State of Illinois
Illinois Emergency Management Agency

2016 Radiological Environmental Monitoring Report of the Honeywell Metropolis Works Facility

IEMA

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Introduction

The Illinois Emergency Management Agency (IEMA) is charged with protecting the citizens of Illinois from the potentially harmful effects of radioactive materials. In support of that mission, IEMA's Division of Nuclear Safety monitors the environment in Illinois for the presence of radionuclides through its radiological environmental monitoring program. This program has three primary functions: 1) collection of diverse samples from carefully chosen locations on a routine basis; 2) analyzing samples for radionuclides; and 3) evaluation of test results on both an annual and historical basis.

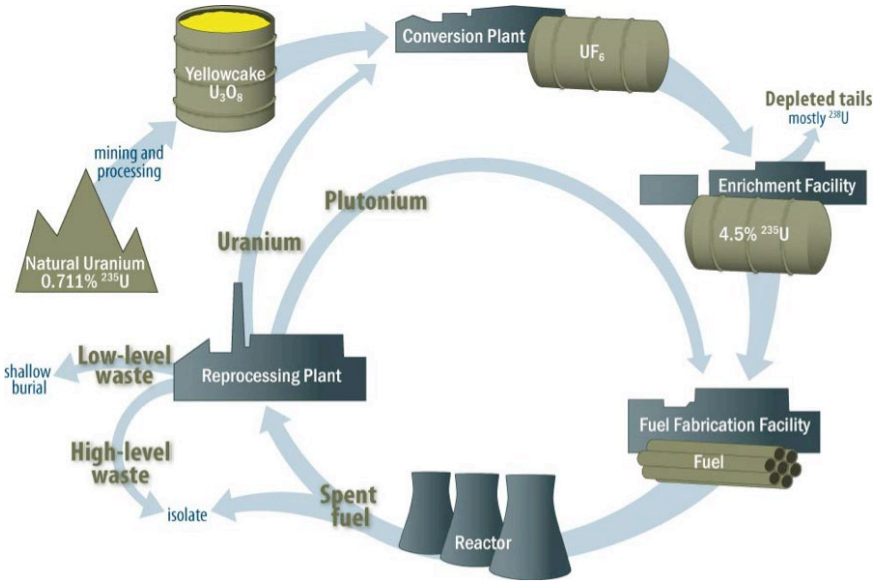
One of the locations monitored by IEMA is the environs of the Honeywell Metropolis Works (HMW) Facility near Metropolis, Illinois. The purpose of this report is to provide updated results of monitoring conducted during calendar year 2016.

Site Description

Located on approximately 1,100 acres of land within Massac County and on the peripheries of Metropolis, Illinois, the Honeywell Metropolis Works (HMW) facility perimeter is formed by U.S. Highway 45 to the north, the Ohio River to the south, a coal terminal to the west, and the city of Metropolis to the east. The facility footprint and the land immediately surrounding the facility form a 60-acre restricted area as required by HMW's United States Nuclear Regulatory Commission's (US NRC) Radioactive Materials License, number SUB-526. This restricted area is intended for the protection of the public from exposure to radiation and radioactive materials.

Opened in 1958, the HMW, a subsidiary company of Honeywell International Inc., plays a crucial role in the nuclear fuel cycle by converting uranium ore (U_3O_8) into uranium hexafluoride (UF_6). HMW is unique in that it is the only facility in the United States that produces UF_6. As depicted in Figure 1, conversion is the second step in the nuclear fuel cycle immediately following mining and processing and preceding enrichment

Figure 1. Nuclear Fuel Cycle



HMW uses a dry conversion process to convert U_3O_8 to UF_6. The process first strips the U_3O_8 of impurities such as sodium and potassium. The material is then treated with nitrogen to form UO_2 and then hydrofluorinated with hydrofluoric acid to form uranium tetra-fluoride (UF_4). The UF_4 is treated with fluorine gas to form UF_6. After HMW converts U_3O_8 into UF_6, the UF_6 is then processed, packaged and transported to enrichment plants, both domestic and foreign, where the UF_6 is enriched either by gaseous diffusion or gas centrifugation. The enriched UF_6 is then sent to fuel fabrication facilities and processed into fuel pellets for nuclear power plants.

Although the HMW facility is licensed by the US NRC, the Illinois Emergency Management Agency (IEMA) maintains a presence in the surrounding communities through our environmental monitoring program. The overall purpose of IEMA's environmental monitoring program, in relation to the HMW facility, is to determine if a radiological environmental impact is detected in the environs of the facility due to its operation, as well as determine long-term trends in environmental radiation levels.

IEMA Radiological Environmental Monitoring Program

The IEMA Radiological Environmental Monitoring program consists of sample collection and laboratory analysis, as well as review and analysis of the resulting data. As part of the 2016 HMW monitoring program, samples were collected from various locations around the HMW facility. Sampling included water, vegetation, air, direct radiation, soil, and sediment. Analyses vary from media to media but focus primarily on natural uranium. A general description of sample collection, analysis, and results follows. Sample result tables are located in Appendix B.

Sampling and Monitoring Activities

Air Sampling

Air particulate samples are collected from a network of four strategically positioned environmental monitoring stations (EMS) within the environs of HMW. Each EMS is comprised of a continuous low-volume vacuum pump and air filter assembly. Particulate filter samples are exchanged and analyzed weekly.

Soil Sampling

Soil samples are collected from four sampling locations during the second and third quarters of the year and analyzed for radionuclides that may have been transported from the environment and incorporated into the soil.

Vegetation Sampling

Vegetation samples are collected from four sampling locations during the second and third quarters of the year and analyzed for radionuclides that may have been transported from the environment and incorporated into or on plant tissue.

Sediment Sampling

Sediment samples are collected from two sampling locations during the second and third quarters of the year and analyzed for radionuclides that may have entered the water stream and settled out of solution or suspension.

Water Sampling

Water samples are collected and analyzed from four local waterways and one public water supply location on a quarterly basis.

Direct Radiation Monitoring

Measurements of direct gamma radiation are collected using optically-stimulated luminescent dosimeters (OSLs). A network of eighteen OSL dosimeters is arrayed around the HMW facility; dosimeters are exchanged and analyzed quarterly. OSLs METR-31 and METR-32 were added during the fourth quarter of 2016, and were placed near the entrances to the HMW facility.

General Sampling and Monitoring Information

Every effort is made to collect all scheduled environmental samples; however, occasionally samples are unobtainable due to weather conditions, water levels, or obstructed access. Appendix A contains maps of all sampling and monitoring locations.

Laboratory Analysis

Soil, sediment, vegetation, water, and air samples were analyzed by the IEMA Radiochemistry Laboratory located in Springfield, IL. The laboratory participates in semi-annual proficiency testing programs through Environmental Resource Associates, an accredited proficiency testing provider, and the Department of Energy (DOE) Radiological and Environmental Science Laboratory's Mixed Analyte Performance Evaluation Program (MAPEP).

Gross Alpha/Beta Analysis

Air particulate filters are exchanged and analyzed weekly for airborne radioactivity through gross alpha and beta analysis. Since radionuclides associated with natural uranium emit either alpha or beta particles, analysis of air particulate samples for gross alpha/beta activity provides a good method of screening for the presence of radioactive materials. Results from each of the five air monitoring stations are displayed in Appendix B -Tables B.1 – B.4.

Two "trigger" levels are used to determine if additional analysis is required for air particulate samples. These levels represent approximately 25% and 100% of the total uranium effluent concentration limit of 90 fCi/m^3 established in 10CFR20, Appendix B.

Triggering levels are set at:

- Gross alpha results at or above 25.0 fCi/m3 are evaluate to determine if Kinetic Phosphorescence Analyzer (KPA) analysis will need to be performed.

- Samples with gross alpha results at or above 90 fCi/m3 require KPA analysis.

Gamma Analysis

Soil, vegetation, and sediment samples are analyzed using a high-purity germanium detector in a process called gamma spectroscopy, which allows for the identification of individual radionuclides. Gamma spectroscopy results for soil, sediment, and vegetation are reported using Proctactinium-234m Pa-234m) as a surrogate radionuclide for Uranium-238 (a component of natural uranium). Uranium-238 daughter products, Radium-226 and Thorium-230, are also reported. Gamma spectroscopy results for soil, vegetation, and sediment are displayed in Appendix B-Tables B.5, B.6, and B.7.

Kinetic Phosphorescence Analyzer (KPA) Analysis

Water samples are analyzed for the presence of uranium using Kinetic Phosphorescence Analyzer (KPA). Air particulate samples with results above the established Gross alpha/beta Triggering Levels may also be analyzed using KPA. KPA results are displayed in Appendix B- Table B.8.

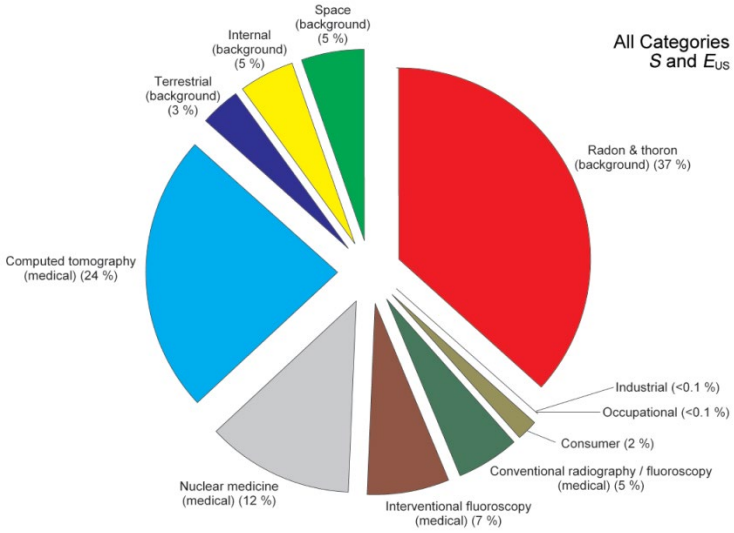
Optically Stimulated Luminescence Analysis

Optically Stimulated Luminescence (OSL) dosimeters provide a direct measurement of the total dose received from all sources of gamma radiation, including naturally occurring radionuclides and cosmic rays. The dosimeters are used to monitor for small changes in ambient background levels of gamma radiation that could result from releases of radioactive material or exposure to large quantities of stored material on-site.

OSLs are analyzed by IEMA staff using a Landauer In Light System Auto Reader. Results found in Appendix B-Table B.11 are expressed as the average milliroentgen (mR) per quarter, and are also calculated to the approximate mR per year that would have been accrued by an individual at that location for an entire year.

The ambient gamma results can be compared to the average annual radiation exposure to an individual of 620 mR/year from various sources (according to the 2009 National Council on Radiation Protection's (NCRP) Report 160). Approximately 8% (49.6 mR/year) of that exposure is from Terrestrial and Cosmic radiation (background radiation), Figure 2.

Figure 2. Sources of Radiation Exposure to Man



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Minimum Detectable Concentration (MDC)

All analytical methods have limitations: amounts that are too small to be detected. The Minimum Detectable Concentration (MDC) is an "a priori" measure of that limitation – an estimate of the lower limit of detection. It is defined as the smallest quantity that an analytical method has 95% likelihood of detecting. For example, the MDC for IEMA's method for tritium in water is 200 picocuries per liter (pCi/L). Given a sample with a tritium concentration of 200 pCi/L, our laboratory would detect that tritium approximately 95 times out of 100. Samples with less than 200 pCi/L could be detected, but with less certainty. Conversely, samples with more than 200 pCi/L would be more likely to be detected, approaching 100% as concentrations increase. Analytical methods are chosen, in part, on their MDC. As a general rule, methods are chosen such that their MDC is less than 10% of any applicable regulatory limit.

Sampling and Monitoring Results

Air Sampling Results

Air particulate sample results for EMSs located at the Metropolis Airport, Dorothy Miller Park, and on North Avenue were comparable to results obtained from background EMSs located in Marion and Springfield, IL and were consistent with data previously collected by IEMA as part of its HMW radiological environmental monitoring program. Sample results from EMSs located at the nearest residence location indicate a slight elevation in gross alpha/beta concentrations. Due to its proximity to the HWM facility, increases in air particulate concentrations are expected when the plant is operational.

Two air particulate samples collected from the nearest residence in January 2016 had results above the 25.0 fCi/m³ trigger level established by IEMA to determine if KPA analysis was necessary. The gross alpha/ beta concentrations quickly returned to levels more typically seen at that location, and it was determined that KPA analysis was unnecessary.

Soil Sampling Results

Gamma spectroscopy results for soil samples were comparable to results obtained from the background sampling locations and were consistent with data previously collected by IEMA as part of its HMW radiological environmental monitoring program. A soil sample taken from the nearest residence on August 22 indicated an increase in Pa-234m concentration compared to other sampling locations and to background samples. Due to the sampling locations proximity to the HWM facility, slight increases in the soil uranium concentration may be expected. IEMA will continue to sample and monitor the soil at this location.

Vegetation Sampling Results

All gamma spectroscopy results for vegetation samples were below established MDCs.

Sediment Sampling Results

Gamma spectroscopy result concentrations, although above the established MDC for some radionuclides, are comparable to the background location sampling data and consistent with data previously collected by IEMA as part of its HMW radiological environmental monitoring program.

Water Sampling Results

All KPA results were consistent with data previously collected by IEMA as part of its HMW radiological environmental monitoring program.

Direct Radiation Monitoring Results

OSL results indicated that the highest annual exposures were found at locations METR-31 and 32. These two OSLs represent IEMA's nearest direct radiation monitoring points to the HMW plant. METR-31 and 32 are located near the entrances to the plant, where shipments of uranium ore are delivered. Therefore, much of the elevated exposure rate can be attributed to their close proximity to these transportation activities, and is not attributable to plant operations. All other OSL results were consistent with historical data collected by IEMA as part of its HMW radiological environmental monitoring program.

Background Reference Areas

For comparison, samples are collected and analyzed from background reference areas located in Springfield, Marion, and/or Kincaid, Illinois. The tables in Appendix C provide the analytical results of samples collected from these background reference areas.

Summary

In 2016, with the exception of two air particulate samples collected at the nearest residence sampling location, sampling and monitoring results from IEMA's HMW radiological environmental monitoring program indicate that radioactivity levels remain consistent with data collected in previous years. As seen in previous years, results from sampling and monitoring locations found near the facility indicate slightly elevated levels of radioactivity in the soil and air when compared to samples collected away from the facility or from background reference areas. Similarly, direct radiation monitoring near the facility shows a slight increase in exposure in those areas when compared to other monitoring locations found away from the facility and background reference areas.

APPENDIX A
Maps of Monitoring and Sampling Locations around Metropolis

Map A.1. Sampling Locations

Map Key:

- OSL*
- Water
- Air Sampler
- Honeywell
- Soil
- Sediment
- Vegetation

*OSL = Optically-Stimulated Luminescence Dosimeter

Sample icons are stacked to indicate multiple types of samples collected at the same location

Map A.2. Optically Stimulated Luminescence (OSL) Monitoring Locations

Map Key:

- OSL*
- Water
- Air Sampler
- Honeywell
- Soil
- Sediment
- Vegetation

***OSL = Optically-Stimulated Luminescence Dosimeter**

Sample icons are stacked to indicate multiple types of samples collected at the same location

APPENDIX B
Sample Analysis Results for Samples Collected from the Environs of the HMW Facility

Table B.1 Sample Results for Alpha / Beta Screening of Air Particulate Filters
Nearest Residence
Results are in femtocuries per cubic meter (fCi/m^3)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Nearest Residence				
1/4/2016	5.2	1.6	40.1	4.6
1/11/2016	26.1	1.6	43.7	4.6
1/19/2016	61.1	1.6	97.1	4.6
1/25/2016	3.0	1.6	27.4	4.6
2/2/2016	8.1	1.6	39.8	4.6
2/8/2016	7.0	1.6	45.8	4.6
2/16/2016	2.0	1.6	27.8	4.6
2/22/2016	9.2	1.6	103.8	4.6
2/29/2016	12.9	1.6	89.8	4.6
3/7/2016	4.0	1.6	33.2	4.6
3/14/2016	5.7	1.6	32.5	4.6
3/21/2016	5.9	1.6	24.8	4.6
3/28/2016	7.2	1.6	38.2	4.6
4/4/2016	11.6	1.6	31.0	4.6
4/11/2016	8.8	1.6	32.6	4.6
4/18/2016	3.0	1.6	25.1	4.6
4/25/2016	5.9	1.6	49.9	4.6
5/2/2016	10.2	1.6	64.7	4.6
5/9/2016	5.1	1.6	56.1	4.6
5/16/2016	7.0	1.6	33.8	4.6
5/23/2016	3.8	1.6	24.5	4.6
5/31/2016	7.8	1.6	68.5	4.6
6/6/2016	5.3	1.6	43.3	4.6
6/13/2016	6.1	1.6	43.1	4.6
6/20/2016	<MDC	1.6	<MDC	4.6
6/27/2016	9.4	1.6	93.5	4.6

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Nearest Residence				
7/11/2016	5.8	1.6	108.2	4.6
7/18/2016	9.6	1.6	51.8	4.6
7/25/2016	3.4	1.6	37.7	4.6
8/1/2016	3.2	1.6	33.4	4.6
8/8/2016	3.1	1.6	28.9	4.6
8/15/2016	5.2	1.6	23.0	4.6
8/22/2016	7.6	1.6	22.3	4.6
8/29/2016	6.2	1.6	32.5	4.6
9/6/2016	2.8	1.6	36.5	4.6
9/12/2016	8.5	1.6	30.0	4.6
9/19/2016	3.4	1.6	37.9	4.6
9/26/2016	2.8	1.6	65.0	4.6
10/3/2016	<MDC	1.6	21.7	4.6
10/11/2016	9.6	1.6	43.7	4.6
10/17/2016	5.4	1.6	39.5	4.6
10/24/2016	12.4	1.6	35.8	4.6
10/31/2016	6.4	1.6	53.1	4.6
11/7/2016	8.3	1.6	48.1	4.6
11/14/2016	3.8	1.6	34.6	4.6
11/21/2016	6.3	1.6	54.3	4.6
11/28/2016	2.8	1.6	43.8	4.6
12/6/2016	5.1	1.6	28.4	4.6
12/12/2016	4.6	1.6	29.8	4.6
12/27/2016	5.3	1.6	37.6	4.6

Table B.2 Sample Results for Alpha / Beta Screening of Air Particulate Filters
Metropolis Airport
Results are in femtocuries per cubic meter (fCi/m³)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Airport 1 Mi. NNE				
1/4/2016	5.8	1.6	36.5	4.6
1/11/2016	2.7	1.6	18.9	4.6
1/19/2016	7.5	1.6	41.2	4.6
1/25/2016	3.0	1.6	30.3	4.6
2/2/2016	3.3	1.6	34.6	4.6
2/8/2016	3.7	1.6	31.5	4.6
2/16/2016	2.0	1.6	27.3	4.6
2/22/2016	3.6	1.6	40.7	4.6
2/29/2016	3.7	1.6	41.5	4.6
3/7/2016	2.4	1.6	27.3	4.6
3/14/2016	2.9	1.6	20.4	4.6
3/21/2016	2.5	1.6	19.4	4.6
3/28/2016	2.8	1.6	21.4	4.6
4/4/2016	2.0	1.6	23.4	4.6
4/11/2016	3.3	1.6	23.9	4.6
4/18/2016	2.4	1.6	27.1	4.6
4/25/2016	2.6	1.6	35.5	4.6
5/2/2016	2.9	1.6	32.6	4.6
5/9/2016	1.7	1.6	31.2	4.6
5/16/2016	3.5	1.6	29.8	4.6
5/23/2016	2.5	1.6	20.8	4.6
5/31/2016	5.0	1.6	37.9	4.6
6/6/2016	4.1	1.6	37.8	4.6
6/13/2016	4.7	1.6	41.3	4.6
6/20/2016	<MDC	1.6	<MDC	4.6
6/27/2016	4.4	1.6	40.2	4.6

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Airport 1 Mi. NNE				
7/11/2016	3.0	1.6	44.1	4.6
7/18/2016	5.2	1.6	33.7	4.6
7/25/2016	4.8	1.6	49.3	4.6
8/1/2016	<MDC	1.6	<MDC	4.6
8/8/2016	2.7	1.6	29.0	4.6
8/15/2016	<MDC	1.6	21.7	4.6
8/22/2016	1.9	1.6	14.3	4.6
8/29/2016	4.2	1.6	27.1	4.6
9/6/2016	2.7	1.6	33.6	4.6
9/12/2016	4.0	1.6	22.3	4.6
9/19/2016	2.4	1.6	40.1	4.6
9/26/2016	1.9	1.6	60.8	4.6
10/3/2016	<MDC	1.6	23.5	4.6
10/11/2016	7.3	1.6	45.7	4.6
10/17/2016	3.7	1.6	39.5	4.6
10/24/2016	1.9	1.6	29.1	4.6
10/31/2016	4.7	1.6	49.4	4.6
11/7/2016	4.4	1.6	44.5	4.6
11/14/2016	2.7	1.6	33.2	4.6
11/21/2016	3.9	1.6	49.5	4.6
11/28/2016	2.2	1.6	42.1	4.6
12/6/2016	4.7	1.6	29.6	4.6
12/12/2016	3.7	1.6	32.7	4.6
12/27/2016	4.5	1.6	34.9	4.6

Table B.3 Sample Results for Alpha / Beta Screening of Air Particulate Filters
North Avenue
Results are in femtocuries per cubic meter (fCi/m³)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Fire Station North Ave				
1/4/2016	5.1	1.6	38.2	4.6
1/11/2016	<MDC	1.6	16.7	4.6
1/19/2016	3.1	1.6	38.6	4.6
1/25/2016	2.0	1.6	30.0	4.6
2/2/2016	3.2	1.6	35.3	4.6
2/8/2016	3.2	1.6	28.5	4.6
2/16/2016	2.5	1.6	25.2	4.6
2/22/2016	<MDC	1.6	33.4	4.6
2/29/2016	2.4	1.6	26.0	4.6
3/7/2016	2.1	1.6	25.1	4.6
3/14/2016	2.2	1.6	18.6	4.6
3/21/2016	3.5	1.6	18.9	4.6
3/28/2016	2.7	1.6	20.1	4.6
4/4/2016	2.6	1.6	23.5	4.6
4/11/2016	2.2	1.6	18.5	4.6
4/18/2016	2.1	1.6	26.8	4.6
4/25/2016	1.8	1.6	30.4	4.6
5/2/2016	2.6	1.6	25.0	4.6
5/9/2016	<MDC	1.6	28.8	4.6
5/16/2016	2.9	1.6	26.2	4.6
5/23/2016	3.8	1.6	25.0	4.6
5/31/2016	4.9	1.6	30.0	4.6
6/6/2016	4.8	1.6	41.8	4.6
6/13/2016	4.9	1.6	35.1	4.6
6/20/2016	<MDC	1.6	<MDC	4.6
6/27/2016	3.6	1.6	35.9	4.6

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Fire Station North Ave				
7/11/2016	3.6	1.6	48.3	4.6
7/18/2016	2.5	1.6	31.4	4.6
7/25/2016	3.1	1.6	34.2	4.6
8/1/2016	2.6	1.6	27.0	4.6
8/8/2016	2.2	1.6	29.9	4.6
8/15/2016	<MDC	1.6	19.2	4.6
8/22/2016	<MDC	1.6	11.7	4.6
8/29/2016	2.7	1.6	26.3	4.6
9/6/2016	2.8	1.6	33.9	4.6
9/12/2016	2.6	1.6	23.4	4.6
9/19/2016	2.3	1.6	39.6	4.6
9/26/2016	1.9	1.6	61.2	4.6
10/3/2016	<MDC	1.6	18.8	4.6
10/11/2016	7.1	1.6	43.0	4.6
10/17/2016	2.0	1.6	36.1	4.6
10/24/2016	<MDC	1.6	26.7	4.6
10/31/2016	5.0	1.6	47.7	4.6
11/7/2016	5.8	1.6	48.5	4.6
11/14/2016	3.0	1.6	35.5	4.6
11/21/2016	3.8	1.6	48.5	4.6
11/28/2016	2.2	1.6	38.0	4.6
12/6/2016	4.8	1.6	28.1	4.6
12/12/2016	4.2	1.6	29.9	4.6
12/27/2016	4.7	1.6	36.5	4.6

Table B.4 Sample Results for Alpha / Beta Screening of Air Particulate Filters
Dorothy Miller Park
Results are in femtocuries per cubic meter (fCi/m³)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Dorothy Miller Park				
1/4/2016	4.8	1.6	32.8	4.6
1/11/2016	2.1	1.6	16.2	4.6
1/19/2016	4.5	1.6	37.8	4.6
1/25/2016	3.1	1.6	29.2	4.6
2/2/2016	2.3	1.6	33.2	4.6
2/8/2016	<MDC	1.6	6.5	4.6
2/16/2016	3.1	1.6	29.0	4.6
2/22/2016	2.5	1.6	24.7	4.6
2/29/2016	2.7	1.6	26.7	4.6
3/7/2016	2.4	1.6	25.2	4.6
3/14/2016	1.8	1.6	19.6	4.6
3/21/2016	1.7	1.6	17.3	4.6
3/28/2016	2.4	1.6	19.5	4.6
4/4/2016	2.6	1.6	23.4	4.6
4/11/2016	<MDC	1.6	17.5	4.6
4/18/2016	2.4	1.6	24.9	4.6
4/25/2016	<MDC	1.6	31.1	4.6
5/2/2016	1.7	1.6	24.3	4.6
5/9/2016	1.6	1.6	22.7	4.6
5/16/2016	3.9	1.6	28.5	4.6
5/23/2016	3.7	1.6	24.6	4.6
5/31/2016	4.7	1.6	30.7	4.6
6/6/2016	3.5	1.6	32.0	4.6
6/13/2016	5.4	1.6	37.4	4.6
6/20/2016	3.5	1.6	29.0	4.6
6/27/2016	3.9	1.6	31.0	4.6

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Dorothy Miller Park				
7/11/2016	2.6	1.6	28.6	4.6
7/18/2016	3.2	1.6	28.5	4.6
7/25/2016	3.3	1.6	34.2	4.6
8/1/2016	2.5	1.6	26.5	4.6
8/8/2016	2.7	1.6	26.7	4.6
8/15/2016	<MDC	1.6	21.6	4.6
8/22/2016	<MDC	1.6	10.8	4.6
8/29/2016	2.5	1.6	24.4	4.6
9/6/2016	2.5	1.6	34.4	4.6
9/12/2016	2.2	1.6	23.9	4.6
9/19/2016	2.3	1.6	35.8	4.6
9/26/2016	2.3	1.6	66.7	4.6
10/3/2016	<MDC	1.6	6.5	4.6
10/11/2016	7.4	1.6	42.8	4.6
10/17/2016	<MDC	1.6	33.0	4.6
10/24/2016	<MDC	1.6	27.2	4.6
10/31/2016	5.3	1.6	50.8	4.6
11/7/2016	5.1	1.6	48.1	4.6
11/14/2016	3.8	1.6	30.5	4.6
11/21/2016	3.7	1.6	52.0	4.6
11/28/2016	1.9	1.6	42.3	4.6
12/6/2016	3.6	1.6	28.3	4.6
12/12/2016	4.9	1.6	30.3	4.6
12/27/2016	4.8	1.6	36.5	4.6

Table B.5 Gamma Spectroscopy Sample Results for Soil Samples
Results in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226		Th-230	
Date	Result	MDC	Result	MDC	Result	MDC
Airport 1 Mi. NNE						
5/2/2016	1.8	1.5	1.6	0.3		
8/22/2016	1.6	1.5	1.3	0.3	<MDC	2.0
Intersection of Gurley and Devers						
5/2/2016	<MDC	1.5	1.2	0.3		
8/22/2016	<MDC	1.5	1.3	0.3	<MDC	2.0
Massac Creek at Country Club Road						
5/2/2016	<MDC	1.5	0.7	0.3		
8/22/2016	<MDC	1.5	0.3	0.3	<MDC	2.0
Nearest Residence						
5/2/2016	1.7	1.5	1.3	0.3		
8/22/2016	3.4	1.5	2.0	0.3	<MDC	2.0

Table B.6 Gamma Spectroscopy Sample Results for Vegetation Samples
Results in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226		Th-230	
Date	Result	MDC	Result	MDC	Result	MDC
Airport 1 Mi. NNE						
5/2/2016	<MDC	11.2	<MDC	1.6	<MDC	8.5
8/22/2016	<MDC	11.2	<MDC	1.6	<MDC	8.5
Intersection of Gurley and Devers						
5/2/2016	<MDC	11.2	<MDC	1.6	<MDC	8.5
8/22/2016	<MDC	11.2	<MDC	1.6	<MDC	8.5
Massac Creek at Country Club Road						
5/2/2016	<MDC	11.2	<MDC	1.6	<MDC	8.5
8/22/2016	<MDC	11.2	<MDC	1.6	<MDC	8.5
Nearest Residence						
5/2/2016	<MDC	11.2	<MDC	1.6	<MDC	8.5
8/22/2016	<MDC	11.2	<MDC	1.6	<MDC	8.5

Table B.7 Gamma Spectroscopy Sample Results for Sediment Samples
Results in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226		Th-230	
Date	Result	MDC	Result	MDC	Result	MDC
Ohio River At Joppa, 4 Mi. DnS						
5/2/2016	<MDC	1.4	0.8	0.2		
8/22/2016	<MDC	1.4	0.5	0.2	<MDC	5.9
Public Boat Launch near Harrah's Casino						
5/2/2016	<MDC	1.4	0.8	0.2		
8/22/2016	<MDC	1.4	0.7	0.2	<MDC	5.9

Table B.8 KPA (Total Uranium) Sample Results for Water Samples
Results in picocuries per liter (pCi/L)

Location	Uranium	
Date	Result	MDC
Massac Creek at Country Club Road		
2/2/2016	0.1	0.1
5/2/2016	<MDC	0.1
8/22/2016	<MDC	0.1
11/28/2016	<MDC	0.1
Ohio River, 2 Mi. UpS		
2/2/2016	0.4	0.1
5/2/2016	0.3	0.1
Ohio River at Joppa, 4 Mi. DnS		
2/2/2016	0.7	0.1
5/2/2016	0.5	0.1
8/22/2016	0.4	0.1
11/28/2016	0.4	0.1
Public Boat Launch near Harrah's Casino		
8/22/2016	0.3	0.1
11/28/2016	0.4	0.1
Metropolis PWS (Untreated)		
2/2/2016	0.4	0.1
5/2/2016	0.3	0.1
8/22/2016	0.5	0.1
11/28/2016	0.4	0.1
Small Creek in Fort Massac State Park		
5/2/2016	<MDC	0.1

Table B.9 Summary of Ambient Gamma Results

Location	Quarter 1 mR/day	Quarter 2 mR/day	Quarter 3 mR/day	Quarter 4 mR/day	Annual Exposure mR/year
METR-01	0.10	0.07	0.10	0.08	32.03
METR-02	0.07	0.07	0.09	0.08	27.28
METR-03	0.10	0.09	0.11	0.10	35.77
METR-04	0.11	0.09	0.12	0.09	36.50
METR-05	0.10	0.09	0.12	0.10	37.14
METR-06	0.10	0.09	0.12	0.11	37.23
METR-16	0.11	0.11	0.13	0.10	40.79
METR-20	0.09	0.07	0.08	0.10	31.85
METR-21	0.11	0.10	0.11	0.12	40.42
METR-22	0.11	0.09	0.10	0.11	37.05
METR-25	0.06	0.06	0.07	0.06	22.27
METR-26	0.11	0.09	0.13	0.12	40.79
METR-27	0.09	0.08	0.10	0.09	31.57
METR-28	0.10	0.07	0.09	0.09	31.57
METR-29	0.09	0.10	0.11	0.11	37.60
METR-30	0.09	0.09	0.12	0.09	35.13
METR-31				0.13	47.45
METR-32				0.17	62.42

METR-31 and METR-32 added in the fourth quarter of 2016.
The Annual Dose column is based on averages of all available data.
Quarters estimated to be 91.25 days in length.

APPENDIX C
Sample Analysis Results for Samples Collected from Established Background Locations

Table C.1 Sample Results for Alpha / Beta Screening of Air Particulate Filters
Springfield Background Location
Results are in femtocuries per cubic meter (fCi/m^3)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Knotts Street, Springfield				
1/4/2016	6.8	3.3	46.3	8.3
1/11/2016	<MDC	3.3	18.3	8.3
1/19/2016	4.5	3.3	44.7	8.3
1/25/2016	<MDC	3.3	34.5	8.3
2/1/2016	<MDC	3.3	33.1	8.3
2/8/2016	<MDC	3.3	24.4	8.3
2/16/2016	<MDC	3.3	28.2	8.3
2/22/2016	<MDC	3.3	24.7	8.3
2/29/2016	3.4	3.3	28.8	8.3
3/7/2016	<MDC	3.3	21.9	8.3
3/14/2016	<MDC	3.3	26.3	8.3
3/21/2016	<MDC	3.3	15.9	8.3
3/28/2016	<MDC	3.3	17.3	8.3
4/4/2016	<MDC	3.3	22.0	8.3
4/11/2016	<MDC	3.3	17.8	8.3
4/18/2016	<MDC	3.3	27.6	8.3
4/25/2016	<MDC	3.3	28.9	8.3
5/2/2016	<MDC	3.3	19.8	8.3
5/9/2016	<MDC	3.3	20.1	8.3
5/16/2016	<MDC	3.3	13.7	8.3
5/23/2016	3.4	3.3	21.5	8.3
5/31/2016	3.4	3.3	21.6	8.3
6/6/2016	<MDC	3.3	24.5	8.3
6/13/2016	<MDC	3.3	20.5	8.3
6/20/2016	3.5	3.3	26.5	8.3
6/27/2016	3.5	3.3	30.6	8.3

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Knotts Street, Springfield				
7/5/2016	<MDC	3.3	19.0	8.3
7/11/2016	<MDC	3.3	27.6	8.3
7/18/2016	<MDC	3.3	24.7	8.3
7/25/2016	<MDC	3.3	29.1	8.3
8/1/2016	<MDC	3.3	32.2	8.3
8/8/2016	<MDC	3.3	26.7	8.3
8/16/2016	<MDC	3.3	31.1	8.3
8/22/2016	<MDC	3.3	34.3	8.3
8/29/2016	3.5	3.3	22.8	8.3
9/6/2016	<MDC	3.3	28.6	8.3
9/12/2016	<MDC	3.3	17.8	8.3
9/20/2016	<MDC	3.3	38.9	8.3
9/26/2016	<MDC	3.3	58.4	8.3
10/3/2016	<MDC	3.3	14.8	8.3
10/11/2016	5.9	3.3	35.8	8.3
10/18/2016	<MDC	3.3	30.2	8.3
10/24/2016	<MDC	3.3	23.5	8.3
10/31/2016	<MDC	3.3	34.6	8.3
11/7/2016	4.3	3.3	38.0	8.3
11/14/2016	<MDC	3.3	28.6	8.3
11/21/2016	4.2	3.3	58.3	8.3
11/28/2016	<MDC	3.3	37.0	8.3
12/6/2016	<MDC	3.3	24.7	8.3
12/12/2016	4.1	3.3	30.9	8.3
12/19/2016	6.7	3.3	42.2	8.3
12/27/2016	5.7	3.3	39.7	8.3

Table C.2 Sample Results for Alpha / Beta Screening of Air Particulate Filters
Marion Background Location
Results are in femtocuries per cubic meter (fCi/m³)

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Marion Office				
1/4/2016	4.4	1.5	35.9	4.5
1/11/2016	<MDC	1.5	18.5	4.5
1/19/2016	3.6	1.5	36.8	4.5
1/25/2016	2.8	1.5	28.5	4.5
2/2/2016	1.8	1.5	30.4	4.5
2/8/2016	2.1	1.5	26	4.5
2/16/2016	<MDC	1.5	22.7	4.5
2/22/2016	1.6	1.5	26.4	4.5
2/29/2016	3.2	1.5	25	4.5
3/7/2016	2	1.5	23.7	4.5
3/14/2016	2.6	1.5	15.4	4.5
3/21/2016	<MDC	1.5	15.4	4.5
3/28/2016	2.7	1.5	18.6	4.5
4/4/2016	4.8	3	45.7	4.5
4/11/2016	2.1	1.5	17.4	4.5
4/18/2016	2.1	1.5	25.2	4.5
4/25/2016	<MDC	1.5	26.6	4.5
5/2/2016	1.6	1.5	16.2	4.5
5/16/2016	<MDC	1.5	48.1	4.5
5/23/2016	3.7	1.5	23.3	4.5
5/31/2016	3.4	1.5	23.7	4.5
6/6/2016	4.3	1.5	24.1	4.5
6/13/2016	4.6	1.5	29.2	4.5
6/20/2016	3.2	1.5	26.9	4.5
6/27/2016	2.6	1.5	30	4.5

Location	Alpha		Beta	
Date	Result	MDC	Result	MDC
Marion Office				
7/11/2016	1.9	1.5	19.1	4.5
7/18/2016	3.3	1.5	31	4.5
7/25/2016	2.6	1.5	31.4	4.5
8/1/2016	2.4	1.5	25.9	4.5
8/8/2016	<MDC	1.5	25.5	4.5
8/15/2016	<MDC	1.5	21.4	4.5
8/22/2016	<MDC	1.5	6.5	4.5
8/29/2016	2.7	1.5	24.7	4.5
9/6/2016	2.3	1.5	30	4.5
9/12/2016	1.9	1.5	20.3	4.5
9/19/2016	1.7	1.5	34	4.5
9/26/2016	1.7	1.5	53.8	4.5
10/3/2016	<MDC	1.5	18.4	4.5
10/11/2016	6.3	1.5	40.5	4.5
10/17/2016	1.6	1.5	37	4.5
10/24/2016	<MDC	1.5	23.5	4.5
10/31/2016	4.6	1.5	44.3	4.5
11/7/2016	4.1	1.5	28.5	4.5
11/14/2016	3.4	1.5	30.3	4.5
11/21/2016	4.1	1.5	51.3	4.5
11/28/2016	1.9	1.5	39.8	4.5
12/6/2016	3.9	1.5	25.7	4.5
12/12/2016	4.9	1.5	27.9	4.5
12/27/2016	4.2	1.5	35.2	4.5

Table C.3 Gamma Spectroscopy Sample Results for Soil Samples
Kincaid, IL Background Reference Area
Results are in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226		Th-230	
Date	Result	MDC	Result	MDC	Result	MDC
East Boat Dock						
4/14/2016	<MDC	1.7	1.4	0.3	<MDC	8.1
7/7/2016	<MDC	1.7	1.3	0.3	<MDC	8.1
Strawkaws Boat Ramp						
4/14/2016	<MDC	1.7	2.5	0.3	<MDC	8.1
7/7/2016	<MDC	1.7	1.1	0.3	<MDC	8.1
West Boat Ramp						
4/14/2016	<MDC	1.7	2.0	0.3	<MDC	8.1
7/7/2016	<MDC	1.7	1.7	0.3	<MDC	8.1

Table C.4 Gamma Spectroscopy Sample Results for Vegetation Samples
Kincaid, IL Background Reference Area
Results are in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226		Th-230	
Date	Result	MDC	Result	MDC	Result	MDC
East Boat Dock						
7/7/2016	<MDC	9.6	<MDC	1.5	<MDC	23
Strawkaws Boat Ramp						
7/7/2016	<MDC	9.6	<MDC	1.5	<MDC	23
West Boat Ramp						
7/7/2016	<MDC	9.6	<MDC	1.5	<MDC	23

Table C.5 Gamma Spectroscopy Sample Results for Sediment Samples
Kincaid, IL Background Reference Area
Results are in picocuries per gram (pCi/g)

Location	Pa-234m		Ra-226		Th-230	
Date	Result	MDC	Result	MDC	Result	MDC
East Boat Dock						
4/14/2016	<MDC	1.1	1.5	0.2	<MDC	2.9

Table C.6 Summary of Ambient Gamma Results
Kincaid, IL Background Reference Area

Location	Quarter 1 mR/day	Quarter 2 mR/day	Quarter 3 mR/day	Quarter 4 mR/day	Annual Exposure mR/year
KC-01	0.12	0.10	0.10	0.11	39.33
KC-02	0.11	0.09	0.12	0.11	39.60
KC-03	0.11	0.10	0.10	0.09	37.14
KC-04	0.12	0.09	0.11	0.11	38.78
KC-05	0.10	0.12	0.08	0.09	35.95
KC-06	0.09	0.08	0.07	0.09	30.20
KC-07	0.10	0.10	0.09	0.10	35.50
KC-08	0.09	0.10	0.10		35.41
KC-09	0.11	0.11	0.10	0.08	36.68
KC-10		0.11	0.10	0.10	37.84
KC-11	0.13	0.11	0.12	0.10	42.16
KC-12		0.12	0.12	0.10	40.64
KC-13	0.12	0.11	0.12	0.11	41.15
KC-14	0.12	0.12	0.10	0.10	40.88
KC-15	0.11	0.09	0.11	0.10	37.60

Blanks in the table indicate that the dosimeter was missing at the end of the quarter.
The Annual Dose column is based on averages of all available data.
Quarters estimated to be 91.25 days in length.

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