

Annual Radioactive Effluent Release Report 2024

**UNIT 1 AND UNIT 2 (Docket Numbers 50-456 and 50-457)
ISFSI (Docket Number 72-73)**

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 1 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

TABLE OF CONTENTS

1.0 LIST OF ACRONYMS AND DEFINITIONS 3

2.0 EXECUTIVE SUMMARY 5

 2.1 Comparison to Regulatory Limits 7

3.0 INTRODUCTION 9

 3.1 About Nuclear Power 9

 3.2 About Radiation Dose 11

 3.3 About Dose Calculation 13

4.0 DOSE ASSESSMENT FOR PLANT OPERATIONS 15

 4.1 Regulatory Limits 15

 4.2 Regulatory Limits for Gaseous Effluent Doses 15

 4.3 Regulatory Limits for Liquid Effluent Doses 16

 4.4 40 CFR 190 Regulatory Dose Limits for a Member of the Public 17

 4.5 Onsite Doses (Within Site Boundary) 17

5.0 SUPPLEMENTAL INFORMATION 18

 5.1 Gaseous Batch Releases 18

 5.2 Liquid Batch Releases 18

 5.3 Abnormal Releases 18

 5.4 Land Use Census Changes 19

 5.5 Meteorological Data 19

 5.6 Effluent Radiation Monitors Out of Service Greater Than ODCM Requirements 19

 5.7 Offsite Dose Calculation Manual (ODCM) Changes 20

 5.8 Process Control Program (PCP) Changes 20

 5.9 Radioactive Waste Treatment System Changes 20

 5.10 Other Supplemental Information 20

6.0 BIBLIOGRAPHY 22

TABLES

Table 1, Braidwood Nuclear Power Station Unit 1 and Unit 2 Dose Summary 7

Table 2, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for BNPS 8

Table 3, Gaseous Effluents Summation of All Releases Unit 1 and Unit 2 23

Table 4, Gaseous Effluents – Mixed Level Release Batch Mode Unit 1 and 2 24

Table 5, Gaseous Effluents – Mixed Level Release Continuous Mode Unit 1 and 2 25

Table 6, Liquid Effluents – Summation of All Releases Unit 1 and 2 26

Table 7, Batch Mode Liquid Effluents Unit 1 and 2 27

Table 8, Continuous Mode Liquid Effluents Unit 1 and 2 28

Table 9, Resins, Filters, and Evaporator Bottoms Summary Shipped from the BNPS Site 29

Table 10, Dry Active Waste (DAW) Summary Shipped from the BNPS Site 30

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 2 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

Table 11, Irradiated Components Summary Shipped from the BNPS Site.....31

Table 12, Other Waste Summary Shipped from the BNPS Site.....32

Table 13, Sum of All Low-Level Waste Shipped from the BNPS Site.....33

Table 14, Solid Waste Disposition from the BNPS Site.....34

Table 15, Classification of Atmospheric Stability.....36

FIGURES

Figure 1, Pressurized Water Reactor (PWR) [1]..... 9

Figure 2, Boiling Water Reactor (BWR) [2] 10

Figure 3, Sources of Radiation Exposure [3]..... 11

Figure 4, Potential exposure pathways to Members of the Public due to Plant Operations [6] 13

ATTACHMENTS

Attachment 1, ARERR Release Summary Tables (RG-1.21 Tables)23

Attachment 2, Solid Waste Information.....29

Attachment 3, Meteorological Data Summary.....35

**Company: Constellation Energy
Generation****Plant: Braidwood Nuclear Power Station**

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. Grab Sample: A single discrete sample drawn at one point in time.
9. Indicator: A sampling location that is potentially affected by plant effluents due to its proximity and/or direction from the plant.
10. 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.
11. ISFSI: Independent Spent Fuel Storage Installation
12. 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.
13. 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.
14. MDC: Minimum Detectable Concentration. Essentially synonymous with MDA for the purposes of radiological monitoring.
15. Mean: The sum of all of the values in a distribution divided by the number of values in the distribution, synonymous with average.

**Company: Constellation Energy
Generation****Plant: Braidwood Nuclear Power Station**

16. Microcurie (μCi): 3.7×10^4 disintegrations per second, or 2.22×10^6 disintegrations per minute.
17. millirem (mrem): 1/1000 rem; a unit of radiation dose equivalent in tissue.
18. Milliroentgen (mR): 1/1000 Roentgen; a unit of exposure to X- or gamma radiation.
19. N/A: Not Applicable
20. NEI: Nuclear Energy Institute
21. NRC: Nuclear Regulatory Commission
22. ODCM: Offsite Dose Calculation Manual
23. OSLD: Optically Stimulated Luminescence Dosimeter
24. 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.
25. PWR: Pressurized Water Reactor
26. REC: Radiological Effluent Control
27. REMP: Radiological Environmental Monitoring Program
28. 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.
29. 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).
30. TLD: Thermoluminescent Dosimeter
31. TRM: Technical Requirements Manual
32. TS: Technical Specification
33. Unrestricted Area: An area, access to which is neither limited nor controlled by the licensee.

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 5 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

2.0 EXECUTIVE SUMMARY

Braidwood Nuclear Power Station (BNPS) 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 by 40 CFR 190. Operational doses to the public during 2024 were calculated to be within the limits required by regulation and compared to other sources of radiation dose and pose no health hazard. These doses are summarized and compared to the regulatory limits in Section 2.1 Comparison to Regulatory Limits below.

The quantity of radioactive material released from Braidwood Nuclear Power Plant was determined from in-house and vendor laboratory analysis of continuous inline sampling media and batch sample media from all ODCM specified effluent pathways. These pathways include continuous releases from the Unit 1 and Unit 2 Station Vent Stack, Condensate Polisher Sump, Waste Water Treatment, and Circulating Water Blowdown. The ODCM specified effluent pathways also include batch releases from the Unit 1 and Unit 2 Primary Containments, Waste Gas Decay Tanks, and Liquid Radwaste Batch Release Tanks.

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 2024, the gaseous effluent dose assessments for locations from the Land Use Census showed that the critical receptor for Braidwood Nuclear Power Station is a Child due to Inhalation, at the Nearest Residence. The maximum Annual Organ Dose calculated for this receptor was 2.06E-02 mrem, to the thyroid. This represents 6.85E-02 percent of the ODCM Annual Dose Limit of 30 mrem.

The maximum annual dose calculated to any organ due to radioactive liquid effluents was 3.09E-01 mrem, for a Child/Infant to the GI-LLI due to ingestion of potable water and fish. This represents 1.55E+00 percent of the ODCM Annual Dose Limit of 20 mrem.

Solid radioactive waste shipped offsite for processing or direct disposal included 1.48E+02 Curies and 3.82E+02 m³, shipped in 21 shipments.

In addition to monitoring radioactive effluents, BNPS 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).

**Company: Constellation Energy
Generation****Plant: Braidwood Nuclear Power Station**

An Independent Spent Fuel Storage Installation (ISFSI) was placed in service at Braidwood Station in 2011. The ISFSI is a closed system, and the only exposure would be due to direct radiation. In 2024, the direct dose to the nearest resident from the ISFSI was not detectable based environmental dosimeters from the Radiological Environmental Monitoring Program. Currently, there is no offsite direct dose contribution from the ISFSI facility or any other waste or radioactive material storage areas on-site as evidenced by dosimetry data that is indistinguishable from the existing environmental dosimeters.

The volume and quantity of radioactive waste shipped offsite from Braidwood Nuclear Power Plant for processing and disposal was determined from data maintained in the radwaste shipping database. Radwaste processed for shipment was in accordance with Constellation procedure RW-AA-100, "PROCESS CONTROL PROGRAM FOR RADIOACTIVE WASTES" and consistent with the UFSAR.

Meteorological data was obtained from the 320-foot meteorological tower located on the Braidwood Station premises. During 2024, the Braidwood site joint met data recovery was 99.7% which exceeded the goal of 90%.

**Company: Constellation Energy
Generation**

Plant: Braidwood Nuclear Power Station

2.1 Comparison to Regulatory Limits

During 2024 all liquid and gaseous radioactive effluents from Braidwood Nuclear Power Station were well below regulatory limits, as summarized in Table 1 and Table 2.

Table 1, Braidwood Nuclear Power Station Unit 1 and Unit 2 Dose Summary¹
Summary of Gaseous and Liquid Effluent Doses to Members of the Public

		Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual
Liquid Effluent Dose Limit, Total Body	Limit	3.0 mrem	3.0 mrem	3.0 mrem	3.0 mrem	6.0 mrem
	Total Body Dose	1.02E-01	1.09E-01	3.00E-02	6.77E-02	3.09E-01
	% of Limit	3.40E+00	3.64E+00	1.00E+00	2.26E+00	5.15E+00
Liquid Effluent Dose Limit, Any Organ	Limit	10 mrem	10 mrem	10 mrem	10 mrem	20 mrem
	Max Organ Dose	1.02E-01	1.09E-01	3.02E-02	6.80E-02	3.09E-01
	% of Limit	1.02E+00	1.09E+00	3.02E-01	6.80E-01	1.55E+00
Gaseous Effluent Dose Limit, Gamma Air (Noble Gas)	Limit	10 mrad	10 mrad	10 mrad	10 mrad	20 mrad
	Gamma Air Dose	3.47E-05	3.30E-05	2.18E-05	2.73E-05	1.17E-04
	% of Limit	3.47E-04	3.30E-04	2.18E-04	2.73E-04	5.84E-04
Gaseous Effluent Dose Limit, Beta Air (Noble Gas)	Limit	20 mrad	20 mrad	20 mrad	20 mrad	40 mrad
	Beta Air Dose	1.35E-05	1.72E-05	9.31E-06	1.20E-05	5.20E-05
	% of Limit	6.75E-05	8.60E-05	4.65E-05	6.00E-05	1.30E-04
Gaseous Effluent Organ Dose Limit (Iodine, Tritium, Particulates with > 8-day half-life)	Limit	15 mrem	15 mrem	15 mrem	15 mrem	30 mrem
	Max Organ Dose ²	1.31E-03	3.50E-03	4.99E-03	1.08E-02	2.06E-02
	% of Limit	8.75E-03	2.33E-02	3.32E-02	7.17E-02	6.85E-02

¹ Table 1 demonstrates compliance with 10 CFR Part 50, App. I Limits. C-14 was not included in organ dose calculations from airborne effluents conforming to 10 CFR 50, Appendix I.

² Highest Dose Receptor to the Nearest Resident is the Child

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 8 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

Table 2, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for BNPS¹

	Whole Body	Thyroid	Max Other Organ
Gaseous ²	2.05E-02	2.06E-02	2.04E-02
Carbon-14	2.20E-01	2.20E-01	1.10E+00
Liquid	3.09E-01	3.08E-01	3.09E-01
Direct Shine	0.00E+00	0.00E+00	0.00E+00
Total Site Dose	5.50E-01	5.49E-01	1.43E+00
Total w/Other Nearby Facility³	N/A	N/A	N/A
Limit	25 mrem	75 mrem	25 mrem
% of Limit	2.2%	0.7%	5.7%

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.

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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.

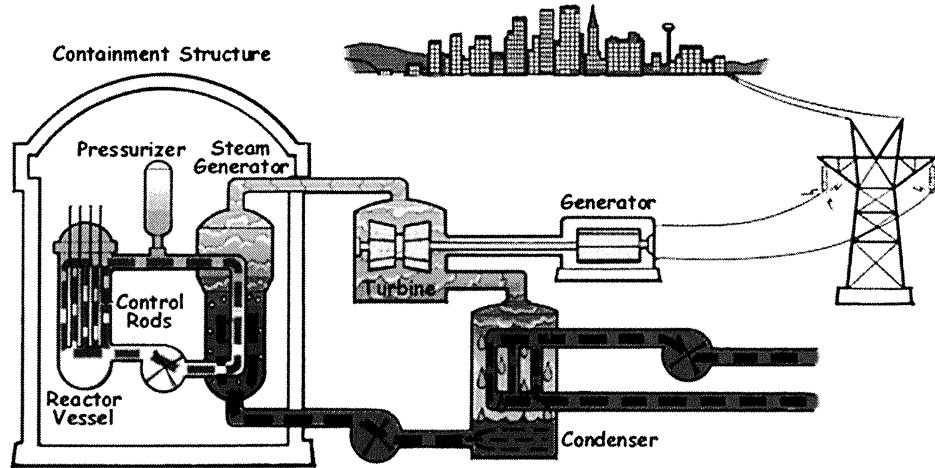


Figure 1, Pressurized Water Reactor (PWR) [1]

**Company: Constellation Energy
Generation****Plant: Braidwood Nuclear Power Station**

3.1 (Continued)

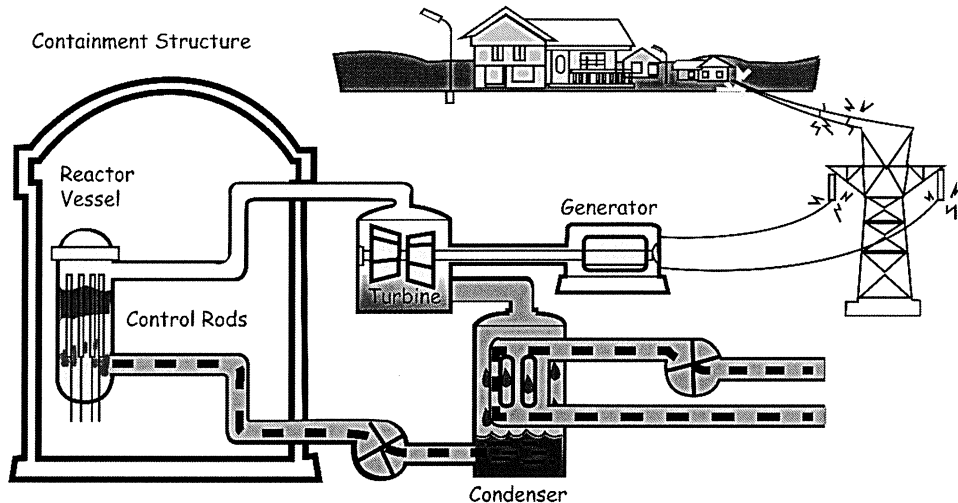


Figure 2, Boiling Water Reactor (BWR) [2]

Electricity is generated by a nuclear power plant similarly to the way that electricity is generated at other 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 in order to ensure that dose to the public due to plant operation remains within required limits.

Company: Constellation Energy
Generation

Plant: Braidwood Nuclear Power Station

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.

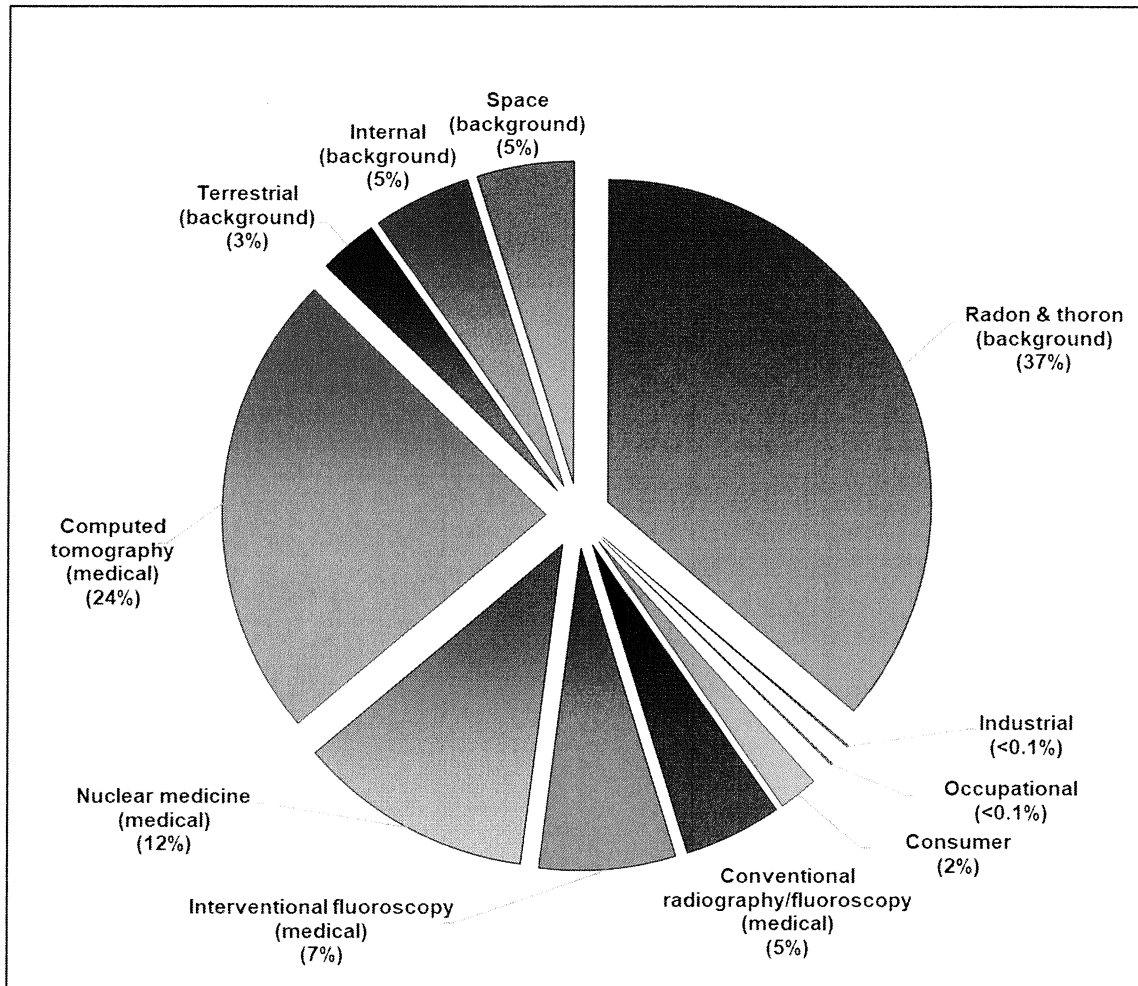


Figure 3, Sources of Radiation Exposure [3]

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 12 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

3.2 (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 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, smoking cigarettes, and building materials. A small fraction of this 2% is due to industrial activities including generation of 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].

Company: Constellation Energy Generation

Plant: Braidwood Nuclear Power Station

3.3 About Dose Calculation

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.

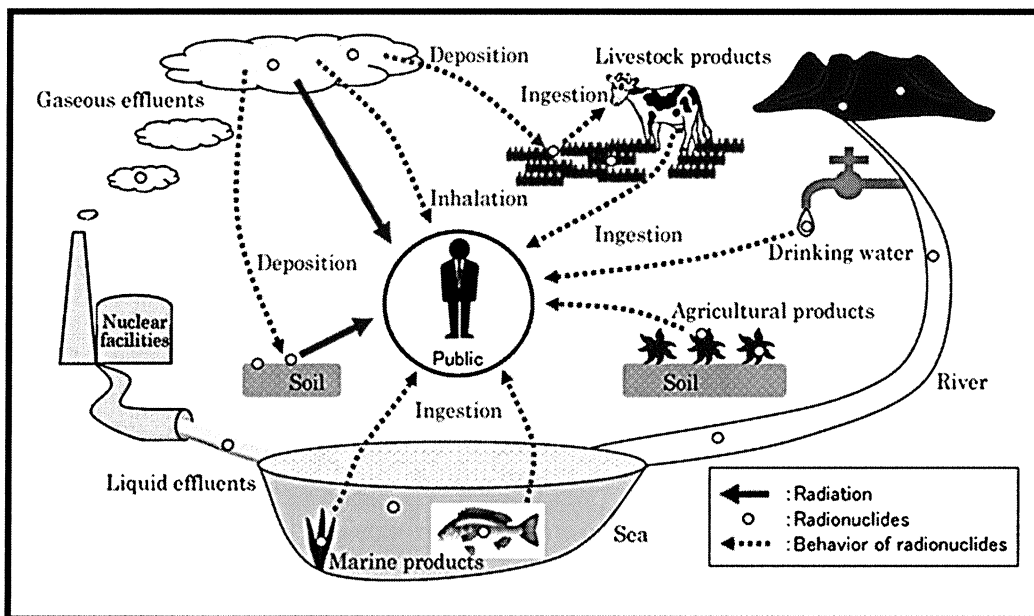


Figure 4, Potential exposure pathways to Members of the Public due to Plant Operations [6]

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, 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.

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 14 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

3.3 (Continued)

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 and invertebrate pathways are determined by using concentration at the release point, bioaccumulation factors for the fish or invertebrate and an estimate of the quantity of fish consumed.

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 the most likely to be exposed to radiation dose as a result 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 are 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 effluents releases are not exceeding safety standards for the environment or people living near the plant.

**Company: Constellation Energy
Generation****Plant: Braidwood Nuclear Power Station**

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 BNPS must adhere. BNPS 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 BNPS 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 2024 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 and Table 2, Total Annual Offsite-Dose Comparison to 40 CFR 190 Limits for BNPS.

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

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 16 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

4.2 (Continued)

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

**Company: Constellation Energy
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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)

BNPS 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. Braidwood had no non-occupational or members of the public on-site during 2024.

**Company: Constellation Energy
Generation**

Plant: Braidwood Nuclear Power Station

5.0 SUPPLEMENTAL INFORMATION

5.1 Gaseous Batch Releases

5.1.1 BNPS Unit 1 and Unit 2

	<u>Units</u>	<u>Quarter 1</u>	<u>Quarter 2</u>	<u>Quarter 3</u>	<u>Quarter 4</u>	<u>Annual</u>
1. Number of Batch Releases		95	100	104	126	425
2. Total duration of batch releases	minutes	7.69E+03	1.26E+04	5.03E+03	2.31E+04	4.84E+04
3. Maximum batch release duration	minutes	1.83E+03	2.27E+03	3.11E+02	2.18E+03	2.27E+03
4. Average batch release duration	minutes	8.10E+01	1.26E+02	4.83E+01	1.83E+02	1.14E+02
5. Minimum batch release duration	minutes	2.90E+01	2.80E+01	3.00E+01	2.50E+01	2.50E+01

5.2 Liquid Batch Releases

5.2.1 BNPS Unit 1 and Unit 2

	<u>Units</u>	<u>Quarter 1</u>	<u>Quarter 2</u>	<u>Quarter 3</u>	<u>Quarter 4</u>	<u>Annual</u>
1. Number of Batch Releases		22	31	17	28	98
2. Total duration of batch releases	minutes	5.21E+04	3.68E+04	6.78E+04	7.61E+04	2.33E+05
3. Maximum batch release duration	minutes	5.08E+03	2.71E+03	1.34E+04	6.56E+03	1.34E+04
4. Average batch release duration	minutes	2.37E+03	1.19E+03	3.99E+03	2.72E+03	2.38E+03
5. Minimum batch release duration	minutes	4.53E+02	1.70E+01	3.57E+02	1.10E+01	1.10E+01
6. Avg stream flow during periods of release of liquid effluent into a flowing stream	m ³ /sec	2.33E+02	2.36E+02	7.21E+01	3.97E+01	1.45E+02

5.3 Abnormal Releases

5.3.1 Gaseous Abnormal Releases

No abnormal (unplanned) gaseous releases or discharges from the site were made during the report period.

5.3.2 Liquid Abnormal Releases

No abnormal (unplanned) liquid releases or discharges from the site were made during the report period.

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 19 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

5.4 Land Use Census Changes

The Land Use Census identified a new potential goat milk receptor at the 10 km (6.2 mile) distance. The landowner stated the goats consume 100% store bought feed. The goats would consume a minimal amount of potentially contaminated forage. This location is being added to the REMP sampling program and the ODCM. Milk samples are being collected in accordance with ODCM requirements. Dose calculations for the goat milk pathway will be performed. The above changes will be reevaluated in the next Land Use Census.

5.5 Meteorological Data

In accordance with ODCM Control 5.2, the ARERR should include a summary of meteorological data collected over the reporting year. During 2024, Braidwood site joint met data recovery was 99.7% which exceeded the goal of 90%. Joint Frequency Distribution (JFD) and meteorological data collected during 2024 is retained onsite. This data is available for review by the NRC upon request.

During 2024, the goal of 90% joint data recovery was met. The Braidwood Station meteorological monitoring program produced 52,554 hours of valid data out of a possible 52,704 parameter hours during 2024 (366 days x 24 hours/day x 6 measured priority parameters), which represents an overall data recovery rate of 99.7%. Priority parameters are all parameters except dew point temperature and precipitation.

For the year, winds measured at 34 ft. most frequently came from the West-Northwest (9.66%) and fell into the 3.6 - 7.5 mph wind speed class (42.11%). Calms (wind speeds at or below the sensor threshold) were measured 0.06% of the time and speeds greater than 24.5 mph were measured 0.00% of the time. Stability based on the 199 - 30 ft. differential temperature most frequently fell into the neutral classification (39.92%).

5.6 Effluent Radiation Monitors Out of Service Greater Than ODCM Requirements

One effluent radiation monitor was declared out of service for greater than ODCM requirements during the report period:

The Containment Purge System Noble Gas Activity Monitor (1RE-PR-0001B) remained inoperable for longer than allowed by the ODCM Radioactive Effluent Technical Standards. On 11/5/2024, 1RE-PR-0001B exceeded the 7-day action statement in accordance with ODCM Table 12.2-3, Action 37 due to continued communications module failures.

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 20 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

5.7 Offsite Dose Calculation Manual (ODCM) Changes

There were no changes to the ODCM during the report period.

5.8 Process Control Program (PCP) Changes

There were no changes to the PCP during the report period.

5.9 Radioactive Waste Treatment System Changes

There were no changes or modifications to the gaseous radioactive waste, liquid radioactive waste, or ventilation exhaust treatment systems during the report period.

5.10 Other Supplemental Information

5.10.1 Outside Tanks

No outside tanks exceeded ODCM or Technical Specification Limits.

5.10.2 Independent Spent Fuel Storage Installation (ISFSI) Monitoring Program

An Independent Spent Fuel Storage Installation (ISFSI) was placed in service at Braidwood Station in 2011. The ISFSI is a closed system, and the only exposure would be due to direct radiation. In 2024, the direct dose to the nearest resident from the ISFSI was not detectable based environmental dosimeters from the Radiological Environmental Monitoring Program. Currently, there is no offsite direct dose contribution from the ISFSI facility or any other waste or radioactive material storage areas on-site as evidenced by dosimetry data that is indistinguishable from the existing environmental dosimeters.

5.10.3 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. Carbon-14 production and release estimates were calculated using active core coolant mass, average neutron flux by energy and reactor coolant nitrogen concentrations to determine Carbon-14 generation based upon an effective full power year. The estimated generation for Braidwood Nuclear Power Station during 2024 was 8.48 Curies.

Annual Radioactive Effluent Release Report	YEAR: 2024	Page 21 of 36
Company: Constellation Energy Generation	Plant: Braidwood Nuclear Power Station	

Public dose estimates were performed using methodology from the ODCM which is based on Regulatory Guide 1.109 methodology. C-14 dose is included in dose calculation results in Table 2.

5.10.4 Errata/Corrections to Previous ARERRs

None

**Company: Constellation Energy
Generation****Plant: Braidwood Nuclear Power Station**

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

1.0 GASEOUS EFFLUENTS

Table 3, Gaseous Effluents Summation of All Releases Unit 1 and Unit 2 ¹

A. Fission & Activation Gases	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total	Est. Total Error %
1. Total Release	Ci	1.44E-01	2.53E-01	1.15E-01	1.48E-01	6.60E-01	7.59E+00
2. Average Release Rate for Period	μCi/sec	1.83E-02	3.21E-02	1.45E-02	1.87E-02	2.09E-02	
B. Iodine							
1. Total Iodine – 131	Ci	7.27E-08	2.22E-09	<LLD	2.68E-08	1.02E-07	3.32E+01
2. Average Release Rate for Period	μCi/sec	9.25E-09	2.82E-10	<LLD	3.37E-09	3.23E-09	
C. Particulates							
1. Particulates with half-lives > 8 days.	Ci	7.77E-07	0.00E+00	2.66E-08	0.00E+00	8.04E-07	1.98E+01
2. Average Release Rate for Period	μCi/sec	9.88E-08	0.00E+00	3.35E-09	0.00E+00	2.54E-08	
D. Tritium							
1. Total Release	Ci	1.45E+01	3.89E+01	5.55E+01	1.18E+02	2.27E+02	8.07E+00
2. Average Release Rate for Period	μCi/sec	1.85E+00	4.95E+00	6.99E+00	1.48E+01	7.17E+00	
E. Gross Alpha							
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD	1.98E+01
2. Average Release Rate for Period	μCi/sec	N/A	N/A	N/A	N/A	N/A	
F. Carbon-14							
1. Total Release	Ci	2.21E+00	2.00E+00	2.22E+00	2.06E+00	8.48E+00	
2. Average Release Rate for Period	μCi/sec	2.80E-01	2.54E-01	2.79E-01	2.59E-01	2.68E-01	

¹ % of limit is provided in Table 1, Braidwood Nuclear Power Station Unit 1 and Unit 2 Dose Summary.

**Company: Constellation Energy
Generation**

Plant: Braidwood Nuclear Power Station

Table 5, Gaseous Effluents – Mixed Level Release Continuous Mode Unit 1 and 2

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
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Iodines						
Br-82	Ci	< LLD	2.73E-05	< LLD	3.05E-05	5.78E-05
I-131	Ci	< LLD	< LLD	< LLD	1.53E-06	1.53E-06
	Ci					
	Ci					
Total for Period	Ci	<LLD	2.73E-05	<LLD	3.20E-05	5.93E-05
Particulates						
None	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Tritium						
H-3	Ci	1.18E+01	3.77E+01	5.45E+01	1.11E+02	2.15E+02
Gross Alpha						
Alpha	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
Carbon-14						
C-14	Ci	2.21E+00	2.00E+00	2.22E+00	2.06E+00	8.48E+00

2.0 LIQUID EFFLUENTS

Table 6, Liquid Effluents – Summation of All Releases Unit 1 and 2 ¹

A. Fission & Activation Products	Unit	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual	Est. Total Error %
1. Total Release	Ci	6.90E-03	6.17E-03	2.31E-02	1.82E-02	5.43E-02	2.64E+00
2. Average diluted concentration	μCi/mL	4.64E-10	6.25E-10	1.39E-09	1.11E-09	9.42E-10	
B. Tritium							
1. Total Release	Ci	1.11E+03	9.80E+02	3.74E+02	3.94E+02	2.86E+03	5.85E+00
2. Average diluted concentration	μCi/mL	7.48E-05	9.93E-05	2.25E-05	2.41E-05	4.96E-05	
C. Dissolved & Entrained Gases							
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD	2.64E+00
2. Average diluted concentration	μCi/mL	N/A	N/A	N/A	N/A	N/A	
D. Gross Alpha Activity							
1. Total Release	Ci	<LLD	<LLD	<LLD	<LLD	<LLD	1.47E+01
2. Average diluted concentration	μCi/mL	N/A	N/A	N/A	N/A	N/A	
E. Volume of Waste Released (prior to dilution)							
	Liters	1.04E+10	7.55E+09	1.05E+10	1.07E+10	3.91E+10	
F. Volume of Dilution Water Used During Period							
	Liters	1.49E+10	9.78E+09	1.66E+10	1.63E+10	5.77E+10	

¹ % of limit is provided in Table 1, Braidwood Nuclear Power Station Unit 1 and Unit 2 Dose Summary.

**Company: Constellation Energy
Generation**

Plant: Braidwood Nuclear Power Station

Table 7, Batch Mode Liquid Effluents Unit 1 and 2

Radionuclide Released	Units	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Total for year
Fission and Activation Products						
Na-24	Ci	0.00E+00	0.00E+00	3.29E-05	8.49E-07	3.38E-05
Cr-51	Ci	0.00E+00	0.00E+00	1.93E-04	2.16E-04	4.09E-04
Mn-54	Ci	8.26E-05	0.00E+00	1.73E-04	5.38E-06	2.61E-04
Fe-55	Ci	0.00E+00	1.39E-04	1.29E-03	0.00E+00	1.42E-03
Co-57	Ci	0.00E+00	0.00E+00	1.52E-05	0.00E+00	1.52E-05
Co-58	Ci	2.73E-04	4.74E-04	2.74E-04	3.85E-03	4.87E-03
Co-60	Ci	5.03E-03	4.14E-03	3.43E-03	1.29E-03	1.39E-02
Sr-92	Ci	1.75E-05	0.00E+00	0.00E+00	0.00E+00	1.75E-05
Zr-97	Ci	1.32E-05	0.00E+00	0.00E+00	0.00E+00	1.32E-05
Ru-105	Ci	4.26E-05	0.00E+00	0.00E+00	0.00E+00	4.26E-05
Ag-110m	Ci	1.11E-03	1.07E-04	4.78E-05	1.72E-05	1.29E-03
Sb-124	Ci	0.00E+00	2.48E-04	2.58E-03	5.80E-04	3.41E-03
Sb-125	Ci	2.81E-04	1.06E-03	1.50E-02	1.22E-02	2.86E-02
I-132	Ci	0.00E+00	0.00E+00	5.96E-06	0.00E+00	5.96E-06
I-134	Ci	0.00E+00	0.00E+00	0.00E+00	4.14E-06	4.14E-06
Cs-136	Ci	2.43E-05	0.00E+00	0.00E+00	0.00E+00	2.43E-05
Cs-138	Ci	0.00E+00	0.00E+00	2.64E-05	0.00E+00	2.64E-05
W-187	Ci	1.95E-05	0.00E+00	0.00E+00	0.00E+00	1.95E-05
Total for Period	Ci	6.90E-03	6.17E-03	2.31E-02	1.82E-02	5.43E-02
Tritium						
H-3	Ci	1.11E+03	8.91E+02	3.66E+02	3.06E+02	2.67E+03
Gross Alpha						
Alpha	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
Entrained Gases						
None	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A

Annual Radioactive Effluent Release Report		YEAR: 2024	Page 28 of 36
Company: Constellation Energy Generation		Plant: Braidwood Nuclear Power Station	

Table 8, Continuous Mode Liquid Effluents Unit 1 and 2

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
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A
Tritium						
H-3	Ci	2.71E+00	8.91E+01	7.65E+00	8.83E+01	1.88E+02
Gross Alpha						
Alpha	Ci	<LLD	<LLD	<LLD	<LLD	<LLD
Entrained Gases						
None	Ci	N/A	N/A	N/A	N/A	N/A
Total for Period	Ci	N/A	N/A	N/A	N/A	N/A

**Company: Constellation Energy
Generation**

Plant: Braidwood Nuclear Power Station

Attachment 2, Solid Waste Information

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

Table 9, Resins, Filters, and Evaporator Bottoms Summary Shipped from the BNPS Site

Waste Class	Volume		Curies Shipped
	ft ³	m ³	
A	4.92E+03	1.39E+02	5.46E+01
B	1.21E+02	3.43E+00	9.31E+01
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
All	5.04E+03	1.43E+02	1.48E+02
Major Nuclides for the Above Table: H-3, C-14, Mn-54, Fe-55, Co-58, Co-60, Ni-59, Ni-63, Sr-90, Nb-94, Tc-99, Sb-124, Sb-125, I-129, Cs-137, Pu-238, Pu-239, Pu-241, Am-241, Cm-242, Cm-243, Cm-244			
Waste Class A			≥ 1% Abundance
Nuclide Name	Abundance	Curies	
H-3	56.89%	3.11E+01	
Mn-54	1.23%	6.71E-01	
Fe-55	5.36%	2.93E+00	
Co-60	12.1%	6.61E+00	
Ni-63	22.35%	1.22E+01	
Waste Class B			≥ 1% Abundance
Nuclide Name	Abundance	Curies	
H-3	3.41%	3.17E+00	
Mn-54	2.53%	2.36E+00	
Fe-55	4.22%	3.93E+00	
Co-60	31.19%	2.90E+01	
Ni-63	53.12%	4.95E+01	
Sb-125	2.59%	2.41E+00	
Waste Class C			≥ 1% Abundance
Nuclide Name	Abundance	Curies	
NONE	N/A	N/A	
Total Combined			≥ 1% Abundance
Nuclide Name	Abundance	Curies	
H-3	23.18%	3.42E+01	
Mn-54	2.05%	3.03E+00	
Fe-55	4.64%	6.85E+00	
Co-60	24.13%	3.56E+01	
Ni-63	41.74%	6.17E+01	
Sb-125	1.93%	2.85E+00	

Company: Constellation Energy
Generation

Plant: Braidwood Nuclear Power Station

Attachment 2, Solid Waste Information

Table 10, Dry Active Waste (DAW) Summary Shipped from the BNPS Site

Waste Class	Volume		Curies Shipped
	ft ³	m ³	
A	8.22E+03	2.33E+02	5.00E-01
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
All	8.22E+03	2.33E+02	5.00E-01
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, Sr-90, Zr-95, Nb-95, Tc-99, Sb-125, I-129, Cs-137, Pu-238, Pu-239, Pu-241, Am-241, Cm-242, Cm-243, Cm-244			
Waste Class A			≥ 1% Abundance
Nuclide Name	Abundance	Curies	
H-3	11.66%	5.83E-02	
Cr-51	4.98%	2.49E-02	
Mn-54	1.52%	7.58E-03	
Fe-55	27.07%	1.35E-01	
Co-58	17.22%	8.61E-02	
Co-60	20.44%	1.02E-01	
Ni-63	4.36%	2.18E-02	
Zr-95	3.21%	1.61E-02	
Nb-95	6.1%	3.05E-02	
Sb-125	1.07%	5.35E-03	
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	
H-3	11.66%	5.83E-02	
Cr-51	4.98%	2.49E-02	
Mn-54	1.52%	7.58E-03	
Fe-55	27.07%	1.35E-01	
Co-58	17.22%	8.61E-02	
Co-60	20.44%	1.02E-01	
Ni-63	4.36%	2.18E-02	
Zr-95	3.21%	1.61E-02	
Nb-95	6.1%	3.05E-02	
Sb-125	1.07%	5.35E-03	

Attachment 2, Solid Waste Information

Table 11, Irradiated Components Summary Shipped from the BNPS Site

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

**Company: Constellation Energy
Generation**

Plant: Braidwood Nuclear Power Station

Attachment 2, Solid Waste Information

Table 12, Other Waste Summary Shipped from the BNPS Site

Waste Class	Volume		Curies Shipped
	ft ³	m ³	
A	2.34E+02	6.63E+00	4.12E-03
B	0.00E+00	0.00E+00	0.00E+00
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
All	2.34E+02	6.63E+00	4.12E-03
Major Nuclides for Above Table: H-3, C-14, Cr-51, Mn-54, Fe-55, Fe-59, Co-58, Co-60, Ni-63, Sr-90, Zr-95, Nb-95, Tc-99, Sb-125, I-129, Cs-137, Pu-238, Pu-239, Pu-241, Am-241, Cm-242, Cm-244			
Waste Class A			≥ 1% Abundance
Nuclide Name	Abundance		Curies
Cr-51	10.08%		4.15E-04
Mn-54	1.54%		6.33E-05
Fe-55	25.52%		1.05E-03
Co-58	23.63%		9.74E-04
Co-60	18.88%		7.78E-04
Ni-63	3.69%		1.52E-04
Zr-95	4.57%		1.88E-04
Nb-95	8.27%		3.41E-04
Sb-125	1.01%		4.15E-05
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
Cr-51	10.08%		4.15E-04
Mn-54	1.54%		6.33E-05
Fe-55	25.52%		1.05E-03
Co-58	23.63%		9.74E-04
Co-60	18.88%		7.78E-04
Ni-63	3.69%		1.52E-04
Zr-95	4.57%		1.88E-04
Nb-95	8.27%		3.41E-04
Sb-125	1.01%		4.15E-05

Company: Constellation Energy
Generation

Plant: Braidwood Nuclear Power Station

Attachment 2, Solid Waste Information

Table 13, Sum of All Low-Level Waste Shipped from the BNPS Site

Waste Class	Volume		Curies Shipped
	ft ³	m ³	
A	1.34E+04	3.79E+02	5.51E+01
B	1.21E+02	3.43E+00	9.31E+01
C	0.00E+00	0.00E+00	0.00E+00
Unclassified	0.00E+00	0.00E+00	0.00E+00
All	1.35E+04	3.82E+02	1.48E+02
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, Sr-90, Zr-95, Nb-94, Nb-95, Tc-99, Sb-124, Sb-125, I-129, Cs-137, Pu-238, Pu-239, Pu-241, Am-241, Cm-242, Cm-243, Cm-244			
Waste Class A			≥ 1% Abundance
Nuclide Name	Abundance	Curies	
H-3	56.48%	3.11E+01	
Mn-54	1.26%	6.78E-01	
Fe-55	5.56%	3.06E+00	
Co-60	12.17%	6.71E+00	
Ni-63	22.19%	1.22E+01	
Waste Class B			≥ 1% Abundance
Nuclide Name	Abundance	Curies	
H-3	3.41%	3.17E+00	
Mn-54	2.53%	2.36E+00	
Fe-55	4.22%	3.93E+00	
Co-60	31.19%	2.90E+01	
Ni-63	53.12%	4.95E+01	
Sb-125	2.59%	2.41E+00	
Waste Class C			≥ 1% Abundance
Nuclide Name	Abundance	Curies	
None	N/A	N/A	
Total Combined			≥ 1% Abundance
Nuclide Name	Abundance	Curies	
H-3	23.14%	3.43E+01	
Mn-54	2.05%	3.03E+00	
Fe-55	4.72%	6.99E+00	
Co-60	24.12%	3.58E+01	
Ni-63	42.62%	6.17E+01	
Sb-125	1.92%	2.85E+00	

**Company: Constellation Energy
Generation**

Plant: Braidwood Nuclear Power Station

Attachment 2, Solid Waste Information

2.0 SOLID WASTE DISPOSITION

Table 14, Solid Waste Disposition from the BNPS Site

Number of Shipments	Mode of Transportation	Destination
6	Hittman Transportation	Energy Solutions - Memphis 1790 Dock St. Memphis, TN
9	Hittman Transportation	Energy Solutions-Bear Creek Facility 1560 Bear Creek Road, Oak Ridge, TN
5	Hittman Transportation	Energy Solutions LLC., Clive, UT Clive Disposal Site - Containerized Waste Facility Clive, UT
1	Hittman Transportation	Waste Control Specialists LLC Compact Waste Disposal Facility, Andrews, TX
21	Total	

**Company: Constellation Energy
Generation**

Plant: Braidwood Nuclear Power Station

Attachment 3, Meteorological Data Summary

2.1 Joint Frequency Distributions

1. Period of Record: 2024
2. Stability Class: All
 - a. Periods of calm (hours): 5.27 Hours
 - b. Hours of Valid Data: 52,554 of 52,706
 - c. Meteorological data are reported in percentage of total for all stability classes.
3. Tower Elevation: 320 ft

Wind Speed (mph)							
Wind Direction	< 3.5	3.6-7.5	7.6-12.5	12.6-18.5	18.6-24.5	>24.5	Total
N	0.97	1.71	1.06	0.02	0.00	0.00	3.76
NNE	0.98	2.01	1.79	0.20	0.00	0.00	4.98
NE	1.27	2.61	1.31	0.09	0.00	0.00	5.28
ENE	2.53	3.45	0.65	0.00	0.00	0.00	6.63
E	3.25	3.24	0.16	0.01	0.00	0.00	6.66
ESE	1.42	3.35	0.74	0.09	0.00	0.00	5.60
SE	0.61	2.75	1.25	0.27	0.00	0.00	4.88
SSE	0.61	2.91	1.96	0.29	0.01	0.00	5.78
S	0.29	2.10	3.14	1.77	0.28	0.00	7.58
SSW	0.27	1.47	2.31	1.61	0.47	0.00	6.13
SW	0.36	1.96	3.05	1.48	0.24	0.00	7.09
WSW	0.68	2.31	1.61	0.59	0.06	0.00	5.25
W	1.79	3.49	2.21	1.51	0.47	0.00	9.47
WNW	1.64	3.49	3.18	1.24	0.12	0.00	9.67
NW	1.25	2.70	1.72	0.17	0.00	0.00	5.84
NNW	0.90	2.55	1.76	0.07	0.00	0.00	5.28
Total	18.82	42.10	27.90	9.41	1.65	0.00	99.88

Attachment 3, Meteorological Data Summary

2.2 Stability class

Table 15, Classification of Atmospheric Stability

Stability Condition	Pasquill Categories	Percentage
Extremely Unstable	A	7.08%
Moderately Unstable	B	6.91%
Slightly Unstable	C	7.42%
Neutral	D	39.92%
Slightly Stable	E	26.17%
Moderately Stable	F	8.19%
Extremely Stable	G	4.25%