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Docket No. 50-312
Rancho Seco Nuclear Generating Station
License No. DPR-54

ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT FOR 2016

Attention: Zahira Cruz

In accordance with 10 CFR 50.36a(a)(2) and Rancho Seco Quality Manual (RSLBD-010), Appendix A, Section 1.5.2.4, we are submitting the Rancho Seco 2016 Annual Radioactive Effluent Release Report for the period of January 1 through December 31, 2016.

If you or members of your staff have questions requiring additional information or clarification, please contact me at (916) 732-4893.

Sincerely,

A handwritten signature in black ink, appearing to read "Dan Tallman".

Dan A. Tallman
Manager, Rancho Seco Assets

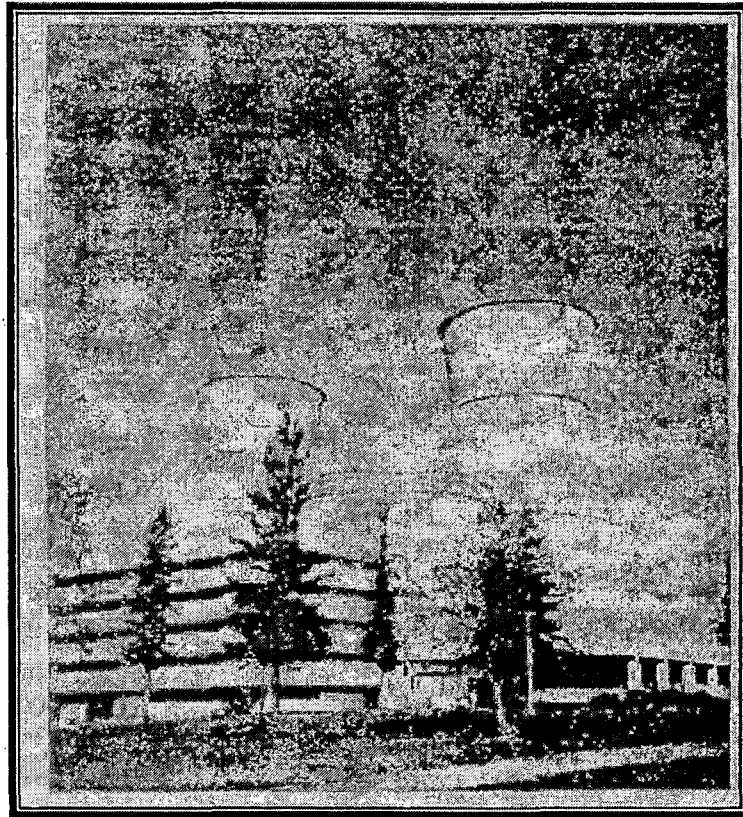
Enclosures (Attachment: Rancho Seco Annual Radioactive Effluent Release Report for 2016)

Cc: NRC, Jack Parrot, Region IV w/Attachment
DPG Chron w/ Attachment
RIC 1F.099 wAttachment
RIC 1L.320 (Report only)

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**RANCHO SECO
NUCLEAR GENERATING STATION**

LICENSE NUMBERS DPR-54 and SNM-2510



ANNUAL RADIOACTIVE EFFLUENT RELEASE REPORT

JANUARY – DECEMBER 2016

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None	

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INTRODUCTION

Rancho Seco Nuclear Generating Station (RSNGS) Unit No. 1 is located in Sacramento County, California approximately 25 miles southeast of Sacramento and 26 miles north-northeast of Stockton. Rancho Seco Unit No. 1 began commercial operation on April 17, 1975. The single unit on the Rancho Seco site was a pressurized water reactor supplied by Babcock and Wilcox. The rated capacity was 913 megawatts electrical. Because of a public vote on June 6, 1989, Sacramento Municipal Utility District (SMUD) shutdown the Rancho Seco Nuclear Generating Station and completed defueling operations on December 8, 1989. Transfer of the spent fuel rod assemblies from the Spent Fuel Pool into dry storage at the Independent Spent Fuel Storage Installation (ISFSI) was completed on August 21, 2002. Radiological dismantlement of the nuclear facility was completed in December 2008 and the release of the Rancho Seco property, except for the area associated with the Interim Onsite Storage Building (IOSB), from NRC license DPR-54 was approved on September 25, 2009. With the completion of Phase I of decommissioning, the facility was placed in a SAFSTOR-type condition awaiting a suitable disposal option for the low-level radioactive waste in storage in the IOSB. In 2014, the Class B & C radioactive waste stored in the IOSB was shipped to a suitable disposal facility in Texas. Phase II of decommissioning (the IOSB and surrounding area) began in 2015 and is expected to be completed in the first quarter of 2017.

This Annual Radioactive Effluent Release Report (ARERR) provides a summary of gaseous and liquid effluent releases made from Rancho Seco during the period of January 1 through December 31, 2016. This report also provides a summary of solid radioactive waste shipments during the reporting period.

In the current condition, there are no radioactive liquids or liquid systems at the facility. Radioactive material handling during limited remediation activities associated with the Phase II decommissioning effort, as well as subsequent waste packaging activities were monitored with local air sampling as was the exhaust ventilation system. None of these portable air samples returned activity levels above MDA, eliminating the potential of radioactive material being released from the facility in gaseous effluents. Accordingly, there were no radioactive liquid or gaseous effluent releases made from Rancho Seco during the reporting period.

One shipment of solid radioactive waste was made during the reporting period utilizing contract brokerage services.

This report has been prepared by SMUD to meet the requirements of Rancho Seco Quality Manual (RSQM), Appendix A, Section 1.5.2.4 and Offsite Dose Calculation Manual (ODCM) Revision 23, Step 6.10.1. It is presented in accordance with the format of USNRC Regulatory Guide 1.21. Radiation doses associated with radioactive effluents in liquids and gasses would be calculated for a hypothetical individual who receives the maximum possible exposure at or beyond the applicable Site Boundary, had any releases occurred.

Since there were no releases of radioactivity in gaseous and liquid effluents during this report period, the limits of 10 CFR 20 were not exceeded, nor were the numerical guidelines of 10 CFR 50, Appendix I exceeded. A 40 CFR 190 dose evaluation is not required because radioactive effluent releases did not exceed twice the numerical guidelines of 10 CFR 50, Appendix I.

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I. SUPPLEMENTAL INFORMATION

A. Regulatory Limits & Guidelines for Effluent Releases

1. Gaseous Effluents

- a. Dose rate limit at or beyond the Site Boundary for Gaseous Effluents for Tritium and radioactive material in particulate form with half-lives greater than 8 days (ODCM Technical Requirement 6.9.3):
1500 mrem/year to any organ
- b. Dose commitment to a member of the public at or beyond the Site Boundary for Gaseous Effluents from Tritium and radioactive material in particulate form with half-lives greater than 8 days (ODCM Technical Requirement 6.9.4, numerical guidelines of 10 CFR 50, Appendix I):
7.5 mrem per calendar quarter to any organ
15 mrem per calendar year to any organ

2. Liquid Effluents

- a. The concentration of radioactive material in liquid effluents released beyond the Site Boundary for Liquid Effluents shall not exceed the limits of 10 CFR 20, Appendix B, Table 2, Column 2.
- b. Dose commitment to a member of the public at or beyond the Site Boundary for Liquid Effluents from radioactive materials in liquid effluents shall be limited to (numerical guidelines of 10 CFR 50, Appendix I):
1.5 mrem per calendar quarter to the total body
5 mrem per calendar quarter to any organ
3 mrem per calendar year to the total body
10 mrem per calendar year to any organ

NOTE: The noble gas source term was removed when spent fuel transfer to the ISFSI was completed in August 2002. Reference to noble gases was completely removed from the ODCM.

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B. Maximum Effluent Concentrations

1. Gaseous Effluents

The concentrations listed in 10 CFR 20, Appendix B, Table 2, Column 1 (air) are not directly used in calculations for determining permissible gaseous effluent release rates. The annual dose limits of 10 CFR 20 for unrestricted areas are the doses associated with the concentrations of 10 CFR 20, Appendix B, Table 2, Column 1. ODCM Technical Requirement dose rate limits (mrem/yr) for gaseous effluents are provided to ensure that the dose rate from gaseous effluents at any time at the Site Boundary for Gaseous Effluents will be within the annual dose limits of 10 CFR 20 for unrestricted areas. These dose rate limits (listed above in part A) are used for determining permissible gaseous effluent release rates.

2. Liquid Effluents

The concentration values listed in 10 CFR 20, Appendix B, Table 2, Column 2 are used in calculations to determine permissible liquid discharge flow rates. The most conservative Maximum Effluent Concentration (MEC) value for each radionuclide detected in the liquid effluent sample is used in the calculations.

C. Measurement Methods for Total Radioactivity

The methods listed below are examples should radioactive effluents be discharged.

1. Gaseous Effluents

Liquid Scintillation (H-3)
Gamma Spectroscopy (HPGe)
Beta Proportional (Sr-90, gross beta)
Alpha Proportional (gross alpha)

2. Liquid Effluents

Gamma Spectroscopy (HPGe)
Liquid Scintillation (H-3)
Beta Proportional (Sr-90, gross beta)
Alpha Proportional (gross alpha)

NOTE: HPGe refers to Hyper-Pure Germanium

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D. Batch Releases (via monitored pathways)

Liquid Discharges	<u>Quarter 1</u>	<u>Quarter 2</u>	<u>Quarter 3</u>	<u>Quarter 4</u>
Number of batch releases	0	0	0	0
Total time period for batch releases (hours)	N/A	N/A	N/A	N/A
Maximum time period for a batch release (hours)	N/A	N/A	N/A	N/A
Average time period for a batch release (hours)	N/A	N/A	N/A	N/A
Minimum time period for a batch release (hours)	N/A	N/A	N/A	N/A
Average Plant Effluent Flow (cfs)	N/A	N/A	N/A	N/A

None

E. Unplanned Releases

This section describes unplanned releases of radioactivity in liquid and gaseous effluent.

Gaseous

None

Liquid

None

F. Radioactive Effluent Monitoring Instrumentation Inoperable for Greater Than 30 Days

None

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II. ESTIMATION OF ERROR

The methods for establishing error estimates included review of applicable station procedures, inspection of sampling equipment, engineering estimates, statistical applications, review of calibration setpoint data, and communication with plant personnel. The various sources of error (s) in reported values of gaseous effluents, liquid effluents, and solid waste are assumed to be independent, and thus the total error is calculated according to the formula:

$$\text{Total Error} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 \dots + \sigma_i^2}$$

where: σ_i = relative error associated with component i

Sources of error for gaseous effluents include fan error (flow), grab sampling, collection, filter efficiency, counting, and calibration.

Sources of error for liquid effluents include collection container volume, dilution water flow rate, grab sampling, counting, and calibration.

Sources of error for solid waste include offsite lab smear analysis, dose rate meter calibration, dose rate meter reading, computer program dose-to-curie calculation, sample volume measurement, gamma spec counting, gamma spec calibration, and waste volume determination.

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III. GASEOUS EFFLUENTS

Table III-A, Gaseous Effluents - Summation of All Releases, provides a detailed summary of gaseous effluent releases per quarter. This table summarizes releases of tritium and particulates with half-lives greater than 8 days. The methodology used to calculate the Percent of ODCM Technical Requirement limit is as follows:

$$\% \text{ Tech Req Limit} = \frac{\sum_i [(F_i)(\text{Avg Rel Rate})(X/Q)(\text{Dose Factor})]}{(\text{Dose Rate Limit})} \times 100\%$$

where:

F_i = The fraction of the total number of Curies of nuclide i out of the total curies in that category for that quarter (unitless).

NOTE: F_i always equals 1.0 for H-3 because it is the only nuclide in the category.

$$\text{Avg Rel Rate} = \frac{(\text{Total Curies per category per quarter}) \left(\frac{1 \text{ E} + 06 \mu\text{Ci}}{\text{Ci}} \right)}{(\# \text{ seconds in the quarter})}$$

X/Q = A default dispersion factor determined to be conservative when compared to the use of actual data (sec/m³).

Dose Factor = The values derived for each nuclide i from NRC Regulatory Guide 1.109 (K_i, L_i+1.1M_i, or R_{aij}). [Units in (mrem/yr)/(μCi/m³)]

Dose Rate Limit = The Technical Requirement (i.e., Regulatory) limits for dose rate listed in Section I of this report (mrem/yr).

NOTE: Particulates with half-lives less than 8 days are not included in this calculation.

The methodology used to calculate the Estimated Total Error (%) in Table III-A is presented in Section II of this report.

Table III-B, Gaseous Effluents - Ground Level Releases, provides a complete quarterly summary of the amount of radioactivity (Ci) released per radionuclide in each quarter. Data from continuous and batch releases are provided for particulates and tritium. Data reported for batch releases results only from unplanned releases.

Table III-C, Gaseous Effluents - Typical Lower Limits of Detection, provides a listing of the typical lower limit of detection (LLD) concentrations in μCi/cc for various radionuclides.

Table III-D, Radiological Impact on Man Due to Gaseous Effluent Releases, provides a summary of calculated radiation doses delivered to a maximum exposed hypothetical individual at the Site Boundary for Gaseous Effluents (actual doses will be assessed in the 2015 Annual REMP Report). The maximum calculated organ dose is listed for each quarter along with an annual total. The direct radiation dose results, based on monitoring badge dosimetry, are also listed. Presented in this table for each category is a comparison versus ODCM Technical Requirement dose limits with the exception of direct radiation measurements.

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TABLE III-A: GASEOUS EFFLUENTS - SUMMATION OF ALL RELEASES

	<u>Unit</u>	<u>Quarter 1</u>	<u>Quarter 2</u>	<u>Quarter 3</u>	<u>Quarter 4</u>	<u>Est. Total Error, %</u>
A. Particulates						
1. Particulates with half-lives>8 days	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	N/A
2. Average Release Rate for period	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
3. Percent of Tech Req limit	%	N/A	N/A	N/A	N/A	
4. Gross Alpha radioactivity	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
B. Tritium						
1. Total Release	Ci	0.00E+00	0.00E+00	0.00E+00	0.00E+00	N/A
2. Average Release Rate for period	µCi/sec	0.00E+00	0.00E+00	0.00E+00	0.00E+00	
3. Percent of Tech Req limit	%	N/A	N/A	N/A	N/A	

TABLE III-B: GASEOUS EFFLUENTS - GROUND LEVEL RELEASES

Nuclides Released

1. Particulates

None

2. Tritium

None

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TABLE III-C: GASEOUS EFFLUENTS - TYPICAL LOWER LIMITS OF DETECTION

<u>RADIONUCLIDES</u>	<u>LLD ($\mu\text{Ci/cc}$)</u>
1. Tritium (H-3)	2.27 E-10
2. Particulates:	
Manganese-54	2.08 E-12
Cobalt-58	2.29 E-12
Iron-59	5.89 E-12
Cobalt-60	3.11 E-12
Strontium-89	2.00 E-15
Strontium-90	5.00 E-15
Cesium-134	1.52 E-12
Cesium-137	1.88 E-12
Barium-140	3.06 E-12
Cerium-141	1.15 E-12
Cerium-144	3.69 E-12

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TABLE III-D: RADIOLOGICAL IMPACT ON MAN DUE TO GASEOUS EFFLUENT RELEASES

CALCULATED RADIATION DOSES AT THE SITE BOUNDARY FOR GASEOUS EFFLUENTS:

	<u>Unit</u>	<u>Quarter 1</u>	<u>Quarter 2</u>	<u>Quarter 3</u>	<u>Quarter 4</u>	<u>2016 Annual</u>
A. Tritium, Particulate						
1. Maximum Organ Dose	mrem	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
2. Percent Tech Req limit	%	N/A	N/A	N/A	N/A	N/A
B. Direct Radiation						
1. Dose (Monitoring Badges) ¹	mrem	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
2. Percent of Tech Req limit	%	N/A	N/A	N/A	N/A	N/A

NOTE: No releases of gaseous radioactive effluent were made from Rancho Seco Nuclear Generating Station in 2016.

¹ None of the Indicator stations indicate significant radiation attributable to facility operations.

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IV. LIQUID EFFLUENTS

Table IV-A, Liquid Effluents - Summation of All Releases, provides a detailed summary of liquid effluent releases per quarter. This table summarizes releases of fission and activation products, tritium, dissolved and entrained gases, and gross alpha radioactivity. Also listed is the volume of waste released prior to dilution and the volume of dilution water used during each quarter.

The following methodology is used to calculate the Average Diluted Concentration and the Percent of ODCM Technical Requirement Limit in Table IV-A:

$$\% \text{ Tech Req Limit} = \sum_i^n \left[\frac{C_i}{\text{MEC}_i} \right]$$

where: n = The total number of radionuclides identified
C_i = The average diluted concentration of radionuclide i

$$= \frac{(\text{Total Release per Category per Quarter in } \mu\text{Ci})}{(\text{Total Release Volume (part F in Table IV - A) in ml)}$$

MEC_i = The MEC of the ith radionuclide, from 10 CFR 20, Appendix B, Table 2, Column 2

The methodology used to calculate the estimated total error in Table IV-A is presented in Section II of this report.

Table IV-B, Liquid Effluents, provides a complete quarterly summary of the amount of radioactivity (Ci) released per radionuclide in each quarter. Data is provided for fission and activation products, and for dissolved and entrained gases. Tritium and gross alpha are not included in this table (they are listed in Table IV-A). Since no continuous releases of liquid radioactive effluent are made from RSNGS, data is provided only for batch releases.

Table IV-C, Liquid Effluents - Typical Lower Limits of Detection, provides a listing of the typical lower limit of detection (LLD) concentrations in $\mu\text{Ci/ml}$ for various radionuclides.

Table IV-D, Radiological Impact on Man Due To Liquid Effluent Releases, provides a summary of calculated radiation doses delivered to a maximum exposed hypothetical individual at the Site Boundary for Liquid Effluents (actual doses will be assessed in the 2015 Annual REMP Report). The maximum calculated total body dose and organ dose are listed for each quarter along with an annual total. A comparison versus ODCM Technical Requirement dose limits is also presented.

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TABLE IV-A: LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

	<u>Unit</u>	<u>Quarter 1</u>	<u>Quarter 2</u>	<u>Quarter 3</u>	<u>Quarter 4</u>	<u>Est. Total Error. %</u>
A. Fission & Activation Products						
1. Total Release (not including tritium, gases, alpha)	Ci	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	N/A
2. Average diluted concentration during period	µCi/ml	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	
3. Percent of Tech Req limit	%	N/A	N/A	N/A	N/A	
B. Tritium						
1. Total Release	Ci	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	N/A
2. Average diluted concentration during period	µCi/ml	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	
3. Percent of Tech Req limit	%	N/A	N/A	N/A	N/A	
C. Dissolved and Entrained Gases						
1. Total Release	Ci	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	N/A
2. Average diluted concentration during period	µCi/ml	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	
D. Gross Alpha radioactivity						
1. Total Release	Ci	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	N/A
E. Volume of Waste Released (prior to dilution)						
	Liters	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	N/A
F. Volume of dilution water used during period						
	Liters	N/A	N/A	N/A	N/A	N/A

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TABLE IV-B: LIQUID EFFLUENTS

Nuclides Released

1. Fission and activation products
(excluding tritium, gross alpha)

None

2. Dissolved and entrained gases

None

NOTE: No releases of liquid radioactive effluent were made from Rancho Seco Nuclear Generating Station in 2016.

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TABLE IV-C: LIQUID EFFLUENTS - TYPICAL LOWER LIMITS OF DETECTION

<u>RADIONUCLIDES</u>		<u>BATCH MODE: LLD ($\mu\text{Ci/ml}$)</u>
1.	Tritium (H-3)	2.60 E-06
2.	Particulates:	
	Manganese-54	2.11 E-09
	Iron-59	3.71 E-09
	Cobalt-57	2.12 E-09
	Cobalt-58	1.93 E-09
	Cobalt-60	1.98 E-09
	Zinc-65	4.34 E-09
	Strontium-90	5.00 E-10
	Ruthenium-106	1.79 E-08
	Silver-110m	1.94 E-09
	Antimony-125	5.78 E-09
	Cesium-134	1.93 E-09
	Cesium-136	2.23 E-09
	Cesium-137	2.30 E-09
	Barium-140	7.75 E-09
	Cerium-141	3.60 E-09
	Cerium-144	1.59 E-08

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TABLE IV-D: RADIOLOGICAL IMPACT ON MAN DUE TO LIQUID EFFLUENT RELEASES

CALCULATED RADIATION DOSE COMMITMENTS FOR LIQUID EFFLUENTS:

	<u>Unit</u>	<u>Quarter 1</u>	<u>Quarter 2</u>	<u>Quarter 3</u>	<u>Quarter 4</u>	<u>2016 Annual</u>
A. Maximum Total Body Dose	mrem	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Percent Tech Req limit	%	N/A	N/A	N/A	N/A	N/A
B. Maximum Organ Dose	mrem	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00	0.00 E+00
Percent Tech Req limit	%	N/A	N/A	N/A	N/A	N/A

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V. SOLID WASTE

A. SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (Not irradiated fuel)

Table V-A: Low-Level Waste

Resins, Filters, and Evaporator Bottoms	Volume		Curies Shipped
Waste Class	ft ³	m ³	Curies
A	0.00 E+00	0.00 E+00	0.00 E+00
B	0.00 E+00	0.00 E+00	0.00 E+00
C	0.00 E+00	0.00 E+00	0.00 E+00
All	0.00 E+00	0.00 E+00	0.00 E+00

Major Nuclides for the Above Table: None

Dry Active Waste	Volume		Curies Shipped
Waste Class	ft ³	m ³	Curies
A	1.05 E+03	2.97 E+01	2.22 E-04
B	0.00 E+00	0.00 E+00	0.00 E+00
C	0.00 E+00	0.00 E+00	0.00 E+00
All	1.05 E+03	2.97 E+01	2.22 E-04

Major Nuclides for the Above Table: Cs-137, Co-60

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Table V-A: Low-Level Waste (continued)

Irradiated Components	Volume		Curies Shipped
Waste Class	ft ³	m ³	Curies
A	0.00 E+00	0.00 E+00	0.00 E+00
B	0.00 E+00	0.00 E+00	0.00 E+00
C	0.00 E+00	0.00 E+00	0.00 E+00
All	0.00 E+00	0.00 E+00	0.00 E+00

Major Nuclides for the Above Table: None

Other Waste	Volume		Curies Shipped
Waste Class	ft ³	m ³	Curies
A	0.00 E+00	0.00 E+00	0.00 E+00
B	0.00 E+00	0.00 E+00	0.00 E+00
C	0.00 E+00	0.00 E+00	0.00 E+00
All	0.00 E+00	0.00 E+00	0.00 E+00

Major Nuclides for the Above Table: None

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Table V-A: Low-Level Waste (continued)

Sum of All Low-Level Waste Shipped from Site	Volume		Curies Shipped
Waste Class	ft ³	m ³	Curies
A	1.05 E+03	2.97 E+01	2.22 E-04
B	0.00 E+00	0.00 E+00	0.00 E+00
C	0.00 E+00	0.00 E+00	0.00 E+00
All	1.05 E+03	2.97 E+01	2.22 E-04

Major Nuclides for the Above Table: Cs-137; Co-60