Constellation

TS 6.9.1.8
TS 6.14.1.c

LG-24-053

April 30, 2023

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Limerick Generating Station, Units 1 and 2
Renewed Facility Operating License Nos. NPF-39 and NPF-85
NRC Docket Nos. 50-352 and 50-353 and 72-065

Subject: Annual Radioactive Effluent Release Report No. 49

The attachment to this letter satisfies the requirements of Section 6.9.1.8 of the Limerick Generating Station (LGS) Technical Specifications (TS) and Section 6.2 of the Offsite Dose Calculation Manual (ODCM). Attachment 1 is the Annual Radioactive Effluent Release Report No. 49, 2023 Limerick Generating Station.

Section 6.14.1.c of the LGS TS requires a copy of the ODCM to be submitted with the Annual Radioactive Effluent Release Report if the ODCM was revised during the period. The ODCM was not revised from January 1, 2023 to December 31, 2023 and is not submitted.

Limerick has reviewed the Dosimeter of Legal Record (DLR) data for the nearest residence from the ISFSI modules currently loaded. In 2023 there was no facility-related dose to the nearest resident from the ISFSI.

There are no commitments contained in this letter.

If you have any questions or require additional information, please contact Laura Lynch at 610-718-2003.

Respectfully,

Michael F. Gillin
Site Vice President – Limerick Generating Station
Constellation Energy Generation, LLC

Attachment 1: Annual Radioactive Effluent Release Report No. 49, 2023 Limerick Generating Station

cc: Administrator, Region I, USNRC (w/attachment)
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Constellation

Limerick Generating Station

Annual Radioactive Effluent Release Report 2023

Document Number: 49

Docket Nos. 50-352 and 50-353 and 72-065

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1.0 LIST OF ACRONYMS AND DEFINITIONS

1. Alpha Particle (α): A charged particle emitted from the nucleus of an atom having a mass and charge equal in magnitude of a helium nucleus.
2. BWR: Boiling Water Reactor
3. Composite Sample: A series of single collected portions (aliquots) analyzed as one sample. The aliquots making up the sample are collected at time intervals that are very short compared to the composite period.
4. Control: A sampling station in a location not likely to be affected by plant effluents due to its distance and/or direction from the plant.
5. Counting Error: An estimate of the two-sigma uncertainty associated with the sample results based on total counts accumulated.
6. Curie (Ci): A measure of radioactivity; equal to 3.7×10^{10} disintegrations per second, or 2.22×10^{12} disintegrations per minute.
7. Direct Radiation Monitoring: The measurement of radiation dose at various distances from the plant is assessed using thermoluminescent dosimeters (TLDs), optically stimulated luminescent dosimeters (OSLDs), and/or pressurized ionization chambers.
8. D/Q: The relative deposition factor (m^{-2}).
9. Grab Sample: A single discrete sample drawn at one point in time.
10. Indicator: A sampling location that is potentially affected by plant effluents due to its proximity and/or direction from the plant.
11. Ingestion Pathway: The ingestion pathway includes milk, fish, drinking water and garden produce. Also sampled (under special circumstances) are other media such as vegetation or animal products when additional information about particular radionuclides is needed.
12. ISFSI: Independent Spent Fuel Storage Installation
13. LLD: Lower Limit of Detection. An *a priori* measure of the detection capability of a radiochemistry measurement based on instrument setup, calibration, background, decay time, and sample volume. An LLD is expressed as an activity concentration. The MDA is used for reporting results. LLD are specified by a regulator, such as the NRC and are typically listed in the ODCM.
14. MDA: Minimum Detectable Activity. For radiochemistry instruments, the MDA is the *a posteriori* minimum concentration that a counting system detects. The smallest concentration or activity of radioactive material in a sample that will yield a net count above instrument background and that is detected with 95% probability, with only 5% probability of falsely concluding that a blank observation represents a true signal.
15. MDC: Minimum Detectable Concentration. Essentially synonymous with MDA for the purposes of radiological monitoring.
16. Mean: The sum of all the values in a distribution divided by the number of values in the distribution, synonymous with average.

17. Microcurie (µCi): 3.7 x 10^4 disintegrations per second, or 2.22 x10^6 disintegrations per minute.
18. millirad (mrad): 1/1000 rad; a unit of radiation absorbed dose.
19. millirem (mrem): 1/1000 rem; a unit of radiation dose equivalent in tissue.
20. Milliroentgen (mR): 1/1000 Roentgen; a unit of exposure to X-ray or gamma radiation.
21. N/A: Not Applicable
22. ND: None Detected
23. NEI: Nuclear Energy Institute
24. NRC: Nuclear Regulatory Commission
25. ODCM: Offsite Dose Calculation Manual
26. OSLD: Optically Stimulated Luminescence Dosimeter
27. Protected Area: A 10 CFR 73 security term is an area encompassed by physical barriers and to which access is controlled for security purposes. The fenced area immediately surrounding the plant and around ISFSI are commonly classified by the licensee as "Protected Areas." Access to the protected area requires a security badge or escort.
28. PWR: Pressurized Water Reactor
29. REC: Radiological Effluent Control
30. REMP: Radiological Environmental Monitoring Program
31. Restricted Area: A 10 CFR 20 defined term where access to which is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials.
32. TEDE: Total Effective Dose Equivalent (TEDE) means the sum of the effective dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).
33. TLD: Thermoluminescent Dosimeter
34. TRM: Technical Requirements Manual
35. TS: Technical Specification
36. Unrestricted Area: An area, access to which is neither limited nor controlled by the licensee.
37. X/Q: The relative effluent concentration without plume depletion (sec/m^3).

2.0 EXECUTIVE SUMMARY

Limerick Generating Station (LGS) Radiological Effluent Control (REC) Program was established to limit the quantities of radioactive material that may be released based on calculated radiation doses or dose rates. Dose to Members of the Public due to radioactive materials released from the plant is limited by Technical Specifications, 10 CFR 20, and 40 CFR 190. Operational doses to the public during 2023 were calculated and found to be within the limits required by these regulations. These doses are summarized and compared to the regulatory limits in Section 2.1 Comparison to Regulatory Limits below.

The Annual Radioactive Effluent Release Report (ARERR) is published per REC requirements and provides data related to plant operation, including: quantities of radioactive materials released in liquid and gaseous effluents; radiation doses to members of the public; solid radioactive waste shipped offsite for processing or direct disposal; and other information as required by site licensing documents.

In 2023, the gaseous effluent dose assessments for locations from the Land Use Census showed that the critical receptor for Limerick Generating Station is the Child thyroid. This is due to the pathways of Inhalation, Ground Plane, and Vegetation located at the Vegetation location. The maximum Annual Organ Dose calculated for this receptor was 1.79E-04 mrem to the thyroid.

The maximum dose calculated to any organ due to radioactive liquid effluents was 1.04E-02 mrem, to the liver of the teenager age group, due to ingestion of fish and standing on contaminated sediment at the LGS Outfall.

In 2023, LGS shipped offsite 53 shipments of solid radioactive waste for processing or direct disposal that had a total volume of 7.49E+02 m3 and 8.41E+02 Ci of radioactivity.

In addition to monitoring radioactive effluents, LGS has a Radiological Environmental Monitoring Program (REMP) that monitors for levels of radiation and radioactive materials in the local environment. Data from the REMP is published in the Annual Radiological Environmental Operating Report (AREOR).

2.1 Comparison to Regulatory Limits

During 2023, all solid, liquid, and gaseous radioactive effluents from Limerick Generating Station were well below regulatory limits, as summarized in Table 1 and Table 2.

Table 1, Limerick Generating Station Site Dose Summary[1]

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluents						
	Limit	**3 mrem**	**3 mrem**	**3 mrem**	**3 mrem**	**6 mrem**
	Total Body Dose[2]	1.39E-04	5.37E-03	2.56E-03	1.62E-06	8.06E-03
	% Of Limit	0.005	0.179	0.085	<0.001	0.134
	Limit	**10 mrem**	**10 mrem**	**10 mrem**	**10 mrem**	**20 mrem**
	Maximum Organ Dose[3]	1.83E-04	6.75E-03	3.42E-03	1.62E-06	1.04E-02
	% Of Limit	0.002	0.068	0.034	<0.001	0.052
Gaseous Effluents						
	Limit	**10 mrad**	**10 mrad**	**10 mrad**	**10 mrad**	**20 mrad**
	Gamma Air Dose[4]	3.45E-04	6.35E-04	1.07E-04	5.54E-05	1.14E-03
	% Of Limit	0.003	0.006	0.001	0.001	0.006
	Limit	**20 mrad**	**20 mrad**	**20 mrad**	**20 mrad**	**40 mrad**
	Beta Air Dose[5]	2.04E-04	3.97E-04	6.39E-05	3.24E-05	6.97E-04
	% Of Limit	0.001	0.002	<0.001	<0.001	0.002
	Limit	**5 mrem**	**5 mrem**	**5 mrem**	**5 mrem**	**10 mrem**
	NG Total Body Dose[6]	3.28E-04	6.02E-04	1.02E-04	5.28E-05	1.08E-03
	% Of Limit	0.007	0.012	0.002	0.001	0.011
	Limit	**15 mrem**	**15 mrem**	**15 mrem**	**15 mrem**	**30 mrem**
	NG Skin Dose[7]	5.43E-04	1.01E-03	1.68E-04	8.76E-05	1.81E-03
	% Of Limit	0.004	0.007	0.001	0.001	0.006
	Limit	**15 mrem**	**15 mrem**	**15 mrem**	**15 mrem**	**30 mrem**
	Maximum Organ Dose[8]	1.04E-05	5.99E-05	4.05E-05	6.78E-05	1.79E-04
	% Of Limit	<0.001	<0.001	<0.001	<0.001	0.001

[1] Table 1 demonstrates compliance with 10 CFR Part 50, App. I Limits. Carbon-14 dose is not included in this table.
[2] Adult, LGS Outfall
[3] Teenager, LGS Outfall, Liver
[4] Site Boundary, All Age Groups
[5] Site Boundary, All Age Groups
[6] Site Boundary, All Age Groups
[7] Site Boundary, All Age Groups
[8] Child, Vegetation, Thyroid

Table 2, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for LGS[1]

	Whole Body	Thyroid	Max Other Organ
Limit	**25 mrem**	**75 mrem**	**25 mrem**
Gaseous[2] - Noble Gas	1.08E-03	1.08E-03	1.81E-03
Gaseous - Particulates & Iodine	1.13E-04	1.79E-04	1.14E-04
Carbon-14	2.39E-01	2.39E-01	1.19E+00
Liquid	8.06E-03	4.91E-03	1.04E-02
Direct Shine	0	0	0
Total Site Dose	**2.48E-01**	**2.45E-01**	**1.20E+00**
% Contribution of Carbon-14 to Gaseous Dose	96	97	99
Nearby Facility	2.17E-02	2.17E-02	2.17E-02
Total w/Other Nearby Facility[3]	**2.70E-01**	**2.66E-01**	**1.22E+00**
% of Limit	**1.08**	**0.36**	**4.90**

[1] Table 2 is a summation of Units to show compliance with 40 CFR Part 190 Limits.
[2] Gaseous dose values in Table 2 include organ dose from Noble Gas, Iodine, Tritium, and particulates.
[3] Other fuel cycle sources within 5 miles of the site are considered in this analysis.

3.0 INTRODUCTION

3.1 About Nuclear Power

Commercial nuclear power plants are generally classified as either Boiling Water Reactors (BWRs) or Pressurized Water Reactors (PWRs), based on their design. A BWR includes a single coolant system, where water used as reactor coolant boils as it passes through the core, and the steam generated is used to turn the turbine generator for power production. A PWR, in contrast, includes two separate water systems: radioactive reactor coolant and a secondary system. Reactor coolant is maintained under high pressure, preventing boiling. The high-pressure coolant is passed through a heat exchanger, called a steam generator, where the secondary system water is boiled, and the steam is used to turn the turbine generator for power production.

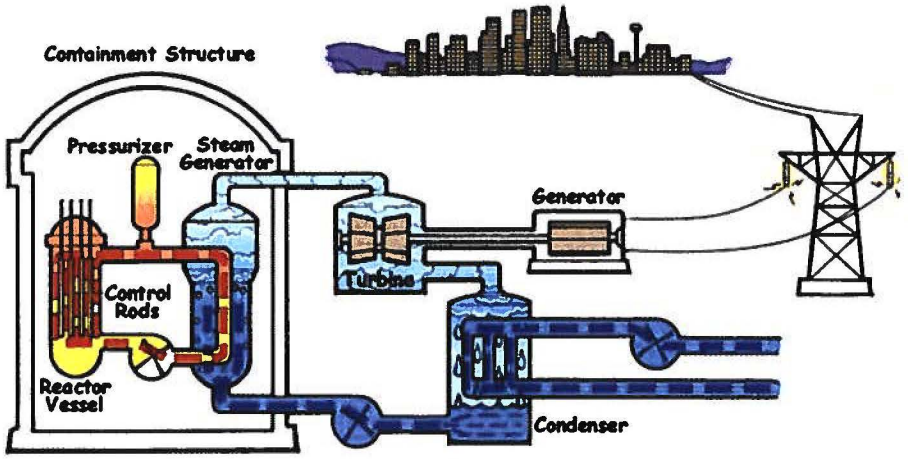

Figure 1, Pressurized Water Reactor (PWR) **[1]**

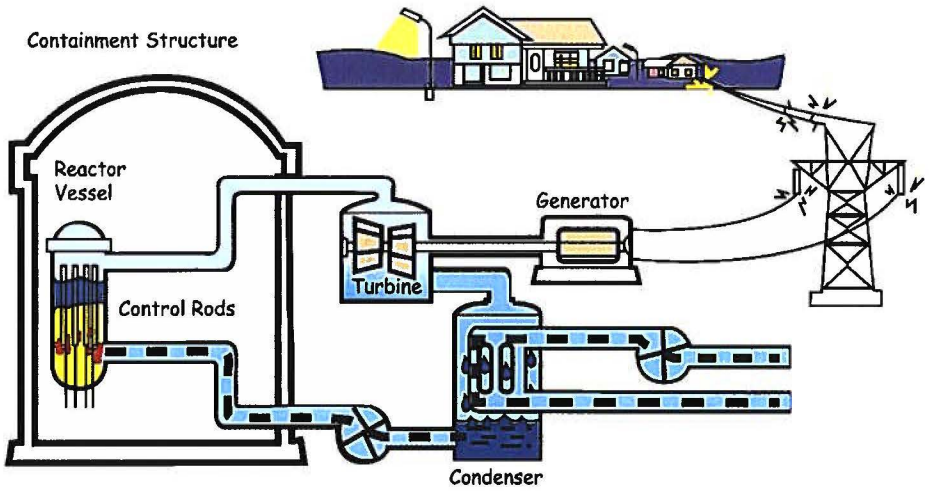

Figure 2, Boiling Water Reactor (BWR) **[2]**

3.1 (Continued)

Electricity is generated by a nuclear power plant similarly to the way that electricity is generated at conventional types of power plants, such as those powered by coal or natural gas. Water is boiled to generate steam; the steam turns a turbine that is attached to a generator, and the steam is condensed back into water to be returned to the boiler. What makes nuclear power different from these other types of power plants is that the heat is generated by fission and decay reactions occurring within and around the core containing fissionable uranium (U-235).

Nuclear fission occurs when certain nuclides (primarily U-233, U-235, or Pu-239) absorb a neutron and break into several smaller nuclides (called fission products) as well as producing some additional neutrons.

Fission results in production of radioactive materials including gases and solids that must be contained to prevent release or treated prior to release. These effluents are generally treated by filtration and/or hold-up prior to release. Releases are generally monitored by sampling and by continuously-indicating radiation monitors. The effluent release data is used to calculate doses to ensure that dose to the public due to plant operation remains within required limits.

3.2 About Radiation Dose

Ionizing radiation, including alpha, beta, and gamma radiation from radioactive decay, has enough energy to break chemical bonds in tissues and result in damage to tissue or genetic material. The amount of ionization that will be generated by a given exposure to ionizing radiation is quantified as dose. Radiation dose is generally reported in units of millirem (mrem) in the US.

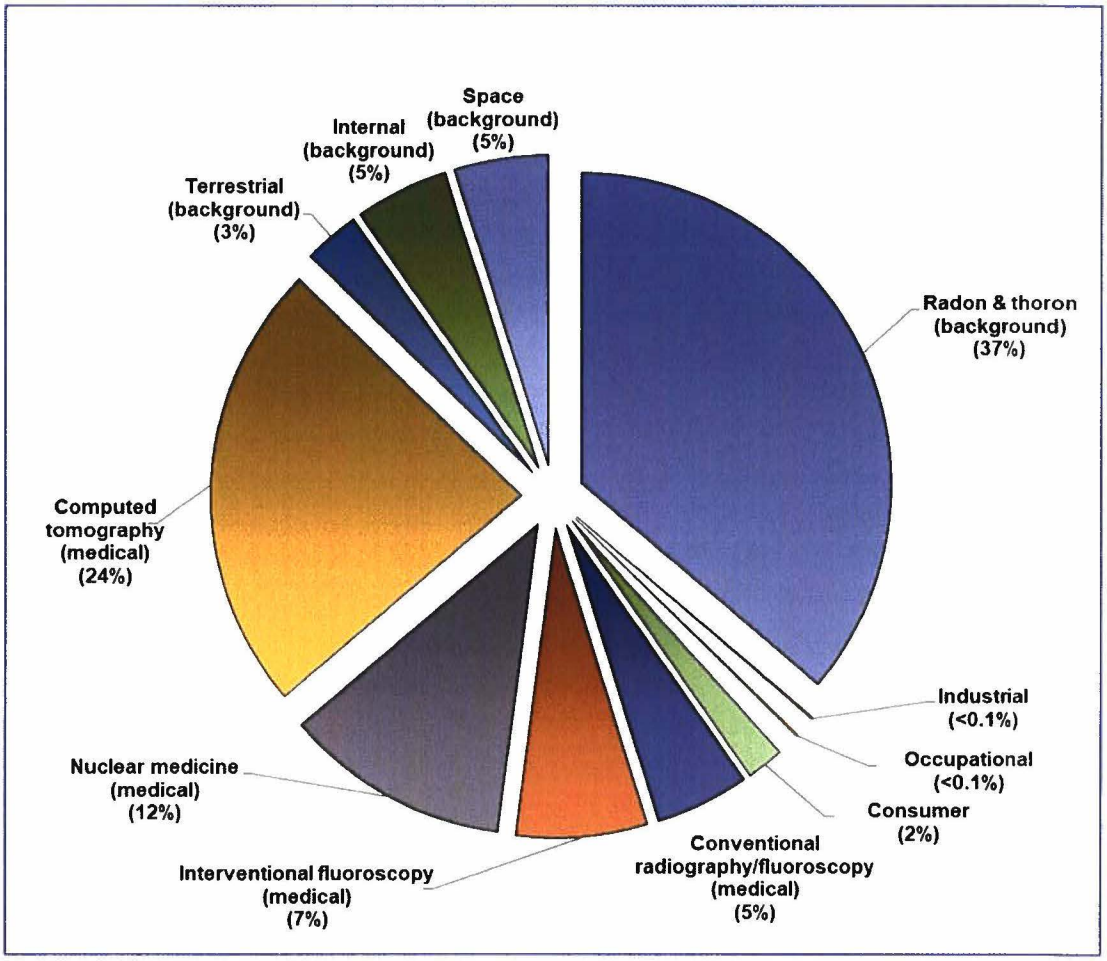

Figure 3, Sources of Radiation Exposure (NCRP Report No. 160) **[3]**

0 (Continued)

The National Council on Radiation Protection (NCRP) has evaluated the population dose for the US and determined that the average individual is exposed to approximately 620 mrem per year [3]. There are many sources for radiation dose, ranging from natural background sources to medical procedures, air travel, and industrial processes. Approximately half (310 mrem) of the average exposure is due to natural sources of radiation including exposure to radon, cosmic radiation, and internal radiation, and terrestrial sources due to naturally occurring radionuclides. The remaining 310 mrem of exposure is due to man-made sources of exposure, with the most significant contributors being medical (48% of total mrem per year) due to radiation used in various types of medical scans and treatments. Of the remaining 2% of dose, most is due to consumer activities such as air travel, cigarette smoking, and building materials. A small fraction of this 2% is due to industrial activities including generation of electricity by nuclear power.

Readers that are curious about common sources and effects of radiation dose that they may encounter can find excellent sources of information from the Health Physics Society, including the Radiation Fact Sheets [4], and from the US Nuclear Regulatory Commission website [5].

3.3 About Dose Calculation

The concentrations of radioactive material in the environment resulting from plant operations are very small, and it is not possible to determine doses directly using measured activities of environmental samples. To overcome this, dose calculations based on measured activities of effluent streams are used to model the dose impact for Members of the Public due to plant operation and effluents. There are several mechanisms that can result in dose to Members of the Public, including: ingestion of radionuclides in food or water; inhalation of radionuclides in air; immersion in a plume of noble gases; and direct radiation from the ground, the plant, or from an elevated plume.

3.3 (Continued)

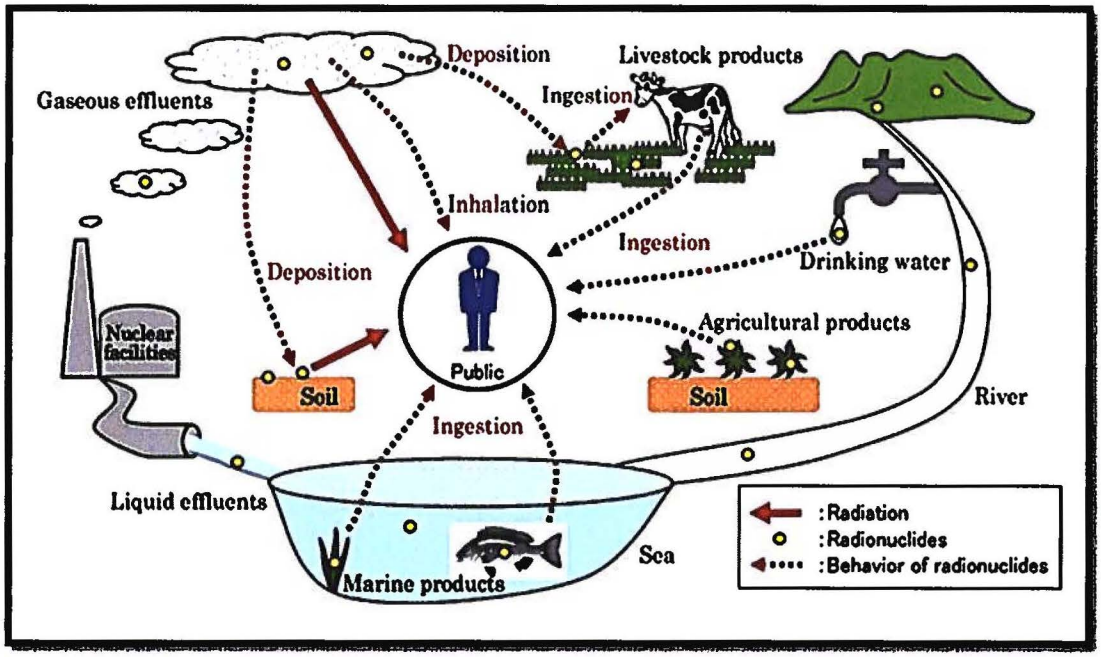

Figure 4, Potential exposure pathways to Members of the Public due to Plant Operations **[6]**

Each plant has an Offsite Dose Calculation Manual (ODCM) that specifies the methodology used to obtain the doses in the Dose Assessment section of this report. The dose assessment methodology in the ODCM is based on NRC Regulatory Guide 1.109 [7] and NUREG-0133 [8]. Doses are calculated by determining what the nuclide concentration will be in air, in water, on the ground, or in food products based on plant effluent releases. Release points are continuously monitored to quantify what concentrations of nuclides are being released. For gaseous releases, meteorological data is used to determine how much of the released activity will be present at a given location outside of the plant, either deposited onto the ground or in gaseous form. Intake patterns and nuclide bio-concentration factors are used to determine how much activity will be transferred into animal milk or meat. Finally, human ingestion factors and dose factors are used to determine how much activity will be consumed and how much dose the consumer will receive. Inhalation dose is calculated by determining the concentration of nuclides and how much air is breathed by the individual.

For liquid releases, dilution and mixing factors are used to model the environmental concentrations in water. Drinking water pathways are modeled by determining the concentration of nuclides in the water at the point where the drinking water is sourced (e.g., taken from wells, rivers, or lakes). Fish pathways are determined by using concentration at the release point, bioaccumulation factors for the fish, and an estimate of the quantity of fish consumed.

3.3 (Continued)

Each year a Land Use Census is performed to determine what potential dose pathways currently exist within a five-mile radius around the plant, the area most affected by plant operations. The Annual Land Use Census identifies the locations of vegetable gardens, nearest residences, milk animals, and meat animals. The data from the census is used to determine who is most likely to be exposed to radiation dose because of plant operation.

There is significant uncertainty in dose calculation results, due to modeling dispersion of material released and bioaccumulation factors, as well as assumptions associated with consumption and land-use patterns. Even with these sources of uncertainty, the calculations do provide a reasonable estimate of the order of magnitude of the exposure. Conservative assumptions are made in the calculation inputs, such as the number of various foods and water consumed, the amount of air inhaled, and the amount of direct radiation exposure from the ground or plume, such that the actual dose received is likely lower than the calculated dose. Even with the built-in conservatism, doses calculated for the maximum exposed individual due to plant operation are a very small fraction of the annual dose that is received due to other sources. The calculated doses due to plant effluents, along with REMP results, serve to provide assurance that radioactive effluent releases are not exceeding safety standards for the environment or people living near the plant.

4.0 DOSE ASSESSMENT FOR PLANT OPERATIONS

4.1 Regulatory Limits

Regulatory limits are detailed in station licensing documents, such as the plant Technical Specifications and the Offsite Dose Calculation Manual (ODCM). These documents contain the limits to which LGS must adhere. LGS drives to maintain the philosophy to keep dose "as low as is reasonably achievable" (ALARA), and actions are taken to reduce the amount of radiation released to the environment. Liquid and gaseous release data show that the dose from LGS is well below the ODCM limits. The instantaneous concentration of liquid radioactive material released shall be limited to ten times the concentration specified in 10 CFR 20, Appendix B, Table 2, Column 2, for radionuclides other than dissolved or entrained noble gases. For dissolved or entrained noble gases, the total concentration released shall be limited to 2.0×10^{-4} microcuries/ml.

The annual whole body, skin, and organ dose was computed using the 2023 source term, using the dose calculation methodology provided in the ODCM. The calculated doses due to gaseous effluents are used to demonstrate compliance with offsite dose limits are presented in Table 1, Limerick Generating Station Site Dose Summary, and Table 2, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for LGS.

4.2 Regulatory Limits for Gaseous Effluent Doses

1. Fission and activation gases:

   a. Noble gases dose rate due to radioactive materials released in gaseous effluents from the site to areas at and beyond the site boundary shall be limited to the following:

      1) Less than or equal to 500 mrem/year to the total body

      2) Less than or equal to 3000 mrem/year to the skin

   b. Noble gas air dose due to noble gases released in gaseous effluents, from the site to areas at and beyond the site boundary shall be limited to the following:

      1) Quarterly

         a) Less than or equal to 10 mrad gamma

         b) Less than or equal to 20 mrad beta

      2) Yearly

         a) Less than or equal to 20 mrad gamma

         b) Less than or equal to 40 mrad beta

2. Iodine, tritium, and all radionuclides in particulate form with half-lives greater than 8 days.

   a. The dose rate for iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents released from the site to areas at and beyond the site boundary shall be limited to the following:

      1) Less than or equal to 1500 mrem/yr to any organ

   b. The dose to a MEMBER OF THE PUBLIC from iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 DAYS in gaseous effluents released from the site to areas at and beyond the site boundary shall be limited to the following:

      1) Quarterly

         a) Less than or equal to 15 mrem to any organ

      2) Yearly

         a) Less than or equal to 30 mrem to any organ

4.3 Regulatory Limits for Liquid Effluent Doses

1. The dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released from the site to unrestricted areas shall be limited to the following:

    a. Quarterly

        1) Less than or equal to 3 mrem total body

        2) Less than or equal to 10 mrem critical organ

    b. Yearly

        1) Less than or equal to 6 mrem total body

        2) Less than or equal to 20 mrem critical organ

4.4 40 CFR 190 Regulatory Dose Limits for a Member of the Public

1. Total Dose (40 CFR 190)

    a. The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC in the unrestricted area due to releases of radioactivity and to radiation from uranium fuel cycle sources shall be limited to the following:

        1) Less than or equal to 25 mrem, Total Body or any Organ except Thyroid.

        2) Less than or equal to 75 mrem, Thyroid.

4.5 Onsite Doses (Within Site Boundary)

LGS classifies individuals within the site boundary as either occupationally exposed individuals or members of the public. This section evaluates dose to non-occupationally exposed workers and members of the public that may be onsite for various reasons. The report must include any other information as may be required by the Commission to estimate maximum potential annual radiation doses to the public resulting from effluent releases as required by 10 CFR 50.36a(a)(2). While within controlled or restricted areas, the limits from Sections 4.1 through 4.4 do not apply; however, 10 CFR 20.1301 dose limit of 100 mrem per year TEDE and dose rate limit of 2 mrem per hour from external sources continue to apply. Occupancy times within the controlled areas are generally sufficiently low to compensate for the increase in the atmospheric dispersion factor above the site boundary. Groups of concern include the following receptor locations: National Guard, Railroad Tracks, and Fricks Lock. Use of a conservative assumption of 91 days/year (25%) spent inside the site boundary by these groups conservatively represents the most-exposed individual.

The maximum gaseous dose to members of the public at these locations is based on the following assumptions:

- Long term annual average meteorology data X/Q and D/Q, and actual effluent releases for the sectors encompassing the National Guard (NNE), Railroad Tracks (W), and Fricks Lock (WSW).
- Dose is from ground plane and inhalation only. No ingestion dose is included.
- The maximum calculated dose for activities on site was 5.04E-03 mrem at the Railroad Tracks in the West sector (Table 3).

All Doses calculated were a small fraction of the 10 CFR 20.1301 limits (100 mrem).

Table 3, 2023 Onsite Doses to Members of the Public

Location	Sector	Approx. Distance (Meters)	X/Q s/m^3	D/Q 1/m^2	Total Body Dose (mrem)[1]		Total
					Noble Gas	Iodine, Particulate, C-14 & H-3	
National Guard	NNE	556	4.00E-07	4.43E-09	6.68E-05	3.54E-04	4.21E-04
Railroad Tracks	W	225	2.66E-06	2.36E-08	4.45E-04	4.59E-03	5.04E-03
Fricks Lock	WSW	450	5.58E-07	4.78E-09	9.33E-05	9.64E-04	1.06E-03

5.0 SUPPLEMENTAL INFORMATION

5.1 Gaseous Batch Releases

5.1.1 LGS Site

None

[1] The limit for sum of the Total Body Dose and Organ Dose = 100 mrem (ref. 10 CFR 20.1301)

5.2 Liquid Batch Releases

5.2.1 LGS Site

Liquid	Qtr. 1	Qtr. 2	Qtr. 3	Qtr. 4	Total
Number of Batch Releases	7	57	33	0	97
Total time period for batch releases (min)	6.99E+02	6.28E+03	2.94E+03	N/A	9.92E+03
Maximum time period for batch release (min)	1.08E+02	1.26E+02	1.15E+02	N/A	1.26E+02
Average time period for batch release (min)	9.99E+01	1.10E+02	8.90E+01	N/A	1.02E+02
Minimum time period for batch release (min)	8.00E+01	5.50E+01	6.70E+01	N/A	5.50E+01
Average stream flow (Schuylkill River) during periods of release of effluents into a flowing stream (LPM)	3.55E+06	2.19E+06	2.63E+06	4.15E+06	3.13E+06

5.3 Abnormal Releases

5.3.1 Gaseous Abnormal Releases

None

5.3.2 Liquid Abnormal Releases

None

5.4 Insignificant Releases

In January of 2016, new pathways were identified and classified as a less significant Effluent Pathway. Gaseous effluents from the Main Turbine lubrication oil (MTLO) and Reactor Feed Pump Turbine (RFPT) lubrication oil vapor extractor exhaust vents to the Turbine Building roof. These pathways are not continuously monitored. Tritium analysis was performed in January and December 2016 of the water vapor exiting the vent and of nearby standing water. The tritium in the water is the result of condensation and direct deposition from the discharge of the entrained water vapor from the exhaust vents. This condensation does occur year-round but increases during seasonally cold weather.

The lube oil exhaust vents and associated systems were operating as designed to remove accumulated water from the lubricating and seal oil for the various turbine systems. The water was discharged as entrained vapor out the Turbine Building roof vent and a portion of it condensed on lower temperature surfaces. This water includes tritium, as the source is from the primary system.

Based on Regulatory Guide 1.21, Rev. 2, Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste, these release pathways are considered less significant. A significant release point is any location from which radioactive material is released that contributes greater than 1 percent of the activity discharged from all the release points for a particular type of effluent considered.

Regulatory Guide 1.109 lists the three types of effluent as (1) liquid effluents, (2) noble gases discharged to the atmosphere, and (3) all other radionuclides discharged to the atmosphere. The percentage of U1 and U2 MTLO exhaust vent activity in 2023 compared to the total tritium activity released from the site is calculated below.

Vent	Tritium Released, Ci	Site Gaseous Annual Release of Tritium, Ci	Percentage of Tritium Released Relative to Site Gaseous Annual Release of Tritium, Ci
		2023	2023
U1 MTLO extractor exhaust vent	2.71E-01	1.48E+01	1.84%
U2 MTLO extractor exhaust vent	2.15E-01		1.46%
U1 and U2 RFPT extractor exhaust vent	<LLD		N/A

5.5 Land Use Census Changes

During the 2023 annual Land Use Census review, the meat location in sector ESE at a distance from the plant of 1579 meters, had an increase in its meteorology D/Q values ranging from 22.9% to 28.5% higher than current default ODCM D/Q value of 1.14E-09 ($1/m^2$) over the last three years. An ODCM change will be made to include this updated value.

5.6 Meteorological Data

During 2023, the LGS meteorological program achieved a 99.1% joint frequency distribution data recovery.

In accordance with Regulatory Guide 1.21, the meteorological data does not need to be reported in the ARERR, but the data is summarized and maintained as documentation (records). An annual meteorological summary report that provides the joint frequency distributions of wind direction and wind speed by atmospheric stability class (see Regulatory Guide 1.23) is prepared and maintained in records for the life of the plant.

5.7 Effluent Radiation Monitors Out of Service Greater Than 30 Days

None

5.8 Offsite Dose Calculation Manual (ODCM) Changes

None

5.9 Process Control Program (PCP) Changes

The last change made to RW-AA-100, Rev. 12, "Process Control Program for Radioactive Wastes," was last revised in 2017.

5.10 Radioactive Waste Treatment System Changes

None

5.11 Carbon-14

Carbon-14 (C-14) is a naturally occurring radionuclide with a 5,730-year half-life. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. Nuclear power plants also produce C-14, but the amount is infinitesimal compared to what has been distributed in the environment due to weapons testing and what is produced by natural cosmic ray interactions.

In accordance with Regulatory Guide 1.21, "Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste," the NRC recommended re-evaluating "principal radionuclides" and reporting C-14 as appropriate. C-14 production and release estimates were calculated using active core coolant mass, average neutron flux by energy, and reactor coolant nitrogen concentrations to determine C-14 generation based upon an effective full power year. The estimated generation for Limerick Generating Station during 2023 was 32.0 Curies.

Public dose estimates were performed using methodology from the ODCM, which is based on Regulatory Guide 1.109 methodology. C-14 is not included in the dose limits of Table 1 but is included in the dose calculation results of Table 2, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for LGS.

5.12 Independent Spent Fuel Storage Installation (ISFSI) Monitoring Program

An ISFSI was placed in service starting July 21, 2008. Direct radiation exposure was determined using dosimetry measurements (minus background levels) obtained from the REMP for the nearest residence to the ISFSI. In 2023, there was no facility related dose detected to the nearest resident from the ISFSI. There were no gaseous or liquid releases from the ISFSI in 2023.

5.13 Errata/Corrections to Previous ARERRs

An error was found in the 2021 and 2022 ARERR Table 3, Onsite Doses to Members of the Public. Long-term annual meteorological X/Q and D/Q is used to calculate doses. Short-term annual meteorological X/Q and D/Q data was used in 2021 and 2022 requiring re-calculation of the data. The requirements are that the limit for sum of the Total Body Dose and Organ Dose shall be less than100 mrem TEDE (ref. 10CFR20.1301). The new calculations were performed and are a small fraction of the 100 mrem limit. The National Guard was also added to 2021 and 2022 Table 3 locations.

The maximum calculated dose for activities on site was ~~4.37E-02~~ 1.01E-02 mrem at the Railroad Tracks in the West sector (Table 3). All Doses calculated were a small fraction of the 10 CFR 20.1301 limits.

Table 3, 2021 Onsite Doses to Members of the Public

Location	Sector	Approx. Distance (Meters)	X/Q s/m^3	D/Q 1/m^2	Total Body Dose (mrem)[1]		Total
					Noble Gas	Iodine, Particulate, C-14 & H-3	
National Guard	NNE	556	4.00E-07	4.43E-09	7.54E-04	4.05E-04	1.16E-03
Railroad Tracks	W	225	~~1.08E-06~~ 2.66E-06	~~9.44E-09~~ 2.36E-08	~~1.26E-02~~ 5.02E-03	~~5.18E-03~~ 5.06E-03	~~4.37E-02~~ 1.01E-02
Info Center	ESE	884	~~4.54E-07~~ 7.33E-07	~~5.35E-09~~ 9.27E-09	~~3.47E-03~~ 1.38E-03	~~1.44E-03~~ 1.39E-03	~~1.21E-02~~ 2.77E-03
Fricks Lock	WSW	450	~~2.87E-07~~ 5.58E-07	~~2.37E-09~~ 4.78E-09	~~2.64E-03~~ 1.05E-03	~~1.09E-03~~ 1.06E-03	~~9.17E-03~~ 2.11E-03

The maximum calculated dose for activities on site was ~~1.992E-02~~ 9.01E-03 mrem at the Railroad Tracks in the West sector (Table 3). All Doses calculated were a small fraction of the 10 CFR 20.1301 limits.

Table 3, 2022 Onsite Doses to Members of the Public

Location	Sector	Approx. Distance (Meters)	X/Q s/m^3	D/Q 1/m^2	Total Body Dose (mrem)[1]		Total
					Noble Gas	Iodine, Particulate, C-14 & H-3	
National Guard	NNE	556	4.00E-07	4.43E-09	1.06E-03	1.51E-04	1.21E-03
Railroad Tracks	W	225	~~1.08E-06~~ 2.66E-06	~~9.44E-09~~ 2.36E-08	~~7.642E-03~~ 7.08E-03	~~2.095E-03~~ 1.93E-03	~~1.992E-02~~ 9.01E-03
Fricks Lock	WSW	450	~~3.05E-07~~ 5.58E-07	~~2.68E-09~~ 4.78E-09	~~1.604E-03~~ 1.48E-03	~~4.385E-04~~ 4.05E-04	~~4.178E-03~~ 1.89E-03

[1] The limit for sum of the Total Body Dose and Organ Dose = 100 mrem (ref. 10 CFR 20.1301)

5.14 Other Supplemental Information

5.14.1 Temporary Outside Tanks

In 2023, the LGS site did not use temporary outside tanks to hold radioactive materials more than 10 Curies. This requirement does not apply to tritium.

5.14.2 Program Deviations

- 05/30/23 - Radioactive Contamination Found in Sewage Sample. Sewage was sampled on 05/30/23 and positive Co-60 was identified with an activity of 8.65E-8 µCi/ml. The sewage was resampled on 05/27/23 and the reanalysis detected 3.38E-8 µCi/ml of activity with Co-60 detected. Tritium was <LLD. Sewage was sampled on 5/30/23 at 09:10 (with increased inventory) and only natural activity was detected. There was a level 3 personnel contamination event on 05/07/23, and Co-60 was detected in the whole-body count of the individual. Performed calculations to ensure sanitary sewerage levels were not exceeded per 10 CFR 20.2003.

- 11/22/23 - Positive Fe-55 and Sr-89 result in the 2023 3rd quarter liquid radwaste composite. Vendor lab results determined that the 3rd quarter composite results for radwaste liquid effluent Fe-55 had an activity of 1.14E-05 µCi/ml with a positive re-analysis of 6.92E-06 µCi/ml. Sr-89 had an activity of 6.66E-08 µCi/ml with a positive re-analysis of 5.61E-08 µCi/ml. No ODCM limits were exceeded. This is most likely due to additional releases from outage activities.

- 12/14/23 - Tritium found in the Power Block Foundation Sump (PBFS). The PBFS was sampled on 12/14/23 at 0900 for tritium. Tritium results were positive at 1.27E-04 µCi/ml. The sample was then distilled, and results were 1.38E-04 µCi/ml, the hold pond was secured, and a sample of the hold pond was obtained on 12/14/23 at 1805 for tritium and gamma isotopic. The "raw" tritium results for this sample were 2.70E-06 µCi/ml, and the distilled tritium results were 3.15E-06 µCi/ml. The gamma isotopic had no activity. The positive tritium was a result of leakage identified from the end bell area of the Unit 1 Steam Seal Evaporator identified on 12/16/23. Sample obtained from the leak had gamma isotopic total activity of 4.26E-05 µCi/ml and tritium activity of 5.13E-03 µCi/ml. Leakage was directed to the floor drain system via a catch containment but has been identified as leaking down into the condenser area ending up in the PBFS. The hold pond is an ODCM discharge point and continued to have positive tritium intermittently until 01/14/24. The PBFS tritium continues to decrease in trend. No tritium was detected in any monitoring wells that was not previously identified or in the environment. There were no station reportable events due to the leak.

- 12/28/23 - Radioactive Contamination Found in Sewage Sample. Sewage was sampled on 12/27/23 and positive Co-60 was identified with an activity of 2.36E-08 µCi/ml. Tritium analysis was <LLD. The sewage was resampled on 12/28/23 and no radioactivity was identified. A sewage sample in May 2023 was positive for Co-60 this year at 8.65E-08 µCi/ml. The sum of the two positive Co-60 sewage samples in 2023 had activity of 1.10E-07 µCi/ml. Calculations were performed to ensure sanitary sewerage levels were not exceeded per 10 CFR 20.2003.

6.0 NEI 07-07 ONSITE RADIOLOGICAL GROUNDWATER MONITORING PROGRAM

Limerick Generating Station has developed a Radiological Groundwater Protection Program (RGPP) in accordance with NEI 07-07, Industry Ground Water Protection Initiative – Final Guidance Document [9]. The purpose of the RGPP is to ensure timely detection and an effective response to situations involving inadvertent radiological releases to groundwater to prevent migration of licensed radioactive material off-site and to quantify impacts on decommissioning. The RGPP data is reported in the AREOR.

6.1 Voluntary Notification

During 2023, Limerick Generating Station did not make a voluntary NEI 07-07 notification to State/Local officials, NRC, and to other stakeholders required by site procedures.

7.0 BIBLIOGRAPHY

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[17] "Regulatory Guide 4.13 - Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry: Environmental Applications, Revision 2," Nuclear Regulatory Commision, June, 2019.

[18] "Regulatory Guide 4.15 - Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operations to License Termination) -- Effluent Streams and the Environment," Nuclear Regulatory Commission, July, 2007.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

1.0 GASEOUS EFFLUENTS

Table 4, Gaseous Effluents – Summation of All Releases from the LGS Site[1]

A. Fission & Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for Year	Est. Total Error %
1. Total Release	Ci	2.50E+00	5.34E+00	8.43E-01	3.59E-01	9.04E+00	36.6
2. Average release rate for the period	µCi/sec	3.21E-01	6.79E-01	1.06E-01	4.52E-02	2.87E-01	
3. Percent of Limit	%						
B. Iodine							
1. Total Iodine – 131	Ci	<LLD	<LLD	<LLD	<LLD	<LLD	20.4
2. Average release rate for the period	µCi/sec	N/A	N/A	N/A	N/A	N/A	
3. Percent of Limit	%						
C. Particulates							
1. Particulates with half-lives > 8 days	Ci	<LLD	7.08E-05	<LLD	<LLD	7.08E-05	22.6
2. Average release rate for the period	µCi/sec	N/A	9.00E-06	N/A	N/A	2.24E-06	
3. Percent of Limit	%						
D. Tritium							
1. Total Release	Ci	2.39E-01	9.35E+00	1.42E+00	3.75E+00	1.48E+01	15.7
2. Average release rate for the period	µCi/sec	3.07E-02	1.19E+00	1.78E-01	4.72E-01	4.68E-01	
3. Percent of Limit	%						
E. Gross Alpha							
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD	22.6
2. Average release rate for the period	µCi/sec	N/A	N/A	N/A	N/A	N/A	
3. Percent of Limit	%						
F. Carbon-14							
1. Total Release	Ci	7.01E+00	7.94E+00	9.59E+00	7.44E+00	3.20E+01	
2. Average release rate for the period	µCi/sec	9.01E-01	1.01E+00	1.21E+00	9.36E-01	1.01E+00	
3. Percent of Limit[2]	%						

[1] % of limit is provided in Table 1, Limerick Generating Station Site Dose Summary.

[2] % of Limit is provided in Table 2, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for LGS.

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 5, Gaseous Effluents – Mixed Level Release Continuous Mode from the LGS Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
Kr-85m	Ci	4.61E-02	8.89E-02	1.53E-02	6.77E-03	1.57E-01
Kr-85	Ci	1.01E-01	1.41E-01	2.65E-02	1.94E-02	2.89E-01
Kr-87	Ci	6.63E-02	1.17E-01	2.06E-02	1.06E-02	2.15E-01
Kr-88	Ci	1.02E-01	1.67E-01	3.01E-02	1.76E-02	3.17E-01
Ar-41	Ci	8.06E-02	2.15E-01	3.47E-02	6.83E-03	3.37E-01
Xe-131m	Ci	2.53E-03	3.54E-03	6.64E-04	4.86E-04	7.22E-03
Xe-133	Ci	4.28E-01	1.13E+00	1.83E-01	3.73E-02	1.78E+00
Xe-135m	Ci	5.32E-01	1.12E+00	1.89E-01	7.03E-02	1.91E+00
Xe-135	Ci	5.89E-01	1.53E+00	1.91E-01	8.94E-02	2.40E+00
Xe-138	Ci	5.50E-01	8.26E-01	1.52E-01	1.01E-01	1.63E+00
Total for Period	**Ci**	**2.50E+00**	**5.34E+00**	**8.43E-01**	**3.59E-01**	**9.04E+00**
Iodines						
I-133	Ci	1.10E-04	3.78E-04	3.98E-05	1.62E-04	6.90E-04
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	**1.10E-04**	**3.78E-04**	**3.98E-05**	**1.62E-04**	**6.90E-04**
Particulates						
Cr-51	Ci	<LLD	1.23E-05	<LLD	<LLD	1.23E-05
Co-58	Ci	<LLD	1.10E-05	<LLD	<LLD	1.10E-05
Co-60	Ci	<LLD	4.74E-05	<LLD	<LLD	4.74E-05
	Ci					
Total for Period	**Ci**	**<LLD**	**7.08E-05**	**<LLD**	**<LLD**	**7.08E-05**
Tritium						
H-3	**Ci**	**2.39E-01**	**9.35E+00**	**1.42E+00**	**3.75E+00**	**1.48E+01**
Gross Alpha						
Alpha	**Ci**	**<LLD**	**<LLD**	**<LLD**	**<LLD**	**<LLD**
Carbon-14						
C-14	**Ci**	**7.01E+00**	**7.94E+00**	**9.59E+00**	**7.44E+00**	**3.20E+01**

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 6, Gaseous Effluents – Mixed Level Release Batch Mode from the LGS Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission Gases						
None	Ci	N/A	N/A	N/A	N/A	N/A
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
(List Others)	Ci					
Total for Period	**Ci**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Iodines						
None	Ci	N/A	N/A	N/A	N/A	N/A
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Particulates						
None	Ci	N/A	N/A	N/A	N/A	N/A
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Tritium						
H-3	**Ci**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Gross Alpha						
Alpha	**Ci**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Carbon-14						
C-14	**Ci**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

2.0 LIQUID EFFLUENTS

Table 7, Liquid Effluents – Summation of All Releases from the LGS Site[1]

A. Fission & Activation Products	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for Year	Est. Total Error %
1. Total Release	Ci	3.67E-04	1.18E-02	2.64E-02	<LLD	3.86E-02	21.1
2. Average diluted concentration	µCi/mL	2.16E-08	2.97E-08	3.77E-07	<LLD	3.14E-08	
3. Percent of Limit	%						
B. Tritium							
1. Total Release	Ci	2.09E+00	1.15E+01	5.33E+00	1.05E-01	1.91E+01	6.4
2. Average diluted concentration	µCi/mL	1.23E-04	2.90E-05	7.61E-05	1.41E-07	1.55E-05	
3. Percent of Limit	%						
C. Dissolved & Entrained Gases							
1. Total Release	Ci	2.17E-04	2.29E-03	4.55E-04	<LLD	2.97E-03	21.1
2. Average diluted concentration	µCi/mL	1.28E-08	5.77E-09	6.49E-09	<LLD	2.41E-09	
3. Percent of Limit	%						
D. Gross Alpha Activity							
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD	23.0
2. Average diluted concentration	µCi/mL	<LLD	<LLD	<LLD	<LLD	<LLD	
3. Percent of Limit	%						
E. Volume of Waste Released (prior to dilution)	Liters	4.74E+05	4.12E+06	2.02E+06	5.60E+07	6.26E+07	
F. Volume of Dilution Water Used During Period	Liters	1.65E+07	3.93E+08	6.80E+07	6.88E+08	1.17E+09	

[1] % of limit is provided in Table 1, Limerick Generating Station Site Dose Summary

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 8, Liquid Effluents – Continuous Mode from the LGS Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
None	Ci	N/A	N/A	N/A	N/A	N/A
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
	Ci					
Total for Period	**Ci**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
Tritium						
H-3	**Ci**	**<LLD**	**<LLD**	**<LLD**	**1.05E-01**	**1.05E-01**
Gross Alpha						
Alpha	**Ci**	**<LLD**	**<LLD**	**<LLD**	**<LLD**	**<LLD**
Entrained Gases						
None	Ci	N/A	N/A	N/A	N/A	N/A
	Ci					
	Ci					
Total for Period	**Ci**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)

Table 9, Liquid Effluents – Batch Mode from the LGS Site

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
NA-22	Ci	<LLD	3.70E-06	<LLD	N/A	3.70E-06
NA-24	Ci	<LLD	3.01E-05	1.53E-05	N/A	4.53E-05
CR-51	Ci	1.37E-05	9.44E-04	<LLD	N/A	9.57E-04
MN-54	Ci	4.59E-05	6.66E-04	1.96E-04	N/A	9.07E-04
FE-55	Ci	<LLD	<LLD	2.31E-02	N/A	2.31E-02
CO-57	Ci	<LLD	1.52E-06	<LLD	N/A	1.52E-06
CO-58	Ci	7.48E-05	1.35E-03	7.65E-04	N/A	2.19E-03
FE-59	Ci	8.73E-06	2.24E-05	6.03E-06	N/A	3.72E-05
CO-60	Ci	1.35E-04	5.11E-03	1.52E-03	N/A	6.76E-03
ZN-65	Ci	6.48E-05	6.42E-04	4.12E-04	N/A	1.12E-03
ZN-69m	Ci	9.26E-06	6.36E-06	<LLD	N/A	1.56E-05
SR-89	Ci	<LLD	<LLD	1.35E-04	N/A	1.35E-04
Y-91m	Ci	<LLD	<LLD	1.30E-06	N/A	1.30E-06
NB-97	Ci	<LLD	1.99E-05	<LLD	N/A	1.99E-05
AG-110m	Ci	1.36E-05	7.85E-06	<LLD	N/A	2.14E-05
SB-122	Ci	<LLD	2.75E-04	<LLD	N/A	2.75E-04
SB-124	Ci	<LLD	1.58E-03	1.03E-04	N/A	1.69E-03
SB-125	Ci	<LLD	5.24E-04	1.21E-04	N/A	6.46E-04
CS-134	Ci	<LLD	1.58E-05	2.22E-06	N/A	1.80E-05
CS-137	Ci	1.41E-06	2.87E-04	5.77E-05	N/A	3.46E-04
CS-138	Ci	<LLD	1.15E-05	<LLD	N/A	1.15E-05
LA-140	Ci	<LLD	<LLD	1.87E-05	N/A	1.87E-05
LA-141	Ci	<LLD	2.97E-04	<LLD	N/A	2.97E-04
AU-199	Ci	<LLD	1.42E-05	<LLD	N/A	1.42E-05
	Ci					
Total for Period	**Ci**	**3.67E-04**	**1.18E-02**	**2.64E-02**	**N/A**	**3.86E-02**
Tritium						
H-3	**Ci**	**2.09E+00**	**1.15E+01**	**5.33E+00**	**N/A**	**1.90E+01**
Gross Alpha						
Alpha	**Ci**	**<LLD**	**<LLD**	**<LLD**	**N/A**	**<LLD**
Entrained Gases						
Xe-133	Ci	9.33E-05	8.39E-04	2.65E-04	N/A	1.20E-03
Xe-135	Ci	1.24E-04	1.46E-03	1.90E-04	N/A	1.77E-03
	Ci					
Total for Period	**Ci**	**2.17E-04**	**2.29E-03**	**4.55E-04**	**N/A**	**2.97E-03**

Attachment 2, Solid Waste Information

1.0 SOLID WASTE SHIPPED OFFSITE FOR BURIAL OR DISPOSAL (NOT IRRADIATED FUEL)

Table 10, Resins, Filters, and Evaporator Bottoms Summary Shipped from the LGS Site

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	5.48E+03	1.55E+02	1.34E+02	+/-25%
B	1.71E+02	4.84E+00	7.06E+02	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
Unclassified	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	5.65E+03	1.60E+02	8.39E+02	+/-25%

Major Nuclides for Above Table: H-3, C-14, Cr-51, Mn-54, Fe-55, Fe-59, Co-58, Co-60, Ni-59, Ni-63, Zn-65, Sr-90, Tc-99, I-129, Cs-134, Cs-137, Ce-144, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-242, Cm-244

Waste Class A		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
C-14	11.99%	1.60E+01
Mn-54	6.23%	8.32E+00
Fe-55	15.75%	2.10E+01
Co-58	3.8%	5.08E+00
Co-60	49.88%	6.66E+01
Ni-63	2.34%	3.13E+00
Zn-65	5.98%	7.99E+00
Cs-137	1.58%	2.11E+00
Waste Class B		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
Mn-54	3.61%	2.54E+01
Fe-55	37.91%	2.68E+02
Co-60	48.21%	3.40E+02
Zn-65	7.75%	5.47E+01
Waste Class C		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A
Total Combined		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
C-14	1.91%	1.60E+01
Mn-54	4.02%	3.38E+01
Fe-55	34.39%	2.89E+02
Co-58	1.19%	9.98E+00
Co-60	48.47%	4.07E+02
Ni-63	1.09%	9.14E+00
Zn-65	7.47%	6.27E+01

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Table 11, Dry Active Waste (DAW) Summary Shipped from the LGS Site

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	2.08E+04	5.89E+02	1.37E+00	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
Unclassified	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	2.08E+04	5.89E+02	1.37E+00	+/-25%

Major Nuclides for Above Table: H-3, C-14, Mn-54, Fe-55, Co-58, Co-60, Ni-63, Zn-65, Tc-99, I-129, Cs-137, Ce-144

Waste Class A		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
Mn-54	5.02%	6.89E-02
Fe-55	46.62%	6.40E-01
Co-60	44.54%	6.11E-01
Zn-65	1.51%	2.08E-02

Waste Class B		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

Waste Class C		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

Total Combined		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
Mn-54	5.02%	6.89E-02
Fe-55	46.62%	6.40E-01
Co-60	44.54%	6.11E-01
Zn-65	1.51%	2.08E-02

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Table 12, Irradiated Components Summary Shipped from the LGS Site

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	0.00E+00	0.00E+00	0.00E+00	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
Unclassified	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	0.00E+00	0.00E+00	0.00E+00	+/-25%

Major Nuclides for Above Table: N/A

Waste Class A		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

Waste Class B		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

Waste Class C		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

Total Combined		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

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Table 13, Other Waste Summary Shipped from the LGS Site

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	0.00E+00	0.00E+00	0.00E+00	+/-25%
B	0.00E+00	0.00E+00	0.00E+00	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
Unclassified	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	0.00E+00	0.00E+00	0.00E+00	+/-25%

Major Nuclides for Above Table: N/A

Waste Class A		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

Waste Class B		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

Waste Class C		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

Total Combined		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A

Attachment 2, Solid Waste Information

Table 14, Sum of All Low-Level Waste Shipped from the LGS Site

Waste Class	Volume ft^3	Volume m^3	Curies Shipped	% Error (Activity)
A	2.63E+04	7.44E+02	1.35E+02	+/-25%
B	1.71E+02	4.84E+00	7.06E+02	+/-25%
C	0.00E+00	0.00E+00	0.00E+00	+/-25%
Unclassified	0.00E+00	0.00E+00	0.00E+00	+/-25%
All	2.65E+04	7.49E+02	8.41E+02	+/-25%

Major Nuclides for Above Table: H-3, C-14, Cr-51, Mn-54, Fe-55, Fe-59, Co-58, Co-60, Ni-59, Ni-63, Zn-65, Sr-90, Tc-99, I-129, Cs-134, Cs-137, Ce-144, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-242, Cm-244

Waste Class A		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
C-14	11.86%	1.60E+01
Mn-54	6.22%	8.39E+00
Fe-55	16.06%	2.17E+01
Co-58	3.77%	5.09E+00
Co-60	49.82%	6.72E+01
Ni-63	2.33%	3.14E+00
Zn-65	5.94%	8.01E+00
Cs-137	1.56%	2.11E+00
Waste Class B		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
Mn-54	3.61%	2.54E+01
Fe-55	37.91%	2.68E+02
Co-60	48.21%	3.40E+02
Zn-65	7.75%	5.47E+01
Waste Class C		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
None	N/A	N/A
Total Combined		**≥ 1% Abundance**
Nuclide Name	Abundance	Curies
C-14	1.9%	1.60E+01
Mn-54	4.02%	3.38E+01
Fe-55	34.41%	2.89E+02
Co-58	1.19%	1.00E+01
Co-60	48.47%	4.07E+02
Ni-63	1.09%	9.15E+00
Zn-65	7.46%	6.27E+01

Attachment 2, Solid Waste Information

2.0 SOLID WASTE DISPOSITION

Table 15, Solid Waste Disposition from the LGS Site

Number of Shipments	Mode of Transportation	Destination
2	Hittman Transport Services	"Energy Solution Radwaste Processing Inc. Gallaher Road Facility"
16	Hittman Transport Services	"Energy Solutions - Bear Creek 1560 BEAR CREEK ROAD"
4	Hittman Transport Services	"Energy Solutions Services, Inc. (MPF)1790 Dock Street"
29	Hittman Transport Services	"Energy Solutions, LLC. Clive Disposal Site - Containerized Waste Facility"
2	Hittman Transport Services	"Waste Control Specialists LLC Compact Waste Disposal Facility"
53	Total	