Zion
Environmental Radioactivity Survey

2017

WISCONSIN DEPARTMENT
of HEALTH SERVICES

Division of Public Health
Bureau of Environmental and Occupational Health
Radiation Protection Section

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Zion Environmental Monitoring Survey

Executive Summary

Wisconsin Stat. § 254.41 mandates the Wisconsin Department of Health Services (DHS) to conduct environmental radiation monitoring around the nuclear power facilities that affect Wisconsin. This environmental monitoring report is for the Zion nuclear generating plant, located in Zion, Illinois, for the 2017 calendar year. It provides descriptions and results of this environmental monitoring program.

The monitoring program consists of the collection of various types of samples from the air, water, and terrestrial exposure pathways, sample analysis, and interpretation of the data. The sampling program includes samples of ambient gamma radiation, surface water, soil, and vegetation collected from selected locations at planned sampling intervals.

Program Summary

For 2017, all sample results from the Zion environmental monitoring area were less than state and federal standards or guidelines.

DHS environmental monitoring programs provide an ongoing baseline of radioactivity measurements to assess any Wisconsin health concerns from the operation of nuclear power generating facilities in or near Wisconsin or other radiological incidents that may occur within Wisconsin or worldwide. These monitoring programs show the following:

- Environmental radioactivity levels have been trending downward in the time period since the 1950s-1960s atmospheric nuclear testing and such radiological incidents as the Chernobyl nuclear reactor incident of 1986.
- There were no incidents during 2017 that required additional environmental monitoring.
- There are no radioactive problems in types of food consumed in Wisconsin and no health problems related to radioactivity for Wisconsin citizens.

DHS's ongoing environmental monitoring programs will continue to provide assurances to the citizens of Wisconsin that the environment surrounding the Zion nuclear power facility and other monitoring areas will continue to be evaluated.

Zion is currently undergoing decommissioning; DHS will continue monitoring Zion throughout the entire decommissioning process. Decommissioning is expected to be completed in 2020.

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Introduction

Wisconsin Stat. § 254.41 mandates the Wisconsin Department of Health Services (DHS) to conduct environmental radiation monitoring around the nuclear power facilities that impact Wisconsin. This environmental monitoring report is for the Zion nuclear facility located in Zion, Illinois, for the 2017 calendar year. It provides descriptions and results of this environmental monitoring program.

Wisconsin DHS Zion Environmental Monitoring Sampling Program

The monitoring program consists of the collection of various types of samples from the air, water, and terrestrial exposure pathways. The sampling program includes samples of ambient gamma radiation as measured by thermoluminescent dosimeters (TLD), surface water, soil, and vegetation collected from selected locations at planned sampling intervals.

Table 1 provides a listing of presently used sampling sites. Table 2 provides a listing of samples collected, collection frequency, sites where samples are collected, number of samples collected, number of samples that were missed or analysis deviations, and a listing of the required analyses. Table 3 provides an explanation of missing samples or nonroutine sample analyses. Figure 1 provides a map showing the location of each environmental sampling site.

Program Modifications

There were no program modifications for 2017.

Laboratory Services and Quality Assurance

Analysis of the samples is performed under contract with the Wisconsin State Laboratory of Hygiene (WSLH). WSLH maintains a quality assurance program. Analytical procedures provide for routine replicate analyses to verify methods and instrument operation. Traceable sources are used daily to regularly calibrate instrumentation and conduct performance checks. Instrumentation quality control charts are maintained and available upon written request.

WSLH participates in the Environmental Resource Associates' Proficiency Testing program and has performed satisfactorily over the report period. In addition, WSLH participates in the Multi Analytical Performance Evaluation Program (MAPER) for environmental matrix analysis. Proficiency testing results are available from WSLH.

In late 2014, WSLH experienced some staffing issues that impacted their capacity. Starting in 2015 and through 2017 calendar year, monthly surface water and milk samples were sent to ATI Environmental Inc. for analysis.

Detection Limits

Detection limits, required by DHS, are expressed as a lower limit of detection (LLD). The required DHS LLD as indicated in Table 4 under the heading "LLD" is an "a priori" estimate of the capability for detecting an activity concentration by a given measurement system, procedure, and type of sample. Counting statistics of the appropriate instrument background are used to compute the LLD for each specific analysis. Using 4.66 times the standard deviation (s_b) of the instrument background, the LLD for each specific analysis is defined at the 95% Confidence Level.

The LLD for each radioisotope listed in Table 4 has been calculated from the following equation:

$$LLD = \frac{4.66\ s_b}{E * V * 2.22 * Y * S * \exp(-dt)}$$

Where:

LLD	is the "a priori" lower limit of detection as defined above, as picocuries per unit mass or volume.
s_b	is the standard deviation of the background counting rate or of the counting rate of blank sample as appropriate, as counts per minute.
E	is the counting efficiency, as counts per disintegration.
V	is the sample size in units of mass or volume.
2.22	is the number of disintegrations per minute per picocurie.
Y	is the fractional radiochemical yield, when applicable.
S	is the self-absorption correction factor.
d	is the radioactive decay constant for the particular radionuclide.
t	is the elapsed time, for environmental samples, between sample collection, or end of the sample collection period, and time of counting.

Typical values for E, V, Y and dt have been used to calculate the LLD.

Reporting of Sample Analysis Results

Results for specific analyses are reported as either a “less than” (<) value or an actual activity value The reporting of results in Table 4 under the heading “Range” and in Tables 5–9 is an “a posteriori” calculation based on the actual analysis performed using the actual sample values for E, V, Y, and dt. Typically the reported “less than” (<) results are lower than the required DHS LLD, indicating that the required DHS LLD has been met.

An actual activity value is accompanied by an uncertainty term for that analysis. The uncertainty term is a plus or minus counting uncertainty term at the 2 sigma (95%) confidence interval and is printed as (+- or $\pm$). Examples and explanations of data reporting are:

Example	Nuclide	Activity reported
1	^{137}Cs	< 10 pCi/liter
2	^{137}Cs	15 $\pm$ 3 pCi/liter

In example 1 we can be 95% confident that the sample activity, if any, is less than the LLD of 10 pCi/liter. In example 2 we can be 95% confident that the actual sample activity is greater than the LLD for that analysis and is between 12 and 18 pCi/liter.

Table 1. Wisconsin DHS Zion environmental monitoring sampling sites.

Sample site	Distance and direction (miles)	Location description
ZI-1	3.8 N	Chiwaukee Prairie
ZI-4	5.9 NW	Junction of Highway 31 and County ML.
ZI-5	3.5 N	Prairie Harbor Yacht Club
ZI-T41	4.7 NW	Junction of 122th Street and 39th Avenue
ZI-T42	3.8 N	Chiwaukee Prairie

Table 2. Sample collection summary and required analyses.

Sample Type	Collection and Frequency	Site Locations	Number of Samples Collected	Number of Samples Deviations	Required Analyses
TLD	C/Q	T41 - T42	8	0	direct exposure
Surface Water	G/A	5	1	0	GA, GB, GI, Sr, H
Vegetation	G/A	1, 4	2	0	GA, GB, GI
Soil	G/A	1, 4	2	0	GA, GB, GI

Collection type: C/ = continuous; G/ = grab

Frequency: /W = weekly; /M = monthly; /Q = quarterly; /A = annually; /BW = bi-weekly; /SA = semi-annually

Required analyses: GA = gross alpha; GB = gross beta; GI = gamma isotopic; Sr = strontium; H = tritium

Table 3. Missing sample report and listing of non-routine analyses.

Sample type	Date	Site	Explanation
No non-Routine analysis			

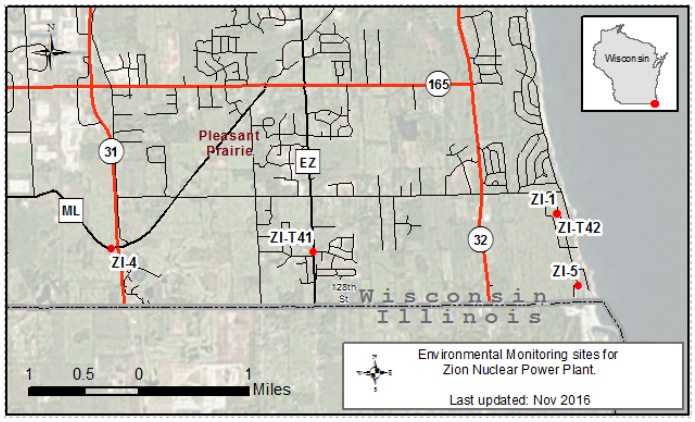

Figure 1. Wisconsin DHS environmental monitoring sites for the Zion environmental monitoring program.

Results and Discussion for the Zion Environmental Monitoring Program

Ambient Gamma Radiation—Thermoluminescent Dosimeters (TLDs)

Table 4 provides a summary of reported activities by DHS for ambient gamma radiation. Table 5 provides results from the individual sample analyses.

Ambient gamma radiation (TLD) data for 2017 from the DHS network was comparable for all sites. There were no significant differences in exposure regardless of the distance from Zion. The average quarterly exposure from the two sites located within Wisconsin was 13.3 $\pm$ 2.3 milliroentgens. The average yearly exposure was at background levels and was comparable to other areas within Wisconsin. Ambient gamma radiation was not influenced by the Zion decommissioning.

Surface Water

Table 4 provides a summary of reported activities by DHS for surface water samples. Table 7 provides results from the individual sample analyses. During this reporting period, samples were sent to ATI Environmental Inc. Midwest Laboratory as a result of WSLH's inability to analyze strontium.

The average yearly exposure was at background levels and was comparable to data from previous years. The surface water samples uniformly show activities below state or federal standards. Influence by the Zion facility is not evident from surface water sample analysis.

Vegetation

Table 4 provides a summary of reported activities by DHS for vegetation samples. Table 6 provides results from individual sample analyses.

The gamma isotopic analysis detected concentrations above the LLD of naturally occurring beryilium-7 (^{7}Be) and potassium-40 (^{40}K) at sites ZI-1 and ZI-4. Influence by the Zion facility is not evident from vegetation sample analysis. All samples with values above the LLD were below state or federal standards. All other gamma emitting isotopes measured below detection levels.

Soil

Table 4 provides a summary of reported activities by DHS for soil samples. Table 6 provides results from individual sample analyses.

Gross beta concentration at site ZI-1 was above the LLD. The gamma isotopic analysis detected naturally occurring radioisotope potassium-40 (^{40}K) was above the LLD. The reported activities for cesium-137 (^{137}Cs) were also detected in previous years and are attributable to fallout from previous atmospheric nuclear tests. Naturally occurring radioisotopes from the uranium-238 (^{238}U), and thorium-232 (^{232}Th) decay series are commonly detected but have not been quantified or reported. Influence by the Zion facility is not evident from soil sample analysis.

Dose to an Average Individual

Federal regulations 10 CFR 20, 10 CFR 50 Appendix I and 40 CFR 190 restrict the annual exposure of the population from all parts of the nuclear fuel cycle, including nuclear power plants. Doses resulting from gaseous and liquid effluent releases from the Zion facility are less than the limits as stated in these federal regulations.

DHS limits for permissible levels of radiation exposure from external sources in unrestricted areas are defined in Wis. Admin. Code § DHS 157.23. Doses resulting from gaseous and liquid effluent releases from the Zion facility are less than the limits stated in Wis. Admin. Code § DHS 157.23.

References

Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors, NUREG-1301, Generic Letter 89-01, Supplement No. 1, April 1991.

Wisconsin Admin. Code § DHS 157.23

U.S. Environmental Protection Agency (EPA), Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11, EPA-520/1-88-020, (Office of Radiation Programs Washington, DC), September 1988.

U.S. Environmental Protection Agency, Environmental Radiation Requirements for Normal Operations of Activities in the Uranium Fuel Cycle, EPA 520/4-76-016, 40 CFR Part 190, November 1976.

U.S. Nuclear Regulatory Commission, Title 10, Part 20.

U.S. Nuclear Regulatory Commission, Title 10, Part 50, Appendix I.

Sample Activity Summary

Table 4. Sample activity summary for the Wisconsin DHS Zion environmental monitoring program for 2017.

Sample type (units)	LLD	Number of samples [a]	Analysis	Range
Ambient gamma (mR/Std Qtr)	1.0 [b]	8 / 8	ambient gamma	10.3 – 16.8
Vegetation (pCi/kg wet)	5000	2 / 0	Gross Alpha	< 2560
	4000	2 / 2	Gross Beta	4840 - 6820
	350	2 / 0	Barium 140	< 94
	600	2 / 2	Beryllium 7	692 - 1360
	80	2 / 0	Cesium 134	< 12
	90	2 / 0	Cesium 137	< 13
	100	2 / 0	Cobalt 58	< 12
	100	2 / 0	Cobalt 60	< 15
	80	2 / 0	Iodine 131	< 41
	200	2 / 0	Iron 59	< 30
	100	2 / 0	Lanthanum 140	< 22
	90	2 / 0	Manganese 54	< 12
	100	2 / 0	Niobium 95	< 14
	2000	2 / 2	Potassium 40	5000 - 5020
	250	2 / 0	Zinc 65	< 27
	200	2 / 0	Zirconium 95	< 21
Surface water (pCi/liter)	3.0	1 / 0	Gross Alpha	< 1.6
	3.0	1 / 0	Gross Alpha Sus Sol	< 0.6
	3.0	1 / 0	Gross Beta	< 2.9
	3.0	1 / 0	Gross Beta Sus Sol	< 0.8
	300	1 / 0	H-3	< 206
	2.0	1 / 0	Sr-89	< 0.23
	1.0	1 / 0	Sr-90	0.27
			gamma isotopic	
	15	1 / 0	Mn-54	< 7.21
	15	1 / 0	Co-58	< 6.48
	30	1 / 0	Fe-59	< 15.0
	15	1 / 0	Co-60	< 8.28
	30	1 / 0	Zn-65	< 17.4
	15	1 / 0	Nb-95	< 6.29
	30	1 / 0	Zr-95	< 13.0
	15	1 / 0	I-131	< 11.3
	15	1 / 0	Cs-134	< 7.03
	15	1 / 0	Cs-137	< 8.55
	60	1 / 0	Ba-140	< 29.5
	15	1 / 0	La-140	< 12.8

Table 4 (cont'd). Sample activity summary for the Wisconsin DHS Zion environmental monitoring program for 2017.

Sample type (units)	LLD	Number of samples [a]	Analysis	Range
Soil (pCi/kg dry)	6000	2 / 2	Gross Alpha	7540 - 13700
	10000	2 / 2	Gross Beta	12000 - 22700
		0 / 0	gamma isotopic	< 0
	80	2 / 0	Cesium 134	< 30
	80	2 / 2	Cesium 137	101 - 250
	90	2 / 0	Cobalt 58	< 56
	90	2 / 0	Cobalt 60	< 30
	600	2 / 0	Iron 59	< 168
	60	2 / 0	Manganese 54	< 39
	100	2 / 0	Niobium 95	< 98
	800	2 / 2	Potassium 40	8500 - 19500
	300	2 / 0	Zinc 65	< 88
	250	2 / 0	Zirconium 95	< 115

a - Number of analyses / number of analyses detected above the WI DHS LLD.
b - 1.0 mR/TLD
c - Sample was more than six months old, too old to run Gross alpha/beta

Table 5. Wisconsin DHS TLD network for the Zion environmental monitoring program.

	1st quarter	2nd quarter	3rd quarter	4th quarter
Date Placed:	01/10/17	04/11/17	07/19/17	10/18/17
Date Removed:	04/11/17	07/19/17	07/19/17	01/16/18
Days in the Field:	91	99	91	90

Individual quarterly date is reported as: mR / Standard Quarter + 2 sigma counting error.

T-41	14.7 +- 1.0	13.8 +- 1.0	14.7 +- 0.9	16.8 +- 1.2
T-42	11.1 +- 0.7	10.3 +- 0.8	11.0 +- 0.6	13.9 +- 1.4

Table 6. Wisconsin DHS analysis results for vegetation and soil samples collected for the Zion environmental monitoring program.

	Vegetation pCi/kilogram (wet)			Soil pCi/kilogram (dry)	
Site:	**ZI-1**	**ZI-4**		**ZI-1**	**ZI-4**
Collection date:	05/30/17	05/30/17	Collection date:	5/30/2017	5/30/2017
gross alpha	< 1360	< 2560	Gross Alpha	7540 ± 3020	13700 ± 3850
gross beta	6820 ± 502	4840 ± 538	Gross Beta	12000 ± 1110	22700 ± 1440
gamma isotopic			gamma isotopic		
Barium 140	< 94.2	< 75.9	Cesium 134	< 22.1	< 29.8
Beryllium 7	1360 ± 152	692 ± 108	Cesium 137	250 ± 31.3	101 ± 18.7
Cesium 134	< 12.1	< 12.4	Cobalt 58	< 32.5	< 55.7
Cesium 137	< 12.6	< 11.1	Cobalt 60	< 21.9	< 29.5
Cobalt 58	< 12.1	< 11.2	Iron 59	< 121	< 168
Cobalt 60	< 15.4	< 14.2	Manganese 54	< 20.8	< 38.5
Iodine 131	< 41.4	< 36	Niobium 95	< 66.3	< 97.8
Iron 59	< 29.7	< 29.9	Potassium 40	8500 ± 1480	19500 ± 3230
Lanthanum 140	< 21.6	< 21.9	Zinc 65	< 66.9	< 87.5
Manganese 54	< 12	< 9.78	Zirconium 95	< 71.6	< 115
Niobium 95	< 13.3	< 13.5			
Potassium 40	5000 ± 910	5020 ± 914			
Zinc 65	< 27.2	< 26.1			
Zirconium 95	< 20.2	< 20.7			

Soil: Naturally occurring radioisotopes such as radium-226 (^{226}Ra), bismuth-214 (^{214}Bi), lead-214 (^{214}Pb), actinium-228 (^{228}Ac), bismuth-212 (^{212}Bi), lead-212 (^{212}Pb) from the naturally occurring uranium-238 (^{238}U), and thorium-232 (^{232}Th) decay series are commonly detected but have not been quantified or reported.

Radioisotopes other than those reported were not detected

Table 7. Wisconsin DHS analysis results for surface water samples collected for the Zion environmental monitoring program.

Measurements in units of pCi/liter

Site ZI-5	
Collection date:	05/30/17
Gross Alpha	< 1.6
Gross Alpha Sus Sol	< 0.6
Gross Beta	< 2.9
Gross Beta Sus Sol	< 0.8
Tritium	< 206
Strontium 89	< 0.2
Strontium 90	0.27 ± 0.1
gamma isotopic	
Barium 140	< 30
Cesium 134	< 7
Cesium 137	< 9
Cobalt 58	< 7
Cobalt 60	< 8
Iodine 131	< 11
Iron 59	< 15
Lanthanum 140	< 13
Manganese 54	< 7
Niobium 95	< 6
Zinc 65	< 17
Zirconium 95	< 13

Radioisotopes other than those reported were not detected.

Appendices

Appendix A—Radionuclide Concentration Levels needing review by state radiological coordinator (SRC)

Should radioactivity concentrations exceed SRC review levels for a given radionuclide, the SRC will be consulted for review and assessment.

Medium	Radionuclide	SRC Review Level [a]
Water (pCi/l)	Gross Alpha	10
	Gross Beta	30
	H-3	10,000
	Mn-54	100
	Fe-59	40
	Co-58	100
	Co-60	30
	Zr-Nb-95	40
	Cs-134	10
	Cs-137	20
	Ba-La-140	100
	Sr-89	8
	Sr-90	8
	Zn-65	30
Vegetation (pCi/kg wet)	Gross Beta	30,000
	I-131	100
	Cs-134	200
	Cs-137	200
	Sr-89	1,000
	Sr-90	1,000
Soil, Bottom Sediment (pCi/kg)	Gross Beta	5,000
	Cs-134	5,000
	Cs-137	5,000
	Sr-89	5,000
	Sr-90	5,000

Radionuclides will be monitored by the Wisconsin Department of Health Services, Radiation Protection Sections, Environmental Monitoring program and concentrations above the listed levels will be reported to the Wisconsin state radiological coordinator (SRC) for further review and assessment.

Appendix B—Sample Point Locations

The sample point locations.

Sample Point	Location Description
ZI-1	Chiwaukee Prairie.
ZI-4	Junction of Highway 31 and County ML.
ZI-5	Prairie Harbor Yacht Club
ZI-T41	Junction of 122th Street and 39th Avenue
ZI-T42	Chiwaukee Prairie.