2016

ANNUAL REPORT

Docket Number 50-607
License Number R-130

1. Introduction

The University of California, Davis, McClellan Nuclear Research Center (MNRC) consists of a research reactor, associated radiography and positioning equipment, and a wide variety of equipment to support broad-based research activities. This MNRC Annual Report is published each year in support of the license provided by the United States Nuclear Regulatory Commission (NRC). The aforementioned license is for the operation of a steady-state TRIGA™ reactor with pulsing and square wave capability.

It is the primary intent of this document to provide information relevant to the safe operation of the UCD/MNRC. A brief description of the MNRC facility and administration is followed by operational events and health physics information concerning this facility during CY 2016.

2. UCD/MNRC Facility Description

The UCD/MNRC is located on the McClellan Industrial Park site; the reactor is housed in Building 258. The McClellan Industrial Park site is approximately 2600 acres, located eight miles northeast of Sacramento, California.

The UCD/MNRC facility is a three level 14,720 sq. ft. rectangular-shaped enclosure that surrounds a 2 MW research reactor. The UCD/MNRC provides four neutron beams to four bays for radiography and other research and commercial activities. All four bays are capable of using radiography film techniques, but 3 normally uses electronic imaging devices. Space, shielding and environmental controls are provided by the enclosure for neutron radiography operations performed on a variety of samples. Adequate room has been provided to handle the components in a safe manner.

In addition to the radiography bays, the UCD/MNRC reactor also has several in-core facilities ranging from a pneumatic tube system to a central irradiation facility.

For more detailed information on the UCD/MNRC project, the reader is referred to the UCD/MNRC Safety Analysis Report.

3.0 UCD/MNRC Administration

UCD/MNRC Organization. The UCD/MNRC is licensed by the Nuclear Regulatory commission (NRC) to operate under the provisions of operating license R-130.

The University of California Regents have designated the Chancellor at UC Davis to be the license holder. The UCD Chancellor has in-turn delegated the Vice Chancellor for Research to be the licensee of record.

The UCD/MNRC is under the direction of the UCD/MNRC Director.

4.0 Facility Modifications (Section 50.59 of 10CFR Part 50), and experiments.

None

5.0 Approved Changes to Experiments

None

6.0 Licensing and Regulatory Activities

6.1 NRC Items

a. The Nuclear Regulatory Commission conducted a semi-annual audit the week of 09 February 2016. No significant findings reported.
b. The Nuclear Regulatory Commission conducted an audit the week of 29 Aug 2016. No significant findings reported.
c. On 24 June 2016 the Nuclear Regulatory Commission requested the LAR submitted 15 July 2011 be withdrawn and incorporated or folded into the 2018 Relicensing package. The LAR has been withdrawn.
d. On June 2, 2016, relicensing packages were submitted to the NRC for 2 SRO license renewals. These have been completed and both SRO's are relicensed until 2022.

6.2 Nuclear Safety Committee (UCD/NSC)

a. The Nuclear Safety Committee held its semi-annual meetings on 2 February and 12 August 2016.
b. The Nuclear Safety Committee performed an Operations audit for 2016 on 11 January 2017.
c. The Nuclear Safety Committee performed an audit of the Radiation Safety Program on 25 and 28 October 2016.
d. The Nuclear Safety Committee performed a Security audit on 11 October 2016.

7.0 OPERATIONS

OPERATING HISTORY:

TOTAL OPERATING HOURS THIS YEAR:	1028.08
TOTAL OPERATING HOURS:	50500.14
TOTAL MEGAWATT HOURS THIS YEAR:	942.74
TOTAL MEGAWATT HOURS:	65159.88
TOTAL NUMBER OF PULSES PERFORMED THIS YEAR:	0
TOTAL NUMBER OF PULSES PERFORMED:	484

7.1 UNSCHEDULED REACTOR SHUTDOWNS and NOTED PROBLEM AREAS:

In 2016, there were four(4) unscheduled shutdowns at the MNRC reactor facility. The following is a list of the unscheduled shutdowns:

2016 UNSCHEDULED REACTOR SHUTDOWNS

Type of Failures	Total Number
CSC	0
Other	4
TOTAL NUMBER OF UNSCHEDULED SHUTDOWNS IN 2016	4

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CSC	0	0	0	0	0	0	0	0	0	0	0	0
Other	1	0	0	1	1	0	0	0	0	0	0	1
Notes	1			2	3							2

Notes:
1: Off Site Power spike/bump caused the reactor CAM to reboot.
2: Scram-Database Timeout
3: Rx Room RAM pegged high. GM tube failure.

January

1. There was one unscheduled shutdown in the month of January.
   a. Rx CAM Particulate Channel alarmed after power spike. Rx manually scrammed.
2. There was one callback to the facility in January.
   a. Transmit Trouble (Security System), cleared on acknowledgement.

February

1. There were no unscheduled shutdowns in the month of February.
2. There were no callbacks to the facility in February.

March

1. There were no unscheduled shutdowns in the month of March.
2. There were two callbacks to the facility in March.
   a. UPS faults, both cleared on acknowledgement

April

1. There was one unscheduled shutdown in the month of April.
   a. NM-1000, Database timeout message cleared on acknowledgment.
2. There were no callbacks to the facility in the month of April.

May

1. There was one unscheduled shutdown in the month of May.
   a. Reactor Room RAM pegged High momentarily, See Anomaly report
2. There were no callbacks to the facility in the month of May.

June

1. There were no unscheduled shutdowns in the month of June.
2. There were four(4)callbacks to the facility in the month of June.
   a. Stack CAM Fault High Air Flow.
   b. CSC Alarm, improper reset.
   c. UPS fault-area wide power failure.
   d. Stack CAM fault Low Flow Alarm

July

1. There were no unscheduled shutdowns in July.
2. There was one callback to the facility in the month of July.
   a. Rod Withdrawal Prohibit alert. Cleared on acknowledgement.

August

1. There were no unscheduled shutdowns in the month of August.
2. There was one callback to the facility in the month of August.
   a. Rod Withdrawal Prohibit alert. Cleared on acknowledgement.

September

1. There were no unscheduled shutdowns in the month of September.
2. There were two callbacks to the facility in the month of September.
   a. Rod Withdrawal Prohibit alert. Cleared on acknowledgement.
   b. Window sensor (Security System). Cause undetermined.

October

1. There were no unscheduled shutdowns in the month of October.
2. There were no callbacks to the facility in the month of October.

November

1. There were no unscheduled shutdowns in the month of November.
2. There were no callbacks to the facility in the month of November.

December

1. There was one unscheduled shutdown in December.
   a. Scram Database Timeout - See anomaly report.
2. There was one callback to the facility in the month of December.
   a. Scram Database Timeout - See anomaly report.

7.2 ANOMALIES:

During 2016, there were 3 reported anomalies at the MNRC facility and two Radiological Incident Investigations. The specifics are listed below:

1. There was one anomaly reported in the month of April. The report is as follows:

Anomaly Report 4/21/2016 0800	Reactor Power Level – Shutdown performing Prestart Checklist

NM-1000 Internal display failure.

During the performance of the Prestart Checks for Reactor Startup, the NM-1000 cabinet display interface (the Burr-Brown terminal) was found to be not functioning. All of the prestart checklist items had been completed satisfactorily, but the NM-1000 Stack fault message could not be cleared from the CSC status monitor. Input commands to the terminal were not accepted and the LED display was non-functional.

Work Order 16-0266 was issued to troubleshoot and repair the display problem.

The Facilities Electronics Engineer began troubleshooting the problem and soon discovered that a component on a communications card that provides the link to the Burr-Brown terminal had failed. (Basically a burned out resister had caused other components to fail). See Work order 16-0266.

The communications card was repaired by the Electronics Engineer and the Burr-Brown terminal was replaced with a new identical one.

A complete visual inspection of the NM-1000 system was performed and no other obvious problems were identified.

After the repairs/inspection was completed, the NM-1000 was re-energized satisfactorily and all the constants were verified SAT. (None had changed). The Burr-Brown terminal display and functions checked out SAT.

The NM-1000 portions of the Prestart Checklist were all performed SAT.

The Acting Director was briefed on the repairs and status.

The Reactor Supervisor and Acting Director granted permission to startup the reactor.

What Actions were taken to correct this anomaly?

Communications card repaired and the interface terminal was replaced.

What corrective actions are needed to prevent this anomaly from re-occurring?

As components and equipment age, failures will occur. It is not possible to predict exactly which component will fail when. Proper troubleshooting and experienced and knowledgeable staff/technicians are the only way to mitigate these failures when and if they occur.

Note: The original vendor of this equipment (General Atomics –TRIGA group) long ago declared this and other vendor provided equipment obsolete and no longer supports its maintenance or repair. They also no longer carry or provide spare parts.

2. There was one anomaly reported in the month of May. The report is as follows:

Anomaly Report May 25, 2016

The Reactor was operating at 1 MW, with the startup just having been completed at 0920 hrs.

At 0940 on 25 May 2016 the Reactor Room RAM alarmed (Criticality Alarm/ Evacuation Horn sounded)) with indications pegged high.

The readings on the CSC Status monitor were 7.6 E6 and the RMS II module was pegged high at greater than 10,000 mr/hr.

The Reactor was scrammed.

No personnel were in the reactor room at the time of the alarm.

All other CAM and RAM readings were normal, with no alert or alarm conditions.

After a few seconds, the readings from the Reactor Room RAM returned to normal.

The facility evacuation per the Casualty Procedure Immediate Actions was terminated.

Actions to correct Anomaly:

Local radiation survey in the reactor room showed normal readings.

Indications are that this was an electrical spike or possibly a GM tube problem with the instrument.

The Reactor Room RAM modules were replaced with the calibrated spare assemblies and source checked SAT.

After replacing the Reactor Room RAM modules all readings were normal with no spikes and stable.

The Radiation Safety Officer and the Reactor Supervisor granted permission to restart the reactor.

3. There was one anomaly reported in the month of December. The report is as follows:

Anomaly Report 5 December 2016

The reactor was started up at 1522 hours and 50% power (1MW) achieved at 1532 hours.

At 1542 hours the reactor automatically scrammed with the "Scram-Database Timeout" message displayed on the Control System Console (CSC) status and HiRes monitors.
No other messages were displayed.

The CSC and Data Acquisition Cabinet (DAC) computers were rebooted. All indications were normal. The Reactor Supervisor was notified and concurred with the Senior Reactor Operator that the reactor could be restarted. Permission was granted to restart the reactor.

On 6 December 2016 at 0400 hours (approximately 12 hours later) and with the reactor shutdown, the UCD dispatchers contacted the duty SRO and notified him of a console alarm (i.e. a Callback). Upon arriving at the facility, the SRO observed that the CSC status and HiRes monitors again displaying the "Scram-Database Timeout" message. The SRO again rebooted both the CSC and DAC computers and also inspected the NM-1000 display. After rebooting, all indications were normal.

Further investigation revealed no obvious failure or fault that directly results in this particular error message and automatic scram action to occur. The Facilities Electronics Engineer (also a qualified SRO) believes that there might be an issue with one of the CSC or DAC computers dynamic RAM components.

Reactor Prestart checks and NM-1000 diagnostics do not show any issues.

4. There was one Radiological Investigation Report written in February. That report is as follows:

RADIOLOGICAL INVESTIGATION REPORT NO. 16-01

TITLE: Lost Dosimeter in High Radiation Area

DATE/TIME OF OCCURANCE: February 5th 2016 at ~10:00 am

DESCRIPTION: An employee was performing routine work in the demineralizer area in the equipment room, which is classified as high radiation area. It is estimated that around 10:00 am the employee's

OSL badge came off and landed under a segment of the primary piping in the demineralizer area. The employee noticed his badge was missing at 2:30 pm at which time he was able to quickly locate it. During the ~4.5 hours the employee was not wearing his OSL badge no work was performed that would have resulted in any measureable exposure as indicated by their pocket ion chamber. The employee took an exposure reading at the location where the OSL badge had been and found it to be ~10 mrem/hr. It is therefore likely that the badge received ~45 mrem of dose that the employee did not.

DOSE CONSEQUENCES: No additional dose was received due to the misplacing of the dosimeter. Based on known radiation levels in the demineralizer area and the amount of time the worker spent in the area the dose the worker received was <1 mrem. This was confirmed by the pocket ion chamber reading. The effected dosimeter was worn for 4 days before this incident. No work by the employee took place during this time that would have incurred more than 1-2 mrem. The spare dosimeter issued to the worker will therefore only differ from the dose the worker received by, at most, 1-2 mrem. This is not considered statistically significant.

IMMEDIATE CORRECTIVE ACTION: The employee recorded their dose received for that day as measured by their pocket ion chamber. This dose was < 1 mrem. The effected dosimeter was taken and a spare dosimeter was issued to the employee.

PERMANENT CORRECTIVE ACTION: The frequency at MNRC when a dosimeter is misplaced in a high radiation area is very low (i.e. much less than once per year). Furthermore, the frequency when an employee is performing work, which would incur a significant dose, when they are not wearing their OSL/TLD dosimeter, is essentially zero. This incident does not appear to be indicative of a larger issue and no permanent corrective action, beyond reminding MNRC radiation workers to periodically check to see that their dosimetry is in place while in a high radiation area, is required.

5. There was one Radiological Investigation Report written in June. That report is as follows:

RADIOLOGICAL INVESTIGATION REPORT NO. 16-02

TITLE: Uncontrolled decompression of ArAr dating sample (IR-0513)

DATE/TIME OF OCCURANCE: June 29th 2016 at ~13:30 hrs (reactor shutdown)

DESCRIPTION: IR-0513 is an ArAr dating experiment that was irradiated in the central facility for ~40 MWhrs before it was removed and allowed to "cool" in the reactor tank for ~3 weeks. The experiment encapsulation is comprised of a reusable inner and outer aluminum cylinder. The seal on both cylinders is opened by impacting the top of the seal with a dead-blow hammer. This encapsulation had been used successfully once before for a 24 hour irradiation. The previous designed used a disposable aluminum cylinder sealed by an interference fit. Two workers were involved in dismantling the experiment in the equipment room. The outer containment was opened without incident. No moisture was found between the two containments. When the seal on the outer container was unseated the contents rapidly decompressed due to an unexpected gas build up. The cap of the inner encapsulation and some of the aluminum foil (used to pack the samples) was ejected 3-4 feet from the worker opening the encapsulation. The packing aluminum foil appeared to have become heavily oxidized by this point.

CAUSE: The cause for the gas buildup is unknown and will likely remain unknown as there is some danger associated with trying to recreate the exact scenario. The cause is thought to be that the protective aluminum oxide layer, which forms on all aluminum exposed to oxygen, became damaged. Once the metallic aluminum became exposed, moisture in the air sealed inside the sample reacted with the aluminum and generated hydrogen gas. The mechanism for exposing the metallic aluminum could have been radiolytic in nature or been the result of residual corrosive material on the samples. The researcher was contacted and stated that the sample was prepared in an identical manner as the previous samples. It is unclear why this gas buildup was seen in this specific irradiation and not the other ~10 similar ArAr dating experiments.

DOSE CONSEQUENCES: One of the workers received 5 mrem whole body and the second worker received 2 mrem whole body. This does is typical of the doses received while dismantling previous ArAr experiments. Therefore, no measurable external dose from this occurrence was received by either employee. Given that both workers found no contamination (other than on their gloves) on themselves immediately after the occurrence or after decontaminating the equipment room, the likelihood of uptake of radiological material is small.

IMMEDIATE CORRECTIVE ACTION: The two workers restricted access to the area of potential contamination. All material ejected from the experiment containment was collected and segregated as radioactive material. Standard decontamination procedures were implemented. Decontamination took approximately 1.5 hours and was followed by a survey that found no measureable contamination in the area.

PERMANENT CORRECTIVE ACTION: Unless the exact cause of the gas buildup can be determined all future similar experiments shall be sealed in a moisture free environment and shall be opened "semi-remotely" in a radiological fume hood. This restriction includes experiments containing cadmium.

7.3 MAINTENANCE OTHER THAN PREVENTIVE:

January

System #	Description	Work Performed
5320	Data Acquisition and Control (DAC)	Replaced Scram Check Relays K1, K3, and K4 on the Action Pak drawer and K1 relay on the DC input/output drawer in the DAC

February

System #	Description	Work Performed
1001	Reactor CAM	Replaced failed Rx CAM monitor

March

System #	Description	Work Performed
1800	Reactor Ventilation	DOP test Reactor Room Exhaust HEPA filters
1803	Rad-Vac	DOP test Radiological Vacuum Cleaner
5490	Helium Supply	Replace expended Helium Supply bottle
5720	Security System	Replace Keypad at East Gate

April

System #	Description	Work Performed
5330	Nuclear Instrumentation	Troubleshot and Repaired interface problem with the NM-1000. Component failures on communications card to the Burr-Brown terminal. See anomaly report.

May

System #	Description	Work Performed
5490	Helium Supply	Replaced expended helium supply bottle
5710	Radiation Area Monitoring (RAM)	Replaced failed Reactor Room RAM system with calibrated spare modules.

June

System #	Description	Work Performed
5710	Radiation Area Monitoring (RAM)	Replaced failed Spare (ex Reactor Room) RAM GM tube recalibrated SAT.
5740	Fire Protection System	Replaced failed Air Compressor

July

System #	Description	Work Performed
5490	Helium Supply	Replaced expended helium supply bottle

August

1. MNRC completed the annual reactor maintenance shutdown during the month of August. Technical Specification required periodic maintenance as well as general maintenance was performed.

2. Parametric values noted during testing are as follows:

Control Rod Worth:

Transient Rod: $1.94 | Shim 1: $2.66 | Shim 2: $2.60
Shim 3: $2.68 | Shim 4: $2.98 | Regulating Rod: $2.76

Control Rod Scram Drop Times:

Transient Rod: 0.34 sec | Shim 1: 0.39 sec | Shim 2: 0.37 sec
Shim 3: 0.41 sec | Shim 4: 0.39 sec | Regulating Rod: 0.36 sec

Shutdown Margin: $6.00

The normal nuclear instrument calorimetric calibration was performed. Both the NPP channel and the NM-1000 channels of the Nuclear Instruments were satisfactory, and no adjustments were required.

At Power Scram values: NPP-1000: 108% indicated, NM-1000: 104% indicated.

System #	Description	Work Performed
1001	Reactor Room CAM	Troubleshot and repaired Rx Rm CAM CRT failure.
5110	Makeup Water System	Replaced Makeup Water tank outlet resin bottle.
5170	Auxiliary Makeup Water System	Replaced propane gas line.

September

System #	Description	Work Performed
5490	Helium Supply	Replaced expended helium supply bottle
5170	Auxiliary Makeup Water System	Replaced Depleted Resin bottles

October

System #	Description	Work Performed
5490	Helium Supply	Replaced expended helium supply bottle

November

System #	Description	Work Performed
5490	Helium Supply	Replaced expended helium supply bottle

December

System #	Description	Work Performed
5350	Emergency Lighting	Replaced 2 emergency lights and replaced batteries in 1 other.

7.4 Training

January

1. Three Senior Reactor Operators completed training on Normal, Abnormal, and Emergency Procedures.
2. Three Senior Reactor Operators completed training on Administrative Controls Procedures and Regulations
3. One Senior Reactor Operator completed training on several Nuclear Theory modules.

February

1. One Senior Reactor Operator completed training on Normal, Abnormal, and Emergency Procedures.
2. One Senior Reactor Operator completed training on several Nuclear Theory modules.
3. One Senior Reactor Operators completed training on Administrative Controls Procedures and Regulations

March

1. No scheduled training for March.

April

1. Hosted and conducted training for University of California Berkeley Nuclear Engineering classes. (Classroom and Practical Lab training)
2. All Senior Reactor Operators satisfactorily completed the Biennial Requalification Exam.

May

1. All Facility personnel completed Annual ALARA and annual safety training.

June

1. No scheduled training in June.

July

1. MNRC conducted summer school classes for the University COSMOS program.
2. Senior Reactor Operators completed training on Fuel and Fuel handling

August

1. All licensed successfully completed the Annual Operators Examination.

September

1. No scheduled training for September.

October

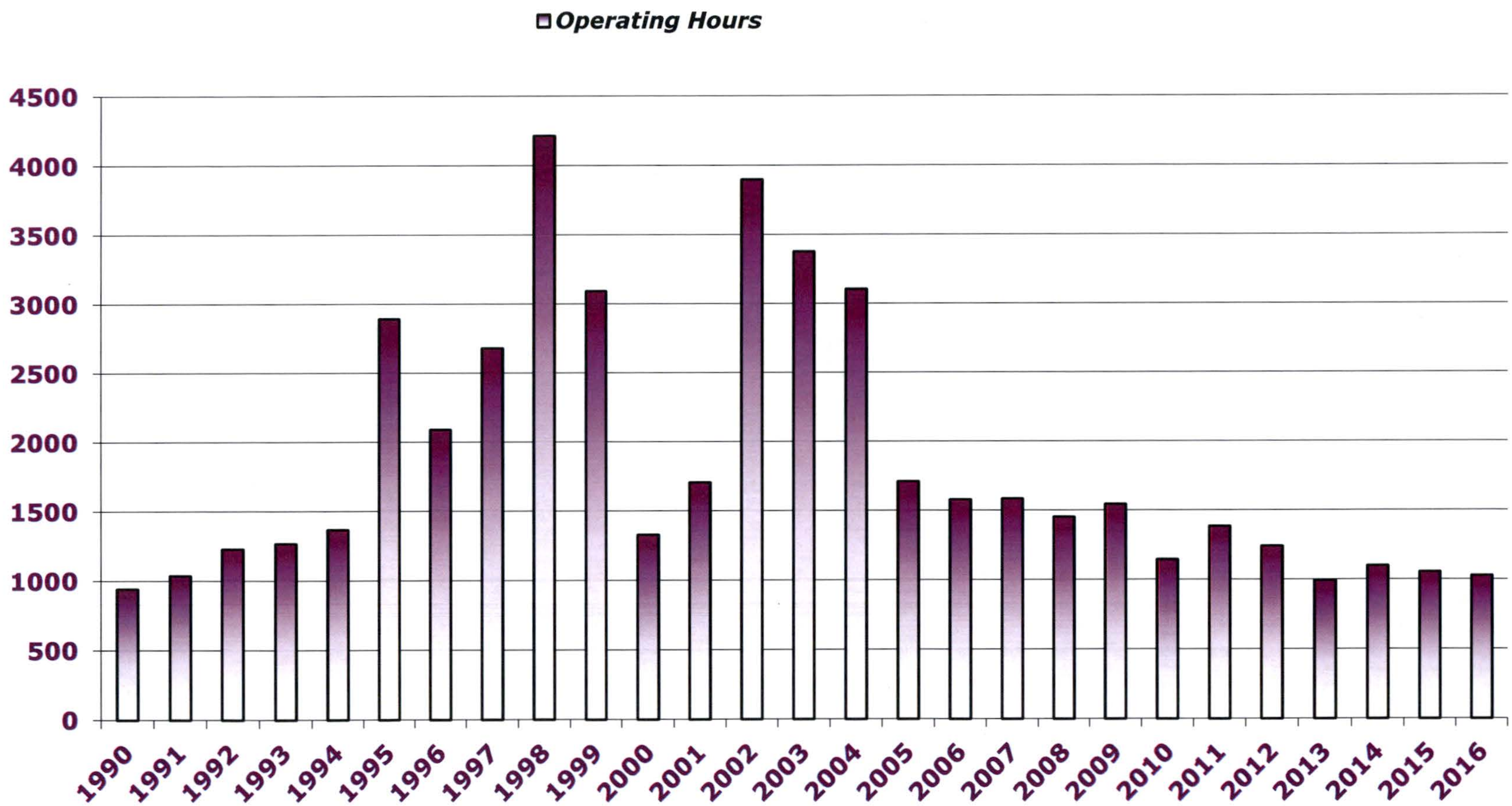
1. Two Senior Reactor Operators completed training on Normal, Abnormal and Emergency Procedures.

November

1. Two Senior Reactor Operators completed training on Normal, Abnormal and Emergency Procedures.

December

1. Senior Reactor Operators participated in the annual Security Drill.


Operating Hours
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
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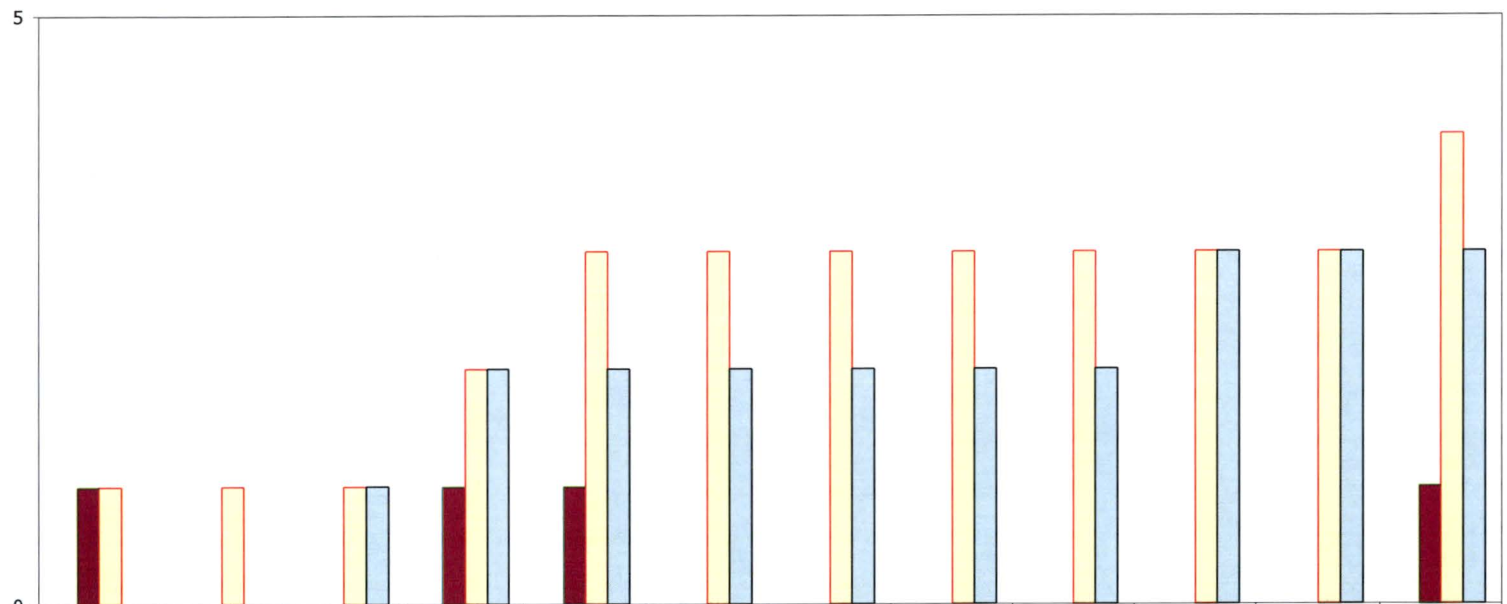
2015
2016

Unscheduled Reactor Shutdowns 2016

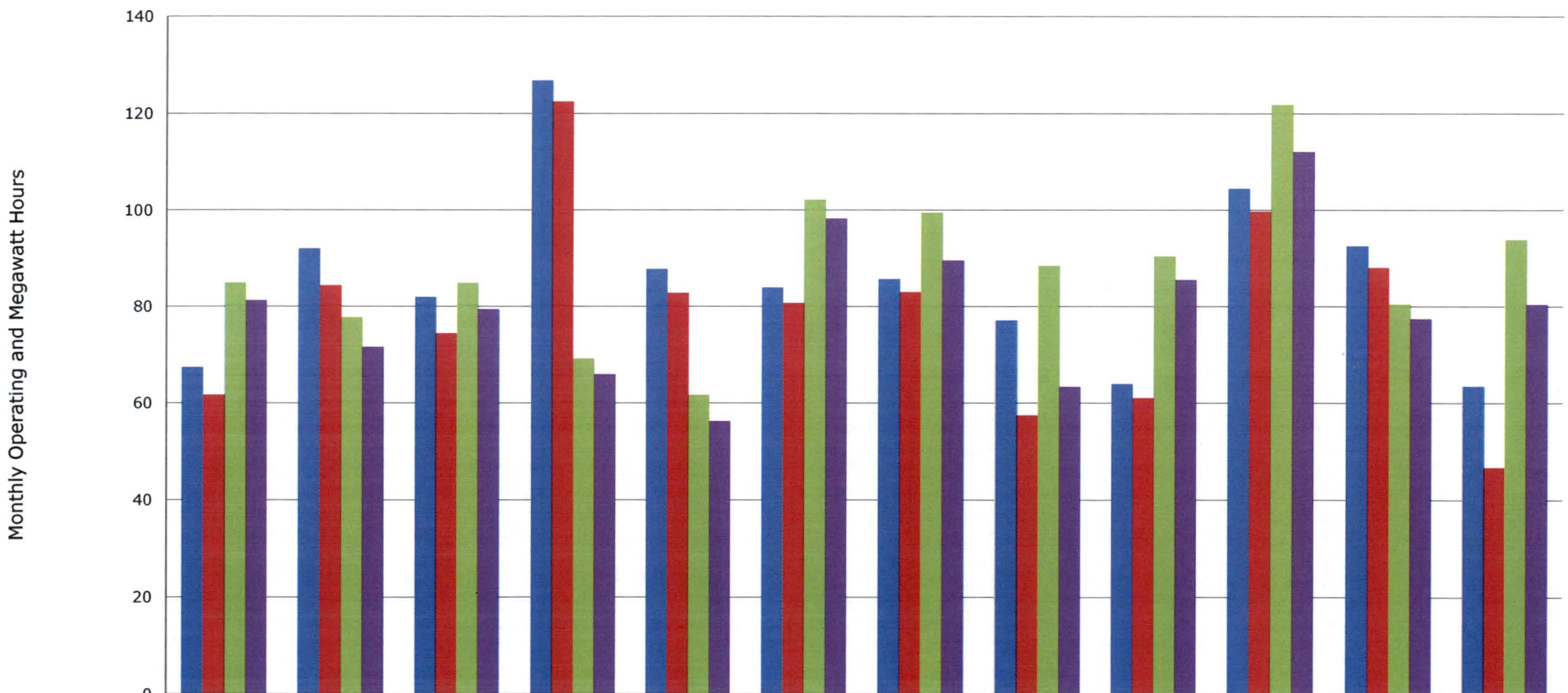


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
CSC	0	0	0	0	0	0	0	0	0	0	0	0
Other	1	0	0	1	1	0	0	0	0	0	0	1
2016 Total	1	1	1	2	3	3	3	3	3	3	3	4
2015 Total	0	0	1	2	2	2	2	2	2	3	3	3

Months

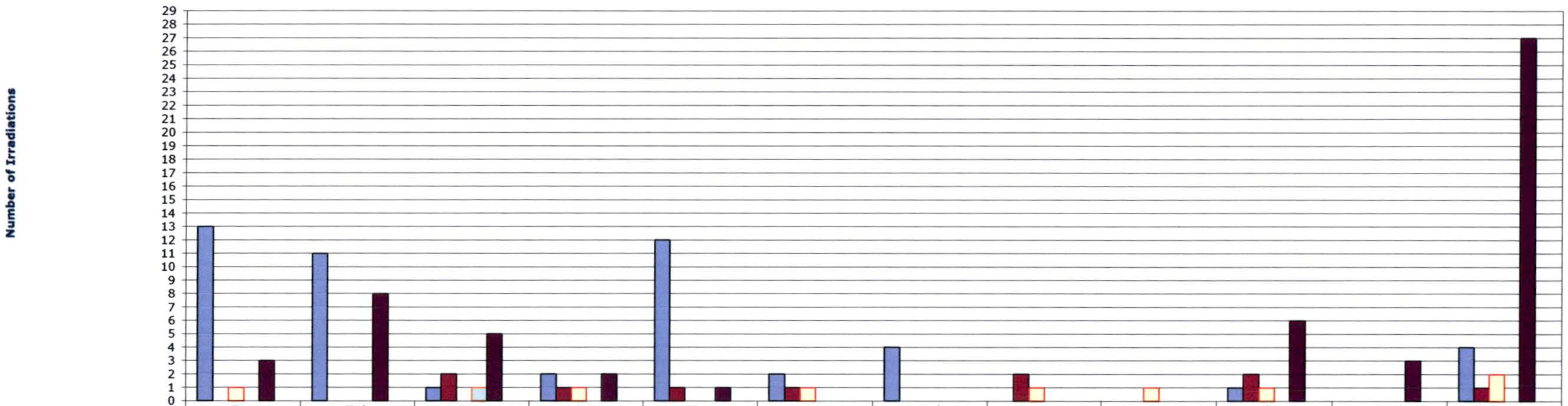
Reactor Hours (2016)

Reactor Hours 2016



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2016 Op-Hrs	67.49	92.15	82.03	126.83	87.87	84	85.78	77.2	64.04	104.54	92.64	63.51
2016 Mw-Hrs	61.7	84.4	74.44	122.44	82.86	80.73	83	57.47	61.09	99.78	88.08	46.75
2015 Op-Hrs	84.98	77.8	84.94	69.25	61.7	102.2	99.51	88.52	90.5	121.85	80.53	93.95
2015 Mw-Hrs	81.33	71.66	79.47	65.99	56.31	98.3	89.62	63.39	85.58	112.12	77.45	80.48

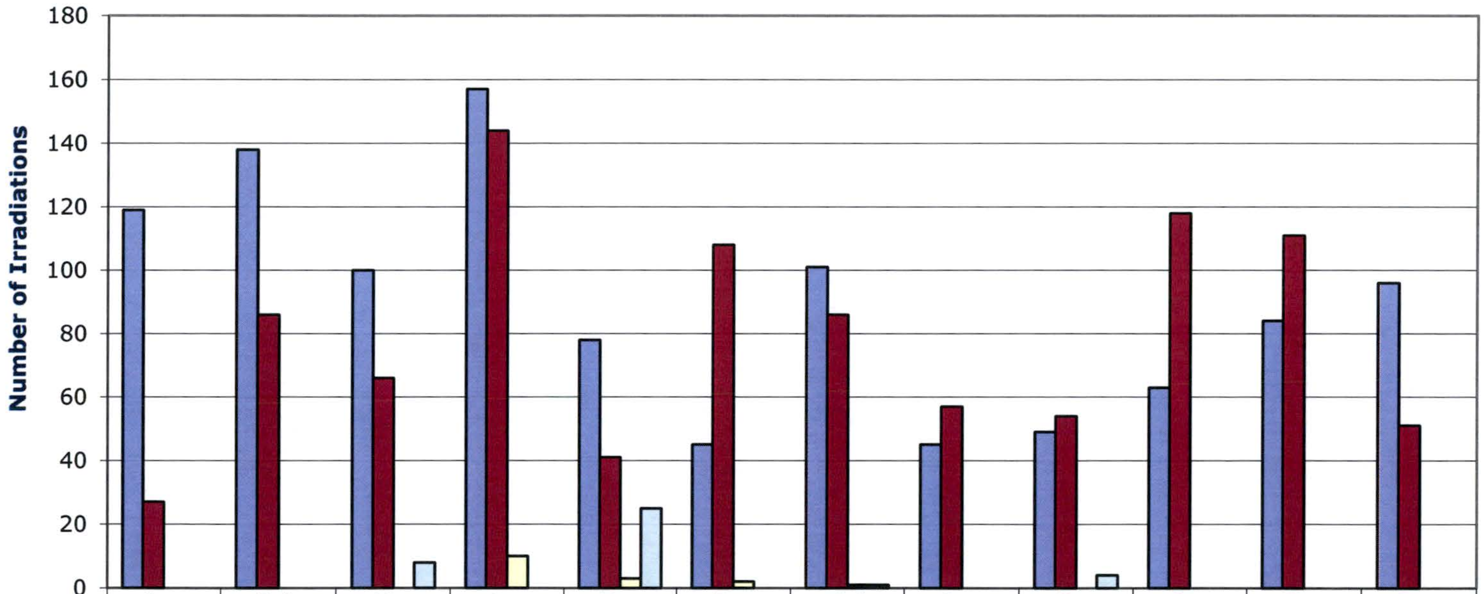
Reactor Tank Irradiation Facilities 2016



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pneumatic	13	11	1	2	12	2	4	0	0	1	0	4
Silicon Fixture	0	0	2	1	1	1	0	2	0	2	0	1
Central Facility	1	0	0	1	0	1	0	1	1	1	0	2
Argon	0	0	1	0	0	0	0	0	0	0	0	0
Neutron Irradiator	3	8	5	2	1	0	0	0	0	6	3	27

Months

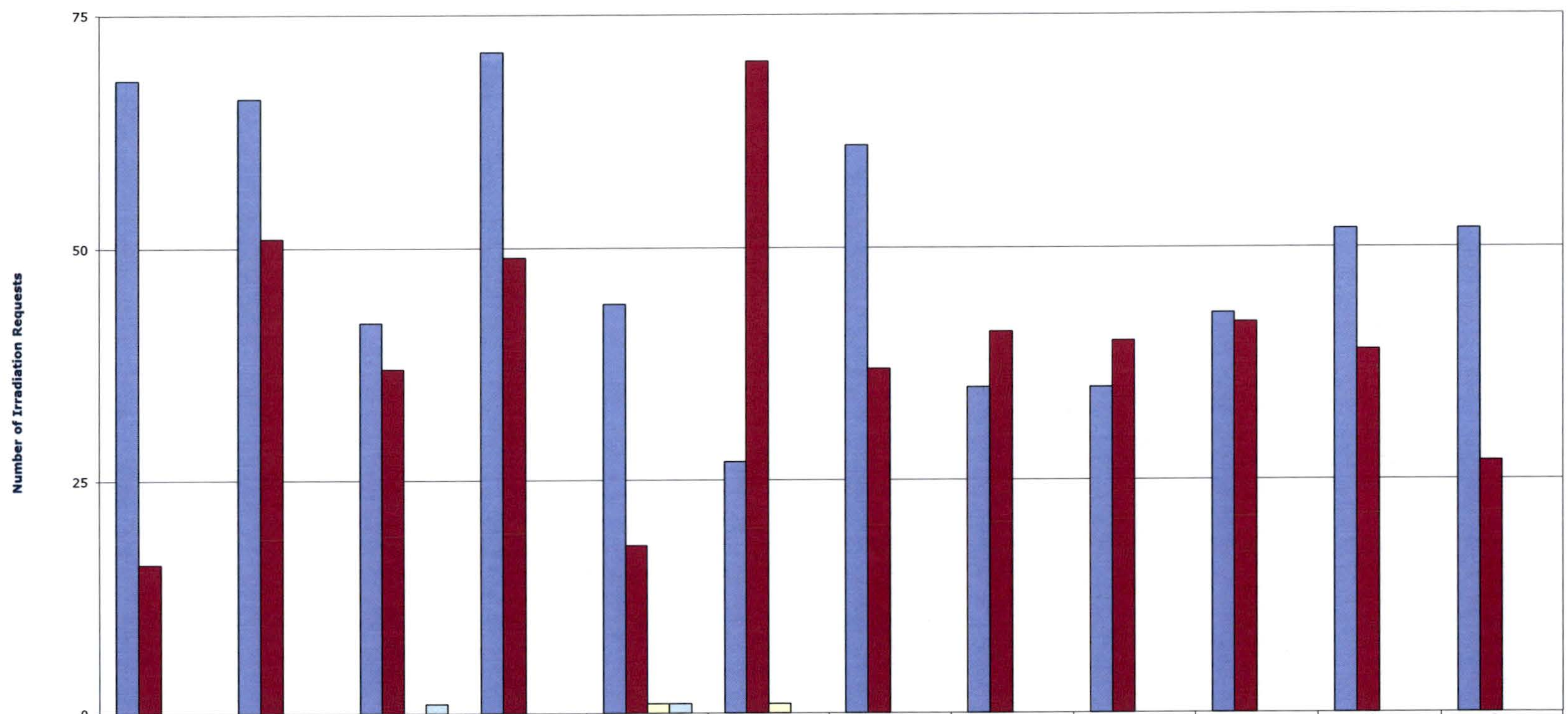
Bay Utilization (Shutter Operations) 2016



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bay 1	119	138	100	157	78	45	101	45	49	63	84	96
Bay 2	27	86	66	144	41	108	86	57	54	118	111	51
Bay 3	0	0	0	10	3	2	1	0	0	0	0	0
Bay 4	0	0	8	0	25	0	1	0	4	0	0	0

Months

Bay Irradiation Requests Completed 2016



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bay 1	68	66	42	71	44	27	61	35	35	43	52	52
Bay 2	16	51	37	49	18	70	37	41	40	42	39	27
Bay 3	0	0	0	0	1	1	0	0	0	0	0	0
Bay 4	0	0	1	0	1	0	0	0	0	0	0	0

Months

8.0 Radioactive Effluents

A summary of the nature and amount of radioactive effluents released or discharged to the environment beyond the effective control of the MNRC, as measured at or prior to the point of such release or discharge, include the following:

8.1 Liquid Effluents

No liquid effluents were released during 2016.

8.2 Airborne Effluents

Airborne radioactivity discharged during 2016 is tabulated in Table 1 below.

TABLE 1
2016 SUMMARY OF AIRBORNE EFFLUENTS

MONTH	TOTAL EST. QUAN. Ar-41 RELEASED (Ci)	EST.MAX AVG. CONC. OF Ar-41 IN UNRESTRICTED AREA (1)(3) (uCi/ml)	FRACTION OF APPLICABLE 10CFR20 Ar-41 CONC. LIMIT FOR UNRESTRICTED AREA (1) (%)	EST. DOSE (2) FROM Ar-41 FOR UNRESTRICTED AREA (1) (mrem)	FRACTION OF APPLICABLE 10CFR20 DOSE CONSTRAINT FOR UNRESTRICTED AREA (1)(4) (%)	TOT. EST. QUANTITY OF ACT. IN PART. FORM WITH HALF-LIFE >8 DAYS (Ci)	AVERAGE CONC. OF PART. ACT. RELEASED WITH HALF-LIFE > 8 DAYS (uCi/ml)
JAN	0.70	3.91E-11	0.4%	2.38E-01	2.38%	NONE	NONE
FEB	1.06	5.91E-11	0.6%	3.60E-01	3.60%	NONE	NONE
MAR	3.93	2.19E-10	2.2%	1.33E+00	13.35%	NONE	NONE
APR	1.64	9.13E-11	0.9%	5.56E-01	5.56%	NONE	NONE
MAY	0.89	4.96E-11	0.5%	3.02E-01	3.02%	NONE	NONE
JUN	1.91	1.09E-10	1.1%	6.64E-01	6.64%	NONE	NONE
JUL	1.79	1.03E-10	1.0%	6.25E-01	6.25%	NONE	NONE
AUG	1.20	6.86E-11	0.7%	4.18E-01	4.18%	NONE	NONE
SEP	1.14	6.50E-11	0.7%	3.96E-01	3.96%	NONE	NONE
OCT	1.97	1.13E-10	1.1%	6.87E-01	6.87%	NONE	NONE
NOV	2.06	1.18E-10	1.2%	7.18E-01	7.18%	NONE	NONE
DEC	0.98	5.61E-11	0.6%	3.41E-01	3.41%	NONE	NONE
TOT	19.27					NONE	NONE
AVG	1.61	9.09 E-11	0.9%	0.55	5.53%		

(1) This location is 240 meters downwind which is the point of maximum expected concentration based on the worst case atmospheric conditions (see MNRC SAR Chapter 11).
(2) Based on continuous occupancy and the calculation techniques used in Appendix A of the MNRC SAR (Ar-41 at 2.3E-10 uCi/ml continuous for one year equals 1.4 mrem).
(3) 10CFR20 Limit for concentration is 1E-8 (Appendix B, Table 2);
(4) Constraint for dose is 10 mrem/year [10CFR20.1101(d)]

8.3 Solid Waste

No solid radioactive waste was shipped this year.

9.0 Radiation Exposure

Radiation exposure received by facility operations personnel, facility users, and visitors during 2016 is summarized in Table 2 below.

TABLE 2
2016 SUMMARY OF PERSONNEL RADIATION EXPOSURES

	NUMBER OF INDIVIDUALS	AVERAGE TEDE PER INDIVIDUAL (mrem)	GREATEST INDIVIDUAL TEDE (mrem)	AVERAGE EXTREMITY (mrem)	GREATEST EXTREMITY (mrem)
FACILITY PERSONNEL(1)	7	55	120	111	398
FACILITY USERS	16	<1.0	1	*	*
VISITORS	648	<1.0	2	*	*

(1) Only 5 of the 7 facility radiation workers were employed at MNRC after January 2016.

* Extremity monitoring was not required.

10.0 Radiation Levels and Levels of Contamination

Radiation levels and levels of contamination observed during routine surveys performed at the MNRC during 2016 are summarized in Table 3 below.

TABLE 3
2016 SUMMARY OF RADIATION LEVELS AND CONTAMINATION LEVELS DURING ROUTINE SURVEYS

	AVERAGE (mrem/hr)	HIGHEST (mrem/hr)	AVERAGE (dpm/100cm^2)	HIGHEST (dpm/100cm^2)
OFFICE SPACES	<0.1	<0.1	<5000(1)	<5000(1)
REACTOR CONTROL RM	<0.1	<0.1	<5000(1)	<5000(1)
RADIOGRAPHY CONTROL RM	<0.1	<0.1	<5000(1)	<5000(1)
COUNTING LAB	<0.1	<0.1	<5000(1)	<5000(1)
STAGING AREA	<0.1	<0.1	<5000(1)	<5000(1)
COMPOUND (I/S Fence)	<0.1	<0.1	<5000(1)	<5000(1)
EQUIPMENT RM	0.5(4)	108(5)	<800(2)	<800(2)
DEMINERALIZER AREA	12.5(4)	320(5)	<800(2)	<800(2)
REACTOR RM	2.1(4)	2000(5)	<800(2)	<800(2)
SILICON STORAGE SHED	<0.1	<0.1	<5000(1)	<5000(1)
RADIOGRAPHY BAYS	0.6(3)	440(6)	<800(2)	<800(2)

(1) <5000 dpm/100 cm^2 = Less than the lower limit of detection for a scanning survey.

(2) <800 dpm/100 cm^2 = Less than the lower limit of detection for a swipe survey.

(3) Due to Bay 1 Storage Areas; all other areas and bays are significantly lower (typically <0.1 mrem/hr).

(4) General area dose rate.

(5) Maximum contact dose rate.

(6) 1 meter dose rate of beam port insert taken behind shielding.

11.0 Environmental Surveys

Environmental surveys performed outside of the MNRC during 2016 are summarized in Tables 4 & 5 below. The environmental survey program is described in the MNRC Facility Safety Analysis Report.

TABLE 4
2016 SUMMARY OF ENVIRONMENTAL TLD RESULTS
(WITH NATURAL BACKGROUND(1) SUBTRACTED)

	AVERAGE (mrem)	HIGHEST (mrem)
ON BASE (OFF SITE 1-20 & 64)	6	13
ON SITE (SITES 50 – 61 & 65-71)	14	22

(1) Natural background assumed to be the off base (Sites 27-42) average of 29 mrem.

TABLE 5
2016 SUMMARY OF RADIOACTIVITY IN WELL WATER

	ALPHA (pCi/l)	BETA (pCi/l)	TRITIUM (pCi/l)	Cs-137 (pCi/l)
AVERAGE	<MDA	2.77	<MDA	<MDA
HIGHEST	<MDA	3.44	<MDA	<MDA

MDA is the minimum detectable activity at the 95% confidence level.

The MDA range for the analyzed radionuclides (pCi/L).

	MIN	MAX
Alpha	1.25	1.90
Beta	1.36	1.92
Tritium	294	354
Cs-137	5.90	15.4