REED COLLEGE

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July 18, 2017

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, 2016 -- June 30, 2017

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OVERVIEW

This report covers the period from July 1, 2016 to June 30, 2017, 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 2100 visitors from schools, colleges, universities, and special groups. Additionally, 1213 visitors were part of Reed College activities (prospective students, family of students, Reed classes, etc.). Fifty 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 30 colleges, universities and K-12.

During the year the reactor was taken critical 116 times on 45 days. The total energy produced was approximately 10 megawatt-hours. A new log channel, fission chamber and uncompensated ion chamber were installed on the reactor during the reporting period.

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, 12 RO candidates and 9 SRO candidates received NRC licenses after passing NRC exams administered in May 2016.

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 was one shipment of low-level radioactive waste from the facility.

The Nuclear Regulatory Commission conducted two regular and one reactive inspection during this reporting period.

PEOPLE

Reactor Staff

During the period July 1, 2016 to June 30, 2017, the staff consisted of:

Table 1 Supervisory Staff 2016-2017

Reactor Director:	Melinda Krahenbuhl	6/11 - present
Reactor Operations Manager:	Christina Barrett	6/15 – present
Radiation Safety Officer:	April Karr Sams	5/16 – present
Operations Supervisor:	Joewie Koh Sarah Brodesser	5/16 – 5/17 5/17 - present
Training Supervisor:	Margie Oxley Sarah Brodesser Colin Whitmore	5/16 - present 5/16 – 5/17 5/17 - present
Requalification Supervisor:	Trent Freeman	5/16 - present
Projects Supervisor	Malcolm McCarthy	5/15 - present

Table 2 Staff 2016-2017

Senior Reactor Operators (SRO)			
Sarah Brodesser	Trenton Freeman	Noah Lerner	Helena Pedrotti
Christina Barrett	Kevin Freymiller	Anthony Loya	Edgar Perez
Sarah Black	Vincent Griffith	Malcolm McCarthy	Anton Zytsev
Audrey Dannar	Melinda Krahenbuhl	Benjamin Morrison	Helen Zhang
Yuka Esashi	Joewie Koh	Margie Oxley	
Reactor Operators (RO)			
Amanda Asato	Hunter Gill	Claire Mashlan-Milander	Andrew Simler
Alexander Abrahams	Natalie Hawkins	Maileen Nakashima	Colin Whitmore
Zachery Beadle	Kristen Hirata	Gray Perez	Gabe Yeung
Brianna Dobson	Palak Jain	Helena Pedrotti	
Toria Ellis	Rhody Kaner	Tenzien Sangpo	
Nick Egan	Emmet Kahn	Matyas Szabo	

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. There are forty licensed operators at Reed College.

Reactor Operations Committee (ROC)

For the 2016 – 2017, 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)
- Lucus Illing (Physics Faculty, Reed College)
- Robert McCollough (Neighborhood Association)
- April Karr Sams (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)
- Joewie Koh (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 routine inspections during Oct. 31-Nov. 3, 2016 and Nov. 28-Dec. 2. 2016. Two Severity Level IV violations were cited. An additional infraction was treated as a non-cited violation. We responded to the violations in a letter dated Jan. 2, 2017. The NRC acknowledged the response in a letter dated Feb. 27, 2017 and will evaluate the proposed corrective actions in a future inspection.

A reactive inspection was conducted on April 17-May 3, 2017. This inspection resulted in no significant findings.

One audit was completed during this period. Karen Langley (recently retired Radiation Safety Officer University of Utah) conducted an external audit on May 22, 2017. 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, 12 out of 13 RO candidates and 9 out 9 of 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.

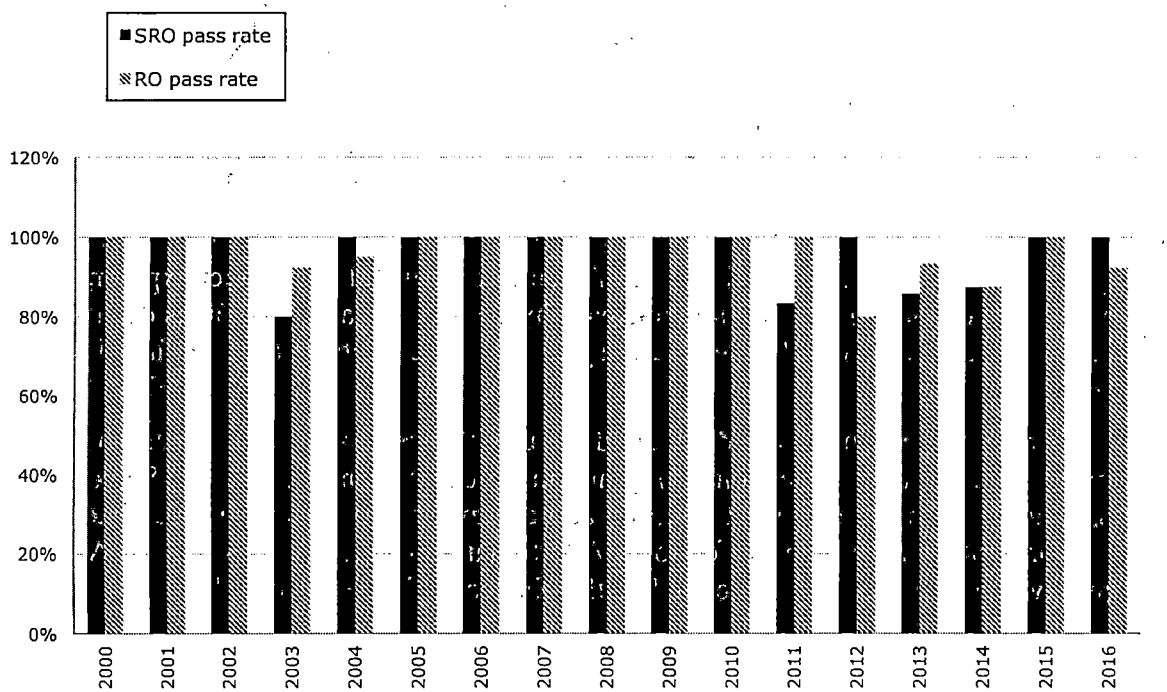

Figure 1 Reed Research Reactor License Exam Results

Outside Users

During the year there were 2100 visitors from schools, colleges, universities, and special groups. Additionally, 1,213 individuals visited as part of Reed College activities (prospective students, family of students, Reed classes, etc.). Fifty members of emergency response organizations came for training.

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

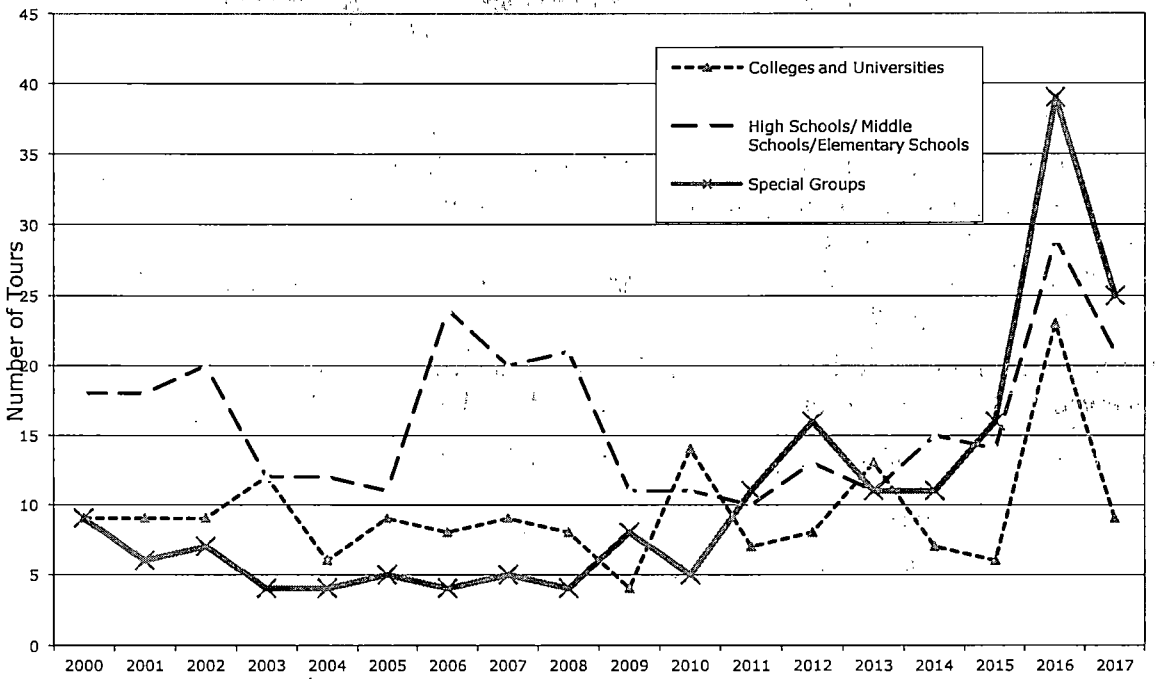

Figure 2 Visiting Groups

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 101 (Molecular Structure and Properties) students explored the properties of alpha, beta and gamma irradiation.

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 116 times on 45 days. The total energy produced was approximately 10 megawatt-hours. Operating history by month appears in Table 3. A history of the data is shown in Figure 3.

Table 3 Operating History 2016-2017

	TIMES CRITICAL	DAYS OPERATED	MW-HOURS
July 2016	0	0	0
August 2016	0	0	0
September 2016	0	0	0
October 2016	14	7	2.68
November 2016	0	0	0
December 2016	0	0	0
January 2017	0	0	0
February 2017	0	0	0
March 2017	0	0	0
April 2017	10	3	1.11
May 2017	58	20	4.30
June 2017	36	15	1.85
Total	116	45	9.94

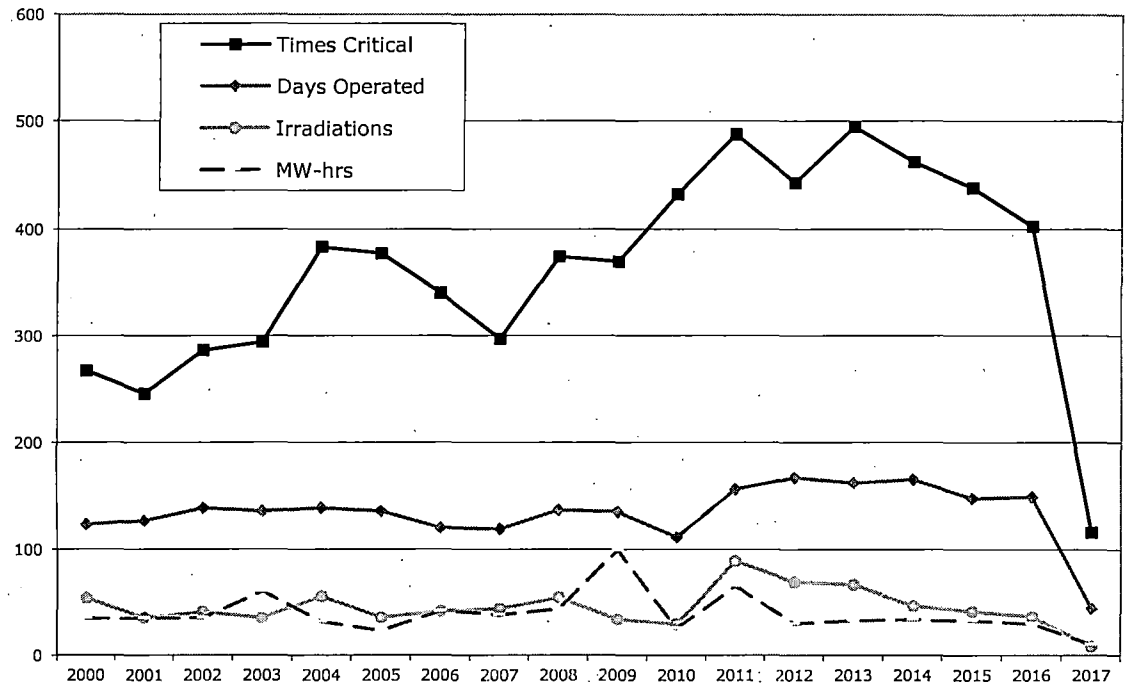

Figure 3. Operations

Unplanned Reactor Shutdowns

There were 3 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 CHANNEL	CAUSE OF SCRAM
Oct 9, 2016	Percent power	Loss of high voltage
Oct 19, 2016	Linear channel	High power scram
May 19, 2017	All channels	Loss of facility power

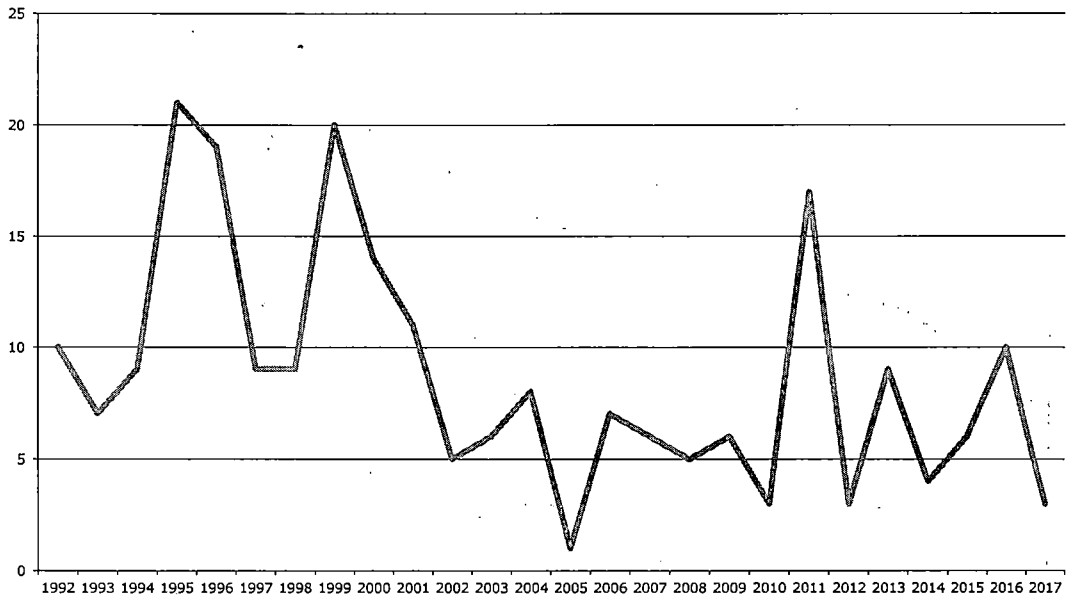

Figure 4 Unplanned Shutdowns

REACTOR MAINTENANCE

Significant Maintenance

Reactor staff performs routine equipment checks on a daily, biweekly, 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. During this period the reactor remained shut down to repair and ultimately replace both the percent and log power channels. The in-core detectors were damaged as a result of a malfunction of the auto water fill sensor. The malfunctioning auto water fill system was deactivated in June 2016 and removed in November 2016.

Table 5 Maintenance 2016-2017

	COMPONENT	EXPLANATION
4/19/2017	Log Channel including Fission Chamber	Replace the channel including the fission chamber.
10/14/16	Detector on the Percent Power channel	Replaced the in core detector.
11/22/16	Auto fill	Removed automatic primary water adding system
4/16/17	Pump Bypass	Pump overheating, bypass installed

RADIATION PROTECTION

Personnel Dosimetry

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

The highest individual doses received were 610 mrem to a left ring dosimeter and 640 mrem to a right ring dosimeter and 41 mrem to chest dosimeter. An in house evaluation found the doses were the result of a single project. The doses are below occupational dose limits and no further action was required.

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 April 1, 2016 to March 31, 2017 are shown in Table 5. Dosimeters from April 1, 2017 to June 30, 2017 are currently being processed. An "M" indicates less than 1 mrem above background during the quarter.

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

LOCATION	HEIGHT (M)	RADIATION DETECTED	APRIL 1-JUNE 30	JUL 1 – SEP 30	OCT 1 - DEC 31	JAN 1 - MAR 31	TOTAL
Reactor East Wall	1.5	β, γ	M	M	M	M	M
Reactor North Wall	1.6	β, γ	5	3	5	1	14
Reactor West Wall	1.0	β, γ, n	7	10	3	7	27
Reactor South Wall	1.6	β, γ, n	7	0	2	0	9
Reactor North Wall - High	2.3	β, γ	M	M	M	M	M
Control Room	1.5	β, γ	3	6	3	3	15
Outside North	2.8	β, γ	M	M	M	M	M
Outside Roof	0.4	β, γ, n	M	M	M	M	M
Outside East	1.5	β, γ	M	M	M	M	M
Outside South	0.4	β, γ	M	M	M	M	M
Counting Room	1.5	β, γ	M	3	M	M	3

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 2.0 x 10^{-10} μCi/ml, which would deliver a dose to a member of the public of approximately 1.0 mrem, well below regulatory guidelines and constraints. Figure 5 shows the gaseous releases for each year.

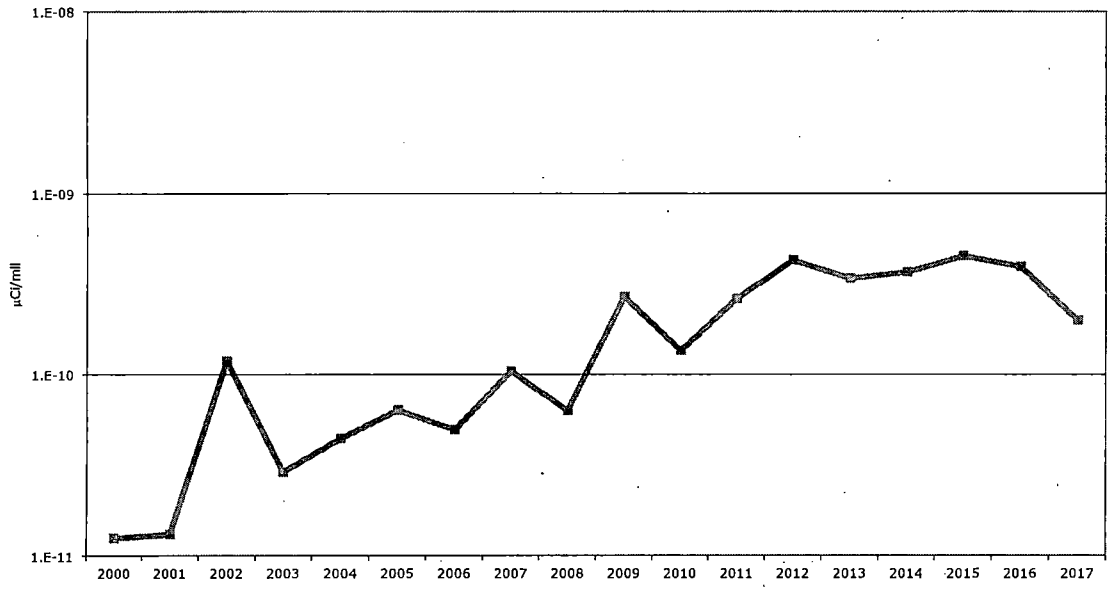

Figure 5 Gaseous Releases Activity (μCi/ml) at Site Boundary

Liquid Waste Releases

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

Solid Waste Disposal

There was one shipment 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.