WASHINGTON STATE UNIVERSITY | Nuclear Science Center

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Re: Docket No. 50-27; Facility License R-76

The Annual Report for the WSU facility, License R-76, Docket 50-27, prepared by C. Corey Hines, Assistant Director for Reactor Operations and Reactor Supervisor of the WSU Facility, is hereby submitted. The report covers the operating period July 1, 2016 through June 30, 2017.

Respectfully Submitted

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Enclosure

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2017

ANNUAL OPERATIONS REPORT

ANNUAL OPERATIONS REPORT FOR THE WASHINGTON STATE UNIVERSITY TRIGA REACTOR

FACILITY LICENSE R-76 FOR THE REPORTING PERIOD JULY 1, 2016 TO JUNE 30, 2017

NUCLEAR SCIENCE CENTER | Washington State University, Pullman, WA

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1. Narrative Summary of Operation for Fiscal Year 2017

A. Operating Experience

Core 35A has accumulated 9486 MWH from beginning of life (BOL) through June 30, 2017. During the reporting period of July 1, 2016 to June 30, 2017, a total of 887 samples were irradiated, for a total of 9,427 user-hours. Additionally, 21 pulses greater than $1.00 of reactivity addition were performed during the reporting period. The quarterly operations summaries are shown in Table I.

B. Changes in Facility Design, Performance Characteristics, and Operating Procedures Related to Reactor Safety.

The Standard Operating Procedures (SOP) were revised and approved by the Reactor Safeguards Committee on May 9, 2017. The new SOP numbers are used in this report.

C. Results of Surveillance Tests and Requirements

The annual pulsing limit calculations were not completed within the prescribed period. Pulsing operations were suspended until the calculations were completed on June 21, 2017.

2. Energy and Cumulative Output

The quarterly operations summaries are given in Table I. The cumulative energy output since the 1967 TRIGA fuel core was put in to service is 1625 megawatt days (MWD). The mixed Standard Fuel and 30/20 LEU Fuel Core 35A installed in 2008 has accumulated 395 MWD.

Table I
Fiscal Year 2016 Summary of Reactor Operation[1]

	Q3 2016	Q4 2016	Q1 2017	Q2 2017	Totals
Hours of Operation	277	405	301	363	1347
Megawatt Hours	232	304	254	315	1106
No of Sample Irradiations	58	57	48	68	231
No. of Samples	252	180	194	261	887
No. of Commercial Irradiations	23	29	28	37	117
User Hours	1990	1353	2623	3460	9427
No. of Pulses > $1.00	5	4	2	10	21

3. Emergency Shutdowns and Inadvertent Scrams

There were no emergency shutdowns or unplanned shutdown periods that occurred during the reporting period. The dates and causes of the ten inadvertent scrams are listed in Table II. No scrams were due to exceeding the limiting safety systems setting or safety limit.

[1] Number of samples and sample irradiations do not include commercial irradiations. User hours denotes the total user hours, including commercial irradiations.

Table II
Inadvertent Scrams

Date	Description of Scram
7/5/2016	Loss of power to the building caused a scram.
9/14/2016	Operator switched to test during rundown.
11/14/2016	Fuel temperature (indication) scram due to electrical interference. Power channels did not high power scram, nor did they show an increase above steady state power levels. A trainee was moving a chair adjacent to the console and may have knocked the area of the fuel temperature monitoring channels too hard, which has been known to cause scrams in the past. Restart OK.
11/16/2016	While practicing for a material shipment over the east side of the pool, an operator dropped a 24 inch long welding rod in the reactor pool and it started traveling toward the core. The operator yelled for a manual scram, and the reactor was shutdown by manual scram. The welding rod was retrieved from the west side of the pool, and never hit the core itself.
12/7/2016	A trainee switched the mode selector switch to test instead of rundown.
12/13/2016	Manual scram due to a false fire alarm. No fire was observed.
4/3/2017	Pulse high power scram while performing a power calibration with the reactor at 1.0 MW. The reset button on the LOG-N channel was pressed to clear the erroneous short period alarm received during startup. Normally, pressing the reset on the LOG-N channel does not scram the reactor, but there was electrical noise with the channel causing an indication of high power on the pulse channel. Power level and fuel temperature traces did not indicate a power excursion.
4/3/2017	A trainee switched the mode selector to test instead of rundown.
4/5/2017	Spurious high power SCRAM due to a loose connection on the pulse channel. Power level traces and fuel temperature traces do not indicate a power excursion.
5/18/2017	Loss of building power caused a scram.

4. Major Maintenance

Although they are not part of routine preventative maintenance, the below listed items were performed.

7/19/2016: *UPS*
It was found that the uninterrupted power supply in the Information Technology (IT) closet, Room 115T, had burnt up a battery, identified by a strong burning odor coming from the first floor. WSU Facility Services contacted IT personnel to replace the battery. The IT representative stated that the problem should be resolved, but to contact them if we experience any further issues.

9/28/2016: *Control Blade 2*
The magnet on the control drive was not staying engaged when trying to pull blade 2 out of the core. The limit switch for blade 2 was adjusted so that the blade magnet would make contact with the armature disk.

10/31/2016: *EGM Flow Rate Meter*
The EGM flow rate meter model RMB-54-SSV, serial number T48Y5700173 was replaced with a recently calibrated EGM flow rate meter model RMB-54-SSV-NIST, serial number T42Z570067.

1/11/2017: *Pulse Rod Connecting Rod Linkages*
When reassembling the pulse rod to the pulse rod drive, the SRO observed that the lock washers at the connecting rod linkages needed to be replaced. All nine fasteners were replaced with new bolts, washers and nuts of the same specifications.

1/11/2017: *Pulse Rod Limit Switch*
The pulse rod cylinder in light was not engaged on the console when the pulse rod cylinder was fully inserted into the core. The rod had slipped passed the limit switch when the rod and drive were being connected. The pulse rod drive was removed and the limit switch was adjusted so that the limit switch was engaged when the pulse rod was down.

1/11/2017: *Pulse Rod Cylinder Limit Switch*
The pulse cylinder in light was not engaged on the console when the pulse rod cylinder was fully inserted into the core. It was found that one of the two limit switches was not engaging properly. The limit switch was adjusted so that both switches are engaging correctly.

4/20/2017: *Primary Heat Exchanger Pump*
The primary pump was aspirating air in and releasing it into the pool through the outlet pipe. The pump leaked water when it was not running. WSU Facility Services representatives disassembled the primary heat exchange pump at the motor/impellor junction. They noted that the nut which holds the impeller in place was loose, which may have been the cause of the problem. WSU Facility Services representatives took the pump to the repair shop and fitted it with a new seal. Upon replacing the pump, they tightened the nut for the impeller. The pump was tested and was functioning without leaks.

5/16/2017: *Purification Pump*
The purification pump in room 101A was leaking small amounts of water. On 5/24/2017 the purification system was isolated and the water purification system pump was removed and decontaminated. WSU Facility Services representatives took the pump to the repair shop to replace a seal. The pump was reinstalled and is functioning properly.

6/5/2017: *Ion Exchanger*
The gasket on the ion exchanger was damaged and would not provide a proper seal. The old gasket was removed and the ion exchanger lid was cleaned. A small amount of grease was applied to the gasket slot on the lid and new gasket material was inserted. They system exhibited normal (non-leaking) behavior.

5. Changes, Tests, and Experiments Performed Under 10 CFR 50.59 Criteria

There were no changes to the facility made under 10 CFR50.59 criteria during the 2016-2017 reporting year.

6. Radioactive Effluent Discharges

A. Radioactive Liquid Effluent Releases

The liquid effluent releases for the facility during the reporting period are provided in Table III.

Table III
Monthly Liquid Effluent Releases

Month	Volume (gallons)
July 2016	0
August	0
September	0
October	0
November	0
December	0
January 2017	0
February	0
March	3348
April	0
May	0
June	3714

Approximately 7062 gallons of liquid effluent were released from the storage tank during the reporting period. Prior to discharge, a sample of the liquid in the tank was analyzed using gamma spectroscopy and liquid scintillation counting. The March and June gamma spectroscopy reports indicated an activity of 0.00 µCi and 0.73 µCi respectively. A total activity of 0.73 µCi was released as liquid effluent during this reporting period.

B. Radioactive Gaseous Effluent Release

During the reporting period, no measurable quantity of gaseous or particulate material with a half-life greater than eight days was detected. The argon-41 release did not exceed 20% of the effluent release limit. A total of 0.3872 Ci of argon-41 was released, with an average argon-41 concentration of 1.97×10^{-11} µCi/mL of air, after environmental dilution. The argon-41 release is used in the 2017 Annual Report for Radioactive Air Emission License (RAEL-004), stack number 7. Per COMPLY v1.7, the reactor facility (stack 7) is in compliance at level 4 with an effective dose equivalent of 3.4×10^{-4} mrem/yr. The monthly releases are summarized in Table IV.

Table IV
Monthly Argon-41 Releases[2]

Month	Quantity (Ci)	Conc. After Dilution, (μCi/mL)	% of DAC Limit
July 2016	2.1×10^{-3}	1.2×10^{-12}	4.1×10^{-5}
August	3.8×10^{-2}	2.3×10^{-11}	7.6×10^{-4}
September	2.7×10^{-2}	1.7×10^{-11}	5.6×10^{-4}
October	2.5×10^{-2}	1.5×10^{-11}	4.9×10^{-4}
November	3.7×10^{-2}	2.3×10^{-11}	7.7×10^{-4}
December	2.8×10^{-2}	1.7×10^{-11}	5.6×10^{-4}
January 2017	1.2×10^{-2}	7.0×10^{-12}	2.3×10^{-4}
February	2.5×10^{-2}	1.7×10^{-11}	5.5×10^{-4}
March	5.9×10^{-2}	3.5×10^{-11}	1.2×10^{-3}
April	6.0×10^{-2}	3.7×10^{-11}	1.2×10^{-3}
May	4.2×10^{-2}	2.5×10^{-11}	8.3×10^{-4}
June	3.3×10^{-2}	2.0×10^{-11}	6.8×10^{-4}

C. Radioactive Solid Waste Disposal

During the reporting period, 4.37 mCi in 28 cubic feet of non-compacted solid waste was transferred to the WSU Radiation Safety Office for packaging and disposal.

7. Personnel and Visitor Radiation Doses

The quarterly doses of the WSU Nuclear Science Center reactor staff and experimenters are given in Table V. The maximum quarterly dose of a reactor staff member was 51 mrem, whole body.

A total of 1524 individual persons visited the Nuclear Science Center during the reporting period, of which 691 entered a controlled access area (CAA).[3] A total of 59 group tours, consisting of 526 individuals, visited the center during the reporting period, also entering a CAA. All doses were less than or equal to 0.2 mrem as determined by digital pocket dosimeter.

[2] Quantity released based on 4500 CFM effluent of ventilation system in AUTO mode of operation. Concentration after dilution is based on 10 CFR 20 effluent release limit of 1.0×10^{-8} μCi/mL for Ar-41 (Table 2, Col.1), and a dilution factor of 3.4×10^{-3} (WSU Technical Specifications 3.5.2). DAC limits are based on 10 CFR 20 derived air concentration limit of 3.0×10^{-6} μCi/mL for Ar-41 (Table 1, Col. 3) and a dilution factor of 3.4×10^{-3}.
[3] A controlled access area is an area in the building where radioactive materials are used or stored and is a part of the licensed reactor facility.

Table V
Quarterly Reactor and Experimenter Staff Dose[4] (in mrem)

Badge No.	Q3 2016	Q4 2016	Q1 2017	Q2 2017
10452	1	--	--	--
10921	36	20	25	14
11525	--	2	M	--
11524	--	M	M	--
11528	--	M	M	--
10838	6	2	M	--
11516	--	4	24	21
11205	2	4	1	3
11225	8	7	7	--
11241	9	6	5	--
10460	--	--	--	--
08141	8	25	6	5
11520	--	2	8	2
11685	--	--	M	--
10910	38	13	9	9
10916	51	49	16	13
11220	--	--	--	--
10904	5	M	M	--
11686	--	--	M	--
10392	8	--	--	--
11532	--	4	5	M
11109	--	M	3	--
11255	8	7	2	M
11224	--	--	--	--
10451	15	36	13	10
10641	25	4	5	2
11694	--	--	--	3
11222	6	9	9	2
11523	--	M	2	1
08594	--	5	11	1
07748	8	4	2	M
10643	13	9	10	5

[4] "--" denotes data not available either due to departure from the facility or new personnel starting at the facility. An 'M' denotes that the dosimeter reading was less than or equal to the background radiation level for that quarter.

8. Reactor Facility Radiation and Contamination Levels

The limit of quantification (LOQ) for building survey samples collected for removable contamination determination by liquid scintillation assay averaged over one year is 8.8×10^{-8} μCi/cm^2. Routine building surveys showed average counts less than the LOQ for all CAAs and all non-CAAs.

Table VI
Average Removable Contamination for
Weekly Monitoring in CAAs and Non-CAAs[5]

Location	Measured Activity Above LOQ (μCi/cm²)
201B	M
201A	M
201 Reactor Bridge Steps	M
201 Sample Drop Tube	M
201 Reactor Bridge South	M
201 Reactor Bridge North	M
201 Experimenter Platform	M
201 Laboratory Benches	M
201 Floor South	M
201-C Heat Exchanger Floor	M
201 Floor North	M
106 Ion Exchanger Pit	M
101-A Purification Pump Pit	M
101 Doorway	M
101 Shipment Bench	M
101 Sample Preparation Bench	M
101 Sample Drop Hood #2	M
101 Shipment Bench	M
101 Hood #1	M
101 Hood #18	M
101 Hood #4	M
B21 Panoramic Irradiator	M
B21 Floor	M
RM 2 South Floor	M
RM 2 Thermal Column	M
RM 2 Thermal Column Floor	M
RM 2 North Floor	M
RM 2 Cave Floor West	M
RM 2 Cave Floor East	M

The routine area radiation surveys of the building in CAAs and non-CAAs are given in Table VII. The highest average dose rate for a single location in a CAA was 9.61 mrem/hr, which occurred in Room 2 East Cave. This value is less than the limit

[5] Bolded text indicates a non-CAA. Regular text indicates a CAA. "M" indicates the value is below the LOQ value of 8.8×10^{-8} μCi/cm². Room 101 hood #4 was added to swipes and surveys in week 11 of 2017. Room 101 shipping bench, and room 101 sample prep bench were added to swipes and surveys in week 13 of 2017.

for CAAs. The lowest average dose rate in a CAA was 0.04 mrem/hr (a level considered background), which occurred in Room 2 Thermal Column. The average dose rate in the radiochemistry sample hoods (a non-CAA) was 0.15 mrem/hr. The East and West cave are storage areas designed to house radioactive sources such that they are shielded and are locked away from daily activities. This space is posted as a high radiation area. Personnel do not typically work in this area and it is kept locked when not in use.

Table VII
Average Radiation Dose Rates for
Weekly Monitoring in CAAs and Non-CAAs[6]

Location	Average Dose Rate (mRem/hr)
Room 201 B	0.06
Room 201 A	0.06
Room 201 Bridge	1.06
Room 201 Benches	0.30
Room 201 South	0.74
Room 201 East	0.62
Room 201 C Heat Exchanger	0.09
Room 201 North	0.62
Room 106 Ion Exchanger Pit	1.74
Room 101 A Purification Pit	2.40
Sample Storage	0.31
Room 101 Doorway	0.04
Room 101 Shipment Bench	0.03
Room 101 Sample Prep Bench	0.01
Room 101 Sample Drop Hood 2	0.37
Room 101 Shipping Bench	0.01
Room 101 Hood 1	0.07
Room 101 Hood 2	0.06
Room 101 Hood 4	0.01
Room B21 Panoramic Irradiator	0.04
Room 2 South	0.24
Room 2 Thermal Column	0.04
Room 2 North	0.07
Room 2 West Cave	1.24
Room 2 East Cave	9.61

[6] Bolded text indicates a non-CAA. Regular text indicates a CAA. Room 101 hood #4 was added to swipes and surveys in week 11 of 2017. Room 101 shipping bench and room 101 sample prep bench were added to swipes and surveys in week 13 of 2017.

9. Environmental Monitoring Program

The environmental monitoring program is used to determine the average background radiation levels through the use of offsite thermoluminescent dosimeters (TLD's) at locations. The offsite radiation monitoring program is defined and required by the Technical Specifications TLD's 3, 7, 9, 15 through 35, and 39 through 44 are used in the offsite radiation monitoring program. The TLD's that are used to calculate the background do not have to meet the less than 20% above background requirement. The average background radiation level is then compared to the nearest occupied dwelling. TLD 4, 5, 6, 8, 9, and 10 show abnormally high readings for Q3 2016, Q4 2016, Q1 2017, and Q2 2017 due to irradiated graphite reflector elements stored in the radioactive waste shed on the north side of the facility. The Radiation Safety Office has shielded the reflector barrels such that no public dose rate limits are exceeded. TLD 9 has been removed from background radiation calculations.

Average quarterly dose rates for offsite locations are listed in Table VIII and are used to calculate the Technical Specification threshold of 20% above the background radiation level and compared to the limiting values which are listed in Table XI. The average environmental radiation levels for the closest offsite point of extended occupancy, is listed in Table X. Table IX shows the quarterly environmental radiation levels for those TLD's located at onsite locations. These locations are not required to be compared to background radiation levels.

The closest offsite points of extended occupancy are compared in Figure 1 to both the background radiation levels and the 20% above background radiation levels. The ALARA effluent release limits in Technical Specification 3.5.2(3) specify that annual radiation exposure due to reactor operation, at the closest offsite extended occupancy, shall not, on an annual basis, exceed the average offsite background radiation by more than 20%. For the reporting period, the average background radiation dose rate for off-site locations was 0.35 mrem/day, while the average radiation dose rate at the closest extended occupancy area 600 meters away was 0.27 mrem/day. This result indicates that no exposure level above normal background radiation was found, and that no dose levels exceeded Technical Specifications requirements for an offsite area of extended occupancy.

Table VIII
Environmental Radiation Levels at Offsite Locations of the Nuclear Science Center[7]
(dose rate in mrem/day)

Location	Q3 2016	Q4 2016	Q1 2017	Q2 2017	Average
Fence E of NRC	0.28	0.31	0.27	0.29	0.29
Fence, N of Rad Waste Shed	0.57	0.63	0.44	0.48	0.53
Fence directly N Rad Waste Shed	5.90	5.34	5.65	5.34	5.56
S NRC, on parking lot fence	0.27	0.30	0.28	0.30	0.29
Fence S Roundtop Dr, 10th pole W of pole C14	0.31	0.34	0.32	0.31	0.32
Telephone pole C12	0.29	0.29	0.28	0.34	0.30
Telephone pole near golf course gate	0.28	0.30	0.28	0.31	0.29
E across fairway on pine tree	0.30	0.30	0.28	0.29	0.29
Maple tree #54 along driving range	0.29	0.29	0.27	0.30	0.29
NW to fence uphill from driving range	0.31	0.51	--	0.33	0.38
Follow fence E to fence corner	0.32	0.33	0.29	0.37	0.33
S to lone spruce tree near water hazard	0.30	0.27	0.27	0.29	0.28
Roundtop hill park, NW fence corner	0.28	0.31	0.29	0.28	0.29
Deciduous tree edge of 18th green	0.32	0.31	0.31	0.30	0.31
6ft pine tree, 3rd W down cart path from clubhouse	0.30	0.33	0.29	0.32	0.31
3rd to last tree after gap in same line of trees	0.27	0.31	0.27	0.29	0.28
SW to fence along path near 2nd to last tee box at bottom hill	0.31	0.30	0.31	0.31	0.31
Follow fence partway up hill after fence turns S	0.29	0.30	0.27	0.30	0.29
Follow fence, 15th pole E after fence turns W	0.29	0.32	0.31	0.30	0.30
Follow fence about halfway between last TLD and corner	0.31	0.31	0.31	0.32	0.31
Largest bush S of NRC	0.30	0.29	0.31	0.30	0.30
2nd fence S NRC, W end at gate	0.28	0.30	0.29	0.31	0.29
S Fairway Rd, 1st light post on right	0.30	0.30	--	0.09	0.23
S Fairway Rd, 2nd light post on right	0.28	0.27	0.26	0.31	0.28
Ellis Way and Hog Lane sign	0.25	0.29	0.26	0.30	0.28
Bottom of radio antenna hill, fence next to shrub left of gate	0.30	0.33	0.29	0.32	0.31
3rd fence S of NRC, SE corner, cow pasture	0.31	0.29	0.33	0.31	0.31
Airport fence W end runway at gate	0.26	0.32	0.25	0.30	0.28
Fence/entry bar E of Jewett Observatory	0.25	0.31	0.30	0.29	0.29
Granite rock Terrell Mall, hole in back	--	0.34	--	0.27	0.31

[7] Offsite defined by the Technical Specification 1.0 and 5.1.1 as any location which is outside the site boundary. The "--" indicates a TLD which was missing.

Table IX
Environmental Radiation Levels at Onsite Locations of the Nuclear Science Center[8]
(dose rate in mrem/day)

Location	Q3 2016	Q4 2016	Q1 2017	Q2 2017	Average
E lower loading dock	0.29	0.30	0.33	0.29	0.30
Pool room truck door fence S end	0.96	1.16	0.72	0.99	0.96
Pool room truck door fence N end	3.13	2.42	1.53	2.24	2.33
E wall rad waste shed	1.18	0.98	0.57	0.71	0.86
N wall rad waste shed	0.77	0.76	0.88	1.08	0.87
Cooling tower fence, NE corner	20.37	17.09	21.05	18.06	19.14
Room 101 window	0.38	0.36	0.32	0.36	0.35
Railing next to upper liquid waste tank	0.35	0.35	0.33	0.36	0.35
Room 2 truck door fence	0.30	0.31	0.28	0.32	0.30
Transformer vault vent louvers	0.31	0.33	0.32	0.38	0.33
NRC main entrance, light fixture	0.33	0.38	0.35	0.33	0.35
NRC roof, pool room vent stack	0.26	0.32	0.32	0.31	0.30
NRC roof, guide wire E end of building	0.31	0.36	0.32	0.32	0.33
NRC roof, E pool room vent support leg	0.51	0.61	0.69	0.58	0.60
NRC roof, air conditioning support leg	0.32	0.34	0.32	0.32	0.32
NRC roof, W pool room vent support leg	0.58	0.54	0.64	0.80	0.64

Table X
Environmental Radiation Levels for the Closest Offsite Point of Extended Occupancy
(dose rate in mrem/day)

Location	Q3 2016	Q4 2016	Q1 2017	Q2 2017	Average
Apt complex C, gas meter	0.26	0.27	0.27	0.28	0.27
Apt complex B, gas meter	0.23	0.29	0.25	0.30	0.27
1st fence S apt complex A	0.23	0.30	0.28	0.28	0.27

Table XI
Background Environmental Radiation Levels
(dose rate in mrem/day)

Description	Q3 2016	Q4 2016	Q1 2017	Q2 2017	Average
Background radiation levels	0.49	0.32	0.29	0.30	0.35
20% above background radiation levels	0.59	0.39	0.35	0.37	0.42

[8] Onsite defined by the Technical Specification 1.0 and 5.1.1 as any location within the site boundary.

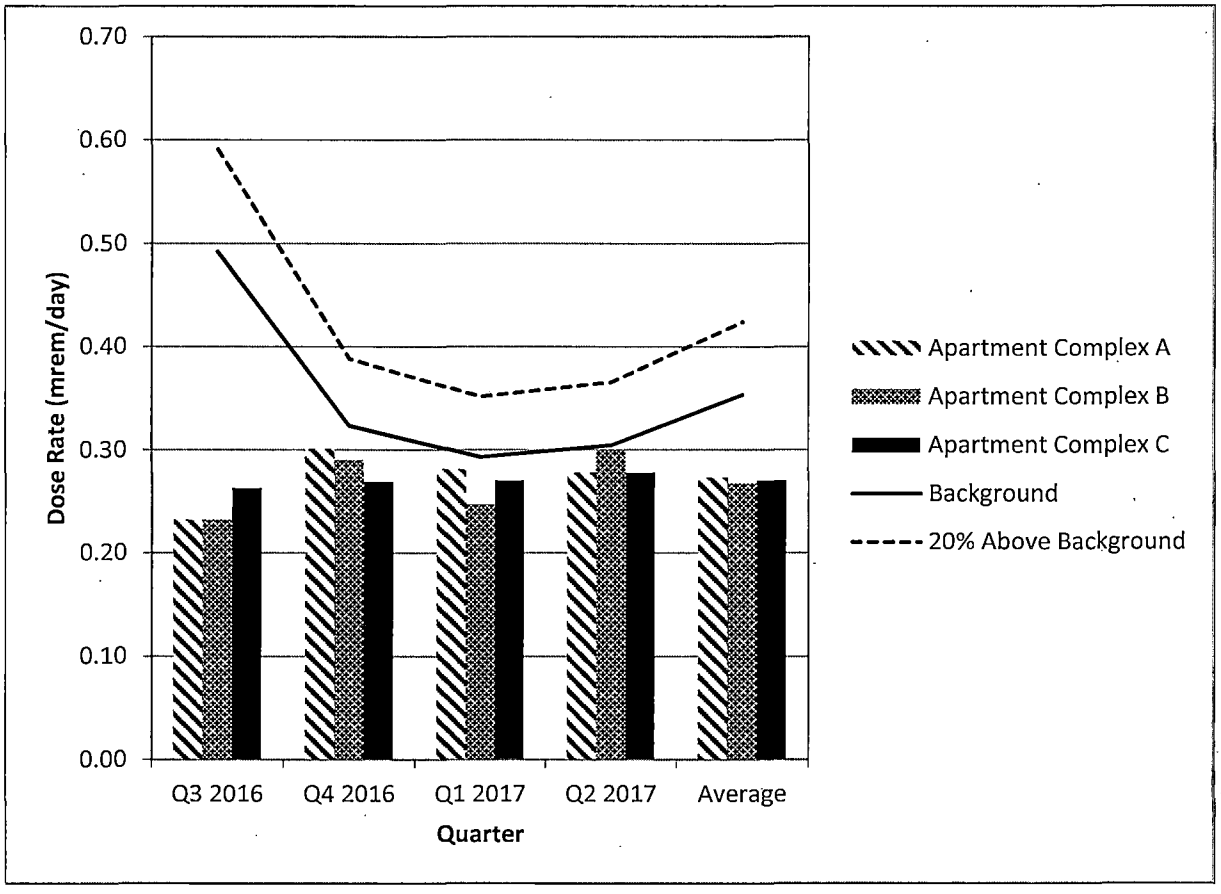

Figure 1: Environmental radiation levels for the closest off-site point of extended occupancy as compared to background radiation levels and 20% above background radiation levels.