January 2020

Nuclear Material Events Database

Annual Report

Fiscal Year 2019

Prepared for the U.S. Nuclear Regulatory Commission
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ABSTRACT

This report presents information on trending and analysis of incidents/accidents (events) reported to the Nuclear Regulatory Commission (NRC) that involve radioactive material. The events are reported by NRC licensees, Agreement States, and non-licensees, and are recorded in the NRC's Nuclear Material Events Database. The reported events are classified into categories based on event reporting requirements defined in Title 10 of the Code of Federal Regulations. The categories in this report are (1) Lost/Abandoned/Stolen Material, (2) Medical, (3) Radiation Overexposure, (4) Release of Licensed Material or Contamination, (5) Leaking Sealed Source, (6) Equipment, (7) Transportation, and (8) Other.

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ACRONYMS

ADPH	Alabama Department of Public Health
ALARA	as low as reasonably achievable
ALI	annual limit on intake
AO	abnormal occurrence
AU	authorized user
CDPHE	Colorado Department of Public Health & Environment
CEDE	committed effective dose equivalent
CFR	Code of Federal Regulations
CHHSA	California Health and Human Services Agency
CT	computed tomography
DDE	deep dose equivalent
DE	dose equivalent
EDE	effective dose equivalent
EQP	Equipment
EXP	Radiation Overexposure
FBI	Federal Bureau of Investigation
FBRC	Florida Bureau of Radiation Control
FY	fiscal year
GTCC	greater than class C
HEPA	high efficiency particulate air
HLW	high-level waste
IAEA	International Atomic Energy Agency
IEMA	Illinois Emergency Management Agency
INL	Idaho National Laboratory
LAS	Lost/Abandoned/Stolen Material
LDE	lens dose equivalent
LDEQ	Louisiana Department of Environmental Quality
LKS	Leaking Sealed Source
LS	least squares
MED	Medical
NA	not applicable
NDHHS	Nebraska Department of Health and Human Services
NMED	Nuclear Material Events Database

NR	not recovered
NRC	Nuclear Regulatory Commission
ORPS	Oregon Department of Health Radiation Protection Services
OTH	Other
REAC/TS	Radiation Emergency Assistance Center/Training Site
RLM	Release of Licensed Material or Contamination
RSO	radiation safety officer
SCDHEC	South Carolina Department of Health and Environmental Control
SDE	shallow dose equivalent
SNM	special nuclear material
SSE	error sum of squares
SSR	regression sum of squares
SST	total sum of squares
TDSHS	Texas Department of State Health Services
TEDE	total effective dose equivalent
TRS	Transportation

EXECUTIVE SUMMARY

The Nuclear Regulatory Commission's (NRC) Nuclear Material Events Database (NMED) contains records of events involving nuclear material reported to the NRC by NRC licensees, Agreement States, and non-licensees. The reported events are classified based on reporting requirements defined by Title 10 of the Code of Federal Regulations. The event reports are evaluated to identify statistically significant trends and events of higher significance (referred to as significant events in this report).

The significant events that occurred in Fiscal Year 2019 are summarized below. Some of these events are considered potential Abnormal Occurrences (AOs) until they complete NRC's formal AO determination process and are reported in NUREG-0090, *Report to Congress on Abnormal Occurrences*. Note that a single event may be listed in more than one event type category.

Lost/Abandoned/Stolen Radioactive Sources/Material Events

Eleven significant events occurred involving the loss of seven Category 1-3 sources as defined by the International Atomic Energy Agency's *Code of Conduct on the Safety and Security of Radioactive Sources (2004)*. Nine Category 2 sources and four Category 3 sources were lost; all of which were recovered except two Category 3 sources.

Regarding the eleven significant events:

- None of the events involved Category 1 sources.
- Seven of the events involved the loss of Category 2 sources (nine total sources). These were all radiography sources contained within radiography exposure devices. Three devices were stolen by an employee (a potential Abnormal Occurrence), two devices fell from trucks en route to jobsites, two devices were left uncontrolled at jobsites, one device was uncontrolled after a radiographer was arrested for driving while intoxicated, and one device was lost during shipping. All of these sources were recovered.
- Four of the events involved the loss of Category 3 sources (four total sources). These were all radiography sources contained within radiography exposure devices. Two devices were lost during shipping, one device fell from an oil platform into the Gulf of Mexico, and one device was lost for unknown reasons. The two devices lost during shipping were recovered; the other two were not.

Medical Events

Seven significant events occurred, all of which were classified as potential Abnormal Occurrences. Four of the events involved Y-90 microsphere treatments; two of which were doses delivered to unintended sites and two were doses greater than prescribed. One event involved strontium breakthrough in an Rb-82 generator whose eluate was subsequently administered to eight patients. One event involved a dose of sodium iodide that was greater than prescribed. One event involved prostate brachytherapy seeds that were implanted into an unintended site.

Radiation Overexposure Events

Five significant events occurred. Three of the events involved radiographers who received exposures from unshielded radiography sources. One event involved a thief who stole three radiography devices and may have purposely exposed himself (a potential Abnormal Occurrence). One event involved internal exposure from ingestion/inhalation at a radioactive source manufacturing facility (a potential Abnormal Occurrence).

In addition to the five events above, one other significant event occurred prior to FY19 that was recently added to NMED. This event involved an extremity exposure at a radiopharmaceutical manufacturing facility.

Release of Licensed Material or Contamination Events
One significant event occurred. This event involved internal exposure from ingestion/inhalation at a radioactive source manufacturing facility (a potential Abnormal Occurrence).

Leaking Sealed Source Events
One significant event occurred. This event involved a source that was breached while a research irradiator was being dismantled.

Equipment Events
Seven significant events occurred. Three of the events involved radiographers who received exposures from unshielded radiography sources. One event involved a panoramic irradiator whose source rack became stuck in the up/exposed position for a few hours. One event involved strontium breakthrough in an Rb-82 generator whose eluate was subsequently administered to eight patients. One event involved internal exposure from ingestion/inhalation at a radioactive source manufacturing facility (a potential Abnormal Occurrence). One event involved a source that was breached while a research irradiator was being dismantled.

Transportation Events
No significant events occurred.

Other Events
No significant events occurred.

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1. INTRODUCTION

1.1 Overview and Objectives

Nuclear material event reports are evaluated to identify statistically significant trends and significant events. The reported information aids in understanding why the events occurred and in identifying any actions necessary to improve the effectiveness of the nuclear material regulatory program.

A database for tracking nuclear material events was developed by the Nuclear Regulatory Commission (NRC) in 1981. In 1993, using existing material events databases, the NRC developed a new and more comprehensive database for tracking material events. This database, designated the Nuclear Material Events Database (NMED), contains records of events involving nuclear material reported to the NRC by NRC licensees, Agreement States, and non-licensees. The database is maintained by the Idaho National Laboratory (INL) and contains approximately 26,000 records of material events submitted to the NRC from January 1990 to present.

The events in this report are classified into the following categories based on event reporting requirements defined by Title 10 of the Code of Federal Regulations (CFR):

- Lost/Abandoned/Stolen Material (LAS),
- Medical (MED),
- Radiation Overexposure (EXP),
- Release of Licensed Material or Contamination (RLM),
- Leaking Sealed Source (LKS),
- Equipment (EQP),
- Transportation (TRS), and
- Other (OTH).

A description of categories addressed in this report and associated screening criteria are presented in Appendix A.

1.2 NMED Data

A single occurrence report may be captured in more than one NMED event category. For example, a report may describe a loss of licensed material that also resulted in a radiation overexposure. In such a case, both event categories are recorded in the NMED and identified by the same report number (referred to as an item number in the database).

The data presented in this report are limited to reportable events that occurred between October 1, 2009, and September 30, 2019. The data were downloaded from the NMED on November 15, 2019. Because the NMED is a dynamic database that is updated daily, variations in data may be encountered over time. Furthermore, even though many events were reported and entered in the database for operational experience purposes, only those events required to be reported by 10 CFR are addressed in this report.

This report displays annual trend data for each of the event categories for a 10-year period. A trend analysis was performed on each event category to identify the existence or absence of a statistically significant trend. If a statistically significant trend exists, the display indicates the direction and

approximate rate of change with a trend line. For the purposes of this report, a statistically significant trend exists if the analysis indicates that the computed fit and slope of a least squares linear model is valid at a 95% confidence level. A primer on the statistical methods employed in the trend analysis is presented in Appendix B.

Note that the trending methodology is not normalized; the trend only considers the number of reported events and does not directly account for external issues such as changes to regulatory requirements or changes in the number of licensees. For example, an increasing trend in the number of medical events could be caused by an increase in the number of medical procedures being performed. Likewise, an event type showing a decreasing trend for NRC licensees and an increasing trend for Agreement State licensees could be caused by States becoming Agreement States (resulting in fewer NRC licensees and more Agreement State licensees).

Reporting guidance for Agreement States is provided in the *Handbook on Nuclear Material Event Reporting in the Agreement States*. The handbook is an appendix to the NRC Office of Nuclear Material Safety and Safeguards procedure SA-300, *Reporting Material Events*. Access to NMED is available to the staff of NRC, Agreement State, and Federal agencies at http://nmed.inl.gov.

For assistance on searches or other questions, contact Robert Sun (nmednrc@nrc.gov, 301-415-3421).

2. ANALYSIS OF NMED DATA

Event reports submitted to the NRC involving nuclear material are reviewed, categorized, and entered into the NMED. Charts are provided to display trends in annual data for the most recent 10-year period (FY10-19).

2.1 All NMED Events

Figure 1 displays the annual number and trend of NMED events that occurred during the 10-year period. The trend analysis determined that the NRC-regulated events represent a statistically significant decreasing trend (indicated by the trend line). However, the Total events and Agreement State-regulated events do not represent statistically significant trends (indicated by the absence of trend lines).

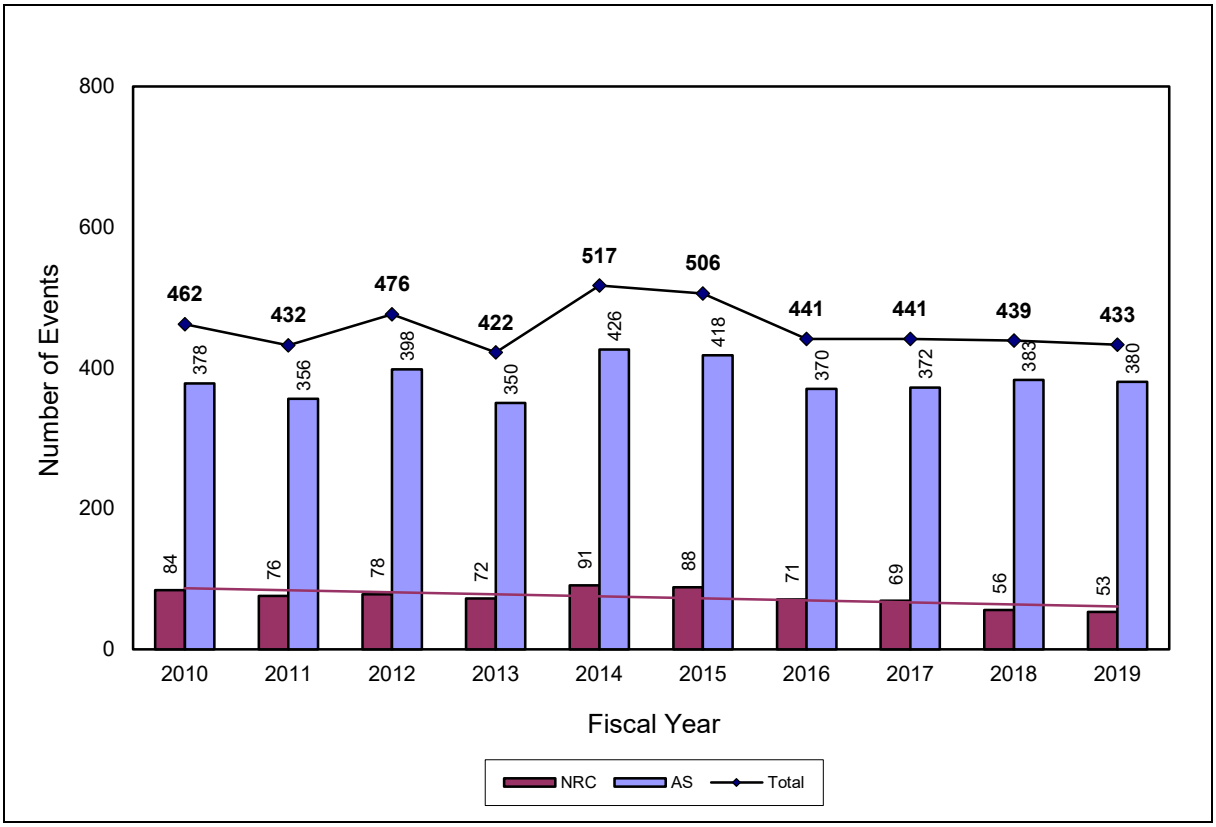

Figure 1. All NMED Events (4,569 total)

The following observations are made regarding the data in Figure 1.

- In FY19, 402 occurrences accounted for 433 events; a single occurrence can be classified in different event categories.
- The most recent year's data are typically many records less than their final value when subsequent updates and late reports are received (see Appendix D, Figure D-1).
- The transition of states from NRC to Agreement State jurisdiction could result in increasing trends in Agreement State data and decreasing trends in NRC data.

Table 1 displays a summary of the trending analysis for all NMED event types included in this report. A more detailed discussion of the trending analysis results can be found in the section of this report devoted to each event type.

Table 1. Summary of Trending Analysis

Event Type	Total	NRC	Agreement State
All NMED Events	-	↘	-
Lost/Abandoned/Stolen Material (LAS)	-	-	-
Medical (MED)	-	-	-
Radiation Overexposure (EXP)	-	-	-
Release of Licensed Material or Contamination (RLM)	↘	↘	-
Leaking Sealed Source (LKS)	-	-	-
Equipment (EQP)	-	-	-
Transportation (TRS)	-	-	-
Other (OTH)	NA	NA	NA

Notes:

- ↗ indicates a statistically significant increasing trend.
- ↘ indicates a statistically significant decreasing trend.
- - indicates no statically significant trend.
- NA indicates that the data does not support trending analysis.

2.2 Lost/Abandoned/Stolen Material

2.2.1 Ten-Year Data

Figure 2 displays the annual number and trend of LAS events that occurred during the 10-year period. The trend analysis determined that the data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines).

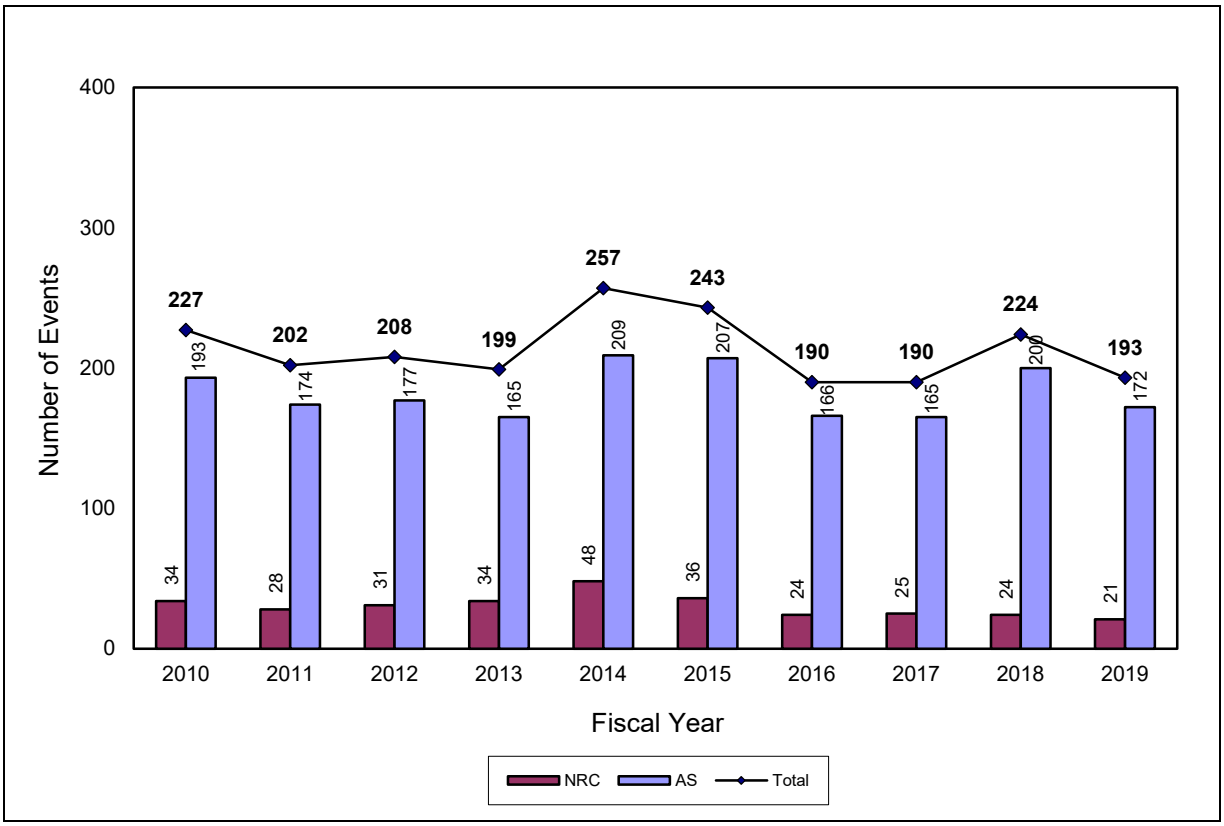

Figure 2. Lost/Abandoned/Stolen Material Events (2,133 total)

Appendix C contains a list of radionuclides derived from the International Atomic Energy Agency's (IAEA) *Code of Conduct on the Safety and Security of Radioactive Sources (2004)*. These radionuclides are grouped by the amount of radioactivity into five categories that correspond to the relative hazard, with Category 1 being the most hazardous.

For this report, IAEA Category 1 through 3 source events (excluding irretrievable well-logging source events) are considered significant. Regardless of IAEA category, events involving irretrievable well-logging sources are not considered significant. Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

Table 2 displays the number of sources lost (approximately 3,446, excluding irretrievable well-logging sources) during the 10-year period and the number that have not been recovered (approximately 1,735), grouped by IAEA category where possible. These included two Category 1 sources, 56 Category 2 sources, and 40 Category 3 sources; all of which were recovered, with the exception of two Category 2 and five Category 3 sources.

Table 2. Number of Sources Lost/Abandoned/Stolen (LAS) and Sources Not Recovered (NR) - Excluding Irretrievable Well Logging Sources

Category		Fiscal Year 2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
1	LAS[4]	0	0	0	0	0	2	0	0	0	0	**2**
	NR[5]	0	0	0	0	0	0	0	0	0	0	**0**
2	LAS	0	2	3	10	5	9	8	7	3	9	**56**
	NR	0	1	0	0	0	0	0	1	0	0	**2**
3	LAS	4	4	7	3	4	4	5	1	4	4	**40**
	NR	1	0	1	0	0	1	0	0	0	2	**5**
4	LAS	76	44	44	24	53	45	43	35	38	44	**446**
	NR	26	23	14	8	26	20	18	9	17	18	**179**
5	LAS	89	82	83	71	88	87	82	55	66	61	**764**
	NR	28	11	25	8	33	36	46	15	29	26	**257**
< 5	LAS	1	1	0	1	1	2	1	10	4	1	**22**
	NR	1	0	0	0	0	2	1	1	4	1	**10**
Activity Not Known[1]	LAS	13	12	9	7	3	3	1	1	3	3	**55**
	NR	1	0	0	0	0	1	0	0	0	0	**2**
Nuclide Not Known[2]	LAS	0	6	0	1	0	1	0	1	0	1	**10**
	NR	0	5	0	0	0	0	0	0	0	0	**5**
Other[3]	LAS	183	210	193	174	330	193	227	157	219	165	**2051**
	NR	127	139	132	92	257	110	163	67	114	74	**1275**
Total	**LAS**	**366**	**361**	**339**	**291**	**484**	**346**	**367**	**267**	**337**	**288**	**3446**
	NR	**184**	**179**	**172**	**108**	**316**	**170**	**228**	**93**	**164**	**121**	**1735**

Notes:

1. The "Activity Not Known" category includes sources containing radionuclides listed in Appendix C for which the activity was not reported. Therefore, the sources were not included in Categories 1 through 5.
2. The "Nuclide Not Known" category includes those sources for which the radionuclide was not reported. Thus, the sources were not included in Categories 1 through 5 or Other.
3. The "Other" category includes sources containing radionuclides not included in Appendix C.
4. Events involving a larger number of sources are sometimes entered as a single source with an aggregate activity (for example, the loss of a container of brachytherapy seeds may be entered as a single source with a total combined activity).

5. Events involving the loss/theft of multiple sources may involve the recovery of only some of the sources and are entered as being partially recovered (rather than marking each source individually). The Category 1 through 3 "not recovered" source counts were corrected for the "partially recovered" source events.

Tables 3 and 4 provide more detail regarding the 10-year and current year "not-recovered" data highlighted in Table 2 in yellow and green, respectively. Table 3 displays radionuclide data pertaining to the IAEA Category 1 through 3 sources lost during the 10-year period that have not yet been recovered. The Decayed Activity values are conservative estimates in that the values are typically decayed from the loss date instead of the manufacturer's assay date. As a result, the actual decayed activities (based on the manufacturer's assay date) are likely less than the estimates. Table 4 is similar to Table 3, but limited to the current year.

Table 3. Summary of IAEA Category 1-3 Sources Not Recovered (FY10-19)

Radionuclide	Half-life[1]	Number of Sources Not Recovered[2,3]	Total Activity (Ci)	Total Decayed Activity (Ci)[4]	Total Decayed Activity IAEA Category
Ir-192	73.83 days	5	94.3	9.0	3
Pu-238	87.7 years	2	5.3	5.0	3
Total		**7**	**99.6**	**14.0**	**3**

Notes:

1. Half-life values from the Chart of the Nuclides, 16th Edition.
2. Events involving a larger number of sources are sometimes entered as a single source with an aggregate activity (for example, the loss of a container of brachytherapy seeds may be entered as a single source with a total combined activity).
3. Events involving the loss/theft of multiple sources may involve the recovery of only some of the sources and are entered as being partially recovered (rather than marking each source individually). The source counts were corrected for the "partially recovered" source events.
4. The source activities were decayed from the event date to 11/14/2019 (data download date).

Table 4. Summary of IAEA Category 1-3 Sources Not Recovered (FY19)

Radionuclide	Half-life[1]	Number of Sources Not Recovered[2,3]	Total Activity (Ci)	Total Decayed Activity (Ci)[4]	Total Decayed Activity IAEA Category
Ir-192	73.83 days	2	27.3	9.0	3
Total		**2**	**27.3**	**9.0**	**3**

Notes:

1. Half-life values from the Chart of the Nuclides, 16th Edition.
2. Events involving a larger number of sources are sometimes entered as a single source with an aggregate activity (for example, the loss of a container of brachytherapy seeds may be entered as a single source with a total combined activity).
3. Events involving the loss/theft of multiple sources may involve the recovery of only some of the sources and are entered as being partially recovered (rather than marking each source individually). The source counts were corrected for the "partially recovered" source events.

4. The source activities were decayed from the event date to 11/14/2019 (data download date).

2.2.2 FY19 Data

One hundred ninety-three LAS events occurred in FY19, four of which involved irretrievable well logging sources. Excluding the irretrievable well logging sources, approximately 288 sources were lost/abandoned/stolen, 121 of which have not been recovered. Of the 288 lost sources, none were Category 1, nine were Category 2, and four were Category 3 sources; all of which were recovered except two Category 3 sources.

Eleven of the FY19 LAS events were considered significant (involved Category 1-3 sources). Note that regardless of IAEA category, events involving irretrievable well logging sources are not considered significant.

Significant Events - Category 1 Source Events
None

Significant Events - Category 2 Source Events
Item Number 190076 - The California Health and Human Services Agency (CHHSA) received a radiation safety allegation. A witness claimed that they observed a radiography exposure device unsecured and unattended on the ground behind a radiography services company truck on 11/30/2018. Pictures of the truck and unsecured exposure device were submitted with the complaint. The exposure device contained a 2.66 TBq (71.8 Ci) Ir-192 source and had a contact exposure rate of 35 mR/hour. Two radiographers had been working with the exposure device, but were not in direct control of it for over 30 minutes. CHHSA contacted the radiography services company assistant radiation safety officer (RSO) on 12/14/2018 to obtain a copy of the field utilization log. Both radiographers were determined to be trustworthy and reliable. Two NRC reportable violations were identified during a teleconference with the radiographers on 12/20/2018. An office conference was held with the company owner, RSO, assistant RSO, and the two radiographers involved in the incident. Enhanced training regarding control of exposure devices was given to all radiography staff.

Item Number 190106 - A radiography exposure device containing a 2.66 TBq (72 Ci) Ir-192 source was uncontrolled for 15 hours following work site activities on 3/1/2019. The device was left unsecured the entire time until discovered on the morning of 3/2/2019 by the radiography crew that left it. The device was subsequently secured in possession of the corporate RSO. The cause of the incident was determined to be operator error. Corrective actions included removal of personnel, procedure revisions, and retraining for all affected personnel. The North Carolina Department of Health and Human Services performed an investigation.

Item Number 190141 - A radiography services company lost control of a radiography exposure device containing a 1.81 TBq (49 Ci) Ir-192 source. The incident occurred as the result of an employee being arrested for driving while intoxicated on 2/24/2019. The vehicle containing the exposure device/source was impounded. The keys to the vehicle were left with the impound yard. The vehicle was locked with its alarm set within a fenced lot, behind a locked gate, and under video surveillance. Keys to the darkroom, where the source was stored, were located in the vehicle center console. No individuals accessed the vehicle while it was in the impound lot. The radiography services company retrieved the vehicle shortly after being notified of the arrest and impoundment. The source was out of the company's control for approximately 11 hours. No radiation exposures occurred as a result of this event. The involved individual's employment was terminated. Other personnel received additional instruction.

Item Number 190162 - A radiography exposure device containing a 3.16 TBq (85.3 Ci) Ir-192 source was lost and subsequently recovered. A technician lost the device on 4/1/2019 between approximately midnight and 1:00 a.m. He had left the device unsecured on the tailgate of a truck when leaving the radiography service company's Long Beach, California, office to drive to a jobsite in El Segundo, California. The technician reported the loss to the Long Beach office upon arrival at the jobsite at

approximately 1:10 a.m. A radiography crew was sent from the Long Beach office to search the route taken by the technician. The crew recovered the exposure device at approximately 1:30 a.m. from the breakdown lane of limited access Highway 91 westbound, about four miles from the Long Beach office. The exposure device was transported to the Long Beach office, where a leak test was performed that showed no leakage. The damaged device was then sent to manufacturer for repair. The source capsule was undamaged. However, the source assembly's female connector was damaged and could not be repaired. The California Health and Human Services Agency investigated the incident on 5/3/2019. Four violations were cited and an office conference was held on 6/4/2019. It was determined that the technician failed to: properly secure the exposure device, block and brace the device, perform radiation surveys required for transport, and limit public radiation exposure in an unrestricted area to 0.02 mSv (2 mrem) in one hour. The technician received written disciplinary notice and time off without pay. He was restricted from working with radioactive material for six months and will receive further training and testing until management confirms he is cleared to return to work with radioactive material. Additionally, the radiography group held stand-down meetings to review the incident. Annual refresher training was held that emphasized transportation regulations and safety procedures. The field auditing frequency was increased with an elevated focus on transportation preparation and labeling practices. This event was classified as an EQP and LAS event.

Item Number 190200 - A radiography services company reported that three radiography exposure devices were stolen and recovered on 4/28/2019. Each device contained an Ir-192 source with activities of 1.11, 1.81, and 2.96 TBq (30, 49, and 80 Ci), respectively. The thief was an employee or former employee and threatened to use the devices. He was apprehended at his apartment later that same day. The radioactive material was secured; the sources were found in the exposure devices. The devices were returned to the storage facility. Apparently, during an FBI interview, the thief stated that he had taken the back plate off of a device and had it sitting in his lap for over an hour. He may have also handled a source. Depending on the orientation of the exposure device, there is a very real possibility that the thief received an acute radiation exposure of over 450 cSv (rem) and possibly a whole body exposure greater than that. The Arizona Department of Health Services investigated the incident. This event was classified as an EXP and LAS event, as well as a potential Abnormal Occurrence.

Item Number 190326 - The Harris County, Texas, Hazardous Material Response Team reported that a law enforcement officer found a radiography exposure device containing a 1.44 TBq (39 Ci) Ir-192 source, at the intersection of Miller Road 2 and State Highway 90 in Houston, Texas, on 7/22/2019. The radiography services company that owned the device stated that a radiographer placed it on the tailgate of his vehicle and failed to secure it before driving to a gas station. While driving away from the gas station, the radiographer noticed a law enforcement officer holding what appeared to be a radiography exposure device. The radiographer stopped, checked his device, and discovered that it was not in his possession. The radiographer approached the officer and identified the exposure device.

Item Number 190468 - A radiography services company reported the loss and recovery of a radiography exposure device containing a 1.11 TBq (30 Ci) Ir-192 source. The company shipped the device to the manufacturer on 9/11/2019 for disposal. When the shipment did not arrive, the company RSO contacted the common carrier on 9/16/2019 and initiated a search. The last place the package was scanned was at the carrier's facility in Memphis, Tennessee, on 9/12/2019. The carrier located the package in Memphis, Tennessee, on 9/20/2019. The shipper's declaration papers had been torn off. The package was subsequently delivered to the manufacturer.

Significant Events - Category 3 Source Events

Item Number 190001 - A radiography services company reported the loss and recovery of a radiography exposure device containing a 330 GBq (8.92 Ci) Ir-192 source. On 11/29/2018, the company shipped the package from Sanford, Florida, to their Corpus Christi, Texas, location. When the shipment did not arrive, the company contacted the common carrier on 12/10/2018 and was told that it was delayed. The last known location of the package was Memphis, Tennessee. The company again contacted the carrier on

12/13/2018 and was told that the package could not be located. The carrier subsequently delivered the package on 12/21/2018.

Item Number 190128 - A laboratory reported the loss and recovery of a 347.8 GBq (9.4 Ci) Ir-192 radiography source. The laboratory shipped the source to the manufacturer in Baton Rouge, Louisiana, but it had not arrived as of 3/4/2019. The laboratory reported on 3/11/2019 that the common carrier found the package. The carrier had held the package in their Memphis, Tennessee, shipping center because they needed a copy of the shipping papers in order to send it on to its destination. The laboratory emailed a copy of the shipping papers to the common carrier and the package was delivered on 3/11/2019.

Item Number 190384 - A radiography exposure device fell overboard from an oil platform in the Gulf of Mexico. The device contained a 777 GBq (21 Ci) Ir-192 source. A radiographer had fallen down some stairs and dropped the device, which then bounced overboard. The water is approximately 200 feet deep at that location. The source was locked in the shielded position at the time of the event. The company will not attempt to retrieve the device.

Item Number 190489 - A radiography services company lost a radiography exposure device containing a 233.1 GBq (6.3 Ci) Ir-192 source. The loss was discovered on 10/1/2019 during an inventory check. The company believed that the device was located at one of their satellite locations in Orange, Texas. The company required each site RSO to personally search every truck, darkroom, and storage location. The source was not found. All other devices and sources were accounted for. The company contacted service companies it routinely conducts business with, but they did not have the device or source. The device utilization log showed that the missing device was last signed out on 3/3/2019. That log showed that it was signed back in and returned to the storage vault on the same day. The company was unable to contact the radiographer that last signed out the device. Corrective actions included requiring the weekly inventory of radioactive sources and devices to list each serial number, in addition to the total number of devices. The weekly and quarterly inventories from each office will be emailed to the corporate RSO in order to reconcile all sources in possession. No source/device exchanges will be allowed in the field unless the RSO/alternate RSO is notified and the exchange is documented in the utilization log. When a source/device is transferred to another office, the receiving office is required to confirm receipt by email.

Events of Interest

Item Number 190232 - A construction materials testing company reported the loss and recovery of a 166.5 MBq (4.5 mCi) Cs-137 source from a moisture/density gauge. On 4/25/2019, a technician performing compaction testing at a construction site noted erroneous gauge readings. The gauge was taken to a gauge services company on 4/29/2019 for evaluation. On 5/21/2019, the gauge services company discovered that the Cs-137 source was missing from the end of the source rod. The welds holding the source to the rod had failed. Personnel from the testing company and an NRC inspector went back to the construction site on 5/21/2019. A survey were the gauge first gave erroneous readings identified radiation levels twice as high as background levels. The location was marked and a 15-foot perimeter was established to secure the area. On 5/30/2019, an environmental remediation company arrived on site, located the source, and secured it in a shielded container. The source was found approximately two-feet underground, beneath a four-inch thick concrete sidewalk that had been poured on 5/8/2019. After securing the source, surveys of the surrounding soil and concrete found no residual contamination. The source was transported to a waste broker for disposal. The gauge manufacturer was aware of the potential for weld failures and had been inspecting gauges and notifying customers (the testing company had no record of this notification). This event was classified as an EQP and LAS event.

Item Number 190426 - A recycling company found a moisture/density gauge in a 55-gallon drum on 8/28/2019. The drum was crimped at the top so the gauge would not fall out. The gauge contained a 1.85 GBq (50 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source. They employed a contractor to take radiation readings and perform a swipe test of the gauge. The gauge housing appeared to be damaged, but the source housing seemed intact. The contractor was unable to inspect the bottom of the

gauge inside the drum. Radiation readings were 13 mR/hour on contact with the side of the gauge, 200 mR/hour on contact at the bottom, and 3 mR/hour one foot from the side. Swipe test results were less than background. The Oregon Department of Health Radiation Protection Services (ORPS) believes that the gauge is damaged, because normal radiation readings for the gauge at one meter should be 400 μR/hour. ORPS will investigate. This event was classified as an EQP and LAS event.

2.2.3 Events Recently Added to NMED That Occurred Prior to FY19

Forty-seven LAS events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. None of these events were considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events - Category 1 Source Events
None

Significant Events - Category 2 Source Events
None

Significant Events - Category 3 Source Events
None

Events of Interest
None

2.3 Medical

2.3.1 Ten-Year Data

Figure 3 displays the annual number and trend of MED events that occurred during the 10-year period. The trend analysis determined that the data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines).

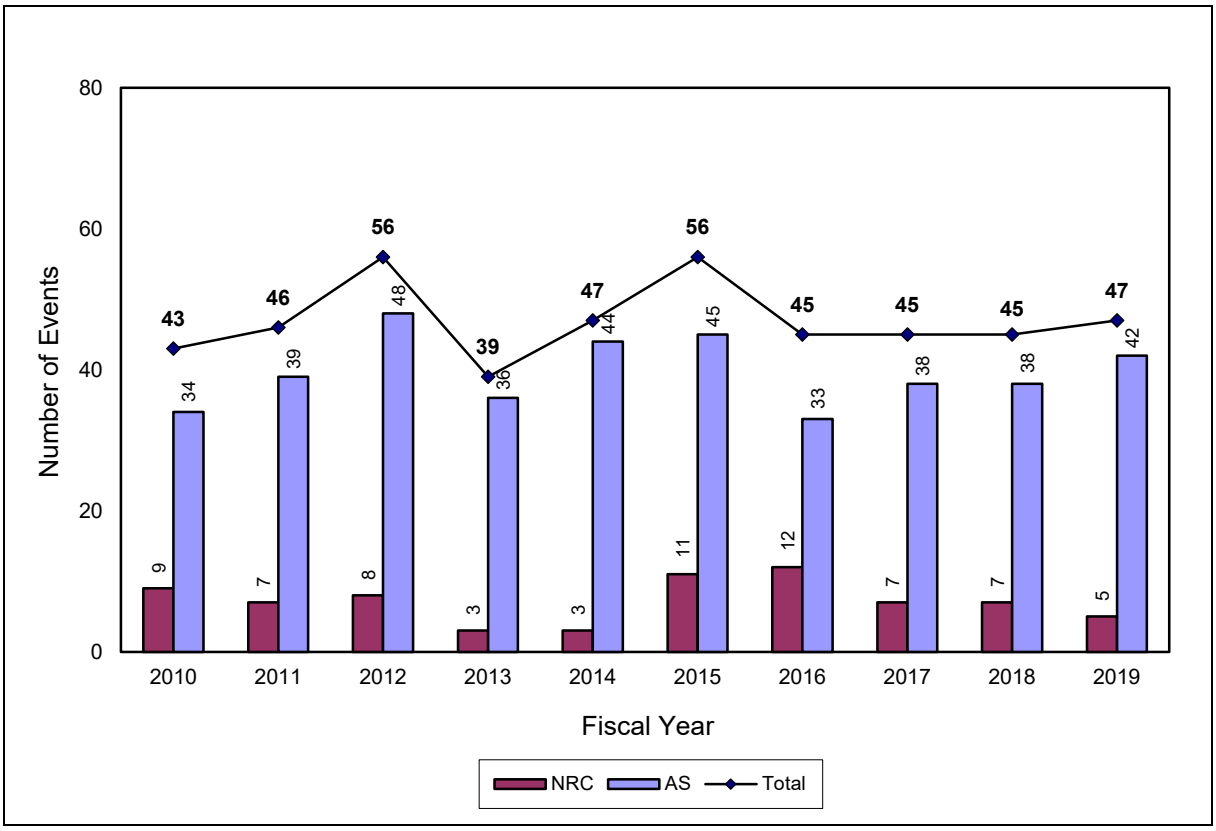

Figure 3. Medical Events (469 total)

Table 5 lists the number of MED events that were classified as Abnormal Occurrences (AOs) in NUREG-0090, *Report to Congress on Abnormal Occurrences*. Note that recent events are considered potential AOs until they complete NRC's formal AO determination process and are reported in NUREG-0090. Potential AO events are included in Table 5. Also included are events involving doses to an embryo/fetus or a nursing child (reportable per 10 CFR 35.3047). By definition, these events are not medical events (reportable per 10 CFR 35.3045) and are captured in NMED as an "Other" event. However, they are included here for reference.

Table 5. Medical and Embryo/Fetus or Nursing Child - AOs or Potential AOs

	Fiscal Year										
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Total**
Medical	12	14	13	7	11	14	7	10	8	7	**103**
Embryo	2	1	1	2	1	1	1	0	0	0	**9**
Total	**14**	**15**	**14**	**9**	**12**	**15**	**8**	**10**	**8**	**7**	**112**

For this report, events classified as AOs (or potential AOs) are considered significant. Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.3.2 FY19 Data

Forty-seven MED events occurred in FY19, seven of which were considered significant and classified as potential AOs.

Significant Events - AOs or Potential AOs

Item Number 190004 - A hospital reported that a strontium breakthrough occurred on an Rb-82 generator, resulting in levels of Sr-82/Sr-85 exceeding the manufacturer's specified limits. The hospital failed to identify the strontium breakthrough and doses were subsequently administered to eight patients from 12/15/2018 to 12/17/2018. The hospital discovered the breakthrough on 12/17/2018. The manufacturer's protocol recommends that each Rb-82 injection (stress and/or rest) be within a range of 1.11-2.22 GBq (30-60 mCi). The eight patients were administered the following: Rb-82 from 2.23 to 3.33 GBq (60.4 to 90 mCi), Sr-82 from 37.96 to 75.18 MBq (1.026 to 2.032 mCi), and Sr-85 from 25.72 to 49.17 MBq (0.695 to 1.329 mCi). The calculated doses were 100.7 to 256.9 cGy (rad) to the red marrow, 117.12 to 299.36 cGy (rad) to the bone surface, and 27.02 to 68.4 cGy (rad) effective dose. The patients were followed for 10 weeks, which determined that none of them exhibited indications of bone marrow suppression. The hospital contacted the Colorado Department of Public Health and Environment (CDPHE) and the manufacturer. The manufacturer suggested looking for evidence that lactated ringers may have been used to elute the generator. CDPHE performed an onsite investigation on 12/21/2018. The investigation identified two primary failures leading to the event. The first was human error in the inadvertent use of lactated ringers to elute the Rb-82 generator. The second was inadequate practices in conducting the strontium breakthrough analyses. Corrective actions taken by the hospital included immediately stopping the Rb-82 generator program. If the medical center restarts the program, they committed to utilizing an automated medication dispensing system to store the normal saline, with a required scanning of the medication prior to each patient administration. Additionally, they will perform daily audits of the IV fluid, modify their forms, obtain new equipment, and train personnel. This event was classified as an EQP and MED event.

Item Number 190049 - A patient received a dose to an unintended site during a Y-90 microsphere treatment on 2/1/2019. The patient was prescribed 779.22 MBq (21.06 mCi) to the liver for an intended dose of 5,600 cGy (rad), but was only administered 373.7 MBq (10.1 mCi), the majority of which was delivered to the spleen. During the administration, the physician began to feel pressure in the syringe. Using a smaller gauge syringe made no difference, so the treatment was aborted. It was suspected that microspheres were clumping in the catheter and obstructing flow. The hospital reported on 2/4/2019 that an uptake was observed in the patient's spleen. The Illinois Emergency Management Agency (IEMA) performed a reactive inspection on 2/5/2019. The hospital stated that approximately 259 MBq (7 mCi) of Y-90 was delivered to the patient's spleen during withdrawal of the catheter. Therefore, only approximately 114.7 MBq (3.1 mCi) was delivered to the patient's liver. The incident resulted in an underdose to the intended site (liver) of approximately 85.3%. The hospital suspects that a clump of microspheres loosened from the catheter while it was being retracted back into the guiding catheter, allowing the microspheres to flow into the larger splenic artery. Dosimetry estimates indicated that the spleen received 10,648 cGy (rad). The hospital's investigation did not locate any physical obstruction, verified that the catheter placement was correct, and did not find any errors in the administration. No other causes were identified. IEMA's review found no regulatory or procedural violations. The patient and referring physician were informed of the incident. The patient was monitored to determine if any adverse impacts develop, but is reported as doing fine. The hospital identified possible avenues to prevent recurrence, which were detailed in a report. Corrective actions included generating a new written procedure.

Item Number 190069 - A patient received a dose to an unintended site during a Y-90 microsphere treatment on 2/13/2019. The patient was prescribed 1.16 GBq (31.3 mCi) to the right lobe of the liver to treat metastases from colorectal cancer. A dose of 1.25 GBq (33.7 mCi) was drawn up to be injected and 1.17 GBq (31.68 mCi) was delivered. A post-treatment Bremsstrahlung scan showed that some of the microspheres traveled to the stomach and left lobe of the liver. The patient was informed and monitored for potential complications. Doses were estimated to be 2,900 cGy (rad) to the right lobe of the liver (which received 63.2% of the activity), 2,170 cGy (rad) to the left lobe (which received 33.5% of the activity), and 9,190 cGy (rad) to the stomach (which received 3.3% of the activity). The patient was prescribed prophylactic medication to help prevent ulceration. The patient subsequently began to experience nausea and vomiting. An endoscopy was performed on 3/7/2019 and revealed mild to moderate erythema in the gastric antrum, which was expected to resolve in one to two weeks with continued treatment. The hospital determined that the most likely cause of the event was undetected movement of the catheter tip. This may have resulted from patient movement and exacerbated by reduced slack in the catheter after pulling it back to correct its initial position. Corrective actions included updating procedures and providing retraining to personnel. The Pennsylvania Department of Environmental Protection performed a reactive inspection.

Item Number 190251 - A patient received a dose greater than prescribed during a Y-90 microsphere treatment on 6/11/2019. The patient was prescribed 0.304 GBq (8.22 mCi) for a dose of 12,000 cGy (rad), but was administered 3 GBq (81.08 mCi) for a dose of 69,800 cGy (rad). The Florida Bureau of Radiation Control performed an inspection. An authorized physician discussed the incident with the patient and a few family members. Hospital staff failed to properly assay the microspheres in the hot laboratory and reconcile it to the prescribed dose. No additional time-out was performed, which would have included the usual time-out checklist in addition to confirmation of the prescribed and assayed therapy dose. The therapy dose was not confirmed prior to administration. Additionally, the correct dose ordered for the patient was either never received by the microsphere vendor or it was never actually ordered. No adequate documentation process existed, to include document retention, for dose orders. There is now a formal time-out in the procedure room when a therapy dose is brought in by a nuclear medicine technologist and includes the same checklist as the original procedural time-out, in addition to the prescribed and assayed dose. The hospital improved the process and documentation of dose assay to include two nuclear medicine technologists. The radiopharmaceutical ordering and shipment tracking and reconciliation process were enhanced. The hospital will ensure that patient identifiers are utilized in the microsphere vendor order reference number field. The hospital provided interventional nursing and associate training regarding post procedural care and radiation safety for microsphere patients. The administered dose was added onto the standard radiology report template. The written directive worksheet was revised to make it easier to differentiate the prescribed dose and administered dose. The current microsphere protocol was evaluated.

Item Number 190315 - A patient received more dose than prescribed during a hyperthyroidism treatment on 7/16/2019. The patient was prescribed 0.518 GBq (14 mCi) of I-131 sodium iodide for a dose of 40,000 cGy (rad), but was administered 1.221 GBq (33 mCi), resulting in a dose of 96,500 cGy (rad). The certified nuclear medicine technologist administered the wrong I-131 capsule without verifying that it was for the patient. All technologists were re-educated on the importance of following procedures for administration of radiopharmaceuticals.

Item Number 190451 - Brachytherapy seeds were incorrectly placed during a prostate implant procedure on 8/1/2019. All 52 Pd-103 brachytherapy seeds that were intended to deliver 10,000 cGy (rad) to the patient's prostate were implanted inferior to the prostate by 4 cm. Each seed contained an activity of 47.8 MBq (1.292 mCi), for a total activity of 2,486.4 MBq (67.2 mCi). The incident was not discovered until 9/11/2019 during the post-implant dosimetry review. The physician was using ultrasound imaging to locate the prostate and misidentified the penile bulb as the prostate. The penile bulb was similar in size (10.8 cc versus 12 cc for the prostate) and in close proximity to the prostate. The referring physician and

patient were notified. The estimated exposure to 90% of the penile bulb was 7,399 cGy (rad). The patient was elderly and not sexually active; therefore, there was no increased risk of erectile dysfunction. The hospital identified the urethral structure as additional tissue at risk, but anticipates the effect to be the same as if the seeds had been correctly placed. The estimated dose to the prostate was 0 cGy (rad). The hospital will perform a second implant procedure to this patient. The cause of the event was determined to be human error. Corrective actions included providing additional instruction to personnel.

Item Number 190466 - A patient received a dose greater than prescribed during a Y-90 microsphere treatment on 9/16/2019. The patient was prescribed 1.6 GBq (43.2 mCi) to the liver for a dose of 25,100 cGy (rad), but was administered 3.32 GBq (89.6 mCi), resulting in a dose of 56,200 cGy (rad). The dose administered was intended for a different patient. The patient and authorized user were informed of the incident. The North Carolina Department of Health and Human Services conducted a reactive inspection. The cause of the incident was determined to be human error. Corrective actions included procedural review and revision and personnel retraining.

Events of Interest

Item Number 190132 - A patient received a dose to an unintended site during two fractions of remote high dose rate afterloader treatment on 3/7/2019 and 3/11/2019. The patient was prescribed three fractions using an afterloader containing a 251.6 GBq (6.8 Ci) Ir-192 source. For one of the sites to be treated, the catheter length was to be set at 1500 mm. Before the first treatment, the planner noticed that the length had been incorrectly set at 1293 mm and changed the setting to 1500 mm, but failed to press the enter key. Therefore, the setting was not changed. The plan was approved and the treatment was completed on 3/7/2019. A second treatment was completed on 3/11/2019, using the same incorrect catheter length. On 3/14/2019, a fourth physicist reviewed the plan prior to the third treatment and discovered the error. The error resulted in the intended target tissue receiving 50% of the prescribed dose of 1400 cGy (rad) and unintended tissue (thighs) receiving a dose of 700 cGy (rad). The patient and prescribing physician were notified of the event on 3/14/2019. A treatment plan was developed to correct the exposure to the intended tissue. The oncology center stated that the patient should not experience any adverse effects from the error. The error was due to the failure of the technician to correctly change the distance in the treatment plan and the failure of individuals who reviewed the first two treatments to catch the error. Involved individuals received additional instruction on performing thorough reviews of treatment plans prior to performing a treatment.

Item Number 190194 - A patient received a dose to an unintended site during remote high dose rate afterloader treatment on 4/22/2019. The patient was prescribed three fractions of 800 cGy (rad) to the uterus, for a total of 2,400 cGy (rad) using an afterloader containing an Ir-192 source. During the third fraction, all three source guide tubes used were too long (132 cm instead of 120 cm) and the entire 800 cGy (rad) was erroneously delivered to the vagina. In total, the uterus only received 1,600 cGy (rad) of the prescribed 2,400 cGy (rad). The patient and her treating physician were informed. The patient returned to hospital for monitoring. The patient had a very mild skin reaction that resolved without any major intervention. The California Health and Human Services Agency conducted a site visit on 4/29/2019. The cause of the incident was determined to be human error. The patient received her corrected third fraction on 4/29/2019. Corrective actions included storing the black end guide tubes (120 cm) on the wall and the green end guide tubes (132 cm) on a different rack, instead of keeping both length guide tubes on the same storage rack. The doctor will also use a ruler to verify the length of the guide tubes before each treatment. The NRC Registry of Radioactive Sealed Sources and Devices indicates that the Ir-192 source contains a maximum activity of 407 GBq (11 Ci).

Item Number 190197 - Two patients received a dose to an unintended site during remote high dose rate afterloader treatments in October 2018 and March 2019. Each patient was prescribed 1,000 cGy (rad) to the vaginal cavity across two fractions using an afterloader containing an Ir-192 source. During the treatments, a technician erroneously entered an applicator length of 120 cm into the device console, rather than 125 cm, effectively causing a 5 cm offset. About two years earlier, the length of the vaginal

applicator changed from 120 cm to 125 cm. The Massachusetts Radiation Control Program performed a special inspection. The first patient received 5% of the prescribed dose at the target area. The largest dose differences were in the distal part of the vaginal wall that received about 1,000 cGy (rad) instead of about 200 cGy (rad). The activity of the Ir-192 source at the time of the procedure was 151.7 GBq (4.1 Ci). The patient was informed by the referring physician on 8/23/2019. The second patient received 5% of the prescribed dose at the target area. The largest dose differences were in the distal part of the vaginal wall that received about 1,000 cGy (rad) instead of about 50 cGy (rad). The activity of the Ir-192 source at the time of the procedure was 140.6 GBq (3.8 Ci). The patient was informed by the referring physician on 5/14/2019. To prevent future occurrences, the hospital immediately reorganized how they store applicators and catheters, placing the applicator that utilizes a different treatment length in a separate cabinet. They introduced a time out procedure and posted it, indicating items that need to be verified before treatment. They changed their Quality Management Program form that is filed during every administration to include the verification of the total length of the rigid tube connected to the transfer tube and also color coded high-risk items on the form. The lead medical physicist conducted a detailed annual review of their treatment procedures with authorized users, medical physicists, and therapists placing emphasis on the importance of time out and on verifying planned parameters versus delivery parameters. The lead medical physicist also explained to users how the rigid guide tube and the transfer guide tube total length can differ between applicators. A risk management meeting was held to further analyze their workflow in place.

Item Number 190237 - A patient received a dose that was 87% greater than prescribed during one fraction of high dose rate afterloader treatment on 5/21/2019. The afterloader contained a 273.25 GBq (7.385 Ci) Ir-192 source. The patient was prescribed 10 fractions, two per day for five days. The prescribed dose was 625 cGy (rad) per fraction, for a total dose of 6250 cGy (rad). However, during one fraction, the patient received a dose of 1,167.3 cGy (rad). After the pretreatment setup for this fraction was completed satisfactorily, including a time out, the treatment was commenced. During the test run of the dummy source to check the clearance of each channel, the system gave an "electronic defective" error and the treatment was aborted. The physicist confirmed that no dose had been delivered. The physicist then loaded the first treatment plan in the list (which was not the correct plan for this patient), viewed the pre-treatment report, and obtained the treatment code required to start a treatment delivery. The doctor then actuated the treatment. The physicist and doctor were actively monitoring the patient via closed-circuit television when the physicist realized that he did not hear the system change to a different channel. He turned to the treatment console and recognized that all of the dwell times were in channel one and something was wrong. He interrupted the treatment and informed the doctor that the wrong treatment plan was delivered. The event occurred because no time out and no plan verification was performed after the aborted test. The patient was notified on 5/21/2019. The cancer center expects no harm to the patient. The overall treatment plan was modified to deliver a total dose of 6165 cGy (rad) over nine fractions. Several corrective actions were implemented. If there is an aborted treatment, the entire review process will be re-done to ensure there have been no changes to the patient setup or treatment plan parameters. The pretreatment report will be printed out, reviewed, and compared to the approved treatment plan. The treatment console and closed-circuit television will be monitored at all times that a patient is under care. Training will be performed to ensure the clinical team understands the updated time out and plan verification process.

Item Number 190270 - A patient received a dose to an unintended site during a remote high dose rate afterloader treatment on 6/26/2019. The patient was prescribed two fractions at 500 cGy (rad) per fraction using an afterloader containing a 127.61 GBq (3.449 Ci) Ir-192 source. During the first fraction, a vaginal cylinder was placed in the vaginal canal and the positioning was verified with a cone beam CT scan. Upon completion of the treatment, it was discovered that the vaginal cylinder was dislodged from the initial position. The cylinder was between the patient's legs, outside the vaginal canal, in contact with the perineal region. The patient indicated that she had coughed at some point during the treatment, which may have contributed to the dislodgement of the cylinder. The estimated skin dose was 500 cGy (rad). No

erythema was observed at the time of discovery. The patient and referring physician were notified. The Ohio Department of Health conducted an inspection on 7/15/2019. It was determined that the applicator was properly secured for the prescribed treatment, but was dislodged by patient coughing. To prevent future occurrences, the hospital purchased a more rigorous immobilization device for the applicator. They will also research/review and update the brachytherapy monitoring procedures and devices throughout the hospital system.

Item Number 190464 - A patient received a dose to an unintended site during remote high dose rate afterloader treatment on 9/11/2019. The patient was prescribed 550 cGy (rad) over five fractions for a total dose of 2,750 cGy (rad) to the cervix using an afterloader containing an Ir-192 source. The patient ultimately received the full intended dose to the tumor. There was no overdose to any critical structures, including bladder, rectum, and bowel. However, a small region of the surface of the right vaginal wall (approximately 1 cm) inadvertently received a total of 366 cGy (rad) during three fractions due to the wrong treatment distances being entered into the treatment planning system by the physicist for two of the seven catheters. That small region should have received negligible dose. The patient was not expected to be at an increased risk for toxicity due to the error. The patient and referring physician were immediately notified upon discovery. The Massachusetts Radiation Control Program performed an investigation.

Embryo/Fetus or Nursing Child Dose Events - AOs or Potential AOs
Doses to an embryo/fetus or nursing child are reportable per 10 CFR 35.3047. By definition, these events are not medical events (reportable per 10 CFR 35.3045) and are captured in NMED as “Other” events. However, it is appropriate to also discuss these events in this section. None of these events occurred in FY19.

2.3.3 Events Recently Added to NMED That Occurred Prior to FY19

Five MED events and no embryo/fetal dose events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. None of the MED events were considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events - AOs or Potential AOs
None

Events of Interest
Item Number 190425 - A patient received a dose to an unintended site during a gamma knife treatment for trigeminal neuralgia on 8/1/2017. The incident involved a gamma knife unit containing Co-60 sources not to exceed 511.49 TBq (13,824 Ci). The planned treatment time was 36.8 minutes with a single treatment position targeting a volume of 0.1 cc for a prescribed dose of 2,500 cGy (rad). With eight to nine minutes of treatment time remaining, the patient began to make significant movements. The patient complied when asked to hold still for the remaining treatment time. When it was subsequently noted that the patient’s head fixation frame had shifted, the treatment was stopped with 4.04 minutes remaining. The posterior pins were still in position, but the anterior pins were almost touching the skin about two inches above the original pin sites. The treatment plan could no longer be used to complete the treatment. If the frame came loose when the patient was told to hold still with eight to nine minutes of treatment time remaining, an unintended 0.1 cc target volume received approximately four to five minutes of dose or roughly 270 to 340 cGy (rad). The intended treatment site received between 2,230 and 2,160 cGy (rad). The patient’s family was informed. A second treatment plan was developed and administered to complete the treatment that same morning. This incident will be incorporated into annual training review. The gamma knife manufacturer was contacted in order to assess the possibilities for managing the frame fixation issue.

Embryo/Fetus or Nursing Child Dose Events - AOs or Potential AOs
None

2.4 Radiation Overexposure

2.4.1 Ten-Year Data

Figure 4 displays the annual number and trend of EXP events that occurred during the 10-year period. The trend analysis determined that the data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines).

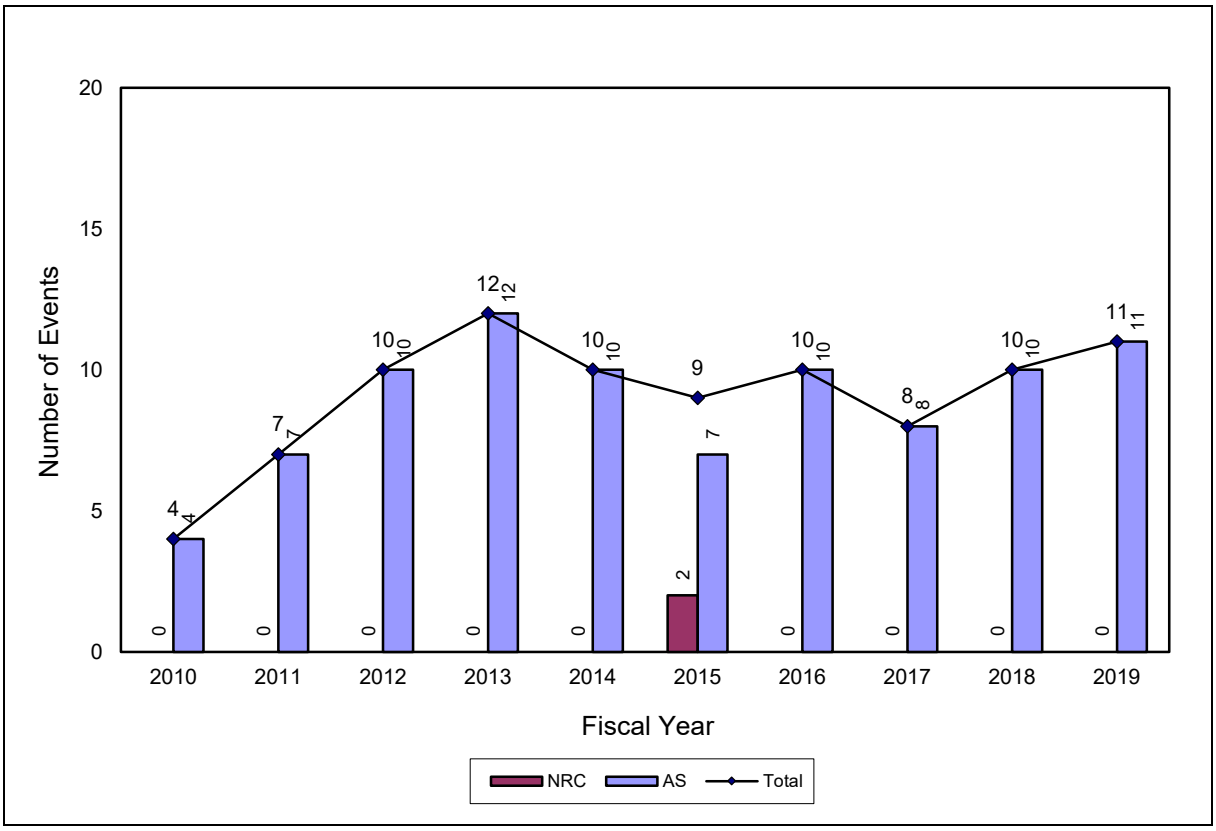

Figure 4. Radiation Overexposure Events (91 total)

The significance of individual EXP events may be determined by the CFR reporting requirement applicable to the event. For example, an event that is required to be immediately reported is typically more significant than an event with a 30-day reporting requirement. For this report, events requiring immediate or 24-hour reporting are considered significant. Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

Table 6 displays the number of events based on the different reporting requirement time categories. Note that each event is counted only once. If an event involved exposures that were reportable in more than one category, the event is counted in only the most restrictive category.

Table 6. EXP Events Classified by CFR Reporting Requirement

	Fiscal Year										
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Total**
Immediate	0	1	1	0	0	0	1	0	1	1	**5**
24-Hour	1	0	4	1	3	4	1	2	4	3	**23**
30-Day	3	6	5	11	7	5	8	6	5	7	**63**
Total	**4**	**7**	**10**	**12**	**10**	**9**	**10**	**8**	**10**	**11**	**91**

2.4.2 FY19 Data

Eleven EXP events occurred in FY19, five of which were considered significant.

Significant Events - Immediate Reporting

Item Number 190180 - A radiographer received a radiation overexposure on 4/11/2019. The radiographer, working alone in a permanent shooting room, cranked out a 2.48 TBq (67 Ci) Ir-192 source for an exposure, then failed to retract the source back into the exposure device before setting up for the next exposure. The radiographer's personal dosimeter badge was sent for emergency processing and revealed an exposure of 8.149 cSv (rem). The radiography services company calculated an extremity exposure of 39.684 cSv (rem) to the left hand and 9.338 cSv (rem) to the right hand. The radiographer was monitored by a medical physician. The Alabama Department of Public Health (ADPH) performed an investigation on 4/12/2019. The primary cause of the incident was human error. Specifically, the radiographer failed to retract the source at the end of the exposure, failed to observe the radiation actuated visible alarm, bypassed the audible alarm feature of the shooting room, and failed to observe his survey meter upon entry into the shooting room. The investigation concluded that all safety features were operating properly at the time of the incident. Corrective actions included counseling employees, modifying procedures, obtaining new equipment, and additional personnel training. The company installed an infrared beam linked with the area monitor that will activate when the exposure rate is over 2 mR/hour and the beam is broken. That infrared beam will work in conjunction with a red light, which will be lowered for easy viewing. The company will commence weekly notifications to ADPH to increase field monitoring. As of 4/17/2019, this incident had a final International Nuclear Event Scale rating level of 2. This event was classified as an EQP and EXP event.

Item Number 190200 - A radiography services company reported that three radiography exposure devices were stolen and recovered on 4/28/2019. Each device contained an Ir-192 source with activities of 1.11, 1.81, and 2.96 TBq (30, 49, and 80 Ci), respectively. The thief was an employee or former employee and threatened to use the devices. He was apprehended at his apartment later that same day. The radioactive material was secured; the sources were found in the exposure devices. The devices were returned to the storage facility. Apparently, during an FBI interview, the thief stated that he had taken the back plate off of a device and had it sitting in his lap for over an hour. He may have also handled a source. Depending on the orientation of the exposure device, there is a very real possibility that the thief received an acute radiation exposure of over 450 cSv (rem) and possibly a whole body exposure greater than that. The Arizona Department of Health Services investigated the incident. This event was classified as an EXP and LAS event, as well as a potential Abnormal Occurrence.

Significant Events - Within 24-Hour Reporting

Item Number 180480 - A radiation overexposure event occurred during radiography at a refinery on 10/22/2018. The radiography exposure device contained a 1.27 TBq (34.3 Ci) Ir-192 source. Two radiographers' (a carded instructor and a carded radiographer) pocket ion chambers went off-scale while moving the source guide tube. An additional complete revolution of the crank moved the source into the shielded position. Dose reconstruction indicated 743 mR whole body exposure to one radiographer. The

second radiographer received 294 mR whole body exposure and 0.51 Sv (51 rem) extremity exposure to the hands. Body badges were sent in for immediate processing. Following an extensive reenactment and dose calculations, it appears that the second radiographer did indeed receive an extremity radiation exposure of 0.51 mSv (51 rem). The radiographers did not follow company radiation safety procedures or general health and safety principles while using radioactive material. They did not perform a proper post exposure survey. They ignored a crimped source guide tube that did not allow the source to retract into the exposure device. They ignored that the locking mechanism was red and not green. The instructor was unaware of how to use a go/no-go gauge/tool on the controls and pigtail. The work had been performed in a poorly lit, high/excessive noise area, and the audible alarming equipment could not be heard or read. The source was secured and surveyed properly when the assistant RSO arrived at the jobsite. Corrective actions included a safety stand-down and retraining for all radiographers on procedures and the use of safety equipment. The radiography services company increased the frequency of internal audits, removed the individuals from radiation work areas, and retrained them on operations of equipment and survey techniques. The radiographer's employment was terminated, but the carded instructor remained employed. This event was classified as an EQP and EXP event.

Item Number 190164 - A radioactive source manufacturer reported a possible internal radiation overexposure of three individuals. On 4/1/2019, an individual was trying to clean up a small area of rusty contamination using a HEPA filtered vacuum. The vacuum was previously used in a different area to clean up Am-241 metal. The individual turned on the vacuum and felt blow back. He turned off the vacuum and told a second individual to shut the doors. After shutting the doors, the second individual left the room. The first individual was in the room for approximately 20 minutes. The second individual and the RSO were in the room for about one minute. A nose swab was performed on the first individual, which revealed 66,000 dpm. After his clothing was removed, he took a shower, blew his nose, and then follow-up swabs were performed. Results revealed 4,884 dpm from the right nostril and 1,729 dpm from the left nostril. A third set of swabs were performed on day two and results revealed 67 dpm from the right nostril and 36 dpm from the left nostril. The RSO contacted REAC/TS, who suggested that the first and second individuals see their medical doctors. Bioassay samples were collected and sent out for processing on 4/3/2019. Inhalation estimates for the three individuals were 2.7, 1.11, and 0.088 kBq (73.1, 29.9, and 2.38 nCi). Those intakes resulted in whole body exposures of approximately 0.128, 0.052, and 0.0042 Sv (12.8, 5.2, and 0.42 rem), respectively. The committed bone doses to the individuals were estimated to be 2.99, 1.22, and 0.97 Sv (299, 122, and 9.7 rem). The root cause was the failure of the HEPA vacuum, inadequate procedures, and poor emergency training. The use of the vacuum in the affected area was not a routine practice and should not have been performed. As of 9/25/2019, this incident had a final International Nuclear Event Scale rating level of 2. This event was classified as an EQP, EXP, and RLM event, as well as a potential Abnormal Occurrence.

Item Number 190302 - A radiographer received a radiation overexposure at a job site in Herscher, Illinois, on 7/11/2019. The radiographer failed to retract a 3.256 TBq (88 Ci) Ir-192 source into the exposure device before walking out to exchange film between shots. The radiographer's direct reading dosimeter (0 to 200 mR) was off-scale. The corporate RSO estimated that the radiographer worked for two minutes at one foot from the source. The Illinois Emergency Management Agency (IEMA) interviewed the site RSO and both members of the radiography team on 7/12/2019. Initial exposure estimates revealed 15 cSv (rem) to the radiographer's whole body. However, it was determined that a tungsten collimator (5 HVL) had been used. A partial reenactment indicated that the collimator was facing towards the radiographer, with the source opening facing away. The radiographer stated that he was wearing an alarming rate meter, but did not hear an alarm. He further stated that he was not looking at his survey meter. He estimated that the total time to walk up to the exposed source, replace the film, and reposition the collimator was 45 seconds. His whole body dosimeter revealed 9.38 mSv (938 mrem). The radiographer's extremities were monitored for swelling/reddening from exposure. IEMA performed a full reenactment on 7/15/2019. IEMA recorded reenactments performed by the radiographer and compiled time and proximity estimates. The radiographer's hand was located six inches from the side of

the source shielded by the collimator for 20 seconds. It is believed that the radiographer then picked up (in his palm) the collimator for repositioning, which resulted in 20 seconds of exposure to direct contact with the collimator and two seconds of exposure to the unshielded source at 0.5 inches, while the film was replaced. IEMA calculations place the exposure to the radiographer's right hand at approximately 155.6 cSv (rem). Whole body exposure calculations revealed approximately 900 mSv (mrem) and agreed with the individual's dosimeter result. A second exposure scenario was discussed as a possibility, but cannot be confirmed. The alarming rate meter was immediately tested after the incident and found to be operational. The alarming rate meter, direct reading dosimeter, and survey meter were sent to the corporate RSO for investigation. That equipment was also determined to be operational. IEMA confirmed that there were no abnormalities in the radiographer's bloodwork, which agrees with exposure estimates to date. Corrective actions included providing additional training to personnel. This event was classified as an EQP and EXP event.

Events of Interest

Item Number 180456 - A member of the public was exposed to an unshielded Cs-137 source after a moisture/density gauge was damaged at a construction site in Omaha, Nebraska, on 10/3/2018. The gauge contained a 1.63 GBq (44 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source. While the authorized user (AU) was performing a measurement with the Cs-137 source rod extended, a skid loader backed over the gauge. The AU was able to dive out of the way. The AU then tried to get the operator of the skid loader to stop, but the loader operator continued without acknowledgement. The construction project supervisor was informed of the accident, but was not interested in stopping work for the damaged gauge and told the AU to get the gauge and leave. A construction worker (member of the public) picked up the damaged gauge (with the source rod extended) and threw it to an area outside the work location. The worker later stated that he did not throw the gauge, but carried it. That worker's whole body exposure was estimated to be 5.711 mSv (571.1 mrem), assuming that he carried the gauge at 1 cm from the trunk of his body for one minute. The AU contacted his RSO, who responded to the work site. The Nebraska Department of Health and Human Services (NDHHS) was notified and dispatched personnel to the site. The AU maintained surveillance of the gauge and informed personnel to stay away from the gauge location. When the RSO arrived, radiation surveys were performed, which showed approximately 0.5 mR/hour in the area and 10 mR/hour near the extended Cs-137 rod. The source was stuck into the ground to provide shielding. Calculations indicated that the exposure rate at the 15-foot exclusion boundary would have been 40 µR/hour. When NDHHS arrived at the site, a confirmatory radiation survey of the gauge was completed with a result of 10.5 mR/hour. Part of the trigger mechanism was broken and sheared off. A wipe test was performed on the source rod and revealed negative results. The gauge was then manipulated to place the Cs-137 source rod assembly back into the shielded position. After an unsuccessful attempt, the sliding spring lock was still open and radiation results were 385 mR/hour on contact with the port hole. The RSO was able to clean off the excess mud and dirt on the port hole using nip tongs and the sliding spring lock was shut. Another wipe test revealed negative results. A radiation survey of the gauge measured 20.8 mR/hour and confirmed that the Cs-137 source was in the shielded position. The RSO placed the gauge back into its shipping container and applied duct tape to prevent any movement of the source rod from the shielded position. A radiation survey of the transport container revealed 8.9 mR/hour on contact and 0.4 mR/hour at three feet. The Transportation Index of the container was labeled as 0.6 mR/hour. On 10/12/2018, NDHHS met at the incident site with the involved parties to perform a dose reconstruction. Using props and taking measurements of the location of the source in relation to the worker who carried the gauge, the highest exposure calculation was less than 0.01 mSv (1 mrem) to his gonads. NDHHS did not assign blame to the AU. The annual safety training will discuss job site awareness. AUs will ensure that equipment operators are aware of their presence, both visually and verbally. The gauge was repaired and returned to service. This event was classified as an EQP and EXP event personnel.

Item Number 190267 - A polyester manufacturer reported that 22 workers (members of the public) received radiation exposures while cleaning vats in March and April 2019. Seven of those individuals

received exposures exceeding 1 mSv (100 mrem). The vats had Cs-137 fixed nuclear gauges with shutters in the open position. The level density gauge contained an 11.1 GBq (300 mCi) source and the filling dip tubes contained 0.74 GBq (20 mCi) sources. Radiation exposures were estimated based on each individual's time in the vessels and distance from the sources. The midpoint exposure estimate for the seven individuals ranged from 1.12 to 1.05 mSv (112 to 205 mrem). The South Carolina Department of Health and Environmental Control (SCDHEC) conducted a site visit on 6/14/2019. Based on the 30-day notification provided to SCDHEC on 6/26/2019, it is unknown if the individuals were notified. The cause was the failure to lock out/tag out the nuclear gauges prior to allowing individuals to work inside the vats. Corrective actions included reviewing and updating the lock out/tag out procedure, the permit required confined space entry procedure, all department procedures related to radiation sources, and retraining of all personnel.

2.4.3 Events Recently Added to NMED That Occurred Prior to FY19

One EXP event was recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. This event was considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events - Immediate Reporting
None

Significant Events - Within 24-Hour Reporting
Item Number 180115 - A radiopharmaceutical manufacturer reported that an employee received an extremity overexposure. The employee's exposure record for 2/26 to 3/4/2018 indicated an acute exposure of 68.8 cGy (rad) to the right hand and 2.9 cGy (rad) to the left hand. The RSO determined that the exposure resulted from F-18 contamination on the employee’s glove. The Florida Bureau of Radiation Control investigated the incident on 3/21/2018. They confirmed that the exposure was caused by the contamination on the employee's glove. It was also noted that the frisker volume was turned down and the frisker was located too close to the source, making it difficult to detect contamination on hands. The employee was restricted from further occupational radiation exposure. The frisker was relocated further away from the licensed source.

Events of Interest
None

2.5 Release of Licensed Material or Contamination

2.5.1 Ten-Year Data

Figure 5 displays the annual number and trend of RLM events that occurred during the 10-year period. The trend analysis determined that the Total and NRC-regulated events represent statistically significant decreasing trends (indicated by the trend lines). However, the Agreement State-regulated events do not represent a statistically significant trend (indicated by the absence of a trend line).

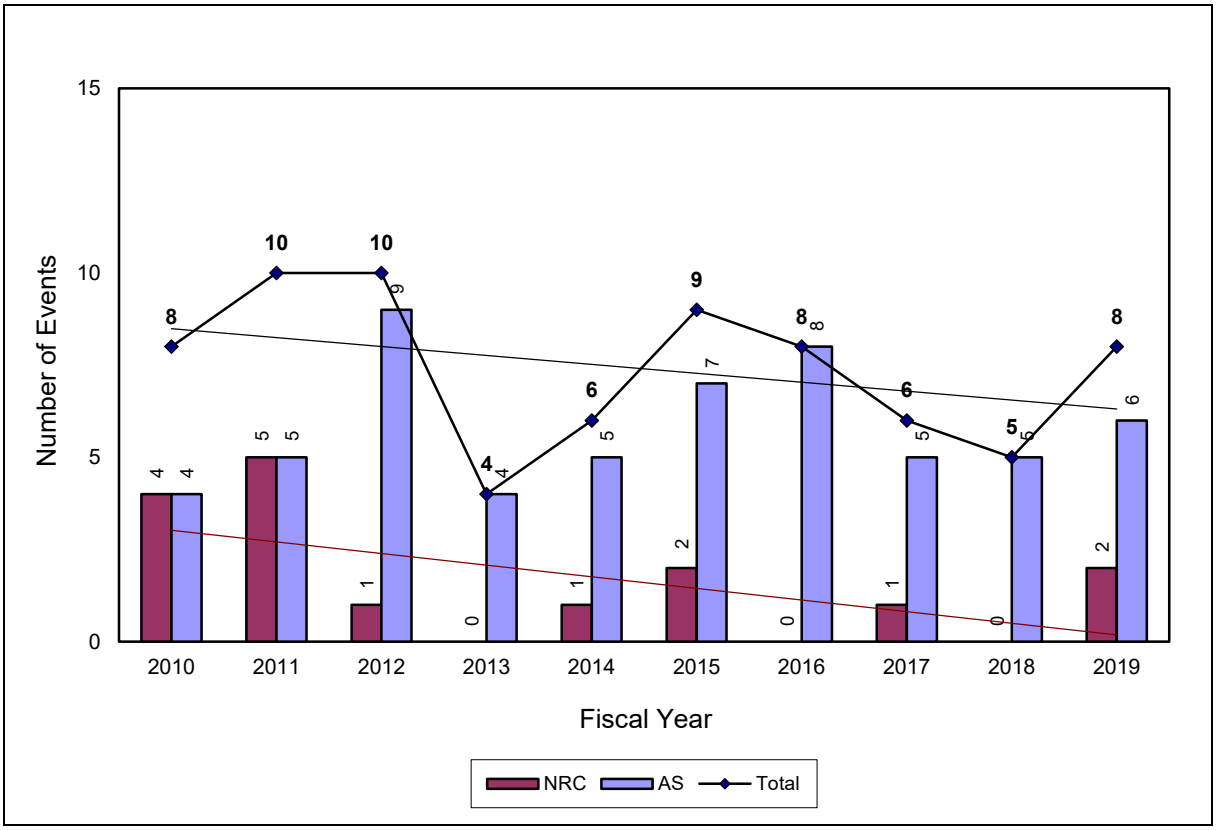

Figure 5. Release of Licensed Material or Contamination Events (74 total)

The significance of individual RLM events may be determined by the CFR reporting requirement applicable to the event. For example, an event that is required to be immediately reported is typically more significant than an event with a 30-day reporting requirement. For this report, events requiring immediate reporting are considered significant. Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

Table 7 displays the number of events based on the different reporting requirement time categories. Note that each event is counted only once. If an event involved exposures that were reportable in more than one category, the event is counted in only the most restrictive category.

Table 7. RLM Events Classified by CFR Reporting Requirement

	Fiscal Year										
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Total**
Immediate	2	0	2	1	1	0	1	3	1	1	**12**
24-Hour	4	9	6	2	3	9	7	3	4	6	**53**
30-Day	2	1	2	1	2	0	0	0	0	1	**9**
Total	**8**	**10**	**10**	**4**	**6**	**9**	**8**	**6**	**5**	**8**	**74**

2.5.2 FY19 Data

Eight RLM events occurred in FY19, one of which was considered significant.

Significant Events - Immediate Reporting

Item Number 190164 - A radioactive source manufacturer reported a possible internal radiation overexposure of three individuals. On 4/1/2019, an individual was trying to clean up a small area of rusty contamination using a HEPA filtered vacuum. The vacuum was previously used in a different area to clean up Am-241 metal. The individual turned on the vacuum and felt blow back. He turned off the vacuum and told a second individual to shut the doors. After shutting the doors, the second individual left the room. The first individual was in the room for approximately 20 minutes. The second individual and the RSO were in the room for about one minute. A nose swab was performed on the first individual, which revealed 66,000 dpm. After his clothing was removed, he took a shower, blew his nose, and then follow-up swabs were performed. Results revealed 4,884 dpm from the right nostril and 1,729 dpm from the left nostril. A third set of swabs were performed on day two and results revealed 67 dpm from the right nostril and 36 dpm from the left nostril. The RSO contacted REAC/TS, who suggested that the first and second individuals see their medical doctors. Bioassay samples were collected and sent out for processing on 4/3/2019. Inhalation estimates for the three individuals were 2.7, 1.11, and 0.088 kBq (73.1, 29.9, and 2.38 nCi). Those intakes resulted in whole body exposures of approximately 0.128, 0.052, and 0.0042 Sv (12.8, 5.2, and 0.42 rem), respectively. The committed bone doses to the individuals were estimated to be 2.99, 1.22, and 0.97 Sv (299, 122, and 9.7 rem). The root cause was the failure of the HEPA vacuum, inadequate procedures, and poor emergency training. The use of the vacuum in the affected area was not a routine practice and should not have been performed. As of 9/25/2019, this incident had a final International Nuclear Event Scale rating level of 2. This event was classified as an EQP, EXP, and RLM event, as well as a potential Abnormal Occurrence.

Events of Interest

Item Number 190204 - A 103.6 TBq (2,800 Ci) Cs-137 source was breached on 5/2/2019, causing widespread contamination and a possible uptake event. A university had contracted with a radioactive source service company to dispose of their research irradiator. The contractor was removing the irradiator source in a mobile hot cell on a loading dock. When the source tube could not be unthreaded from the housing, small cuts were made in the housing. When the source was eventually removed from the source tube, a visual inspection noted a cut in the source wall. The source had been breached and contamination was inadvertently spread inside the building. The contractor encapsulated the breached source and placed it in the source drawer, which was then placed in a transfer cask. The Seattle Police Department and Seattle Fire Department Hazardous Materials team were notified. The university RSO contacted his staff for assistance and notified the Washington State Department of Health. The majority of surveys taken at the loading dock level indicated that surfaces were contaminated between 50,000 and 300,000 cpm. A total of 18 individuals were evaluated for exposure to radioactive material. Contamination was found on 13 individuals, 10 of whom were decontaminated on site. The highest exposed individual had urine bioassay sample results of 99.9 Bq/L (2,700 pCi/L), which resulted in an internal exposure of 0.1 mSv (10

mrem). The highest contamination in the building was between 35,000 and 875,000 dpm/100 cm^2 near the double doors leading to the loading dock. Contamination levels decreased down the hallway on either side. Low levels of contamination were found on multiple floors of the building. Radioactive contamination was found in the ventilation exhaust ducting that serves the loading dock. That prompted development of an offsite sample plan. On 5/29/2019, an environmental contractor submitted a final status survey for most areas on floors three through seven. The north loading dock where the work was performed had not been entered or assessed. A detailed plan for entering that area was under development. Decontamination and release efforts were divided into three distinct phases. Different contractors are or will be working on each phase. The Department of Energy is coordinating the facility decontamination. This event was classified as an EQP, LKS, and RLM event.

2.5.3 Events Recently Added to NMED That Occurred Prior to FY19

One RLM event was recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. This event was not considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events - Immediate Reporting
None

Events of Interest
None

2.6 Leaking Sealed Sources

2.6.1 Ten-Year Data

Figure 6 displays the annual number and trend of LKS events that occurred during the 10-year period. The trend analysis determined that the data do not represent statistically significant trends (indicated by the absence of trend lines).

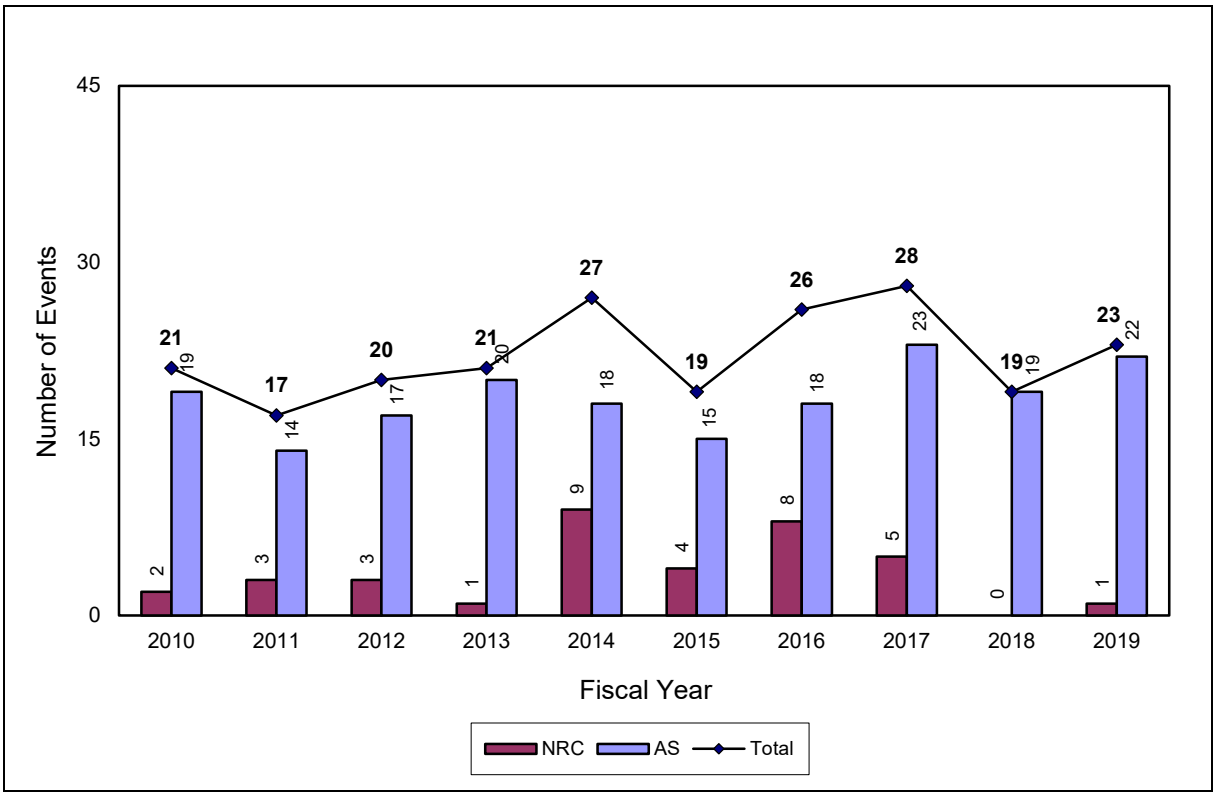

Figure 6. Leaking Sealed Source Events (221 total)

It is not possible to discern the significance of LKS events strictly from the CFR reporting requirements (as in Sections 2.4 and 2.5). There are essentially no immediate or 24-hour reporting requirements for leaking sources. The exception is 39.77(a), which is an immediate report to the NRC Regional office of a ruptured well logging source. Therefore, event significance will be determined on an event-by-event basis based on the severity of the event (e.g., significant exposure to workers, members of the public, and/or the environment). Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.6.2 FY19 Data

Twenty-three LKS events occurred in FY19, one of which was considered significant.

Significant Events

Item Number 190204 - A 103.6 TBq (2,800 Ci) Cs-137 source was breached on 5/2/2019, causing widespread contamination and a possible uptake event. A university had contracted with a radioactive source service company to dispose of their research irradiator. The contractor was removing the irradiator source in a mobile hot cell on a loading dock. When the source tube could not be unthreaded from the housing, small cuts were made in the housing. When the source was eventually removed from the source tube, a visual inspection noted a cut in the source wall. The source had been breached and contamination was inadvertently spread inside the building. The contractor encapsulated the breached source and placed it in the source drawer, which was then placed in a transfer cask. The Seattle Police Department and

Seattle Fire Department Hazardous Materials team were notified. The university RSO contacted his staff for assistance and notified the Washington State Department of Health. The majority of surveys taken at the loading dock level indicated that surfaces were contaminated between 50,000 and 300,000 cpm. A total of 18 individuals were evaluated for exposure to radioactive material. Contamination was found on 13 individuals, 10 of whom were decontaminated on site. The highest exposed individual had urine bioassay sample results of 99.9 Bq/L (2,700 pCi/L), which resulted in an internal exposure of 0.1 mSv (10 mrem). The highest contamination in the building was between 35,000 and 875,000 dpm/100 cm^2 near the double doors leading to the loading dock. Contamination levels decreased down the hallway on either side. Low levels of contamination were found on multiple floors of the building. Radioactive contamination was found in the ventilation exhaust ducting that serves the loading dock. That prompted development of an offsite sample plan. On 5/29/2019, an environmental contractor submitted a final status survey for most areas on floors three through seven. The north loading dock where the work was performed had not been entered or assessed. A detailed plan for entering that area was under development. Decontamination and release efforts were divided into three distinct phases. Different contractors are or will be working on each phase. The Department of Energy is coordinating the facility decontamination. This event was classified as an EQP, LKS, and RLM event.

Events of Interest
None

2.6.3 Events Recently Added to NMED That Occurred Prior to FY19

Six LKS event was recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. None of these events were considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events
None

Events of Interest
None

2.7 Equipment

2.7.1 Ten-Year Data

Figure 7 displays the annual number and trend of EQP events that occurred during the 10-year period. The trend analysis determined that the data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines).

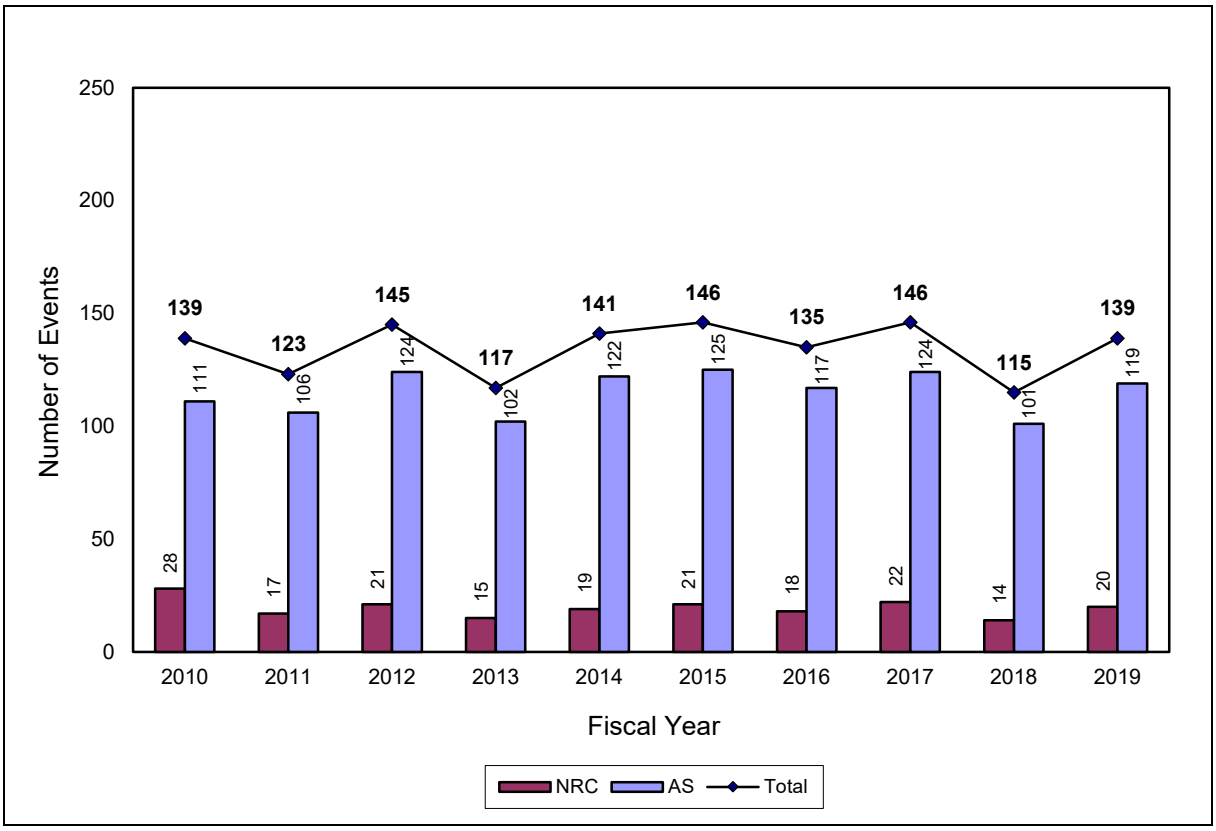

Figure 7. Equipment Events (1,346 total)

It is not possible to discern the significance of EQP events strictly from the CFR reporting requirements (as in Sections 2.4 and 2.5) because essentially all of the CFRs associated with EQP events require reporting within 24-hours. Therefore, event significance will be determined on an event-by-event basis based on the severity of the event (e.g., significant exposure to workers, members of the public, and/or the environment). Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.7.2 FY19 Data

One hundred thirty-nine EQP events occurred in FY19, seven of which were considered significant.

Significant Events

Item Number 180463 - A panoramic irradiator source rack became stuck in the up/exposed position on 10/14/2018. The irradiator contained 88,800 TBq (2,400,000 Ci) of Co-60 sources. An alarm of the source positioning indicators alerted operators of a moving source. When the source rack failed to reach the down position in the allotted time period, a fault was recorded at the control panel. The RSO was contacted, responded to the site, and placed a call to the manufacturer for assistance. Before the manufacturer returned the call, the RSO successfully lowered source rack #2 to the shielded position, but was unable to lower source rack #1 to the shielded position. The RSO believed that the guide cable for source rack #1 had broken. After about 3.5 hours of the sources being stuck in the up position, the rack

deluge system (sprinklers above the sources) was deployed as a precautionary step to cool the sources and product close to the sources. When the manufacturer returned the phone call, it was verified that the guide cable had broken. The manufacturer directed the operators to raise source rack #2 then lower source rack #1. After two attempts, they successfully lowered source rack #1. The operators then lowered source rack #2. The overall time that the sources were in the up position was approximately five hours. The manufacturer arrived at the irradiator facility on 10/16/2018 and replaced the broken guide cable. They also replaced the other three guide cables as a precautionary measure. It was determined that the cable broke in the interior of the rack channel where there is no opportunity for wear from a static rack bushing. The irradiation company believes that the cables broke from fatigue. There is a visual cable check on the monthly maintenance checklist, but there was no evidence of cable wear. The company established a 10-year replacement schedule for the guide cables. The manufacturer took the cables for further investigation. Nobody entered the vault while the sources were in the up position and no radiation exposure to workers occurred.

Item Number 180480 - A radiation overexposure event occurred during radiography at a refinery on 10/22/2018. The radiography exposure device contained a 1.27 TBq (34.3 Ci) Ir-192 source. Two radiographers' (a carded instructor and a carded radiographer) pocket ion chambers went off-scale while moving the source guide tube. An additional complete revolution of the crank moved the source into the shielded position. Dose reconstruction indicated 743 mR whole body exposure to one radiographer. The second radiographer received 294 mR whole body exposure and 0.51 Sv (51 rem) extremity exposure to the hands. Body badges were sent in for immediate processing. Following an extensive reenactment and dose calculations, it appears that the second radiographer did indeed receive an extremity radiation exposure of 0.51 mSv (51 rem). The radiographers did not follow company radiation safety procedures or general health and safety principles while using radioactive material. They did not perform a proper post exposure survey. They ignored a crimped source guide tube that did not allow the source to retract into the exposure device. They ignored that the locking mechanism was red and not green. The instructor was unaware of how to use a go/no-go gauge/tool on the controls and pigtail. The work had been performed in a poorly lit, high/excessive noise area, and the audible alarming equipment could not be heard or read. The source was secured and surveyed properly when the assistant RSO arrived at the jobsite. Corrective actions included a safety stand-down and retraining for all radiographers on procedures and the use of safety equipment. The radiography services company increased the frequency of internal audits, removed the individuals from radiation work areas, and retrained them on operations of equipment and survey techniques. The radiographer's employment was terminated, but the carded instructor remained employed. This event was classified as an EQP and EXP event.

Item Number 190004 - A hospital reported that a strontium breakthrough occurred on an Rb-82 generator, resulting in levels of Sr-82/Sr-85 exceeding the manufacturer's specified limits. The hospital failed to identify the strontium breakthrough and doses were subsequently administered to eight patients from 12/15/2018 to 12/17/2018. The hospital discovered the breakthrough on 12/17/2018. The manufacturer's protocol recommends that each Rb-82 injection (stress and/or rest) be within a range of 1.11-2.22 GBq (30-60 mCi). The eight patients were administered the following: Rb-82 from 2.23 to 3.33 GBq (60.4 to 90 mCi), Sr-82 from 37.96 to 75.18 MBq (1.026 to 2.032 mCi), and Sr-85 from 25.72 to 49.17 MBq (0.695 to 1.329 mCi). The calculated doses were 100.7 to 256.9 cGy (rad) to the red marrow, 117.12 to 299.36 cGy (rad) to the bone surface, and 27.02 to 68.4 cGy (rad) effective dose. The patients were followed for 10 weeks, which determined that none of them exhibited indications of bone marrow suppression. The hospital contacted the Colorado Department of Public Health and Environment (CDPHE) and the manufacturer. The manufacturer suggested looking for evidence that lactated ringers may have been used to elute the generator. CDPHE performed an onsite investigation on 12/21/2018. The investigation identified two primary failures leading to the event. The first was human error in the inadvertent use of lactated ringers to elute the Rb-82 generator. The second was inadequate practices in conducting the strontium breakthrough analyses. Corrective actions taken by the hospital included immediately stopping the Rb-82 generator program. If the medical center restarts the program, they

committed to utilizing an automated medication dispensing system to store the normal saline, with a required scanning of the medication prior to each patient administration. Additionally, they will perform daily audits of the IV fluid, modify their forms, obtain new equipment, and train personnel. This event was classified as an EQP and MED event.

Item Number 190164 - A radioactive source manufacturer reported a possible internal radiation overexposure of three individuals. On 4/1/2019, an individual was trying to clean up a small area of rusty contamination using a HEPA filtered vacuum. The vacuum was previously used in a different area to clean up Am-241 metal. The individual turned on the vacuum and felt blow back. He turned off the vacuum and told a second individual to shut the doors. After shutting the doors, the second individual left the room. The first individual was in the room for approximately 20 minutes. The second individual and the RSO were in the room for about one minute. A nose swab was performed on the first individual, which revealed 66,000 dpm. After his clothing was removed, he took a shower, blew his nose, and then follow-up swabs were performed. Results revealed 4,884 dpm from the right nostril and 1,729 dpm from the left nostril. A third set of swabs were performed on day two and results revealed 67 dpm from the right nostril and 36 dpm from the left nostril. The RSO contacted REAC/TS, who suggested that the first and second individuals see their medical doctors. Bioassay samples were collected and sent out for processing on 4/3/2019. Inhalation estimates for the three individuals were 2.7, 1.11, and 0.088 kBq (73.1, 29.9, and 2.38 nCi). Those intakes resulted in whole body exposures of approximately 0.128, 0.052, and 0.0042 Sv (12.8, 5.2, and 0.42 rem), respectively. The committed bone doses to the individuals were estimated to be 2.99, 1.22, and 0.97 Sv (299, 122, and 9.7 rem). The root cause was the failure of the HEPA vacuum, inadequate procedures, and poor emergency training. The use of the vacuum in the affected area was not a routine practice and should not have been performed. As of 9/25/2019, this incident had a final International Nuclear Event Scale rating level of 2. This event was classified as an EQP, EXP, and RLM event, as well as a potential Abnormal Occurrence.

Item Number 190180 - A radiographer received a radiation overexposure on 4/11/2019. The radiographer, working alone in a permanent shooting room, cranked out a 2.48 TBq (67 Ci) Ir-192 source for an exposure, then failed to retract the source back into the exposure device before setting up for the next exposure. The radiographer's personal dosimeter badge was sent for emergency processing and revealed an exposure of 8.149 cSv (rem). The radiography services company calculated an extremity exposure of 39.684 cSv (rem) to the left hand and 9.338 cSv (rem) to the right hand. The radiographer was monitored by a medical physician. The Alabama Department of Public Health (ADPH) performed an investigation on 4/12/2019. The primary cause of the incident was human error. Specifically, the radiographer failed to retract the source at the end of the exposure, failed to observe the radiation actuated visible alarm, bypassed the audible alarm feature of the shooting room, and failed to observe his survey meter upon entry into the shooting room. The investigation concluded that all safety features were operating properly at the time of the incident. Corrective actions included counseling employees, modifying procedures, obtaining new equipment, and additional personnel training. The company installed an infrared beam linked with the area monitor that will activate when the exposure rate is over 2 mR/hour and the beam is broken. That infrared beam will work in conjunction with a red light, which will be lowered for easy viewing. The company will commence weekly notifications to ADPH to increase field monitoring. As of 4/17/2019, this incident had a final International Nuclear Event Scale rating level of 2. This event was classified as an EQP and EXP event.

Item Number 190204 - A 103.6 TBq (2,800 Ci) Cs-137 source was breached on 5/2/2019, causing widespread contamination and a possible uptake event. A university had contracted with a radioactive source service company to dispose of their research irradiator. The contractor was removing the irradiator source in a mobile hot cell on a loading dock. When the source tube could not be unthreaded from the housing, small cuts were made in the housing. When the source was eventually removed from the source tube, a visual inspection noted a cut in the source wall. The source had been breached and contamination was inadvertently spread inside the building. The contractor encapsulated the breached source and placed

it in the source drawer, which was then placed in a transfer cask. The Seattle Police Department and Seattle Fire Department Hazardous Materials team were notified. The university RSO contacted his staff for assistance and notified the Washington State Department of Health. The majority of surveys taken at the loading dock level indicated that surfaces were contaminated between 50,000 and 300,000 cpm. A total of 18 individuals were evaluated for exposure to radioactive material. Contamination was found on 13 individuals, 10 of whom were decontaminated on site. The highest exposed individual had urine bioassay sample results of 99.9 Bq/L (2,700 pCi/L), which resulted in an internal exposure of 0.1 mSv (10 mrem). The highest contamination in the building was between 35,000 and 875,000 dpm/100 cm^2 near the double doors leading to the loading dock. Contamination levels decreased down the hallway on either side. Low levels of contamination were found on multiple floors of the building. Radioactive contamination was found in the ventilation exhaust ducting that serves the loading dock. That prompted development of an offsite sample plan. On 5/29/2019, an environmental contractor submitted a final status survey for most areas on floors three through seven. The north loading dock where the work was performed had not been entered or assessed. A detailed plan for entering that area was under development. Decontamination and release efforts were divided into three distinct phases. Different contractors are or will be working on each phase. The Department of Energy is coordinating the facility decontamination. This event was classified as an EQP, LKS, and RLM event.

Item Number 190302 - A radiographer received a radiation overexposure at a job site in Herscher, Illinois, on 7/11/2019. The radiographer failed to retract a 3.256 TBq (88 Ci) Ir-192 source into the exposure device before walking out to exchange film between shots. The radiographer's direct reading dosimeter (0 to 200 mR) was off-scale. The corporate RSO estimated that the radiographer worked for two minutes at one foot from the source. The Illinois Emergency Management Agency (IEMA) interviewed the site RSO and both members of the radiography team on 7/12/2019. Initial exposure estimates revealed 15 cSv (rem) to the radiographer's whole body. However, it was determined that a tungsten collimator (5 HVL) had been used. A partial reenactment indicated that the collimator was facing towards the radiographer, with the source opening facing away. The radiographer stated that he was wearing an alarming rate meter, but did not hear an alarm. He further stated that he was not looking at his survey meter. He estimated that the total time to walk up to the exposed source, replace the film, and reposition the collimator was 45 seconds. His whole body dosimeter revealed 9.38 mSv (938 mrem). The radiographer's extremities were monitored for swelling/reddening from exposure. IEMA performed a full reenactment on 7/15/2019. IEMA recorded reenactments performed by the radiographer and compiled time and proximity estimates. The radiographer's hand was located six inches from the side of the source shielded by the collimator for 20 seconds. It is believed that the radiographer then picked up (in his palm) the collimator for repositioning, which resulted in 20 seconds of exposure to direct contact with the collimator and two seconds of exposure to the unshielded source at 0.5 inches, while the film was replaced. IEMA calculations place the exposure to the radiographer's right hand at approximately 155.6 cSv (rem). Whole body exposure calculations revealed approximately 900 mSv (mrem) and agreed with the individual's dosimeter result. A second exposure scenario was discussed as a possibility, but cannot be confirmed. The alarming rate meter was immediately tested after the incident and found to be operational. The alarming rate meter, direct reading dosimeter, and survey meter were sent to the corporate RSO for investigation. That equipment was also determined to be operational. IEMA confirmed that there were no abnormalities in the radiographer's bloodwork, which agrees with exposure estimates to date. Corrective actions included providing additional training to personnel. This event was classified as an EQP and EXP event.

Events of Interest

Item Number 180456 - A member of the public was exposed to an unshielded Cs-137 source after a moisture/density gauge was damaged at a construction site in Omaha, Nebraska, on 10/3/2018. The gauge contained a 1.63 GBq (44 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source. While the authorized user (AU) was performing a measurement with the Cs-137 source rod extended, a skid loader backed over the gauge. The AU was able to dive out of the way. The AU then tried to get the operator of

the skid loader to stop, but the loader operator continued without acknowledgement. The construction project supervisor was informed of the accident, but was not interested in stopping work for the damaged gauge and told the AU to get the gauge and leave. A construction worker (member of the public) picked up the damaged gauge (with the source rod extended) and threw it to an area outside the work location. The worker later stated that he did not throw the gauge, but carried it. That worker's whole body exposure was estimated to be 5.711 mSv (571.1 mrem), assuming that he carried the gauge at 1 cm from the trunk of his body for one minute. The AU contacted his RSO, who responded to the work site. The Nebraska Department of Health and Human Services (NDHHS) was notified and dispatched personnel to the site. The AU maintained surveillance of the gauge and informed personnel to stay away from the gauge location. When the RSO arrived, radiation surveys were performed, which showed approximately 0.5 mR/hour in the area and 10 mR/hour near the extended Cs-137 rod. The source was stuck into the ground to provide shielding. Calculations indicated that the exposure rate at the 15-foot exclusion boundary would have been 40 μR/hour. When NDHHS arrived at the site, a confirmatory radiation survey of the gauge was completed with a result of 10.5 mR/hour. Part of the trigger mechanism was broken and sheared off. A wipe test was performed on the source rod and revealed negative results. The gauge was then manipulated to place the Cs-137 source rod assembly back into the shielded position. After an unsuccessful attempt, the sliding spring lock was still open and radiation results were 385 mR/hour on contact with the port hole. The RSO was able to clean off the excess mud and dirt on the port hole using nip tongs and the sliding spring lock was shut. Another wipe test revealed negative results. A radiation survey of the gauge measured 20.8 mR/hour and confirmed that the Cs-137 source was in the shielded position. The RSO placed the gauge back into its shipping container and applied duct tape to prevent any movement of the source rod from the shielded position. A radiation survey of the transport container revealed 8.9 mR/hour on contact and 0.4 mR/hour at three feet. The Transportation Index of the container was labeled as 0.6 mR/hour. On 10/12/2018, NDHHS met at the incident site with the involved parties to perform a dose reconstruction. Using props and taking measurements of the location of the source in relation to the worker who carried the gauge, the highest exposure calculation was less than 0.01 mSv (1 mrem) to his gonads. NDHHS did not assign blame to the AU. The annual safety training will discuss job site awareness. AUs will ensure that equipment operators are aware of their presence, both visually and verbally. The gauge was repaired and returned to service. This event was classified as an EQP and EXP event personnel.

Item Number 180509 - Radiographers were exposed to a 3.55 TBq (96 Ci) Ir-192 source on 11/9/2018. After changing film between exposures, the radiography crew went to expose the source and realized that the source was still in the collimated position. The crew retracted the source into the radiography exposure device and checked their pocket dosimeters, which were off-scale. The survey meter was found to be in the off position. The dosimeters were sent for emergency processing. The radiographers were removed from the work site until further notice. Dosimetry results revealed that one dosimeter received 9.98 mSv (998 mrem) and the other dosimeter received 3.7 mSv (370 mrem). The Colorado Department of Health investigated the incident. The cause of the event was determined to be human error. Corrective actions included providing additional training to personnel.

Item Number 180512 - A dry storage panoramic irradiator Co-60 source rack failed to fully retract on 11/9/2018, leaving the source partially exposed. The RSO activated the radiation monitor remotely and confirmed elevated radiation readings. He raised the source rack and was then able to lower to its full down/safe position. The RSO stated that at no time were any workers exposed or potentially exposed to radiation, since there was no access to the vault. All other irradiator systems worked properly. The company is conducting a root cause investigation. This is the first of four similar events for this licensee within a year (Item Numbers 180512, 190171, 190195, and 190433).

Item Number 180523 - A chemical company reported that a fixed nuclear gauge source withdrawal cable broke, causing the Cs-137 source to fall and be damaged such that it could not go back into the vessel on 10/12/2018. The age of the cable was a factor in the failure. The gauge contained six sources ranging in

activity from 0.37 to 7.4 GBq (10 to 200 mCi), for a total activity of 74 GBq (2 Ci). Three individuals potentially received from 0.42 to 0.85 mSv (42 to 85 mrem). The total time spent in the vessel was 15 to 30 minutes. The source was taken out of service and returned to the manufacturer. Corrective actions included a new quality management plan.

Item Number 190124 - A moisture/density gauge was damaged on 3/8/2019. The gauge had been left unsecured on the tailgate of a truck when leaving a jobsite. The gauge fell from the tailgate onto US-192 just west of Knotty Pine Road in West Melbourne, Florida, and was hit by oncoming traffic. The gauge technician picked up the pieces of the gauge. The Brevard County Fire and Rescue Hazardous Material teams, the Brevard County Emergency Management radiological coordinator, and the Florida Bureau of Radiation Control (FBRC) responded to the scene. When FBRC arrived, the remains of the gauge [a broken source rod, gauge base with the 1.85 GBq (50 mCi) Am-Be source intact, gauge display, detector, and assorted electronic pieces] were in the bed of the truck. After surveying the items, it was apparent that the end of the source rod containing the 0.37 GBq (10 mCi) Cs-137 source had sheared off and was missing. The technician took the FBRC inspector to the location where the gauge was struck. Upon surveying the area, the source (still attached to the sheared rod) was found in the street next to the curb. The inspector retrieved the source and performed contamination and radiation surveys. No removable contamination was detected. Surveys revealed 592 mR/hour at one inch and 23 mR/hour at one foot. The inspector placed the source into a small lead shield, secured it with duct tape, and placed it into the gauge transport container along with the gauge base. He placed a sand bag on top of the source and closed the container. The licensee locked the container and secured it in the bed of the truck. The gauge pieces were transported to an authorized gauge vendor on 3/11/2019 for proper processing. To prevent recurrence, the licensee provided additional gauge use and transportation training to their employees. This event was classified as an EQP and TRS event.

Item Number 190169 - A radiography trainee was exposed to a 703 GBq (19 Ci) Ir-192 source on 3/12/2019. The RSO and radiography trainee were shooting welds in a fixed shooting bay in a manufacturing fabrication shop. The quality control and quality assurance safety checks had been performed before operations began. During radiography work, the trainee proceeded to change out the film on the pipe while the RSO went to retrieve a new piece of pipe. The source had not been retracted into the exposure device. The safety alarms/lights were not flashing and the trainee assumed the source had been retracted into the shielded exposure device. However, the trainee's survey meter pegged and his pocket dosimeter went off-scale. The survey meter was functioning properly when removed from the high radiation field and the trainee's pocket dosimeter appeared to function properly when re-zeroed after the off-scale reading. The trainee's personnel monitor was sent for processing and revealed 2.488 cSv (rem). The Louisiana Department of Environmental Quality (LDEQ) investigation documented that there was no excessive radiation exposure to the trainee. Corrective actions included retraining in radiation health and safety and the proper use of survey equipment, shooting cell alarm systems were rewired to operate on independent circuit breakers, and battery powered back-ups were installed for 24-hour shooting cell alarm functionality. Corrective actions were demonstrated by the RSO to an LDEQ inspector during a site investigation on 6/19/2019.

Item Number 190171 - A dry storage panoramic irradiator Co-60 source rack failed to fully retract on 4/6/2019, leaving the source partially exposed. A bearing pulley, which is part of the slack cable switch/mechanism failed to function as intended. This caused the source cable to bind where it passes through the slack cable switch. When company personnel freed the cable from the slack cable switch, the source easily returned to its full down/safe position. The slack cable switch was repaired in a way that will prevent recurrence. The New York State Department of Health will conduct a site visit. This is the second of four similar events for this licensee within a year (Item Numbers 180512, 190171, 190195, and 190433).

Item Number 190195 - A dry storage panoramic irradiator Co-60 source rack failed to fully retract on 4/23/2019, leaving the source partially exposed. The RSO was notified, arrived approximately 15 minutes

later, and found that the source had gotten stuck slightly above the down (safe) position when the cycle ended. All of the safety alarm systems worked as designed and the operator did not attempt to enter the irradiator or take any action. The RSO contacted the manufacturer and was able to free the source rack and return it to to its full down/safe position. The root cause for the incident has not yet been determined. The RSO will work with the manufacturer to assess the equipment and decide the course of action. The New York State Department of Health will continue to monitor the event. This is the third of four similar events for this licensee within a year (Item Numbers 180512, 190171, 190195, and 190433).

Item Number 190226 - A moisture/density gauge was damaged by a vehicle driving at a high rate of speed through a job site on 5/16/2019 in Middleton, Idaho. The gauge contained a 1.48 GBq (40 mCi) Am-Be source and a 0.3 GBq (8 mCi) Cs-137 source. Pieces of the gauge were scattered approximately 50 feet from the impact site. The Cs-137 source rod disconnected from the gauge. The onsite technician contacted the RSO, who arrived on site to investigate the incident. The accident site was roped off, the area was surveyed, the source rod was placed back in the gauge, and the damaged gauge was placed into a container and transported back to the company office. Surveys of the area after the incident revealed no surface contamination. A police report was filed. Leak test results were negative and the gauge was sent for disposal on 6/6/2019.

Item Number 190232 - A construction materials testing company reported the loss and recovery of a 166.5 MBq (4.5 mCi) Cs-137 source from a moisture/density gauge. On 4/25/2019, a technician performing compaction testing at a construction site noted erroneous gauge readings. The gauge was taken to a gauge services company on 4/29/2019 for evaluation. On 5/21/2019, the gauge services company discovered that the Cs-137 source was missing from the end of the source rod. The welds holding the source to the rod had failed. Personnel from the testing company and an NRC inspector went back to the construction site on 5/21/2019. A survey were the gauge first gave erroneous readings identified radiation levels twice as high as background levels. The location was marked and a 15-foot perimeter was established to secure the area. On 5/30/2019, an environmental remediation company arrived on site, located the source, and secured it in a shielded container. The source was found approximately two-feet underground, beneath a four-inch thick concrete sidewalk that had been poured on 5/8/2019. After securing the source, surveys of the surrounding soil and concrete found no residual contamination. The source was transported to a waste broker for disposal. The gauge manufacturer was aware of the potential for weld failures and had been inspecting gauges and notifying customers (the testing company had no record of this notification). This event was classified as an EQP and LAS event.

Item Number 190240 - A construction materials testing technician was unable to retract a Cs-137 source rod back into a moisture/density gauge at a job site on 5/24/2019. The technician placed the gauge, with the source rod extended, in the bed of his truck and drove approximately 15 miles back to the office. When he arrived, other technicians were able to retract the source. A radiation survey confirmed that the source was secured in its shield. The Virginia Department of Health will perform a reactive inspection.

Item Number 190261 - A radiography trainee was exposed to an unshielded radiography source. The radiographer and trainee were performing radiography on a pipe on 6/21/2019. Following an exposure, the trainee failed to retract the 2.82 TBq (76.3 Ci) Ir-192 source into the radiography exposure device. The radiographer went to the darkroom to complete some paperwork, while the trainee took down the film and moved the collimator to the next exposure location. The trainee then realized that he had not retracted the source. He reported his mistake to the radiographer. The trainee was not wearing a dosimetry badge, self-reading or electronic pocket dosimeter, or alarming rate meter. He did not conduct an exposure device survey prior to moving the exposure device and collimator. While he had carried a survey meter with him and acted as though he was surveying the exposure device, guide tube, and collimator, he admitted that he never looked at the meter face to check for radiation levels. The radiographer and trainee took the trainee's dosimeter, which had been left in the truck, exposed it to the source for a few seconds, and reported that he received 145 mR on his dosimeter. When the RSO questioned them, they told him what happened. Based on reenactment, the RSO determined that the

trainee was exposed to the source for about six seconds. His calculations indicated that the trainee may have received 1,456 cGy (rad) to the hand. The RSO did not take credit for the collimator shielding and used 5.9 R/hour/Ci at one foot as a basis for the calculation. The radiographer and trainee were placed on administrative leave pending a decision from the company's review board. The Texas Department of State Health Services (TDSHS) conducted an investigation. TDSHS learned that there had been a miscommunication in the exposure that the company reported for the trainee's hand; the exposure was not 1,456 cGy (rad). The company worked with a consultant to calculate the trainee's dose to be 18.34 cSv (rem) to the hands and 1.52 mSv (151.56 mrem) whole body. The exposure was well below reporting requirements; no overexposure occurred. The exposure aspect of the incident was retracted on 8/1/2019. Corrective actions included terminating the trainee's employment and a division-wide safety stand down for retraining on the importance of radiographic monitoring equipment.

Item Number 190327 - A moisture/density gauge was damaged at a temporary jobsite in Huron, California, on 7/22/2019. The gauge contained a 1.85 GBq (50 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source. The user backed his truck into the gauge causing the Cs-137 source rod to break off. When the user attempted to retrieve the source rod it separated from the rest of the gauge assembly. He cordoned off the area and placed sandbags on top of the gauge. The RSO had a survey meter and measured 5.5 mR/hour next to the source rod. The RSO followed instructions provided by the manufacturer to place the source rod in a shielded container. She used an 18-inch long pair of tongs to pick up the source rod and place it inside a container made from a lead sheet. She then placed the lead container inside another brass tube prior to placing it inside a Type A container. The survey meter measured 0.2 mR/hour at one meter from the Type A container. The damaged gauge was sent to the manufacturer for disposal. The California Health and Human Services Agency will follow up on the investigation.

Item Number 190394 - A construction materials testing company reported an equipment problem involving a moisture/density gauge that contained a 0.3 GBq (8 mCi) Cs-137 source and a 1.48 GBq (40 mCi) Am-Be source. On 8/12/2019, while a technician was using the gauge to perform density testing at a job site in Greenville, Texas, the tip of the insertion rod that holds the Cs-137 source came off in the test hole. The RSO and a representative from a licensed gauge service company responded to the site, recovered the source, and placed it into a recovery pig. The RSO stated that the source holder, which is screwed and welded onto the end of the insertion rod, was intact with the source, spring, and spacer in place. However, it had broken off approximately 1/4 inch below the threads/weld. A survey of the test hole and surrounding area found no radiation readings above background. A wipe test was taken and analyzed at the service company's facility. Results indicated that the source was not leaking. The source and gauge were taken to the service company's facility for evaluation. The gauge was sent to the manufacturer for inspection, but they were unable to determine the cause of the failure. From the serial number, they determined that the gauge was at least 25 years old. The rod was sent to a firm for metallurgical examination that found no indication of a manufacturing defect. The failure resulted from pitting and intergranular cracking of the sensitized Type 420 stainless steel heat affected weld zone and was most likely associated with its service environment and normal operation. The manufacturer had serviced this gauge on 9/22/2014 and inspected the failed area, but did not observe any cracks or pitting. They had not seen this type of failure in the past. The manufacturer did not believe a notice of this failure was warranted because it was not a material defect and the material used had been changed to a different form of stainless steel. The Texas Department of State Health Services performed an investigation.

Item Number 190404 - An oil field services company reported that a hydraulic fracking blender truck transporting a nuclear density gauge caught fire on Highway 285 South near Orla, Texas, on 8/17/2019. The gauge contained a 3.7 GBq (100 mCi) Cs-137 source. The driver could not extinguish the fire with two onboard fire extinguishers. By the time the fire department arrived, the truck was fully involved in the fire. After the fire was out, the dose rate at 30 cm from the gauge was 0.02 mSv/hour (2 mrem/hour), which was normal. The company took the truck to their facility and performed a leak test, the results of

which were below limits. They performed additional radiation surveys on 8/19/2019. They found dose rates as high as 0.05 mSv/hour (5 mrem/hour) at one meter from the gauge. They contacted their manufacturing section and an individual familiar with the gauge stated that the shielding was probably compromised, but believed the source was undamaged. The gauge was returned to the manufacturing facility for inspection. Leak test results reported to the Texas Department of State Health Services on 8/28/2019 revealed 0 dpm. The company provided pictures of the gauge internals on 9/17/2019 that showed that over half of the shielding material was missing and the source holder was completely exposed. The company disposed of the gauge and source. This event was classified as an EQP and TRS event.

Item Number 190426 - A metal recycling facility found a moisture/density gauge in a 55-gallon drum at their facility on 8/28/2019. The drum was crimped at the top so the gauge would not fall out. The gauge contained a 1.85 GBq (50 mCi) Am-Be source and a 0.37 GBq (10 mCi) Cs-137 source. They employed a contractor to take radiation readings and perform a swipe test of the gauge. The gauge housing appeared to be damaged, but the source housing seemed intact. The contractor was unable to inspect the bottom of the gauge inside the drum. Radiation readings were 13 mR/hour on contact with the side of the gauge, 200 mR/hour on contact at the bottom, and 3 mR/hour one foot from the side. Swipe test results were less than background. The Oregon Department of Health Radiation Protection Services (ORPS) believes that the gauge is damaged, because normal radiation readings for the gauge at one meter should be 400 µR/hour. The gauge is under the control of the recycling facility. ORPS will conducted an investigation.

Item Number 190433 - A dry storage panoramic irradiator Co-60 source rack failed to fully retract on 8/28/2019, leaving the source partially exposed. The source rack was stuck three inches above the full down/safe position. All of the safety and alarm systems worked as designed and the operator did not attempt to enter the irradiator or take any action. The RSO was able to free the source by lifting it just an inch or two and then letting it back down. The RSO contacted the manufacturer and they were expected to be on site the week of 9/2/2019. The vault will not be used until the issue is resolved. The RSO locked out all operator key access to the vault. After the previous event (Item Number 190195), the manufacturer removed the vault, reconditioned it, and returned it to the licensee. The New York State Department of Health will continue to monitor the event. This is the fourth of four similar events for this licensee within a year (Item Numbers 180512, 190171, 190195, and 190433).

2.7.3 Events Recently Added to NMED That Occurred Prior to FY19

Thirteen EQP events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. None of these events were considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events
None

Events of Interest
Item Number 190235 - An assistant radiographer was exposed to a 1.44 TBq (39 Ci) Ir-192 radiography source at an excavation site in Briggsdale, Colorado, on 4/3/2018. The assistant radiographer attached the drive cable assembly and guide tube to the exposure device while it was on the tail gate of the truck. He then carried the assembled radiography equipment to the exposure location. After placing the crank handle on the ramp to the excavation site, he carried the exposure device another 8 to 10 feet into the excavation site. He then began a radiation survey of the area and the exposure device. When he reached the front of the device, radiation readings were higher than expected. The assistant moved away from the device and checked his dosimeter, which was off-scale. With the survey meter in hand and radiation readings showing a normal range, the radiographer approached the crank handle, picked it up, and made a one-quarter to one-half turn, which fully retracted the source into the exposure device. Surveys confirmed

that the source was fully shielded. The crew immediately ceased operations and contacted their RSO. The Colorado Department of Public Health & Environment (CDPHE) performed an on-site investigation on 4/5/2018. The assistant radiographer's dosimeter was immediately processed. Results revealed 7.45 mSv (745 mrem) DDE, 7.45 mSv (745 mrem) LDE, and 7.07 mSv (707 mrem) SDE. The radiographer and assistant radiographer were interviewed and a reenactment of the incident was conducted. The likely cause of the incident was the way the assistant carried the assembled radiography equipment to the exposure location. He carried the exposure device in his left hand, the coiled drive cable assembly over his right shoulder, and the guide tube looped back over the device and secured with his left hand against the device handle. In this configuration, the source collimator could have depressed the locking mechanism button. The assistant then placed the coiled drive cable assembly on the ground and proceeded to drag it behind him to the exposure location. This could have actuated the crank handle enough to partially expose the source. CDPHE recommended that the radiographers wait until they reach the exposure location before assembling the radiography equipment, which would have prevented the incident. They also recommended that the radiographer provide more oversight of the exposure device set-up process for inexperienced assistants.

Item Number 190290 - A radiographer failed to lock a 1.03 TBq (27.8 Ci) Ir-192 source in the exposure device prior to relocating the device to an alternate position. Operations were being conducted at the intersection of Universal Boulevard and Sand Lake Road in Orlando, Florida, on 10/14/2017. The source slipped out and remained out until the assistant radiographer noticed high radioactivity levels in the work area and notified the radiographer. The assistant's pocket dosimeter read 11 mR. The radiographer's pocket dosimeter had an upper range of 200 mR and was off scale. Both employees were wearing alarming dosimeters, but only the assistant's dosimeter alarmed. The two employee's film badges were priority shipped for processing. Both were suspended from work pending film badge analysis and investigation. Dosimetry results revealed 3.12 mSv (312 mrem) to the radiographer and 0.33 mSv (33 mrem) to the assistant. The RSO interviewed involved personnel and examined the radiography equipment on 10/20/2017. The radiography exposure device was determined to be functional. The cause of the event was failure to follow procedures. The RSO walked through a recreation of the incident with the affected employees to retrain them on proper procedures. In addition, the corporate RSO and the local RSO gave refresher training to all radiography personnel in the region.

2.8 Transportation

2.8.1 Ten-Year Data

Figure 8 displays the annual number and trend of TRS events that occurred during the 10-year period. The trend analysis determined that the data does not represent statistically significant trends in the number of events (indicated by the absence of trend lines).

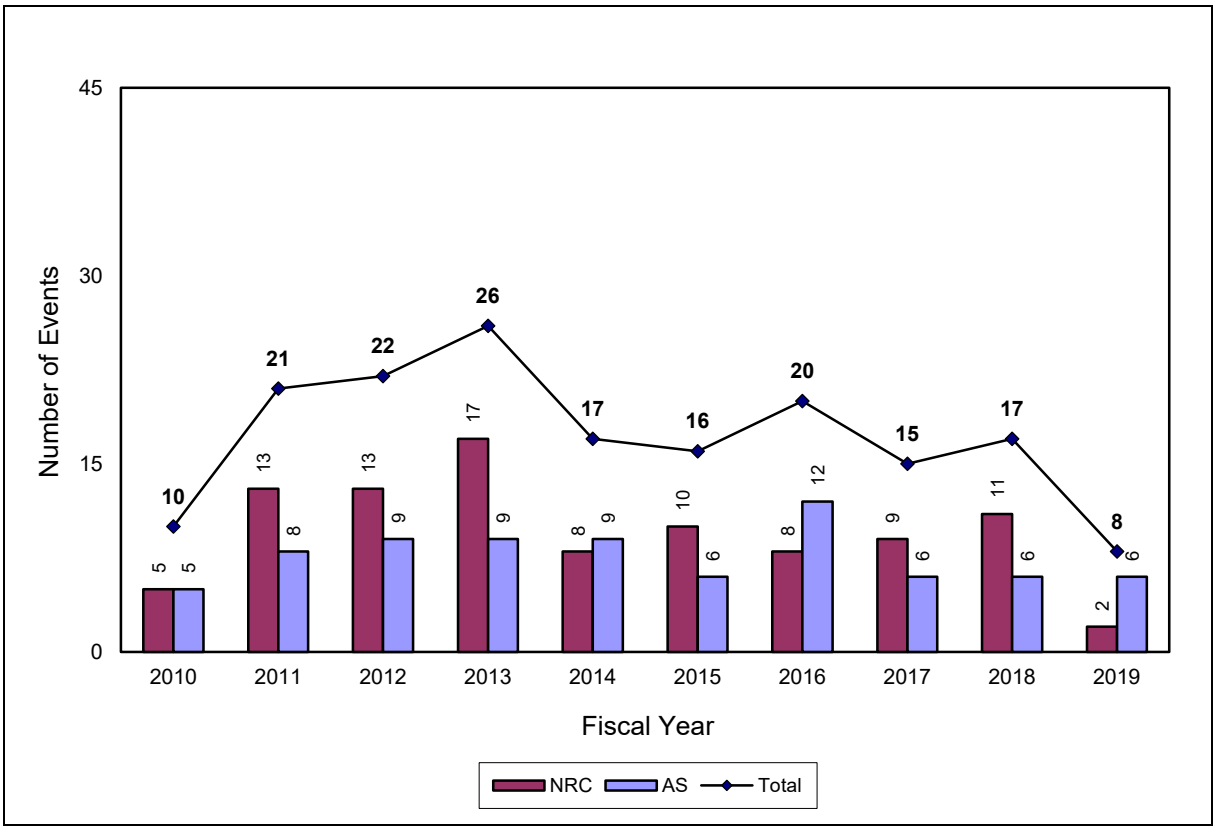

Figure 8. Transportation Events (172 total)

It is not possible to discern the significance of TRS events strictly from the CFR reporting requirements (as in Sections 2.4 and 2.5). Therefore, event significance will be determined on an event-by-event basis based on the severity of the event (e.g., significant exposure to workers, members of the public, and/or the environment). Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.8.2 FY19 Data

Eight TRS events occurred in FY19, none of which were considered significant.

Significant Events
None

Events of Interest
Item Number 190124 - A moisture/density gauge was damaged on 3/8/2019. The gauge had been left unsecured on the tailgate of a truck when leaving a jobsite. The gauge fell from the tailgate onto US-192 just west of Knotty Pine Road in West Melbourne, Florida, and was hit by oncoming traffic. The gauge technician picked up the pieces of the gauge. The Brevard County Fire and Rescue Hazardous Material teams, the Brevard County Emergency Management radiological coordinator, and the Florida Bureau of Radiation Control (FBRC) responded to the scene. When FBRC arrived, the remains of the gauge [a

broken source rod, gauge base with the 1.85 GBq (50 mCi) Am-Be source intact, gauge display, detector, and assorted electronic pieces] were in the bed of the truck. After surveying the items, it was apparent that the end of the source rod containing the 0.37 GBq (10 mCi) Cs-137 source had sheared off and was missing. The technician took the FBRC inspector to the location where the gauge was struck. Upon surveying the area, the source (still attached to the sheared rod) was found in the street next to the curb. The inspector retrieved the source and performed contamination and radiation surveys. No removable contamination was detected. Surveys revealed 592 mR/hour at one inch and 23 mR/hour at one foot. The inspector placed the source into a small lead shield, secured it with duct tape, and placed it into the gauge transport container along with the gauge base. He placed a sand bag on top of the source and closed the container. The licensee locked the container and secured it in the bed of the truck. The gauge pieces were transported to an authorized gauge vendor on 3/11/2019 for proper processing. To prevent recurrence, the licensee provided additional gauge use and transportation training to their employees. This event was classified as an EQP and TRS event.

Item Number 190404 - An oil field services company reported that a hydraulic fracking blender truck transporting a nuclear density gauge caught fire on Highway 285 South near Orla, Texas, on 8/17/2019. The gauge contained a 3.7 GBq (100 mCi) Cs-137 source. The driver could not extinguish the fire with two onboard fire extinguishers. By the time the fire department arrived, the truck was fully involved in the fire. After the fire was out, the dose rate at 30 cm from the gauge was 0.02 mSv/hour (2 mrem/hour), which was normal. The company took the truck to their facility and performed a leak test, the results of which were below limits. They performed additional radiation surveys on 8/19/2019. They found dose rates as high as 0.05 mSv/hour (5 mrem/hour) at one meter from the gauge. They contacted their manufacturing section and an individual familiar with the gauge stated that the shielding was probably compromised, but believed the source was undamaged. The gauge was returned to the manufacturing facility for inspection. Leak test results reported to the Texas Department of State Health Services on 8/28/2019 revealed 0 dpm. The company provided pictures of the gauge internals on 9/17/2019 that showed that over half of the shielding material was missing and the source holder was completely exposed. The company disposed of the gauge and source. This event was classified as an EQP and TRS event.

2.8.3 Events Recently Added to NMED That Occurred Prior to FY19

Three TRS events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. None of these events were considered significant. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events
None

Events of Interest
None

2.9 Other

2.9.1 Ten-Year Data

Figure 10 displays the annual number of OTH events that occurred during the 10-year period. Because OTH events do not fit a defined criterion that ensures consistency within the data, trending analysis is not performed on this data.

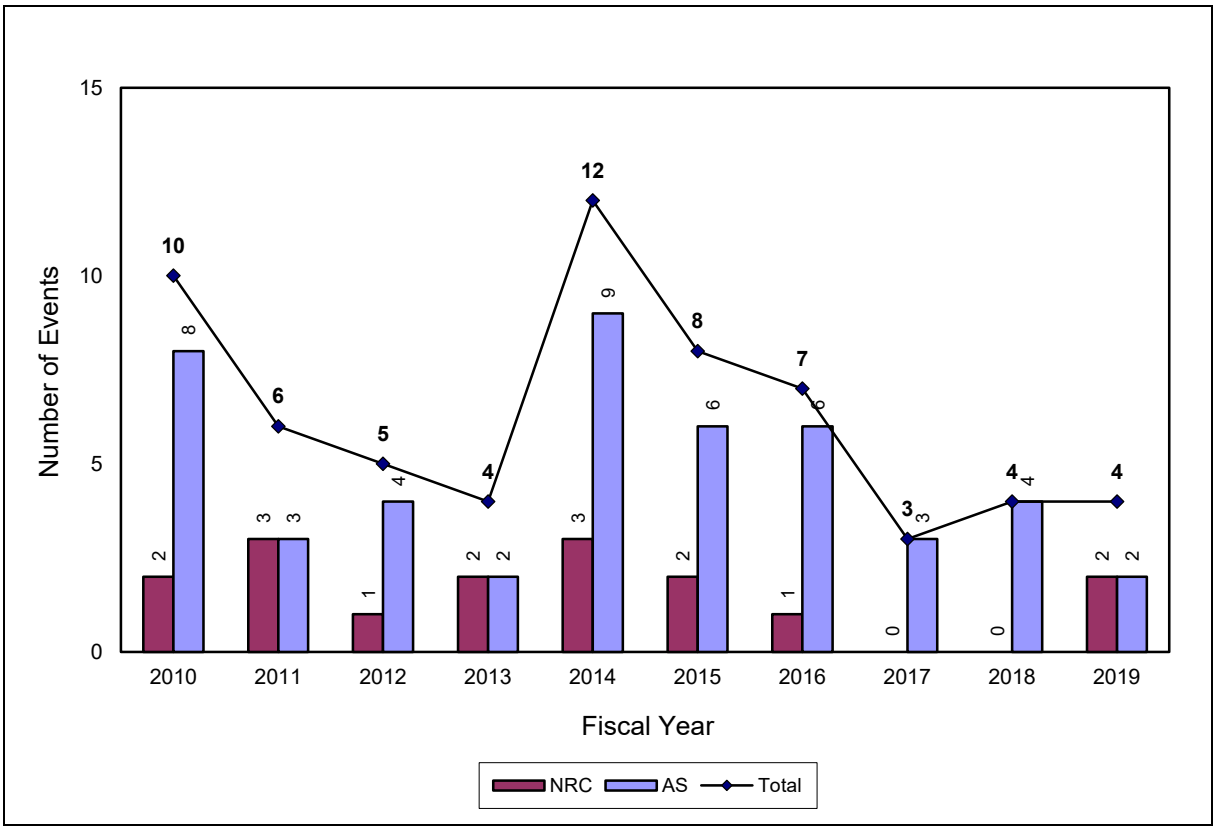

Figure 9. Other Events (63 total)

It is not possible to discern the significance of OTH events strictly from the CFR reporting requirements (as in Sections 2.4 and 2.5). Therefore, event significance will be determined on an event-by-event basis based on the severity of the event (e.g., significant exposure to workers, members of the public, and/or the environment). Events possessing one or more unusual aspects, but that do not meet the significant event threshold, are considered events of interest.

2.9.2 FY19 Data

Four OTH events occurred in FY19, none of which were considered significant.

Significant Events
None

Events of Interest
Item Number 190062 - A member of the public received a radiation exposure during radiography performed at a metal fabrication company on 1/11/2019. Radiography was being performed on a large steel tank. The radiography exposure device contained a 2.49 TBq (67.4 Ci) Ir-192 source. Radiographer 1 was on scaffolding inside of the tank operating the radiography exposure device. Radiographer 2 was on the outside of the tank setting up the film using a man lift operated by an employee of metal fabrication company (a member of the public). Communication between the radiographers was through a manway in

the tank. The intent was that radiographer 2 and the lift operator would exit the restricted area prior to any exposure. On one particular exposure, radiographer 2 tried to communicate to radiographer 1 that he was going to set up the film. However, radiographer 1 misunderstood, thought they were already set up, and cranked out the source. Meanwhile, radiographer 2 and the lift operator took the lift up to the weld, placed the film, lowered the lift, and exited the area. Radiographer 2 then went to the manway to say that he was ready for the shot. After recognizing the problem, radiographer 2 checked his pocket dosimeter, which read 120 mR (he started the day at 10 mR). The radiographers notified the RSO of the incident. Radiographer 2's dosimeter was sent for processing and revealed 1.35 mSv (135 mrem). It is possible that some of the exposure was received prior to this event. Radiographer 2 estimated that he was three to four feet from the source and the lift operator was four to five feet from the source for a 40-second exposure time. Exposure calculations at four feet with 5/16 inch steel thickness indicates about 1.55 mSv (155 mrem), which is greater than radiographer 2's processed dosimeter result of 1.35 mSv (135 mrem). Using radiographer 2's processed dosimeter result as the basis, the lift operator's dose was calculated to be 0.76 mSv (76 mrem). The Minnesota Department of Health investigated the incident on 1/14/2019 and 1/22/2019 and agrees with the 0.76 mSv (76 mrem) exposure calculation. Corrective actions include using radios for this type of operation to aid in communication.

2.9.3 Events Recently Added to NMED That Occurred Prior to FY19

No OTH events were recently added to NMED that occurred prior to the current fiscal year and had not been included in any previous annual report. Note that this data may differ from the associated Appendix D graph, which displays the number of events added and subtracted from specific years within the most recent 10-year period, including events moved between years due to changes in the recorded event date.

Significant Events
None

Events of Interest
None

Appendix A

Event Type Descriptions and Criteria

Appendix A
Event Type Descriptions and Criteria

The NMED events covered by this report are divided into the following categories based on the event reporting requirements defined in 10 CFR. Note that the tables in this appendix do not contain the full text of the applicable CFRs.

Lost/Abandoned/Stolen Material (LAS)

The LAS event category includes those events where licensed radioactive material is lost or found, abandoned or discovered, and stolen or recovered. The radioactive material involved can be sealed or unsealed material, specifically or generally licensed, exempt or non-exempt quantities, involve a licensee or a non-licensee, and can be found anywhere. Abandoned well logging sources are included in this category.

NMED LAS reportable events are those that meet the reporting requirements of 10 CFR Part 20.2201. Events that do not meet the 20.2201 reporting requirement thresholds are captured as not-reportable LAS events. Additionally, LAS events involving non-Atomic Energy Act material are entered into NMED as not-reportable events.

All reportable LAS events will be coded as one of the following reporting requirements. For events involving more than one source, the decision of 10 × or 1,000 × the 10 CFR Part 20 Appendix C quantity is based on the aggregate quantity of licensed material.

Table A-1. Primary LAS Reporting Requirements

Primary LAS Reporting Requirements	Reporting Requirement Summary
20.2201(a)(1)(i)	Aggregate activity ≥ 1,000 × 10 CFR Part 20 Appendix C quantity
20.2201(a)(1)(ii)	Aggregate activity > 10 and < 1,000 × 10 CFR Part 20 Appendix C quantity
39.77(d)	Irretrievable well logging source

The following additional (secondary) CFRs will be added as applicable. This should occur infrequently. For the 10 CFR 37 requirements, the event will instead be coded as OTH if there was no actual theft, sabotage, or diversion of Category 1 or 2 quantities of radioactive material.

Table A-2. Secondary LAS Reporting Requirements

Secondary LAS Reporting Requirements	Reporting Requirement Summary
30.55(c)	Theft/diversion of 10 Ci (or 100 Ci per year) of H 3 (not generally licensed).
37.57(a)	Unauthorized entry resulted in actual ~~or attempted~~ theft, sabotage, or diversion of a category 1 or category 2 quantity of material.
37.57(b)	Suspicious activity related to possible theft, sabotage, or diversion of a category 1 or category 2 quantity of material
37.81(a)	A shipment of category 1 quantities of material is lost or missing.
37.81(b)	A shipment of category 2 quantities of material is lost or missing.
37.81(c)	Actual ~~or attempted~~ theft or diversion (or related suspicious activities) of a shipment of category 1 quantities of material.
37.81(d)	Actual ~~or attempted~~ theft or diversion (or related suspicious activities) of a shipment of category 2 quantities of material.
37.81(e)	Recovery of any lost or missing shipment of category 1 quantities of material.
37.81(f)	Recovery of any lost or missing shipment of category 2 quantities of material.

39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.
40.64(c)(1)	Theft/diversion of 15 lb (or 150 lb per year) of source material (uranium or thorium).
73.71(a)(1)	Lost shipment of any SNM.
73.App G(I)(a)(1)	Actual or attempted theft or unlawful diversion of SNM.
74.11(a)	Loss, theft or unlawful diversion (actual or attempted) of SNM or the unauthorized production of enriched uranium.
76.120(a)(2)	Loss, other than normal operating loss, of special nuclear material.
76.120(a)(3)	Actual or attempted theft or unlawful diversion of special nuclear material.
150.16(b)(1)	Actual or attempted theft or unlawful diversion of SNM.
150.17(c)(1)	Attempted theft or unlawful diversion of more than 6.8 kg (15 lb) of Uranium or Thorium at any one time or more than 68 kg (150 lb) in any one calendar year.
150.19(c)	Theft/diversion of 10 Ci (or 100 Ci per year) of H-3 (not generally licensed). Note: This requirement is just like 30.55(c), but applies to Agreement States and offshore waters.

Medical (MED)

MED events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-3. MED Reporting Requirements

MED Reporting Requirements	Reporting Requirement Summary
35.3045(a)(1)(i)(A)	Total dose delivered that differs from the prescribed dose by 20% or more; and differs from the prescribed dose by more than 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(i)(B)	Total dosage delivered that differs from the prescribed dosage by 20% or more or falls outside the prescribed range; and results in a dose that differs from prescribed by more than 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(i)(C)	Fractionated dose delivered that differs from the prescribed dose for a single fraction by 50% or more; and differs from the prescribed dose by more than 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(A)	Administration of a wrong radioactive drug containing byproduct material or the wrong radionuclide for a brachytherapy procedure that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(B)	Administration of a radioactive drug containing byproduct material by the wrong route of administration that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(C)	Administration of a dose or dosage to the wrong individual or human research subject that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(D)	Administration of a dose or dosage delivered by the wrong mode of treatment that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(ii)(E)	Leaking sealed source that results in a dose that exceeds 0.05 Sv (5 rem) EDE, 0.5 Sv (50 rem) to an organ or tissue, or 0.5 Sv (50 rem) SDE to the skin.
35.3045(a)(1)(iii)	Dose to the skin, organ, or tissue, other than the treatment site, that exceeds by 0.5 Sv (50 rem) or more and 50% or more the expected dose to that site from the procedure if the administration had been given in accordance with the written directive prepared or revised before administration.
35.3045(a)(2)(i)	For permanent implant brachytherapy, the total source strength administered differs by 20% or more from the total source strength documented in the post-implant portion of the written directive, excluding sources that were implanted in the correct site but migrated outside of the treatment site.
35.3045(a)(2)(ii)	For permanent implant brachytherapy, the total source strength administered outside of the treatment site exceeds 20% of the total source strength documented in the post-implant portion of the written directive, excluding sources that were implanted in the correct site but migrated outside of the treatment site.
35.3045(a)(2)(iii)(A)	For permanent implant brachytherapy, an administration that includes the wrong radionuclide.
35.3045(a)(2)(iii)(B)	– For permanent implant brachytherapy, an administration that includes the wrong individual or research subject.
35.3045(a)(2)(iii)(C)	For permanent implant brachytherapy, an administration that includes sealed sources implanted directly into a location discontiguous from the treatment site, as documented in the post-implant portion of the written directive.
35.3045(a)(2)(iii)(D)	For permanent implant brachytherapy, an administration that includes a leaking sealed source resulting in a dose that exceeds 0.5 Sv (50 rem) to an organ or tissue.

35.3045(b)	Event resulting from patient intervention in which the administration of byproduct material or radiation from byproduct material results in unintended permanent functional damage to an organ or a physiological system, as determined by a physician.

Events are not considered MED events if they involve:

- Only a linear accelerator,
- Doses administered in accordance with a written directive (even if the directive is in error), or
- Patient intervention, unless the event results in unintended permanent functional damage to an organ or physiological system.

Events are considered MED events if, for example, a linear accelerator is used for therapy by mistake instead of a teletherapy unit or a teletherapy unit instead of a linear accelerator.

For purposes of determining whether to categorize an event as MED or EXP, MED events occur to patients only (i.e., those being administered a medical procedure). For example, if a patient receives too much dose during a procedure, the event would be categorized as MED rather than EXP. However, radiation exposure received from a cause other than the patient's medical procedure may be categorized as EXP.

Radiation Overexposure (EXP)

EXP events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-4. EXP Reporting Requirements

EXP Reporting Requirements	Reporting Requirement Summary
20.2202(a)(1)(i)	An individual received a total effective dose equivalent of 25 rem (0.25 Sv) or more.
20.2202(a)(1)(ii)	An individual received a lens dose equivalent of 75 rem (0.75 Sv) or more.
20.2202(a)(1)(iii)	An individual received a shallow-dose equivalent to the skin or extremities of 250 rad (2.5 Gy) or more.
20.2202(b)(1)(i)	Loss of control of material causing or threatening to cause an individual to receive a total effective dose equivalent exceeding 5 rem (0.05 Sv) in a period of 24 hours.
20.2202(b)(1)(ii)	Loss of control of material causing or threatening to cause an individual to receive an eye dose equivalent exceeding 15 rem (0.15 Sv) in a period of 24 hours.
20.2202(b)(1)(iii)	Loss of control of material causing or threatening to cause an individual to receive a shallow-dose equivalent to the skin or extremities exceeding 50 rem (0.5 Sv) in a period of 24 hours.
20.2203(a)(2)(i)	Doses in excess of the occupational dose limits for adults in 20.1201.
20.2203(a)(2)(ii)	Doses in excess of the occupational dose limits for a minor in 20.1207.
20.2203(a)(2)(iii)	Doses in excess of the limits for an embryo/fetus of a declared pregnant woman in 20.1208.
20.2203(a)(2)(iv)	Doses in excess of the limits for an individual member of the public in 20.1301.
20.2203(a)(2)(v)	Doses in excess of any applicable limit in the license.
39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.

The EXP event category includes all regulatory overexposures of radiation workers or exposures of members of the public to radiation. The overexposure can be external or internal and can be whole body, extremity, skin, lens of the eye, or internal dose. When the overexposure involves multiple individuals or an individual with multiple overexposure types (such as whole body and extremity), the different types of overexposures are entered separately. Note that dosimeters record exposure if improperly stored near a radiation source and, depending on the type of dosimeter, may react as though they are in a radiation field when exposed to heat or humidity.

It is NRC policy to classify only those events that positively involve a personnel overexposure, and not just a dosimeter exposure, as reportable EXP events. For example, either the licensee does not contest the personnel overexposure, or in cases where the licensee does contest the overexposure, the State or NRC determines the event to be personnel overexposure.

EXP limits do not apply to patients receiving medical procedures.

Release of Licensed Material or Contamination (RLM)

RLM events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-5. RLM Reporting Requirements

RLM Reporting Requirements	Reporting Requirement Summary
20.2202(a)(2)	Release of radioactive material, inside or outside of a restricted area, so that had an individual been present for 24 hours, the individual could have received an intake 5 times the ALI.
20.2202(b)(2)	Release of material, inside or outside of a restricted area, so that, had an individual been present for 24 hours, the individual could have received an intake in excess of 1 ALI.
20.2203(a)(2)(vi)	Doses in excess of the ALARA constraints for air emissions established under 20.1101(d).
20.2203(a)(3)(i)	Radiation or concentrations of radioactive material in a restricted area in excess of any applicable limit in the license.
20.2203(a)(3)(ii)	Radiation or concentrations of radioactive material in an unrestricted area in excess of 10 times any applicable limit set forth in Part 20 or in the license.
20.2203(a)(4)	Levels of radiation or releases of radioactive material in excess of the standards in 40 CFR Part 190, or of license conditions related to those standards.
30.50(a) 40.60(a) 70.50(a) 76.120(b)	Event that prevents immediate protective actions necessary to avoid exposures to radiation or radioactive materials that could exceed regulatory limits or releases of material that could exceed regulatory limits.
30.50(b)(1) 40.60(b)(1) 70.50(b)(1) 76.120(c)(1)	Unplanned contamination event that requires access to be restricted for > 24 hours, involves > 5 times the lowest ALI, and has access restricted for a reason other than to allow isotopes with a half-life of < 24 hours to decay.
30.50(b)(3) 40.60(b)(3) 70.50(b)(3) 76.120(c)(3)	Event that requires unplanned medical treatment at a medical facility of an individual with spreadable radioactive contamination on the individual's clothing or body.
39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.
50.72(b)(3)(xii) 72.75(c)(3)	Event requiring the transport of a radioactively contaminated person to an offsite medical facility for treatment.

The RLM event category includes two types of events. The first type is a radioactive release to air or water exceeding the 10 CFR Part 20 Appendix B annual limit on intake (ALI). The second type of RLM event involves contamination events such as a radioactive spill outside of work areas, removable contamination found on equipment, or material tracked around a laboratory such that additional radiological control measures had to be implemented. This category does not include spills inside of laboratory hoods, radiopharmaceutical dose preparation areas, or hot cells where radioactive work routinely requires cleanup or changing of absorbent paper after the performance of a task. Should there be multiple release types (e.g., surface, air, water, or person) or areas of contamination associated with the release, this information is entered individually.

Leaking Sealed Source (LKS)

LKS events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-6. LKS Reporting Requirements

LKS Reporting Requirements	Type of Source
31.5(c)(5)	Generally licensed
34.27(d)	Radiography
35.67(e)	Medical
39.35(d)(1)	Well logging (leaking)
39.77(a)	Well logging (ruptured)
30.50(b)(2)	All other sources

The NRC requires that most sealed sources be periodically leak tested to verify that the material is still sealed and that the source is still considered safe to use without contamination controls, including protective clothing or gloves. Sources are generally exempt from leak testing under the following conditions [see 10 CFR Part 31.5(c)(2), 34.27(c), 35.67(f), and 39.35(e)]:

- Sources containing only gaseous radioactive material (like H-3, Kr-85, etc.),
- Sources containing licensed material with a half-life of 30 days or less,
- Sources containing <= 100 μCi of other beta and/or gamma emitting material,
- Sources containing <= 10 μCi of alpha emitting material,
- Sources held in storage in the original shipping container prior to initial installation,
- Seeds of Ir-192 encased in nylon ribbon, or
- Sources in storage and not in use (must be leak tested prior to use or transfer).

A source is considered leaking if a leak test can detect greater than 0.005 μCi of removable radioactive material. The leaking source is then removed from service, disposed of or returned to the manufacturer for repair, and a report is sent to the NRC or Agreement State with the details of the leaking source.

For regulatory reporting purposes, a leaking source is generally considered a failed device under 10 CFR Part 30. Therefore, in most cases an LKS event is also coded as an EQP event. An exception is the Ni-63 foil source, which is coded as only an LKS event.

Equipment (EQP)

EQP events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-7. EQP Reporting Requirements

EQP Reporting Requirements	Reporting Requirement Summary
21.21(d)(1)(i)	A failure to comply or a defect affecting the construction or operation of a facility or an activity that is subject to licensing requirements.
21.21(d)(1)(ii)	A failure to comply or a defect affecting a basic component that is supplied for a facility or an activity that is subject to licensing requirements.
30.50(a) 40.60(a) 70.50(a) 76.120(b)	Event that prevents immediate protective actions necessary to avoid exposures to radiation or radioactive materials that could exceed regulatory limits or releases of material that could exceed regulatory limits.
30.50(b)(2) 40.60(b)(2) 70.50(b)(2) 72.75(d)(1) 76.120(c)(2)	Equipment is disabled or fails to function as designed.
30.50(b)(4) 40.60(b)(4) 70.50(b)(4) 76.120(c)(4)	Unplanned fire or explosion that damages any licensed material or any device, container, or equipment containing licensed material.
31.5(c)(5)	Actual or indicated failure to shielding, the on-off mechanism or indicator, or upon the detection 0.005 uCi or more of removable radioactive material.
34.101(a)(1)	Unintentional disconnection of the radiographic source assembly from the control cable.
34.101(a)(2)	Inability to retract and secure the radiographic source assembly to its fully shielded position.
34.101(a)(3)	Failure of any radiographic component (critical to the safe operation of the device) to properly perform its intended function.
35.3204	Eluate exceeding the permissible concentration of Mo-99, Sr-82, and Sr-85, as listed in 35.204(a), at the time of generator elution; more than 0.15 kBq Mo-99 per MBq Tc-99m, more than 0.02 kBq Sr-82 per MBq Rb-82 chloride, or more than 0.2 kBq Sr-85 per MBq Rb-82 chloride.
36.83(a)(1)	An irradiator source stuck in an unshielded position.
36.83(a)(2)	Fire or explosion in an irradiator radiation room.
36.83(a)(3)	Damage to the irradiator source racks.
36.83(a)(4)	Failure of the irradiator cable or drive mechanism used to move the source racks.
36.83(a)(5)	Inoperability of the irradiator access control system.
36.83(a)(6)	Detection of irradiator source by the product exit monitor.
36.83(a)(7)	Detection of irradiator radioactive contamination attributable to licensed radioactive material.
36.83(a)(8)	Structural damage to the irradiator pool liner or walls.
36.83(a)(9)	Abnormal water loss or leakage from the irradiator source storage pool.
36.83(a)(10)	Irradiator pool water conductivity exceeding 100 microsiemens per centimeter.
39.77(a)	Ruptured well logging sealed source.
39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.

72.75(c)(1)	Defect in any spent fuel, HLW, or reactor-related GTCC waste storage structure, system, or component that is important to safety.
72.75(c)(2)	Significant reduction in the effectiveness of any spent fuel, HLW, or reactor-related GTCC waste storage confinement system during use.
72.242(d)	Design or fabrication deficiency for any spent fuel storage cask delivered to a licensee which affects the ability of components important to safety to perform their safety function.

The EQP event category includes all types of radiological equipment problems, including generally licensed device problems covered in 10 CFR Part 31; radiography equipment problems covered in 10 CFR Part 34; irradiator problems covered in 10 CFR Part 36; well logging problems covered in 10 CFR Part 39, and other types of equipment covered in 10 CFR Part 30, 40, 70, and 76. EQP events are defined as the failure of, or a defect in, any piece of equipment that either contains licensed radioactive materials as an integral part, or whose function is to interact with such materials.

Transportation (TRS)

TRS events are determined and coded per the 10 CFR reporting requirements listed below.

Table A-8. TRS Reporting Requirements

TRS Reporting Requirements	Reporting Requirement Summary
20.1906(d)(1)	Transported package exceeds removable surface contamination limits.
20.1906(d)(2)	Transported package exceeds external radiation limits.
71.5	Transportation of licensed material.
71.95(a)(1)	Significant reduction in the effectiveness of any NRC-approved Type B or Type AF packaging during use.
71.95(a)(2)	Defects with safety significance in any NRC-approved Type B or fissile material packaging, after first use.
71.95(a)(3)	Conditions of approval in the Certificate of Compliance were not observed in making a shipment.
71.95(b)	Conditions in the Certificate of Compliance were not followed during a shipment.

Other (OTH)

The OTH event category includes the following types of events:

1. Doses to an embryo/fetus or nursing child reportable per 10 CFR Part 35.3047. Note that these events are not MED events (reportable per 10 CFR Part 35.3045).
2. Dose in an unrestricted area in excess of 2 mrem in an hour, but no individual received a dose in excess of limits (if a dose in excess of limits is received, the event is an EXP event).
3. 10 CFR 37 events that do not result in the actual theft, sabotage, or diversion of Category 1 or 2 quantities of radioactive material. Otherwise, the event is as an LAS event.
4. Reportable events that do not specifically fit into one of the previous event types.

For items 1-3 above, OTH events are determined and coded per the 10 CFR reporting requirements listed below. Due to the nature of item 4 above, other reporting requirements may also be used.

Table A-9. OTH Reporting Requirements

OTH Reporting Requirements	Reporting Requirement Summary
20.2203(a)(2)(iv)	Dose in an unrestricted area in excess of 2 mrem in an hour, but no dose received in excess of limits.
35.3047(a)	Dose to an embryo/fetus greater than 50 mSv (5 rem) DE from administration of byproduct material or radiation from byproduct material to a pregnant individual unless specifically approved, in advance, by the authorized user.
35.3047(b)(1)	Dose to a nursing child greater than 50 mSv (5 rem) TEDE resulting from an administration of byproduct material to a breast-feeding individual.
35.3047(b)(2)	Dose to a nursing child resulting in unintended permanent functional damage to an organ or physiological system, as determined by a physician, resulting from an administration of byproduct material to a breast-feeding individual.
37.57(a)	Unauthorized entry resulted in ~~actual or~~ attempted theft, sabotage, or diversion of a category 1 or category 2 quantity of material.
37.57(b)	Suspicious activity related to possible theft, sabotage, or diversion of a category 1 or category 2 quantity of material
37.81(c)	~~Actual or~~ attempted theft or diversion (or related suspicious activities) of a shipment of category 1 quantities of material.
37.81(d)	~~Actual or~~ attempted theft or diversion (or related suspicious activities) of a shipment of category 2 quantities of material.
39.77(b)	Theft or loss of radioactive material, radiation overexposures, excessive levels and concentrations of radiation for events involving well logging operations, and certain other accidents.

Appendix B

Statistical Trending Methodology

Appendix B
Statistical Trending Methodology

General

The following is a general discussion of statistical trending techniques.

A common approach to the statistical analysis of trend is based on regression methods. In particular, it is often the case that a relationship exists between the values assumed by a pair of variables. For example, if x is time (in years), and y is the rate of events per year, then we could use regression methods to study whether there is a relationship between time and event rate.

Regardless of the application, it is standard practice to refer to x as the independent variable and y as the dependent variable. Another common term for the dependent variable is "response variable," and the terms covariant and explanatory variable are sometimes used for the independent variable. Also, it is typical with regression modeling that the independent variable can be measured with little or no error, but the dependent variable involves a random error. Consequently, even if there is a deterministic functional relationship between the two variables, when data pairs (x_1, y_1), (x_2, y_2),..., (x_n, y_n) are plotted, the points will not coincide exactly with the function, but instead will tend to be scattered. Such a plot is called a scatter diagram, and shows the variation in the data. The plots in this report are bar charts containing the same information.

Fitting a Straight Line to Data

Consider a linear function

$$f(x) = \alpha + \beta x \tag{B-1}$$

where α and β are unknown parameters. A common model is that y is the sum of a linear function of the form (1) and a random error term, e. Standard results on estimation and inference about the parameters of the model assume that e is a normally distributed random variable with mean 0 and constant (but unknown) variance, σ^2. These assumptions mean that:

- Each yi is an observed value of a random quantity that is normally distributed [with mean f(xi)], and
- All the observations yi are of variables with a common variance, σ2.

The y_i are also assumed to be observations of random quantities that are independent of each other.

Under these conditions, the usual approach to estimating the unknown parameters α and β is the method of least squares (LS). In this method, α and β are selected so that the sum of the squares of the vertical distances between the data points and the fitted line is as small as possible. The LS method leads to the estimates

$$\hat{\beta} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})y_i}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \text{ and} \tag{B-2}$$

$$\hat{\alpha} = \bar{y} - \hat{\beta}\bar{x}\,, \tag{B-3}$$

where $\bar{x}$ and $\bar{y}$ are arithmetic averages. The estimated LS regression line is then

$$\hat{y} = \hat{\alpha} - \hat{\beta}x\,, \tag{B-4}$$

and an estimate of σ is

$$s = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \hat{y}_i)^2}{n-2}} \,. \tag{B-5}$$

Testing for Trend

A trend exists whenever the true slope, β, is not zero. We start the analysis with the idea that β is zero, and then ask whether the data tell us otherwise. Two quantities computed from the data are used in this assessment. The first, the *error sum of squares* (SSE), appears in the numerator of s. It is defined as

$$SSE = \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \,. \tag{B-6}$$

This quantity is the number that is minimized in order to find the estimates of α and β. The differences being squared in SSE represent random variations that remain after the linear fitting process. The second quantity is the *regression sum of squares* (SSR), defined by the following equation

$$SSR = \sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2 \,. \tag{B-7}$$

Note that SSR looks at deviations between the fitted line and the default notion that the data are constant and have no slope.

One can show by algebra that

$$SSE + SSR = SST \,, \tag{B-8}$$

where the *total sum of the squares* (SST), is defined as

$$SST = \sum_{i=1}^{n} (y_i - \bar{y})^2 \,. \tag{B-9}$$

SST measures the overall variation in the data. It is the numerator that would be used to estimate the variance in a sample from a normally-distributed random variable, where all the data in the sample have the same distribution (and thus no trend). This variance measures "random variation" in such a sample.

In the framework of the linear function (1), the regression's effectiveness is measured by the *SSR* term defined above. When it is small, the fitted curve will not differ very much from the horizontal line $y = \bar{y}$. *SSE* will be approximately equal to *SST*, and, from the data, both *SSE* and *SST* will be estimates of mere random variation. In this case, the data does not provide evidence that β is different from zero.

On the other hand, if the y values tend to vary linearly with respect to the independent variable, x, then some of the variation in the y values can be attributed to this dependence on x. Since *SSR* assesses the difference between the least squares predictions of the y values and the arithmetic mean, $\bar{y}$, it is a measure of the variation which is "explained" by the linear relationship. When the slope of the fitted line is large, more of these differences will tend to be large, resulting in a large value of *SSR*.

In the equation, $SST = SSE + SSR$, the total variation is partitioned into two parts, the variation due to random error and the variation due to the linear relationship. The fraction of the total variation that is due to the linear relationship is called the coefficient of determination, or r^2, and is defined by:

$$r^2 = \frac{SSR}{SST} \,. \tag{B-10}$$

r^2 is a fraction that varies from 0 to 1. It will be near 0 if most of the variation is due to randomness, and it will be near 1 if most of the variation is due to the linear relationship.

The closeness to 1 needed for the data to show that the slope is not zero depends on the number of data points. If the dependent data are independent, normally-distributed at each x, with constant variance, and no trend, then the quantity, F, defined by

$$F = \frac{(n-2)\,r^2}{1-r^2} \tag{B-11}$$

can be shown to have an F distribution with degrees of freedom 1 and $n - 2$, where n is the number of data points. When the data satisfy the assumptions except that there is a significant trend, r^2 will be closer to 1 and the computed F statistic will be much larger. Specifically, if the computed F exceeds the upper fifth percentile of the F distribution with 1 and $n - 2$ degrees of freedom, we infer that the data contain evidence that β is not zero, at the 5% level of significance. In this case, we reject the null hypothesis that $\beta = 0$ and conclude that a statistically significant trend exists, with 95% confidence.

As an example, for an assumed set of data fit to the linear model, assume the $r^2 = 0.9369$ and that n is 13. Then the calculated F is 163.3. The upper 95th percentile of the $F(1,11)$ distribution is 4.84. Since 163.3 far exceeds the upper 95th F percentile, the linear model is statistically significant. In this example, the data show that it would be very unlikely for a trend not to exist. The linear model explains too much of the variation in the data for a trend not to exist.

Applying the Model to the NMED Data

The method described above was applied for each category of NMED event data, for the overall NMED data, and for additional subgroups of data when trends were found in the overall data. When the calculated F exceeded the 95th percentile, the trend line was shown on the graph and identified as being statistically significant.

In future reports, methods slightly different than that explained above could be employed because the NMED data in many cases does not follow the assumptions listed above. In particular, three considerations apply.

- The data are counts, and thus are discrete rather than being normally distributed. This problem is most pronounced when the counts are relatively low or sparse. Also, normally-distributed data in general can be negative, but the counts are always greater than or equal to zero.
- Variations in counts tend to increase as the counts increase. If the events occur at random, with a constant occurrence rate in a particular year or quarter, then the variance of the count for that year or quarter is equal to the mean or average for that year or quarter. Thus, the assumption of a constant variance for the data in each year may not apply.
- Finally, more than one count can be associated with a single reported incident in a single event category. This situation would occur, for example, if several pieces of equipment fail in an event or if several types of overexposure occur. In these cases, the data are not independent.

One way to address the first two concerns is to identify the number of licensees in various NMED categories and study the event occurrence rates rather than the counts. The rates are more likely to come from a continuum, and might have a more constant variance.

Taking logarithms of the counts and then applying the LS method avoids the problem of possible negative trend lines. The resulting models can be converted back to the scale of the counts after the regression line is identified. In the scale of the counts, the resulting trend, if any, has a slight curvature.

Weighted regression is a method similar to the LS method described above, but it compensates explicitly for the effect of the different variances from year to year.

Another approach that deals with the first two concerns is to apply regression methods that have been designed specifically for counts. Poisson regression, for example, is based on the idea that the data in each time period are counts observed from a Poisson distribution, with an occurrence rate that is described by the model. Given occurrence rates in each time period, and independent counts, the probability of seeing the observed data is easily computed by multiplying the occurrence probabilities for the individual time periods. The slope and intercept parameter estimates are selected so that the model maximizes the resulting "likelihood function."

The third issue may have little effect on the results of a trend analysis, as long as there are many counts with relatively few occurring in clumps, no trends in the occurrence of clumps, and no large clumps of counts coming from a single occurrence report. The best way to address the dependence issue is to identify and remove the duplicate counts prior to the trend analysis.

Appendix C

IAEA Radionuclide Categorization

Appendix C
IAEA Radionuclide Categorization

Table C-1 lists the radionuclides that this report uses to determine the significance for events involving the loss, abandonment, or theft of radioactive sources. This list is derived from the IAEA *Code of Conduct on the Safety and Security of Radioactive Sources (2004)* and from IAEA Safety Guide RS-G-1.9, *Categorization of Radioactive Sources*. Based on the amount of radioactivity involved, the radionuclides are grouped into five categories, with Category 1 being the most hazardous. These categories may be summarized as follows (derived from IAEA Safety Guide RS-G-1.9, *Categorization of Radioactive Sources*):

Category 1: **Extremely dangerous.** These sources could cause permanent injury within a few minutes if handled. Doses could be fatal to someone in close proximity to an unshielded source for periods ranging from a few minutes to an hour.

Category 2: **Very dangerous.** These sources could cause permanent injury within minutes to hours if handled. Doses could be fatal to someone in close proximity to an unshielded source for periods ranging from hours to days.

Category 3: **Dangerous.** These sources could cause permanent injury within hours if handled. Doses could possibly (but unlikely) be fatal to someone in close proximity to an unshielded source for periods ranging from days to weeks.

Category 4: **Unlikely to be dangerous.** These sources would not cause permanent injury, although delayed health effects are possible. Doses could possibly (but unlikely) cause temporary injury to someone in close proximity to an unshielded source for a period of many weeks.

Category 5: **Most unlikely to be dangerous.** These sources would not cause permanent injury.

Table C-1. IAEA Code of Conduct Category 1 through 5 Radionuclide Activity Thresholds

Radionuclide	Category 1		Category 2		Category 3		Category 4		Category 5	
	TBq	Ci [1]	TBq	Ci [1]	TBq	Ci [1]	TBq	Ci [1]	TBq	Ci [1]
Am-241	60	1,622	0.6	16.2	0.06	1.62	0.0006	0.0162	1.0e-08	2.7e-07
Am-241/Be	60	1,622	0.6	16.2	0.06	1.62	0.0006	0.0162	1.0e-08	2.7e-07
Cf-252	20	541	0.2	5.4	0.02	0.54	0.0002	0.0054	1.0e-08	2.7e-07
Cm-244	50	1,352	0.5	13.5	0.05	1.35	0.0005	0.0135	1.0e-08	2.7e-07
Co-60	30	811	0.3	8.1	0.03	0.81	0.0003	0.0081	1.0e-07	2.7e-06
Cs-137	100	2,703	1.0	27.0	0.10	2.70	0.001	0.0270	1.0e-08	2.7e-07
Gd-153	1,000	27,030	10.0	270.3	1.00	27.03	0.01	0.2703	1.0e-05	2.7e-04
Ir-192	80	2,162	0.8	21.6	0.08	2.16	0.0008	0.0216	1.0e-08	2.7e-07
Pm-147	40,000	1,081,200	400.0	10,812.0	40.00	1,081.20	0.4	10.8120	1.0e-05	2.7e-04
Pu-238	60	1,622	0.6	16.2	0.06	1.62	0.0006	0.0162	1.0e-08	2.7e-07
Pu-239/Be	60	1,622	0.6	16.2	0.06	1.62	0.0006	0.0162	1.0e-08	2.7e-07
Ra-226	40	1,081	0.4	10.8	0.04	1.08	0.0004	0.0108	1.0e-08	2.7e-07
Se-75	200	5,406	2.0	54.1	0.20	5.41	0.002	0.0541	1.0e-06	2.7e-05
Sr-90 (Y-90)	1,000	27,030	10.0	270.3	1.00	27.03	0.01	0.2703	1.0e-08	2.7e-07
Tm-170	20,000	540,600	200.0	5,406.0	20.00	540.60	0.2	5.4060	1.0e-06	2.7e-05
Yb-169	300	8,109	3.0	81.1	0.30	8.11	0.003	0.0811	1.0e-05	2.7e-04

Notes

1. The primary values are given in TeraBequerel (TBq). Curie (Ci) values are provided for practical usefulness only and are rounded after conversion.

Appendix D

Revision of Data

Appendix D
Revision of Data

The NMED is a dynamic database with new reports and revisions to previous reports being added on a continuing basis. This activity can result in additions or subtractions to data that was published in previous issues of this report. Numerical changes in NMED numbers can result from several different types of technical changes to coded data. The most common types of changes to database records are:

- Record additions due to late reporting
- Record additions or subtractions due to changes in event type
- Changes between fiscal years due to event date changes on individual events
- Record additions or subtractions due to changes in event reportability
- Record additions or subtractions due to reclassifying a single combined event as multiple individual events (or vice versa)
- Record deletions due to duplicated records or NRC direction

Figures D-1 through D-9 below display the changes in the data published in the previous annual report. A positive value indicates that records were added and a negative value indicates that records were removed.

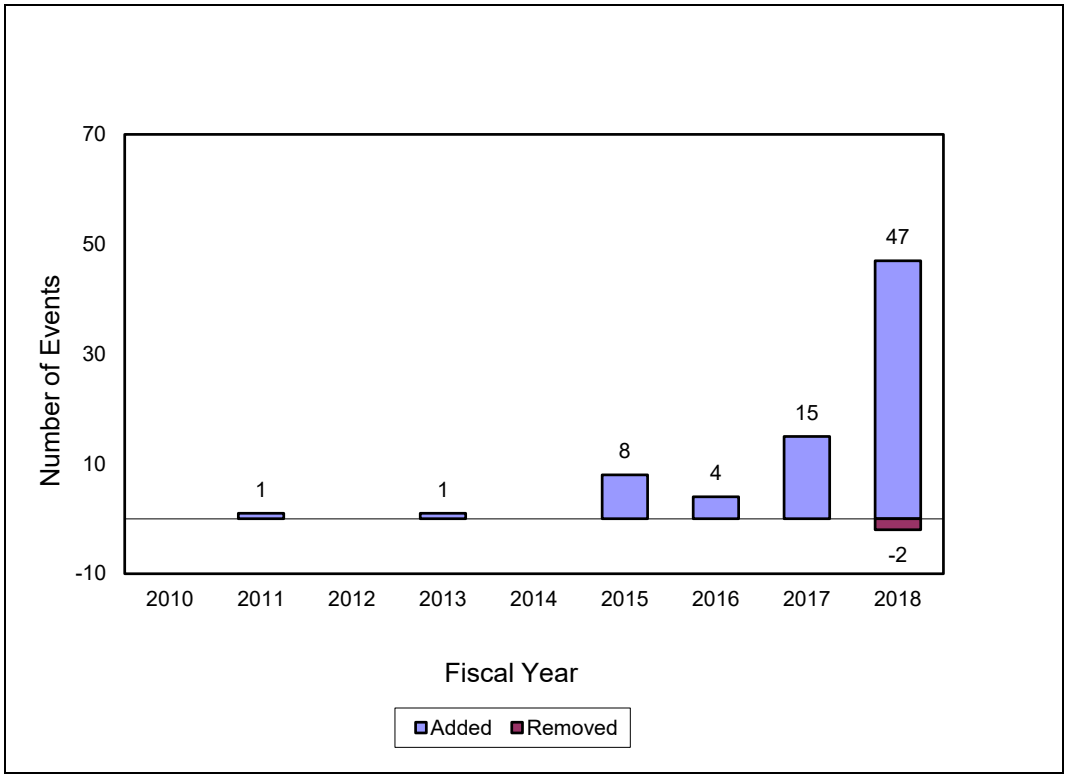

Figure D-1. Changes to All NMED Event Data

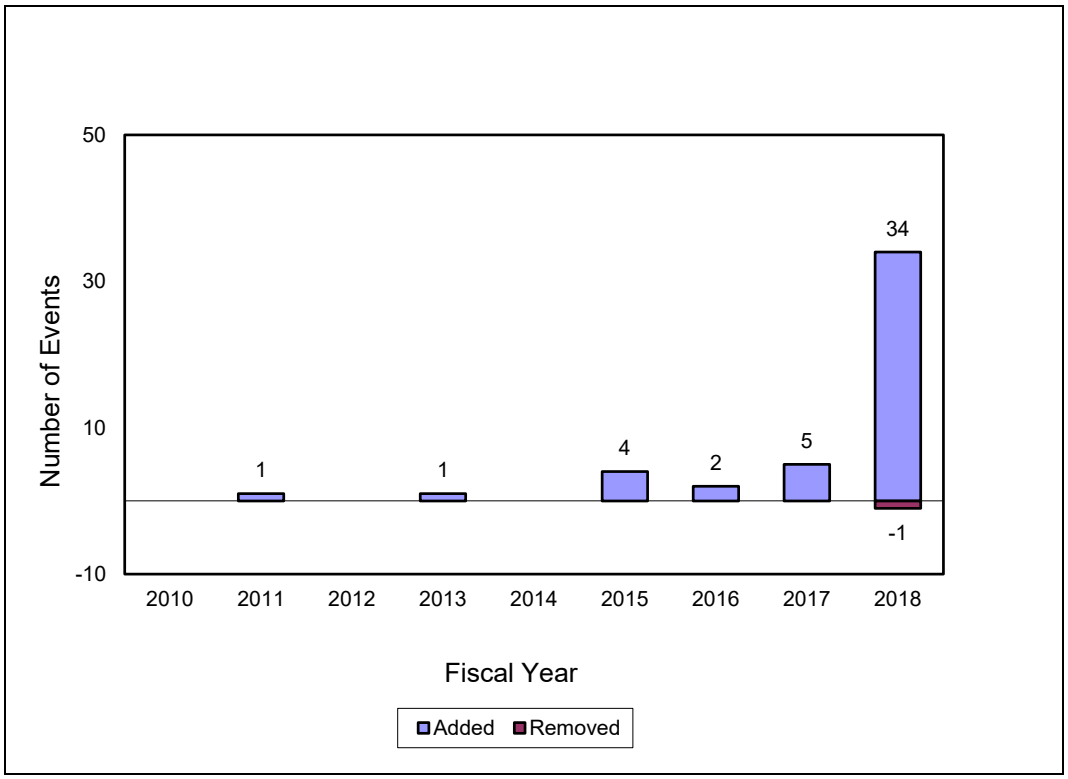

Figure D-2. Changes to LAS Data

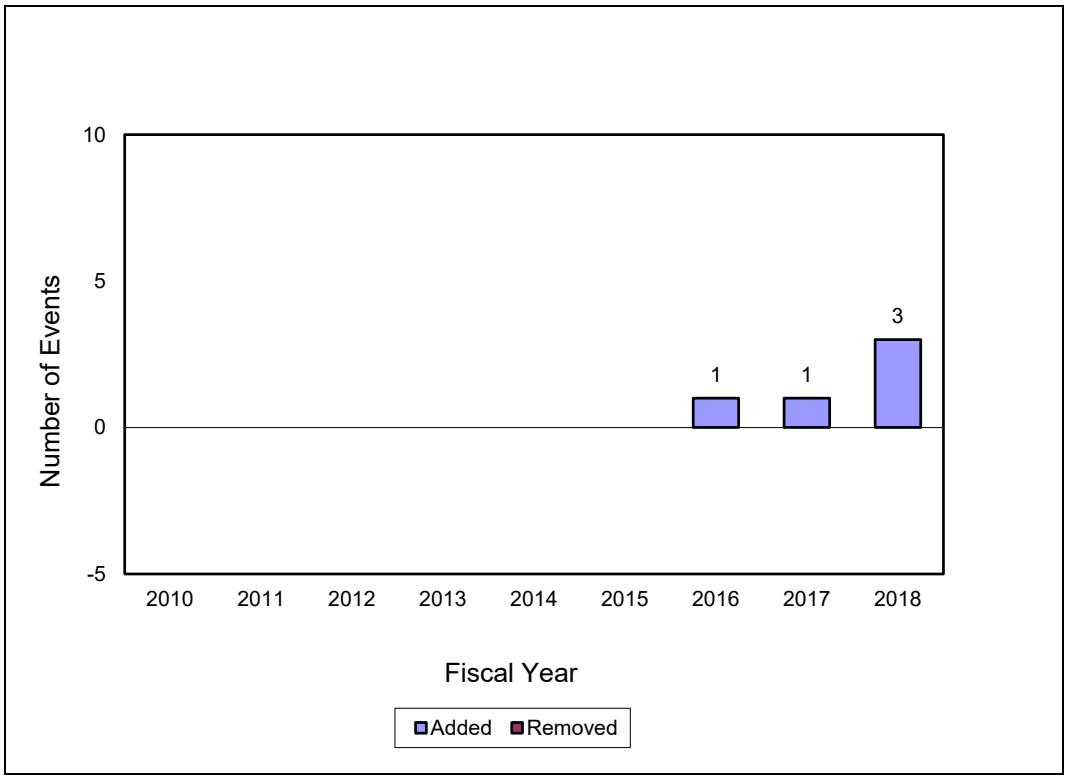

Figure D-3. Changes to MED Data

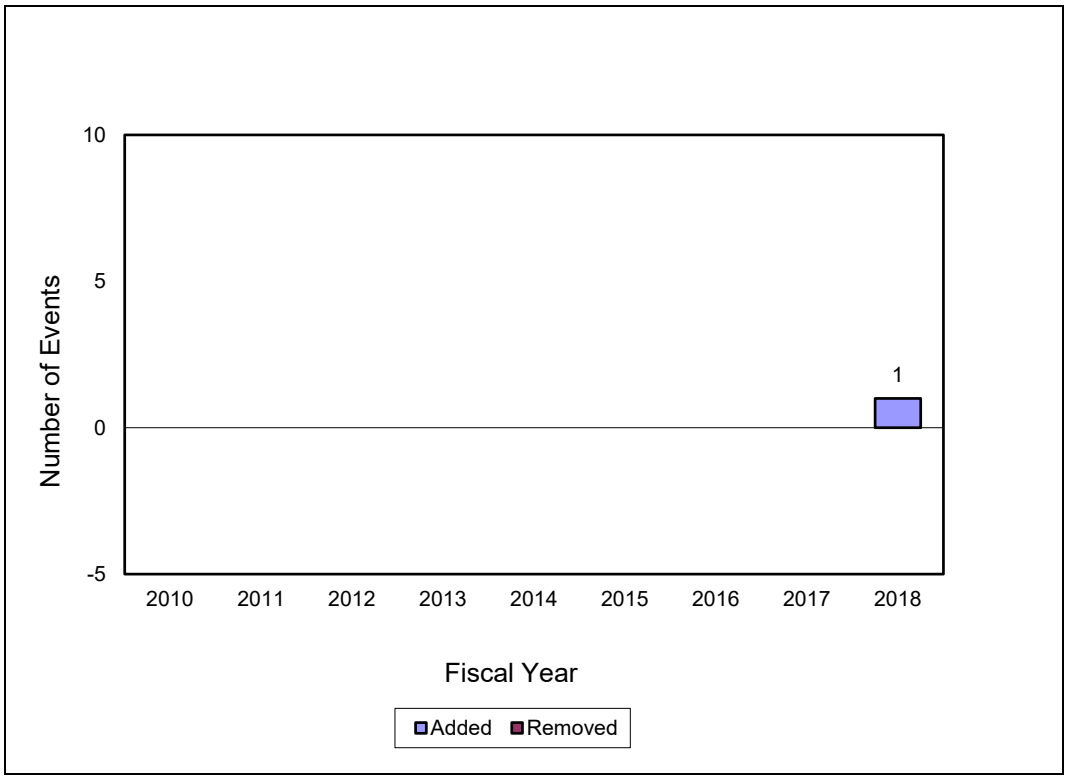

Figure D-4. Changes to EXP Data

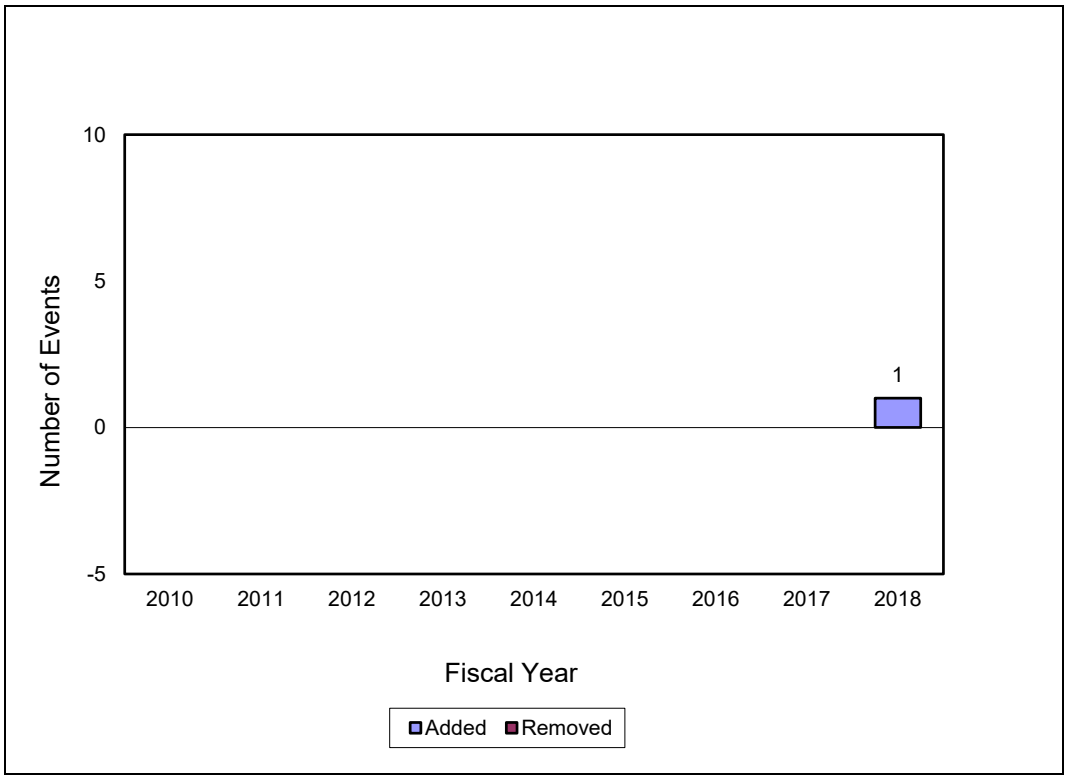

Figure D-5. Changes to RLM Data

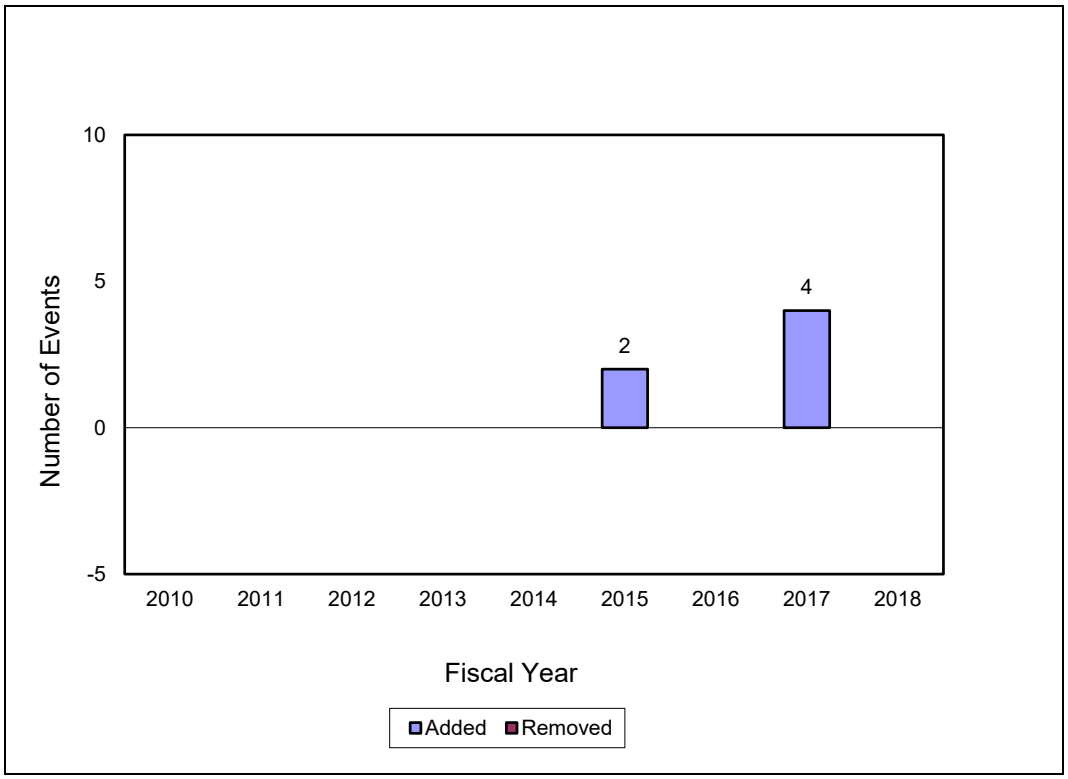

Figure D-6. Changes to LKS Data

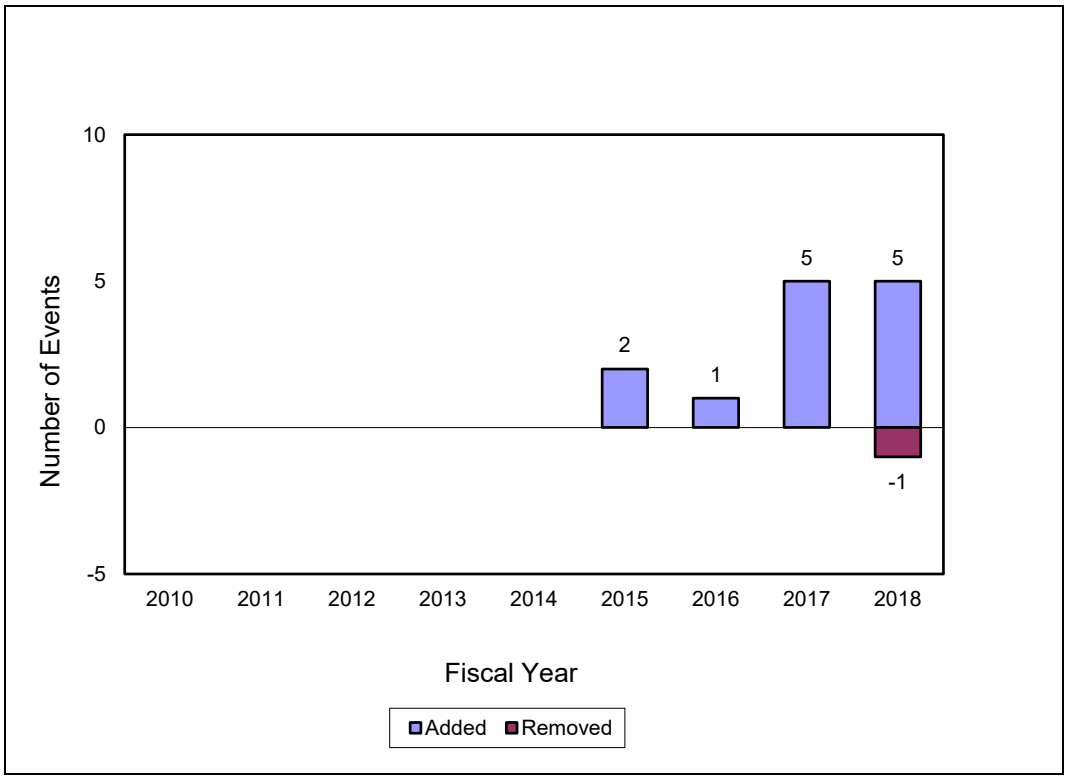

Figure D-7. Changes to EQP Data

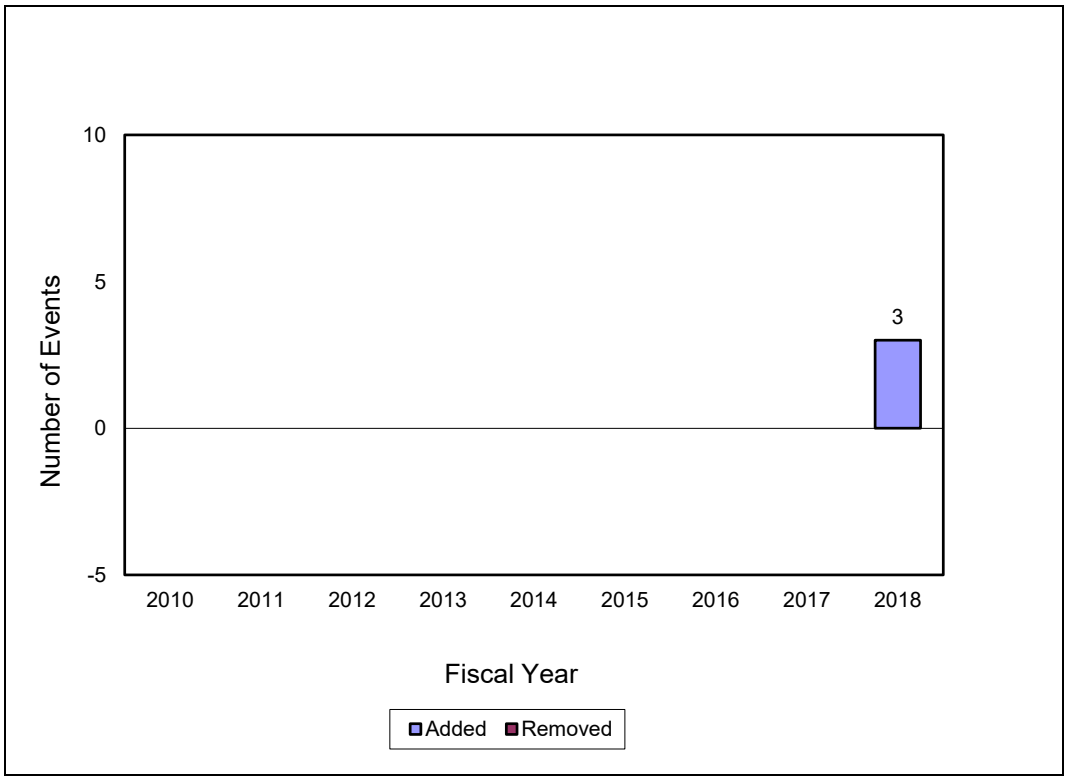

Figure D-8. Changes to TRS Data

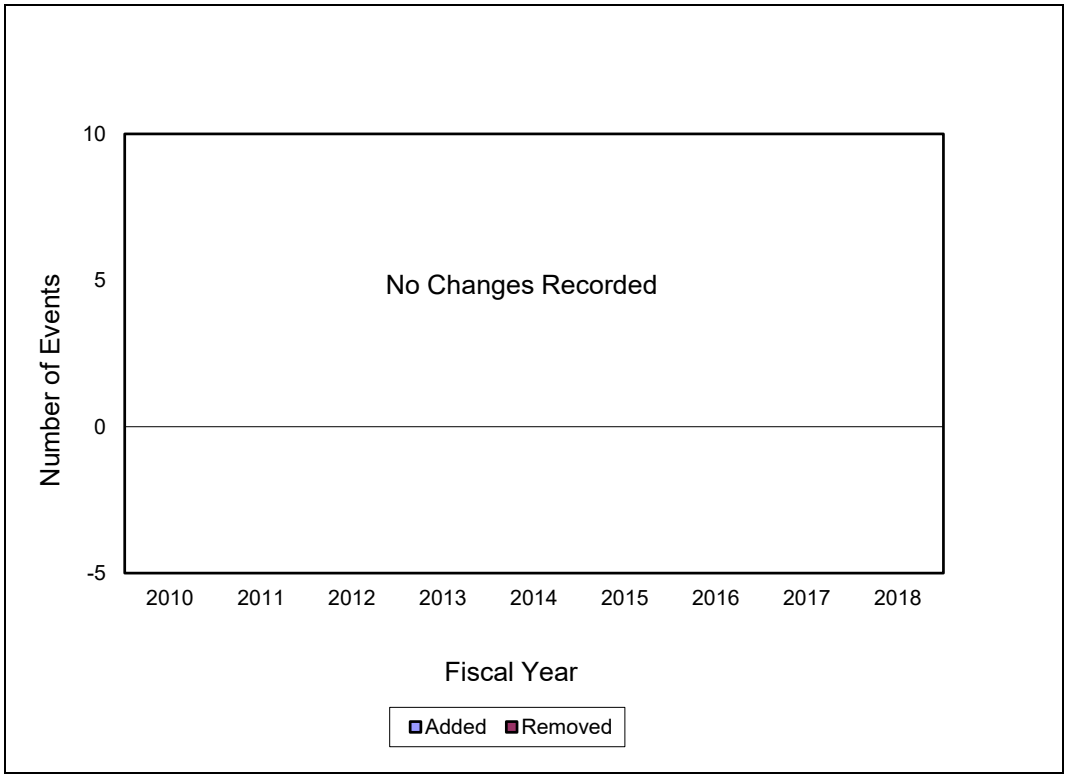

Figure D-9. Changes to OTH Data