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Reference: Washington State University Modified TRIGA Reactor
License No. R-76; Docket No. 50-027

Subject: 2024 Annual Report for the WSU Nuclear Science Center

The annual report for the WSU reactor facility is hereby submitted. The report covers the operating period from July 1, 2023 through June 30, 2024.

Respectfully submitted,

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Director

Enclosure

cc: Clark J. Filip, Reactor Manager, Nuclear Science Center
WA Department of Health, Office of Radiation Protection

2024

ANNUAL OPERATIONS REPORT

WASHINGTON STATE UNIVERSITY TRIGA REACTOR

FACILITY LICENSE R-76 FOR THE REPORTING PERIOD
JULY 1, 2023 TO JUNE 30, 2024

NUCLEAR SCIENCE CENTER | Washington State University, Pullman, WA

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1. Narrative Summary of Operation for Fiscal Year 2024

A. Operating Experience

Core 35A has accumulated 17,189 MWH from beginning of life (BOL) through June 30, 2024. During the reporting period of July 1, 2023 to June 30, 2024, a total of 1383 samples were irradiated, for 9,752 user-hours. Additionally, 11 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:

No changes in facility design, performance characteristics, or operating procedures related to reactor safety were made.

C. Results of Surveillance Tests and Requirements:

Technical Specification requirement 6.4.4(8) and 6.4.4(9) biennial review of the physical security plan and annual review of the radiation protection program was not completed on time by the Reactor Safeguards Committee. The issue was addressed at the 1/24/2024 RSC Meeting.

Technical Specification requirement 4.3(2), radionuclide content of the reactor pool water was missed in March 2024 during the reactor ventilation system replacement. Three SROs incorrectly interpreted the TS that this surveillance requirement could be skipped during the scheduled shutdown for the reactor ventilation system replacement. Radionuclide content in February and April 2024 were normal and no other abnormal conditions were observed.

All other surveillance tests and requirements were performed and completed within the prescribed time period.

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 into service is 1,913 megawatt days (MWD). The mixed Standard Fuel and 30/20 LEU Fuel Core 35A installed in 2008 has accumulated 683 MWD.

Table I. Fiscal Year 2024 Summary of Reactor Operation[1]

	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Totals
Hours of Operation	316	357	203	289	1165
Megawatt Hours	274	344	200	288	1106
Sample Irradiations	141	85	70	97	393
Samples	478	271	246	388	1383
External Irradiations	14	41	23	24	102
Pulses > $1.00	1	2	3	5	11
User Hours	907	3536	2128	3181	9752

3. Emergency Shutdowns and Inadvertent Scrams

During the reporting period, there were no emergency shutdowns.

The dates and causes of the seven inadvertent scrams are listed in Table II. No scrams were due to exceeding the limiting safety system setting or safety limit.

Table II. Inadvertent Scrams

Date	Description
8/25/2023	Facility power flickered during a thunderstorm causing loss of power to console and air scram.
8/29/2023	Storm caused power to flicker scramming CE 1 and 3.
9/19/2023	Control Element 1 disengaged during operation when knocked by an operator inserting a sample for irradiation.
11/1/2023	Control Element 1 disengaged during operation when knocked by an operator removing a sample post-irradiation.
11/7/2023	High Power scram occurred immediately after initiation of a pulse.
1/12/2024	Control Element 1 scrammed at power due to excessive tapping of the lower button by the operator.
4/17/2024	Control Element 1 scrammed at power when the operator was raising the blade. The replacement CE motor was swapped with the original, rebuilt motor.
5/31/2024	Operator inadvertently selected test instead of rundown on mode selector switch.

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

4. Major Maintenance

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

7/7/2023: The bulk pool water temperature probe failed due to water intrusion. The heat exchanger inlet temperature probe was found to be within one degree Celsius of the pool water temperature and was used until the pool temperature probe was repaired and replaced to its original location.

8/1/2023: The pulse air regulator was replaced with an identical model.

8/16/2023: A new purification loop filter was installed upstream of the ion exchanger tank.

8/23/2023: Control element 4 drive motor failed and was replaced with a new, spare motor while the original control element motor was being rebuilt.

8/31/2023: Control element 1 drive motor was rebuilt as a preventative maintenance measure and replaced with the new, spare drive motor while being rebuilt.

11/8/2023: An electrical fault resulting in pulse rod air scrams was traced to a loose connection on the mode selector switch which was re-soldered and the issue was resolved.

12/15/2023: Ventilation system damper 4 was not fully closing or was closing slowly. The damper actuator was greased and the issue was resolved.

12/21/2023: Ventilation system fan 4 heating coil was leaking a large amount of steam in the penthouse. The leaking pipe was repaired.

1/15/2024: Ventilation system fan 4 heating coil steam trap froze and burst. The steam trap was repaired.

1/29/2024: Ventilation system damper 4 would not reliably shut during the reactor startup checkout. The damper was manually cycled and the damper reliably returned to service.

3/22/2024: Unused beam port H2 air pressure regulator failed and was leaking air. The air supply was capped off.

5/28/2024: The EGM pump did not start during the reactor startup checkout due to a bad electrical connection. The pump was replaced with an identical replacement.

5/30/2024: The pool make-up water accumulator stopped functioning. The accumulator wheel was removed, cleaned, and returned to service.

6/11/2024: Two irradiation rotator motors failed and were replaced with identical replacements.

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

A total of three proposed changes to the facility was reviewed during the 2023-2024 year. The proposals were screened with the 10 CFR 50.59 requirements and found to screen out, thus allowing the change to be made. The following change was made to the facility under 50.59 criteria:

50.59-111-2023: A cartridge filter was added to the purification loop immediately upstream of the ion exchange resin tank. The filter is meant to extend the life of the ion exchange resin by particulate collection prior to primary coolant contact with the ion exchanger. A higher horsepower ion exchange pump was also added for the increased head pressure introduced by the filter.

50.59-112-2023: A new control element drive motor for control element 4 was installed due to the original failing. The new control element drive motor was tested and utilized until the original control drive motors could be rebuilt, tested, reinstalled, and returned to service.

50.59-113-2024: Fans, dampers, duct work, and electrical service components of the reactor ventilation system were removed, replaced, tested, and commissioned into service. Pneumatic damper controls were removed and replaced with electronic damper actuators. A condensing unit was added to the ventilation system to provide moderate cooling capability for the reactor pool room.

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 2023	0
August	0
September	0
October	0
November	0
December	0
January 2024	0
February	0
March	0
April	0
May	6,560
June	0

Approximately 6,560 gallons of liquid effluents were released on two occasions in May 2024 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 May 10, 2024 gamma spectroscopy report indicated an activity of 0.0 µCi. The May 29, 2024 gamma spectroscopy report indicated an activity of 1.87 µCi. The two May 2024 liquid effluent releases were the only two releases during the reporting period.

B. Radioactive Gaseous Effluent Release

During the reporting period, no emission of a measurable quantity of gaseous or particulate material with a half-life greater than eight days was detected. The measured argon-41 out of the common exhaust stack did not exceed 20% of the effluent release limit. A total of 2.27 Ci of argon-41 was released, with an average argon-41 concentration of 1.15×10^{-10} µCi/mL of air, after environmental dilution. The argon-41 release and the pool water analysis is used in the 2024 Annual Report for Radioactive Air Emission License (RAEL-004), stack number 7. Per COMPLY v1.7, the reactor facility (stack 7) complies at level 4 with an effective dose equivalent of 2.7×10^{-3} mrem/yr. The monthly releases from Ar-41 are summarized in Table IV.

Table IV. Monthly Argon-41 Releases[2]

Month	Quantity (Ci)	Conc. After Dilution (µCi/mL)	% of DAC Limit
July 2023	2.1E-01	1.3E-10	4.2E-03
August	2.5E-01	1.5E-10	4.9E-03
September	1.9E-01	1.2E-10	3.8E-03
October	3.1E-01	1.9E-10	6.2E-03
November	1.5E-01	9.2E-11	3.1E-03
December	2.2E-01	1.3E-10	4.4E-03
January 2023	1.5E-01	8.7E-11	2.9E-03
February	2.5E-01	1.6E-10	5.4E-03
March	8.9E-02	5.3E-11	1.8E-03
April	1.0E-01	6.4E-11	2.1E-03
May	1.9E-01	1.2E-10	3.8E-03
June	1.6E-01	9.9E-11	3.3E-03

C. Radioactive Solid Waste Disposal

During the reporting period, no 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 to a reactor staff member was 136 mrem, whole body. A total of 1,763 individual persons visited the Nuclear Science Center during the reporting period, of which 948 entered a controlled access area (CAA).[3] A total of 41 group tours, consisting of 466 individuals, visited the center during the reporting period, also entering a CAA. None of these tour groups received measured exposures above 0.1 mR as determined by digital pocket dosimeters.

[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] (mrem)

Badge No.	Q3 2023	Q4 2023	Q1 2024	Q2 2023
00706	13	--	--	--
07401	--	3	--	--
07378	M	M	M	--
03959	104	14	18	M
10921	20	M	--	--
07398	--	M	3	13
01340	17	8	5	15
07441	--	--	43	21
07767	--	--	--	M
03396	53	29	3	M
01327	M	M	M	M
05374	M	M	M	--
01160	34	24	27	25
08141	M	M	M	M
03652	1	M	M	M
07393	--	M	--	8
03768	4	M	M	M
07379	M	M	M	M
07349	1	--	--	--
07882	--	--	--	M
03653	M	M	M	M
03651	6	M	M	M
00704	29	33	32	16
07429	--	M	M	M
07396	M	M	M	2
07117	M	M	M	M
07416	--	M	M	--
07402	M	3	M	M

8. Reactor Facility Radiation and Contamination Levels

The limit of quantification (LOQ) for building removable contamination determination survey samples as measured by liquid scintillation assay is 8.93×10^{-8} µCi/cm^2; the survey sample data that was collected for removable contamination determination were averaged over one year. Routine building surveys showed average levels of removable activity to be less than the LOQ for all non-CAAs.

[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.

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

Location	Measured Activity Above LOQ (µCi/cm^2)
201 B	M
201A	M
201 RX BRIDGE STEPS	M
210 SAMPLE DROP TUBE	M
201 RX BRIDGE - SOUTH	M
201 RX BRIDGE - NORTH	M
201 EXPERIMENTER PLATFORM	1.1E-07
201 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 DOOR WAY	M
101 SAMPLE PREP BENCH	M
101 SAMPLE DROP HOOD #2	M
101 HOOD #1	M
101 HOOD #2	M
RAM STORAGE SAFE	M
101 ISLAND	M
101 NORTH LAB BENCH	M
101 HOOD #3	M
101 HOOD #4	M
101 SHIPPING BENCH	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 WEST CAVE FLOOR	M
RM 2 EAST CAVE FLOOR	M

The results for 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 27.58 mrem/hr, which occurred in Room 2 East Cave. This value is less

[5] Bolded text indicates a non-CAA. Regular text indicates a CAA. "M" indicates the value is below the LOQ value of 8.80 x 10^{-8} µCi/cm^2.

than the limit for CAAs. The lowest average dose rate in a CAA was 0.04 mrem/hr (a level considered background), which occurred in Room 201B. The average dose rate in the radiochemistry sample hoods (a non-CAA) was 0.09 mrem/hr. The East and West cave are secured storage areas that are designed to house radioactive sources, and provide shielding. The space is posted as a high radiation area. Personnel do not typically work in this area and it is 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	0.04
ROOM 201 A	0.04
ROOM 201 BRIDGE	1.0
ROOM 201 BENCHES	0.27
ROOM 201 SOUTH	0.24
ROOM 201 EAST	0.26
ROOM 201 C HEAT EXCHANGER	0.15
ROOM 201 NORTH	0.21
ROOM 106 ION EXCHANGER PIT	1.0
ROOM 101 A PURIFICATION PIT	2.1
ROOM 101 DOORWAY	0.32
ROOM 101 SAMPLE PREP BENCH	0.04
SAMPLE STORAGE	0.16
ROOM 101 SAMPLE DROP HOOD	0.05
ROOM 101 HOOD 1	0.05
ROOM 101 HOOD 2	0.09
101 NORTH LAB BENCH	0.05
101 HOOD #3	0.04
ROOM 101 HOOD 4	0.05
ROOM 101 SHIPPING BENCH	0.04
ROOM B21 PANORAMIC IRRADIATOR	0.04
ROOM 2 SOUTH	0.26
ROOM 2 THERMAL COLUMN	0.04
ROOM 2 NORTH	0.16
ROOM 2 WEST CAVE	1.85
ROOM 2 EAST CAVE	27.58

[6] Bolded text indicates a non-CAA. Regular text indicates a CAA. "M" indicates the value is below the LOQ value of 9.09×10^{-8} $\mu Ci/cm^2$.

9. Environmental Monitoring Program

The environmental monitoring program is used to determine the offsite background radiation levels; thermoluminescent dosimeters (TLD's) are used to make the measurements. The offsite radiation monitoring program is required by the Technical Specifications. The TLDs that are used for offsite monitoring are designated as TLD numbers 3, 7, 9, 15 through 35, and 39 through 44. The average background radiation level is then compared to the nearest occupied dwelling.

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 TLDs located at onsite locations. The onsite 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 0.31 mrem/day. This result indicates that no exposure level above normal background radiation were 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[7,8]

Location	Q3 2023	Q4 2023	Q1 2024	Q2 2023	Average
Fence E of NSC	0.33	0.29	0.35	0.37	0.34
Fence, N of Rad Waste Shed	0.36	0.33	0.41	0.38	0.37
Fence directly N Rad Waste Shed	0.53	0.48	0.55	0.58	0.53
S NSC, on parking lot fence	0.33	0.31	0.32	0.34	0.33
Fence S Roundtop Dr, 10th pole W of pole C14	0.37	0.36	0.38	0.37	0.37
Telephone pole C12	0.36	0.31	0.38	0.40	0.36
Telephone pole near golf course gate	0.34	0.30	0.40	0.37	0.35
E across fairway on pine tree	0.33	0.30	0.36	0.34	0.33
Maple tree #54 along driving range	0.30	0.27	0.31	--	0.29
NW to fence uphill from driving range	0.37	0.31	0.36	0.36	0.35
Follow fence E to fence corner	0.36	0.31	0.35	0.38	0.35
S to lone spruce tree near water hazard	0.35	--	--	0.38	0.37
Roundtop hill park, NW fence corner	--	0.32	0.34	0.33	0.33
Deciduous tree edge of 18th green	0.31	0.32	--	0.34	0.33
6ft pine tree, 3rd W down cart path from clubhouse	0.34	0.34	0.38	0.38	0.36
3rd to last tree after gap in same line of trees	0.30	0.26	0.34	0.33	0.31
SW to fence along path near 2nd to last tee box at bottom hill	0.35	0.32	0.35	0.35	0.34
Follow fence partway up hill after fence turns S	0.32	0.33	0.36	0.36	0.35
Follow fence, 15th pole E after fence turns W	0.33	0.31	0.35	0.37	0.34
Follow fence about halfway between last TLD and corner	0.34	--	0.38	0.38	0.37
Largest bush S of NSC	0.35	--	0.39	0.38	0.37
2nd fence S NSC, W end at gate	0.33	0.29	0.35	0.36	0.33
S Fairway Rd, 1st light post on right	0.32	0.29	0.32	0.38	0.33
S Fairway Rd, 2nd light post on right	0.32	0.28	0.36	0.36	0.33
Ellis Way and Hog Lane sign	0.29	0.27	0.37	0.39	0.33
Bottom of radio antenna hill, fence next to shrub left of gate	0.29	0.26	0.33	0.33	0.30
3rd fence S of NSC, SE corner, cow pasture	0.33	0.33	0.37	0.39	0.36
Airport fence W end runway at gate	--	0.33	--	0.38	0.36
Fence/entry bar E of Jewett Observatory	0.32	0.27	0.36	--	0.32
Railing at Terrell Mall / Library	0.28	0.25	0.32	0.33	0.29

[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.

[8] Dose rate in mrem/day.

Table IX. Environmental Radiation Levels at Onsite Locations[9,10]

Location	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Average
E lower loading dock	0.34	0.29	0.39	0.36	0.35
Pool room truck door fence S end	0.54	0.56	0.56	0.54	0.55
Pool room truck door fence N end	0.61	0.59	0.69	0.56	0.61
E wall rad waste shed	0.66	0.49	0.51	0.44	0.53
N wall rad waste shed	0.75	0.77	0.74	0.78	0.76
Cooling tower fence, NE corner	0.72	0.74	0.84	0.93	0.81
Room 101 window	0.37	0.33	0.42	0.41	0.38
Railing next to upper liquid waste tank	0.36	0.31	0.39	0.44	0.38
Room 2 truck door fence	0.32	0.30	0.41	0.36	0.35
Transformer vault vent louvers	0.39	0.32	0.41	0.42	0.39
NSC main entrance, light fixture	0.40	0.38	--	0.47	0.41
NSC roof, pool room vent stack	0.33	0.31	0.37	0.32	0.33
NSC roof, guide wire E end of building	0.34	0.27	0.38	0.36	0.34
NSC roof, E pool room vent support leg	0.62	0.59	0.55	0.65	0.60
NSC roof, air conditioning support leg	0.38	0.29	0.37	0.36	0.35
NSC roof, W pool room vent support leg	0.57	0.69	0.63	0.63	0.63

Table X. Environmental Radiation Levels for the Closest Offsite Point of Extended Occupancy[10]

Location	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Average
Apt complex C, gas meter	0.30	0.28	0.33	0.37	0.32
Apt complex B, gas meter	0.29	0.26	0.34	0.33	0.30
1st fence S apt complex A	0.29	--	--	0.35	0.32

Table XI. Background Environmental Radiation Levels[10]

Description	Q3 2023	Q4 2023	Q1 2024	Q2 2024	Average
Background radiation levels	0.33	0.30	0.36	0.37	0.34
20% above background radiation levels	0.40	0.36	0.43	0.44	0.41

[9] Onsite defined by the Technical Specification 1.0 and 5.1.1 as any location within the site boundary. The "--" indicates a TLD which was missing.

[10] Dose rate in mrem/day.

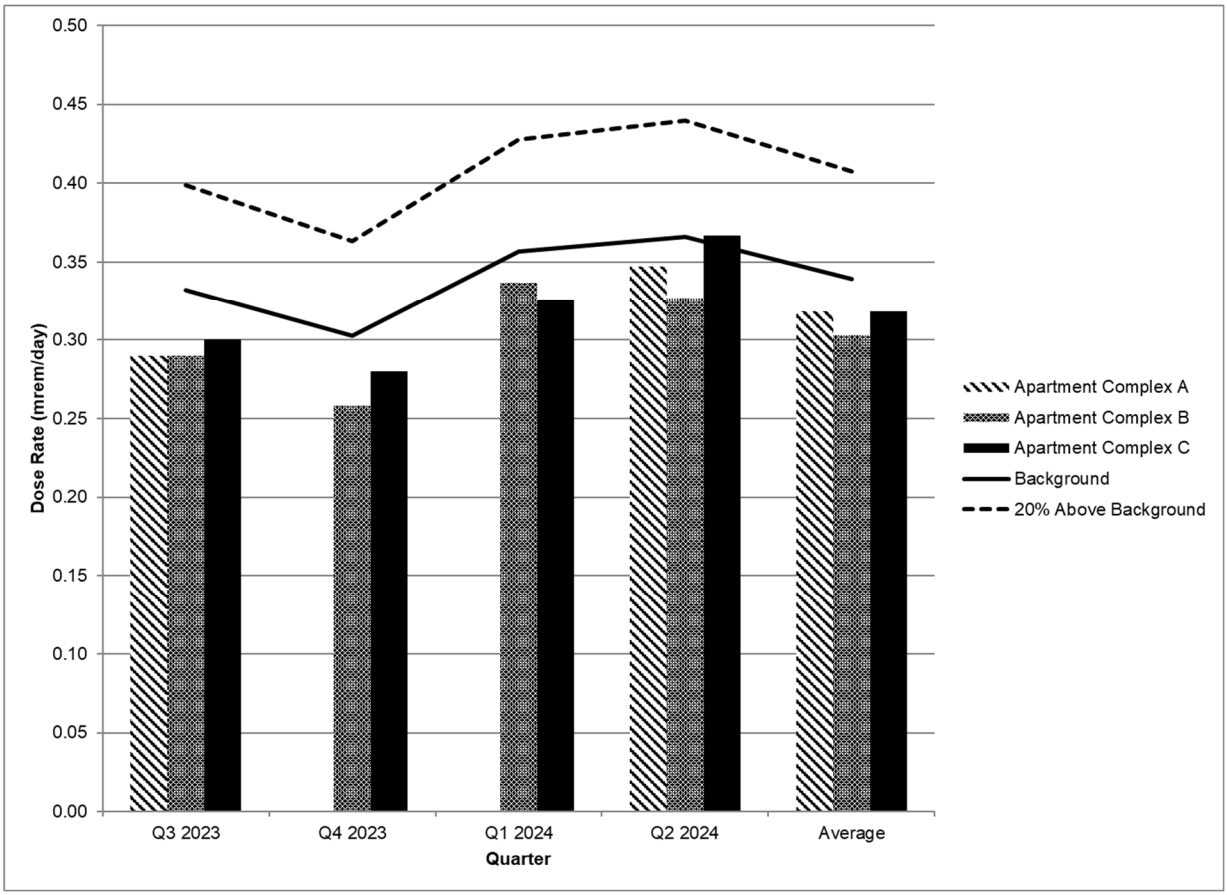

Figure I: Environmental radiation levels for the closest offsite point of extended occupancy radiation levels as compared to background radiation levels and 20% above background radiation levels. Note: The Apartment Complex A dosimeter was not recovered for two quarters due to theft. The environmental dosimeter was relocated and concealed nearby to prevent future thefts.