

*Protecting Our Water Environment*



*Metropolitan Water Reclamation District of Greater Chicago*

***MONITORING AND RESEARCH  
DEPARTMENT***

*REPORT NO. 11-56*

*RADIOLOGICAL MONITORING OF THE RAW SEWAGE,  
FINAL EFFLUENT, SLUDGE, AND BIOSOLIDS OF THE  
METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO*

*2010 ANNUAL REPORT*

*DECEMBER 2011*

**Metropolitan Water Reclamation District of Greater Chicago**  
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2010 ANNUAL REPORT

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## 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, 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.

This study was conducted to determine the concentration of radioactive material 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 and one final effluent sample (composited over a period of 24 hours) were collected once a month from each of the District's seven Water Reclamation Plants (WRPs). Sewage sludge samples were also collected once a month from all the WRPs. Biosolids samples from the Hanover Park WRP East lagoon and Hanover Park WRP West lagoon were collected in March, June, September, and November 2010. Final air-dried biosolids samples from the Calumet WRP East and West Solids Management Area (SMA) were collected in July 2010. Biosolids samples from the Harlem Avenue Solids Management Area (HASMA), Lawn-dale Avenue Solids Management Area (LASMA), and Vulcan Solids Drying Sites (SDS) samples were collected in May, June, July, August, and September 2010. Marathon SDS biosolids samples were collected in May, June, August, and September 2010.

The raw sewage, final effluent, waste-activated sludge, anaerobically digested biosolids, lagooned biosolids, and air-dried biosolids samples from the WRPs and various biosolids management locations 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 demonstrate 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 2010 monitoring data was compared with the historical data of the last fourteen 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 fifteen years.

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. 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), 35C IAC, Section 302.207. 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 meets the standard all the time and is unlikely to have any adverse effect on the radiological quality of the receiving waters.

Measurable concentrations of gross alpha and gross beta radioactivity were found in Hanover Park WRP lagooned biosolids and in biosolids from the solids drying areas of the District. 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, eight were detected in measurable quantities in these samples. All these radionuclides are of natural origin.

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 2010 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 883 square miles. The area served by the District includes the City of Chicago and 125 suburban communities with a combined population of 5.25 million people. In addition, a waste-load equivalent of 5.1 million people is contributed within the District's service area by industrial and commercial sources. On the average, the District treats 1.5 billion gallons per day 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. 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 is removed from the wastewater and becomes concentrated in the biosolids, or remains in solution and passes with the effluent to the receiving water. Radioactivity contained in WRP effluents and the potential radioactivity concentration in municipal biosolids 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, sludge, and biosolids for possible radioactive contamination. As a part of its monitoring program, the District's Radiochemistry Laboratory routinely monitors raw sewage, final effluent, and sludge samples from all the WRPs, and biosolids samples from solids drying areas (SDAs) 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 SDAs are also examined for gamma-emitting radionuclides. In 1996, the Radiochemistry Section expanded its monitoring program of District sludge and biosolids in response to the increased emphasis on sludge characteristics brought about by adoption of USEPA biosolids regulations (40 CFR Part 503). Although there are no standards for radioactivity in these regulations, the District expanded its database to include 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, sewage sludge, and biosolids from the District's seven WRPs and biosolids from the District's SDAs. 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 2010 radiological monitoring data are compared with the historical data of the last fourteen years.

## MATERIALS AND METHODS

### Sample Collection

**Raw Sewage.** One raw sewage sample (composited over a period of 24 hours) was collected once a month 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, Calumet WRP East drying cells, and Calumet WRP West drying cells.

### Sample Analysis

The samples of raw sewage, final effluent, sludge and biosolids were analyzed by the District's radiochemistry laboratory from the inception of the program through 2007. The samples collected in 2008 were analyzed by the Environmental Inc., Midwest Laboratory (EIML) and samples collected in 2009 and 2010 were analyzed by Eberline Analytical Corporation.

The sludge and biosolids samples were also analyzed for gamma-emitting radionuclides by the District's radiochemistry laboratory from the inception of the program through 2007. The samples collected in 2008 were analyzed by the EIML and samples collected in 2009 and 2010 were analyzed by Eberline Analytical Corporation.

## RESULTS AND DISCUSSION

### Stickney Water Reclamation Plant

In 2010, the gross alpha radioactivity in the raw sewage of the Stickney WRP ranged from 1.9 to 17.5 pCi/L (Table 1). The gross alpha radioactivity in the effluent was below the detection limit (1.1 to 6.3 pCi/L) (Table 1). The gross alpha radioactivity in anaerobically digested biosolids ranged from less than 4.4 pCi/g dw to 15.3 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 2010 are summarized in Table 2. The gross alpha radioactivity in raw sewage was below the detection limit (3.6 to 6.3 pCi/L) with detected values ranging from 4.6 to 8.6 pCi/L. The gross alpha radioactivity in the effluent was below the detection limit (2.6 to 5.2 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 5.2 to 12.4 pCi/g dw.

The gross beta radioactivity in the raw sewage of the Stickney WRP ranged from 8.6 to 18.6 pCi/L, and in the effluent it ranged from 5.5 to 10.7 pCi/L (Table 3). The gross beta radioactivity in anaerobically digested biosolids ranged from 11.8 to 27.0 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 2010 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 20.5 to 27.3 pCi/g dw.

### Calumet Water Reclamation Plant

In 2010, the gross alpha radioactivity in the raw sewage of the Calumet WRP was below the detection limit (1.6 to 6.2 pCi/L) with the detected values ranging from 3.5 to 13.1 pCi/L (Table 5). The gross alpha radioactivity in the effluent was below the detection limit (1.5 to 4.6 pCi/L) except for the March and October samples which were 2.1 and 4.7 pCi/L (Table 5) respectively. The gross alpha radioactivity in anaerobically digested biosolids ranged from less than 3.8 pCi/g dw to 19.0 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 2010 are summarized in Table 6. The gross alpha radioactivity in the raw sewage was below the detection limit (3.5 to 5.5 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (2.3 to 5.1 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 5.1 to 17.6 pCi/g dw.

TABLE 1: GROSS ALPHA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS - 2010

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<3.8	<2.2	9.0
February	9.6	<6.3	7.0
March	5.0	<3.4	5.0
April	6.1	<4.4	6.5
May	3.9	<3.7	15.3
June	6.9	<3.7	10.3
July	17.5	<1.9	5.1
August	2.5	<1.9	12.5
September	1.9	<1.8	7.0
October	<3.5	<4.2	<4.5
November	2.2	<1.1	6.3
December	2.7	<3.9	<4.4

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



TABLE 2: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2010

Year <sup>1</sup>	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
2005	<6.3	<4.3	11.3
2006	6.2	<4.8	10.4
2007	<6.1	<5.2	9.9
2008	8.6	<4.0	12.4
2009	<4.8	<3.6	9.6
2010	5.5	<3.2	7.0

<sup>1</sup>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).

TABLE 3: GROSS BETA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	10.4	8.7	27.0
February	16.8	9.4	16.6
March	16.8	9.4	11.8
April	14.8	5.5	22.2
May	10.6	10.7	26.4
June	18.5	6.8	27.0
July	18.6	7.5	13.4
August	8.6	8.7	21.8
September	11.6	6.4	22.7
October	10.8	6.3	14.3
November	11.3	9.3	21.0
December	13.0	7.2	21.3

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

TABLE 4: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN STICKNEY WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2010

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
2005	17.4	8.8	23.2
2006	15.9	8.4	25.4
2007	17.0	8.4	26.1
2008	17.9	7.8	26.8
2009	12.6	8.1	24.6
2010	13.5	8.0	20.5

TABLE 5: GROSS ALPHA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<3.0	<1.5	9.5
February	<6.2	<4.6	7.8
March	3.5	2.1	11.4
April	7.3	<2.6	11.7
May	<2.4	<4.6	17.6
June	<3.3	<2.6	14.2
July	13.1	<1.9	14.9
August	<2.5	<3.8	19.0
September	<1.6	<2.1	<3.8
October	<3.2	4.7	9.1
November	<1.7	<4.4	6.0
December	<3.1	<3.7	11.2

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

TABLE 6: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2010

Year <sup>1</sup>	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
2005	<5.3	<4.5	13.6
2006	<5.3	<5.0	12.8
2007	<5.5	<5.1	11.5
2008	<4.6	<2.3	17.6
2009	<3.5	<3.2	11.4
2010	<4.2	<3.2	11.0

<sup>1</sup> 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).

The gross beta radioactivity in the raw sewage of the Calumet WRP ranged from less than 3.3 pCi/L to 14.3 pCi/L, and in the effluent it ranged from less than 5.1 pCi/L to 13.1 pCi/L (Table 7). The gross beta radioactivity in the Calumet WRP anaerobically digested biosolids ranged from 16.0 to 28.3 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 2010 are summarized in Table 8. The gross beta radioactivity in the raw sewage ranged from 8.5 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 30.6 pCi/g dw.

### **North Side Water Reclamation Plant**

In 2010, the gross alpha radioactivity in the raw sewage of the North Side WRP was below the detection limit (1.6 to 4.8 pCi/L) with the detected values ranging from 1.3 to 3.3 pCi/L (Table 9). The gross alpha radioactivity in the effluent was below the detection limits (1.5 to 4.4 pCi/L) (Table 9). The gross alpha radioactivity in waste-activated sludge ranged from 4.1 to 9.6 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 2010 are summarized in Table 10. The gross alpha radioactivity in the raw sewage was below the detection limit (2.8 to 5.0 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (2.3 to 4.9 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 5.7 to 10.8 pCi/L, and in the effluent it ranged from 4.9 to 30.9 pCi/L except for April and June samples which were below the detection limit, 6.0 and 5.6 pCi/L respectively (Table 11). The gross beta radioactivity in the North Side WRP waste-activated sludge ranged from 6.7 to 19.1 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 2010 are summarized in Table 12. The gross beta radioactivity in the raw sewage ranged from 7.0 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 16.2 pCi/g dw.

### **John E. Egan Water Reclamation Plant**

In 2010, the gross alpha radioactivity in the raw sewage of the Egan WRP was below the detection limits (2.0 to 5.7 pCi/L) with the detected values ranging from 2.7 to 7.0 pCi/L (Table 13). The gross alpha radioactivity in the effluent was below the detection limits (2.3 to 4.6 pCi/L) with the detected values ranging from 0.7 to 7.7 pCi/L (Table 13). The gross alpha radioactivity in anaerobically digested biosolids samples ranged from 4.6 to 14.0 pCi/g dw (Table 13).

TABLE 7: GROSS BETA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	8.0	<5.1	28.3
February	9.1	9.7	16.0
March	11.2	9.7	17.1
April	10.8	<5.5	22.5
May	11.4	<5.2	24.3
June	8.0	8.1	27.0
July	14.3	6.7	24.6
August	<3.3	6.1	25.2
September	10.9	6.6	21.9
October	9.0	7.7	20.1
November	8.5	13.1	19.8
December	7.1	8.5	25.0

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

TABLE 8: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN CALUMET WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2010

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
2005	12.1	8.3	23.2
2006	11.4	8.1	26.2
2007	9.8	6.9	25.5
2008	8.5	7.0	30.6
2009	10.3	9.0	25.5
2010	9.3	7.7	22.6



TABLE 9: GROSS ALPHA RADIOACTIVITY IN NORTH SIDE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
January	<2.6	<4.4	6.6
February	<4.8	<1.6	6.2
March	<2.4	<3.4	5.1
April	3.3	<2.8	4.8
May	3.2	<3.1	9.6
June	<3.7	<1.9	4.1
July	3.1	<4.0	9.6
August	2.1	<3.2	8.7
September	<1.6	<1.5	6.0
October	<2.1	<1.8	5.6
November	1.3	<2.4	7.5
December	<3.8	<4.1	5.4

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

TABLE 10: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN NORTH SIDE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2010

Year <sup>1</sup>	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
2005	<4.4	<3.8	7.1
2006	<4.8	<4.8	7.2
2007	<5.0	<4.9	7.0
2008	<2.8	<2.3	7.8
2009	<3.1	<3.4	6.8
2010	<2.8	<2.9	6.6

<sup>1</sup>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).

TABLE 11: GROSS BETA RADIOACTIVITY IN NORTH SIDE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
January	7.8	12.5	19.1
February	8.0	10.1	10.5
March	8.8	5.8	8.3
April	6.4	<6.0	17.4
May	7.8	30.9	18.1
June	8.0	<5.6	11.5
July	5.7	7.9	15.3
August	6.9	5.6	16.6
September	10.8	5.1	13.7
October	8.5	4.9	15.1
November	8.5	5.0	12.0
December	8.3	6.7	6.7

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

TABLE 12: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN NORTH SIDE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2010

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
2005	10.3	7.4	13.5
2006	10.1	8.0	14.4
2007	9.0	6.5	14.4
2008	7.5	6.3	16.2
2009	7.0	7.3	15.0
2010	7.9	8.8	13.7

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

TABLE 13: GROSS ALPHA RADIOACTIVITY IN JOHN E. EGAN WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<3.5	<4.1	9.4
February	<5.7	<4.1	9.2
March	5.3	<3.7	7.4
April	6.1	<3.9	8.3
May	<3.3	<4.6	14.0
June	<4.1	2.5	6.3
July	4.1	7.7	9.7
August	7.0	<4.2	12.2
September	<2.0	0.7	6.7
October	<2.4	<3.5	6.4
November	2.7	<2.6	5.4
December	<2.5	<2.3	4.6

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

The yearly average gross alpha radioactivity in the Egan WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2010 are summarized in [Table 14](#). The gross alpha radioactivity in the raw sewage was below the detection limit (2.8 to 5.4 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (2.0 to 5.2 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 4.4 to 13.8 pCi/g dw.

The gross beta radioactivity levels in the raw sewage of the Egan WRP ranged from 7.5 to 18.1 pCi/L, and in the effluent it ranged from 7.1 to 34.5 pCi/L except for April and August samples which were less than the detection limit of 5.7 and 3.4 pCi/L respectively ([Table 15](#)). The gross beta radioactivity in the Egan WRP anaerobically digested biosolids ranged from 12.7 to 19.1 pCi/g dw.

The yearly average gross beta radioactivity at the Egan WRP raw sewage, final effluent, and anaerobically digested biosolids from 1996 to 2010 are summarized in [Table 16](#). The gross beta radioactivity in the raw sewage ranged from 9.0 to 22.5 pCi/L and in the effluent it ranged from 6.8 to 12.7 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 15.1 to 21.7 pCi/g dw.

### **Hanover Park Water Reclamation Plant**

In 2010, the gross alpha radioactivity levels in the raw sewage of the Hanover Park WRP were below the detection limit (2.1 to 4.4 pCi/L) with the detected values ranging from 2.3 to 6.2 pCi/L ([Table 17](#)). The gross alpha radioactivity in the effluent was also below the detection limits (1.5 to 4.6 pCi/L) except for June and November samples which were 2.0 and 1.0 pCi/L respectively ([Table 17](#)). The gross alpha radioactivity in anaerobically digested biosolids ranged from 3.9 to 10.6 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 2010 are summarized in [Table 18](#). The gross alpha radioactivity in the raw sewage was below the detection limit (2.6 to 5.0 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (1.9 to 5.0 pCi/L). The gross alpha radioactivity in anaerobically digested biosolids ranged from 3.2 to 10.2 pCi/g dw.

The gross beta radioactivity levels in the raw sewage of the Hanover Park WRP ranged from less than 5.3 pCi/L to 13.7 pCi/L and in the effluent it ranged from less than 6.3 pCi/L to 13.0 pCi/L ([Table 19](#)). The gross beta radioactivity in the Hanover Park WRP anaerobically digested biosolids ranged from 8.2 to 14.9 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 2010 are summarized in [Table 20](#). The gross beta radioactivity in the raw sewage ranged from 8.9 to 20.3 pCi/L and in the effluent it ranged from 6.6 to 11.2 pCi/L. The gross beta radioactivity in anaerobically digested biosolids ranged from 11.2 to 15.5 pCi/g dw.

TABLE 14: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN JOHN E. EGAN WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2010

Year <sup>1</sup>	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
2005	<4.8	<4.2	10.1
2006	<4.8	<4.8	9.8
2007	<5.4	<5.2	9.3
2008	<2.8	<2.0	13.8
2009	<4.4	<3.3	9.5
2010	<4.1	<3.7	7.7

<sup>1</sup>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).

TABLE 15: GROSS BETA RADIOACTIVITY IN JOHN E. EGAN WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	8.7	10.8	19.1
February	9.0	7.1	14.9
March	14.6	9.8	12.7
April	10.0	<5.7	18.6
May	14.3	7.1	18.8
June	7.6	34.5	16.6
July	7.5	7.9	16.2
August	18.1	<3.4	16.9
September	9.6	7.8	17.9
October	12.8	10.0	13.9
November	11.7	9.1	17.5
December	12.6	18.5	13.5



TABLE 16: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN JOHN E. EGAN WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2010

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
2005	13.7	10.9	17.6
2006	13.0	11.0	18.5
2007	11.4	8.7	18.2
2008	9.0	6.8	21.7
2009	10.4	8.1	18.1
2010	11.4	11.0	15.1

TABLE 17: GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Biosolids Gross Alpha (pCi/g dw)
January	<3.2	<3.5	5.8
February	<4.4	<3.0	7.9
March	6.2	<4.4	5.6
April	2.3	<2.4	6.4
May	2.3	<4.6	10.6
June	<3.6	2.0	4.0
July	NA	NA	3.9
August	<2.2	<1.9	7.7
September	<2.1	<1.6	7.2
October	<3.4	<1.5	6.9
November	<2.8	1.0	5.0
December	2.4	<3.8	4.1

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

NA = Not available.

TABLE 18: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2010

Year <sup>1</sup>	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
2005	<4.6	<4.1	8.0
2006	<5.0	<4.6	7.5
2007	<5.0	<5.0	7.0
2008	<2.7	<1.9	10.2
2009	<2.6	<3.5	7.2
2010	<3.2	<2.7	6.3

<sup>1</sup>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).

TABLE 19: GROSS BETA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
January	9.1	11.1	12.9
February	9.5	<6.3	10.1
March	13.7	8.1	8.2
April	8.5	9.1	12.4
May	8.8	8.4	13.3
June	9.2	13.0	14.9
July	NA	NA	8.8
August	6.0	8.6	11.2
September	<5.3	6.9	14.3
October	13.7	10.6	9.4
November	13.1	11.0	8.8
December	11.9	9.8	10.0

NA = Not analyzed.

TABLE 20: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND ANAEROBICALLY DIGESTED BIOSOLIDS FROM 1996 THROUGH 2010

Year	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Biosolids Gross Beta (pCi/g dw)
1996	19.7	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
2005	13.3	10.8	12.3
2006	12.9	11.2	13.6
2007	9.8	9.2	13.0
2008	8.9	8.1	15.5
2009	10.8	8.6	12.0
2010	9.7	9.1	11.2

## **James C. Kirie Water Reclamation Plant**

In 2010, the gross alpha radioactivity levels in the raw sewage of the Kirie WRP was below the detection limit (1.0 to 4.5 pCi/L) except for March, July and November samples which were 3.6, 4.2 and 2.5 pCi/L respectively (Table 21). The gross alpha radioactivity in the effluent was below the detection limit (1.7 to 5.9 pCi/L) except for the July sample which was 16.1 pCi/L (Table 21) and in the waste-activated sludge ranged from 4.6 to 18.3 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 2010 are summarized in Table 22. The gross alpha radioactivity in the raw sewage was below the detection limit (3.1 to 5.6 pCi/L). The gross alpha radioactivity in the effluent was also below the detection limit (2.3 to 5.6 pCi/L). The gross alpha radioactivity in waste-activated sludge ranged from 3.1 to 9.3 pCi/g dw.

The gross beta radioactivity level in the raw sewage of the Kirie WRP ranged from less than 5.6 pCi/L to 16.9 pCi/L, and in the effluent it ranged from 5.0 to 19.9 pCi/L except for the February sample which was less than 5.8 pCi/L (Table 23). The gross beta radioactivity in the Kirie WRP waste-activated sludge ranged from 7.5 to 28.8 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 2010 are summarized in Table 24. The gross beta radioactivity in the raw sewage ranged from 9.6 to 22.7 pCi/L and in the effluent it ranged from 8.0 to 16.8 pCi/L. The gross beta radioactivity in waste-activated sludge ranged from 13.3 to 17.7 pCi/g dw.

## **Lemont Water Reclamation Plant**

In 2010, the gross alpha radioactivity levels in the raw sewage of the Lemont WRP ranged from 5.0 to 84.3 pCi/L except for the April and August samples which were below the detection limit (3.4 and 4.7 pCi/L) respectively (Table 25). The gross alpha radioactivity in the effluent ranged from 2.4 to 15.2 pCi/L except for August, September, and October samples which were below the detection limit (2.7 to 4.5 pCi/L) (Table 25). The gross alpha radioactivity in the waste-activated sludge ranged from 10.0 to 154.0 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 2010 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 10.8 pCi/L) except for 2008, 2009, and 2010 samples which were 6.7, 8.9, and 6.7 pCi/L respectively. 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 7.3 to 42.4 pCi/L, and in the effluent it ranged from 7.9 to 31.3 pCi/L (Table 27). The gross beta radioactivity in the Lemont waste-activated sludge ranged from 10.6 to 81.4 pCi/g dw (Table 27).

TABLE 21: GROSS ALPHA RADIOACTIVITY IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
January	<3.3	<3.6	4.6
February	<4.5	<5.9	5.7
March	3.6	<2.1	4.8
April	<3.3	<3.4	9.2
May	<4.4	<1.7	9.2
June	<4.2	<2.8	7.7
July	4.2	16.1	18.3
August	<4.0	<2.5	12.3
September	<1.0	<1.8	6.3
October	<3.4	<3.2	7.9
November	2.5	<3.3	5.1
December	<2.1	<3.6	6.1

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

TABLE 22: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2010

Year <sup>1</sup>	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
2005	<5.1	<4.7	7.9
2006	<5.3	<4.8	6.8
2007	<5.6	<5.6	6.8
2008	<3.1	<2.3	9.3
2009	<3.7	<3.6	8.6
2010	<3.4	<4.2	7.5

<sup>1</sup>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).



TABLE 23: GROSS BETA RADIOACTIVITY IN JAMES C. KIRIE WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
January	10.9	9.4	17.4
February	16.9	<5.8	10.0
March	8.3	7.5	7.5
April	<5.6	10.8	15.8
May	12.4	5.5	17.6
June	12.6	9.0	16.1
July	7.1	19.9	28.8
August	6.6	5.0	18.8
September	7.3	6.9	11.7
October	12.4	9.6	19.1
November	13.3	10.6	9.6
December	12.6	12.0	10.7

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

TABLE 24: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN JAMES C. KIRIE  
 WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND  
 WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2010

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
2005	16.1	15.2	14.8
2006	13.4	12.6	13.7
2007	13.0	11.1	14.6
2008	11.8	8.7	17.7
2009	9.6	8.0	15.8
2010	10.5	9.3	14.1

TABLE 25: GROSS ALPHA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Alpha (pCi/L)	Effluent Gross Alpha (pCi/L)	Sludge Gross Alpha (pCi/g dw)
January	22.2	5.9	45.4
February	12.5	10.8	10.0
March	23.9	15.2	27.8
April	<3.4	2.4	75.0
May	21.6	4.0	57.2
June	5.0	7.2	65.7
July	84.3	8.0	55.2
August	<4.7	<4.5	154.0
September	6.6	<2.7	125.0
October	29.8	<4.1	69.9
November	6.4	4.7	77.8
December	31.3	10.5	89.0

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

TABLE 26: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2010

Year <sup>1</sup>	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
2005	24.2	<10.5	110.4
2006	16.1	<10.1	90.0
2007	15.2	<10.8	76.8
2008	23.6	6.7	124.8
2009	16.5	8.9	70.0
2010	21.0	6.7	71.0

<sup>1</sup>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).

TABLE 27: GROSS BETA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE ON A MONTHLY BASIS – 2010

Month	Raw Sewage Gross Beta (pCi/L)	Effluent Gross Beta (pCi/L)	Sludge Gross Beta (pCi/g dw)
January	26.6	18.5	40.6
February	15.6	31.3	10.6
March	23.9	22.2	20.8
April	10.8	13.3	42.5
May	24.3	11.3	36.2
June	8.6	16.8	36.7
July	40.9	22.2	36.7
August	7.3	7.9	81.4
September	29.3	18.3	74.1
October	42.4	23.4	49.0
November	26.1	21.1	51.4
December	36.4	20.9	53.9

The yearly average gross beta radioactivity at the Lemont WRP raw sewage, final effluent, and waste-activated sludge from 1996 to 2010 are summarized in [Table 28](#). The gross beta radioactivity in the raw sewage ranged from 24.4 to 66.0 pCi/L and in the effluent it ranged from 13.4 to 24.9 pCi/L. The gross beta radioactivity in waste-activated sludge ranged from 44.5 to 121.9 pCi/g dw.

### **Hanover Park Water Reclamation Plant Lagoons**

[Table 29](#) presents the gross alpha and gross beta radioactivity concentrations in the Hanover Park WRP lagooned biosolids for 2010.

Average gross alpha radioactivity in the Hanover Park WRP East lagooned biosolids was 8.4 pCi/g dw and ranged from 5.6 to 12.7 pCi/g dw. Average gross alpha radioactivity in the Hanover Park WRP West lagooned biosolids was 9.2 pCi/g dw and ranged from 4.4 to 13.9 pCi/g dw.

Average gross beta radioactivity in the Hanover Park WRP East lagooned biosolids was 12.8 pCi/g dw and ranged from 11.2 to 14.4 pCi/g dw. Average gross beta radioactivity in the Hanover Park WRP West lagooned biosolids was 12.4 pCi/g dw and ranged from 7.9 to 16.3 pCi/g dw.

The yearly average gross alpha radioactivity in Hanover Park WRP lagooned biosolids, since the inception of this program, from 1998 to 2010 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 2010 is summarized in [Table 31](#). The gross beta radioactivity in lagooned biosolids ranged from 11.6 pCi/g dw at the Hanover Park WRP West Lagoon in 2003 to 18.1 pCi/g dw at the Hanover Park WRP West Lagoon in 1999.

### **Gross Alpha and Gross Beta Radioactivity in Metropolitan Water Reclamation District of Greater Chicago's Air-Dried Biosolids**

[Table 32](#) presents the gross alpha and gross beta radioactivity concentrations in District's air-dried biosolids for 2010.

Average gross alpha radioactivity in biosolids ranged from 9.2 pCi/g dw at the HASMA to 29.6 pCi/g dw at the Calumet West SMA. Average gross beta radioactivity in biosolids ranged from 20.3 pCi/g dw at the HASMA to 32.2 pCi/g dw at the Calumet West SMA.

The yearly average gross alpha radioactivity in the District's air-dried biosolids from

TABLE 28: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN LEMONT WATER RECLAMATION PLANT RAW SEWAGE, FINAL EFFLUENT, AND WASTE-ACTIVATED SLUDGE FROM 1996 THROUGH 2010

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
2005	34.9	24.9	68.6
2006	26.4	21.7	64.2
2007	26.3	20.0	64.8
2008	27.0	18.8	107.4
2009	24.8	19.9	48.3
2010	24.4	18.9	44.5

TABLE 29: GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN HANOVER PARK  
WATER RECLAMATION PLANT LAGOONED BIOSOLIDS – 2010

Lagoon Location	No. of Samples	Gross Alpha (pCi/g dw)			Gross Beta (pCi/g dw)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
East	4	8.4	5.6	12.7	12.8	11.2	14.4
West	4	9.2	4.4	13.9	12.4	7.9	16.3



TABLE 30: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT LAGOONED BIOSOLIDS FROM 1998 THROUGH 2010

Year <sup>1</sup>	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	NA	NA
2001	13.6	13.2
2002	9.1	13.7
2003	9.0	8.6
2004	13.3	13.8
2005	9.4	9.7
2006	10.8	10.9
2007	9.4	7.9
2008	12.2	12.5
2009	7.0	8.8
2010	8.4	9.2

<sup>1</sup>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.  
NA = Not analyzed.

TABLE 31: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN HANOVER PARK WATER RECLAMATION PLANT LAGOONED BIOSOLIDS FROM 1998 THROUGH 2010

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	NA	NA
2001	13.6	14.8
2002	14.1	15.3
2003	13.8	11.6
2004	14.8	14.8
2005	14.8	13.4
2006	14.6	12.8
2007	12.9	12.9
2008	16.0	16.4
2009	15.4	15.3
2010	12.8	12.4

NA = Not analyzed.

TABLE 32: GROSS ALPHA AND GROSS BETA RADIOACTIVITY IN METROPOLITAN WATER  
RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS - 2010

Sample Location	No. of Samples	Gross Alpha (pCi/g dw)			Gross Beta (pCi/g dw)		
		Average	Minimum	Maximum	Average	Minimum	Maximum
LASMA	5	14.4	5.8	19.8	22.9	8.7	28.7
Calumet East	1	26.4	26.4	26.4	28.4	28.4	28.4
Calumet West	1	29.6	29.6	29.6	32.2	32.2	32.2
HASMA	5	9.2	2.8	15.2	20.3	12.0	25.6
39 Marathon	4	14.8	5.5	18.9	24.5	9.3	30.9
Vulcan	5	14.7	9.3	18.5	23.6	15.5	27.6

1996 to 2010 is summarized in Table 33. The gross alpha radioactivity in the biosolids ranged from 5.1 pCi/g dw at the Vulcan SDA in 1996 to 29.6 pCi/g dw at the Calumet West SMA in 2010.

The yearly average gross beta radioactivity in the District’s air-dried biosolids from 1996 to 2010 is summarized in Table 34. The gross beta radioactivity in the biosolids ranged from 14.1 pCi/g dw at the Calumet East SMA in 2009 to 32.2 pCi/g dw at the Calumet West SMA in 2010.

**Radium-226, Radium-228, and Strontium-90 Radioactivity in the Raw Sewage and Final Effluent of Metropolitan Water Reclamation District of Greater Chicago’s Water Reclamation Plants**

In 2010, four raw sewage and four effluent samples each from the District’s seven WRPs were analyzed for the concentration of radium-226, radium-228, and strontium-90 radioactivity. Tables 35 and 36 show the average concentration of these radionuclides in the four raw sewage and final effluent samples, respectively, from the WRPs for 2010. The average radium-226 radioactivity concentration in the raw sewage at all the WRPs was below the detection limit (0.31 to 0.66 pCi/L) except for Calumet (0.44 pCi/L), Lemont (13.4 pCi/L), Southwest (0.72 pCi/L), and Westside (0.32 pCi/L) WRPs. The average radium-228 radioactivity concentration in the raw sewage of the WRPs was below the detection limit (1.44 to 2.38 pCi/L) except for the Lemont WRP (5.00 pCi/L). The average strontium-90 radioactivity concentration was below the detection limit (1.78 to 2.32 pCi/L) at all the WRPs. The radium-226 radioactivity concentration in final effluent was below the detection limit (0.24 to 0.36 pCi/L) except for Calumet (0.40 pCi/L), Egan (0.34 pCi/L), and Lemont WRP (5.9 pCi/L). The radium-228 concentration in final effluent was below the detection limit (1.46 to 1.61 pCi/L) except for Kirie (1.36 pCi/L), Lemont (2.65 pCi/L), and Stickney WRP (1.65 pCi/L). The strontium-90 radioactivity concentration in final effluent at all the WRPs was below the detection limit (1.82 to 2.28 pCi/L).

**Gamma Radioactivity in Metropolitan Water Reclamation District of Greater Chicago’s Water Reclamation Plants Sludge and Biosolids**

In 2010, 20 sludge samples from five WRPs, 21 biosolids samples from six solids drying sites, and eight biosolids samples from the Hanover Park WRP lagoons were analyzed for gamma-emitting radionuclides. The following is a list of radionuclides monitored:

Beryllium-7	Silver-108m	Barium-133
Sodium-22	Silver-110	Bismuth-207
Potassium-40	Antimony-125	Bismuth-212
Manganese-54	Cesium-134	Lead-212

TABLE 33: YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN METROPOLITAN WATER  
 RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

Year <sup>1</sup>	Gross Alpha Radioactivity (pCi/g dw)							
	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	NA	NA	7.1	5.7	6.6	6.1	5.1	5.6
1997	NA	NA	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

TABLE 33 (Continued): YEARLY AVERAGE GROSS ALPHA RADIOACTIVITY IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

Year <sup>1</sup>	Gross Alpha Radioactivity (pCi/g dw)							
	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2005	11.8	13.7	16.0	17.8	17.2	13.6	15.5	15.3
2006	10.9	14.9	10.2	12.8	12.6	12.7	8.9	NS
2007	13.5	14.0	13.9	12.8	14.4	10.8	12.8	NS
2008	17.4	19.5	17.6	15.9	18.1	21.1	17.8	NS
2009	7.5	18.0	9.3	10.5	8.9	NS	9.1	NS
2010	26.4	29.6	14.4	9.2	14.8	NS	14.7	NS

<sup>1</sup>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.

NA = Not analyzed.

NS = No sample.

TABLE 34: YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

Year	Gross Beta Radioactivity (pCi/g dw)							
	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
1996	NA	NA	23.0	23.8	27.5	22.5	22.4	24.2
1997	NA	NA	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

TABLE 34 (Continued): YEARLY AVERAGE GROSS BETA RADIOACTIVITY IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

Year	Gross Beta Radioactivity (pCi/g dw)							
	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2005	24.7	24.1	22.2	26.8	27.7	26.2	27.4	26.6
2006	25.2	24.4	27.0	27.5	27.9	27.1	25.5	NS
2007	23.2	30.4	24.2	24.0	25.2	25.1	23.1	NS
2008	27.0	32.2	29.7	27.1	28.8	31.9	28.2	NS
2009	14.1	20.6	16.5	22.5	16.5	NS	17.0	NS
2010	28.4	32.2	22.9	20.3	24.5	NS	23.6	NS

NA = Not analyzed.

NS = No sample.



TABLE 35: CONCENTRATION OF RADIUM-226, RADIUM-228, AND STRONTIUM-90 IN  
 RAW SEWAGE OF METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER  
 CHICAGO'S WATER RECLAMATION PLANTS – 2010

Sample Location WRP	No. of Samples	Radium-226 (pCi/L)			Radium-228 (pCi/L)			Strontium-90 (pCi/L)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	0.44	0.22	0.89	<1.51	<1.09	<1.96	<1.97	<1.37	<2.59
John E. Egan	4	<0.66	<0.40	<1.05	<2.38	<1.36	<3.53	<2.06	<1.41	<2.63
Hanover Park	4	<0.52	0.21	<0.90	<2.24	<1.66	<3.14	<1.91	<1.27	<2.86
Kirie	4	<0.44	<0.34	<0.53	<1.45	<1.33	<1.56	<1.78	<1.17	<2.36
Lemont	4	13.4	7.61	18.90	5.00	2.72	7.8	<1.81	<1.18	<2.33
North Side	4	<0.31	<0.28	<0.36	<1.46	<1.20	<1.67	<2.00	1.51	<2.60
Southwest	4	0.72	0.38	1.41	<1.51	1.24	<1.78	<2.32	1.57	<2.95
Westside	4	0.32	0.20	0.53	<1.44	<1.21	<1.67	<2.03	1.46	<2.57

TABLE 36: CONCENTRATION OF RADIUM-226, RADIUM-228, AND STRONTIUM-90 IN FINAL EFFLUENT OF METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S WATER RECLAMATION PLANTS – 2010

Sample Location WRP	No. of Samples	Radium-226 (pCi/L)			Radium-228 (pCi/L)			Strontium-90 (pCi/L)		
		Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.
Calumet	4	0.40	0.20	0.67	<1.61	<1.37	<2.07	<2.12	<1.37	<2.84
John E. Egan	4	0.34	<0.11	0.85	<1.52	<1.16	<1.96	<1.86	1.20	<2.66
Hanover Park	4	<0.32	0.14	<0.60	<1.48	<1.06	<1.74	<2.28	<1.54	<3.12
Kirie	4	<0.24	0.18	<0.33	1.36	<1.28	1.58	<2.05	<1.20	<2.58
Lemont	4	5.90	3.73	10.00	2.65	<1.38	3.71	<1.82	1.39	<2.23
North Side	4	<0.35	<0.19	<0.63	<1.46	<1.21	<1.68	<2.10	<1.44	<2.74
Stickney	4	<0.36	<0.19	<0.60	1.65	<1.28	2.47	<2.11	<1.53	<2.51

Cobalt-57	Cesium-137	Bismuth-214
Cobalt-60	Cerium-144	Lead-214
Zinc-65	Europium-152	Radium-226
Niobium-94	Gadolinium-153	Actinium-228
Ruthenium-106	Europium-154	Protactinium-231

Of the 27 radionuclides analyzed, nine were detected at measurable levels. All of these radionuclides are of natural origin.

Table 37 presents the concentrations of gamma-emitting radionuclides in the sludge and biosolids from the District WRPs for 2010.

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 treatment 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 was transported by truck to the Stickney WRP for treatment.

The yearly average potassium-40, radium-226, and cesium-137 radioactivity in the District's WRPs sludge and biosolids from 1997 to 2010 are summarized in Tables 38, 39, and 40 respectively. The potassium-40 radioactivity in the WRPs sludge ranged from 2.4 pCi/g dw at the Hanover Park WRP in 1997 to 22.2 pCi/g dw at the Calumet WRP in 2009. The radium-226 radioactivity in the WRPs sludge, excluding Lemont WRP, ranged from 1.7 pCi/g dw at the Hanover Park WRP in 2009 to 6.2 pCi/g dw at the Hanover Park WRP in 2008. The radium-226 radioactivity at the Lemont WRP ranged from 31.9 pCi/g dw in 2010 to 86.8 pCi/g dw in 2001. The cesium-137 radioactivity in the WRPs sludge ranged from non-detectable levels to 0.11 pCi/g dw in 1998 at the Stickney WRP.

Table 41 presents the concentration of gamma-emitting radionuclides in the Hanover Park WRP lagooned biosolids for 2010. The data presents an average of three samples analyzed from both the Hanover Park WRP East and West lagoons

The yearly average potassium-40, radium-226, and cesium-137 radioactivity in the Hanover Park WRP lagooned biosolids from 1998 to 2010 is summarized in Table 42. The yearly average potassium-40 radioactivity at the Hanover Park East lagoon ranged from 2.8 to 6.9 pCi/g dw. The yearly average radium-226 radioactivity ranged from 1.8 to 6.7 pCi/g dw, and cesium-137 radioactivity ranged from non-detectable levels to 0.2 pCi/g dw. The yearly average

TABLE 37: CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN  
WATER RECLAMATION PLANT SLUDGE AND BIOSOLIDS – 2010

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	13.7	12.4	15.6	1.8	1.5	2.2	ND	ND	ND
John E. Egan	4	11.3	7.0	14.4	2.3	1.4	3.6	ND	ND	ND
Hanover Park	4	7.1	4.1	10.7	1.9	1.5	2.7	ND	ND	ND
Stickney	4	15.7	10.0	22.3	1.5	1.2	1.9	ND	ND	ND
Lemont	4	10.9	8.1	14.3	31.9	19.4	45.7	ND	ND	ND

TABLE 37 (Continued): CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES  
IN WATER RECLAMATION PLANT SLUDGE AND BIOSOLIDS – 2010

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	10.7	6.5	15.9	ND	ND	1.4	0.8	0.6	0.9
John E. Egan	4	7.2	4.8	12.2	ND	ND	ND	0.8	ND	1.4
Hanover Park	4	4.4	6.2	3.5	ND	ND	ND	ND	ND	ND
Stickney	4	19.0	10.8	36.1	ND	ND	ND	0.8	0.6	1.3
Lemont	4	13.1	5.2	24.0	10.9	ND	12.3	6.2	5.4	7.0

TABLE 37 (Continued): CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES  
IN WATER RECLAMATION PLANT SLUDGE AND BIOSOLIDS – 2010

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	1.5	2.2	2.0	1.7	2.1	1.9	1.7	2.1
John E. Egan	4	2.3	1.4	3.6	2.4	1.5	3.9	ND	ND	2.6
Hanover Park	4	1.9	ND	2.7	1.6	1.2	1.9	ND	ND	1.5
Stickney	4	1.5	1.2	1.9	1.7	0.9	2.7	1.8	1.2	3.1
Lemont	4	31.9	19.4	45.7	34.7	20.6	49.4	44.0	34.8	52.6

ND = Not detected.

TABLE 38: YEARLY AVERAGE POTASium-40 RADIOACTIVITY (pCi/g dw) IN WATER  
RECLAMATION PLANT SLUDGE AND BIOSOLIDS FROM 1997 THROUGH 2010

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
2005	8.3	6.9	4.7	9.9	6.1
2006	9.4	8.9	5.3	10.3	6.7
2007	10.5	7.6	4.6	11.7	7.3
2008	11.2	8.8	6.7	12.2	11.1
2009	22.2	10.7	10.0	20.2	13.5
2010	13.7	11.3	7.1	15.7	10.9

TABLE 39: YEARLY AVERAGE RADIUM-226 RADIOACTIVITY (pCi/g dw) IN WATER  
RECLAMATION PLANT SLUDGE AND BIOSOLIDS FROM 1997 THROUGH 2010

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
2005	4.4	3.9	3.1	3.5	70.8
2006	4.5	3.9	3.8	3.4	56.7
2007	4.3	3.9	4.0	3.4	52.4
2008	6.0	5.6	6.2	4.4	45.2
2009	3.2	2.8	1.7	1.9	38.3
2010	1.8	2.3	1.9	1.5	31.9



TABLE 40: YEARLY AVERAGE CESIUM-137 RADIOACTIVITY (pCi/g dw) IN WATER  
RECLAMATION PLANT SLUDGE AND BIOSOLIDS FROM 1997 THROUGH 2010

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
2005	0.05	ND	ND	0.06	ND
2006	0.06	ND	ND	0.05	ND
2007	0.05	ND	ND	0.06	ND
2008	0.07	0.05	ND	0.07	ND
2009	ND	ND	ND	ND	ND
2010	ND	ND	ND	ND	ND

ND = Not detected.

TABLE 41: CONCENTRATION (pCi/g dw) OF GAMMA-EMITTING RADIONUCLIDES IN HANOVER PARK WATER RECLAMATION PLANT LAGOONED BIOSOLIDS - 2010

Radionuclides	No. of Samples	Hanover Park East Lagoon	Hanover Park West Lagoon
Beryllium-7	3	6.6	4.2
Potassium-40	3	6.3	6.0
Cesium-137	3	ND	ND
Bismuth-212	3	ND	ND
Lead-212	3	0.7	0.7
Bismuth-214	3	1.8	1.5
Lead-214	3	1.7	1.6
Radium-226	3	1.8	1.5
Actinium-228	3	ND	2.0

ND = Not detected.

TABLE 42: YEARLY AVERAGE POTASSIUM-40, RADIUM-226, AND CESIUM-137 RADIOACTIVITY (pCi/g dw)  
IN HANOVER PARK WATER RECLAMATION PLANT LAGOONED BIOSOLIDS FROM 1998 THROUGH 2010

Year	Hanover Park WRP East Lagoon			Hanover Park WRP West Lagoon		
	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
2005	4.7	3.9	ND	4.5	3.8	ND
2006	4.2	3.9	0.04	3.8	3.6	0.04
2007	3.9	4.0	ND	4.2	3.8	ND
2008	6.5	6.7	ND	4.7	4.4	0.05
2009	6.9	1.8	ND	6.7	1.8	ND
2010	6.3	1.8	ND	6.0	1.5	ND

ND = Not detected.  
NA = Not analyzed.

potassium-40 radioactivity in the Hanover Park West lagooned biosolids ranged from 3.5 to 6.7 pCi/g dw, radium-226 radioactivity ranged from 1.5 to 5.7 pCi/g dw, and cesium-137 radioactivity ranged from non-detectable levels to 0.3 pCi/g dw.

Table 43 presents the concentration of gamma-emitting radionuclides in the District's air-dried biosolids collected from six solids drying area in 2010.

The yearly average potassium-40, radium-226, and cesium-137 radioactivity in the District's air-dried biosolids from 1996 to 2010 are summarized in Tables 44, 45, and 46 respectively. The potassium-40 radioactivity in the biosolids ranged from 4.9 to 17.5 pCi/g dw. The radium-226 radioactivity in the biosolids ranged from 0.6 to 5.2 pCi/g dw. The cesium-137 radioactivity in biosolids ranged from non-detectable levels to 0.6 pCi/g dw.

TABLE 43: CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS – 2010

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	1	7.7	7.7	7.7	1.4	1.4	1.4	ND	ND	ND
Calumet West	1	8.6	8.6	8.6	1.4	1.4	1.4	ND	ND	ND
HASMA	5	4.9	1.4	7.2	0.7	0.4	1.0	ND	ND	ND
LASMA	5	5.9	3.6	8.3	0.6	0.4	0.8	ND	ND	ND
Marathon	4	6.7	4.6	7.6	0.7	0.4	1.0	ND	ND	0.08
Vulcan	5	5.8	3.6	9.8	0.8	0.4	1.4	ND	ND	0.1

TABLE 43 (Continued): CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN  
 METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S  
 AIR-DRIED BIOSOLIDS – 2010

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	1	1.5	1.5	1.5	0.8	0.8	0.8	1.4	1.4	1.4
Calumet West	1	ND	ND	ND	ND	ND	ND	1.1	1.1	1.1
HASMA	5	4.4	ND	14.4	ND	ND	0.7	0.5	0.2	0.8
∞ LASMA	5	ND	ND	0.8	ND	ND	0.7	0.6	0.4	0.8
Marathon	4	ND	ND	ND	ND	ND	ND	0.6	0.4	0.9
Vulcan	5	ND	ND	2.9	ND	ND	0.4	0.5	0.2	0.9

TABLE 43 (Continued): CONCENTRATION OF GAMMA-EMITTING RADIONUCLIDES IN  
 METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S  
 AIR-DRIED BIOSOLIDS – 2010

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	1	1.4	1.4	1.4	1.4	1.4	1.4	1.0	1.0	1.0
Calumet West	1	1.4	1.4	1.4	1.0	1.0	1.0	1.1	1.1	1.1
HASMA	5	0.7	0.4	1.0	0.6	0.4	1.0	ND	ND	0.9
59 LASMA	5	0.6	0.4	0.8	0.6	0.3	0.9	0.6	ND	0.9
Marathon	4	0.7	0.4	1.0	0.6	0.3	0.9	0.7	0.6	0.9
Vulcan	5	0.8	ND	1.4	0.7	0.2	1.4	ND	ND	1.0

ND = Not detected.

TABLE 44: YEARLY AVERAGE POTASIUM-40 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

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
2005	8.0	9.7	8.6	9.2	10.0	8.8	9.9	9.9
2006	8.6	7.6	12.5	9.2	12.1	8.9	9.6	NS
2007	8.8	17.5	10.7	8.6	11.1	8.7	9.4	NS



TABLE 44 (Continued): YEARLY AVERAGE POTASSIUM-40 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2008	7.6	11.2	9.0	8.3	8.9	9.1	8.9	NS
2009	6.2	8.9	7.1	10.2	7.1	NS	9.1	NS
2010	7.7	8.6	5.9	4.9	6.7	NS	5.8	NS

NS = No sample.

TABLE 45: YEARLY AVERAGE RADIUM-226 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

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
2005	4.7	4.3	3.7	4.0	3.8	4.0	3.7	3.8
2006	4.5	4.9	3.0	3.9	3.2	4.2	3.7	NS
2007	4.4	3.6	3.4	3.7	3.4	3.9	3.6	NS

TABLE 45 (Continued): YEARLY AVERAGE RADIUM-226 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2008	4.2	3.8	4.1	3.7	3.6	4.4	3.8	NS
2009	1.4	1.9	0.9	1.3	1.0	NS	1.2	NS
2010	1.4	1.4	0.6	0.7	0.7	NS	0.8	NS

NS = No sample.

TABLE 46: YEARLY AVERAGE CESIUM-137 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

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
64 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
2005	0.06	0.06	0.06	0.08	0.08	0.07	0.07	0.07
2006	0.07	0.06	0.04	0.07	0.05	0.07	0.07	NS
2007	0.04	0.04	0.05	0.06	0.06	0.06	0.06	NS

TABLE 46 (Continued): YEARLY AVERAGE CESIUM-137 RADIOACTIVITY (pCi/g dw) IN METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO'S AIR-DRIED BIOSOLIDS FROM 1996 THROUGH 2010

Year	Calumet East	Calumet West	LASMA	HASMA	Marathon	Stony Island	Vulcan	RASMA
2008	0.05	0.06	0.06	0.06	0.06	0.07	0.07	NS
2009	ND	ND	ND	ND	ND	NS	ND	NS
2010	ND	ND	ND	ND	ND	NS	ND	NS

NS = No sample.  
 ND = Not detected.