

Kansas Department of Health and Environment
Report of Radiological Environmental Monitoring of the Environs Surrounding
Wolf Creek Generating Station



July 2012-June 2013
Division of Public Health, Bureau of Environmental Health
Radiation and Asbestos Control Section
1000 SW Jackson St., Suite 330
Topeka, Kansas 66612-1365

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 Environmental Radiation Surveillance Report
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Introduction

Wolf Creek Generating Station (WCGS) is a pressurized water nuclear reactor capable of producing over 1,200 megawatts of electrical power. Located near Burlington Kansas, the plant is operated by Wolf Creek Nuclear Operating Corporation (WCNOC). The facility releases radioactive material to the environment in the form of liquid and gaseous effluents. This report details the results of surveillance of the environs surrounding WCGS conducted by the Kansas Department of Health and Environment (KDHE) from July 1, 2012 through June 30, 2013.

KDHE's Wolf Creek Environmental Radiation Surveillance (ERS) program began in 1979 in accordance with Kansas Administrative Regulation (K.A.R.) 28-19-81 with the initial selection of surface water sampling locations. The ERS program parallels (and partially overlaps) the WCNOC Radiological Environmental Monitoring Program (REMP).

The purpose of the ERS program is to detect, identify, and measure radioactive material and direct radiation released to the environment from the operation of WCGS. Data indicating the release of elevated levels of radioactive material will be used to determine the need for corrective and/or protective actions to protect the health and safety of the public.

The ERS program includes the following monitoring methods:

- Measurement of ambient external radiation levels using optically stimulated luminescence dosimeters
- Monitoring of radionuclides present in ambient air through weekly collection and laboratory analysis of continuous air samples
- Monitoring of radionuclides present in water, terrestrial vegetation, aquatic vegetation, fish, sediments, and soil through scheduled and random sample collection and laboratory analysis.

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Results Summary

The most significant radionuclide present in surface water samples collected in the Coffey County Lake is tritium (^3H), a beta emitter. The highest ^3H concentration measured in the Coffey County Lake during SFY 2013 was 15,394 pCi/l in February, 2013. This maximum Coffey County Lake ^3H concentration is 77% of the National Primary Drinking Regulation maximum contaminant level (MCL) of 20,000 pCi/l. *The water from the Coffey County Lake is not used as a drinking water source.* The average CCL surface water ^3H concentration for SFY 2013 was 12,171 pCi/l, or 61% of MCL. Coffey County Lake is not approved for any aquatic recreation other than fishing. All other non-CCL surface water and offsite ground water samples collected in the environs of WCGS during SFY 2013 indicated no radionuclides present attributable to the operation of WCGS.

Aquatic vegetation samples are the best indicators for monitoring the seasonal fluctuations of fission and activation product levels in the Coffey County Lake. No aquatic vegetation sample showed any nuclides attributable to WCGS operation. Five trending samples and six random samples were analyzed.

Sediment samples have been excellent indicators for the long-term buildup of fission and activation product activity levels in the Coffey County Lake. The highest fission product activity in sediments during SFY 2013 was 205 pCi/kg-dry ^{137}Cs in a shoreline sediment sample from the John Redmond Reservoir control location.

Airborne sample analysis indicated that no radionuclides attributable to the operation of WCGS were present above the lower limits of detection during SFY 2013.

Sample analysis of aquatic vegetation, offsite ground water, sediments, terrestrial vegetation, soil, milk, grain, and vegetable samples collected in the environs of WCGS during SFY 2013 indicated no radionuclides present attributable to the operation of WCGS.

Samples of eight species of fish were taken from the Coffey County Lake during SFY 2013. Sample analysis of edible fish portions collected in the environs of WCGS during SFY 2013 indicated that no gamma emitters attributable to WCGS operation were present. The highest ^3H concentration in tissue was 8,852 pCi/kg-wet found in a channel catfish sample taken from the CCL. Using an ICRP 30 dose conversion factor for ingestion ($h_{E,50}$) of 6.40×10^{-8} mrem per pCi ^3H ingested, a standard man consuming 21 kg/y of fish containing 8,852 pCi/kg ^3H would receive a committed effective dose equivalent of 0.01 mrem. The projected dose equivalent is far below the 100 mrem/yr regulatory limit for a member of the public.

Data from direct radiation monitoring sites revealed no significant changes from preoperational data. The lowest direct radiation levels are found closest to the WCGS. The direct radiation levels on the Coffey County Lake baffle dikes at the 1,200 m exclusion area boundary are the

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lowest of any monitored site. The limestone used to construct the baffle dikes has a lower natural background radioactivity than the original soil present before the construction of the Coffey County Lake. This effect of construction on the terrestrial component of natural background radiation was noted on radiation surveys conducted around the WCGS site before bringing the initial fuel load on the site. The water from the Coffey County Lake also acts as an effective shield from terrestrial radiation that was present before Coffey County Lake filling.

The ratio of KDHE results to WCNOG results ranged from 1.0-1.5. A summary of comparison data may be found in the Results Comparison Table.

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Results Summary Table

Type of Sample	Number of Sampling Stations	Total Samples Collected
Air (particulate and iodine)	5	520
Soil	5	5
Random Soil	10	10
Direct Radiation	31	248
Surface Water	5	39
Offsite Ground Water	6	24
Onsite Ground Water	4	11
Sediments	6	12
Random Sediments	17	17
Aquatic Vegetation	5	5
Random Aquatic Vegetation	6	6
Milk	2	8
Fish	2	15
Game Animals/Domestic Meat	0	1
Terrestrial Vegetation	8	8
Random Terrestrial Vegetation	10	11
Total	122	940

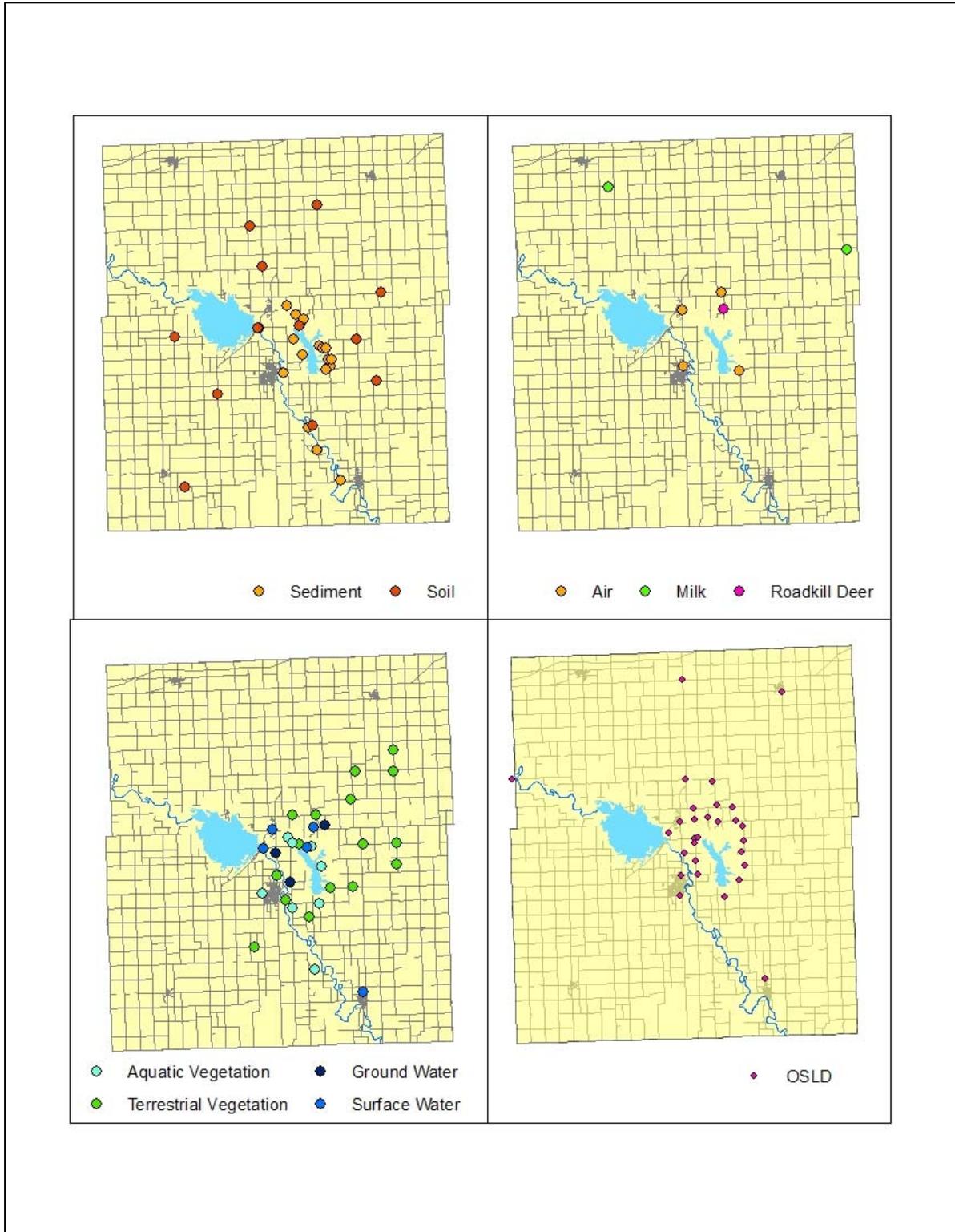
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Results Comparison Table

Description	Average	Standard Deviation	Minimum	Maximum	N
OSLD direct radiation, mR per 90 day quarter	17.8	2.8	11.5	23.1	248
Airborne particulate and radioiodine cartridge gamma isotopic analysis (⁷ Be) pCi/m ³	0.12	0.07	<0.02	0.519	260
Coffey County Lake Surface Water tritium (³ H), pCi/l (Spillway/MUDS)	12171	1161	10938	15394	24
John Redmond Reservoir, control (N-1) (³ H), pCi/l	<350	NA	NA	NA	12
Coffey County Lake (Spillway) (³ H), pCi/l	12111	1133	10962	14125	12
Coffey County Lake MUDS (³ H), pCi/l	12232	1234	10938	15394	12
Neosho River Near LeRoy (³ H), pCi/l	<350	NA	NA	NA	2
New Strawn City Lake (³ H), pCi/l	<350	NA	NA	NA	1
Offsite ground water tritium (³ H), pCi/l (All Stations)	<350	NA	NA	NA	24
Onsite ground water tritium (³ H), pCi/l (Stations where activity was detected)	1619	850	508	3084	11
Surface and Ground Water Gamma Isotopic Analysis	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any surface water or ground water sample evaluated.				
Gamma isotopic analysis of soil, pasturage, garden vegetables, and grain.	Gamma isotopic analysis indicated that no gamma emitters attributable to Wolf Creek Generating Station operation were present above the lower limits of detection in any soil, milk, pasturage, garden vegetable and grain sample evaluated.				
Maximum activity attributable to Wolf Creek Generating Station operation, pCi/kg					
Coffey County Lake fish, wet	8,663 pCi/kg ³ H, 5/21/2013				
Comparison Of KDHE and WCNOG Results					
Analysis	Average Ratio of KDHE results to WCNOG results		Comments		
OSLD Direct Radiation	1.0		12 Collocated Sites Coffey County Lake Spillway Comparison of ⁴⁰ K results 2 Fish from CCL		
Surface Water ³ H	1.04				
Sediment gamma isotopic	1.5				
Fish tritium (³ H)	1.1				

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Sample Location Maps



Sample Results

Inhalation Pathway

Air Particulate and Iodine

Air samples were collected weekly. Five air-sampling sites, four of which are collocated with WCNOG, have continuously operating low-volume air samplers contained in a fiberglass housing mounted on utility poles approximately one meter from the ground. Air samplers are located at Sharpe, KS (A-1), east of the Coffey County Lake dam (H-1), Burlington, KS (L-1), New Strawn, KS (P-1), and near Westphalia, KS (D-2). The collocated sites include the highest calculated annual average ground level relative concentration (X/Q) area at Sharpe, the highest calculated annual average ground level relative deposition (D/Q) area at New Strawn, and a control location near Westphalia. An average flow rate of 30 liters per minute is used with 47 mm diameter glass fiber particulate filters and 5 percent triethylenediamine (TEDA) impregnated carbon cartridges for radioiodine activity (the major isotope of concern is ^{131}I). TEDA binds the iodine chemically and reduces losses from desorption.

Field assay of each particulate filter was performed at the time of collection. The particulate filter was counted using a thin window GM 'pancake' detector (Ludlum Model 44-40 or equivalent) and a count rate instrument. A sample net count rate of greater than two times the net count rate of the current control (Near Westphalia, D-2) air sample indicates a potential anomaly and the filter is then flagged for individual gamma isotopic analysis.

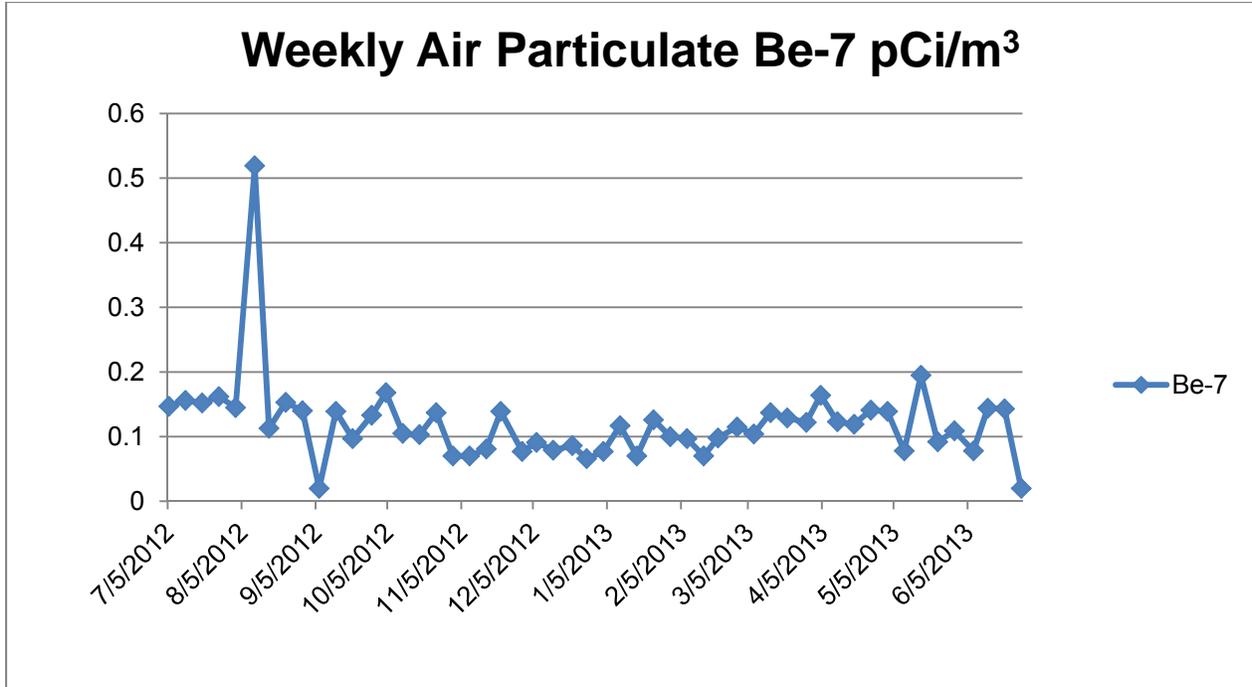
Gamma isotopic analysis was performed on two composite samples, one composed of the five particulate filters and the other of the five charcoal cartridges. Indication of ^{131}I or any other fission or activation product requires gamma isotopic analysis of each individual particulate filter and associated charcoal cartridge.

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Table 1, Weekly air particulate/iodine monitoring, pCi/m³

Number of Samples	Average ⁷ Be Concentration	Average Iodine Concentration
260	0.12	<0.33

Graph 1, Weekly Particulate ⁷Be Concentration, pCi/m³



Airborne Pathway

Soil

Four indicator, one control, and ten random annual soil samples were collected. Indicator soil samples were collected near Stringtown Cemetery, east of the CCL dam, at the CCL MUDS area, and at the public environmental education area. One control soil sample was collected east of WCGS at the Scott Valley Church. Random soil samples were collected at ten locations within the ten mile zone around WCGS. Soil samples collected from the Coffey County public use areas are split with WCNOG.

A gamma isotopic analysis is performed on all soil samples collected.

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Table 2, Annual Samples for Radionuclide Deposition on Soil, pCi/kg KDHE (WCNOC)

Nuclide	A-1	E-1	H-1
	Near Stringtown Cemetery	Scott Valley Church (control)	East of CCL Dam
Date	10/3/2012	12/13/2012	3/9/2013
¹³⁷ Cs	242 ± 8	240 ± 8	273 ± 9
⁴⁰ K	12600 ± 374	11100 ± 333	14100 ± 500
	P-1 (MUDS)	R-1 (EEA)	
Date	1/23/2013	1/23/2013	
¹³⁷ Cs	133 ± 5 (148.3 ± 39.1)	171 ± 6 (173.8 ± 29.5)	
⁴⁰ K	12600 ± 600.9 (11641.0 ± 718.7)	10000 ± 500 (8935.2 ± 626.4)	

Table 3, Random Samples for Radionuclide Deposition on Soil, pCi/kg

Location	Date	Nuclide	
		¹³⁷ Cs	⁴⁰ K
Near 19th and Lynx RD	8/30/2012	219 ± 7	18300 ± 536
Field Near Fauna RD and 14th LN	10/3/2012	221 ± 8	13800 ± 423
Between 23rd and 24th RD on Planter RD	10/16/2012	12 ± 5	17600 ± 785
Near 10th and Iris RD	11/26/2012	239 ± 19	13800 ± 619
Near 17th and Trefoil RD	11/29/2012	241 ± 15	7380 ± 369
Field off Trefoil on 11th RD	1/23/2013	323 ± 11	12900 ± 600
8th RD and Oxen Lane	2/19/2013	284 ± 15	16200 ± 800
Field Near 14th RD and Fauna LN	4/17/2013	46 ± 2	11900 ± 531
14th and Shetland RD	6/11/2013	136 ± 5	11900 ± 400
22nd RD Between Kafir and Lynx RD	6/26/2013	30.5 ± 2	13200 ± 400

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Direct Radiation Pathway

Direct Radiation Monitoring

Direct radiation monitoring was accomplished using Landauer Luxel optically stimulated luminescence dosimeters (OSLDs). OSLDs are read by Landauer. OSLD readings are corrected for transit and handling exposure.

Thirty-one locations around the WCGS were monitored by KDHE, including three control locations greater than ten miles from WCGS. Two OSLDs were used per site to generate an average quarterly reading. The dosimeters are contained in specially constructed holders suspended approximately one meter above the ground. Staff members exchange OSLDs quarterly. KDHE has collocated OSLDs with WCNOG at twelve sites.

Table 4, Quarterly Direct Radiation Monitoring, mR/Standardized 90-day Qtr.

Location	Quarter 1	Quarter 2	Quarter 3	Quarter 4
1. A-1 (1), North of WCGS	17.1	23.1	17.5	20.7
2. A-2, Sharpe	17.1	23.1	15.5	17.7
3. A-3, Forward Staging Area	16.6	19.6	15.0	18.2
4. B-1, East Sharpe	18.6	22.1	16.5	20.7
5. B-2, Waverly Control	17.1	22.1	15.5	19.2
6. C-1, near residence	16.1	22.6	16.0	18.2
7. D-1 (9), near residence	16.1	21.1	14.5	18.7
8. E-1, near residence	18.1	22.1	16.5	18.7
9. F-1, near residence	18.1	22.1	17.0	20.2
10. G-1 (14), WCNOG gate	15.1	22.6	17.0	20.7
11. H-0 (42), CCL baffle dike A	13.6	17.1	11.5	13.7
12. H-1, east of CCL dam	15.1	21.6	14.5	18.7
13. H-2, LeRoy control	15.1	21.6	15.0	17.7
14. J-1, near residence	12.1	19.6	15.0	17.7
15. K-1 (29), near residence	16.1	17.1	13.5	17.2
16. L-1 (27), near residence	16.1	22.6	17.0	21.2
17. L-2, Burlington	16.1	20.6	15.5	19.2
18. L-3, Coffey County Shop	14.6	19.6	14.5	16.7
19. M-1 (26), near residence	17.1	20.6	14.5	17.2
20. N-1, near pasture	15.1	23.1	16.0	18.7
21. P-0 (43), CCL baffle dike B	13.1	16.6	12.0	14.2
22. P-1, New Strawn	15.6	20.6	15.5	20.7
23. P-2, Hartford Control	15.1	18.6	14.0	16.7
24. P-3, CCL entrance	15.6	22.1	16.5	19.7
25. P-4 (46), CCL near MUDS	16.1	21.6	16.0	19.2
26. P-5, JRR public use area	15.6	21.1	15.0	18.2
27. Q-1, near residence	18.1	21.1	16.0	18.7
28. R-0 (41), Stringtown cemetery	16.1	23.1	16.0	19.7
29. R-1 (37), near residence	17.6	21.6	15.0	18.7
30. R-2 (44), CCL EEA	17.1	21.6	15.5	18.7
31. R-3, near Coffey County Airport	23.1	22.6	15.5	20.7

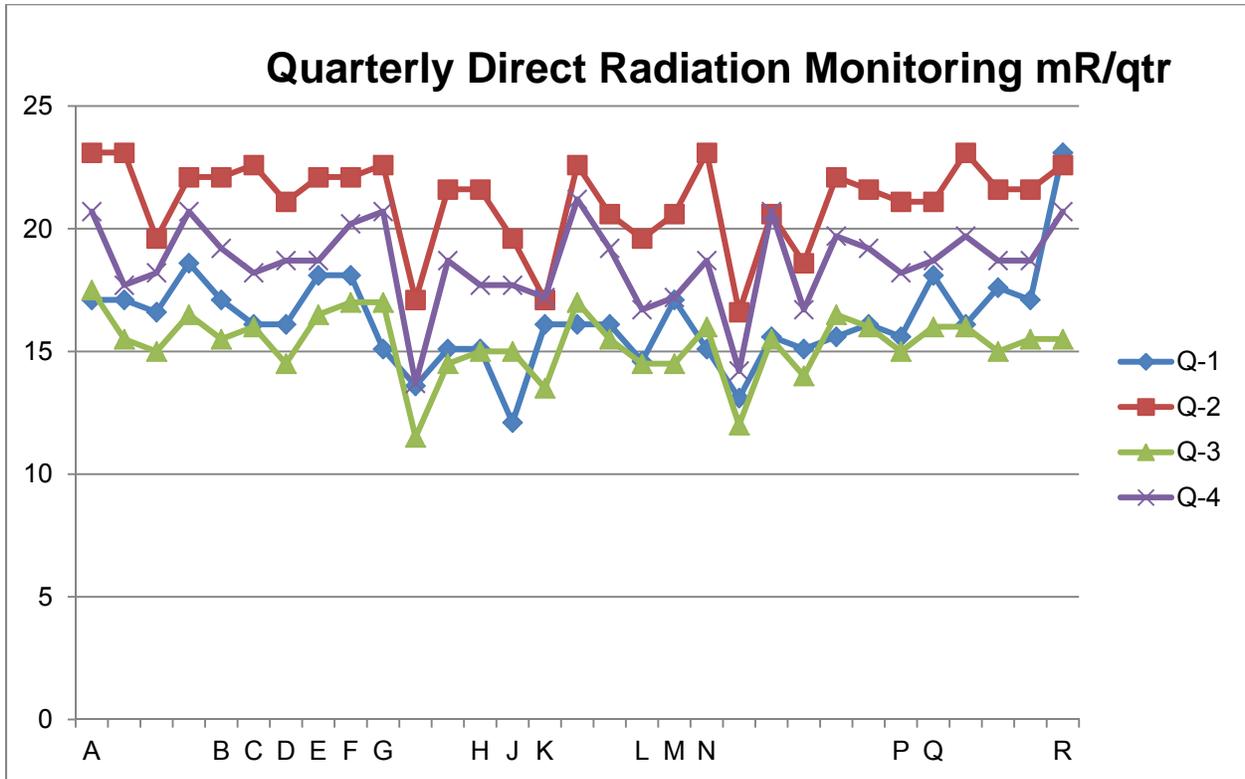
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Table 5, Quarterly Collocated Direct Radiation Monitoring, mR/Standardized 90-day Qtr.

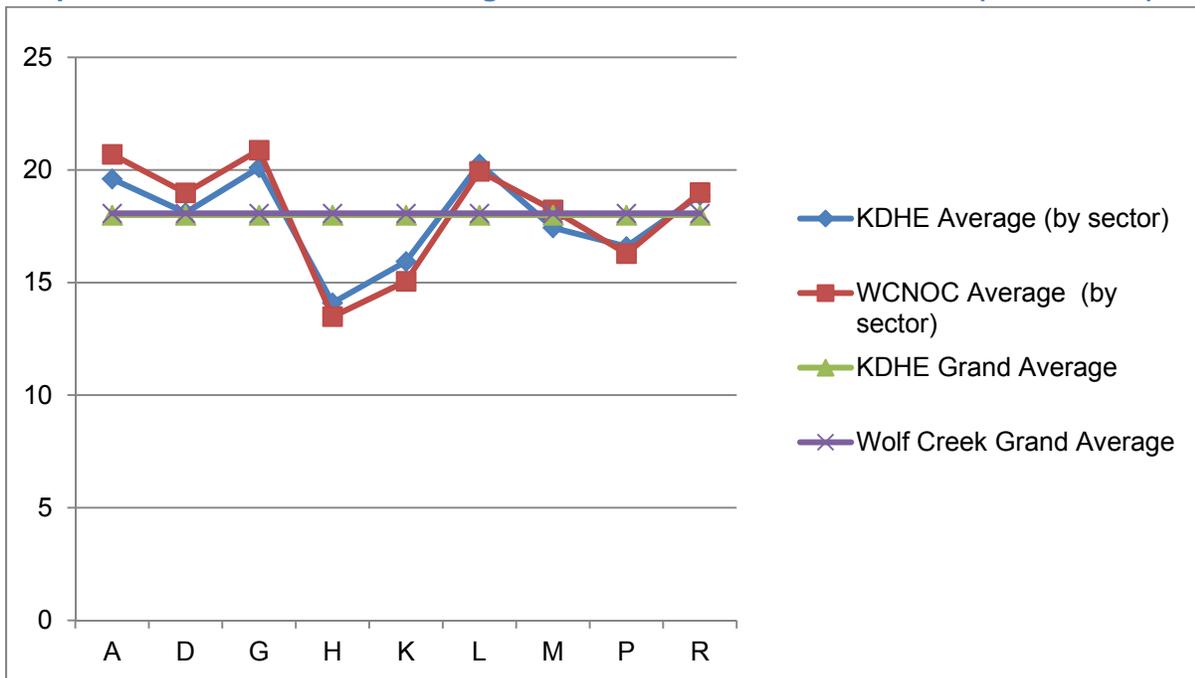
Location KDHE(WCNOG)	KDHE Monitoring Period	KDHE	WCNOG
1. A-1 (1)	7/3/2012-10/9/2012	17.1	23.7
	10/9/2012-1/16/2013	23.1	20.4
	1/16/2013-4/9/2013	17.5	19.1
	4/9/2013-7/11/2013	20.7	19.6
2. D-1 (9)	7/3/2012-10/9/2012	16.1	19.6
	10/9/2012-1/16/2013	21.1	18.6
	1/16/2013-4/9/2013	14.5	18.5
	4/9/2013-7/11/2013	18.7	19.2
3. G-1 (14)	7/3/2012-10/9/2012	15.1	24.4
	10/9/2012-1/16/2013	22.6	21.6
	1/16/2013-4/9/2013	17.0	17.5
	4/9/2013-7/11/2013	20.7	20.1
4. H-0 (42)	7/3/2012-10/9/2012	13.6	13.5
	10/9/2012-1/16/2013	17.1	14.7
	1/16/2013-4/9/2013	11.5	13.0
	4/9/2013-7/11/2013	13.7	12.7
5. K-1 (29)	7/3/2012-10/9/2012	16.1	16.6
	10/9/2012-1/16/2013	17.1	14.8
	1/16/2013-4/9/2013	13.5	14.8
	4/9/2013-7/11/2013	17.2	14.0
6. L-1 (27)	7/3/2012-10/9/2012	16.1	21.6
	10/9/2012-1/16/2013	22.6	19.8
	1/16/2013-4/9/2013	17.0	19.2
	4/9/2013-7/11/2013	21.2	19.2
7. M-1 (26)	7/3/2012-10/9/2012	17.1	21.0
	10/9/2012-1/16/2013	20.6	16.9
	1/16/2013-4/9/2013	14.5	18.3
	4/9/2013-7/11/2013	17.2	16.6
8. P-0 (43)	7/3/2012-10/9/2012	13.1	14.3
	10/9/2012-1/16/2013	16.6	13.2
	1/16/2013-4/9/2013	12.0	12.4
	4/9/2013-7/11/2013	14.2	12.8
9. P-4 (46)	7/3/2012-10/9/2012	16.1	22.0
	10/9/2012-1/16/2013	21.6	18.1
	1/16/2013-4/9/2013	16.0	18.3
	4/9/2013-7/11/2013	19.2	19.2
10. R-0 (41)	7/3/2012-10/9/2012	16.1	22.6
	10/9/2012-1/16/2013	23.1	18.4
	1/16/2013-4/9/2013	16.0	18.4
	4/9/2013-7/11/2013	19.7	20.6
11. R-1 (37)	7/3/2012-10/9/2012	17.6	18.5
	10/9/2012-1/16/2013	21.6	20.1
	1/16/2013-4/9/2013	15.0	17.3
	4/9/2013-7/11/2013	18.7	16.6
12. R-2 (44)	7/3/2012-10/9/2012	17.1	20.4
	10/9/2012-1/16/2013	21.6	18.6
	1/16/2013-4/9/2013	15.5	15.9
	4/9/2013-7/11/2013	18.7	20.5

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Graph 2, Quarterly direct radiation results for KDHE OSLD sites

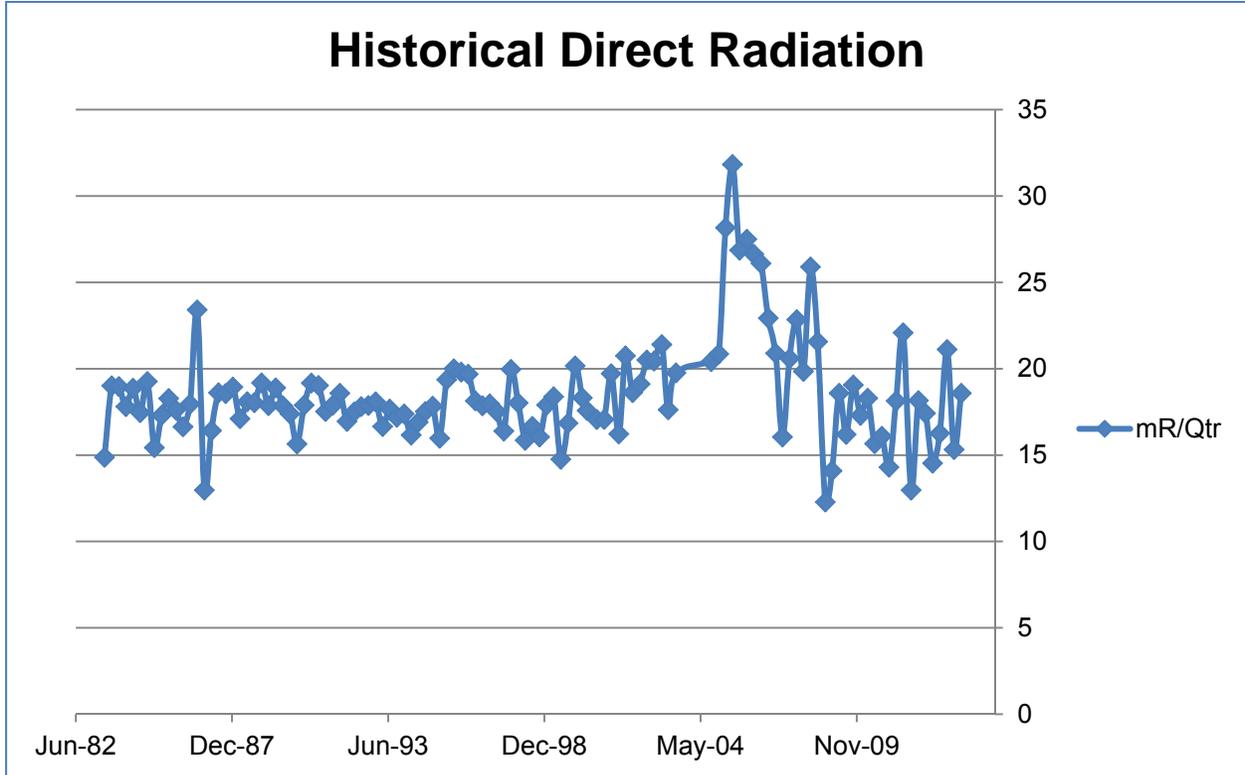


Graph 3 Direct radiation monitoring results for co-located OSLD sites (mR/Quarter)



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Graph 4 Historical KDHE direct radiation monitoring results (mR/qtr)



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Waterborne Pathway

Surface Water

Surface water sampling was accomplished through the collection of one-gallon grab samples at the indicated locations. A control sample was collected monthly from John Redmond Reservoir. One sample was collected monthly from the Coffey County Lake (CCL) at the spillway. One sample was collected monthly at the public fishing area on CCL, near the Makeup Discharge Structure (MUDS). Samples were collected monthly from the Neosho River near Leroy only when Coffey County Lake was overflowing to Wolf Creek at the spillway. Discharges to the river occurred during May and June of 2013. A sample was also collected annually from the New Strawn City Lake.

A gamma isotopic and tritium (^3H) analysis was done on each CCL water sample and ^3H analysis was done quarterly on a composite sample from JRR. Samples from John Redmond Reservoir and the Coffey County Lake Spillway were split with WCNOC.

Table 6 Monthly samples for waterborne radionuclides (^3H) in surface water, pCi/L

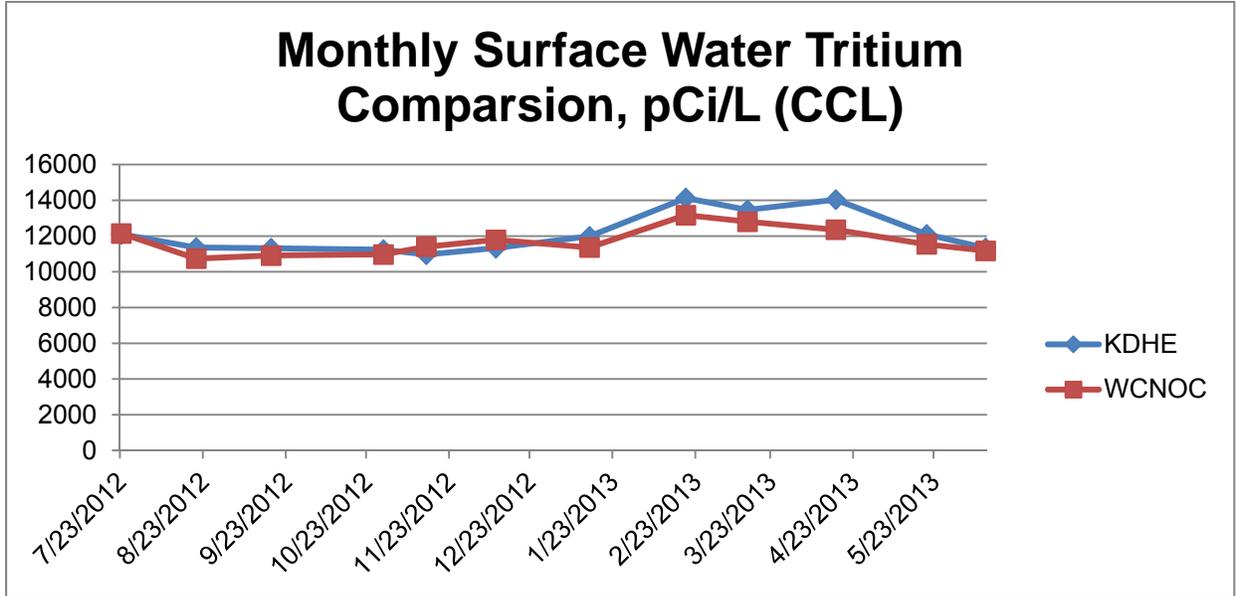
CCL Spillway			John Redmond Reservoir (Control)			MUDS	
Date	KDHE	WCNOC	Date	KDHE	WCNOC	Date	KDHE
7/23/2012	12102 ± 338	12145 ± 331	7/23/2012	<350	<156	7/19/2012	12351 ± 338
8/20/2012	11357 ± 317	10735 ± 308	8/20/2012	<350	<150	8/20/2012	11510 ± 318
9/17/2012	11315 ± 336	10909 ± 311	9/17/2012	<350	<154	9/17/2012	10938 ± 332
10/29/2012	11231 ± 324	10971 ± 312	10/29/2012	<350	<151	10/15/2012	11242 ± 323
11/14/2012	10962 ± 317	11404 ± 297	11/14/2012	<350	<142	11/14/2012	12322 ± 339
12/10/2012	11326 ± 325	11791 ± 317	12/10/2012	<350	<150	12/10/2012	11151 ± 323
1/14/2013	11985 ± 319	11358 ± 305	1/14/2013	<350	<138	1/14/2013	12713 ± 326
2/19/2013	14125 ± 151	13170 ± 324	2/19/2013	<350	<143	2/14/2013	15394 ± 351
3/14/2013	13464 ± 343	12805 ± 328	3/14/2013	<350	<145	3/19/2013	13185 ± 339
4/16/2013	14037 ± 492	12354 ± 320	4/16/2013	<350	<145	4/11/2013	12021 ± 327
5/20/2013	12094 ± 326	11536 ± 306	5/20/2013	<350	<145	5/16/2013	12714 ± 333
6/11/2013	11333 ± 324	11175 ± 305	6/11/2013	<350	<142	6/11/2013	11243 ± 319
H-1 Neosho River Near Leroy, KDHE							
Date							
5/30/2013	<350						
6/28/2013	<350						

Table 7 Annual samples for deposition of airborne radionuclides in surface water, pCi/L

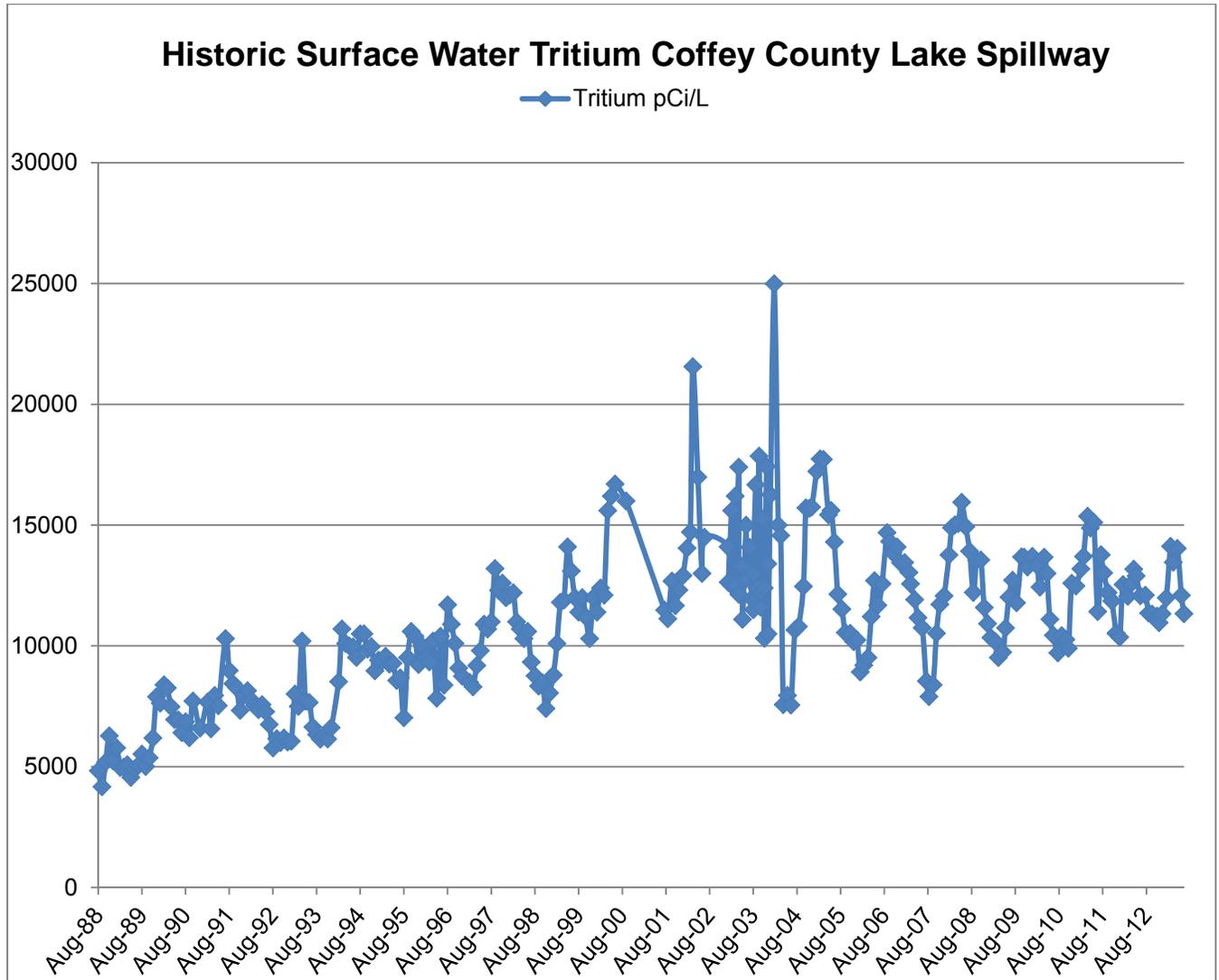
New Strawn City Lake	
Date	^3H
6/26/2013	<350

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Graph 6 Comparison of CCL Spillway monthly surface water tritium results (pCi/L)



Graph 7 Historical KDHE surface water tritium results (CCL Spillway)



Ground Water

Ground water was collected quarterly offsite at wells in sectors B (control), C, F, G, and J. The control sample location was hydrologically up gradient from the facility and the other five are hydrologically down gradient. Samples were split with WCNOG. Samples were collected within the Wolf Creek owner controlled area along the Essential Service Water-buried pipe (two locations) and in the Wolf Creek protected area near the Auxiliary Building.

Gross alpha, beta, tritium and gamma isotopic analysis are done on each sample.

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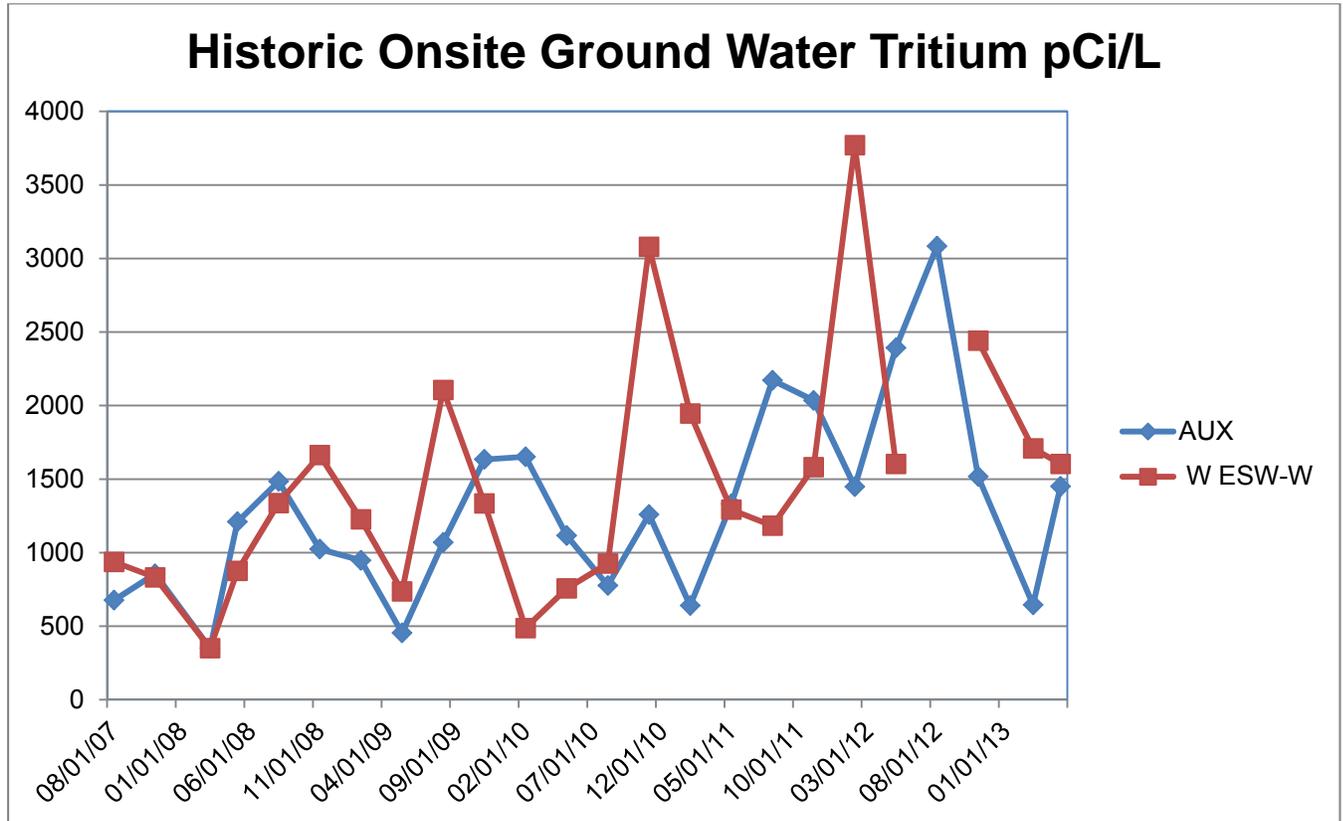
Table 8 Quarterly samples for waterborne radionuclides in ground water, pCi/L

Offsite Ground Water					
B-1 (B-12)			G-1 (G-2)		
Date	³ H KDHE	³ H WCNOC	Date	³ H KDHE	³ H WCNOC
8/20/2012	<350	<150	8/20/2012	<350	<150
11/14/2012	<350	<142	11/14/2012	<350	<142
3/8/2013	<350	<141	3/8/2013	<350	<141
5/20/2013	<350	<145	5/20/2013	<350	<145
F-1 (F-1)			C-2 (C-49)		
Date	³ H KDHE	³ H WCNOC	Date	³ H KDHE	³ H WCNOC
8/20/2012	<350	<150	8/20/2012	<350	<150
11/14/2012	<350	<142	11/14/2012	<350	<142
3/8/2013	<350	<141	3/8/2013	<350	<140
5/20/2013	<350	<145	5/20/2013	<350	<145
J-1 (J-2)			C-1 (C-10)		
Date	³ H KDHE	³ H WCNOC	Date	³ H KDHE	³ H WCNOC
8/20/2012	<350	<150	8/20/2012	<350	<150
11/14/2012	<350	<142	11/14/2012	<350	<142
3/8/2013	<350	<141	3/8/2013	<350	<141
5/20/2013	<350	<145	5/20/2013	<350	<145
Onsite Ground Water					
Auxiliary Building			EAST ESW-W		
Date	³ H KDHE	³ H WCNOC	Date	³ H KDHE	³ H WCNOC
11/28/2012	2441 ± 209	2606 ± 161	8/14/2012	<350	<153
3/6/2013	1709 ± 180	1582 ± 135	11/28/2012	<350	<148
5/20/2013	1603 ± 179	1260 ± 122	3/6/2013	<350	<146
			5/20/2013	508 ± 165	270 ± 95
WEST ESW-W					
Date	³ H KDHE	³ H WCNOC			
8/14/2012	3084 ± 199	2785 ± 168			
11/28/2012 ¹	1517 ± 192	1707 ± 137			
3/6/2013	645 ± 159	643 ± 104			
5/20/2013	1603 ± 179	1018 ± 114			

¹Sampled from West ESW-S

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Graph 8 Historic Owner Controlled Area (Onsite) Groundwater Tritium, pCi/L



Shoreline and Bottom Sediments

Shoreline sediment and bottom sediment were collected in the environment surrounding WCGS. Indicator bottom sediment samples were collected in the Coffey County Lake discharge cove, public environmental education area, and the CCL MUDS public access fishing area. A control sample of bottom sediment was obtained from John Redmond Reservoir. Indicator shoreline sediment was collected at the CCL discharge cove, the CCL MUDS public access fishing area, Wolf Creek below the CCL dam, and Stringtown Cemetery. A control sample of shoreline sediment was collected at JRR. Ten random bottom sediments were collected on CCL. Seven random shoreline sediments were collected on CCL and the Neosho River. The CCL and JRR samples are split with WCNOG.

A gamma isotopic analysis is done on all sediment samples collected.

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Table 9 Annual samples for waterborne radionuclides in sediments, pCi/kg dry

Location	Type	Date	¹³⁷ Cs KDHE (WCNOC)	⁶⁰ Co KDHE (WCNOC)	⁴⁰ K KDHE (WCNOC)
MUDS	Bottom	9/5/2012	14 ± 2 (26.4 ± 15.3)	<11.0 (<14.5)	9380 ± 334 (7502.3 ± 470.1)
JRR	Bottom	11/19/2012	120 ± 6 (45.4 ± 23.9)	<11.0 (<10.8)	22000 ± 1090 (9398.0 ± 590.9)
JRR	Shoreline	11/19/2012	13 ± 1 (<16.9)	<11.0 (<8.7)	7590 ± 273 (6356.2 ± 415.4)
CCL Discharge Cove	Bottom	11/29/2012	173 ± 29 (111.0 ± 55.6)	<11.0 (<42.6)	18400 ± 980 (11192.0 ± 1056.0)
CCL Discharge Cove	Shoreline	11/29/2012	<8.0 ± (<17.1)	<11.0 (<9.5)	18900 ± 828 (6074.1 ± 461.5)
EEA	Bottom	4/30/2013	59 ± 3 (55.8 ± 15.7)	<11.0 (<12.3)	13200 ± 664 (11576.0 ± 574.2)
EEA	Shoreline	4/30/2013	10 ± 1 (<24.4)	<11.0 (<19.4)	14300 ± 417 (11221.0 ± 701.1)
CCL Discharge Cove	Bottom	6/6/2013	146 ± 6 (97.4 ± 40.6)	<11.0 (<33.7)	17500 ± 500 (11336.0 ± 1043.0)
CCL Discharge Cove	Shoreline	6/6/2013	<8.0 (<19.3)	<11.0 (<9.8)	8530 ± 308 (7355.9 ± 498.8)
JRR	Bottom	6/11/2013	140 ± 5 (<54.8)	<11.0 (<27.3)	25400 ± 700 (12752.0 ± 1135.0)
JRR	Shoreline	6/11/2013	205 ± 2 (<25.0)	<11.0 (<18.9)	12700 ± 400 (13061.0 ± 712.2)
CCL Discharge Cove	Shoreline	6/11/2013	19.6 ± 1.9	<11.0	6870 ± 220
Wolf Creek	Shoreline	6/21/2013	32.8 ± 1.7	<11.0	11700 ± 300

Table 10 Random samples for waterborne radionuclides in sediments, pCi/kg dry

Date	Location	Type	⁶⁰ Co	¹³⁷ Cs
7/2/2012	Neosho River near 9 th and Planter	Shoreline	<11.0	51 ± 2
7/9/2012	Neosho River Near Leroy Bridge	Shoreline	<11.0	<8.0
10/1/2012	Near Stringtown Cemetery	Shoreline	<11.0	121 ± 8
10/3/2012	CCL East of Dam	Shoreline	<11.0	24 ± 2
10/3/2012	CCL East of Dam	Shoreline	<11.0	<8.0
10/15/2012	N End CCL	Bottom	<11.0	16 ± 2
10/15/2012	N End CCL	Bottom	<11.0	17 ± 2
10/15/2012	N End CCL	Bottom	<11.0	<8.0
10/15/2012	N End CCL	Bottom	<11.0	14 ± 2
10/15/2012	N End CCL	Bottom	<11.0	32 ± 2
1/23/2013	Neosho River East of Burlington	Shoreline	<11.0	<8.0
2/19/2013	Neosho River near Oxen Lane & 8th	Shoreline	<11.0	61 ± 3
6/6/2013	SW End CCL	Bottom	<11.0	14 ± 2
6/6/2013	E End CCL	Bottom	<11.0	39 ± 2
6/6/2013	SE End CCL	Bottom	<11.0	26 ± 2
6/6/2013	SE End CCL	Bottom	<11.0	17 ± 2
6/6/2013	E End CCL	Bottom	<11.0	11 ± 2

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Aquatic Vegetation and Algae

Annual aquatic vegetation (algae and/or rooted) indicator samples were collected from the Coffey County Lake and Wolf Creek below the Coffey County Lake dam. Control samples of aquatic vegetation were obtained at John Redmond Reservoir. The Coffey County Lake samples are split with WCNOG.

Gamma isotopic analysis is performed on all aquatic vegetation samples.

Table 11 Annual samples for waterborne radionuclides in aquatic vegetation KDHE, pCi/kg (dry) (WCNOG), pCi/kg (wet)

Location	Sample Type	Date	⁴⁰ K	⁷ Be
Wolf Creek	Water Willow	6/21/2013	19100 ± 2310	<360
JRR above dam	Algae	6/28/2013	6640 ± 1480	3070 ± 524
CCL MUDS	American Pondweed	9/5/2012	<152 (1925.1 ± 262.8)	<360 (314.4 ± 161.8)
CCL DC (Alternate Location)	American Lotus	8/15/2012	14500 ± 700 (2653.4 ± 287.5)	5400 ± 300 (1196.2 ± 173.8)
CCL EEA	Spikerush	6/21/2013	17200 ± 807	2660 ± 226

Table 12 Random samples for waterborne radionuclides in aquatic vegetation KDHE, pCi/kg

Location	Sample Type	Date	⁴⁰ K	⁷ Be
Off 6th RD Between Oxford and Planter	Water Plantain	7/2/2012	19600 ± 900	1430 ± 144
Mathias Lake	American Lotus	7/2/2012	20700 ± 900	<360
Burlington Near 16th and Hudson RD	Horsetails	7/9/2012	17700 ± 812	<360
Northern End of CCL	Pondweed	10/15/2012	13100 ± 400	2230 ± 100
Northern End of CCL	Naiad	10/15/2012	12600 ± 390	2450 ± 130
CCL DC	Cattails	6/21/2013	12100 ± 586	643 ± 117

Ingestion Pathway

Milk

Milk was sampled quarterly in Coffey County at two locations. Indicator samples were obtained from the Sunrise Dairy near Westphalia, KS. Control samples were obtained from Linsey Dairy near Lebo, KS. Each milk sample is analyzed for low levels of radioiodine and other gamma emitting nuclides. No gamma emitting nuclides attributable to Wolf Creek operation were detected in any milk sample.

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Table 13 Quarterly samples for radionuclides in milk, pCi/L

Linsey Dairy			Sunrise Dairy		
Date	¹³¹ I	⁴⁰ K	Date	¹³¹ I	⁴⁰ K
07/26/12	<1	1510 ± 60	9/27/2012	<1	1470 ± 51
11/1/2012	<1	1520 ± 60	1/13/2012	<1	1450 ± 58
02/14/13	<1	1500 ± 59	3/10/2013	<1	1490 ± 59
05/02/13	<1	1510 ± 60	6/11/2013	<1	1400 ± 56

Fish/Game Animals/Domestic Meat

Fish samples were collected from the Coffey County Lake and below John Redmond Reservoir on the Neosho River. Sample portions from fish collected in the Coffey County Lake and below John Redmond Reservoir on the Neosho River were split with WCNO. Fish collected at John Redmond Reservoir on the Neosho River are used for control samples. Fifteen fish for a total of nine species were sampled.

Game animal sampling is usually limited to the collection of edible meat portions from road-killed deer. Sample portions of road-killed deer are usually collected as available by WCNO and split with KDHE for laboratory analysis. One deer sample was obtained during SFY 2013.

A gamma isotopic analysis is done on all samples collected. Sample portions were edible. Tritium in tissue analysis (fat and water) is done on at least one species of fish from each location sampled.

Table 14 Annual samples for radionuclides in fish pCi/kg, wet)

Location	Date	Type	³ H KDHE (WCNO)	Gamma Activity
Coffey County Lake	10/17/2012	White Crappie	NA (7099.0 ± 232.0)	No Gamma Activity Was Detected Above MDA in Any Fish Sample
		White Bass	NA (7122.0 ± 231.0)	
		Blue Catfish	8121 ± 279 (7269.0 ± 235.0)	
		Walleye	NA (6808.0 ± 226.0)	
		Common Carp	NA (7670.0 ± 235.0)	
John Redmond Reservoir	11/14/2012	Common Carp	NA (<119.0)	
		Bigmouth Buffalo	NA (<110.0)	
		Smallmouth Buffalo	<1200 (<120.0)	
Coffey County Lake	5/21/2013	Smallmouth Bass	8663 ± 278 (8140 ± 233)	
		Common Carp	NA (8158 ± 229)	
		Smallmouth Buffalo	NA (8022 ± 223)	
		Channel Catfish	NA (8852 ± 242)	
John Redmond Reservoir	6/11/2013	Common Carp	NA (<156)	
		Channel Catfish	<1200 (<156)	
		Smallmouth Buffalo	NA (<156)	

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Table 15 Random samples for radionuclides in game, pCi/kg

Sample Location	Date	Sample Type	⁴⁰ K KDHE (WCNOC)
1.5 Mi. North of WCGS	9/17/2012	Roadkill Deer	3230 ± 131 (2639.5 ± 258.2)

Terrestrial Vegetation and Food Products

Terrestrial vegetation samples were taken at various locations around WCGS. This includes samples of crops grown throughout Coffey County, broadleaf vegetation taken from gardens near the WCGS boundary, and pasturage near WCGS. Samples collected on WCNOG property and samples of crops were split with WCNOG. A control sample was collected at Scott Valley Church approximately 6 miles from WCGS. Ten random samples were collected from locations around WCGS within the 50 mile zone.

A gamma isotopic analysis was done on each vegetation sample and edible portions of food products collected.

Table 16 Annual Samples for Terrestrial Vegetation and Food Products, pCi/kg

Sample ID	Location	Sample Type	Date	⁴⁰ K KDHE (WCNOC)	⁷ Be KDHE (WCNOC)
WCFV-1-E-087-5.8	Scott Valley Church (Control)	Pasturage	4/30/2013	29000 ± 1040	4910 ± 234
NR-D2	Kerry Trostle Farm	Irrigated Corn	8/29/2012	<152.0 (3033.4 ± 252.6)	<360 (<34.1)
NR-D1	Coffey County	Irrigated Soybeans	11/19/2012	23600 ± 1050 (14309.0 ± 346.4)	<360 (<77.9)
NR-U1	Sector K, 4.5 mi. SSW of Wolf Creek	Irrigated Corn	8/15/2012	<152.0 (2993.5 ± 270.7)	<360 (<80.8)
WCFV-1-A-005-2.5	Sharpe	Pasturage	6/21/2013	23100 ± 970	<360
WCFV-1-R-330-2.9	EEA	Pasturage	6/3/2013	27100 ± 1100 (7466.5 ± 475.6)	4110 ± 260 (1017.9 ± 200.4)
WCFV-3-P-289-1.6	MUDS	Pasturage	6/3/2013	11900 ± 596 (5868 ± 644.2)	4140 ± 232 (1830.1 ± 342.4)
WCFV-1-H-157-3.1	East of Dam	Pasturage	6/3/2013	18800 ± 7010	4120 ± 198

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Table 17, Random Samples for Vegetation and Food Products, pCi/kg

Location	Sample Type	Date	⁷ Be	⁴⁰ K
Field Near 12th and Reaper	Corn	8/10/2012	<360.0	3770 ± 129
Field Near 13th and US 75	Corn on Cob	8/10/2012	<360.0	319 ± 101
Field Near 18th and Reaper	Red Milo	8/20/2012	<360.0	<152.0
Field Between 21st and 22nd on Underwood	Red Milo	8/23/2012	<360.0	3670 ± 160
Near 15th and Shetland	Corn on Cob	9/5/2012	557 ± 47	3370 ± 143
11th Place and Milo Lane	White Milo	9/5/2012	<360	<152
Near 20th and Reaper	Soybeans	10/4/2012	1560 ± 200	7750 ± 480
Between 13th and 14th on Underwood	Soybeans	10/16/2012	<360.0	<152.0
Near 20th and Reaper	Soybeans	10/16/2012	<360.0	<152.0
Field Near 10th RD and Oxen Lane	Wheat	10/25/2012	<360.0	<152.0
Field Near 8th and Kafir Lane	Corn	6/26/2013	1830 ± 171	4680 ± 279

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KDHE Radiochemistry Laboratory

Quality Assurance

The KDHE Radiation Laboratory has an established internal Quality Assurance program. Quality Control elements include routine calibrations and performance checks on counting equipment and participation in an environmental radioactivity laboratory intercomparison studies program. This program is currently accomplished with blind samples purchased from Environmental Resource Associates. Results for SFY 2013 are presented in Table 18.

Equipment

The following is a description of the equipment used by the KHEL Radiochemistry laboratory.

Multichannel gamma-spectrometer

Gamma radiation is measured spectra determined with a Canberra Genie-2000 Multichannel Analyzer (MCA) system. Detectors available are three high purity germanium detectors (efficiencies – 20 % - 40%) and one germanium-lithium (GeLi) Detector (efficiency 20%).

Low background alpha/beta system

Low background alpha/beta gas-flow internal proportional counters – one Tennelec LB5100, one Oxford Series 5XLB, one Tennelec LB4000 multi-detector and one Canberra 2201.

Internal proportional counter (IPC)

Gross alpha and radium analyses are performed with windowless gas-flow internal proportional counters – four Protean MPC 2000 and two NMC PC5.

Liquid scintillation

Analysis for tritium in water is performed using a one Wallac 1409 and one PE Tri-Carb 3100 TR.

Miscellaneous equipment

The Radiochemistry Section has various devices used for special purposes. A Ludlum Model 2200 single channel analyzer is used with a radon flask scintillation counter for radon and radium analyses. Another Ludlum Model 2200 single channel analyzer is used with a halogen quenched GM pancake probe for routine monitoring of personnel and incoming samples.

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Table 18 KDHE Radiochemistry Laboratory ERA Intercomparison Studies

Analyte	Analysis Date	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Barium-133	10/15/2012	pCi/L	84.8	84.8	71.3-93.3	Acceptable
	1/9/2013	pCi/L	53.8	54.4	44.9-60.2	Acceptable
Cesium-134	1/9/2013	pCi/L	28.4	29.9	23.4-32.9	Acceptable
	10/15/2012	pCi/L	187	183	165-203	Acceptable
Cesium-137	1/9/2013	pCi/L	79.6	75.3	67.8-85.5	Acceptable
	1/9/2013	pCi/L	79.6	75.3	67.8-85.5	Acceptable
Cobalt-60	10/15/2012	pCi/L	81.3	78.3	70.5-88.5	Acceptable
	1/9/2013	pCi/L	102	97.7	87.9-110	Acceptable
Gross Alpha	7/17/2012	pCi/L	50.0	48.2	25.1-60.6	Acceptable
	1/14/2013	pCi/L	23.2	24.8	12.5-33.0	Acceptable
	5/3/2013	pCi/L	34.8	40.8	21.1-51.9	Acceptable
Gross Beta	7/13/2012	pCi/L	34.0	36.8	24.2-44.4	Acceptable
	1/18/2013	pCi/L	20.0	19.3	11.3-27.5	Acceptable
	5/1/2013	pCi/L	20.3	21.6	13.0-29.7	Acceptable
Iodine-131	7/12/2012	pCi/L	29.9	26.5	22.0-31.2	Acceptable
	1/9/2013	pCi/L	21.6	22.7	18.8-27.7	Acceptable
	4/10/2013	pCi/L	25.8	23.8	19.7-28.3	Acceptable
Strontium-89	7/27/2012	pCi/L	37.0	47.9	37.5-55.2	Not Acceptable
	1/30/2013	pCi/L	25.3	48.0	37.6-55.3	Not Acceptable
	4/15/2013	pCi/L	42.2	41.3	31.6-48.4	Acceptable ¹
Strontium-90	7/27/2012	pCi/L	22.1	28.7	20.9-33.4	Acceptable
	2/15/2013	pCi/L	34.4	39.8	29.2-45.8	Acceptable
	4/30/2013	pCi/L	30.2	23.9	17.2-28.0	Not Acceptable ¹

¹ The KDHE radiochemistry laboratory, under certification of the Environmental Protection Agency is required to pass one PT study for certified analytes per year, and participates in extra PT studies throughout the year as additional Quality Assurance checks.

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Table 19 Method Detection Limits

GeLi [HPGe] detection system^a						
Environmental Sampling						
	Water and Milk	Filter	Wipe	Soil and Sediment	Biota	Vegetation and Food Products
Minimum sample size	2000 ml	1500 m ³	Total	0.45 kg	0.3 kg	1 kg
Minimum Counting Time	8 hr.	3 hr	3 hr.	15 hr.	15 hr.	15 hr.
Method Detection Limit	pCi/L	pCi/m ³	pCi/wipe	pCi/kg-dry	pCi/kg-wet	pCi/kg-dry
⁷ Be	64[22]	0.03 [0.02]	N/A	346 [186]	231 [144]	35[19]
⁴⁰ K	88 [39]	0.03 [0.02]	N/A	828 [654]	459 [262]	360 [72]
⁵¹ Cr	52 [32]	0.01 [0.009]	5 [3]	35 [22]	41 [32]	55 [46]
⁵⁴ Mn	4 [2]	0.004 [0.003]	1 [0.7]	7 [11]	30 [15]	51 [24]
⁵⁸ Co	4 [2]	0.008 [0.002]	2 [1]	11 [23]	37 [20]	60 [36]
⁵⁹ Fe	8 [3]	0.01 [0.01]	3 [2]	22 [16]	41 [15]	107 [52]
⁶⁰ Co	11 [7]	0.01 [0.0053]	2.5 [1.7]	11 [35]	43 [26]	56 [50]
⁶⁵ Zn	8 [4]	0.01 [0.007]	N/A	48 [30]	38 [22]	125 [63]
⁹⁵ Nb	7 [3]	0.009 [0.007]	2.5 [1.4]	13 [30]	44 [26]	48 [4]
⁹⁵ Zr	6 [3]	0.01 [0.002]	0.5 [0.3]	20 [27]	27 [19]	86 [54]
⁹⁹ Mo	5 [3]	0.002 [0.0014]	1 [0.6]	83 [43]	33 [21]	****
¹⁰³ Ru	10 [7]	0.004 [0.003]	N/A	10 [20]	29 [21]	44 [47]
¹⁰⁶ Ru	55 [43]	0.07 [0.05]	1.5 [1]	100 [192]	43 [29]	46 [65]
^{110m} Ag	4 [3]	0.006 [0.0002]	N/A	47 [33]	47 [34]	86 [55]
¹²⁵ Sb	35 [12]	0.02 [0.01]	N/A	30 [44]	96 [51]	126 [6]
¹³¹ I	5 [3] (1) ^b	0.00027 [0.00027] ^c	1.5 [1]	10 [20]	37 [23]	45 [13]
¹³⁴ Cs	5 [3]	0.007 [0.004]	1.4 [1]	14 [29]	37 [24]	57 [39]
¹³⁷ Cs	7 [4]	0.006 [0.004]	1 [0.3]	11 [29]	32 [21]	52 [56]

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¹⁴⁰ Ba	10 [6]	0.004 [0.003]	N/A	36 [17]	24 [15]	157 [39]
¹⁴⁰ La	9 [5]	0.01 [0.02]	N/A	12 [9]	34 [21]	47 [6]
¹⁴¹ Ce	8 [3]	0.002 [0.001]	N/A	19 [23]	22 [13]	63 [3]
¹⁴⁴ Ce	35 [14]	0.013 [0.0096]	N/A	96 [103]	110 [70]	267 [14]
²²⁶ Ra	116 [69]	0.05 [0.03]	N/A	828 [654]	323 [195]	858 [51]
²²⁸ Ac	30 [18] 15 h	0.0127 [0.0099]	N/A	68 [33]	146 [87]	27 [12]
²²⁸ Th	387 [142]	0.09 [0.06]	N/A	859 [317]	944 [356]	2100 [167]
²³⁴ Th	618 [87] 15 h	0.159 [0.0423]	N/A	1009 [378]	1300 [556]	570 [94]
²³⁵ U	N/A	N/A	45 [30] 15 h	N/A	N/A	N/A
²³⁹ Np	41 [33]	0.01 [0.009]	5 [3]	64 [44]	40 [30]	97 [71]

^a GeLi = Germanium lithium; HPGe = High purity germanium.

^b Two methods of analysis are done: **1)** 8 hour direct gamma isotopic analysis of a 2000 mP milk or water sample that has a method detection limit (MDL) of 3 pCi/P, and **2)** 3 hour gamma isotopic analysis of ion exchange resin after a 1500 mP milk sample is filtered through an ion exchange column that has an MDL of 1 pCi/P.

^c The MDL for ¹³¹I when analyzing a charcoal cartridge is 0.03 [0.02] pCi/m³ based upon a 250 m³ sample volume. If the sample volume is increased to 1500 m³, the MDL is 0.002 [0.001] pCi/m³.

Method detection limits of present analytical methods for selected radionuclides monitored by the KHEL Radiochemistry Laboratory. These limits are intended as guides to order of magnitude sensitivities and are calculated with a 95% level of confidence (activity will be detected 95% of the time if it is present).

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Low Background Alpha and Beta Counting System					
	Water	Milk	Wipe	Soil & Sediment	Vegetation & Food Products
Minimum Sample Size	1000 ml	1000 ml	Total	0.01 kg	0.1 kg
Minimum Counting Time	200 min.	200 min.	200 min.	200 min.	200 min.
Method Detection Limit	pCi/L	pCi/L	pCi/wipe	pCi/kg-dry	pCi/kg-dry
⁸⁹ Sr	1	2	3	200	500
⁹⁰ Sr	1	2	4	200	500
¹³¹ I	1	N/A	N/A	N/A	N/A
²²⁸ Ra	1.2	N/A	0.3	60	N/A
Gross Beta					
	Water	Filter	Wipe	Soil and Sediment	
Minimum Sample Size	200 ml	250 m ³	Total	0.001 kg	
Minimum Counting Time	200 min.	100 min.	100 min.	100 min.	
Method Detection Limit	4 pCi/l	0.004 pCi/m ³	2 pCi/Wipe	160 pCi/kg-dry	
Gross Alpha					
	Water	Filter	Wipe		
Minimum Sample Size	200 ml	250 m ³	Total		
Minimum Counting Time	200 min.	100 min.	100 min.		
Method Detection Limit	1 pCi/l	0.0006 pCi/ m ³	0.5 pCi/Wipe		

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Random Scintillation Counting System				
^{226}Ra (radium) in water				
Minimum Sample Size		1000 ml		
Minimum Counting Time		200 min.		
Method Detection Limit		0.04 pCi/l		
Liquid Scintillation Counting System				
	Tritium (^3H)		^{222}Rn (Radon)	
	In water	In Tissue	In Water	
Minimum Sample Size	10 ml	3 g	10 ml	
Minimum Counting Time	100 min.	120 min.	60 min.	
Method Detection Limit	350 pCi/l	1200 pCi/kg-wet	25 pCi/l	