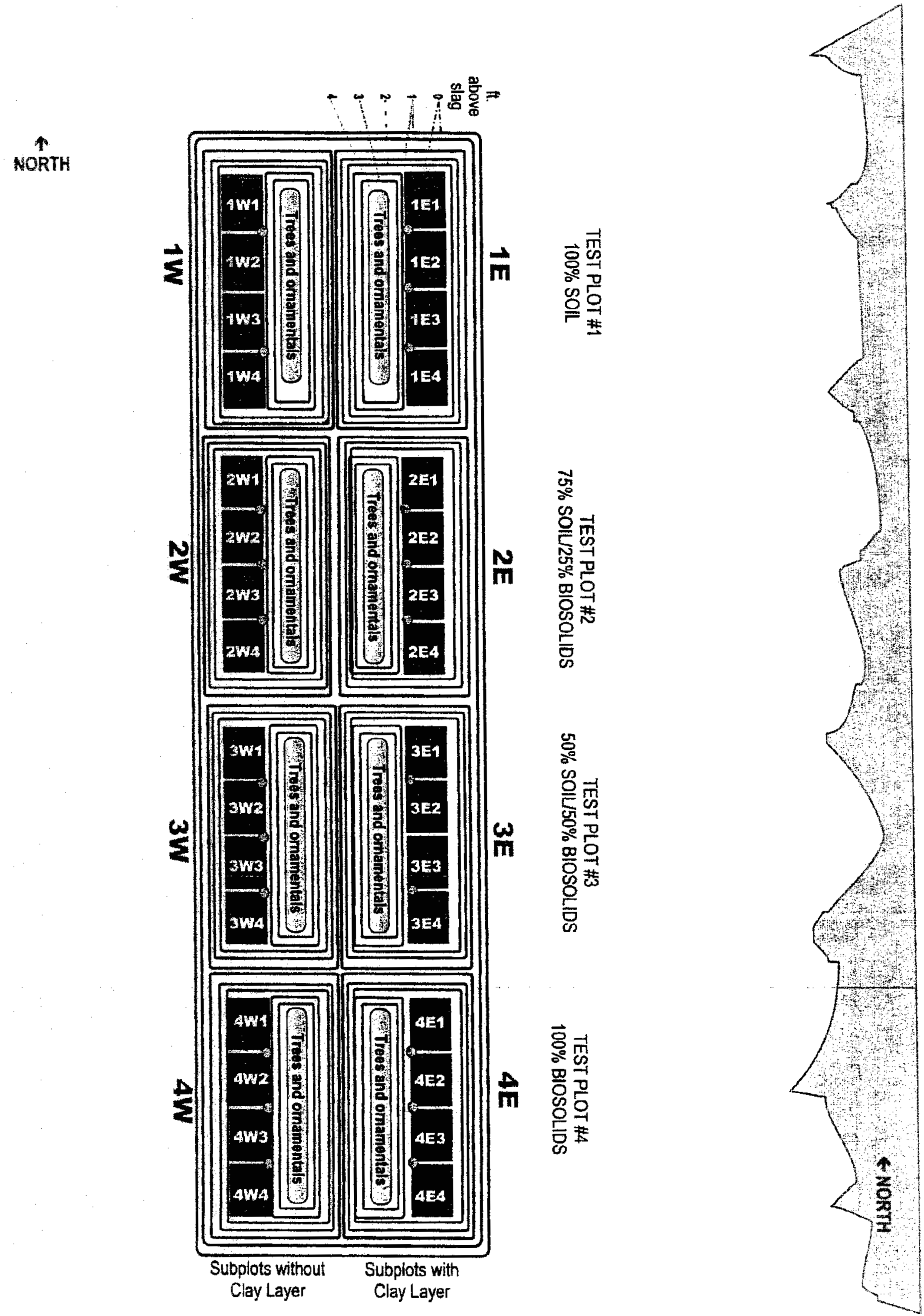
FIGURE 29

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



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 March and September 2001. The soil was sampled by compositing several cores at the 0- to 6-inch and the 6- to 12-inch depths. In March 2001, the soil samples were collected as composites of each of the eight amendment plots and samples were collected as composites of each of the thirty-two turfgrass testing subplots in September 2001. The samples were air-dried and analyzed for chemical constituents.

The concentrations of chemical constituents in the 0- to 6-inch depth for the two sampling events performed during March and September 2001 are presented in Tables 56 through 58. In March, surface soil pH for all plots ranged between 6.7 and 6.9. Surface soil EC ranged between 0.34 and 2.52 decisiemens per meter (dS/m) among the plots, and increased as the proportion of biosolids in the amendment mixture increased. Available phosphorus concentrations ranged from 9 to 617 mg/kg and increased with increasing biosolids content in the amendment mixtures applied to both the east and west

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TABLE 56

MEAN CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN SURFACE SOIL OF USX PLOTS (0 - 6 INCH DEPTH) - MARCH 2001

Plot[1]	pH[2]	EC[2]	Available P	TKN[3]	NH_4-N[2]	NO_3-N[2]	SO_4-S[2]
		dS/m	----------mg/kg----------				
1 East	6.8	0.69	25	1,668	0.4	9.9	226
2 East	6.8	0.78	284	4,546	1.4	22.6	261
3 East	6.8	0.88	231	6,185	1.5	30.5	302
4 East	6.7	2.52	544	15,083	28.3	311	781
1 West	6.9	0.34	9	1,714	0.3	6.5	122
2 West	6.7	0.97	203	4,830	1.4	23.1	395
3 West	6.8	1.06	215	6,590	2.1	53.2	356
4 West	6.6	1.31	617	15,569	3.6	118	441

[1]Plot designations 1, 2, 3, and 4 represent amendments of 0, 25, 50, and 100 percent biosolids, respectively.
[2]Concentration in 1:2 (soil:water) extract.
[3]TKN = Total Kjeldahl nitrogen.

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TABLE 57

MEAN CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN SURFACE SOIL OF USX PLOTS (0 - 6 INCH DEPTH)- SEPTEMBER 2001[1]

Plot[2]	pH[3]	EC[3]	Available P	TKN[4]	NH_4-N[3]	NO_3-N[3]	SO_4-S[3]
		dS/m	mg/kg				
1 East	6.9	0.30	18	1,315	0.3	0.5	419
2 East	6.7	0.67	237	4,641	0.7	11.4	540
3 East	6.9	0.86	238	5,915	1.3	16.9	508
4 East	6.4	1.87	456	9,823	5.8	129	947
1 West	7.3	0.26	10	1,767	0.2	0.9	122
2 West	7.3	0.42	175	4,603	0.5	9.9	316
3 West	7.1	0.39	279	6,903	2.2	30.0	175
4 West	6.2	1.93	529	11,691	1.6	112	1,158

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

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TABLE 58

MEAN TOTAL CONCENTRATIONS OF METALS IN SURFACE SOIL OF USX PLOTS (0-6 INCH DEPTH)- SEPTEMBER 2001[1]

Plot[2]	Zn	Cd	Cu	Cr	Ni	Pb	Mn	Fe	Mo
	mg/kg								
1 East	67	1.3	21	24	21	28	470	11,704	0.4
2 East	340	3.8	93	57	29	49	438	12,390	1.6
3 East	595	6.1	163	199	34	73	1,551	13,155	4.5
4 East	952	8.8	250	148	32	106	595	12,165	6.9
1 West	358	3.9	96	54	25	55	447	12,490	2.6
2 West	344	3.8	87	117	30	56	1,034	12,885	2.4
3 West	554	5.7	145	176	32	73	1,192	13,346	4.0
4 West	1,070	10.0	282	174	33	122	720	13,190	8.2

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

plots. The TKN, NH_4-N, and NO_3-N concentrations ranged from 1,668 to 15,569 mg/kg, 0.3 to 28.3 mg/kg, and 6.5 to 311 mg/kg, respectively. The concentration of SO_4-S ranged from 122 to 781 mg/kg and generally increased with the amount of biosolids in the amendment. These results show that the biosolids amendments generally increased the nutrient content of the plots as indicated by the increase in levels of TKN, NH_4-N, NO_3-N, available phosphorus and SO_4-S with an increase in the proportion of biosolids in the amendment blend.

In September, mean surface soil pH and EC for all subplots ranged between 6.2 and 7.3 and 0.26 and 1.93 dS/m, respectively, and increased as the proportion of biosolids in the amendment mixture increased. Mean available phosphorus concentrations ranged from 10 to 529 mg/kg, and increased with the amount of biosolids added to the mixture. The mean TKN, NH_4-N, and NO_3-N concentrations ranged from 1,315 to 11,691 mg/kg, 0.2 to 5.8 mg/kg, and 0.5 to 129 mg/kg, respectively. The mean concentration of SO_4-S ranged from 122 to 1,158 mg/kg, and generally increased with the amount of biosolids in the amendment.

Mean concentrations of Zn, Cd, Cu, Cr, Ni, Pb, Mn, Fe, and Mo in the subplots at the 0- to 6-inch depth are presented in Table 58. The mean concentrations of Zn, Cd, Cu, Cr, Pb, and Mo generally increased with a higher proportion of biosolids in the amendments. The mean concentrations of Zn ranged from 67 to 1,070 mg/kg, Cd ranged from 1.3 to 10.0 mg/kg, Cu ranged from 21 to 282 mg/kg, Cr ranged from 24 to 199 mg/kg, Pb ranged from 28 to 122 mg/kg, and Mo ranged from 0.4 to 8.2 mg/kg. Among the plots, the mean concentrations of Ni and Fe were in a narrow range and did not increase with the biosolids amendment. The mean concentrations of Mn were more variable, and the trend did not coincide with the amount of biosolids in the amendments. The mean concentrations of Ni ranged from 21 to 34 mg/kg, Mn ranged from 438 to 1,551 mg/kg, and Fe ranged from 11,704 to 13,346 mg/kg.

The concentrations of chemical constituents in the 6- to 12-inch depth for the sampling conducted in March and September are presented in Tables 59 and 60. In March, the soil pH varied between 6.7 and 7.2 for all plots. The EC, which ranged between 0.35 and 2.71 dS/m were higher than at the 0- to 6-inch depth and increased with increasing proportion of biosolids in the amendments applied to the plots. Concentrations of TKN, NH_4-N, and NO_3-N showed trends similar to those found at the 0- to 6-inch depth. Mean TKN, NH_4-N, and NO_3-N concentrations ranged from 1,681 to 15,934 mg/kg, 0.3 to 52.4 mg/kg, and 4.3 to 303 mg/kg, respectively. These forms of nitrogen were consistently found at higher levels in biosolids amended plots and generally increased with a higher proportion

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TABLE 59

MEAN CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN SUBSURFACE SOIL OF USX PLOTS (6 - 12 INCH DEPTH) - MARCH 2001

Plot[1]	pH[2]	EC[2]	TKN[3]	NH_4-N[2]	NO_3-N[2]
		dS/m	------------mg/kg	-------------	
1 East	7.0	1.34	1,681	0.3	10.0
2 East	7.0	1.76	2,073	1.9	14.2
3 East	6.9	1.94	2,603	2.6	30.5
4 East	6.7	2.61	15,934	36.4	303
1 West	7.2	0.35	1,963	0.3	4.3
2 West	6.9	1.34	4,959	1.9	59.5
3 West	6.9	1.17	6,254	1.8	74.4
4 West	6.9	2.71	11,279	52.4	249

[1]Plot designations 1, 2, 3, and 4 represent amendments of 0, 25, 50, and 100 percent biosolids, respectively.
[2]Concentration in 1:2 (soil:water) extraction.
[3]TKN = Total Kjeldahl nitrogen.

TABLE 60

MEAN CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN SUBSURFACE SOIL OF USX PLOTS (6 - 12 INCH DEPTH) - SEPTEMBER 2001[1]

Plot	pH[2]	EC[2]	TKN[3]	NH_4-N[2]	NO_3-N[2]
		dS/m	------------mg/kg------------		
1 East	7.1	1.25	1,707	0.4	0.9
2 East	6.9	1.54	3,277	1.0	7.8
3 East	7.1	1.46	3,775	1.2	9.7
4 East	6.4	2.74	10,149	7.8	75.9
1 West	7.5	0.61	1,980	0.1	1.1
2 West	7.4	1.02	4,571	0.8	11.0
3 West	7.3	0.71	6,211	1.1	26.1
4 West	6.2	2.98	12,549	2.2	82.3

[1]Values are the mean of values for four subplots.
[2]Concentration in 1:2 (soil:water) extract.
[3]TKN = Total Kjeldahl nitrogen.

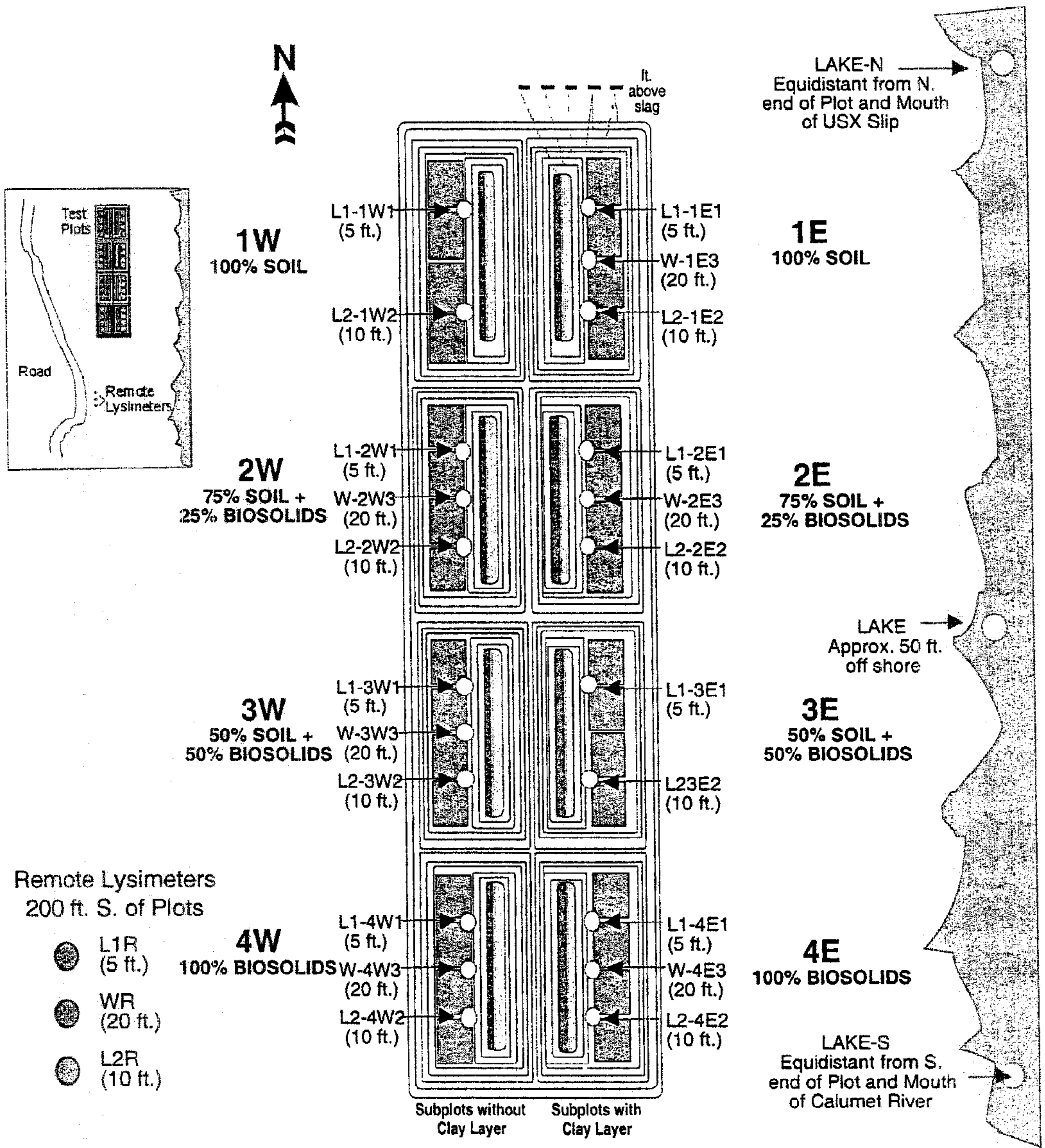
of biosolids in the amendment blend. In September, the trends in concentrations of constituents in the 6- to 12-inch soil depth were similar to those observed in March. The mean soil pH and EC ranged between 6.2 to 7.5 and 0.61 to 2.98 dS/m, respectively. Mean TKN, NH_4-N, and No_3-N concentrations ranged from 1,707 to 12,549 mg/kg, 0.1 to 7.8 mg/kg, and 0.9 to 82.3 mg/kg, respectively.

MONTHLY WELL, LYSIMETER, AND LAKE MONITORING

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 30). 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- to 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 through

FIGURE 30

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



Letters L and W in groundwater sampling device designations represent lysimeters and observation wells.

December 2001. Mean concentrations for various inorganic parameters by sampling location are presented in Table 61.

The legend for coding the groundwater monitoring and lake sampling locations is shown in Figure 30. In all 5-foot lysimeters within the plots, mean pH ranged from 7.4 to 8.9. The mean pH of the 10-foot lysimeters within the plots ranged from 7.4 to 7.9. Mean well pH within the plots ranged from 7.4 to 7.8. The mean pH of the 5- and 10-foot lysimeters and the well at the remote site were 7.3, 7.5, and 7.4, respectively. The mean pH observed in the three Lake Michigan sample points was 7.2 as shown in Table 61.

Mean total dissolved solids concentrations ranged from 1,064 to 3,242 mg/L in the wells and lysimeters within the plots. These levels are similar to those found in the lysimeters and well at the remote site which ranged from 1,054 to 1,687 mg/L. The mean total dissolved solids concentrations in the Lake Michigan samples ranged from 194 to 337 mg/L.

Mean TKN concentrations ranged from 1.05 to 42.2 mg/L, 1.45 to 19.9 mg/L, and 0.44 to 1.40 mg/L in the 5- and 10-foot lysimeters and wells within the plots, respectively. Mean TKN levels found in similar devices at the remote site were 0.83, 0.59, and 0.55 mg/L, respectively. Mean TKN concentrations in the Lake Michigan samples ranged from 0.24 to 0.26 mg/L.

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TABLE 61

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JANUARY THROUGH DECEMBER 2001

Parameter	Units	Sample Point Identification[2]					
		L1E1 @ 5′	L1E2 @ 10′	W1E3 @ 20′	L2E1 @ 5′	L2E2 @ 10′	W2E3 @ 20′
pH		7.4	7.4	7.5	7.9	7.6	7.7
EC	mS/m	223	291	203	216	285	203
Total Dissolved Solids	mg/L	1624	1949	1450	1985	2268	1154
Cl^-	"	17	30	37	24	25	106
$SO_4^=$	"	345	NA	483	650	806	351
TKN	"	1.05	1.45	0.51	3.84	2.34	0.77
NH_4-N	"	0.138	0.117	0.227	0.136	0.226	0.475
NO_2-N	"	0.033	0.040	0.019	0.543	0.317	0.031
NO_3-N	"	3.84	10.1	0.589	22.5	29.3	0.701
Total P	"	0.16	0.17	0.09	0.25	0.15	0.09
Alkalinity as $CaCO_3$	"	510	466	487	366	402	375
Hardness	"	738	1617	856	1122	1257	574
As	"	<0.08	<0.08	0.09	0.17	<0.08	<0.08
Cd	"	0.016	0.010	<0.007	<0.007	<0.007	<0.007
Cr	"	0.034	0.035	0.016	0.035	0.019	0.013
Cu	"	0.084	0.076	0.016	0.151	0.035	0.011
Hg	µg/L	<0.04	<0.04	<0.04	<0.04	0.07	0.05
Mn	mg/L	0.281	1.49	1.13	0.642	1.27	1.21
Ni	"	0.09	0.14	0.05	0.12	0.07	0.04
Pb	"	0.11	<0.06	0.06	0.13	0.11	0.06
Sb	"	0.13	0.15	0.08	0.16	0.13	0.07
Zn	"	0.043	0.066	0.013	0.056	0.018	0.012
FC	#/100 mL	ND	ND	ND	ND	ND	ND

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 61 (Continued)

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JANUARY THROUGH DECEMBER 2001

Parameter	Units	Sample Point Identification[2]				
		L3E1 @ 5′	L3E2 @ 10′	L4E1 @ 5′	L4E2 @10′	W4E3 @ 20′
pH		7.7	7.7	8.9	7.4	7.4
EC	mS/m	218	177	158	249	224
Total Dissolved Solids	mg/L	1849	1484	1327	2505	1558
Cl^-	"	26	22	114	21	81
$SO_4^=$	"	460	714	138	1052	812
TKN	"	5.05	4.42	42.2	2.86	1.40
NH_4-N	"	0.546	1.15	27.3	1.37	1.10
NO_2-N	"	0.750	0.069	0.091	0.162	0.035
NO_3-N	"	22.9	1.69	2.52	8.43	0.832
Total P	"	0.17	0.18	0.67	0.16	0.08
Alkalinity as $CaCO_3$	"	217	263	366	388	69
Hardness	"	995	764	100	1303	703
As	"	0.16	<0.08	<0.08	<0.08	0.09
Cd	"	<0.007	<0.007	<0.007	<0.007	0.007
Cr	"	0.027	0.027	0.014	0.046	0.016
Cu	"	0.091	0.092	0.037	0.067	0.014
Hg	µg/L	0.09	0.08	0.60	0.15	<0.04
Mn	mg/L	0.479	0.980	0.102	0.629	5.64
Ni	"	0.10	0.11	0.07	0.13	0.10
Pb	"	<0.06	0.11	<0.06	0.10	0.06
Sb	"	0.16	0.14	0.12	0.13	0.09
Zn	"	0.039	0.028	0.017	0.017	0.207
FC	#/100 mL	ND	ND	ND	ND	ND

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 61 (Continued)

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JANUARY THROUGH DECEMBER 2001

Parameter	Units	Sample Point Identification[2]				
		L1W1 @ 5′	L1W2 @ 10′	L2W1 @ 5′	L2W2 @ 10′	W2W3 @ 20′
pH		8.0	7.5	7.7	7.9	7.7
EC	mS/m	234	292	240	256	191
Total Dissolved Solids	mg/L	3152	2543	2201	2335	1082
Cl^-	"	22	23	15	18	109
$SO_4^=$	"	NA	1481	758	846	301
TKN	"	1.64	2.09	3.02	3.21	0.59
NH_4-N	"	0.120	0.136	0.230	0.374	0.305
NO_2-N	"	<0.006	0.059	0.089	0.043	0.021
NO_3-N	"	20.4	22.6	25.0	4.52	0.616
Total P	"	<0.08	0.16	0.23	0.17	0.09
Alkalinity as $CaCO_3$	"	412	383	498	697	357
Hardness	"	1816	1848	1030	1589	433
As	"	<0.08	0.16	<0.08	0.20	0.08
Cd	"	<0.007	<0.007	<0.007	0.013	<0.007
Cr	"	0.058	0.032	0.025	0.041	0.010
Cu	"	0.228	0.134	0.081	0.070	0.009
Hg	µg/L	<0.04	<0.04	<0.04	0.09	0.04
Mn	mg/L	0.218	0.316	0.243	0.567	0.441
Ni	"	0.24	0.11	0.08	0.10	0.04
Pb	"	0.16	0.12	0.12	0.13	<0.06
Sb	"	0.22	0.16	0.17	0.23	0.07
Zn	"	0.080	0.086	0.040	0.046	0.024
FC	#/100 mL	NA	ND	ND	ND	ND

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 61 (Continued)

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JANUARY THROUGH DECEMBER 2001

Parameter	Units	Sample Point Identification[2]					
		L3W1 @ 5′	L3W2 @ 10′	W3W3 @20′	L4W1 @ 5′	L4W2 @10′	W4W3 @ 20′
pH		7.9	7.8	7.8	8.1	7.7	7.4
EC	mS/m	229	392	185	217	210	259
Total Dissolved Solids	mg/L	1746	3242	1064	1554	1631	1572
Cl^-	"	21	39	71	20	54	60
$SO_4^=$	"	659	1975	373	390	898	727
TKN	"	4.98	1.96	0.44	6.57	19.9	1.03
NH_4-N	"	1.74	0.327	0.223	0.488	15.1	0.726
NO_2-N	"	0.115	0.621	0.009	0.233	1.01	0.030
NO_3-N	"	8.59	1.79	0.175	1.08	0.484	0.210
Total P	"	0.19	0.16	0.08	0.37	0.20	0.09
Alkalinity as $CaCO_3$	"	300	219	285	372	111	279
Hardness	"	779	2018	542	1178	716	928
As	"	0.16	0.19	0.08	0.21	<0.08	0.10
Cd	"	<0.007	<0.007	<0.007	<0.007	<0.007	0.007
Cr	"	0.024	0.040	0.011	0.037	0.019	0.015
Cu	"	0.077	0.113	0.012	0.163	0.101	0.041
Hg	µg/L	0.09	<0.04	0.05	0.09	0.11	0.04
Mn	mg/L	0.228	0.591	0.614	1.99	0.307	4.84
Ni	"	0.09	0.11	0.04	0.14	0.08	0.08
Pb	"	0.12	0.15	<0.06	0.14	<0.06	0.06
Sb	"	0.15	0.21	0.07	0.21	<0.07	0.09
Zn	"	0.042	0.073	0.041	0.120	0.034	0.281
FC	#/100 mL	ND	ND	2	ND	ND	ND

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 61 (Continued)

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JANUARY THROUGH DECEMBER 2001

Parameter	Units	Sample Point Identification[2]					
		LR1 @ 5′	LR2 @ 10′	WR3 @ 20′	LAKE-N	LAKE	LAKE-S
pH		7.3	7.5	7.4	7.2	7.2	7.2
EC	mS/m	142	189	153	105	128	112
Total Dissolved Solids	mg/L	1368	1687	1054	337	194	251
Cl^-	"	9	24	39	13	14	15
$SO_4^=$	"	273	228	350	23	24	23
TKN	"	0.83	0.59	0.55	0.26	0.26	0.24
NH_4-N	"	0.160	0.201	0.354	0.052	0.047	0.047
NO_2-N	"	0.041	0.020	0.032	0.014	0.009	0.009
NO_3-N	"	1.04	0.983	0.535	0.507	0.465	0.657
Total P	"	0.17	0.17	0.14	0.10	0.09	0.09
Alkalinity as $CaCO_3$	"	544	775	354	104	107	106
Hardness	"	549	948	632	140	140	143
As	"	0.17	<0.08	0.08	0.08	<0.08	<0.08
Cd	"	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Cr	"	0.017	0.023	0.010	0.009	0.008	0.009
Cu	"	0.349	0.108	0.012	0.007	0.007	0.007
Hg	µg/L	<0.04	<0.04	<0.04	0.04	0.05	0.04
Mn	Mg/L	0.104	0.045	0.523	0.045	0.041	0.038
Ni	"	0.66	0.12	0.04	0.03	0.04	0.04
Pb	"	0.12	0.12	<0.06	<0.06	<0.06	<0.06
Sb	"	0.15	0.16	0.08	<0.07	<0.07	<0.07
Zn	"	0.366	0.077	0.027	0.012	0.011	0.019
FC	#/100ml	ND	ND	ND	89	15	7

[1]MDL was used in calculating the mean. If all values were less than the MDL, the mean is reported as <MDL.
[2]Lysimeters are at 5- and 10-ft. depths, observation wells are 20 ft. deep. Remote lysimeters and well 200 ft. south of the plots are designated LR and WR respectively. Lake sampling locations are designated Lake-N, Lake, and Lake-S.
NA = No analysis; insufficient samples volume.
ND = Not detected.

Mean NH_4-N concentrations ranged from 0.120 to 27.3 mg/L, 0.117 to 15.1 mg/L, and 0.223 to 1.10 mg/L in the 5- and 10-foot lysimeters and wells within the plots, respectively. Mean NH_4-N levels found in similar devices at the remote site were 0.160, 0.201, and 0.354 mg/L, respectively. Mean NH_4-N concentrations in the Lake Michigan samples ranged from 0.047 to 0.052 mg/L.

Mean NO_2-N concentrations ranged from <0.006 to 0.750 mg/L, 0.040 to 1.01 mg/L, and 0.009 to 0.035 mg/L in the 5- and 10-foot lysimeters and wells within the plots, respectively. Mean nitrite-N concentrations found in similar devices at the remote site were 0.041, 0.020, and 0.032 mg/L, respectively. The mean concentrations of nitrite-N in the Lake Michigan samples ranged from 0.009 to 0.014 mg/L.

Mean NO_3-N concentrations ranged from 1.08 to 25.0 mg/L, 0.484 to 29.3 mg/L, and 0.175 to 0.832 mg/L in the 5- and 10-foot lysimeters and wells within the plots, respectively. Mean NO_3-N concentrations found in similar devices at the remote site were 1.04, 0.983, and 0.535 mg/L, respectively. The mean NO_3-N concentrations in the Lake Michigan samples ranged from 0.465 to 0.657 mg/L.

Mean total phosphorus concentrations ranged from <0.08 to 0.67 mg/L, 0.15 to 0.20 mg/L, and 0.08 to 0.09 mg/L in the 5- and 10-foot lysimeters and wells within the plots, respectively. Mean total phosphorus concentrations found in similar devices at the remote site were 0.17, 0.17, and 0.14 mg/L, respectively. Mean total phosphorus concentrations in the Lake Michigan samples ranged from 0.09 to 0.10 mg/L.

Mean alkalinity and hardness in all lysimeter and well samples in the plots ranged from 69 to 697 mg/L and 100 to 2,018 mg/L, respectively. Mean alkalinity and hardness in the remote lysimeters and well and in the Lake Michigan samples ranged from 104 to 775 mg/L and 140 to 948 mg/L, respectively.

Mean As concentrations in wells and lysimeters in the amended plots ranged from <0.08 to 0.21 mg/L. Mean As concentrations in the remote lysimeters and well and in the Lake Michigan samples ranged from <0.08 to 0.17 mg/L.

Mean Cd concentrations in wells and lysimeters in the plots ranged from <0.007 to 0.016 mg/L. Mean Cd concentrations in the remote lysimeters and well and in the Lake Michigan samples were <0.007 mg/L.

Mean Cr concentrations ranged from 0.010 to 0.058 mg/L in the lysimeters and wells within the plots. Mean Cr concentrations found in the remote lysimeters and well and in the Lake Michigan samples ranged from 0.008 to 0.023 mg/L.

Mean Cu concentrations ranged from 0.009 to 0.228 mg/L in the lysimeters and wells within the plots. Mean Cu levels found in the lysimeters and well at the remote site and in the Lake Michigan samples ranged from 0.007 to 0.349 mg/L.

Mean Hg concentrations ranged from <0.04 to 0.60 μg/L in the lysimeters and wells within the plots. Mean Hg concentrations in the remote lysimeters and well and in the Lake Michigan samples ranged from <0.04 to 0.05 μg/L.

Mean Mn concentrations in all lysimeters and wells within the plots, ranged from 0.102 to 5.64 mg/L. Mean Mn concentrations in the remote lysimeters and well and in the Lake Michigan samples ranged from 0.038 to 0.523 mg/L.

Mean Ni concentrations in all lysimeters and wells within the plots, ranged from 0.04 to 0.24 mg/L. Mean Ni concentrations in the remote lysimeters and well and in the Lake Michigan samples ranged from 0.03 to 0.66 mg/L.

Mean Pb concentrations in all lysimeters and wells in the plots ranged from <0.06 to 0.16 mg/L. The mean Pb concentrations in the remote lysimeters and well and in the Lake Michigan samples ranged from <0.06 to 0.12 mg/L.

Mean Sb concentrations in all lysimeters and wells in the plots ranged from <0.07 to 0.23 mg/L. The mean Sb concentrations in the remote lysimeters and wells and in the Lake Michigan samples ranged from <0.07 to 0.16 mg/L.

Mean Zn concentrations ranged from 0.012 to 0.281 mg/L in the lysimeters and wells within the plots. Mean Zn concentrations in the remote lysimeters and well and in the Lake Michigan samples ranged from 0.011 to 0.366 mg/L.

Fecal coliforms were detected at only one of the sampling devices at the USX site. This occurred at the plot 3W well in December, which had a fecal coliform detection of 2 per 100 mL. Samples from the wells were often turbid due to the well installation process, causing the mean detection limits for fecal coliforms in all devices to range from <1 to <20 per 100 ml. Fecal coliforms were detected in the Lake Michigan samples, however, at mean levels of 89, 15, and 7 per 100 ml at the north, middle, and south sampling points, respectively.

Quarterly sampling and analyses for 111 organic priority pollutants were conducted in January, March, August and October of 2001. Because of the small liquid sample volume obtained from the lysimeters, samples 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 these composite samples are presented in Table 62. Only seven organic priority pollutants were found in the composite well and lysimeter samples at this site. Methyl chloride was found in the composite sample from plot 1E and remote well at a maximum concentration of 6 μg/L, and in the composite of wells for plots 3W, 4E and 4W at 5 μg/L. Phenol was detected at a maximum concentration of 129 μg/L in the 5-foot lysimeter composite sample of plots 3E, 3W, 4E, and 4W. Phenol was also detected two other times in the 5-foot lysimeter composite samples of plots 3E, 3W, 4E, and 4W at 92 μg/L and 99 μg/L. Anthracene was found in a composite sample of the three wells from plots 3W, 4E and 4W at a concentration of 14 μg/L. Bis(2-ethylhexyl)phthalate was found in a composite sample of the 10-foot lysimeter of plots 3E, 3W, 4E, and 4W at a concentration of 6,133 μg/L. Fluoranthene was detected at a maximum concentration of 27 μg/L in a composite sample from the three wells in plots 3W, 4E, and 4W and in another composite sample of plot 1 and remote wells at a concentration of 26 μg/L. Phenanthrene was detected at a maximum concentration of 50 μg/L in a composite sample from the three wells in plots 3W, 4E, and 4W, and in another composite of these same devices and

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 62

MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING QUARTERLY SAMPLING IN 2001

Compound	Reporting Limit µg/L (ppb)	Values Found in µg/L (ppb)	Composite Source
<u>Volatile Organic Compounds</u>			
Acrolein	33	--	
Acrylonitrile	2	--	
Benzene	2	--	
Bromoform	2	--	
Carbon tetrachloride	2	--	
Chlorobenzene	2	--	
Chlorodibromomethane	2	--	
Chloroethane	4	--	
2-Chloroethylvinyl ether	2	--	
Chloroform	2	--	
Dichlorobromomethane	1	--	
1,1-Dichloroethane	2	--	
1,2-Dichloroethane	2	--	
1,1-Dichloroethylene	1	--	
1,2-Dichloropropane	2	--	
1,3-Dichloropropene	1	--	
Ethyl benzene	2	--	
Methyl bromide	8	--	
Methyl chloride	3	6	Plot 1E & Remote Well
Methylene chloride	2	--	
1,1,2,2 Tetrachloroethane	3	--	
Tetrachloroethylene	2	--	
Toluene	2	--	
1,2-trans Dichloroethylene	1	--	
1,1,1-Trichloroethane	1	--	
1,1,2-Trichloroethane	2	--	
Trichloroethylene	2	--	
Vinyl chloride	3	--	
Trichlorofluoromethane	4	--	
<u>Acid Extractable Compounds</u>			
2-Chlorophenol	3	--	
2,4-Dichlorophenol	3	--	
2,4-Dimethylphenol	4	--	
4,6-Dinitro-o-cresol	17	--	
2,4-Dinitrophenol	20	--	

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TABLE 62 (Continued)

MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING QUARTERLY SAMPLING IN 2001

Compound	Reporting Limit µg/L (ppb)	Values Found in µg/L (ppb)	Composite Source
2-Nitrophenol	2	--	
4-Nitrophenol	12	--	
Parachlorometacresol	3	--	
Pentachlorophenol	13	--	
Phenol	1	129	Plots 3E, 3W, 4E & 4W-L1
2,4,6-Trichlorophenol	3	--	
Base/Neutral Extractable Compounds			
Acenaphthene	2	--	
Acenaphthylene	2	--	
Anthracene	1	14	Plots 3W, 4E, & 4W Wells
Benzidine	12	--	
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	--	
Bis(2-ethylhexyl)phthalate	50	6,133	Plots 3 & 4-L2
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	--	

TABLE 62 (Continued)

MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING QUARTERLY SAMPLING IN 2001

Compound	Reporting Limit µg/L (ppb)	Values Found in µg/L (ppb)	Composite Source
Di-n-octyl phthalate	6	--	
1,2-Diphenylhydrazine	4	--	
Fluoranthene	2	27	Plots 3W, 4E, & 4W Wells
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	--	
Phenanthrene	2	50	Plots 3W, 4E, & 4W Wells
Pyrene	2	22	Plot 1E & Remote Well
1,2,4-Trichlorobenzene	4	--	
<u>Pesticides & PCBs</u>			
Aldrin	0.06	--	
a-BHC-alpha	0.06	--	
b-BHC-beta	0.07	--	
BHC-gamma	0.06	--	
BHC-delta	0.06	--	
Chlordane	0.3	--	
4,4'-DDT	0.09	--	
4,4'-DDE	0.06	--	
4,4'-DDD	0.08	--	
Dieldrin	0.06	--	
a-Endosulfan-alpha	0.06	--	
b-Endosulfan-beta	0.06	--	
Endosulfan sulfate	0.06	--	
Endrin	0.06	--	
Endrin aldehyde	0.09	--	
Heptachlor	0.09	--	

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 62 (Continued)

MAXIMUM CONCENTRATIONS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING QUARTERLY SAMPLING IN 2001

Compound	Reporting Limit µg/L (ppb)	Values Found in µg/L (ppb)	Composite Source
Heptachlor epoxide	0.06	--	
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	--	
(Total PCB)	(0.3)	--	
Toxaphene	1.0	--	

-- Not found, below reporting limit.

plots at a concentration of 27 μg/L. Pyrene was found at a concentration of 22 μg/L in the composite sample from plot 1E and remote well.

Due to the industrial nature of this site and the questionable origins of the fill material used there, it is not possible to determine the source of these organic priority pollutants. However, the pattern and frequency of their detection is not consistent with biosolids as their source.

CONCENTRATIONS OF PLANT NUTRIENTS AND TRACE ELEMENTS IN TISSUE SAMPLES OF COMMON TURF GRASSES AND TREES GROWN IN THE USX RESEARCH AND DEMONSTRATION PLOTS

The project was designed to evaluate the performance of four turf blends and eleven tree species grown on slag material at the USX site capped with topsoil and mixtures of topsoil and 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 30 and the details of the turf blends and woody tree species are given in Table 63 .

The amendments were applied up to a depth of one foot for growing turf grass and four feet for growing trees. The demonstration consists of two sets of plots (designated as east and west) for each amendment. The set of plots designated as east received a six-inch layer of silty clay loam prior to receiving any amendment. The silty clay loam subsurface layer was used to simulate the clay rich B-horizon that is generally found in the natural soil profiles. The silty clay loam layer is expected to minimize leaching and thus the loss of available plant nutrients from the amendments and is also expected to preserve moisture in the root zone.

UPTAKE OF NUTRIENTS AND TRACE ELEMENTS BY TURF GRASS

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, P, and S to determine the effect of various amendments on uptake of common plant nutrients and trace elements. The concentrations of all the chemical constituents analyzed in the tissue samples of four turf blends are presented in Tables 64 through 67.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 63

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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 64

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN 2001 TISSUE SAMPLES OF SCPD[1] TURF BLEND GROWN AT THE USX DEMONSTRATION PLOTS

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	54.6	44.6	123.1	91.2	99.3	134.4	182.8	126.7
Cd	0.18	0.15	0.45	0.20	0.45	0.33	0.55	0.43
Cu	11.74	8.44	23.21	17.81	18.09	21.69	24.25	26.23
Cr	0.54	1.26	0.59	0.53	0.40	0.58	0.40	0.28
Ni	2.33	3.03	3.38	2.09	3.11	3.69	9.08	9.65
Pb	0.98	1.05	<0.1	<0.1	0.30	0.45	0.18	<0.1
K	19,995	24,282	32,017	27,996	27,311	29,148	34,208	32,965
Na	97.9	70.6	142.7	294.9	159.2	277.6	220.3	170.5
Ca	5,718	5,531	4,885	5,051	4,392	5,465	5,170	4,873
Mg	3,071	3,392	4,224	3,552	3,299	4,229	4,129	3,586
Mn	110.8	98.7	54.1	42.9	64.9	98.0	180.4	158.6
Fe	170.0	344.6	98.1	122.4	118.0	152.6	102.1	105.1
Mo	7	7	11	6	10	10	12	15
TKN[2]	25,043	23,368	44,579	46,804	40,953	49,343	48,440	52,993
TP[3]	4,184	4,306	4,736	5,451	5,649	5,575	5,721	6,010
S	9,753	9,244	9,420	8,855	8,485	9,244	10,135	10,581

[1]SCPD = Standard Chicago Park District Turf Blend: 70 percent Kentucky Bluegrass, 15 percent creeping red fescue, 10 percent perennial rye.
[2]TKN = Total Kjeldahl nitrogen.
[3]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 65

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS OBSERVED DURING 2001 IN TISSUE SAMPLES OF MWRDGC[1] TURF BLEND GROWN IN THE USX DEMONSTRATION PLOTS AMENDED WITH MIXTURES OF TOPSOIL AND BIOSOLIDS

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	28.6	33.7	53.1	60.4	68.2	104.3	126.9	108.9
Cd	0.55	0.15	0.65	0.40	0.85	0.50	1.13	0.95
Cu	8.24	9.34	16.59	14.84	17.59	18.94	23.81	20.63
Cr	0.49	0.56	0.39	0.50	0.23	0.45	0.43	0.33
Ni	3.25	1.78	2.48	1.74	2.86	3.16	5.06	6.95
Pb	0.93	0.40	0.23	<0.1	0.20	<0.1	0.20	<0.1
K	25,355	29,722	26,517	27,426	28,141	30,536	36,538	35,765
Na	112.2	72.2	138.1	153.1	163.7	276.0	276.5	236.3
Ca	5,933	5,096	4,080	4,561	4,495	5,690	4,590	4,655
Mg	4,081	4,489	3,539	3,699	3,702	4,511	4,307	3,971
Mn	61.0	67.2	39.3	32.2	34.3	87.0	139.4	130.1
Fe	177.1	152.4	104.6	105.5	89.4	130.4	88.7	94.8
Mo	10	9	5	6	8	7	6	7
TKN[2]	22,510	28,681	39,916	40,112	42,824	47,679	49,327	49,227
TP[3]	3,439	4,414	4,932	4,659	5,988	5,126	6,264	5,792
S	8,181	9,840	7,253	8,670	8,539	9,654	8,218	7,336

[1]MWRDGC = Metropolitan Water Reclamation District of Greater Chicago. 70 percent tall fescue, 30 percent Kentucky Bluegrass.
[2]TKN = Total Kjeldahl nitrogen.
[3]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 66

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN 2001 TISSUE SAMPLES OF VIDOT1[1] TURF BLEND GROWN AT THE USX DEMONSTRATION PLOTS AMENDED WITH MIXTURES OF TOPSOIL AND BIOSOLIDS

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	38.7	43.2	103.6	116.0	104.1	136.6	138.3	225.7
Cd	0.20	0.10	0.30	0.18	0.25	0.33	0.45	0.50
Cu	8.29	9.29	19.81	16.26	21.51	21.39	23.70	26.53
Cr	0.61	1.31	0.36	0.85	0.23	0.33	0.30	0.45
Ni	3.00	3.05	3.55	2.49	2.74	3.74	4.93	8.55
Pb	0.40	1.10	0.18	0.85	<0.1	<0.1	<0.1	<0.1
K	21,412	21,427	32,012	29,960	27,633	28,183	32,470	35,283
Na	86.8	93.8	120.8	189.7	287.2	240.3	192.5	315.8
Ca	6,643	6,226	4,684	5,467	5,725	6,217	6,287	6,522
Mg	3,175	3,482	3,569	3,895	3,769	4,611	4,317	4,682
Mn	90.8	85.1	40.6	62.8	40.0	89.5	145.0	203.4
Fe	198.4	389.7	98.9	170.5	92.2	97.6	105.8	119.5
Mo	12	10	12	9	11	12	15	20
TKN[2]	22,719	25,948	44,503	44,237	41,726	50,917	52,755	54,234
TP[3]	4,393	4,325	5,107	5,784	4,521	5,798	6,383	6,468
S	9,485	8,645	9,780	12,252	9,164	10,231	11,231	14,217

[1]VIDOT1 = Variation of Illinois Department of Transportation lawn mixture: 50 percent perennial rye, 30 percent Kentucky Bluegrass, 20 percent creeping red fescue.
[2]TKN = Total Kjeldahl nitrogen.
[3]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 67

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN 2001 TISSUE SAMPLES OF IDOT[1] TURF BLEND GROWN AT THE USX DEMONSTRATION PLOTS

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	34.4	42.4	133.4	104.7	98.6	114.0	202.6	209.4
Cd	0.38	0.20	0.70	0.23	0.53	0.33	0.68	0.65
Cu	7.36	8.41	19.81	17.69	21.34	17.64	28.70	27.85
Cr	0.59	0.79	0.61	0.45	0.28	0.80	0.35	0.30
Ni	3.65	2.60	3.68	2.69	2.64	4.21	7.25	7.75
Pb	0.85	1.03	0.23	<0.1	<0.1	0.33	0.18	<0.1
K	18,920	22,475	31,457	32,138	30,171	31,491	38,055	35,908
Na	99.9	114.3	406.7	241.7	375.9	269.3	269.6	282.5
Ca	6,296	5,586	6,308	5,467	5,692	5,379	5,825	6,397
Mg	3,244	3,706	5,301	4,115	4,294	4,181	4,568	4,967
Mn	105.2	81.2	51.1	46.5	34.1	132.9	192.8	210.7
Fe	143.9	243.6	126.8	99.2	92.9	154.8	89.6	95.3
Mo	12	10	10	10	11	10	16	19
TKN[2]	17,967	23,717	48,386	45,384	51,577	43,932	51,585	54,570
TP[3]	3,780	4,204	4,884	6,158	6,456	5,763	6,188	6,262
S	7,380	8,578	7,610	10,106	7,862	9,352	11,133	10,849

[1]IDOT 1B = Illinois Department of Transportation. Low maintenance: 75 percent tall fescue, 15 percent perennial rye, 10 percent creeping red fescue.
[2]TKN = Total Kjeldahl nitrogen.
[3]TP = Total phosphorus.

The Zn concentrations in the tissue samples of turf grasses ranged from 28.6 to 225.7 mg/kg among the plots, and the uptake of Zn increased with increasing amounts of biosolids in the amendments. The highest concentrations of Zn were detected in the tissue samples taken from the turf blends grown in the plots treated with 100% biosolids. No discernable differences in Zn uptake were observed in the tissue samples of the turf blends grown in plots amended with and without a silty clay loam subsurface layer. However, the levels of Zn uptake observed among the turf blends were considerably different, which indicates that Zn removal from amendments is influenced by the blend of turf grasses grown. Only traces of Cd (0.10 to 1.13 mg/kg), Cr (0.23 to 1.31 mg/kg), and Pb (<0.10 to 1.10 mg/kg) were detected in the tissue samples of all the four turf blends evaluated. The concentrations of Cd, Cr, and Pb in tissue samples did not change with increasing biosolids proportion in the amendments. The Cu, Ni, and Mo concentrations in the tissues ranged from 7.36 to 28.70 mg/kg, 1.74 to 9.65 mg/kg, and 5 to 20 mg/kg, respectively, and higher concentrations were observed in the tissue samples taken from the subplots amended with higher proportions of biosolids. In addition, the concentrations of Cu, Ni, and Mo were similar among the turf blends evaluated.

The concentrations of K, Na, Ca, and Mg in the tissues ranged from 18,920 to 38,055, 70.6 to 406.7, 4,080 to 6,643, and 3,071 to 5,301 mg/kg, respectively. There was no noticeable effect of the silty clay loam subsurface layer on the uptake of these elements by the turf grasses. Although there was no notable differences in the concentrations of K and Na among various turf blends, subtle differences in Ca and Mg concentrations were observed. There was no increase in Ca concentrations with increasing biosolids content in the amendments, but there was a slight increase in the uptake of K, Na, and Mg by some turf blends. The Mn and Fe concentrations in tissue samples ranged from 32.2 to 210.7 and 88.7 to 389.7 mg/kg, respectively. The uptake of Mn and Fe did not vary much among the turf blends, and it did not increase with increasing the biosolids proportions.

The total Kjeldahl nitrogen (TKN) concentrations in tissue samples ranged from 17,967 to 54,570 mg/kg, and there was a noticeable increase in uptake levels with increasing biosolids proportion in the amendments. No clear differences in TKN uptake were observed among the turf blends. The total P (TP) concentrations ranged from 3,439 to 6,468 mg/kg and a noticeable increase in uptake was seen with increasing proportions of biosolids. The concentrations of S ranged from 7,253 to 14,217 mg/kg, and the uptake of S among the turf blends was significantly different. But there was only a slight increase in S uptake with increasing contents of biosolids in the amendments.

UPTAKE OF NUTRIENTS AND TRACE ELEMENTS BY TREES

Several species of shade and ornamental trees were grown in the demonstration plots. The tree species included in the shade group were Marmo Hybrid Maple (*Acer x freemanii*), Autumn Purple Ash (*Fraxinus americana*), Skyline Honeylocust (*Gleditsia triacanthos inermis*), Siouxland Cottonless Cottonwood (*Populus deltoides*), Red Oak (*Quercus rubra*), and Homestead Hybrid Elm (*Ulmus x*). The tree species included in the ornamental group were Amur Maple (*Acer ginnala*), Apple Serviceberry (*Amelanchier x grandiflora*), Thornless Cockspur Hawthorn (*Crataegus crusgalli inermis*), Donald Wyman Crabapple (*Malus*), and Zumi Crabapple (*Malus zumi calocarpa*). Leaves of each tree 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 concentrations of chemical constituents in the leaves of all the tree species evaluated are shown in Tables 68 through 78.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 68

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF AMUR MAPLE GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	38	47	51	55	68	51	62	70
Cd	0.20	0.10	0.25	0.30	0.43	0.28	0.63	0.60
Cu	8.71	12.34	5.09	5.39	6.16	5.81	4.59	4.06
Cr	0.61	0.76	0.89	1.09	0.66	0.71	0.98	0.88
Ni	0.28	0.45	0.38	0.53	0.60	0.88	0.95	0.75
Pb	1.14	1.74	1.51	2.55	1.28	1.90	1.58	1.60
K	6,079	5,854	6,959	7,808	9,003	8,675	9,476	11,406
Na	48.0	56.8	35.8	39.3	34.0	42.8	46.3	31.3
Ca	14,221	15,381	15,851	16,284	16,227	16,437	14,761	13,289
Mg	3,353	3,473	3,303	3,342	3,294	3,321	3,550	2,902
Mn	38.2	44.3	113.4	91.2	194.9	151.4	350.4	240.7
Fe	64.8	105.1	111.7	170.8	126.4	133.2	100.6	71.4
Mo	0.28	0.33	0.55	1.03	0.70	1.15	1.10	1.43
TKN[1]	16,146	13,836	19,481	19,413	20,287	20,961	19,067	22,133
TP[2]	951	997	556	515	546	555	739	890
S	4,924	10,864	8,806	8,209	6,970	4,564	10,820	9,029

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 69

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF APPLE SERVICEBERRY GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	18	25	24	28	26	30	33	31
Cd	<0.01	<0.01	0.10	0.10	<0.01	<0.01	0.10	0.10
Cu	5.41	5.89	4.99	5.71	7.16	6.44	7.01	8.41
Cr	1.19	0.96	0.99	1.44	0.79	1.11	1.43	1.18
Ni	0.40	0.63	0.80	0.65	1.35	1.55	1.90	1.90
Pb	1.94	1.76	1.16	3.05	1.33	2.00	2.05	1.63
K	6,839	8,504	7,584	7,600	7,095	7,783	7,558	8,893
Na	25.3	28.8	19.0	36.8	23.0	16.8	27.5	21.0
Ca	20,506	19,304	18,934	20,087	16,854	19,667	17,796	14,601
Mg	4,868	5,178	4,575	4,463	4,754	4,539	4,390	3,920
Mn	106.8	161.5	305.8	92.6	345.6	425.9	393.7	329.2
Fe	158.4	113.9	93.5	224.7	108.9	136.7	132.0	108.2
Mo	0.40	0.58	1.23	1.35	2.68	2.13	3.45	4.23
TKN[1]	16,170	15,256	15,306	18,437	15,467	15,452	19,407	17,915
TP[2]	1,122	1,393	1,247	525	1,231	1,414	819	1,282
S	7,019	6,664	5,298	10,133	7,096	7,447	5,231	4,663

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 70

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF THORNLESS COCKSPUR HAWTHORN GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	18	19	17	28	21	19	21	16
Cd	0.05	0.05	0.05	0.15	0.05	0.05	0.15	<0.01
Cu	7.94	8.64	5.61	7.71	7.61	6.79	8.49	6.59
Cr	0.59	0.49	0.34	0.99	0.41	0.59	0.73	0.68
Ni	1.05	1.38	0.78	0.83	0.95	1.33	1.65	1.08
Pb	0.84	1.06	0.51	2.10	0.40	1.10	0.85	0.83
K	5,296	5,229	6,169	5,583	4,940	4,919	5,103	5,431
Na	41.3	60.3	34.5	56.5	45.5	33.8	65.5	38.3
Ca	27,329	29,359	24,104	25,759	30,472	24,974	24,679	23,081
Mg	4,679	4,675	4,351	5,327	5,429	5,205	5,580	5,113
Mn	48.1	47.0	28.2	52.6	64.3	70.1	78.0	62.0
Fe	101.0	94.0	81.0	181.9	94.9	125.9	111.2	118.2
Mo	0.10	0.10	0.35	0.48	0.53	0.68	0.55	0.53
TKN[1]	19,052	19,355	22,789	23,702	12,647	22,361	22,128	23,101
TP[2]	549	517	433	446	362	448	588	565
S	8,849	6,404	7,016	5,290	4,965	10,921	7,662	8,112

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 71

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF DONALD WYMAN CRABAPPLE GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

Parameter	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	11	17	17	18	17	22	19	22
Cd	<0.01	<0.01	0.05	<0.01	<0.01	<0.01	0.08	0.08
Cu	6.54	6.99	6.04	7.96	8.01	7.51	8.01	7.39
Cr	0.34	0.49	0.46	0.81	0.39	0.44	0.60	0.48
Ni	1.03	1.05	1.15	1.05	0.93	1.43	1.18	1.20
Pb	0.34	1.21	0.69	1.78	0.68	0.90	1.08	0.68
K	11,416	10,781	11,856	13,423	8,498	12,180	15,028	13,701
Na	28.8	52.8	33.5	30.8	25.0	25.3	29.3	18.8
Ca	15,106	19,406	16,819	13,439	13,894	14,474	9,289	10,824
Mg	2,713	2,501	2,963	2,990	2,893	2,674	2,304	2,293
Mn	37.9	58.1	43.1	59.5	64.8	94.3	152.0	102.8
Fe	51.6	51.0	59.9	89.3	116.2	89.1	55.9	68.9
Mo	0.38	0.55	0.55	0.90	0.73	1.73	1.48	1.53
TKN[1]	18,358	15,954	20,321	20,691	16,895	19,010	20,313	19,633
TP[2]	751	673	548	588	454	617	917	856
S	5,158	5,056	9,952	8,400	6,344	5,738	5,991	12,906

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 72

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF ZUMI CRABAPPLE GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	15	17	21	27	24	31	20	23
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.05
Cu	6.61	7.19	5.86	6.81	7.61	7.81	7.04	6.76
Cr	0.51	0.54	0.69	1.39	0.91	0.66	0.78	0.88
Ni	0.95	1.00	1.43	1.03	1.00	1.10	1.85	1.73
Pb	0.84	1.19	0.99	3.15	1.73	1.13	1.78	1.25
K	10,651	11,706	10,116	9,563	13,750	12,345	10,823	12,233
Na	33.8	50.5	51.0	47.3	43.3	42.0	44.3	51.3
Ca	15,456	17,136	15,631	14,892	14,279	14,067	10,909	11,094
Mg	2,528	2,471	2,459	2,670	2,387	2,644	2,529	2,039
Mn	44.0	47.6	88.5	72.0	139.8	161.2	301.6	264.5
Fe	52.0	72.8	62.3	205.2	69.9	87.3	53.9	58.9
Mo	0.55	0.75	1.00	1.45	1.53	1.85	1.55	1.55
TKN[1]	16,096	16,955	17,892	18,280	18,359	17,656	19,118	19,601
TP[2]	640	703	524	455	626	635	922	914
S	9,574	9,341	8,062	6,304	15,250	9,681	9,211	7,682

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 73

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF MARMO HYBRID MAPLE GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	65	76	59	59	47	45	51	54
Cd	0.20	0.20	0.43	0.55	0.68	0.53	0.43	1.30
Cu	12.69	14.86	6.69	4.96	4.91	4.86	4.89	3.28
Cr	2.10	2.41	1.29	2.16	0.98	1.10	1.90	0.60
Ni	1.30	2.05	1.18	1.20	0.83	1.73	0.83	0.74
Pb	3.95	5.71	2.66	5.26	1.68	2.45	3.48	1.55
K	4,952	5,015	5,828	5,101	5,066	7,951	6,303	9,032
Na	37.0	51.9	18.9	30.1	21.3	35.3	31.0	43.1
Ca	14,746	16,151	16,293	19,196	20,818	16,026	16,923	15,033
Mg	4,863	5,254	4,463	4,756	5,487	4,318	4,761	3,754
Mn	460.0	346.6	362.3	449.2	511.2	359.3	393.6	352.6
Fe	178.3	212.3	172.4	287.7	89.7	114.6	99.3	77.4
Mo	0.25	0.23	0.40	0.28	0.29	0.61	0.21	0.40
TKN[1]	15,523	17,693	19,114	19,742	17,737	18,704	17,275	19,137
TP[2]	740	837	704	543	610	2,052	2,697	3,298
S	6,588	9,836	10,496	35,885	12,540	5,137	6,344	8,485

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 74

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF AUTUMN PURPLE ASH GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	22	23	22	24	19	20	19	21
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	13.19	10.64	9.29	13.96	8.94	11.89	12.39	8.85
Cr	1.23	1.09	0.96	1.54	0.70	0.98	1.10	1.13
Ni	0.80	0.83	0.78	0.93	1.30	0.83	0.63	0.76
Pb	3.68	3.56	2.86	4.56	1.90	2.63	2.38	3.75
K	5,063	4,553	5,261	3,595	9,276	4,105	4,286	3,975
Na	18.5	25.1	16.9	14.4	13.5	13.0	9.5	25.1
Ca	16,249	15,173	13,188	18,376	14,983	16,073	12,411	13,573
Mg	4,298	4,517	3,415	5,486	3,366	4,830	3,667	4,017
Mn	48.1	68.3	40.9	42.1	51.4	48.8	36.0	48.7
Fe	298.7	319.0	268.4	373.7	118.3	244.4	245.4	243.7
Mo	0.13	0.15	0.33	0.48	0.89	0.71	0.59	0.55
TKN[1]	18,805	17,145	18,203	20,123	18,593	21,456	17,744	17,775
TP[2]	495	460	395	378	558	1,252	1,448	1,454
S	11,562	28,629	11,786	5,272	6,512	8,702	9,870	25,296

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 75

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF SKYLINE HONEYLOCUST GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	32	38	30	31	42	31	34	31
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05
Cu	7.06	7.99	6.11	5.26	12.34	6.71	5.34	5.68
Cr	0.78	0.96	0.66	0.86	0.90	0.63	0.45	0.40
Ni	0.38	0.40	0.28	0.38	0.53	0.40	0.18	0.34
Pb	3.20	4.96	2.56	3.39	3.25	2.58	1.35	1.20
K	8,146	7,831	9,681	9,251	10,846	14,461	13,608	15,152
Na	141.5	152.1	138.1	93.9	135.8	118.8	69.8	70.9
Ca	14,469	15,916	16,403	21,653	18,828	14,068	16,523	13,853
Mg	3,240	3,205	2,891	3,584	3,605	2,489	2,372	1,999
Mn	72.5	71.5	50.1	68.8	74.0	58.1	87.0	57.5
Fe	88.8	118.4	152.5	142.7	54.5	130.2	54.6	82.2
Mo	0.30	0.25	0.48	0.65	0.74	0.99	0.96	0.90
TKN[1]	18,752	19,427	25,209	25,646	25,680	27,508	33,974	32,798
TP[2]	826	1,010	770	714	925	2,752	3,588	3,435
S	11,447	6,215	6,671	8,600	10,893	27,723	9,998	5,198

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 76

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF SIOUXLAND COTTONLESS COTTONWOOD GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	258	379	363	307	316	310	255	297
Cd	2.63	2.73	3.60	3.47	3.50	2.58	2.78	3.63
Cu	11.89	9.76	7.89	7.51	7.81	7.39	6.43	7.20
Cr	0.25	0.31	0.34	0.56	0.35	0.45	0.53	0.55
Ni	2.05	1.25	0.80	1.30	1.40	0.98	1.49	1.71
Pb	0.50	1.56	0.94	1.84	0.63	1.00	0.85	0.98
K	17,196	14,921	17,061	17,071	21,883	23,663	20,319	26,004
Na	32.0	63.4	47.9	49.4	42.3	28.3	61.6	49.6
Ca	10,851	13,733	12,613	11,433	10,208	9,043	11,283	10,513
Mg	4,032	5,094	3,887	3,954	3,924	3,825	5,056	4,114
Mn	87.4	103.9	129.7	131.0	166.1	140.4	123.8	105.5
Fe	118.9	158.4	94.9	106.1	66.6	67.6	85.9	83.6
Mo	0.88	1.05	5.30	4.70	4.24	4.51	3.70	4.23
TKN[1]	26,332	20,165	26,906	28,030	25,919	26,558	29,851	20,095
TP[2]	643	695	1,287	1,161	1,476	6,785	9,189	11,433
S	5,287	7,737	8,503	21,911	8,701	5,221	5,358	7,448

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 77

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF RED OAK GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
Parameter	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	46	57	39	54	37	NA	NA	NA
Cd	0.10	<0.01	0.05	<0.01	<0.01	NA	NA	NA
Cu	6.09	6.24	4.91	3.96	4.74	NA	NA	NA
Cr	0.93	0.74	0.69	0.93	0.90	NA	NA	NA
Ni	0.80	1.28	0.75	1.00	0.83	NA	NA	NA
Pb	2.38	2.39	1.69	3.00	1.68	NA	NA	NA
K	6,246	5,293	4,708	6,516	5,678	NA	NA	NA
Na	36.8	55.1	48.4	55.8	33.8	NA	NA	NA
Ca	13,391	16,673	14,961	15,021	15,171	NA	NA	NA
Mg	4,371	4,036	4,294	3,466	3,115	NA	NA	NA
Mn	167.5	97.0	334.4	106.6	81.5	NA	NA	NA
Fe	204.3	191.6	173.2	179.5	123.6	NA	NA	NA
Mo	1.00	1.55	2.58	0.74	2.59	NA	NA	NA
TKN[1]	17,428	18,362	18,484	21,349	17,501	NA	NA	NA
TP[2]	469	509	532	459	2,248	NA	NA	NA
S	9,133	18,383	5,345	6,250	9,122	NA	NA	NA

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 78

CONCENTRATIONS OF NUTRIENTS AND TRACE ELEMENTS IN LEAF TISSUE SAMPLES OF HOMESTEAD HYBRID ELM GROWN IN THE USX DEMONSTRATION PLOTS IN 2001

Parameter	Amendments							
	0 Percent Biosolids		25 Percent Biosolids		50 Percent Biosolids		100 Percent Biosolids	
	1E	1W	2E	2W	3E	3W	4E	4W
	mg/Kg							
Zn	45	54	45	43	39	41	58	55
Cd	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cu	8.96	9.96	10.81	11.76	12.19	11.11	14.65	13.05
Cr	0.95	0.84	0.34	0.73	0.40	0.40	0.43	0.45
Ni	1.43	2.93	0.50	0.53	0.40	0.53	0.94	0.71
Pb	2.25	2.69	0.46	1.23	0.28	0.63	0.85	0.55
K	9,853	10,701	16,806	17,013	14,791	17,306	17,734	17,999
Na	99.5	67.4	34.6	39.3	44.8	53.3	39.4	68.1
Ca	23,521	23,966	19,756	22,706	22,283	23,841	20,103	20,268
Mg	3,486	3,893	3,243	4,282	4,100	3,706	3,808	3,576
Mn	64.9	57.1	81.2	67.4	161.2	129.9	178.2	179.2
Fe	155.4	166.5	113.9	124.1	71.0	76.2	82.4	86.9
Mo	0.55	0.93	1.98	2.21	3.24	2.74	1.90	2.05
TKN[1]	24,279	28,150	36,987	36,101	39,422	42,193	42,475	35,594
TP[2]	1,202	1,264	1,023	968	2,822	3,184	3,749	4,005
S	10,705	17,462	5,144	4,998	7,300	8,511	18,066	5,087

[1]TKN = Total Kjeldahl nitrogen.
[2]TP = Total phosphorus.

Only traces of Cd (<0.01 to 0.15 mg/kg) were detected in the leaves of most of the tree species evaluated. The Cd concentrations in the leaves of Amur Maple, Marmo Hybrid Maple, and Siouxland Cottonless Cottonwood were much higher than the leaves of the other species, and they ranged from 0.10 to 0.63, 0.20 to 1.30, and 2.58 to 3.63 mg/kg, respectively. The concentrations of Cr in the leaf tissue ranged from 0.25 to 2.41 mg/Kg. The concentrations of Ni in the leaf tissue samples ranged from 0.18 to 2.93 mg/kg. The concentrations of Pb in the leaves of Marmo Hybrid Maple, Autumn Purple Ash, and Skyline Honeylocust were relatively higher, ranging from 1.20 to 5.71 mg/kg, as compared to the Pb concentrations in the leaves of other shade trees evaluated on the USX demonstration plots which ranged from 0.28 to 3.15 mg/kg. The concentrations of Cd, Cr, Ni, and Pb in the tree leaves did not increase with increasing biosolids proportion in the amendments.

The concentrations of Mo in leaves of most of the trees evaluated were fairly low and ranged from 0.10 to 1.85 mg/kg except in the leaves of Apple Serviceberry, Siouxland Cottonless Cottonwood, Red Oak, and Homestead Hybrid Elm where the concentrations ranged from 0.40 to 5.30 mg/kg. The concentrations of Cu ranged from 3.28 to 14.86 mg/kg, with the highest concentrations occurring in the leaf tissue of Amur Maple, Marmo Hybrid Maple, Autumn Purple Ash, Skyline Honeylocust, Siouxland Cottonless Cottonwood, and Homestead Hybrid Elm. The Cu concentrations generally did not change with increasing proportions of biosolids, except in the Homestead Hybrid Elm and Marmo Hybrid Maple where the concentrations increased from 8.96 to 14.65 mg/kg and decreased from 14.86 to 3.28 mg/kg, respectively, as biosolids content in the amendments increased. The concentrations of Fe ranged from 51.0 to 373.7 mg/kg but the concentrations in Autumn Purple Ash leaves were higher than in the rest of the tree species studied. Fairly high levels of Zn (255 to 379 mg/kg) were observed in the leaves of Siouxland Cottonless Cottonwood, but the Zn concentrations in leaves of the rest of the trees were much lower, ranging from 11 to 76 mg/kg. The Zn and Fe concentrations did not increase with increasing contents of biosolids, except in Amur Maple, Apple Serviceberry, and Donald Wyman Crabapple leaves where slight increases in Zn levels were noted.

The Mn concentration in leaves of tree species evaluated were quite variable and ranged from 28.2 to 511.2 mg/kg. The Mn concentrations were lowest in Thornless Cockspur Hawthorn, Donald Wyman Crabapple, Autumn Purple Ash, Skyline Honeylocust, Siouxland Cottonless Cottonwood, and Homestead Hybrid Elm. The Mn concentrations were intermediate in the leaves of Amur Maple, Apple Serviceberry, Zumi Crabapple, and Red Oak, and they were the highest in the leaves of Marmo Hybrid Maple.

The K concentrations ranged from 3,595 to 17,999 mg/kg in the leaves of most tree species evaluated. The highest concentrations of K (14,921 to 26,004 mg/kg) were detected in the leaves of Siouxland Cottonless Cottonwood. These observations show that different tree species may accumulate different amounts of nutrients and trace elements. No increase in K uptake by trees was observed with increasing proportions of biosolids in the amendments, except for a few selected species such as Amur Maple, Marmo Hybrid Maple, and Skyline Honeylocust.

The highest (23,081 to 30,472 mg/kg) and the lowest (9,043 to 13,733 mg/kg) concentrations of Ca were observed in the leaves of Thornless Cockspur Hawthorn and Siouxland Cottonwood, respectively. The concentrations of Ca in all other tree species were largely between these two ranges. Interestingly, the uptake of Ca decreased with increasing biosolids proportions in the amendments. This may indicate that the bioavailability of Ca is lower in the biosolids than that in the topsoil.

The concentrations of Na in the leaves of all the tree species ranged from 9.5 to 152.1 mg/kg, with the lowest (9.5 to 25.1 mg/kg) and the highest (69.8 to 152.1 mg/kg) concentrations of Na found in the leaves of Autumn Purple Ash and Skyline Honeylocust, respectively.

The Mg concentrations in Donald Wyman Crabapple and Zumi Crabapple leaves ranged from 2,039 to 2,990 mg/kg, which is about half of the concentrations (1,999 to 5,580 mg/kg) found in the rest of the tree species.

The TKN concentration in the leaves of the tree species evaluated in this study ranged from 12,647 to 42,475 mg/kg. The highest TKN concentrations were found in the leaves of Skyline Honeylocust, Siouxland Cottonwood, and Homestead Hybrid Elm. There was no increase in TKN concentration with increasing proportions of biosolids in the amendments except in Skyline Honeylocust and Homestead Hybrid Elm, which further emphasizes the differential response of various plant species to nutrients and trace elements.

The TP concentrations in Thornless Cockspur Hawthorn were the lowest, ranging from 362 to 588 mg/kg throughout the plots. The TP concentrations were highest in Siouxland Cottonless Cottonwood, ranging from 643 to 11,433 mg/kg and increasing with increasing biosolids content in the amendments. The TP concentrations in Marmo Hybrid Maple, Skyline Honeylocust, Red Oak, and Homestead Hybrid Elm ranged from 459 to 4,005 mg/kg, and the uptake of P by these species generally increased with increasing amounts of biosolids in the amendments. The TP concentrations in the leaves of the remaining species of Amur Maple, Apple Serviceberry, Donald Wyman

Crabapple, Zumi Crabapple, and Autumn Purple Ash were quite low, ranging from 378 to 1,454 mg/kg.

The S concentration was quite variable among the leaf tissue of various tree species, and it ranged from 4,564 to 35,885 mg/kg. There was no increase in S uptake by leaves with increasing proportions of biosolids in the amendments.

There was no noticeable difference in the uptake of chemical constituents by turf grasses and trees grown in plots amended with and without a silty clay loam subsurface layer. Increased concentrations of some chemical constituents in the tissue samples were observed with increasing amounts of biosolids in the amendments. Reduced uptake of Cu, Ca, Na, and Mg was observed for certain tree species with increasing biosolids levels. In general, the concentration of trace elements, i.e., Cd, Cu, Cr, Ni, and Pb, in the tree leaves was low, which suggests that the leaf fall from the trees grown on biosolids-amended sites may not pose a potential risk of heavy metal accumulation in the environment or bioaccumulation in the herbivorous food chains.

Biosolids Stockpile Salinity Study

Beginning in the mid 1990s, the District placed an increased 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 for loading onto trucks were sampled and analyzed for pH, EC, NO_3-N, and NH_4-N in 1:2 (biosolids:water ratio) extracts. Saturation paste extracts of some of the samples were also analyzed for the previously described parameters. In 2001, a total of 60 biosolids samples from stockpiles at the Calumet, LASMA, HASMA, Marathon, RASMA, Stony Island, and Vulcan SMAs were collected and analyzed.

A summary of pH, EC, NO_3-N, and NH_4-N in biosolids stockpiles sampled at the District's SMAs in 2001 is presented in Table 79. In 2001, biosolids pH ranged from 6.0 (Stony Island) to 8.2 (Vulcan) in the 1:2 biosolids:water extract and from 6.7 to 7.1 in the saturation paste extract.

The EC varied widely between the SMAs. In the 1:2 biosolids:water extracts, the EC levels ranged from 1.7 dS/m (HASMA) to 13.3 dS/m (Calumet). In the saturation paste extracts, the EC levels ranged from 1.8 dS/m (Stony Island) to

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TABLE 79

SUMMARY OF pH, EC, NO_3-N, AND NH_4-N IN 1:2 (SAMPLE: WATER) AND SATURATION PASTE EXTRACTS OF BIOSOLIDS STOCKPILES SAMPLED DURING 2001

	pH			EC (dS/m)			NO_3-N (mg/L)			NH_3-N (mg/L)		
SMA	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
	1:2 Extract											
Calumet	6.1	7.9	6.9	2.2	13.3	5.4	1.6	153	38	6.5	1,214	382
HASMA	6.4	7.4	6.9	1.7	9.5	4.9	1.7	66	28	57	919	458
LASMA	7.1	7.9	7.5	4.7	7.6	6.4	1.9	5.3	3.7	548	801	707
Marathon	6.7	7.6	7.2	7.2	10.5	8.9	2.3	24	9.6	679	1,061	891
RASMA	6.4	7.9	6.9	4.5	9.4	6.7	1.3	642	131	1.1	855	416
Stony Is.	6.0	7.6	7.1	4.6	11.7	8.5	0.0	596	54	195	1,461	868
Vulcan	6.3	8.2	7.3	5.2	9.3	7.5	0.7	398	59	421	1,095	709
	Saturation Paste Extract											
Calumet	6.9	6.9	6.9	3.8	4.0	3.9	31	33	32	106	121	113
HASMA	6.8	6.9	6.9	3.7	3.7	3.7	64	64	64	57	63	60
Marathon	6.7	6.8	6.8	9.8	10.7	10.2	846	921	883	161	173	167
RASMA	6.9	7.0	6.9	6.7	6.8	6.7	20	20	20	510	525	518
Stony Is.	6.9	7.1	7.0	1.8	10.6	6.2	2.5	211	101	7.5	1,152	565

10.7 dS/m (Marathon). Mean EC at the SMAs ranged from 4.9 to 8.9 dS/m in the 1:2 extracts and from 3.7 to 10.2 in the saturation paste extracts.

The NO_3-N and NH_4-N concentrations varied widely between the SMAs. The NO_3-N concentrations were usually much lower than NH_4-N concentrations. In the 1:2 biosolids:water extract, the NO_3-N concentrations ranged from 0.0 (Stony Island) to 642 mg/L (RASMA), and NH_4-N concentrations ranged from 1.1 (RASMA) to 1,461 mg/L (Stony Island). In the saturation paste extract, the NO_3-N concentrations ranged from 2.5 (Stony Island) to 921 mg/L (Marathon), and NH_4-N concentrations ranged from 7.5 (Stony Island) to 1,152 mg/L (Stony Island).

The data show that the salinity, NO_3-N, and NH_4-N levels in biosolids produced at the SMAs varied widely during 2001. More specific studies to identify the factors involved in this variability might help in developing management practices to consistently produce biosolids having low salinity and NH_4-N.

Biosolids Nutrient Mineralization and Leaching Studies

Leaching of nutrients to groundwater is a potential concern when biosolids are used as a soil amendment or soil substitute at some land application sites. The rate of nutrient leaching from biosolids and the potential for impacting groundwater are governed by the microbial flora, initial nutrient levels, mineralization rates in biosolids, aerobic and/or anoxic/anaerobic conditions, organic matter content, soil texture, and site hydrologic conditions such as precipitation, soil drainage, and depth to groundwater. A column leaching study was started in July 2001 to evaluate the release of nutrients, and to determine the impact on concentrations of nutrients in leachates generated from the biosolids-amended soil layer. The study was designed to specifically evaluate the potential for nutrient leaching associated with using biosolids as a soil amendment for the proposed restoration and vegetation of slag at the USX brownfield site located on the southern lakefront of Chicago, where the potential for impacts on groundwater are a concern.

In this study, biosolids were mixed with overburden soil collected from the LASMA lagoons to achieve biosolids soil amendments containing 0, 25, 50, and 100 percent biosolids (on a volume basis). These were used to study the leaching of nutrients. Three replicate columns (4-inch diameter by 3-inch deep) of each mixture were prepared by placing the mixtures on top of a 1-inch layer of sand in small leaching columns. The columns were leached initially with 300 mL of a 0.005M $CaCl_2$ solution and then placed in a growth chamber at 25°C for incubation. During the 10-week incubation period, the columns were leached once every week with 75 mL of the

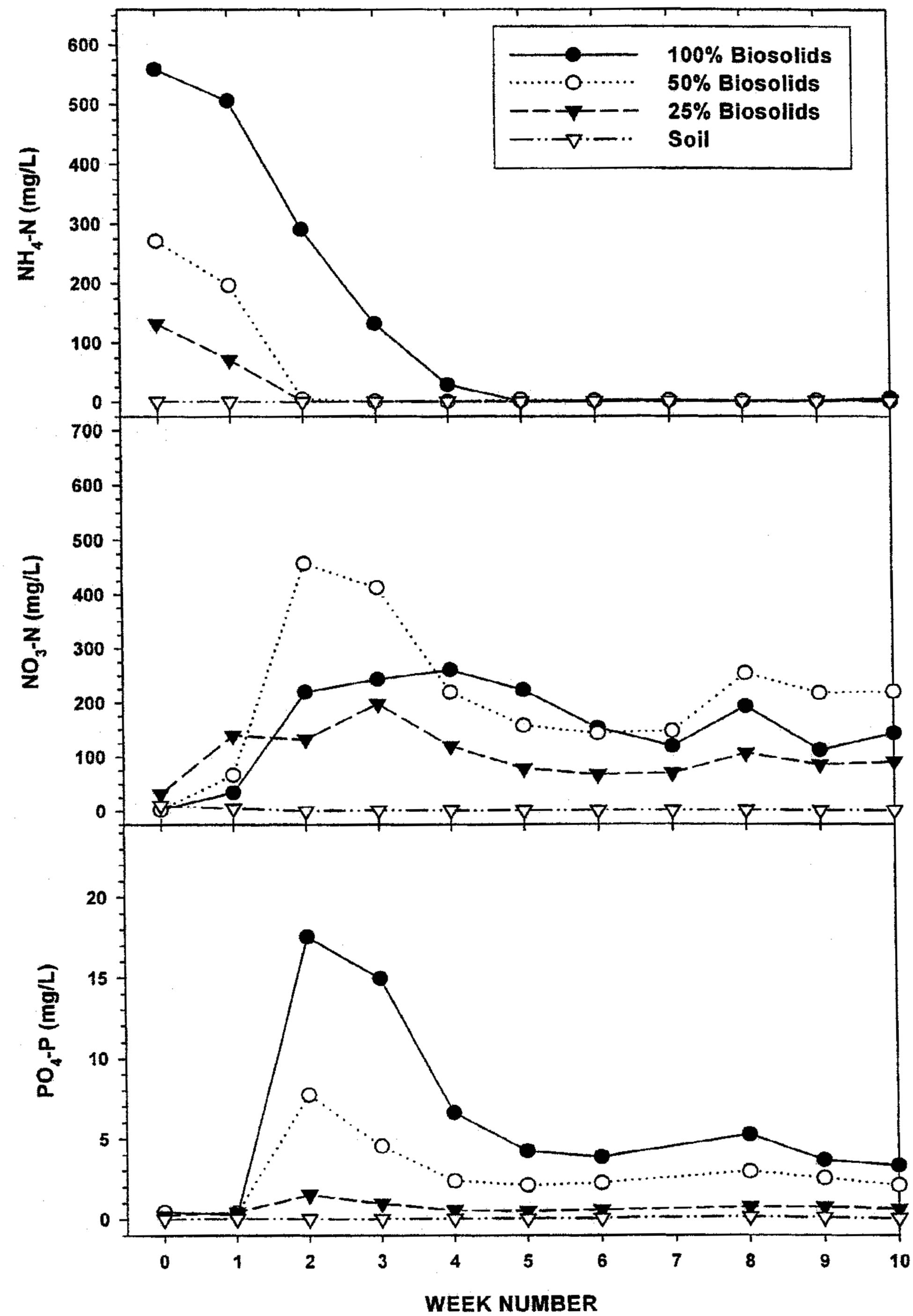
$CaCl_2$ solution. This leaching volume represents a rainfall event of approximately one third of an inch. The leachate collected at each leaching event was analyzed for chemical constituents.

The concentrations of NH_4-N, NO_3-N, and PO_4-P in leachates generated from the columns of the soil/biosolids mixtures during the study period are presented in Figure 31. In the first week of the study, NH_4-N was lowest in the leachate from the unamended soil, and it increased as the proportion of biosolids in the mixtures increased. The concentration of NH_4-N in the unamended soil leachate remained near zero throughout the study. In all other mixtures the concentrations of NH_4-N in the leachate decreased sharply during the first 5 weeks due to transformation of NH_4-N to NO_3-N, and then it remained at levels similar to concentrations in the unamended soil leachate thereafter.

Initially (week 0), the concentrations of NO_3-N in the leachates were relatively low for all the mixtures, and it was highest in the 25 percent biosolids amendment mixture. The leachate NO_3-N concentrations in the unamended soil remained near zero for the duration of the study. The leachate concentrations of NO_3-N increased to maximum levels of 197 mg/L (week 3), 456 mg/L (week 2), and 260 mg/L (week 4) for 25 percent biosolids, 50 percent biosolids, and 100 percent

FIGURE 31

MEAN CONCENTRATIONS OF NH_4-N, NO_3-N, AND PO_4-P IN LEACHATES OF COLUMNS OF BIOSOLIDS AMENDED SOIL INCUBATED AT 25°C



biosolids mixtures, respectively, and then declined afterwards. Throughout the study period, the NO_3-N concentrations were the highest in the 50 percent biosolids amendment, except during weeks 4 through 6 when the concentrations were the highest in the 100 percent biosolids amendment. By the end of the study, the NO_3-N concentrations in the leachate from the amended mixtures had decreased appreciably from their highest levels, but they were all higher than the concentrations in the unamended soil leachate.

The concentration of PO_4-P in the unamended soil leachate ranged from 0 to 0.15 mg/L throughout the study. In the leachates of the biosolids-amended mixtures, the PO_4-P concentrations were similar to levels in the unamended soil during week 1. Then, the PO_4-P concentrations in the biosolids amendments increased to their highest levels in week 2, when the mean leachate concentrations were 1.5, 7.5, and 18 mg/L for the 25 percent biosolids, 50 percent biosolids, and 100 percent biosolids amendments, respectively. After week 1, the PO_4-P concentrations in the leachates were always in the increasing order of soil, 25 percent biosolids, 50 percent biosolids, and 100 percent biosolids. The PO_4-P concentrations in the leachates from biosolids amended mixtures decreased rapidly from week 2 to week 4. Then, the PO_4-P concentrations in the biosolids mixtures remained at a level almost constant above the concentrations in the unamended soil for the remainder of the study.

The results of this study show that the use of biosolids as an amendment or soil substitute will result in increased concentrations of nutrients in soil water that may leach below the depth of biosolids placement or incorporation. The concentrations of nutrients observed in this study are only relative compared to the potential for nutrient leaching under field conditions. Compared to the unamended soil in this study, in which no nutrients were added, a soil that is fertilized adequately for establishing vegetation would generate higher leachate nutrient concentrations. In the field, as the leachate leaves the amended soil layer and percolates deeper through the soil, the concentration of nutrients in the leachate will decrease due to dilution by soil water, sorption onto soil particles, and utilization by vegetation and soil microorganisms.

Additional work is being conducted to compare the mineralization of nutrients in the various types of biosolids produced by the District. The information obtained from this work will be used to determine the conditions under which the different types of biosolids can be used most economically as a soil substitute or amendment with minimal impacts of excessive nutrients.

Trace Element Phytotoxicity Studies

Land application of biosolids is governed by the USEPA's Part 503 regulations. These regulations established biosolids concentration limits on nine trace elements based on a comprehensive risk assessment. The final regulatory limits for zinc, nickel, and copper were based on the assessment of risk of phytotoxicity resulting from application of biosolids to land. In an effort to evaluate the validity of the USEPA's risk assessment for phytotoxicity and to demonstrate the protection afforded by the Part 503 rule, a study was initiated to determine the phytotoxic threshold concentration of Zn in the leaves of various plant species. This represents the Zn concentration in plant leaves that causes a 50 percent growth reduction.

In their risk assessment, the USEPA determined that the phytotoxic threshold leaf Zn concentration is 400 mg/kg. To test this threshold we spiked soils with eight levels of $ZnSO_4$ including 0, 125, 250, 500, 1000, 2000, 4000 and 8000 mg Zn/kg soil (Zn dosage levels 0 through 7, respectively), and grew a variety of grasses and other crop species in the spiked soils measuring the leaf Zn concentration and the resulting dry matter accumulation after six weeks of growth.

Two of the plant species studied were Kentucky bluegrass (*Poa pratensis* L., v. Banjo) and corn (*Zea mays* L.). The mean leaf Zn concentration and dry matter production for Kentucky bluegrass for plants grown in soil spiked with the eight Zn dosage levels is presented in Table 80. Statistical grouping analysis was conducted to determine which mean dry matter values were not significantly different. Zinc dosage levels with the same group index in Table 80 had mean plant dry matter production values that were not significantly different. Table 80 indicates that Kentucky bluegrass dry matter production was not significantly decreased at leaf Zn concentrations of at least 569 mg/kg, and leaf Zn concentration of 900 mg/kg produced approximately 50 percent growth reduction relative to the control (no Zn treatment). Additional statistical analysis was conducted to model the effect of leaf Zn concentration on dry matter production. An initially constant one-knot spline model was used to estimate the leaf Zn concentration at which dry matter production begins to decline, and the leaf Zn concentration associated with a 50 percent reduction in dry matter production (Part 503 risk assessment phytotoxic threshold).

The analysis indicated that for Kentucky bluegrass dry matter yield is first observed to decrease when the leaf Zn concentration reaches 690 mg/kg, and that the leaf Zn

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TABLE 80

EFFECT OF LEAF ZN CONCENTRATION ON SHOOT DRY MATTER PRODUCTION FOR KENTUCKY BLUEGRASS

Zn Dosage Level	Mean Shoot Dry matter	Mean Leaf Concentration	Group Index*
	mg/plant	mg/kg	
0	38.6	59.6	0
1	43.6	251	0
2	37.5	359	0
3	32.5	569	0
4	16.2	900	1
5	10.9	4290	1
6	6.0	11397	1
7	0.0	NA	2

* Dosage levels with the same group index had no statistically significant difference in mean shoot dry matter production.

concentration needs to be at 713 mg/kg to result in a 50 percent reduction in dry matter yield.

The mean leaf Zn concentration and dry matter yield for corn for plants grown in soil spiked with the eight Zn dosage levels is presented in Table 81. Corn dry matter production was not significantly decreased at leaf Zn concentrations of at least 244 mg/kg, and leaf Zn concentration of 635 mg/kg produced approximately 20 percent growth reduction relative to the control (Table 81). The results of the statistical analysis using the one-knot spline model indicated that for corn, dry matter yield is first observed to decrease when the leaf Zn concentration reached 560 mg/kg and a 50 percent reduction in dry matter yield was observed when the leaf Zn concentration reached 928 mg/kg.

These results confirm that the risk assessment utilized to develop the Part 503 regulation was conservative and protective. The Part 503 risk assessment utilized a leaf concentration of 400 mg/kg to represent the point at which plant dry matter yield would decrease by 50 percent. The results of this study indicate that leaf Zn concentration must reach 713 and 928 mg/kg to result in a 50 percent reduction in dry matter yield for Kentucky bluegrass and corn, respectively. In fact, this study demonstrated that dry matter yield was not

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TABLE 81

EFFECT OF LEAF ZN CONCENTRATION ON SHOOT DRY MATTER PRODUCTION FOR CORN

Zn Dosage Level	Mean Shoot Dry matter	Mean Leaf Concentration	Group Index*
	mg/plant	mg/kg	
0	2714	39.1	0
1	2794	111	0
2	3146	244	1
3	2212	635	2
4	909	1265	3
5	455	7283	4
6	264	12700	5
7	0.0	NA	6

* Dosage levels with the same group index had no statistically significant difference in mean shoot dry matter production.

reduced at all until the leaf Zn concentration reached 690 and 560 mg/kg for Kentucky bluegrass and corn, respectively.

Technical Support for Biosolids Management

The Land Reclamation and Soil Science Section provides technical support for biosolids management to both the M&O Department and the biosolids users. This ensures the successful and safe use of the District's biosolids in each project and also ensures full regulatory compliance of these projects. 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 beneficial use of biosolids. The section's support for biosolids management consists of the following:

1. Monitoring of air-dried biosolids products for compliance with USEPA standards.
2. Collecting samples for internal studies and external requirements.
3. Reporting relevant information to contractors, IEPA, and USEPA.
4. Educating biosolids users on state and federal regulations governing biosolids use, and to

provide technical information related to specific planned uses of biosolids.

5. Documenting biosolids use at major projects to produce case studies.
6. Initiating and documenting demonstration scale projects using biosolids.
7. Serving on the District's Biosolids Marketing Committee.
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 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 2001, 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, or supported, in 2001 include:

1. Construction of soccer fields at Morton West High School, Berwyn, Illinois, using biosolids as a soil conditioner.
2. Rehabilitation of fairways using biosolids as a soil conditioner and topsoil substitute at Northshore Country Club, Longwood Golf Course, and Cinder Ridge Golf Course.
3. Development of a recreational park and athletic fields using biosolids as a soil conditioner by the Village of Blue Island.
4. Renovation of roadway medians using biosolids as a soil conditioner by the Village of Markham.

5. Use of biosolids, as a topsoil substitute, in the final protective layer at various landfills.
6. Use of biosolids, as a soil conditioner, in soil reclamation for production of trees for biomass at the Continental Cement Company, Hannibal, Missouri.
7. Development of RFPs for studies of biosolids geotechnical and physical properties.
8. Development of detailed plans for establishment of plots to demonstrate use of biosolids to grow trees and promote vegetative cover on landfill and roadside embankment slopes.
9. A Field Day at the USX Slag Reclamation Research and Demonstration Plots to promote biosolids use in establishment of public parks at brownfield sites.
10. Attend and make presentations at public meetings in Pembroke Township, Kankakee County, Illinois to support application of biosolids to farmland.

ANALYTICAL MICROBIOLOGY AND BIOMONITORING SECTION

The Analytical Microbiology and Biomonitoring Section of the EM&R Division 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 2001, 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 for disinfection control.

b. Bypasses to Lake Michigan. Monitoring the Lake Michigan shoreline and Chicago area beaches for the presence and density of fecal coliforms and *E.coli*, and concentration of conventional pollutants 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. Monitoring Wells. Monitoring fecal coliform presence and density in groundwater for TARP, as required by Illinois Environmental Protection Agency (IEPA) operational permits.

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

f. Part 503 Compliance Monitoring. Analysis of biosolids for fecal coliforms.

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

h. Reviews. Review research reports and draft legislation 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. Reviews. Review research reports and draft legislation 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 draft legislation for any impact on District operations.

IV. BIOMONITORING GROUP ACTIVITIES

a. Whole Effluent Toxicity (WET) Testing for 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 draft legislation 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 for more than 25 years. 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 fecal coliform 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 bypasses to Lake Michigan occur after large amounts of rainfall. The Analytical Microbiology Group also conducts microbiological analyses in support of other sections. In 2000 the Group began developing a database of *E.coli* to fecal coliform (FC) ratios in water samples from Lake Michigan, District WRPs, and the Chicago area waterways; in 2001 the Group added to this database.

Table 82 summarizes the number and type of analyses performed by the Analytical Microbiology Group in 2001. Bacterial analyses for TC, FC, fecal streptococci (FS), *Pseudomonas aeruginosa* (PA), and *Salmonella* species (SAL) 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.

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TABLE 82

ANALYTICAL MICROBIOLOGY GROUP SAMPLES AND ANALYSES
2000 THROUGH 2001

		Analysis or Test Performed[1]										
Year	Samples	TC	FC	FS	PA	SAL	SPC	EC	ENT	IQC	ID-CONF	Total
2000	2,847	77	2,809	0	0	0	85	302	0	7,594	285	11,152
2001	3,483	34	3,351	0	0	0	29	495	0	8,214	237	12,360

[1]TC = Total Coliform; FC = Fecal Coliform; FS = Fecal Streptococcus; PA = Pseudomonas aeruginosa; SAL = Salmonella sp.; SPC - Standard 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.

CERTIFICATION BY THE IDPH

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

- heterotrophic plate count for water;
- total coliform (TC) and *E.coli (MMO-MUG)*;
- TC with broth verification; and
- FC for the examination of water from public water supplies and their sources by the membrane filtration (MF) and multiple tube fermentation (MTF) techniques.

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 14, 2000, 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 (July 1998), Title 77, part 465. The Analytical Microbiology Group is scheduled for certification review again in November 2002. 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.

In compliance with the NPDES permits the Analytical Microbiology Group performed most probable number (MPN) analyses for FC bacteria on 78 samples from retention ponds at the Hanover Park WRP. Results were reported to the plant as soon as data were available.

PART 503 COMPLIANCE MONITORING

In 2001 the Analytical Microbiology Group performed MPN analyses for FC bacteria on 38 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.

At 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). In 2001 the FC density in District's Class B biosolids were monitored for quality assurance purposes, even though there is no pathogen monitoring requirement for Class B biosolids. The Analytical Microbiology Group performed MPN analyses for FC bacteria on samples of centrifuge feed and cake samples from the Stickney and Calumet WRPs. The results of this monitoring are shown in Table 83 and confirm that the District's Class B biosolids meet the Class B FC requirements, i.e., the geometric mean of the FC density is less than 2×10^6 FC MPN/g dry weight.

DATABASE OF *E.COLI* TO FC RATIOS

In 1986 the USEPA recommended the monitoring of *E.coli* instead of FC densities in ambient waters to protect human health. In 2000 the USEPA published guidance to assist the

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TABLE 83

FECAL COLIFORM (FC) DENSITY IN CLASS B BIOSOLIDS CENTRIFUGE FEED AND CAKE SAMPLES FROM TWO DISTRICT WATER RECLAMATION PLANTS

WRP	n[1]	Minimum FC[2] MPN[3]/g dry wt	Maximum FC[2] MPN[3]/g dry wt	Geometric Mean[4] FC[2] MPN[3]/g dry wt
Calumet Centrifuge Feed	8	4,300	332,900	14,544
Calumet Centrifuge Cake	8	15,300	159,300	50,393
Stickney Centrifuge Feed	8	198,800	1,453,000	338,679
Stickney Centrifuge Cake	8	83,600	228,300	118,276

[1]Number of samples.
[2]FC levels were determined using Method 9221 E, *Standard Methods*, 18th edition.
[3]MPN = most probable number.
[4]The geometric mean FC density of at least seven biosolids samples must be less than 2,000,000 MPN per g of biosolids (dry weight basis) in order to meet Class B biosolids FC monitoring requirements.

states in the implementation of the ambient water quality criteria for bacteria which it recommended in 1986. Anticipating that the Illinois Pollution Control Board (IPCB) will eventually adopt bacteriological water quality standards based upon *E.coli*, the District began developing a database of *E.coli* to FC ratios during 2000. This database will facilitate the comparison of *E.coli* densities with the District's historical database of FC densities. The results of 932 analyses were entered into this database in 2001.

Water samples from ten bathing beaches on Lake Michigan were analyzed for *E.coli* using the QuantiTray 2000 method (IDEXX Laboratories, Inc., Westbrook, ME) following the manufacturer's instructions. (The QuantiTray 2000 method is used by the Chicago Park District and by the IDPH for monitoring beaches.) These samples were all collected following diversions of CSOs to Lake Michigan. Fecal coliform levels were determined in water samples from Lake Michigan using SM 9211 B, SM 18^{th} ed. (the 7-hour test). Data collected in 2001 are shown in Table 84. *E.coli* to FC ratios were calculated by dividing the average of the $\log_{10}$ *E.coli* cfu/100 mL by the average of the $\log_{10}$ FC cfu/100 mL. The *E.coli* to FC ratios determined for eight of the ten beaches range from approximately 0.9 to 1.0, while the *E.coli* to FC ratios for the other two

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TABLE 84

ESCHERICHIA COLI (EC) TO FECAL COLIFORM (FC) RATIOS
FOR CHICAGO AREA LAKE MICHIGAN BEACHES
FOLLOWING STORM EVENTS FOR 2001

Sample Source	n[1]	Average Log$_{10}$[2] EC cfu /100mL	Average Log$_{10}$[2] FC cfu /100mL	Ratio of Average Log$_{10}$ EC to Average Log$_{10}$ FC
Calumet Beach	7	2.021	2.266	0.8918
Rainbow Beach	7	2.189	2.509	0.8724
31st Street Beach	1	3.020	3.653	0.8265
Oak Street Beach	1	3.384	3.204	1.0560
North Avenue Beach	1	1.806	2.991	0.6038
Kenilworth Beach	4	2.031	2.266	0.8962
Wilmette Beach	4	2.826	2.918	0.9692
Gillson Beach	4	2.648	3.050	0.8683
Lighthouse Beach	3	2.726	2.894	0.9420
Dempster Beach	4	2.574	2.862	0.8994

[1]n = number of samples analyzed.
[2]For all calculations "less than" values were treated as the numeric value, for example <10 became 10.

locations were 0.8 (31st Street Beach), and 0.6 (North Avenue Beach). These data indicate that the *E.coli* to FC ratio for the Lake Michigan beach samples following diversions to the lake is relatively high, that is, $\geq$0.9 in most cases. The 0.8 and 0.6 values shown in Table 84 were determined from single samples.

In addition, WRP effluents and samples from the Chicago area waterways were analyzed for *E.coli* using SM 9213 D.3, SM 18th ed., (the m-Tec procedure). (The m-TEC procedure is recommended by the USEPA for monitoring ambient waters.) Fecal coliform densities in effluent and waterway samples were determined using SM 9222 D, SM 18th ed., (the FC membrane filtration procedure). The *E.coli* to FC ratios for WRP effluents determined in 2001 are shown in Table 85. The E.coli to FC ratios were > 0.9 for all five WRP effluents studied.

The *E.coli* to FC ratios for waterway samples collected monthly at 13 sample points on the Calumet River, 25 sample points on the Chicago River, and 21 sample points on the Des Plaines River are shown in Table 86. The *E.coli* to FC ratios were >0.9 for all three river systems.

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TABLE 85

ESCHERICHIA COLI (EC) TO FECAL COLIFORM (FC) RATIOS
FOR FIVE DISTRICT WATER RECLAMATION PLANTS IN 2001

WRP Effluent Sampled	n[1]	Log_{10} Average[2] EC per 100 mL	Log_{10} Average[2] FC per 100 mL	Ratio of Average Log_{10} EC to Average Log_{10} FC
Stickney	1	4.041	4.342	0.9307
John E. Egan	71	1.250	1.291	0.9680
Hanover Park	71	1.267	1.338	0.9472
James C. Kirie	71	1.217	1.247	0.9758
North Side	10	3.838	4.020	0.9307

[1]n = number of samples analyzed.
[2]For all calculations "less than" values were treated as the numeric value, for example <10 became 10.

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TABLE 86

ESCHERICHIA COLI (EC) TO FECAL COLIFORM (FC) RATIOS FOR CHICAGO AREA WATERWAY SAMPLES IN 2001

River System	Number of Sample Points in River System	n[1]	Average Log_{10}[2] EC cfu /100mL	Average Log_{10}[2] FC cfu /100mL	Ratio of Average Log_{10} EC to Average Log_{10} FC
Calumet	13	30	2.355	2.496	0.9434
Chicago	25	57	2.769	2.921	0.9479
Des Plaines	21	78	2.556	2.695	0.9482
Total	59	165	2.560	2.704	0.9466

[1]n = number of samples analyzed.

[2]For all calculations "less than" values were treated as the numeric value, for example <10 became 10.

SUPPORT OF OTHER SECTIONS

The Analytical Microbiology Group supported a variety of Environmental Monitoring and Research and Industrial Waste Division programs in 2001. 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. In 2001 the Analytical Microbiology Group assisted the M&O Department measure total residual chlorine in effluent at the Lemont WRP. Table 87 is a summary of the major programs receiving support from 1999 through 2001, and the number of analyses performed for each program.

Virology Group Activities

In 2001 the Virology Group analyzed 26 sludge samples for compliance with the Part 503 sludge disposal regulations and to support the District's request to have its sludge process trains (SPTs) certified as a Processes to Further Reduce Pathogens (PFRPs). Enteric virus 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

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TABLE 87

INDICATOR BACTERIA ANALYSES PERFORMED BY THE ANALYTICAL MICROBIOLOGY GROUP FOR VARIOUS DISTRICT PROGRAMS 1999 THROUGH 2001

	Total Coliform			Fecal Coliform			Escherichia coli		
Program	1999	2000	2001	1999	2000	2001	1999	2000	2001
Effluent Analysis	8	12	11	818	745	797	-[1]	128	228
Land Reclamation	-	-	-	169	332	451	-	-	-
Sludge Indicator Organism Density	-	-	-	114	34	38	-	-	-
District Waterway Surveys	10	-	-	521	751	953	-	114	165
Industrial Waste Surveys	30	-	-	39	9	12	-	-	2
Research Support	-	-	-	94	-	34	-	-	-
Lake Michigan Monitoring[2]	-	7		82	74	198	28	29	100
Major Treatment Facility Monitoring	-	-	-	-	-	11	-	-	-
Illinois Waterway	-	-	-	195	294	245	-	-	-
TARP	-	-	-	633	570	707	-	-	-
Emergency Response	-	-	-	-	-	-	-	-	-
Combined Sewer Overflow	-	-	-	-	-	-	-	-	-
Other[3]	193	62	23	-	-	-	-	-	-
Total	241	81	34	2,665	2,809	3,446	28	271	495

[1]No samples analyzed.
[2]Includes festivals and District bypasses to Lake Michigan.
[3]Includes drinking water.

one plaque forming unit (PFU) per four grams total solids (dry weight basis). Results of these analyses are shown in Table 88.

Positive recovery studies were performed on these samples for quality assurance purposes. The recovery of spiked viruses ranged from 16.5 to 76.1 percent and was dependent upon the sample spiked. Coefficients of variation (CV) for replicate positive recovery studies were generally low, ranging from 0 to 30.7 percent. The average CV for the recovery studies was 14.2 percent.

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.

Parasitology Group Activities

In 2001 the Parasitology Group analyzed 26 sludge samples for compliance with the Part 503 sludge disposal regulations and to support the District's request to have its sludge process trains (SPTs) certified as a processes to Further Reduce Pathogens (PFRPs). *Ascaris* densities in all samples of biosolids produced by the District's codified process were

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TABLE 88

VIROLOGICAL ANALYSIS OF BIOSOLIDS FOR DISPOSAL IN 2001[1]

Drying Area	Number Samples Positive/Number Samples Collected	PFU/4 g dry wt Range[2,3]	Percent Recovery of Seeded Viruses[4] Range
Calumet	0/12	<0.1954 - <0.8600	18.9 - 93.6
RASMA[5]	0/1	<0.9093	16.5
LASMA[6]	0/5	<0.8000 - <0.8571	24.35 - 57.7
Vulcan	0/1	<0.4103	55.05
HASMA[7]	0/4	<0.8332 - <0.9998	29.8 - 76.1
Marathon	0/3	<0.4444 - <0.8716	20.1 - 48.3

[1]Results of analyses performed in the District's Virology Laboratory.
[2]Confirmed plaque forming units/4 g.
[3]Failure to detect viruses in sludge eluates is recorded as less than (<) the limit of test sensitivity.
[4]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.
[5]Ridgeland Avenue Sludge Management Area.
[6]Lawndale Avenue Sludge Management Area.
[7]Harlem Avenue Sludge Management Area.

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 89. Positive recovery studies were performed on these samples for quality assurance purposes. The average recovery of spiked *Ascaris* eggs was 68.3 percent (four samples). These data are shown in Table 90. Since 1996 when the District began monitoring the levels of FC bacteria (see Analytical 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.

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TABLE 89

ASCARIS ANALYSIS OF BIOSOLIDS FOR DISPOSAL IN 2001[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 wt
Calumet	12	12	< 0.0133 - < 0.2906
RASMA[3]	1	1	< 0.1258
LASMA[4]	5	5	< 0.0961 - 0.9641
Vulcan	1	1	< 0.0288
HASMA[5]	4	4	< 0.1825 - 0.0340
Marathon	3	3	< 0.2249 - 0.3381

[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 October 1999.
[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-2/013,1999).
[3]Ridgeland Avenue Sludge Management Area.
[4]Lawndale Avenue Sludge Management Area.
[5]Harlem Avenue Sludge Management Area.

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TABLE 90

PERCENT RECOVERIES OF "SPIKED *Ascaris suum*" OVA FROM 4 g, 50 g, and 300 g FINAL AIR-DRIED BIOSOLIDS SAMPLES[1]

% Total Solids	Sample Weight Analyzed dry (g)	Estimated Ova Spiked	Percent Total Ova Recovered[2]
75.21	4	5.1×10^3	88.89
75.21	50	5.1×10^3	83.26
75.21	300	5.1×10^3	62.82
23.72	50	4.9×10^3	38.07

[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 October 1999.
[2]Percent total ova recovered (viable and non-viable).

Biomonitoring Group Activities

In 2001 acute whole effluent toxicity (WET tests) with fish *(Pimephales promelas)* and daphnids *(Ceriodaphnia dubia)* were conducted on effluent samples from all seven of the District's WRPs. No acute toxicity was observed to be associated with any of the effluents. Chronic WET tests were also conducted on effluent samples from the Hanover Park WRP. No chronic toxicity was observed. Biomonitoring reports for the Hanover Park and James C. Kirie WRPs were submitted to the IEPA in compliance with the respective NPDES permits. These data are shown in Table 91.

In November of 2000 the Biomonitoring Laboratory was audited by the District's Quality Assurance Coordinator and subsequently by an independent Audit Team comprised of experts in the bioassay field from four different independent bioassay laboratories, Tetra Tech, Inc., The Advent Group, Inc., Chadwick & Associates, Inc., and the Hampton Roads Sanitation District. The Audit Team submitted a report to the District, which contained a number of recommendations to improve the Biomonitoring Laboratory's performance. In 2001 the Biomonitoring Laboratory concentrated on addressing the recommendations of the Audit Team and strengthening its quality assurance program.

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TABLE 91

RESULTS[1] OF WHOLE EFFLUENT TOXICITY (WET) TESTS[2] FOR WATER RECLAMATION PLANT EFFLUENTS DURING 2001

Effluent Tested	Date(s) Collected	WET Test	Result
Stickney WRP	01/08/01	Acute *Pimephales promelas* (Survival)	NTE
		Acute *Ceriodaphnia dubia* (Survival)	NTE
James C. Kirie WRP	01/22/01	Acute *Pimephales promelas* (Survival)	NTE
		Acute *Ceriodaphnia dubia* (Survival)	NTE
North Side WRP	01/29/01	Acute *Pimephales promelas* (Survival)	NTE
		Acute *Ceriodaphnia dubia* (Survival)	NTE
North Side WRP	09/17/01	Acute *Pimephales promelas* (Survival)	NTE
		Acute *Ceriodaphnia dubia* (Survival)	NTE
Calumet WRP	09/24/01	Acute *Pimephales promelas* (Survival)	NTE
		Acute *Ceriodaphnia dubia* (Survival	NTE
Lemont WRP	10/15/01	Acute *Pimephales promelas* (Survival)	NTE
		Acute *Ceriodaphnia dubia* (Survival)	NTE
John E. Egan WRP	10/22/01	Acute *Pimephales promelas* (Survival)	NTE
		Acute *Ceriodaphnia dubia* (Survival)	NTE
Hanover Park WRP	12/10/01	Acute *Pimephales promelas* (Survival)	NTE
		Acute *Ceriodaphnia dubia* (Survival)	NTE

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 91 (CONTINUED)

RESULTS[1] OF WHOLE EFFLUENT TOXICITY (WET) TESTS[2] FOR WATER RECLAMATION PLANT EFFLUENTS DURING 2001

Effluent Tested	Date(s) Collected	WET Test	Result
Hanover Park WRP	2/25-3/2/01	Chronic *Pimephales promelas*	
		(Survival)	NTE
		(Growth)	NTE
		Chronic *Ceriodaphnia dubia*	
		(Survival)	NTE
		(Reproduction)	NTE

[1]Results: NTE = no toxic effect.
[2]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 600/4-91/002, (Third Edition), 1994.

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 includes the study of the benthic invertebrate and fish communities, characterization of the physical habitat, and assessment of sediment toxicity and sediment chemistry. 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

During July through September of 2001, fish were collected by electrofishing and seining at 13 deep-draft and 14 shallow-water biological monitoring stations on Chicago area waterways.

Two thousand, six hundred and ninety-four fish were identified, weighed, and measured for length. The fish were also examined for parasites and disease.

In 2001, 29 species of fish were identified from the following deep-draft waterways: North Shore Channel, North Branch of the Chicago River, Chicago Sanitary and Ship Canal, Calumet River, Little Calumet River, and the Calumet-Sag Channel. The most abundant fish species collected in the deep-draft waterways included gizzard shad, carp, and largemouth bass (Table 92). Thirteen different species of game fish were collected in the deep-draft waterways during 2001.

In the shallow-water ecosystems, 23 species of fish were collected from the West Branch of the DuPage River, Salt Creek, Higgins Creek, West Fork North Branch of the Chicago River, Middle Fork North Branch of the Chicago River, Skokie River, North Branch of the Chicago River, and the Des Plaines River. The dominant fish species in the shallow-water streams were bluegill, fathead minnows, and green sunfish (Table 93). During 2001, 8 different game fish species were collected from the shallow-water streams.

Illinois Waterways Water/Sediment Quality Survey

In 1984, the Research and Development Department established a long-term water and sediment monitoring program along the Illinois Waterways 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 sediments.

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TABLE 92

2001 FISH DISTRIBUTION IN CHICAGO AREA DEEP-DRAFT WATERWAYS

Waterway	Total Number of Fish	Total Number of Species	Dominant Fish
North Shore Channel	909	16	Gizzard Shad, Bluegill, Carp, & Green Sunfish
North Branch Chicago River	186	15	Carp, Gizzard Shad, & Largemouth Bass
Chicago Sanitary and Ship Canal	353	13	Gizzard Shad, Carp, & Pumpkinseed Sunfish
Calumet River	157	13	Gizzard Shad, Largemouth Bass, & Smallmouth Bass
Little Calumet River	210	16	Gizzard Shad, Largemouth Bass, & Carp
Calumet-Sag Channel	127	10	Gizzard Shad, Carp, & Largemouth Bass

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TABLE 93

2001 FISH DISTRIBUTION IN CHICAGO AREA SHALLOW-WATER STREAMS

Waterway	Total Number of Fish	Total Number of Species	Dominant Fish
West Branch DuPage River	65	8	Green Sunfish and Bluegill
Salt Creek	17	6	Sand Shiner, Yellow Bullhead, Green Sunfish, & Bluegill
Higgins Creek	323	7	Fathead Minnow and Bluegill
West Fork North Branch Chicago River	25	7	Gizzard Shad, Carp, Largemouth Bass, White Sucker, Bluegill, & Green Sunfish
Middle Fork North Branch Chicago River	7	4	Largemouth Bass & Gizzard Shad
Skokie River	43	3	Green Sunfish, Bluegill, & Largemouth Bass
North Branch Chicago River	12	5	Green Sunfish, Bluegill, & Largemouth Bass
Des Plaines River	260	19	Bluntnose Minnow, Spotfin Shiner, Green Sunfish, & Bluegill

Historically, water samples were collected annually during May, August, and October from each of 49 sampling stations. During October, sediment samples were collected at 14 selected stations. Similar monitoring studies were conducted during 2001.

The mean dissolved oxygen (DO) and ammonium nitrogen concentrations measured at 11 selected stations in the 6 navigational pools (Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, and Peoria) during May, August, and October 2001 are presented in Table 94.

During 2001, the mean DO concentration increased substantially along the waterways from the Lockport pool (mean = 4.3 mg/L) to the Peoria pool (mean = 9.4 mg/L). The increase in DO along the waterway system may be attributable to reaeration at the Brandon Road, Dresden Island, and Marseilles navigational dams and to photosynthesis.

The mean ammonium nitrogen concentration decreased considerably from the Lockport pool (mean = 0.50 mg/L) to the Peoria pool (mean = 0.08 mg/L) during the 2001 surveys. Nutrient uptake by floating algae, attached periphyton, and rooted aquatic vegetation resulting in primary production, instream nitrification, and dilution from the Kankakee River and other tributaries may account for the decrease in ammonium nitrogen along the waterways.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 94

MEAN CONCENTRATION OF DISSOLVED OXYGEN AND AMMONIUM NITROGEN MEASURED AT SELECTED MONITORING STATIONS IN THE LOCKPORT, BRANDON ROAD, DRESDEN ISLAND, MARSEILLES, STARVED ROCK, AND PEORIA NAVIGATIONAL POOLS OF THE ILLINOIS WATERWAYS DURING 2001[1]

Station Number	Navigational Pool	Dissolved Oxygen (mg/L)	Ammonium Nitrogen (mg/L)
1	Lockport	4.3	0.50
3	Brandon Road	5.7	0.48
8	Dresden Island	7.6	0.24
15	Marseilles	8.7	0.11
20	Marseilles	9.9	0.07
24	Starved Rock	10.4	0.05
29	Peoria	11.0	0.03
35	Peoria	11.2	0.05
40	Peoria	9.8	0.09
45	Peoria	7.5	0.13
49	Peoria	7.6	0.12

[1]Water samples were collected twice from each sampling station during the months of May, August, and October.

Table 95 shows the mean concentrations of total nitrogen (TN) and total phosphorus (TP) measured during 2001 at 11 stations in the Lockport, Brandon Road, Dresden Island, Marseilles, Starved Rock, and Peoria navigational pools.

During 2001, the mean TN concentration decreased along the waterways from the Lockport pool (mean = 6.7 mg/L) to the Peoria pool (mean = 4.3 mg/L). The decrease in TN may be as a result of nutrient uptake by aquatic plants, instream nitrification, and dilution from major tributaries. Similarly, the mean TP in the water column also decreased in concentration from the Lockport pool (mean = 1.13 mg/L) to the Peoria pool (mean = 0.50 mg/L). Nutrient uptake from biological production and sedimentation of particulate phosphorus may be two processes that reduced the TP.

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 dissolved oxygen (DO) field monitoring program. A two-year monitoring program in the Calumet Waterway System was initiated in July 2001 and will continue through July 2003.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 95

MEAN CONCENTRATION OF TOTAL NITROGEN AND TOTAL PHOSPHORUS MEASURED AT SELECTED MONITORING STATIONS IN THE LOCKPORT, BRANDON ROAD, DRESDEN ISLAND, MARSEILLES, STARVED ROCK, AND PEORIA NAVIGATIONAL POOLS OF THE ILLINOIS WATERWAYS DURING 2001[1]

Station Number	Navigational Pool	Total Nitrogen[2] (mg/L)	Total Phosphorus (mg/L)
1	Lockport	6.7	1.13
3	Brandon Road	6.2	1.04
8	Dresden Island	5.9	0.89
15	Marseilles	4.6	0.57
20	Marseilles	4.5	0.56
24	Starved Rock	4.2	0.48
29	Peoria	4.4	0.50
35	Peoria	4.9	0.50
40	Peoria	4.4	0.47
45	Peoria	4.0	0.53
49	Peoria	3.7	0.51

[1]Water samples were collected twice from each monitoring station during the months of May, August, and October.
[2]Total nitrogen includes total kjeldahl nitrogen, nitrite-nitrogen, and nitrate-nitrogen.

DO is measured hourly using remote (in situ) water quality monitors (monitors) deployed in protective stainless steel housing enclosures. The monitors are 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 July through December of 2001 that were above the Illinois Pollution Control Board's (IPCB) DO standards are presented in Table 96.

During the six-month monitoring period, the stations that recorded the lowest percentage of DO values in compliance with the IPCB DO standards were Torrence Avenue on the Grand Calumet River and Ashland Avenue on the Little Calumet River (71 and 59 percent, respectively). Overall during the six-month monitoring period, 45,529 of 48,979 DO measurements (93 percent) were above the IPCB's DO water quality standards in the Calumet Waterway System.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 96

NUMBER AND PERCENT OF DISSOLVED OXYGEN VALUES ABOVE
THE ILLINOIS POLLUTION CONTROL BOARD'S WATER QUALITY STANDARDS
IN THE CALUMET WATERWAY SYSTEM DURING JULY THROUGH DECEMBER 2001[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	2,148	2,148	100
		Grand Calumet River		
Torrence Avenue	4.0	3,860	2,724	71
		Little Calumet River		
ConRail RR	4.0	3,988	3,953	99
C&W Indiana RR	4.0	4,153	4,148	>99
Halsted Street	4.0	4,153	4,129	99
Ashland Avenue	5.0	4,164	2,434	59

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 96 (Continued)

NUMBER AND PERCENT OF DISSOLVED OXYGEN VALUES ABOVE THE ILLINOIS POLLUTION CONTROL BOARD'S WATER QUALITY STANDARDS IN THE CALUMET WATERWAY SYSTEM DURING JULY THROUGH DECEMBER 2001[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-Sag Channel		
Divison Street	3.0	3,966	3,916	98
Kedzie Avenue	3.0	4,164	4,133	>99
Cicero Avenue	3.0	3,994	3,956	99
River Mile 311.7	3.0	3,829	3,772	99
Southwest Highway	3.0	3,493	3,452	99
104th Avenue	3.0	2,964	2,797	94
Route 83	3.0	4,103	3,967	97

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

TOXIC SUBSTANCES SECTION

The Toxic Substances Section has established the capability to analyze for all the organic priority pollutants listed by the USEPA. These include more than 100 organic parameters. The NPDES permits for District WRPs also require the Section to analyze for non-listed organic compounds when the detected peaks are ten times higher than the background level. Other projects require the analysis of numerous non-listed organic compounds. The Toxic Substances Section currently analyzes for more than 120 non-listed organic compounds.

There are a variety of projects conducted by this Section which are interdisciplinary in nature. Frequently, the Section is called upon to carry out specialized analyses in support of litigation, administrative hearings, and various technical assistance projects. The Section provides assistance to the Industrial Waste Division in emergency situations and performs specialized analyses in connection with hazardous and toxic industrial waste spills. It also collaborates in pollution control of waterways and Lake Michigan.

An Internal Quality Control Program continued in 2001 to ensure the high quality of the laboratory analyses and results, and to evaluate the performance of the numerous parameters analyzed.

Monitoring of Organic Priority Pollutants in District WRPs

In compliance with NPDES permit requirements, the District analyzes the raw sewage, final effluent, and sludge from its seven WRPs. It determines levels of 111 organic priority pollutants following USEPA 600 Series Methods.

Tables 97, 98, and 99 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 January and June 2001.

The highest values of purgeable compounds or VOCs observed in the raw sewage were for toluene in concentrations of 29 µg/L and 24 µg/L at the Calumet and Hanover Park WRPs, respectively.

The highest values of purgeable compounds found in the final effluent were for chloroform in concentrations of 13 µg/L and 7 µg/L at the Hanover Park and Lemont WRPs, respectively.

The highest values of purgeable compounds in the sludge samples were for toluene in concentrations of 24.2 mg/Kg and 3.20 mg/Kg dry weight (based on the solids content), at the Hanover Park and Stickney WRPs, respectively.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 97

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT RAW SEWAGE - 2001

Type of Compound	Reporting Limit µg/L	Values in µg/L (ppb)[1]							
								Stickney[2]	
		Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Southwest	West Side
Purgeables									
Benzene	2	14	ND	ND	ND	ND	ND	2	ND
Chloroform	2	2	2	4	4	5	2	2	4
Ethyl benzene	2	2	ND	ND	ND	ND	ND	ND	ND
Methylene chloride	2	4	ND	ND	6	2	3	2	4
Tetrachloroethylene	2	5	ND	2	ND	ND	2	ND	ND
Toluene	2	29	2	24	2	10	3	6	5
Trichloroethylene	2	ND	ND	ND	ND	ND	24	ND	ND
Base/Neutral/Acid Extractables									
Phenol	4	56	ND	ND	ND	ND	ND	ND	ND
Benzo(a)pyrene	2	2	ND	ND	ND	ND	ND	ND	ND
3,4-Benzofluoranthene	2	2	ND	ND	ND	ND	ND	ND	ND
Benzo(k)fluoranthene	2	2	ND	ND	ND	ND	ND	ND	ND
Butylbenzyl phthalate	4	ND	ND	ND	ND	ND	6	ND	ND
Chrysene	2	2	ND	ND	ND	ND	ND	ND	ND
Di-n-octyl phthalate	6	6	ND	ND	ND	ND	ND	ND	ND
Fluoranthene	2	5	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	2	2	ND	ND	ND	ND	ND	ND	ND
Phenanthrene	2	2	ND	ND	ND	ND	ND	ND	ND
Pyrene	2	4	ND	ND	ND	ND	ND	ND	ND
Pesticides and PCBs									
Heptachlor	0.09	ND	ND	ND	0.14	ND	ND	ND	ND

[1]Average results of two samples from January and June.
[2]Stickney WRP receives two influent raw sewages.
ND = Not Detected.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 98

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT FINAL EFFLUENT - 2001

Type of Compound	Reporting Limit µg/L	Values in µg/L (ppb)[1]						
		Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Stickney
<u>Purgeables</u>								
Chlorodibromomethane	2	ND	2	ND	ND	ND	ND	ND
Chloroform	2	ND	6	13	ND	7	ND	ND
Dichlorobromomethane	1	ND	4	2	ND	ND	ND	ND
Methylene chloride	2	ND	ND	ND	2	ND	ND	ND
Trichloroethylene	2	ND	ND	ND	ND	ND	2	ND
<u>Base/Neutral/Acid Extractables</u>								
Di-n-octyl phthalate	6	ND	ND	12	ND	ND	ND	ND
<u>Pesticides and PCBs</u>								
None Found								

[1]Average results of two samples from January and June.
ND = Not Detected.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 99

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT SLUDGES - 2001

Type of Compound	Values in mg/Kg (ppm)[1]						
	Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Stickney
(Average Total Solids)	(2.14%)	(2.62%)	(1.74%)	(0.74%)	(2.32%)	(1.26%)	(3.56%)
<u>Purgeables</u>							
Chloroform	ND	ND	ND	ND	0.17	ND	ND
Toluene	0.65	0.76	24.2	ND	0.17	0.48	3.20
<u>Base/Neutral/Acid Extractables</u>							
Chrysene	2.24	1.60	1.49	ND	ND	ND	2.08
Fluoranthene	2.62	2.94	2.59	1.35	ND	ND	3.31
Phenanthrene	1.96	1.60	1.44	ND	ND	ND	2.08
Pyrene	2.24	2.60	2.24	ND	ND	ND	2.86
<u>Pesticides and PCBs</u>							
None Found							

[1]Average results of two samples based on solids content from January and June.
ND = Not Detected.

The highest value of base/neutral/acid extractable (BNA) compounds in the raw sewage was phenol in a concentration of 56 µg/L at the Calumet WRP.

The highest value of BNA compounds for the final effluents was di-n-octyl phthalate at a concentration of 12 µg/L at the Hanover Park WRP.

The highest values of BNA compounds detected in the sludge were fluoranthene at concentrations of 3.31 mg/Kg and 2.94 mg/Kg dry weight (based on total solids content) at the Stickney and Egan WRPs, respectively.

No pesticides or PCBs were found in any final effluent or sludge samples. The only pesticide compound detected in the raw sewage sample was heptachlor at a concentration of 0.14 µg/L at the Kirie WRP.

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

1. Only six of the 111 listed organic priority pollutants were detected in the final effluent samples: five of the 30 purgeable compounds (chlorodibromomethane, chloroform, dichlorobromomethane, trichloroethylene and methylene chloride), one of the 57 BNA

extractable compounds (di-n-octyl phthalate), 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, tetrachloroethylene, toluene, phenol, benzo(a)pyrene, 3,4-benzofluoranthene, benzo(k)fluoranthene, butylbenzyl phthalate, chrysene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene.

3. Other compounds (methylene chloride, trichloroethylene, and di-n-octyl phthalate) 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 three WRPs. Chlorodibromomethane and dichlorobromomethane could be the by-products from the disinfection process, since they were only present in the final effluents.

Monitoring of Non-Listed Organic Compounds in District WRPs

In addition to the listed organic compounds (priority pollutants), the concentrations of non-listed organic compounds were determined in the raw sewage, final effluent, and sludge at District WRPs. These compounds were detected in the samples taken in January and June 2001. Table 100 shows the frequency of occurrence of non-listed organic compounds in District WRP samples during 2001.

The non-listed purgeable compounds found were solvents, hydrocarbons, and products from anaerobic biological degradation. Only four purgeable compounds occurred five times in District WRP effluents, whereas 19 compounds occurred 66 times in raw sewage samples. This indicates high removal efficiencies for these compounds during the treatment process.

Fifty-one non-listed BNA compounds were found in District WRP samples during 2001. The majority of these compounds come from human and animal wastes, industrial waste, and gasoline and/or oil derivatives. Seven compounds occurred 16 times in the effluents, whereas 50 compounds occurred 424 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 100

FREQUENCY OF NON-LISTED ORGANIC COMPOUNDS IN
DISTRICT WRP SAMPLES - 2001

Type of Compound	Raw Sewage 16 Samples[1] Times Found	(%)	Effluent 14 Samples[1] Times Found	(%)	Sludge 14 Samples[1] Times Found	(%)
Purgeables						
Labile sulfide group	0	0	0	0	2	14
Acetone	16	100	1	7	10	71
Dimethyl sulfide	6	38	1	7	3	21
Carbon disulfide	1	6	2	14	1	7
Methyl acetate	0	0	0	0	1	7
Tetrahydrofuran	0	0	1	7	1	7
Diethyl ether	1	6	0	0	0	0
2-Butanone (MEK)	1	6	0	0	0	0
Ethyl acetate	3	19	0	0	0	0
Acetaldehyde	3	19	0	0	0	0
Propionaldehyde	2	13	0	0	0	0
Acetonitrile	1	6	0	0	0	0
Hexane	1	6	0	0	0	0
4-Methyl-2-pentanone	1	6	0	0	0	0
Isopropylbenzene (Cumene)	2	13	0	0	2	14
Styrene	2	13	0	0	0	0
Xylenes	4	25	0	0	0	0
n-Propylbenzene	1	6	0	0	0	0
a-Methylstyrene	1	6	0	0	0	0
2-Ethyltoluene	1	6	0	0	0	0
Limonene	15	94	0	0	8	57
4-Isopropyltoluene	4	25	0	0	6	43
Base/Neutral/Acid Extractables						
2-Methyl propanoic acid	0	0	0	0	3	21
Butanoic acid	8	50	0	0	4	29
3-Methyl butanoic acid	10	63	0	0	4	29
2-Methyl butanoic acid	2	13	0	0	2	14
Pentanoic acid	6	38	0	0	3	21

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 100 (Continued)

FREQUENCY OF NON-LISTED ORGANIC COMPOUNDS IN DISTRICT WRP SAMPLES - 2001

Type of Compound	Raw Sewage 16 Samples[1] Times Found	(%)	Effluent 14 Samples[1] Times Found	(%)	Sludge 14 Samples[1] Times Found	(%)
Base/Neutral/Acid Extractables (Continued)						
Ethylene glycol butyl ether	12	75	0	0	1	7
Aniline	2	13	0	0	0	0
Decane	3	19	1	7	4	29
Benzyl alcohol	11	69	0	0	1	7
o-Cresol	1	6	0	0	0	0
Acetophenone	2	13	0	0	0	0
m-and/or p-Cresol	9	56	0	0	6	43
Hexanoic acid	2	13	0	0	4	29
Undecane	9	56	0	0	8	57
Heptanoic acid	1	6	0	0	4	29
Benzoic acid	6	38	0	0	2	14
Octanoic acid	1	6	0	0	4	29
Dodecane	8	50	0	0	7	50
Diethylene glycol butyl ether	15	94	0	0	1	7
a-Terpineol	15	94	0	0	0	0
Phenylacetic acid	14	88	0	0	11	79
Nonanoic acid	8	50	4	29	2	14
Tridecane	10	63	0	0	7	50
Tripropylene glycol methyl	4	25	0	0	0	0
1-H-Indole	6	38	0	0	5	36
1-Phenylpropanoic acid	4	25	0	0	1	7
Decanoic acid	8	50	0	0	6	43
Tetradecane	11	69	0	0	9	64
N,N-Dimethyl-1-dodecanamine	14	88	0	0	8	57
Pentadecane	2	13	0	0	2	14
Dodecanol	14	88	0	0	13	93
Trimethylnaphthalene isomer	3	19	0	0	0	0
Dodecanoic acid	15	94	2	14	13	93
Hexadecane	4	25	0	0	2	14

TABLE 100 (Continued)

FREQUENCY OF NON-LISTED ORGANIC COMPOUNDS IN
DISTRICT WRP SAMPLES - 2001

Type of Compound	Raw Sewage 16 Samples[1] Times Found	(%)	Effluent 14 Samples[1] Times Found	(%)	Sludge 14 Samples[1] Times Found	(%)
Base/Neutral/Acid Extractables (Continued)						
Octyl phenol isomers	5	31	0	0	6	43
Tridecanoic acid	6	38	0	0	2	14
Heptadecane	7	44	0	0	8	57
Tetradecanol	11	69	0	0	9	64
Tetradecanoic acid	15	94	1	7	11	79
Nonyl phenol isomers	13	81	0	0	10	71
Octadecane	4	25	0	0	4	29
Caffeine	15	94	0	0	0	0
Petadecanoic acid	15	94	0	0	9	64
Carbazole	1	6	0	0	1	7
Nonadecane	8	50	0	0	6	43
Hexadecanol	15	94	0	0	6	43
cic-9-Hexadecenoic acid	10	63	0	0	7	50
Hexadecanoic acid	15	94	3	21	13	93
Heptadecanoic acid	14	88	0	0	8	57
Z-9-Octadecenoic acid	15	94	3	21	13	93
Octadecanoic acid	15	94	2	14	13	93

[1]Represents two sampling cycles (January and June 2001) for each of the seven WRPs (n = 14), with the Stickney WRP having two influents (n = 16 for raw sewage).

Toxicity Characteristic Leaching Procedure

The Toxicity Characteristic Leaching Procedure (TCLP) test is required under the Resource Conservation Recovery Act to characterize waste material, such as biosolids and scum, to ensure that it is safe for disposal. The original sample undergoes a series of tests, of which total PCBs are analyzed within the Toxic Substances Section. A TCLP extract is also made from the sample for subsequent analyses. Following USEPA Method 1311, the sample is shaken with an acetate buffer solution for 18 hours and filtered using specialized equipment to yield a TCLP extract, which is the filtrate. Separate extracts are generated for VOCs and non-VOCs. The respective extract is analyzed for a subset of the priority pollutant compounds, both inorganic and organic. The Section analyzes for 30 organic compounds (10 VOCs, 12 BNA extractable compounds, six pesticides, and two herbicides), using USEPA Methods 624, 625, 608, and *Standard Methods* 6640B, respectively. The TCLP samples analyzed in 2001 were from Stony Island, Calumet East, RASMA, LASMA, and HASMA (Ridgeland, Lawndale, and Harlem Avenue Solids Management areas). None of the samples was found to be hazardous.

Special Studies of Clean Air Act Compounds

The Toxic Substances Section provides analytical support to the Wastewater Treatment Research Section by analyzing organic hazardous air pollutants found in both raw sewage samples and in air samples collected in 6 liter canisters.

Raw sewage samples were collected twice a year at each of the District's seven WRPs during 2001, and analyzed for 87 compounds as required by the USEPA's Clean Air Act. The data were used as the input values for various mathematical models which predict VOC air emissions. These were the same samples collected and analyzed for in "Monitoring for Organic Priority Pollutants in District Water Reclamation Plants", with extra compounds added and several compounds removed, due to low volatility, from the organic priority pollutant list. Results of the listed Clean Air Act compounds found in the raw sewage samples are shown in Table_101.

As part of the District's support for this study, the Toxic Substances Section has also analyzed air samples collected in 6 liter canisters. The samples were collected at the Stickney and Calumet WRPs and surrounding solids management areas in August and October, 2001, respectively. A total of 24 samples were analyzed by a preconcentrator utilizing liquid nitrogen, followed by separation/detection with a gas

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TABLE 101

CLEAN AIR ACT LIST OF ORGANIC COMPOUNDS IN DISTRICT RAW SEWAGE[1] - 2001

Compounds	Reporting Limit µg/L	Values in µg/L (ppb)							
								Stickney	
		Calumet	Egan	Hanover Park	Kirie	Lemont	North Side	Southwest	West Side
Acetaldehyde	58	ND	ND	ND	ND	ND	ND	194	92
Acetonitrile	5	ND	ND	6	ND	ND	ND	ND	ND
Acetophenone	5	14	ND	ND	ND	ND	ND	ND	ND
Benzene	2	14	ND	ND	ND	ND	ND	2	ND
Carbon disulfide	2	ND	ND	ND	4	ND	ND	ND	ND
Chloroform	2	2	2	4	4	5	2	2	4
Total Cresols/Cresylic Acid	19	30	ND	ND	ND	ND	ND	ND	ND
Cumene	2	10	ND	ND	ND	ND	ND	ND	ND
Ethyl benzene	2	2	ND	ND	ND	ND	ND	ND	ND
Heptachlor	0.09	ND	ND	ND	0.14	ND	ND	ND	ND
Hexane	3	ND	ND	ND	ND	ND	ND	ND	3
Methyl ethyl ketone	6	ND	ND	ND	ND	ND	ND	8	ND
Methylene chloride	2	4	ND	ND	6	2	3	2	4
Propionaldehyde	35	ND	ND	ND	ND	ND	ND	461	213
Styrene	2	3	ND	ND	ND	ND	ND	ND	ND
Tetrachloroethene	2	5	ND	2	ND	ND	2	ND	ND
Toluene	2	29	2	24	2	10	3	6	5
Trichloroethene	2	ND	ND	ND	ND	ND	24	ND	ND
o-Xylene	2	3	ND	ND	ND	ND	ND	ND	ND
m-and/or p-Xylenes	3	6	ND	ND	ND	ND	ND	ND	ND
Total Xylenes	2	9	ND	ND	ND	ND	ND	ND	ND

[1]Average results of two samples from January and June 2001.
ND = Not Detected.

chromatograph/mass spectrometer. Acetone and ethyl alcohol were detected in 23 and 21 of the 24 samples with a range of 1.47 to 13.2 and 2.31 to 22.3 parts per billion by volume (ppbv), respectively. Also, commonly found were toluene (12 times) within a range of 0.52 to 9.23 ppbv, carbon disulfide (11 times) within a range of 0.53 to 1.78 ppbv, limonene (8 times) within a range of 0.48 to 14.1 ppbv, propene (8 times) within a range of 0.46 to 4.81 ppbv, and dimethyl sulfide (8 times) within a range of 0.45 to 120 ppbv, heaviest at Stickney aerated grit tanks. The heaviest sites were the Vulcan solids drying area with 23 different compounds found, and the TARP Main Stream Pumping Station, which had 16 different compounds identified, most of which can be found in fuels. In 2002, a more extensive sampling is planned, with possible sampling at selected sewer sites.

Industrial Waste Monitoring

The industrial waste monitoring project began in 1992 to internally analyze and monitor total toxic organics (TTOs) in industrial waste discharges. It was also designed to serve the District's industrial waste pretreatment program. Samples from different industries were analyzed for specific target analytes from the USEPA organic priority pollutant list.

Each of the USEPA listed industrial categories have a different set of target analytes. Because of the diverse range of organic analytes, most of these industrial waste samples are analyzed for three separate groups of compounds:

- VOCs by purge and trap gas chromatograph/mass spectrometer (GC/MS);
- BNA extractable compounds by GC/MS; and
- organochlorine pesticides and/or PCBs (PP) by gas chromatograph/electron capture detector (GC/ECD).

In addition to the samples collected from the USEPA listed categories, other samples were also collected for surveillance and special analyses. A list of all the categories of analyses, number of analytes in each category, and number of samples received are shown in Table 102.

Environmental Monitoring

Environmental monitoring projects include analysis of samples taken from:

- Lake Michigan during diversion of river waters following storm related events;
- discharge of combined sewer overflows into the O'Hare CUP reservoir;

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 102

NUMBER OF SAMPLES AND ANALYSES PERFORMED BY INDUSTRIAL WASTE CATEGORY - 2001

	Categories of Analyses	Analysis Type[1]	# of Analytes	# of Samples	# of Analyses
413	Electroplating	VOC, BNA, PP	113	24	2712
414	Organic Chemicals and Plastics	VOC, BNA	42	16	672
423	Steam Electric Power Generating	VOC, BNA, PP	113	1	113
433	Metal Finishing	VOC, BNA, PP	113	52	5876
439-46	Pharmaceutical Manufacturing	VOC	5	4	20
465	Coil Coating and Can Making	VOC, BNA	14	1	14
467	Aluminum Forming	VOC, BNA, PP	50	2	100
	PCBs Only	PP	6	14	84
	Surveillance	VOC, BNA, PP	125	4	500
	Trip Blanks	VOC	33	38	1254
	Totals			156	11,345

[1]VOC = volatile organic compounds, BNA = base/neutral/acid extractable compounds, PP = pesticides and/or PCBs.

- sludge and soil projects;
- spills;
- land reclamation projects; and
- other events not directly tied to Industrial Waste monitoring.

The analyses are generally for the analytes listed in USEPA Methods 608, 624, and 625 using GC/MS and GC/ECD. Other analytes of concern in certain samples (submitted for trouble-shooting) may require alternate methods using GC with flame ionization detector (GC/FID) or UV/visible.

DIVERSION OF WATER TO LAKE MICHIGAN

In 2001, diversion of river water to Lake Michigan happened four times. This occurred on July 25, August 2 and 31, and October 13. A total of 20 samples were taken at three sites, two sites near Calumet Harbor, and one site from Wilmette Harbor. Each site was sampled soon after the lake diversion and then again 2 - 6 hours later. In most cases, priority pollutants were present at a higher concentration during the later sampling. The highest concentrations found were at Calumet Harbor's 95th Street Bridge during the October storm, which showed concentrations of chloroform, bromodichloromethane, and dibromochloromethane at 9, 3, and 2 µg/L early, and 15, 6, and 3 µg/L later, respectively. The compounds found in Lake diversion samples collected at different times during the events are shown in Table 103.

BIOSOLIDS DEMONSTRATION PROJECT AT THE USX SITE

Evaluation of the water quality in monitoring wells on the USX site was started in 2000, and it is being conducted quarterly for the analysis of organic compounds. This is being done to monitor the impact of the biosolids/topsoil applications on groundwater quality. The Toxic Substances Section analyzed samples quarterly in 2001, and this will be continued in 2002. The results of the analyses for 2001 are reported in the Land Reclamation and Soil Science Section under the USX Research and Demonstration Project.

AMBIENT CHEMICAL WATER QUALITY MONITORING

The District has a monitoring program for the ambient waterways within its jurisdiction since 1970, and the data are evaluated for compliance with the Illinois Pollution Control Board (IPCB) water quality standards. In 2001 the waterways sampling was increased to expand and enhance the long term database of chemical ambient water quality in the Chicago metropolitan area, and to determine effects of pollution control activities on stream water quality. A total of 59 sampling sites were identified as compared to 51 sampling sites in

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TABLE 103

PRIORITY POLLUTANTS FOUND IN LAKE DIVERSION SAMPLES DURING 2001

Sampling Location	Date Sampled	Time Collected	Compounds Found (Concentration in µg/L)
Calumet Harbor, Ewing Street Bridge	7/25/01	11:05 a.m.	None
Calumet Harbor, Ewing Street Bridge	7/25/01	2:40 p.m.	None
Calumet Harbor, 95th Street Bridge	7/25/01	11:20 a.m.	None
Calumet Harbor, 95th Street Bridge	7/25/01	2:30 p.m.	None
Wilmette Harbor	8/2/01	12:00 p.m.	Acetone (10), Toluene (3)
Wilmette Harbor	8/2/01	5:30 p.m.	Acetone (13), Toluene (4)
Calumet Harbor, Ewing Street Bridge	8/2/01	11:00 a.m.	Chloroform (5), Toluene (3)
Calumet Harbor, Ewing Street Bridge	8/2/01	1:00 a.m.	None
Calumet Harbor, Ewing Street Bridge	8/2/01	3:00 p.m.	None
Calumet Harbor, Ewing Street Bridge	8/2/01	5:00 p.m.	Chloroform (2), Acetone (11)
Calumet Harbor, 95th Street Bridge	8/2/01	11:00 a.m.	None
Calumet Harbor, 95th Street Bridge	8/2/01	5:00 p.m.	Chloroform (4), Carbon disulfide (4), Phenol (5), 2,4,6-Trichlorophenol (6)
Wilmette Harbor	8/31/01	1:00 a.m.	None
Wilmette Harbor	8/31/01	4:00 a.m.	Acetone (10), Carbon disulfide (6), Toluene (2)
Wilmette Harbor	10/13/01	7:05 p.m.	4,4'-DDE (0.07)
Wilmette Harbor	10/13/01	10:20 p.m.	Tetrachloroethene (3)
Calumet Harbor, Ewing Street Bridge	10/13/01	9:00 p.m.	None
Calumet Harbor, Ewing Street Bridge	10/14/01	3:30 a.m.	Chloroform (7), Bromodichloromethane (3), Dibromochloromethane (2)
Calumet Harbor, 95th Street Bridge	10/13/01	9:00 p.m.	Chloroform (9), Bromodichloromethane (3), Dibromochloromethane (2)
Calumet Harbor, 95th Street Bridge	10/14/01	3:00 a.m.	Chloroform (15), Bromodichloromethane (6), Dibromochloromethane (3)

2000. The Toxic Substances Section participates in this project by analyzing samples semiannually for organic priority pollutants and quarterly for aromatic gasoline pollutants; benzene, ethyl benzene, toluene and xylenes (BETX). During 2001, a total of 115 samples were analyzed for 113 priority pollutants, and those same 115 samples plus another 66 were analyzed for BETX. A summary of compounds found in these samples is shown in Table 104.

Toxic Substances Quality Control/Quality Assurance Program

The extensive quality control/quality assurance (QA/QC) program continued in 2001 for organic analyses, as per the laboratory accreditation requirements of the IEPA's Environmental Laboratory Accreditation Program (IL ELAP). It consisted of the analysis of approximately 1,500 GC/MS purgeable runs, 1,000 GC/MS BNA runs, and 950 GC/ECD pesticides/PCBs and herbicides runs.

COMPLIANCE WITH PROTOCOLS

The QA/QC program applied USEPA protocols included analyzing instrument checks and developing calibration curves for the determination of listed BNAs, VOCs, pesticides, PCBs, and herbicides. Protocols also included analysis of method blanks, equipment blanks, check standards, recovery of

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TABLE 104

PRIORITY POLLUTANTS FOUND IN AMBIENT WATER MONITORING DURING 2001

Type of Compound	Reporting Limit µg/L	Number of Occurrences Out of 115 Samples	Maximum Value µg/L
<u>Purgeables</u>			
Chloroform	2	16	15
Dichlorobromomethane	1	8	6
Methyl chloride	3	1	3
Methylene Chloride	2	2	2
Tetrachloroethylene	2	1	2
Toluene	2	1*	5
<u>Base/Neutral/Acid Extractables</u>			
Benzo(a)pyrene	2	1	2
3,4-Benzofluoranthene	2	1	3
Benzo(k)fluoranthene	2	1	2
Bis(2-ethylhexyl)phthalate	50	6	1349
Chrysene	2	1	3
Fluoranthene	2	2	6
Indeno(1,2,3-cd)pyrene	2	1	2
Phenanthrene	2	1	4
Pyrene	2	2	5
<u>Pesticides and PCBs</u>			
None Found			

*Toluene is a BETX component with one occurrence out of 181 samples.

pollutant standards from laboratory control samples and matrix spikes/matrix spike duplicates, recovery of surrogates from samples and QC samples, and studies of initial demonstration of method performance and method detection limit (MDL).

The Section has complied with the standardized quality assurance and quality control as specified in the USEPA 600 series analytical methods (i.e., Methods 608, 624, and 625) and the ASTM Standard Methods 6640B for the analysis of the target compounds. The analytical instruments and analytical processes are calibrated with reference materials that are traceable to the National Institute for Standards and Technology. More than three calibration points are used with the lowest of these points near the MDL and the highest point near the upper linear range of the calibration curve for the analytical system. The linearity of calibration curves is within the limits of the USEPA or ATSM specified methods.

For verification of calibration, the specifications outlined for each compound are followed as stated in the methods. Method blanks are analyzed on a routine basis with each batch of samples prepared, and adhere to the general guidelines pertaining to common laboratory contaminants. Matrix spikes are performed at least once for every 20 samples for VOC, BNA, and herbicide analysis, and every 10 samples for pesticide/PCB analysis. The recovery of the compound is compared to the percent recovery (%R) limits as specified in the methods to ensure that the analyses are yielding acceptable results. Evaluation of the QC/QA program showed that the Toxic Substances Laboratory performance met the requirements of the USEPA during 2001.

PERFORMANCE EVALUATION STUDIES

When the USEPA stopped supplying Water Pollution Performance Evaluation Study samples, participating laboratories were required to purchase these samples from accredited commercial sources. The District has been obtaining performance evaluation samples from Environmental Resource Associates. These include two sets of eleven samples for water analysis and two sets of six samples for soils analysis. Performance evaluation studies are run semiannually for both water and soil. Each of these sets contains all the 113 analytes of EPA Methods 608, 624, 625, and the *Standard Methods* 6640B, requiring identification as well as quantitation. This is an improvement over the limited subset of identified analytes that the USEPA previously supplied or the National Environmental Laboratory Accreditation Conference specified.

Laboratory Certification

The Toxic Substances Laboratory has achieved the laboratory certification under the IL ELAP for organic compounds in wastewater and solid waste. The Section will continue to maintain and update if necessary the extensive Quality Assurance Plan, nine Standard Operating Procedures for analytical methods, and recordkeeping system which includes, among others, daily monitoring of cold room temperatures, records of instrument maintenance/services, checks of analytical balances, sample tracking logs, and sample disposal logs.

RADIOCHEMISTRY SECTION

The Radiochemistry Section is responsible for the radiological monitoring of waters, wastewaters and sludges, 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 received its certification from the Illinois Department of Nuclear Safety (IDNS) on October 2, 2001. 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 the area's 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 2001 since there are radioactivity water quality standards for the General Use waters.

Since 1978, the Section has conducted radiological monitoring of sludges from both the LASMA and HASMA drying sites. Beginning in 1993, sludge sampling was greatly increased to include digested sludges from District WRPs and air-dried sludges ready for final disposal.

The Section also maintains the radioactive material license issued to the District by the Illinois Department of Nuclear Safety (IDNS), assuring that the activities are conducted according to the license conditions and regulations.

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 the radioactive material license issued to the District by the IDNS up-to-date;
- reporting information regarding low-level radioactive waste to IDNS;
- monitoring of personnel and work areas in the Radiochemistry Laboratory;
- leak testing of sealed nickel-63 detectors used in gas chromatographs;
- leak testing of nuclear gauges; and
- monitoring users of these devices for radiation exposure.

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 IDNS. In 2001, the relevant forms were received from the IDNS, completed, and returned to the IDNS.

The radiological monitoring of District employees and work areas 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 196 dosimeters were analyzed in 2001. No employee of the District was exposed to an overdose of radiation.

The Radiochemistry Laboratory is regularly surveyed for radiation contamination. A total of 120 wipe tests were performed in 2001. No contamination was found in any work area.

As per IDNS 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 2001.

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 2001:

Varian A-12876	Two leak tests
Varian A-12877	Two leak tests
Finnigan 5678	Two leak tests
Finnigan 5680	Two leak tests
Hewlett-Packard U-1440	Two leak tests
Hewlett-Packard U-1451	Two leak tests

No leaks were detected in any detectors used by the District.

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 2001. No leaks were detected in any of these gauges.

Certification by the IDNS

In response to the District's request for certification of the radiochemistry laboratory, the IDNS conducted an on-site evaluation of the laboratory on February 16, 2001. The evaluation included the radiochemistry laboratory facilities, personnel, equipment, record keeping, quality control procedures, and radioanalytical procedures.

The radiochemistry laboratory was certified by the IDNS on October 2, 2001. The laboratory is approved for the examination of gross alpha/beta, tritium, and photon emitting radionuclides in public water supplies.

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 2001, the Radiochemistry Section analyzed two Quality Assessment water samples for tritium, gross alpha, gross beta, cobalt-60, 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.

Levels of Radioactivity in Raw and Treated Wastewaters

Radiological monitoring of raw wastewaters and final effluents from the District's seven WRPs continued in 2001. 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 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 U.S. Environmental Protection Agency, 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, Chatsworth, 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 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 105 presents the 2001 yearly averages of gross alpha radioactivity for the raw sewage and final effluent from the District's seven WRPs. With the exception of the Stickney Southwest and Lemont WRPs, average raw sewage gross alpha radioactivity at all the WRPs was less than the LLD (4.7 to 5.3 pCi/L). The gross alpha radioactivity at the Stickney Southwest WRP was 7.2 pCi/L and at the Lemont WRP it was 33.3 pCi/L. The gross alpha radioactivity in the final effluent at all the WRPs was less than the LLD (4.4 to 9.1 pCi/L). This level of radioactivity in Lemont raw sewage has been observed since the Village of Lemont began water-treatment process for 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.

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TABLE 105

AVERAGE GROSS ALPHA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WRPs - 2001

WRP Type of Sample	Gross Alpha Radioactivity (pCi/L)
Stickney	
Raw (West Side)	<5.0
Raw (Southwest)	7.2
Secondary - Final Effluent	<4.4
Calumet	
Raw	<5.1
Secondary - Final Effluent	<4.5
North Side	
Raw	<4.9
Secondary - Final Effluent	<4.5
Hanover Park	
Raw	<4.7
Tertiary - Final Effluent	<4.4
John E. Egan	
Raw	<5.0
Tertiary - Final Effluent	<4.6
Lemont	
Raw	33.3
Secondary - Final Effluent	<9.1
James C. Kirie	
Raw	<5.3
Tertiary - Final Effluent	<4.9

< = Less than LLD.

Table 106 presents the 2001 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, 50.0 and 22.3 pCi/L, respectively. At the remaining six WRPs, the average raw sewage gross beta radioactivity ranged from 12.8 to 22.9 pCi/L, and the average final effluent total beta radioactivity ranged from 8.5 to 13.3 pCi/L.

Levels of Radioactivity in Sludges

In 1993, the Radiochemistry Section revised and expanded its monitoring program of District sludges in response to the increased emphasis on sludge characteristics 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 sludge.

During 2001, sludge samples were collected monthly at all WRPs. Biosolids samples were also collected monthly from the eight sludge drying sites of the District from May through September.

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TABLE 106

AVERAGE GROSS BETA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WRPs - 2001

WRP Type of Sample	Gross Beta Radioactivity (pCi/L)
Stickney	
Raw (West Side)	16.5
Raw (Southwest)	22.9
Secondary - Final Effluent	9.2
Calumet	
Raw	13.6
Secondary - Final Effluent	9.4
North Side	
Raw	12.8
Secondary - Final Effluent	8.5
Hanover Park	
Raw	14.2
Tertiary - Final Effluent	9.6
John E. Egan	
Raw	16.0
Tertiary - Final Effluent	9.5
Lemont	
Raw	50.0
Secondary - Final Effluent	22.3
James C. Kirie	
Raw	17.6
Tertiary - Final Effluent	13.3

Sludge samples were processed according to the *Standard Methods* (20^{th} 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 thorium-230 standard for gross alpha, and cesium-137 standard for gross beta radioactivity determinations. The results, in pCi/g of dry weight (DW), were averaged and are tabulated in Tables 107 and 108.

In Table 107, the average gross alpha radioactivity of WRP digester draws from the Calumet, John E. Egan, Hanover Park, and Stickney WRPs and activated sludge from the Lemont, North Side, and James C. Kirie WRPs ranged from a low of 7.8 pCi/g DW at the North Side WRP to a high of 141.1 pCi/g DW at the Lemont WRP. The average gross beta radioactivity of these sludges ranged from a low of 14.2 pCi/g DW at the Hanover Park WRP to a high of 90.7 pCi/g DW at the Lemont WRP.

Table 108 presents the gross alpha and gross beta data for air-dried biosolids from the District solids drying sites. The average total alpha radioactivity ranged from a low of 13.1 pCi/g DW for the Calumet East drying site to a high of 17.7 pCi/g DW for the RASMA drying site. The average total beta radioactivity ranged from a low of 21.0 pCi/g DW for the Calumet West drying site to a high of 26.7 pCi/g DW for the RASMA drying site.

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TABLE 107

GROSS ALPHA AND GROSS BETA RADIOACTIVITY OF WRP SLUDGES - 2001

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	12.6	5.3	18.0	24.1	19.5	29.7
John E. Egan Digester Draw	12	10.5	4.4	15.2	20.7	17.4	23.2
Lemont[1] Activated Sludge	12	141.1	81.4	180.5	90.7	56.2	149.7
Hanover Park Digester Draw	12	9.4	4.3	16.1	14.2	12.6	16.4
James C. Kirie[1] Activated Sludge	12	9.2	3.0	17.1	15.8	10.3	19.7
North Side[1] Activated Sludge	12	7.8	3.2	12.1	15.8	11.0	21.2
Stickney Digester Draw	12	12.3	3.8	18.6	27.3	21.3	31.2

[1]No digesters at this WRP.

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TABLE 108

GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN DISTRICT BIOSOLIDS - 2001

Drying Site Location	No. of Samples	Gross Alpha (pCi/g DW)			Gross Beta (pCi/g DW)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
LASMA	5	17.5	15.4	20.2	25.8	23.0	28.2
Calumet East	5	13.1	9.1	16.4	23.4	12.0	26.1
Calumet West	5	17.6	13.5	20.9	21.0	17.1	24.4
HASMA	5	16.4	11.1	21.5	25.0	21.3	27.8
Marathon	5	17.5	14.9	21.6	24.2	22.7	25.6
Stony Island	5	15.2	11.9	20.1	25.0	22.1	27.7
Vulcan	5	15.8	10.7	20.4	23.2	17.5	28.3
RASMA	5	17.7	15.7	19.0	26.7	24.6	29.0

Sludge samples were also processed for the determination of specific 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 reconcentration 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 from 661.6 Kev photopeak, and potassium-40 radioactivity from 1461 Kev photopeak. Two of these three radionuclides, potassium-40 and radium-226, 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 109 presents the potassium-40, cesium-137, and radium-226 concentrations in the District's sewage sludge. The

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TABLE 109

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WRP SLUDGES - 2001

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	3	8.3	7.1	8.7	4.8	4.5	5.0	0.05	0.04	0.05
John E. Egan	3	8.3	7.1	9.6	4.1	4.0	4.2	ND	ND	ND
Hanover Park	3	4.9	4.0	6.3	4.5	4.3	4.5	ND	ND	ND
Stickney	3	10.5	9.8	10.9	3.8	3.7	3.9	0.06	ND	0.08
Lemont	2	8.6	8.5	8.7	72.6	68.9	76.4	ND	ND	ND

ND = Not Detected.

average potassium-40 radioactivity ranged from 4.9 pCi/g DW at Hanover Park WRP to 10.5 pCi/g DW at Stickney WRP. The average cesium-137 radioactivity ranged from non-detectable levels at Egan, Hanover Park, and Lemont WRPs to 0.06 pCi/g DW at Stickney WRP. The average radium-226 radioactivity ranged from 3.8 pCi/g DW at Stickney WRP to 72.6 pCi/g DW at Lemont WRP.

Table 110 presents the potassium-40, cesium-137, and radium-226 concentrations in the District's biosolids from the drying sites. The average potassium-40 radioactivity in the biosolids ranged from 7.4 pCi/g DW at Calumet West to 11.3 pCi/g DW at RASMA and Vulcan drying sites. The average cesium-137 radioactivity ranged from 0.06 pCi/g DW at Calumet East to 0.09 pCi/g DW at Stony Island, LASMA, and Marathon drying sites. The average radium-226 radioactivity ranged from 3.6 pCi/g DW at HASMA to 5.2 pCi/g DW at Calumet West drying site.

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,

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TABLE 110

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN DISTRICT BIOSOLIDS - 2001

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	10.4	3.4	13.8	4.6	3.5	5.6	0.06	0.04	0.08
Calumet West	5	7.4	6.6	8.1	5.2	4.7	5.9	0.08	0.06	0.10
RASMA	5	11.3	9.4	12.3	3.8	<0.9	4.9	0.08	0.07	0.10
Stony Island	5	8.9	8.2	9.6	4.4	3.8	4.9	0.09	0.06	0.10
HASMA	5	11.1	9.6	12.4	3.6	2.2	4.4	0.07	0.05	0.09
LASMA	5	9.9	8.9	10.7	3.9	1.8	4.8	0.09	0.07	0.10
Marathon	5	10.3	9.8	11.0	4.3	4.0	4.5	0.09	0.07	0.11
Vulcan	5	11.3	9.8	13.8	4.0	3.7	4.3	0.07	0.05	0.09

Chicago, and Des Plaines River systems comprising 170 miles (273.6 km) of waterways. There were fifteen 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.

As a part of a special project, weekly samples were collected from five locations of the lower Des Plaines River, and analyzed for gross alpha and gross beta radioactivity.

The waterways samples were processed using U.S. Environmental Protection Agency, 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 111 presents the 2001 average values for gross alpha and gross beta radioactivity for the Chicago waterways at each of the 43 sampling locations. The average gross alpha radioactivity in the water samples was found to be less than the detection limits (3.4 to 6.1 pCi/L). The average gross beta radioactivity ranged from less than 4.4 to 14.8 pCi/L.

Table 112 presents the 2001 average values for gross alpha and gross beta radioactivity for the lower Des Plaines River at each of the five locations. The average gross alpha radioactivity in the lower Des Plaines River water samples was

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 111

AVERAGE GROSS ALPHA AND GROSS BETA
RADIOACTIVITY FOR THE CHICAGO WATERWAYS - 2001

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Lake-Cook Rd., Des Plaines	<5.3	8.3
Oakton Street, Des Plaines	<5.3	7.9
Belmont Ave., Des Plaines	<4.7	8.3
Roosevelt Road, Des Plaines	<4.8	7.9
Ogden Avenue, Des Plaines	<4.8	8.1
Willow Springs Rd., Des Plaines	<4.8	8.8
Stephen Street, Des Plaines	<4.8	8.2
Lake-Cook Rd., Buffalo Creek	<5.0	<6.4
Elmhurst Rd., Higgins Creek	<6.1	7.6
Wille Rd., Higgins Creek	<5.3	14.8
Higgins Rd., Salt Creek	<5.5	<7.0
Arlington Heights Rd., Salt Creek	<5.3	<9.3
Devon Ave., Salt Creek	<5.0	8.2
Wolf Rd., Salt Creek	<4.4	9.1
First Ave., Salt Creek	<5.0	9.3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 111 (CONTINUED)

AVERAGE GROSS ALPHA AND GROSS BETA
RADIOACTIVITY FOR THE CHICAGO WATERWAYS - 2001

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Route 19, Popular Creek	<5.6	<6.0
Longmeadow Ln., W. Br. Dupage River	<4.7	<6.8
Walnut Lane, W. Br. Dupage River	<4.4	9.8
Lake St., W. Br. Dupage River	<4.9	9.9
Central St., N. Shore Channel	<3.4	<4.4
Oakton St., N. Shore Channel	<4.0	<5.4
Touhy Avenue, N. Shore Channel	<4.2	7.3
Dundee Rd., W. Fork N. Branch	<4.8	12.2
Golf Rd., W. Fork N. Branch	<4.7	8.6
Lake-Cook Rd., Middle Fork, N. Branch	<5.9	<7.6
Glenview Rd., Middle Fork, N. Branch	<4.6	7.5
Lake-Cook Rd., Skokie River	<4.8	<6.2
Frontage Rd., Skokie River	<4.5	7.8
Dempster St., N. Br. Chicago River	<4.8	7.9
Albany Ave., N. Br. Chicago River	<4.7	<7.4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 111 (CONTINUED)

AVERAGE GROSS ALPHA AND GROSS BETA
RADIOACTIVITY FOR THE CHICAGO WATERWAYS - 2001

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Lake Shore Dr., Chicago River	<4.1	<5.8
Well St., Chicago River	<4.3	<7.0
Cicero Ave., Chicago Sanitary & Ship Canal	<4.1	8.1
Harlem Ave., Chicago Sanitary & Ship Canal	<4.5	8.2
Ewing Ave., Calumet River	<3.9	<5.2
130th St., Calumet River	<3.9	<6.5
Avenue O (127th St.), Wolf Lake	<3.6	<5.2
Indiana Ave., Little Calumet River	<4.4	8.2
Halsted Ave., Little Calumet River	<4.4	7.8
Wentworth Ave., Little Calumet River	<4.6	9.7
Ashland Ave., Little Calumet River	<4.8	8.9
Joe Orr Road, Thorn Creek	<5.8	8.5
170th St., Thorn Creek	<5.0	9.0

< = Less than LLD.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 112

AVERAGE GROSS ALPHA AND GROSS BETA RADIOACTIVITY
OF THE LOWER DES PLAINES RIVER - 2001

Location	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
Material Services Bridge, Joliet	<5.0	8.7
Lockport Powerhouse Forebay, Lockport	<4.5	8.4
Jefferson Street, Joliet	<4.5	8.2
Empress Casino, Joliet	<4.6	8.5
Upstream of I-55 at mouth of Jackson Creek, Channahon	<4.5	9.0

< = Less than LLD.

less than the detection limits (4.5 to 5.0 pCi/L). The average gross beta radioactivity ranged from 8.2 to 9.0 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 for gross beta particle activity minus the naturally occurring potassium-40 beta particle activity.

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, collecting of appropriate data, developing of guidelines for data collection method, and performing statistical analyses. Since 1999, section personnel have been performing these tasks using PC computing media. They also developed programs to interconnect SAS with Visual Basic, Access, and Excel 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 2001, the section provided statistical and computing support to various projects undertaken within the EM&R Division. These include providing statistical support to:

1. Wastewater Treatment Research Section on the development of pretreatment local limits based on the USEPA's 1987 guidance manual. Environmental criterion were used to determine the limits for pollutants at each of the District's seven WRPs.

2. Land Reclamation and Soil Science Section on the concentration of metals in street dust collected from the drainage basins of the Stickney and Calumet WRPs. Statistical analyses were done to determine if there were any significant differences in the mean concentrations of metals in the street dust, surface soil, auto graveyard, and scrap metal yards.
3. Aquatic Ecology and Water Quality Section in designing a graphic program that produces graphs for the required weekly dissolved oxygen reports.
4. Development of automation programs to produce tables, graphs using Visual Basic for Applications, and SAS for conducting assignments and assisting division staff.
5. Numerous requests, short projects, and reports by personnel from other departments, and on requests received from outside the District.

Water Quality Data

Each year, this section prepares an annual report describing the water quality of the streams and channels within the District's jurisdiction for the preceding year. Surface water quality data for 1999 and 2000 were evaluated regarding compliance with water quality standards set by the Illinois Pollution Control Board (IPCB). An annual report for 1999 was produced and a draft of 2000 water quality annual report was also prepared in 2001.

COMPLIANCE OF GENERAL USE WATERS

In 2000, 28 water quality parameters were assayed. These included:

1.	temperature;	2.	ammonium nitrogen;
3.	phenols;	4.	total arsenic;
5.	total barium;	6.	total boron;
7.	total cadmium;	8.	total chromium (trivalent and hexavalent);
9.	soluble iron;	10.	total lead;
11.	total nickel;	12.	total manganese;
13.	total mercury;	14.	total zinc;
15.	total selenium;	16.	dissolved oxygen;
17.	pH;	18.	chloride;
19.	un-ionized ammonia	20.	total dissolved solids;
21.	sulfate;	22.	weak acid dissociable cyanide;
23.	fluoride;	24.	fecal coliform;

25. gross beta radioactivity; 26. total silver;

27. total copper; and 28. total iron.

The first 15 parameters listed above were in total compliance in General Use Waters of all river systems. Of the remaining 13 parameters, 11 parameters had compliance rates greater than 72.4 percent in all river systems. Gross beta radioactivity had total compliance in the Chicago and Des Plaines River systems, but no data for gross beta radioactivity was taken in the Calumet River system. Fecal coliform had the lowest compliance rate, varying from 31.8 to 58.3 percent in the Chicago, Calumet, and Des Plaines River systems.

COMPLIANCE OF SECONDARY CONTACT WATERS

Twenty-two water quality parameters were covered by the IPCB water quality standards for samples taken in the secondary contact waters. These included:

1. temperature; 2. phenols;

3. cyanide; 4. fluoride;

5. total silver; 6. total arsenic;

7. total barium; 8. total cadmium;

9. total copper; 10. total chromium;

11. soluble iron;
12. total lead;
13. total nickel;
14. total manganese;
15. total mercury;
16. total zinc;
17. total selenium;
18. dissolved oxygen;
19. pH;
20. un-ionized ammonia;
21. total dissolved solids; and
22. total iron.

The first 15 parameters listed above were in complete compliance in all river systems. The compliance rates of the remaining 7 parameters varied from 92.4 to 100.0 percent in the Chicago, and Calumet River Systems.

APPENDIX I

MEETINGS AND SEMINARS 2001

MEETINGS AND SEMINARS 2001

1. Association of Metropolitan Sewerage Agencies Winter Meeting, San Diego, California, January 2001.

2. Illinois Environmental Protection Agency, Meeting on TMDLs for the DuPage River Watershed, Lisle, Illinois, January 2001.

3. Illinois Water Environment Association, Government Affairs in Water Pollution Control Seminar, Lisle, Illinois, January 2001.

4. Lake Michigan Water Analysts Winter Meeting, Kenosha, Wisconsin, January 2001.

5. United States Department of Agriculture, Annual Meeting of Regional Research Committee W-170, Las Vegas, Nevada, January, 2001.

6. Water Environment Research Foundation Research Council Meeting, Arlington, Virginia, January 2001.

7. Pesticide/Herbicide Applicators Training/Examination for Fulton County Research and Development Department Staff, Jacksonville, Illinois, February 2001.

8. United States Environmental Protection Agency, Region V, Great Lakes Conference, Chicago, Illinois, February 2001.

9. Water Environment Federation/American Water Works Association/CWEA Biosolids Joint Residuals and Management Conference, San Diego, California, February 2001.

10. Central States Water Environment Association, 2001 Education Seminar, Madison, Wisconsin, March 2001.

11. Illinois Water Environment Association, 2001 Annual Conference, Rockford, Illinois, March 2001.

12. Los Angeles County Sanitation District and South Coast Air Quality Management District Air Monitoring Laboratories, Training for Air Analysis, Playa DelRay, California, March 2001

MEETINGS AND SEMINARS 2001

13. Michigan Water Environment Association, Land Application for Biosolids Conference, Lansing, Michigan, March 2001.

14. Pittsburgh Conference 2001, New Orleans, Louisiana, March 2001.

15. Water Environment Federation, TMDL Science Issues Conference, St. Louis, Missouri, March 2001.

16. "The Geochemical Complexity of a Man-made Aquifer and its Impacts on Monitoring, Remediation, and Biodiversity," United States Environmental Protection Agency, Chicago, Illinois, April 2001.

17. "The Illinois Waterway Ecosystem Restoration Study and The Reuse of Dredged Material from the Peoria Pool," United States Environmental Protection Agency, Chicago, Illinois, April 2001.

18. American Society for Microbiology , 101st General Meeting, Orlando, Florida, May 2001.

19. "Applying a Performance Based Approach to U.S. EPA SW-846/3535A, Solid Phase Extraction," Countryside, Illinois, May 2001.

20. Association of Metropolitan Sewerage Agencies, 2001 National Environmental Policy Forum Meeting, Washington, D.C., May 2001.

21. Lake Michigan Water Analysts Spring Meeting, Northbrook, Illinois, May 2001.

22. United States Environmental Protection Agency, Region V, Annual National Forum on Contaminants in Fish, Chicago, Illinois, May 2001.

23. United States Environmental Protection Agency, Region V, Horizon Technology, Inc. and Mallinckrodt Baker, Inc., Implementation of Analytical Methods for RCRA Site Assessment and Monitoring Seminar, Chicago, Illinois, May 2001.

MEETINGS AND SEMINARS 2001

24. Illinois Department of Public Health, Response to Bioterrorism: What Clinical Laboratories Need to Know Training Course, Chicago, Illinois, June 2001.

25. Manhattan College, Environmental Engineering Department, Water Quality Modeling Course, Riverdale, New York, June 2001.

26. North American Benthological Society, 49th Annual Meeting, LaCrosse, Wisconsin, June 2001.

27. United States Environmental Protection Agency, Stakeholder Meeting on Nutrient Criteria, Arlington, Virginia, June 2001.

28. United States Environmental Protection Agency, Region V, and Water Environment Federation, Innovative Processes to Produce Useful Materials and Energy from Biosolids Animal Manure - A Symposium, Chicago, Illinois, June 2001.

29. United States Environmental Protection Agency, Region V, Stakeholder Workshop - Great Lakes Strategy, Chicago, Illinois, July 2001.

30. Water Environment Research Foundation, Project OO-ECO-2 Meeting, Lakewood, Colorado, July 2001.

31. Source Sampling and CEMS Workshop, Raleigh, North Carolina, August 2001.

32. United States Environmental Protection Agency, Public Forum on the Draft National Beach Guidance and Grant Performance Criteria for Recreational Waters, Chicago, Illinois, August 2001.

33. United States Geological Survey, Inter-Agency Technical Task Force on E.coli Meeting, Gary, Indiana, August 2001.

34. University of Illinois, McCook/Thornton Aeration Pilot Plant Study Presentation, Urbana-Champaign, Illinois, August 2001.

MEETINGS AND SEMINARS 2001

35. American Bar Association 2001 Environmental Conference, Chicago, Illinois, September 2001.

36. Comprehensive Capillary GC Seminar, Rosemont, Illinois, September 2001.

37. American Society of Agronomy, 2001 Annual Meeting, Charlotte, North Carolina, October 2001.

38. Illinois Department of Public Health, Environmental Laboratory Seminar, Springfield, Illinois, October 2001.

39. National Biosolids Partnership Steering Committee, Denver, Colorado, October 2001.

40. Water Environment Federation 74th Annual Conference, Atlanta, Georgia, October, 2001.

41. Environmental GC Analysis Seminar, Schaumburg, Illinois, November 2001.

42. Lake Michigan: State of the Lake 2001 Conference, Muskegon, Michigan, November 2001.

43. Society of Environmental Toxicology and Chemistry, 22nd Annual Meeting, Baltimore, Maryland, November 2001.

44. Agilent Technologies 2001 HPLC Educational Seminar Series Open Forum XI, Lincolnshire, Illinois, December 2001

45. Water Environment Research Foundation, Project Subcommittee Meeting, Cincinnati, Ohio, December 2001.

APPENDIX II

PAPERS PRESENTED 2001

PAPERS PRESENTED 2001

1. "Use of Biosolids to Remediate Brownfield Sites." Presented at the United States Department of Agriculture, Annual Meeting of Regional Research Committee W-170, Las Vegas, Nevada, by Thomas C. Granato, January 2001.

2. "Does Termination of Long-Term Annual Biosolids Applications to Land Cause a Time Bomb of Increased Metal Uptake by Corn?" Presented at the Water Environment Federation/ American Water Works Association/California Water Environment Association, Joint Residuals and Biosolids Management Conference, Biosolids 2001: "Building Public Support," San Diego, California, by Thomas C. Granato, Prakasam Tata, Richard I. Pietz, George Knafl, Carl R. Carlson, Jr., Richard Lanyon, and Cecil Lue-Hing, February 2001.

3. "Suitability of Biosolids for Use as a Topsoil Substitute in Urban Reclamation Projects." Presented at the Water Environment Federation/American Water Works Association/California Water Environment Association, Joint Residuals and Biosolids Management Conference, Biosolids 2001: "Building Public Support," San Diego, California, by Prakasam Tata, Thomas C. Granato, Richard I. Pietz, Cecil Lue-Hing, and Richard Lanyon, February 2001.

4. "Continuous DO Monitoring in Chicago's Deep-Draft Waterways." Presented at the Illinois Water Environment Association 2001 Annual Conference, Rockford, Illinois, by Irwin Polls, March 2001.

5. "Main Drivers for the Solids Management Practices at the Metropolitan Water Reclamation District of Greater Chicago - A Historical Perspective." Presented at the Illinois Water Environment Association 2001 Annual Conference, Rockford, Illinois, by Prakasam Tata, March 2001.

6. "Management of Solids at the Metropolitan Water Reclamation District of Greater Chicago - Past and Present Practices." Presented at the Michigan Water Environment Association Land Application of Biosolids Seminar, Lansing, Michigan, by Prakasam Tata, March 2001.

7. "Overview of Illinois Pollution Control Board Part 742 Tiered Approach to Corrective Action Objectives (TACO)

and Implications for Land Application of Biosolids in the State of Illinois." Presented at the Illinois Water Environment Association 2001 Annual Conference, Rockford, Illinois, by Thomas C. Granato, March 2001.

8. "Process Control Troubleshooting of Activated Sludge Process by SOUR Relationships." Presented at the Illinois Water Environment Association 2001 Annual Conference, Rockford, Illinois, by Kamlesh Patel, Prakasam Tata, Bernard Sawyer, and David T. Lordi, March 2001.

9. "Radiological Monitoring of the Raw Sewage, Final Effluent, Sludge, and Biosolids of the Metropolitan Water Reclamation District of Greater Chicago." Presented at the Illinois Water Environment Association 2001 Annual Conference, Rockford, Illinois, by Abdul Khalique, Richard Pietz, Prakasam Tata, and Richard Lanyon, March 2001.

10. "So You Want to Get Your Low Tech Process Certified as Equivalent to a PFRP; Stay Tuned!" Presented at the Central States Water Environment Association 2001 Education Seminar, Madison, Wisconsin, by Prakasam Tata, Richard Lanyon, and Cecil Lue-Hing, March 2001.

11. "Uptake of Heavy Metals by Vegetables Grown in Biosolids Amended Soil - Are USEPA Rules Protective?" Presented at the Illinois Water Environment Association 2001 Annual Conference, Rockford, Illinois, by Albert Cox, March 2001.

12. "Use of Reflectors to Enhance Synergism of Solar Radiation and Solar Heating to Disinfect Drinking Water." Presented at the American Society for Microbiology 101st General Meeting, Orlando, Florida, by Geeta K. Rijal and Roger S. Fujioka, May 2001.

13. "An Innovative Way to Treat Poultry Waste for Odor Control and Nitrogen Management." Presented at the United States Environmental Protection Agency, Region V, and Water Environment Federation, Innovative Processes to Produce Useful Materials and Energy from Biosolids and Animal Manure - A Symposium, Chicago, Illinois, by Prakasam Tata and Raymond Loehr, June 2001.

PAPERS PRESENTED 2001

14. "Testing and Evaluation of Biosolids to Meet Requirements of an Urban Market." Presented at the United States Environmental Protection Agency, Region V, and Water Environment Federation, Innovative Processes to Produce Useful Materials and Energy from Biosolids and Animal Manure - A Symposium, Chicago, Illinois, by Albert Cox, Thomas C. Granato, Richard I. Pietz, and Prakasam Tata, June 2001.

15. "Water Quality Issues in Chicago Area Waterways." Presented at the American Bar Association 2001 Environmental Conference, Chicago, Illinois, by Irwin Polls, September 2001.

16. "Residual Impact of a High Metal Content Biosolids on Cd and Zn Uptake in Garden Vegetables." Presented at the American Society of Agronomy 2001 Annual Meeting, Charlotte, North Carolina, by Albert Cox, October 2001.

17. "The Effects of Age on *Pimephales promelas* Survival in Acute Whole Effluent Toxicity Tests." Presented at the Water Environment Federation 74th Annual Conference, Atlanta, Georgia, by James Zmuda, Jon Yamanaka, Zainul Abedin, Bernard Sawyer, Prakasam Tata, Cecil Lue-Hing, and George Knafl, October 2001.

APPENDIX III

PAPERS PUBLISHED 2001

PAPERS PUBLISHED 2001

1. Granato, T.C., P. Tata, R.I. Pietz, G. Knafl, C.R. Carlson, Jr., R. Lanyon, and C. Lue-Hing. "Does Termination of Long-Term Annual Biosolids Applications to Land Cause a Time Bomb of Increased Metal Uptake by Corn?" Proceedings of the Water Environment Federation/American Water Works Association/California Water Environment Association, Joint Residuals and Biosolids Management Conference, Biosolids 2001: "Building Public Support," Water Environment Federation, Alexandria, Virginia, 2001.

2. Granato, T.C., P. Tata, R.I. Pietz, C. Lue-Hing, and R. Lanyon. "Use of Biosolids as a Soil Substitute in Urban Markets - The Metropolitan Water Reclamation District of Greater Chicago Experience." Proceedings of the Water Environment Federation Innovative Uses of Biosolids and Biosolids Management Conference, Water Environment Federation, Alexandria, Virginia, 2001.

3. Tata, P., D. Bernstein, J.S. Jain, R.I. Pietz, C. Lue-Hing, and R. Lanyon. "Advances in Conventional and Innovative Uses of Biosolids." Proceedings of the Water Environment Federation Innovative Uses of Biosolids and Biosolids Management Conference, Water Environment Federation, Alexandria, Virginia, 2001.

4. Tata, P., R.I. Pietz, and C. Lue-Hing. "Solids Management at the Metropolitan Water Reclamation District of Greater Chicago - Past and Present." Proceedings of the Virginia Water Environment Association Education Seminar, Virginia Water Environment Association, Alexandria, Virginia, 2001.

5. Tata, P., T.C. Granato, R.I. Pietz, C. Lue-Hing, and R. Lanyon. "Suitability of Biosolids for Use as a Topsoil Substitute in Urban Reclamation Projects." Proceedings of the Water Environment Federation/American Water Works Association/California Water Environment Association, Joint Residuals and Biosolids Management Conference, Biosolids 2001: "Building Public Support," Water Environment Federation, Alexandria, Virginia, 2001.

6. Zmuda, J., J. Yamanaka, Z. Abedin, B. Sawyer, P. Tata, C. Lue-Hing, and G. Knafl. "The Effects of Age on *Pimephales promelas* Survival in Acute Whole Effluent Tox-

icity Tests." Proceedings of the Water Environment Federation 74th Annual Conference, Water Environment Federation, Alexandria, Virginia, 2001.

APPENDIX IV

RESEARCH AND DEVELOPMENT DEPARTMENT
2001 SEMINAR SERIES

RESEARCH AND DEVELOPMENT DEPARTMENT
2001 SEMINAR SERIES

Date	Subject
Friday February 23, 2001	***Illinois Environmental Protection Agency's Anticipated Regulatory and Program Initiatives Related to Water Quality*** Mr. Toby Frevert, Acting Division Manager Water Pollution Control Illinois Environmental Protection Agency Springfield, Illinois
Friday March 30, 2001	***Coping with the Challenges of Meeting Water Quality Standards in the New Millennium*** Mr. Richard Lanyon, Director of Research and Development Metropolitan Water Reclamation District of Greater Chicago (District), Chicago, Illinois
Friday April 27, 2001	***Developments in United States Environmental Protection Agency's QUAL2E Model*** Professor Jerry Rogers University of Houston Houston, Texas
Friday May 25, 2001	***E. coli Standards for Bathing Beach Waters - The New Twist*** Mr. Arnold Leder, Permit Compliance System Manager, Region 5 United States Environmental Protection Agency Chicago, Illinois
Friday June 29, 2001	***Use Attainability Analysis of River Systems*** Professor Vladamir Novotny Marquette University and President, Aqua Nova International Milwaukee, Wisconsin
Friday July 27, 2001	***Long-term Infrastructure Management at Wastewater Treatment Plants*** Mr. Anthony Bouchard, Vice President CTE Engineers Chicago, Illinois

RESEARCH AND DEVELOPMENT DEPARTMENT
2001 SEMINAR SERIES

Date	Subject
Friday August 31, 2001	***Continuous Dissolved Oxygen Monitoring in Chicago Area Waterways*** Mr. Irwin Polls, Microbiologist Research and Development Department District, Cicero, Illinois
Friday September 28, 2001	***Emissions of Volatile Organic Compounds from Sewers*** Professor Richard Corsi University of Texas Austin, Texas
Friday October 26, 2001	***Cogitation on The Rationale Behind Pretreatment Local Limits*** Ms. Doris Bernstein, Research Scientist Mr. William Stuba, Industrial Waste Enforcement Supervisor Research and Development Department District, Cicero, Illinois
Friday November 16, 2001	***Innovative Partnerships with Industry for Toxics Reduction and an Effective Pretreatment Program*** Mr. Richard Sustich, Assistant Director of Research and Development, Industrial Waste Division District, Chicago, Illinois

LOCATION:
Stickney Water Reclamation Plant
Dr. Cecil Lue-Hing Research and Development Complex
6001 West Pershing Road, Cicero, Illinois 60804-4112

TIME: 10:00 A.M.

FOR INFORMATION CONTACT:
Dr. Prakasam Tata, Assistant Director Research & Development
Environmental Monitoring and Research Division (708) 588-4059

APPENDIX V

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION EMPLOYEES

Environmental Monitoring and Research Division

Sec. 121 – Administration

Tata, Prakasam, Assistant Director of R&D
Messina, Deborah, Secretary

Sawyer, Bernard, Research Scientist 4
Martinez, Adela, Principal Clerk Typist

Pietz, Richard, Research Scientist 4
Urlacher, Nancy, Administrative Assistant
Scrima, Joan, Principal Clerk Typist

Sec. 122 - Wastewater Treatment Research

Jain, Jain, Research Scientist 3
Lordi, David, Research Scientist 3
Franklin, Laura, Principal Clerk Typist
Patel, Kamlesh, Research Scientist 2
Zhang, Heng, Research Scientist 2
Kaschak, John, Research Scientist 1
MacDonald, Dale, Research Scientist 1
Bernstein, Doris, Research Scientist 1
Oskouie, Ali, Research Scientist 1
Farooqui, Saeed, Laboratory Tech 2
Tate, Tiffany, Laboratory Tech 2
Byrnes, Marc, Laboratory Tech 1
Gallagher, Dustin, Laboratory Tech 1
Pierson, Rodney, Laboratory Tech 1
Rahman, Shafiq, Laboratory Tech 1
Saric, Ronald, Laboratory Tech 1

Sec. 124 – Analytical Microbiology & Biomonitoring

Zmuda, James, Microbiologist 4
Bickhem, Donna, Principal Clerk Typist
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
Patel, Minaxi, Laboratory Tech 2
Shukla, Hemangini, Laboratory Tech 2
Kaehn, James, Laboratory Tech 1
Mangkorn, Damrong, Laboratory Tech 1
Roberts, David, Laboratory Tech 1
Vacant, Laboratory Tech 1
Credit, Eben, Laboratory Assistant
Yates, Marguerite, Laboratory Assistant

Sec. 127- Toxic Substances (Egan)

Khalil, Mary, Instrument Chemist 4
Bailey, Bonnie, Principal Clerk Typist
Liao, Anna, Instrument Chemist 3
Clayton, Frederick, Instrument Chemist 3
Olchowka, Victor, Instrument Chemist 2
Xiao, Jun, Instrument Chemist 2
Wu, Dongmei, Instrument Chemist 1
Shin, Joan, Instrument Chemist 1
Gandhi, Bharat, Laboratory Tech 2
Shah, Pragna, Laboratory Tech 2
Wadley, Tyronne, Laboratory Tech 2
Vermillion, John, Laboratory Tech 2

Sec. 123 – Land Reclam. & Soil Science

Granato, Thomas, Soil Scientist 3
Nelson, Scott, Soil Scientist 2
Cox, Albert, Soil Scientist 2
Vacant, Soil Scientist 1
Pump, Gary, Sanitary Chemist 2
Dennison, Odona, Sanitary Chemist 1
Grunwald, Pawel, Sanitary Chemist 1
Hermann, Robert, Laboratory Tech 2
Stefanich, Tricia, Laboratory Tech 2
Reddy, Thota, Laboratory Tech 1
Shingles, Craig, Laboratory Tech 1
Joyce, Colleen, Laboratory Assistant
Agnew, Philip, 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

Polls, Irwin, Microbiologist 4
Dennison, Sam, Biologist 3
Sopcak, Michael, Biologist 2
Wasik, Jennifer, Biologist 1
Hartford, Mary Lynn, Laboratory Tech 2
Rose, Rebecca, Laboratory Tech 2
Schackart, Richard, Laboratory Tech 2
Szafoni, John, Laboratory Tech 2
Minarik, Thomas, Laboratory Tech 1
Vick, Justin, Laboratory Tech 1

Sec. 128 – Radiochemistry

Khalique, Abdul, Radiation Chemist
Kawalko, Sheila, Sanitary Chemist 1
Robinson, Harold, Laboratory Tech 1

Sec. 129 – Experimental Design & Statistical Evaluation

Abedin, Zainul, Biostatistician
Vacant, Associate Statistician

Rev. 11-29-01