REED COLLEGE

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July 27, 2016

Document Control Desk
US Nuclear Regulatory Commission
Washington, DC 20555

Docket 50-288

Enclosed is Reed College Reactor's Annual Report.

Please feel free to contact me for additional information.

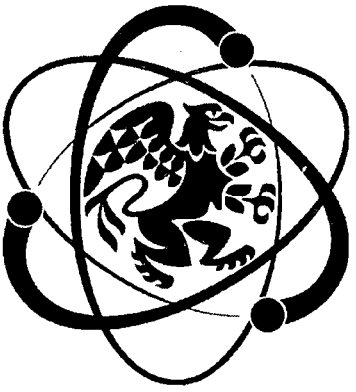
Regards,

Melinda P. Krahenbuhl
Director, Reed College Reactor

A020
NRR

REED RESEARCH REACTOR ANNUAL REPORT

July 1, 2015 -- June 30, 2016



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OVERVIEW

This report covers the period from July 1, 2015 to June 30, 2016, and is intended to fulfill the reporting requirements of the U.S. Nuclear Regulatory Commission License No. R-112, Docket 50-288, the U.S. Department of Energy, and the Oregon Department of Energy Rule No. 345-030-010.

Reed College operates a 250 kW TRIGA® Mark I reactor. The Reed College Research Reactor has been a resource for research and educational projects in the Portland area since 1968. The main uses of the Reed Research Reactor are instruction and research, especially in the field of trace-element analysis.

During the year there were 1642 visitors from schools, colleges, universities, and special groups. Specifically, 727 visitors were part of Reed College activities (prospective students, family of students, Reed classes, etc.). Eighty-eight members of emergency response organizations came for training. Including tours and research conducted at the facility, the Reed Research Reactor contributed to the educational programs of 52 colleges, universities and K-12.

During the year the reactor was taken critical 402 times on 149 days. The total energy produced was approximately 30 megawatt-hours.

The reactor staff consists of a Director, a Reactor Operations Manager, and Reed College undergraduate students who are licensed by the Nuclear Regulatory Commission as reactor operators or senior reactor operators. During the reporting period, 15 RO candidates and 7 SRO candidates received NRC licenses after passing NRC exams in May 2015. Twelve RO candidates and 9 SRO candidates took exams in May 2016. In July 2016, all 12 RO candidates and 9 SRO candidates were granted NRC licenses.

There were no radiation exposures to individuals in excess of the any limits during the year. There were no releases of liquid radioactive material from the facility and airborne releases were well within regulatory limits. There were no shipments of low-level radioactive waste from the facility.

The Nuclear Regulatory Commission conducted inspections during Nov. 16-18, 2015 and June 27-29, 2016.

PEOPLE

Reactor Staff

During the period July 1, 2015 to June 30, 2016, the staff consisted of:

Table 1 Supervisory Staff 2015-2016

Reactor Director:	Melinda Krahenbuhl	6/11 - present
Reactor Operations Manager:	Christina Barrett	6/15 – present
Radiation Safety Officer:	Kathleen Fisher April Karr	1/03 – 1/16 5/16 – present
Operations Supervisor:	Ilana Novakoski Joewie Koh	5/15 – 5/16 5/16 - present
Training Supervisor:	Charlie McIntyre Margie Oxley Sarah Brodesser	5/15 - 5/16 5/16 – present 5/16 - present
Requalification Supervisor:	Joewie Koh Trent Freeman	(5/15 - 5/16) (5/16 - present)
Projects Supervisor	Malcolm McCarthy	(5/15 - present)

Table 2 Staff 2015-2016

Senior Reactor Operators (SRO)			
Lily Ben-Avi	Vincent Griffith	Malcolm McCarthy	Helena Pedrotti
Christina Barrett	Josh Hepworth	Charlie McIntyre	Edgar Perez
Sarah Black	Melinda Krahenbuhl	Ilana Novakoski	Nathan Showell
Audrey Dannar	Joewie Koh	Evan Peairs	Natalie Stone
Kevin Freymiller	Simran Mahtani	Alexander Pan	Reilly Villanueva
Reactor Operators (RO)			
Amanda Asato	Natalie Hawkins	Anthony Loya	Andrew Simler
Sarah Brodesser	Kristen Hirata	Benjamin Morrison	Anton Zaytsev
Yuka Esashi	Palak Jain	Margie Oxley	
Trenton Freeman	Rhody Kaner	Helena Pedrotti	
Hunter Gill	Noah Lerner	Marin Sklan	

The list of operators includes everyone who held a license at any time during the reporting period. Reactor Operators who upgrade their licenses to Senior Reactor Operators during the reporting period are listed under Senior Reactor Operators. For the 2015-2016 year. There are 32 licensed operators at Reed College.

Reactor Operations Committee (ROC)

For the 2015 – 2016, the membership of the Reactor Operation committee is listed.

Reactor Operations Committee

- Wayne Lei - (Director of Research and Development, Portland General Electric)
- Norm Dyer (OAR Services)
- John Essick (Physics Faculty, Reed College)
- Robert McCollough (Neighborhood Association)
- Kathleen Fisher / April Karr (Director, Reed Environmental Health and Safety)
- Dan Gerrity – (Chemistry Faculty, Reed College)
- Steve Reese (Radiation Center Director, Oregon State University)
- Nigel Nicholson (Dean of the Faculty, Reed College)
- Melinda Krahenbuhl (Director, RRR)
- Christina Barrett (Reactor Operations Manager, RRR)
- Ilana Novakoski (Supervisor, RRR)

FACILITIES

Reactor Facility

In addition to the reactor, Reed College has a radiochemistry lab. The equipment available at the reactor facility includes high purity germanium gamma spectrometers, ion chambers, beta counters, Geiger Muller tubes, and alpha detectors. These instruments are used for experiments and training in nuclear science and radiation detection. One exit monitor is in the control room. A liquid scintillation detector serves both the reactor and broad scope license users. The reactor facility has several systems for performing irradiations, described below.

Rotating Specimen Rack Facility

The rotating specimen rack is located in a well on top of the graphite reflector surrounding the core. The rack consists of a circular array of 40 tubular receptacles, each of which can accommodate two irradiation tubes. The rack automatically rotates during irradiation to ensure each sample receives the same neutron flux. The approximate thermal neutron flux in a rotating rack position at full power is 1.7×10^{12} n/cm^{2}s with a cadmium ratio of 6.

Pneumatic Transfer System

The pneumatic transfer system ("rabbit") consists of an irradiation chamber in the outer F-ring of the core and its associated blower and piping. This allows samples to be transferred in and out of the reactor core very rapidly while the reactor is at power. The flux in the core terminal is approximately 5×10^{12} n/cm^{2}s when the reactor is at full power.

In-Core Facilities

The central thimble is a water-filled irradiation chamber about 3 cm in diameter. It provides the highest available neutron flux, about 1×10^{13} n/cm^{2}s.

Foil-insertion holes, 0.8 cm in diameter, are drilled at various positions through the grid plates. These holes allow inserting special holders containing flux wires into the core, to obtain neutron flux maps of the core.

In-Pool Facilities

Near core, in-pool irradiation facilities can be arranged for larger samples. Neutron fluxes will be lower than in the rotary specimen rack and will depend on the sample location.
An iridium gamma irradiator is also in the reactor pool for gamma only irradiations.

Beam Facilities

The central thimble can be evacuated with gas, producing a vertical neutron beam. The flux above the beam exit is approximately 1×10^{6} n/cm^{2}s when the reactor is at full power.

INSPECTIONS AND AUDITS

The Nuclear Regulatory Commission conducted inspections during Nov. 16-18, 2015 and June 27-29, 2016.

One audit was completed during this period. Kevin Herminhuysen (Reactor Operator – The Ohio State) conducted an external audit on May 23-25, 2016. Recommendations are currently being evaluated.

USERS

Reactor Operations Seminar

The Reed Research Reactor conducts an annual seminar series. This non-credit course serves as an introduction to nuclear reactor theory, health physics, and reactor operation. Some of the students continue with in-depth reactor operator training and subsequently apply for a Reactor Operator (RO) license. If successful, the individual may be hired to operate the reactor. In addition, existing ROs may take the NRC Senior Reactor Operator (SRO) exam to upgrade their licenses.

During the reporting period, 15 out of 15 RO candidates and 7 out of 7 SRO candidates received NRC licenses after passing NRC exams in May 2015. Fifteen out of 15 RO candidates and 9 out of 9 SRO candidates received NRC licenses after passing NRC exams in May 2016.

Figure 1 is a graph of the pass rate for RO and SRO since 2000.

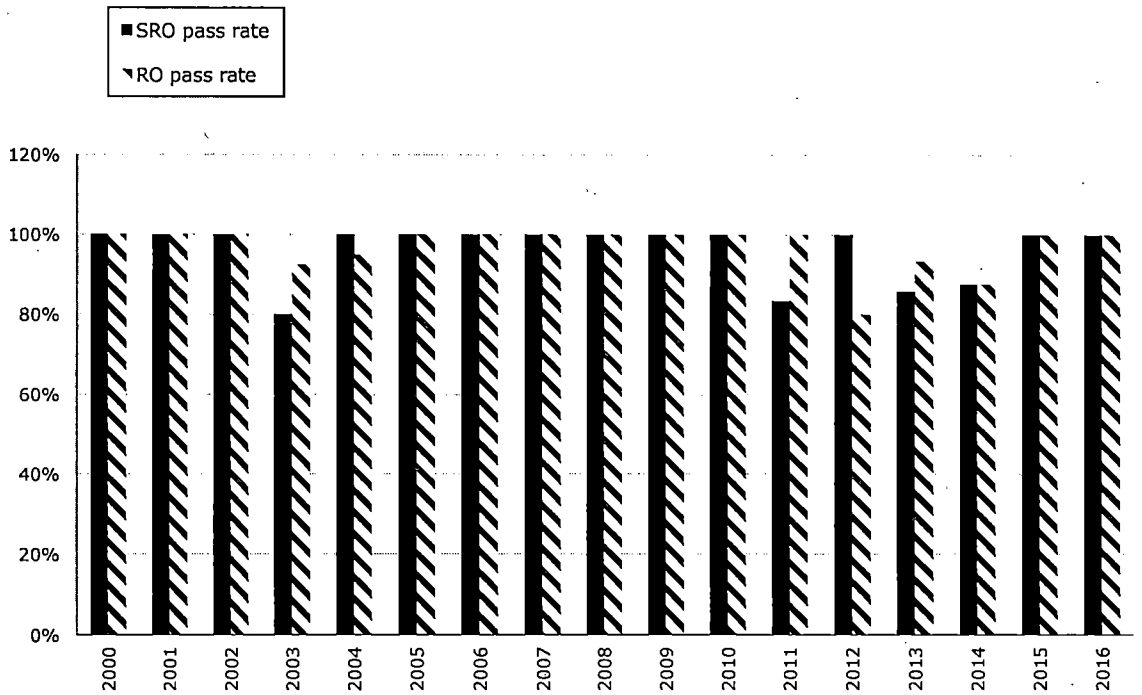

Figure 1 Reed Research Reactor License Exam Results

Outside Users

During the year there were 1642 visitors from schools, colleges, universities, and special groups. Additionally, 727 individuals visited as part of Reed College activities (prospective students, family of students, Reed classes, etc.). Eighty-eight members of emergency response organizations came for training.

Figure 2 is a graph showing the history of visiting groups.

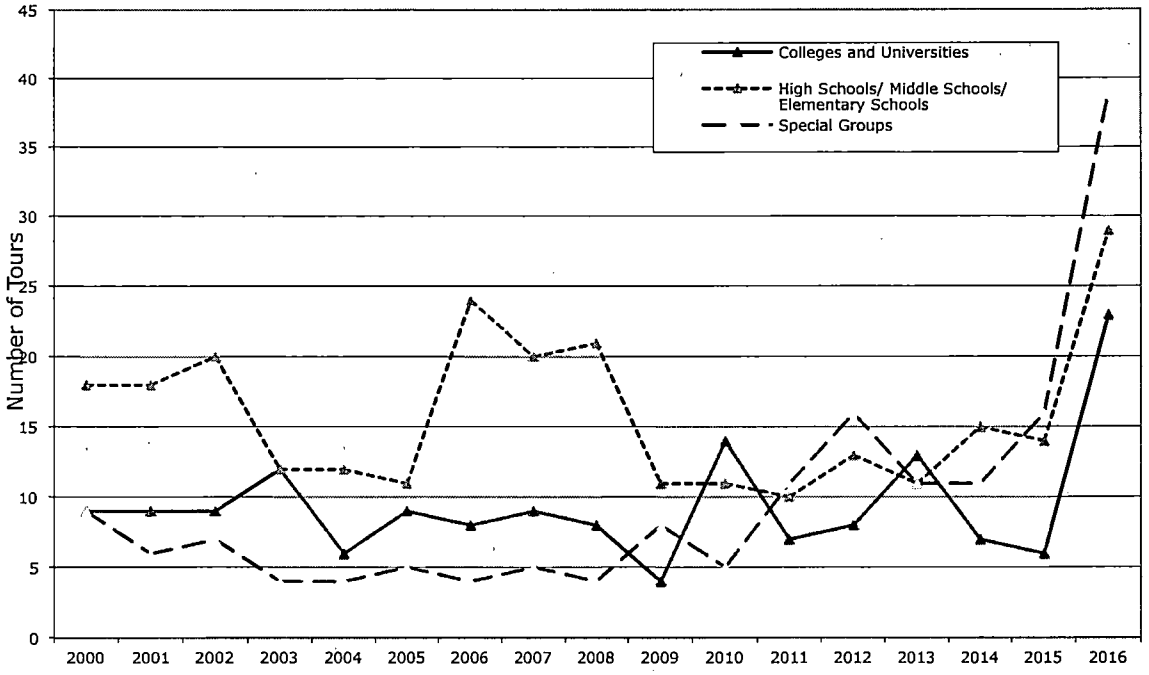

Figure 2 Visiting Groups

Many reactor tours include hands-on use of facility equipment to conduct experiments in radiation science, health physics, and nuclear physics. A typical lab involves determining the background of a Geiger Muller scaler system and then determining the half-life of a sample of radioactive material.

Several special programs for gifted children use the reactor for projects. These are designed to enrich their educational program and prepare them for college. Some of the groups who use the reactor target minority and disadvantaged youth who are historically under-represented in science professions. Additionally several Boy Scouts of America troops have visited the facility to complete the Nuclear Science merit badge.

High School Student Project

The Reed Research Reactor continues to be used in independent science projects initiated by students from several Oregon and Washington State high schools.

Scaler Kits

Through the generosity of Portland General Electric, the reactor lends out kits containing a Geiger counter, a scaler, and some small exempt sources to local high schools.

Reed Classes

- Chemistry Thesis "Separation and Quantification of Radioactive ^{14}C from irradiated graphite" by Ilana Novakoski

- Chemistry 101 (Molecular Structure and Properties) students explored the properties of alpha, beta and gamma irradiation.
- Chemistry 311 (Analytical Chemistry) students quantified the extent of chemical reaction using potassium as the tracer
- Physics 332 (Advanced Laboratory II) students completed independent projects
- Independent Chemistry project – "Self Shielding properties of Cadmium"

Industrial and Commercial Applications

The Reed Research Reactor is available for industrial or commercial concerns when it does not conflict with our educational goals. As in the past, the primary operations involved analysis of environmental samples. The facility also provides radiation protection training to interested parties and schools in the area.

REACTOR OPERATIONS

Operations

During the year the reactor was taken critical 402 times on 149 days. The total energy produced was approximately 30 megawatt-hours. Operating history by month appears in Table 3. A history of the data is shown in Figure 3.

Table 3 Operating History 2015-2016

	TIMES CRITICAL	DAYS OPERATED	MW-HOURS
July 2015	17	10	1.51
August 2015	20	9	2.09
September 2015	77	20	6.52
October 2015	62	16	2.07
November 2015	35	12	1.85
December 2015	23	9	1.38
January 2016	12	11	1.06
February 2016	48	20	4.83
March 2016	28	16	2.07
April 2016	68	22	5.00
May 2016	12	4	0.60
June 2016	0	0	0
Total	402	149	29.9

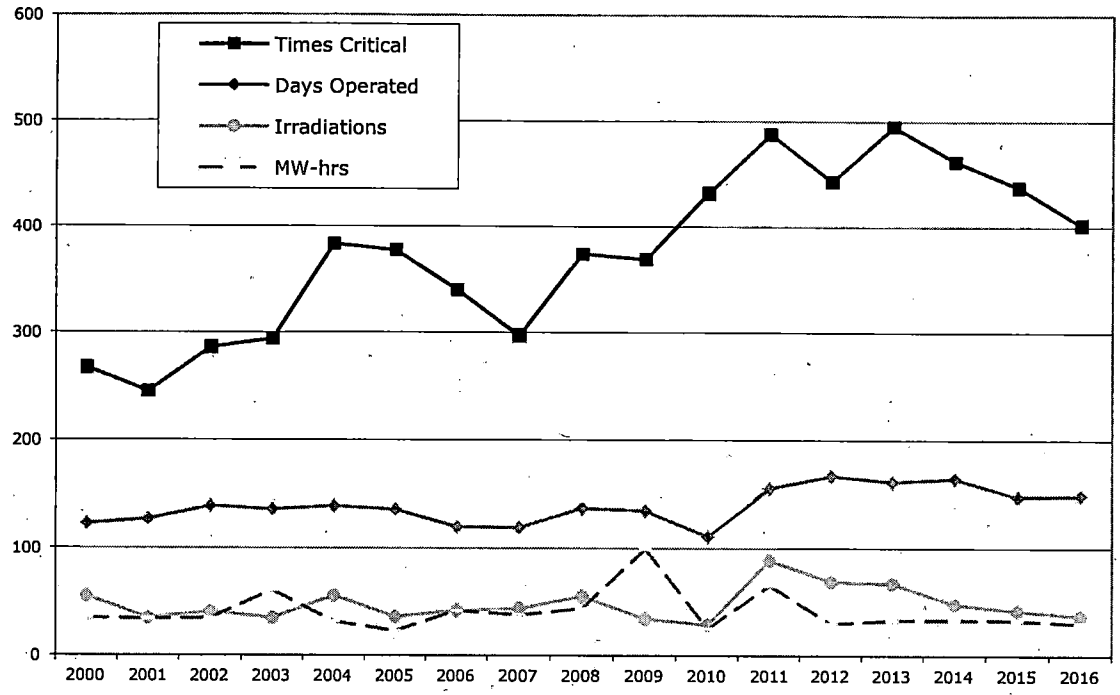

Figure 3. Operations

Unplanned Reactor Shutdowns

There were 10 inadvertent reactor shutdowns (scrams) as shown in Table 4. The number of unplanned reactor shutdowns is shown in Figure 4.

Table 4 Unplanned Reactor Shutdowns

DATE	SCRAM TYPE	CAUSE OF SCRAM
Aug. 29, 2015	Power Transient	Reactor Facility lost power
Sept. 20, 2015	Power Transient	Power transient due to work conducted on console
Sept. 23, 2015	Linear High Power	Overshot high power SCRAM set point
Oct. 11, 2015	Linear High Power	Overshot high power SCRAM set point
Oct. 15, 2015	Linear High Power	Overshot high power SCRAM set point
Oct. 15, 2015	Linear High Power	Overshot high power SCRAM set point
Oct. 23, 2015	Linear High Power	Overshot high power SCRAM set point
Nov. 15, 2015	Linear High Power	Overshot high power SCRAM set point
Feb. 19, 2016	Linear High Power	Overshot high power SCRAM set point
Apr. 28, 2016	Power Transient	Reactor Facility lost power

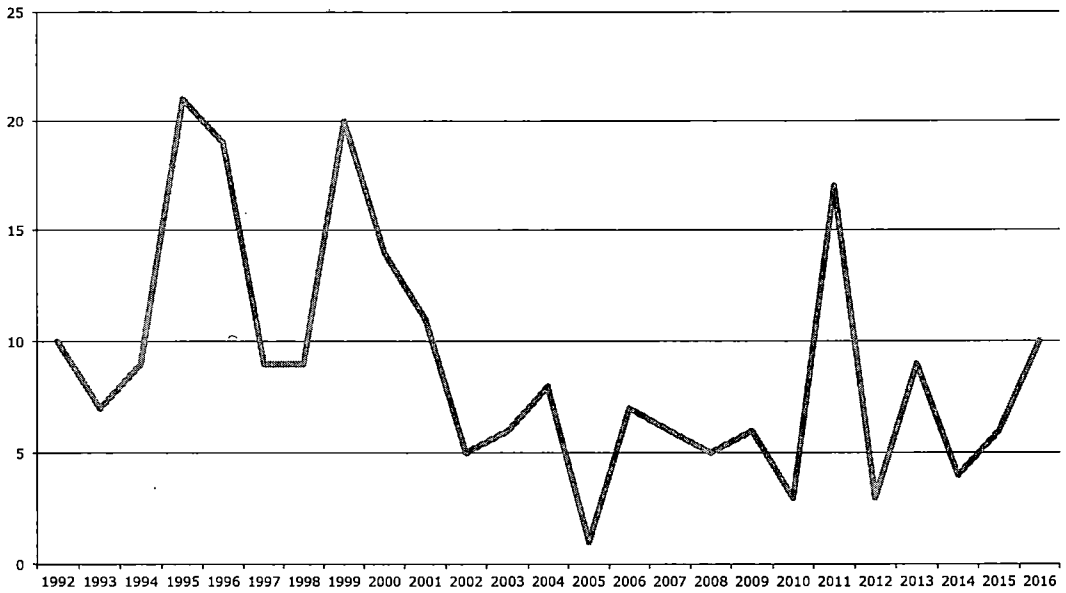

Figure 4 Unplanned Shutdowns

REACTOR MAINTENANCE

Significant Maintenance

Reactor staff performs routine equipment checks on a daily, weekly, bimonthly, semiannual (January and July) and annual (January) basis as required by facility procedures. Reed College maintenance personnel assist with routine preventative maintenance to auxiliary equipment. The following is a list of significant maintenance preformed during this reporting period.

Table 5 Maintenance 2015-2016

DATE	COMPONENT	EXPLANATION
Dec. 11, 2015	Secondary Cooling System	Replace High Point Vent
Jan. 11, 2016	Continuous Air Monitor	Replace broken gas-filled chamber
Jan. 13, 2016	Shim Rod Motor	Re-soldered broken wire
Jan. 28, 2016	Primary Filter	Replace O-ring fixture
Feb. 16, 2016	Water Leveler	Replaced sensor on automatic water addition system
Apr. 20, 2016	Shim Rod Motor	Magnet adjusted to be flush with control rod
May 5, 2016	Percent Power Ramp Up	Replaced Ramp Up test button
June, 2016	Log and Percent Power Channels	Maintenance conducted on electronics after water damage

RADIATION PROTECTION

Personnel Dosimetry

Dosimeters are changed on a calendar quarter schedule. Individuals were issued beta-gamma sensitive ring badges and whole-body badges.

No doses received were high enough to initiate an investigation. The highest individual doses received were 70 mrem to a left ring dosimeter and 60 mrem to a right ring dosimeter. No chest badge indicated a dose above the minimum detectable quantity.

Fixed Area Dosimetry

Radiation levels are continually monitored to provide an indication of the average radiation levels in the reactor bay and dose outside the facility. All dosimeters monitor beta and gamma radiation. Three locations also measure neutron dose.

The deep dose equivalent radiation measured by fixed dosimeters during the period July 1, 2015 to March 31, 2016 are shown in Table 5. Dosimeters from April 1, 2016 to June 30, 2016 are currently being processed. An "M" indicates less than 1 mrem during the quarter.

Table 6 Area Radiation Dosimeters
(doses are in mrem per calendar quarter)

LOCATION	HEIGHT (M)	RADIATION DETECTED	JUL 1 – SEP 30	OCT 1 - DEC 31	JAN 1 - MAR 31	TOTAL
Reactor East Wall	1.5	β, γ	3	M	2	5
Reactor North Wall	1.6	β, γ	4	4	4	12
Reactor West Wall	1.0	β, γ, n	10	8	4	22
Reactor South Wall	1.6	β, γ, n	6	7	7	20
Reactor North Wall - High	2.3	β, γ	5	6	1	12
Control Room	1.5	β, γ	M	6	5	11
Outside North	2.8	β, γ	M	M	M	M
Outside Roof	0.4	β, γ, n	M	M	M	M
Outside East	1.5	β, γ	M	M	M	M
Outside South	0.4	β, γ	M	M	M	M
Counting Room	1.5	β, γ	92	M	M	92

Gaseous Releases

The only routine release of gaseous radioactivity is from ^{41}Ar (1.83-hour half-life) and ^{16}N (7.13-second half-life). These come from activation of pool water and air in the pool water and in the irradiation facilities. For the reporting period, the average gaseous activity at the site boundary was 3.96×10^{-10} μCi/ml, which would deliver a dose to a member of the public of approximately 1.98 mrem, well below regulatory guidelines and constraints. Figure 5 shows the gaseous releases for each year.

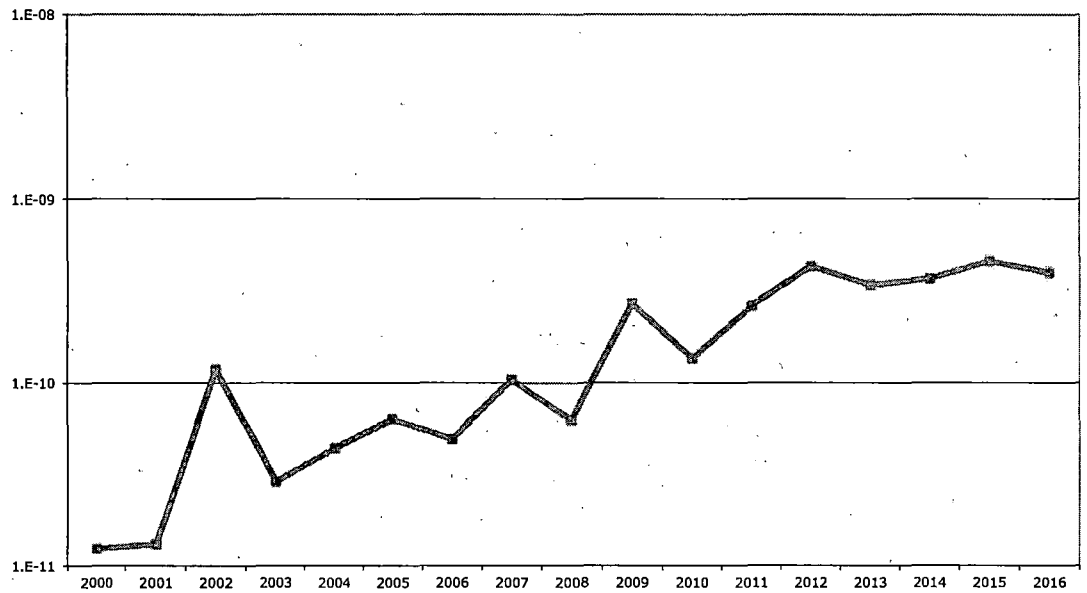

Figure 5 Gaseous Releases Activity (μCi/ml) at Site Boundary

Liquid Waste Releases

No liquid radioactive waste was released from the Reed Research Reactor during this report period.

Solid Waste Disposal

There were no shipments of low-level radioactive waste from the facility during this reporting period.

Environmental Sampling

Soil samples taken from the area surrounding the facility showed no activity above background. Water from the facility's secondary cooling system and the nearby canyon were sampled for activation products and tritium, but showed no activity above normal background.