Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

# RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 02-1

RESEARCH AND DEVELOPMENT

ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

2000

ANNUAL REPORT

January 2002

*Metropolitan Water Reclamation District of Greater Chicago*
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# RESEARCH AND DEVELOPMENT

# ENVIRONMENTAL MONITORING AND RESEARCH DIVISION

# 2000

# ANNUAL REPORT

Research and Development Department
Richard Lanyon, Director

January 2002

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## ACKNOWLEDGMENTS

This 2000 Annual Report is the result of the efforts of not only the scientists and engineers who perform the monitoring and research initiatives of the Department, but also the impressive efforts of support staff and other personnel who contribute their valuable time, energy, and know-how to the production of the report. These individuals deserve special recognition and thanks.

Special thanks are due to Bonnie Bailey, Donna Bickhem, Laura Franklin, Adela Martinez-Johnson, Deborah Messina, Joan Scrima, and Nancy Urlacher for their immaculate typing, zealous adherence to Department formatting tradition, responsiveness to turnaround times, and dedication to moving the report forward. Special thanks also go to Margo Neniskis, Science Communications International, for her professional expertise, editorial wisdom, and seeing the polished report through to publication.

## 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 81 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 2000. These were to:

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

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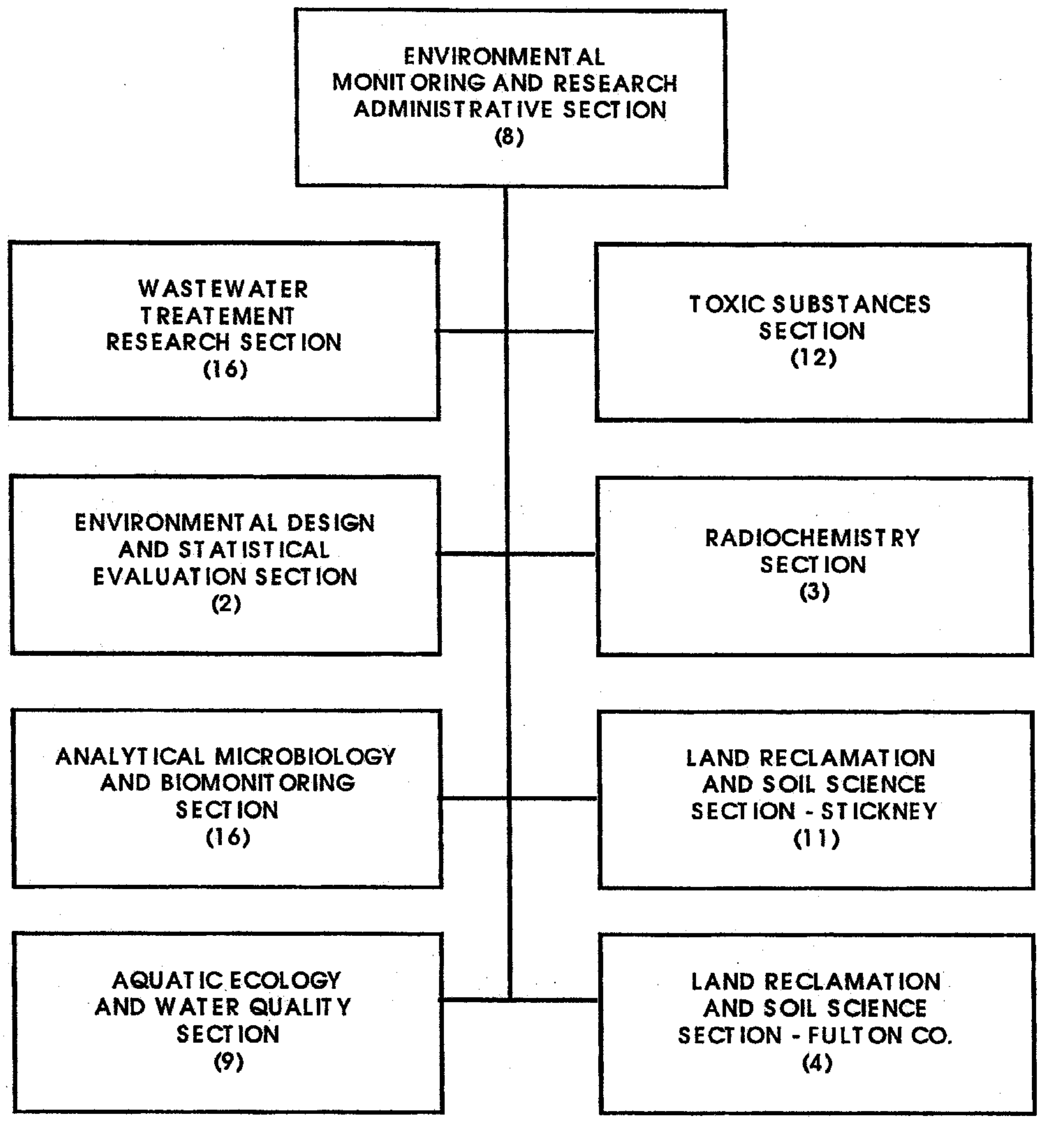
FIGURE 1

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



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 2000, the section was primarily concerned with studies relating to odor control, sludge treatment technologies, respirometry, 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 2000, a comparison of summer and winter polymers used in the centrifugal dewatering of anaerobically digested sludge was carried out at the Stickney WRP. The testing procedure is performed twice at Stickney, once in summer and once in winter, as sludge characteristics during these seasons vary and the sludges require different polymers at this WRP. Based on these full-scale tests, polymers are switched, as appropriate.

In addition, the test procedures used by the District in the selection and procurement of polymers for the centrifugal dewatering of anaerobically digested sludge were documented and published as Research and Development (R&D) Department Report No. 2000-13, *Test Procedures for the Selection and Procurement of Polymers for Centrifugal Dewatering of Anaerobically Digested Sludge.*

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

In 2000, 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 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 March 2000 at the Hanover Park WRP is presented in Table 1.

## 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

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TABLE 1

GRAVITY BELT THICKENER POLYMER TEST RESULTS
AT THE HANOVER PARK WRP - MARCH 2000

| | |
|---|---|
| Number of Vendors Involved in Tests | 3 |
| Number of Polymers Submitted for Testing | 6 |
| Number of Polymers Qualified for Bidding | 6 |
| Polymer Selected | Polydyne C6267 |
| Polymer Dosage, lbs/dry ton | 4.49 |

air drying sites. 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. A similar odor monitoring program will be initiated in the spring of 2001 for the Stony Island and the 119th and Ridgeland Avenue Sludge Management Area (RASMA) drying areas.

Each location uses a similar process to monitor odors. R&D personnel (or 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 Calumet WRP), depending on the program. The odor monitoring personnel make subjective observations regarding the character and intensity of odors at 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 odor complaints regarding 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 complaints for all WRPs are summarized in Table 2.

## Odor Monitoring Program 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 to three years 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 four sludge drying sites at least three times a week. Figure 2 summarizes the observations of odor monitoring personnel during 2000.

For each month, average odor intensity data from the 13 stations were calculated. The percentage of visits at which

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TABLE 2

CITIZEN ODOR COMPLAINTS REGARDING DISTRICT WRPs OR SLUDGE DRYING SITES - 2000

| | Total Number of Complaints 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 | 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 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 5 | 3 | 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 Complaints | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 5 | 3 | 0 |
| Number Confirmed | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

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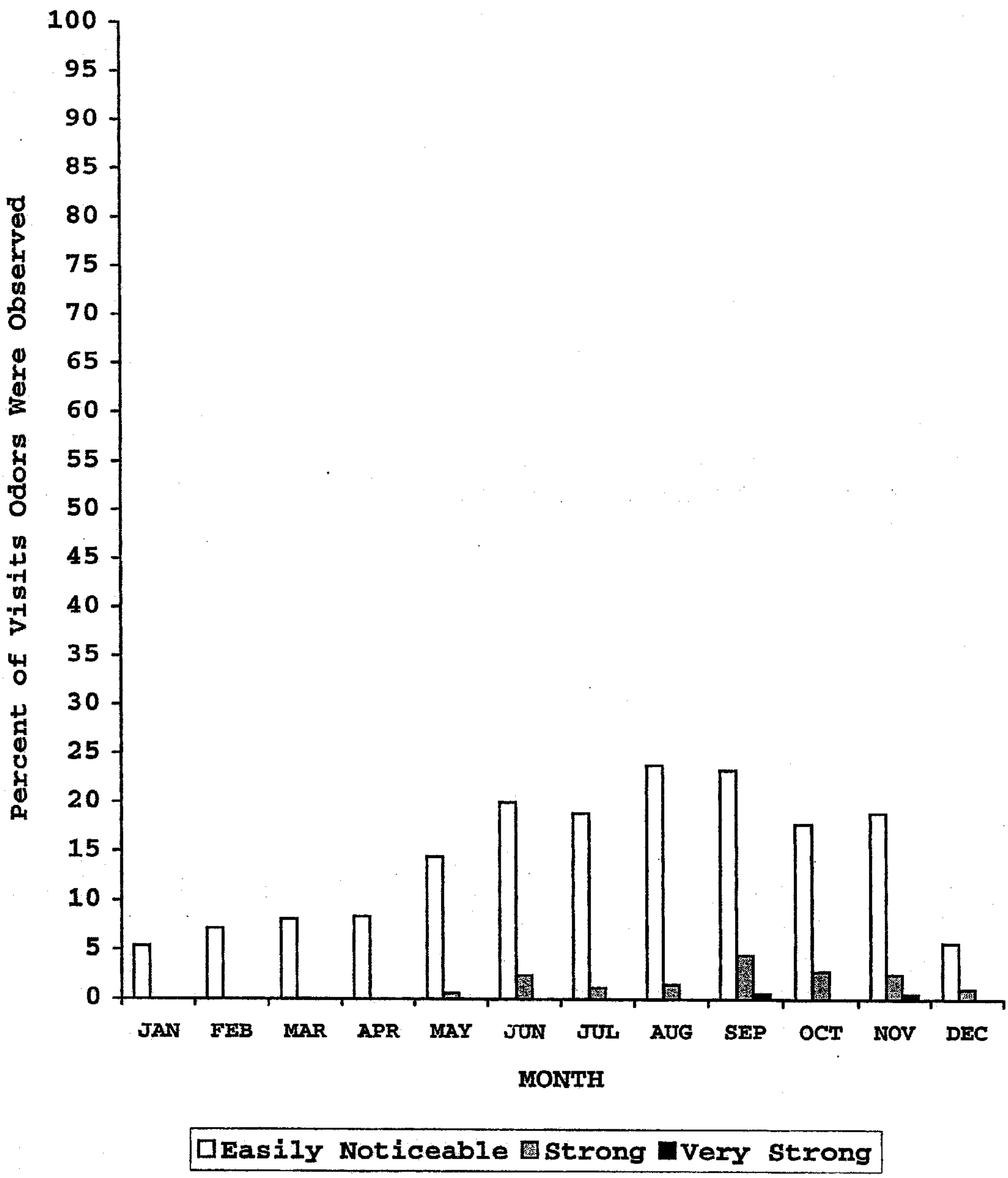
FIGURE 2

ODOR OBSERVANCE AT HASMA, VULCAN, LASMA, AND MARATHON SITES - 2000



easily noticeable, strong, and very strong odors were observed was plotted by month. Although there are peaks of easily noticeable odor observations during the year, the strong and very strong odor observations were low throughout the year.

The best indication of the District's success in processing sludge in a low odor manner is the number of odor complaints from citizens in the vicinity of the processing operation. M&O reported no odor complaints from citizens regarding the sludge processing facilities in 2000, as shown in Table 2.

## Odor Monitoring Program 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 2000 in terms of frequency of occurrence. The odors were at generally low levels in 2000, with no very strong odors being observed. No odor complaints were reported from the public regarding these facilities during 2000, as shown in Table 2.

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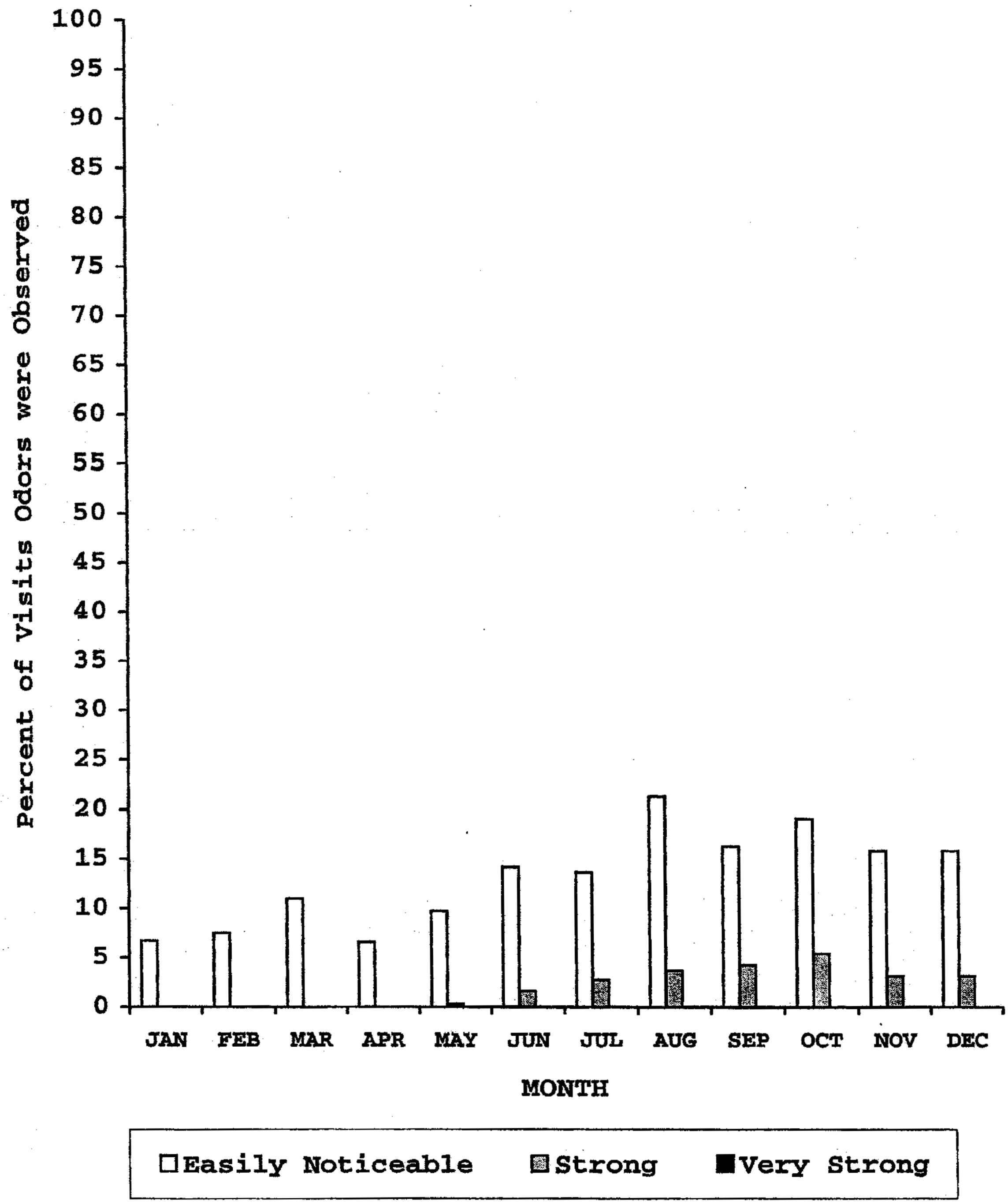
FIGURE 3

ODOR OBSERVANCE AT CALUMET WRP - 2000



## Odor Monitoring Program 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. Figure 4 summarizes the observations of odor monitoring personnel during 2000. 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 was plotted by month. Odor of an easily noticeable or greater intensity were observed generally less than 15 percent of the observations 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 2000, as shown in Table 2.

## Odor Monitoring Program 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

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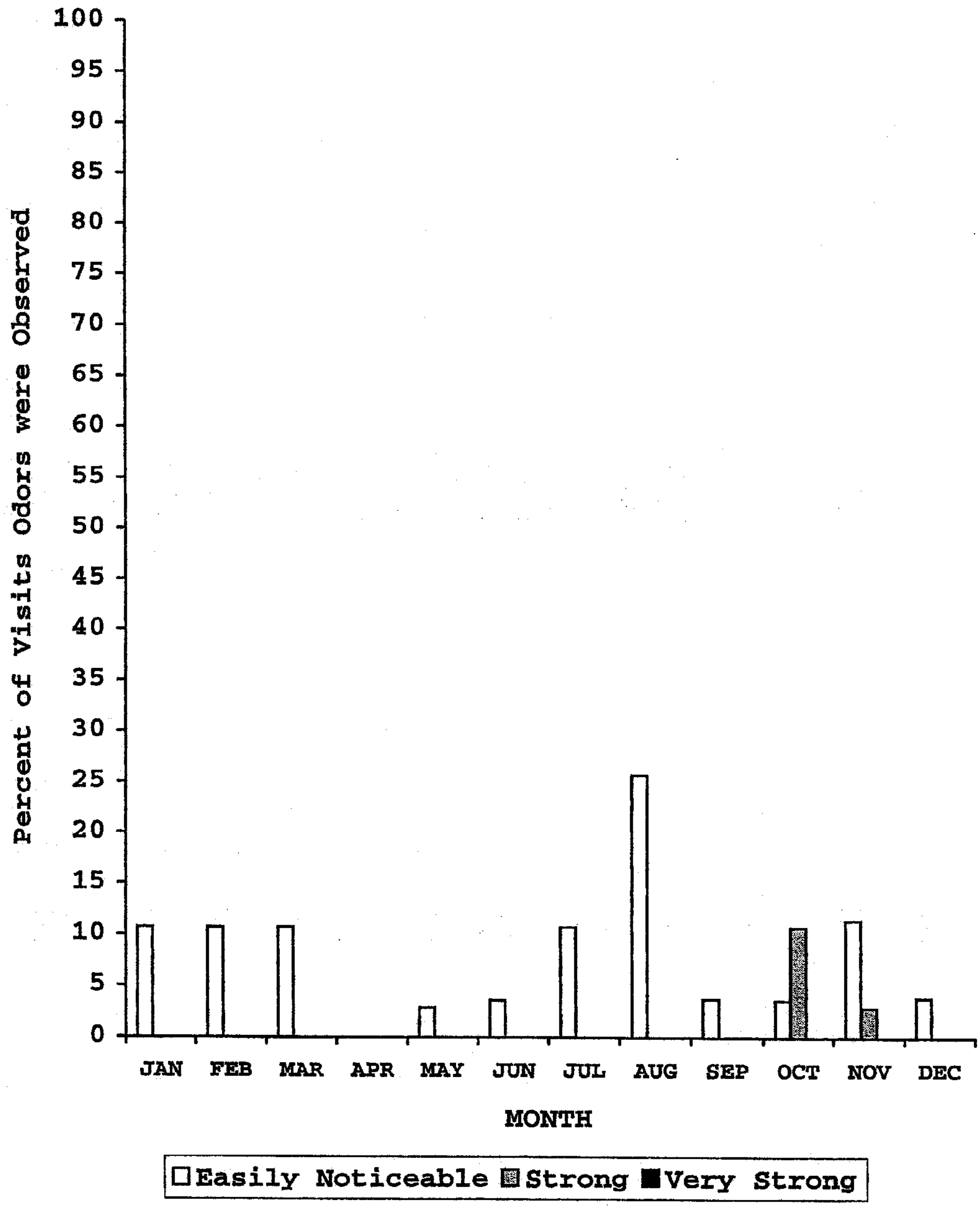
FIGURE 4

ODOR OBSERVANCE AT JOHN E. EGAN WRP - 2000



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 5 summarizes the observations of odor monitoring personnel during 2000. 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 5, easily noticeable odors were observed less than 25 percent of the time for most part of the year. No very strong odors were observed.

Eighteen citizen complaints were received from the public regarding this WRP during 2000, as shown in Table 2. 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.

Figure 6 summarizes the observations of odor monitoring personnel during 2000 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

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FIGURE 5

STICKNEY WRP ODOR OBSERVANCE WITHIN PLANT BOUNDARIES - 2000

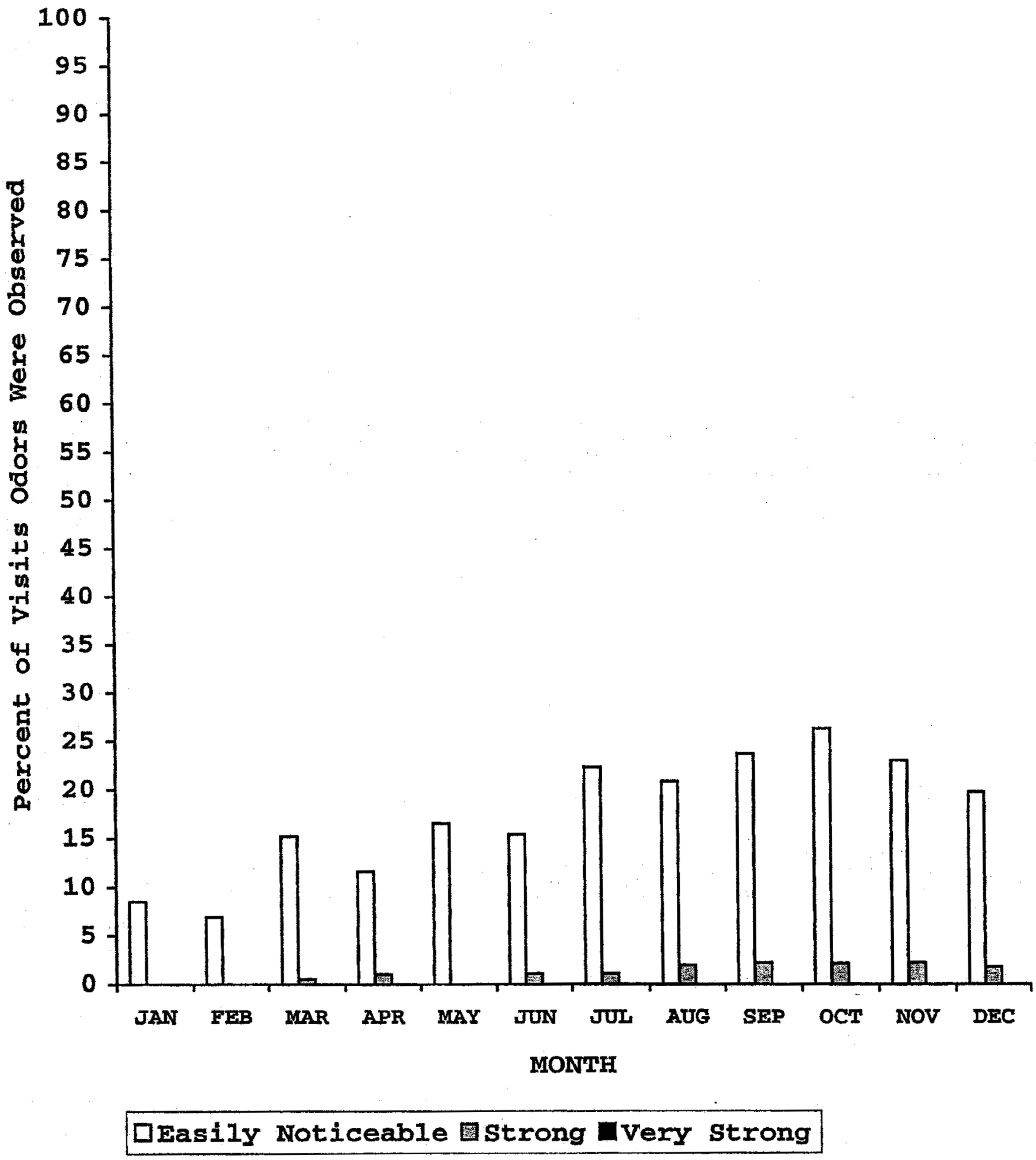

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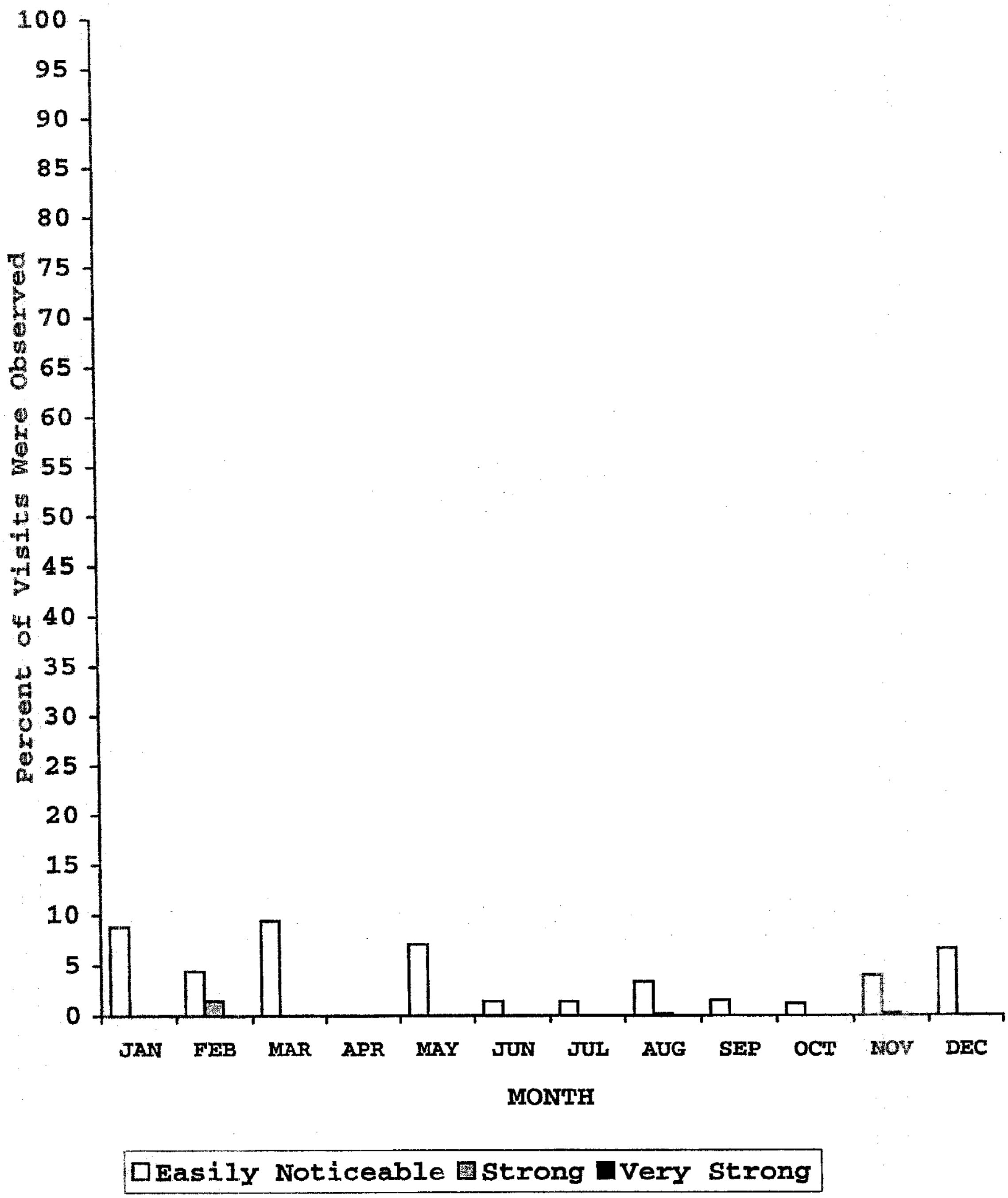
FIGURE 6

ODOR OBSERVANCE AT JAMES C. KIRIE WRP - 2000



than 10 percent of the observations. No odor complaints were received from the public regarding this facility during 2000, as shown in Table 2.

## Odor Survey of the North Side WRP

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

R&D personnel visited 13 stations within and around WRP boundaries at least once a week. Figure 7 summarizes the observations of odor monitoring personnel from January through December 2000. For each month, average odor intensity data from the 13 stations on District property were monitored one day a week and plotted. The percentage of visits at which easily noticeable, strong, and very strong odors observed were plotted by year.

There were no citizen odor complaints reported by the M&O Department during 2000, as shown in Table 2.

## 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

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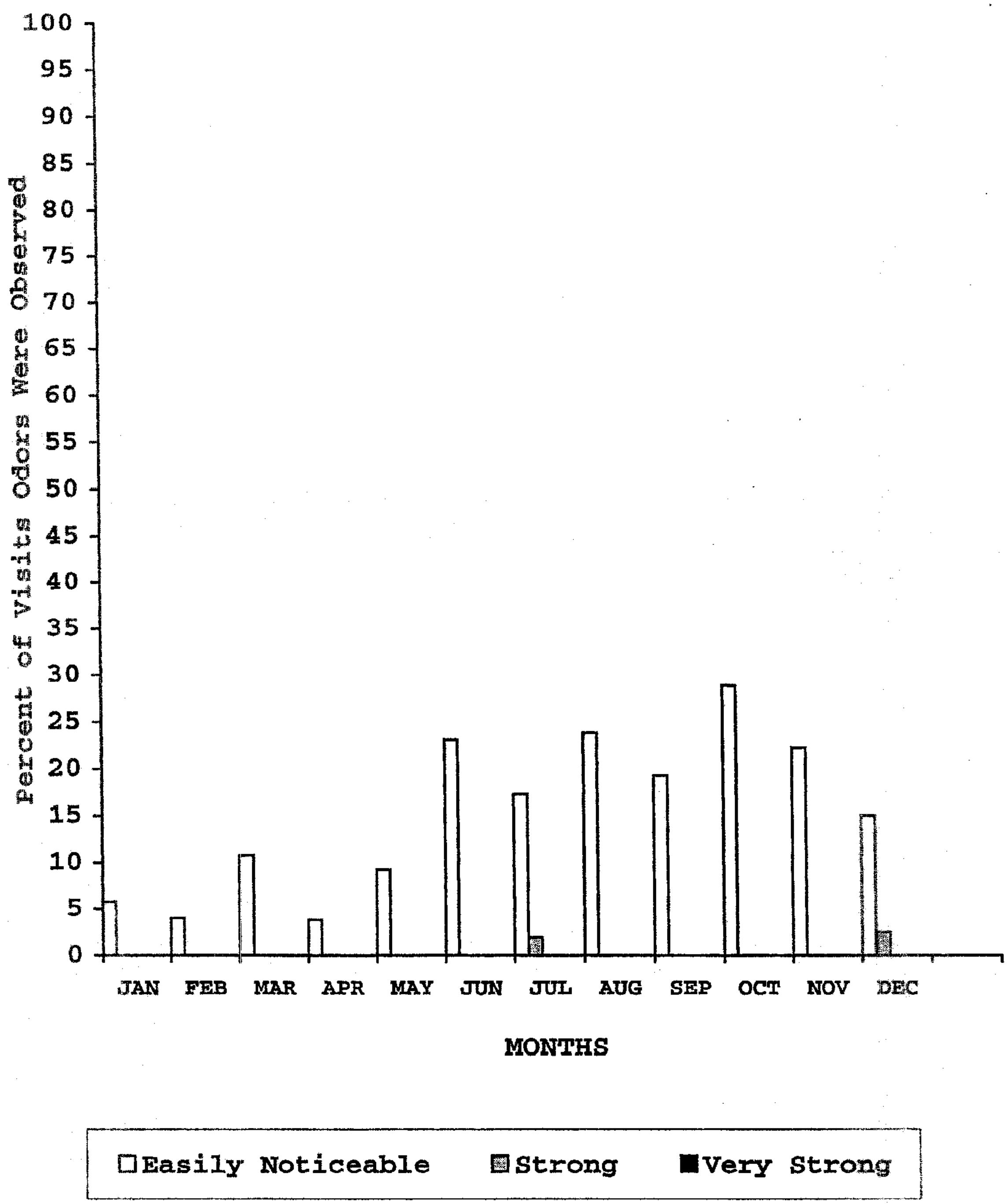
FIGURE 7

ODOR OBSERVANCE AT NORTH SIDE WRP - 2000



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 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. 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.

The data indicate that overall, there would be no significant increase in odor potential if the lagooning process were shortened or omitted altogether. A report on the results of this study is under preparation.

Zinc Concentrations in Calumet WRP Digested Sludge

The R&D and M&O Departments continually monitor sludge quality to ensure compliance with United States Environmental Protection Agency (USEPA) Part 503 Regulations. The policy of the District is to produce a final sludge product that qualifies as an Exceptional Quality sludge suitable for any beneficial use. Exceptional quality is defined by the USEPA Part 503 Regulations which establish specific risk-based limits for various heavy metals and pathogens found in sewage sludge.

The USEPA alternate pollutant limit for zinc in the final sludge product is 2800 mg/Kg dry weight. The District had an established target level for zinc in the Calumet WRP digester draw of 1691 mg/Kg, so that the zinc concentration in the final air-dried biosolids would always be below the alternate pollutant limit value.

A field study begun in 1997 to determine the causes of increased zinc concentrations in the digester draw at the Calumet WRP was completed in 1999, and the final results were reported in 2000. An intensive interceptor sewer sampling program was conducted in conjunction with Industrial Waste Division field personnel. Results indicated that two previously unidentified industrial dischargers were major sources of zinc entering the Calumet WRP. Enforcement actions against these dischargers have resulted in the concentrations in Calumet WRP digester draw returning to levels below the District established zinc target level of 1691 mg/Kg dry weight. The zinc levels have remained below the target level throughout 2000.

The investigation and results have been published in R&D Department Report No. 2000-5, *Study of Zinc Concentrations in Calumet Water Reclamation Plant Digester Draw.*

## Evaluation of On-line Respirometry for Aeration Control at the James C. Kirie WRP

This project was undertaken to evaluate the application of on-line respirometry for aeration control of the activated sludge treatment process. Respirometry may be used to measure the biological response and oxygen requirement of sewage entering the aeration tank. Therefore, it can be used to predict and control the oxygen requirement of the sewage treated in an activated sludge treatment process. A proposed benefit of on-line respirometry is significant energy savings by not delivering more air than necessary.

This joint project of the R&D and M&O Departments was conducted at the James C. Kirie WRP. The project was partially funded ($50,000) by the Community Environmental Center of the Electric Power Research Institute, St. Louis, Missouri. The objective of this project was to evaluate the application of on-line respirometry to control the air supply to an activated sludge treatment process, and to measure electrical energy savings.

Under the original experimental plan, three of the six identical aeration tanks at the Kirie WRP were selected for this study. During this study, the air supply was originally proposed to be measured by three different means in three different tanks; namely, on-line respirometers, automatic dissolved oxygen (DO) control, and manual control. In respirometric control, the air supply to the aeration tank would be based on the oxygen uptake rates of the mixed liquor as determined by the on-line respirometers. In automatic DO control, the measurement of air supply would be based on the currently implemented District protocol and practices, whereas in manual control, the air supply to the test tank would be held constant without any automatic control systems. The results of the three simultaneous measurements were proposed to be compared for the electrical energy consumption needed to provide the air supply, and for a given level of wastewater treatment.

The original test protocol was revised in order to collect additional data and to expeditiously conclude the study. The revised test protocol included reducing air supply to the experimental aeration tank on an incremental basis until nitrification failed, and ammonia level in the experimental tank effluent significantly exceeded the effluent ammonia level of the control tank. The gradual reduction in air to the experimental aeration tank was in relation to the air fed to the control aeration tank.

Sufficient data were collected to develop and validate two mathematical models showing relationships between the air supply or oxygen input required, and the activated sludge aeration tank operating parameters, oxygen transfer efficiency, oxygen uptake rates, and the effluent ammonia concentration.

The study concluded that aeration control using the automated DO probe system at the Kirie WRP provides optimum air supply. Therefore, the potential for electrical energy savings using on-line respirometry at the Kirie WRP is not substantial. As a result, an application of the on-line respirometry is not advantageous for the Kirie WRP under current operating conditions.

In a system where air supplied far exceeds the actual air demand, the opportunities for electrical energy savings using on-line respirometry are promising. Before using on-line respirometry for controlling air at WRPs, however, more work needs to be done using program logic controls, computer-coded algorithms, and blowers that can respond to such controls to actually demonstrate the applicability of on-line respirometry using the models developed in this study. The reliability of on-line respirometry from an operation and maintenance point of view should also be investigated.

A final report on this study has been published as R&D Department Report No. 2000-10, *Evaluation of Potential Electrical Energy Savings Using On-Line Respirometry for Control of Aeration at the James C. Kirie Water Reclamation Plant.*

## 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 storm water 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 verify that the TARP system is not adversely affecting 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 8). Of these 115 wells, 106 are currently being monitored. The TARP wells are located alongside completed portions of the 125 miles of completed TARP tunnels.

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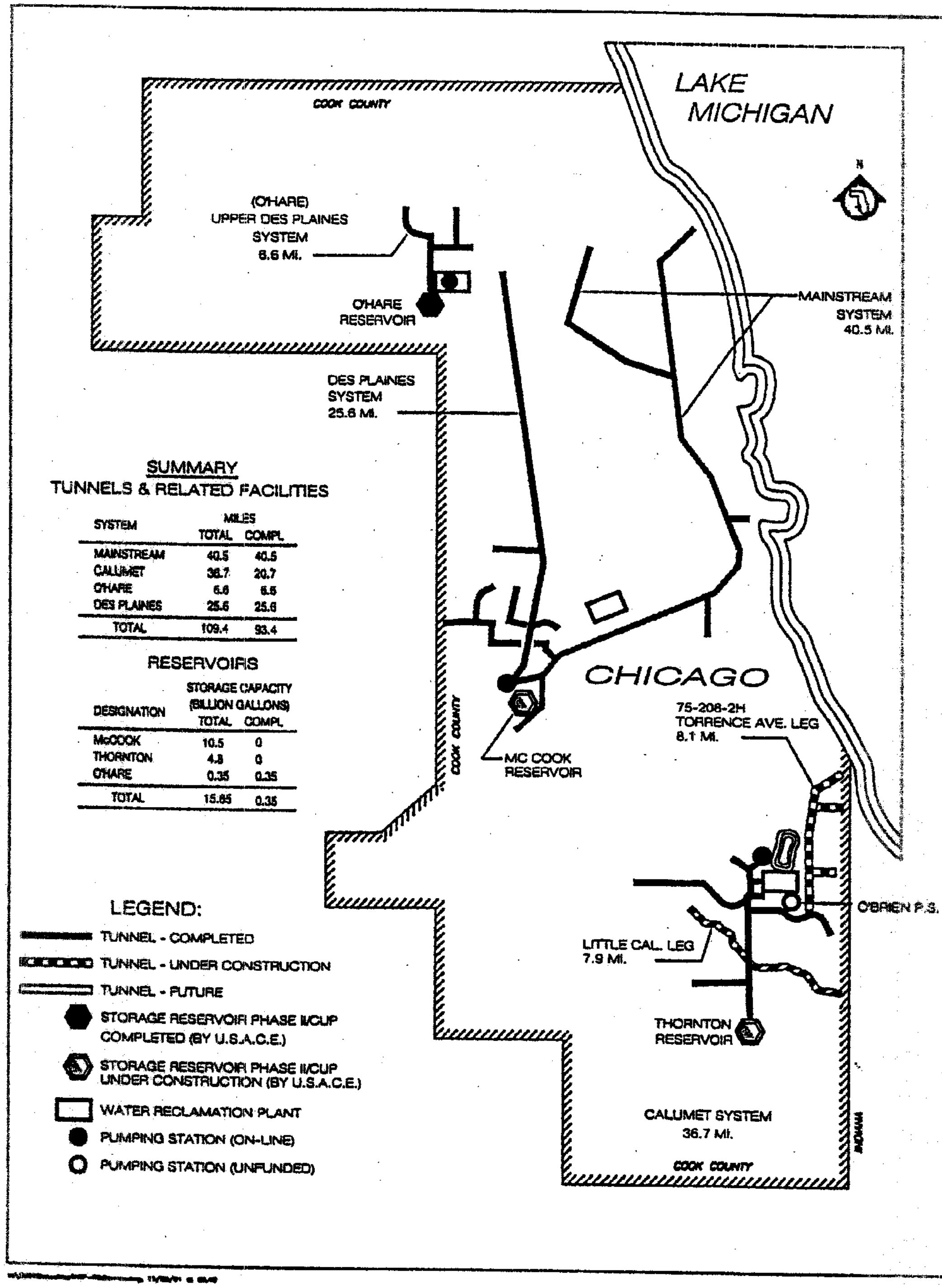
FIGURE 8

LOCATIONS OF TARP TUNNELS




SUMMARY

TUNNELS & RELATED FACILITIES

| SYSTEM | MILES TOTAL | MILES COMPL |
|---|---|---|
| MAINSTREAM | 40.5 | 40.5 |
| CALUMET | 36.7 | 20.7 |
| O'HARE | 6.6 | 6.6 |
| DES PLAINES | 25.6 | 25.6 |
| TOTAL | 109.4 | 93.4 |

RESERVOIRS

| DESIGNATION | STORAGE CAPACITY (BILLION GALLONS) TOTAL | COMPL |
|---|---|---|
| McCOOK | 10.5 | 0 |
| THORNTON | 4.8 | 0 |
| O'HARE | 0.35 | 0.35 |
| TOTAL | 15.65 | 0.35 |

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 from six times per year. The same reduced sampling frequency was also granted for nine Calumet TARP System wells (QC-2.2, QC-9, QC-11 through QC-15, QC-17, and QC-18), and eleven Des Plaines TARP system wells (QD-34, QD-39 through QD-45, and QD-47 through QD-49). On September 21, 2000, the IEPA gave the District permission to reduce the monitoring frequency of the Mainstream observation wells (OM-1 through OM-23) from once every two weeks to once every two months.

The water quality monitoring wells are sampled for the following parameters: $NH_4$-N, electrical conductivity (EC), 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 system.

## Evaluation of Settling Characteristics of Combined Sewer Overflows

In order to provide technical assistance to the Army Corps of Engineers (ACOE) in the design of the McCook Reservoir, a study was conducted to evaluate the settling characteristics of CSOs under quiescent conditions.

Two types of CSOs were used for these settling tests. One is the TARP pumpback, which is collected in the Mainstream Deep Tunnel during the occurrence of a CSO and is returned to the Stickney WRP for treatment after the rain. The other is the Racine Avenue Pumping Station 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 was also used in the settling tests for the purpose of comparison. Both CSO and raw sewage samples were collected as grab samples over approximately a one-hour period. The settling tests were conducted on the same day the samples were collected.

The settling tests were conducted under static conditions in two identical PVC columns, which were 10-feet tall with a diameter of 6 inches and a volume of nearly 15 gallons (see Figure 9). The columns were installed in the pilot plant room of the District's research laboratory, located at the Stickney WRP.

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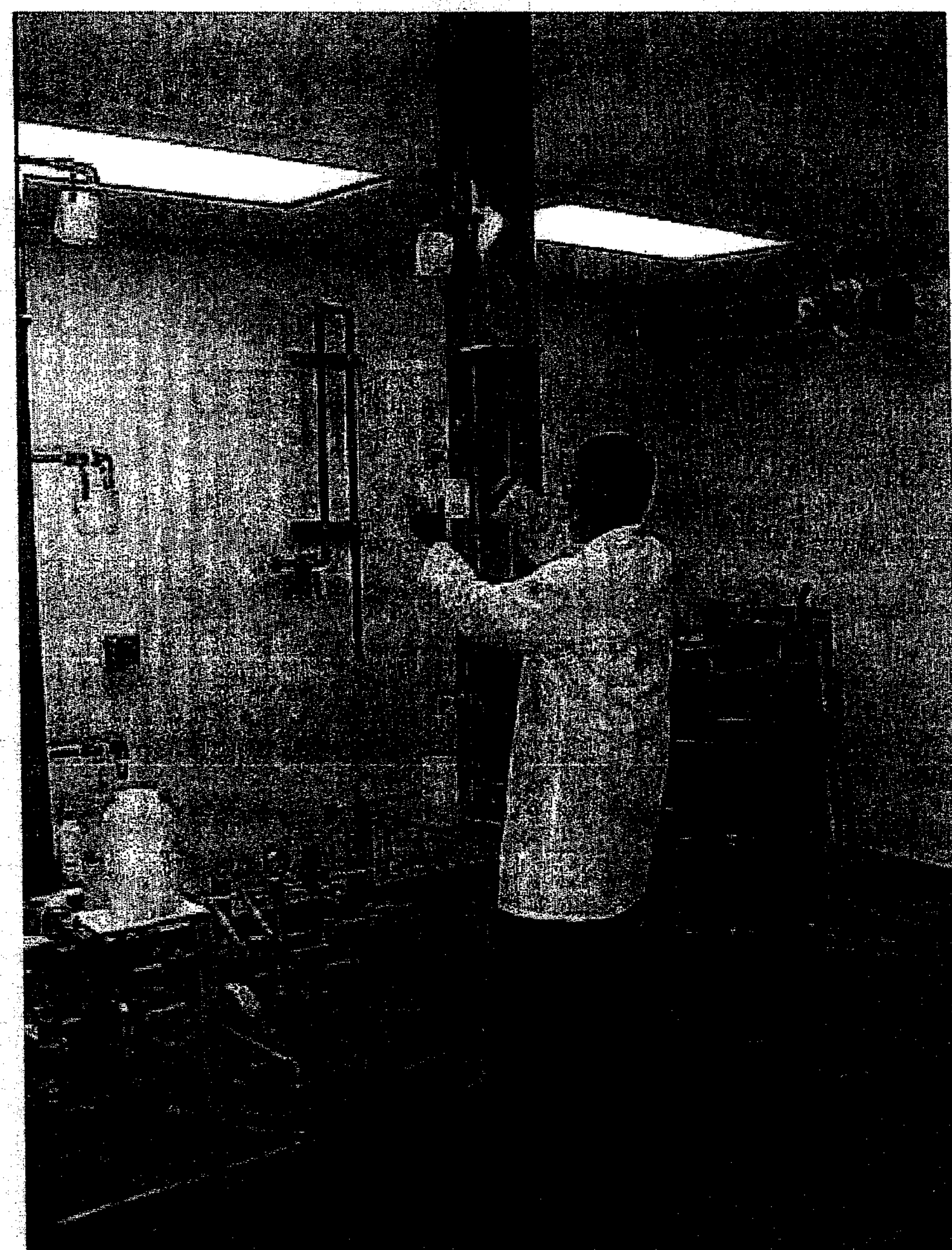
FIGURE 9

SAMPLING OF CSO AT DIFFERENT DEPTHS OF THE SETTLING COLUMN



The two columns were filled sequentially. Forty to fifty gallons of collected CSOs or raw sewage were thoroughly mixed in a drum before being pumped into the settling columns. The wastewater in the columns was agitated with air bubbles created by sparging compressed air through an air hose located at the bottom of the columns during filling to prevent solids from settling.

A settling test began immediately after the column was filled to a mark set at four inches below the top and air bubbling stopped. Samples were withdrawn from three sampling ports located four, six, and eight feet below the water surface of each column, at various time intervals. All sampling ports were flushed prior to sampling. These samples were analyzed for suspended solids (SS) and water temperature.

The settling velocity was calculated by dividing the average depth of water above each sampling port by the settling time after the test started. Weight fraction was defined as the ratio of SS left in a location during the test to the initial SS, assuming a uniform SS distribution throughout the column at the beginning of the test.

The results of the static settling tests are presented graphically in Figures 10 through 14. The study will continue through the year 2001 conducting more settling tests using

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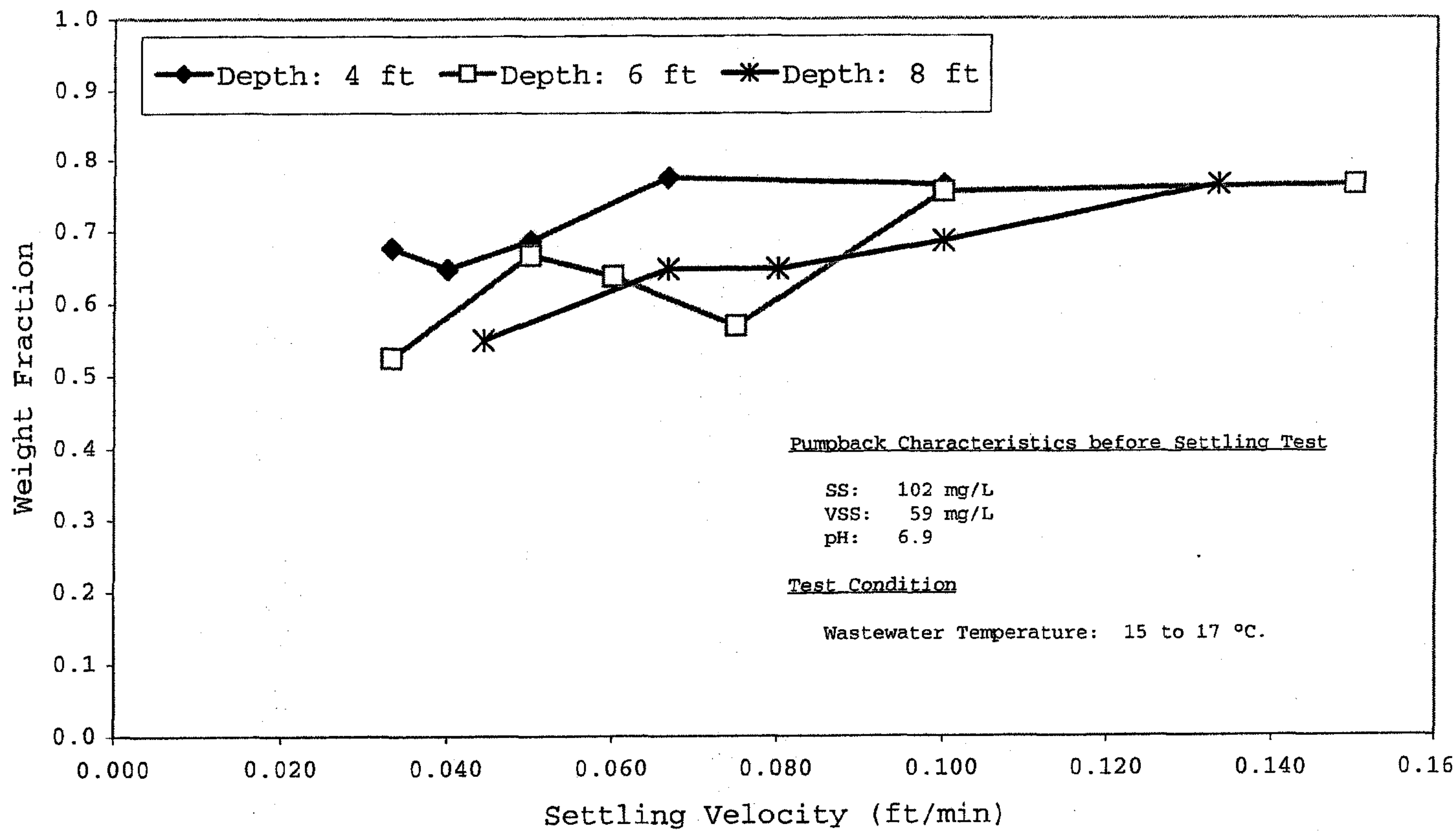
FIGURE 10

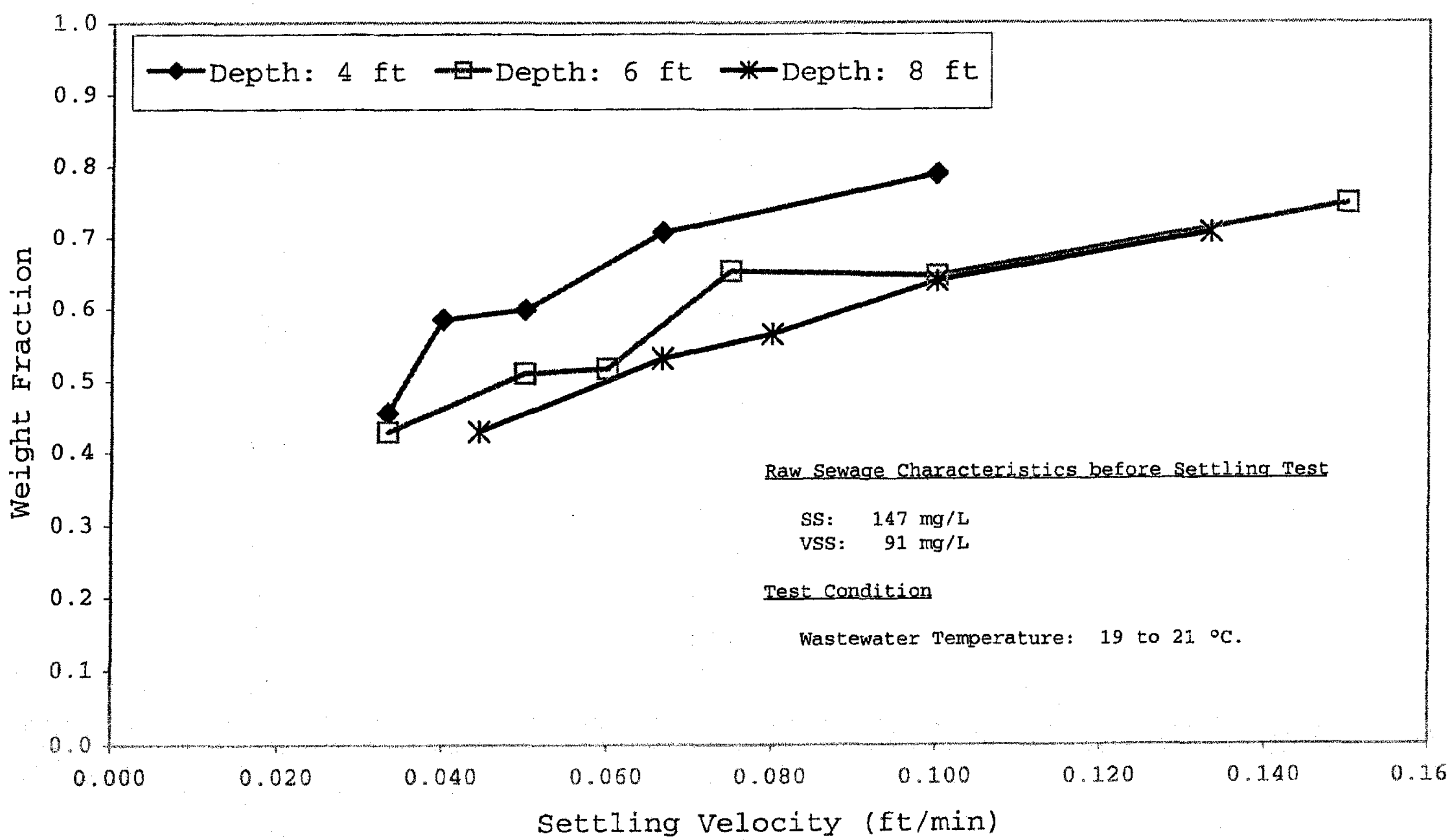
STATIC SETTLING CHARACTERISTICS OF STICKNEY TARP PUMPBACK
COLLECTED AND TESTED ON NOVEMBER 14, 2000



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 11

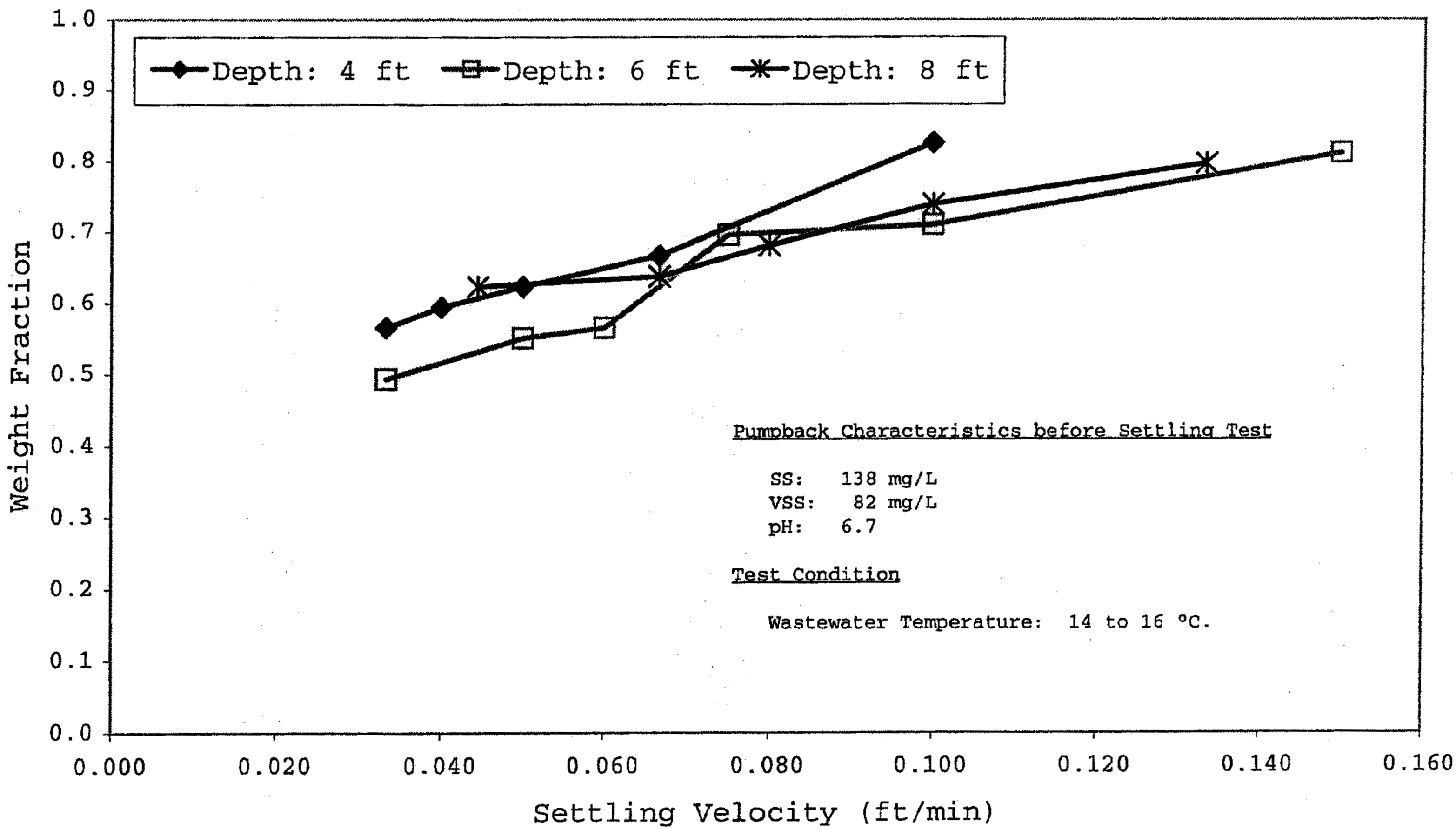
STATIC SETTLING CHARACTERISTICS OF STICKNEY WRP WEST SIDE RAW SEWAGE COLLECTED AND TESTED ON NOVEMBER 15, 2000



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 12

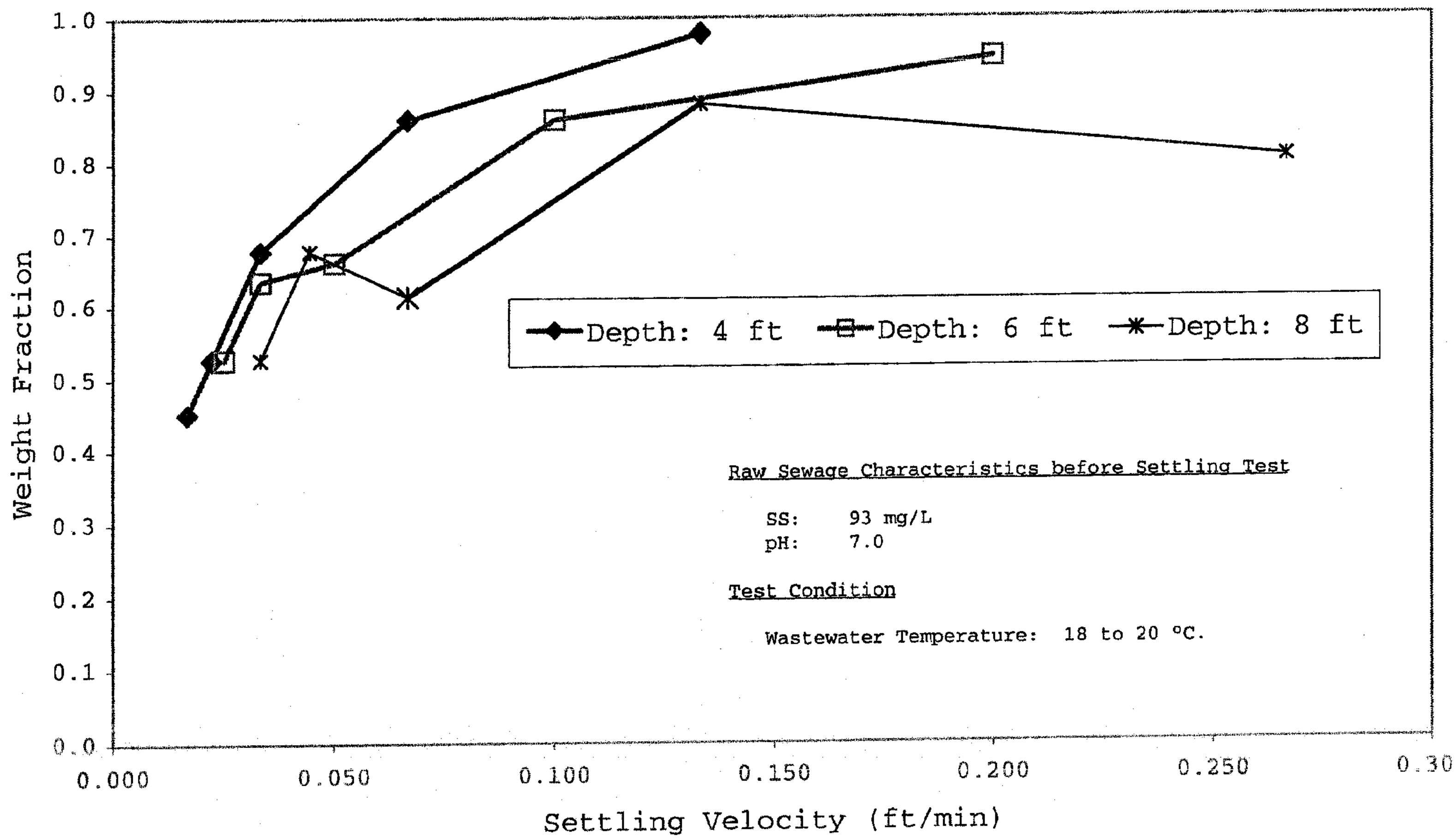
STATIC SETTLING CHARACTERISTICS OF STICKNEY TARP PUMPBACK
COLLECTED AND TESTED ON NOVEMBER 16, 2000



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 13

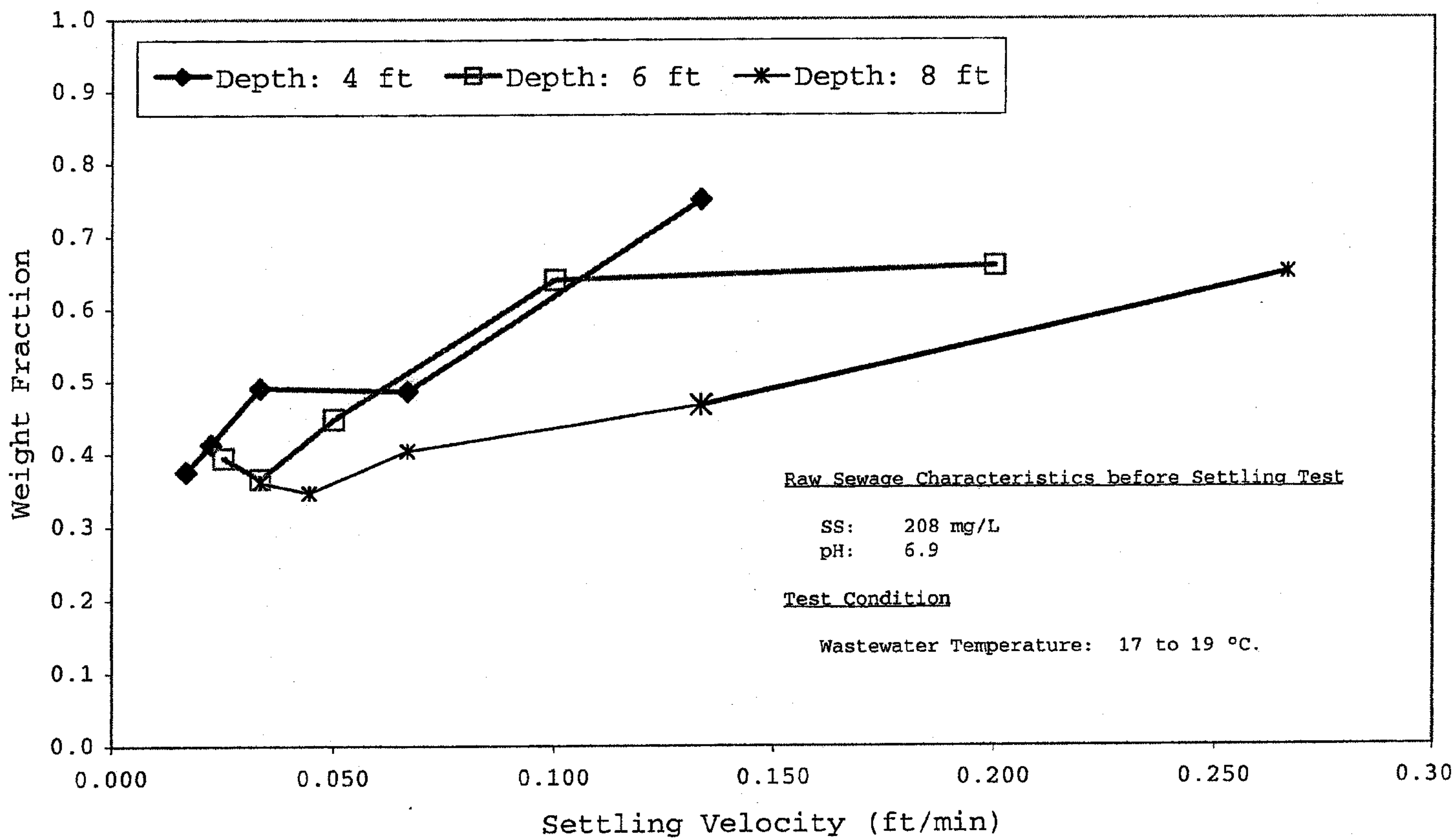
STATIC SETTLING CHARACTERISTICS OF STICKNEY WRP WEST SIDE RAW SEWAGE COLLECTED AND TESTED ON NOVEMBER 21, 2000



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 14

STATIC SETTLING CHARACTERISTICS OF STICKNEY WRP WEST SIDE RAW SEWAGE COLLECTED AND TESTED ON NOVEMBER 22, 2000



CSOs from the TARP pumpback and the overflow from the Racine Avenue Pumping Station during storm events.

## Chemical Characteristics of CSOs

The objective of the project is to summarize the characteristics of CSOs collected from TARP overflows during 1995 through 1997. Two studies were conducted during this period. One study focused on the occurrence and levels of organic priority pollutants and Clean Air Act volatile organic compounds (VOCs) in CSOs and TARP flows. The other study focused on conventional pollutants, particularly total suspended solids (TSS) and biochemical oxygen demand ($BOD_5$) in CSOs.

### VOCS IN CSOs AND TARP FLOWS

The study on organic priority pollutants and Clean Air Act VOCs in CSOs is considered an enhanced follow-up to a previous District study initiated in 1987. The 1987 study sought to determine if significant amounts of organic priority pollutants were contained in CSOs, as it was felt that this information would be relevant to the future operation of the proposed TARP reservoirs.

With the passage of the Clean Air Act Amendments of 1990, an expanded list of organic pollutants commonly referred to as VOCs became relevant to District operations. Therefore in the 1995 study of CSOs, the list of analytes was expanded to include the traditional organic priority pollutants as well as the Clean Air Act VOCs.

More samples from more sampling locations were collected in 1995 for the determination of organic priority pollutants and VOCs than in the previous study. In this report, all the compounds are referred to as organic priority pollutants. The CSOs from several locations within the service area of the District were sampled during various rainfall events from 1995 through 1997. These locations were:

1. The TARP Mainstream Pumping Station.
2. The TARP Calumet Pump Station.
3. The Kirie WRP influent sewage pump station.
4. The 125th Street drop shaft station (CDS-13).
5. The Racine Avenue drop shaft station (DS-M28).
6. The Riverside drop shaft station (DS-D45).
7. The Evanston drop shaft station (DS-M106).
8. The Lake Street overflow stations (CS-106A).
9. The Evanston overflow station (CS-106B).

These locations can be classified into three groups:

1. The first group is the three TARP pump stations, pumping CSOs from the TARP systems into the District's WRPs during and after the rainfall events. Two of these pump stations, Mainstream and Calumet, operate independently from the

WRPs, and pump CSOs collected in the TARP tunnels back to the Stickney and Calumet WRPs after a rain event subsides using transfer tunnels separate from the raw sewage wet wells of the WRPs. CSOs from these two pump stations will be referred to as TARP pumpback hereafter. One pump station, Kirie, acts as the WRP influent sewage pump station as well as the TARP pump station. This station pumps dry-weather sewage into the WRP if there is no rain, and CSO into the WRP if there is rain, as both sewage and CSOs flow through the TARP tunnel to the Kirie WRP wet well. The CSO pumped at the Kirie pump station is hereafter called pumpage.

2. The second group is TARP drop shaft stations where CSOs are discharged from the collection systems into the TARP systems during rain.
3. The third group is overflow stations where CSOs are discharged to receiving waterways during heavy rain when the TARP systems are full.

In 1995, 28 samples were collected at five locations during 13 rainfall events. In 1996, 47 samples were collected at nine locations during 22 rainfall events. In 1997, 28 samples were taken at seven locations during 17 rainfall events. Each sample was a grab sample collected either from the pumpage of a TARP pump station or from the overflow at a TARP drop shaft or overflow station. The samples were analyzed for 160 organic priority pollutants including most of the USEPA-listed organic priority pollutants and Clean Air Act VOCs.

## CONVENTIONAL POLLUTANTS

The conventional pollutant parameters in CSOs, such as TS, TSS, $NH_4$-N, and $BOD_5$ of the CSOs entering the future TARP reservoir were determined. In this study, the CSOs discharged into the TARP systems at four TARP drop shaft stations and into receiving waterways at three overflow stations were sampled for conventional parameters during various rainfall events from 1995 through 1997. These locations were:

1. The 125th Street drop shaft station.
2. The Racine Avenue drop shaft station.
3. The Riverside drop shaft station.
4. The Evanston drop shaft station.
5. The Riverside overflow station.
6. The Lake Street overflow station.
7. The Evanston overflow station.

Samples of CSOs from these stations were collected by automatic samplers at predetermined time intervals during rainfall events of more than 0.5 inch rainfall, for the determination of conventional parameter concentrations. Four hundred twenty-one samples were collected at three TARP drop shaft stations during 13 rainfall events in 1995. Two hundred thirty-nine samples were collected at six TARP drop shaft and overflow stations during seven rainfall events in 1996. In 1997, 175 samples were collected at six TARP drop shaft and overflow stations during eight rainfall events. All 1995 samples were analyzed for TS, $BOD_5$, and $NH_4$-N, and all 1996 and 1997 samples were analyzed for TSS and $BOD_5$.

Samples of the actual pumpback and pumpage from these TARP pump stations are routinely collected by the M&O Department during each pumpback event, and analyzed for a variety of conventional pollutants. Thus, no special sampling was required for this aspect of the current study.

## CONCLUSIONS - ORGANIC PRIORITY POLLUTANTS

The results of organic compound analysis of 103 samples collected at nine locations during 52 rainfall sampling events from 1995 through 1997 were divided into two categories in terms of the type of TARP stations: TARP pump stations and TARP drop shaft and overflow stations. The following conclusions were drawn from the study of these results:

1. The number of organic priority pollutants detected and the type of most frequently detected

organic priority pollutants varied from location to location. The average number of organic priority pollutants found in the pumpback and pumpage of the three TARP pump stations was more than that in the six TARP drop shaft and overflow stations. The average number of organic priority pollutants detected in at least one sample from the three TARP pump stations was 28. These consisted of 14 volatile compounds, 12 semi-volatile compounds, and two pesticides and polychlorinated biphenyl compounds (PCBs). Seventeen organic priority pollutants, including seven volatile compounds, eight semi-volatile compounds, and two pesticides and PCBs, were detected in samples from the six TARP drop shaft and overflow stations.

2. At the three TARP pump stations, in 71 samples collected from the pumpback and pumpage during and after various rainfall events during 1995 through 1997, three volatile organic priority pollutants were the predominant pollutants. The most frequently detected organic priority pollutants were acetone with 97 percent, toluene with 82 percent, and chloroform with 82 percent

occurrence. The predominant semi-volatile compounds found were 4-methylphenol with 54 percent, phenol with 44 percent, and phenanthrene with 38 percent occurrence. Pesticides and PCBs were detected much less frequently. The predominant compounds under the category of pesticides and PCBs were PCB-1260 with 8 percent, PCB-1248 with 7 percent, and PCB-1254 with 6 percent occurrence.

3. At the three TARP pump stations, the concentrations of the organic priority pollutants detected in the pumpback and pumpage varied widely from sample to sample. The highest concentration found for volatile compounds was 1371 μg acetone/L, and for semi-volatile compounds was 454.3 μg 4-methylphenol/L. The concentrations of pesticides and PCBs in the samples collected were generally low, less than 2.4 μg/L. No general correlation between the quantity of rainfall and concentrations of pollutants in the samples collected was observed.

4. The trend of occurrence of the predominant volatile and semi-volatile compounds in the CSOs

from the six TARP drop shaft and overflow stations was similar to that in the pumpback and pumpage from the three TARP pump stations. The most frequently detected VOCs were acetone, with a frequency of 81 percent, tetrachloroethene 69 percent, and chloroform 69 percent. Phenanthrene with a frequency of detection of 66 percent, fluoranthene 66 percent, and pyrene 47 percent were the predominant semi-volatile compounds in the CSOs. The predominant pesticides and PCBs found were 4,4'-DDE, 4,4'-DDT and 4,4'-DDD with frequency of detection ranging from 31 to 34 percent.

5. The concentrations of organic pollutants in the samples from the six TARP drop shaft and overflow stations varied widely. The highest concentration detected for VOCs was 173.0 μg acetone/L, and for semi-volatile compounds was 1845 μg 4-methylphenol/L. The concentrations of pesticides and PCBs were normally low, less than 0.3 μg/L. No general correlation between the quantity of rainfall and concentrations of

organic pollutants at the six TARP drop shaft and overflow stations was observed.

6. The types and concentrations of organic priority pollutants found in the pumpback and pumpage from the three TARP pump stations and the CSOs from the six TARP drop shaft and overflow stations were similar to those found in the raw sewage influents to the District treatment facilities. However, on occasion, some organic priority pollutants were found in higher concentrations, in the samples of CSOs, than in the composite raw sewage samples, perhaps due to the fact that these were grab samples.

CONCLUSIONS - CONVENTIONAL POLLUTANTS

The following conclusions were drawn from the data originating from routine monitoring data collected for TARP pumpbacks to the District's WRPs, and data from the study on conventional pollutants in CSOs conducted jointly by the District and the ACOE:

1. Based on the data from the District's routine monitoring, the concentrations of the conventional pollutants in the pumpback and pumpage varied widely during the period of 1995 to 1997

when the pumpback and pumpage were sampled for the analysis of organic priority pollutants. The concentration of TSS from TARP pumpback at the TARP Mainstream Pumping Station ranged from 14 to 356 mg/L, $BOD_5$ from 10 to 174 mg/L, and $NH_4$-N from 1.28 to 9.12 mg/L. The concentration of TSS from TARP pumpback at the TARP Calumet Pump Station ranged from 22 to 610 mg/L, $BOD_5$ from 10 to 174 mg/L, and $NH_4$-N from 1.60 to 13.7 mg/L. The concentration of TSS from TARP pumpage at the Kirie WRP Influent Pump Station ranged from 36 to 1504 mg/L, $BOD_5$ from 29 to 245 mg/L, and $NH_4$-N from 2.60 to 12.51 mg/L.

2. Based on the data from the study on CSOs at the seven TARP drop shaft and overflow stations during 1995 through 1997, the average concentrations of the conventional pollutants over a rainfall event varied from location to location.
3. No pattern between rainfall and the time-weighted average concentrations of conventional pollutants in CSOs was observed based on 28 sets of data collected at the seven TARP drop shaft and overflow stations during various rainfall events during the period.

4. Generally, the average $BOD_5$ concentration in the CSOs from the same rainfall event was relatively high when the average concentration of corresponding suspended solids was high. However, the correlation was not linear.

5. No correlation between the average concentrations of conventional pollutants and the number of organic priority pollutants detected was found from the data obtained from either the TARP pump stations or the TARP drop shaft and overflow stations.

The report, *Chemical Characteristics of Combined Sewer Overflows and Tunnel and Reservoir Plan Flows in 1995 through 1997,* was published as R&D Report No. 2000-7 in April 2000.

## Oxygen Transfer Efficiency of Diffuser Plates at the North Side WRP

The oxygen transfer efficiency (OTE) of the diffuser plates in the selected aeration tanks at the North Side WRP were measured during the summer and fall of 1999, using an off-gas technique.

The scope of this project included:

1. conducting a series of off-gas tests in one selected aeration tank in Battery B to evaluate

the effect of cleaning the diffuser plates on OTE;

2. performing off-gas tests to determine OTE in several tanks in Batteries A, B, and C in which all diffuser plates were installed in 1986;
3. conducting off-gas tests in three aeration tanks in Battery D at the locations that were chosen in a previous study in 1995 to follow up on the OTE change, if any, in these tanks; and
4. conducting additional off-gas tests to investigate the factors that may have an influence on the DO levels in the aeration tanks.

All off-gas tests were conducted under reasonably controlled conditions. 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. Throughout the off-gas tests, sewage flow to the test battery was adjusted to approximately 50 million gallons per day (MGD). In Batteries A, B and C, the air flow to each test tank was set at 2100 standard cubic feet per minute (scfm), unless otherwise noted. In Battery D, the air flow to each test tank was set at 2800 scfm without exception.

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

The major conclusions of the study were:

1. Cleaning of the diffuser plates with steam/hot water did not significantly improve the SOTE values. However, the average air flow rates through the cleaned diffuser plates increased noticeably.
2. Average SOTE values for the 19 tested aeration bays in Batteries A, B, and C ranged from 0.0983 to 0.138, while average DO concentrations in these bays ranged from 0.45 to 4.10 mg/L.
3. The average DO concentrations generally varied with the average off-gas flow rates, not with SOTE values. In most cases, average DO concentrations increased with the average off-gas flow rates. However, linear regression analysis between these two variables showed that the $R^2$ coefficient was only 0.42.
4. SOTE values at the selected test stations in Tanks D5, D6, and D7 ranged from 0.100 to 0.154 in the 1999 study, and from 0.0628 to 0.0115 at

the same locations in the 1995 study. In the 1999 study, significantly higher SOTE values were obtained in Tanks D6 and D7 where the diffuser plates (installed in 1993) were relatively new, compared to those in Tank D5 with older diffuser plates (installed in 1961). However, no such trend was observed in the 1995 study.

## Investigation of Ammonia Spike Incidents at the Stickney WRP

The proposed reissued National Pollutant Discharge Elimination System (NPDES) permit for the Stickney WRP requires that ammonia-nitrogen (ammonia) in the final effluent not exceed a maximum daily concentration of 5 mg/L. The monthly average concentration limits are also contained in the current permit will also remain unchanged in the proposed reissued 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. These two incidents were labeled as "ammonia spikes."

As a result of these two incidents, the M&O Department expressed a concern and requested the R&D Department to identify major ammonia contributing sources to the Stickney WRP and to determine the likely cause(s) of ammonia spikes. In response to this request from the M&O Department, the R&D Department conducted the following study.

The main objectives of this study were to:

- identify the main sources contributing ammonia to the Stickney WRP,
- assess the impact of variation in ammonia concentrations from the ammonia contributing sources on the performance of ammonia removal at the Stickney WRP, and
- analyze the operating data of the Stickney WRP for possible causes of the two incidents of ammonia spikes in the final effluent, resulting in daily average ammonia concentrations in the final effluent exceeding 5.0 mg/L.

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

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

For monitoring ammonia discharges from CPC, Post-DC, and LASMA, auto-samplers were used to collect hourly samples during the period August 14 through September 5, 2000. Flow rates from CPC were recorded daily on a totalizer. Flow rates from Post-DC and LASMA were estimated.

For determining the ammonia contribution from the TARP pumpback, investigators examined routinely collected monitoring data. These data included the flow rates and concentrations of both ammonia and $BOD_5$ for the period August 14 to September 5, 2000. The ammonia contribution in the domestic sewage for the period August 14 to September 5, 2000, was estimated by subtracting the ammonia loadings of the above mentioned four sources from the total ammonia load entering the Stickney WRP.

Investigation of the possible causes of the two ammonia spikes started with the collection of historical data a few days before and after the incidents. These data included the ammonia and $BOD_5$ concentrations in the raw sewage and the influent of the aeration tanks, hourly sewage flow rates, the amount of air supplied to the aeration tanks, and DO levels in the aeration tanks. Available information on the sources contributing ammonia to the Stickney WRP pertaining to the two incidents was also collected.

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

A preliminary report indicated the following:

1. The four previously identified sources contributed 51 percent of the total ammonia loading to the Stickney WRP during the source investigation period August 14 through September 5, 2000. The average ammonia contribution from each source was: 8.2 percent from the TARP pumpback, 11.0 percent from CPC, 10.8 percent from Post-DC, and

21.0 percent from LASMA. The remaining 49 percent was from domestic sources.

2. During the period of source investigation, the TARP pumpback ammonia loading had the most variability among the four individual sources, contributing from 0 to 21.7 percent of the total ammonia on a daily average basis. Considering that the TARP pumpback usually occurs only within a few hours of the day after a rain event, the impact from TARP pumpback on spiking can be quite significant. The discharge from CPC was found to be the second most variable source, contributing from 0 to 16.9 percent of the total ammonia on a daily average basis. The ammonia loadings in the Post-DC centrate and overflows from LASMA were much less variable. These last two sources ranged from 6.5 to 14.9 percent and from 9.4 to 26.7 percent, respectively, of the total ammonia loadings, on a daily average basis.

3. The causes of the two incidents of final effluent ammonia spikes appear to be different in nature. The April 7, 2000 incident appears to have resulted from a combination of high ammonia

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

4. The high ammonia levels on July 22, 2000 appears to have resulted from low DO levels in the aeration tanks, which led to inefficient nitrification on that day. As the daily average ammonia concentration in the raw sewage and ammonia load to the aeration tanks was only slightly higher than normal, the unusually high ammonia concentration in the final effluent could not have been caused by the ammonia load alone on that day. Considering the short time (three to nine hours) it takes for the TARP pumpback to travel from the pump station to the aeration tanks, the TARP pumpback between the night of July 21 and early morning of July 22, which contained a high concentration of ammonia and exerted a high

$BOD_5$, could have been responsible for causing the low DO levels in the aeration tanks in the first and second shifts on July 22, 2000.

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

## Reevaluation of Local Limits

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. For each pollutant, the smallest (i.e., 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 initial evaluation consisted of 1999 data for two of the District WRPs, Hanover Park and Lemont. The limits were calculated using the average removal method. The Lemont influent was used as the background level since it has little or no industrial discharge. The USEPA literature values were used for the removal across the primary treatment and the biological inhibition levels.

This methodology proved to be problematic. The limits derived using the USEPA guidance document procedure for copper and zinc were below zero at the Hanover Park WRP. The use of the Lemont influent concentrations as the background level for toxic pollutants caused the maximum loading of copper and zinc to be unfairly low. The Lemont water source is mostly well water with higher levels of copper and zinc than Lake Michigan water which is the water source for most of the District WRPs.

The other pollutants of concern had limits approaching zero. The extremely low limits derived from this methodology would be unrealistically stringent. The current limits have a proven record of protecting the WRPs from passthrough and interference. The parameters with the most impact on the end result are the pollutant background level and the removal efficiency. In some cases, the average removal efficiency may not reflect the actual pollutant removal from the water.

Using the USEPA guidance document procedure, the Lemont WRP had high limits for all pollutants. The water quality protection limits are based on state water quality criteria since there are no NPDES Permits. The water quality limit is very high due to the small flow from the WRP going into the large flow of the channel. There are no sludge processing facilities at this WRP, therefore, there are no restrictions due to sludge quality. In addition, the extremely small industrial flow allows for a higher concentration of toxic pollutants using the USEPA methodology.

The work on this project is still in progress and is expected to be completed by the end of the year 2001. The limits will be recalculated with background levels reflecting the Lake Michigan water composition.

## Research Services to the Army Corps of Engineers 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. To minimize the possibility of odor formation, and to maintain aerobic conditions, an aeration system will be designed to maintain 2 mg DO/L in a completely mixed environment. 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.

Plans for laboratory, field, and/or pilot-scale tests will be developed for the Cryogenic Oxygen Barge, and U-tube aeration systems. Tests to determine the OTE, size of the aeration system needed, and feasibility of utilizing a COB, and/or U-tube system in the McCook Reservoir will be performed. If these systems are shown to be impractical, tests will be developed to evaluate air/oxygen injection systems for supplemental oxygenation of the McCook Reservoir especially during small events (CSOs less than 30 feet deep). Similarly, plans for laboratory, field and/or pilot-scale tests will be developed to obtain information on odor formation in the wash down system.

Prior to testing, 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 have been submitted to the ACOE, Chicago Office. Based on any future response from the ACOE, additional work may be undertaken by the District.

# 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.

BIOSOLIDS MONITORING

In 2000, the monitoring activities at the Fulton County site remained similar in quantity and nature to those conducted in 1999. No supernatant or dewatered liquid fertilizer from Holding Basin 1 were applied to Fulton County fields during 2000. Air-dried, anaerobically digested biosolids from the District's Calumet WRP were shipped to the Fulton County site in 2000 and land-applied.

The water monitoring included:

- quarterly sampling of 20 groundwater monitoring wells; quarterly sampling of 15 lysimeters in the supernatant application area;
- 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; and
- sampling of 60 field runoff retention basins as needed.

Water samples were collected monthly from 19 lysimeters and three drainage tiles at the St. David Coal Refuse Pile, three lysimeters at the Morgan Mine Coal Refuse Pile, and ten lysimeters at the United Electric Coal (UEC) Refuse Pile. 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 80 fields for chemical analysis, and plant samples were collected from 11 hay fields, 36 soybean fields, and 17 corn fields for chemical analysis in 2000. Climatological conditions were monitored at the project weather station.

The metals monitored were:

- Zinc (Zn)
- Cadmium (Cd)
- Copper (Cu)
- Chromium (Cr)
- Nickel (Ni)
- Lead (Pb)

A number of chemical parameters were also used in the analysis. These included:

- Total Phosphorus (P)
- Nitrogen-phosphorus-potassium (N-P-K)
- Sulfate ($SO_4$)

- Nitrite plus Nitrate Nitrogen ($NO_2$+$NO_3$-N)
- Nitrate-Nitrogen ($NO_3$-N)
- Alkalinity as Calcium Carbonate ($CaCO_3$)

Biosolids have been applied to fields at the Fulton County site since 1972. Table 3 shows the concentrations of total metals, TKN, and total P found in 1999 corn field soils (0- to 15-cm deep) which received different cumulative rates of biosolids. The concentrations generally increased with higher biosolids loading rates.

Plant tissue samples (grain, leaf, and/or stover) are collected annually from fields leased to local farmers at the Fulton County site. Table 4 shows the concentrations of total metals, TKN, and total P found in 1999 corn grain collected from fields with different cumulative loading rates of biosolids. No clear pattern of an increase in the grain tissue concentration for any of the parameters was apparent with higher cumulative biosolids loading rates.

Table 5 shows the concentration of total metals in corn leaf tissue samples from the same corn fields in 1999. Zinc and cadmium concentrations in the leaf tissue were lower with a decrease in cumulative biosolids applied to each field. The concentrations of all other elements, however, remain fairly constant despite the cumulative amount of biosolids applied to each field.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

MEAN CONCENTRATIONS OF TOTAL METALS, TKN, AND PHOSPHORUS IN 1999 CORN FIELDS AT THE FULTON COUNTY RECLAMATION SITE[1]

| Field Number | Cumulative Biosolids Applied[2] | | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Total P |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----Dry Solids---- | | mg/Kg | | | | | | | |
| | Mg/ha | tons/acre | | | | | | | | |
| 2 | 1,726 | 770 | 1,137 | 58 | 440 | 734 | 110 | 244 | 4,985 | 9,780 |
| 4 | 1,437 | 642 | 1,015 | 53 | 414 | 718 | 103 | 225 | 5,253 | 8,064 |
| 15 | 1,260 | 563 | 939 | 50 | 386 | 641 | 95 | 203 | 3,800 | 6,789 |
| 16E | 1,453 | 649 | 826 | 47 | 341 | 626 | 89 | 195 | 3,629 | 7,017 |
| 16W | 1,453 | 649 | 834 | 47 | 353 | 617 | 86 | 194 | 3,993 | 3,169 |
| 18[3] | 1.0 | 0.5 | 67 | 2 | 15 | 20 | 23 | 11 | 1,320 | 795 |
| 19 | 644 | 287 | 675 | 40 | 275 | 512 | 68 | 171 | 2,759 | 4,796 |
| 20 | 531 | 237 | 706 | 40 | 295 | 524 | 74 | 171 | 3,552 | 5,072 |
| 21 | 618 | 276 | 638 | 37 | 253 | 465 | 68 | 156 | 2,141 | 4,601 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS, TKN, AND PHOSPHORUS IN 1999 CORN FIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Total P |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----Dry Solids---- | | ----------mg/Kg---------- | | | | | | | |
| | Mg/ha | tons/acre | | | | | | | | |
| 22 | 455 | 203 | 897 | 54 | 363 | 688 | 91 | 219 | 3,513 | 6,087 |
| 23 | 473 | 211 | 751 | 44 | 298 | 560 | 79 | 179 | 3,053 | 4,899 |
| 24 | 1.1 | 0.5 | 103 | 5 | 29 | 44 | 31 | 14 | 906 | 1,158 |
| 31 | 557 | 249 | 863 | 50 | 378 | 654 | 90 | 191 | 3,368 | 5,746 |
| 32 | 388 | 173 | 815 | 45 | 328 | 561 | 102 | 174 | 3,312 | 5,369 |
| 33 | 903 | 403 | 1,094 | 59 | 445 | 738 | 120 | 225 | 5,109 | 8,124 |
| 34-1 | 566 | 253 | 690 | 41 | 262 | 495 | 73 | 158 | 2,805 | 4,895 |
| 38C | 9.4 | 4.2 | 105 | 3 | 20 | 27 | 32 | 16 | 1,361 | 1,145 |

[1]Sampling depth 0-15 cm.
[2]Through 1999.
[3]Only commercial fertilizer was applied to this field.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

MEAN CONCENTRATIONS OF TOTAL METALS, TKN, AND PHOSPHORUS IN 1999
CORN GRAIN SAMPLES FROM THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied[1] | | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Total P |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----Dry Solids---- | | ---mg/Kg--- | | | | | | | |
| | Mg/ha | tons/acre | | | | | | | | |
| 2 | 1,726 | 770 | 33 | <1 | 2 | <1 | 1.13 | 0.13 | 17,675 | 4,810 |
| 4 | 1,437 | 642 | 35 | <1 | 2 | <1 | 1.13 | 0.13 | 14,763 | 4,868 |
| 15 | 1,260 | 563 | 29 | <1 | 2 | <1 | 0.88 | <0.10 | 10,125 | 4,365 |
| 16E | 1,453 | 649 | 28 | <1 | 2 | <1 | 1.13 | 0.30 | 14,875 | 4,350 |
| 16W | 1,453 | 649 | 34 | <1 | 2 | <1 | 1.68 | <0.10 | 13,138 | 3,750 |
| 18[2] | 1.0 | 0.5 | 24 | <1 | 2 | <1 | 1.38 | 0.18 | 13,038 | 3,933 |
| 19 | 644 | 287 | 31 | <1 | 2 | <1 | 0.88 | 0.15 | 15,038 | 4,323 |
| 20 | 531 | 237 | 32 | <1 | 2 | <1 | 1.88 | <0.10 | 14,550 | 3,965 |
| 21 | 618 | 276 | 32 | <1 | 2 | <1 | 1.88 | 0.18 | 14,862 | 3,990 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS, TKN, AND PHOSPHORUS IN 1999 CORN GRAIN SAMPLES FROM THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Total P |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----Dry Solids---- | | ------------------------mg/Kg------------------------ | | | | | | | |
| | Mg/ha | tons/acre | | | | | | | | |
| 22 | 455 | 203 | 32 | <1 | 2 | <1 | 1.88 | <0.10 | 14,562 | 4,683 |
| 23 | 473 | 211 | 30 | <1 | 1 | <1 | 1.38 | <0.10 | 14,675 | 4,698 |
| 24 | 1.1 | 0.5 | 25 | <1 | 2 | <1 | 1.38 | 0.28 | 12,275 | 3,965 |
| 31 | 557 | 249 | 27 | <1 | 1 | <1 | 1.38 | <0.10 | 15,525 | 4,313 |
| 32 | 388 | 173 | 37 | <1 | 2 | <1 | 1.63 | <0.10 | 16,150 | 4,140 |
| 33 | 903 | 403 | 36 | <1 | 3 | <1 | 3.13 | <0.10 | 13,975 | 4,605 |
| 34-1 | 566 | 253 | 30 | <1 | 2 | <1 | 1.38 | <0.10 | 12,850 | 3,723 |
| 38C | 9.4 | 4.2 | 28 | <1 | 2 | <1 | 1.63 | 0.18 | 12,125 | 4,540 |

[1]Through 1999.
[2]Only commercial fertilizer was applied to this field.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

MEAN CONCENTRATIONS OF TOTAL METALS FOR 1999
CORN LEAF SAMPLES AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied[1] | | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|
| | -----Dry Solids------ | | -------------------mg/Kg-------------------- | | | | | |
| | Mg/ha | tons/acre | | | | | | |
| 2 | 1,726 | 770 | 128 | 12 | 15 | <2 | <0.05 | 0.52 |
| 4 | 1,437 | 642 | 144 | 10 | 16 | <2 | <0.05 | <0.20 |
| 15 | 1,260 | 563 | 78 | 5 | 12 | <2 | <0.05 | 0.84 |
| 16E | 1,453 | 649 | 90 | 4 | 10 | <2 | 0.38 | <0.20 |
| 16W | 1,453 | 649 | 130 | 5 | 12 | <2 | 0.49 | 3.12 |
| 18[2] | 1.0 | 0.5 | 26 | <0.8 | 8 | <2 | <0.05 | 1.28 |
| 19 | 644 | 287 | 98 | 5 | 11 | 4 | <0.05 | <0.20 |
| 20 | 531 | 237 | 106 | 6 | 10 | <2 | <0.05 | <0.20 |
| 21 | 618 | 276 | 124 | 6 | 13 | <2 | <0.05 | <0.20 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS FOR 1999
CORN LEAF SAMPLES AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|
| | -----Dry Solids------ | | ---------mg/Kg--------- | | | | | |
| | Mg/ha | tons/acre | | | | | | |
| 22 | 455 | 203 | 188 | 8 | 16 | <2 | <0.05 | 1.60 |
| 23 | 473 | 211 | 125 | 7 | 10 | <2 | <0.05 | 0.93 |
| 24 | 1.1 | 0.5 | 34 | <0.8 | 12 | <2 | <0.05 | 0.45 |
| 31 | 557 | 249 | 90 | 8 | 10 | <2 | <0.05 | 1.60 |
| 32 | 388 | 173 | 83 | 5 | 11 | <2 | <0.05 | 2.53 |
| 33 | 903 | 403 | 104 | 5 | 11 | <2 | <0.05 | 3.00 |
| 34-1 | 566 | 253 | 65 | 5 | 10 | <2 | 0.63 | <0.20 |
| 38C | 9.4 | 4.2 | 32 | <0.8 | 6 | <2 | 0.09 | 0.22 |

[1]Through 1999.
[2]Only commercial fertilizer was applied to this field.

Another monitored crop of economic importance is soybeans. Table 6 shows the concentrations of total metals, TKN, and total P found in soils (0- to 15-cm) from those fields where soybeans were planted in 1999.

Table 7 displays the concentrations of total metals in soybean grain for 1999. Generally, the metal concentrations in the soybean grain were relatively insensitive to the varying cumulative amounts of biosolids applied over time.

Tables 8 and 9 show the grain yields for corn and soybean fields for 1999. Table 8 shows that corn grain yields were generally higher on placed land fields (19, 20, 21, 22, 23, 31, and 34-1) (i.e. fields not strip mined) than on the mine spoil fields (2, 4, 15, 24, 32, 33, and 38C). For soybeans, Table 9, 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 application and yield data to produce recommendations leading to increased productivity for not only the Fulton County site, but farms in the Chicagoland area that are

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6

MEAN CONCENTRATIONS OF TOTAL METALS, TKN, AND PHOSPHORUS IN 1999 SOYBEAN FIELDS AT THE FULTON COUNTY RECLAMATION SITE[1]

| Field Number | Cumulative Biosolids Applied[2] | | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Total P |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----Dry Solids---- | | ----------mg/Kg---------- | | | | | | | |
| | Mg/ha | tons/acre | | | | | | | | |
| 1 | 1,546 | 690 | 1,188 | 68 | 521 | 879 | 128 | 267 | 3,926 | 8,523 |
| 7E | 1,394 | 622 | 1,057 | 66 | 393 | 767 | 113 | 244 | 4,554 | 6,981 |
| 7W | 1,394 | 622 | 382 | 23 | 120 | 253 | 51 | 87 | 2,079 | 3,200 |
| 8 | 1,222 | 546 | 850 | 48 | 392 | 635 | 91 | 197 | 2,507 | 6,849 |
| 11 | 1,409 | 629 | 999 | 57 | 413 | 747 | 111 | 239 | 4,128 | 6,696 |
| 12 | 1,306 | 583 | 1,180 | 47 | 346 | 582 | 90 | 182 | 3,230 | 6,237 |
| 13 | 1,163 | 519 | 1,040 | 62 | 457 | 789 | 108 | 244 | 4,146 | 7,659 |
| 14 | 1,278 | 571 | 805 | 45 | 348 | 590 | 89 | 187 | 3,399 | 6,213 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS, TKN, AND PHOSPHORUS
IN 1999 SOYBEAN FIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Total P |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----Dry Solids---- | | ----mg/Kg---- | | | | | | | |
| | Mg/ha | tons/acre | | | | | | | | |
| 25 | 788 | 352 | 1,047 | 53 | 348 | 632 | 101 | 227 | 3,114 | 6,009 |
| 26 | 1,012 | 452 | 983 | 54 | 336 | 643 | 108 | 211 | 3,675 | 5,888 |
| 27 | 755 | 337 | 954 | 55 | 379 | 633 | 105 | 220 | 3,882 | 6,222 |
| 28 | 800 | 357 | 1,071 | 63 | 430 | 716 | 127 | 237 | 4,077 | 6,351 |
| 30 | 1,118 | 499 | 989 | 47 | 395 | 636 | 106 | 202 | 4,557 | 6,879 |
| 34-2 | 567 | 253 | 690 | 41 | 262 | 495 | 73 | 158 | 2,805 | 4,895 |
| 35 | 1,008 | 450 | 877 | 48 | 363 | 604 | 84 | 199 | 4,475 | 6,840 |
| 36 | 1,048 | 468 | 755 | 40 | 307 | 506 | 79 | 165 | 3,689 | 5,511 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS, TKN, AND PHOSPHORUS IN 1999 SOYBEAN FIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Total P |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----Dry Solids---- | | --------------------- | | | mg/Kg | | | | ---------------------- |
| | Mg/ha | tons/acre | | | | | | | | |
| 37 | 768 | 343 | 754 | 42 | 304 | 511 | 81 | 164 | 3,234 | 5,245 |
| 39 | 442 | 197 | 559 | 34 | 226 | 386 | 76 | 125 | 2,490 | 3,859 |
| 40 | 497 | 222 | 786 | 47 | 325 | 576 | 85 | 183 | 3,326 | 5,257 |
| 42 | 721 | 322 | 1,018 | 60 | 419 | 728 | 107 | 231 | 4,104 | 6,747 |
| 43 | 793 | 354 | 893 | 47 | 356 | 600 | 92 | 193 | 4,290 | 6,321 |
| 44 | 598 | 267 | 734 | 42 | 329 | 531 | 87 | 165 | 3,419 | 5,579 |
| 47 | 903 | 403 | 1,142 | 61 | 502 | 778 | 116 | 236 | 5,199 | 8,412 |
| 50[3] | 6.6 | 3.0 | 58 | 3 | 18 | 25 | 25 | 7 | 1,127 | 670 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS, TKN, AND PHOSPHORUS
IN 1999 SOYBEAN FIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Total P |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----Dry Solids---- | | ------------------------mg/Kg------------------------ | | | | | | | |
| | Mg/ha | tons/acre | | | | | | | | |
| 51 | 45 | 20 | 96 | 3 | 25 | 35 | 23 | 21 | 1,826 | 1,115 |
| 52[3] | 9.1 | 4.1 | 65 | 3 | 19 | 25 | 26 | 7 | 1,088 | 743 |
| 54 | 14 | 6.4 | 85 | 2 | 25 | 25 | 36 | 9 | 1,319 | 873 |
| 55 | 9.4 | 4.2 | 81 | 3 | 25 | 26 | 35 | 12 | 1,613 | 885 |
| 56 | 13 | 5.9 | 118 | 3 | 29 | 33 | 41 | 19 | 1,379 | 950 |
| 59 | 2.5 | 1.1 | 52 | 1 | 12 | 20 | 15 | 10 | 1,119 | 754 |
| 60 | 3.1 | 1.4 | 53 | 1 | 17 | 19 | 22 | 5 | 1,092 | 778 |
| 61 | 2.2 | 1.0 | 68 | 2 | 25 | 25 | 36 | 5 | 1,212 | 730 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS, TKN, AND PHOSPHORUS IN 1999 SOYBEAN FIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb | TKN | Total P |
|---|---|---|---|---|---|---|---|---|---|---|
| | ----Dry Solids---- | | ----mg/Kg---- | | | | | | | |
| | Mg/ha | tons/acre | | | | | | | | |
| 63-1-1 | 22 | 9.6 | 62 | 2 | 24 | 24 | 30 | 3 | 1,440 | 674 |
| 64 | 2.2 | 1.0 | 103 | 2 | 24 | 28 | 37 | 13 | 1,124 | 948 |
| 65 | 0.4 | 0.2 | 116 | 2 | 21 | 24 | 33 | 9 | 1,166 | 1,011 |
| 75 | 336 | 150 | 199 | 11 | 83 | 149 | 34 | 46 | 1,215 | 2,064 |

[1]Sampling depth 0 to 15 cm.
[2]Through 1999.
[3]Only commercial fertilizer was applied to the field.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7

MEAN CONCENTRATIONS OF TOTAL METALS IN 1999 SOYBEAN GRAIN SAMPLES FROM THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied[1] | | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|
| | -----Dry Solids------ | | --------------------mg/Kg-------------------- | | | | | |
| | Mg/ha | tons/acre | | | | | | |
| 1 | 1,546 | 690 | 52 | 1 | 16 | 5 | 16 | 2.8 |
| 7E | 1,394 | 622 | 46 | <1 | 12 | <1 | 10 | <0.1 |
| 7W | 1,394 | 622 | 45 | 1 | 11 | <1 | 10 | <0.1 |
| 8 | 1,222 | 546 | 48 | <1 | 13 | <1 | 11 | <0.1 |
| 11 | 1,409 | 629 | 53 | 1 | 14 | <1 | 14 | <0.1 |
| 12 | 1,306 | 583 | 55 | 1 | 12 | <1 | 15 | <0.1 |
| 13 | 1,163 | 519 | 55 | 2 | 11 | <1 | 14 | 0.3 |
| 14 | 1,278 | 571 | 56 | 2 | 12 | <1 | 14 | <0.1 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS IN 1999 SOYBEAN GRAIN SAMPLES FROM THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|
| | -----Dry Solids------ | | --------------------mg/Kg-------------------- | | | | | |
| | Mg/ha | tons/acre | | | | | | |
| 25 | 788 | 352 | 54 | <1 | 13 | <1 | 11 | <0.1 |
| 26 | 1,012 | 452 | 48 | <1 | 13 | <1 | 9 | <0.1 |
| 27 | 755 | 337 | 63 | 1 | 16 | <1 | 12 | <0.1 |
| 28 | 800 | 357 | 63 | 2 | 13 | <1 | 15 | <0.1 |
| 30 | 1,118 | 499 | 59 | 2 | 15 | <1 | 10 | <0.1 |
| 34-2 | 567 | 253 | 52 | <1 | 10 | <1 | 12 | <0.1 |
| 35 | 1,008 | 450 | 53 | 1 | 10 | <1 | 15 | <0.1 |
| 36 | 1,048 | 468 | 54 | 1 | 10 | <1 | 16 | <0.1 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS IN 1999 SOYBEAN GRAIN SAMPLES FROM THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|
| | -----Dry Solids------ | | --------------------mg/Kg-------------------- | | | | | |
| | Mg/ha | tons/acre | | | | | | |
| 37 | 768 | 343 | 53 | 1 | 10 | <1 | 15 | <0.1 |
| 39 | 442 | 197 | 57 | 2 | 09 | 1 | 13 | 0.2 |
| 40 | 497 | 222 | 42 | <1 | 08 | <1 | 9 | <0.1 |
| 42 | 721 | 322 | 48 | <1 | 14 | <1 | 6 | <0.1 |
| 43 | 793 | 354 | 46 | <1 | 13 | 1 | 8 | <0.1 |
| 44 | 598 | 267 | 41 | 1 | 11 | <1 | 4 | <0.1 |
| 47 | 903 | 403 | 40 | <1 | 10 | <1 | 4 | <0.1 |
| 50[2] | 6.6 | 3 | 28 | <1 | 13 | <1 | 6 | <0.1 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS IN 1999 SOYBEAN GRAIN SAMPLES FROM THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|
| | -----Dry Solids------ | | --------------------mg/Kg-------------------- | | | | | |
| | Mg/ha | tons/acre | | | | | | |
| 51 | 45 | 20 | 33 | <1 | 13 | <1 | 7 | <0.1 |
| 52[2] | 9.1 | 4.1 | 23 | <1 | 12 | <1 | 2 | <0.1 |
| 54 | 14 | 6.4 | 39 | <1 | 17 | <1 | 5 | <0.1 |
| 55 | 9.4 | 4.2 | 36 | <1 | 16 | <1 | 5 | <0.1 |
| 56 | 13 | 5.9 | 30 | <1 | 14 | <1 | 5 | <0.1 |
| 59 | 2.5 | 1.1 | 19 | <1 | 10 | <1 | 2 | <0.1 |
| 60 | 3.1 | 1.4 | 47 | 2 | 08 | <1 | 11 | <0.1 |
| 61 | 2.2 | 1 | 45 | 2 | 08 | <1 | 11 | <0.1 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7 (Continued)

MEAN CONCENTRATIONS OF TOTAL METALS IN 1999 SOYBEAN GRAIN SAMPLES FROM THE FULTON COUNTY RECLAMATION SITE

| Field Number | Cumulative Biosolids Applied | | Zn | Cd | Cu | Cr | Ni | Pb |
|---|---|---|---|---|---|---|---|---|
| | -----Dry Solids------ | | --------------------mg/Kg-------------------- | | | | | |
| | Mg/ha | tons/acre | | | | | | |
| 63-1-1 | 22 | 9.6 | 48 | 2 | 10 | <1 | 11 | <0.1 |
| 64 | 2.2 | 1 | 28 | <1 | 13 | <1 | 5 | 1.3 |
| 65 | .4 | 0.2 | 28 | <1 | 13 | <1 | 5 | <0.1 |
| 75 | 336 | 150 | 47 | <1 | 09 | <1 | 4 | <0.1 |

[1]Through 1999.
[2]Only commercial fertilizer was applied to the field.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 8

1999 CORN GRAIN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Type[1] | Cumulative Biosolids Applied[2] | | Corn Grain Yield |
|---|---|---|---|---|
| | | ------Dry Solids------ | | bu/acre |
| | | Mg/ha | tons/acre | |
| 2 | MS | 1,726 | 770 | 130.0 |
| 4 | MS | 1,437 | 642 | 135.0 |
| 15 | MS | 1,260 | 563 | 120.4 |
| 16E | 1/4 MS | 1,453 | 649 | 136.8 |
| 16W | 1/4 MS | 1,453 | 649 | 136.8 |
| 18[3] | 1/2 MS | 1.0 | 0.5 | 140.0 |
| 19 | PL | 644 | 287 | 160.0 |
| 20 | PL | 531 | 237 | 150.0 |
| 21 | PL | 618 | 276 | 165.0 |
| 22 | PL | 455 | 203 | 140.0 |
| 23 | PL | 473 | 211 | 162.0 |
| 24 | MS | 1.1 | 0.5 | 105.2 |
| 31 | PL | 557 | 249 | 122.8 |
| 32 | MS | 388 | 173 | 122.8 |
| 33 | MS | 903 | 403 | 122.8 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 8 (Continued)

1999 CORN GRAIN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Type | Cumulative Biosolids Applied | | Corn Grain Yield |
|---|---|---|---|---|
| | | ------Dry Solids------ | | bu/acre |
| | | Mg/ha | tons/acre | |
| 34-1 | PL | 567 | 253 | 122.8 |
| 38C | MS | 9.4 | 4.2 | 85.0 |

[1]MS = mine-spoil; fractions appearing before MS indicate the proportion of the field surface 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 1999.
[3]Only commercial fertilizer was applied to the field.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9

1999 SOYBEAN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Type[1] | Cumulative Biosolids Applied[2] | | Soybean Yield |
|---|---|---|---|---|
| | | ------Dry Solids------ | | bu/acre |
| | | Mg/ha | tons/acre | |
| 1 | MS | 1,546 | 690 | 38.0 |
| 7E | MS | 1,394 | 622 | 43.0 |
| 7W | MS | 1,394 | 622 | 43.0 |
| 8 | MS | 1,222 | 546 | 43.0 |
| 11 | MS | 1,409 | 629 | 41.0 |
| 12 | MS | 1,306 | 583 | 41.0 |
| 13 | MS | 1,163 | 519 | 41.0 |
| 14 | MS | 1,278 | 571 | 41.0 |
| 25 | PL | 788 | 352 | 30.0 |
| 26 | PL | 1,012 | 452 | 15.0 |
| 27 | 2/3 MS | 755 | 337 | 41.0 |
| 28 | PL | 800 | 357 | 38.0 |
| 30 | MS | 1,118 | 499 | 28.0 |
| 34-2 | PL | 567 | 253 | 52.8 |
| 35 | PL | 1,008 | 450 | 55.0 |
| 36 | PL | 1,048 | 468 | 54.0 |

TABLE 9 (Continued)

1999 SOYBEAN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Type | Cumulative Biosolids Applied | | Soybean Yield |
|---|---|---|---|---|
| | | ------Dry Solids------ | | bu/acre |
| | | Mg/ha | tons/acre | |
| 37 | PL | 768 | 343 | 52.0 |
| 39 | MS | 442 | 197 | 53.2 |
| 40 | 1/5 MS | 497 | 222 | 56.1 |
| 42 | MS | 721 | 322 | 45.0 |
| 43 | MS | 793 | 354 | 28.0 |
| 44 | MS | 598 | 267 | 45.0 |
| 47 | MS | 903 | 403 | 45.0 |
| 50[3] | 7/8 MS | 6.6 | 3.0 | 50.0 |
| 51 | 1/4 MS | 45 | 20 | 40.0 |
| 52[3] | MS | 9.1 | 4.1 | 48.0 |
| 54 | MS | 14 | 6.4 | 40.0 |
| 55 | MS | 9.4 | 4.2 | 35.0 |
| 56 | MS | 13 | 5.9 | 45.0 |
| 59 | PL | 2.5 | 1.1 | 52.0 |
| 60 | MS | 3.1 | 1.4 | 30.0 |
| 61 | MS | 2.2 | 1.0 | 30.0 |

TABLE 9 (Continued)

1999 SOYBEAN YIELDS AT THE FULTON COUNTY RECLAMATION SITE

| Field Number | Type | Cumulative Biosolids Applied | | Soybean Yield |
|---|---|---|---|---|
| | | ------Dry Solids------ | | bu/acre |
| | | Mg/ha | tons/acre | |
| 63-1-1 | MS | 22 | 9.6 | 30.0 |
| 64 | MS | 2.2 | 1.0 | 35.0 |
| 65 | MS | 0.4 | 0.2 | 36.0 |
| 75 | MS | 336 | 150 | 40.0 |

[1]MS = mine-spoil; fractions appearing before MS indicate the proportion of the field surface 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 1999.
[3]Only commercial fertilizer was applied to the field.

receiving biosolids from the District's water reclamation plants.

## MISCELLANEOUS INITIATIVES

During the year 2000, Fulton County R&D Laboratory staff assisted the M&O Department in conducting two requested surveys at the site. The first was to examine and make recommendations for improving income-producing alfalfa fields. The second was to find areas requiring further reclamation work to improve the water quality of the Acid-Mine Lake. This included a survey of the reclaimed Acid-Mine Lake and the UEC coal refuse areas. Also, preparations were made to generate the data required to request further reductions in monitoring at the site.

### 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 one of the longest running biosolids research initiatives 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 publication of its 503 regulations in 1993. All 27 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 each year and for each treatment are listed in Table 10, along with the cumulative totals of biosolids applied per plot through 2000. Check plots receive a commercial fertilizer mix comprised of nitrogen, phosphorus and potassium (N-P-K) in relative dosages of 336-224-112 Kg/ha annually. Biosolids-amended plots receive 112 Kg/ha of potassium annually.

The corn hybrid planted in 1997 through 2000 was Pioneer 3394. The lowest grain yields came from plots with 16.8 dry Mg/ha (7.5 tons/acre) of biosolids while the highest yields came from the maximum-amended plots receiving 67.2 dry Mg/ha (30.0 tons/acre). For stover, the highest yields occurred in the maximum-amended plots, 67.2 dry Mg/ha (30.0 tons/acre) of

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TABLE 10

CORN GRAIN AND STOVER YIELDS ON BIOSOLIDS-AMENDED MINE SPOIL AT THE FULTON COUNTY RECLAMATION SITE - 2000

| Biosolids Application[1] | | | | Corn Yields[2] | | | |
|---|---|---|---|---|---|---|---|
| Annual[3] | | Cumulative[4] | | Grain | | Stover | |
| ---------------Dry Solids--------------- | | | | | | | |
| Mg/ha | (tons/acre) | 1816.6 | (tons/acre) | Mg/ha | (bu/acre) | Mg/ha | (tons/acre) |
| 0.0 | (0.0) | 0.0 | (0.0) | 2.4 | (38) | 1.7 | (0.8) |
| 16.8 | (7.5) | 454.7 | (203.0) | 1.5 | (23) | 2.3 | (1.0) |
| 33.6 | (15.0) | 909.4 | (406.0) | 2.3 | (36) | 2.0 | (0.9) |
| 67.2 | (30.0) | 1816.6 | (811.0) | 4.7 | (74) | 2.5 | (1.1) |

[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.
[2]Grain yields are reported at 15.5 percent moisture, and stover yields includes total dry matter for cobs and stalks.
[3]Four treatments are applied annually.
[4]Cumulative biosolids applications 1973-2000.

applied biosolids, and the lowest occurred in the fertilized control plots (Table 10).

The 2000 yields of both corn grain and corn stover are the lowest for the past four years (Table 11). In 2000, the growing season was shortened by a cool spring and mild weather and the plots received the lowest amount of precipitation for the four year period as reported in Table 11. However, the major cause of low yields would seem to be due to predation on both the seeds and young seedlings by various birds, especially red-winged blackbirds. The plots had to be replanted three times. The yields would probably have been similar to those in 1997 and 1999 had it not been for this predation.

During the year 2001, a new herbicide-ready genetically modified corn hybrid (Pioneer 33P69) will be planted in a side-by-side study with the previous Pioneer 3394 hybrid. This experiment will allow comparison of yields and uptake of metals between the two hybrids. Pioneer 3394 is to be replaced because its parent seed stock is being eliminated from production. The experiment will also allow the observation of the response of the genetically modified hybrid to biosolids at various application rates.

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TABLE 11

CORN GRAIN AND STOVER YIELDS ON BIOSOLIDS-AMENDED MINE SPOIL AT THE FULTON COUNTY RECLAMATION SITE 1997 - 2000

| Year | Rainfall inches | Plot Biosolids Application[1] | | Corn Yields | | | |
|---|---|---|---|---|---|---|---|
| | | | | Grain | | Stover | |
| | | -----Dry Solids----- | | | | | |
| | | Mg/ha | (tons/acre) | Mg/ha | (bu/acre) | Mg/ha | (tons/acre) |
| 1997 | 35.31 | 0.0 | (0.0) | 6.9 | 110 | 5.4 | 2.4 |
| | | 16.8 | (7.5) | 5.9 | 94 | 3.5 | 1.6 |
| | | 33.6 | (15.0) | 8.0 | 127 | 5.0 | 2.2 |
| | | 67.2 | (30.0) | 9.2 | 146 | 7.4 | 3.3 |
| 1998 | 49.12 | 0.0 | (0.0) | 3.8 | 60 | 2.5 | 1.1 |
| | | 16.8 | (7.5) | 1.8 | 29 | 1.4 | 0.6 |
| | | 33.6 | (15.0) | 2.7 | 43 | 1.7 | 0.7 |
| | | 67.2 | (30.0) | 5.2 | 82 | 1.8 | 0.8 |
| 1999 | 33.72 | 0.0 | (0.0) | 8.1 | 130 | 6.4 | 2.9 |
| | | 16.8 | (7.5) | 1.3 | 21 | 2.2 | 1.0 |
| | | 33.6 | (15.0) | 4.9 | 78 | 4.0 | 1.8 |
| | | 67.2 | (30.0) | 8.6 | 138 | 5.8 | 2.6 |
| 2000 | 30.84 | 0.0 | (0.0) | 2.4 | 38 | 1.7 | 0.8 |
| | | 16.8 | (7.5) | 1.5 | 23 | 2.3 | 1.0 |
| | | 33.6 | (15.0) | 2.3 | 36 | 2.0 | 0.9 |
| | | 67.2 | (30.0) | 4.7 | 74 | 2.5 | 1.1 |

[1]Four treatments are applied annually.

Chemical Parameters of Subsurface and Surface Water 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 treatment 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 12). Each of the ten treatment plots was approximately 0.405 ha (1 acre). In establishing the treatments, a specific 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

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TABLE 12

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.

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.

Water was collected from lysimeters on a monthly basis. Yearly means of four selected chemical parameters for 1997 through 2000 are presented in Table 13. These are pH, sulfate ($SO_4$), ammonium nitrogen ($NH_4$-N), and nitrite + nitrate nitrogen ($NO_2$+$NO_3$-N). The pH values in the biosolids-amended plots ranged from 6.8 to 7.5 in 2000. These 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 1998 lysimeter water from control plot 1. Mean sulfate levels ranged from 865 to 2,119 mg/L in 2000; however, because of no samples sulfate was not measured in groundwater from the control plot. The mean $NH_4$-N concentrations ranged from 0.14 to 0.49 mg/L in 2000, and the mean $NO_2$+$NO_3$-N concentrations ranged from 0.33 to 56.1 mg/L in 2000 (Table 13).

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TABLE 13

YEARLY MEANS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE ST. DAVID, ILLINOIS, COAL REFUSE PILE RECLAMATION SITE 1997 - 2000

| 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. | 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 |
| | | 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 | 0865 | 2071 | NA |
| $NH_4$-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 |
| $NO_2$+$NO_3$-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 | 60.70 | 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 |

NA = Samples are not available due to insufficient precipitation.

## Chemical Parameters of Subsurface and Surface Waters 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 biosolids, lime, and clay loading rates, plant species seedings, and lysimeter/ surface monitoring procedures as the St. David coal refuse reclamation site. The same monitoring requirements were followed as in the case of 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 2000 are presented in Table 14 for UEC and Table 15 for Morgan Mine. The pH of water collected from the UEC lysimeters in 2000 ranged from 6.9 to 7.4 and from 6.5 to 6.9 for the Morgan Mine lysimeters.

In 2000, mean sulfate concentrations in all the UEC lysimeters ranged between 1,582 mg/L and 3,059 mg/L (Table 14), and in the Morgan Mine lysimeters the concentrations ranged from 1,754 mg/L to 3,502 mg/L (Table 15). For the nitrogen species, the mean $NH_4$-N levels ranged from 0.30 to 25.0 mg/L and 0.78 to 3.02 mg/L for the UEC and Morgan Mine lysimeters, respectively, in 2000. The mean $NO_2$+$NO_3$-N levels ranged from 0.4 to 133 mg/L for UEC and from 3.34 to 302 mg/L for Morgan Mine during 2000 (Tables 14 and 15).

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TABLE 14

YEARLY MEANS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE UNITED ELECTRIC COAL REFUSE PILE RECLAMATION SITE 1997 - 2000

| Chemical Parameters | Year | Plot 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. | 7.3 | 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 |
| $NH_4$-N | 1997 | 4.02 | 0.62 | 1.72 | 0.37 | 0.38 | 0.45 | 0.84 | 19.50 | 3.49 | NA |
| | 1998 | 1.13 | 0.66 | 0.75 | 0.43 | 0.40 | 0.51 | 0.38 | 23.50 | 0.40 | NA |
| | 1999 | 0.20 | 0.43 | 0.52 | 0.47 | 0.40 | 0.34 | 0.60 | 14.30 | 0.40 | NA |
| | 2000 | NA | 0.61 | 0.48 | 0.43 | 0.30 | 0.83 | 0.73 | 25.00 | 0.36 | NA |
| $NO_2$+$NO_3$-N | 1997 | 17.4 | 77.4 | 169.0 | 68.6 | 11.0 | 40.5 | 24.6 | 2.3 | 10.1 | NA |
| | 1998 | 111 | 35.4 | 73.4 | 39.2 | 9.5 | 22.8 | 13.7 | 2.6 | 3.6 | NA |
| | 1999 | 109 | 14.3 | 43.1 | 13.1 | 5.4 | 23.8 | 2.4 | 2.3 | 1.6 | NA |
| | 2000 | NA | 133.0 | 111.0 | 38.2 | 5.6 | 81.8 | 35.5 | 0.4 | 7.7 | NA |

NA = Samples are not available due to low precipitation.

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TABLE 15

YEARLY MEANS OF CHEMICAL PARAMETERS IN WATER FROM LYSIMETERS AT THE MORGAN MINE COAL REFUSE RECLAMATION SITE 1997 - 2000

| Chemical Parameters | Year | Plot 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 |
| | | 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 |
| $NH_4$-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 |
| $NO_2+NO_3$-N | 1997 | 2.27 | 1.13 | 55.9 |
| | 1998 | 2.33 | 1.07 | 76.4 |
| | 1999 | 2.08 | 1.78 | 85.4 |
| | 2000 | 7.55 | 3.34 | 302 |

## Hanover Park Fischer Farm

The Hanover Park Fischer Farm is a 48 hectare (120 acres) tract of land which utilizes all of the biosolids produced by the Hanover Park WRP. The farm, located on the south side of the WRP grounds, has 18 gently sloping fields, each surrounded by a berm to control surface runoff. An 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 for the site limits the annual biosolids application rate to 56 dry Mg/ha (25 dry tons/acre). The crop plan for 2000 included 13 fields used for biosolids application of which 12 fields produced corn. Although, the remaining field was planted with corn, flooding of this field precluded crop production.

Groundwater monitoring is required by the IEPA operating permit. Fields and monitoring locations at the Fischer Farm are shown on Figure 15. 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 2000 are compared in Table 16. In addition to the parameters defined elsewhere in this section, the following elements are also measured in this project:

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FIGURE 15

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

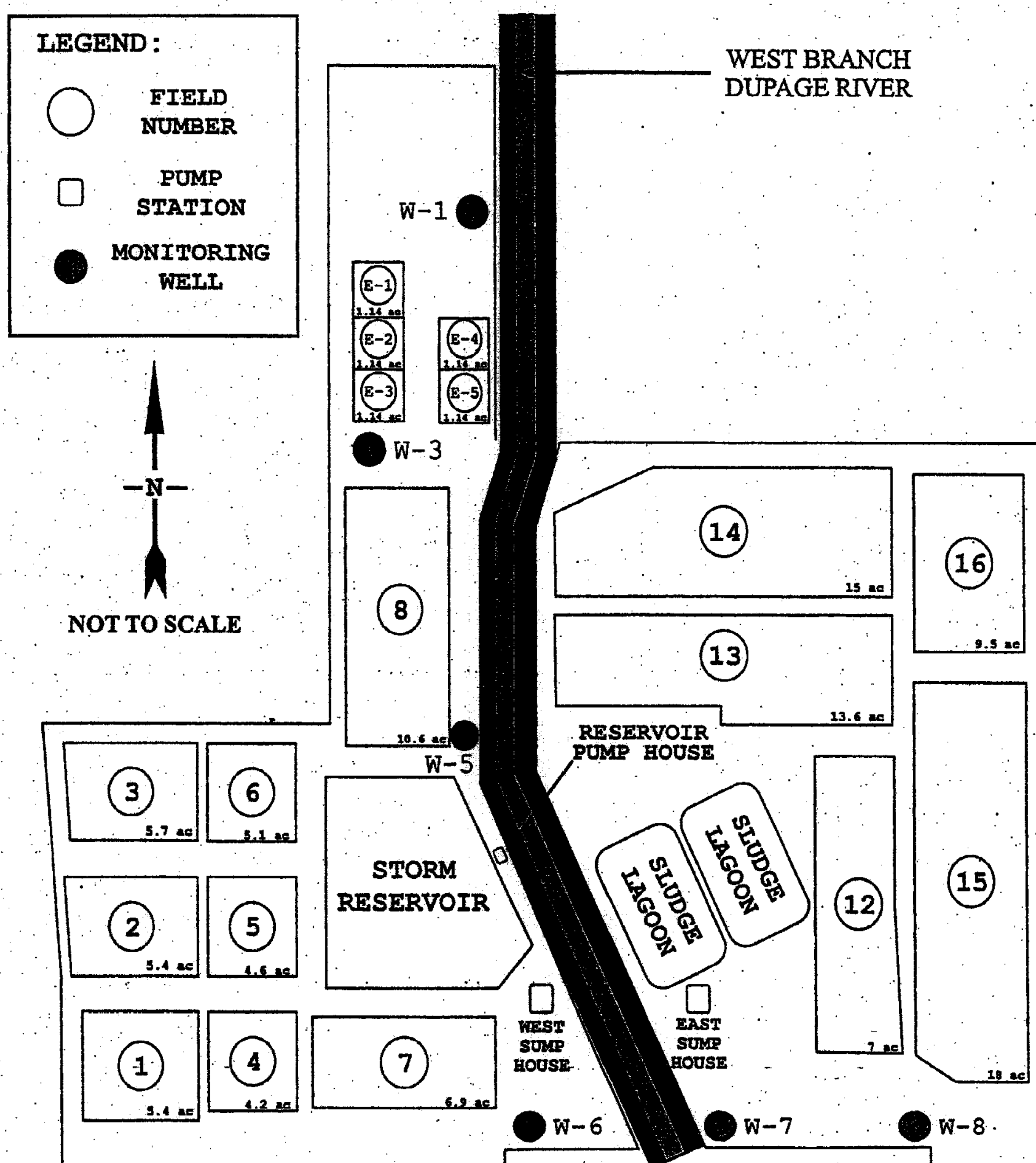

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TABLE 16

HANOVER PARK WRP FISCHER FARM AVERAGE[1] ANNUAL WELL WATER ANALYSIS FOR 1979 AND 2000

| Parameter | Units | 1979[2] | 2000[3] |
|---|---|---|---|
| pH | | 7.0 | 7.7 |
| EC | mS/m | 102 | 73 |
| Total P | mg/L | 0.2 | 0.10 |
| $Cl^-$ | " | 61 | 19 |
| $SO_4^=$ | " | 122 | 115 |
| TKN | " | 5.4 | 8.2 |
| $NH_4$-N | " | 0.1 | 6.24 |
| $NO_2$+$NO_3$-N | " | 0.3 | 0.065 |
| Alkalinity as $CaCO_3$ | " | 386 | 375 |
| Zn | " | 0.2 | 0.0293 |
| Cd | " | <0.02 | 0.0007 |
| Cu | " | <0.02 | 0.0156 |
| Cr | " | <0.02 | 0.0011 |
| Ni | " | <0.1 | 0.0046 |
| Mn | " | 0.80 | 0.0653 |
| Fe | " | 122 | 5.94 |
| FC[4] | per 100 mL | 2.6 | 2.1 |

[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 2000 twice per month.
[4]Geometric mean.

- Aluminum (Al)
- Arsenic (As)
- Boron (B)
- Calcium (Ca)
- Calcium Carbonate ($CaCO_3$)
- Fecal Coliform (FC)
- Iron (Fe)
- Magnesium (Mg)
- Manganese (Mn)
- Mercury (Hg)
- Potassium (K)
- Selenium (Se)
- Sodium (Na)

This comparison is used to determine any impact on groundwater quality from continuous biosolids application since 1979. In many respects, the groundwater quality in 2000 had improved over that of 1979, as shown by the reduced levels of Zn, Fe, and EC. Overall, twenty-one years of biosolids application has not adversely affected the groundwater quality at the Hanover Park Fischer Farm.

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 ground water. The annual mean analysis of water from these wells for 2000 is shown in Table 17.

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 18 shows the mean, minimum, and maximum values of $NH_4$-N in well 7 from 1991 through 2000. This increase in $NH_4$-N occurred in 1999 and continued in 2000. The District will continue to monitor the wells and identify and control the source of $NH_4$-N affecting well 7. At this time, it does not appear to be land applied biosolids causing the changes in $NH_4$-N values at the Fisher Farm site.

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

In 1986, paved solids drying areas were constructed at the John E. Egan WRP and the Calumet WRP 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 designed to handle biosolids production at the Egan and Calumet WRPs by air drying

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TABLE 17

HANOVER PARK WRP FISCHER FARM AVERAGE[1] ANNUAL WELL WATER ANALYSIS - 2000[2]

| Parameter | Units | Concentration |
|---|---|---|
| pH | | 7.7 |
| EC | mS/m | 147. |
| Total P | mg/L | 0.12 |
| $Cl^-$ | " | 299. |
| $SO_4^=$ | " | 186. |
| TKN | " | 1.6 |
| $NH_4$-N | " | 0.47 |
| $NO_2$+$NO_3$-N | " | 0.366 |
| Alkalinity as $CaCO_3$ | " | 279. |
| Zn | " | 0.2018 |
| Cd | " | 0.0016 |
| Cu | " | 0.0203 |
| Cr | " | 0.0013 |
| Ni | " | 0.0059 |
| Mn | " | 0.2262 |
| Fe | " | 18.7 |
| FC[3] | per 100 mL | 1.9 |

[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.

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TABLE 18

MEAN ANALYSIS OF HANOVER PARK FISCHER FARM WELL 7
$NH_4$-N LEVELS 1991 - 2000

| 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 |

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. In contrast, 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 permits for these three drying facilities require groundwater monitoring. Lysimeters were installed for sampling groundwater immediately below the drying sites in October 1986 at the John E. Egan and Calumet West drying facilities, and in November 1990 at the Calumet East drying facility. During 2000, samples were taken once per month at both of the Calumet drying sites and twice per month at the Egan drying site.

Table 19 presents the analysis of water from the two lysimeters at the John E. Egan WRP. The table shows the average values for the year for 28 parameters previously defined in this section. Table 20 presents the analysis of water samples taken in 2000 from the three lysimeters at the Calumet West drying facility, and Figure 16 shows the location of the lysimeters at the site. Table 21 presents the analysis of

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 19

MEAN[1] ANALYSIS OF WATER SAMPLES FOR
JOHN E. EGAN SOLIDS DRYING FACILITY - 2000

| Parameter | Units | Lysimeter Location[2] North | Lysimeter Location[2] South |
|---|---|---|---|
| pH | | 7.3 | 7.4 |
| EC | mS/m | 110 | 104 |
| Total Dissolved Solids | mg/L | 1,170 | 972 |
| Total Dissolved Organic C | " | 12 | 8 |
| $Cl^-$ | " | 72 | 122 |
| $SO_4^=$ | " | 177 | 199 |
| TKN | " | 0.33 | 0.45 |
| $NH_4$-N | " | 0.06 | 0.06 |
| Total P | | 0.10 | 0.10 |
| $NO_2$+$NO_3$-N | " | 0.10 | 4.8 |
| Alkalinity as $CaCO_3$ | " | 674 | 291 |
| Al | " | 0.03 | 0.03 |
| As | " | 0.030 | 0.026 |
| B | " | 0.201 | 0.206 |
| Ca | " | 176 | 130 |
| Cd | " | 0.0005 | 0.0006 |
| Cr | " | <0.002 | <0.002 |
| Cu | " | 0.0055 | 0.0085 |
| Fe | " | 0.291 | 0.01 |
| Hg | µg/L | 0.09 | 0.10 |
| K | mg/L | 1.9 | 9.4 |
| Mg | " | 89.1 | 43.1 |
| Mn | " | 0.0387 | 0.1853 |
| Na | " | 31.9 | 60.3 |
| Ni | " | 0.0030 | 0.0115 |
| Pb | " | <0.002 | <0.002 |
| Se | " | 0.005 | 0.004 |
| Zn | " | 0.0107 | 0.0147 |

[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.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 20

MEAN[1] ANALYSIS OF WATER SAMPLES FOR THE CALUMET WEST SOLIDS DRYING FACILITY - 2000

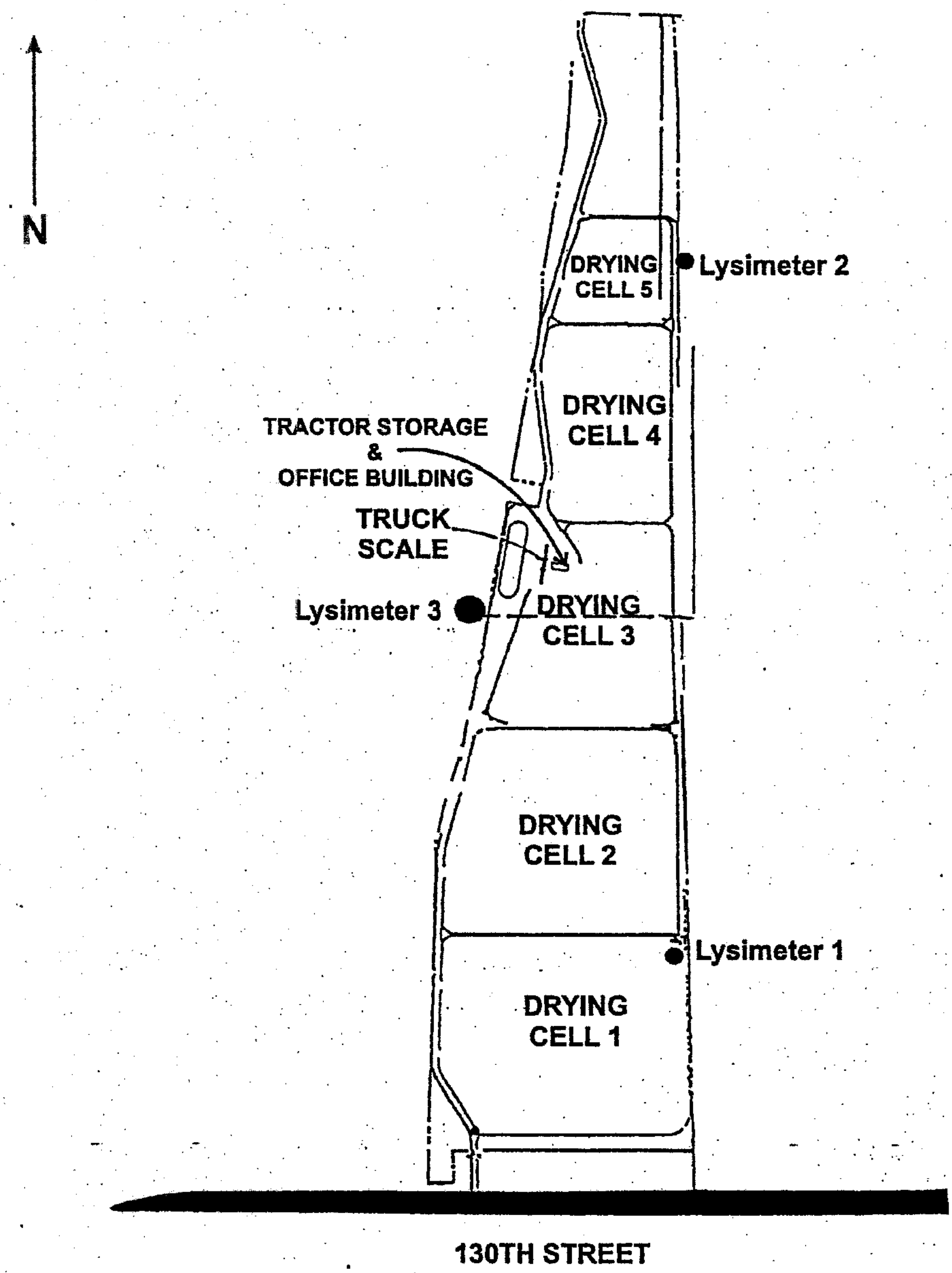
| Parameter | Units | Lysimeter[2] 1 | 2 | 3 |
|---|---|---|---|---|
| pH | | 7.3 | 7.2 | 7.3 |
| EC | mS/m | 211 | 248 | 250 |
| Total Dissolved Solids | mg/L | 2,259 | 3,131 | 3,247 |
| Total Dissolved Organic Carbon | " | 8 | 11 | 7 |
| $Cl^-$ | " | 139 | 36 | 26 |
| $SO_4^=$ | " | 1,062 | 1,643 | 1,707 |
| TKN-N | " | 0.40 | 0.35 | 0.39 |
| $NH_4$-N | " | 0.14 | 0.14 | 0.11 |
| Total P | " | 0.09 | 0.09 | 0.07 |
| $NO_2+NO_3$-N | " | 0.227 | 0.303 | 0.419 |
| Alkalinity as $CaCO_3$ | " | 116 | 174 | 153 |
| Al | " | 0.23 | 0.21 | 0.20 |
| Ca | " | 244 | 341 | 359 |
| Cd | " | 0.003 | <0.004 | <0.004 |
| Cr | " | 0.008 | 0.011 | 0.009 |
| Cu | " | 0.018 | 0.026 | 0.023 |
| Fe | " | 0.37 | 0.05 | 0.04 |
| Hg | µg/L | 0.10 | 0.10 | 0.10 |
| K | mg/L | 9.0 | 8.6 | 6.9 |
| Mg | " | 113 | 185 | 198 |
| Mn | " | 0.075 | 0.256 | 0.092 |
| Na | " | 228 | 210 | 208 |
| Ni | " | 0.02 | 0.02 | <0.02 |
| Pb | " | 0.04 | <0.05 | <0.05 |
| Zn | " | 0.012 | 0.018 | 0.015 |

[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 16

LOCATION OF THE LYSIMETERS AT THE CALUMET WEST SOLIDS DRYING FACILITY



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21

MEAN[1] ANALYSIS OF WATER SAMPLES FOR THE CALUMET EAST SOLIDS DRYING FACILITY - 2000

| Parameter | Units | Lysimeter[2] 1 | 2 | 3 |
|---|---|---|---|---|
| pH | | 7.4 | 7.5 | 7.6 |
| EC | mS/m | 363 | 310 | 201 |
| Total Dissolved Solids | mg/L | 4,695 | 4,048 | 2,373 |
| Total Dissolved Organic Carbon | " | 16 | 14 | 17 |
| $Cl^-$ | " | 173 | 163 | 84 |
| $SO_4^=$ | " | 2,296 | 1,785 | 854 |
| TKN-N | " | 0.91 | 1.15 | 0.41 |
| $NH_4$-N | " | 0.20 | 0.42 | 0.07 |
| Total P | " | 2.71 | 2.45 | 0.61 |
| $NO_2$+$NO_3$-N | " | 0.571 | 0.246 | 0.043 |
| Alkalinity as $CaCO_3$ | " | 534 | 468 | 523 |
| Al | " | 0.36 | 0.29 | 0.18 |
| Ca | " | 555 | 548 | 288 |
| Cd | " | <0.004 | <0.004 | <0.004 |
| Cr | " | 0.025 | 0.015 | 0.010 |
| Cu | " | 0.168 | 0.089 | 0.041 |
| Fe | " | 0.09 | 0.14 | 0.05 |
| Hg | µg/L | 0.11 | 0.12 | 0.11 |
| K | mg/L | 11.1 | 7.4 | 3.7 |
| Mg | " | 341 | 279 | 198 |
| Mn | " | 0.108 | 0.074 | 0.069 |
| Na | " | 221 | 159 | 87.8 |
| Ni | " | 0.02 | 0.02 | 0.02 |
| Pb | " | 0.06 | 0.05 | 0.03 |
| Zn | " | 0.104 | 0.057 | 0.034 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21 (Continued)

MEAN ANALYSIS OF WATER SAMPLES FOR THE CALUMET EAST SOLIDS DRYING FACILITY - 2000

| Parameter | Units | Lysimeter 4 | Lysimeter 5 | Lysimeter 6 |
|---|---|---|---|---|
| pH | | 7.5 | 7.7 | 7.7 |
| EC | mS/m | 297 | 186 | 157 |
| Total Dissolved Solids | mg/L | 4,023 | 1,640 | 1,394 |
| Total Dissolved Organic Carbon | " | 10 | 8 | 9 |
| $Cl^-$ | " | 339 | 173 | 17 |
| $SO_4^=$ | " | 1,407 | 505 | 574 |
| TKN-N | " | 1.14 | 0.71 | 0.54 |
| $NH_4$-N | " | 0.49 | 0.41 | 0.32 |
| Total P | " | 0.050 | 0.06 | 0.08 |
| $NO_2$+$NO_3$-N | " | 0.11 | 0.184 | 0.265 |
| Alkalinity as $CaCO_3$ | " | 391 | 243 | 279 |
| Al | " | 0.15 | 0.12 | 0.16 |
| Ca | " | 429 | 191 | 171 |
| Cd | " | <0.004 | <0.004 | 0.003 |
| Cr | " | 0.011 | 0.008 | 0.007 |
| Cu | " | 0.026 | 0.018 | 0.020 |
| Fe | " | 8.84 | 2.06 | 0.61 |
| Hg | µg/L | 0.10 | <0.10 | 0.10 |
| K | mg/L | 6.7 | 4.3 | 3.9 |
| Mg | " | 281 | 98.7 | 92.6 |
| Mn | " | 0.094 | 0.056 | 0.046 |
| Na | " | 140 | 93.4 | 79.6 |
| Ni | " | <0.02 | <0.02 | 0.02 |
| Pb | " | 0.04 | 0.04 | <0.05 |
| Zn | " | 0.017 | 0.012 | 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: Nos. 1, 2, and 3, 28 feet; Nos. 4, 5, and 6, 22 feet.

water samples taken in 2000 from the six lysimeters at the Calumet East drying facility, and Figure 17 shows the location of the lysimeters at the site. The data indicate that the shallow groundwater at all three sites is highly mineralized. 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 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, six lysimeters were installed for sampling groundwater (every two weeks) immediately above the limestone

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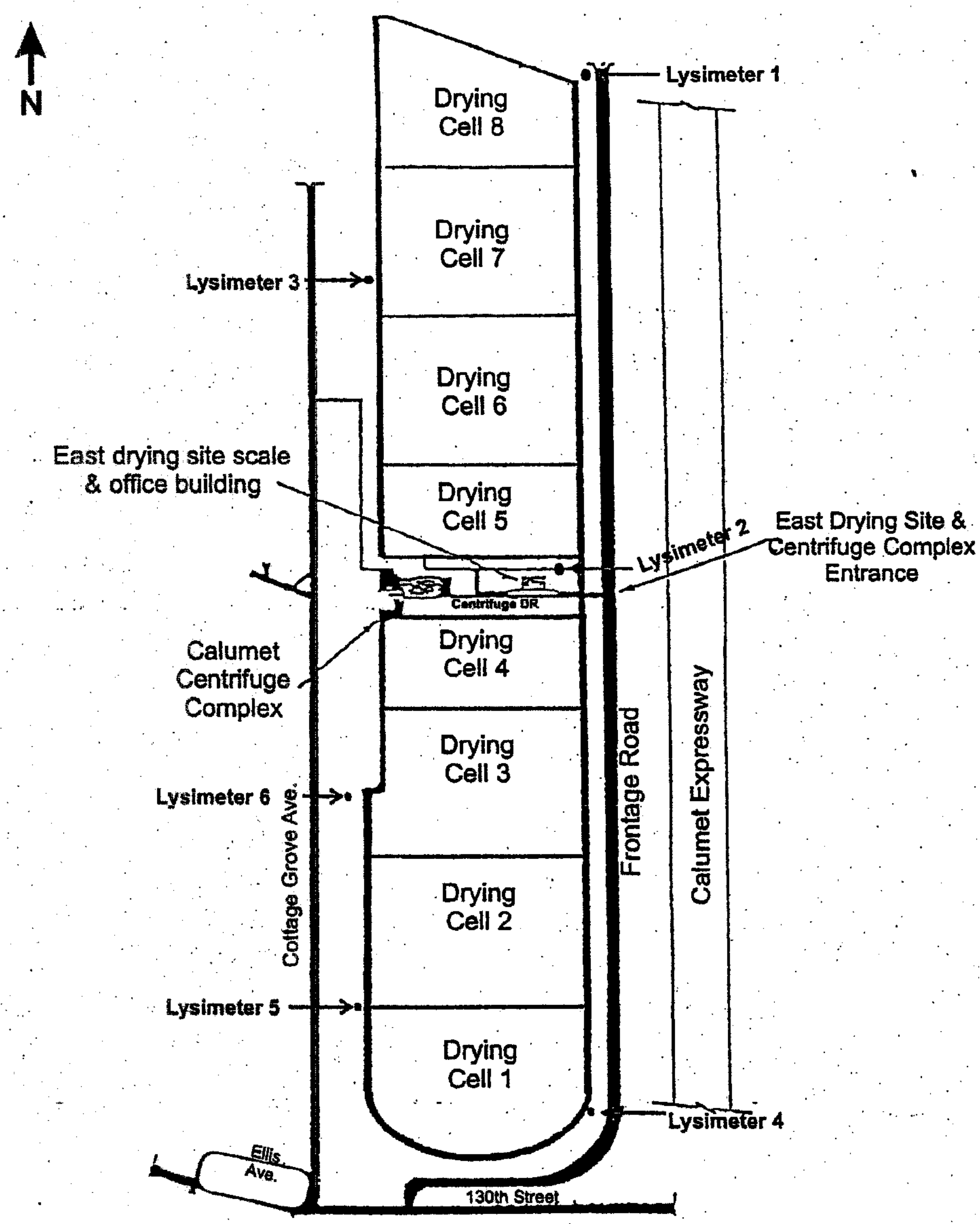
FIGURE 17

LOCATION OF THE LYSIMETERS AT THE CALUMET EAST SOLIDS DRYING FACILITY



bedrock which is located 6-12 m (20-40 ft) below the surface in this area. However, only three of the six lysimeters were functional. In early 1985, six more lysimeters were installed at the site; three to replace the nonfunctional lysimeters and three new ones. By April 1985, nine functional 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 18.

In all, 30 parameters are included in the analysis. The average monitoring results for the five wells for quarterly samples taken in 2000 is presented in Table 22. The water quality is typical of limestone aquifers. Calcium, Mg, and Na are the major cations, and $CaCO_3$ (as a measure of alkalinity) and $SO_4$ are the major anions. There is no indication that biosolids constituents have entered the aquifer underlying the site.

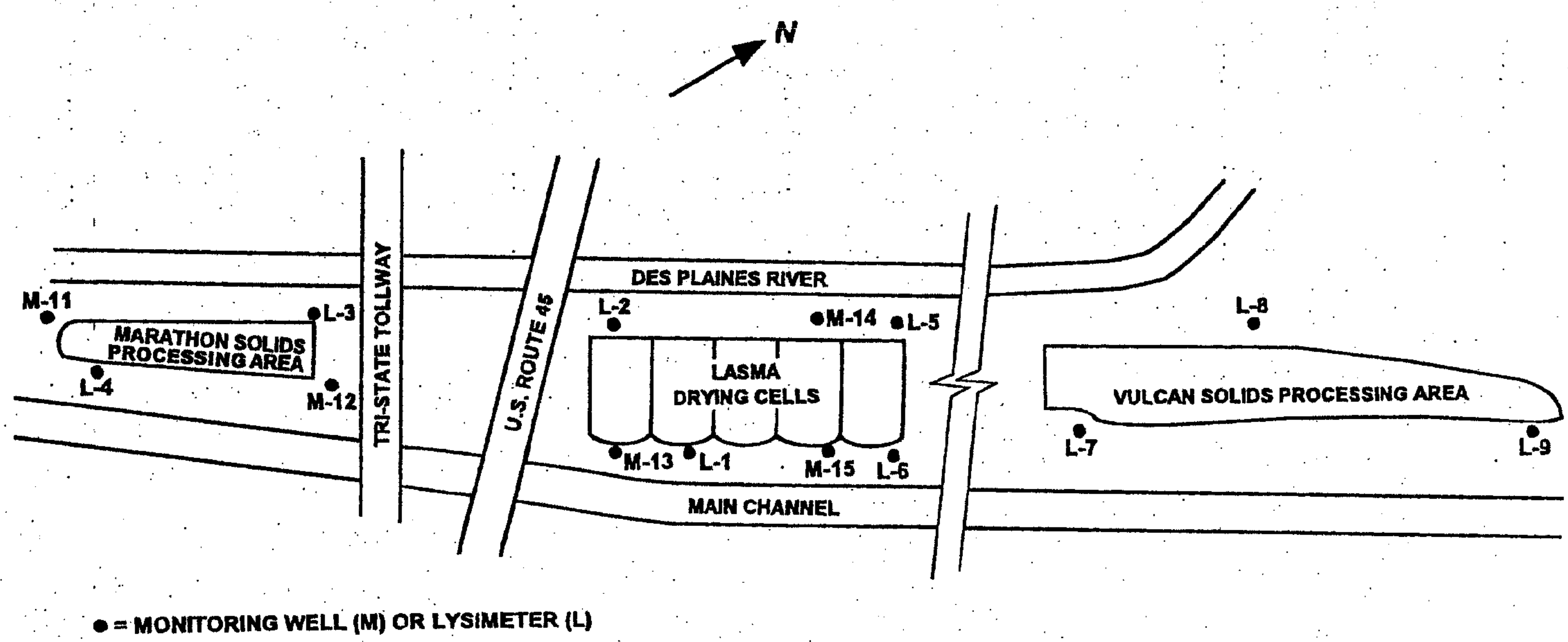
The operating permit for LASMA required monthly lysimeter monitoring in 2000 for 28 parameters. The average lysimeter monitoring results are presented in Table 23. Lysimeter water is highly mineralized and is affected by the fill material in which the lysimeters are located. The lysimeters are located in a marshland covered with imported fill.

In November 2000, a meeting was held with the IEPA regarding the LASMA site. Reports were discussed of elevated

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 18

LOCATION OF THE MONITORING WELLS AND LYSIMETERS AT LASMA



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 22

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LASMA MONITORING WELLS - 2000

| Parameter | Units | Monitoring Well Number[2] | | | | |
|---|---|---|---|---|---|---|
| | | M-11 | M-12 | M-13 | M-14 | M-15 |
| pH | | 7.6 | 7.6 | 7.6 | 7.4 | 7.2 |
| EC | mS/m | 82 | 103 | 134 | 70 | 137 |
| Total Dissolved Solids | mg/L | 690 | 883 | 1,345 | 577 | 1,669 |
| Total Dissolved Organic C | " | 9 | 7 | 8 | 6 | 11 |
| $Cl^-$ | " | 5 | 13 | 9 | 6 | 7 |
| $SO_4^=$ | " | 189 | 289 | 521 | 118 | 702 |
| TKN | | 1.34 | 0.63 | 0.82 | 0.45 | 0.73 |
| $NH_4$-N | " | 1.01 | 0.35 | 0.4 | 0.29 | 0.52 |
| $NO_2$+$NO_3$-N | " | 0.189 | 0.029 | 0.025 | 0.052 | 0.031 |
| Total P | " | 0.07 | 0.08 | 0.20 | 0.08 | 0.07 |
| Alkalinity as $CaCO_3$ | " | 346 | 301 | 322 | 304 | 345 |
| Al | " | 0.05 | 0.05 | 0.17 | 0.06 | 0.05 |
| As | " | <0.2 | 0.1 | 0.1 | <0.2 | <0.2 |
| B | " | 1.30 | 1.80 | 1.53 | 1.33 | 1.18 |
| Ca | " | 107 | 83.2 | 171 | 81.3 | 235 |
| Cd | " | <0.004 | <0.004 | <0.004 | <0.004 | <0.004 |
| Cr | " | 0.009 | 0.007 | <0.006 | <0.006 | 0.006 |
| Cu | " | 0.007 | 0.006 | 0.009 | 0.007 | 0.008 |
| Fe | " | 0.20 | 0.05 | 0.09 | 0.05 | 0.53 |
| Hg | µg/L | <0.10 | 0.090 | <0.10 | <0.10 | <0.10 |
| K | mg/L | 9.4 | 10.4 | 11.0 | 8.8 | 10.9 |
| Mg | " | 53.1 | 41.1 | 86.3 | 46.1 | 116 |
| Mn | " | 0.013 | 0.008 | 0.019 | 0.010 | 0.015 |
| Na | " | 63.4 | 144 | 96.5 | 47.1 | 64.4 |
| Ni | " | 0.02 | 0.02 | <0.02 | <0.02 | <0.02 |
| Pb | " | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Se | " | 0.3 | 0.3 | <0.4 | 0.3 | <0.4 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 22 (Continued)

MEAN ANALYSIS OF WATER SAMPLES FROM LASMA MONITORING WELLS - 2000

| Parameter | Units | Monitoring Well Number | | | | |
|---|---|---|---|---|---|---|
| | | M-11 | M-12 | M-13 | M-14 | M-15 |
| Zn | " | 1.07 | 0.57 | 0.64 | 0.47 | 1.87 |
| FC | #/100mL | <1 | <1 | <1 | <1 | <1 |
| Static Water Elevation | Feet | 580.7 | 578.3 | 583.2 | 585.7 | 579.2 |

[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 23

MEAN[1] ANALYSIS OF WATER SAMPLES FROM LASMA LYSIMETERS - 2000

| Parameter | Units | Lysimeter No.[2] L-1 | L-2 | L-3 | L-4 | L-5 |
|---|---|---|---|---|---|---|
| pH | | 7.3 | 7.4 | 7.5 | 7.3 | 7.5 |
| EC | mS/m | 184 | 198 | 132 | 264 | 153 |
| Total Dissolved Solids | mg/L | 1,505 | 2,400 | 1,424 | 4,142 | 1,313 |
| Total Dissolved Organic C | " | 17 | 12 | 16 | 35 | 9 |
| $Cl^-$ | " | 49 | 377 | 155 | 57 | 34 |
| $SO_4^=$ | " | 533 | 590 | 90 | 1,600 | 543 |
| TKN | " | 5.82 | 0.60 | 4.63 | 17.75 | 0.24 |
| $NH_4$-N | " | 4.39 | 0.14 | 3.64 | 10.46 | 0.14 |
| $NO_2$+$NO_3$-N | " | 0.329 | 0.261 | 0.105 | 0.045 | 0.100 |
| Total P | " | 0.06 | 0.05 | 1.65 | 1.27 | 0.07 |
| Alkalinity as $CaCO_3$ | " | 479 | 442 | 348 | 972 | 279 |
| Al | " | 0.08 | 0.05 | 0.11 | 0.05 | 0.05 |
| As | " | <0.2 | <0.2 | 0.1 | 0.1 | <0.2 |
| B | " | 0.51 | 0.22 | 0.23 | 0.25 | 0.74 |
| Ca | " | 246 | 300 | 114 | 630 | 157 |
| Cd | " | <0.004 | <0.004 | <0.004 | <0.004 | <0.004 |
| Cr | " | 0.008 | 0.010 | 0.007 | 0.012 | 0.009 |
| Cu | " | 0.018 | 0.065 | 0.013 | 0.015 | 0.015 |
| Fe | " | 3.76 | 2.24 | 1.06 | 24.0 | 0.10 |
| Hg | µg/L | 0.25 | 0.19 | 0.14 | 0.20 | 0.26 |
| K | mg/L | 7.0 | 4.2 | 3.7 | 8.9 | 3.8 |
| Mg | " | 104 | 149 | 50.2 | 268 | 109 |
| Mn | " | 0.166 | 0.115 | 0.066 | 1.11 | 0.021 |
| Na | " | 50.3 | 200 | 97.5 | 44.5 | 53.6 |
| Ni | " | 0.02 | 0.02 | 0.02 | 0.02 | <0.02 |
| Pb | " | <0.05 | 0.04 | <0.05 | 0.03 | <0.05 |
| Se | " | <0.4 | <0.4 | 0.30 | 0.30 | <0.4 |
| Zn | " | 0.044 | 0.056 | 0.027 | 0.026 | 0.027 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 23 (Continued)

MEAN ANALYSIS OF WATER SAMPLES FROM LASMA LYSIMETERS - 2000

| Parameter | Units | Lysimeter No. L-6 | L-7 | L-8 | L-9 |
|---|---|---|---|---|---|
| pH | | 7.8 | 7.7 | NA | 7.5 |
| EC | mS/m | 171 | 348 | NA | 155 |
| Total Dissolved Solids | mg/L | 1,492 | NA | NA | 1,778 |
| Total Dissolved Organic C | " | 14 | NA | NA | 21 |
| $Cl^-$ | " | 88 | NA | NA | 107 |
| $SO_4^=$ | " | NA | NA | NA | 507 |
| TKN | " | 1.18 | NA | NA | 1.20 |
| $NH_4$-N | " | 0.71 | 14.9 | NA | 0.51 |
| $NO_2$+$NO_3$-N | " | 0.237 | <0.005 | NA | 0.343 |
| Total P | " | 0.52 | NA | NA | 0.06 |
| Alkalinity as CaCO3 | " | 424 | NA | NA | 516 |
| Al | " | <0.04 | NA | NA | 0.05 |
| As | " | <0.2 | NA | NA | <0.2 |
| B | " | 0.261 | NA | NA | 0.391 |
| Ca | " | 205 | NA | NA | 246 |
| Cd | " | <0.004 | NA | NA | <0.004 |
| Cr | " | <0.006 | NA | NA | 0.009 |
| Cu | " | 0.051 | NA | NA | 0.017 |
| Fe | " | 0.04 | NA | NA | 0.05 |
| Hg | µg/L | 0.21 | NA | NA | 5.42 |
| K | mg/L | 4.8 | NA | NA | 3.4 |
| Mg | " | 101 | NA | NA | 127 |
| Mn | " | 0.032 | NA | NA | 0.182 |
| Na | " | 47.3 | NA | NA | 58.4 |
| Ni | mg/L | <0.02 | NA | NA | 0.02 |
| Pb | " | <0.05 | NA | NA | <0.05 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 23 (Continued)

MEAN ANALYSIS OF WATER SAMPLES FROM LASMA LYSIMETERS - 2000

| Parameter | Units | Lysimeter No. L-6 | L-7 | L-8 | L-9 |
|---|---|---|---|---|---|
| Se | " | <0.4 | NA | NA | 0.3 |
| Zn | " | 0.038 | NA | NA | 0.032 |

[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.

levels of $NH_4$-N concentration in lysimeter L-4, Hg values in lysimeter L-9, and B and Zn values in the monitoring well water samples in relation to the surrounding water bodies.

Prior to the meeting, the $NH_4$-N concentrations in lysimeter L-4 were tabulated and presented from 1984 through 2000, as shown in Table 24. The mean $NH_4$-N concentration in this lysimeter has been lower from 1995 to 2000, 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 were tabulated and presented from 1984 through 2000, as shown in Table 25. There was a mean Hg concentration increase 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 additional monitoring at the site. This replacement lysimeter is scheduled to be installed in 2001.

The IEPA also expressed an interest in the B and Zn levels in the monitoring wells at LASMA. Table 26 shows the B

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 24

MEAN $NH_4$-N ANALYSIS OF WATER FROM LASMA LYSIMETER L-4
1984 - 2000

| 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 |

NA = No analysis.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 25

MEAN MERCURY ANALYSIS OF WATER FROM LASMA LYSIMETER L-9
1984 - 2000

| 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 | .10 | 0.80 |
| 1991 | 2.40 | .00 | 18.4 |
| 1992 | 12.1 | 4.20 | 40.8 |
| 1993 | 8.03 | .00 | 30.4 |
| 1994 | 4.88 | 1.30 | 8.30 |
| 1995 | 4.07 | .00 | 8.20 |
| 1996 | 4.88 | .00 | 8.70 |
| 1997 | 4.91 | .00 | 8.67 |
| 1998 | 5.78 | 2.07 | 8.83 |
| 1999 | 7.13 | 4.98 | 10.8 |
| 2000 | 5.42 | 1.74 | 8.57 |

NA = No analysis.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 26

MEAN BORON ANALYSIS OF LASMA WELLS
1983 - 2000

| 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 |

levels from 1983 through 2000, and the concentrations in each well have not varied significantly throughout this period. Table 27 shows the Zn concentrations from April 1999 through July 2000, which have remained consistently low and were not increasing. 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 119th and Ridgeland Avenue Solids Management Area (RASMA) was originally constructed with a clay base. 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 19.

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 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.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 27

MEAN ZINC ANALYSIS OF LASMA WELLS
APRIL 1999 - JULY 2000

| 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 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 19

LOCATION OF THE LYSIMETERS AT RASMA

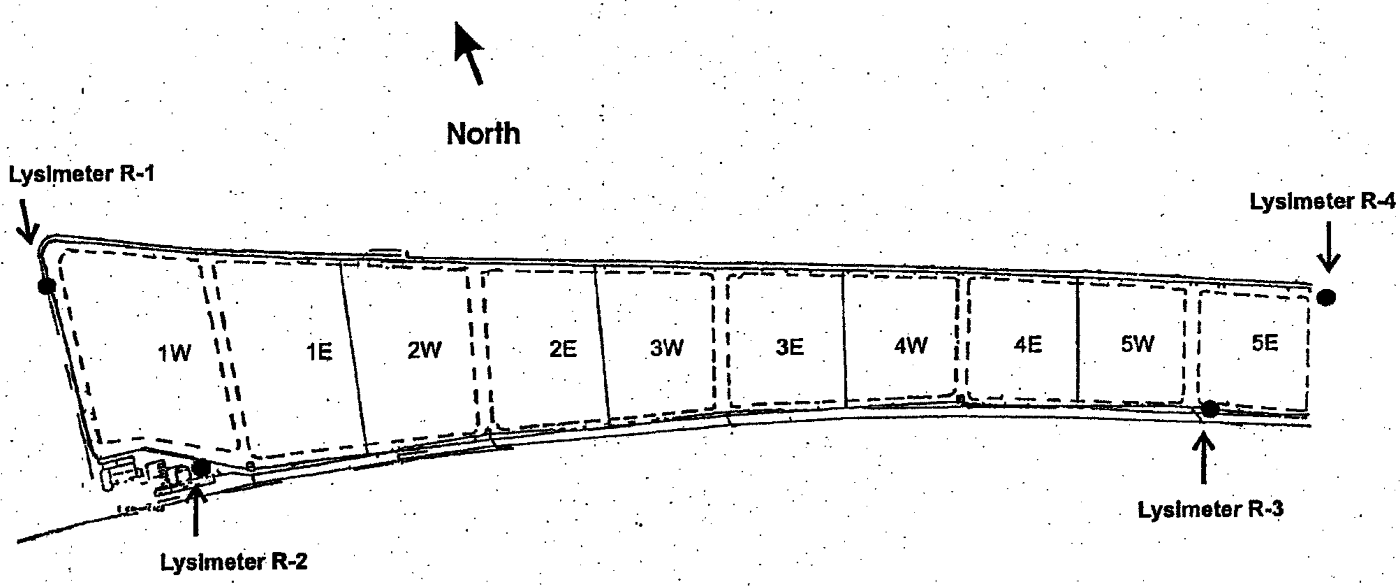


Table 28 presents the analysis of lysimeter water for 2000. The average values presented show that the shallow groundwater at this site is highly mineralized. The principal dissolved constituents are Ca, Mg, Na, $SO_4$, Cl, and $HCO_3$ (alkalinity). As with other groundwater monitoring programs, the current IEPA operating permit requires biweekly groundwater monitoring of 28 parameters.

## 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 20. Table 29 presents the analysis of water sampled from the four lysimeters in 2000. 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 1 (L-1) has had a high background $NH_4$-N content and lysimeter L-1N produced water of quality similar to the other HASMA

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28

MEAN[1] ANALYSIS OF WATER FROM RASMA LYSIMETERS - 2000

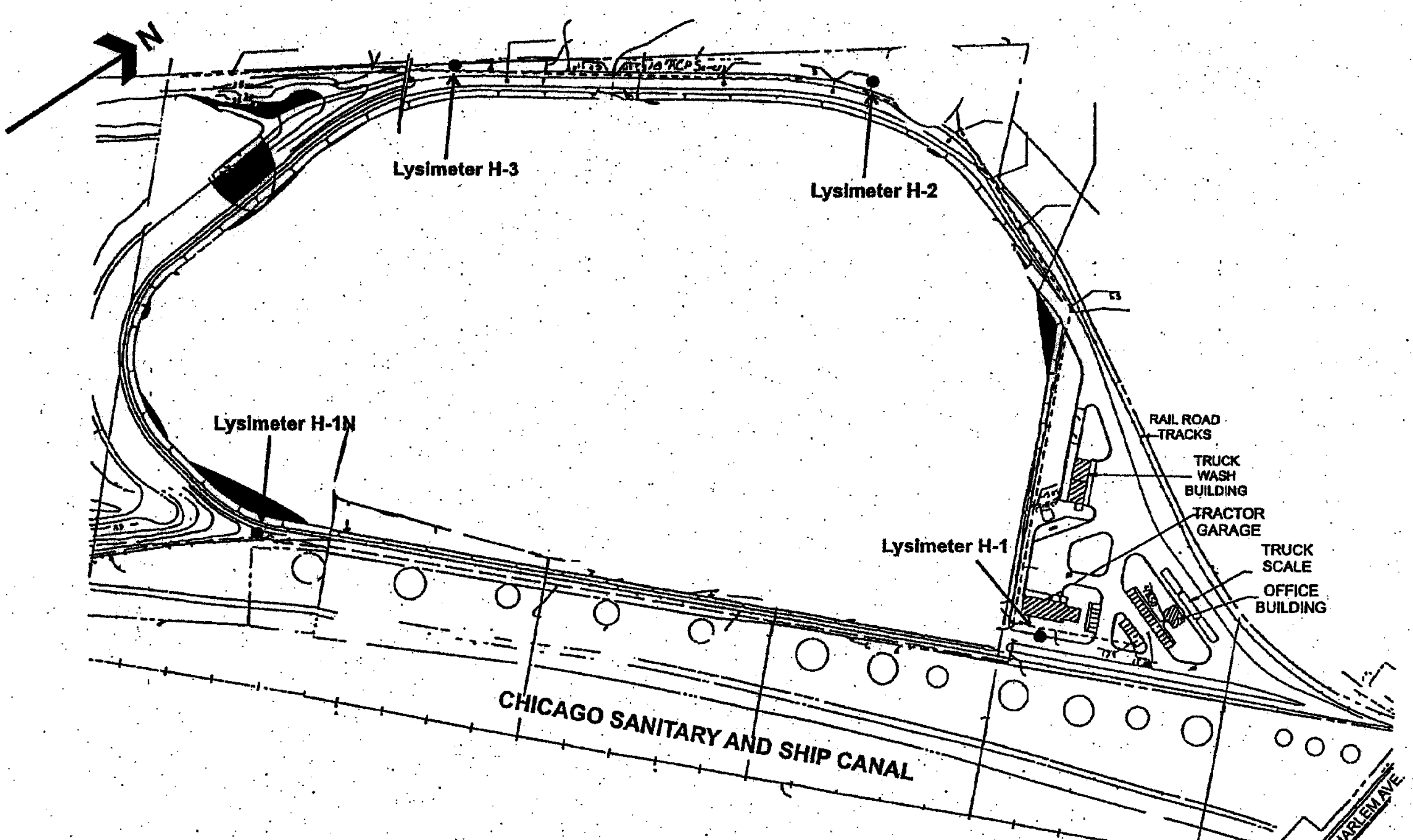
| Parameter | Units | Lysimeter No. L-1 | L-2 | L-3 | L-4 |
|---|---|---|---|---|---|
| pH | | 7.1 | 7.6 | 7.4 | 7.3 |
| EC | mS/m | 322 | NA | 146 | 183 |
| Total Dissolved Solids | mg/L | 2,148 | 2,700 | NA | 1,327 |
| Total Dissolved Organic C | " | NA | 40 | NA | 17 |
| $Cl^-$ | " | 26 | 188 | NA | 120 |
| $SO_4^=$ | " | NA | NA | NA | 364 |
| TKN | " | 8.98 | 1.59 | 0.48 | 1.24 |
| $NH_4$-N | " | 6.87 | 0.19 | 0.36 | 0.53 |
| $NO_2$+$NO_3$-N | " | 0.09 | 2.5 | 0.02 | 0.42 |
| Total P | " | 0.24 | 0.15 | <0.04 | 0.09 |
| Alkalinity as $CaCO_3$ | " | 478 | 484 | NA | 309 |
| Al | " | NA | NA | NA | 0.12 |
| Ca | " | NA | NA | NA | 208 |
| Cd | " | NA | NA | NA | 0.003 |
| Cr | " | NA | NA | NA | 0.008 |
| Cu | " | NA | NA | NA | 0.018 |
| Fe | " | NA | NA | NA | 0.27 |
| Hg | µg/L | NA | NA | NA | 0.10 |
| K | mg/L | NA | NA | NA | 3.0 |
| Mg | " | NA | NA | NA | 65.8 |
| Mn | " | NA | NA | NA | 0.364 |
| Na | " | NA | NA | NA | 71.9 |
| Ni | " | NA | NA | NA | 0.02 |
| Pb | " | NA | NA | NA | 0.03 |
| Zn | " | NA | NA | NA | 0.063 |

[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 20

LOCATION OF THE LYSIMETERS AT HASMA



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 29

MEAN[1] ANALYSIS OF WATER SAMPLES FROM HASMA LYSIMETERS - 2000

| Parameter | Units | Lysimeter No.[2] L-1 | L-2 | L-3 | L-4 |
|---|---|---|---|---|---|
| pH | | 7.3 | 7.6 | 7.2 | 7.3 |
| EC | mS/m | 293 | 128 | 139 | 166 |
| Total Dissolved Solids | mg/L | 3,713 | 933 | 1,855 | 2,031 |
| Total Dissolved Organic C | " | 68 | 38 | 13 | 17 |
| $Cl^-$ | " | 95 | 40 | 144 | 97 |
| $SO_4^=$ | " | 1,615 | 66 | 529 | 312 |
| TKN | " | 182 | 7.14 | 7.62 | 0.74 |
| $NH_4$-N | " | 139 | 4.96 | 6.07 | 0.13 |
| $NO_2+NO_3$-N | " | 16.3 | 1.39 | 0.619 | 0.290 |
| Total P | " | 0.11 | 0.59 | 0.13 | 0.15 |
| Alkalinity as $CaCO_3$ | " | 994 | 719 | 443 | 1,054 |
| Al | " | 0.17 | 0.27 | 0.11 | 0.10 |
| Ca | " | 431 | 197 | 311 | 375 |
| Cd | " | 0.003 | 0.005 | 0.003 | <0.004 |
| Cr | " | 0.012 | 0.011 | 0.008 | 0.009 |
| Cu | " | 0.035 | 0.067 | 0.021 | 0.018 |
| Fe | " | 0.27 | 0.39 | 0.04 | 0.03 |
| Hg | µg/L | 0.09 | <0.10 | 0.13 | 0.09 |
| K | mg/L | 19.2 | 2.9 | 1.6 | 1.6 |
| Mg | " | 257 | 122 | 87.8 | 161 |
| Mn | " | 0.623 | 0.194 | 0.064 | 0.630 |
| Na | " | 76.8 | 41.9 | 53.1 | 44.8 |
| Ni | " | 0.03 | 0.03 | 0.02 | 0.02 |
| Pb | " | 0.03 | 0.04 | 0.03 | 0.03 |
| Zn | " | 0.286 | 0.075 | 0.060 | 0.068 |

[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.

lysimeters. The elevated $NH_4$-N values at lysimeter L-1 were of concern to the IEPA. Table 30 shows the yearly mean, minimum, and maximum $NH_4$-N values from 1990 to 2000. 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 is not due to biosolids drying at the site. The District is planning to install another lysimeter at the HASMA site in 2001 which will lie south of the site 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 facility is used to process biosolids for final distribution. In 2000, 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 21 shows the location of the lysimeters at the Stony Island drying site. Table 31 presents the average values for the analysis of water from the four

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 30

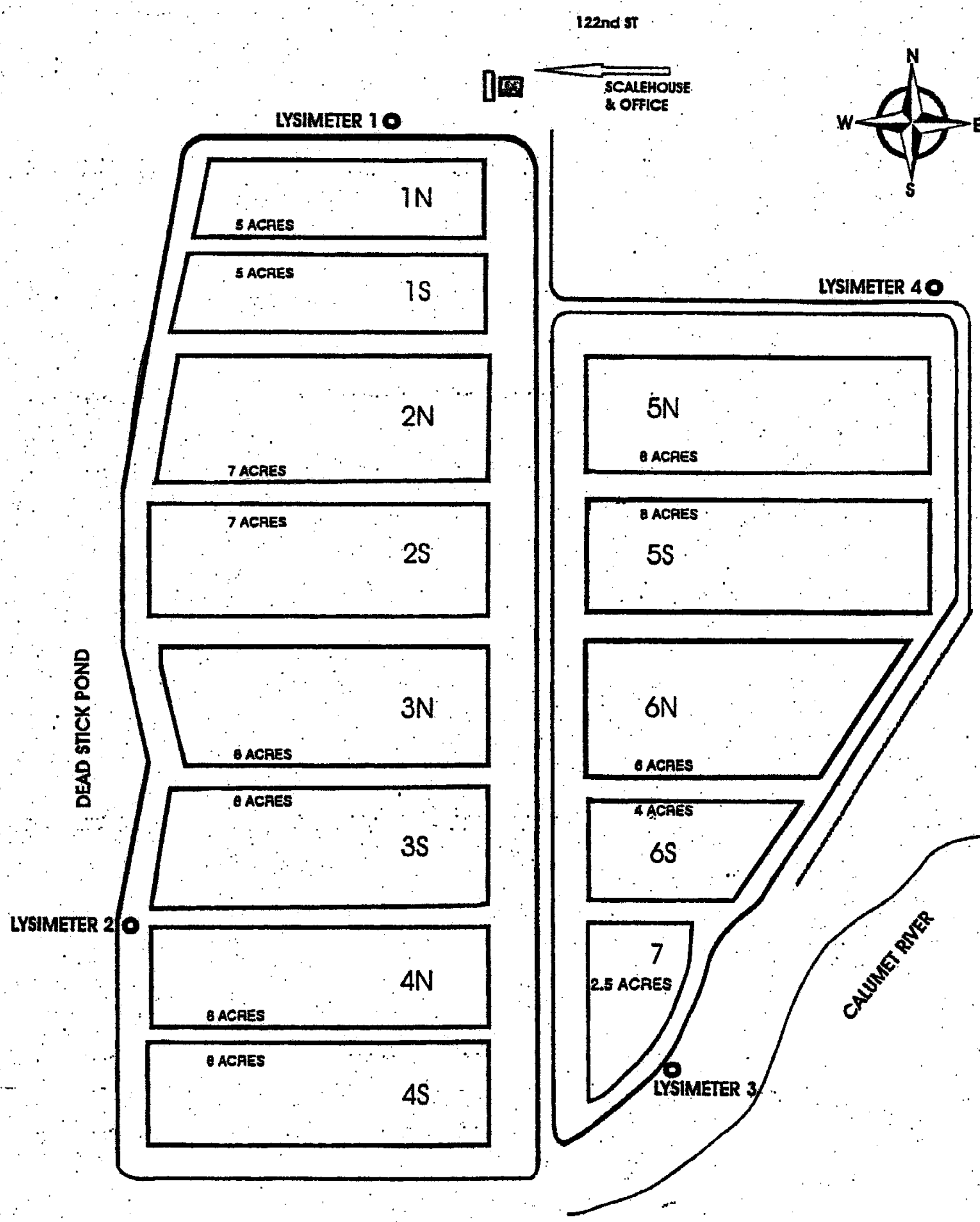
YEARLY $NH_4$-N VALUES IN HASMA LYSIMETER 1
1990 - 2000

| 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 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 21

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



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 31

MEAN[1] ANALYSIS OF WATER FROM STONY ISLAND LYSIMETERS - 2000

| Parameter | Units | Lysimeter Number L-1 | L-2 | L-3 | L-4 |
|---|---|---|---|---|---|
| pH | | 7.3 | 7.4 | 7.4 | 7.5 |
| EC | mS/m | 314 | 305 | 282 | 214 |
| Total Dissolved Solids | mg/L | 2,489 | 2,628 | 2,966 | 1,647 |
| Total Dissolved Organic C | " | 63 | 35 | 63 | 36 |
| $Cl^-$ | " | 300 | 482 | 61 | 313 |
| $SO_4^=$ | " | 380 | 683 | 835 | 161 |
| TKN | " | 51.9 | 11.8 | 8.43 | 6.85 |
| $NH_4$-N | " | 44.7 | 8.76 | 3.73 | 4.33 |
| NO2+NO3-N | " | 0.107 | 0.101 | 0.084 | 0.036 |
| Total P | " | 0.26 | 1.28 | 0.20 | 0.07 |
| Alkalinity as $CaCO_3$ | " | 1,194 | 425 | 1,099 | 637 |
| Al | " | 0.22 | 0.18 | 0.16 | 0.16 |
| Ca | " | 304 | 203 | 557 | 206 |
| Cd | " | 0.004 | <0.004 | <0.004 | <0.004 |
| Cr | " | 0.012 | 0.010 | 0.011 | 0.008 |
| Cu | " | 0.021 | 0.023 | 0.024 | 0.018 |
| Fe | " | 20.0 | 7.63 | 20.4 | 4.31 |
| Hg | µg/L | 0.09 | 0.10 | 0.09 | 0.09 |
| K | mg/L | 29.4 | 64.6 | 6.3 | 6.9 |
| Mg | " | 168 | 158 | 174 | 93.1 |
| Mn | " | 0.470 | 0.870 | 0.696 | 0.262 |
| Na | " | 251 | 330 | 53.2 | 189 |
| Ni | " | <0.02 | 0.02 | 0.02 | 0.02 |
| Pb | " | 0.04 | 0.04 | 0.04 | 0.04 |
| Zn | " | 0.113 | 0.017 | 0.016 | 0.014 |

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

lysimeters at the Stony Island drying facility for samples taken at monthly intervals in 2000. The lysimeter water is highly mineralized.

The IEPA questioned the high levels of $NH_4$-N at lysimeter 1 (L-1). Table 32 shows the annual mean $NH_4$-N concentrations in all four lysimeters from 1991 to 2000. Lysimeter 1 showed a continual increase in the $NH_4$-N concentration staring in 1996, while $NH_4$-N levels in lysimeters 2, 3, and 4 remained stable.

Investigators examined whether the $NH_4$-N in water from L-1 was originating from the drying site. Table 33 shows the annual means of $NH_4$-N, $NO_2$+$NO_3$-N, K, Na, and Cl from 1991 through 2000. As the $NH_4$-N levels increased, so did the K, Cl, and Na levels. The $NO_2$+$NO_3$-N levels did not show a marked increase and remained stable, ranging from 0.05 to 0.24 mg/L from 1991 through 2000. 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.

Investigators then studied the soil profile and geological survey maps of the Lake Calumet region where the Stony Island site is located. This investigation revealed that

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 32

YEARLY $NH_4$-N MEANS FROM ALL STONY ISLAND LYSIMETERS
1991 - 2000

| 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 |

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TABLE 33

YEARLY MEANS OF $NH_4$-N, $NO_2$+$NO_3$-N, K, Na, AND Cl
FROM STONY ISLAND LYSIMETER 1
1991 - 2000

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

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 22 shows a map of the region and the relationship of the landfill areas just north of the Stony Island site. Figure 23 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 2000 (Table 33). The concentration of K followed the same increasing trend as $NH_4$-N, due to the similar ionic radius and groundwater migration rates of the two cations.

The IEPA suggested testing for B, a common tracer of landfill contamination, in the Stony Island lysimeters. Boron analysis has been added to the permit, and will be monitored along with the other required parameters in 2001.

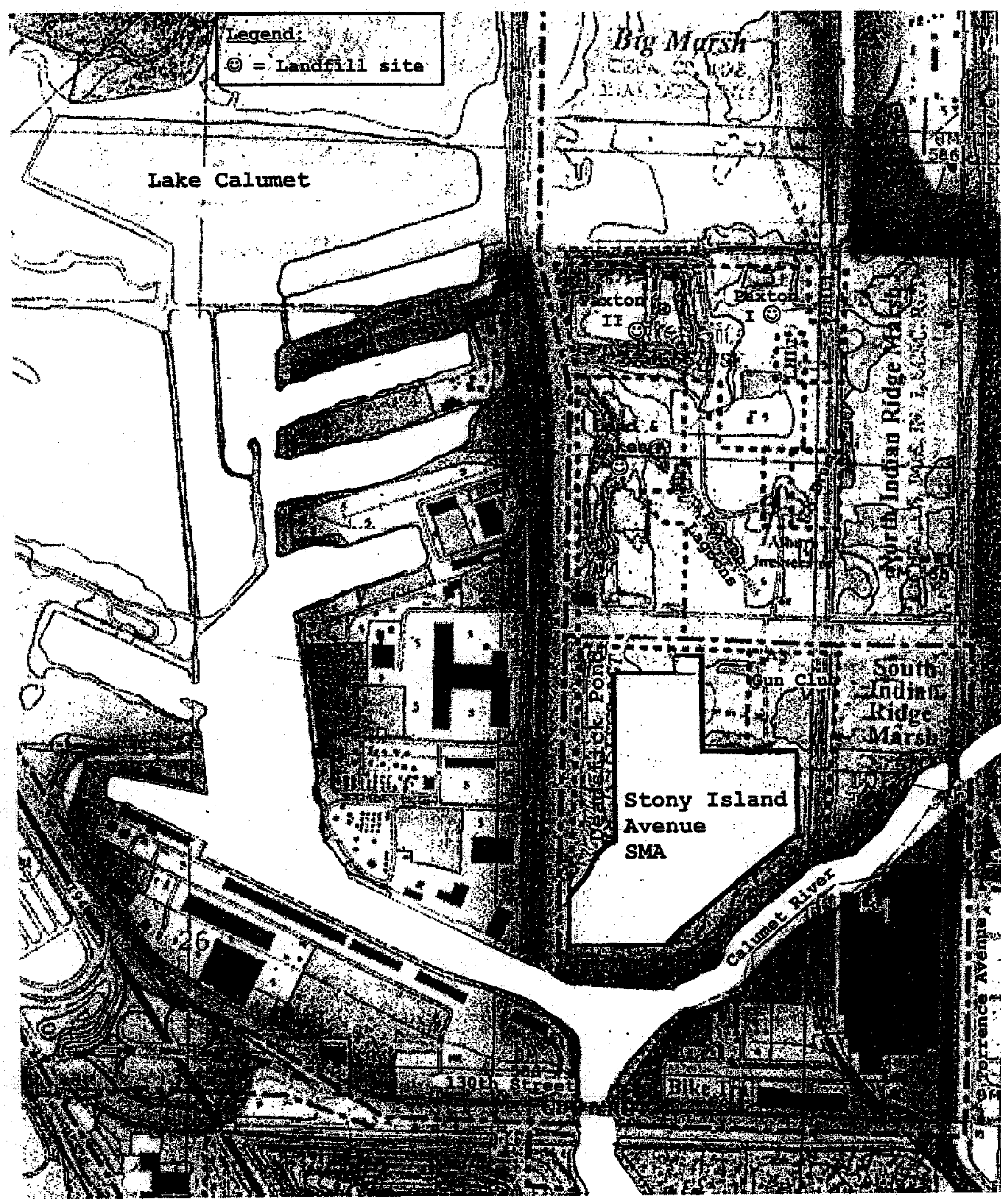
## USX Research and Demonstration Project

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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 22

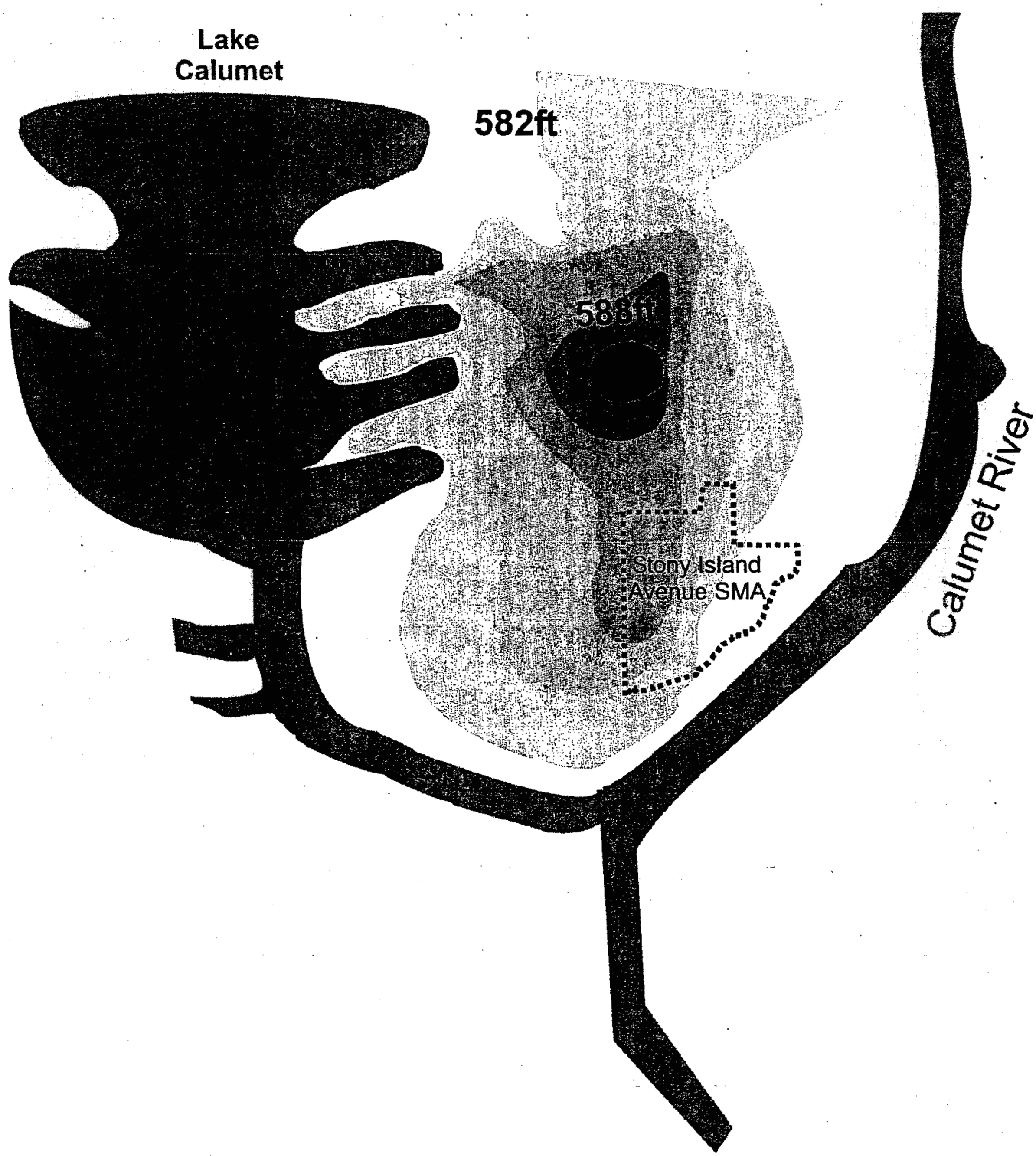
MAP OF LAKE CALUMET REGION LANDFILL SITES AND STONY ISLAND AVENUE SOLIDS MANAGEMENT AREA



METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 23

GROUNDWATER ELEVATION LEVELS IN THE LAKE CALUMET REGION



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 120 acres of lakefront park 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 initiative continues with four separate analyses as described below. These consist of various soil amendments and monitoring of chemical and metal constituents in the area. As with other solids management areas (SMAs), groundwater is monitored monthly with lysimeters. Lake water monitoring is also performed at USX.

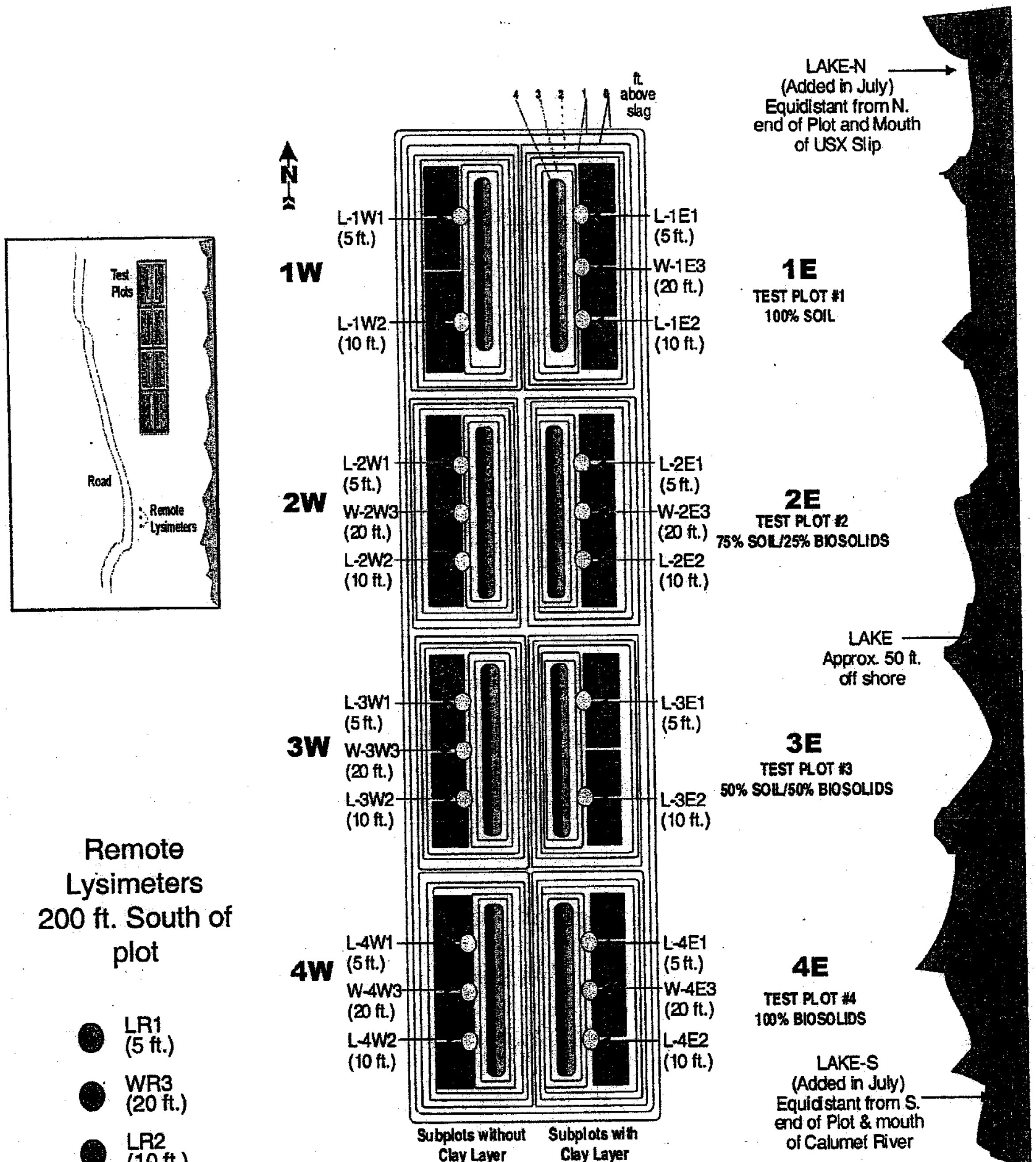
PLOTS AND AMENDMENT TREATMENTS

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 one plot for each amendment. Prior to the application of these amendments, each plot was divided into two subplots, and a six-inch layer of silty clay loam was applied to the eastern subplots Figure 24. 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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

FIGURE 24

MAP OF USX BIOSOLIDS DEMONSTRATION PLOTS WITH SAMPLING LOCATIONS




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

minimize leaching of water from the nutrient-rich amendments into the porous slag, thereby retaining more moisture and nutrients in the plant's root zone.

In June of 2000, the amendments were placed on each of the four plots to a depth of one foot where turf was to be established, and four feet where trees were to be established. Prior to the planting of tree and turf species on each of the subplots, the soil was sampled at 0- to 6-inch and 6- to 12-inch depths and saved for chemical analysis. The results of these chemical analyses were averaged by subplot, and the resulting means for the 0- to 6-inch depth are presented in Table 34.

CHEMICAL CONSTITUENTS OF THE 0- TO 6-INCH SOIL DEPTH

For all subplots, pH ranged between 6.1 and 7.0. Mean EC ranged between 0.52 and 2.70 millimhos per centimeter (mmhos/cm) among the subplots, and increased as the proportion of biosolids in the amendment mixture increased. Mean available phosphorus concentrations ranged from 31 to 560 mg/Kg and increased with increasing biosolids content in the amendment mixtures applied to both the east and west subplots. The TKN, $NH_4$-N, and nitrate-N means ranged from 1,830 to 14,660 mg/Kg, 0.3 to 9.6 mg/Kg, and 5.1 to 372 mg/Kg, respectively. Plots amended with biosolids had increased fertility as shown by the

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 34

MEAN CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN SOIL AMENDMENTS OF USX SUBPLOTS (0 - 6 INCH DEPTH) - 2000

| Plot | pH | EC | Available P | TKN | $NH_4$-N | $NO_3$-N | Carbon % |
|---|---|---|---|---|---|---|---|
| 1 East | 6.6 | 0.52 | 31 | 1,830 | 0.3 | 5.1 | 2.2 |
| 2 East | 6.7 | 1.99 | 382 | 8,560 | 2.4 | 195 | 8.6 |
| 3 East | 6.5 | 2.05 | 472 | 14,660 | 7.0 | 185 | 11.1 |
| 4 East | 6.1 | 2.44 | 560 | 11,400 | 4.2 | 298 | 12.4 |
| 1 West | 6.7 | 0.63 | 60 | 2,930 | 0.5 | 35.5 | 3.2 |
| 2 West | 7.0 | 1.86 | 226 | 6,580 | 1.1 | 139 | 7.6 |
| 3 West | 6.8 | 1.89 | 322 | 8,680 | 2.2 | 164 | 9.7 |
| 4 West | 6.2 | 2.70 | 556 | 11,330 | 9.6 | 372 | 16.8 |

increased amounts of the various nitrogen forms found, as compared to the topsoil plot. The levels of TKN, $NH_4$-N, and $NO_3$-N found in the plots generally increased with the increased proportion of biosolids in the amendment blend, with few exceptions. Mean organic carbon concentrations increased as biosolids level in the amendment mixture increased, ranging from 2.2 percent in the eastern subplot of topsoil to 16.8 percent in the western subplot of the 100 percent biosolids plot (4 west).

Mean concentrations of Zn, Cd, Cu, Cr, Ni, Pb, Mn, Fe, and molybdenum (Mo) found in the subplots at the 0- to 6-inch depth are presented in Table 35. 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 75 to 1,399 mg/Kg, Cd ranged from <0.18 to 10.0 mg/Kg, Cu ranged from 25 to 311 mg/Kg, Cr ranged from 31 to 170 mg/Kg, Pb ranged from 21 to 138 mg/Kg, and Mo ranged from <0.63 to 9.70 mg/Kg. The mean concentrations of Ni, Mn, and Fe were in a narrow range even after amendment treatments. The mean concentrations of Ni ranged from 23 to 35 mg/Kg, Mn ranged from 345 to 1,017 mg/Kg, and Fe ranged from 19,630 to 26,390 mg/Kg.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 35

MEAN CONCENTRATIONS OF TOTAL METALS IN SOIL AMENDMENTS OF USX SUBPLOTS (0-6 INCH DEPTH) - 2000

| Plot | Zn | Cd | Cu | Cr | Ni | Pb | Mn | Fe | Mo |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | mg/Kg | | | | |
| 1 East | 75 | <0.18 | 25 | 31 | 23 | 21 | 543 | 20,050 | <0.63 |
| 2 East | 630 | 3.46 | 136 | 105 | 30 | 70 | 519 | 20,820 | 4.80 |
| 3 East | 967 | 6.04 | 212 | 163 | 32 | 99 | 864 | 26,390 | 6.34 |
| 4 East | 977 | 6.68 | 224 | 110 | 27 | 101 | 345 | 23,780 | 9.70 |
| 1 West | 197 | 0.90 | 52 | 49 | 26 | 30 | 548 | 19,630 | 0.40 |
| 2 West | 541 | 3.33 | 123 | 170 | 31 | 57 | 1,017 | 21,340 | 2.66 |
| 3 West | 700 | 4.27 | 158 | 145 | 32 | 67 | 754 | 19,980 | 4.39 |
| 4 West | 1,399 | 10.0 | 311 | 160 | 35 | 138 | 482 | 22,940 | 8.87 |

CHEMICAL CONSTITUENTS OF THE 6- TO 12-INCH SOIL DEPTH

Soil samples were collected from the 6- to 12-inch depths of the sub-subplots. These samples were analyzed and the results were averaged to produce the mean values of chemical constituents by subplot. The results of these analyses are presented in Table 36. The mean soil pH varied between 6.3 and 7.1 for all subplots. Mean EC, ranging between 0.75 and 2.77 mmhos/cm, increased with increasing proportion of biosolids in the amendments applied to the plots. Levels 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 1,640 to 17,230 mg/Kg, 0.3 to 31.0 mg/Kg, and 4.7 to 234 mg/Kg, respectively. These forms of nitrogen were consistently found at higher levels in biosolids amended plots and generally increased with a higher proportion of biosolids in the amended blend.

WOODY PLANT AND TURF STUDY

In August of 2000, woody plants were planted on berms located on each of the eight subplots. Ornamental trees planted were Amur maple, apple serviceberry, thornless cockspur hawthorn, Donald Wyman crabapple, and Zumi crabapple. Shade trees planted were Marmo hybrid maple, autumn purple ash, Skyline honey locust, Siouxland cottonwood, red oak, and

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TABLE 36

MEAN CONCENTRATIONS OF CHEMICAL CONSTITUENTS IN SOIL AMENDMENTS OF USX SUBPLOTS (6 - 12 INCH DEPTH) - 2000

| Plot | pH | EC | TKN | $NH_4$-N | $NO_3$-N |
|---|---|---|---|---|---|
| | | mmhos/cm | ------------ | mg/Kg | ------------ |
| 1 East | 6.8 | 0.91 | 1,640 | 0.3 | 4.7 |
| 2 East | 6.9 | 1.90 | 6,980 | 1.9 | 179 |
| 3 East | 7.1 | 2.35 | 12,740 | 31.0 | 128 |
| 4 East | 6.5 | 2.59 | 11,840 | 18.5 | 215 |
| 1 West | 6.8 | 0.75 | 3,880 | 0.7 | 19.4 |
| 2 West | 7.1 | 1.64 | 6,240 | 3.2 | 71.4 |
| 3 West | 7.0 | 2.02 | 10,480 | 5.1 | 115 |
| 4 West | 6.3 | 2.77 | 17,230 | 22.4 | 234 |

Homestead hybrid elm. Future measurements of the plants' changes in height and trunk diameter, and evaluations of vigor and appearance will provide valuable information on the performance of these species in different amendments, as well as the ability of these amendments to supply nutrients critical to plant growth.

In October 2000, four turf blends were directly seeded on 25- by 25-foot test areas within each subplot. Prior to planting, each test area was planted by sod to separate the turf treatments. Despite the late planting, the seed germinated and turf was established by late fall. The seed mixes to be tested were the District mixture (70 percent tall fescue and 30 percent Kentucky bluegrass), the standard Chicago Park District mixture (70 percent Kentucky bluegrass, 15 percent creeping red fescue, 10 percent perennial rye, and 5 percent redtop), the Illinois Department of Transportation (IDOT) 1-B low maintenance mixture (75 percent tall fescue, 15 percent perennial rye, and 10 percent creeping red fescue), and a variation of the IDOT 1 lawn mixture (50 percent perennial rye, 30 percent Kentucky bluegrass, and 20 percent creeping red fescue). The performance of these turf blends will be rated periodically by evaluating color, density, ground coverage, pest and disease resistance, biomass production, and overall quality. Chemical analyses will be conducted on turf tissue samples to determine the levels of metals and macronutrients.

MONTHLY WELL, LYSIMETER, AND LAKE MONITORING

Prior to the application of the amendments, one well and two lysimeters were installed in each subplot and at a remote site for the purpose of groundwater monitoring (Figure 24). Due to difficult drilling conditions, wells could not be installed in west subplot 1 and east subplot 3. 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 subplot 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 June through December 2000. Mean values for various inorganic parameters by sampling location are presented in Table 37.

The legend for coding the groundwater monitoring and lake sampling locations is shown in Figure 24. In all 5-foot lysimeters within the plots, mean pH ranged from 7.6 to 8.7.

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TABLE 37

MEAN[1] ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JUNE - DECEMBER 2000

| Parameter | Units | Sample Point Identification[2] | | | | | |
|---|---|---|---|---|---|---|---|
| | | L1E1 @ 5' | L1E2 @ 10' | W1E3 @ 20' | L2E1 @ 5' | L2E2 @ 10' | W2E3 @ 20' |
| pH | | 7.8 | 7.3 | 7.5 | 7.9 | 7.6 | 7.4 |
| EC | mS/m | 132 | 97 | 115 | 121 | 135 | 135 |
| Total Dissolved Solids | mg/L | 1646 | 2655 | 1347 | 1897 | 2205 | 1357 |
| $Cl^-$ | " | 25 | 27 | 47 | 24 | 28 | 269 |
| $SO_4^=$ | " | 816 | 132 | 539 | 277 | 935 | 338 |
| TKN | " | 2.44 | 1.35 | 0.83 | 3.52 | 1.96 | 0.73 |
| $NH_4$-N | " | 0.28 | 0.29 | 0.19 | 0.43 | 0.33 | 0.20 |
| $NO_2$-N | " | 0.56 | 1.11 | 0.02 | 1.05 | 1.02 | 0.01 |
| $NO_3$-N | " | 6.77 | 6.67 | 0.82 | 49.4 | 4.09 | 0.12 |
| Total P | " | 0.18 | 0.14 | 0.09 | 0.12 | 0.11 | 0.06 |
| Alkalinity as $CaCO_3$ | " | 281 | 189 | 334 | 180 | 268 | 368 |
| Hardness | " | 922 | 993 | 787 | 919 | 1281 | 578 |
| Cd | " | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | 0.004 |
| Cr | " | 0.013 | 0.026 | 0.006 | 0.013 | 0.018 | 0.008 |
| Cu | " | 0.018 | 0.028 | 0.011 | 0.025 | 0.019 | 0.012 |
| Hg | µg/L | <0.1 | 0.15 | <0.1 | <0.1 | 0.14 | <0.1 |
| Ni | mg/L | <0.02 | <0.02 | <0.02 | 0.10 | <0.02 | 0.10 |
| Pb | " | <0.03 | <0.03 | <0.03 | <0.03 | 0.03 | <0.03 |
| Zn | " | 0.008 | 0.017 | 0.007 | 0.018 | <0.006 | 0.008 |
| FC | #/100 mL | ND | ND | ND | ND | ND | ND |

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TABLE 37 (Continued)

MEAN ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JUNE - DECEMBER 2000

| Parameter | Units | Sample Point Identification | | | | |
|---|---|---|---|---|---|---|
| | | L3E1 @ 5′ | L3E2 @ 10′ | L4E1 @ 5′ | L4E2 @10′ | W4E3 @ 20′ |
| pH | | 7.6 | 7.6 | 8.7 | 8.0 | 7.6 |
| EC | mS/m | 237 | 176 | 109 | 165 | 127 |
| Total Dissolved Solids | mg/L | 3024 | 2354 | 1277 | 2740 | 1591 |
| $Cl^-$ | " | 53 | 162 | 113 | 63 | 132 |
| $SO_4^=$ | " | 1252 | 880 | 131 | 1069 | 720 |
| TKN | " | 7.10 | 5.71 | 14.81 | 2.74 | 1.38 |
| $NH_4$-N | " | 0.90 | 1.90 | 9.83 | 0.33 | 0.50 |
| $NO_2$-N | " | 10.6 | 25.2 | 1.96 | 1.65 | 0.05 |
| $NO_3$-N | " | 124 | 62.8 | 3.07 | 20.1 | 3.88 |
| Total P | " | 0.12 | 0.13 | 0.13 | 0.14 | 0.06 |
| Alkalinity as $CaCO_3$ | " | 61 | 119 | 198 | 326 | 97 |
| Hardness | " | 1446 | 1291 | 149 | 1347 | 732 |
| Cd | " | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Cr | " | 0.013 | 0.009 | 0.007 | 0.007 | 0.006 |
| Cu | " | 0.034 | 0.034 | 0.016 | 0.030 | 0.012 |
| Hg | µg/L | <0.1 | <0.1 | 0.22 | <0.1 | 0.10 |
| Ni | mg/L | 0.10 | 0.10 | <0.02 | <0.02 | 0.10 |
| Pb | " | <0.03 | <0.03 | 0.04 | <0.03 | <0.03 |
| Zn | " | 0.006 | <0.006 | <0.006 | <0.006 | 0.110 |
| FC | #/100 mL | ND | ND | ND | ND | ND |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 37 (Continued)

MEAN ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JUNE - DECEMBER 2000

| Parameter | Units | Sample Point Identification | | | | |
|---|---|---|---|---|---|---|
| | | L1W1 @ 5' | L1W2 @ 10' | L2W1 @ 5' | L2W2 @ 10' | W2W3 @ 20' |
| pH | | 8.1 | 7.5 | 8.1 | 7.9 | 7.5 |
| EC | mS/m | 141 | 172 | 129 | 142 | 148 |
| Total Dissolved Solids | mg/L | NA | 2078 | 1171 | 2145 | 1265 |
| $Cl^-$ | " | NA | 27 | 17 | 28 | 103 |
| $SO_4^=$ | " | NA | 780 | 320 | 421 | 361 |
| TKN | " | NA | 1.42 | 4.19 | 3.16 | 0.94 |
| $NH_4$-N | " | NA | 0.24 | 0.58 | 0.34 | 0.39 |
| $NO_2$-N | " | NA | 1.32 | 0.40 | 1.03 | 0.02 |
| $NO_3$-N | " | NA | 7.00 | 18.0 | 4.36 | 0.35 |
| Total P | " | NA | 0.14 | 0.16 | 0.15 | 0.08 |
| Alkalinity as $CaCO_3$ | " | NA | 291 | 111 | 246 | 444 |
| Hardness | " | NA | 771 | 381 | 1041 | 501 |
| Cd | " | NA | <0.003 | <0.003 | <0.003 | <0.003 |
| Cr | " | NA | 0.007 | 0.007 | 0.013 | 0.006 |
| Cu | " | NA | 0.031 | 0.018 | 0.023 | 0.011 |
| Hg | µg/L | NA | 0.10 | 0.16 | 0.12 | <0.1 |
| Ni | mg/L | NA | <0.02 | <0.02 | <0.02 | 0.02 |
| Pb | " | NA | <0.03 | <0.03 | <0.03 | <0.03 |
| Zn | " | NA | 0.014 | <0.006 | 0.009 | 0.027 |
| FC | #/100 mL | NA | ND | ND | ND | ND |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 37 (Continued)

MEAN ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JUNE - DECEMBER 2000

| Parameter | Units | Sample Point Identification L3W1 @ 5' | L3W2 @ 10' | W3W3 @20' | L4W1 @ 5' | L4W2 @10' | W4W3 @ 20' |
|---|---|---|---|---|---|---|---|
| pH | | 7.8 | 7.7 | 7.6 | 7.7 | 7.5 | 7.6 |
| EC | mS/m | 163 | 193 | 135 | 221 | 110 | 145 |
| Total Dissolved Solids | mg/L | 1946 | 2702 | 1195 | 2508 | 1561 | 1183 |
| $Cl^-$ | " | 22 | 83 | 135 | 25 | 41 | 88 |
| $SO_4^=$ | " | 926 | 1068 | 371 | 1749 | 637 | 339 |
| TKN | " | 6.32 | 2.17 | 0.62 | 20.6 | 11.2 | 0.89 |
| $NH_4$-N | " | 0.87 | 0.28 | 0.22 | 6.89 | 7.07 | 0.45 |
| $NO_2$-N | " | 1.20 | 0.07 | 0.01 | 2.33 | 6.78 | 0.06 |
| $NO_3$-N | " | 52.5 | 2.61 | 0.13 | 117 | 6.09 | 0.36 |
| Total P | " | 0.18 | 0.10 | 0.09 | 0.42 | 0.21 | 0.06 |
| Alkalinity as $CaCO_3$ | " | 118 | 99 | 284 | 222 | 89 | 304 |
| Hardness | " | 1414 | 1286 | 554 | 2303 | 696 | 572 |
| Cd | " | <0.003 | <0.003 | <0.003 | <0.003 | 0.010 | <0.003 |
| Cr | " | 0.016 | 0.025 | <0.006 | 0.015 | 0.019 | 0.006 |
| Cu | " | 0.040 | 0.028 | 0.007 | 0.058 | 0.051 | 0.018 |
| Hg | µg/L | <0.1 | <0.1 | 0.10 | 0.11 | <0.1 | 0.11 |
| Ni | mg/L | 0.03 | <0.02 | 0.02 | 0.06 | <0.02 | 0.02 |
| Pb | " | <0.03 | <0.03 | 0.03 | <0.03 | <0.03 | 0.03 |
| Zn | " | 0.010 | <0.006 | 0.012 | 0.009 | 0.048 | 0.012 |
| FC | #/100 mL | ND | ND | ND | ND | ND | ND |

TABLE 37 (Continued)

MEAN ANALYSIS OF WATER FROM LYSIMETERS, WELLS, AND LAKE SAMPLES AT THE USX SITE JUNE - DECEMBER 2000

| Parameter | Units | Sample Point Identification | | | | | |
|---|---|---|---|---|---|---|---|
| | | LR1 @ 5' | LR2 @ 10' | WR3 @ 20' | LAKE-N | LAKE | LAKE-S |
| pH | | 7.9 | 8.0 | 7.6 | 7.6 | 7.7 | 7.6 |
| EC | mS/m | 142 | 189 | 122 | 31 | 31 | 32 |
| Total Dissolved Solids | mg/L | 1542 | 2673 | 1143 | 204 | 204 | 215 |
| $Cl^-$ | " | 14 | 85 | 50 | 12 | 13 | 13 |
| $SO_4^=$ | " | 433 | 1394 | 380 | 28 | 26 | 27 |
| TKN | " | 1.39 | 1.44 | 0.70 | 0.17 | 0.27 | 0.40 |
| $NH_4$-N | " | 0.31 | 0.28 | 0.38 | 0.06 | 0.07 | 0.07 |
| $NO_2$-N | " | 0.62 | 0.44 | 0.01 | 0.01 | 0.01 | 0.01 |
| $NO_3$-N | " | 0.24 | 3.62 | 0.24 | 0.30 | 0.33 | 0.37 |
| Total P | " | 0.10 | 0.11 | 0.08 | 0.07 | 0.08 | 0.07 |
| Alkalinity as $CaCO_3$ | " | 296 | 626 | 336 | 110 | 106 | 105 |
| Hardness | " | 324 | 1840 | 652 | 143 | 139 | 140 |
| Cd | " | <0.003 | <0.003 | 0.003 | <0.003 | <0.003 | <0.003 |
| Cr | " | <0.006 | 0.020 | 0.009 | 0.006 | 0.006 | 0.008 |
| Cu | " | 0.024 | 0.030 | 0.013 | 0.006 | 0.007 | 0.007 |
| Hg | µg/L | <0.1 | <0.1 | 0.11 | <0.1 | <0.1 | <0.1 |
| Ni | mg/L | <0.02 | <0.02 | 0.02 | <0.02 | 0.02 | <0.02 |
| Pb | " | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | 0.03 |
| Zn | " | <0.006 | 0.017 | 0.008 | 0.007 | 0.007 | 0.011 |
| FC | #/100ml | ND | ND | ND | 7 | 30 | 45 |

[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.

The mean pH of the 10-foot lysimeters within the plots ranged from 7.3 to 8.0. Mean well pH within the plots ranged from 7.4 to 7.6. The mean pH of the 5- and 10-foot lysimeters and the well at the remote site were 7.9, 8.0, and 7.6, respectively. The mean pH observed in the Lake Michigan samples ranged from 7.6 to 7.7 as shown in Table 37.

Mean total dissolved solids ranged from 1,171 to 3,024 mg/L in the wells and lysimeters within the plots. These levels are equivalent to those found in the lysimeters and well at the remote site which ranged from 1,143 to 2,673 mg/L. The mean total dissolved solids concentrations in the Lake Michigan samples ranged from 204 to 215 mg/L.

Mean TKN levels ranged from 2.44 to 20.6 mg/L, 1.35 to 11.2 mg/L, and 0.62 to 1.38 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 1.39, 1.44, and 0.70 mg/L, respectively. Mean TKN concentrations in the Lake Michigan samples ranged from 0.17 to 0.40 mg/L.

Mean $NH_4$-N levels ranged from 0.28 to 9.83 mg/L, 0.24 to 7.07 mg/L, and 0.19 to 0.50 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 0.31, 0.28, and 0.38 mg/L, respectively. Mean $NH_4$-N concentrations in Lake Michigan samples ranged from 0.06 to 0.07 mg/L.

Mean $NO_2$-N levels ranged from 0.40 to 10.6 mg/L, 0.07 to 25.2 mg/L, and 0.01 to 0.06 mg/L in the 5- and 10-foot lysimeters and wells within the plots, respectively. Mean nitrite-N levels found in similar devices at the remote site were 0.62, 0.44, and 0.01 mg/L, respectively. The mean concentrations of nitrite-N at the three Lake Michigan sample points were 0.01 mg/L.

Mean $NO_3$-N levels ranged from 3.07 to 124 mg/L, 2.61 to 62.8 mg/L, and 0.12 to 3.88 mg/L in the 5- and 10-foot lysimeters and wells within the plots, respectively. Mean $NO_3$-N levels found in similar devices at the remote site were 0.24, 3.62, and 0.24 mg/L, respectively. The mean $NO_3$-N concentrations in Lake Michigan samples ranged from 0.30 to 0.37 mg/L.

Mean total phosphorus levels ranged from 0.12 to 0.42 mg/L, 0.10 to 0.21 mg/L, and 0.06 to 0.09 mg/L in the 5- and 10-foot lysimeters and wells within the plots, respectively. Mean total phosphorus levels found in similar devices at the remote site were 0.10, 0.11, and 0.08 mg/L, respectively. Mean total phosphorus concentrations in Lake Michigan samples ranged from 0.07 to 0.08 mg/L.

Mean alkalinity and hardness in all lysimeter and well samples in the plots ranged from 61 to 444 mg/L and 149 to 2,303 mg/L, respectively. Mean alkalinity and hardness in the remote lysimeters and well and in Lake Michigan samples ranged from 105 to 626 mg/L and 139 to 1,840 mg/L, respectively.

Mean Cd concentrations in wells and lysimeters in the amended plots ranged from <0.003 to 0.01 mg/L. Mean Cd concentrations in the remote lysimeters and well and in Lake Michigan samples ranged from <0.003 to 0.003 mg/L.

Mean Cr levels ranged from <0.006 to 0.026 mg/L in the lysimeters and wells within the plots. Mean Cr levels found in the remote lysimeters and well and in Lake Michigan samples ranged from <0.006 to 0.020 mg/L.

Mean Cu concentrations ranged from 0.007 to 0.058 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 Lake Michigan samples ranged from 0.006 to 0.030 mg/L.

Mean Hg concentrations ranged from <0.1 to 0.22 µg/L in the lysimeters and wells within the plots. Mean Hg concentrations in the remote lysimeters and well and in Lake Michigan samples ranged from <0.1 to 0.11 µg/L.

Mean Ni levels in all lysimeters and wells within the plots, ranged from <0.02 to 0.10 mg/L. Mean Ni concentrations in the remote lysimeters and well and in Lake Michigan samples ranged from <0.02 to 0.02 mg/L.

Mean Pb levels in all lysimeters and wells in the plots ranged from <0.03 to 0.04 mg/L. The mean Pb concentrations in the remote lysimeters and well and in Lake Michigan samples ranged from <0.03 to 0.03 mg/L.

Mean Zn levels ranged from <0.006 to 0.110 mg/L in the lysimeters and wells within the plots. Mean Zn concentrations in the remote lysimeters and well and in Lake Michigan samples ranged from <0.006 to 0.017 mg/L.

FCs were not detected in any of the sampling devices at the USX site. 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 <29 per 100 ml. FCs were detected in Lake Michigan, however, at mean levels of 7, 30, and 45 per 100 ml at the north, middle, and south sampling points, respectively.

Quarterly sampling and analyses for 111 organic priority pollutants were conducted in both August and October of 2000. Because of the small liquid sample volume obtained from the lysimeters, samples were composited as follows: the 5-foot lysimeters from the subplots of plot 1 (topsoil amendment) and the remote site; the 5-foot lysimeters from the subplots of plot 3 (50 percent biosolids/50 percent topsoil), and plot 4 (100 percent biosolids); the 10-foot lysimeters from the subplots of plot 1 and the remote site; the 10-foot lysimeters from both subplots of plots 3 and 4; the wells from the east subplot of plot 1 and the remote site; and the wells from the western subplot of plot 3 and both subplots of plot 4.

The levels of organic priority pollutants found in these composite samples are presented in Table 38. Only five organic priority pollutants were found in the composite well and lysimeter samples at this site. Dichlorobromomethane was found in the 10-foot lysimeter composite sample of plots 3 and 4 at the detection limit (1 µg/L). Methylene chloride was detected at a level of 4 µg/L in the 5-foot lysimeter composite sample of plots 3 and 4. Bis(2-ethylhexyl)phthalate was found in this composite sample also, at a level of 380 µg/L. Phenanthrene was detected at a level of 10 µg/L in a composite sample from the three wells in plots 3 and 4. Endrin was found at the detection limit (0.06 µg/L) in the composite sample from the 5-foot lysimeters in plots 3 and 4. In the two quarterly sampling events that occurred in the year 2000, these five priority pollutants were not found concurrently in the same composites, nor were they found in the composite samples of other devices located in the same treatments. 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.

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TABLE 38

LEVELS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING AUGUST AND OCTOBER 2000

| Compound | Reporting Limit µg/L (ppb) | Values Found in µg/L (ppb) | Composite Source |
|---|---|---|---|
| Volatile Organic Compounds | | | |
| Acrolein | 33 | -- | |
| Acrylonitrile | 2 | -- | |
| Benzene | 2 | -- | |
| Bromoform | 2 | -- | |
| Carbon tetrachloride | 2 | -- | |
| Chlorobenzene | 2 | -- | |
| Chlorodibromomethane | 2 | -- | |
| Chloroethane | 4 | -- | |
| 2-Chloroethylvinyl ether | 2 | -- | |
| Chloroform | 2 | -- | |
| Dichlorobromomethane | 1 | 1 | Plots 3&4-L2 |
| 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 | -- | |
| Methylene chloride | 2 | 4 | Plots 3&4-L1 |
| 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 | -- | |
| Acid Extractable Compounds | | | |
| 2-Chlorophenol | 3 | -- | |
| 2,4-Dichlorophenol | 3 | -- | |
| 2,4-Dimethylphenol | 4 | -- | |
| 4,6-Dinitro-o-cresol | 17 | -- | |
| 2,4-Dinitrophenol | 20 | -- | |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38 (Continued)

LEVELS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING AUGUST AND OCTOBER 2000

| 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 | -- | |
| 2,4,6-Trichlorophenol | 3 | -- | |
| Base/Neutral Extractable Compounds | | | |
| Acenaphthene | 2 | -- | |
| Acenaphthylene | 2 | -- | |
| Anthracene | 1 | -- | |
| 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 | 380 | Plots 3&4-L1 |
| 4-Bromophenyl phenyl ether | 4 | -- | |
| Butylbenzyl phthalate | 4 | -- | |
| 2-Chloronaphthalene | 4 | -- | |
| 4-Chlorophenyl phenyl ether | 4 | -- | |
| Chrysene | 2 | -- | |
| Dibenzo(a,h)anthracene | 2 | -- | |
| 1,2-Dichlorobenzene | 4 | -- | |
| 1,3-Dichlorobenzene | 4 | -- | |
| 1,4-Dichlorobenzene | 4 | -- | |
| 3,3'-Dichlorobenzidine | 11 | -- | |
| Diethyl phthalate | 6 | -- | |
| Dimethyl phthalate | 4 | -- | |
| Di-n-butyl phthalate | 5 | -- | |
| 2,4-Dinitrotoluene | 4 | -- | |
| 2,6-Dinitrotoluene | 4 | -- | |
| Di-n-octyl phthalate | 6 | -- | |
| 1,2-Diphenylhydrazine | 4 | -- | |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38 (Continued)

LEVELS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING AUGUST AND OCTOBER 2000

| Compound | Reporting Limit µg/L (ppb) | Values Found in µg/L (ppb) | Composite Source |
|---|---|---|---|
| Fluoranthene | 2 | -- | |
| Fluorene | 4 | -- | |
| Hexachlorobenzene | 4 | -- | |
| Hexachlorobutadiene | 5 | -- | |
| Hexachlorocyclopentadiene | 50 | -- | |
| Hexachloroethane | 4 | -- | |
| Indeno(1,2,3-cd)pyrene | 2 | -- | |
| Isophorone | 6 | -- | |
| Naphthalene | 5 | -- | |
| Nitrobenzene | 8 | -- | |
| N-Nitrosodimethylamine | 5 | -- | |
| N-Nitrosodi-n-propylamine | 6 | -- | |
| N-Nitrosodiphenylamine | 4 | -- | |
| Phenanthrene | 2 | 10 | Plots 3&4-Wells |
| Pyrene | 2 | -- | |
| 1,2,4-Trichlorobenzene | 4 | -- | |
| Pesticides & PCBs | | | |
| 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 | 0.06 | Plots 3&4-L1 |
| Endrin aldehyde | 0.09 | -- | |
| Heptachlor | 0.09 | -- | |
| Heptachlor epoxide | 0.06 | -- | |
| PCB-1242 | 0.3 | -- | |
| PCB-1254 | 0.3 | -- | |
| PCB-1221 | 0.6 | -- | |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38 (Continued)

LEVELS OF ORGANIC PRIORITY POLLUTANTS FOUND IN COMPOSITE SAMPLES FROM USX WELLS AND LYSIMETERS DURING AUGUST AND OCTOBER 2000

| Compound | Reporting Limit µg/L (ppb) | Values Found in µg/L (ppb) | Composite Source |
|---|---|---|---|
| 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.

However, the pattern and frequency of their detection is not consistent with biosolids as their source.

## Nu Earth Vegetable Garden

The Nu Earth vegetable garden was established at the Stickney WRP in 1977. The purpose of the garden was to study the accumulation of trace metals into edible portions of common garden vegetables that were fertilized with Nu Earth biosolids (air-dried Imhoff sludge, no longer produced by the District), which was distributed throughout the Chicago area during the 1970s. The treatments included equal increments of 9, 18, 36, and 45 dry tons of Nu Earth per acre per year from 1977 through 1981, and a control plot that received inorganic fertilizer and no Nu Earth. Six common garden vegetables (carrot, beet, Swiss chard, spinach, tomato, and green beans) were grown on the plots annually until 1993, then every two years thereafter until 1998.

After 1981, no Nu Earth was applied to the plots, and all plots received inorganic fertilizer. Soil pH was maintained between 7.0 and 7.5 throughout the study.

During the period of Nu Earth application (1977 to 1981), the annual Nu Earth rate and the cumulative loading increased the concentrations of Cd, Ni, and Zn in all vegetables and Cu in spinach, Swiss chard, and beet. There was no significant effect on the concentrations of Cr and Pb. The concentrations of Cd, Ni, and Zn in vegetable tissue after cessation of biosolids application is summarized in Tables 39, 40, and 41, respectively. The data show that concentrations of Cd, Ni, and Zn in edible tissue tended to decrease with time following cessation of Nu Earth applications.

The results of the study show that Nu Earth applications tended to increase the uptake of some metals in edible vegetable tissues, and the metal uptake by vegetables decreases with time following cessation of Nu Earth application. The final report of the Nu Earth vegetable garden is in preparation.

## Biosolids Salinity Study

Beginning in the mid 1990s, the District placed an increased emphasis on local marketing to increase the awareness of the cost-effectiveness of using biosolids for urban land reclamation. In local use, biosolids are often applied to soils at heavy 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.

The biosolids salinity survey was started in 1997 to study changes in salt concentration (salinity) and composition

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 39

Cd CONCENTRATION (mg/Kg) IN VEGETABLES GROWN IN SOIL RECEIVING NU EARTH ANNUALLY 1977 - 1981

| Years Averaged[1] | Annual Nu Earth Rate (dry tons/acre) 0 | 9 | 18 | 36 | 45 |
|---|---|---|---|---|---|
| | | | Beet | | |
| 1980-1981 | 1.0 | 2.3 | 3.9 | 5.7 | 6.9 |
| 1982-1985 | 1.1 ns[2] | 2.0 ns | 2.7 ** | 3.9 ns | 5.2 ns |
| 1986-1989 | 0.6 ** | 1.4 ** | 2.1 ** | 2.9 ** | 4.1 ** |
| 1990-1993 | 0.9 ns | 1.8 ** | 3.3 * | 5.1 ns | 7.0 ns |
| 1994-1998 | 0.8 ns | 1.8 * | 3.1 * | 3.9 * | 6.2 ns |
| | | | Carrot | | |
| 1980-1981 | 1.8 | 3.7 | 5.1 | 4.1 | 4.4 |
| 1982-1985 | 1.0 ** | 2.4 * | 3.0 * | 3.7 ns | 4.0 * |
| 1986-1989 | 1.6 ns | 3.3 ns | 4.2 ns | 5.2 ns | 6.0 ** |
| 1990-1993 | 1.4 ns | 3.1 ns | 4.2 ns | 5.3 ns | 5.3 ns |
| 1994-1998 | 1.3 ns | 1.4 ** | 5.2 ns | 4.3 ns | 2.4 ** |
| | | | Swiss Chard | | |
| 1980-1981 | 2.4 | 6.5 | 12.5 | 19.7 | 25.6 |
| 1982-1985 | 3.3 * | 6.8 ns | 11.4 ns | 14.5 ** | 17.1 ** |
| 1986-1989 | 3.3 * | 6.9 ns | 13.4 ns | 13.7 ** | 13.8 ** |
| 1990-1993 | 2.4 ns | 5.6 ns | 9.0 * | 15.5 * | 14.3 ** |
| 1994-1998 | 2.7 ns | 7.8 ns | 9.9 ns | 13.8 ** | 17.7 ** |
| | | | Spinach | | |
| 1980-1981 | 4.5 | 9.4 | 11.4 | 15.0 | 12.0 |
| 1982-1985 | 7.8 * | 15.9 * | 19.2 ** | 22.1 * | 22.4 ** |
| 1986-1989 | 6.7 * | 15.2 * | 16.3 ns | 21.8 ns | 19.2 ** |
| 1990-1993 | ND | ND | ND | ND | ND |
| 1994-1998 | 8.5 ** | 17.1 ns | 15.3 ns | 22.9 * | 17.9 * |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 39 (Continued)

Cd CONCENTRATION (mg/Kg) IN VEGETABLES GROWN IN SOIL RECEIVING NU EARTH ANNUALLY 1977 - 1981

| Years Averaged | Annual Nu Earth Rate (dry tons/acre) | | | | |
|---|---|---|---|---|---|
| | 0 | 9 | 18 | 36 | 45 |
| | | | Green Beans | | |
| 1980-1981 | 0.1 | 0.1 | 0.2 | 0.4 | 0.4 |
| 1982-1985 | 0.1 * | 0.1 ns | 0.2 ns | 0.3 ns | 0.3 ns |
| 1986-1989 | 0.1 ns | 0.3 * | 0.2 ns | 0.2 * | 0.3 ns |
| 1990-1993 | 0.0 ** | 0.1 ns | 0.2 ns | 0.2 ** | 0.3 ns |
| 1994-1998 | 0.0 ** | 0.0 ** | 0.0 ** | 0.0 ** | 0.1 ** |
| | | | Tomato | | |
| 1980-1981 | 1.2 | 1.5 | 2.4 | 3.1 | 3.2 |
| 1982-1985 | 1.5 ns | 1.9 ns | 2.3 ns | 2.8 ns | 3.0 ns |
| 1986-1989 | 1.8 * | 2.2 ** | 2.7 ns | 2.7 ns | 3.3 ns |
| 1990-1993 | 1.6 ns | 2.1 ** | 2.4 ns | 2.8 ns | 3.5 ns |
| 1994-1998 | 0.8 ns | 1.4 ns | 1.8 ns | 1.8 ** | 2.0 ** |

[1]Values represent average for years included in each period.
[2]Notation following values indicate significance probability that values are different from those for the 1980-1981 period.
ns = not significant.
*, ** = significant at 0.05 and 0.01 probability levels, respectively.
ND = no data.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 40

Ni CONCENTRATION (mg/Kg) IN VEGETABLES GROWN IN SOIL RECEIVING NU EARTH ANNUALLY 1977 - 1981

| Years Averaged[1] | Annual Nu Earth Rate (dry tons/acre) | | | | |
|---|---|---|---|---|---|
| | 0 | 9 | 18 | 36 | 45 |
| | Beet | | | | |
| 1980-1981 | 0.4 | 0.5 | 0.8 | 1.4 | 2.2 |
| 1982-1985 | 3.8 **[2] | 4.1 ** | 5.2 ** | 5.7 ** | 10.0 ** |
| 1986-1989 | 1.0 ns | 2.1 ns | 0.8 * | 1.0 ** | 1.3 ** |
| 1990-1993 | 0.1 ** | 0.2 ** | 0.2 ** | 0.4 ** | 0.5 ** |
| 1994-1998 | 1.1 ns | 0.5 ** | 0.9 ns | 0.9 * | 0.9 ** |
| | Carrot | | | | |
| 1980-1981 | 0.5 | 0.7 | 0.9 | 1.6 | 3.0 |
| 1982-1985 | 2.7 ** | 2.0 * | 2.4 ** | 3.3 ** | 4.2 ns |
| 1986-1989 | 0.9 ns | 1.2 ns | 1.0 ns | 1.7 ns | 1.8 ** |
| 1990-1993 | 0.9 ns | 0.7 ns | 1.1 ns | 1.5 ns | 1.5 ** |
| 1994-1998 | 0.3 ns | 0.7 ns | 1.1 ns | 1.6 ns | 1.2 ** |
| | Swiss Chard | | | | |
| 1980-1981 | 2.3 | 3.1 | 4.8 | 5.8 | 6.5 |
| 1982-1985 | 3.0 ns | 4.3 ns | 5.6 ns | 5.0 ns | 5.7 ns |
| 1986-1989 | 3.6 ns | 4.7 ns | 6.1 ns | 3.7 * | 6.0 ** |
| 1990-1993 | 2.3 ns | 2.7 ns | 7.3 ns | 3.8 ns | 3.0 ** |
| 1994-1998 | 1.0 ** | 1.4 ** | 1.4 ** | 1.7 ** | 2.3 ** |
| | Spinach | | | | |
| 1980-1981 | 1.0 | 1.2 | 2.4 | 2.7 | 5.4 |
| 1982-1985 | 7.6 ** | 5.7 ** | 6.8 ** | 8.6 ** | 9.0 ns |
| 1986-1989 | 3.4 ** | 4.6 ns | 3.9 ns | 3.4 ns | 4.7 ns |
| 1990-1993 | ND | ND | ND | ND | ND |
| 1994-1998 | 0.5 * | 1.3 ns | 1.0 * | 1.3 ** | 1.7 * |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 40 (Continued)

Ni CONCENTRATION (mg/Kg) IN VEGETABLES GROWN IN SOIL RECEIVING NU EARTH ANNUALLY 1977 - 1981

| Years Averaged | Annual Nu Earth Rate (dry tons/acre) 0 | 9 | 18 | 36 | 45 |
|---|---|---|---|---|---|
| | | | Green Beans | | |
| 1980-1981 | 1.6 | 2.4 | 4.0 | 7.1 | 9.0 |
| 1982-1985 | 1.9 ns | 2.1 ns | 4.4 ns | 9.0 ns | 10.5 ns |
| 1986-1989 | 1.5 ns | 1.8 ns | 3.0 ns | 3.3 ns | 3.9 ** |
| 1990-1993 | 1.6 ns | 2.9 ns | 2.7 * | 5.3 ns | 6.4 ns |
| 1994-1998 | 1.6 ns | 2.5 ns | 2.6 ns | 3.3 * | 2.9 ** |
| | | | Tomato | | |
| 1980-1981 | 1.1 | 1.0 | 1.1 | 1.2 | 1.8 |
| 1982-1985 | 3.5 ** | 3.6 ** | 6.4 ** | 3.2 ** | 4.3 ** |
| 1986-1989 | 0.1 ** | 0.2 ** | 0.3 ** | 0.5 ** | 1.3 * |
| 1990-1993 | 0.4 ** | 0.4 ** | 0.6 ** | 0.7 * | 0.8 ** |
| 1994-1998 | 1.2 ns | 0.9 ns | 1.1 ns | 1.3 ns | 2.8 ns |

[1]Values represent average for years included in each period.
[2]Notation following values indicate significance probability that values are different from those for the 1980-1981 period.
ns = not significant.
*, ** = significant at 0.05 and 0.01 probability levels, respectively.
ND = no data.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 41

Zn CONCENTRATION (mg/Kg) IN VEGETABLES GROWN IN SOIL RECEIVING NU EARTH ANNUALLY 1977 - 1981

| Years Averaged[1] | Annual Nu Earth Rate (dry tons/acre) 0 | 9 | 18 | 36 | 45 |
|---|---|---|---|---|---|
| | | | Beet | | |
| 1980-1981 | 34 | 52 | 63 | 90 | 119 |
| 1982-1985 | 31 *[2] | 42 * | 49 * | 65 * | 77 ** |
| 1986-1989 | 22 ** | 27 ** | 28 ** | 39 ** | 49 ** |
| 1990-1993 | 29 * | 36 ** | 44 ** | 55 ** | 66 ** |
| 1994-1998 | 45 ns | 45 ns | 51 * | 58 ** | 68 ** |
| | | | Carrot | | |
| 1980-1981 | 23 | 33 | 33 | 35 | 41 |
| 1982-1985 | 26 ns | 29 ns | 29 ns | 30 ns | 34 * |
| 1986-1989 | 26 * | 28 ns | 28 ns | 32 ns | 31 * |
| 1990-1993 | 25 ns | 32 ns | 28 ns | 33 ns | 32 * |
| 1994-1998 | 24 ns | 26 ns | 35 ns | 31 ns | 25 ** |
| | | | Swiss Chard | | |
| 1980-1981 | 72 | 152 | 239 | 338 | 398 |
| 1982-1985 | 61 ns | 123 ns | 176 ns | 278 ns | 347 ns |
| 1986-1989 | 74 ns | 126 ns | 142 ** | 162 ** | 151 ** |
| 1990-1993 | 51 ** | 87 ** | 111 ** | 178 ** | 168 ** |
| 1994-1998 | 59 ns | 124 ns | 139 ** | 213 * | 201 ** |
| | | | Spinach | | |
| 1980-1981 | 208 | 259 | 245 | 273 | 251 |
| 1982-1985 | 180 ns | 315 ns | 306 ns | 300 ns | 314 ns |
| 1986-1989 | 151 ns | 244 ns | 239 ns | 262 ns | 264 ns |
| 1990-1993 | ND | ND | ND | ND | ND |
| 1994-1998 | 176 ns | 241 ns | 196 ns | 273 ns | 214 ns |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 41 (Continued)

Zn CONCENTRATION (mg/Kg) IN VEGETABLES GROWN IN SOIL RECEIVING NU EARTH ANNUALLY 1977 - 1981

| Years Averaged | Annual Nu Earth Rate (dry tons/acre) 0 | 9 | 18 | 36 | 45 |
|---|---|---|---|---|---|
| | Green Beans | | | | |
| 1980-1981 | 30 | 32 | 34 | 37 | 37 |
| 1982-1985 | 29 ns | 24 * | 29 ns | 28 ns | 31 ns |
| 1986-1989 | 24 ** | 25 ** | 24 ** | 29 ** | 27 ** |
| 1990-1993 | 33 ns | 37 ns | 41 ** | 40 ns | 39 ns |
| 1994-1998 | 37 * | 39 ** | 20 * | 42 * | 44 * |
| | Tomato | | | | |
| 1980-1981 | 30 | 32 | 35 | 38 | 39 |
| 1982-1985 | 27 ns | 30 ns | 31 * | 32 ** | 33 ** |
| 1986-1989 | 26 * | 26 ** | 26 ** | 28 ** | 31 ** |
| 1990-1993 | 33 ns | 33 ns | 35 ns | 35 ns | 34 * |
| 1994-1998 | 24 ** | 28 * | 29 * | 27 ** | 29 ** |

[1]Values represent average for years included in each period.
[2]Notation following values indicate significance probability that values are different from those for the 1980-1981 period.
ns = not significant.
*, ** indicate significant at 0.05 and 0.01 probability levels, respectively.
ND = no data.

of biosolids during their generation through the District's sludge processing trains. The salinity survey was conducted at three stages of the sludge processing trains:

1. Digester draw and centrifuge cake (February 1998 to May 1999)
2. Drying beds (August 1997 to August 1998)
3. Biosolids stockpiles (June 1998 to present)

In the stockpile salinity survey, biosolids that were completely processed and stockpiled for loading to trucks were sampled and analyzed for pH, EC, $NO_3$-N, and $NH_4$-N in 1:2 (sample:water ratio) extracts. Saturated paste extracts of some of the samples were also analyzed for the previously described parameters. In 2000, a total of 73 biosolids samples from stockpiles at the Calumet SMA, HASMA, 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 from 1998 to 2000 is presented in Table 42. During the survey period biosolids pH ranged from 5.7 (Vulcan, 1999) to 7.7 (Stony Island, 1998; LASMA, 1999; and Calumet, 2000).

The EC varied widely from year to year and among SMAs. During the sampling period, the EC levels ranged from 0.9 mmhos/cm (RASMA in 2000) to 13 mmhos/cm (Calumet in 1998). Mean EC at the WRPs ranged from 4.3 to 9.5 mmhos/cm.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 42

SUMMARY OF pH, EC, $NO_3$-N, AND $NH_4$-N IN WATER EXTRACTS[1] OF BIOSOLIDS STOCKPILES
1998 - 2000[2]

| SMA | pH | | | EC (mmhos/cm) | | | $NO_3$-N (mg/L) | | | $NH_4$-N (mg/L) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min. | Max. | Mean | Min. | Max. | Mean | Min. | Max. | Mean | Min. | Max. | Mean |
| | | | | | | | 1998 | | | | | |
| Calumet | 6.3 | 7.6 | 6.9 | 4.8 | 13 | 7.5 | 0.0 | 345 | 87 | 155 | 1,274 | 552 |
| HASMA | 6.0 | 6.7 | 6.2 | 5.7 | 7.6 | 6.7 | 46 | 320 | 201 | 147 | 637 | 319 |
| LASMA | 6.5 | 6.8 | 6.7 | 6.4 | 9.0 | 7.8 | 2.3 | 85 | 34 | 506 | 825 | 654 |
| RASMA | 6.0 | 6.3 | 6.1 | 4.2 | 7.1 | 5.9 | 57 | 292 | 183 | 109 | 327 | 211 |
| Stony Is. | 6.4 | 7.7 | 7.2 | 5.3 | 9.8 | 8.0 | 0.2 | 22 | 8.7 | 415 | 1,110 | 77 |
| Vulcan | 6.3 | 6.3 | 6.3 | 5.9 | 6.5 | 6.2 | 168 | 190 | 182 | 243 | 302 | 273 |
| Mean | | | 6.6 | | | 7.0 | | | 116 | | | 464 |
| | | | | | | | 1999 | | | | | |
| Calumet | 6.0 | 7.6 | 6.7 | 2.7 | 10 | 6.3 | 0.4 | 727 | 181 | 4.3 | 1,138 | 463 |
| HASMA | 5.9 | 7.1 | 6.6 | 5.4 | 9.3 | 7.4 | 0.9 | 416 | 156 | 60 | 1,171 | 557 |
| LASMA | 7.5 | 7.7 | 7.6 | 5.2 | 5.9 | 5.5 | 0.3 | 0.5 | 0.4 | 584 | 589 | 586 |
| Marathon | 7.1 | 7.1 | 7.1 | 9.4 | 9.6 | 9.5 | 4.6 | 5.3 | 4.9 | 1,201 | 1,202 | 1,201 |
| RASMA | 5.9 | 6.8 | 6.4 | 1.6 | 8.5 | 5.4 | 17 | 360 | 140 | 15 | 577 | 242 |
| Stony Is. | 6.2 | 7.5 | 6.7 | 3.3 | 10 | 6.7 | 0.0 | 314 | 88 | 6.1 | 1,371 | 657 |
| Vulcan | 5.7 | 7.0 | 6.3 | 5.0 | 7.8 | 6.6 | 4.6 | 489 | 238 | 52 | 960 | 389 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 42 (Continued)

SUMMARY OF pH, EC, $NO_3$-N, AND $NH_4$-N IN WATER EXTRACTS OF BIOSOLIDS STOCKPILES
1998 - 2000

| SMA | pH | | | EC (mmhos/cm) | | | $NO_3$-N (mg/L) | | | $NH_4$-N (mg/L) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min. | Max. | Mean | Min. | Max. | Mean | Min. | Max. | Mean | Min. | Max. | Mean |
| Mean | | | 6.8 | | | 6.8 | | | 115 | | | 585 |
| 2000 | | | | | | | | | | | | |
| Calumet | 5.9 | 7.7 | 6.7 | 1.3 | 10 | 4.3 | 0.0 | 293 | 49 | 5.1 | 1,181 | 258 |
| HASMA | 5.9 | 7.1 | 6.7 | 2.5 | 10 | 6.0 | 0.1 | 210 | 32 | 34 | 956 | 459 |
| LASMA | 7.1 | 7.2 | 7.2 | 5.8 | 6.9 | 6.3 | 0.0 | 0 | 0 | 656 | 884 | 770 |
| RASMA | 5.9 | 7.4 | 6.3 | 0.9 | 8.7 | 4.9 | 0.0 | 144 | 72 | 2.6 | 927 | 272 |
| Stony Is. | 5.8 | 7.3 | 6.7 | 1.8 | 9.0 | 4.9 | 0.0 | 264 | 52 | 3.6 | 1,214 | 461 |
| Vulcan | 6.0 | 6.9 | 6.5 | 3.8 | 8.1 | 6.6 | 0.0 | 201 | 36 | 5.6 | 834 | 485 |
| Mean | | | 6.7 | | | 5.5 | | | 40 | | | 451 |

[1]Ratio used for extraction was 1:2 for solids and water.
[2]Duplicate analysis of 1 to 32 samples collected at each sludge management area each year.

The $NO_3$-N and $NH_4$-N concentrations varied widely between the SMAs and during the 3-year period. The $NO_3$-N concentrations were usually much lower than $NH_4$-N concentrations. The $NO_3$-N concentrations ranged from 0 (Calumet, 1998) to 727 mg/L (Calumet, 1999), and $NH_4$-N concentrations ranged from 2.6 (RASMA, 2000) to 1,371 mg/L (Stony Island, 1999). The mean concentrations of $NO_3$-N for all SMAs were much lower in 2000, 40 mg/L, than in 1998 and 1999, 116 and 115 mg/L, respectively.

The data collected to date indicate that salinity and the concentration of nitrogen species in the processed biosolids vary widely with time and among the biosolids management areas. The sampling and analysis of biosolids stockpiles will be continued to better evaluate the trends in salinity and concentration of nitrogen species in the completely processed biosolids.

## Evaluation of Topsoil Properties of Biosolids

The Biosolids Topsoil Properties Study was started in fall 2000 and is ongoing. The purpose of this work is to measure the chemical and physical properties of the District's biosolids to evaluate their suitability as a topsoil substitute or amendment. For the initial phase of this work, biosolids from the High and Low Solids Processing Trains (SPTs) produced at the Calumet and Stickney WRPs were used. In this study, air-dried biosolids (approximately 65 percent solids) samples were collected from stockpiles that were waiting for final disposition at the drying sites.

Biosolids samples were analyzed for parameters that are usually used in the selection of topsoil for establishing vegetation. The tests and analyses required for evaluating the physical properties of biosolids will be outsourced. The tests and analyses required for evaluating the chemical properties are conducted at the District's soil science laboratories. The tests conducted are basic chemical properties, total concentration of elements, and concentration of extractable or plant available nutrients using various testing procedures.

A summary of some chemical properties and the concentrations of the nutrient elements in biosolids from the Calumet and Stickney WRPs is presented in Table 43. The pH of biosolids from the two WRPs were similar (mean pH = 6.8), except for biosolids from the Stickney Low Solids SPT (pH = 6.0). The salinity as measured by EC was higher in the Calumet than in the Stickney biosolids. The lowest EC was observed in the Stickney Low Solids biosolids (EC = 2.5 dS/m). The organic carbon (OC) content was lowest in the Calumet High Solids SPT

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TABLE 43

TOPSOIL PROPERTIES OF BIOSOLIDS FROM THE HIGH SOLIDS AND LOW SOLIDS SPTs AT THE CALUMET AND STICKNEY WRPs[1] - 2000

| Parameter[2] | Calumet | | Stickney | |
|---|---|---|---|---|
| | High Solids SPT | Low Solids SPT | High Solids SPT | Low Solids SPT |
| pH | 6.8 | 6.7 | 6.9 | 6.0 |
| EC (dS/m) | 6.8 | 4.8 | 3.2 | 2.5 |
| OC (%) | 8.6 | 13 | 11 | 14 |
| CEC[3] ($cmol_+/Kg$) | 80 | 66 | 75 | 77 |
| | Total Nutrients (mg/Kg) | | | |
| TKN | 25,034 | 17,158 | 23,084 | 18,636 |
| Total P | 28,345 | 20,665 | 20,222 | 21,277 |
| | Plant Available Nutrients (mg/Kg) | | | |
| $NH_4$-N | 2,318 | 1,168 | 3,055 | 869 |
| $NO_3$-N | 132 | 70 | 143 | 271 |
| P | 274 | 429 | 392 | 522 |
| Ca | 8,226 | 5,061 | 5,043 | 4,560 |
| Mg | 1,564 | 1,459 | 1,620 | 1,505 |
| K | 901 | 632 | 845 | 846 |
| Na | 542 | 240 | 341 | 196 |
| $SO_4$-S | 1,658 | 1,759 | 971 | 1061 |
| B | 5.5 | 5.4 | 5.8 | 6.8 |
| Fe | 47 | 92 | 202 | 108 |
| Mn | 74 | 37 | 100 | 66 |
| Zn | 1,010 | 479 | 243 | 226 |
| Cu | 10 | 34 | 93 | 71 |

[1]Means ± standard deviations of 2 to 3 replicate analyses of 2 to 3 biosolids samples from each WRP and SPT.
[2]Extraction methods: pH and EC - saturated paste; $NH_4$-N and $NO_3$-N - potassium chloride; P - Bray P1; Ca, Mg, K, and Na - neutral ammonium acetate; $SO_4$-S - water; B - hot water; Fe, Mn, Zn, and Cu - ammonium bicarbonate-DTPA.
[3]Cation exchange capacity.

material, and there was very little variation among the other biosolids.

The concentrations of nutrient elements were either within the range or above the levels considered adequate for the growth of most plant species. The TKN and $NH_4$-N concentrations were lowest in the biosolids from the Low Solids SPT. The $NH_4$-N concentration in biosolids from the Low Solids SPT was roughly half of the biosolids from the High Solids SPT at the Calumet WRP and about one-third of the Stickney WRP High Solids SPT biosolids.

Other noteworthy differences in the nutrient element concentration among the biosolids were for the Calumet High Solids SPT. In these biosolids, the plant available concentration of Zn was much higher, and concentrations of plant available Fe and Cu were much lower than in the other biosolids.

A review of the analytical results from the Analytical Laboratory Division for biosolids distributed during 2000 showed instances of low levels of total P, TKN, and $NH_4$-N being reported as compared to the historical trends. The Land Reclamation and Soil Science Section has begun an investigation that includes reanalysis of some of the suspected low nutrient biosolids samples, and a more thorough data review to determine if the low nutrient levels reported are due to analytical error or other possible causes.

An evaluation of the chemical properties of biosolids shows that some properties that are critical to the suitability of biosolids for use as topsoil tend to vary between the Calumet and Stickney WRPs and the SPTs. The biosolids produced in the Low Solids SPT tend to have the lowest salinity and $NH_4$-N levels. These biosolids are probably most desirable for use as topsoil because salinity and soluble $NH_4$-N are the most critical chemical properties that can initially limit seed germination and early plant growth in freshly applied biosolids.

## 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 to demonstrate 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 these practices. 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 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 2000, the section provided technical support, in the form of one or more of the activities listed above for the following biosolids projects and potential users. Examples of biosolids projects conducted in 2000 include:

1. Construction of soccer fields at Morton West High School using biosolids as a soil conditioner, Berwyn, Illinois.

2. Rehabilitation of fairways using biosolids as a soil conditioner and topsoil substitute at Hickory Hills Golf Course, Northshore Country Club, Longwood Golf Course, and others.

3. Development of a recreational park and athletic fields using biosolids as a soil conditioner by the Village of Blue Island.

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

5. Use of biosolids, as a topsoil substitute, to renovate recreational areas at Miller Meadow Forest Preserve, North Riverside, Illinois.

6. Use of biosolids, as a soil conditioner and topsoil substitute, to increase productivity of a day-lily farm, Wilmington, Illinois.

7. Use of biosolids, as a soil conditioner, in soil reclamation for production of trees for biomass at the Continental Cement Company, Hannibal, Missouri.

8. Use of biosolids, as a topsoil substitute, in revegetating roadside soils at Illinois Department of Transportation project sites.

9. Publication of an educational pamphlet promoting beneficial use of District biosolids.

## 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 three groups, which perform specific monitoring or research activities:

I. Analytical Microbiology Group

II. Virology and Parasitology Group

III. Biomonitoring Group

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 Section personnel can be involved 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 2000, Section personnel participated in a variety of monitoring and research activities. These are summarized below by group.

## 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.

The Analytical Microbiology Group also monitors the Lake Michigan shoreline and Chicago area beaches for the presence and density of fecal coliforms, and concentration of conventional pollutants following diversion of storm water and combined sewage to the lake. 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 District began developing a database of *E. coli* to FC ratios in water samples from Lake Michigan, District WRPs, and the Chicago area waterways. This included monitoring District waterways in Cook County upstream and downstream of the Calumet, North Side, Stickney, and Lemont WRPs.

## CERTIFICATION BY THE IDPH

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

- heterotrophic plate count (HPC) for water;
- MMO-MUG (see Appendix I for complete definition of this testing procedure) for total coliform (TC) and *Escherichia coli* (*E. Coli*);
- 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 Group's facilities, equipment, and procedures were the subject of the biennial on-site evaluation for certification by the IDPH in 2000, and were found to be in general compliance with the provisions of *Standard Methods for the Examination of Water and Wastewater* (unless otherwise mentioned, using the 18th Edition), 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 (e.g., drinking water) from District facilities and other locations as required.

Table 44 summarizes the number and type of analyses performed by the Group in 2000. 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 HPC is a procedure for estimating the number of viable heterotrophic bacteria in water. Waste activated sludge was examined microscopically (BIO-E) for protozoan and filamentous organisms. Bacteria were identified to species (ID-CONF) using specific biochemical metabolic characteristics.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 44

NUMBERS OF SAMPLES AND ANALYSES PERFORMED 1998 - 2000

| Year | Number Samples | Number of Analyses or Tests Performed[1] | | | | | | | | | | | Total Count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TC | FC | FS | PA | SAL | HPC | *E. coli* | ENT | IQC | BIO-E | ID-CONF | |
| 1998 | 3,034 | 300 | 2,629 | 24 | 24 | 24 | 287 | 14 | 10 | 5,646 | 427 | 1,342 | 10,727 |
| 1999 | 2,905 | 241 | 2,665 | 24 | 10 | 89 | 213 | 31 | 10 | 5,284 | 146 | 706 | 9,419 |
| 2000 | 2,847 | 77 | 2,809 | 0 | 0 | 0 | 85 | 302 | 0 | 7,594[2] | 0 | 285 | 11,152 |

[1]Abbreviations not elsewhere defined include: FS = Fecal Streptococcus; PA = Pseudomonas aeruginosa; SAL = Salmonella sp.; ENT = Enterococcus sp.; and IQC - internal Quality Control testing (reported as the number of procedures performed).
[2]This number reflects an increase in the number of quality control procedures required by the IDPH in 2000.

## NPDES COMPLIANCE MONITORING

FC 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 to maintain 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 those periods.

In compliance with the NPDES permits, the Analytical Microbiology Group performed most probable number analyses for FC bacteria on 24 samples from the Hanover Park WRP lagoons. Current NPDES permits also require the monitoring of FC levels in retention ponds at the Hanover Park WRP. As a result, 30 samples from the Hanover Park WRP retention ponds and related plant processing streams were analyzed. Results were reported to the plant as soon as data were available.

## 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 guidelines for the implementation of the ambient water quality criteria for bacteria which it recommended in 1986. Since the Illinois

Pollution Control Board (IPCB) is likely to adopt similar standards based on *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. Currently, the database contains the results of 496 analyses.

In 2000, the Analytical Microbiology Group began analyzing water samples from the bathing beaches on Lake Michigan for *E. coli* using the QuantiTray 2000 method following the manufacturer's instructions. FC levels were determined in water samples from Lake Michigan using the seven hour test procedure (procedure 9211 B, as prescribed in *Standard Methods*). Test results are shown in Table 45.

In 2000 the Analytical Microbiology Group began analyzing WRP effluents and samples from the Chicago area waterways for *E. coli* using the m-Tec procedure (procedure 9213 D.3, as prescribed in *Standard Methods*). FC densities in effluent and waterway samples are determined using the FC membrane filtration procedure (procedure 9222 D, as prescribed in *Standard Methods*). Data collected in 2000 are shown in Table 46.

## SUPPORT OF OTHER SECTIONS

The Analytical Microbiology Group supported a variety of Environmental Monitoring and Research and Industrial Waste

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 45

*E. COLI* TO FC RATIOS FOR LAKE MICHIGAN SAMPLES - 2000

| Location | n[1] | $Log_{10}$ Average[2] *E. coli*/100 mL | $Log_{10}$ Average[2] FC/100 mL | Average *E. coli* to Average FC Ratio |
|---|---|---|---|---|
| Calumet Beach | 1 | 1.041 | 1.000 | 1.1000 |
| Rainbow Beach | 2 | 1.568 | 1.978 | 0.3895 |
| Cal 1-River mouth | 2 | 1.190 | 1.775 | 0.2605 |
| Cal 2-Off U.S. Steel | 2 | 1.204 | 1.653 | 0.3556 |
| Cal 3-at breakwater bend | 2 | 0.398 | 1.602 | 0.0625 |
| Cal 4-at breakwater gap | 2 | 1.146 | 1.648 | 0.3146 |
| Cal 5-off boat launch | 2 | 0.301 | 1.000 | 0.2000 |
| Cal 6-off Coast Guard Sta. | 2 | 0.544 | 1.000 | 0.3500 |
| Cal 7-Howard Slip | 2 | 2.712 | 2.681 | 1.0729 |

[1]Number of samples.
[2]For all calculations "less than" counts were treated as the numeric value, for example <10 became 10.

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TABLE 46

*E. COLI* TO FC RATIOS IN DISTRICT WRP EFFLUENTS - 2000

| WRP | n[1] | $Log_{10}$ Average[2] *E. coli*/100 mL | $Log_{10}$ Average[2] FC/100 mL | Average *E. coli* to Average FC Ratio |
|---|---|---|---|---|
| Stickney | 2 | 3.922 | 3.924 | 0.9940 |
| North Side | 10 | 4.051 | 4.229 | 0.6633 |
| Calumet | 1 | 3.799 | 4.000 | 0.6300 |
| John E. Egan | 29 | 2.225 | 2.511 | 0.5174 |
| James C. Kirie | 29 | 3.104 | 3.369 | 0.5437 |
| Hanover Park | 29 | 1.893 | 2.162 | 0.5392 |
| Lemont | 1 | 4.041 | 4.362 | 0.4783 |

[1]Number of samples.
[2]For all calculations "less than" counts were treated as the numeric value, for example <10 became 10.

Division programs in 2000. 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 sampling activities.

Larger support goes to monitoring fecal coliform presence and density in groundwater for TARP, as required by IEPA operational permits. Sampling is also performed to monitor the presence and density of fecal coliforms in groundwater and wells around biosolids handling sites in Cook County as part of USEPA Part 503 Compliance Monitoring. Finally, the Analytical Microbiology Group reviews research reports and drafts of legislation to determine the impact on District operations.

Table 47 summarizes the major programs receiving support from 1998 through 2000, and the number of analyses performed for each program.

## Virology and Parasitology Group Activities

In 2000 the Virology and Parasitology Groups analyzed sludge samples for compliance with the USEPA Part 503 sludge disposal regulations. This analysis also supports the District's request to have its sludge processing trains (SPTs)

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 47

ANALYTICAL MICROBIOLOGY GROUP
NUMBERS OF ANALYSES PERFORMED FOR VARIOUS DISTRICT PROGRAMS 1998 - 2000

| Program | Total Coliform | | | Fecal Coliform | | | Fetal Streptococci | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 2000 | 1998 | 1999 | 2000 | 1998 | 1999 | 2000 |
| Effluent Analysis | 10 | 8 | 12 | 892 | 818 | 745 | - | - | - |
| Land Reclamation | - | - | - | 440 | 169 | 332 | - | - | - |
| Sludge Indicator Organism Density | - | - | - | 148 | 114 | 34 | - | - | - |
| District Waterway Surveys | 10 | 10 | - | 541 | 521 | 751 | 10 | 10 | - |
| Industrial Waste Surveys | - | 30 | - | 40 | 39 | 9 | - | - | - |
| Research Support | 14 | - | - | 14 | 94 | - | 14 | 14 | - |
| Lake Michigan Monitoring[1] | - | - | 7 | 55 | 82 | 74 | - | - | - |
| Major Treatment | - | - | - | 35 | - | - | - | - | - |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 47 (Continued)

ANALYTICAL MICROBIOLOGY GROUP
NUMBERS OF ANALYSES PERFORMED FOR VARIOUS DISTRICT PROGRAMS 1998 - 2000

| Program | Total Coliform | | | Fecal Coliform | | | Fetal Streptococci | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1998 | 1999 | 2000 | 1998 | 1999 | 2000 | 1998 | 1999 | 2000 |
| Facility Monitoring | | | | | | | | | |
| Illinois Waterway | - | - | - | - | 195 | 294 | - | - | - |
| TARP | - | - | - | 464 | 633 | 570 | - | - | - |
| Emergency Response | - | - | - | - | - | - | - | - | - |
| Combined Sewer Overflow | - | - | - | - | - | - | - | - | - |
| Other[2] | 266 | 193 | 62 | - | - | - | - | - | - |
| Total | 300 | 241 | 81 | 2,629 | 2,665 | 2,809 | 24 | 24 | 0 |

[1]Includes festivals and District bypasses to Lake Michigan.
[2]Includes drinking water.

certified as a Processes to Further Reduce Pathogens (PFRPs). The analytical methods for enteric viruses and *Ascaris* used in the District for the analysis of sludge were published and approved by the USEPA (EPA/625/R-92/013). The *Ascaris* method employs a combination of sieving, flotation, centrifugation, and microscopic analysis to extract and enumerate *Ascaris* ova. The enteric virus method involves the elution of viruses from solids, concentration of the eluates, and an assay for plaque-forming viruses using brilliant green monkey kidney (BGM-K) cells.

COMPLIANCE WITH PART 503 SLUDGE DISPOSAL REGULATIONS

In 1996 the District began monitoring the levels of FC bacteria (see Analytical Microbiology Group Activities above), enteric viruses, and viable *Ascaris* in its dried sludge product for compliance with the Class A biosolids criteria in the Part 503 sludge disposal regulations. Since that time, all biosolids produced by the District's codified process were in compliance with these criteria for shipment and use under the District's Controlled Solids Distribution Program.

In 2000, 44 samples of final product were collected and analyzed for enteric viruses and viable *Ascaris* ova, using USEPA analytical methods, as stated in the Part 503 regulations. All biosolids produced by the District's codified process were determined to be Class A with respect to pathogens. Results of these analyses are shown in Tables 48 and 49.

## CERTIFICATION OF THE DISTRICT'S SPTS

In March 1998 the District submitted a petition to the USEPA's Pathogen Equivalence Committee (PEC) to have its SPTs (at the Stickney and Calumet WRPs) certified as PFRPs, i.e., processes which produce Class A sludge with respect to reducing pathogens. The District requested this certification because this will provide for more disposal and utilization options for Class A sludge under the District's Biosolids Marketing Program. The petition contained analytical data which demonstrated that the District's SPTs, when operated under conditions using codified protocols, do at all times produce Class A final product.

After reviewing the District's petition, the PEC requested that the District collect additional data. Specifically, the PEC requested that 1) large samples of biosolids be analyzed for viable *Ascaris* ova, and 2) the analytical methods used by the District for the petition be validated. The USEPA analytical method for enumerating viruses in sludge was modified by Biovir Laboratories and the District to increase the sensitivity of the method. This modified method was then used

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 48

VIROLOGICAL ANALYSIS OF BIOSOLIDS FOR DISPOSAL IN 2000[1]

| Drying Area | Number Samples Positive/Number Samples Collected | Range[2,3] |
|---|---|---|
| Calumet | 0/28 | <0.3834 - <0.9167 |
| RASMA | 0/3 | <0.3137 - <0.4444 |
| LASMA | 0/1 | <0.3410 |
| Vulcan | 0/3 | <0.3833 - <0.4445 |
| HASMA | 0/4 | <0.4048 - <0.4679 |
| Marathon | 0/2 | <0.4000 - <0.5357 |
| Stony Island | 0/3 | <0.4103 - <0.8573 |

[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.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 49

VIABLE *ASCARIS* OVA ANALYSIS OF BIOSOLIDS FOR DISPOSAL IN 2000[1]

| Drying Area | Number Samples Positive/Number Samples Collected | Range[2,3] |
|---|---|---|
| Calumet | 1/28 | <0.019 - 0.590 |
| RASMA | 1/3 | <0.031 - 0.199 |
| LASMA | 0/1 | <0.189 |
| Vulcan | 0/3 | <0.108 - <0.290 |
| HASMA | 2/4 | <0.127 - 0.379 |
| Marathon | 1/2 | <0.179 - 0.100 |
| Stony Island | 2/3 | <0.247 - 0.123 |

[1]Results of analyses performed in the District's Helminth Laboratory.
[2]Total Viable *Ascaris* per 4 g.
[3]Failure to detect viable Ascaris ova is recorded as less than (<) the limit test sensitivity.

to collect data to support the petition. Data collected in 2000 at the request of the PEC are outlined below.

First, 20 liters of a composited digester feed sample from the Stickney WRP were processed to collect the *Ascaris* ova. A total of 103 viable *Ascaris* ova were collected from the sample and identified. An equivalent portion of final product sample was analyzed for viable *Ascaris* eggs to demonstrate that a two-log reduction in viable *Ascaris* eggs takes place in the Stickney SPTs.

Second, virus levels in Stickney WRP raw sewage and digester feed were determined using the USEPA standard method and the modified method. Six samples of raw sewage and eight samples of digester feed were analyzed. These data are shown in Tables 50 and 51. The results, which are consistent with data previously collected in the District, show that virus levels in raw sewage entering the Stickney WRP are relatively low, and that viruses are concentrated in the digester feed. Virus levels as measured with the District's method were in all cases equal to or greater than the levels measured with the USEPA method.

## Biomonitoring and Toxicity Group Activities

Whole effluent toxicity (WET) tests with fathead minnows (*Pimephales promelas*) and daphnids (*Ceriodaphnia dubia*) were

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TABLE 50

VIRUS[1] LEVELS IN RAW SEWAGE TO STICKNEY WRP - 2000

| Date Collected | PFU/L[2] |
|---|---|
| 5/3/00 | <10.55 |
| 5/3/00 | <10.62 |
| 6/22/00 | <10.625 |
| 6/22/00 | <12.000 |
| 6/27/00 | <12.000 |
| 6/27/00 | <12.000 |

[1]Viruses were eluted from the wastewater solids using the method in Appendix H, *Environmental Regulations and Technology*, EPA/625/R-92,013, revised October 1999. A double overlay plaque assay with BGM-K cells was used for virus detection.
[2]Confirmed plaque forming units per liter.

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TABLE 51

VIRUS[1] LEVELS IN STICKNEY WRP DIGESTER FEED 2000
USEPA STANDARD METHOD VS. MODIFIED METHOD OF DETECTION[2]

| Date Collected | USEPA Standard Method[3] | Modified Method[4] |
|---|---|---|
| 5/04/00 | <0.501 | 1.495 |
| 5/16/00 | 0.361 | 0.503 |
| 5/31/00 | 0.197 | 1.718 |
| 7/03/00 | 8.505 | 13.105 |
| 7/11/00 | 3.371 | 6.949 |
| 8/08/00 | 0.435 | 3.676 |
| 9/14/00 | 0.889 | 1.790 |
| 10/02/00 | 1.837 | 2.093 |
| Mean Value | 2.020 | 3.916 |
| Range | <0.501 - 8.505 | 0.503 - 13.105 |

[1]A double overlay plaque assay with BGM-K cells was used for virus detection.
[2]Confirmed plaque forming units per 4 g.
[3]Viruses were eluted from biosolids using the USEPA approved method, Method D4994-89, ASTM (1992), as published in Appendix H, *Environmental Regulations and Technology*, EPA/625/R-92/013, revised October 1999.
[4]Viruses were eluted from biosolids using a modified method, Method D4994-89, ASTM (1992), as modified by Biovir Laboratories and the District.

conducted on effluent samples from six of the District's WRPs to assess acute and chronic toxicity of effluents. Biomonitoring reports for the Hanover Park, James C. Kirie, John E. Egan and Lemont WRPs were submitted to the IEPA in compliance with the respective NPDES permits. No acute toxicity was observed in any of the effluents. These data are shown in Table 52.

In 2000 the Biomonitoring Laboratory was audited by the District's Quality Control Coordinator and subsequently by an independent Audit Team. The independent team was 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. The Biomonitoring Laboratory is now in the process of implementing the recommendations of the Audit Team.

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TABLE 52

RESULTS[1] OF WET TESTS CONDUCTED ON WRP EFFLUENTS - 2000

| Effluent Tested | Date(s) Collected | WET Test | Results |
|---|---|---|---|
| Calumet WRP | 11/13/00 | Acute *Pimephales promelas* (Survival)<br>Acute *Ceriodaphnia dubia* (Survival) | NTE<br>NTE |
| North Side WRP | 11/27/00 | Acute *Pimephales promelas* (Survival)<br>Acute *Ceriodaphnia dubia* (Survival) | NTE<br>NTE |
| James C. Kirie WRP | 6/6/00 | Acute *Pimephales promelas* (Survival)<br>Acute *Ceriodaphnia dubia* (Survival) | NTE<br>NTE |
| Lemont WRP | 10/24/00 | Acute *Pimephales promelas* (Survival)<br>Acute *Ceriodaphnia dubia* (Survival) | NTE<br>NTE |
| John E. Egan WRP | 12/4/00 | Acute *Pimephales promelas* (Survival)<br>Acute *Ceriodaphnia dubia* (Survival) | NTE<br>NTE |
| Hanover Park WRP | 7/16-21/00 | Chronic *Pimephales promelas*<br>(Survival)<br>(Growth) | NTE<br>NOEC=50% |

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TABLE 52 (Continued)

RESULTS OF WET TESTS CONDUCTED ON WRP EFFLUENTS - 2000

| Effluent Tested | Date(s) Collected | WET Test | Results |
|---|---|---|---|
| Hanover Park WRP (Continued) | | Chronic *Ceriodaphnia dubia*<br>(Survival)<br>(Reproduction) | NTE<br>NOEC=50% |
| | 10/1-6/00 | Chronic *Pimephales promelas*<br>(Survival)<br>(Growth) | NTE<br>NOEC=50% |
| | | Chronic *Ceriodaphnia dubia*<br>(Survival)<br>(Reproduction) | NTE<br>NOEC=50% |

[1]Results: NTE = no toxic effect; NOEC (No Observed Effect Concentration) = percent effluent at which no effect on test organisms is observed

## 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 M&O and Engineering Departments.

### Fish Monitoring

During June through September, 2000, fish were collected by electrofishing at 25 monitoring stations in the deep-draft reaches of the Chicago and Calumet Waterway Systems (Figure 25). During this time, specialists identified, weighed, and measured for length 1,847 fish. The fish were also examined for parasites and disease. In 2000, 31 species of fish were identified from the North Shore Channel, North and South Branches of the Chicago River, Chicago River, Chicago Sanitary and Ship Canal, Calumet River, Little Calumet River, and the

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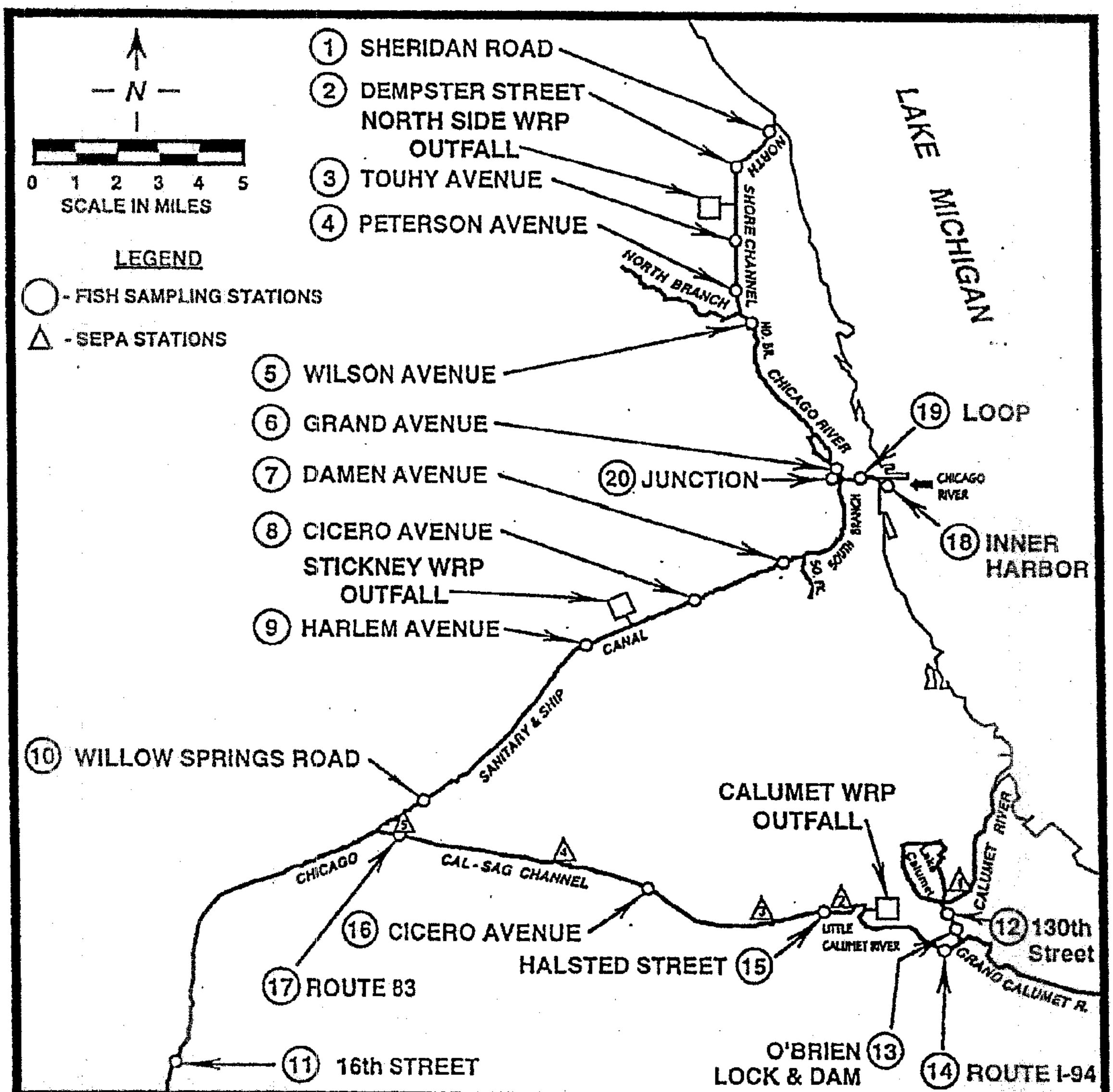
FIGURE 25

FISH MONITORING STATIONS IN THE
CHICAGO AND CALUMET WATERWAY SYSTEMS



Cal-Sag Channel. The most abundant fish species collected during the 2000 surveys included bluegill sunfish, carp, emerald shiners, gizzard shad, and largemouth bass (Table 53). Seventeen different species of game fish were collected in the deep-draft waterways during 2000.

Forty-four composite samples of fish fillets from selected deep-draft segments in the Chicago and Calumet Waterway Systems were provided to the IEPA for the annual Illinois sport fish consumption advisory report.

## Benthic Invertebrate Monitoring

The IEPA is conducting a Use Attainability Analysis on the lower Des Plaines River from the Lockport lock to the Interstate 55 bridge. Included in this analysis is a biological assessment of the benthic invertebrates in the lower Des Plaines River.

During the summer of 2000, benthic invertebrates were collected from one station in the Chicago Sanitary and Ship Canal and nine stations in the Des Plaines River. Sediment samples were collected using a Ponar Grab and Hester-Dendy artificial substrates.

The total number of benthic species identified in the study area ranged from a low of 18 species in the Lockport navigational pool to a high of 47 in the Dresden Island pool.

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TABLE 53

FISH DISTRIBUTION IN THE CHICAGO AND CALUMET WATERWAY SYSTEMS - 2000

| Waterway | Total Number of Fish | Total Number of Species | Dominant Fish |
|---|---|---|---|
| North Shore Channel | 491 | 12 | Gizzard shad, Largemouth bass & Bluegill |
| North Branch Chicago River | 78 | 10 | Bluegill, Carp, Green sunfish, & Largemouth bass |
| Chicago River | 74 | 8 | Gizzard shad, Carp, & Largemouth bass |
| South Branch Chicago River | 48 | 7 | Carp, Gizzard shad, & Largemouth bass |
| Chicago Sanitary and Ship Canal | 254 | 8 | Gizzard shad & Carp |
| Calumet River | 295 | 17 | Gizzard shad, Bluntnose minnow, & Largemouth bass |
| Little Calumet River | 264 | 22 | Gizzard shad, Carp, & Largemouth bass |
| Cal-Sag Channel | 343 | 17 | Emerald shiner, Carp, Largemouth bass, & Yellow bass |

Overall, the benthic invertebrate community was dominated by pollution tolerant oligochaete worms and chironomid midge larvae (Table 54).

These organisms indicate poor sediment quality and physical habitat limitations. It should be noted that the composition of the benthic community was more balanced (worms, midges, caddisflies, and clams) in the Dresden Island pool compared to the Lockport and Brandon Road pools, indicating improved sediment quality.

## Illinois Waterways Water/Sediment Quality Survey

In 1984, the R&D 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.

Historically, water samples were collected annually during May, August, and October from each of 49 sampling stations. Sediment samples were collected at 14 stations during October. Similar studies were conducted during 2000.

The mean DO and $NH_4$-N levels measured at 11 selected stations in the six navigational pools (Lockport, Brandon Road,

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 54

BENTHIC INVERTEBRATE COMMUNITY CHARACTERISTICS
IN THE LOCKPORT, BRANDON ROAD, AND DRESDEN ISLAND NAVIGATIONAL POOLS
JULY - AUGUST 2000

| Navigational Pool | Total Number of Taxa | Mean Number of Individuals (numbers/$m^2$) | Oligochaete Worms (% of total community) | Dominant Benthic Group(s) |
|---|---|---|---|---|
| Lockport | 18 | 340,273 | 98.6 | Worms |
| Brandon Road | 21 | 9,384 | 79.8 | Worms and midges |
| Dresden Island | 47 | 11,624 | 51.5 | Worms, midges, and caddisflies |

Dresden Island, Marseilles, Starved Rock, and Peoria) during May, August, and October 2000 are presented in Table 55.

During 2000, the mean DO concentration increased substantially along the waterways from the Lockport pool (mean = 5.2 mg/L) to the Peoria pool (mean = 8.2 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 $NH_4$-N concentration decreased considerably from the Lockport pool (mean = 0.48 mg/L) to the Peoria pool (mean = 0.14 mg/L) during the 2000 surveys. Nutrient uptake by floating algae, attached periphyton, and rooted aquatic vegetation resulting in primary production, instream nitrification, and dilution from the Kankakee River may account for the decrease in ammonium nitrogen along the waterways.

## Continuous Monitoring of Dissolved Oxygen

To better understand the oxygen dynamics in Chicago area deep-draft waterways, the R&D Department developed a comprehensive DO field monitoring program. A two-year monitoring program in the Chicago Waterway System was initiated in August 1998 and continued through July 2000. The purpose of this monitoring is to aid the District in achieving its long range

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 55

MEAN CONCENTRATION OF DO AND $NH_4$-N MEASURED AT SELECTED SAMPLING STATIONS IN NAVIGATIONAL POOLS OF THE ILLINOIS WATERWAY - 2000[1]

| Station Number | Navigational Pool | DO (mg/L) | $NH_4$-N (mg/L) |
|---|---|---|---|
| 1 | Lockport | 5.2 | 0.48 |
| 3 | Brandon Road | 6.4 | 0.32 |
| 8 | Dresden Island | 7.5 | 0.30 |
| 15 | Marseilles | 8.9 | 0.15 |
| 20 | Marseilles | 9.0 | 0.11 |
| 24 | Starved Rock | 9.2 | 0.09 |
| 29 | Peoria | 10.1 | 0.08 |
| 35 | Peoria | 10.0 | 0.09 |
| 40 | Peoria | 9.5 | 0.13 |
| 45 | Peoria | 8.1 | 0.13 |
| 49 | Peoria | 8.2 | 0.14 |

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

goal of having DO levels comply with or exceed the ICPB standards for DO 100 percent of the time.

DO is measured hourly using remote (in situ) water quality monitors deployed in protective stainless steel housing units. The monitors are located at 20 stations in the waterways from the Wilmette Pumping Station on the North Shore Channel to the Lockport Powerhouse on the Chicago Sanitary and Ship Canal.

The number and percentage of DO values measured with the monitors during the period of January through July 2000 that were above the IPCB's DO standards are presented in Table 56.

During the seven-month monitoring period of January through July 2000, the stations that recorded the lowest percentage of DO values above the IPCB DO standards were Simpson and Linden in the North Shore Channel (32 and 38 percent, respectively). Overall during the seven-month monitoring period, 83,111 of 96,458 DO measurements (86 percent) in the deep-draft Chicago Waterway System either met or exceeded the IPCB's DO water quality standards.

During 2001, a two-year DO monitoring program will be initiated at 13 stations in the Calumet River, Grand Calumet River, Little Calumet River, and the Cal-Sag Channel.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 56

NUMBER AND PERCENT OF DO VALUES MEETING OR EXCEEDING IPCB WATER QUALITY STANDARDS IN THE DEEP-DRAFT CHICAGO WATERWAY SYSTEM JANUARY - JULY 2000[1]

| DO Monitoring Location | Standard (mg/L) | Number of DO Values Equal to Number of DO Values | Percent of DO Values Meeting or Exceeding IPCB Standard | or Exceeding IPCB Standard |
|---|---|---|---|---|
| | | North Shore Channel | | |
| Linden | 5.0 | 4,019 | 1,529 | 38 |
| Simpson | 5.0 | 2,670 | 846 | 32 |
| Main | 5.0 | 4,377 | 2,810 | 64 |
| Devon | 4.0 | 4,699 | 4,696 | >99 |
| | | North Branch of the Chicago River | | |
| Lawrence | 4.0 | 5,205 | 5,203 | >99 |
| Addison | 4.0 | 5,205 | 5,198 | >99 |
| Fullerton | 4.0 | 5,199 | 4,892 | 94 |
| Division | 4.0 | 5,205 | 5,142 | 99 |
| Kinzie | 4.0 | 4,862 | 4,788 | 98 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 56 (Continued)

NUMBER AND PERCENT OF DO VALUES MEETING OR EXCEEDING IPCB WATER QUALITY STANDARDS
IN THE DEEP-DRAFT CHICAGO WATERWAY SYSTEM
JANUARY - JULY 2000[1]

| DO Monitoring Location | Standard (mg/L) | Number of DO Values Equal to Number of DO Values | Percent of DO Values Meeting or Exceeding IPCB Standard | or Exceeding IPCB Standard |
|---|---|---|---|---|
| | | Chicago River | | |
| Clark | 5.0 | 5,205 | 4,685 | 90 |
| | | South Branch of the Chicago River | | |
| Jackson | 4.0 | 5,033 | 4,793 | 95 |
| Loomis | 4.0 | 4,863 | 4,713 | 97 |
| | | Bubbly Creek | | |
| I-55 | 4.0 | 4,977 | 2,758 | 55 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 56 (Continued)

NUMBER AND PERCENT OF DO VALUES MEETING OR EXCEEDING IPCB WATER QUALITY STANDARDS
IN THE DEEP-DRAFT CHICAGO WATERWAY SYSTEM
JANUARY - JULY 2000[1]

| DO Monitoring Location | Standard (mg/L) | Number of DO Values Equal to Number of DO Values | Percent of DO Values Meeting or Exceeding IPCB Standard | or Exceeding IPCB Standard |
|---|---|---|---|---|
| | | Chicago Sanitary and Ship Canal | | |
| Cicero | 4.0 | 4,687 | 3,674 | 78 |
| B&O RR | 4.0 | 5,194 | 5,121 | 99 |
| Rt 83 | 4.0 | 4,867 | 4,479 | 92 |
| Mile 302.6 | 4.0 | 4,869 | 4,677 | 96 |
| Romeoville | 4.0 | 5,222 | 4,199 | 80 |
| Lockport | 4.0 | 4,881 | 3,710 | 76 |
| | | Cal-Sag Channel | | |
| Rt 83 | 3.0 | 5,199 | 5,198 | >99 |

[1]DO 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 2000 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 biosolids from its seven WRPs. It determines levels of 111 organic priority pollutants following USEPA 600 Series Methods.

Tables 57, 58, and 59 present the average concentrations of the compounds found in District raw sewage, final effluent, and biosolids samples, respectively. The data represent two sets of samples taken in January and July 2000.

The highest values of purgeable compounds or VOCs observed in the raw sewage were 70 µg/L of chloroform and 44 µg/L of toluene at the Lemont WRP.

The highest values of purgeable compounds found in the final effluent were for chloroform in concentrations of 18 µg/L and 11 µg/L at the Lemont and Hanover Park WRPs, respectively.

The highest values of purgeable compounds in the biosolids samples were for toluene in concentrations of 91.9 mg/Kg and 30.4 mg/Kg dry weight (based on the solids content), at the Lemont and Hanover Park WRPs, respectively.

The highest values of base/ neutral/ acid extractable (BNA) compounds in the raw sewage were phenol in concentrations of 32 µg/L and 16 µg/L at the Calumet and Hanover Park

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 57

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT RAW SEWAGE - 2000

| 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 |
| Purgeable | | | | | | | | | |
| Benzene | 1 | 19 | ND | ND | ND | ND | ND | 2 | ND |
| Chloroform | 1 | 2 | 4 | 4 | 4 | 70 | 3 | 2 | 4 |
| Ethyl benzene | 2 | 2 | ND | ND | ND | ND | 2 | ND | ND |
| Methylene chloride | 2 | 4 | 2 | 8 | 4 | 8 | 16 | 7 | 3 |
| Tetrachloroethylene | 2 | ND | ND | 9 | ND | 4 | 9 | ND | ND |
| Toluene | 2 | 27 | 8 | 14 | ND | 44 | 9 | 6 | 5 |
| Trichloroethylene | 2 | ND | ND | 2 | ND | ND | ND | ND | ND |
| Base/Neutral/Acid Extractable | | | | | | | | | |
| Phenol | 1 | 32 | 2 | 16 | 2 | 3 | 1 | ND | ND |
| Bis(2-ethylhexyl)phthalate | 25 | ND | 26 | ND | 28 | 39 | ND | ND | ND |
| Diethyl phthalate | 3 | ND | 8 | 8 | 8 | ND | 6 | ND | 4 |
| Di-n-butyl phthalate | 3 | ND | 4 | ND | ND | ND | ND | ND | 4 |
| Phenanthrene | 1 | 1 | ND | ND | ND | ND | ND | ND | ND |
| Pesticides and PCBs | | | | | | | | | |
| None Found | | | | | | | | | |

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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 58

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT FINAL EFFLUENT - 2000

| Type of Compound | Reporting Limit µg/L | Values in µg/L (ppb)[1] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Calumet | Egan | Hanover Park | Kirie | Lemont | North Side | Stickney |
| **Purgeable** | | | | | | | | |
| Chlorodibromomethane | 2 | ND | 4 | ND | ND | ND | ND | ND |
| Chloroform | 1 | 1 | 4 | 11 | 1 | 18 | 1 | 2 |
| Dichlorobromomethane | 1 | ND | 4 | 3 | ND | ND | ND | ND |
| Methylene chloride | 2 | 2 | ND | ND | ND | ND | 3 | ND |
| **Base/Neutral/Acid Extractable** | | | | | | | | |
| Di-n-butyl phthalate | 3 | ND | ND | ND | ND | ND | ND | 4 |
| Di-n-octyl phthalate | 3 | ND | ND | 17 | ND | ND | ND | ND |
| **Pesticides and PCBs** | | | | | | | | |
| None Found | | | | | | | | |

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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 59

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT BIOSOLIDS - 2000

| Type of Compound | Values in mg/Kg (ppm)[1] | | | | | | |
|---|---|---|---|---|---|---|---|
| | Calumet | Egan | Hanover Park | Kirie | Lemont | North Side | Stickney |
| (Average Solids) | (2.56%) | (2.88%) | (1.56%) | (0.71%) | (2.40%) | (1.72%) | (3.82%) |
| Purgeables | | | | | | | |
| Benzene | 0.80 | ND | ND | ND | ND | ND | ND |
| Dichlorobromomethane | ND | ND | ND | ND | ND | 0.06 | ND |
| Ethyl benzene | 0.12 | ND | ND | ND | ND | 0.12 | ND |
| Methyl chloride | ND | ND | ND | ND | 0.75 | ND | ND |
| Methylene chloride | ND | ND | ND | ND | 2.50 | 0.70 | ND |
| Tetrachloroethylene | ND | ND | ND | ND | ND | 0.81 | ND |
| Toluene | 4.49 | 0.76 | 30.4 | ND | 91.9 | 8.37 | 1.62 |
| Trichloroethylene | ND | ND | ND | ND | ND | 0.12 | ND |
| Base/Neutral/Acid Extractable | | | | | | | |
| Phenol | ND | ND | ND | ND | 3.08 | ND | ND |
| Benzo(a)anthracene | 1.64 | ND | ND | ND | ND | ND | ND |
| Benzo(a)pyrene | 2.03 | ND | ND | ND | ND | ND | ND |
| 3,4-Benzofluoranthene | 2.34 | ND | ND | ND | ND | ND | ND |
| Benzo(k)fluoranthene | 1.84 | ND | ND | ND | ND | ND | ND |
| Bis(2-ethylhexyl)phthalate | 202 | ND | ND | ND | 37.7 | ND | 40.3 |
| Chrysene | 1.80 | ND | ND | ND | ND | ND | 1.31 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 59 (Continued)

ANALYSIS OF ORGANIC PRIORITY POLLUTANTS IN DISTRICT BIOSOLIDS - 2000

| Type of Compound | Values in mg/Kg (ppm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | Calumet | Egan | Hanover Park | Kirie | Lemont | North Side | Stickney |
| (Average Solids) | (2.56%) | (2.88%) | (1.56%) | (0.71%) | (2.40%) | (1.72%) | (3.82%) |
| <u>Base/Neutral/Acid Extractable (Cont'd)</u> | | | | | | | |
| Fluoranthene | 3.71 | 3.06 | 0.90 | ND | ND | 1.98 | 2.93 |
| Phenanthrene | 3.24 | 1.08 | ND | ND | 0.75 | 1.45 | 1.31 |
| Pyrene | 2.50 | 1.67 | ND | ND | 0.83 | ND | 1.88 |

Pesticides and PCBs

None Found.

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

WRPs, respectively, and bis(2-ethylhexyl)phthalate in a concentration of 39 μg/L at the Lemont WRP.

The highest value of BNA compounds for the final effluents was di-n-octyl phthalate in a concentration of 17 μg/L at the Hanover Park WRP.

The highest values of BNA compounds detected in the biosolids were bis(2-ethylhexyl)phthalate in concentrations of 202 mg/Kg and 40.3 mg/Kg dry weight (based on solids content) at the Calumet and Stickney WRPs, respectively.

No pesticides or PCBs were found in any final effluent, raw sewage, or biosolids samples.

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

1. Only six of the 111 listed organic priority pollutants were detected in the final effluent samples: four of the 30 purgeable compounds (chlorodibromomethane, chloroform, dichlorobromomethane, and methylene chloride), two of the 57 BNA extractable compounds (di-n-butyl phthalate and 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, tetra-chloroethylene, toluene, trichloroethylene, phenol, bis(2-ethylhexyl)phthalate, diethyl phthalate, and phenanthrene.

3. Other compounds (methylene chloride and di-n-butyl 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. The final effluent of all the seven WRPs had lower concentrations than found in the raw sewage with the exception of the Hanover Park WRP. This could be due to the disinfection process. Chlorodibromomethane and dichlorobromomethane could be the by-products from the disinfection process as well, since they were only present in the final effluents.

<u>Monitoring of Non-Listed Organic Compounds in District WRPs</u>

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 biosolids at District WRPs. These compounds were detected in the samples taken in January and July 2000.

The non-listed purgeable compounds found were solvents, hydrocarbons, and products from anaerobic biological degradation. Only two purgeable compounds occurred three times in District WRP effluents, whereas 19 compounds occurred 93 times in raw sewage samples. This indicates excellent removal efficiencies for these compounds during the treatment process.

Fifty-three non-listed BNA compounds were found in District WRP samples during 2000. The majority of these compounds come from human and animal wastes, industrial waste, and gasoline and/or oil derivatives. Seven compounds occurred 22 times in the effluents, whereas 50 compounds occurred 484 times in the raw sewage, indicating good removal efficiencies of many of these compounds during the wastewater treatment process. Table 60 shows the frequency of occurrence of non-listed organic compounds in District WRP samples during 2000.

## 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

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TABLE 60

FREQUENCY OF NON-LISTED ORGANIC COMPOUNDS IN DISTRICT WRP SAMPLES - 2000

| Type of Compound | Raw Sewage 16 Samples[1] | | Effluent 14 Samples[1] | | Biosolids 14 Samples[1] | |
|---|---|---|---|---|---|---|
| | Times Found | (%) | Times Found | (%) | Times Found | (%) |
| Purgeable | | | | | | |
| Labile sulfide group | 3 | 19 | 0 | 0 | 7 | 50 |
| Acetone | 16 | 100 | 0 | 0 | 11 | 79 |
| Dimethyl sulfide | 11 | 69 | 1 | 7 | 8 | 57 |
| Carbon disulfide | 1 | 6 | 0 | 0 | 2 | 14 |
| Methyl acetate | 6 | 38 | 0 | 0 | 11 | 79 |
| Tetrahydrofuran | 4 | 25 | 2 | 14 | 2 | 14 |
| 2-Butanone (MEK) | 2 | 12 | 0 | 0 | 1 | 7 |
| Ethyl acetate | 3 | 19 | 0 | 0 | 0 | 00 |
| 4-Methyl-2-pentanone | 1 | 6 | 0 | 0 | 0 | 00 |
| Isopropylbenzene (Cumene) | 2 | 12 | 0 | 0 | 2 | 14 |
| Xylenes | 5 | 31 | 0 | 0 | 2 | 14 |
| Styrene | 2 | 12 | 0 | 0 | 1 | 7 |
| t-Butylbenzene | 2 | 12 | 0 | 0 | 2 | 14 |
| n-Propylbenzene | 2 | 12 | 0 | 0 | 2 | 14 |
| 2-Ethyltoluene | 5 | 31 | 0 | 0 | 2 | 14 |
| 3-and/or 4-Ethyltoluene | 6 | 38 | 0 | 0 | 4 | 29 |
| Nonane | 1 | 6 | 0 | 0 | 3 | 21 |
| Limonene | 15 | 94 | 0 | 0 | 9 | 64 |
| 4-Isopropyltoluene | 6 | 38 | 0 | 0 | 9 | 64 |
| Base/Neutral/Acid Extractable | | | | | | |
| 2-Methyl propanoic acid | 2 | 12 | 0 | 0 | 1 | 7 |
| Butanoic acid | 12 | 75 | 0 | 0 | 3 | 21 |
| 3-Methyl butanoic acid | 13 | 81 | 0 | 0 | 4 | 29 |
| 2-Methyl butanoic acid | 8 | 50 | 0 | 0 | 3 | 21 |
| Pentanoic acid | 14 | 88 | 0 | 0 | 3 | 21 |
| Ethylene glycol butyl ether | 16 | 100 | 0 | 0 | 0 | 00 |
| Aniline | 3 | 19 | 0 | 0 | 0 | 00 |
| Decane | 0 | 00 | 1 | 17 | 2 | 14 |
| Benzyl alcohol | 13 | 81 | 0 | 0 | 0 | 00 |
| o-Cresol | 2 | 12 | 0 | 0 | 0 | 00 |
| Acetophenone | 1 | 6 | 0 | 0 | 0 | 00 |
| m-and/or p-Cresol | 13 | 81 | 0 | 0 | 4 | 29 |
| Hexanoic acid | 12 | 75 | 0 | 0 | 2 | 14 |
| Undecane | 13 | 81 | 0 | 0 | 7 | 50 |
| Heptanoic acid | 2 | 12 | 0 | 0 | 2 | 14 |

TABLE 60 (Continued)

FREQUENCY OF NON-LISTED ORGANIC COMPOUNDS IN DISTRICT WRP SAMPLES - 2000

| Type of Compound | Raw Sewage 16 Samples[1] Times Found | (%) | Effluent 14 Samples[1] Times Found | (%) | Biosolids 14 Samples[1] Times Found | (%) |
|---|---|---|---|---|---|---|
| Base/Neutral/Acid Extractable (Continued) | | | | | | |
| Benzoic acid | 8 | 50 | 1 | 7 | 0 | 00 |
| Octanoic acid | 9 | 56 | 0 | 0 | 4 | 29 |
| Dodecane | 6 | 38 | 0 | 0 | 8 | 57 |
| Diethylene glycol butyl ether | 14 | 88 | 0 | 0 | 0 | 00 |
| α-Terpineol | 16 | 100 | 0 | 0 | 0 | 00 |
| p-Chloroaniline | 0 | 00 | 0 | 0 | 2 | 14 |
| Phenyl acetic acid | 15 | 94 | 0 | 0 | 11 | 79 |
| Nonanoic acid | 10 | 63 | 2 | 14 | 3 | 21 |
| Tridecane | 9 | 56 | 0 | 0 | 7 | 50 |
| 2-Methylnaphthalene | 2 | 12 | 0 | 0 | 0 | 00 |
| 1-H-Indole | 9 | 50 | 0 | 0 | 4 | 29 |
| 1-Phenylpropanoic acid | 8 | 50 | 0 | 0 | 4 | 29 |
| Decanoic acid | 10 | 63 | 0 | 0 | 2 | 14 |
| Tetradecane | 11 | 69 | 0 | 0 | 9 | 64 |
| Undecanoic acid | 0 | 00 | 0 | 0 | 1 | 7 |
| N,N-Dimethyl-1-dodecanamine | 14 | 88 | 0 | 0 | 8 | 57 |
| Pentadecane | 5 | 31 | 0 | 0 | 8 | 57 |
| Dimethylnaphthalene isomers | 1 | 6 | 0 | 0 | 0 | 00 |
| Dodecanol | 15 | 94 | 0 | 0 | 13 | 93 |
| Trimethylnaphthalene isomers | 2 | 13 | 0 | 0 | 2 | 14 |
| Dodecanoic acid | 16 | 100 | 0 | 0 | 10 | 71 |
| Hexadecane | 9 | 56 | 0 | 0 | 6 | 43 |
| Tridecanoic acid | 5 | 31 | 0 | 0 | 1 | 7 |
| Heptadecane | 9 | 56 | 0 | 0 | 10 | 71 |
| 1-Tetradecanol | 12 | 75 | 0 | 0 | 2 | 14 |
| Tetradecanoic acid | 16 | 100 | 0 | 0 | 8 | 57 |
| Nonyl phenol isomers | 14 | 88 | 0 | 0 | 12 | 86 |
| Octadecane | 5 | 31 | 0 | 0 | 0 | 00 |
| Caffeine | 16 | 100 | 0 | 0 | 0 | 00 |
| Pentadecanoic acid | 12 | 75 | 0 | 0 | 5 | 36 |
| Carbazole | 2 | 13 | 0 | 0 | 1 | 7 |
| Nonadecane | 8 | 50 | 0 | 0 | 3 | 21 |
| 1-Hexadecanol | 12 | 75 | 0 | 0 | 2 | 14 |
| cis-9-Hexadecenoic acid | 6 | 38 | 1 | 7 | 0 | 00 |
| Hexadecanoic acid | 16 | 100 | 8 | 57 | 14 | 100 |
| Heptadecanoic acid | 6 | 38 | 0 | 0 | 1 | 7 |
| z-9-Octadecenoic acid | 16 | 100 | 5 | 36 | 11 | 79 |

TABLE 60 (Continued)

FREQUENCY OF NON-LISTED ORGANIC COMPOUNDS IN DISTRICT WRP SAMPLES - 2000

| Type of Compound | Raw Sewage 16 Samples[1] | | Effluent 14 Samples[1] | | Biosolids 14 Samples[1] | |
|---|---|---|---|---|---|---|
| | Times Found | (%) | Times Found | (%) | Times Found | (%) |
| Base/Neutral/Acid Extractable (Continued) | | | | | | |
| Octadecanoic acid | 16 | 100 | 4 | 29 | 12 | 86 |

[1]Represents two sampling cycles (January and July 2000) for each of the seven WRPs (n = 14), with the Stickney WRP having two influents (n = 16 for raw sewage).

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 2000 were from Calumet West, Calumet East, and LASMA. 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 District raw sewage samples.

Raw sewage samples were collected once per month at each of the District's seven WRPs during 2000, 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. Results from the raw sewage sampling are presented in Table 61.

As part of the District's support for this study, the Toxic Substances Section purchased a preconcentrator/gas chromatograph/ mass spectrometer system in late 1998. This system is used to determine the actual VOC emissions by direct measurement from the various WRPs. During 1999 and 2000, standards of the target analytes were purchased and diluted, calibration files were made for these analytes, and contamination problems were resolved. A limited number of grab samples of air were collected at Egan WRP to test the instrumentation. In the year 2001, air samples will be taken at other District's WRPs from various unit processes or at various strategic places within the WRPs to obtain a better overall picture of the VOC emissions from these locations.

## 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.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 61

CLEAN AIR ACT LIST OF ORGANIC COMPOUNDS IN DISTRICT RAW SEWAGE[1] - 2000

| Compounds | Reporting Limit µg/L | Values in µg/L (ppb) Calumet | Egan | Hanover Park | Kirie | Lemont | North Side | Stickney Southwest | Stickney West Side |
|---|---|---|---|---|---|---|---|---|---|
| Acetaldehyde | 58 | ND | ND | ND | ND-133 | ND | ND | ND-77 | ND |
| Acetophenone | 3 | 9-62 | ND | ND | ND-7 | ND | ND | ND | ND |
| Benzene | 1 | 8-44 | ND | ND | ND | ND | ND | 1-5 | ND |
| Biphenyl | 2 | ND | ND | ND | ND | ND | ND | 2-4 | ND |
| Carbon disulfide | 4 | ND | ND | ND | 4-6 | ND | ND | ND | ND |
| Chloroform | 1 | 2-3 | 3-6 | 2-7 | 2-5 | 5-110 | 3-4 | 1-4 | 4-5 |
| o-Cresol | 3 | 3-14 | ND | ND | ND | ND | ND | ND | ND |
| m- and/or p-Cresol | 3 | 9-95 | 3-32 | 5-57 | 4-61 | 3-215 | 7-31 | 4-14 | 5-26 |
| Total Cresols/Cresylic Acid | 3 | 5-107 | 3-32 | 5-57 | 4-61 | 3-215 | 7-31 | 4-14 | 5-26 |
| Cumene | 2 | 2-16 | ND | ND | ND | ND | ND | ND | ND |
| 2,4-D, salts and esters | 0.8 | ND-9.8 | ND-4.0 | ND | ND | ND | ND | ND | ND |
| DDE | 0.05 | ND | ND | ND | 0.05-0.17 | ND | ND | ND-0.06 | ND |
| Ethyl benzene | 2 | 2-5 | ND | ND | ND | ND | 2-3 | ND-2 | ND |
| Ethylene dichloride | 2 | ND | ND | ND | ND-6 | ND | ND-2 | ND | ND |
| Hexane | 3 | ND-3 | ND | ND | ND | ND | ND | ND | ND |
| Isophorone | 2 | ND | ND | ND | ND-5 | ND | ND | ND | ND |
| γ-BHX (Lindane) | 0.03 | ND | ND | ND | ND | ND-0.03 | ND | ND | ND |
| δ-BHX | 0.04 | ND-0.04 | ND | ND | ND-0.04 | ND | ND | ND | ND |
| Total BHC | 0.03 | ND-0.04 | ND | ND | ND-0.04 | ND-0.03 | ND | ND | ND |
| Methoxychlor | 0.15 | ND | ND | ND-0.31 | ND | ND | ND | ND | ND |
| Methyl chloride | 3 | ND | ND-4 | ND-3 | ND-4 | ND | ND | ND | ND |
| Methyl ethyl ketone | 6 | 6-14 | ND | ND | 7-18 | ND-8 | 7-10 | 6-14 | 6-14 |
| Methyl isobutyl ketone | 3 | 4-7 | ND | ND | ND | ND | ND | ND-6 | 4-5 |
| Methylene chloride | 2 | 2-19 | 2-6 | 3-12 | 2-14 | 2-20 | 2-27 | 2-10 | 2-7 |
| Naphthalene | 2 | 2-9 | ND | ND | ND | ND | ND | 4-6 | ND-2 |
| Styrene | 2 | 2-17 | ND | ND | ND | ND-3 | 2-7 | 2-3 | ND-4 |
| Tetrachloroethene | 2 | 2-4 | ND-2 | 2-26 | ND-4 | 2-4 | 2-20 | ND-3 | 2-4 |
| Toluene | 2 | 8-40 | 2-11 | 3-23 | 2-4 | 6-451 | 2-25 | 2-21 | 2-10 |
| Trichloroethene | 2 | ND-2 | ND | 2-20 | ND | ND | 2-8 | 2-3 | ND-2 |

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 61 (Continued)

CLEAN AIR ACT LIST OF ORGANIC COMPOUNDS IN DISTRICT RAW SEWAGE[1] - 2000

| Compounds | Reporting Limit µg/L | Values in µg/L (ppb) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Calumet | Egan | Hanover Park | Kirie | Lemont | North Side | Stickney Southwest | Stickney West Side |
| o-Xylenes | 2 | 2-7 | ND | ND | ND | ND | 2-6 | ND-2 | ND-2 |
| m-and/or p-Xylenes | 3 | 3-19 | ND | ND | 4-5 | ND | 3-14 | 3-4 | 3-5 |
| Total Xylenes | 2 | 3-26 | ND | ND | 4-5 | ND | 2-20 | 2-6 | 2-7 |

[1]Based on a 12 month study from January through December 2000.
ND = Not Detected.

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 62.

## Environmental Monitoring

Environmental monitoring projects include analysis of samples taken from:

- Lake Michigan during diversion of river waters following storm related events;
- discharge of diverted river waters into the O'Hare CUP reservoir;
- sludge and soil projects;
- spills;

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 62

NUMBER OF SAMPLES AND ANALYSES PERFORMED BY INDUSTRIAL WASTE CATEGORY - 2000

| | Categories of Analyses | Analysis Type | # of Analytes | # of Samples | # of Analyses |
|---|---|---|---|---|---|
| 413 | Electroplating | VOC, BNA, PP | 113 | 16 | 1808 |
| 414 | Organic Chemicals and Plastics | VOC, BNA | 42 | 17 | 714 |
| 430 | Pulp, Paper and Paperboard | BNA | 3 | 2 | 6 |
| 433 | Metal Finishing | VOC, BNA, PP | 113 | 55 | 6215 |
| 464-25A | Metal Molding and Casting | VOC, BNA | 4 | 1 | 4 |
| 467 | Aluminum Forming | VOC, BNA, PP | 50 | 3 | 150 |
| 468 | Copper Forming | VOC, BNA | 12 | 1 | 12 |
| 469-16 | Electrical and Electronic Components | VOC, BNA | 37 | 1 | 37 |
| 469-26 | Electrical and Electronic Components | VOC, BNA | 37 | 1 | 37 |
| | PCBs Only | PP | 6 | 16 | 96 |
| | Surveillance | VOC, BNA, PP | 125 | 10 | 1250 |
| | Trip Blanks | VOC | 33 | 29 | 957 |
| | Totals | | | 152 | 11,286 |

- 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), UV/visible, or infrared spectroscopy.

DIVERSION OF WATER TO LAKE MICHIGAN

Diversion of water to Lake Michigan occurred only once in 2000, September 12, at two sites near Calumet Harbor, Ewing Bridge and the 95th Street Bridge. Three samples at each bridge were collected. All six samples contained chloroform, ranging from 1 to 4 µg/L. The Ewing Bridge water samples also showed 2,4,6-trichlorophenol at 3 and 4 µg/L in two of the samples, while the other sample contained naphthalene at 7 µg/L and phenanthrene at 2 µg/L. One of the 95th Street Bridge samples contained only chloroform, while the other two water samples contained just one additional compound, 2,4,6-tri-chlorophenol at 4 µg/L in one and bis(2-ethylhexyl)phthalate at 126 µg/L in the other.

BIOSOLIDS DEMONSTRATION PROJECT AT THE USX SITE

Evaluation of the water quality in monitoring wells on the USX site was started in 2000 and 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 twice in 2000, and will continue doing quarterly analyses in 2001. The results of the analyses were supplied to the Land Reclamation and Soil Science Section.

Toxic Substances Quality Control/Quality Assurance Program

The extensive quality control/quality assurance (QA/QC) program continued in 2000 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 more than 900 GC/MS purgeable runs, 900 GC/MS BNA runs, and 800 GC/ECD pesticides/PCBs and herbicides runs.

COMPLIANCE WITH PROTOCOLS

The QA/QC program applied USEPA protocols when checking instruments and developing calibration curves for the determination of listed BNAs, VOCs, pesticides, PCBs, and herbicides. Protocols also included analysis of water blanks, equipment blanks, check standards, spike recovery of pollutant standards, and surrogates from samples and reagent water.

The USEPA 600 series analytical methods used in the analysis of the target compounds (i.e., Methods 608, 624, and 625) and the ASTM *Standard Methods* 6640B, comply with the standardized quality assurance and quality control as specified in these methods. 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 method detection limit (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 2000.

PERFORMANCE EVALUATION STUDIES

When the USEPA stopped supplying Water Pollution Performance Evaluation Study samples, participating laboratories were required to purchase these samples from approved 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 four 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 program 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, monthly 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 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). The radioactive substances limits for the effluents discharged to the waters of the State for gross beta activity in the known absence of more than 3 pCi/L alpha emitters and more than 10 pCi/L strontium-90 is not to exceed 1,000 pCi/L at any time. Although the present NPDES permits from the IEPA do not include limits for radioactivity in the District's effluents, monitoring continued into 2000 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. 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;
- leak testing an X-ray fluorescent (XRF) paint analyzer; 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 2000, 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, users of moisture/density gauges, and the XRF paint analyzer. A total of 192 dosimeters were analyzed in 2000. 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 2000. 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 the radioactive sealed sources possessed by the District were tested for leakage twice in 2000.

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 2000:

| | |
|---|---|
| Hewlett-Packard S-11225 | 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 the Campbell Pacific Nuclear moisture/density gauge owned by the R&D Department, four Troxler surface moisture/density gauges used by the Construction Division of the Engineering Department, and an XRF paint analyzer owned by the M&O Department. A total of 22 leak tests were performed in 2000. No leaks were detected in any of these gauges.

## 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 125 other 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 2000, 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 one soil sample 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 2000, since 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 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 *Standard Methods for the Examination of Water and Wastewater, (Standard Methods)*, 20th Edition procedures, 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 americium-241, and for beta efficiency using cesium-137 standards obtained from the USEPA Environmental Monitoring System Laboratory in Las Vegas, Nevada.

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. 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 63 presents 2000 yearly averages of gross alpha radioactivity for the raw sewage, and final effluent from the District's seven WRPs. With the exception of the Lemont WRP, average raw sewage gross alpha radioactivity at all the WRPs was less than the LLD (4.5 to 5.2 pCi/L). The gross alpha radioactivity at the Lemont WRP was 44.4 pCi/L. The gross alpha radioactivity in the final effluent at all the WRPs was less than the LLD (4.1 to 7.9 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

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TABLE 63

AVERAGE GROSS ALPHA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WRPs - 2000

| WRP<br>Type of Sample | Gross Alpha Radioactivity<br>(pCi/L) |
|---|---|
| Stickney | |
| Raw (West Side) | <4.8 |
| Raw (Southwest) | <5.2 |
| Secondary - Final Effluent | <4.6 |
| Calumet | |
| Raw | <4.7 |
| Secondary - Final Effluent | <4.5 |
| North Side | |
| Raw | <4.9 |
| Secondary - Final Effluent | <4.1 |
| Hanover Park | |
| Raw | <4.6 |
| Tertiary - Final Effluent | <4.2 |
| John E. Egan | |
| Raw | <4.5 |
| Tertiary - Final Effluent | <4.1 |
| Lemont | |
| Raw | 44.4 |
| Secondary - Final Effluent | <7.9 |
| James C. Kirie | |
| Raw | <4.6 |
| Tertiary - Final Effluent | <4.5 |

< = Less than LLD.

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.

Table 64 presents 2000 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, 66.0 and 22.0 pCi/L, respectively. At the remaining six WRPs, the average raw sewage gross beta radioactivity ranged from 16.1 to 29.5 pCi/L, and the average final effluent total beta radioactivity ranged from 8.9 to 16.8 pCi/L.

## Levels of Radiactivity 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 2000, sludge samples were collected monthly at all WRPs. Biosolids samples were also collected from the eight sludge drying sites of the District.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 64

AVERAGE GROSS BETA RADIOACTIVITY IN RAW AND TREATED WASTEWATER FROM DISTRICT WRPs - 2000

| WRP<br>Type of Sample | Gross Beta Radioactivity<br>(pCi/L) |
|---|---|
| <u>Stickney</u> | |
| Raw (West Side) | 29.5 |
| Raw (Southwest) | 29.1 |
| Secondary - Final Effluent | 9.8 |
| <u>Calumet</u> | |
| Raw | 22.0 |
| Secondary - Final Effluent | 10.2 |
| <u>North Side</u> | |
| Raw | 20.4 |
| Secondary - Final Effluent | 8.9 |
| <u>Hanover Park</u> | |
| Raw | 16.1 |
| Tertiary - Final Effluent | 9.5 |
| <u>John E. Egan</u> | |
| Raw | 20.8 |
| Tertiary - Final Effluent | 10.6 |
| <u>Lemont</u> | |
| Raw | 66.0 |
| Secondary - Final Effluent | 22.0 |
| <u>James C. Kirie</u> | |
| Raw | 22.7 |
| Tertiary - Final Effluent | 16.8 |

Sludge samples were processed according to the *Standard Methods* procedures, and counted for gross alpha and gross beta radioactivity using a Tennelec LB5100 alpha/beta counting system. The instrument was calibrated with americium-241 standard for gross alpha and cesium-137 standards for gross beta radioactivity determinations. The results, in pCi/g of dry weight (DW), were averaged and are tabulated in Tables 65 and 66.

In Table 65, the average gross alpha radioactivity of WRP sludges ranged from a low of 4.8 pCi/g DW at the Kirie WRP to a high of 106.1 pCi/g DW at the Lemont WRP. Average gross beta radioactivity of WRP sludges ranged from a low of 13.8 pCi/g DW at the Hanover Park WRP to a high of 121.9 pCi/g DW at the Lemont WRP.

Table 66 presents gross alpha and gross beta data for biosolids from the District sludge drying sites. Average total alpha radioactivity ranged from a low of 9.2 pCi/g DW for the Vulcan drying site to a high of 12.1 pCi/g DW for the Calumet West and HASMA drying sites. Average total beta radioactivity ranged from a low of 26.3 pCi/g DW for the Vulcan drying site to a high of 30.2 pCi/g DW for the RASMA drying site.

Sludge samples were also processed for the determination of specific radionuclides. The samples were dried on hot

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TABLE 65

GROSS ALPHA AND GROSS BETA RADIOACTIVITY OF WRP SLUDGES - 2000

| WRP Type of Sample | No. of Samples | Gross Alpha (pCi/g DW) | | | Gross Beta (pCi/g DW) | | |
|---|---|---|---|---|---|---|---|
| | | Average | Minimum | Maximum | Average | Minimum | Maximum |
| Calumet Digester Draw | 12 | 8.4 | 7.1 | 9.7 | 25.2 | 21.4 | 29.1 |
| John E. Egan Digester Draw | 12 | 6.9 | 5.5 | 7.8 | 21.3 | 19.4 | 26.7 |
| Lemont[1] Activated Sludge | 12 | 106.1 | 79.9 | 131.0 | 121.9 | 90.9 | 151.6 |
| Hanover Park Digester Draw | 12 | 5.7 | 5.0 | 7.2 | 13.8 | 11.9 | 15.2 |
| James C. Kirie[1] Activated Sludge | 12 | 4.8 | 3.3 | 6.9 | 14.8 | 8.1 | 21.6 |
| North Side[1] Activated Sludge | 11 | 4.9 | 3.7 | 7.1 | 15.0 | 9.6 | 22.0 |
| Stickney Digester Draw | 12 | 7.5 | 5.6 | 10.9 | 27.2 | 21.5 | 31.9 |

[1]No digesters at this WRP.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 66

GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN DISTRICT BIOSOLIDS - 2000

| Drying Site Location | No. of Samples | Gross Alpha (pCi/g DW) | | | Gross Beta (pCi/g DW) | | |
|---|---|---|---|---|---|---|---|
| | | Average | Minimum | Maximum | Average | Minimum | Maximum |
| LASMA | 5 | 9.8 | 7.3 | 11.9 | 28.0 | 25.7 | 31.3 |
| Calumet East | 5 | 10.3 | 8.7 | 11.5 | 27.5 | 23.5 | 30.7 |
| Calumet West | 5 | 12.1 | 8.7 | 14.5 | 27.1 | 24.6 | 31.0 |
| HASMA | 5 | 12.1 | 8.8 | 14.2 | 27.6 | 26.8 | 28.8 |
| Marathon | 5 | 11.7 | 10.1 | 14.2 | 29.7 | 29.2 | 30.6 |
| Stony Island | 5 | 10.5 | 7.9 | 13.8 | 28.6 | 26.5 | 30.6 |
| Vulcan | 5 | 9.2 | 6.8 | 10.4 | 26.3 | 24.2 | 28.0 |
| RASMA | 5 | 11.4 | 9.7 | 13.6 | 30.2 | 28.8 | 33.6 |

plates. The dried samples were ground and passed through a 30-mesh sieve. The samples were packed in three-ounce canisters and 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. 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 67 presents potassium-40, cesium-137, and radium-226 concentrations in the District's sewage sludge. The average potassium-40 radioactivity ranged from 4.1 pCi/g DW at Hanover Park WRP to 10.4 pCi/g DW at Stickney WRP. The average cesium-137 radioactivity ranged from non-detectable levels at Egan, Hanover Park, and Lemont WRPs to 0.08 pCi/g DW at Stickney WRP. The average radium-226 radioactivity ranged from 4.0 pCi/g DW at Stickney WRP to 80.2 pCi/g DW at Lemont WRP.

Table 68 presents potassium-40, cesium-137, and radium-226 concentrations in the District's biosolids from the drying sites. The average potassium-40 radioactivity in the

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 67

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WRP SLUDGES - 2000

| 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 | 7.6 | 7.1 | 8.0 | 4.6 | 4.4 | 4.8 | 0.06 | 0.05 | 0.07 |
| John E. Egan | 4 | 8.1 | 7.2 | 9.1 | 4.3 | 4.0 | 4.5 | ND | ND | ND |
| Hanover Park | 4 | 4.1 | 3.8 | 4.5 | 4.4 | 4.2 | 4.5 | ND | ND | ND |
| Stickney | 4 | 10.4 | 9.9 | 10.9 | 4.0 | 3.6 | 4.2 | 0.08 | 0.06 | 0.10 |
| Lemont | 4 | 8.5 | 7.8 | 9.8 | 80.2 | 69.2 | 97.3 | ND | ND | ND |

ND = Not Detected.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 68

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN DISTRICT BIOSOLIDS - 2000

| Location | Samples | Potassium-40 (pCi/g DW) | | | Radium-226 (pCi/g DW) | | | Cesium-137 (pCi/g DW) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Calumet East | 5 | 10.4 | 8.4 | 12.3 | 3.4 | 1.5 | 4.4 | 0.09 | 0.08 | 0.11 |
| Calumet West | 5 | 9.9 | 5.5 | 15.3 | 4.4 | 3.9 | 4.9 | 0.08 | 0.06 | 0.10 |
| RASMA | 5 | 10.4 | 9.5 | 11.3 | 3.5 | 0.8 | 4.4 | 0.10 | 0.09 | 0.11 |
| Stony Island | 5 | 10.3 | 8.9 | 12.4 | 3.6 | 1.9 | 4.4 | 0.09 | 0.08 | 0.11 |
| HASMA | 5 | 9.6 | 8.8 | 10.4 | 4.0 | 3.6 | 4.3 | 0.11 | 0.08 | 0.15 |
| LASMA | 5 | 9.4 | 9.0 | 10.2 | 3.5 | 1.1 | 4.2 | 0.10 | 0.08 | 0.12 |
| Marathon | 5 | 10.2 | 8.9 | 11.6 | 3.7 | 1.7 | 4.5 | 0.09 | 0.08 | 0.11 |
| Vulcan | 5 | 10.0 | 8.9 | 11.1 | 4.0 | 3.6 | 4.6 | 0.09 | 0.08 | 0.10 |

biosolids ranged from 9.4 pCi/g DW at LASMA to 10.4 pCi/g DW at Calumet East, and RASMA drying sites. The average cesium-137 radioactivity ranged from 0.08 pCi/g DW at Calumet West to 0.11 pCi/g DW at HASMA drying site. The average radium-226 radioactivity ranged from 3.4 pCi/g DW at Calumet East to 4.4 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 District waterways. Radiological monitoring involves the determination of gross alpha and gross beta radioactivity of samples collected from the waterways. The program includes the Calumet, Chicago, and Des Plaines River systems comprising 170 miles (273.6 km) of waterways. There were six sampling locations on the Chicago River, three on the Calumet River, and six 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 *Standard Methods* procedures, and the gross alpha and beta radioactivity was counted using a Tennelec LB5100 gas proportional counter.

Table 69 presents the 2000 average values for gross alpha and gross beta radioactivity for the Chicago waterways at each of the 15 sampling locations. The average gross alpha radioactivity in the water samples ranged from less than 4.1 pCi/L to less than 4.4 pCi/L. The average gross beta radioactivity ranged from 6.6 pCi/L to 16.5 pCi/L.

Table 70 presents the 2000 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 ranged from less than 4.4 pCi/L to less than 4.6 pCi/L. The average gross beta radioactivity ranged from 8.8 pCi/L to 9.3 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, and 50 pCi/L for gross beta radioactivity.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 69

AVERAGE GROSS ALPHA AND GROSS BETA RADIOACTIVITY FOR THE CHICAGO WATERWAYS - 2000

| Location | Gross Alpha (pCi/L) | Gross Beta (pCi/L) |
|---|---|---|
| Central Avenue, North Shore Channel | <4.3 | 6.6 |
| Touhy Avenue, North Shore Channel | <4.2 | 11.5 |
| Cicero Avenue, Chicago Sanitary and Ship Canal | <4.2 | 9.0 |
| Harlem Avenue, Chicago Sanitary and Ship Canal | <4.3 | 9.3 |
| Route 83, Chicago Sanitary and Ship Canal | <4.4 | 9.2 |
| Stephens Street, Chicago Sanitary and Ship Canal | <4.2 | 9.8 |
| Indiana Avenue and 135th Street, Little Calumet River | <4.3 | 7.6 |
| Halsted Street, Little Calumet River | <4.4 | 10.3 |
| Route 83 Bridge, Cal-Sag Channel | <4.4 | 9.7 |
| Longmeadow Lane, Upstream of Hanover Park WRP, DuPage River | <4.2 | 7.3 |
| Walnut Lane, Downstream of Hanover Park WRP, West Branch DuPage River | <4.1 | 9.6 |
| Elmhurst Road, Upstream of Kirie WRP, Higgins Creek | <4.4 | 7.4 |
| Willie Road, Downstream of Kirie WRP, Higgins Creek | <4.2 | 16.5 |
| Higgins Road, Upstream of Egan WRP, Salt Creek | <4.4 | 7.0 |
| Arlington Heights Road, Downstream of Egan WRP, Salt Creek | <4.2 | 9.1 |

< = Less than LLD.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 70

AVERAGE GROSS ALPHA AND GROSS BETA RADIOACTIVITY
OF THE LOWER DES PLAINES RIVER - 2000

| Location | Gross Alpha (pCi/L) | Gross Beta (pCi/L) |
|---|---|---|
| Material Services Bridge, Joliet | <4.5 | 9.1 |
| Lockport Powerhouse Forebay, Lockport | <4.4 | 9.0 |
| Jefferson Street, Joliet | <4.5 | 9.2 |
| Empress Casino, Joliet | <4.5 | 9.3 |
| Upstream of I-55 at mouth of Jackson Creek, Channahon | <4.6 | 8.8 |

< = Less than LLD.

# EXPERIMENTAL DESIGN AND STATISTICAL EVALUATION SECTION

The Experimental Design and Statistical Evaluation Section is responsible for providing assistance in the design of laboratory and full-scale experiments, 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 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 2000, the section provided statistical and computing support to various projects undertaken within the EM&R Division. These included providing statistical support to:

1. Land Reclamation and Soil Science Section to evaluate the effect of time after cessation of biosolids applications on the concentration of cadmium, copper, nickel, and zinc in soil, leaves, and grain of corn from fields at the District's Fulton County site.

2. Wastewater Treatment Research Section to compare the odor threshold values ($ED_{50}$) of the District's freshly produced centrifuge cake and the centrifuge cake aged for more than 1.5 years at the WRPs in lagoons.

3. Analytical Microbiology and Biomonitoring Section on whole effluent toxicity studies with fish, namely, *Pimephales promelas*. Studies were conducted on the variation of mortality rate due to age of the fish and the level of the toxicant. The studies began in the middle of 1999 and were completed in early April 2000. This section provided the statistical data and assistance in drafting the paper *The Effects of Age on Pimephales Survival in Acute Whole Toxicity Tests*. The paper was prepared by the Analytical Microbiology and Biomonitoring Section to be presented at the Water Environment Federation 2001 Annual Conference and Exposition, Atlanta, Georgia.

4. Wastewater Treatment Research Section on the study of oxygen transfer efficiency of diffuser plates in the aeration tanks of the North Side

WRP. The project began in July 1999 and was completed in May 2000.

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 1998 and 1999 were evaluated regarding compliance with water quality standards set by IPCB. An annual report for 1998 was produced and preparation of 1999 annual report began.

### COMPLIANCE OF GENERAL USE WATERS

In 1999, 28 water quality parameters were assayed. These included:

1. temperature;
2. ammonium nitrogen;
3. un-ionized ammonia;
4. phenols;
5. total arsenic;
6. total barium;
7. total boron;
8. total cadmium;
9. total copper;
10. total chromium;
11. soluble iron;
12. total lead;

13. total nickel;
14. total mercury;
15. total zinc;
16. total selenium;
17. dissolved oxygen;
18. pH;
19. chloride;
20. total dissolved solids;
21. sulfate;
22. WAD cyanide;
23. fluoride;
24. fecal coliform;
25. gross beta radioactivity;
26. total silver;
27. total iron; and
28. total manganese.

The first 16 parameters listed above were in total compliance in General Use Waters of all river systems. Of the remaining 12 parameters, 10 parameters had compliance rates greater than 77.0 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 39.1 to 55.6 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 17 parameters listed above were in complete compliance in all river systems. The compliance rates of the remaining five parameters varied from 93.8 to 100.0 percent in the Chicago, Calumet, and Des Plaines River systems.

# APPENDIX I

# LIST OF ABBREVIATIONS

## APPENDIX I

## LIST OF ABBREVIATIONS

| Abbreviation | Definition |
|---|---|
| ACOE | Army Corps of Engineers |
| Al | Aluminum |
| As | Arsenic |
| B | Boron |
| BGM-K | Brilliant Green Monkey Kidney |
| BIO-E | Microsopic Evaluation of Protozoan and Filamentous Organisms |
| BNA | Base/Neutral/Acid Extractable Compound |
| $BOD_5$ | Biochemical Oxygen Demand (5 days) |
| Ca | Calcium |
| $CaCO_3$ | Calcium Carbonate |
| Cd | Cadmium |
| CEC | Cation Exchange Capacity |
| Cr | Chromium |
| CSO | Combined Sewer Overflows |
| Cu | Copper |
| CUP | Chicagoland Underflow Plan |
| DO | Dissolved Oxygen |
| DW | Dry Weight |
| EC | Electrical Conductivity |

APPENDIX I

LIST OF ABBREVIATIONS (Continued)

| Abbreviation | Definition |
|---|---|
| *E. coli* | *Escherichia coli* |
| ECD | Electron Capture Detector |
| EM&R | Environmental Monitoring and Research |
| ENT | Enterococcus |
| FC | Fecal Coliform |
| Fe | Iron |
| FS | Fecal Streptococcus |
| GC/MS | Gas Chromatograph/Mass Spectrometer |
| HASMA | Harlem Avenue Solids Management Area |
| $HCO_3$ | Bicarbonate |
| Hg | Mercury |
| HPC | Heterotrophic Plate Count |
| ID-CONF | Organism Identification Using Specific Biochemical Metabolic Characteristics |
| IDNS | Illinois Department of Nuclear Safety |
| IDOT | Illinois Department of Transportation |
| IDPH | Illinois Department of Public Health |
| IEPA | Illinois Environmental Protection Agency |
| IL ELAP | Illinois Environmental Protection Agency's Environmental Laboratory Accreditation Program |

APPENDIX I

LIST OF ABBREVIATIONS (Continued)

| Abbreviation | Definition |
|---|---|
| IPCB | Illinois Pollution Control Board |
| IQC | Internal Quality Control |
| K | Potassium |
| LASMA | Lawndale Avenue Solids Management Area |
| LLD | Lower Limit of Detection |
| M&O | Maintenance and Operations |
| MDL | Method Detection Limit |
| MF | Membrane Filtration |
| Mg | Magnesium |
| MGD | Million Gallons per Day |
| mmhos/cm | Millimhos per Centimeter |
| MMO-MUG | Minimal Medium with Orthonitrophenol Galactoside/4-Methylumbeliferyl-β-D-Glucuronide |
| Mn | Manganese |
| Mo | Molybdenum |
| MTF | Multiple Tube Fermentation |
| N-P-K | Nitrogen-Phosphorus-Potassium (fertilizer mix) |
| Na | Sodium |
| $NH_4$-N | Ammonium Nitrogen |
| Ni | Nickel |

APPENDIX I

LIST OF ABBREVIATIONS (Continued)

| Abbreviation | Definition |
|---|---|
| $NO_2$-N | Nitrite Nitrogen |
| $NO_2$+$NO_3$-N | Nitrite plus Nitrate Nitrogen |
| $NO_3$-N | Nitrate Nitrogen |
| NPDES | National Pollutant Discharge Elimination System |
| OTE | Oxygen Transfer Efficiency |
| P | Phosphorus |
| PA | *Pseudomonas aeruginosa* |
| Pb | Lead |
| PCB | Polychlorinated Biphenyl |
| PEC | Pathogen Equivalence Committee |
| PFRP | Process to Further Reduce Pathogens |
| PFU | Plaque Forming Units |
| PP | Organochloride Pesticides and/or PCBs |
| R&D | Research and Development |
| RASMA | Ridgeland Avenue Solids Management Area |
| SAL | *Salmonella* |
| scfm | Standard cubic feet per minute |
| Se | Selenium |
| SMA | Solids Management Area |

APPENDIX I

LIST OF ABBREVIATIONS (Continued)

| Abbreviation | Definition |
|---|---|
| $SO_4$ | Sulfate |
| SOTE | Standardized Oxygen Transfer Efficiency |
| SPT | Solids Processing Train or Sludge Processing Train |
| SS | Suspended Solids |
| TARP | Tunnel and Reservoir Plan |
| TC | Total Coliform |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TKN | Total Kjeldahl Nitrogen |
| TS | Total Solids |
| TSS | Total Suspended Solids |
| TVS | Total Volatile Solids |
| USDOE | United States Department of Energy |
| USEPA | United States Environmental Protection Agency |
| VOC | Volatile Organic Compounds |
| VSS | Volatile Suspended Solids |
| WET | Whole Effluent Toxicity |
| WRP | Water Reclamation Plant |
| XRF | X-Ray Fluorescent |
| Zn | Zinc |

# APPENDIX II

# MEETINGS AND SEMINARS 2000

APPENDIX II

MEETINGS AND SEMINARS 2000

1. Annual Meeting of United States Department of Agriculture, Regional Research Committee W-170, Las Vegas, Nevada, January, 2000.

2. Illinois Environmental Protection Agency, Governor's Environmental Forum, Springfield, Illinois, January 2000.

3. Illinois Water Environment Association, Government Affairs in Water Pollution Control Seminar, Lisle, Illinois, January 2000.

4. Lake Michigan Water Analysts Winter Meeting, Kenosha, Wisconsin, January 2000.

5. Water Environment Research Foundation Research Council Meeting, Washington, D.C., January 2000.

6. Illinois Chapter American Fisheries Society Annual Meeting and Workshop, Mt. Vernon, Illinois, February 2000.

7. Illinois Environmental Protection Agency, Bureau of Water, TMDL Public Meeting, Springfield, Illinois, February 2000.

8. Northern Illinois Planning Commission, Tools for Urban Water Resource Management Conference, Chicago, Illinois, February 2000.

9. Water Environment Federation 2000 Program Committee Midyear Meeting, Anaheim, California, February 2000.

10. Water Environment Federation National Biosolids Conference, Boston, Massachusetts, February 2000.

11. Illinois Association of Environmental Laboratories Inc. Meeting, Joliet, Illinois, March 2000.

12. Illinois Water Environment Association 21st Annual Conference, Peoria, Illinois, March 2000.

APPENDIX II

MEETINGS AND SEMINARS 2000 (Continued)

13. Pittsburgh Conference 2000, New Orleans, Louisiana, March 2000.

14. Water Environment Federation, Water Quality 2000 Revisited Meeting, Washington, D.C., March 2000.

15. Water Environment Research Foundation Project Subcommittee Meeting, Washington, D.C., March 2000.

16. Biosolids Management in the 21st Century, College Park, Maryland, April 2000.

17. Central States Water Environment Association 5th Annual Education Seminar, Madison, WI, April 2000.

18. "Endocrine Disrupters in Drinking Water," Chicago, Illinois, April 2000.

19. "Practical Aspects of Nutrient Control Strategies," Madison, Wisconsin, April 2000.

20. Water Environment Federation, Odors & VOC Emissions 2000 Specialty Conference, Cincinnati, Ohio, April 2000.

21. Association of Metropolitan Sewerage Agencies, 2000 National Environmental Policy Forum & 30th Anniversary Annual Meeting, Washington, D.C., May 2000.

22. "Building a Data Warehouse Using SAS/Warehouse Administrative Software," Overland Park, Kansas, May 2000.

23. City of Chicago, Calumet Research Summit Meeting, Chicago, Illinois, May 2000.

24. Lake Michigan Water Analysts Spring Meeting, Chicago, Illinois, May 2000.

25. United States Environmental Protection Agency, Nutrient Criteria Development Stakeholders Meeting, Arlington, Virginia, May 2000.

APPENDIX II

MEETINGS AND SEMINARS 2000 (Continued)

26. Air and Waste Management Association, 93rd Annual Conference, Salt Lake City, Utah, June 2000.

27. Annual Meeting North American Benthological Society, Keystone, Colorado, June 2000.

28. University of Wisconsin, Analysis and Interpretation of Contaminated Sediments Short Course, Madison, Wisconsin, June 2000.

29. Water Environment Research Foundation Research Council Meeting, Seattle, Washington, June 2000.

30. Association of Metropolitan Sewerage Agencies Summer Meeting, Louisville, Kentucky, July 2000.

31. "Illinois Water Supplies: Is the Well Running Dry?," Chicago, Illinois, July 2000.

32. Advanced Composting Workshop, Bourbonnais, Illinois, August 2000.

33. Illinois Environmental Protection Agency, Bureau of Water Public Hearing Meeting, Springfield, Illinois, August 2000.

34. National Biosolids Partnership Steering Committee, Alexandria, Virginia, August 2000.

35. Cole-Palmer Workshop, Vernon Hills, Illinois, September 2000.

36. "Ecological Assessment of Aquatic Resources: Application, Implementation, and Communication," Pellston, Michigan, September 2000.

37. Illinois Association of Environmental Laboratories Inc. Meeting, Willowbrook, Illinois, September 2000.

MEETINGS AND SEMINARS 2000 (Continued)

38. Illinois Environmental Protection Agency, Watershed Management Committee Meeting, Springfield, Illinois, September 2000.

39. Joint United States Environmental Protection Agency Region V and Water Environment Federation, Symposium on Innovative Uses of Biosolids, Chicago, Illinois, September 2000.

40. "Multivariate Statistical Methods: Practical Applications," Chicago, Illinois, September 2000.

41. Radiation Safety Officer Refresher Training Course, Radiation Safety Associates, Inc., Hebron, Connecticut, September 2000.

42. United States Environmental Protection Agency, Introduction to BASINS Software Workshop, Chicago, Illinois, September 2000.

43. Endocrine Disrupter Briefing, United States Environmental Protection Agency, Region V, Chicago, Illinois, October 2000.

44. Hydrogen Sulfide Health Research and Risk Assessment Symposium, API, EPA, CIIT, Chapel Hill, North Carolina, October 2000.

45. Illinois Department of Public Health Environmental Laboratory Seminar, Springfield, Illinois, October 2000.

46. Lake Michigan Water Analysts Fall Meeting, Milwaukee, Wisconsin, October 2000.

47. Water Environment Federation 73rd Annual Conference, Anaheim California, October, 2000.

48. Illinois Water 2000 Conference, Urbana, Illinois, November 2000.

MEETINGS AND SEMINARS 2000 (Continued)

49. Illinois Water Environment Association Industrial Pretreatment Committee Annual Meeting, Lombard, Illinois, November 2000.

50. Society of Environmental Toxicology and Chemistry Annual Meeting, Nashville, Tennessee, November 2000.

51. Soil Science Society of America Annual Meeting, Minneapolis, Minnesota, November 2000.

52. "Using Models to Develop Air Toxics Reduction Strategies: Lake Michigan as a Test Case," Lake Michigan Forum, The Delta Institute, Science Advisory Board of the International Joint Committee, Milwaukee, Wisconsin, November 2000.

53. Illinois Pollution Control Board, Regulatory Hearing Antidegredation, Springfield, Illinois, December 2000.

54. The Midwest Environmental Laboratory Summit, Chicago, Illinois, December 2000.

APPENDIX III

PAPERS PRESENTED 2000

APPENDIX III

PAPERS PRESENTED 2000

1. "An Update of Ongoing Research at the Metropolitan Water Reclamation District of Greater Chicago: Characterizing Zn Toxicity to Plants; Examining Trace Element Content of Urban Soils and Street Dusts; and Determining Changes in Phytoavailability of Metals in Biosolids Amended Soils Over Long Time Periods." Presented at Annual Meeting of United States Department of Agriculture Regional Research Committee W-170, Las Vegas, Nevada, January 2000, by Thomas Granato.

2. "Changes in Phytoavailability of Trace Elements Following Cessation of Biosolids Applications to Land." Presented at Annual Meeting of the Illinois Water Environment Association, Peoria, Illinois, March 2000, by Thomas Granato, Richard Pietz, George Knafl, Carl Carlson, Jr., Prakasam Tata, and Cecil Lue-Hing.

3. "Chicago River Fishery." Presented at Suburban Radio Association Meeting, Riverside, Illinois, March 2000, by Sam Dennison.

4. "Enhancement of Reductive Dechlorination of Perchloroethene by Adding Acclimated Cultures into Unacclimated Anaerobically Digested Sludge." Presented at the Illinois Water Environment Association Annual Conference, Peoria, Illinois, March 2000, by Heng Zhang.

5. "Fish Populations in Chicago's Waterways Benefit from Improved Wastewater Collection and Treatment Practices." Presented at Thirteenth Annual Meeting of the Illinois Water Environment Association, Peoria, Illinois, March 2000, by Sam Dennison, Irwin Polls, Bernard Sawyer, Prakasam Tata, and Richard Lanyon.

6. "Potential for the Use of On-Line Respirometry for the Control of Aeration." Presented at the Illinois Water Environment Association Annual Conference, Peoria, Illinois, March 2000, by Kamlesh Patel, Stanley Soszynski, Prakasam Tata, Jain S. Jain, and David T. Lordi.

PAPERS PRESENTED 2000 (Continued)

7. "Trends in VOC Emissions from POTWs of the Metropolitan Water Reclamation District of Greater Chicago." Presented at the Water Environment Federation Specialty Conference Odor and VOC Emissions 2000, Cincinnati, Ohio, April 2000, by David T. Lordi, Prakasam Tata, and Stanley Soszynski.

8. "Macroinvertebrates and Fish in the Calumet River." Presented at Calumet Research Summit, Chicago, Illinois, May 2000, by Sam Dennison.

9. "Overview of the USX Slag Reclamation Demonstration Site." Presented at City of Chicago Department of Development and Planning Neighborhood Meeting, Chicago, Illinois, May 2000, by Thomas Granato.

10. "Fish in the Waterways." Presented at Senior Circle of Friends Meeting, Chicago, Illinois, July 2000, by Sam Dennison.

11. "Fish in the Chicago Waterway System." Presented at Alsip Sertoma Meeting, Crestwood, Illinois, August 2000, by Sam Dennison.

12. "Fish in Chicago's Waterways." Presented at Brookfield Rotary Meeting, Brookfield, Illinois, September 2000, by Sam Dennison.

13. "Using Biosolids as a Soil Substitute in Urban Areas." Presented at Joint United States Environmental Protection Agency, Region V, and Water Environment Federation Symposium on Innovative Uses of Biosolids, Chicago, Illinois, September 2000, by Thomas Granato, Richard Pietz, Prakasam Tata, and Cecil Lue-Hing.

14. "Evaluation and Testing of Analytical Methods for Cyanide Species in Municipal and Industrial Contaminated Waters." Presented at the Water Environment Federation Annual Conference, Anaheim, California, October 2000, by A. Zheng, D.A. Dzombak, R.G. Luthy, M. Delaney, S.M. Drop, J.M. Flaherty, B. Sawyer, J.R. Sebroski, R.S. Swartling, P. Tata, and L. Zilitinkevitch.

PAPERS PRESENTED 2000 (Continued)

15. "Potential for the Use of On-Line Respirometry for the Control of Aeration." Presented at the Water Environment Federation Annual Conference, Anaheim, California, October 2000, by Prakasam Tata, Kamlesh Patel, Stanley Soszynski, Jain S. Jain, and David T. Lordi.

16. "Phytoavailability of Trace Elements Following Cessation of Biosolids Applications to Land." Presented at Annual Meeting of the Soil Science Society of America, Minneapolis, Minnesota, November 2000, by Thomas Granato, Richard Pietz, George Knafl, Carl Carlson, Jr., Prakasam Tata, and Cecil Lue-Hing.

17. "Advances in Conventional and Innovative Uses of Biosolids." Presented at Joint United States Environmental Protection Agency, Region V and Water Environment Federation Symposium on Innovative Uses of Biosolids, Chicago, Illinois, September 2000, by Prakasam Tata, Doris Bernstein, Jain S. Jain, Richard Pietz, Cecil Lue-Hing, and Richard Lanyon.

# APPENDIX IV

## PAPERS PUBLISHED 2000

APPENDIX IV

PAPERS PUBLISHED 2000

1. Pietz, R. I., R. Johnson, R. Sustich, T. C. Granato, P. Tata, and C. Lue-Hing. "EPA, AMSA Surveys: Trend Shows Metal Concentrations Down," pages 9-15, In Biosolids Technical Bulletin, Volume 6, Number 1, Water Environment Federation, 2000.

2. Tata, P., C. Lue-Hing, and G.J. Knafl. "Class A Biosolids Production by a Low-Cost Conventional Technology," Water Environment Research, Washington, D.C., July/August 2000, Vol. 72, No. 4.

3. Tata, P., C. Lue-Hing, and G.J. Knafl. "Statistical Evaluation of Pathogen Inactivation for a Conventional Low-Cost Technology Class A Biosolids Process," Water Environment Research, Washington, D.C., July/August 2000, Vol. 72, No. 4.

# APPENDIX V

# CONSULTANTS AND ADVISORS 2000

APPENDIX V

CONSULTANTS AND ADVISORS 2000

1. Dr. Krishna R. Pagilla, Ph.D., P.E., Assistant Professor, Department of Chemical and Environmental Engineering, Illinois Institute of Technology, Chicago, Illinois.

# APPENDIX VI

## RESEARCH AND DEVELOPMENT DEPARTMENT
## 2000 SEMINAR SERIES

## RESEARCH AND DEVELOPMENT DEPARTMENT
## 2000 SEMINAR SERIES

| Date | Subject |
|---|---|
| **Friday**<br>**January 28, 2000** | ***Biological Phosphorus Removal at Wastewater Treatment Plants***<br>Dr. David R. Zenz, Senior Associate<br>CTE Engineers<br>Chicago, Illinois |
| **Friday**<br>**February 25, 2000** | ***Nitrogen and Phosphorus Budgets for the State of Illinois***<br>Professor Mark B. David<br>University of Illinois<br>Urbana-Champaign, Illinois |
| **Friday**<br>**March 31, 2000** | ***Effect of Pumping on Polymer Dosage for Centrifuged Dewatering***<br>Dr. David R. Zenz, Senior Associate<br>Mr. Anthony Bouchard, Vice President<br>CTE Engineers,<br>Chicago, Illinois<br>and<br>Mr. Stanley Soszynski, Research Scientist<br>Research and Development Department<br>District, Cicero, Illinois |
| **Monday**<br>**April 3, 2000** | ***Overview of Nutrient Control Strategies, Approaches, and Capabilities***<br>Dr. Glen Daigger, Senior Vice President<br>CH2M Hill<br>Denver, Colorado |
| **Friday**<br>**April 28, 2000** | ***Illinois Environmental Protection Agency's Perspective on TMDLs***<br>Mr. Bruce Yurdin, Manager<br>Watershed Division<br>Illinois Environmental Protection Agency<br>Springfield, Illinois |
| **Friday**<br>**May 26, 2000** | **Instrumentation and Automation Trends, Reliability, and Practices at POTWs**<br>Dr. Michael Sweeney, Director<br>Metropolitan Sewer District<br>Louisville, Kentucky |

**RESEARCH AND DEVELOPMENT DEPARTMENT**
**2000 SEMINAR SERIES**

| Date | Subject |
|---|---|
| **Friday**<br>**June 30, 2000** | ***Simulation of Water Quality in Salt Creek and Other Streams***<br>Professor Steve Melching<br>Marquette University<br>Milwaukee, Wisconsin |
| **Friday**<br>**July 28, 2000** | ***Nutrient Enrichment of the Mississippi River Basin and Possible Causes of Hypoxia***<br>Dr. Derek Winstanley, Director<br>Illinois State Water Survey<br>Champaign, Illinois |
| **Friday**<br>**August 25, 2000** | ***Urban Stream and River Restoration Perspectives and Future Direction***<br>Dr. Don Roseboom<br>Illinois State Water Survey<br>Peoria, Illinois |
| **Friday,**<br>**September 29, 2000** | **Effect of Fish Age on the Results of Biomonitoring**<br>Dr. James Zmuda, Microbiologist<br>Research and Development Department<br>District, Cicero, Illinois |
| **Friday**<br>**October 27, 2000** | **Water Quality Standards – What is Appropriate, Total or Dissolved Metals?**<br>Professor Herb Allen<br>University of Delaware<br>Newark, Delaware |
| **Friday,**<br>**November 17, 2000** | **Know Your POTWs Full-Treatment Capacity and Investigate Rerating and Debottlenecking Opportunities**<br>Dr. Movva P. Reddy<br>MPR Engineering Corporation, Inc.<br>Longwood, Florida |

**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 VII

# ENVIRONMENTAL MONITORING AND RESEARCH DIVISION EMPLOYEES

# Environmental Monitoring and Research Division Employees

**Section 121 – Administration**

**Tata, Prakasam, Assistant Director of R&D, EM&R Division**

Messina, Deborah, Secretary

Sawyer, Bernard, Research Scientist 4
Martinez, Adela, Principal Clerk Typist
Pietz, Richard, Research Scientist 4
Urlacher, Nancy, Administrative Assistant
Vacant, Principal Clerk Typist

**Section 122 - Wastewater Treatment**

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
Szafoni, John, Laboratory Tech 1
Minarik, Thomas, Laboratory Tech 1
Pierson, Rodney, Laboratory Tech 1
Rahman, Shafiq, Laboratory Tech 1
Gallagher, Dustin, Laboratory Tech 1

**Section 123 – Land Reclamation & Soil**

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
Zumpano, Sarah, 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
Saric, Ronald, Laboratory Assistant

**Section 124 – Microbiology**

Zmuda, James, Microbiologist 4
Vacant, Principal Clerk Typist
Vacant, Microbiologist 3
Gore, Richard, Microbiologist 2
Yamanaka, Jon, Biologist 1
Billett, George, Laboratory Tech 2
Kaplan, Maria, Laboratory Tech 2
Maka, Andrea, Laboratory Tech 2
Patel, Minaxi, Laboratory Tech 2
Shukla, Hemangini, Laboratory Tech 2
Renfro, Brenda, Laboratory Tech 1
Mangkorn, Damrong, Laboratory Tech 1
Roberts, David, Laboratory Tech 1
Brazinski, Carmen, Laboratory Tech 1
Credit, Eben, Laboratory Assistant
Yates, Marguerite, Laboratory Assistant

**Section 125 - Land Reclamation & Soil (Fulton Cty)**

Carlson, Jr., Carl, Sanitary Chemist II
Boucek, Jr., Emil, Field and Lab Tech
DeWees, Josh, Field and Lab Tech
Swango, Rosalie, Field and Lab Tech

**Section 126 - Aquatic Ecology & Water Quality**

Polls, Irwin, Microbiologist 4
Dennison, Sam, Biologist 3
Vacant, Biologist 2
Vacant Biologist 1
Hartford, Mary Lynn, Laboratory Tech 2
Rose, Rebecca, Laboratory Tech 2
Schackart, Richard, Laboratory Tech 2
Sopcak, Michael, Laboratory Tech 2
Grunwald, Pawel, Laboratory Tech 1
Vick, Justin, Laboratory Tech 1

**Section 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
Vacant, Laboratory Tech 2
Vermillion, John, Laboratory Tech 2

**Section 128 – Radiochemistry**

Khalique, Abdul, Radiation Chemist
Kawalko, Sheila, Sanitary Chemist 1
Robinson, Harold, Laboratory Tech 1

**Section 129 – Experimental Design & Statistical Eval**

Abedin, Zainul, Biostatistician
Vacant, Assoc. Statistician