Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 05-7

RADIOLOGICAL MONITORING OF THE RAW SEWAGE, FINAL EFFLUENT, SLUDGES, AND BIOSOLIDS OF THE METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO 2004 ANNUAL REPORT

JULY 2005

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July 2005

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ACKNOWLEDGMENT

The authors wish to acknowledge Mr. Harold Robinson for sample preparation. Special thanks are due to Mrs. Nancy Urlacher for typing the report.

DISCLAIMER

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

SUMMARY AND CONCLUSIONS

The discharge of radioactive materials into the sanitary sewer system of the Metropolitan Water Reclamation District of Greater Chicago (District) is regulated by the Illinois Emergency Management Agency, Division of Nuclear Safety (IEMA-DNS). In Illinois, hospitals, industries, research organizations, and other radioactive material license holders are authorized to dispose of radionuclides into the District's sanitary sewer system in accordance with 32 Illinois Administrative Code (IAC), Section 340.1030. Naturally occurring radionuclides in groundwater and stormwater runoff also enter the sanitary sewer system.

The purpose of wastewater treatment is to reduce or remove pollutants from raw sewage to ensure adequate effluent quality before it is discharged to surface water. The low concentrations of radioactive material from natural and man-made sources discharged into the sanitary sewer system may become concentrated in the sewage sludge during wastewater treatment and sludge processing.

There have been several reported cases of radioactive contamination in wastewater treatment plants (WRPs) in the United States over the last 25 years (1).

This study was conducted to determine the radioactivity concentration in raw sewage, final effluent, waste-activated sludge, anaerobically digested biosolids, and air-dried biosolids at the facilities owned and operated by the District. Radiological monitoring was conducted to develop baseline data on radioactivity occurring in the District's sewage sludge and biosolids, and to compare the current radioactivity levels with the radioactivity levels in the past.

One raw sewage sample (composited over a period of 24 hours) was collected once a week, and one final effluent sample (composited over a period of 24 hours) was collected once a month from each of the District's seven WRPs. Sewage sludge and biosolids samples were collected once a month from all the WRPs. Biosolids samples from the Hanover Park WRP East lagoons were collected in May, July, and September of 2004 and Hanover Park WRP West lagoon were collected in July and September of 2004. Final air-dried biosolids samples from the Calumet WRP East, Calumet WRP West, Stony Island, Harlem Avenue Solids Management Area (HASMA), Lawndale Avenue Solids Management Area (LASMA), Marathon, and Vulcan drying areas were collected monthly from May through September 2004, and from Ridgeland Avenue Solids Management Area (RASMA) samples were collected in August and September, 2004.

The raw sewage, final effluent, waste-activated sludge, anaerobically digested biosolids, lagooned biosolids, and biosolids samples from the WRPs were analyzed for gross alpha and gross beta radioactivity. Biosolids samples from the District's solids drying areas, lagooned biosolids samples from Hanover Park WRP, and quarterly sludge and biosolids samples from Hanover Park, Stickney, Calumet, John E. Egan (Egan), and Lemont WRPs were also analyzed for gamma-emitting radionuclides.

The analytical data demonstrates that radioactivity in the final effluent of all the WRPs is generally lower than the corresponding

raw sewage of the WRP. This indicates that the WRPs remove radioactivity from the raw sewage. Analytical data also indicate that the radioactivity removed is concentrated in the sewage sludge generated at the various WRPs. The 2004 radiological monitoring data was compared with the historical data of the last eight years. The data show that there was not a major change in the radioactivity concentrations of sludge and biosolids samples of the WRPs over the last nine years except for the Lemont WRP.

The amount of gross alpha and gross beta radioactivity in the final effluent is less than the allowable contaminant levels in the drinking water standards set by the United States Environmental Protection Agency (USEPA) National Primary Drinking Water Regulations, 40 CFR Part 141, published in 2000 (2). The USEPA limit for gross alpha radioactivity (excluding radon and uranium) is 15 pCi/L and for gross beta radioactivity (excluding naturally occurring potassium-40) the limit is 50 pCi/L. The gross beta radioactivity in the final effluent is also less than the General Use water quality standard, 100 pCi/L, established by the Illinois Pollution Control Board (IPCB) and published in 1999, 35C IAC, Section 302.207(3). There are no IPCB standards for gross alpha radioactivity in General Use waters. However, the District uses the IPCB General Use water limit for gross beta radioactivity as the standard for monitoring effluents. The monitoring data indicate that the discharge of the final effluent from the seven WRPs is not likely to have any adverse effect on the radiological quality of the Chicago area waterways.

Measurable concentrations of gross alpha and gross beta radioactivity were found in Hanover Park WRP lagooned biosolids. The average gross alpha radioactivity in the lagooned biosolids ranged from 13.3 to 13.8 pCi/g dw. The average gross beta radioactivity in the lagooned biosolids was 14.8 pCi/g dw.

Measurable concentrations of gross alpha and gross beta radioactivity were found in biosolids samples collected from all of the solids drying areas of the District. The average gross alpha and beta radioactivity of biosolids from these areas ranged from 14.9 to 22.6 pCi/g dw and 21.8 to 25.2 pCi/g dw, respectively.

Samples of the anaerobically digested biosolids from four WRPs (Calumet, Egan, Hanover Park, and Stickney), waste-activated sludge from the Lemont WRP, lagooned biosolids from Hanover Park WRP, and biosolids samples from the solids drying areas were further analyzed for 27 specific radionuclides by gamma spectroscopy. Of these radionuclides, nine were detected in measurable quantities in these samples. Eight of these radionuclides are of natural origin, and one, cesium-137, is a manmade radionuclide.

Average potassium-40 radioactivity in the WRP sludge and biosolids samples ranged from 4.6 to 9.8 pCi/g dw, radium-226 radioactivity ranged from 3.6 to 65.6 pCi/g dw, and cesium-137 radioactivity ranged from not detectable to 0.07 pCi/g dw.

Average potassium-40 radioactivity in Hanover Park lagooned biosolids ranged from 2.8 to 4.1 pCi/g dw, and radium-226 radioactivity ranged from 3.7 to 4.2 pCi/g dw. Cesium-137 radioactivity was not detected in Hanover Park WRP lagooned biosolids.

Average potassium-40 and radium-226 radioactivity in all biosolids samples taken

from the District biosolids drying areas ranged from 7.0 to 10.5 pCi/g dw and 3.7 to 4.8 pCi/g dw, respectively. The average cesium-137 radioactivity ranged from 0.06 to 0.08 pCi/g dw. The average radioactivity concentration of the other six naturally occurring radionuclides in biosolids ranged from a non-detectable level to 1.8 pCi/g dw.

The presence of unduly high levels of radioactivity in biosolids is of environmental concern. The District routinely monitors the radiological quality of its biosolids to see if any unusually high radioactivity concentrations are occurring. This helps the District ensure worker safety, minimize the buildup of radionuclides in landfills, and ensure that the biosolids are low in radioactivity and suitable for land application as fertilizer. Radioactivity concentrations found in the District's biosolids in 2004 do not pose any significant risk to human health or the environment.

INTRODUCTION

The District is located within the boundaries of Cook County, Illinois, and serves an area of 872 square miles. The area served by the District includes the city of Chicago and 125 suburban communities with a combined population of 5.1 million people. In addition, a waste load equivalent of 4.9 million people is contributed within the District's service area by industrial and commercial sources. On the average the District treats 1,500 million gallons per day (MGD) of wastewater at its seven WRPs.

The discharge of radionuclides to the District's sewerage system is regulated by the IEMA-DNS. Radioactivity in the sewerage system may come from a variety of sources including industries, hospitals, and research organizations (4). Naturally occurring and atmospheric fallout radionuclides also enter the sewerage system from groundwater and through stormwater runoff. Radionuclides in the sanitary sewer system pass through the wastewater treatment process where some fraction of these radionuclides are removed from the wastewater and become concentrated in the sludge, or remain in solution and pass with the effluent to the receiving water. Radioactivity contained in WRP effluents and the potential radioactivity concentration in municipal sludge may be of environmental concern because of the discharge of effluents to receiving waters and the landfilling or land application of biosolids as fertilizer and soil conditioner.

The District monitors the quality of its raw sewage, effluents, sludges, and biosolids for possible radioactive contamination. As a part of its monitoring program, the District's Radiochemistry Laboratory routinely analyzes raw sewage, final effluent, and sludge samples from all the WRPs, and biosolids samples from solids drying areas for gross alpha and gross beta radioactivity. Samples of the anaerobically digested biosolids from four WRPs (Calumet, Egan, Hanover Park, and Stickney), waste-activated sludge from the Lemont WRP, lagooned biosolids from the Hanover Park WRP, and biosolids samples from the District's solids drying areas are also examined for gamma-emitting radionuclides. In 1996, the Radiochemistry Section expanded its monitoring program of District sludges and biosolids in response to the increased emphasis on sludge characteristics brought about by adoption of USEPA sludge regulations (40 CFR Part 503). Although there are no standards for radioactivity in these regulations, the District expanded its database on the radiological characteristics of its biosolids to be prepared to address any future regulatory limits on radioactivity in biosolids.

This report presents the gross alpha and gross beta radioactivity concentrations in raw sewage, final effluent, and sewage sludge from the District's seven WRPs and biosolids from the District's solids drying areas. The concentrations of gross alpha and gross beta radioactivity and gamma-emitting radionuclides in quarterly samples of anaerobically digested biosolids, lagooned biosolids, and air-dried biosolids samples are also reported. The 2004 radiological monitoring data is compared with the historical data of the last eight years.

MATERIALS AND METHODS

Sample Collection

Raw Sewage. One raw sewage sample (composited over a period of 24 hours) was collected once a week from the Stickney, Egan, North Side, James C. Kirie (Kirie), Hanover Park, Calumet, and Lemont WRPs. The samples were preserved with hydrochloric acid.

Final Effluent. One final effluent sample (composited over a period of 24 hours) was collected once a month from the effluent sampler at all the WRPs. The samples were preserved with hydrochloric acid.

Sludge and Biosolids. Anaerobically digested biosolids samples were collected monthly from the Stickney, Calumet, Egan, and Hanover Park WRPs. Waste-activated sludge samples were collected monthly from the Lemont, North Side, and Kirie WRPs; these WRPs do not have digesters.

Lagooned biosolids samples were collected quarterly from Hanover Park WRP East, and Hanover Park WRP West lagoons.

Final air-dried biosolids samples were collected from solids drying areas of the District. The samples analyzed for radioactivity included biosolids from the Marathon Drying Cells, LASMA Drying Cells, Vulcan Drying Cells, HASMA Drying Cells, RASMA Drying Cells, Stony Island Drying Area, Calumet WRP East Drying Area, and Calumet WRP West Drying Area.

Analytical Methodology

Gross Alpha and Gross Beta Radioactivity. *Raw Sewage and Final Effluent.* Gross alpha and gross beta radioactivity concentrations in the samples were determined using U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory Procedure, March 1979.

A known volume of a thoroughly mixed sample was transferred to a beaker. Nitric acid (3M, 20 mL) was added to the beaker. The sample was evaporated to near dryness on a hot plate at low heat. It was then quantitatively transferred with nitric acid (3M) to a tared stainless steel planchet and dried under an infrared lamp, followed by oven drying at 103°C to constant weight. The sample was counted for gross alpha and gross beta radioactivity on a Tennelec LB5100 Gas Proportional Counter. A National Institute of Standards and Technology (NIST) traceable cesium-137 standard from North American Scientific, Inc. was used for calibration of counters and self-absorption for gross beta determination. For gross alpha radioactivity determination, a NIST traceable americium-241 standard was used up to June 2001, and a thorium-230 standard was used since July 1, 2001.

Sludge and Biosolids. Gross alpha and gross beta radioactivity concentrations in the samples were determined using Standard Methods for the Examination of Water and Wastewater, 20th Edition, (Standard Methods 1998) procedures as follows:

A thoroughly mixed liquid sludge or biosolids sample (40 to 50 g) or air-dried biosolids sample (4 to 5 g) was transferred to a tared evaporating dish. The sample was dried to constant weight at 103°C. The difference in weight over the empty dish represents the total solids. The sample was then incinerated at 550°C to constant weight. The resi-

due in the dish represents the fixed solids. The fixed solids were ground to a fine powder, and a weighed portion of the powder (80 to 100 mg) was transferred to a tared stainless steel planchet. The residue was distributed to a uniform thickness and spread with a few drops of 0.5 percent (w/v) acrylic (Lucite) solution in acetone. It was then dried to constant weight at 103°C and counted for gross alpha and gross beta radioactivity on a Tennelec LB5100 Gas Proportional Counter. A NIST traceable cesium-137 standard from North American Scientific, Inc. was used for efficiency calibration of gas proportional counters and self-absorption for gross beta determination. For gross alpha radioactivity determination, NIST traceable americium-241 standard was used for the efficiency calibration of the counters and self-absorption for gross alpha determination up to June 2001, and a thorium-230 standard was used since July 1, 2001 in accordance with the USEPA requirements. The higher gross alpha radioactivity concentration in sludge and biosolids since 2001 is due to the fact that thorium-230 efficiency calibration is used for gross alpha determination.

Gamma Radioactivity. Gamma radioactivity in the sludge and biosolids samples was determined as follows:
The sludge or biosolids sample was dried on a hot plate at low heat. It was then ground and passed through a 30-mesh sieve. The sieved material was packed in a tared 3-oz canister, weighed, and sealed with a vinyl electrical tape to avoid loss of gaseous progeny of uranium and thorium. The sample was stored for at least 30-days for radium-radon to reach equilibrium before counting. The sample was analyzed by a gamma spectroscopy system equipped with a high-purity germanium detector and Ginie-2000 software analysis package from Canberra Industries. The radium-226 radioactivity concentration was calculated from a 186 KeV photopeak, cesium-137 radioactivity from a 661.6 KeV photopeak, and potassium-40 radioactivity from a 1461 KeV photopeak. The energy and efficiency calibration of the system was verified before the sample was counted using a NIST traceable mixed gamma standard from North American Scientific, Inc.

Calculations

Gross alpha and gross beta radioactivity in sludge and biosolids samples were calculated as pCi/g dw using the following equation:

$$\text{Radioactivity (pCi/g dw)} = \frac{\text{Net cpm x A}}{\text{2.22 x counting efficiency x B x C}}$$

where:

cpm = counts per minute

A = wt. of fixed solids in evaporating dish, g

B = wt. of fixed solids in planchet, g

C = wt. of total solids in evaporating dish, g

2.22 = conversion factor from disintegrations per minute (dpm) to picocurie (pCi)

Gross alpha and gross beta radioactivity in the raw sewage and effluent were calculated as pCi/L using the following equation:

$$\text{Radioactivity (pCi/L)} = \frac{\text{Net cpm}}{2.22 \times \text{counting efficiency} \times \text{sample volume}}$$

Lower Limit of Detection (LLD)

The LLD is the smallest quantity of sample radioactivity that will yield a net count for which there is a predetermined level of confidence that radioactivity is present (5). The LLD that has a 95 percent probability of being detected was calculated as follows:

$$\text{LLD (pCi/L)} = \frac{4.66\ (B)^{1/2}}{2.22 \times E \times V \times T \times F}$$

where:

B = background counts

E = fractional counting efficiency

V = sample volume in liters

T = counting time in minutes

F = gamma fraction for the isotope line (applied only to gamma spectroscopic measurements)

4.66 = $2\sqrt{2}K$, where K is the value for upper percentile of the standardized normal variate corresponding to the preselected risk (5%) for concluding falsely that activity is present.

When the sample radioactivity was less than the LLD, the radioactivity concentration was reported as below the detection limit.

For calculation purposes, less than LLD values were considered as real numbers; i.e., <1 was considered as 1. Average gross alpha and gross beta radioactivity for raw sewage was calculated by adding radioactivity concentrations in weekly samples and dividing the sum by the number of weekly samples collected during the month. If any value in the individual data set with the less than symbol was higher than the average value, then the average value was reported with the less than symbol. If all the values in the individual data set with the less than symbol were lower than the average value, then the average value was reported without the less than symbol.

In a set of data points with a combination of real number and LLD values, the highest real number was considered as the maximum value if the number was higher than the highest LLD value of the data set, otherwise LLD was reported as the maximum value. The lowest real number was considered as the minimum value if the number was lower than the lowest LLD value of the data set, otherwise LLD was reported as the minimum value.

The LLD is inversely proportional to the counting efficiency and varies with the nature of the sample. A sample with a higher total solids content results in a greater thickness of solids in the counting planchet. The higher solids content in the planchet leads to a lower counting efficiency and a higher detection limit. Consequently, the detection limit will vary with the solids content of the samples and the thickness of the solids in the planchet.

RESULTS AND DISCUSSION

Stickney WRP

In 2004, the gross alpha radioactivity in the raw sewage of the Stickney WRP ranged from below the detection limit (3.7 pCi/L) to 10.4 pCi/L (Table 1). The gross alpha radioactivity in the effluent was below the detection limit (2.8 to 5.8 pCi/L) except for the January sample which was 6.8 pCi/L (Table 1). The gross alpha radioactivity in anaerobically digested biosolids ranged from 6.8 to 19.9 pCi/g dw (Table 1)

The yearly average gross alpha radioactivity in the Stickney WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2004 are summarized in Table 2. The gross alpha radioactivity in the raw sewage ranged from below the detection limit (3.6 pCi/L) to 6.1 pCi/L. The gross alpha radioactivity in the effluent was below the detection limit (2.6 to 4.7 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 5.2 to 12.3 pCi/g dw.

The gross beta radioactivity in the raw sewage of the Stickney WRP ranged from 14.7 to 22.0 pCi/L, and in the effluent it ranged from 5.9 to 16.9 pCi/L (Table 3). The gross beta radioactivity in anaerobically digested biosolids ranged from 19.7 to 28.5 pCi/g dw (Table 3).

The yearly average gross beta radioactivity in the Stickney WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2004 are summarized in Table 4. The gross beta radioactivity in the raw sewage ranged from 11.7 to 29.3 pCi/L, and in the effluent it ranged from 5.9 to 11.4 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 22.8 to 27.3 pCi/g dw.

Calumet WRP

In 2004, the gross alpha radioactivity in the raw sewage of the Calumet WRP was below the detection limit (3.6 to 5.8 pCi/L) (Table 5). The gross alpha radioactivity in the effluent was also below the detection limit (3.0 to 7.6 pCi/L) except for the February sample which was 4.5 pCi/L (Table 5). The gross alpha radioactivity in anaerobically digested biosolids ranged from 10.5 to 22.7 pCi/g dw (Table 5).

The yearly average gross alpha radioactivity in the Calumet WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2004 are summarized in Table 6. The gross alpha radioactivity in the raw sewage was below the detection limit (3.7 to 5.1 pCi/L). In the effluent the gross alpha radioactivity was also below the detection limit (3.0 to 4.5 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 5.1 to 14.1 pCi/g dw.

The gross beta radioactivity in the raw sewage of the Calumet WRP ranged from 9.3 to 16.6 pCi/L, and in the effluent it ranged from 4.6 to 17.8 pCi/L (Table 7). The gross beta radioactivity in Calumet WRP anaerobically digested biosolids ranged from 19.2 to 28.8 pCi/g dw (Table 7).

The yearly average gross beta radioactivity in the Calumet WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2004 are summarized in Table 8. The gross beta radioactivity in the raw sewage ranged from 9.3 to 24.9 pCi/L and in

the effluent it ranged from 6.9 to 14.1 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 21.0 to 25.2 pCi/g dw.

North Side WRP

In 2004, the gross alpha radioactivity in the raw sewage of the North Side WRP was below the detection limit (3.2 to 4.7 pCi/L, Table 9). The gross alpha radioactivity in the effluent was also below the detection limits (2.9 to 5.3 pCi/L) except for the January sample which was 3.1 pCi/L (Table 9). The gross alpha radioactivity in waste-activated sludge ranged from 4.8 to 12.3 pCi/g dw (Table 9).

The yearly average gross alpha radioactivity in the North Side WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2004 are summarized in Table 10. The gross alpha radioactivity in the raw sewage was below the detection limit (3.3 to 4.9 pCi/L), and in the effluent it was also below the detection limit (2.8 to 4.5 pCi/L). The gross alpha radioactivity in waste-activated sludge ranged from 2.6 to 7.8 pCi/g dw.

The gross beta radioactivity in the raw sewage of the North Side WRP ranged from 9.7 to 12.2 pCi/L, and in the effluent it ranged from 6.3 to 13.1 pCi/L (Table 11). The gross beta radioactivity in North Side WRP waste-activated sludge ranged from 8.5 to 17.3 pCi/g dw (Table 11).

The yearly average gross beta radioactivity in the North Side WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2004 are summarized in Table 12. The gross beta radioactivity in the raw sewage ranged from 8.5 to 20.4 pCi/L and in the effluent it ranged from 5.7 to 10.9 pCi/L. The gross beta radioactivity in waste-activated sludge ranged from 12.8 to 15.8 pCi/g dw.

John E. Egan WRP

In 2004, the gross alpha radioactivity in the raw sewage of the Egan WRP was below the detection limits (3.5 to 5.8 pCi/L) (Table 13). The gross alpha radioactivity in the effluent was below the detection limits (2.3 to 5.9 pCi/L, Table 13). The gross alpha radioactivity in anaerobically digested biosolids samples ranged from 7.4 to 16.0 pCi/g dw (Table 13).

The yearly average gross alpha radioactivity in the Egan WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2004 are summarized in Table 14. The gross alpha radioactivity in the raw sewage was below the detection limit (3.6 to 5.0 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (3.0 to 4.8 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 4.4 to 10.5 pCi/g dw.

The gross beta radioactivity levels in the raw sewage of the Egan WRP ranged from 12.2 to 15.8 pCi/L, and in the effluent it ranged from 8.3 to 13.8 pCi/L (Table 15). The gross beta radioactivity in Egan WRP anaerobically digested biosolids ranged from 14.5 to 23.2 pCi/g dw.

The yearly average gross beta radioactivity at the Egan WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2004 are summarized in Table 16. The gross beta radioactivity in the raw sewage ranged from 10.8 to 22.5 pCi/L and in the effluent it ranged from 6.9 to 12.7 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 18.3 to 21.3 pCi/g dw.

Hanover Park WRP

In 2004, the gross alpha radioactivity levels in the raw sewage of the Hanover Park WRP were below the detection limit (3.4 to 5.2 pCi/L) except for the June sample which was 5.4 pCi/L (Table 17). The gross alpha radioactivity in the effluent was below the detection limits (2.2 to 5.5 pCi/L, Table 17). The gross alpha radioactivity in anaerobically digested biosolids ranged from 5.0 to 10.5 pCi/g dw (Table 17).

The yearly average gross alpha radioactivity in the Hanover Park WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2004 are summarized in Table 18. The gross alpha radioactivity in the raw sewage was below the detection limit (3.4 to 4.7 pCi/L), and the gross alpha radioactivity in the effluent was also below the detection limit (3.0 to 4.4 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 3.2 to 9.4 pCi/g dw.

The gross beta radioactivity levels in the raw sewage of the Hanover Park WRP ranged from 11.7 to 15.8 pCi/L, and in the effluent it ranged from 7.4 to 14.8 pCi/L (Table 19). The gross beta radioactivity in the Hanover Park WRP anaerobically digested biosolids ranged from 10.4 to 14.8 pCi/g dw (Table 19).

The yearly average gross beta radioactivity in the Hanover Park WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2004 are summarized in Table 20. The gross beta radioactivity in the raw sewage ranged from 9.7 to 20.3 pCi/L and in the effluent it ranged from 6.6 to 11.7 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 11.8 to 14.2 pCi/g dw.

James C. Kirie WRP

In 2004, the gross alpha radioactivity levels in the raw sewage of the Kirie WRP was below the detection limit (3.5 to 5.8 pCi/L) except for the March and May samples which were 4.2 pCi/L and 5.2 pCi/L, respectively (Table 21). The gross alpha radioactivity in the effluent was below the detection limits (2.8 to 6.6 pCi/L, Table 21). The gross alpha radioactivity in waste-activated sludge ranged from 5.3 to 9.7 pCi/g dw (Table 21).

The yearly average gross alpha radioactivity in the Kirie WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2004 are summarized in Table 22. The gross alpha radioactivity in the raw sewage was below the detection limit (3.6 to 5.3 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (2.8 to 4.9 pCi/L). The gross alpha radioactivity in waste-activated sludge ranged from 3.1 to 9.2 pCi/g dw.

The gross beta radioactivity level in the raw sewage of Kirie WRP ranged from 12.3 to 19.4 pCi/L, and in the effluent it ranged from 3.9 to 21.3 pCi/L (Table 23). The gross beta radioactivity in Kirie WRP waste-activated sludge ranged from 8.8 to 17.5 pCi/g dw (Table 23).

The yearly average gross beta radioactivity in the Kirie WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2004 are summarized in Table 24. The gross beta radioactivity in the raw sewage ranged from 11.6 to 22.7 pCi/L and in the effluent it ranged from 8.1 to 16.8 pCi/L. The gross beta radioactivity in waste-activated sludge ranged from 13.3 to 16.8 pCi/g dw.

Lemont WRP

In 2004, the gross alpha radioactivity levels in the raw sewage of the Lemont WRP ranged from below the detection limit (7.8 pCi/L) to 35.2 pCi/L (Table 25). The gross alpha radioactivity in the effluent ranged from less than the detection limit (4.7 pCi/L) to 10.6 pCi/L (Table 25). The gross alpha radioactivity in the waste-activated sludge ranged from 53.0 to 152.9 pCi/g dw (Table 25).

The yearly average gross alpha radioactivity in the Lemont WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2004 are summarized in Table 26. The gross alpha radioactivity in the raw sewage ranged from 13.4 to 44.4 pCi/L. The gross alpha radioactivity in the effluent was below the detection limit (5.0 to 9.7 pCi/L). The gross alpha radioactivity in the waste-activated sludge ranged from 38.9 to 141.1 pCi/g dw.

The gross beta radioactivity levels in the raw sewage of the Lemont WRP ranged from 20.2 to 46.5 pCi/L, and in the effluent it ranged from 9.1 to 25.8 pCi/L (Table 27). The gross beta radioactivity in Lemont waste-activated sludge ranged from 42.3 to 91.9 pCi/g dw (Table 27).

The yearly average gross beta radioactivity at the Lemont WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2004 are summarized in Table 28. The gross beta radioactivity in the raw sewage ranged from 26.4 to 66.0 pCi/L and in the effluent it ranged from 13.4 to 24.1 pCi/L. The gross beta radioactivity in waste-activated sludge ranged from 61.1 to 121.9 pCi/g dw.

Hanover Park WRP Lagoons

Table 29 presents the gross alpha and gross beta radioactivity concentrations in Hanover Park WRP lagooned biosolids for 2004.

Average gross alpha radioactivity in Hanover Park WRP East lagooned biosolids was 13.3 pCi/g dw and ranged from11.1 to 15.8 pCi/g dw. Average gross alpha radioactivity in Hanover Park WRP West lagooned biosolids was 13.8 pCi/g dw and ranged from 9.4 to 18.2 pCi/g dw.

Average gross beta radioactivity in Hanover Park WRP East lagooned biosolids was 14.8 pCi/g dw and ranged from 13.6 to 16.0 pCi/g dw. Average gross beta radioactivity in Hanover Park WRP West lagooned biosolids was 14.8 pCi/g dw and ranged from 14.4 to 15.1 pCi/g dw.

The yearly average gross alpha radioactivity in Hanover Park WRP lagooned biosolids from 1998 to 2004 is summarized in Table 30. The gross alpha radioactivity in the lagooned biosolids ranged from 4.6 pCi/g dw at Hanover Park WRP West lagoon in 1999 to 13.8 pCi/g dw at Hanover Park WRP West lagoon in 2004.

The yearly average gross beta radioactivity in the Hanover Park WRP lagooned biosolids from 1998 to 2004 is summarized in Table 31. The gross beta radioactivity in lagooned biosolids ranged from 11.6 pCi/g dw at Hanover Park WRP West Lagoon in 2003 to 18.1 pCi/g dw at Hanover Park WRP West Lagoon in 1999.

Gross Alpha and Gross Beta Radioactivity in District Biosolids

Table 32 presents the gross alpha and gross beta radioactivity concentrations in biosolids

from the District's solids drying areas for 2004.

Average gross alpha radioactivity in biosolids ranged from 14.9 pCi/g dw at the LASMA drying site to 22.6 pCi/g dw at the RASMA drying site. Average gross beta radioactivity in biosolids ranged from 21.8 pCi/g dw at the Calumet East drying site to 25.2 pCi/g dw at the RASMA drying site.

The yearly average gross alpha radioactivity in the District's biosolids from 1996 to 2004 is summarized in Table 33. The gross alpha radioactivity in the biosolids ranged from 5.1 pCi/g dw at Vulcan drying site in 1996 to 22.6 pCi/g dw at RASMA drying site in 2004.

The yearly average gross beta radioactivity in the District's biosolids from 1996 to 2004 is summarized in Table 34. The gross beta radioactivity in the biosolids ranged from 21.0 pCi/g dw at Calumet West drying site in 2001 to 30.2 pCi/g dw at RASMA drying site in 2000.

Gamma Radioactivity in District WRP Sludges and Biosolids

In 2004, 20 sludge samples from five WRPs, 37 biosolids samples from eight solids drying sites, and 5 biosolids samples from Hanover Park WRP lagoons were analyzed for gamma-emitting radionuclides. The following is a list of radionuclides monitored:

Beryllium-7	Silver-108m
Sodium-22	Silver-110
Potassium-40	Antimony-125
Manganese-54	Cesium-134
Cobalt-57	Cesium-137
Cobalt-60	Cerium-144
Zinc-65	Europium-152
Niobium-94	Gadolinium-153
Ruthenium-106	Europium-154
Barium-133	Bismuth-207
Bismuth-212	Lead-212
Bismuth-214	Lead-214
Radium-226	Actinum-228
Protactinium-231	

Of the 27 radionuclides analyzed, 9 were detected at measurable levels. Of these, 8 radionuclides are of natural origin, and one, cesium-137, is a manmade radionuclide.

Table 35 presents the concentrations of gamma-emitting radionuclides in the sludge and biosolids from the District WRPs for 2004. Average potassium-40 radioactivity ranged from 4.6 pCi/g dw at the Hanover Park WRP to 9.8 pCi/g dw at the Stickney WRP. Average radium-226 radioactivity ranged from 3.6 pCi/g dw at the Hanover Park WRP to 65.6 pCi/g dw at the Lemont WRP. Average cesium-137 radioactivity was 0.06 pCi/g at the Calumet WRP and 0.07 pCi/g dw at the Stickney WRP. Cesium-137 was not detected at the Hanover Park, Egan, and Lemont WRPs. Average beryllium-7 radioactivity ranged from 0.7 pCi/g at the Hanover Park WRP to 7.8 pCi/g dw at the Stickney WRP. Average bismuth-212, lead 212, bismuth-214, lead-214, and actinium-228 radioactivity at the Calumet,

Egan, Hanover Park, and Stickney WRPs was relatively low, and ranged from non-detectable levels to 2.0 pCi/g dw. At the Lemont WRP average bismuth-212 radioactivity was 3.4 pCi/g dw, lead-212 was 4.2 pCi/g dw, bismuth-214 was 31.5 pCi/g dw, lead-214 was 34.7 pCi/g dw, and actinium-228 was 26.3 pCi/g dw. These radionuclides are the decay products of either naturally occurring uranium or thorium.

The village of Lemont uses groundwater for its community water supply. This groundwater contains naturally occurring radium-226. The village uses an ion exchange system to remove radium-226 from groundwater. The backwash water from the Lemont community water supply system is discharged into the Lemont WRP. The District treats the raw sewage containing this radium-226 at the Lemont WRP to remove contaminants. The radium-226 removed during the wastewater treatment process is concentrated in sludge. The Lemont WRP does not have sludge treatment facilities, and it is transported by truck to either the Calumet or Stickney WRP to be treated at these facilities.

The yearly average potassium-40, radium-226, and cesium-137 radioactivity in the District's WRPs sludges and biosolids from 1997 to 2004 are summarized in Tables 36, 37, and 38, respectively. The potassium-40 radioactivity in the WRP sludge ranged from 2.4 pCi/g dw at the Hanover Park WRP in 1997 to 11.7 pCi/g dw at the Stickney WRP in 1998. The radium-226 radioactivity in the WRP sludges, excluding Lemont WRP, ranged from 2.1 pCi/g dw at the Stickney WRP in 1999 to 5.5 pCi/g dw at the Calumet WRP in 2004. The radium-226 radioactivity at the Lemont WRP ranged from 44.9 pCi/g dw in 1997 to 86.8 pCi/g dw in 2001. The cesium-137 radioactivity in the WRP sludges ranged from non-detectable levels to 0.11 pCi/g dw in 1998 at the Stickney WRP.

Table 39 presents the concentration of gamma-emitting radionuclides in Hanover Park WRP lagooned biosolids for 2004. The potassium-40 radioactivity at the Hanover Park WRP East and West lagoons was 2.8 and 4.1 pCi/g dw, respectively. The radium-226 radioactivity was 3.7 pCi/g dw in the Hanover Park East lagoon and 4.2 pCi/g dw in the Hanover Park West lagooned biosolids. Cesium-137 radioactivity was not detected in either of the two lagooned biosolids. The radioactivity concentration of other naturally occurring radionuclides ranged from 0.3 to 1.9 pCi/g dw.

The yearly average potassium-40, radium-226, and cesium-137 radioactivity in the Hanover Park WRP lagooned biosolids from 1998 to 2004 is summarized in Table 40. The yearly average potassium-40 radioactivity at the Hanover Park East lagoon ranged from 2.8 to 5.0 pCi/g dw. The yearly average radium-226 radioactivity ranged from 3.7 to 5.2 pCi/g dw, and cesium-137 radioactivity ranged from non-detectable levels to 0.2 pCi/g dw.

The yearly average potassium-40 radioactivity in the Hanover Park West lagooned biosolids ranged from 3.5 to 5.3 pCi/g dw, radium-226 radioactivity ranged from 3.7 to 5.7 pCi/g dw, and cesium-137 radioactivity ranged from non-detectable to 0.3 pCi/g dw.

Table 41 presents the concentration of gamma-emitting radionuclides in the District's biosolids collected from 8 solids drying sites in 2004. The average potassium-40 radioactivity ranged from 7.0 pCi/g dw in the Calumet East biosolids to 10.5 pCi/g dw in the Marathon biosolids. The overall concentration range of potasium-40 for the District's

biosolids was 4.8 to 12.0 pCi/g dw. The average radium-226 radioactivity ranged from 3.7 pCi/g dw in the RASMA biosolids to 4.8 pCi/g dw in the Calumet East and Calumet West biosolids. The overall concentration range of radium-226 for the District's biosolids was from 3.2 to 5.4 pCi/g dw. The average cesium-137 radioactivity ranged from 0.06 pCi/g dw in the Calumet East, Calumet West, RASMA, and Marathon biosolids to 0.08 pCi/g dw in the LASMA biosolids. The overall concentration range of cesium-137 radioactivity for the District's biosolids was from non-detectable levels to 0.09 pCi/g dw. Average Beryllium-7, bismuth-212, lead-212, bimuth-214, lead-214, and actinium-228 radioactivity ranged from non-detectable levels to 1.8 pCi/g dw.

The yearly average potassium-40, radium-226, and cesium-137 radioactivity in the District's biosolids from 1996 to 2004 are summarized in Tables 42, 43, and 44, respectively. The potassium-40 radioactivity in the biosolids ranged from 7.0 pCi/g dw at the Calumet West drying site in 1996 and Calumet East drying site in 2004 to 14.4 pCi/g dw at the HASMA drying site in 2002. The radium-226 radioactivity in the biosolids ranged from 2.9 pCi/g dw at the Vulcan drying site in 1999 to 5.2 pCi/g dw at the Calumet West drying site in 2001. The cesium-137 radioactivity in biosolids ranged from 0.05 pCi/g dw at the Calumet East drying site in 2002 to 0.6 pCi/g dw at the Stony Island drying site in 1996.

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METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 1

GROSS ALPHA RADIOACTIVITY IN STICKNEY WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS - 2004

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<6.1	6.8	10.8
February	<7.8	<4.6	6.8
March	4.9	<3.0	12.8
April	<6.1	<4.3	14.0
May	<4.4	<4.6	11.4
June	7.4	<2.8	10.1
July	<3.7	<3.0	13.4
August	5.9	<3.9	11.7
September	10.4	<5.8	19.9
October	<5.2	<4.2	14.0
November	<5.3	<3.4	11.2
December	<5.4	<3.0	8.6

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 2

YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN STICKNEY WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2004

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
1996	<3.8	<3.1	5.3
1997	<3.6	<3.1	5.3
1998	4.6	<2.6	5.2
1999	5.0	<3.6	6.1
2000	<5.0	<4.6	7.5
2001	6.1	<4.4	12.3
2002	<5.2	<4.7	11.3
2003	5.0	<3.6	11.7
2004	<6.0	<4.1	12.1

* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 3

GROSS BETA RADIOACTIVITY IN STICKNEY WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2004

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	18.7	13.1	25.2
February	22.0	16.9	19.7
March	17.4	7.9	24.0
April	18.1	8.1	24.8
May	15.2	9.4	26.4
June	19.0	7.7	28.5
July	14.7	7.2	27.8
August	18.0	10.5	25.2
September	19.2	8.8	22.8
October	17.2	13.6	24.0
November	16.4	5.9	23.0
December	16.1	8.5	26.0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 4

YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN STICKNEY WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2004

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
1996	11.7	5.9	22.8
1997	20.4	9.0	23.4
1998	26.4	11.4	23.6
1999	28.9	11.1	25.9
2000	29.3	9.8	27.2
2001	19.7	9.2	27.3
2002	17.3	9.0	24.7
2003	16.6	7.7	24.8
2004	17.7	9.8	24.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 5

GROSS ALPHA RADIOACTIVITY IN CALUMET WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS - 2004

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<5.1	<7.6	15.0
February	<5.1	4.5	12.6
March	<3.7	<3.2	10.5
April	<4.7	<4.6	10.8
May	<4.3	<4.9	11.8
June	<4.3	<3.0	14.5
July	<3.6	<3.3	11.2
August	<5.2	<4.3	19.9
September	<5.8	<6.1	22.7
October	<5.3	<4.7	15.5
November	<5.2	<3.7	13.1
December	<5.3	<3.3	11.9

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 6

YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN CALUMET WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2004

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
1996	<3.7	<3.5	5.9
1997	<4.0	<3.5	5.1
1998	<3.8	<3.0	6.1
1999	<4.6	<3.8	6.5
2000	<4.7	<4.5	8.4
2001	<5.1	<4.5	12.6
2002	<4.8	<4.1	12.1
2003	<4.3	<3.8	12.4
2004	<4.8	<4.4	14.1

* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 7

GROSS BETA RADIOACTIVITY IN CALUMET WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2004

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	14.8	17.8	24.0
February	16.6	14.0	25.7
March	13.9	11.4	19.2
April	11.9	5.6	28.8
May	11.1	9.2	26.1
June	11.5	4.6	24.5
July	11.0	6.0	25.1
August	12.3	7.3	27.0
September	11.5	8.2	24.4
October	13.8	9.2	26.0
November	10.6	8.5	22.5
December	9.3	8.7	23.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 8

YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN CALUMET WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2004

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
1996	9.3	6.9	21.5
1997	18.6	11.2	21.4
1998	19.5	13.2	23.7
1999	24.9	14.1	22.6
2000	22.0	10.2	25.2
2001	13.6	9.4	24.1
2002	15.9	9.4	21.0
2003	15.1	9.6	23.7
2004	12.3	9.2	24.8

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 9

GROSS ALPHA RADIOACTIVITY IN NORTH SIDE WRP RAW SEWAGE,
FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE
ON A MONTHLY BASIS - 2004

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (Pci/g dw)
January	<4.4	3.1	6.2
February	<4.5	<3.2	4.8
March	<3.2	<2.9	7.4
April	<4.2	<4.1	7.1
May	<4.2	<4.3	7.4
June	<4.0	<2.9	8.2
July	<3.2	<3.2	12.3
August	<4.4	<3.8	9.6
September	<4.7	<5.3	7.7
October	<4.2	<4.0	7.9
November	<4.3	<3.3	8.5
December	<4.6	<3.2	7.3

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 10

YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN NORTH SIDE WRP RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2004

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
1996	<3.3	<3.0	3.5
1997	<3.6	<3.3	2.6
1998	<3.3	<2.8	3.0
1999	<4.0	<3.5	3.7
2000	<4.9	<4.1	4.9
2001	<4.9	<4.5	7.8
2002	<4.0	<4.0	6.6
2003	<3.6	<3.5	6.2
2004	<4.1	<3.6	7.8

* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 11

GROSS BETA RADIOACTIVITY IN NORTH SIDE WRP RAW SEWAGE,
FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE
ON A MONTHLY BASIS - 2004

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
January	12.1	13.1	8.9
February	10.2	12.7	8.5
March	11.4	7.4	15.4
April	12.2	6.5	12.5
May	11.0	10.0	15.6
June	9.8	10.1	14.5
July	10.9	10.3	17.3
August	10.5	7.8	10.8
September	9.9	7.9	13.5
October	9.7	11.3	13.2
November	11.9	6.3	10.6
December	11.0	7.8	13.2

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 12

YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN NORTH SIDE WRP RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2004

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
1996	8.5	5.7	14.8
1997	16.1	<7.8	14.0
1998	18.4	9.8	14.4
1999	19.1	10.9	13.6
2000	20.4	8.9	15.0
2001	12.8	8.5	15.8
2002	11.3	8.4	12.8
2003	10.0	7.9	13.3
2004	10.9	9.3	12.8

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 13

GROSS ALPHA RADIOACTIVITY IN JOHN E. EGAN WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS - 2004

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<3.8	<3.5	10.8
February	<4.4	<2.3	8.3
March	<3.5	<3.2	7.4
April	<4.8	<4.4	9.3
May	<4.1	<4.7	8.1
June	<4.0	<3.0	8.9
July	<3.6	<3.3	12.6
August	<4.5	<3.8	16.0
September	<5.8	<5.9	9.2
October	<4.5	<4.2	8.3
November	<4.9	<3.9	10.6
December	<5.0	<3.4	9.8

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 14

YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN JOHN E. EGAN WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2004

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
1996	<3.6	<3.2	5.6
1997	<3.7	<3.3	4.4
1998	<3.8	<3.0	4.8
1999	<4.0	<3.5	5.2
2000	<4.5	<4.1	6.9
2001	<5.0	<4.6	10.5
2002	<4.8	<4.8	10.2
2003	<4.2	<3.6	9.7
2004	<4.4	<3.8	9.9

* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 15

GROSS BETA RADIOACTIVITY IN JOHN E. EGAN WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS - 2004

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	14.6	9.8	18.8
February	15.8	12.4	23.2
March	13.5	9.5	16.6
April	13.5	8.3	20.6
May	14.2	11.3	19.0
June	12.2	12.2	20.0
July	13.0	11.2	22.7
August	13.2	10.8	21.5
September	14.8	13.8	18.1
October	14.9	13.8	14.5
November	13.5	11.4	18.4
December	13.4	11.2	18.2

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 16

YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN JOHN E. EGAN WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2004

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
1996	10.8	6.9	20.3
1997	17.5	11.9	19.0
1998	19.1	12.7	20.5
1999	22.5	12.3	19.7
2000	20.8	10.6	21.3
2001	16.0	9.5	20.7
2002	15.4	12.0	18.3
2003	14.0	10.5	18.6
2004	13.9	11.3	19.3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 17

GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2004

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<3.8	<3.8	10.5
February	<4.2	<2.2	7.5
March	<3.6	<3.1	8.6
April	<4.3	<4.2	9.8
May	<4.5	<4.6	9.1
June	5.4	<2.9	6.2
July	<3.4	<3.1	8.6
August	<4.5	<3.8	10.1
September	<4.8	<5.5	10.2
October	<4.3	<4.1	5.0
November	<4.6	<3.7	7.8
December	<5.2	<3.3	5.5

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 18

YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2004

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
1996	<3.4	<3.1	4.7
1997	<3.6	<3.3	3.2
1998	<3.5	<3.0	4.0
1999	<4.2	<3.5	4.3
2000	<4.6	<4.2	5.7
2001	<4.7	<4.4	9.4
2002	<4.5	<4.0	8.0
2003	<4.1	<3.5	7.1
2004	<4.4	<3.7	8.2

* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 19

GROSS BETA RADIOACTIVITY IN HANOVER PARK WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS - 2004

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	15.1	11.0	12.7
February	15.8	10.8	11.8
March	12.1	10.5	12.5
April	13.7	7.4	14.8
May	14.0	9.1	13.4
June	13.0	9.9	12.8
July	14.5	10.8	11.4
August	13.3	14.3	11.1
September	11.7	10.3	11.0
October	15.1	14.8	10.8
November	12.4	11.3	10.4
December	13.5	11.6	12.6

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 20

YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN HANOVER PARK WRP RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2004

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
1996	9.7	6.6	13.2
1997	14.3	9.3	11.8
1998	20.3	10.3	13.5
1999	18.4	10.8	13.0
2000	16.1	9.5	13.8
2001	14.2	9.6	14.2
2002	14.5	11.7	12.0
2003	13.5	10.6	12.0
2004	13.6	11.0	12.1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 21

GROSS ALPHA RADIOACTIVITY IN JAMES C. KIRIE WRP RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2004

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
January	<4.6	<3.8	6.1
February	<5.8	<3.5	5.3
March	4.2	<3.3	8.8
April	<4.8	<4.7	5.3
May	5.2	<4.9	8.3
June	<4.5	<3.3	6.8
July	<3.5	<2.8	9.7
August	<5.1	<4.2	9.5
September	<5.6	<6.6	6.1
October	<4.9	<4.6	5.6
November	<5.1	<4.2	7.6
December	<5.5	<3.9	6.5

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 22

YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN JAMES C. KIRIE WRP RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2004

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
1996	<3.7	<3.3	5.0
1997	<3.8	<3.4	3.1
1998	<3.6	<2.8	3.2
1999	<4.2	<3.7	4.1
2000	<4.6	<4.5	4.8
2001	<5.3	<4.9	9.2
2002	<4.6	<4.1	7.4
2003	<4.2	<3.8	7.2
2004	<4.9	<4.2	7.1

* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 23

GROSS BETA RADIOACTIVITY IN JAMES C. KIRIE WRP RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS - 2004

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
January	19.4	9.0	8.8
February	18.9	17.9	12.2
March	14.1	12.9	15.7
April	14.8	9.6	12.1
May	14.8	15.3	16.0
June	13.6	11.0	14.4
July	13.5	3.9	12.7
August	17.1	12.7	14.7
September	17.0	14.8	12.9
October	17.8	21.3	11.7
November	15.7	13.4	11.4
December	12.3	13.6	17.5

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 24

YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN JAMES C. KIRIE WRP RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2004

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
1996	11.6	8.1	16.8
1997	19.2	12.6	14.6
1998	22.3	15.6	14.2
1999	21.4	15.5	13.5
2000	22.7	16.8	14.8
2001	17.6	13.3	15.8
2002	17.4	14.8	14.0
2003	16.1	12.2	13.5
2004	15.7	12.9	13.3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 25

GROSS ALPHA RADIOACTIVITY IN LEMONT WRP RAW SEWAGE,
FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE
ON A MONTHLY BASIS - 2004

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
January	10.5	10.6	70.1
February	10.4	7.5	53.0
March	<8.3	6.3	67.6
April	12.2	<8.9	53.8
May	<7.8	<8.5	68.4
June	10.2	<4.7	106.2
July	35.2	9.6	104.4
August	21.0	<8.1	152.9
September	32.1	<12.8	151.7
October	28.6	<10.0	143.7
November	26.7	<7.8	143.6
December	22.8	7.8	86.7

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 26

YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN LEMONT WRP RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 TO 2004

Year*	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
1996	13.4	<5.4	45.3
1997	21.1	<5.9	38.9
1998	22.8	<5.0	48.8
1999	35.4	<6.8	76.6
2000	44.4	<7.9	106.1
2001	33.3	<9.1	141.1
2002	23.8	<9.7	121.2
2003	16.4	<9.3	86.5
2004	18.6	<8.6	100.2

* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

< = The quantity listed is the smallest amount that could be measured at the 95 percent confidence level (lower limit of detection).

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 27

GROSS BETA RADIOACTIVITY IN LEMONT WRP RAW SEWAGE,
FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE
ON A MONTHLY BASIS – 2004

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
January	22.3	20.0	49.5
February	23.6	25.0	43.7
March	20.6	19.5	44.7
April	24.4	14.0	42.3
May	21.1	19.4	51.0
June	20.2	9.1	64.6
July	46.5	21.8	70.9
August	30.2	25.8	78.9
September	34.4	21.8	74.8
October	36.6	25.0	91.9
November	30.9	12.9	80.6
December	31.2	16.7	68.3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 28

YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN LEMONT WRP RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2004

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
1996	26.6	13.4	73.4
1997	44.3	20.8	77.0
1998	42.4	19.4	84.1
1999	59.1	21.8	101.4
2000	66.0	22.0	121.9
2001	50.0	22.3	90.7
2002	37.1	24.1	79.5
2003	26.4	18.4	61.1
2004	28.3	19.3	63.4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 29

GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN HANOVER PARK WRP LAGOONED BIOSOLIDS – 2004

Lagoon Location	No. of Samples	Gross Alpha (pCi/g dw)			Gross Beta (pCi/g dw)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
East	3	13.3	11.1	15.8	14.8	13.6	16.0
West	2	13.8	9.4	18.2	14.8	14.4	15.1

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 30

YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WRP LAGOONED BIOSOLIDS FROM 1998 THROUGH 2004

YEAR*	HANOVER PARK EAST GROSS ALPHA (pCi/g dw)	HANOVER PARK WEST GROSS ALPHA (pCi/g dw)
1998	6.2	6.5
1999	5.0	4.6
2000	N/A	N/A
2001	13.6	13.2
2002	9.1	13.7
2003	9.0	8.6
2004	13.3	13.8

* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

N/A = Not available

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 31

YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN HANOVER PARK WRP LAGOONED BIOSOLIDS FROM 1998 THROUGH 2004

YEAR	HANOVER PARK EAST GROSS BETA (pCi/g dw)	HANOVER PARK WEST GROSS BETA (pCi/g dw)
1998	15.2	17.2
1999	15.2	18.1
2000	N/A	N/A
2001	13.6	14.8
2002	14.1	15.3
2003	13.8	11.6
2004	14.8	14.8

N/A = Not available

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 32

GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN DISTRICT AIR-DRIED BIOSOLIDS - 2004

Sample Location	No. of Samples	Gross Alpha (pCi/g dw)			Gross Beta (pCi/g dw)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
LASMA	5	14.9	11.8	19.8	24.3	20.4	25.7
Calumet East	5	15.4	9.7	23.3	21.8	19.8	23.4
Calumet West	5	20.5	10.9	28.6	22.5	19.1	27.8
HASMA	5	15.8	12.7	19.9	23.8	21.3	27.6
Marathon	5	15.0	9.1	21.1	24.1	19.6	28.7
Stony Island	5	17.2	12.3	21.1	25.0	23.2	26.7
Vulcan	5	16.2	9.8	21.4	24.2	23.4	24.8
RASMA	2	22.6	20.8	24.3	25.2	24.7	25.7

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 33

YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN DISTRICT AIR-DRIED BIOSOLIDS
FROM 1996 THROUGH 2004

	Gross Alpha Radioactivity (pCi/g dw)							
Year*	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	N/A	N/A	7.1	5.7	6.6	6.1	5.1	5.6
1997	N/A	N/A	7.2	8.2	6.9	6.6	6.6	8.1
1998	7.7	7.4	7.5	7.9	8.1	7.6	7.7	8.1
1999	6.9	7.4	6.8	7.4	6.8	7.9	6.0	6.7
2000	10.3	12.1	9.8	12.1	11.7	10.5	9.2	11.4
2001	13.1	17.6	17.5	16.4	17.5	15.2	15.8	17.7
2002	12.4	16.6	14.4	14.9	15.0	13.5	15.0	15.2
2003	16.2	17.0	15.7	16.8	15.4	14.6	15.8	16.6
2004	15.4	20.5	14.9	15.8	15.0	17.2	16.2	22.6

* Am-241 self-absorption standards were used up to June 30, 2001, and Th-230 self-absorption standards were used from July 1, 2001 for generating attenuation curve for gross alpha radioactivity.

N/A = Not available

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 34

YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN DISTRICT AIR-DRIED BIOSOLIDS
FROM 1996 THROUGH 2004

	Gross Beta Radioactivity (pCi/g dw)							
Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	N/A	N/A	23.0	23.8	27.5	22.5	22.4	24.2
1997	N/A	N/A	25.2	26.3	23.2	26.1	26.4	26.0
1998	23.8	21.8	23.8	24.4	24.9	24.5	24.9	24.9
1999	23.7	24.4	21.5	28.6	25.4	25.0	22.8	24.6
2000	27.5	27.1	28.0	27.6	29.7	28.6	26.3	30.2
2001	23.4	21.0	25.8	25.0	24.2	25.0	23.2	26.7
2002	24.7	22.1	24.9	25.7	27.4	23.8	26.7	27.0
2003	25.3	26.5	26.8	25.0	25.6	23.3	24.9	26.5
2004	21.8	22.5	24.3	23.8	24.1	25.0	24.2	25.2

N/A = Not available

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 35

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WRP SLUDGES AND BIOSOLIDS - 2004

Sample Location WRP	No. of Samples	Potassium-40 (pCi/g dw)			Radium-226 (pCi/g dw)			Cesium-137 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	8.6	8.2	9.3	5.5	4.6	7.5	0.06	0.04	0.08
John E. Egan	4	8.2	6.3	10.2	3.8	3.6	3.9	ND	ND	ND
Hanover Park	4	4.6	4.2	5.1	3.6	3.2	4.2	ND	ND	ND
Stickney	4	9.8	9.4	10.4	4.0	3.7	4.3	0.07	0.06	0.09
Lemont	4	6.3	5.6	6.7	65.6	37.7	88.6	ND	ND	ND

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 35 (Continued)

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WRP SLUDGES AND BIOSOLIDS - 2004

Sample Location WRP	No. of Samples	Beryllium-7 (pCi/g dw)			Bismuth-212 (pCi/g dw)			Lead-212 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	4.8	2.0	6.9	0.4	ND	0.6	0.6	0.5	0.6
John E. Egan	4	3.2	1.6	4.5	0.3	ND	0.3	0.4	0.3	0.4
Hanover Park	4	0.7	ND	1.0	ND	ND	ND	0.3	0.2	0.3
Stickney	4	7.8	3.7	11.0	0.3	ND	0.4	0.4	0.4	0.5
Lemont	4	2.4	ND	5.2	3.4	1.9	5.0	4.2	2.3	6.0

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 35 (Continued)

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN WRP SLUDGES AND BIOSOLIDS - 2004

Sample Location WRP	No. of Samples	Bismuth-214 (pCi/g dw)			Lead-214 (pCi/g dw)			Actinium-228 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	1.8	1.4	2.5	2.0	1.6	2.9	1.6	1.2	2.5
John E. Egan	4	1.2	1.1	1.5	1.3	1.2	1.7	0.9	ND	1.2
Hanover Park	4	1.0	0.9	1.1	1.1	0.9	1.1	0.7	ND	0.9
Stickney	4	1.0	0.9	1.1	1.1	1.0	1.3	1.0	0.9	1.0
Lemont	4	31.5	17.4	48.6	34.7	19.2	53.2	26.3	15.2	35.3

ND = Not detected.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 36

YEARLY AVERAGE POTASIUM-40 RADIOACTIVITY (pCi/g dw) IN WRP SLUDGES AND BIOSOLIDS FROM 1997 THROUGH 2004

Year	Calumet	Egan	Hanover Park	Stickney	Lemont
1997	7.5	6.1	2.4	9.1	6.1
1998	9.0	10.1	5.1	11.7	8.5
1999	8.3	8.8	5.3	10.9	8.3
2000	7.6	8.1	4.1	10.4	8.5
2001	8.5	8.9	5.2	11.0	9.5
2002	8.5	8.3	4.9	11.1	7.9
2003	8.8	7.4	5.0	10.3	7.2
2004	8.6	8.2	4.6	9.8	6.3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 37

YEARLY AVERAGE RADIUM-226 RADIOACTIVITY (pCi/g dw) IN WRP SLUDGES AND BIOSOLIDS FROM 1997 THROUGH 2004

Year	Calumet	Egan	Hanover Park	Stickney	Lemont
1997	4.5	3.8	3.8	3.4	44.9
1998	4.5	4.5	4.7	3.4	55.8
1999	4.2	3.8	3.1	2.1	74.6
2000	4.6	4.3	4.4	4.0	80.2
2001	4.8	4.6	4.3	3.5	86.8
2002	4.0	4.2	3.8	3.4	85.0
2003	4.2	4.0	3.4	3.3	58.0
2004	5.5	3.8	3.6	4.0	65.6

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 38

YEARLY AVERAGE CESIUM-137 RADIOACTIVITY (pCi/g dw) IN WRP SLUDGES AND BIOSOLIDS
FROM 1997 THROUGH 2004

Year	Calumet	Egan	Hanover Park	Stickney	Lemont
1997	0.08	0.03	ND	0.10	0.06
1998	0.09	0.04	0.02	0.11	ND
1999	0.10	0.02	ND	0.10	ND
2000	0.06	ND	ND	0.08	ND
2001	0.06	ND	ND	0.07	ND
2002	0.06	ND	ND	0.08	ND
2003	0.07	ND	ND	0.06	ND
2004	0.06	ND	ND	0.05	ND

ND = Not Detected

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 39

CONCENTRATION (pCi/g dw) OF GAMMA-EMITTING RADIONUCLIDES IN HANOVER PARK WRP LAGOONED BIOSOLIDS - 2004

Radionuclides	No. of Samples	Hanover Park East Lagoon	Hanover Park West Lagoon
Beryllium-7	3	1.9	1.7
Potassium-40	3	2.8	4.1
Cesium-137	3	ND	ND
Bismuth–212	3	0.3	0.3
Lead–212	3	0.5	0.4
Bismuth–214	3	0.9	1.1
Lead–214	3	1.0	1.2
Radium–226	3	3.7	4.2
Actinium–228	3	0.7	0.8

ND = Not Detected

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 40

YEARLY AVERAGE POTASSIUM-40, RADIUM-226, AND CESIUM-137 RADIOACTIVITY (pCi/g dw)
IN HANOVER PARK WRP LAGOONED BIOSOLIDS
FROM 1998 THROUGH 2004

	Hanover Park WRP East Lagoon			Hanover Park WRP West Lagoon		
Year	Potassium-40	Radium-226	Cesium-137	Potassium-40	Radium-226	Cesium-137
1998	4.4	5.2	0.2	4.8	5.1	0.3
1999	5.0	4.4	ND	4.6	4.2	ND
2000	NA	NA	NA	NA	NA	NA
2001	4.0	4.6	ND	4.2	5.7	ND
2002	5.0	4.2	ND	5.3	4.7	ND
2003	3.8	3.8	ND	3.5	3.7	ND
2004	2.8	3.7	ND	4.1	4.2	ND

ND = Not Detected
NA = No analysis

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 41

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN DISTRICT AIR-DRIED BIOSOLIDS – 2004

Sample Location	No. of Samples	Potassium-40 (pCi/g dw)			Radium-226 (pCi/g dw)			Cesium-137 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet East	5	7.0	6.4	8.0	4.8	4.3	5.3	0.06	ND	0.08
Calumet West	5	7.5	4.8	11.7	4.8	3.9	5.4	0.06	0.04	0.07
RASMA	2	9.4	8.9	9.9	3.7	3.6	3.8	0.06	0.06	0.07
Stony Island	5	8.8	8.2	9.4	4.0	3.7	4.3	0.07	0.06	0.09
HASMA	5	8.8	8.4	9.3	3.8	3.4	4.3	0.07	0.06	0.09
LASMA	5	9.7	9.5	10.4	4.1	3.8	4.4	0.08	0.07	0.08
Marathon	5	10.5	9.6	12.0	3.8	3.2	4.3	0.06	0.06	0.08
Vulcan	5	9.2	8.7	9.7	3.9	3.6	4.1	0.07	0.07	0.08

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 41 (Continued)

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN DISTRICT AIR-DRIED BIOSOLIDS – 2004

Sample Location	No. of Samples	Beryllium-7 (pCi/g dw)			Bismuth-212 (pCi/g dw)			Lead-212 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet East	5	1.8	ND	6.1	0.5	0.4	0.6	0.9	0.6	1.0
Calumet West	5	1.0	ND	1.6	0.6	0.5	0.7	1.0	0.9	1.0
RASMA	2	ND	ND	ND	0.4	0.4	0.5	0.7	0.7	0.8
Stony Island	5	1.5	ND	3.7	0.4	0.3	0.5	0.7	0.6	0.9
HASMA	5	ND	ND	1.3	0.5	0.5	0.6	0.8	0.8	0.9
LASMA	5	ND	ND	0.8	0.6	0.5	0.6	0.9	0.8	0.9
Marathon	5	ND	ND	ND	0.5	0.4	0.6	0.8	0.8	0.9
Vulcan	5	ND	ND	0.9	0.5	0.5	0.6	0.8	0.8	0.9

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 41 (Continued)

CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN DISTRICT AIR-DRIED BIOSOLIDS – 2004

Sample Location	No. of Samples	Bismuth-214 (pCi/g dw)			Lead-214 (pCi/g dw)			Actinium-228 (pCi/g dw)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet East	5	1.4	1.0	1.9	1.5	1.2	2.0	1.0	0.8	1.3
Calumet West	5	1.4	1.3	1.7	1.5	1.4	1.9	1.0	0.9	1.1
RASMA	2	1.1	1.0	1.2	1.2	1.1	1.4	0.9	0.8	0.9
Stony Island	5	1.1	0.9	1.2	1.2	1.0	1.3	0.9	0.9	1.0
HASMA	5	1.1	1.0	1.3	1.2	1.0	1.4	0.9	0.8	0.9
LASMA	5	1.2	1.1	1.3	1.4	1.3	1.5	0.8	0.8	0.9
Marathon	5	1.1	1.1	1.2	1.2	1.2	1.3	0.9	0.8	0.9
Vulcan	5	1.1	1.0	1.3	1.3	1.1	1.5	0.8	0.8	0.9

ND = Not Detected.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 42

YEARLY AVERAGE POTASIUM-40 RADIOACTIVITY (pCi/g dw) IN DISTRICT AIR-DRIED BIOSOLIDS
FROM 1996 THROUGH 2004

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	7.4	7.0	9.0	9.6	9.7	8.6	9.9	10.4
1997	10.2	10.1	9.8	10.0	8.8	9.0	9.7	9.8
1998	9.8	8.6	11.7	9.7	10.8	8.9	9.8	9.3
1999	11.3	9.3	10.7	10.6	10.4	10.0	12.4	10.9
2000	10.4	9.9	9.4	9.6	10.2	10.3	10.0	10.4
2001	10.4	7.4	9.9	11.1	10.3	8.9	11.3	11.3
2002	10.9	7.1	10.8	14.4	11.6	9.4	11.3	11.5
2003	11.4	11.8	10.4	10.0	11.0	8.9	9.9	10.4
2004	7.0	7.5	9.7	8.8	10.5	8.8	9.2	9.4

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 43

YEARLY AVERAGE RADIUM-226 RADIOACTIVITY (pCi/g dw) IN DISTRICT AIR-DRIED BIOSOLIDS
FROM 1996 THROUGH 2004

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	4.6	4.5	4.3	4.1	3.9	3.6	3.6	4.0
1997	3.6	3.7	3.1	3.4	3.1	3.3	3.1	3.0
1998	3.6	4.3	4.0	3.6	4.0	3.8	3.0	3.5
1999	3.8	4.1	3.7	3.5	3.5	3.6	2.9	3.6
2000	3.4	4.4	3.5	4.0	3.7	3.6	4.0	3.5
2001	4.6	5.2	3.9	3.6	4.3	4.4	4.0	3.8
2002	4.6	4.5	4.0	3.5	3.8	4.0	3.6	4.0
2003	4.4	4.6	4.0	3.9	3.8	3.8	4.0	3.8
2004	4.8	4.8	4.1	3.8	3.8	4.0	3.9	3.7

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE 44

YEARLY AVERAGE CESIUM-137 RADIOACTIVITY (pCi/g dw) IN DISTRICT AIR-DRIED BIOSOLIDS
FROM 1996 THROUGH 2004

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	0.2	0.3	0.4	0.4	0.4	0.6	0.4	0.3
1997	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1998	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
1999	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
2000	0.09	0.08	0.1	0.11	0.09	0.09	0.09	0.1
2001	0.06	0.08	0.09	0.07	0.09	0.09	0.07	0.08
2002	0.05	0.07	0.09	0.08	0.09	0.08	0.08	0.09
2003	0.07	0.07	0.09	0.09	0.08	0.07	0.08	0.08
2004	0.06	0.06	0.08	0.07	0.06	0.07	0.07	0.06