Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

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REDUCTIONS IN METAL CONCENTRATIONS IN SLUDGE AND BIOSOLIDS FROM WATER RECLAMATION PLANTS AT THE METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO FROM 1982 THROUGH 2000

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REDUCTIONS IN METAL CONCENTRATIONS IN SLUDGE AND BIOSOLIDS FROM WATER RECLAMATION PLANTS AT THE METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO FROM 1982 THROUGH 2000

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

LIST OF TABLES (Continued)

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DISCLAIMER

SUMMARY

The Metropolitan Water Reclamation District of Greater Chicago (District) treats the wastewater from the city of Chicago and 125 adjacent suburban communities. The District's sewered population is approximately 5.5 million people, the commercial and industrial population equivalent is about 4.5 million, and the combined sewer overflow capture equivalent is about 0.6 million people, making the population equivalent served by the District about 10.6 million. The average daily flow from this residential, commercial, industrial complex, and the combined sewer overflow captures collected at the seven water reclamation plants (WRPs) owned and operated by the District, is 1,500 MGD of sewage. The District's WRPs range in size from 3.40 MGD to 1,200 MGD design flow. The treatment of this large volume of wastewater currently results in the production of approximately 190,000 dry tons of biosolids yearly that require ultimate disposition.

The District, like most municipal agencies treating wastewater, has found that effective management of its biosolids during the past 30 years is one of the most difficult operational functions which it must perform. In order to implement a more effective program for utilizing its biosolids,

the District in 1967 adopted a policy of beneficially utilizing biosolids on land whenever possible.

The District, to improve the quality of its biosolids with respect to metals for land application, initiated several internal programs. These programs, along with the implementation of the Federal Water Pollution Control Act of 1972 (FWPCA) and 40 CFR Part 503 Sewage Sludge Regulations in 1993, resulted in a reduction in the metals content of the District's biosolids.

The District, in the late 1960's, recognized the impact of industrial discharges on wastewater treatment plant operations. In 1969, pretreatment regulations were established by adopting an ordinance which set specific limits on the concentrations of critical pollutants having the potential to impact the operations of the District's WRPs. In addition, the FWPCA was amended in 1977 to require the establishment of national pretreatment standards governing industrial discharges into the nation's publicly owned treatment works (POTWs).

In 1978, the United States Environmental Protection Agency (USEPA) promulgated the General Pretreatment Regulations. These regulations established the responsibilities of the USEPA, the states, and POTWs in implementing the National Pretreatment Program. In 1985, the District submitted its final Pretreatment Program proposal to the USEPA, and the USEPA issued its approval of the District's local Pretreatment Program.

The District, in May 1992, in anticipation of the Part 503 Sewage Sludge Regulations being developed by the USEPA, adopted a program for the Calumet area known as the 503 Enforcement Initiative (503EI). This program was implemented District-wide beginning in October 1992 to assure that the sludge and biosolids produced by the District's seven WRPs would meet the high quality limits of the regulations with respect to metals. The program emphasized optimization of the District's existing pretreatment program, increased monitoring of industrial point source discharges into its sewerage system, and provided innovative pollution prevention assistance to the industrial community.

The District's programs and those implemented by the USEPA had a major impact on the metal content of the sludge and biosolids produced by the District's WRPs. Reductions occurred in the metal content of digester draw, waste activated, and gravity concentration tank sludges prior to the implementation of the Part 503 Sewage Sludge Regulations. The District's 503EI, in response to the sludge regulations, resulted in a significant continuing decline in the metal content of the biosolids produced by the District's WRPs.

The District's pretreatment programs resulted in a marked reduction in the metal content of the sludge and biosolids produced by the District's seven WRPs from 1982 through 2000. Reductions in metals occurred from 1982 through 1991 as a result of the implementation of the District's pretreatment program and the water quality based copper discharge limits in NPDES permits for the Hanover Park and James Kirie WRPs. Additional reductions in metals occurred from 1992 through 2000 as a result of implementing the 503EI.

Reductions occurred in those metals categorically regulated by the pretreatment regulations (cadmium, chromium, copper, lead, nickel and zinc). With the exception of cadmium at the Calumet and Lemont WRPs, which showed increases of 33 to 72 mg/dry kg and 9 to 14 mg/dry kg, respectively, reductions for these six metals at the District's seven WRPs from 1982 through 1991 ranged from a decrease of 11 percent for chromium at the Calumet WRP to a decrease of 91 percent for cadmium at the Hanover Park WRP. The yearly mean concentrations of these six metals in biosolids produced by the District's WRPs after 1992 were all considerably below the Part 503 Sewage Sludge Regulations limits for exceptional quality (EQ) biosolids.

The changes in the concentrations of the six pretreatment metals ranged from an increase of 3 percent for copper at the Calumet WRP (320 to 330 mg/kg) to a decrease of 90 percent for cadmium at the Calumet (42 to 4 mg/kg) and Stickney (41 to 4 mg/kg) WRPs. The reductions observed for these metals indicate that the pretreatment programs implemented by the District were very effective.

For the nonpretreatment metals (arsenic, mercury, molybdenum, and selenium), the changes in metal content were more difficult to assess because of problems related to the analytical reliability of their analyses. Mercury was the only nonpretreatment metal analyzed prior to 1991. Mercury, which is subject to the District's local discharge limits, from 1982 through 1991 showed changes ranging from an increase of 150 percent (0.2 to 0.5 mg/dry kg) at the Calumet WRP to a decrease of 58 percent at the North Side WRP. From late 1993 through 2000, the levels of the nonpretreatment metals in the sludge and biosolids produced by the District's WRPs were low and well below the EQ limits for these metals in biosolids to be land applied.

An evaluation of the pollutant loadings from categorically regulated significant industrial users (SIUs) during full implementation of the 503EI, from 1992 through 1998, showed an overall reduction of 52.4 percent for the six pretreatment metals. These reductions in annual metal discharges lead to reductions in the metals content of the sludge and biosolids produced by the District's seven WRPs from 1992 through 2000. For the nonpretreatment metals, the changes ranged from an increase of 300 percent for selenium (1 to 4 mg/kg) at the Egan WRP to a reduction of 70 percent for mercury at the Egan WRP. This variation reflects the problems associated with the analytical reliability of the early data for these metals.

The substantial reductions in the pretreatment metals, along with the low concentrations of the nonpretreatment metals, have resulted in final biosolids products from the District's WRPs that more than meet the EQ criteria for metals in the USEPA Part 503 Sewage Sludge Regulations. The 2000 District-wide non-weighted mean concentration of the 10 metals in the sludge and biosolids from the District's seven WRPs were 63 to 95 percent below the EQ limit. The USEPA recognized these efforts by presenting the District with the 1996 National Excellence Award for Pretreatment Programs in the Large Category (greater than 100 SIUs).

INTRODUCTION

The Metropolitan Water Reclamation District of Greater Chicago (District) treats the wastewater from the city of Chicago and 125 adjacent suburban communities covering an area of 872 square miles. The District's sewered population is approximately 5.5 million people, the commercial and industrial population equivalent is about 4.5 million people, and the combined sewer overflow equivalent is about 0.6 million, making the population equivalent served by the District about 10.6 million. From this residential, commercial and industrial complex, the District collects and treats an average wastewater flow of 1,500 MGD at seven WRPs. The District's WRPs range in size from 3.40 MGD to 1,200 MGD design flow. The treatment of this large volume of wastewater currently results in the production of approximately 190,000 dry tons of biosolids yearly that require ultimate disposition.

The District, like many municipal agencies operating POTWs, has found that finding beneficial uses for its biosolids during the past 30 years in the United States has been one of the most difficult operational functions, and it continues to be so. For many municipal agencies, landfilling, incineration, and land application are the major methods of disposal and/or utilization.

In 1967, the District's governing board faced with increasing solids production rates, rising fuel costs, and the limited availability of land for final disposition, adopted a policy of solids utilization rather than disposal. The District has always endeavored, when economically justified, to incorporate the beneficial use of biosolids into its sludge management programs.

The District initiated several internal programs to reduce the metal content of its biosolids for beneficial utilization. These internal programs, along with the implementation of the regulations of the FWPCA, and the 40 CFR Part 503 Sewage Sludge Regulations in 1993, resulted in a significant improvement of the District's biosolids with respect to metals.

The objectives of this paper are:

1. To give a historical overview of the metal content in the digester draw and waste-activated sludges from the District's seven WRPs from 1982 through 2000.
2. To show the impact of the District's pretreatment program on the metal content of the

sludge and biosolids produced from 1982 through 1991.

3. To show the impact of the District's 503EI initiative on the concentrations of pretreatment regulated metals (cadmium, chromium, copper, lead, nickel, and zinc) and nonpretreatment metals (arsenic, mercury, molybdenum, and selenium) in the sludge and biosolids produced by the WRPs from 1992 through 2000.

WATER RECLAMATION PLANTS

The District owns and operates seven WRPs, with design flows in the range of 3.4 to 1,200 MGD. All seven WRPs use the activated sludge process, and each WRP handles its sludge/biosolids in somewhat different ways, depending upon local factors. A brief description of the sludge management operations at the seven WRPs follows.

Lemont WRP, located in Lemont, Illinois, has a design capacity of 3.4 MGD. Wastewater processes include both primary and secondary (activated sludge) treatment. Solids produced at the WRP (primary and waste-activated sludge) are gravity concentrated. The concentrated solids are transported to either the Calumet WRP or Stickney WRP for further processing. No final biosolids product is produced at this WRP.

James C. Kirie WRP, located in Des Plaines, Illinois, has a design capacity of 72 MGD. Wastewater processes include primary, secondary (activated sludge), and tertiary (sand filtration) treatment. Solids produced at the WRP are sent via a force main to the John E. Egan WRP for further treatment. No final sludge product is produced at this WRP.

John E. Egan WRP, located in Schaumburg, Illinois, has a design flow of 30 MGD. Wastewater processes include primary, secondary (activated sludge), and tertiary (sand filtration) treatment. All raw sludge solids including waste-activated sludge at the WRP are anaerobically digested. Following digestion, the solids are conditioned with a cationic polymer and centrifuged. The centrifuged cake may be land applied as a Class B biosolids product or transported by truck to lagoons at the Calumet WRP where it is aged prior to air-drying. During the winter or when the centrifuges are not operating, liquid digested solids are sent via pipeline to the North Side (NS) WRP, where the NS waste-activated sludge solids and the digested solids from the John Egan WRP are sent via pipeline to the Stickney WRP for further treatment.

North Side WRP, located in Skokie, Illinois, has a design capacity of 333 MGD. Wastewater processes at this WRP include primary and secondary (activated sludge) treatment. Solids produced at this WRP are sent via pipeline to the Stickney WRP for further treatment. No final biosolids product is produced at this WRP.

Calumet WRP, located in Chicago, Illinois, has a design capacity of 354 MGD. Wastewater processes at this WRP include primary and secondary (activated sludge) treatment. All solids produced at this WRP are anaerobically digested. Following digestion, solids are conditioned with a cationic polymer, centrifuged, and transported by truck to high solids lagoons dedicated for storage and further stabilization of centrifuge cake. The centrifuge cake may also be applied to agricultural land as a Class B product. During the winter or when the centrifuges are not operating, liquid digested solids are sent to low solids lagoons dedicated for storage and further stabilization.

Stickney WRP, located in Stickney, Illinois, has a design capacity of 1,200 MGD. Wastewater processes include primary and secondary (activated sludge) treatment. All primary and waste-activated sludge solids produced at this WRP are gravity thickened and are further dewatered in pre-digestion centrifuges. The dewatered solids (about 6 percent) are anaerobically digested. Following digestion, these solids are processed through two biosolids process trains, liquid (low solids) or centrifuge cake (high solids), to produce an air-dried final Class A biosolids product. Centrifuge cake may also be applied to agricultural land as a Class B biosolids product or transported to lagoons dedicated to the aging and further stabilization of centrifuge cake.

Hanover Park WRP, located in Hanover Park, Illinois, has a design capacity of 12 MGD. Wastewater processes at this WRP include primary, secondary (activated sludge), and tertiary (sand filtration) treatment. All solids produced at this WRP are thickened by gravity belt thickeners, anaerobically digested, and lagooned. Lagooned digested biosolids are then applied by injection to fields on a 111 acre (45 ha) farm at the site. All the biosolids produced at the Hanover Park WRP are beneficially utilized on farmland at the site.

FEDERAL REGULATIONS AND THE DISTRICT'S PROGRAMS AND INITIATIVES TO REDUCE METALS IN BIOSOLIDS

The Federal Water Pollution Control Act (FWPCA) of 1972 and 1977

The FWPCA established the ambitious goals of: (a) making the nation's waterways swimmable by 1983, and (b) eliminating the discharge of pollutants into the nation's waterways by 1985. To this end, Congress directed the USEPA to conduct comprehensive studies of the impact of industrial pollution on the nation's waterways, and to implement comprehensive national regulations governing wastewater discharges from industries found to be significant sources of pollution. Recognizing that a signifi-cant portion of the nation's industrial facilities do not discharge wastewater directly into the nation's waterways, Congress subsequently amended the FWPCA in 1977 to require the USEPA to establish national pretreatment standards governing industrial discharges into the nation's POTWs.

In 1978, the General Pretreatment Regulations were promulgated, which established the responsibilities of the USEPA, the states, and POTWs in implementing the National Pretreatment Program. The General Pretreatment Regulations included general discharge regulations applicable to all indirect dischargers, intended to achieve the following objectives:

1. To prevent the introduction of pollutants that pass-through POTWs and are discharged into receiving waters.
2. To prevent the introduction of pollutants that interfere with the operations of POTWs, including interference with the use or disposal of sludges generated by POTWs.
3. To improve opportunities to recycle and reclaim municipal and industrial wastewaters and sludges.

The General Pretreatment Regulations also require all POTWs which receive categorically regulated industrial discharges, or with design flows greater than 5 MGD to develop and maintain local pretreatment programs. Local pretreatment programs must be approved by the USEPA or a state with delegated approval authority for pretreatment program oversight, and must include the necessary legal authority and procedures to perform the following functions:

1. Identify and locate all possible industrial users (IUs) which might be subject to regulation under the local pretreatment program.

2. Identify the character and volume of pollutants discharged by IUs into the POTW.
3. Notify IUs of the applicability of pretreatment program regulations and the requirements governing the generation and disposal of hazardous wastes under the Federal Resource Conservation and Recovery Act.
4. Receive and analyze self-monitoring reports and other information submitted by IUs under the General Pretreatment Regulations.
5. Randomly sample and analyze discharges from IUs to the POTW, and conduct surveillance and inspection activities in order to identify instances of noncompliance with applicable standards, independent of information supplied by IUs.
6. Investigate instances of noncompliance by IUs, and issue enforcement actions, including authority to assess or seek civil penalties, sufficient to elicit a prompt return to compliance.

7. Comply with the public participation and public access to information provisions of the National Pretreatment Program.

In conformance with the General Pretreatment Regulations, the District submitted its final pretreatment program proposal to the USEPA in July 1985, and on November 18, 1985, the USEPA issued its approval of the District's local pretreatment program.

Pretreatment Regulations and Program

DEVELOPMENT OF THE DISTRICT'S PRETREATMENT PROGRAM

Recognizing the potential adverse impact of industrial discharges on wastewater treatment plant operations, many POTWs in the United States, including the District, established Pretreatment Programs during the late 1960s to control the discharges from the IUs tributaries to their treatment facilities. The District's Sewage and Waste Control Ordinance (Ordinance), in which the District established general discharge regulations applicable to discharges from all IUs, including specific limits on the concentrations of critical pollutants having the potential to impact the operations of the District's WRPs, was adopted in 1969. The discharge limits contained in the Ordinance were designed to prevent the pass-through of pollutants into receiving streams, and interference with the physical and biological treatment processes employed at the District's WRPs, and to a lesser degree, to ensure the quality of biosolids generated for disposal.

The general discharge limits established by the District in 1969, as well as several other municipal agencies during this period, are indicated in Table 1.

NATIONAL PERFORMANCE STANDARDS

In addition to the General Pretreatment Regulations, Congress directed the USEPA to establish National Performance Standards for specific industrial categories identified as the major sources of pollutants discharged into the nation's waterways.

In developing the National Performance Standards, the USEPA surveyed the industrial community within each category and collected information regarding industrial processes, wastewater treatment technologies, and effluent discharge characteristics. The USEPA evaluated both the technical and economical feasibilities of the various treatment options in the establishment of discharge standards.

To date, the USEPA has established direct and indirect (pretreatment) discharge standards for 27 industrial categories,

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 1

COMPARISON OF DISTRICT'S LOCAL DISCHARGE LIMITS FOR POLLUTANTS REGULATED UNDER PART 503 SEWAGE SLUDGE REGULATIONS WITH THOSE OF THREE OTHER MUNICIPAL AGENCIES

	Municipal Agencies[1]			
Pollutant	Metropolitan Water Reclamation District of Greater Chicago	Hampton Roads Sanitation District	Metropolitan Waste Control Commission Twin Cities Area	East Bay Municipal Utility District
	mg/L			
Arsenic	NL[2]	0.1	NL	2.0
Cadmium	2.0	0.1	2.0	1.0
Chromium	25.0	5.0	8.0	2.0
Copper	3.0	5.0	6.0	5.0
Lead	0.5	2.0	1.0	2.0
Mercury	0.0005	0.02	0.1	0.05
Molybdenum	NL	NL	NL	NL
Nickel	10.0	2.0	6.0	5.0
Selenium	NL	NL	NL	NL
Zinc	15.0	5.0	8.0	5.0

[1]General discharge limits for industrial waste pretreatment established by the Municipal Agency - period 1969 to 1980.
[2]No limit established by local or federal agencies.

as indicated in Table 2. These categorical discharge standards are based upon the best available treatment technology for the pollutants discharged from each industrial category, and represent the highest degree of pollutant reduction economically achievable using such technology.

Unlike local discharge limits established by POTWs to prevent pass-through or interference, categorical discharge standards are applicable to all members of an industrial category, nationwide, regardless of which POTW a particular IU discharges to, and whether or not the POTW has established local discharge limits. Thus, as federal categorical discharge standards became effective during the 1980s, IUs were required to install and maintain wastewater treatment technology sufficient to comply with the standards, whether or not the local POTW had a pretreatment program in place. In the absence of an approved local pretreatment program, the IU is subject to direct state or federal enforcement of categorical discharge standards.

PRETREATMENT PROGRAM ACTIVITIES 1985 - 1992

Between 1985 and 1992, the District maintained its pretreatment program by conducting annual inspections and four days of sampling at the facilities of all SIUs. In some cases,

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 2

INDUSTRIAL CATEGORIES SUBJECT TO ESTABLISHED FEDERAL CATEGORICAL PRETREATMENT STANDARDS

Industrial Category	40 CFR Part	Existing Sources Compliance Date
Aluminum forming	467	10/24/86
Battery manufacturing	461	9/9/87
Builders' paper and board mills	431	7/1/84
Coil coating I	465	12/1/85
Coil coating II (Canmaking)	465	11/17/86
Copper forming	468	8/15/86
Electrical and electronic components I	469	7/14/86
Electroplating	413	7/15/86
Inorganic chemicals I	415	8/12/85
Inorganic chemicals II	415	8/22/87
Iron and steel	420	7/10/85
Leather tanning and finishing	425	11/25/85
Metal finishing	433	2/15/86
Metal molding and casting	464	10/31/88
Nonferrous metal forming	471	8/23/88
Nonferrous metal manufacturing I	421	3/8/87
Nonferrous metal manufacturing II	421	9/20/88
Organic chemicals, plastics and synthetic fibers	414	11/05/90
Pesticides	455	10/4/88
Petroleum refining	419	12/1/85
Pharmaceutical manufacturing	439	10/27/86
Plastics molding and forming	463	1/30/88
Porcelain enameling	466	11/25/85
Pulp, paper, and paperboard	430	7/1/84
Rubber processing	428	None
Steam electric generating	125,423	7/1/84
Textile mills	410	9/2/85
Timber products processing	429	1/26/84

increased monitoring was performed where IUs demonstrated patterns of noncompliance with applicable discharge standards.

As a result of the inclusion of water quality based copper discharge limits in the National Pollutant Discharge Elimination System (NPDES) permits for the District's Hanover Park and James Kirie WRPs, continuous (365 days per year) sampling of certain IUs that use copper in their industrial processes was implemented during this period. Within this limited focus area, the District found that continuous monitoring had a deterrent effect on these IUs. Therefore, the District has been able to maintain compliance with its NPDES permit discharge limits through selective continuous monitoring without difficulty.

THE 503 ENFORCEMENT INITIATIVE 1992 - 1997

Sustich et al. (1997) described the following initiatives in the District's Pretreatment Program which were implemented in response to the Standards for the Use and Disposal of Sewage Sludge (40 CFR Part 503), promulgated by the USEPA in February 1993 (USEPA, 1993):

> In anticipation of the Part 503 regulations, the District, in mid-1992, conducted an initial compliance assessment with regard to the high quality sludge standards. Through this assessment, the District determined that sludges produced at some of its WRPs would not meet the high quality

limits, and that reduction in the concentrations of three metals (cadmium, chromium, and lead) was needed .... The District found that the average concentrations of cadmium in digester sludge produced at the Calumet and Stickney WRPs did not meet the high quality sludge limits, and while the average concentrations of chromium and lead at District WRPs met the high quality limits, individual analyses for these metals indicated periodic excursions beyond the high quality limits. The District's efforts to achieve the high quality sludge standards became known as the 503 Enforcement Initiative (503EI).

503EI IMPLEMENTATION

Guiding Principle

The District established as the guiding principle of the 503EI, that a substantial reduction in the discharge of heavy metals, and the high quality sludge limits, could be achieved through (a) optimization of the District's existing Pretreatment Program, (b) increased monitoring of industrial point source discharges into its sewerage system, and (c) innovative Pollution Prevention (P2) assistance to the industrial community.

Pretreatment Program Optimization

In January 1993, following approval by the state of Illinois legislature in August 1992, the District amended its Sewage and Waste Control Ordinance (Ordinance) to include the following enforcement mechanisms, which were designed to elicit more decisive action by IUs to attain compliance with applicable standards:

- authority to assess administrative civil penalties, in the range from $100 to $2,000 per day of violation

- authority to assess fees for late filing of reports required under the Ordinance, in the range from $100 to $1,000 per day

- authority to impose liens on property owned by IUs, in response to nonpayment of late filing fees

<u>Increased Monitoring of Industrial Point Source Discharges (40 CFR 403)</u>

Under the federal General Pretreatment Regulations, POTWs are required to inspect and sample each significant industrial user (SIU) tributary to their sewerage systems, at least once annually. In addition, each SIU is required to conduct self-monitoring of its wastewater discharge, at least twice annually. While the District had, for a number of years, performed these mandated inspection and sampling activities, and had required its SIUs to conduct the mandated self-monitoring, most SIUs were left effectively unmonitored for more than 90 percent of each calendar year.

Under the 503EI, the District substantially increased its resources committed to inspection and sampling of SIUs who are categorically regulated for the discharge of metals .... These increased resources were targeted exclusively toward regulated SIUs which the District established had a higher than average propensity for discharging metals of concern, the District considered the following factors:

- annual mass discharge of metals of concern

- five-year enforcement history

- adequacy of industrial pretreatment facilities

- adequacy of spill prevention, control and countermeasure facilities

- acceptability of discharge monitoring point

- presence of state certified wastewater treatment plant operator

Each regulated SIU was assessed a numeric score for the factors above, and the population was then ranked by numeric score for the selection of targets for continuous discharge monitoring. During the first quarter of 1993, the District installed continuously operated automatic sampling equipment at the top 100 SIUs (out of 600 SIUs) identified through the selection process described above. Through the increased SIU monitoring described here, the District was able to substantially reduce sludge metals concentrations at its WRPs, and the high quality sludge limits were consistently being met by April 1993.

METALS

The District implemented its first pretreatment standards for discharges into sewers in 1969 to reduce the adverse impacts of metals on the performance of its WRPs. In subsequent years, as described in the section FEDERAL REGULATIONS AND THE DISTRICT'S PROGRAMS AND INITIATIVES TO REDUCE METALS IN BIOSOLIDS, stricter pretreatment standards were imposed by the District under approved local and USEPA categorical standards. In 1993, the USEPA implemented the Part 503 Sewage Sludge Regulations for land application. Also, in 1993 the District implemented District wide an initiative (503EI) to drastically reduce metals in the sludge and biosolids generated from its WRPs. The impact of these pretreatment standards, regulations, and enforcement initiatives has been to reduce the metal content in the sludge and biosolids produced by the District's WRPs from 1982 through 2000, but particularly between 1992 and 2000.

From a historical perspective, there are three periods of interest in evaluating the metals content of the sludge and biosolids produced by the District's seven WRPs. The first period is the broad span of 1982 to 2000 which gives a historical overview of metal concentrations in the sludge and biosolids from the District's WRPs during this interval. The second period is from 1982 to 1991, which reflects the approval of the District's pretreatment program by USEPA on November 18, 1985, maintaining the pretreatment program by conducting annual inspections and four days of sampling at the facilities of SIUs, and water quality based copper discharge limits in NPDES permits for the Hanover Park and Kirie WRPs. The third period of 1992 to 2000 reflects the implementation of the 503EI, and the impact of this initiative on the metal concentrations in the sludge and biosolids produced by the District's WRPs.

The metals shown for these three periods are the 10 metals originally regulated in the Part 503 Sewage Sludge Regulations (arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, selenium, and zinc).

Sludge and Biosolids from District WRPs 1982 - 2000

The mean yearly concentrations of the 10 metals are shown for the sludge and biosolids from each of the District's seven WRPs from 1982 through 2000 in Tables 3 through 12. For the Calumet, Egan, Hanover Park, Stickney WRPs, the metal concentrations are shown for the digester draw. At the Kirie and Lemont WRPs, the metal levels are shown for the waste-activated sludge produced by

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

YEARLY MEANS FOR ARSENIC[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1982	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA	NA	NA
1991	5	1	1	0[2]	6	22	2
1992	0	0	NR	11	0	0	1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3 (Continued)

YEARLY MEANS FOR ARSENIC[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1993	3	2	1	12	2	1	2
1994	3	2	2	7	2	2	2
1995	5	2	2	3	2	2	2
1996	11	3	2	6	2	4	2
1997	9	3	3	5	3	4	3
1998	7	3	3	6	2	4	3
1999	7	4	3	4	3	4	3
2000	8	4	4	6	3	3	3

NA = No analysis.

[1]Arsenic limit for exceptional quality biosolids is 41 mg/kg.

[2]Concentrations less than the detection limit are reported as zero.

NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

YEARLY MEANS FOR CADMIUM[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1982	33	151	197	132	85	9	131
1983	54	159	221	104	55	16	128
1984	68	167	57	128	124	25	141
1985	96	101	66	107	83	23	110
1986	70	95	23	120	64	22	95
1987	90	62	12	132	47	23	92
1988	77	61	13	98	35	29	69
1989	85	41	12	103	36	16	56
1990	62	34	18	67	24	17	39
1991	72	28	18	47	26	14	37
1992	42	25	15	41	19	4	32

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4 (Continued)

YEARLY MEANS FOR CADMIUM[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs
FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	----------	----------	----------	mg/dry kg	----------	----------	----------
1993	15	21	13	23	16	3	24
1994	7	19	13	18	15	3	23
1995	7	16	13	13	13	2	19
1996	6	5	4	8	3	2	5
1997	4	5	3	7	3	2	5
1998	4	3	2	6	2	2	4
1999	5	4	3	5	3	2	5
2000	4	4	3	4	3	2	4

[1]Cadmium limit for exceptional quality biosolids is 39 mg/kg.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

YEARLY MEANS FOR CHROMIUM[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs
FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1982	379	1090	667	2019	900	45	904
1983	488	1327	651	1694	918	60	799
1984	704	1066	655	1747	888	57	826
1985	723	903	382	1524	698	55	685
1986	507	738	185	1412	565	68	572
1987	543	850	172	1499	715	72	643
1988	493	833	165	1311	681	64	698
1989	503	492	158	1200	404	52	551
1990	316	305	145	1017	234	66	252
1991	338	223	156	904	201	19	180
1992	289	218	135	1017	191	32	193

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5 (Continued)

YEARLY MEANS FOR CHROMIUM[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1993	205	206	110	667	180	33	145
1994	85	129	78	439	108	23	135
1995	82	130	62	425	122	23	116
1996	82	85	51	338	69	24	59
1997	101	90	43	339	75	20	68
1998	67	123	50	258	115	16	80
1999	68	118	38	277	93	17	68
2000	73	203	43	251	195	16	77

[1]Chromium limit of 1200 mg/kg for exceptional quality biosolids was deleted by USEPA from the Part 503 Sludge Regulations in 1995.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6

YEARLY MEANS FOR COPPER[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1982	353	2100	1975	1278	1875	676	1140
1983	344	2005	2564	1146	1854	855	1066
1984	352	1824	3212	1342	1542	727	1042
1985	359	1818	2416	968	1526	727	858
1986	342	1673	1730	862	1408	769	756
1987	344	2747	1926	871	2488	384	993
1988	357	2235	1701	853	1873	380	916
1989	318	1279	1498	798	1116	264	675
1990	254	849	1222	597	574	292	487
1991	295	732	1162	528	537	341	452
1992	320	862	1054	580	671	411	541

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6 (Continued)

YEARLY MEANS FOR COPPER[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1993	310	751	845	481	558	424	521
1994	296	709	836	509	513	487	445
1995	287	683	702	436	523	423	456
1996	307	654	724	385	490	374	405
1997	306	683	722	395	500	436	432
1998	331	679	830	377	508	470	510
1999	356	778	874	390	591	458	534
2000	330	825	793	387	596	406	538

[1]Copper limit for exceptional quality biosolids is 1500 mg/kg.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7

YEARLY MEANS FOR LEAD[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	-----------------	-----------------	-----------------	mg/dry kg	-----------------	-----------------	-----------------
1982	467	289	194	524	254	342	328
1983	572	290	277	459	226	332	296
1984	837	304	449	478	235	519	268
1985	517	290	279	396	239	432	256
1986	404	265	193	396	222	293	427
1987	229	402	263	423	361	143	413
1988	215	329	238	342	261	140	244
1989	174	211	177	309	148	74	173
1990	181	159	157	276	99	58	165
1991	154	104	118	273	78	60	148

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7 (Continued)

YEARLY MEANS FOR LEAD[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs
FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1992	136	158	144	302	106	69	172
1993	140	92	75	263	58	69	137
1994	119	81	80	248	50	61	111
1995	113	69	72	212	51	42	97
1996	145	59	50	184	40	33	86
1997	262	60	47	176	45	34	87
1998	135	55	45	163	43	32	89
1999	119	55	48	144	44	33	88
2000	108	46	42	139	33	23	68

[1]Lead limit for exceptional quality biosolids is 300 mg/kg.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 8

YEARLY MEANS FOR MERCURY[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1982	0.2	3.9	4.7	4.6	2.9	1.5	4.3
1983	0.4	3.9	4.4	3.3	2.2	2.5	3.6
1984	0.4	3.5	3.7	3.3	2.0	2.1	3.0
1985	0.4	3.4	4.0	2.3	2.4	1.0	3.0
1986	0.6	3.3	5.4	2.3	2.3	1.1	12.3
1987	1.6	3.1	4.8	1.2	2.1	0.7	3.8
1988	0.6	2.6	4.2	1.5	1.9	0.8	2.1
1989	0.7	2.7	3.8	1.8	2.1	1.0	2.1
1990	0.6	3.5	4.1	1.8	2.0	0.8	2.0
1991	0.5	3.0	4.4	2.0	1.9	0.8	1.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 8 (Continued)

YEARLY MEANS FOR MERCURY[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1992	0.8	3.0	4.0	1.6	1.9	0.6	2.1
1993	1.4	2.5	4.2	1.7	1.4	1.0	2.0
1994	1.3	2.3	4.4	1.7	1.5	0.9	1.7
1995	0.8	2.1	3.4	2.2	1.1	0.8	1.7
1996	0.4	2.0	3.7	1.8	1.3	0.3	1.9
1997	0.3	1.9	3.3	1.2	1.1	0.4	1.2
1998	0.7	0.8	2.2	1.0	0.8	0.5	0.6
1999	0.5	1.3	2.2	0.7	0.6	0.5	0.8
2000	0.7	0.9	1.7	0.7	0.6	0.6	0.8

[1]Mercury limit for exceptional quality biosolids is 17 mg/kg.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9

YEARLY MEANS FOR MOLYBDENUM[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	-----	-----	-----	mg/dry kg	-----	-----	-----
1982	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA	NA	NA
1991	5	34	8	0[2]	9	24	9
1992	8	9	NR	12	5	3	10

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9 (Continued)

YEARLY MEANS FOR MOLYBDENUM[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1993	8	20	10	9	14	3	10
1994	10	23	10	13	13	5	10
1995	16	17	8	21	10	7	9
1996	NA	NR	NR	25	6	NR	NA
1997	NA	NR	NR	NA	8	NR	NA
1998	15	15	10	24	8	4	NA
1999	13	17	10	13	12	4	7
2000	11	20	11	14	13	5	8

[1]Ceiling limit for molybdenum in Part 503 Sludge Regulations is 75 mg/kg.
NA = No analysis.
[2]Concentrations less than the detection limit are reported as zero.
NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 10

YEARLY MEANS FOR NICKEL[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	-----------------	-----------------	--------	mg/dry kg	--------	-----------------	-----------------
1982	92	376	121	364	139	65	224
1983	101	343	146	271	109	77	199
1984	98	165	236	264	117	94	240
1985	84	157	240	209	77	99	222
1986	82	148	164	194	70	72	170
1987	89	165	158	247	107	124	193
1988	74	188	121	185	147	115	179
1989	40	118	126	160	92	45	158
1990	45	82	84	135	68	44	91
1991	46	87	63	124	75	28	92

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 10 (Continued)

YEARLY MEANS FOR NICKEL[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs
FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1992	40	104	74	109	89	27	102
1993	42	87	57	74	68	24	73
1994	32	71	50	70	55	20	72
1995	33	52	38	69	42	18	48
1996	32	39	29	61	29	18	37
1997	31	42	31	55	33	17	41
1998	34	48	30	55	38	18	56
1999	30	45	30	52	35	16	40
2000	30	62	31	54	61	14	43

[1] Nickel limit for exceptional quality biosolids is 420 mg/kg.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 11

YEARLY MEANS FOR SELENIUM[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	----------	----------	----------	mg/dry kg	----------	----------	----------
1982	NA	NA	NA	NA	NA	NA	NA
1983	NA	NA	NA	NA	NA	NA	NA
1984	NA	NA	NA	NA	NA	NA	NA
1985	NA	NA	NA	NA	NA	NA	NA
1986	NA	NA	NA	NA	NA	NA	NA
1987	NA	NA	NA	NA	NA	NA	NA
1988	NA	NA	NA	NA	NA	NA	NA
1989	NA	NA	NA	NA	NA	NA	NA
1990	NA	NA	NA	NA	NA	NA	NA
1991	5	2	2	0[2]	2	25	3
1992	23	1	NR	NR	0	5	3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 11 (Continued)

YEARLY MEANS FOR SELENIUM[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	----------	----------	----------	mg/dry kg	----------	----------	----------
1993	<1	1	1	NR	1	<1	1
1994	0	1	1	2	1	0	1
1995	8	1	1	3	1	3	1
1996	11	2	2	3	2	4	2
1997	10	2	2	3	2	2	2
1998	13	4	4	3	3	4	5
1999	10	4	5	3	3	3	5
2000	12	4	5	3	3	4	4

[1]Ceiling limit for Selenium in Part 503 Sludge Regulations is 100 mg/kg.
NA = No analysis.
[2]Concentrations less than the minimum detection limit are reported as zero.
NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 12

YEARLY MEANS FOR ZINC[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs
FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	----------	----------	----------	mg/dry kg	----------	----------	----------
1982	2352	2803	1899	2233	2754	4818	1891
1983	2275	3505	1805	2129	3283	4682	1716
1984	2577	3573	1514	2186	2993	4545	1704
1985	2414	2830	1131	2070	2427	5511	1524
1986	2715	2481	1018	2264	1991	7271	1281
1987	2454	NR	929	2452	2067	805	1421
1988	2321	2461	966	2127	2073	570	1330
1989	2017	2261	943	1976	2040	445	1136
1990	2123	2207	795	1815	1655	596	955
1991	1860	1167	720	1643	1013	546	777

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 12 (Continued)

YEARLY MEANS FOR ZINC[1] IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs
FROM 1982 THROUGH 2000

Year	Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Concentration
	mg/dry kg						
1992	1432	1320	778	1827	1084	561	881
1993	1363	1005	663	1333	763	612	816
1994	1393	803	693	1495	581	574	1490
1995	1429	708	612	1073	543	483	660
1996	1626	671	582	1165	511	455	557
1997	1789	713	615	874	542	443	559
1998	1429	713	620	840	575	457	556
1999	1077	734	754	902	553	536	565
2000	1125	744	610	872	551	546	549

[1]Zinc limit for exceptional quality biosolids is 2800 mg/kg.
NR = Not reported.

these two plants. For the North Side WRP, metal concentrations are reported for gravity concentration sludge, since this is the material which is pumped to Stickney for further processing. The yearly mean, minimum, and maximum concentrations for each of the 10 metals at the District's seven WRPs from 1982 through 2000 are shown in Appendix AI.

ARSENIC

The yearly means for arsenic in the sludge and biosolids produced by the District's seven WRPs from 1991 through 2000 are shown in Table 3. Arsenic is not regulated by the pretreatment regulations (nonpretreatment metal). The analysis of District biosolids for arsenic was not initiated until 1991. Analysis for arsenic has been subject to problems of analytical reliability, making a comparison of the levels reported in 1991 and 1992 with those in later years at the District's seven WRPs difficult to interpret.

The arsenic concentration for EQ biosolids in the Part 503 Sewage Sludge Regulations is 41 mg/dry kg. Table 3 shows that the arsenic levels in the sludge and biosolids produced by the seven District WRPs from 1992 through 2000 were within the range of 0 to 22 mg/dry kg, and were well below the EQ limit.

CADMIUM

The yearly means for cadmium in sludge and biosolids produced by the District's seven WRPs are shown in Table 4. They ranged from 2 mg/dry kg at several WRPs (Hanover Park 1998, Kirie 1998, and Lemont 1995 - 2000) to 221 mg/dry kg at the Hanover Park WRP (1983). From 1982 through 2000, the Lemont WRP waste-activated sludge had the lowest range of mean cadmium levels (2 to 29 mg/dry kg). The highest ranges of mean cadmium concentrations from 1982 through 2000 occurred in digester draw sludge from the Hanover Park WRP (2 to 221 mg/dry kg) and the Egan WRP (3 to 167 mg/dry kg).

The impact of the pretreatment regulations and the 503EI on cadmium reduction in biosolids produced by the District's WRPs from 1982 through 2000 will be discussed later in this report. Table 4 shows that the yearly mean cadmium levels in the sludge and biosolids produced at the District's seven WRPs after 1992 were below the cadmium limit of 39 mg/kg for EQ biosolids. Yearly mean cadmium concentrations in sludge and biosolids continued to decline from 1993 through 1995, and have remained essentially constant since 1996.

CHROMIUM

The yearly means for chromium in the sludge and biosolids produced by the District's seven WRPs from 1982 through 2000 are shown in Table 5. They ranged from 16 mg/dry kg at the Lemont WRP (1998 and 2000) to 2019 mg/dry kg at the Stickney WRP (1982). During that interval, the Lemont WRP waste-activated sludge had the lowest range in mean chromium levels (16 to 72 mg/dry kg) while the highest range of mean chromium concentrations occurred in the digester draw from the Stickney WRP (251 to 2019 mg/dry kg).

The USEPA deleted the chromium EQ limit of 1200 mg/kg from the Part 503 Sewage Sludge Regulations in 1995. Although there is no EQ limit for chromium, Table 5 shows that the mean yearly chromium levels in the sludge and biosolids produced by the District's seven WRPs were below 1200 mg/kg after 1992. This can be attributed to the implementation of 503EI in 1992 which will be discussed later in this report.

COPPER

The yearly means for copper in the sludge and biosolids produced by the District's seven WRPs from 1982 through 2000 are shown in Table 6. They ranged from 254 mg/dry kg at the Calumet WRP (1990) to 3212 mg/dry kg at the Hanover Park WRP

(1984). The range in mean copper levels during this interval was the lowest in digester draw sludge from the Calumet WRP (254 to 359 mg/dry kg) and the highest in digester draw sludge from the Hanover Park WRP (702 to 3212 mg/dry kg).

Table 6 shows that after 1992, the mean yearly concentrations of copper in the sludge and biosolids produced by the District's seven WRPs were well below the copper EQ limit of 1500 mg/kg. Yearly mean copper levels at the District's WRPs have remained fairly constant since 1993. This trend indicates that the implementation of the pretreatment programs and the monitoring of SIUs under the 503EI to be discussed later in this report were effective for copper removal.

LEAD

The yearly means for lead in the sludge and biosolids produced by the District's seven WRPs from 1982 through 2000 are shown in Table 7. They ranged from 23 mg/dry kg at the Lemont WRP (2000) to 837 mg/dry kg at the Calumet WRP (1984). The range in mean lead concentrations during that interval was the lowest in waste-activated sludge from the Kirie WRP (33 to 361 mg/dry kg) and the highest in digester draw from the Calumet WRP (108 to 837 mg/dry kg) and Stickney WRP (139 to 524 mg/dry kg).

Table 7 shows that since 1993, the mean yearly levels of lead in the sludge and biosolids produced by the District's seven WRPs have been fairly constant and well below the lead EQ limit of 300 mg/kg. The impact of the pretreatment programs on lead reduction in the sludge and biosolids is very evident, and it will be discussed later in this report.

MERCURY

The yearly means for mercury in the sludge and biosolids produced by the District's WRPs from 1982 through 2000 are shown in Table 8. They ranged from 0.2 mg/dry kg at the Calumet WRP (1982) to 12.3 mg/dry kg at the North Side WRP (1986). Mercury is regulated by the District's local discharge limits (Table 1), but not by the USEPA categorical pretreatment standards. Mercury levels were generally the lowest in digester draw from the Calumet WRP and the highest in digester draw from the Hanover Park WRP.

The mean yearly mercury concentrations in the sludge and biosolids produced by the District's WRPs from 1982 to 2000 were always below the mercury EQ limit of 17 mg/kg established by the USEPA in 1993. Continued reductions in mercury occurred at the District's WRPs after the Part 503 Sewage Sludge Regulations were implemented in 1993.

MOLYBDENUM

The yearly means for molybdenum in the sludge and biosolids produced by the District's WRPs from 1982 through 2000 are shown in Table 9. Molybdenum is not regulated by the pretreatment regulations, and it is a nonpretreatment metal as shown in Table 1. The analysis of molybdenum in the District's sludge and biosolids was not initiated until 1991. Analytical methods for molybdenum, like arsenic, are not as reliable as methods for other metals. This makes the comparison of molybdenum concentrations reported in 1991 with those in the following years at the District's seven WRPs difficult to interpret.

The mean yearly molybdenum concentrations in the sludge and biosolids produced by the seven WRPs from 1991 through 2000 are shown in Table 9. They ranged from 0 mg/dry kg at the Stickney WRP (1991) to 34 mg/dry kg at the Egan WRP (1991). Molybdenum concentrations were usually the lowest in waste-activated sludge from the Lemont WRP, and the highest in digester draw from either the Egan or Stickney WRPs. Molybdenum concentrations in the sludge and biosolids showed an increase from 1991 through 2000. This apparent increase is probably a result of the analytical unreliability of the 1991 data. No analyses were conducted from 1982 through 1990 due to the unreliability of the analytical methods during this period.

The ceiling concentration limit for molybdenum in the Part 503 Sludge Regulations is 75 mg/kg. Table 9 shows that the sludge and biosolids produced by the District's WRPs after 1991 had molybdenum concentrations well below 75 mg/kg.

NICKEL

The yearly means for nickel in the sludge and biosolids produced by the District's seven WRPs from 1982 through 2000 are shown in Table 10. They ranged from 14 mg/dry kg at the Lemont WRP (2000) to 376 mg/dry kg at the Egan WRP (1982). The range in mean nickel concentrations during that interval was the lowest in digester draw sludge from the Calumet WRP (30 to 101 mg/dry kg), and the highest in digester draw sludge from the Egan WRP (39 to 376 mg/dry kg) and Stickney WRP (52 to 364 mg/dry kg).

Table 10 shows that the yearly mean nickel concentrations in the sludge and biosolids produced at the District's WRPs after 1992 were well below the nickel limit of 420 mg/kg for EQ biosolids, and ranged between 14 and 87 mg/kg. This indicates that the pretreatment programs implemented were very effective in reducing the nickel concentrations in the sludge and biosolids produced by the District's seven WRPs.

SELENIUM

The yearly means for selenium in the sludge and biosolids produced by the District's WRPs from 1982 through 2000 are shown in Table 11. Selenium is not regulated by the pretreatment regulations, as shown in Table 1. The analysis for selenium was not initiated until 1991. The reliability of selenium analysis like arsenic and molybdenum was initially not good. This makes the comparison of the concentrations reported in 1991 with those in the following years at the District's seven WRPs difficult to interpret.

The mean selenium levels in the sludge and biosolids produced by the seven WRPs from 1991 through 2000 are shown in Table 11, and they ranged from 0 mg/dry kg at the several WRPs (Stickney 1991, Kirie 1992, Calumet 1994, and Lemont 1994) to 25 mg/dry kg at the Lemont WRP (1991). Increases in selenium concentrations were observed in the sludge and biosolids produced by the District's WRPs after 1991, and they varied from 33 percent for North Side gravity concentration sludge (3 to 4 mg/dry kg) to 150 percent for Hanover Park digester draw (2 to 5 mg/dry kg). These apparent increases were probably due to the unreliability of the analytical techniques used to obtain the early data.

The ceiling limit for selenium in biosolids is 100 mg/kg. Table 11 shows that yearly mean selenium concentrations in the sludge and biosolids produced by the District's seven WRPs were within the range of 0 mg/kg at the Calumet and Lemont WRPs (1994) to 13 mg/kg at the Calumet WRP (1998) from 1993 through 2000, which is well below the ceiling limit for selenium.

ZINC

The yearly mean zinc concentrations in the sludge and biosolids produced by the District's seven WRPs from 1982 through 2000 are shown in Table 12. They ranged from 14 mg/dry kg at the Lemont WRP (2000) to 376 mg/dry kg at the Egan WRP (1982). The lowest ranges in mean zinc concentrations during that interval occurred in the digester draw sludge from the Hanover Park WRP (610 to 1899 mg/dry kg) and the gravity concentration tank sludge from the North Side WRP (549 to 1891 mg/dry kg). The highest range in mean zinc levels occurred in waste-activated sludge from the Lemont WRP (443 to 4818 mg/dry kg).

The pretreatment regulations had a marked effect on the zinc concentrations in the sludge and biosolids produced by the District's WRPs from 1982 through 2000, and this will be discussed in a later section of this report.

Table 12 shows that after 1992 the yearly mean zinc concentrations in the sludge and biosolids produced at the District's WRPs were well below the EQ biosolids zinc limit of 2800 mg/kg.

Sludge and Biosolids from District WRPs 1982 - 1991

During the time period of 1982 through 1991, the USEPA implemented categorical discharge standards which were applicable to all members of an industrial category, nationwide, regardless of which POTW a particular IU discharged to. The District received USEPA approval of its pretreatment program on November 18, 1985, and it maintained the pretreatment program by conducting annual inspections, as previously described in the section PRETREATMENT PROGRAM ACTIVITIES 1985 - 1992. Water quality based copper discharge limits in the NPDES permits for the Hanover Park and James Kirie WRPs were also implemented during this period. All these factors had an impact on the metal concentrations in the sludge and biosolids produced at the District's seven WRPs during the interval of 1982 through 1991.

The metals concentration in the sludge and biosolids produced by each of the District's seven WRPs during this time period are shown in Tables 13 through 19. The percent increase or decrease for seven metals (cadmium, chromium, copper, lead, nickel, zinc, and mercury) is shown in each table. All metals except mercury were subject to implementation of the federal categorical discharge standards during the 1982 to 1991 time period as required by the FWPCA. The District has its own local limit for mercury as shown in Table 1. The District's Calumet, Stickney, and Hanover Park WRPs were the sources of biosolids for land application during this time period.

Reductions in all seven metals generally occurred at the District's WRPs during 1982 through 1991. With the exception of cadmium at the Calumet and Lemont WRPs, which showed increases of 33 to 72 mg/dry kg, and 9 to 14 mg/dry kg, respectively, reductions in cadmium concentrations ranged from 64 percent at the Stickney WRP to 91 percent at the Hanover Park WRP. Chromium levels were reduced from 11 percent in biosolids at the Calumet WRP to 80 percent in gravity tank concentration sludge at the North Side WRP. Copper reductions

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 13

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS[1] IN CALUMET WRP DIGESTED BIOSOLIDS FROM 1982 THROUGH 1991

	Annual Mean Concentration						Reduction
Metal	1982	1984	1986	1988	1990	1991	1982 - 1991
	mg/dry kg						%
Cadmium	33	68	70	77	62	72	-118
Chromium	379	704	507	493	316	338	11
Copper	353	352	342	357	254	295	16
Lead	467	837	404	215	181	154	67
Nickel	92	98	82	74	45	46	50
Zinc	2352	2577	2715	2321	2123	1860	21
Mercury	0.2	0.4	0.6	0.6	0.6	0.5	-150

[1]Analysis for arsenic, molybdenum, and selenium in biosolids was started in 1991.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 14

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS[1] IN EGAN WRP DIGESTED BIOSOLIDS FROM 1982 THROUGH 1991

	Annual Mean Concentration						Reduction
Metal	1982	1984	1986	1988	1990	1991	1982 - 1991
	mg/dry kg						%
Cadmium	151	167	95	61	34	28	81
Chromium	1090	1066	738	833	305	223	79
Copper	2100	1824	1673	2235	849	732	65
Lead	289	304	265	329	159	104	64
Nickel	376	165	148	188	82	87	77
Zinc	2803	3573	2481	2461	2207	1167	58
Mercury	3.9	3.5	3.3	2.6	3.5	3.0	23

[1]Analysis for arsenic, molybdenum, and selenium in biosolids was started in 1991.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 15

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS[1] IN HANOVER PARK WRP DIGESTED BIOSOLIDS FROM 1982 THROUGH 1991

	Annual Mean Concentration						Reduction
Metal	1982	1984	1986	1988	1990	1991	1982 - 1991
	mg/dry kg						%
Cadmium	197	57	23	13	18	18	91
Chromium	667	655	185	165	145	156	77
Copper	1975	3212	1730	1701	1222	1162	41
Lead	194	449	193	238	157	118	39
Nickel	121	236	164	121	84	63	48
Zinc	1899	1514	1018	966	795	720	62
Mercury	4.7	3.7	5.4	4.2	4.1	4.4	6

[1]Analysis for arsenic, molybdenum, and selenium in biosolids was started in 1991.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 16

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS[1] IN STICKNEY WRP DIGESTED BIOSOLIDS FROM 1982 THROUGH 1991

	Annual Mean Concentration						Reduction
Metal	1982	1984	1986	1988	1990	1991	1982 - 1991
	mg/dry kg						%
Cadmium	132	128	120	98	67	47	64
Chromium	2019	1747	1412	1311	1017	904	55
Copper	1278	1342	862	853	597	528	59
Lead	524	478	396	342	276	273	48
Nickel	364	264	194	185	135	124	66
Zinc	2233	2186	2264	2127	1815	1643	26
Mercury	4.6	3.3	2.3	1.5	1.8	2.0	56

[1]Analysis for arsenic, molybdenum, and selenium in biosolids was started in 1991.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 17

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS[1] IN KIRIE WRP WASTE-ACTIVATED SLUDGE FROM 1982 THROUGH 1991

	Annual Mean Concentration						Reduction
Metal	1982	1984	1986	1988	1990	1991	1982 - 1991
	----------------------mg/dry kg----------------------						------%-----
Cadmium	85	124	64	35	24	26	69
Chromium	900	888	565	681	234	201	78
Copper	1875	1542	1408	1873	574	537	71
Lead	254	235	222	261	99	78	69
Nickel	139	117	70	147	68	75	46
Zinc	2754	2993	1991	2073	1655	1013	63
Mercury	2.9	2.0	2.3	1.9	2.0	1.9	34

[1]Analysis for arsenic, molybdenum, and selenium in biosolids was started in 1991.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 18

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS[1] IN LEMONT WRP WASTE-ACTIVATED SLUDGE FROM 1982 THROUGH 1991

	Annual Mean Concentration						Reduction
Metal	1982	1984	1986	1988	1990	1991	1982 - 1991
	mg/dry kg						%
Cadmium	9	25	22	29	17	14	-56
Chromium	45	57	68	64	66	19	58
Copper	676	727	769	380	292	341	50
Lead	342	519	293	140	58	60	82
Nickel	65	94	72	115	44	28	57
Zinc	4818	4545	7271	570	596	546	89
Mercury	1.5	2.1	1.1	0.8	0.8	0.8	47

[1]Analysis for arsenic, molybdenum, and selenium in biosolids was started in 1991.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 19

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS[1] IN NORTH SIDE WRP GRAVITY CONCENTRATION TANK SLUDGE FROM 1982 THROUGH 1991

	Annual Mean Concentration						Reduction
Metal	1982	1984	1986	1988	1990	1991	1982 - 1991
	mg/dry kg						%
Cadmium	131	141	95	69	39	37	72
Chromium	904	826	572	698	252	180	80
Copper	1140	1042	756	916	487	452	60
Lead	328	268	427	244	165	148	55
Nickel	224	240	170	179	91	92	59
Zinc	1891	1704	1281	1330	955	777	59
Mercury	4.3	3.0	12.3	2.1	2.0	1.8	58

[1]Analysis for arsenic, molybdenum, and selenium in biosolids was started in 1991.

varied from 16 percent at the Calumet WRP to 71 percent at the Kirie WRP. Lead reductions ranged from 39 percent at the Hanover Park WRP to 82 percent at the Lemont WRP. Nickel concentrations were reduced from 46 percent at the Kirie WRP to 77 percent at the Egan WRP, and zinc reductions varied from 21 percent at the Calumet WRP to 89 percent at the Lemont WRP. Changes in mercury concentrations varied from an increase of 150 percent (0.2 to 0.5 mg/dry kg) at the Calumet WRP to a decrease of 58 percent at the North Side WRP.

The reductions in metal concentrations observed in <u>Tables 13</u> through <u>19</u> from 1982 through 1991 reflect the implementation of the District's pretreatment program activities during this time period.

<u>Sludge and Biosolids from District WRPs 1992 - 2000</u>

The District in 1992 implemented the 503EI as previously described in the section FEDERAL REGULATIONS AND THE DISTRICT'S PROGRAMS AND INITIATIVES TO REDUCE METALS IN BIOSOLIDS. This initiative had a marked impact on reducing the metal content of the District's sludge and biosolids. The substantial and repeated monitoring of SIUs, which are categorically regulated for the discharge of metals by the staff of the Industrial Waste Division of the District, was the major contributing factor in reducing the metal content of the sludge and biosolids produced by the District's seven WRPs.

REDUCED POLLUTANT LOADINGS FROM INDUSTRIAL USERS

In order to assess the success of the 503EI, the District analyzed the long-term trends in metals of concern discharged from categorically regulated SIUs. For this analysis, the District used average annual pollutant concentrations based on all available analytical data from District monitoring of SIUs, and total annual wastewater discharge volumes reported by SIUs under the District's User Charge system. The District's assessment indicated that SIU discharges of metals of concern decreased substantially between 1992 and 1998 as shown in Table 20. The overall reduction in metals discharged between 1992 and 1998 was 52.4 percent. Copper had the lowest reduction, 36.1 percent, and cadmium had the highest, 74.6 percent.

REDUCTION IN METAL CONCENTRATIONS IN WRP SLUDGE AND BIOSOLIDS

The trends in metal readings via the influent to the WRPs reported in Table 20 were limited to only SIUs subject to categorical pretreatment standards. However, the District also analyzed the long-term trends in the total loading of

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 20

TRENDS IN ANNUAL DISCHARGES OF METALS OF CONCERN FROM CATEGORICALLY REGULATED SIUs

	Annual Discharge (Pounds)							Percent Reduction
Metal	1992	1993	1994	1995	1996	1997	1998	1992-1998
Cadmium	2631	3141	2046	854	462	431	667	74.6
Chromium	35579	36193	33071	22899	15822	20302	19083	46.4
Copper	14296	15962	15576	16497	11980	9906	9130	36.1
Lead	2305	4894	2759	2614	1390	2496	1083	53.0
Nickel	14737	14081	13531	12168	9104	7662	7918	46.3
Zinc	44192	50030	41742	32178	24563	21768	18521	58.1
Total Metals	113740	124301	108725	87210	63321	62565	56402	52.4

metals of concern to its WRPs, and the percent reduction in metals loadings to the WRPs to confirm the effectiveness of the 503EI. These metals were primarily cadmium, chromium, copper, lead, nickel, and zinc for which industrial users are subject to effluent discharge limits under categorical pretreatment standards. The other four metals (arsenic, mercury, molybdenum, and selenium) were not targets of the 503EI, although mercury is subject to the District's local limits.

Because most metals of concern are present in WRP influents at low concentrations or at concentrations below analytical detection limits, the District determined that it would analyze metal concentration trends in the sludge and biosolids generated at its WRPs because of the known ability of the sludge and biosolids to concentrate metals. For this analysis, the District continued to use the average annual metal concentrations in anaerobically digested biosolids at WRPs with digester facilities, and in concentration tank sludge at WRPs without digester facilities, as previously shown in Tables 3 through 12.

The metals content in the sludge and biosolids produced by each of the District's seven WRPs from 1992 through 2000 are shown in Tables 21 through 27. The metals are separated into two categories in each table, the pretreatment metals and

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN CALUMET WRP DIGESTED BIOSOLIDS FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	----------mg/dry kg----------						------%-----
			Pretreatment Metals				
Cadmium	42	15	7	6	4	4	90
Chromium	289	205	85	82	67	73	75
Copper	320	310	296	307	331	330	-3
Lead	136	140	119	145	135	108	21
Nickel	40	42	32	32	34	30	25
Zinc	1432	1363	1393	1626	1429	1125	21
			Nonpretreatment Metals				
Arsenic	0[1]	3	3	11	7	8	NR
Mercury	0.8	1.4	1.3	0.4	0.7	0.7	12

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21 (Continued)

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN CALUMET WRP DIGESTED BIOSOLIDS FROM 1992 THROUGH 2000

Metal	Annual Mean Concentration 1992	1993	1994	1996	1998	2000	Reduction 1992 - 2000
	--------	--------	mg/dry kg	--------	--------	--------	------%-----
Molybdenum	8	8	10	NR	NR	11	-38
Selenium	23	<1	0	11	13	12	48

NR = Not reported.
[1]Concentrations less than the detection limit are reported as zero.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 22

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN EGAN WRP DIGESTED BIOSOLIDS FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
			Pretreatment Metals				
Cadmium	25	21	19	5	3	4	84
Chromium	218	206	129	85	123	203	7
Copper	862	751	709	654	679	825	4
Lead	158	92	81	59	55	46	71
Nickel	104	87	71	39	48	62	40
Zinc	1320	1005	803	671	713	744	44
			Nonpretreatment Metals				
Arsenic	0[1]	2	2	3	3	4	NR
Mercury	3.0	2.5	2.3	2.0	0.8	0.9	70

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 22 (Continued)

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN EGAN WRP DIGESTED BIOSOLIDS FROM 1992 THROUGH 2000

Metal	Annual Mean Concentration						Reduction
	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
Molybdenum	9	20	23	NR	15	20	-122
Selenium	1	1	1	2	4	4	-300

[1]Concentrations less than the detection limit are reported as zero.
NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 23

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN HANOVER PARK WRP DIGESTED BIOSOLIDS FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
			Pretreatment Metals				
Cadmium	15	13	13	4	2	3	80
Chromium	135	110	78	51	50	43	68
Copper	1054	845	836	724	830	793	25
Lead	144	75	80	50	45	42	71
Nickel	74	57	50	29	30	31	58
Zinc	778	663	693	582	620	610	22
			Nonpretreatment Metals				
Arsenic	NR	1	2	2	3	4	NR
Mercury	4.0	4.2	4.4	3.7	2.2	1.7	58

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 23 (Continued)

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN HANOVER PARK WRP DIGESTED BIOSOLIDS FROM 1992 THROUGH 2000

Metal	Annual Mean Concentration						Reduction
	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
Molybdenum	NR	10	10	NR	10	11	NR
Selenium	NR	1	1	2	4	5	NR

NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 24

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN STICKNEY WRP DIGESTED BIOSOLIDS FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
			Pretreatment Metals				
Cadmium	41	23	18	8	6	4	90
Chromium	1017	667	439	338	258	251	75
Copper	580	481	509	385	377	387	33
Lead	302	263	248	184	163	139	54
Nickel	109	74	70	61	55	54	50
Zinc	1827	1333	1495	1165	840	872	52
			Nonpretreatment Metals				
Arsenic	11	12	7	6	6	6	45
Mercury	1.6	1.7	1.7	1.8	1.0	0.7	56

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 24 (Continued)

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN STICKNEY WRP DIGESTED BIOSOLIDS FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
Molybdenum	12	9	13	25	24	14	-8
Selenium	NR	NR	2	3	3	3	NR

NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 25

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN KIRIE WRP WASTE-ACTIVATED SLUDGE FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
			Pretreatment Metals				
Cadmium	19	16	15	3	2	3	84
Chromium	191	180	108	69	115	195	-2
Copper	671	558	513	490	508	596	11
Lead	106	58	50	40	43	33	69
Nickel	89	68	55	29	38	61	31
Zinc	1084	763	581	511	575	551	49
			Nonpretreatment Metals				
Arsenic	0[1]	2	2	2	2	3	NR
Mercury	1.9	1.4	1.5	1.3	0.8	0.6	68

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 25 (Continued)

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN KIRIE WRP WASTE-ACTIVATED SLUDGE FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
Molybdenum	5	14	13	6	8	13	-160
Selenium	0	1	1	2	3	3	NR

[1]Concentrations less than the detection limit are reported as zero.
NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 26

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN LEMONT WRP WASTE-ACTIVATED SLUDGE FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
			Pretreatment Metals				
Cadmium	4	3	3	2	2	2	50
Chromium	32	33	23	24	16	16	50
Copper	411	424	487	374	470	406	1
Lead	69	69	61	33	32	23	67
Nickel	27	24	20	18	18	14	48
Zinc	561	612	574	455	457	546	3
			Nonpretreatment Metals				
Arsenic	0[1]	1	2	4	4	3	NR
Mercury	0.6	1.0	0.9	0.3	0.5	0.6	0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 26 (Continued)

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN LEMONT WRP WASTE-ACTIVATED SLUDGE FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
Molybdenum	3	3	5	NR	4	5	-67
Selenium	5	<1	0	4	4	4	20

[1]Concentrations less than the detection limit are reported as zero.
NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 27

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN NORTH SIDE WRP GRAVITY CONCENTRATION TANK SLUDGE FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
			Pretreatment Metals				
Cadmium	32	24	23	5	4	4	88
Chromium	193	145	135	59	80	77	60
Copper	541	521	445	405	510	538	0
Lead	172	137	111	86	89	68	60
Nickel	102	73	72	37	56	43	58
Zinc	881	816	1490	557	556	549	38
			Nonpretreatment Metals				
Arsenic	1	2	2	2	3	3	-200
Mercury	2.1	2.0	1.7	1.9	0.6	0.8	62

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 27 (Continued)

TRENDS IN ANNUAL MEAN CONCENTRATIONS OF SELECTED METALS IN NORTH SIDE WRP GRAVITY CONCENTRATION TANK SLUDGE FROM 1992 THROUGH 2000

	Annual Mean Concentration						Reduction
Metal	1992	1993	1994	1996	1998	2000	1992 - 2000
	mg/dry kg						%
Molybdenum	10	10	10	NA	NA	8	20
Selenium	3	1	1	2	5	4	-33

NA = Not available.

those not subjected to categorical pretreatment standards (nonpretreatment metals). The percent increase or decrease for each of the ten metals originally regulated by the Part 503 Sludge Regulations from 1992 through 2000 are shown in each table. As previously described in the section on WATER RECLAMATION PLANTS, the District currently has four WRPs that produce a final biosolids product for land application. These are the Calumet WRP (Table 21), Egan WRP (Table 22), Hanover Park WRP (Table 23), and Stickney WRP (Table 24). The Calumet, Egan, and Stickney WRPs receive sludge from the other District WRPs for further processing, as described in the section on WATER RECLAMATION PLANTS.

Reductions in the categorically related pretreatment metals (cadmium, chromium, copper, lead, nickel, and zinc) have occurred at each District WRP since 1992, as shown in Tables 21 through 27. For the nonpretreatment metals (arsenic, mercury, selenium, and molybdenum), reductions in mercury occurred at each WRP. Molybdenum generally showed slight increases at each of the seven WRPs since 1992, while arsenic and selenium showed small yearly fluctuations. The yearly variations observed in arsenic, selenium, and molybdenum since 1992 are mainly due to the problems associated with the analytical reliability of the analysis for these metals.

The change in the concentrations of the six pretreatment metals in the sludge and biosolids produced by the District's seven WRPs from 1992 through 2000 varied with the WRP as shown in Tables 21 through 27. Reductions in cadmium concentrations ranged from 50 percent at the Lemont WRP to 90 percent at the Calumet and Stickney WRPs, and chromium levels increased from 2 percent at the Kirie WRP (191 to 195 mg/dry kg) and decreased by 75 percent at the Calumet and Stickney WRPs. The change in copper concentrations varied from an increase of 3 percent at the Calumet WRP (320 to 330 mg/dry kg) to a decrease of 33 percent at the Stickney WRP. The reductions in lead concentrations ranged from 21 percent at the Calumet WRP to 71 percent at the Egan and Hanover Park WRPs. For nickel the reductions in the levels varied from 25 percent at the Calumet WRP to 58 percent at the Hanover Park and North Side WRPs. Reductions in zinc concentrations ranged from 3 percent at the Lemont WRP to 52 percent at the Stickney WRP.

The change for the four nonpretreatment metals in the sludge and biosolids produced by the District's WRPs, Tables 21 through 27, varied from an increase of 300 percent for selenium at the Egan WRP (1 to 4 mg/dry kg) to a reduction of 70 percent for mercury at the Egan WRP. This high degree of variation in metal removal and/or increase reflects the analytical unreliability of early data for these metals.

The reductions in the pretreatment metals, along with the low concentrations of the nonpretreatment metals (arsenic, mercury, molybdenum, and selenium) have resulted in the final biosolids from the District's WRPs that more than met the EQ designation for metals in the Part 503 Sewage Sludge Regulations.

Based on the data shown in Tables 21 through 27, the District's efforts in achieving the objectives of substantially reducing the discharge of metals of concern from the regulated community, and ensuring that the District's WRPs produce high quality biosolids for beneficial use were very successful. The 2000 District wide non-weighted mean metal concentration for each of the 10 metals studied was compared with the limit for EQ biosolids in the Part 503 Sewage Sludge Regulations as shown in Table 28. The dramatic reductions in the concentrations of the 10 metals are obvious. The percentage below the EQ limit for the 2000 non-weighted mean concentration of the 10 metals varied from 63 percent for copper to 95 percent for mercury and selenium.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28

COMPARISON OF THE 2000 NON-WEIGHTED MEAN METAL CONCENTRATIONS IN THE SLUDGE AND BIOSOLIDS FROM THE DISTRICT'S WRPs WITH THE LIMITS FOR EXCEPTIONAL QUALITY (EQ) BIOSOLIDS IN THE PART 503 SEWAGE SLUDGE REGULATIONS

Metal	Part 503 EQ Limit	2000 Mean[1]	Percent Below EQ Limit
	-------mg/dry kg-------		--%--
Arsenic	41	4	90
Cadmium	39	3	92
Chromium	NL[2]	123	NL
Copper	1,500	554	63
Lead	300	66	78
Mercury	17	0.9	95
Molybdenum	75[3]	12	84
Nickel	420	42	90
Selenium	100[4]	5	95
Zinc	2,800	714	74

[1]Non-Weighted mean was determined by using the mean 2000 metal concentration in sludge from each of the District's seven WRPs.
[2]No limit established. Original EQ limit for chromium of 1,200 mg/kg was deleted by USEPA on October 25, 1995.
[3]Ceiling limit of 75 mg/kg was adopted by USEPA on February 25, 1994 pending further consideration. Original EQ limit for molybdenum was 18 mg/kg.
[4]Ceiling limit of 100 mg/kg was adopted by USEPA on October 25, 1995. Original EQ limit for selenium was 36 mg/kg.

In 1996, the USEPA recognized these efforts by presenting the District with the 1996 National Excellence Award for Pre-treatment Programs in the Large Category (greater than 100 SIUs).

CONCLUSIONS

The District in 1967 adopted a policy of beneficially using biosolids on land. To reduce the metal content of biosolids for land application, the District initiated several internal programs to improve the quality of its biosolids. These programs, along with federal regulations resulting from implementation of the FWPCA and the Part 503 Sewage Sludge Regulations, resulted in a significant reduction in the metal content of biosolids produced by the District's WRPs.

The District's pretreatment programs, initially implemented in 1969, resulted in a marked reduction in the metal content of sludge and biosolids produced by the District's seven WRPs from 1982 through 2000. From 1982 through 1991, the implementation of categorical discharge standards and limits on the discharge of copper in the NPDES permits for the Hanover Park and Kirie WRPs resulted in a reduction in the metal content of the sludge and biosolids produced by the District's seven WRPs. Additional reductions in metals occurred from 1992 through 2000 as a result of implementing the 503EI. The most notable reductions occurred in those metals categorically regulated by pretreatment regulations (cadmium, chromium, copper, lead, nickel, and zinc).

Problems of analytical reliability for nonpretreatment metals (arsenic, molybdenum, selenium, and mercury) made reductions in metal content of the sludge and biosolids produced by the District's WRPs from 1992 to 2000 difficult to assess. However, in all instances, the levels of these metals in sludges produced by the District's WRPs were low and well below the EQ limits for these metals for land applied biosolids.

The reductions in cadmium, chromium, copper, lead, nickel, and zinc (pretreatment metals) in the sludge and biosolids produced by the District's seven WRPs from 1982 through 1991 were considerable. With the exception of cadmium at the Calumet and Lemont WRPs, which showed increases of 33 to 72 mg/dry kg and 9 to 14 mg/dry kg, respectively, cadmium concentrations in sludge and biosolids produced by the District's WRPs from 1982 through 1991 decreased, ranging from 64 percent at the Stickney WRP to 91 percent at the Hanover Park WRP. Chromium levels were reduced from 11 to 80 percent. During this interval, copper and lead concentrations were reduced by 16 to 71 percent and 39 to 82 percent, respectively. The reductions in nickel and zinc in the sludge and biosolids produced by the District's WRPs from 1982 to 1991 ranged from 46 to 77 percent and 21 to 89 percent, respectively. The reductions observed for these metals reflect the implementation of the pretreatment program activities by the District during this time period.

An evaluation of the pollutant loadings from categorically regulated SIUs from 1992 to 1998 showed an overall reduction of 52.4 percent for the six pretreatment metals (cadmium, chromium, copper, lead, nickel, and zinc). Copper had the lowest reduction, 36.1 percent, and cadmium had the highest, 74.6 percent.

The reductions in annual metal discharges to the WRPs have resulted in significant reductions in metals in the sludge and biosolids produced by the District's seven WRPs during the 503EI period from 1992 to 2000. The changes in the concentrations of the six pretreatment metals previously mentioned from 1992 to 2000 varied from an increase of 3 percent at the Calumet WRP for copper (320 to 330 mg/kg) to a decrease of 90 percent for cadmium at the Calumet and Stickney WRPs. For the nonpretreatment metals (arsenic, mercury, molybdenum, and selenium) the changes from 1992 to 2000 varied from an increase of 300 percent for selenium (1 to 4 mg/kg) at the Egan WRP to a reduction of 70 percent for mercury at the Egan WRP. This variation reflected the problems of analytical reliability of the early data for these metals.

The reductions in the pretreatment metals along with the low concentrations of the nonpretreatment metals in the sludge and biosolids produced by the District's seven WRPs enabled them to more than meet the EQ designation for metals in the Part 503 Sewage Sludge Regulations. The 2000 District-wide non-weighted mean concentrations of the 10 metals for the District's seven WRPs were 63 to 95 percent below the EQ limit. This shows that biosolids produced by the District can be beneficially applied without restrictions for metal content.

REFERENCES

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APPENDIX I

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF METALS IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF ARSENIC IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1983	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1984	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1985	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1986	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF ARSENIC IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1987	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1988	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1989	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1990	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1991	Mean	5	1	1	0	6	22	2
	Minimum	0	0	0	0	0	0	0
	Maximum	8	10	18	0	83	43	14

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF ARSENIC IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		----------------------------mg/dry kg----------------------------						
1992	Mean	0	0	NR	11	0	0	1
	Minimum	0	0	NR	7	0	0	1
	Maximum	12	3	NR	16	1	0	3
1993	Mean	3	2	1	12	2	1	2
	Minimum	0	1	1	1	0	0	1
	Maximum	13	3	4	21	4	10	15
1994	Mean	3	2	2	7	2	2	2
	Minimum	0	0	1	1	1	0	1
	Maximum	12	4	2	19	3	9	4
1995	Mean	5	2	2	3	2	2	2
	Minimum	1	1	1	0	1	0	1
	Maximum	13	3	3	7	5	8	4
1996	Mean	11	3	2	6	2	4	2
	Minimum	6	2	1	2	1	1	2
	Maximum	16	3	3	12	3	6	3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF ARSENIC IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1997	Mean	9	3	3	5	3	4	3
	Minimum	2	3	2	3	2	2	2
	Maximum	31	5	4	9	5	6	4
1998	Mean	7	3	3	6	2	4	3
	Minimum	4	0	1	2	0	2	0
	Maximum	16	6	7	14	4	6	6
1999	Mean	7	4	3	4	3	4	3
	Minimum	3	1	1	2	0	2	0
	Maximum	12	8	6	7	5	8	7
2000	Mean	8	4	4	6	3	3	3
	Minimum	5	0	1	3	0	1	2
	Maximum	10	5	5	13	5	5	5

NA = Not analyzed.
NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF CADMIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	33	151	197	132	85	9	131
	Minimum	17	92	86	79	48	0	79
	Maximum	52	222	389	183	140	30	242
1983	Mean	54	159	221	104	55	16	128
	Minimum	23	114	57	82	16	0	85
	Maximum	101	212	482	145	133	36	204
1984	Mean	68	167	57	128	124	25	141
	Minimum	32	87	42	69	67	6	91
	Maximum	345	233	88	411	204	73	200
1985	Mean	96	101	66	107	83	23	110
	Minimum	53	61	30	83	39	1	75
	Maximum	135	149	100	130	174	54	152
1986	Mean	70	95	23	120	64	22	95
	Minimum	40	54	13	90	29	3	41
	Maximum	98	133	32	138	160	83	154

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF CADMIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1987	Mean	90	62	12	132	47	23	92
	Minimum	52	41	8	106	25	4	56
	Maximum	122	80	17	215	81	57	150
1988	Mean	77	61	13	98	35	29	69
	Minimum	41	37	10	73	20	0	41
	Maximum	115	89	18	126	48	86	93
1989	Mean	85	41	12	103	36	16	56
	Minimum	1	26	9	79	20	0	35
	Maximum	138	60	16	141	54	87	87
1990	Mean	62	34	18	67	24	17	39
	Minimum	42	20	8	51	11	0	22
	Maximum	102	48	30	114	39	40	85
1991	Mean	72	28	18	47	26	14	37
	Minimum	19	20	12	38	18	3	22
	Maximum	117	39	28	55	41	63	55

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF CADMIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1992	Mean	42	25	15	41	19	4	32
	Minimum	15	17	10	31	10	0	18
	Maximum	96	35	30	53	29	12	58
1993	Mean	15	21	13	23	16	3	24
	Minimum	6	8	4	15	6	1	13
	Maximum	26	25	18	42	30	6	40
1994	Mean	7	19	13	18	15	3	23
	Minimum	3	14	10	13	10	1	12
	Maximum	14	28	18	63	32	4	39
1995	Mean	7	16	13	13	13	2	19
	Minimum	4	3	2	8	2	1	4
	Maximum	10	24	16	19	38	6	28
1996	Mean	6	5	4	8	3	2	5
	Minimum	2	3	2	3	2	<1	2
	Maximum	11	14	11	10	10	3	11

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF CADMIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		---mg/dry kg---						
1997	Mean	4	5	3	7	3	2	5
	Minimum	0	3	2	5	1	1	2
	Maximum	6	7	4	10	4	4	10
1998	Mean	4	3	2	6	2	2	4
	Minimum	3	0	0	3	0	1	0
	Maximum	6	4	4	12	3	3	8
1999	Mean	5	4	3	5	3	2	5
	Minimum	2	3	2	1	2	0	2
	Maximum	9	5	4	7	7	4	10
2000	Mean	4	4	3	4	3	2	4
	Minimum	3	3	2	3	2	1	3
	Maximum	7	6	3	6	4	3	9

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF CHROMIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	379	1090	667	2019	900	45	904
	Minimum	281	713	395	1366	586	21	573
	Maximum	577	1810	968	3116	1450	110	1170
1983	Mean	488	1327	651	1694	918	60	799
	Minimum	324	1060	520	1278	725	0	620
	Maximum	798	1590	753	2432	1090	145	1010
1984	Mean	704	1066	655	1747	888	57	826
	Minimum	396	813	357	1262	667	27	627
	Maximum	1617	1640	1010	5553	1310	109	1150
1985	Mean	723	903	382	1524	698	55	685
	Minimum	450	603	279	1128	446	18	513
	Maximum	1180	1350	530	1981	931	191	1010
1986	Mean	507	738	185	1412	565	68	572
	Minimum	364	551	120	1122	456	8	144
	Maximum	738	929	314	1750	715	186	776

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF CHROMIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1987	Mean	543	850	172	1499	715	72	643
	Minimum	336	709	128	1247	471	6	426
	Maximum	768	1150	214	2070	1808	206	817
1988	Mean	493	833	165	1311	681	64	698
	Minimum	255	688	116	1039	422	4	436
	Maximum	601	1040	281	1486	988	474	963
1989	Mean	503	492	158	1200	404	52	551
	Minimum	187	355	83	958	263	0	318
	Maximum	728	699	225	1486	600	215	770
1990	Mean	316	305	145	1017	234	66	252
	Minimum	164	212	99	836	104	9	154
	Maximum	508	391	194	1370	346	208	406
1991	Mean	338	223	156	904	201	19	180
	Minimum	250	146	104	783	133	0	126
	Maximum	482	296	272	1193	285	56	222

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF CHROMIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1992	Mean	289	218	135	1017	191	32	193
	Minimum	225	159	78	674	117	16	101
	Maximum	480	330	245	1670	300	69	284
1993	Mean	205	206	110	667	180	33	145
	Minimum	85	123	45	422	88	19	94
	Maximum	383	435	203	1070	672	60	214
1994	Mean	85	129	78	439	108	23	135
	Minimum	25	98	38	252	71	15	83
	Maximum	143	178	188	549	38	33	177
1995	Mean	82	130	62	425	122	23	116
	Minimum	58	83	40	300	67	12	50
	Maximum	109	160	93	632	196	38	172
1996	Mean	82	85	51	338	69	24	59
	Minimum	58	75	34	179	48	13	37
	Maximum	120	95	83	465	82	43	89

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF CHROMIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1997	Mean	101	90	43	339	75	20	68
	Minimum	47	62	31	229	52	14	49
	Maximum	257	110	63	447	98	32	91
1998	Mean	67	123	50	258	115	16	80
	Minimum	46	85	37	180	70	10	45
	Maximum	135	167	77	323	184	24	265
1999	Mean	68	118	38	277	93	17	68
	Minimum	45	83	32	198	63	10	49
	Maximum	106	163	49	375	151	21	135
2000	Meam	73	203	43	251	195	16	77
	Minimum	59	119	30	175	57	4	35
	Maximum	98	288	84	317	350	23	114

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-4

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF COPPER IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	353	2100	1975	1278	1875	676	1140
	Minimum	263	1450	1080	640	812	360	816
	Maximum	429	2850	2720	1689	3200	1345	2110
1983	Mean	344	2005	2564	1146	1854	855	1066
	Minimum	238	1470	1820	933	1130	97	703
	Maximum	413	2870	3130	1490	5030	4067	1540
1984	Mean	352	1824	3212	1342	1542	727	1042
	Minimum	254	1310	2360	856	1110	238	844
	Maximum	630	2090	4610	4255	2430	1455	1300
1985	Mean	359	1818	2416	968	1526	727	858
	Minimum	294	1420	1800	683	977	207	620
	Maximum	467	2390	3110	1155	2290	2714	1230
1986	Mean	342	1673	1730	862	1408	769	756
	Minimum	272	1210	1520	708	917	157	482
	Maximum	403	2190	2090	978	2430	3897	1060

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-4 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF COPPER IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		----------------	----------------	----------------	mg/dry kg	----------------	----------------	----------------
1987	Mean	344	2747	1926	871	2488	384	993
	Minimum	218	2340	1640	706	2050	40	742
	Maximum	451	3170	2290	1317	2970	655	1280
1988	Mean	357	2235	1701	853	1873	380	916
	Minimum	229	1630	1420	707	1160	50	530
	Maximum	539	2820	2050	1132	3560	897	1240
1989	Mean	318	1279	1498	798	1116	264	675
	Minimum	133	800	1100	650	619	108	466
	Maximum	441	1840	2160	1038	2530	370	942
1990	Mean	254	849	1222	597	574	292	487
	Minimum	79	596	1040	496	298	94	378
	Maximum	298	1020	1540	805	783	478	673
1991	Mean	295	732	1162	528	537	341	452
	Minimum	209	500	809	406	436	110	344
	Maximum	388	845	1400	628	659	681	663

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-4 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF COPPER IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1992	Mean	320	862	1054	580	671	411	541
	Minimum	256	706	695	463	502	259	321
	Maximum	384	1080	1370	1075	974	569	870
1993	Mean	310	751	845	481	558	424	521
	Minimum	220	616	577	419	417	272	276
	Maximum	441	936	1110	564	892	538	1510
1994	Mean	296	709	836	509	513	487	445
	Minimum	213	570	640	201	398	367	295
	Maximum	575	822	1030	678	701	638	956
1995	Mean	287	683	702	436	523	423	456
	Minimum	236	487	595	110	304	267	330
	Maximum	377	793	825	540	683	563	1060
1996	Mean	307	654	724	385	490	374	405
	Minimum	235	535	517	257	310	258	213
	Maximum	391	790	915	452	594	515	910

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-4 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF COPPER IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1997	Mean	306	683	722	395	500	436	432
	Minimum	237	488	684	283	406	314	290
	Maximum	380	899	926	466	662	561	852
1998	Mean	331	679	830	377	508	470	510
	Minimum	268	558	680	280	388	350	292
	Maximum	429	871	1050	455	660	575	1202
1999	Mean	356	778	874	390	591	458	534
	Minimum	242	671	757	285	447	331	324
	Maximum	420	909	970	581	723	657	1028
2000	Mean	330	825	793	387	596	406	538
	Minimum	259	695	339	304	446	372	354
	Maximum	416	923	925	471	747	459	789

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF LEAD IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	467	289	194	524	254	342	328
	Minimum	277	195	120	168	93	108	168
	Maximum	746	341	280	774	352	606	514
1983	Mean	572	290	277	459	226	332	296
	Minimum	325	137	139	372	157	142	149
	Maximum	1074	383	365	567	272	739	394
1984	Mean	837	304	449	478	235	519	268
	Minimum	463	239	276	263	190	64	199
	Maximum	2665	352	552	1366	292	1766	327
1985	Mean	517	290	279	396	239	432	256
	Minimum	328	222	180	278	136	142	169
	Maximum	1061	337	411	468	378	991	385
1986	Mean	404	265	193	396	222	293	427
	Minimum	178	205	147	253	139	6	182
	Maximum	838	353	310	726	374	772	839

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF LEAD IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1987	Mean	229	402	263	423	361	143	413
	Minimum	90	306	176	257	232	6	219
	Maximum	354	532	354	699	521	500	1090
1988	Mean	215	329	238	342	261	140	244
	Minimum	141	272	187	267	193	5	140
	Maximum	364	413	320	525	323	477	412
1989	Mean	174	211	177	309	148	74	173
	Minimum	14	121	119	249	77	4	118
	Maximum	272	338	227	422	361	419	223
1990	Mean	181	159	157	276	99	58	165
	Minimum	80	97	87	212	29	6	87
	Maximum	292	272	327	383	208	151	353
1991	Mean	154	104	118	273	78	60	148
	Minimum	56	76	87	177	47	0	91
	Maximum	223	137	168	368	133	137	250

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF LEAD IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1992	Mean	136	158	144	302	106	69	172
	Minimum	86	30	72	190	33	17	98
	Maximum	183	295	297	525	193	113	335
1993	Mean	140	92	75	263	58	69	137
	Minimum	85	63	51	169	36	44	64
	Maximum	216	116	97	336	90	104	295
1994	Mean	119	81	80	248	50	61	111
	Minimum	52	62	50	121	30	29	52
	Maximum	199	99	98	319	69	107	196
1995	Mean	113	69	72	212	51	42	97
	Minimum	67	50	51	141	31	20	53
	Maximum	154	80	91	284	64	73	173
1996	Mean	145	59	50	184	40	33	86
	Minimum	51	41	27	125	27	13	31
	Maximum	256	82	69	244	68	44	184

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF LEAD IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1997	Mean	262	60	47	176	45	34	87
	Minimum	85	38	26	118	29	24	49
	Maximum	1246	85	92	240	63	47	128
1998	Mean	135	55	45	163	43	32	89
	Minimum	98	32	22	123	30	20	53
	Maximum	186	77	70	208	74	44	152
1999	Mean	119	55	48	144	44	33	88
	Minimum	85	45	38	89	33	21	52
	Maximum	154	63	95	205	51	47	137
2000	Mean	108	46	42	139	33	23	68
	Minimum	69	34	30	81	22	15	35
	Maximum	135	54	103	187	46	32	126

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF MERCURY IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	0.2	3.9	4.7	4.6	2.9	1.5	4.3
	Minimum	<0.1	2.8	2.9	2.4	1.6	0.1	2.2
	Maximum	0.7	5.3	6.0	20.7	4.9	4.0	16.7
1983	Mean	0.4	3.9	4.4	3.3	2.2	2.5	3.6
	Minimum	<0.1	2.4	2.8	1.8	1.6	0.6	1.5
	Maximum	1.2	7.2	5.6	7.6	2.9	9.8	13.2
1984	Mean	0.4	3.5	3.7	3.3	2.0	2.1	3.0
	Minimum	<0.1	2.6	2.4	1.1	1.5	0.2	1.1
	Maximum	1.1	5.6	5.8	8.8	3.0	13.1	9.5
1985	Mean	0.4	3.4	4.0	2.3	2.4	1.0	3.0
	Minimum	0.1	1.8	2.6	0.1	1.3	0.2	1.3
	Maximum	2.1	5.9	5.2	4.9	4.9	3.4	9.6
1986	Mean	0.6	3.3	5.4	2.3	2.3	1.1	12.3
	Minimum	0.1	1.8	3.2	0.2	1.5	0.2	1.8
	Maximum	1.8	5.1	18.3	6.8	3.6	2.2	48.7

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF MERCURY IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1987	Mean	1.6	3.1	4.8	1.2	2.1	0.7	3.8
	Minimum	0.5	2.0	2.6	0.3	1.3	0.1	1.2
	Maximum	4.2	3.9	9.4	3.7	3.3	1.5	15.3
1988	Mean	0.6	2.6	4.2	1.5	1.9	0.8	2.1
	Minimum	0.3	1.6	2.2	0.8	1.2	0.4	0.4
	Maximum	1.1	4.5	5.8	2.2	3.5	1.7	5.1
1989	Mean	0.7	2.7	3.8	1.8	2.1	1.0	2.1
	Minimum	0	1.4	1.8	0.8	1.2	0.2	1.3
	Maximum	5.2	3.6	6.4	2.6	3.0	3.1	3.4
1990	Mean	0.6	3.5	4.1	1.8	2.0	0.8	2.0
	Minimum	0.2	2.6	2.1	0.8	1.3	0.3	1.0
	Maximum	2.5	5.3	6.2	2.9	3.7	4.4	3.3
1991	Mean	0.5	3.0	4.4	2.0	1.9	0.8	1.8
	Minimum	0.2	2.3	3.2	0.9	1.3	0.2	1.2
	Maximum	3.2	4.8	6.0	4.6	3.2	3.1	3.2

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF MERCURY IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1992	Mean	0.8	3.0	4.0	1.6	1.9	0.6	2.1
	Minimum	0.1	1.5	2.4	0.8	1.0	0.1	0.9
	Maximum	3.0	5.2	7.5	3.7	3.6	2.6	4.7
1993	Mean	1.4	2.5	4.2	1.7	1.4	1.0	2.0
	Minimum	0.4	1.4	2.2	0.6	0.9	0.4	0.9
	Maximum	5.6	6.7	6.4	3.8	3.3	3.8	5.4
1994	Mean	1.3	2.3	4.4	1.7	1.5	0.9	1.7
	Minimum	0.6	1.5	3.1	0.7	0.8	0.1	1.0
	Maximum	3.9	3.6	6.2	2.9	2.2	2.6	2.4
1995	Mean	0.8	2.1	3.4	2.2	1.1	0.8	1.7
	Minimum	0.2	1.2	2.4	1.2	0.5	0.4	0.9
	Maximum	2.6	3.4	6.0	4.2	1.8	2.7	4.6
1996	Mean	0.4	2.0	3.7	1.8	1.3	0.3	1.9
	Minimum	0.2	1.2	2.0	0.8	1.0	0.1	0.9
	Maximum	0.8	2.4	6.1	2.6	1.7	0.6	4.5

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF MERCURY IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1997	Mean	0.3	1.9	3.3	1.2	1.1	0.4	1.2
	Minimum	0.1	0.9	0.3	0.6	0.5	0.2	0.5
	Maximum	0.6	3.3	5.4	2.0	2.1	0.6	2.1
1998	Mean	0.7	0.8	2.2	1.0	0.8	0.5	0.6
	Minimum	0.1	0.2	0.2	0.6	0.2	0.3	0.2
	Maximum	1.6	1.3	3.3	2.1	1.5	0.7	1.3
1999	Mean	0.5	1.3	2.2	0.7	0.6	0.5	0.8
	Minimum	0.1	0.7	1.4	0.4	0.3	0.2	0.2
	Maximum	1.1	3.5	4.1	1.1	1.6	0.8	1.8
2000	Mean	0.7	0.9	1.7	0.7	0.6	0.6	0.8
	Minimum	0.3	<0.1	0.3	0.2	0.2	0.3	0.3
	Maximum	1.0	1.4	3.0	1.3	2.1	0.9	3.9

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-7

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF MOLYBDENUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1983	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1984	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1985	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1986	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-7 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF MOLYBDENUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1987	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1988	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1989	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1990	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1991	Mean	5	34	8	0	9	24	9
	Minimum	0	17	0	0	0	0	0
	Maximum	12	51	25	0	41	58	31

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-7 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF MOLYBDENUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1992	Mean	8	9	NR	12	5	3	10
	Minimum	0	0	NR	2	0	0	7
	Maximum	130	52	NR	19	20	40	18
1993	Mean	8	20	10	9	14	3	10
	Minimum	1	10	5	1	7	0	4
	Maximum	13	28	15	18	20	6	17
1994	Mean	10	23	10	13	13	5	10
	Minimum	5	12	7	2	9	0	6
	Maximum	18	34	14	49	21	9	17
1995	Mean	16	17	8	21	10	7	9
	Minimum	7	9	4	8	5	2	4
	Maximum	24	24	14	51	16	13	12
1996	Mean	NA	NR	NR	25	6	NR	NA
	Minimum	NA	NR	NR	12	3	NR	NA
	Maximum	NA	NR	NR	55	10	NR	NA

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-7 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF MOLYBDENUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1997	Mean	NA	NR	NR	NA	8	NR	NA
	Minimum	NA	NR	NR	NA	5	NR	NA
	Maximum	NA	NR	NR	NA	11	NR	NA
1998	Mean	15	15	10	24	8	4	NA
	Minimum	11	13	8	11	0	<1	NA
	Maximum	20	17	12	39	21	6	NA
1999	Mean	13	17	10	13	12	4	7
	Minimum	4	12	7	6	8	1	4
	Maximum	20	26	15	20	17	8	13
2000	Mean	11	20	11	14	13	5	8
	Minimum	7	15	5	10	8	2	5
	Maximum	16	26	16	20	19	7	15

NA = Not analyzed.
NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-8

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF NICKEL IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs OF 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	92	376	121	364	139	65	224
	Minimum	50	209	74	185	78	0	118
	Maximum	168	663	154	721	304	154	434
1983	Mean	101	343	146	271	109	77	199
	Minimum	55	156	89	168	79	0	121
	Maximum	166	482	218	380	182	364	289
1984	Mean	98	165	236	264	117	94	240
	Minimum	50	106	126	106	71	4	126
	Maximum	172	214	356	745	217	267	531
1985	Mean	84	157	240	209	77	99	222
	Minimum	39	99	126	139	46	7	106
	Maximum	125	278	440	254	118	267	429
1986	Mean	82	148	164	194	70	72	170
	Minimum	36	81	91	128	37	23	88
	Maximum	130	247	262	251	110	200	311

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-8 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF NICKEL IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs OF 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1987	Mean	89	165	158	247	107	124	193
	Minimum	33	114	105	144	71	24	84
	Maximum	239	214	222	538	321	727	352
1988	Mean	74	188	121	185	147	115	179
	Minimum	29	148	90	129	86	0	106
	Maximum	153	343	172	241	342	307	323
1989	Mean	40	118	126	160	92	45	158
	Minimum	0	63	79	93	43	0	54
	Maximum	106	240	185	217	151	161	279
1990	Mean	45	82	84	135	68	44	91
	Minimum	8	50	70	88	22	0	44
	Maximum	73	133	107	191	247	67	168
1991	Mean	46	87	63	124	75	28	92
	Minimum	6	52	43	72	53	0	61
	Maximum	71	114	85	173	110	62	136

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-8 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF NICKEL IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs OF 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1992	Mean	40	104	74	109	89	27	102
	Minimum	18	74	50	80	55	9	66
	Maximum	110	213	129	150	118	106	225
1993	Mean	42	87	57	74	68	24	73
	Minimum	25	70	45	30	49	13	48
	Maximum	70	128	77	120	137	40	137
1994	Mean	32	71	50	70	55	20	72
	Minimum	19	61	39	40	42	10	52
	Maximum	118	88	64	200	75	39	120
1995	Mean	33	52	38	69	42	18	48
	Minimum	19	30	21	55	24	10	26
	Maximum	59	72	56	89	65	27	76
1996	Mean	32	39	29	61	29	18	37
	Minimum	23	29	21	42	18	14	21
	Maximum	52	55	45	85	44	25	53

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-8 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF NICKEL IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs OF 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1997	Mean	31	42	31	55	33	17	41
	Minimum	23	32	26	46	24	12	25
	Maximum	52	52	43	67	66	22	65
1998	Mean	34	48	30	55	38	18	56
	Minimum	25	29	22	38	24	14	23
	Maximum	50	85	40	74	62	29	337
1999	Mean	30	45	30	52	35	16	40
	Minimum	24	36	23	34	23	9	13
	Maximum	37	57	56	95	60	22	113
2000	Mean	30	62	31	54	61	14	43
	Minimum	23	20	21	34	22	4	24
	Maximum	39	102	57	66	152	18	109

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-9

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF SELENIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1983	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1984	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1985	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1986	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-9 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF SELENIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1987	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1988	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1989	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1990	Mean	NA	NA	NA	NA	NA	NA	NA
	Minimum	NA	NA	NA	NA	NA	NA	NA
	Maximum	NA	NA	NA	NA	NA	NA	NA
1991	Mean	5	2	2	0	2	25	3
	Minimum	0	0	0	0	0	0	0
	Maximum	8	14	18	0	27	74	19

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-9 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF SELENIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1992	Mean	23	1	NR	NR	0	5	3
	Minimum	0	0	NR	NR	0	0	1
	Maximum	97	11	NR	NR	1	47	20
1993	Mean	<1	1	1	NR	1	<1	1
	Minimum	0	0	1	NR	0	0	1
	Maximum	5	2	2	NR	1	4	2
1994	Mean	0	1	1	2	1	0	1
	Minimum	0	0	0	1	0	0	1
	Maximum	0	3	3	4	3	1	2
1995	Mean	8	1	1	3	1	3	1
	Minimum	0	0	0	1	0	0	1
	Maximum	17	2	3	6	2	7	2
1996	Mean	11	2	2	3	2	4	2
	Minimum	6	1	1	1	1	2	1
	Maximum	18	3	3	4	4	7	4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-9 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF SELENIUM IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1997	Mean	10	2	2	3	2	2	2
	Minimum	6	1	2	2	1	0	2
	Maximum	15	3	3	4	3	3	2
1998	Mean	13	4	4	3	3	4	5
	Minimum	10	0	0	2	0	2	0
	Maximum	20	10	7	5	7	9	11
1999	Mean	10	4	5	3	3	3	5
	Minimum	2	2	2	2	2	1	2
	Maximum	17	8	7	5	5	6	10
2000	Mean	12	4	5	3	3	4	4
	Minimum	7	0	3	2	2	2	1
	Maximum	21	5	6	4	5	7	7

NA = Not analyzed.
NR = Not reported.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-10

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF ZINC IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1982	Mean	2352	2803	1899	2233	2754	4818	1891
	Minimum	1481	1940	1000	1481	1530	755	1340
	Maximum	3745	3720	2800	3140	4550	13106	2540
1983	Mean	2275	3505	1805	2129	3283	4682	1716
	Minimum	1277	2460	1060	1559	2120	167	1200
	Maximum	3322	4730	2610	3009	4430	12667	2540
1984	Mean	2577	3573	1514	2186	2993	4545	1704
	Minimum	1447	2440	1110	1288	2350	407	1200
	Maximum	3386	4450	1740	6043	3880	12075	2230
1985	Mean	2414	2830	1131	2070	2427	5511	1524
	Minimum	1744	2170	822	1478	1580	476	1030
	Maximum	3118	3960	1580	2469	3530	26609	2350
1986	Mean	2715	2481	1018	2264	1991	7271	1281
	Minimum	1916	1990	845	1709	1520	357	882
	Maximum	5650	2910	1430	2704	2640	32865	1580

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-10 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF ZINC IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1987	Mean	2454	402	929	2452	2067	805	1421
	Minimum	1571	306	809	1837	1690	481	968
	Maximum	3368	532	1060	3763	2450	1313	1790
1988	Mean	2321	2461	966	2127	2073	570	1330
	Minimum	1290	1830	785	1708	1260	50	825
	Maximum	2832	3380	1160	2698	3830	1143	1920
1989	Mean	2017	2261	943	1976	2040	445	1136
	Minimum	212	1660	765	1633	1350	77	791
	Maximum	3162	2880	1210	2553	3950	593	1450
1990	Mean	2123	2207	795	1815	1655	596	955
	Minimum	1084	1250	609	1406	655	312	674
	Maximum	3030	3000	962	4009	2620	913	1520
1991	Mean	1860	1167	720	1643	1013	546	777
	Minimum	1474	832	543	1184	806	204	599
	Maximum	2696	1370	1040	2091	1300	992	1000

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-10 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF ZINC IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		mg/dry kg						
1992	Mean	1432	1320	778	1827	1084	561	881
	Minimum	977	1130	570	1197	778	282	473
	Maximum	2300	1570	1510	3500	1610	866	1520
1993	Mean	1363	1005	663	1333	763	612	816
	Minimum	1110	853	531	1070	505	448	549
	Maximum	1746	1350	835	1780	990	761	1490
1994	Mean	1393	803	693	1495	581	574	1490
	Minimum	629	658	529	1070	450	417	542
	Maximum	1955	1030	1160	2010	714	828	10200
1995	Mean	1429	708	612	1073	543	483	660
	Minimum	1073	536	497	877	349	392	419
	Maximum	1998	867	855	1260	886	685	2610
1996	Mean	1626	671	582	1165	511	455	557
	Minimum	1040	528	430	775	350	357	259
	Maximum	2585	749	732	1567	624	562	1620

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-10 (Continued)

YEARLY MEANS, AND MINIMUM AND MAXIMUM CONCENTRATIONS OF ZINC IN SLUDGE AND BIOSOLIDS FROM DISTRICT WRPs FOR 1982 THROUGH 2000

Year		Calumet Digester Draw	Egan Digester Draw	Hanover Park Digester Draw	Stickney Digester Draw	Kirie Waste Activated	Lemont Waste Activated	North Side Gravity Conc.
		----	----	----	mg/dry kg	----	----	----
1997	Mean	1789	713	615	874	542	443	559
	Minimum	1272	586	529	633	428	369	424
	Maximum	2301	859	733	1180	687	613	1010
1998	Mean	1429	713	620	840	575	457	556
	Minimum	877	614	509	683	479	304	362
	Maximum	2041	922	714	1107	867	653	1034
1999	Mean	1077	734	754	902	553	536	565
	Minimum	793	583	542	581	437	360	439
	Maximum	1530	861	1263	1175	728	726	872
2000	Mean	1125	744	610	872	551	546	549
	Minimum	912	616	493	725	388	484	427
	Maximum	1406	913	709	998	828	735	837