Kansas Department of Health and Environment

Report of Radiological Environmental Monitoring of the Environs Surrounding

Wolf Creek Generating Station

July 2015-June 2016

Division of Public Health, Bureau of Community Health Systems

Radiation Control Program

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Contents

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, 2015 through June 30, 2016.

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.

Results Summary

The most significant radionuclide present in surface water samples collected in the Coffey County Lake is tritium (^{3}H), a beta emitter. The highest ^{3}H concentration measured in the Coffey County Lake during SFY 2016 was 10,907 pCi/l in April, 2016. This maximum Coffey County Lake ^{3}H concentration is 55% 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 ^{3}H concentration for SFY 2016 was 9,538 pCi/l, or 48% of MCL. Coffey County Lake is not approved for any aquatic recreation other than fishing. ^{3}H was also found in surface water from the Neosho River during times where CCL flowed over the spillway. The maximum concentration measured was 2,498 pCi/l in April, 2016. This concentration is 12% of MCL, subsequent tests of Neosho River surface water showed no ^{3}H above minimum detectable limit (MDL).

All other non-CCL surface water and offsite ground water samples collected in the environs of WCGS during SFY 2015 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. Three 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 2016 was 276 pCi/kg-dry ^{137}Cs in a shoreline sediment sample from the CCL Environmental Education Area (EEA). No sediment samples showed any nuclides attributable to WCGS operation.

Airborne sample analysis indicated that no radionuclides attributable to the operation of WCGS were present above the lower limits of detection during SFY 2016.

Sample analysis of aquatic vegetation, terrestrial vegetation, soil, milk, grain, and vegetable samples collected in the environs of WCGS during SFY 2016 indicated no radionuclides present attributable to the operation of WCGS.

Samples of nine species of fish were taken from the Coffey County Lake during SFY 2016. Sample analysis of edible fish portions collected in the environs of WCGS during SFY 2016 indicated that no gamma emitters attributable to WCGS operation were present. The highest ^{3}H concentration in tissue was 7,317 pCi/kg-wet found in a Smallmouth Bass sample taken from the CCL. Using an ICRP 30 dose conversion factor for ingestion ($h_{E,50}$) of $6.40X10^{-8}$ mrem per pCi ^{3}H ingested, a standard man consuming 21 kg/y of fish containing 7,317 pCi/kg ^{3}H would

receive a committed effective dose equivalent of 0.0098 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 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 WCNOC results ranged from 0.87-1.0. A summary of comparison data may be found in the Results Comparison Table.

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	4	41
Offsite Ground Water	6	18
Onsite Ground Water	3	12
Sediments	5	13
Random Sediments	16	16
Aquatic Vegetation	4	3
Random Aquatic Vegetation	6	6
Game Animals/Domestic Meat	1	1
Terrestrial Vegetation/Human, Animal Food	8	8
Random Terrestrial Vegetation/Human, Animal Food	9	9
Milk	2	8
Fish	2	19
Total	**117**	**943**

Results Comparison Table

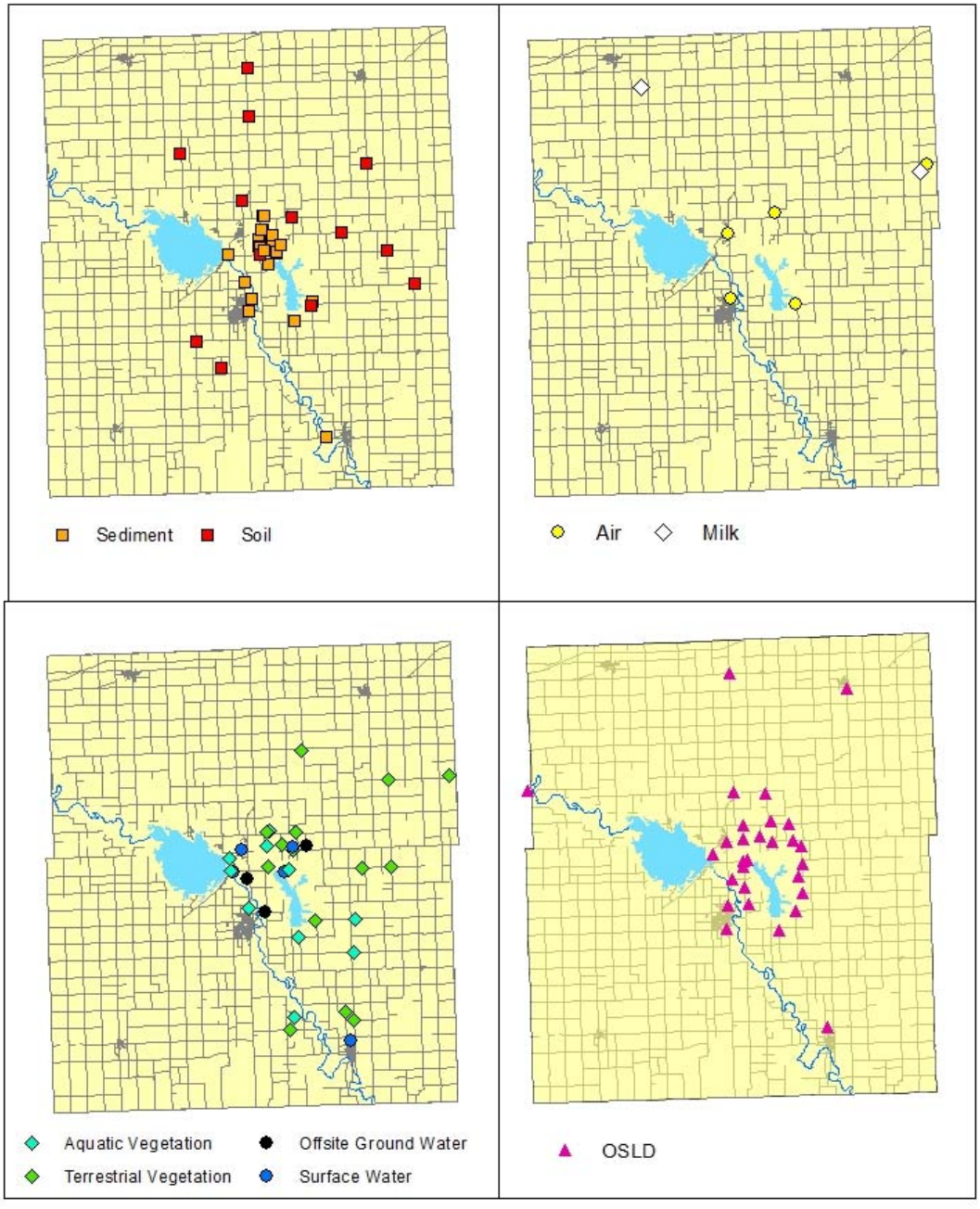
Description	Average	Standard Deviation	Minimum	Maximum	N
OSLD direct radiation, mR per 90 day quarter	16.1	3.6	9.2	24.6	124
Airborne particulate and radioiodine cartridge gamma isotopic analysis (^{7}Be) pCi/m^{3}	0.142	0.044	<0.02	0.233	52
Coffey County Lake Surface Water tritium (^{3}H), pCi/l (Spillway)	9,538.33	822.31	8,339	10,907	12
John Redmond Reservoir, control (N-1) (^{3}H), pCi/l	<193	NA	NA	NA	12
Coffey County Lake MUDS (^{3}H), pCi/l	9,080.5	1,539.08	6,159	11,272	12
Neosho River Near LeRoy (^{3}H), pCi/l	<937	NA	<162	2,498	4
New Strawn City Lake (^{3}H), pCi/l	<162	NA	NA	NA	1
Offsite ground water tritium (^{3}H), pCi/l (All Stations)	<164	NA	NA	NA	18
Onsite ground water tritium (^{3}H), pCi/l (Stations where activity was detected)	1721.33	902.74	743	3360	10
Surface and Offsite 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 offsite 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	^{3}H, 7317 ± 227 pCi/kg (Smallmouth Bass)

Analysis	Comparison Of KDHE and WCNOC Results Average Ratio of KDHE results to WCNOC results	Comments
OSLD Direct Radiation	0.93	12 Collocated Sites
Surface Water ^{3}H	1.04 (N=12)	CCL Spillway
Sediment gamma isotopic	0.88	^{137}Cs, when detected
Fish ^{3}H	N/A	CCL
Offsite Ground Water ^{3}H	0.94	AUX, West-ESW-West

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 WCNOC, 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.

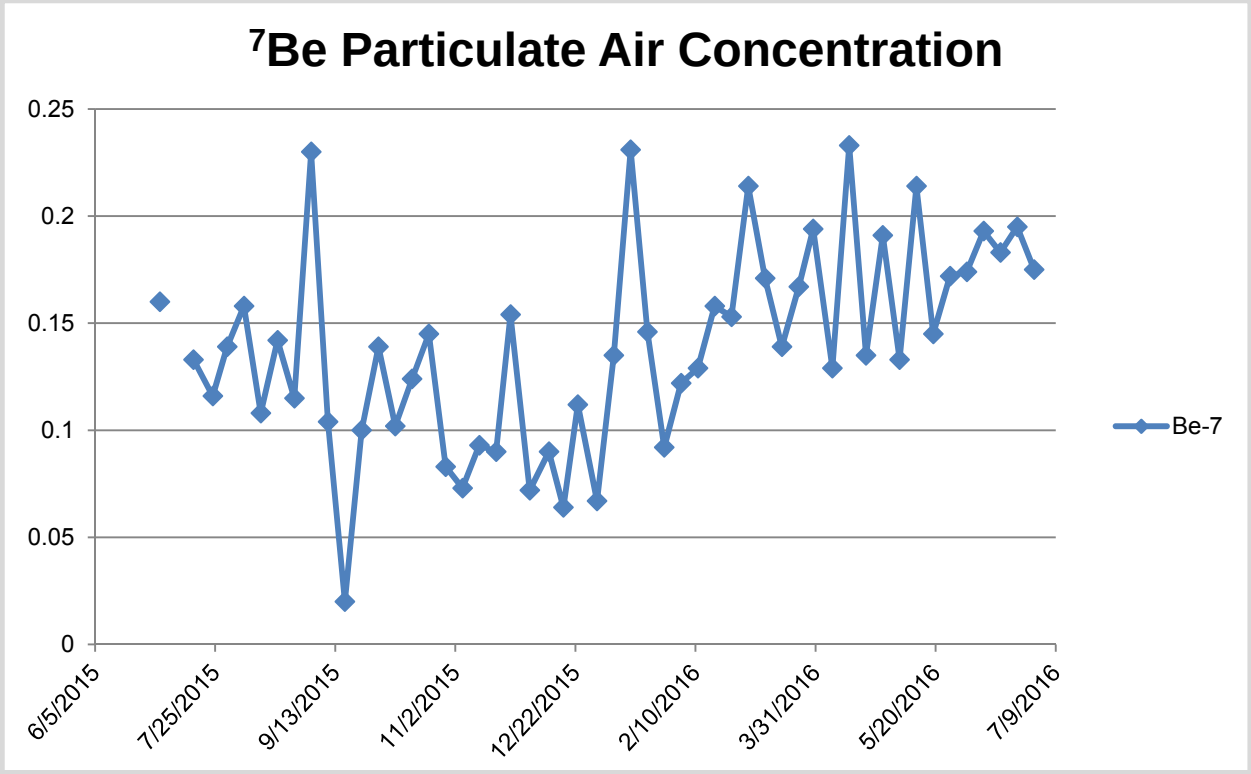
Field assay of each particulate filter was performed at the time of collection. The particulate filter was counted using a thin window GM 'pancake' detector (Ludlum Model 44-40 or equivalent) and a count rate instrument. A sample net count rate of greater than two times the net count rate of the current 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.

Table 1: Weekly Air Particulate/Iodine Monitoring (pCi/m^3)

Number of Samples	Average ^{7}Be Concentration	Average Iodine Concentration
52	0.142 ± 0.26	<0.033

Graph 1: Weekly Particulate ^{7}Be Concentration (pCi/m^3)



**Missing Data from week of 7/9/2015*

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. Soil samples collected from the Coffey County public use areas are split with WCNOC.

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

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

	A-1	E-1	H-1
Nuclide	**Near Stringtown Cemetery**	**Scott Valley Church (control)**	**East of CCL Dam**
Date	3/21/2016	9/14/2015	3/21/2016
^{137}Cs	117 ± 22.5	285 ± 32.4	318 ± 42
^{40}K	12500 ± 666	461 ± 797	12800 ± 836
	P-1 (MUDS)	**R-1 (EEA)**	
Date	10/7/2015	6/1/2016	
^{137}Cs	111 ± 12.7 (118.2 ± 31.7)	100 ± 24 (99.5 ± 26.8)	
^{40}K	9720 ± 471 (11,061 ± 629)	8320 (10764.0 ± 652.5)	

Table 3: Random Samples for Radionuclide Deposition on Soil (pCi/kg)

		Nuclide	
Location	**Date**	**^{137}Cs**	**^{40}K**
20th & Trefoil	10/21/2015	237 ± 37.7	12500 ± 858
Iris Where 21st Would Intersect	12/9/2015	372 ± 37.5	13600 ± 743
Near Entrance to CCL Boat Ramps	1/27/2016	<10.2	11300 ± 757
16th & Shetland	1/27/2016	187 ± 36.9	12600 ± 826
10th & Juneberry Rd	2/15/2016	197 ± 35.4	11400 ± 836
Kafir Ln Between 8th & 9th Rd	2/15/2016	206 ± 32.1	12500 ± 813
18th & HWY 75	3/11/2016	212 ± 30.6	11500 ± 739
13th & Wayside	3/11/2016	244 ± 25.4	4850 ± 329
23rd & Oxen Rd	4/5/2016	312 ± 38.4	11600 ± 746
Forward Staging Area	6/1/2016	50 ± 15.1	11700 ± 631

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 WCNOC at twelve sites.

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

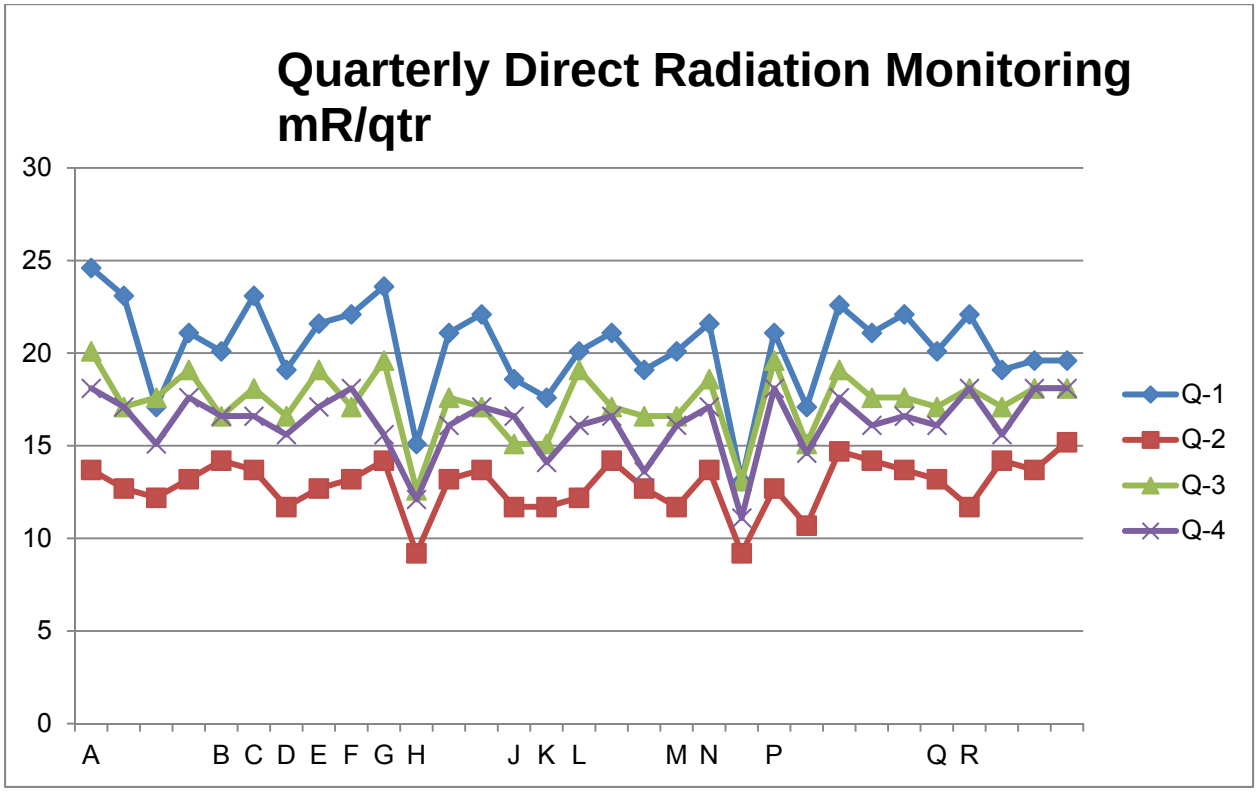
Location	Quarter 1	Quarter 2*	Quarter 3	Quarter 4
1. A-1 (1), North of WCGS	24.6	13.7	20.1	18.1
2. A-2, Sharpe	23.1	12.7	17.1	17.1
3. A-3, Forward Staging Area	17.1	12.2	17.6	15.1
4. B-1, East Sharpe	21.1	13.2	19.1	17.6
5. B-2, Waverly Control	20.1	14.2	16.6	16.6
6. C-1, near residence	23.1	13.7	18.1	16.6
7. D-1 (9), near residence	19.1	11.7	16.6	15.6
8. E-1, near residence	21.6	12.7	19.1	17.1
9. F-1, near residence	22.1	13.2	17.1	18.1
10. G-1 (14), WCNOC gate	23.6	14.2	19.6	15.6
11. H-0 (42), CCL baffle dike A	15.1	9.2	12.6	12.1
12. H-1, east of CCL dam	21.1	13.2	17.6	16.1
13. H-2, LeRoy Control	22.1	13.7	17.1	17.1
14. J-1, near residence	18.6	11.7	15.1	16.6
15. K-1 (29), near residence	17.6	11.7	15.1	14.1
16. L-1 (27), near residence	20.1	12.2	19.1	16.1
17. L-2, Burlington	21.1	14.2	17.1	16.6
18. L-3, Coffey County Shop	19.1	12.7	16.6	13.6
19. M-1 (26), near residence	20.1	11.7	16.6	16.1
20. N-1, near pasture	21.6	13.7	18.6	17.1
21. P-0 (43), CCL baffle dike B	13.1	9.2	13.1	11.1
22. P-1, New Strawn	21.1	12.7	19.6	18.1
23. P-2, Hartford Control	17.1	10.7	15.1	14.6
24. P-3, CCL entrance	22.6	14.7	19.1	17.6
25. P-4 (46), CCL near MUDS	21.1	14.2	17.6	16.1
26. P-5, JRR public use area	22.1	13.7	17.6	16.6
27. Q-1, near residence	20.1	13.2	17.1	16.1
28. R-0 (41), Stringtown cemetery	22.1	11.7	18.1	18.1
29. R-1 (37), near residence	19.1	14.2	17.1	15.6
30. R-2 (44), CCL EEA	19.6	13.7	18.1	18.1
31. R-3, near Coffey County Airport	19.6	15.2	18.1	18.1

**Shipping control dosimeters from QTR 2 showed higher than normal dose compared to the field dosimeters, resulting in lower than normal corrected readings. Results follow historical trends.*

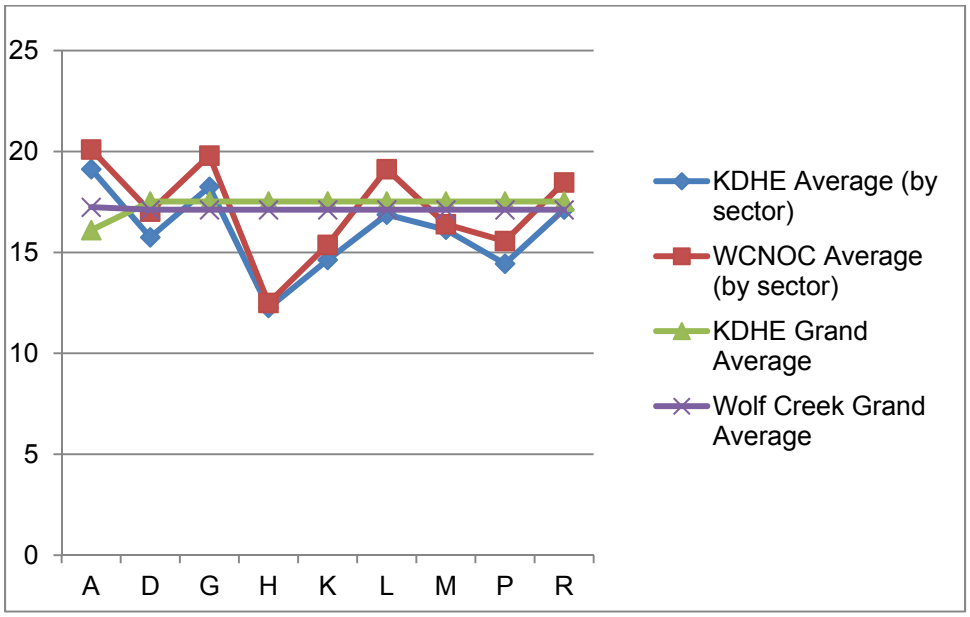
Table 5: Quarterly Collocated Direct Radiation Monitoring, mR/Standardized 90-day Qtr.

Location KDHE(WCNOC)	KDHE Monitoring Period	KDHE	WCNOC
1. A-1 (1)	7/6/2015-10/12/2015	24.6	22.0
	10/12/2015-1/7/2016	13.7	18.3
	1/7/2016-4/8/2016	20.1	21.8
	4/8/2016-7/8/2016	18.1	18.3
2. D-1 (9)	7/6/2015-10/12/2015	19.1	18.1
	10/12/2015-1/7/2016	11.7	16.5
	1/7/2016-4/8/2016	16.6	15.9
	4/8/2016-7/8/2016	15.6	17.6
3. G-1 (14)	7/6/2015-10/12/2015	23.6	20.7
	10/12/2015-1/7/2016	14.2	19.2
	1/7/2016-4/8/2016	19.6	20.3
	4/8/2016-7/8/2016	15.6	19.0
4. H-0 (42)	7/6/2015-10/12/2015	15.1	12.2
	10/12/2015-1/7/2016	9.2	12.9
	1/7/2016-4/8/2016	12.6	13.1
	4/8/2016-7/8/2016	12.1	11.8
5. K-1 (29)	7/6/2015-10/12/2015	17.6	14.4
	10/12/2015-1/7/2016	11.7	15.5
	1/7/2016-4/8/2016	15.1	15.9
	4/8/2016-7/8/2016	14.1	15.7
6. L-1 (27)	7/6/2015-10/12/2015	20.1	21.6
	10/12/2015-1/7/2016	12.2	19.4
	1/7/2016-4/8/2016	19.1	18.6
	4/8/2016-7/8/2016	16.1	16.9
7. M-1 (26)	7/6/2015-10/12/2015	20.1	16.1
	10/12/2015-1/7/2016	11.7	16.4
	1/7/2016-4/8/2016	16.6	17.4
	4/8/2016-7/8/2016	16.1	15.7
8. P-0 (43)	7/6/2015-10/12/2015	13.1	10.7
	10/12/2015-1/7/2016	9.2	13.9
	1/5/2015-4/3/2015	13.1	10.5
	4/8/2016-7/8/2016	11.1	11.7
9. P-4 (46)	7/6/2015-10/12/2015	21.1	21.1
	10/12/2015-1/7/2016	14.2	20.8
	1/7/2016-4/8/2016	17.6	17.6
	4/8/2016-7/8/2016	16.1	18.2
10. R-0 (41)	7/6/2015-10/12/2015	22.1	18.4
	10/12/2015-1/7/2016	11.7	19.7
	1/7/2016-4/8/2016	18.1	16.1
	4/8/2016-7/8/2016	18.1	17.4
11. R-1 (37)	7/6/2015-10/12/2015	19.1	19.3
	10/12/2015-1/7/2016	14.2	18.8
	1/7/2016-4/8/2016	17.1	15.6
	4/8/2016-7/8/2016	15.6	18.2
12. R-2 (44)	7/6/2015-10/12/2015	19.6	20.5
	10/12/2015-1/7/2016	13.7	18.5
	1/7/2016-4/8/2016	18.1	19.1
	4/8/2016-7/8/2016	18.1	20.0

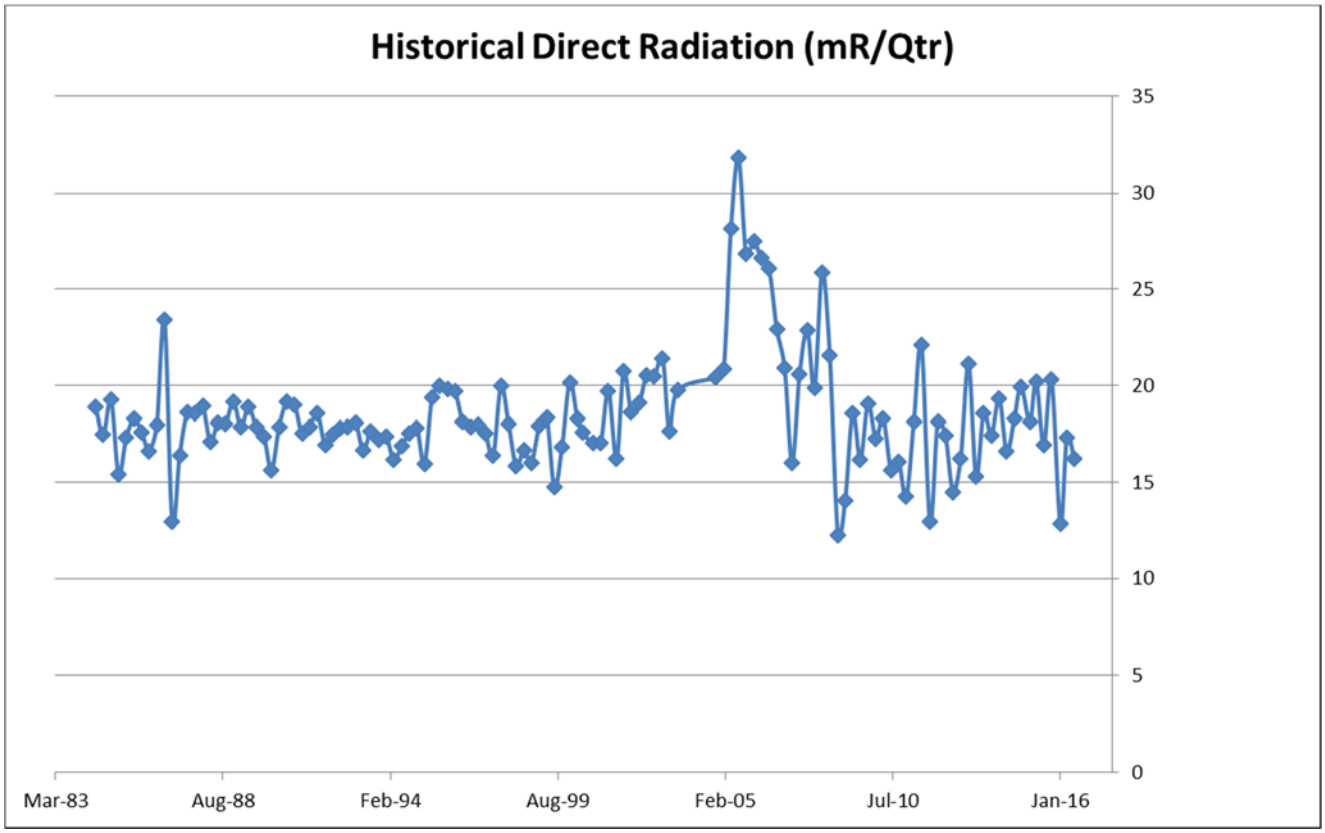
Graph 2: Quarterly Direct Radiation Results for KDHE OSLD Sites



Graph 3: Direct Radiation Monitoring Results for Co-located OSLD Sites (mR/Quarter)



Graph 4: Historical KDHE Direct Radiation Monitoring Results (mR/Qtr)



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 December of 2015 and April, May, and June of 2016. A sample was also collected annually from the New Strawn City Lake.

A gamma isotopic and tritium (^{3}H) analysis was done on each CCL water sample and ^{3}H 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 (^{3}H) in Surface Water (pCi/L)

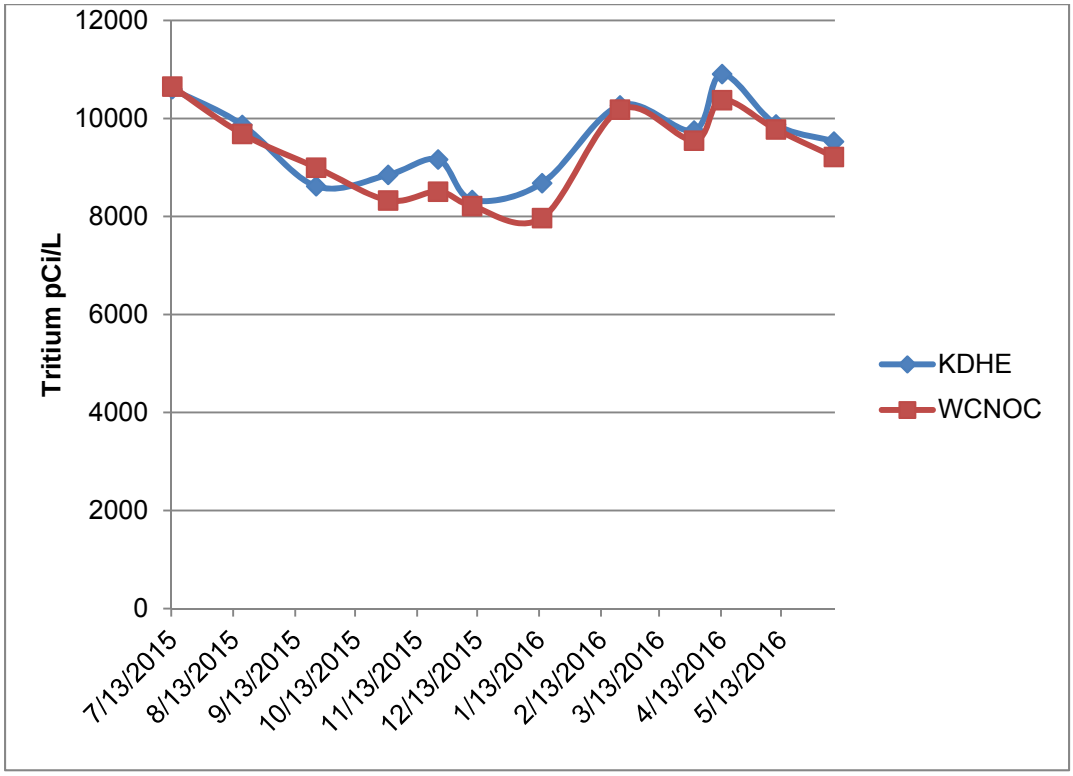
CCL Spillway			John Redmond Reservoir (Control)			MUDS[1]	
Date	KDHE	WCNOC	Date	KDHE	WCNOC	Date	KDHE
7/13/2015	10600 ± 314	10652 ± 308	7/13/2015	<350	<153	7/20/2015	10300 ± 311
8/17/2015	9870 ± 307	9686 ± 293	8/17/2015	<350	<147	8/20/2015	10700 ± 306
9/23/2015	8618 ± 259	8999 ± 286	9/23/2015	<152	<150	9/23/2015	6159 ± 226
10/29/2015	8850 ± 271	8330 ± 270	10/29/2015	<164	<143	10/28/2015	9542 ± 164
11/23/2015	9163 ± 276	8509 ± 273	11/23/2015	<164	<147	11/23/2015	8379 ± 273
12/10/2015	8339 ± 264	8214 ± 267	12/10/2015	<163	<146	12/9/2015	8937 ± 273
1/14/2016	8682 ± 268	7971 ± 264	1/14/2016	<162	<141	1/27/2016	7034 ± 245
2/22/2016	10268 ± 290	10183 ± 282	2/22/2016	<164	<145	2/22/2016	9196 ± 276
3/30/2016	9754 ± 283	9549 ± 291	3/30/2016	<163	<152	3/30/2016	7610 ± 255
4/13/2016	10907 ± 296	10377 ± 304	4/13/2016	<162	<148	4/13/2016	11272 ± 300
5/10/2016	9878 ± 281	9779 ± 296	5/10/2016	<161	<150	5/10/2016	9679 ± 281
6/8/2016	9531 ± 279	9217 ± 286	6/8/2016	<161	<146	6/8/2016	10158 ± 287

H-1 Neosho River Near Leroy	
Date	KDHE
12/31/2015	925 ± 128
4/5/2016	2498 ± 165
5/12/2016	<162
6/8/2016	<163

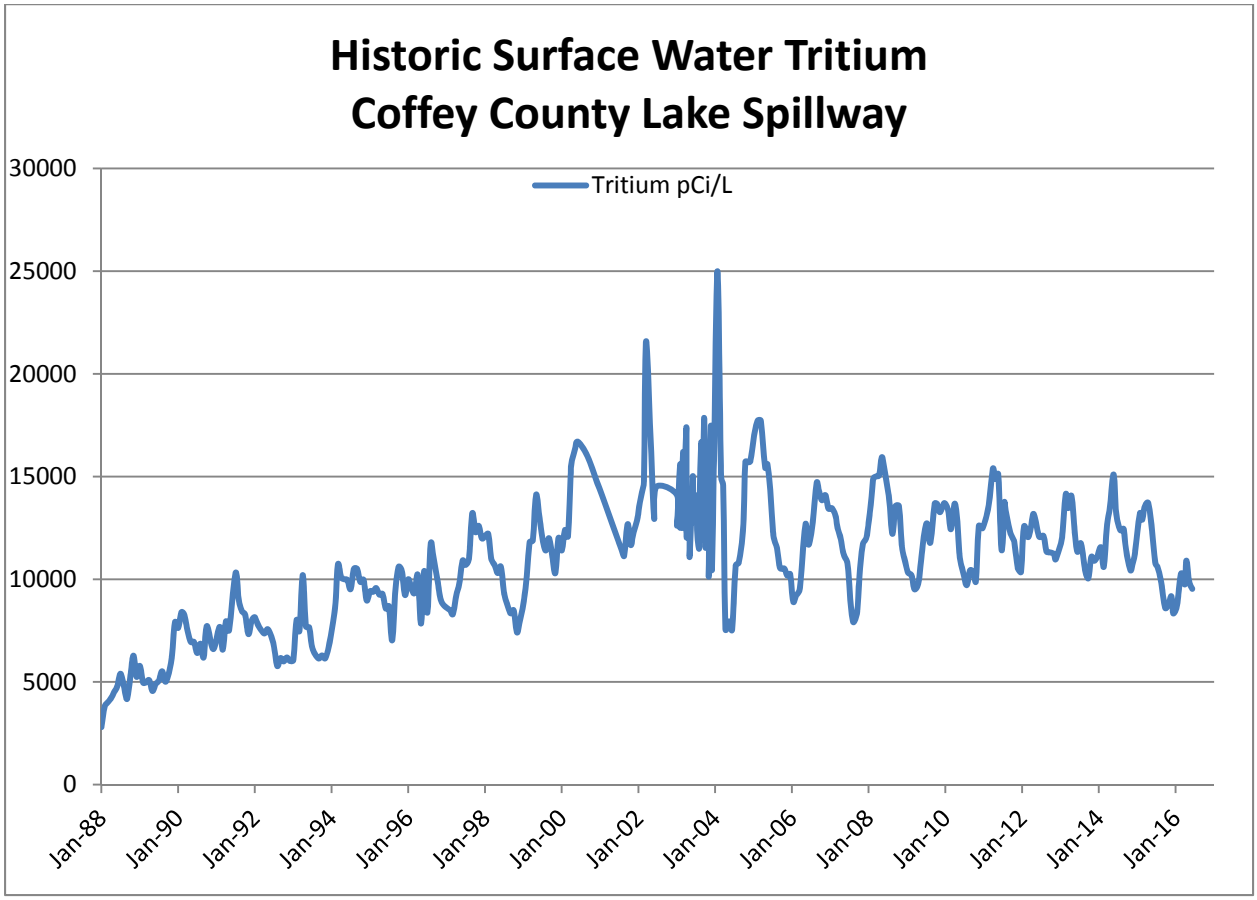
Table 7: Annual Sample for Deposition of Airborne Radionuclides in Surface Water (pCi/L)

New Strawn City Lake	
Date	^{3}H
5/12/2016	<162

Graph 5: Comparison of CCL Spillway Monthly Surface Water Tritium Results (pCi/L)



Graph 6: 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 WCNOC. 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.

The KDHE results from August 2015 offsite groundwater samples are not available due to laboratory error. However, the Wolf Creek results of the split samples for that time and location are included on Table 8.

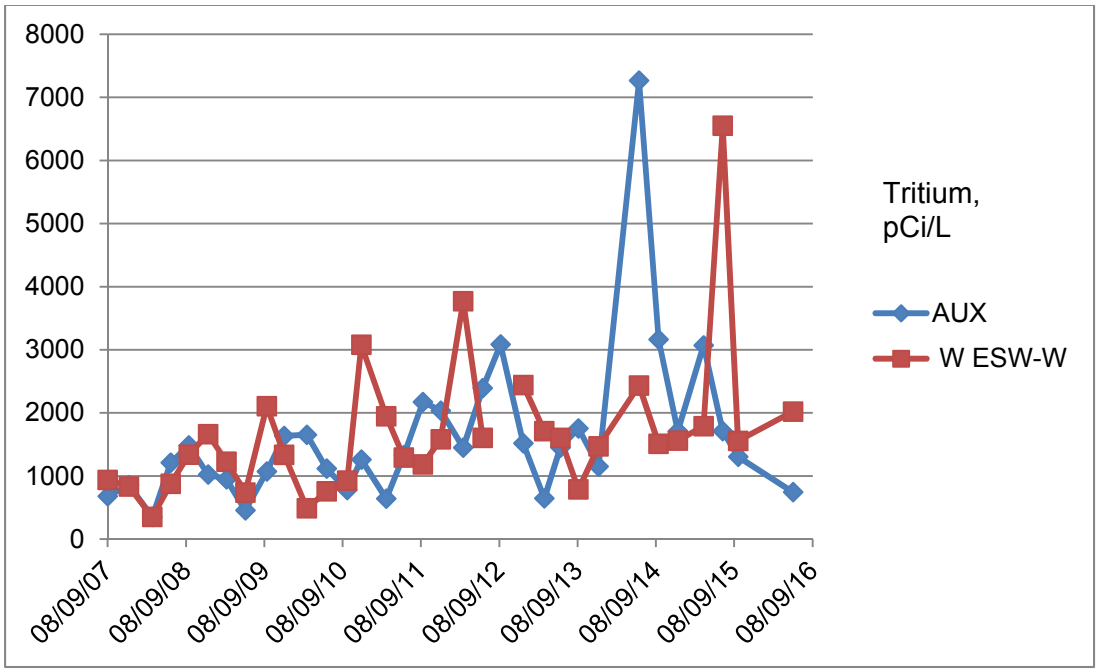
Table 8: Quarterly Samples for Waterborne Radionuclides in Ground Water (pCi/L)

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
8/24/2015	N/A	<145	8/24/2015	N/A	<145
11/23/2015	<164	<147	11/23/2015	<164	<147
2/22/2016	<164	<172	2/22/2016	<164	<145
5/10/2016	<162	<150	5/10/2016	<162	<150
F-1 (F-1)			**C-2 (C-49)**		
Date	^{3}H KDHE	^{3}H WCNOC	Date	^{3}H KDHE	^{3}H WCNOC
8/24/2014	N/A	<179	8/24/2015	N/A	<179
11/23/2015	<164	<147	11/23/2015	<164	<147
2/22/2016	<164	<145	2/22/2016	<164	<145
5/10/2016	<162	<150	5/10/2016	<162	<150
J-1 (J-2)			**C-1 (C-10)**		
Date	^{3}H KDHE	^{3}H WCNOC	Date	^{3}H KDHE	^{3}H WCNOC
8/24/2015	N/A	<179	8/24/2015	N/A	<179
11/23/2015	<164	<147	11/23/2015	<164	<147
2/22/2016	<164	<145	2/22/2016	<164	<172
5/10/2016	<162	<150	5/10/2016	<163	<150

Onsite Ground Water					
Auxiliary Building			**EAST ESW-W**		
Date	^{3}H KDHE	^{3}H WCNOC	Date	^{3}H KDHE	^{3}H WCNOC
8/27/2015	1304 ± 140	1395 ± 137	8/27/2015	<166	<175
			11/9/2015	<165	201 ± 86
			2/22/2016	<164	<172
5/9/2016	743 ± 122	830 ± 109	5/9/2016	<161	<143

WEST ESW-W		
Date	^{3}H KDHE	^{3}H WCNOC
8/27/2015	1556 ± 147	1657 ± 144
11/9/2015	1345 ± 140	1215 ± 125
2/22/2016	3360 ± 185	3287 ± 174
5/9/2016	2020 ± 155	2127 ± 151

Graph 7: 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 public environmental education area, and Wolf Creek off 11th St. A control sample of shoreline sediment was collected from JRR. Ten random bottom sediments were collected on CCL. Six random shoreline sediments were collected on CCL and the Neosho River. The CCL and JRR samples are split with WCNOC.

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

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)
Wolf Creek	Shoreline	8/7/2015	16 ± 1	<11	<1510
JRR	Bottom	11/3/2015	107 ± 36.1 (119.5 ± 40.1)	<8.81 (<16)	19800 ± 553 (18495.0 ± 963.8)
CCL Discharge Cove	Shoreline	11/3/2015	<4.95 (<16.9)	<8.81 (<10.6)	5630 ± 378 (6027.2 ± 437.7)
JRR	Shoreline	11/3/2015	71.1 ± 19.6 (42.3 ± 24.3)	<9.07 (<24.0)	10700 ± 732 (10937.0 ± 646.3)
CCL Discharge Cove	Bottom	11/3/2015	108 ± 23.4 (91.2 ± 39.6)	<4.27 (<26.5)	12600 ± 604 (14026 ± 764.4)
JRR	Bottom	4/25/2016	74.8 ± 17.1 (<77.9)	<8.07 (<62.1)	15100 ± 784 (14399.0 ± 1502.0)
CCL Discharge Cove	Bottom	4/27/2016	78 ± 20.4 (<56)	<7.03 (<33.4)	11100 ± 589 (10166 ± 1016)
JRR	Shoreline	4/25/2016	<6.70 (<37.5)	<5.23 (<30.2)	9980 ± 529 (11582.0 ± 913.6)
CCL Discharge Cove	Shoreline	4/27/2016	78.9 ± 16.7 (199.8 ± 35.1)	<2.72 (<16.3)	8630 ± 455 (12005 ± 801.9)
CCL	Bottom	6/9/2016	<7.91 (<25.3)	<2.70 (<9.6)	7640 ± 542 (10460 ± 607.7)
EEA	Bottom	6/9/2016	39.2 ± 11.2 (<31.7)	<4.8 (<19.7)	10000 ± 557 (11443 ± 674.8)
EEA	Shoreline	6/9/2016	276 ± 39.2 (270.8 ± 37.2)	<3.16 (<23.5)	9510 ± 657 (11155.0 ± 654.2)
Stringtown Cemetery	Bottom	6/17/16	<5.89 (<27.5)	<4.74 (<11.1)	11800 ± 640 (14051.0 ± 801.7)

Table 10: Random Samples for Waterborne Radionuclides in Sediments (pCi/kg dry)

Date	Location	Type	^{60}Co	^{137}Cs
10/14/2015	CCL North End	Bottom	<3.06	<3.41
10/14/2015	CCL North End	Bottom	<7.79	25.3 ± 19
10/14/2015	CCL North End	Bottom	<5.39	<7.81
10/14/2015	CCL North End	Bottom	<6.09	<8.06
10/14/2015	CCL North End	Bottom	<5.17	25 ± 13.8
3/23/2016	Neosho River at Leroy Bridge	Shoreline	<5.81	<8.16
3/23/2016	East of Dam	Shoreline	<11.3	<11.4
3/23/2016	Neosho River Under 12 St. Bridge	Shoreline	<8.65	<7.14
3/23/2016	Neosho River by I-75 Bridge	Shoreline	<5.11	<6.67
4/8/2016	South of Black Bear Bosin	Shoreline	<10.1	<8.16
5/19/2016	CCL	Bottom	<4.70	<10.2
5/19/2016	CCL	Bottom	<4.45	<6.15
5/19/2016	CCL	Bottom	<2.47	<5.96
5/19/2016	CCL	Bottom	<3.38	<8.71
5/19/2016	CCL	Bottom	<7.49	29.3 ± 12.4
6/17/2016	Neosho River at Burlington Spillway	Shoreline	<7.77	85.5 ± 20.9

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. Samples of aquatic vegetation were not able to be obtained from John Redmond Reservoir above the dam or Coffey County Lake Alternate Discharge Cove.

Gamma isotopic analysis is performed on all aquatic vegetation samples.

Table 11: Annual Samples for Waterborne Radionuclides in Aquatic Vegetation KDHE, pCi/kg (dry) (WCNOC), pCi/kg (wet)

Location	Sample Type	Date	^{40}K	^{7}Be
Wolf Creek	Arrowhead	8/7/2015	35400 ± 131	2700 ± 217
CCL MUDS	Naiad	7/29/2015	38700 ± 1480 (3942.4 ± 293.9)	777 ± 205 (<106.2)
CCL EEA	Cattail	6/17/2016	16500 ± 1670 (2253.3 ± 112.1)	4900 ± 644 (452.5 ± 61.9)

Table 12: Random Samples for Waterborne Radionuclides in Aquatic Vegetation KDHE, pCi/kg

Location	Sample Type	Date	^{40}K	^{7}Be
JRR – North End	Duckweed	7/2/2015	8910 ± 512	3240 ± 360
10th & Shetland	Calamus	7/8/2015	10800 ± 581	3540 ± 207
Ditch Near 75 HWY & 13th Lane	Rose Mallow	8/4/2015	11700 ± 423	1190 ± 90
6th & Planter	River Bullrush	8/7/2015	16500 ± 688	1540 ± 142
Bridge East of 12th & Shetland	Water Plantain	8/26/2015	22000 ± 1950	2510 ± 490
CCL – North End	American Pondweed	10/14/2015	19000 ± 2120	<260

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.

Table 13: Quarterly Samples for Radionuclides in Milk (pCi/L)

Linsey Dairy			Sunrise Dairy		
Date	^{131}I	^{40}K	Date	^{131}I	^{40}K
9/4/2015	<1	1390 ± 50	9/17/2015	<1	1410 ± 50
11/17/2015	<0.8	1520 ± 157	12/10/2015	<0.8	1510 ± 157
3/11/2016	<0.534	1480 ± 162	02/25/2016	<0.728	1200 ± 142
6/1/2016	<0.498	1360 ± 68.1	6/16/2016	<0.432	1230 ± 64.8

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 WCNOC. Fish collected at John Redmond Reservoir are used for control samples. Twenty fish from 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 WCNOC and split with KDHE for laboratory analysis. One deer sample was obtained during SFY 2016.

A gamma isotopic analysis is done on all samples collected. Sample portions were edible. Due to small portion size of selected sample, tritium analysis was unable to be performed on KDHE sample of fish from CCL.

Table 14: Annual Samples for Radionuclides in Fish, pCi/kg, (wet)

Location	Date	Type	^{3}H KDHE (WCNOC)	Gamma Activity
Coffey County Lake	10/27/2015	Blue Catfish Wiper Smallmouth Buffalo Walleye White Bass Channel Catfish	NA (6710 ± 224) NA (5848 ± 195) NA (6065 ± 204) NA (6669 ± 217) NA (5890 ± 203) NA (6313 ± 214)	No Gamma Activity Above MDA was Detected in any Fish Sample
John Redmond Reservoir	11/03/2015	Smallmouth Buffalo Common Carp Large Mouth Bass Freshwater Drum	<1300(<114) <1200 (<112) NA (<115) NA (<113)	
Coffey County Lake	05/05/2016	Common Carp Smallmouth Bass Smallmouth Buffalo White Crappie Freshwater Drum	NA (7005 ± 223) NA (7317 ± 227) NA (6407 ± 204) NA (7189 ± 227) NA (6956 ± 224)	
John Redmond Reservoir	04/25/2016	White Crappie Largemouth Bass Common Carp Smallmouth Buffalo	NA (<118) NA (<122) NA (<117) NA (<116)	

Table 15: Random Samples for Radionuclides in Game (pCi/kg)

Sample Location	Date	Sample Type	^{40}K KDHE (WCNOC)
Sector Q, 1.0 Miles from Wolf Creek	11/9/2015	Roadkill Deer	2940 ± 335 (2807.6 ± 326.5)

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 WCNOC property and samples of crops were split with WCNOC. A control sample was collected at Scott Valley Church approximately 6 miles from WCGS. Nine 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-H-157-3.1	East of Dam	Horseradish	6/09/2016	23300 ± 1860	2820 ± 513.0
WCFV-1-E-087-5.8	Scott Valley Church (Control)	Corn	10/21/2015	2160 ± 255	<5.93
WCFV-3-P-289-1.6	MUDS	Pasturage	7/29/2015	17400 ± 733 (5025.7 ± 235.2)	2700.0 ± 196.0 (1064.8 ± 120)
NR-U1	4.5 mi. SSW of Wolf Creek	Irrigated Corn	10/07/2015	2790 ± 316 (2941.1 ± 261.7)	<11.2 (<71.2)
NR-D1	Coffey County	Irrigated Corn	11/02/2015	2730 ± 235 (3103.8 ± 256.7)	<4.24 (<67.6)
WCFV-1-A-005-2.5	Sharpe	Corn on Cob	9/14/2015	2480 ± 213	<6.61
NR-U1	4.5 mi. SSW of Wolf Creek	Irrigated Soybeans	10/27/2015	14600 ± 756 (14647.0 ± 578)	81.5 ± 23.9 (<85.6)
WCFV-1-R-330-2.9	EEA	Pasturage	6/17/2016	13200 ± 1540 (7569.4 ± 254.4)	1760.0 ± 537 (2233.4 ± 122.5)

Table 17: Random Samples for Vegetation and Food Products (pCi/kg)

Location	Sample Type	Date	^{40}K	^{7}Be
Near 17th & Native Ln.	Pears	7/08/2015	1050 ± 43	<360
Field Near 5th and Oxen	Corn on Cob	9/30/2015	2590 ± 234	<17.9
Off 20th Between Xeric & Yearling	Red Milo	9/30/2015	3220 ± 412	654.0 ± 143
Field Near 6th & Shetland	White Milo	9/30/2015	2900 ± 352	293 ± 135
Near 22nd and Planter Rd.	Corn on Cob	10/07/2015	3200 ± 354	<11.6
Field Near 15th & Trefoil	Soybeans	10/21/2015	12500 ± 875	597 ± 172
Field Near 9th Ln. & Native Rd.	Soybeans	10/28/2015	12600 ± 806	<37.5
Off Road to Stringtown Cemetery	Sunflower	10/28/2015	8160 ± 385	137.0 ± 55.6
20th & Underwood	Wheat	6/23/2016	3370 ± 242	216 ± 50.6

Radiochemistry Laboratory

In September of 2016, the KDHE Radiochemistry Laboratory was closed and further sample analysis was performed by the Iowa State Hygienic Laboratory (ISHL) at the University of Iowa. Quality assurance is shown for both the KDHE Radiochemistry Lab as well as ISHL.

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 2015 are presented in Table 18, intercomparison studies were not completed for 2016 due to the closing of the laboratory early in the fiscal year.

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.

Table 18: KDHE Radiochemistry Laboratory ERA Intercomparison Studies

Analyte	Analysis Date	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Barium-133	7/11/2014	pCi/L	61.8	68.7	57.3-75.6	Acceptable
	10/8/2014	pCi/L	38.6	49.1	40.3-54.5	Not Acceptable
	1/12/2015	pCi/L	57.0	67.6	56.4-74.4	Acceptable
	4/8/2015	pCi/L	77.3	82.5	69.3-90.8	Acceptable
Cesium-134	7/11/2014	pCi/L	65.9	72.3	59.0-79.5	Acceptable
	10/8/2014	pCi/L	72.3	89.8	73.7-98.8	Not Acceptable
	1/12/2015	pCi/L	118	124	112-139	Acceptable
	4/8/2015	pCi/L	69.6	75.7	61.8-83.3	Acceptable
Cesium-137	7/11/2014	pCi/L	171	163	147-181	Acceptable
	10/8/2014	pCi/L	84.9	98.8	88.9-111	Not Acceptable
	1/12/2015	pCi/L	118	124	112-139	Acceptable
	4/8/2015	pCi/L	198	189	170-210	Acceptable
Cobalt-60	7/11/2014	pCi/L	79.9	75.5	68.0-85.5	Acceptable
	10/8/2014	pCi/L	77.2	92.1	82.9-104	Not Acceptable
	1/12/2015	pCi/L	58.0	62.4	56.2-71.2	Acceptable
	4/8/2015	pCi/L	85.3	84.5	76.0-95.3	Acceptable
Gross Alpha	7/23/2014	pCi/L	53.4	45.4	23.6-57.4	Acceptable
	1/23/2015	pCi/L	61.2	62.3	32.6-77.3	Acceptable
	5/14/2015	pCi/L	44.0	42.6	22.1-64.0	Acceptable
Gross Beta	8/9/2014	pCi/L	36.0	33.4	21.7-41.1	Acceptable
	1/29/2015	pCi/L	40.1	48.9	33.1-56.0	Acceptable
	4/16/2015	pCi/L	43.3	32.9	21.3-40.6	Not Acceptable
Tritium	7/11/2014	pCi/L	10800	11200	9750-12300	Acceptable
	11/15/2014	pCi/L	6920	6880	5940-7570	Acceptable
	1/9/2015	pCi/L	10500	10600	9220-11700	Acceptable
	5/17/2015	pCi/L	3700	3280	2770-3620	Not Acceptable
Iodine-131	7/11/2014	pCi/L	24.2	26.1	21.7-30.8	Acceptable
	1/7/2015	pCi/L	22.5	22.3	18.5-26.6	Acceptable
	4/8/2015	pCi/L	24.8	23.8	19.7-28.3	Acceptable
Strontium-89	7/11/2014	pCi/L	45.2	42.7	32.9-49.8	Acceptable
	1/13/2015	pCi/L	46.9	52.1	41.2-59.6	Acceptable
	4/17/2015	pCi/L	67.2	63.2	51.1-71.2	Acceptable
Strontium-90	7/11/2014	pCi/L	30.0	31.7	23.1-36.7	Acceptable
	1/27/2015	pCi/L	27.7	32.4	23.7-37.5	Acceptable
	4/17/2015	pCi/L	37.3	41.9	30.8-48.1	Acceptable
Zinc-65	7/11/2014	pCi/L	90.0	82.0	73.8-98.5	Acceptable
	10/8/2014	pCi/L	276	310	279-362	Not Acceptable
	1/12/2015	pCi/L	99.2	98.7	88.8-118	Acceptable
	4/8/2015	pCi/L	224	203	183-238	Acceptable

[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.

Table 19: KDHE Radiochemistry Laboratory 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]
^{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 [.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 ^{131}I when analyzing a charcoal cartridge is 0.03 [0.02] pCi/m^3 based upon a 250 m^3 sample volume. If the sample volume is increased to 1500 m^3, the MDL is 0.002 [0.001] pCi/m^3.

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).

Iowa State Hygienic Laboratory (ISHL)

Quality Assurance

The State Hygienic Laboratory at the University of Iowa (SHL) 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 2016 are presented in Table 20.

Equipment

The following is a description of the equipment used by the State Hygienic Laboratory at the University of Iowa Radiation Laboratory.

Gamma Spectrophotometry

Gamma radiation is measured utilizing two High Purity Germanium Detectors (18% & 35% efficient) connected to DSP^{EC} jr 2.0 digital signal processors and ORTEC Maestro Multi Channel Analyzer (MCA) emulation software. Spectra are analyzed using GammaVision gamma spectroscopy software.

Alpha/Beta Counting

Analyses for gross Alpha/Beta, radium-226/228, and strontium-89/90 are performed utilizing two Canberra LB4200 Multi-Detector Low Background Alpha/Beta Counting Systems, including 24 total detectors.

Liquid Scintillation Counting

Analyses for tritium, radon-222, and surface contamination are performed utilizing two liquid scintillation counters, one Packard TriCarb 2550TR and one Beckman LS6500.

Alpha Spectrometry

Analyses for isotopic uranium, thorium, plutonium, and other alpha emitting radionuclides are performed utilizing two alpha spectrometry systems, one ORTEC Alpha Ensemble and one ORTEC OctêtePLUS, including 12 total detectors.

Miscellaneous equipment

SHL's Radiation Laboratory also possesses a number of handheld Geiger-Muller counters for contamination surveys and incoming sample screening, as well as sample processing equipment, including drying ovens, muffle furnaces, and ball mills, for preparing solid samples for analysis.

Table 20: ISHL Radiochemistry Laboratory ERA Intercomparison Studies

Analyte	Analysis Date	Units	Reported Value	Assigned Value	Acceptance Limits	Performance Evaluation
Barium-133	7/14/2015	pCi/L	62.1	64.7	53.9-71.9	Acceptable
	1/22/2016	pCi/L	88.2	90.5	76.2-99.6	Acceptable
Cesium-134	7/14/2015	pCi/L	47.8	50.1	40.3-55.1	Acceptable
	1/22/2016	pCi/L	23.9	23.2	17.7-25.9	Acceptable
Cesium-137	7/14/2015	pCi/L	90.4	89.8	80.8-101	Acceptable
	1/22/2016	pCi/L	64.5	59.1	53.2-67.8	Acceptable
Cobalt-60	7/14/2015	pCi/L	62	59.9	53.9-68.4	Acceptable
	1/22/2016	pCi/L	87.6	83.4	75.1-94.1	Acceptable
Gross Alpha	7/21/2015	pCi/L	31.9	34.5	17.7-44.5	Acceptable
	1/26/2016	pCi/L	68.1	72.8	38.3-89.7	Acceptable
Gross Beta	7/21/2015	pCi/L	21.1	25.1	15.6-33.1	Acceptable
	1/26/2016	pCi/L	19.4	17.8	10.2-26.0	Acceptable
Tritium	7/14/2015	pCi/L	10400	10600	9220-11700	Acceptable
	1/25/2016	pCi/L	12200	12100	10500-13300	Acceptable
Iodine-131	7/13/2015	pCi/L	28.2	25.7	21.3-30.3	Acceptable
	1/15/2016	pCi/L	25.9	25.1	20.8-29.7	Acceptable
Strontium-89	7/31/2015	pCi/L	36.3	42.1	32.3-49.2	Acceptable
	2/10/2016	pCi/L	69.1	68	55.4-76.2	Acceptable
Strontium-90	7/31/2015	pCi/L	23.3	26.8	19.4-31.2	Acceptable
	2/10/2016	pCi/L	37.1	43.4	32-49.8	Acceptable
Zinc-65	7/14/2015	pCi/L	280	265	238-310	Acceptable
	1/22/2016	pCi/L	109	102	91.8-122	Acceptable

Table 20: ISHL Radiochemistry Laboratory Method Detection Limits

Gamma Spectrometry Detection Limits								
Matrix	Filter	Cartridge	Wipe	Soil & Sediment	Milk	Water	Vegetation	Biota
Minimum Sample Size	1500m^3	1500m^3	N/A	600 g	3000 mL	1000 mL	500 g	500 g
Minimum Count Time	3 hours	16 hours	3 hours	3 hours	3 hours	6 hours	4 hours	4 hours
Units	pCi/m^3	pCi/m^3	pCi	pCi/kg dry	pCi/L	pCi/L	pCi/kg dry	pCi/kg wet
Be-7	0.0090	-	14	59	4.0	13	120	9.2
K-40	0.0050	-	7.5	60	5.0	22	190	38
Am-41	0.0010	-	1.5	27	2.6	6.2	-	12
Mn-54	0.0003	-	0.5	5.9	0.4	2.4	4.5	1.6
Co-57	0.0005	-	0.8	6.2	0.4	1.3	12	2.4
Co-58	0.0004	-	0.6	5.9	-	-	3.1	2.3
Fe-59	0.0007	-	1.1	17	0.4	3.7	7.2	1.5
Co-60	0.0004	-	0.6	7.2	0.9	1.2	15	3.2
Zn-65	0.0008	-	1.2	-	0.5	1.9	36	1.7
Kr-85	0.1130	-	170	-	-	-	-	-
Sr-85	0.0005	-	0.8	-	-	-	-	-
Rb-86	0.0040	-	6.0	-	-	-	-	-
Sr-87m	0.0008	-	1.2	-	-	-	-	-
Kr-88	0.0030	-	4.5	-	-	-	-	-
Y-88	0.0006	-	0.9	-	-	-	-	-
Y-91	0.1430	-	220	-	-	-	-	-
Nb-95	0.0003	-	0.5	4.3	0.5	1.5	6.6	0.9
Zr-95	0.0007	-	1.1	-	0.5	3.2	11	6.8
Zr-97	0.0180	-	27	-	-	-	-	-
Mo-99	0.0020	-	3.0	58	2.7	4.0	-	16
Tc-99m	0.0003	-	0.5	-	0.5	1.5	6.7	-
Ru-103	0.0010	-	1.5	6.7	0.4	0.4	14	2.1
Rh-105	0.0010	-	1.5	-	-	-	-	-
Ru-106	0.0050	-	7.5	25	4.9	5.7	150	23
Ag-110m	0.0003	-	0.5	7.2	0.5	1.8	17	2.9
In-111	0.0004	-	0.6	4.9	0.2	1.0	-	1.8

I-123	0.0007	-	1.1	-	0.6	0.8	15	2.6
Sb-125	0.0009	-	1.4	11	1.5	4.8	22	5.6
Sb-127	0.0007	-	1.1	-	-	-	-	-
I-131	0.0004	0.0063	0.6	6.8	0.3	1.1	4.3	0.9
I-132	0.0009	-	1.4	2.5	0.4	0.9	-	1.0
I-133	0.0010	-	1.5	6.1	0.5	1.9	6.2	2.2
Cs-134	0.0004	-	0.6	5.6	0.4	0.5	3.4	3.3
Cs-136	0.0004	-	0.6	6.8	0.5	1.8	4.4	2.8
Cs-137	0.0009	-	1.4	6.8	0.5	1.7	7.4	3.9
Ba-140	0.0030	-	4.5	22	2.1	2.3	25	8.0
La-140	0.0006	-	0.9	1.5	0.3	0.7	8.4	1.2
Ce-141	0.0006	-	0.9	8.2	0.6	1.2	16	1.8
Ce-143	0.0010	-	1.5	7.1	-	-	27	4.1
Ce-144	0.0040	-	6.0	46	3.4	9.1	92	15
Nd-147	0.0010	-	1.5	12	0.9	5.2	-	-
Yb-169	0.0030	-	4.5	-	1.1	2.9	-	-
Bi-212	0.0390	-	59	98	-	-	560	-
Pb-212	0.0040	-	6.0	12	-	-	17	-
Bi-214	0.0030	-	4.5	15	-	-	36	-
Pb-214	0.0030	-	4.5	28	-	-	69	-
Ra-224	0.0170	-	26	190	-	-	-	-
Ac-228	0.0030	-	4.5	28	1.9	7.6	-	-
Th-228	0.0560	-	84	630	45.6	110.0	910	220
Np-239	0.0030	-	4.5	24	1.9	5.0	27	5.7

All MDAs are reported as activity at time of count.

Table 21: ISHL Radiochemistry Laboratory Individual Analyte Detection Limits (A)

Analyte	Tritium		Gross Alpha				Gross Beta			
Matrix	Water & Urine	Tissue	Water	Soil & Sediment	Filter	Wipe	Water	Soil & Sediment	Filter	Wipe
Requested Sample Size	50 mL	30 g	100 mL	0.1 g	250 m3	N/A	100 mL	0.1 g	250 m3	N/A
Minimum Counting Time	100 min	100 min	500 min	500 min	100 min	100 min	500 min	500 min	100 min	100 min
Minimum Detection Limit	300 pCi/L	300 pCi/g wet	3.0 pCi/L	5000 pCi/kg dry	0.002 pCi/m3	0.4 pCi	4.0 pCi/L	3000 pCi/kg dry	0.002 pCi/m3	0.4 pCi
Counting Methodology	LSC	LSC	GPC	GPC	GPC	GPC	GPC	GPC	GPC	GPC

Table 22: ISHL Radiochemistry Laboratory Individual Analyte Detection Limits (B)

Analyte	Radon-222	Radium-226		Radium-228		Strontium-89	Strontium-90	Iodine-131
Matrix	Water	Water	Soil & Sediment	Water	Soil & Sediment	Water/Milk	Water/Milk	Water/Milk
Requested Sample Size	40 mL	1000 mL	600 g	1000 mL	600 g	1000 mL	1000 mL	3000 mL
Minimum Counting Time	50 min	60 min	180 min	60 min	180 min	60 min	60 min	180 min
Minimum Detection Limit	20 pCi/L	1 pCi/L	20 pCi/kg dry	1 pCi/L	40 pCi/kg dry	10 pCi/L	2 pCi/L	1 pCi/L
Counting Methodology	LSC	GPC	Gamma	GPC	Gamma	GPC	GPC	Gamma