POINT BEACH

April 30, 2025
L-2025-086
10 CFR 72.44
TS 5.6.2

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington D C 20555-0001

RE: Point Beach Nuclear Plant, Units 1 and 2
Docket Nos. 50-266 and 50-301 and 72-005
Renewed Facility Operating Licenses DPR-24 and DPR-27

2024 Annual Monitoring Report

Enclosed is the Annual Monitoring Report for PBNP Units 1 and 2, and results of monitoring in support of the Independent Spent Fuel Storage Installation (ISFSI) Docket 72-005 for the period January 1 through December 31, 2024.

This letter contains no new regulatory commitments and no revisions to existing regulatory commitments.

Should you have any questions regarding this submittal, please contact Ms. Maribel Valdez, Fleet Licensing Manager, at 561-904-5164.

Sincerely,

Kenneth Mack

Kenneth A. Mack
Director, Licensing and Regulatory Compliance

Enclosure: Annual Monitoring Report, Radiological Environmental Monitoring Report and Offsite Dose Calculation Manual

cc: USNRC Regional Administrator, Region III
USNRC Project Manager, Point Beach Nuclear Plant
USNRC Senior Resident Inspector, Point Beach Nuclear Plant
Public Service Commission of Wisconsin
American Nuclear Insurers
WI Division of Public Health, Radiation Protection Section
USNRC Office of Nuclear Material Safety and Safeguards

ENCLOSURE

# ANNUAL MONITORING REPORT 2024

## NEXTERA ENERGY POINT BEACH, LLC
## POINT BEACH NUCLEAR PLANT

**DOCKETS 50-266 (UNIT 1), 50-301 (UNIT 2), 72-005 (ISFSI)**
**RENEWED LICENSES DPR-24 and DPR-27**

**January 1, 2024 through December 31, 2024**

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# SUMMARY

The Annual Monitoring Report for the period from January 1, 2024, through December 31, 2024, is submitted in accordance with Point Beach Nuclear Plant (PBNP) Units 1 and 2, Technical Specification 5.6.2 and filed under Dockets 50-266 and 50-301 for Renewed Facility Operating Licenses DPR-24 and DPR-27, respectively. It also contains results of monitoring in support of the Independent Spent Fuel Storage Installation (ISFSI) Docket 72-005. The report presents the results of effluent and environmental monitoring programs, solid waste shipments, non-radioactive chemical releases, and circulating water system operation.

During 2024, the following Curies (Ci) of radioactive material were released via the liquid and atmospheric pathways:

| | Liquid | Atmospheric |
|---|---|---|
| Tritium (Ci) | 932 | 86.2 |
| [1]Particulate (Ci) | 0.0249 | 0.000952 |
| Noble Gas (Ci) | 1.27 | 69.200 |
| C-14[2] | 0.00898 | 11.15 |

[1]Atmospheric particulate includes radioiodine (I-131 - I-133).
[2]Liquid is measured, atmospheric is calculated.

For the purpose of compliance with the effluent design objectives of Appendix I to 10 CFR 50, doses from effluents are calculated for the hypothetical maximally exposed individual (MEI) for each age group and compared to the Appendix I objectives. Doses less than or equal to the Appendix I values are considered to be evidence that PBNP releases are as low as reasonably achievable (ALARA) and comply with the EPA's limits in 40CFR190. The maximum annual calculated doses in millirem (mrem) or millirad (mrad) are shown below and compared to the corresponding design objectives of 10 CFR 50, Appendix I.

LIQUID RELEASES

| Dose Category | Calculated Dose | Appendix I Dose | % Appendix I |
|---|---|---|---|
| Whole body dose | 0.00611 mrem | 3 mrem | 0.20 |
| Organ dose | 0.00691 mrem | 10 mrem | 0.0691 |

ATMOSPHERIC RELEASES

| Dose Category | Calculated Dose | Appendix I Dose | % Appendix I |
|---|---|---|---|
| Particulate organ dose | 0.0467 mrem | 30 mrem | 0.156 |
| Noble gas gamma ray air dose | 0.00102 mrad | 20 mrad | 0.0051 |
| Noble gas beta air dose | 0.00266 mrad | 40 mrad | 0.00665 |
| Noble gas dose to the whole body | 0.000876 mrem | 10 mrem | 0.00876 |
| Noble gas dose to the skin | 0.00203 mrem | 30 mrem | 0.00677 |

The results show that during 2024, the doses from PBNP effluents were ≤0.20% of the Appendix I design objectives. This is less than the 2023 result of 0.22%. The decrease was expected due to Point Beach having a two-outage year in 2023 and producing 2.46E5 more gallons of batch releases compared to 2024. However, operation of the PBNP radwaste treatment system continues to be ALARA.

A survey of land use with respect to the location of dairy cattle was made pursuant to Section 12.2.5 of the PBNP ODCM. As in previous years, no dairy cattle were found to be grazing at the site boundary. Therefore, the assumption that cattle graze at the site boundary used in the evaluation of doses from PBNP effluents remains conservative. Of the sixteen compass sectors around PBNP, six are over Lake Michigan. A land use census (LUC) of the remaining ten sectors over land identifies any changes in the closest garden, occupied dwelling, and dairy in each sector. The 2023 LUC results confirm the assumption that, for the purpose of calculating effluent doses, the maximally exposed person lives at the site boundary remains conservative.

The 2024 Radiological Environmental Monitoring Program (REMP) collected 721 individual samples for radiological analyses. Quarterly composites of weekly air particulate filters generated an additional 24 samples and quarterly composites of monthly lake water samples resulted in a further 12 samples. This yielded a total of 757 samples. The ambient radiation measurements in the vicinity of PBNP and the ISFSI were conducted using 148 sets of thermoluminescent dosimeters (TLDs).

Air monitoring from six different sites, 5 surrounding the plant and a control location, did not reveal any effect from Point Beach effluents. Terrestrial monitoring consisting of soil, vegetation, and milk found no influence from PBNP. Similarly, samples from the aquatic environment, consisting of lake and well water, and fish revealed no buildup of PBNP radionuclides released in liquid effluents. Therefore, the data shows no environmental effect from plant operation.

In 2024, there were no new storage casks added to the ISFSI. The total number of existing dry storage casks is 56: 16 ventilated, vertical storage casks (VSC-24) and 34 NUHOMS®, horizontally stacked storage modules, and 6 HOLTEC HI-STORM FW Storage Modules. The subset of the PBNP REMP samples used to evaluate the environmental impact of the PBNP ISFSI showed no environmental impact from its operation.

The environmental monitoring conducted during 2024 confirmed that the effluent control program at PBNP ensured a minimal impact on the environment.

One-hundred-eighty-one (181) samples were analyzed for tritium as part of the groundwater protection program (GWPP). These samples came from drinking water wells, monitoring wells, yard drain outfalls, yard manholes, surface water on site, the sump for the subsurface drainage system (SSD - located under the plant foundation), and four groundwater foundation integrity monitoring wells located in the facades. The results show no substantial change in tritium from previous years. No drinking water wells (depth >100 feet) have any detectable tritium that is statistically different than zero. Tritium continues to be confined to the upper soil layer where the flow is toward the lake. Groundwater samples from wells in the vicinity of the remediated, former earthen retention pond continue to show low levels of tritium. Gamma scans of groundwater samples originating within the power block found no plant related gamma emitters. The results of GWPP monitoring indicate no significant change from previous years.

# Part A
# EFFLUENT MONITORING

## 1.0 INTRODUCTION

The PBNP effluent monitoring program is designed to comply with federal regulations for ensuring the safe operation of PBNP with respect to releases of radioactive material to the environment and its subsequent impact on the public. Pursuant to 10 CFR 50.34a, operations should be conducted to keep the levels of radioactive material in effluents to unrestricted areas as low as reasonably achievable (ALARA). In 10 CFR 50, Appendix I, the Nuclear Regulatory Commission (NRC) provides the numerical values for what it considers to be the appropriate ALARA design objectives to which the licensee's calculated effluent doses may be compared. These doses are a small fraction of the dose limits specified by 10 CFR 20.1301 and lower than the Environmental Protection Agency (EPA) limits specified in 40 CFR 190.

10 CFR 20.1302 directs PBNP to make the appropriate surveys of radioactive materials in effluents released to unrestricted and controlled areas. Liquid wastes are monitored by inline radiation monitors as well as by isotopic analyses of samples of the waste stream prior to discharge from PBNP. Airborne releases of radioactive wastes are monitored in a similar manner. The appropriate portions of the radwaste treatment systems are used as required to keep both liquid and atmospheric releases ALARA. Prior to release, results of isotopic analyses are used to adjust the release rate of discrete volumes of liquid and atmospheric wastes (from liquid waste holdup tanks and from gas decay tanks) such that the concentrations of radioactive material in the air and water beyond PBNP are below the PBNP Technical Specification concentration limits for liquid effluents and release rate limits for gaseous effluents.

Solid wastes are shipped offsite for disposal at NRC licensed facilities. The amount of radioactivity in the solid waste is determined prior to shipment in order to determine the proper shipping configuration as regulated by the Department of Transportation and the NRC.

10 CFR 72.210 grants a general license for an Independent Spent Fuel Storage Installation (ISFSI) to all nuclear power reactor sites operating under 10 CFR 50. The ISFSI annual reporting requirement pursuant to 10 CFR 72.44(d)(3) is no longer applicable (Reference: 64 FR 50616). Any release of radioactive materials from the operation of the ISFSI must comply with the limits of Part 20 and Part 50 Appendix I design objectives. The dose criteria for effluents and direct radiation specified by 10 CFR 72.104 states that during normal operations and anticipated occurrences, the annual dose equivalent to any real individual beyond the controlled area must not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ. The dose from naturally occurring radon and its decay products is exempt. Because the loading of the storage casks occurs within the primary auxiliary building of PBNP, the doses from effluents due to the loading process will be assessed and quantified as part of the PBNP Radiological Effluent Control Program.

## 2.0 RADIOACTIVE LIQUID RELEASES

The radioactive liquid release path to the environment is via the circulating water discharge. A liquid waste treatment system in conjunction with administrative controls is used to minimize the impact on the environment and maintain doses to the public ALARA from the liquid releases.

### 2.1 Doses From Liquid Effluent

Doses from liquid effluent are calculated using the methodology of the Offsite Dose Calculation Manual (ODCM). These calculated doses use parameters such as the amount of radioactive material released, the total volume of liquid, the total volume of dilution water, and usage factors (e.g., water and fish consumption, shoreline and swimming factors). These calculations produce a conservative estimation of the dose. For compliance with 10 CFR 50, Appendix I design objectives, the annual dose is calculated to the hypothetical maximally exposed individual (MEI). The MEI is assumed to reside at the site boundary in the highest $\chi$/Q sector and is maximized with respect to occupancy, food consumption, and other uses of this area. As such, the MEI represents an individual with reasonable deviations from the average for the general population in the vicinity of PBNP. A comparison of the calculated doses to the 10 CFR 50, Appendix I design objectives is presented in Table 2-1. The conservatively calculated dose to the MEI is a very small fraction of the Appendix I design objective.

**Table 2-1**
**Comparison of 2024 Liquid Effluent Calculated Doses to 10 CFR 50 Appendix I Design Objectives**

| Annual Limit [mrem] | Highest Total Calculated Dose [mrem] | % of Design Objective |
|---|---|---|
| 3 (whole body) | 0.00611 | 0.20 |
| 10 (any organ) | 0.00691 | 0.0691 |

### 2.2 2024 Circulating Water Radionuclide Release Summary

Radioactive liquid releases via the circulating water discharge are summarized by individual source and total curies released on a quarterly and annual basis (Table 2-2). These releases are composed of batch releases (processed waste and steam generators) and continuous releases (wastewater effluent, and blowdown from Units 1 and 2). The wastewater effluent consists of liquid from turbine hall sumps, plant well house backwashes, sewage treatment plant effluent, water treatment plant backwashes, the Unit 1 and 2 facade sumps and the subsurface drainage system sump.

### 2.3 2024 Isotopic Composition of Circulating Water Discharges

The isotopic composition of circulating water discharges during the current reporting period is presented in Table 2-3. The 2024 liquid batch release of 4.23E+05 gallons (Table 2-2) was a decrease from 2023 processed waste released (6.69+05 gallons), which is consistent with water processing requirements during a two-outage year. The total isotopic curie distribution of fission and activation products released in 2024 was 3.39E-2 Ci which was lower than the 2023 value of gamma emitters and hard-to-detects (9.57E-02 Ci). The total antimony (Sb) in 2024 decreased to 1.81e-4 Ci in comparison to the 2023 value of 4.60E-02 Ci. The Zr-Nb also decreased to 1.93E-05 Ci released when compared to the 2023 total of 1.32E-03 curies. Tin isotope (Sn-113/Sn-117m/Sn-125) totals were not produced in 2024, down from 2.04E-04 Ci in 2023. Te-123m was documented at 9.24E-04 Ci in 2024, which was a decrease from the 9.10E-03 Ci observed in 2023. The 2024 C-14 decreased to 8.98E-03 Ci in 2024 from the 1.35E-02 Ci observed in 2023. Sr-92, which was detected in 2023 at 1.78E-06 Ci, was not present in the 2024 effluent. Tritium increased to 932 Ci in 2024 in comparison to the 890 Ci documented in 2023. In 2024, total noble gases increased to 1.27 Ci, as well as, total Iodine releases of 3.22E-03 Ci. These increases were due to a fuel defect found on one of the fuel assemblies. The assembly was removed from service after the October 2024 outage.

## 2.4 Beach Drain System Releases Tritium Summary

Beach drain is the term used to describe the point at which the site yard drainage system empties onto the beach of Lake Michigan. These outfalls carry yard and roof drain runoff to the beach. The plant foundation has a subsurface drainage system (SSD) around the external base of the foundation. This SSD relieves hydrostatic pressure on the foundation by draining water away from the foundation. The drainage pipes empty out onto the beach. In 2014, the SSD outfalls, designated as S-12 and S-13, were added to the beach drain sampling program. Their quarterly results are presented with the other beach drains.

The quarterly results from the monthly beach drain and SSD samples are presented in Table 2-4. The total monthly flow is calculated assuming that the flow rate at the time of sampling persists for the whole month. In 2024, no tritium was observed at the effluent LLDs. Tritium found in the beach drains is not included in the effluent totals unless it can be shown to be the result of a spill or similar event. Because the source of beach drain tritium has been determined to be recapture, including beach drain tritium in the effluent totals would be double counting (NRC RIS 2008-03, Return/re-use of previously discharged radioactive effluents).

The principal source of water for the beach drains is the yard drain system. Yard drain water sources are rain and snow melt containing recaptured tritium. During the winter natural melting is the principal source. Additionally, various roof drains connect to the yard drain system. In addition to precipitation, the roof drains also carry condensate from various building AC units. A secondary source may be groundwater in leakage. This is evidenced by flow during periods of no precipitation. Because there are no external storage tanks or piping that carries radioactive liquids, the main source of radioactivity for this system is recapture/washout of airborne tritium discharges via the yard drain system. Because of these various recapture sources, the beach drains also are sampled as part of the groundwater monitoring program. These results and other groundwater monitoring results are presented in Part D of this Annual Monitoring Report.

## Table 2-2
## Summary of Circulating Water Discharge
January 1, 2024 through December 31, 2024

| | 1st QTR | 2nd QTR | 3rd QTR | 4th QTR | Annual Totals |
|---|---|---|---|---|---|
| **Total Activity Released (Ci)** | | | | | |
| **Fission & Activation Products**[1] | 1.20E-02 | 4.68E-03 | 7.68E-03 | 9.53E-03 | 3.39E-02 |
| **Gross Alpha** | ND | ND | ND | ND | ND |
| **Tritium** | 9.35E+01 | 2.23E+02 | 3.77E+02 | 2.38E+02 | 9.32E+02 |
| **Noble Gases** | 1.64E-02 | 3.36E-02 | 2.73E-01 | 9.48E-01 | 1.27E+00 |
| **Total Vol Released (gal)** | | | | | |
| **Liquid Batch Releases**[2] | 3.49E+04 | 5.05E+04 | 1.11E+05 | 2.27E+05 | 4.23E+05 |
| **Continuous Releases**[3] | 2.50E+07 | 2.15E+07 | 2.12E+07 | 2.32E+07 | 9.09E+07 |
| **Total Gallons** | 2.50E+07 | 2.16E+07 | 2.13E+07 | 2.34E+07 | 9.13E+07 |
| **Total cc** | 9.48E+10 | 8.16E+10 | 8.07E+10 | 8.87E+10 | 3.46E+11 |
| **Unit 1 Circ Water Dilution Volume (gal)** | 3.53E+10 | 4.91E+10 | 4.97E+10 | 4.53E+10 | 1.79E+11 |
| **Unit 2 Circ Water Dilution Volume (gal)** | 3.53E+10 | 4.92E+10 | 4.98E+10 | 3.67E+10 | 1.71E+11 |
| **Total of Both Units Circ Water Dilution Volume (gal)** | 7.06E+10 | 9.84E+10 | 9.95E+10 | 8.20E+10 | 3.50E+11 |
| **Dilution volume used (cc)**[4] | 1.34E+14 | 1.86E+14 | 1.88E+14 | 1.39E+14 | 6.47E+14 |
| **Avg diluted discharge conc (μCi/cc)** | | | | | |
| **Gamma Scan (+HTDs)**[1] | 8.98E-11 | 2.52E-11 | 4.08E-11 | 6.86E-11 | 2.24E-10 |
| **Gross Alpha** | ND | ND | ND | ND | ND |
| **Tritium** | 6.99E-07 | 1.20E-06 | 2.00E-06 | 1.71E-06 | 5.62E-06 |
| **Noble Gases** | 1.23E-10 | 1.81E-10 | 1.45E-09 | 6.83E-09 | 8.58E-09 |

1 HTDs include Fe-55, C-14, Ni-63, Sr-90, and Tc-99.
2 Liquid Batch Releases are the processed waste tanks and steam generator releases
3 Continuous Batch Releases include Steam Generator Blowdown Filter Outlet, Wastewater Effluent, and Subsurface Drainage
4 Circulating water discharge from the Unit that was overboard for the month or with the lowest dilution flow used for average estimated diluted discharge concentration.
ND: means that the radionuclide was not identified in any samples and all analyses were performed with instrumentation meeting the lower limit of detection as required by the PBNP Offsite Dose Calculation Manual.

**Table 2-3**
**Isotopic Composition of Circulating Water Discharges (Ci)**
January 1, 2024 through December 31, 2024

| Nuclide | 1st QTR (Ci) | 2nd QTR (Ci) | 3rd QTR (Ci) | 4th QTR (Ci) | Annual Total (Ci) |
|---|---|---|---|---|---|
| H-3 | 9.35E+01 | 2.23E+02 | 3.77E+02 | 2.38E+02 | 9.32E+02 |
| C-14 | 3.45E-04 | 1.29E-03 | 4.54E-03 | 2.80E-03 | 8.98E-03 |
| Ag-110m | | 1.34E-06 | | 3.76E-05 | 3.89E-05 |
| As-76 | | | | 2.37E-04 | 2.37E-04 |
| Co-58 | 6.46E-05 | 2.72E-05 | 1.64E-05 | 2.68E-04 | 3.76E-04 |
| Co-60 | 4.24E-05 | 5.71E-05 | 5.88E-05 | 3.26E-04 | 4.84E-04 |
| Cr-51 | | | | 3.36E-05 | 3.36E-05 |
| Cs-137 | | | | | ND |
| F-18 | 1.10E-02 | 2.94E-03 | 2.30E-03 | 1.64E-03 | 1.79E-02 |
| Fe-55 | 3.31E-04 | 1.96E-04 | 1.36E-04 | | 6.63E-04 |
| Fe-59 | 8.41E-06 | | | 5.67E-06 | 1.41E-05 |
| I-131 | | | | 3.14E-03 | 3.14E-03 |
| I-132 | | | | 6.77E-06 | 6.77E-06 |
| I-133 | | | | 7.24E-05 | 7.24E-05 |
| Na-24 | | | 1.37E-06 | | 1.37E-06 |
| Nb-95 | | | | 5.89E-06 | 5.89E-06 |
| Nb-97 | 2.67E-06 | 2.26E-06 | 3.15E-06 | | 8.08E-06 |
| Ni-63 | 3.83E-05 | 8.15E-05 | 5.79E-05 | | 1.78E-04 |
| Sb-124 | | | | 3.95E-06 | 3.95E-06 |
| Sb-125 | 1.29E-04 | 4.48E-05 | 3.27E-06 | | 1.77E-04 |
| Sn-113 | | | | | ND |
| Tc-99 | 9.17E-06 | 3.47E-05 | 5.61E-04 | 3.61E-05 | 6.41E-04 |
| Te-123m | 1.98E-05 | 3.81E-06 | 4.71E-06 | 8.96E-04 | 9.24E-04 |
| Zr-95 | | | | 5.33E-06 | 5.33E-06 |
| Kr-85 | 5.11E-03 | 1.86E-02 | 6.01E-02 | 1.64E-01 | 2.48E-01 |
| Xe-131m | 5.84E-04 | 1.14E-03 | 8.99E-03 | 3.68E-02 | 4.75E-02 |
| Xe-133 | 1.08E-02 | 1.39E-02 | 2.03E-01 | 7.43E-01 | 9.71E-01 |
| Xe-133m | | 1.60E-05 | 3.97E-04 | 3.35E-03 | 3.76E-03 |
| Xe-135 | | | | 5.94E-04 | 5.94E-04 |

ND: means that the radionuclide was not identified in any samples and all analyses were performed with instrumentation meeting the lower limit of detection as required by the PBNP Offsite Dose Calculation Manual.

**Table 2-4**
**Beach and Subsoil System Drains - Tritium Summary**
January 1, 2024 through December 31, 2024

| | S-1 | S-3 | S-7 | S-8 | S-9 | S-10 | S-12 | S-13 |
|---|---|---|---|---|---|---|---|---|
| **1st Qtr** | | | | | | | | |
| H-3 (Ci) | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Flow (gal) | 1.01E+06 | 3.30E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.18E+04 | 0.00E+00 |
| **2nd Qtr** | | | | | | | | |
| H-3 (Ci) | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Flow (gal) | 1.91E+06 | 1.94E+06 | 0.00E+00 | 0.00E+00 | 2.59E+05 | 1.30E+05 | 8.46E+04 | 0.00E+00 |
| **3rd Qtr** | | | | | | | | |
| H-3 (Ci) | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Flow (gal) | 3.05E+06 | 3.11E+05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.89E+05 | 0.00E+00 |
| **4th Qtr** | | | | | | | | |
| H-3 (Ci) | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Flow (gal) | 2.66E+06 | 4.13E+05 | 0.00E+00 | 8.64E+04 | 0.00E+00 | 0.00E+00 | 4.40E+04 | 0.00E+00 |

## 2.6 Land Application of Sewage Sludge and Wastewater

In 1988, pursuant to 10 CFR 20.302(a), Point Beach received NRC approval for the disposal of sewage sludge, which may contain trace amounts of radionuclides, by land application on acreage within the site. Land application of sewage sludge is regulated by the Wisconsin Department of Natural Resources. Point Beach has not land applied sewage sludge for over a decade. Therefore, Point Beach has not renewed its WI DNR permit to dispose of sewage sludge in this manner.

There were no sludge or equalization basin disposals by land application during 2024. All disposals from the PBNP sewage treatment plant (STP) were done at the Manitowoc Sewage Treatment Plant. A total of 56,000 gallons in 10 shipments were sent to Manitowoc. All sludge and equalization basin discharges were analyzed to environmental LLDs, except for 4 which were analyzed to effluent LLDs and less than detectable. Naturally occurring radionuclides such as Ra-226 and K-40 were present in all samples. For the shipments in 2024 the total Ra-226 and K-40 were 32.8 µCi and 43.3 µCi, respectively. Small concentrations of H-3 (30 – 179 pCi/L) were found in all of the shipments for a total of 24.2 µCi. Based on the daily flow at the Manitowoc plant, the H-3 discharge concentration would be on the order of 0.0577 pCi/L or 346620 times lower than the EPA drinking water limit of 20,000 pCi/L.

The STP H-3 is attributable to groundwater in-leakage at the STP lift station whose volume is known to increase after a heavy rain or snow melt event. The STP is in the groundwater flow path from the retention pond area and the lake. The STP H-3 concentrations are comparable to those found in the retention pond area monitoring wells.

## 2.7 Carbon-14

Carbon-14 (C-14) is a naturally occurring radionuclide. Nuclear weapons testing in the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. Small amounts of C-14 also are produced by nuclear reactors, but the amounts produced are less than C-14 produced by weapons testing or that occurs naturally. Based on information from the NRC obtained at industry sponsored workshops, Point Beach began evaluating C-14 liquid discharges in 2009, prior to the issuance of Regulatory Guide 1.21 [RG 1.21], Rev 2 in June of 2009. Point Beach continues to analyze batch liquid waste discharges for C-14 and reporting the results in the Annual Monitoring Report.

The NRC requested that all nuclear plants report C-14 emissions beginning with the 2010 monitoring reports. Pursuant to NRC guidance in RG 1.21(Rev 2), evaluation of C-14 in liquid wastes is not required because the quantity released via this pathway is much less than that contributed by gaseous emissions. However, as stated above, Point Beach began C-14 analyses and reporting prior to the issuance of RG 1.21 (Rev 2). RG 1.21 states that a radionuclide is a principal effluent component if it contributes greater than 1% of the Appendix I design objective dose compared to the other radionuclides in the effluent type, or, if it is greater than 1% of the activity of all radionuclides in the effluent type. In this case, C-14 is compared to other (non-tritium or noble gases) radionuclides discharged in liquids.

For 2024, the annual total of C-14 (8.98E-03 Ci) in liquid discharges is documented in Table 2-3. The 2024 amount of C-14 released makes up about 26% of the non-tritium radionuclides released in liquids (8.98E-03/3.39E-02).

## 3.0 RADIOACTIVE AIRBORNE RELEASES

The release paths to the environment contributing to radioactive airborne release totals during this reporting period were the auxiliary building vent stack, the drumming area vent stack, the letdown gas stripper, the Unit 1 containment purge stack, and the Unit 2 containment purge stack. A gaseous radioactive effluent treatment system in conjunction with administrative controls is used to minimize the impact on the environment from the airborne releases and maintain doses to the public ALARA.

### 3.1 Doses from Airborne Effluent

Doses from airborne effluent are calculated for the maximum exposed individual (MEI) following the methodology contained in the PBNP ODCM. These calculated doses use parameters such as the amount of radioactive material released, the concentration at and beyond the site boundary, the average site weather conditions, and usage factors (e.g., breathing rates, food consumption). In addition to the MEI doses, the energy deposited in the air by noble gas beta particles and gamma rays is calculated and compared to the corresponding Appendix I design objectives. A comparison of the annual Appendix I design objectives for atmospheric effluents to the highest organ dose and the noble gas doses calculated using ODCM methodology is listed in Table 3-2. C-14 is not included in the Appendix I calculations because it is not an Appendix I radionuclide. The C-14 dose calculation has been required since 2010 (see Sections 3.4 through 3.6, below, for a more detailed description) and is treated separately. The comparison between airborne effluent doses with and without C-14 is shown in Table 3-5. The highest Appendix I dose is 4.67e-02 mrem for the infant age group thyroid. Had C-14 been included, the child-bone dose would have been the highest at 1.57E-01 mrem. Even with the inclusion of C-14 the doses demonstrate that releases from PBNP to the atmosphere continue to be ALARA at 0.52% of the dose objective. This percentage is exactly the same as the 2023 result.

### 3.2 Radioactive Airborne Release Summary

Radioactivity released in airborne effluents for 2024 is summarized in Table 3-3. The particulate total increased to 1.64E-04 Ci in 2024 from 3.33E-05 Ci in 2023. This increase is attributed to an increase in F-18 (1.50E-04 2024 compared to 3.06E-06 in 2023). Tritium decreased in 2024 to 86.2 Ci from 90.9 in 2023. Noble gases increased to 69.2 Ci in 2024 from 14.6 Ci in 2023. All increases are directly due to the identification of failed fuel in the Unit 2 reactor which started trending in June of 2023. The defect was removed in October of 2024 during the refueling outage. Radioiodines and noble gases all saw significant increases during airborne releases due to this fuel defect. 2024 noble gases increased 4.7 times over 2023 results (14.6 Ci to 69.2 Ci). Moreover, iodines increased 35 times over the 2023 releases (2.25E-05 Ci to 7.88E-04 Ci) due to the fuel defect.

### 3.3 Isotopic Airborne Releases

The monthly isotopic airborne releases for 2024, from which the airborne doses were calculated, are presented in Table 3-4. Carbon-14 is not included in Table 3-4 because it was calculated and not measured. C-14 is discussed in the following sections.

As in previous years the outage impact of the isotopic mixture is demonstrated in the comparison of the non-outage particulate releases. During the Unit 2 outage in October- November, twelve different particulates were identified in the airborne effluent. Most were released via the open hatches on the 26 and 66-foot elevation of containment. The convective flow through the open hatch during purge is unfiltered. Although the flow is into the façade, there are two circumferential gaps around the façade. It is assumed that the release into façade is transferred to the outside and therefore is treated as a release to the environment.

As was noted in Section 3.2, the total particulate curies observed increased in 2024 when compared to 2023, the increase is attributed to the increase in F-18 released in 2024.

3.4 Carbon-14

C-14 is a naturally occurring radionuclide. Nuclear weapons testing of the 1950s and 1960s significantly increased the amount of C-14 in the atmosphere. Small amounts of C-14 also are produced by nuclear reactors as neutrons interact with the dissolved oxygen and nitrogen in the primary coolant. However, the amount produced by nuclear reactors is much less than that produced by weapons testing or that occur naturally.

The NRC has requested that nuclear plants report C-14 emissions. C-14 is a hard-to-detect radionuclide. It is not a gamma emitter and must be chemically separated from the effluent stream before it can be measured. Because nuclear plants currently are not equipped to perform this type of sampling, RG 1.21 allows for calculating C-14 discharges based on fission rates.

The Electric Power Research Institute (EPRI) developed the methodology for calculating C-14 generation and releases for the nuclear industry. The results were published as Technical Report 1021106 (December 2010), “Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents." In addition to neutron flux, the percent oxygen and nitrogen in the VCTs is used in the C-14 calculation as both gases contribute to the generation of C-14. Pursuant to NRC guidance (Regulatory Guide 1.21, Rev 2, p. 16, June 2009), most of the C-14 emissions from nuclear plant occur in the gaseous phase.

The Point Beach C-14 generation for 2024 was calculated using the EPRI guidance and the current core parameters resulting from the power uprate. The calculated amounts were 5.52 Ci for Unit 1 and 5.64 Ci for Unit 2 yielding a total of 11.15 Ci which is statistically the same as 2016 through 2023. The 2024 calculated total 11.15 Ci is roughly 1242 times higher than the 8.98E-03 Ci of C-14 determined by analyses of composites from liquid waste batch discharges, steam generator blowdown, and other waste streams.

3.5 C-14 Airborne Effluent Dose Calculation

The dose from the airborne C-14 is dependent on its chemical form. The C-14 released to the atmosphere consists of both organic and inorganic species. Both the inorganic and organic C-14 contribute to the inhalation dose. Only the inorganic $^{14}CO_2$ species contributes to the dose from the ingestion of photosynthetically incorporated C-14. The organic forms such as methane, $CH_4$, are not photosynthetically active. For PWRs such as PBNP most of the gaseous C-14 occurs as methane, $^{14}CH_4$, not as carbon dioxide, $^{14}CO_2$.

The amount of $^{14}CO_2$ present in the PBNP airborne effluent has not been measured. However, such measurements have been made at a comparable PWR site similar to the PBNP design. The Ginna nuclear generating station is of similar design to PBNP. It is a Westinghouse 2-loop PWR of the same vintage as PBNP and approximately the same power (prior to the PBNP power uprate). Measurements at Ginna for 18 months in 1980 - 1981 (Kunz, "Measurement of $^{14}C$ Production and Discharge From the Ginna Nuclear Power Reactor," 1982) found that ten percent of the C-14 was discharged as $^{14}CO_2$. Therefore, 10% of the 11.15 Ci of the calculated C-14 for PBNP will be used in the ingestion dose calculations.

C-14 dose calculations were made using the dose factors and the methodology of Regulatory Guide 1.109. In 2018 the inhalation dose factors were updated to reflect a change in the $\chi/Q$ value in the Point Beach ODCM. The inhalation dose was calculated using all forms of C-14. All forms of the C-14 are used because regardless of whether the C-14 is in the form of $^{14}CO_2$ or an organic form, such as $CH_4$, both would be inhaled and contribute to a lung dose.

For the other existing pathways, milk, meat, and produce, the dose depends upon the amount incorporated into biomass consumed by cattle and people: forage for cattle and produce for humans. Incorporation only occurs via photosynthesis. Photosynthesis only incorporates $^{14}CO_2$ and accounts for only 10% of the total C-14 release for these pathways.

The airborne effluent C-14 dose calculations were made as described above. They were made for the MEI as explained in Section 2.1. This approach utilizes all the pathways that are applicable to a hypothetical person residing at the site boundary. Because C-14 is present as a gas, the pathways are milk, meat, and produce (vegetables, fruit, and grain) and the Regulatory Guide 1.109, Table E-5 usage factors are applied to the calculation. As such, the resulting dose will be conservative in that the produce usage factor includes grain and fruit and these pathways do not exist in the vicinity of the point for which the C-14 doses are calculated. Furthermore, because leafy vegetables are included in the produce pathway, they are not used as a separate pathway because that would result in double accounting for leafy vegetable dose contribution.

In 2022 the C-14 dose calculation methodology was changed in the PBNP ODCM to reflect changes in a new software that was implemented. The new changes use the NUREG-0133 methodology for C-14 calculation of dose. The calculations used to determine the dose were updated for the annual C-14 dose contribution.

Carbon-14 is not an Appendix I radionuclide. Therefore, airborne C-14 is not summed with the other airborne radioactive effluents for comparison of airborne effluent dose to the Appendix I dose objectives. However, the C-14 doses are presented and compared to the other radionuclide doses in Table 3-5.

3.6 C-14 Measurements

No C-14 measurements were made of PBNP airborne effluents. In 2010, C-14 was measured in crops grown on fields in the owner controlled area located in the highest $\chi$/Q sector at the site's south boundary. One field was leased for feed corn by a dairy south of the plant. That dairy is part of the REMP. In an adjacent field soybeans were grown by another farmer. These two crops were sampled in this sector and as well as in a background location about 17 miles SW of the plant. Based on the measurement error, there was no statistical difference between the results obtained on site in the highest $\chi$/Q sector as compared to the background site some 17 miles away (2013 AMR, Table 10-3). These results demonstrated that the dose from C-14 in Point Beach airborne effluents should not measurably increase the C-14 dose compared to that received from naturally occurring C-14 in plants (1 mrem: NCRP Report 93, Ionizing Radiation Exposure of the Population of the United States, 1987, p.12).

3.7 Abnormal Release

An abnormal gaseous release occurred in July 2024. The abnormal release involved a hole in the roof of the Primary Auxiliary Building (PAB). On July 9 at 08:22, a 6.5' by 6.5' hold was cut through the roof in the PAB above the Truck bay. This hole was used to take out the old crane skid and replace it with a new one. The hole was continuously monitored by an air sampler. Samples from the drumming area located by the PAB hole were analyzed for noble gas and tritium. Air samplers were also placed by the roll up truck doors and ran whenever the doors were opened. A total of 4 continuous air permits were created; one for the duration of the hole in the roof and 3 for each time the roll up truck door was opened. Tritium was the only contributor to effluent release.amounts. Historic analysis of the area, as well as, the sampling during the evolution shows that the area is a very low isotopic emitter. Tritium accounted for 8.24 uCi/cc released, resulting in 2.99 total Ci being released during the evolution.

## Table 3-1
## Comparison of 2024 Airborne Effluent Calculated Doses to 10 CFR 50 Appendix I Design Objectives

| Category | Annual Appendix I Design Objective | January-December Calculated Dose | Percent of Appendix I Design Objective |
|---|---|---|---|
| Particulate | 30 mrem/organ | 0.0467 mrem | 0.156 |
| Noble gas | 20 mrad (gamma air) | 0.00102 mrad | 0.0051 |
| Noble gas | 40 mrad (beta air) | 0.00266 mrad | 0.00665 |
| Noble gas | 10 mrem (whole body) | 0.000876 mrem | 0.00876 |
| Noble gas | 30 mrem (skin) | 0.00203 mrem | 0.00677 |

## Table 3-2
## Radioactive Airborne Effluent Release Summary
January 1, 2024 through December 31, 2024

| | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | Annual Total |
|---|---|---|---|---|---|
| **Total Noble Gas (Ci)**[1] | 1.96E+00 | 6.05E+00 | 7.84E+00 | 5.33E+01 | 6.92E+01 |
| **Total Radioiodines (Ci)**[2] | 8.15E-06 | 1.84E-06 | 0.00E+00 | 7.78E-04 | 7.88E-04 |
| **Total Particulate (Ci)**[3] | 3.32E-06 | 1.45E-04 | 2.16E-06 | 1.32E-05 | 1.64E-04 |
| Alpha (Ci) | ND | ND | ND | ND | ND |
| All other beta + gamma (Ci) | 3.32E-06 | 1.45E-04 | 2.16E-06 | 1.32E-05 | 1.64E-04 |
| **Total Tritium (Ci)** | 1.46E+01 | 1.51E+01 | 1.97E+01 | 3.68E+01 | 8.62E+01 |
| **Avg. Rel. Rate (μCi/sec)**[4] | 5.07E-01 | 5.27E-01 | 6.81E-01 | 1.15E+00 | |

[1] Total noble gas (airborne releases) and activation gas Ar-41.

[2] Although for dose calculations iodines are grouped with particulates, for this reporting table they are separated from the particulate group.

[3] Total Particulate is the sum of alpha, strontium, and others. It does not include radioiodines or C-14. C-14 is calculated for the year and no monthly values are available.

[4] Average release rate is based off the average tritium release rates.

ND: means that the radionuclide was not identified in any samples and all analyses were performed with instrumentation meeting the lower limit of detection as required by the PBNP Offsite Dose Calculation Manual.

**TABLE 3-3**
**Isotopic Composition of Airborne Releases**
# 2024

| | 1st QTR | 2nd QTR | 3rd QTR | 4th QTR | Annual |
|---|---|---|---|---|---|
| **Nuclide** | (Ci) | (Ci) | (Ci) | (Ci) | **Total** |
| **H-3** | 1.46E+01 | 1.51E+01 | 1.97E+01 | 3.68E+01 | 8.62E+01 |
| **Ar-41** | 1.76E-01 | 1.86E-01 | 1.73E-01 | 1.39E-01 | 6.74E-01 |
| **Kr-85** | 3.91E-02 | 1.17E+00 | 1.33E+00 | 4.41E-01 | 2.98E+00 |
| **Xe-131m** | 2.09E-02 | 9.93E-02 | 1.24E-01 | 5.70E-02 | 3.01E-01 |
| **Xe-133** | 1.72E+00 | 4.58E+00 | 6.19E+00 | 5.25E+01 | 6.50E+01 |
| **Xe-133m** | 7.11E-03 | 7.67E-03 | 2.26E-02 | 9.54E-02 | 1.33E-01 |
| **Xe-135** | 1.77E-03 | 2.20E-03 | 2.19E-03 | 9.19E-02 | 9.81E-02 |
| **I-131** | 8.15E-06 | 1.84E-06 | ND | 7.70E-04 | 7.80E-04 |
| **I-133** | ND | ND | ND | 8.26E-06 | 8.26E-06 |
| **Br-82** | 1.18E-09 | ND | 1.03E-09 | ND | 2.21E-09 |
| **Co-58** | ND | ND | ND | 1.27E-06 | 1.27E-06 |
| **Co-60** | ND | ND | ND | 2.38E-06 | 2.38E-06 |
| **Cr-51** | ND | ND | ND | 1.91E-06 | 1.91E-06 |
| **Cr-134** | ND | ND | ND | 1.21E-07 | 1.21E-07 |
| **Cs-137** | ND | ND | ND | 1.98E-07 | 1.98E-07 |
| **F-18** | 1.40E-06 | 1.45E-04 | 2.16E-06 | 1.50E-06 | 1.50E-04 |
| **Fe-55** | ND | ND | ND | ND | ND |
| **Mn-54** | ND | ND | ND | 1.51E-07 | 1.51E-07 |
| **Nb-95** | ND | ND | ND | 2.15E-06 | 2.15E-06 |
| **Ni-63** | 1.92E-06 | ND | ND | 2.11E-06 | 4.03E-06 |
| **Sr-89** | ND | ND | ND | ND | ND |
| **Sr-90** | ND | ND | ND | ND | ND |
| **Tc-99** | ND | ND | ND | ND | ND |
| **Tc-99M** | ND | ND | ND | 5.75E-08 | 5.75E-08 |
| **Mo-99** | ND | ND | ND | 5.92E-08 | 5.92E-08 |
| **Sn-117m** | ND | ND | ND | 2.18E-08 | 2.18E-08 |
| **Sb-124** | ND | ND | ND | 4.30E-08 | 4.30E-08 |
| **Zr-95** | ND | ND | ND | 1.24E-06 | 1.24E-06 |

ND: means that the radionuclide was not identified in any samples and all analyses were performed with instrumentation meeting the lower limit of detection, as required by the PBNP Offsite Dose Calculation Manual.

## Table 3-4
## Comparison of Airborne Effluent Doses (Appendix I and C-14)

**2024 Appendix I (Airborne Particulate + Tritium) Dose (mrem)**

| | Bone | Liver | T-WB | Thyroid | Kidney | Lung | GI-LLI | Skin |
|---|---|---|---|---|---|---|---|---|
| **Adult** | 3.56E-05 | 1.15E-02 | 1.15E-02 | 1.88E-02 | 1.15E-02 | 1.15E-02 | 1.15E-02 | 1.62E-05 |
| **Teen** | 4.78E-05 | 1.29E-02 | 1.29E-02 | 2.28E-02 | 1.29E-02 | 1.29E-02 | 1.29E-02 | 1.62E-05 |
| **Child** | 9.38E-05 | 1.84E-02 | 1.84E-02 | 3.70E-02 | 1.84E-02 | 1.83E-02 | 1.83E-02 | 1.62E-05 |
| **Infant** | 1.24E-04 | 8.17E-03 | 8.10E-03 | 4.67E-02 | 8.19E-03 | 8.05E-03 | 8.05E-03 | 1.62E-05 |

| | |
|---|---|
| **Ann.Limit** | 3.00E+01 |
| **% Ann Lim** | 1.56E-01 |

**2024 Carbon-14 Dose (mrem)**

| | Bone | Liver | T. Body | Thyroid | Kidney | Lungs | GI-LLI | Skin |
|---|---|---|---|---|---|---|---|---|
| **Adult** | 4.28E-02 | 8.47E-03 | 8.47E-03 | 8.47E-03 | 8.47E-03 | 8.47E-03 | 8.47E-03 | 0.00E+00 |
| **Teen** | 6.92E-02 | 1.37E-02 | 1.37E-02 | 1.37E-02 | 1.37E-02 | 1.37E-02 | 1.37E-02 | 0.00E+00 |
| **Child** | 1.57E-01 | 3.12E-02 | 3.12E-02 | 3.12E-02 | 3.12E-02 | 3.12E-02 | 3.12E-02 | 0.00E+00 |
| **Infant** | 1.31E-01 | 2.78E-02 | 2.78E-02 | 2.78E-02 | 2.78E-02 | 2.78E-02 | 2.78E-02 | 0.00E+00 |

**2024 Total Airborne Non-Noble Gas Dose [Particulate + H-3 + C-14 (mrem)]**

| | Bone | Liver | T-WB | Thyroid | Kidney | Lung | GI-LLI | Skin |
|---|---|---|---|---|---|---|---|---|
| **Adult** | 4.28E-02 | 2.00E-02 | 2.00E-02 | 2.73E-02 | 2.00E-02 | 2.00E-02 | 2.00E-02 | 1.62E-05 |
| **Teen** | 6.93E-02 | 2.66E-02 | 2.66E-02 | 3.65E-02 | 2.66E-02 | 2.66E-02 | 2.66E-02 | 1.62E-05 |
| **Child** | 1.57E-01 | 4.96E-02 | 4.96E-02 | 6.82E-02 | 4.96E-02 | 4.95E-02 | 4.95E-02 | 1.62E-05 |
| **Infant** | 1.31E-01 | 3.60E-02 | 3.59E-02 | 7.45E-02 | 3.60E-02 | 3.59E-02 | 3.59E-02 | 1.62E-05 |

| | |
|---|---|
| **Ann.Limit** | 3.00E+01 |
| **% Limit** | 5.24E-01 |

The percent of limit is calculated using the highest total dose, the Child Age Group.

## 4.0 RADIOACTIVE SOLID WASTE SHIPMENTS

### 4.1 Types, Volumes, and Activity of Shipped Solid Waste

The following types, volumes, and activity of solid waste were shipped from PBNP for offsite disposal or burial during 2024. No Types C or D wastes were shipped. No irradiated fuel was shipped offsite. The volume, activity and type of waste are listed in Table 4-1.

**Table 4-1**
**Quantities and Types of Waste Shipped from PBNP in 2024**

| Type of Waste | Quantity | Activity |
|---|---|---|
| A. Spent resins, filter sludge, evaporator bottoms, etc. | 2.60 $m^3$ | 141.0 Ci |
| | 93.5 $ft^3$ | |
| B. Dry compressible waste, contaminated equipment, etc | 66.8 $m^3$ | 0.059 Ci |
| | 2360.0 $ft^3$ | |
| C. Irradiated components, control rods, etc. | 0.00 $m^3$ | N/A Ci |
| | $ft^3$ | |
| D. Other | 0.0 $m^3$ | N/A Ci |

### 4.2 Solid Waste Disposition

There were three solid waste shipments from PBNP during 2024. The dates and destinations are shown in Table 4-2.

**Table 4-2**
**2024 PBNP Radioactive Waste Shipments**

| 2024 PBNP Radioactive Waste Shipments | |
|---|---|
| Date | Destination |
| 7/26/2024 | Oak Ridge, TN |
| 7/26/2024 | Oak Ridge, TN |
| 10/3/2025 | Erwin, TN |
| | |

### 4.3 Major Nuclide Composition (by Type of Waste)

The major radionuclide content of the 2024 solid waste was determined by gamma isotopic analysis and the application of scaling factors for certain indicator radionuclides based on the measured isotopic content of representative waste stream samples. The estimated isotopic content is presented in Table 4-3. Only those radionuclides with detectable activity are listed.

**Table 4-3**
**2024 Estimated Solid Waste Major Radionuclide Composition**

| Type A | | | Type B | | |
|---|---|---|---|---|---|
| Nuclide | Activity (mCi) | Percent Abundance | Nuclide | Activity (mCi) | Percent Abundance |
| Total Activity | 5.85E-02 | 100.00% | Total Activity | 1.40E+02 | 100.00% |
| H-3 | 3.46E-05 | 0.06% | H-3 | 5.89E-02 | 0.04% |
| Cr-51 | 4.36E-03 | 7.45% | C-14 | 7.48E-02 | 0.05% |
| Mn-54 | 8.33E-04 | 1.42% | Mn-54 | 2.10E+00 | 1.50% |
| Fe-55 | 6.19E-03 | 10.58% | Fe-55 | 4.16E+00 | 2.97% |
| Co-57 | 1.90E-05 | 0.03% | Co-57 | 6.69E-01 | 0.48% |
| Co-58 | 5.80E-03 | 9.91% | Co-58 | 9.86E+00 | 7.04% |
| Fe-59 | 8.83E-04 | 1.51% | Ni-59 | 5.63E-01 | 0.40% |
| Co-60 | 2.26E-02 | 38.61% | Co-60 | 5.68E+01 | 40.58% |
| Ni-63 | 3.28E-04 | 0.56% | Ni-63 | 6.23E+01 | 44.51% |
| Zn-65 | 1.12E-04 | 0.19% | Sr-89 | 3.42E-03 | 0.00% |
| Nb-95 | 1.02E-02 | 17.43% | Sr-90 | 2.54E-02 | 0.02% |
| Zr-95 | 5.55E-03 | 9.48% | Sb-125 | 2.36E+00 | 1.69% |
| Tc-99 | 1.53E-05 | 0.03% | Cs-137 | 9.61E-01 | 0.69% |
| Ag-110m | 4.17E-04 | 0.71% | Ce-144 | 9.09E-04 | 0.00% |
| Sn-113 | 2.91E-04 | 0.50% | Pu-238 | 2.72E-04 | 0.00% |
| Sb-124 | 2.77E-04 | 0.47% | Pu-239 | 1.77E-04 | 0.00% |
| Sb-125 | 5.69E-04 | 0.97% | Am-241 | 4.90E-04 | 0.00% |
| I-129 | 3.14E-06 | 0.01% | Pu-241 | 3.25E-02 | 0.02% |
| Cs-137 | 3.98E-05 | 0.07% | Cm-242 | 3.82E-05 | 0.00% |
| Ce-144 | 4.51E-06 | 0.01% | Cm-243 | 1.80E-04 | 0.00% |
| Am-241 | 1.62E-07 | 0.00% | | | |
| Pu-241 | 1.05E-05 | 0.02% | | | |
| Cm-243 | 1.60E-07 | 0.00% | | | |

## 5.0 NONRADIOACTIVE CHEMICAL RELEASES

### 5.1 Scheduled Chemical Waste Releases

There were no scheduled chemical waste releases of neutralized wastewater to the circulating water system from January 1, 2024 through December 31, 2024.

Scheduled chemical waste releases are based on the analytical results obtained from sampling a representative number of neutralizing tanks.

## 5.2 Miscellaneous Chemical Waste Releases

Miscellaneous chemical waste releases from the wastewater effluent (based on effluent analyses) to the circulating water for January 1, 2024, to June 30, 2024, included 2.08E+07 gallons of clarified effluent. The wastewater contained 2.63E+03 lbs. of suspended solids.

Miscellaneous chemical waste releases from the wastewater effluent (based on effluent analyses) to the circulating water for July 1, 2024, to December 31, 2024, included 2.02E+07 gallons of clarified effluent. The wastewater contained 1.89E+03 lbs. of suspended solids.

Miscellaneous chemical waste released directly to the circulating water, based on amount of chemicals used from January 1, 2024, to June 30, 2024, included 3.83+05 lbs. of sodium bisulfite solution (1.46E+05 lbs. sodium bisulfite), 3.25E+05 lbs. of Sodium Hypochlorite Solution (4.06E+04 lbs. sodium hypochlorite), 1.90E+04 lbs. Acti-Brom 1338 (8.54E+03 lbs. sodium bromide). 3.49E+03 lbs. of biodetergent, and 9.72E+03 lbs. of silt dispersant.

Miscellaneous chemical waste released directly to the circulating water, based on amount of chemicals used from July 1, 2024, to December 31, 2024, included 5.49E+05 lbs. of sodium bisulfite solution (2.09E+05 lbs. sodium bisulfite), 2.87E+05 lbs. Sodium Hypochlorite Solution (3.58E+04 lbs. sodium hypochlorite), 1.94E+04 lbs. Acti-Brom 1338 (8.73E+03 lbs. sodium bromide), 4.24E+03 lbs. of biodetergent, and 4.24E+03 lbs. of silt dispersant.

## 6.0 CIRCULATING WATER SYSTEM OPERATION

The circulating water system operation during this reporting period is described in Table 6-1.

**Table 6-1**
**Circulating Water System Operation for 2024**

| | UNIT | JAN | FEB | MAR | APR | MAY | JUN |
|---|---|---|---|---|---|---|---|
| Average Volume Cooling Water Discharge [million gal/day]* | 1 | 348.5 | 348.5 | 502.2 | 551.5 | 502.2 | 551.5 |
| | 2 | 348.5 | 348.5 | 503.3 | 552.9 | 552.9 | 552.9 |
| Average Cooling Water Intake Temperature [°F] | 1 | 38 | 38 | 40 | 45 | 50 | 53 |
| | 2 | 38 | 38 | 40 | 45 | 50 | 53 |
| Average Cooling Water Discharge Temperature [°F] | 1 | 70 | 71 | 63 | 64 | 70 | 72 |
| | 2 | 70 | 71 | 62 | 63 | 69 | 72 |
| Average Ambient Lake Temperature [°F] | | 37 | 38 | 40 | 44 | 50 | 53 |

* For days with cooling water discharge flow.

**Table 6-1(continued)**
**Circulating Water System Operation for 2024**

| | UNIT | JUL | AUG | SEP | OCT*** | NOV | DEC |
|---|---|---|---|---|---|---|---|
| Average Volume Cooling* Water Discharge [million gal/day] | 1 | 551.5 | 551.5 | 551.5 | 505.8 | 550.4 | 462.8 |
| | 2 | 552.9 | 552.9 | 552.9 | 237.9 | 541.5 | 463.9 |
| Average Cooling Water Intake Temperature [°F] | 1 | 63 | 68 | 65 | 53 | 47 | 39 |
| | 2 | 63 | 68 | 65 | 56 | 47 | 39 |
| Average Cooling Water Discharge Temperature [°F] | 1 | 82 | 88 | 85 | 76 | 67 | 65 |
| | 2 | 82 | 87 | 84 | 68 | 66 | 65 |
| Average Ambient Lake Temperature [°F] | | 63 | 67 | 64 | 53 | 46 | 39 |

* For days with cooling water discharge flow.
*** U2 refueling outage 10/13/24-10/29/24

# Part B
# Miscellaneous Reporting Requirements

## 7.0 ADDITIONAL REPORTING REQUIREMENTS

### 7.1 Revisions to the PBNP Effluent and Environmental Programs

Revision 24 of the Offsite Dose Calculation Manual (ODCM) was issued in February 2022. The site operated under the guidance of this revision until the issuance of Revision 25 on March 11, 2024 and was active until August 30, 2024. Revision 26 was issued on August 30, 2024 and was in use for the rest of 2024.

The ODCM revision 25 deleted the "NOTE: Pursuant to the Procedure, Plan, and Program Review Matrix approved by the Plant General Manager, changes that have been determined to be editorial do not need ORG approval." and added "PBF-7072 ODCM Change Documentation form shall be used to document ODCM changes and included with records of review for retention in addition to the ORG package." This was to ensure changes to the ODCM maintain the levels of radioactive effluent control required by 10 CFR 20.1302, 40 CFR 190, 10CFR 50.36a, 10 CFR 50 Appendix I and do not adversely impact the accuracy or reliability of effluent, dose, or setpoint calculations.

Revision 25 also deleted commentary citing what to do if data was not yet acquired for the Annual Monitoring Report. The commentary "as an addendum in the next Annual Monitoring Report" was replaced it with "in a supplementary report as soon as possible" to precisely match the verbiage contained in TS 5.6.2.

The ODCM revision 26 rewrote "Table 6-2 Note 1" stating "If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided that 1) prior to initiating a batch release, two separate samples are analyzed by two technically qualified people in accordance with the applicable part of Table 6-1 and 6-2, 2) the release rate is reviewed by two technically qualified people, and 3) at a minimum, one grab sample obtained during the discharge, and once every 12 hours through the duration of the release. Otherwise, suspend release of radioactive effluents via this pathway (reference TRM 3.3.1)." This was created to allow liquid releases when RMS monitors are declared out of service.

### 7.2 Interlaboratory Comparison Program

Microbac Labs Inc., the analytical laboratory contracted to perform the radioanalyses of the PBNP environmental samples, participated in several interlaboratory comparison studies including those administered by Environmental Resources Associates (ERA) during 2024. The results of these comparisons can be found in Appendix A of the attached final report for 2024, January – December 2024 from Microbac Labs, which is located in Appendix 1 of this report.

7.3 Special Circumstances

No special circumstances to report regarding operation of the explosive gas monitor for the waste gas holdup system was needed during 2024.

# Part C
# RADIOLOGICAL ENVIRONMENTAL MONITORING

## 8.0 INTRODUCTION

The objective of the PBNP Radiological Environmental Monitoring Program (REMP) is to determine whether the operation of PBNP or the ISFSI has radiologically impacted the environment. To accomplish this, the REMP collects and analyzes air, water, milk, soil, vegetation (grasses and weeds), and fish samples for radionuclides and uses thermoluminescent dosimeters (TLDs) to determine the ambient radiation background. The analyses of the various environmental media provide data on measurable levels of radiation and radioactive materials in the principal pathways of environmental exposure. These measurements also serve as a check of the efficacy of PBNP effluent controls.

The REMP fulfills the requirements of 10 CFR 20.1302, PBNP General Design Criterion (GDC) 17, GDC 64 of Appendix A to 10 CFR 50, and Sections IV.B.2 and IV.B.3 of Appendix I to 10 CFR 50 for the operation of the plant. A subset of the PBNP REMP samples, consisting of air, soil and vegetation, as well as TLDs, provide the means to measure changes in the ambient environmental radiation levels at sites near the ISFSI and at the PBNP site boundary. This is to ensure that radiation levels from the ISFSI are maintained within the dose limits of 10 CFR 72.104. Because the ISFSI is within the PBNP site boundary, radiation doses from PBNP and the ISFSI combined, must be used to assess compliance with 10 CFR 72.122 and 40 CFR 190. Therefore, radiological environmental monitoring for the ISFSI is provided by selected sampling sites, which are part of the PBNP REMP.

For the aquatic environment, the samples include water as well as the biological integrators, such as fish. Because of their migratory behavior, fish are wide area integrators. Grab samples of lake water provide a snapshot of radionuclide concentrations at the time the sample is taken; whereas analysis of fish yield concentrations integrated over time.

The air-grass-cow-milk exposure pathway unites the terrestrial and atmospheric environments. This pathway is important because of the many dairy farms around PBNP. Therefore, the REMP includes samples of air, general grasses, and milk from the PBNP environs. An annual land use survey is made to determine whether the assumptions on the location of dairy cattle remain conservative with respect to dose calculations for PBNP effluents. The dose calculations assume that the dairy cattle are located at the south site boundary, the highest depositional sector. In addition, soil samples are collected and analyzed in order to monitor the potential for long-term buildup of radionuclides in the vicinity of PBNP.

For the measurement of ambient environmental radiation levels that may be affected by direct radiation from PBNP or by noble gas effluents, the REMP employs a series of TLDs situated around PBNP and the ISFSI.

## 9.0 PROGRAM DESCRIPTION

### 9.1 Results Reporting Convention

The vendor used by PBNP to analyze the environmental samples is directed to report analysis results as measured by a detector, which can meet the required lower limit of detection (LLD) as specified in Table 12-1 of the ODCM for each sample. The report provided by the vendor (see Appendix 1) contains values, which can be either negative, positive or zero plus/minus the two sigma counting uncertainty, which provides the 95% confidence level for the measured value.

The LLD is an *a priori* concentration value that specifies the performance capability of the counting system used in the analyses of the REMP samples. The parameters for the *a priori* LLD are chosen such that only a five percent chance exists of falsely concluding a specific radionuclide is present when it is not present at the specified LLD. Based on detector efficiency and average background activity, the time needed to count the sample in order to achieve the desired LLD depends upon the sample size. Hence, the desired LLD may be achieved by adjusting various parameters. When a suite of radionuclides are required to be quantified in an environmental sample such as lake water, the count time used is that required to achieve the LLD for the radionuclide with the longest counting time. Therefore, in fulfilling the requirement for the most difficult to achieve radionuclide LLD, the probability of detecting the other radionuclides is increased because the counting time used is longer than that required to achieve the remaining radionuclide LLDs.

The REMP results in this report are reported as averages of the measurements made throughout the calendar year plus/minus the associated standard deviation. If all net sample concentrations are equal to or less than zero, the result is reported as “Not Detectable” (ND), indicating no detectable level of activity present in the sample. If any of the net sample concentrations indicate a positive result statistically greater than zero, all of the data reported is used to generate the reported statistics. Because of the statistical nature of radioactive decay, when the radionuclide of interest is not present in the sample, negative and positive results centered about zero will be seen. Excluding validly measured concentrations, whether negative or as small positive values below the LLD, artificially inflates the calculated average value. Therefore, all generated data are used to calculate the statistical values (i.e., average, standard deviation) presented in this report. The calculated average may be a negative number.

As mentioned above, radioactive decay is a statistical process which has an inherent uncertainty in the analytical result. No two measurements will yield the exact same result. However, the results are considered equal if the results fall within a certain range based upon the statistical parameters involved in the process. The REMP analytical results are reported at the 95% confidence limit in which the true result may be two standard deviations above or below the reported result. This means that there is only a 5% chance of concluding that the identified radioactive atom is not there when it really is present in the sample. A false positive is an analytical result which statistically shows that the radionuclide is present in the sample when it really is not there. Typically, if the 95% confidence interval for a positive does not include zero, the radionuclide is considered to be present. For example, the result is reported as 100 ± 90. One hundred minus 90 yields a positive result and therefore may be considered to be present. However, this may be a false positive. If the radionuclide was not in the plant effluent, this result would fall into that category which 5% of the time it is falsely concluded that the radionuclide is present when in actuality it is not. This usually happens at low concentrations at or near the LLD where fluctuations in the background during the counting process skew the results to produce a positive result.

In interpreting the data, effects due to the plant must be distinguished from those due to other sources. A key interpretive aid in assessment of these effects is the design of the PBNP REMP, which is based upon the indicator-control concept. Most types of samples are collected at both indicator locations and at control locations. A plant effect would be indicated if the radiation level at an indicator location was significantly larger than that at the control location. The difference would have to be greater than could be accounted for by typical fluctuation in radiation levels arising from other sources.

## 9.2 Sampling Parameters

Samples are collected and analyzed at the frequency indicated in Table 9-1 from the locations described in Table 9-2 and shown in Figures 9-1, 9-2 and 9-3. (The latter two figures show sampling locations not shown in preceding figures due to space limitations. The location of the former retention pond, retired and remediated to NRC unrestricted access criteria, is indicated in Figure 9-3). The list of PBNP REMP sampling sites used to determine environmental impact around the ISFSI is found in Table 9-3. The minimum acceptable sample size is found in Table 9-4. In addition, Table 9-1 indicates the collection and analysis frequency of the ISFSI fence TLDs.

## 9.3 Deviations from Required Collection Frequency

Deviations from the collection frequency given in Table 9-1 are allowed because of hazardous conditions, automatic sampler malfunction, seasonal unavailability, and other legitimate reasons (Section 12.2.2.e of the ODCM). Table 9-5 lists the deviations from the scheduled sampling frequency that occurred during the reporting period.

## 9.4 Assistance to the State of Wisconsin

The Radiation Protection Unit of the Wisconsin Department of Health and Family Services maintains a radiological environmental monitoring program to confirm the results from the PBNP REMP. As a courtesy to the State of Wisconsin, PBNP personnel collect certain environmental samples (Table 9-6) for the State from sites that are near PBNP sampling sites, or are co-located.

9.5 Program Modifications

No procedural program modifications were made to the REMP in 2024.

**Table 9-1**
**PBNP REMP Sample Analysis and Frequency**

| Sample Type | Sample Codes | Analyses | Frequency |
|---|---|---|---|
| Environmental Radiation Exposure | E-01, -02, -03, -04, -05<br>-06, -07, -08, -09, -12<br>-14, -15, -16B, -17, -18,<br>20, -22, -23, -24,<br>-25, -26B, -27, -28<br>-29, -30, 31, -32, -38,<br>-39,-41, -42,-43, -44 -<br>TC | TLD | Quarterly |
| Vegetation | E-01, -02, -03, -04, -06,<br>-20, | Gamma Isotopic Analysis | 2x/yr as available |
| Fish | E-13 | Gamma Isotopic Analysis<br>(Analysis of edible portions only) | 4x/yr as available |
| Well Water | E-10 | Gross Beta, H-3<br>Sr-89, 90, I-131<br>Gamma Isotopic Analysis | Quarterly |
| Lake Water | E-01, -05, -06 | Gross Beta, Sr-89/90, H-3<br><br>I-131<br>Gamma Isotopic Analysis | Monthly / Quarterly composite of monthly collections<br>Monthly<br>Monthly |
| Milk | E-11, -40, -21 | Sr-89, 90<br>I-131<br>Gamma Isotopic Analysis | Monthly |
| Air Filters | E-01, -02, -03, -04,<br>-08, -20 | Gross Beta<br>I-131<br>Gamma Isotopic Analysis | Weekly (particulate)<br>Weekly (charcoal)<br>Quarterly (on composite particulate filters) |
| Soil | E-01, -02, -03, -04,<br>-06, -20 | Gamma Isotopic Analysis | 1x/yr |
| Shoreline Sediment | E-01, -05, -06 | Gamma Isotopic Analysis | 1x/yr |
| ISFSI Ambient Radiation Exposure | North, East, South, West Fence Sections | TLD | Quarterly |

**Table 9-2**
**PBNP REMP Sampling Locations**

| Location Code | Location Description |
|---|---|
| E-01 | Primary Meteorological Tower South of the Plant |
| E-02 | Site Boundary Control Center - East Side of Building |
| E-03 | Tapawingo Road, about 0.4 Miles West of Lakeshore Road |
| E-04 | North Boundary |
| E-05 | Two Creeks Park |
| E-06 | Point Beach State Park - Coast Guard Station; TLD located South of the Lighthouse on Telephone pole |
| E-07 | WPSC Substation on County V, about 0.5 Miles West of Hwy 42 |
| E-08 | G.J. Francar Property at Southeast Corner of the Intersection of Cty. B and Zander Road |
| E-09 | Nature Conservancy |
| E-10 | PBNP Site Well |
| E-11 | Dairy Farm about 3.75 Miles West of Site |
| E-12 | Discharge Flume/Pier |
| E-13 | Pumphouse |
| E-14 | South Boundary, about 0.2 miles East of Site Boundary Control Center |
| E-15 | Southwest Corner of Site |
| E-16B | WSW, Hwy 42, a residence about 0.25 miles North of Nuclear Road |
| E-17 | North of Mishicot, Cty. B and Assman Road, Northeast Corner of Intersection |
| E-18 | Northwest of Two Creeks at Zander and Tannery Roads |
| E-20 | Reference Location, 17 miles Southwest, at Holy Family Convent Property |
| E-21 | Local Dairy Farm just South of Site on Lakeshore and Irish Roads |
| E-22 | West Side of Hwy 42, about 0.25 miles North of Johanek Road |
| E-23 | Greenfield Lane, about 4.5 Miles South of Site, 0.5 Miles East of Hwy 42 |
| E-24 | North Side of County Rt. V, near intersection of Saxonburg Road |
| E-25 | South Side of County Rt. BB, about 0.5 miles West of Norman Road |
| E-26B | 804 Tapawingo Road, about 0.4 miles East of Cty. B, North Side of Road |
| E-27 | Intersection of Saxonburg and Nuclear Roads, Southwest Corner, about 4 Miles WSW |
| E-28 | TLD site on western most pole between the 2nd and 3rd parking lots. |
| E-29 | Area of North Meteorological Tower. |
| E-30 | NE corner at Intersection of Tapawingo and Lakeshore Roads. |
| E-31 | On utility pole North side of Tapawingo Road closest to the gate at the West property line. |
| E-32 | On a conduit/pole located near the junction of property lines, about 500 feet east of the west gate in line with first designated treeline on Tapawingo Road and about 1200 feet south of Tapawingo Road. The location is almost under the power lines between the blue and gray transmission towers. (The conduit/pole is about 6 feet high). |
| E-38 | Tree located at the West end of the area previously containing the Retention Pond. |
| E-39 | Tree located at the East end of the area previously containing the Retention Pond. |
| E-40 | Local Dairy Farm, W side of Hwy 42, about 1.8 miles north of the Nuclear Rd intersection |
| E-41 | NW corner of Woodside and Nuclear Rds (Kewaunee County) |
| E-42 | NW corner of Church and Division, East of Mishicot |
| E-43 | West side of Tannery Rd south of Elmwood (7th utility pole south of Elmwood) |
| E-44 | Utility Pole N Side of Tapawingo Rd near house at 5011 |
| E-TC | Transportation Control; Reserved for TLDs |

**Figure 9-1**
**PBNP REMP Sampling Sites**

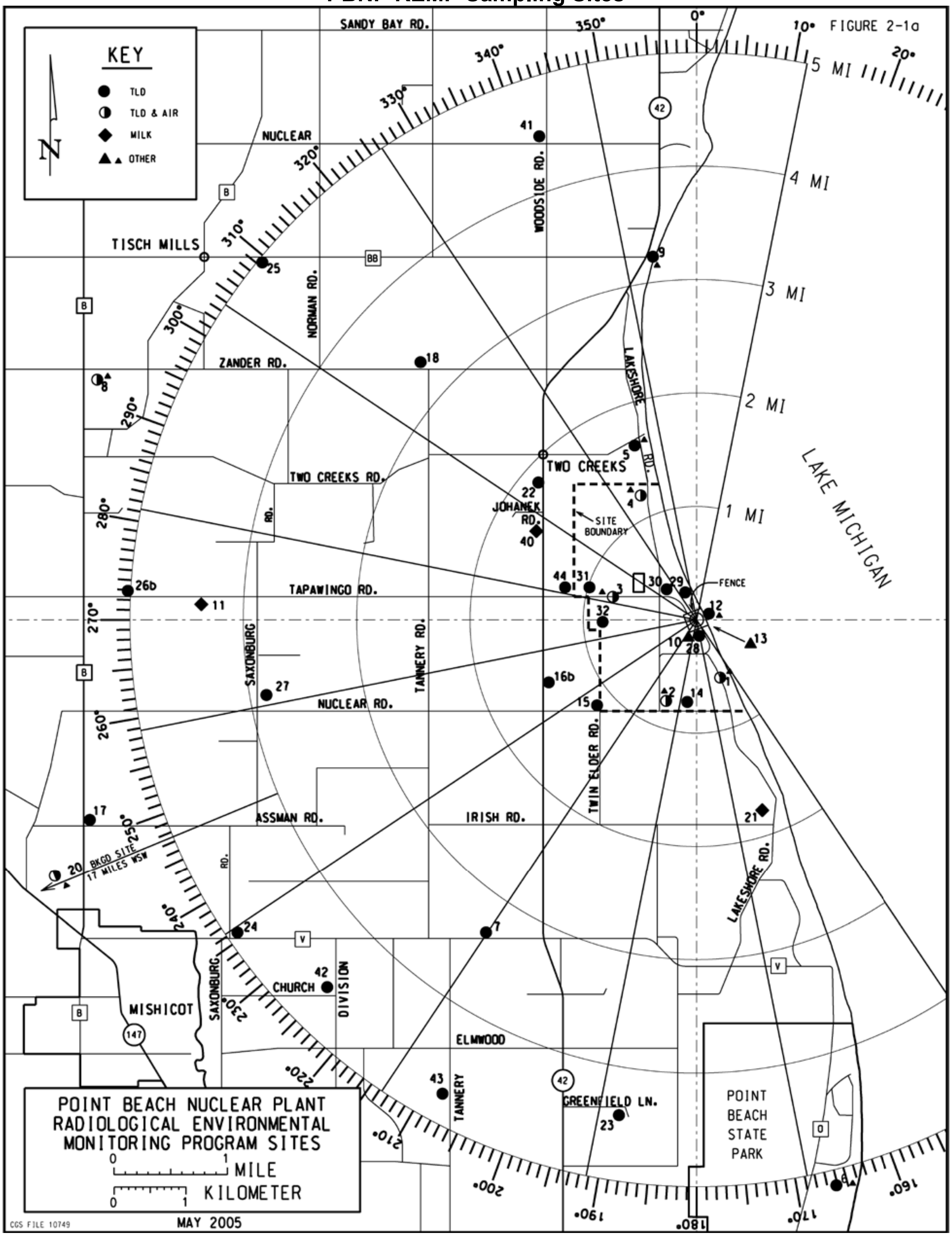


**Figure 9-2**
**Map of REMP Sampling Sites Located Around PBNP**

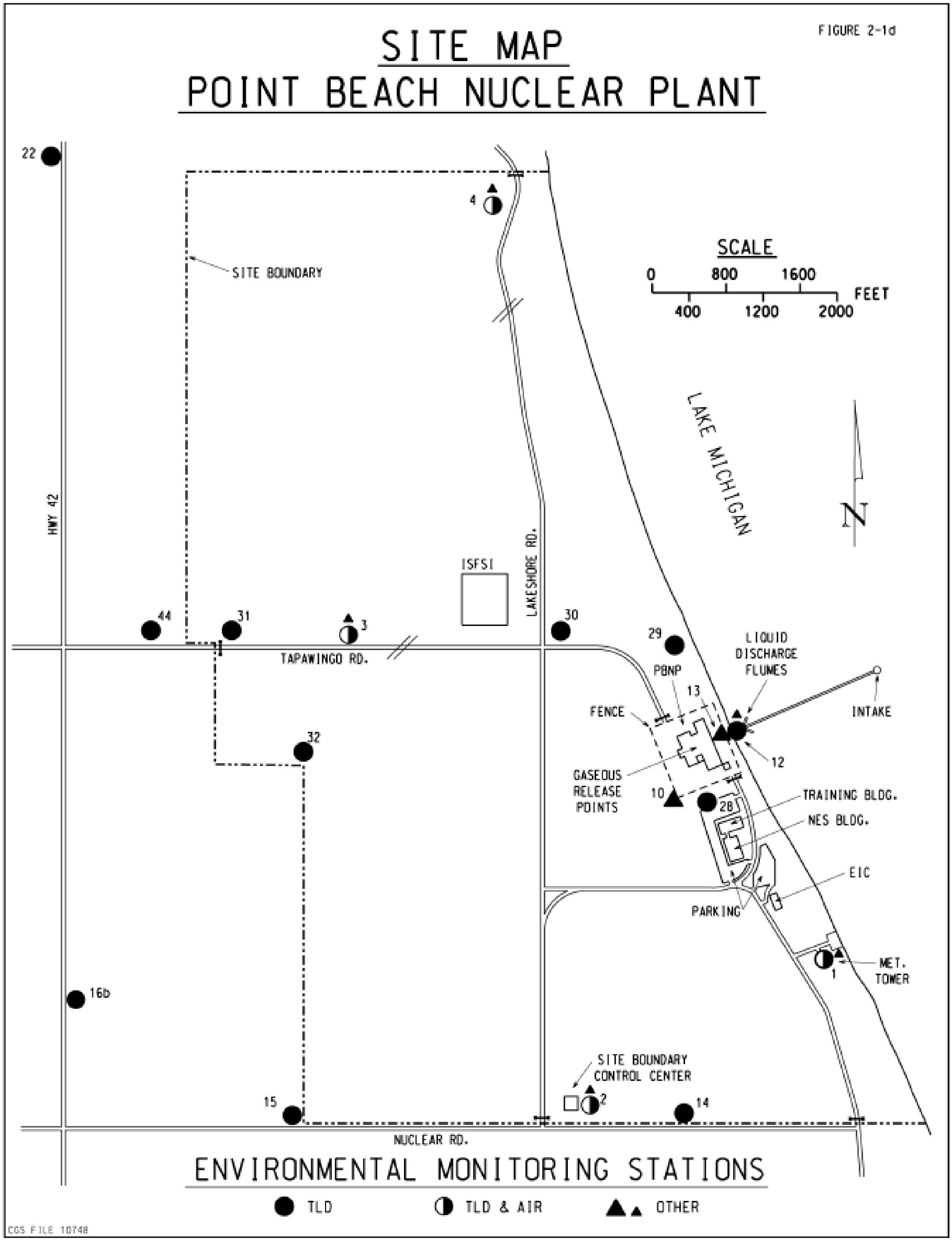


**Figure 9-3**
**Enhanced Map Showing REMP Sampling Sites Closest to PBNP**

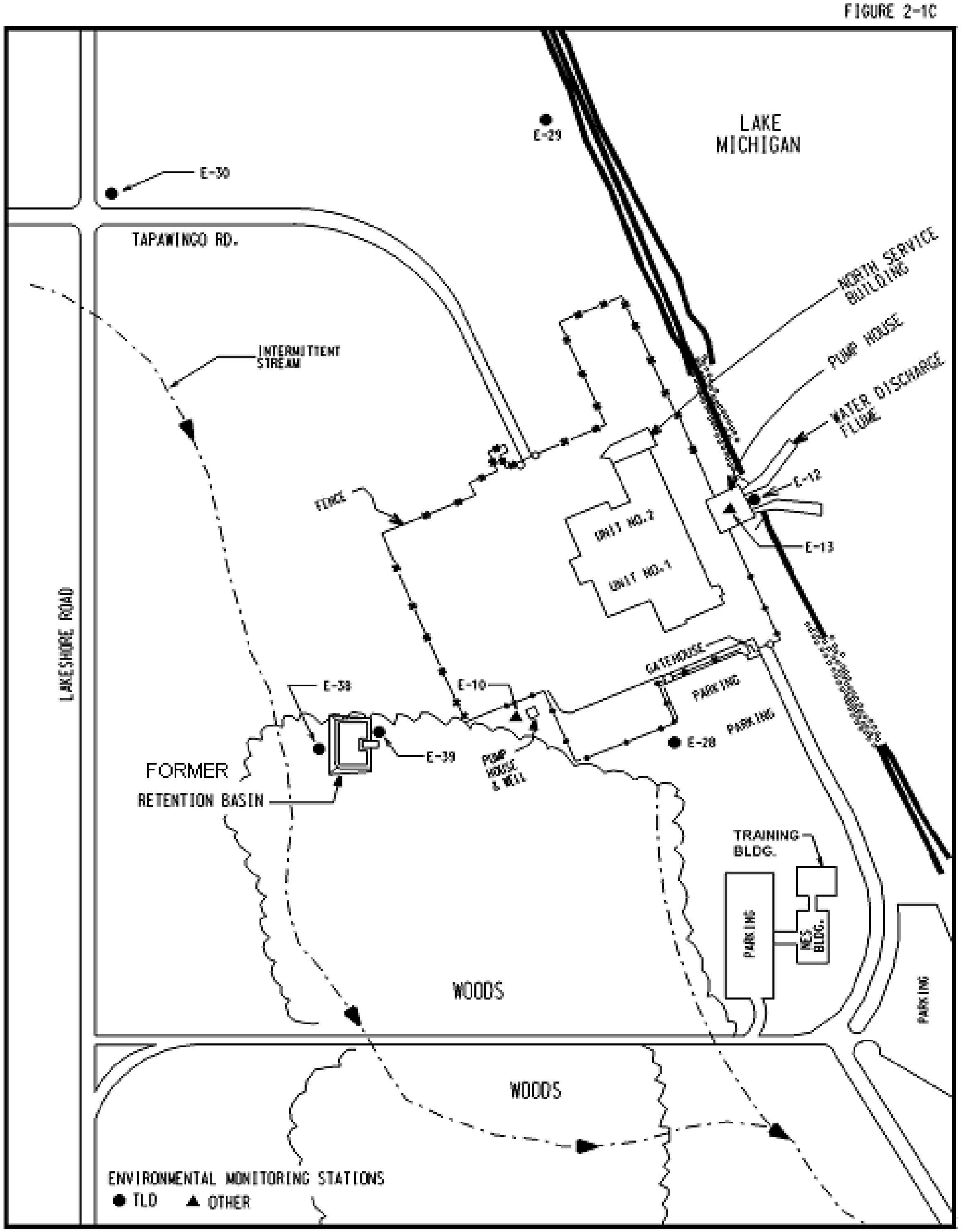


**Table 9-3**
**ISFSI Sampling Sites**

| Ambient Radiation Monitoring (TLD) | Soil, Vegetation and Airborne Monitoring |
|---|---|
| E-03 | E-02 |
| E-28 | E-03 |
| E-29 | E-04 |
| E-30 | |
| E-31 | |
| E-32 | |
| E-44 | |

**Table 9-4**
**Minimum Acceptable Sample Size**

| **Sample Type** | **Size** |
|---|---|
| Vegetation | 100-1000 grams |
| Lake Water | 8 liters |
| Air Filters | 250 $m^3$ (volume of air) |
| Well Water | 8 liters |
| Milk | 8 liters |
| Fish (edible portions) | 1000 grams |
| Soil | 500-1000 grams |
| Shoreline Sediment | 500-1000 grams |

**Table 9-5**
**Deviations from Scheduled Sampling and Frequency During 2024**

| Sample Type | Location | Scheduled Collection Date | Reason for not conducting REMP as required | Plans for Preventing Recurence |
|---|---|---|---|---|
| WW | E-10 | 5/1/2024 | No sample due to water outage at the station | Monitor equipment and work through maintenance work process to correct issue |
| AP/AI | E-20 | 6/27/2024 | No sample due to power failure at the station | Monitor equipment and work through maintenance work process to correct issue |

**Table 9-6**
**Sample Collections for State of Wisconsin**

| Sample Type | Location | Frequency |
|---|---|---|
| Lake Water | E-01 | Monthly |
| Fish | E-13 | Quarterly, As Available |
| Precipitation | E-04<br>E-08 | Twice a month,<br>As Available |
| Milk | E-11<br>E-21 | Monthly |
| Well Water | E-10 | Twice per year |

## 9.6 Analytical Parameters

The types of analyses and their frequencies are given in Table 9-1. The LLDs for the various analyses are found in Section 10 (Table 10-1) with the summary of the REMP results. All environmental LLDs listed in Table 12-1 of the ODCM (also in Table 10-1) were achieved during 2024.

## 9.7 Description of Analytical Parameters in Table 9-1

### 9.7.1 Gamma isotopic analysis

Gamma isotopic analysis consists of a computerized scan of the gamma ray spectrum from 80 keV to 2048 keV. Specifically included in the scan are Mn-54, Fe-59, Co-58, Co-60, Zr-95, Nb-95, Ru-103, Ru-106, I-131, Ba-La-140, Cs-134, Cs-137, Ce-141, and Ce-144. However, other detected nuclear power plant produced radionuclides also are noted. The above radionuclides detected by gamma isotopic analysis are decay corrected to the time of collection. Frequently detected, but not normally reported in the Annual Monitoring Report, are the naturally occurring radionuclides Ra-226, Bi-214, Pb-212, Tl-208, Ac-228, Be-7, and K-40.

### 9.7.2 Gross Beta Analysis

Gross beta analysis is a non-specific analysis that consists of measuring the total beta activity of the sample. No individual radionuclides are identifiable by this method. Gross beta analysis is a quick method of screening samples for the presence of elevated activity that may require additional, immediate analyses.

### 9.7.3 Water Samples

Water samples include both Lake Michigan and well water. The Lake Michigan samples are collected along the shoreline at two locations north and two locations south of PBNP. The well water is sampled from the on-site PBNP well. Gross beta measurements are made on the solids remaining after evaporation of the unfiltered sample to dryness. Gamma isotopic analyses are performed using 1-liter liquid samples. Strontium is determined by chemical separation and beta counting.

### 9.7.4 Air Samples

Particulate air filters are allowed to decay at least 72 hours before gross beta measurements are made in order for naturally occurring radionuclides to become a negligible part of the total activity. Gross beta measurements serve as a quick check for any unexpected activity that may require immediate investigation. Quarterly composites of the particulate air filters are analyzed for long-lived radionuclides such as Cs-134 and Cs-137. Charcoal cartridges for radioiodine are counted as soon as possible so the I-131 will undergo only minimal decay prior to analyses. The weekly charcoal cartridges are screened for I-131 by counting them all at the same time to achieve a lower LLD. If a positive result is obtained, each cartridge is counted individually.

In order to ensure that the air sampling pumps are operating satisfactorily, a gross leak check is performed weekly. The pumps are changed out annually for calibration and maintenance beyond what can be accomplished in the field.

9.7.5 Vegetation

Vegetation samples consist predominantly of green, growing plant material (grasses and weeds most likely to be eaten by cattle if they were present at the sampling site). Care is taken not to include dirt associated with roots by cutting the vegetation off above the soil line.

No special vegetation samples were obtained for C-14 analyses in 2024.

9.7.6 Environmental Radiation Exposure

The 2024 environmental radiation exposure measurements were made using TLD cards. The TLD card is a small passive detector, which integrates radiation exposure. Each TLD consists of a Teflon sheet coated with a crystalline, phosphorus material (calcium sulfate containing dysprosium) which absorbs the gamma ray energy deposited in them. Each TLD is read in four distinct areas to yield four exposure values which are averaged. Prior to the third quarter of 2001, exposure data was obtained using three lithium fluoride (LiF) TLD chips sealed in black plastic. The difference in material types can impact the amount of exposure measured. An evaluation of the response difference between the two types of TLD in 2001 demonstrated that the TLD cards produced a 14% higher response than the LiF chips (2011 AMR, Table 9-7, p. 36).

The reported field exposure is the arithmetic average of the measured exposure values at each location minus the exposure transportation control TLD (exposure received while the field TLD is in storage and transit). The gamma rays may originate from PBNP produced radionuclides or from naturally occurring radionuclides. The TLDs remain at the monitoring site for roughly three months prior to analyses and the results are reported as mrem per seven days. Because the TLDs are constantly bombarded by naturally occurring gamma radiation, even during shipment to and from PBNP, the amount of exposure during transportation is measured using transportation controls with each shipment of TLDs to and from the laboratory. The doses recorded on the transportation controls are subtracted from the monitoring TLDs in order to obtain the net *in situ* dose.

### 9.7.7 ISFSI Ambient Radiation Exposure

The ISFSI fence TLDs are part of the 10CFR72.44 monitoring and are not considered part of the REMP. However, their results can be used indirectly to determine whether the operation of the ISFSI is having an impact on the ambient environmental radiation beyond the site boundary. Impacts are determined by comparison of fence TLD results to the results of the monitoring at PBNP site boundary and other selected locations. These results are used as part of the 40CFR190 compliance demonstration.

## 10.0 RESULTS

### 10.1 Summary of 2024 REMP Results

Radiological environmental monitoring conducted at PBNP from January 1, 2024, through December 31, 2024, consisted of analysis of air filters, milk, lake water, well water, soil, fish, shoreline sediments, and vegetation as well as TLDs. The results are summarized, averages and high values, in Table 10-1 which contain the following information:

| | |
|---|---|
| Sample: | Type of the sample medium |
| Description: | Type of measurement |
| N: | Number of samples analyzed |
| LLD: | *a priori* lower limit of detection |
| Average: | Average value ± the standard deviation of N samples |
| High: | Highest measured value ± it's associated 2 sigma counting error |
| Units: | Units of measurement |

For certain analyses, an LLD, which is lower than that required by REMP, is used because the lower value derives from the counting time required to obtain the LLDs for radionuclides that are more difficult to detect. For these analyses, both LLDs are listed with the technical specification required REMP LLD given in parentheses. The results are discussed in the narrative portion of this report (Section 11). Blank values have not been subtracted from the results presented in Table 10-1. A listing of all the individual results obtained from the contracted analytical laboratory and the laboratory's radioanalytical quality assurance results and Interlaboratory Crosscheck Program results are presented in the Appendix.

In Table 10-1 no results are reported as less than LLD (<LLD). All results are reported to Point Beach by the contracted radioanalytical laboratory "as measured" whether positive or negative (see Section 9-1). Based on these results, a radionuclide is considered detected if it meets the criterion that the measured value minus its 2σ counting error is greater than zero ($x-2\sigma > 0$). A "ND" entry in Table 10-1 means that for this radionuclide the criterion was not satisfied for any of the measurements. If one analysis fulfilled the criterion, then all of the reported results, both positive and negative, were used in calculating the average shown in Table 10-1.

The method of determining averages based on "as measured" results follows the recommendations made in NUREG-0475 (1978), "Radiological Environmental Monitoring by NRC Licensees for Routine Operations of Nuclear Facilities Task Force Report," and in Health Physics Society Committee Report HPSR-1 (1980) "Upgrading Environmental Radiation Data" released as document EPA 520/1-80-012 and in more recent documents such as ANSI N42.23-1996, "Instrument Quality Assurance for Radioassay Laboratories;" ANSI N13.30-1996, "Performance Criteria for Radiobioassay;" DE91-013607, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" and NUREG-1576, "Multi-Agency Radiological Laboratory Analytical Protocols Manual."

In addition to the required radionuclides for each medium analyzed, Table 10-1 also has an additional radionuclide listed known to originate with nuclear power plants. This radionuclide is either Co-60, Ru-103, or any other radionuclide which has the lowest LLD based on the analytical parameters needed to meet the LLDs required for radionuclides specified for the medium being analyzed. The radionuclide is identified by parentheses.

During the analyses for those radionuclides specifically required to be identified, naturally occurring radionuclides such as Ra-226, Be-7 and K-40 are detected in many samples. Their concentrations are presented in Table 10-1 for a comparison to those radionuclides for which specific analyses are required by the regulations. There are no regulatory required LLDs for naturally occurring radionuclides.

Finally, Point Beach reports the results for soil analyses. There is no regulatory requirement for soil analyses in standard RETS (NUREG-0472 and NUREG-1301). Point Beach includes soil analyses in the REMP to be able to compare current results to the historical record.

Table 10-2 contains the ISFSI fence TLD results.

**Table 10-1**
**Summary of Radiological Environmental Monitoring Results for 2024**

| Sample | Description | N | LLD (a) | Average ± 1 Std. Deviation (b) | High ± 2 sigma | Units |
|---|---|---|---|---|---|---|
| *TLD* | Environmental Radiation | 128 | 1 mrem | 1.14 ± 0.22 | 1.78 ± 0.06 | mR/7days |
| | Control (E-20) | 4 | 1 mrem | 1.11 ± 0.07 | 1.21 ± 0.07 | mR/7days |
| *Air* | Gross Beta | 254 | 0.01 | 0.023 ± 0.009 | 0.061 ± 0.005 | pCi/m3 |
| | Control (E-20) Gross beta | 52 | 0.01 | 0.024 ± 0.009 | 0.055 ± 0.005 | pCi/m3 |
| | I-131 | 254 | 0.030 (0.07) | ND | - | pCi/m3 |
| | Control (E-20) I-131 | 52 | 0.030 (0.07) | ND | - | pCi/m3 |
| | Cs-134 | 20 | 0.01(0.05) | ND | - | pCi/m3 |
| | Control (E-20) Cs-134 | 4 | 0.01(0.05) | ND | - | pCi/m3 |
| | Cs-137 | 20 | 0.01(0.06) | ND | - | pCi/m3 |
| | Control (E-20) Cs-137 | 4 | 0.01(0.06) | ND | - | pCi/m3 |
| | Other γ emitters (Co-60) | 20 | 0.1 | ND | - | pCi/m3 |
| | Control (E-20) Other (Co-60) | 4 | 0.1 | ND | - | pCi/m3 |
| | Natural Be-7 | 20 | - | 0.066 ± 0.016 | 0.108 ± 0.018 | pCi/m3 |
| | Control (E-20) Natural Be-7 | 4 | - | 0.067 ± 0.021 | 0.096 ± 0.022 | pCi/m3 |
| *Milk* | Sr-89 | 36 | 5 | ND | - | pCi/L |
| | Sr-90 | 36 | 1 | 0.4 ± 0.2 | 0.8 ± 0.3 | pCi/L |
| | I-131 | 36 | 0.5 | ND | - | pCi/L |
| | Cs-134 | 36 | 5 (15) | ND | - | pCi/L |
| | Cs-137 | 36 | 5 (18) | ND | | pCi/L |
| | Ba-La-140 | 36 | 5 (15) | ND | - | pCi/L |
| | Other gamma emitters(Co-60) | 36 | 15 | ND | - | pCi/L |
| | Natural K-40 | 36 | - | 1309 ± 80 | 1493 ± 89 | pCi/L |
| *Well Water* | Gross beta | 4 | 4 | ND | - | pCi/L |
| | H-3 | 4 | 500 (3000) | ND | - | pCi/L |
| | Sr-89 | 4 | 5(10) | ND | - | pCi/L |
| | Sr-90 | 4 | 1 (2) | ND | - | pCi/L |
| | I-131 | 4 | 0.5 (2) | ND | - | pCi/L |
| | Mn-54 | 4 | 10 (15) | ND | - | pCi/L |
| | Fe-59 | 4 | 30 | ND | - | pCi/L |
| | Co-58 | 4 | 10(15) | ND | - | pCi/L |
| | Co-60 | 4 | 10(15) | ND | - | pCi/L |
| | Zn-65 | 4 | 30 | ND | - | pCi/L |
| | Zr-Nb-95 | 4 | 15 | ND | - | pCi/L |
| | Cs-134 | 4 | 10(15) | ND | - | pCi/L |
| | Cs-137 | 4 | 10(18) | 2.8 ± 1.3 | 2.6 ± 0.8 | pCi/L |
| | Ba-La-140 | 4 | 15 | ND | - | pCi/L |
| | Other gamma emitters(Ru-103) | 4 | 30 | ND | - | pCi/L |

NS = No Sample obtained during the year
(a) When two LLD values are listed, the required LLD per the PBNP REMP is enclosed in the parentheses. Whenever possible, PBNP uses the lower value to obtain greater sensitivity.
(b) "ND" indicates that the sample result is Not Detectable, i.e., sample concentrations were statistically equal to zero or <MDA.

**Table 10-1 (continued)**
**Summary of Radiological Environmental Monitoring Results for 2024**

| Sample | Description | N | LLD (a) | Average ± 1 Std. Deviation (b) | High ± 2 sigma | Units |
|---|---|---|---|---|---|---|
| *Lake Water* | Gross beta | 36 | 4 | 1.5 ± 0.5 | 2.6 ± 0.7 | pCi/L |
| | I-131 | 36 | 0.5 (2) | ND | - | pCi/L |
| | Mn-54 | 36 | 10 (15) | ND | - | pCi/L |
| | Fe-59 | 36 | 30 | -0.2 ± 1.7 | 6.0 ± 3.0 | pCi/L |
| | Co-58 | 36 | 10(15) | ND | - | pCi/L |
| | Co-60 | 36 | 10(15) | ND | - | pCi/L |
| | Zn-65 | 36 | 30 | -0.5 ± 2.2 | 6.1 ± 5.8 | pCi/L |
| | Zr-Nb-95 | 36 | 15 | ND | - | pCi/L |
| | Cs-134 | 36 | 10 (15) | ND | - | pCi/L |
| | Cs-137 | 36 | 10 (18) | 0.4 ± 1.3 | 3.7 ± 1.9 | pCi/L |
| | Ba-La-140 | 36 | 15 | -0.5 ± 1.5 | 3.2 - 3.1 | pCi/L |
| | Other gamma (Ru-103) | 36 | 30 | ND | - | pCi/L |
| | Sr-89 | 12 | 5(10) | ND | - | pCi/L |
| | Sr-90 | 12 | 1 (2) | ND | - | pCi/L |
| | H-3 | 12 | 200 (3000) | 37.0 ± 39.0 | 112.0 ± 92.0 | pCi/L |
| *Fish* | Mn-54 | 12 | 0.13 | ND | - | pCi/g |
| | Fe-59 | 12 | 0.26 | ND | - | pCi/g |
| | Co-58 | 12 | 0.13 | ND | - | pCi/g |
| | Co-60 | 12 | 0.13 | 0.003 ± 0.003 | 0.008 ± 0.003 | pCi/g |
| | Zn-65 | 12 | 0.26 | ND | - | pCi/g |
| | Cs-134 | 12 | 0.13 | ND | - | pCi/g |
| | Cs-137 | 12 | 0.15 | 0.012 ± 0.006 | 0.021 ± 0.017 | pCi/g |
| | Other gamma (Ru-103) | 12 | 0.5 | ND | - | pCi/g |
| | Natural K-40 | 12 | - | 2.49 ± 0.58 | 3.24 ± 0.41 | pCi/g |
| *Shoreline Sediment* | Cs-134 | 3 | 0.18 | ND | - | pCi/g |
| | Cs-137 | 3 | 0.15 | 0.014 ± 0.009 | 0.024 ± 0.013 | pCi/g |
| | Natural Be-7 | 3 | - | 0.068 ± 0.057 | 0.121 ± 0.059 | pCi/g |
| | Natural K-40 | 3 | - | 6.23 ± 0.47 | 6.650 ± 0.399 | pCi/g |
| | Natural Ra-226 | 3 | - | 0.26 ± 0.01 | 0.277 ± 0.149 | pCi/g |
| *Soil* | Cs-134 | 6 | 0.15 | ND | - | pCi/g |
| | Cs-137 | 6 | 0.15 | 0.14 ± 0.09 | 0.242 ± 0.01 | pCi/g |
| | Natural Be-7 | 6 | - | 0.094 ± 0.05 | 0.154 ± 0.05 | pCi/g |
| | Natural K-40 | 6 | - | 15.77 ± 3.08 | 19.55 ± 0.37 | pCi/g |
| | Natural Ra-226 | 6 | - | 0.96 ± 0.43 | 1.494 ± 0.31 | pCi/g |
| *Vegetation* | I-131 | 12 | 0.06 | ND | - | pCi/g |
| | Cs-134 | 12 | 0.06 | ND | - | pCi/g |
| | Cs-137 | 12 | 0.08 | 0.015 ± 0.034 | 0.118 ± 0.024 | pCi/g |
| | Other gamma emitters (Co-60) | 12 | 0.25 | ND | - | pCi/g |
| | Natural Be-7 | 12 | - | 1.17 ± 0.76 | 2.45 ± 0.32 | pCi/g |
| | Natural K-40 | 12 | - | 4.87 ± 1.05 | 6.5 ± 0.57 | pCi/g |

(a) When two LLD values are listed, the required LLD per the PBNP REMP is enclosed in the parentheses. Whenever possible, PBNP uses the lower value to obtain greater sensitivity.
(b) "ND" indicates that the sample result is Not Detectable, i.e., sample concentrations were statistically equal to zero or <MDA.

**Table 10-2**
**Average ISFSI Fence TLD Results for 2024**

| Fence Location | Average | ± | Standard Deviation | Units |
|---|---|---|---|---|
| North | 1.99 | ± | 0.14 | mR/7 days |
| East | 3.05 | ± | 0.06 | mR/7 days |
| South | 2.54 | ± | 0.11 | mR/7 days |
| West | 6.20 | ± | 0.43 | mR/7 days |

## 11.0 DISCUSSION

### 11.1 TLD Cards

The ambient radiation was measured in the general area of the site boundary, at an outer ring 4 to 5 miles from the plant, at special interest areas, and at one control location, roughly 17 miles southwest of the plant. The average indicator TLD is 1.14 ± 0.22 mR/7-days compared to 1.11 ± 0.07 mR/7-days at the background location. These two values are not significantly different from each other. Neither of the indicator TLD values are significantly different from those observed from 2001 through 2023 for the same type of TLD (tabulated below in Table 11-1). Prior to third quarter of 2001 TLD LiF chips were used versus the current TLD cards, see Section 9.7.6 for additional information. The response difference between the two types of TLDs is evident in Table 11-1. Prior to 2001 all of the annual averages are <1 mrem/7-days. Beginning in 2001, all are >1 mrem/7-days.

**Table 11-1**
**Average Indicator TLD Results from 1993 – 2024**

| Year | Average mR/7-days | ± | St. Dev* |
|---|---|---|---|
| 1993 | 0.82 | ± | 0.15 |
| 1994 | 0.90 | ± | 0.12 |
| 1995 | 0.87 | ± | 0.13 |
| 1996 | 0.85 | ± | 0.12 |
| 1997 | 0.87 | ± | 0.11 |
| 1998 | 0.79 | ± | 0.13 |
| 1999 | 0.79 | ± | 0.21 |
| 2000 | 0.91 | ± | 0.15 |
| 2001 | 1.06 | ± | 0.19 |
| 2002 | 1.17 | ± | 0.21 |
| 2003 | 1.10 | ± | 0.20 |
| 2004 | 1.10 | ± | 0.22 |
| 2005 | 1.04 | ± | 0.21 |
| 2006 | 1.14 | ± | 0.21 |
| 2007 | 1.08 | ± | 0.20 |
| 2008 | 1.05 | ± | 0.17 |
| 2009 | 1.08 | ± | 0.17 |
| 2010 | 1.11 | ± | 0.15 |
| 2011 | 1.14 | ± | 0.25 |
| 2012 | 1.17 | ± | 0.17 |
| 2013 | 1.14 | ± | 0.20 |
| 2014 | 1.07 | ± | 0.19 |
| 2015 | 1.18 | ± | 0.20 |
| 2016 | 1.19 | ± | 0.21 |
| 2017 | 1.11 | ± | 0.17 |
| 2018 | 1.11 | ± | 0.17 |
| 2019 | 1.10 | ± | 0.20 |
| 2020 | 1.16 | ± | 0.20 |
| 2021 | 1.21 | ± | 0.22 |
| 2022 | 1.23 | ± | 0.21 |
| 2023 | 1.14 | ± | 0.21 |
| 2024 | 1.14 | ± | 0.22 |

*St. Dev = Standard Deviation

**Table 11-2**
**Average ISFSI Fence TLD Results (mR/7 days)**

| TLD FENCE LOCATION | | | | |
|---|---|---|---|---|
| YEAR | North | East | South | West |
| 1995 | 1.29 | 1.28 | 1.10 | 1.26 |
| 1996 | 2.12 | 1.39 | 1.10 | 1.68 |
| 1997 | 2.05 | 1.28 | 1.00 | 1.66 |
| 1998 | 2.08 | 1.37 | 1.02 | 1.86 |
| 1999 | 2.57 | 1.84 | 1.11 | 3.26 |
| 2000 | 2.72 | 2.28 | 1.25 | 5.05 |
| 2001 | 2.78 | 2.54 | 1.36 | 6.08 |
| 2002 | 2.79 | 2.74 | 1.42 | 6.46 |
| 2003 | 2.70 | 2.60 | 1.50 | 6.88 |
| 2004 | 2.61 | 2.12 | 1.41 | 6.50 |
| 2005 | 2.54 | 2.05 | 1.44 | 5.63 |
| 2006 | 2.73 | 2.35 | 1.38 | 5.80 |
| 2007 | 2.72 | 2.73 | 1.34 | 5.47 |
| 2008 | 2.64 | 2.37 | 1.36 | 5.36 |
| 2009 | 2.36 | 2.35 | 1.20 | 4.63 |
| 2010 | 2.64 | 3.02 | 1.41 | 5.05 |
| 2011 | 2.44 | 2.62 | 1.31 | 4.75 |
| 2012 | 2.59 | 3.27 | 1.40 | 4.92 |
| 2013 | 2.57 | 3.66 | 1.15 | 4.28 |
| 2014 | 2.45 | 3.35 | 1.14 | 4.24 |
| 2015 | 2.31 | 3.24 | 1.17 | 4.36 |
| 2016 | 2.30 | 3.34 | 1.33 | 4.35 |
| 2017 | 2.21 | 3.84 | 1.30 | 4.25 |
| 2018 | 2.24 | 4.21 | 1.49 | 4.32 |
| 2019 | 2.20 | 4.18 | 1.57 | 4.08 |
| 2020 | 2.46 | 4.19 | 1.71 | 4.20 |
| 2021 | 2.33 | 3.97 | 2.27 | 5.89 |
| 2022 | 2.33 | 3.95 | 3.07 | 7.43 |
| 2023 | 2.13 | 3.34 | 2.62 | 6.49 |
| 2024 | 1.99 | 3.05 | 2.54 | 6.20 |

There is no significant change in the exposure in the TLD monitoring locations around the ISFSI (Table 11-3). The results at E-03 and E-31 (W of the ISFSI), and E-32 (SW of the ISFSI) are similar to previous years (1.26, 1.23, and 1.51 respectively) and continue to be higher than E-30 (1.02) on the east side and closest to the ISFSI. E-03, about equidistant between the ISFSI and the site boundary location E-31, continues to be slightly higher than the site boundary location, but the difference is not statistically different. (See Figs. 9-1 and 9-2 for locations).
Although the mR/7-day results for the three TLD locations nearest the site boundary (E-03 1.26 ± 0.017; E-31, 1.23± 0.29; E-32, 1.51 ± 0.35) are higher than at the background site E-20 (1.11 ± 0.14), they are comparable at the 95% confidence level, indicating a small, but not significant, increase in ambient gamma radiation at

the site boundary due to the operation of the ISFSI. In 2018, a TLD monitoring location was added at location E-44 TLD, directly west of E-03 and E-31, but prior to the nearest resident. The average reading at E-44 (1.16 ± 0.24) is similar to the observed readings at E-03, E-31, and background location E-20 (1.26, 1.23, and 1.11 respectively).

Further data supporting this conclusion is the comparison of the TLD results at selected locations around the ISFSI before and after the storage of spent fuel at the ISFSI (Figure 11-1). As stated in Section 9.7.6, the TLD values increased by about 14% in the second half of 2001 when the TLD monitoring devices were changed from LiF chips in the first half of 2001 to calcium sulfate impregnated TLD cards. After that initial change, the measured radiation exposure, as measured by the TLD cards, has remained fairly constant with a slight increase with the addition of stored fuel at the ISFSI. Each year the variations in the TLD results appear to move in concert with each other and with the background site, E-20, which is 17 miles south west of the ISFSI.

Comparing the ISFSI TLD results to results from surrounding REMP indicator and background TLDs reveals minimal impact of the ISFSI on the surrounding radiation levels (Figure 11-2). All ISFSI TLD levels slightly decreased in 2024. As reported two years ago, an increase in the 2022 West ISFSI TLD was expected based on the placement of the new casks on the ISFSI pad in 2021. As previously discussed, the small increase in 2001 is more related to the switch from the LiF chips to the calcium sulfate impregnated Teflon TLD cards as evidenced by the synchronicity with E-20, the background site.

LiF TLD chips were replaced with calcium sulfate impregnated Teflon TLD cards in the third quarter of 2001 resulting in a higher measured background values.

**Figure 11-1**
**ISFSI AREA TLD RESULTS**

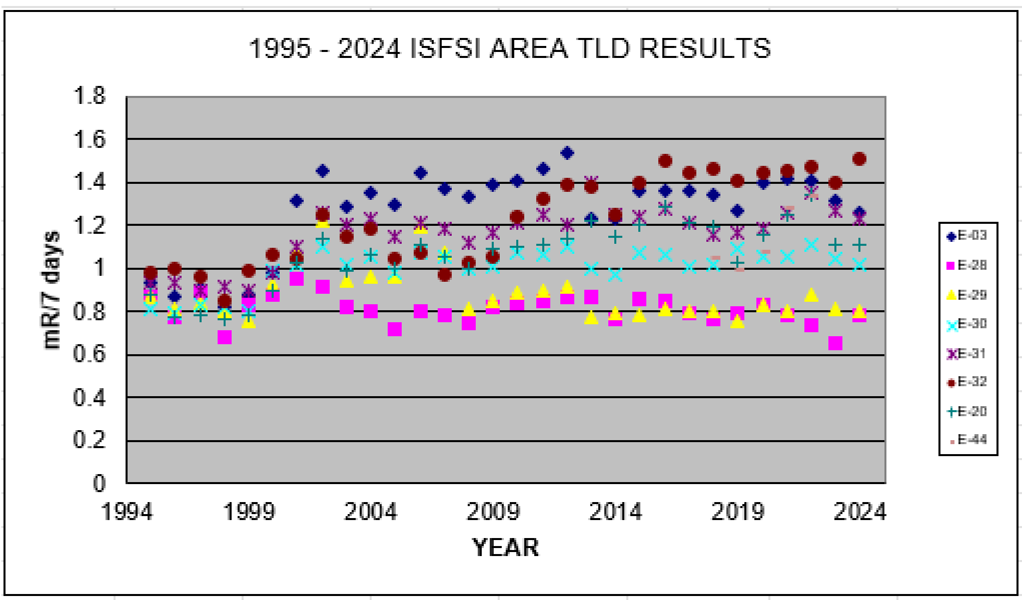
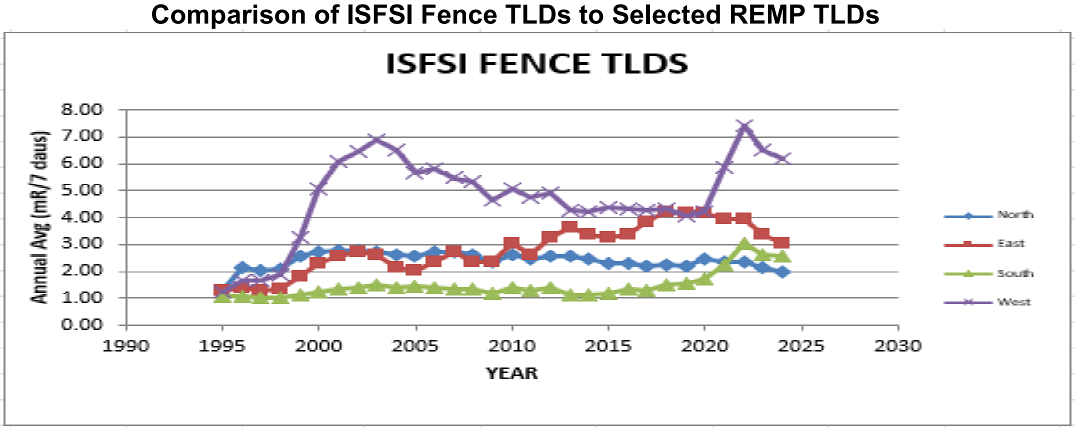


**Table 11-3**
**Average TLD Results Surrounding the ISFSI (mR/7 days)**

| | Sampling Site | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | E-03 | E-28 | E-29 | E-30 | E-31 | E-32 | E-44 | E-20 |
| 1995 | 0.93 | 0.87 | 0.87 | 0.81 | 0.93 | 0.98 | | 0.88 |
| 1996 | 0.87 | 0.78 | 0.81 | 0.79 | 0.93 | 1.00 | | 0.78 |
| 1997 | 0.91 | 0.89 | 0.84 | 0.84 | 0.89 | 0.97 | | 0.79 |
| 1998 | 0.82 | 0.68 | 0.80 | 0.82 | 0.91 | 0.85 | | 0.77 |
| 1999 | 0.88 | 0.83 | 0.76 | 0.80 | 0.90 | 0.99 | | 0.78 |
| 2000 | 0.98 | 0.88 | 0.92 | 0.99 | 0.98 | 1.06 | | 0.90 |
| 2001 | 1.31 | 0.95 | 1.07 | 1.02 | 1.10 | 1.04 | | 1.03 |
| 2002 | 1.45 | 0.91 | 1.22 | 1.10 | 1.26 | 1.25 | | 1.14 |
| 2003 | 1.29 | 0.82 | 0.94 | 1.02 | 1.20 | 1.15 | | 0.99 |
| 2004 | 1.35 | 0.80 | 0.96 | 1.05 | 1.23 | 1.18 | | 1.06 |
| 2005 | 1.30 | 0.72 | 0.96 | 0.98 | 1.15 | 1.04 | | 1.00 |
| 2006 | 1.44 | 0.80 | 1.19 | 1.07 | 1.21 | 1.07 | | 1.11 |
| 2007 | 1.37 | 0.78 | 1.07 | 1.05 | 1.18 | 0.97 | | 1.05 |
| 2008 | 1.33 | 0.75 | 0.81 | 1.00 | 1.12 | 1.03 | | 1.00 |
| 2009 | 1.39 | 0.82 | 0.85 | 1.01 | 1.17 | 1.05 | | 1.09 |
| 2010 | 1.41 | 0.84 | 0.89 | 1.07 | 1.21 | 1.24 | | 1.10 |
| 2011 | 1.46 | 0.85 | 0.90 | 1.06 | 1.25 | 1.32 | | 1.11 |
| 2012 | 1.54 | 0.87 | 0.91 | 1.10 | 1.21 | 1.39 | | 1.14 |
| 2013 | 1.23 | 0.87 | 0.77 | 1.00 | 1.40 | 1.38 | | 1.22 |
| 2014 | 1.23 | 0.77 | 0.79 | 0.97 | 1.25 | 1.25 | | 1.15 |
| 2015 | 1.36 | 0.86 | 0.78 | 1.07 | 1.24 | 1.40 | | 1.20 |
| 2016 | 1.36 | 0.85 | 0.81 | 1.06 | 1.28 | 1.50 | | 1.29 |
| 2017 | 1.36 | 0.79 | 0.80 | 1.01 | 1.21 | 1.44 | | 1.21 |
| 2018 | 1.34 | 0.77 | 0.80 | 1.02 | 1.16 | 1.46 | 1.04 | 1.19 |
| 2019 | 1.27 | 0.79 | 0.76 | 1.09 | 1.17 | 1.41 | 0.99 | 1.03 |
| 2020 | 1.40 | 0.84 | 0.83 | 1.06 | 1.18 | 1.45 | 1.07 | 1.15 |
| 2021 | 1.42 | 0.78 | 0.80 | 1.05 | 1.26 | 1.45 | 1.28 | 1.25 |
| 2022 | 1.41 | 0.74 | 0.88 | 1.11 | 1.35 | 1.47 | 1.33 | 1.34 |
| 2023 | 1.31 | 0.65 | 0.81 | 1.04 | 1.27 | 1.40 | 1.22 | 1.11 |
| 2024 | 1.26 | 0.78 | 0.80 | 1.02 | 1.23 | 1.51 | 1.16 | 1.11 |

*Pre-Operational data are the averages of the years 1992 through 3rd quarter of 1995.
**Sites E-31 and E-32 are located at the Site Boundary to the West and South-West of the ISFSI.
***E-20 is located approximately 17 miles WSW of the ISFSI.
****E-44 Added in 2018

**Figure 11-2**
**Comparison of ISFSI Fence TLDs to Selected REMP TLDs**



## 11.2 Milk

Naturally occurring K-40 (1309 ± 80 pCi/L – annual average) continues to be the most prevalent radionuclide measured in milk at concentrations roughly 3270 times higher than the only potential plant related radionuclide, Sr-90 (0.4 ± 0.2 pCi/L), detected in milk. The annual average Sr-90 concentrations in milk continue to be similar to previous years. Co-60 and Cs-137 revealed two low positive results each with all results being <MDA. Cs-134 had one positive result that was <MDA, while there were no positive results for I-131, Ba-La-140, or Sr-89 obtained in 2024.

The 2024 average Sr-90 concentrations have not changed much over the last few years (Figure 11-3). Over the past twenty-one years, the average has decreased from 1.2 ± 0.5 pCi/L in 1997 to 0.4 ± 0.2 pCi/L in 2024. The graph of the annual averages displays a logarithmic decrease over time (Figure 11-3).

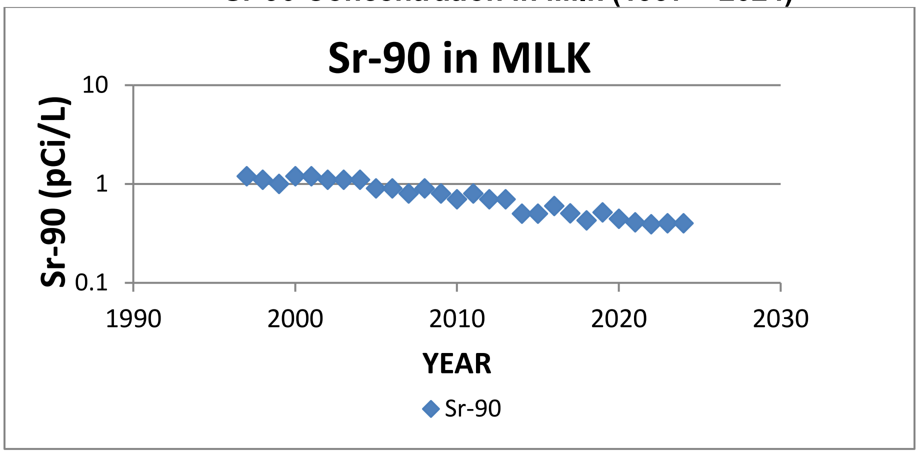
The annual averages are from the monthly Sr-90 measurements from three different dairies (Figure 9-1). The only dairy that has been in the monitoring program over the entire 1997 – 2024 timespan under consideration is located at site E-21. It is located south of the plant. The other two, E-40 and E-11, are replacements for dairies which had dropped out of the program at various times during this time interval. The replacements were chosen to maintain, to the extent possible, the former sampling sites west and north of Point Beach.

Point Beach discharged no airborne Sr-90 in 2024. Since 1997, PBNP has discharged airborne Sr-90 only in 3 years: 1999, 2.4E-08 Ci; 2004, 3.2E-08 Ci; and 2011, 1.6 E-08 Ci. It is interesting to note that nine of highest Sr-90 results occur at E-11 located about 4.4 miles west of PBNP (Fig. 9-1). If the observed Sr-90 activity were from Point Beach the highest Sr-90 concentrations would occur at E-21, the dairy south of the site boundary in the highest X/Q and D/Q meteorological sector. This dairy grows feed corn on site and in a field across the road from the site boundary in the highest D/Q sectors. Feed crops are the dominant source of food for dairy cattle. No cattle have been seen grazing near the site boundary for many years.

The major Sr-90 input to the environment is from fallout from atmospheric weapons testing during the early 1960s with minor inputs during the 50's, 70's and later contributions from the Chernobyl accident in the late 1980s and from Fukushima in 2011. The Sr-90 in milk persists due to its 28.6 year half-life and to cycling in the biosphere. With little or no atmospheric input to the environment, the mode of entry into cattle feed must be root uptake by forage crops and transfer into the milk. Over the time period of this graph (1997 – 2024), these low discharges do not appear to impact the decreasing concentrations as they continue to decrease over time.

It is concluded that the milk data for 2024 show no radiological effects of the plant operation.

**Figure 11-3**
**Sr-90 Concentration in Milk (1997 – 2024)**




11.3 Air

The average annual gross beta concentrations (plus/minus the 2σ uncertainty) in weekly airborne particulates at the indicator and control locations were 0.023 ± 0.018 pCi/m$^3$ and 0.024 ± 0.018 pCi/m$^3$, respectively, and are similar to levels observed from 1993 through 2023 (Figure 11-4).

The 2024 weekly gross beta concentrations reveal higher winter values and lower summer values (Figure 11-5). This is a repeat of the patterns seen in 2006 - 2023. The slight September-October peak is similar to what was observed in 2015 (Figure 11-6). The August-October peak is observed throughout the US and believed to result from weather patterns impacting with naturally occurring airborne radionuclides. This would explain why the control and indicators are moving in concert. Therefore, a plant effect can be ruled out.

**Figure 11-4 Annual Average Air Gross β (1993 – 2024)**

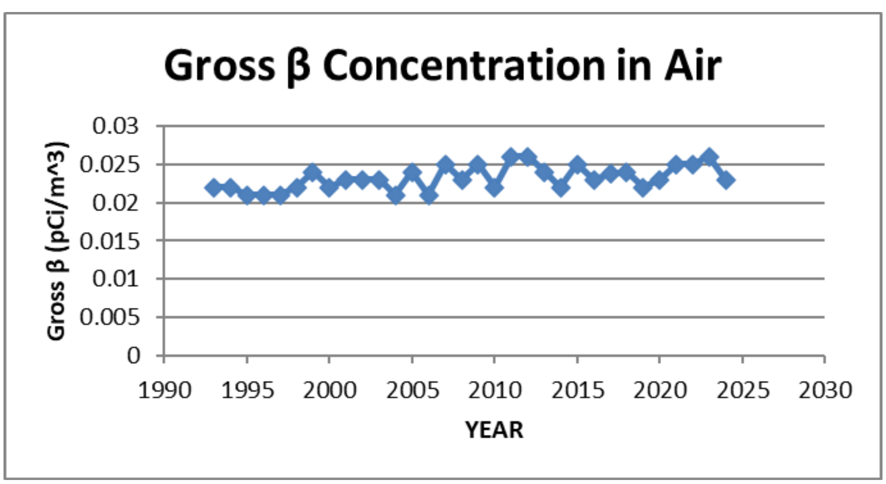


**Figure 11-5 2024 Airborne Gross Beta**

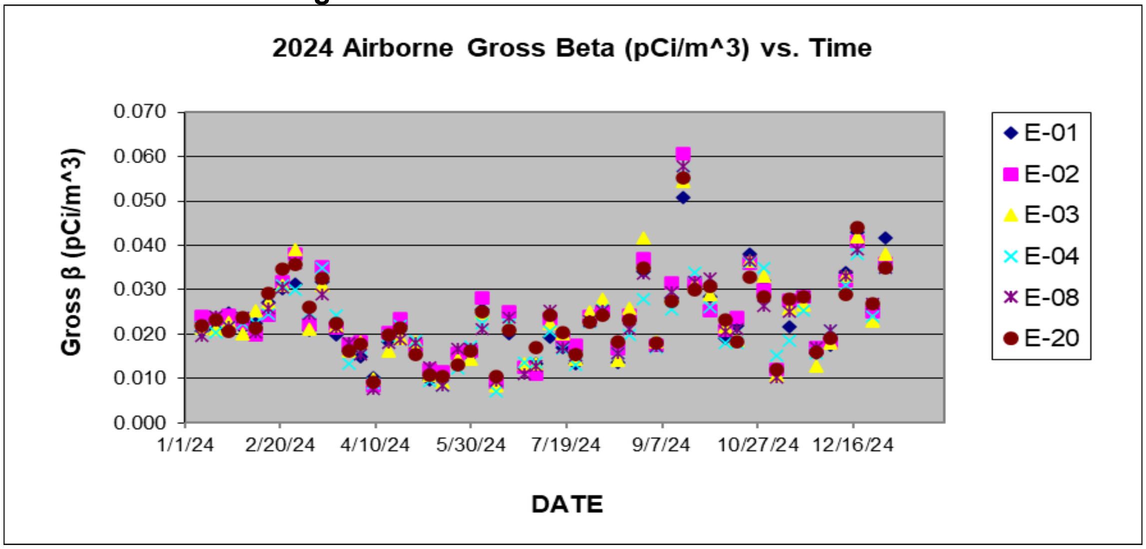
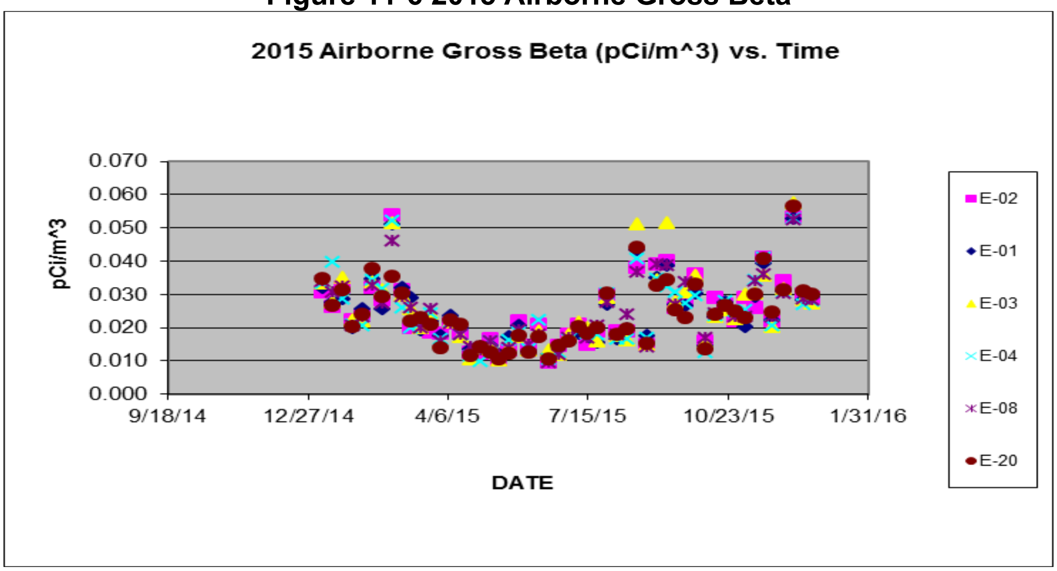



**Figure 11-6 2015 Airborne Gross Beta**




There was no detectable I-131 during 2024. In 2005, the new method of evaluating airborne I-131 was instituted. Instead of counting each charcoal cartridge separately, all six cartridges for the week are counted as one sample in a predetermined geometry to screen the samples for I-131. If any airborne radioiodine is detected, each sample cartridge is counted individually. With no detectable I-131, the reported analytical result is the minimum detectable activity (MDA) conservatively calculated using the smallest of the six sample volumes. The reported MDAs ranged from 0.005 to 0.021 pCi/m$^3$. Because the analysis LLD is based on counting only one cartridge, the use of six cartridges or roughly six times the sample volume with the same count time as would be needed to achieve the desired LLD for only one sample, the actual LLD is about six times lower than the programmatic value given in Table 10-1. Similarly, the actual MDA is about one-sixth of that reported, in the range of 0.001 to 0.0035 pCi/m$^3$.

At each sampling location, the particulate filters are composited quarterly and analyzed for Cs-134, Cs-137 and any other (Co-60) detectable gamma emitters. As summarized in Table 10-1. One sample had a positive result for Cs-137 above the MDC. It was reported at E-20 in the 1st Quarter. E-20 is the control location.

By contrast, naturally occurring Beryllium-7 was found in all of the quarterly composites at concentrations ranging from 0.039 to 0.108 pCi/m$^3$. Be-7 ($T_{1/2}$ = 53.3 days) is produced in the atmosphere by the interaction of cosmic rays with oxygen and nitrogen nuclei. Its half-life is long enough to allow for it to be detected in the quarterly composited filters.

In summary, the 2024 air gamma data from quarterly composites do not indicate a measurable environmental impact from the operation of PBNP.

## 11.4 Lake Water

For the REMP-specified gamma emitting radionuclides listed in Table 10-1, the reported concentrations continue to occur as small, negative and positive values scattered around zero, indicating no radiological impact from the operation of PBNP. Only 17 of the results were positive, of which, five are from north of the plant, at site E-05 (see Figure 9-1).

Four of the seventeen positive results were greater than the minimum detectable concentration (MDC). E-01 saw Ba-La-140 (3.2 ± 3.1 pCi/L MDC=3.0) in March, Zn-65 (6.1 ± 5.8 pCi/L MDC=5.2) in May, and Cs-137 (3.7 ± 1.9 pCi/L MDC=3.5) in July. E-06 had Fe-59 detected in June at 6.0 ± 3.0 pCi/L MDC=5.9. Zn-65, Cs-137, Ba/La-140 and Ru-103 were not released from PBNP in 2024. Fe-50 was only released in the 2nd Quarter, with the positive hit coming in June 2024. All detected isotopes can be considered false positives.

The other few indications of positive concentrations were found for Mn-54, Co-58, Fe-59, Co-60, Zn-65, Ru-103 and Cs-137, but were all found to be less than the MDC. Mn-54, Zn-65, Cs-137, Ba/La-140 and Ru-103 were not identified in the 2024 PBNP effluent, and all hits are therefore determined to be false positives.

Aliquots of the monthly samples are composited quarterly and analyzed for Sr-89/90 and for tritium. There were no positive hits of Sr-89 or Sr-90 detected in any of the twelve quarterly composites. No Sr-90 was discharged in 2024 or in 2012 – 2015 and 2017-2022. A small amount was discharged in March of 2016. Sr-90 has a 28.6 year half-life and, like Cs-137, it is a remnant of atmospheric weapons testing in the ‘50s and ‘60s. Therefore, positive Sr-90 concentrations could be indicative of fallout being recycled in Lake Michigan. However, because the concentrations are below their MDCs, they most likely are false positives and therefore unlikely to be the result of past PBNP discharges.

Tritium, in addition to being produced by water-cooled reactors such as PBNP, also is a naturally occurring radionuclide. It also was produced by atmospheric weapons testing. However, due to its mobility, any tritium now found in Lake Michigan at the concentrations typically found in monitoring programs cannot be from that time period. It is the result of power plant discharges. Point Beach discharges on the order of 600 - 1000 Ci of tritium per year.

Twelve quarterly lake water composites were generated from the monthly samples. Out of the twelve quarterly composites, one had a positive tritium indication and it was lower than the MDC (1$^{st}$ quarter E-06; 112±92, MDC = 174 pCi/L).

In conclusion, the observed tritium concentrations were well below the limit set forth by the EPA for drinking water standards (20,000 pCi/L). As well, based on the results of the gamma scans of Lake Michigan water, there is no measurable impact on the lake from PBNP discharges.

11.5 Fish

Twelve (12) fish were analyzed in 2024 with nine exhibiting detectable amounts of plant related activity. Of these, nine were positive for Cs-137 with two Cs-137 results >MDC. The positive Cs-137 concentrations ranged from 0.008 ± 0.004 to 0.021 ± 0.008 pCi/g. Cs-137 was not released in PBNP effluents for the 2024 calendar year. It is likely that the Cs-137 observed is the recycling of Cs-137 that entered Lake Michigan as fallout from atmospheric weapons testing in the '50s and '60s with lesser amounts from events at Chernobyl and Fukushima.

Positive results below their MDCs were found also for Mn-54, Co-58, Co-60 and Ru-103. All three positive hits were below the MDC. Fe-59 was discharged in the 2$^{nd}$ and 4$^{th}$ quarters during 2024. Mn-54 and Ru-103 were not in any effluent release in 2024. Co-60 was found in one lake trout in July at 0.008 ± 0.003 with an MDC of 0.007 pCi/L.

The highest radionuclide concentration in fish is naturally occurring K-40 with an average concentration of 2.49 ± 0.58 pCi/g.

Based on these results, it is concluded that there is little impact of PBNP discharges on Lake Michigan fish.

11.6 Well Water

All tritium results were less than the MDC for the 2024 well samples. One nuclide, Cs-137, was detected in the 3rd quarter 2024 sample. The result was 2.6 ± 0.8 pCi/L and was slightly greater than the MDC of 1.8. There is no pathway for liquid effluents to have interaction with the aquifer that supplies the drinking well. The result was determined to be a false positive, based on no available pathway and no other nuclides being identified in that sample or any others throughout 2024. Therefore, there is no evidence of PBNP effluents getting into the aquifer supplying drinking water to PBNP.

11.7 Soil

Cs-137 is present in the soils throughout North America and the world resulting from the atmospheric nuclear weapons testing in the 1950s, 1960s, and 1970s and from the 1986 Chernobyl accident, and more recently, from the Fukushima event. Soil is an integrating sample media, in that it is a better indicator of long term buildup of Cs-137 as opposed to current deposition for local sources. In addition to erosion and radioactive decay, human activities can modify the soil Cs-137 concentrations.

In 2024, Cs-137 was detected in all six of the soil samples obtained in September. The concentrations ranged from 0.025 ± 0.01 to 0.242 ± 0.01 pCi/g and all were >MDC. The highest value for Cs-137 was found at E-04. There were three U2 containment hatch airborne releases during the outage between October 16 through October 28, 2024 which contained Cs-137. Activity from the releases measured 1.98E-01 µCi at a concentration of 2.92E-07 pCi/cc. These releases would have been after the soil samples were collected and would not have accounted for these soil results.

The values of Cs-137 observed are consistent with years past, therefore it seems unlikely that the observed soil Cs-137 is attributable to PBNP effluent. The most likely source is recycling of fallout from atmospheric weapons testing in the 50s and 60 as well as the Chernobyl and Fukushima events and subsequently being bound to the soil.

By comparison to naturally occurring radionuclides, Cs-137 continues to be present in soil samples at well below the levels of naturally occurring Be-7, K-40, and Ra-226 (see Table 10-1).

## 11.8 Shoreline Sediment

Shoreline sediment consists of sand and other sediments washed up on the Lake Michigan shore. As in soil samples, the only non-naturally occurring radionuclide found in these samples is Cs-137. All three samples obtained had Cs-137 concentrations statistically different from zero with one sample below the MDC, and two above. All three were well below the LLD of 0.15.

Shoreline sediment Cs-137 concentrations continue to be about one-tenth of that found in soils (Table 10-1). This is expected because Cs-137 in the geological media is bound to fine particles, such as clay, as opposed to the sand found on the beach. Lake Michigan sediments are a known reservoir of fallout Cs-137. Wave action suspends lake sediments depositing them on the beach. The fine particles deposited on the beach eventually are sorted from the beach leaving the heavier sand; hence the lower Cs-137 concentrations in beach samples. In contrast to Cs-137, K-40, which is actually part of the minerals making up the clay and sand, is at a concentration about several hundred times higher than the Cs-137 that is attached to particle surfaces. Therefore, it is not surprising that Cs-137 is present at concentrations 1% or less of the naturally occurring concentrations of K-40.

The most likely source of the observed Cs-137 is the cycling of fallout from atmospheric weapons tests and events such as Chernobyl and Fukushiima in the Lake Michigan environment and not current PBNP discharges. As with soil, the naturally occurring radionuclides such as K-40, and Ra-226 are found in the shoreline sediment samples. Therefore, the shoreline sediment data indicate no radiological effects from current plant operation.

## 11.9 Vegetation

The REMP collects general vegetation, non-cultivated plants which would be consumed by grazing cattle.
The naturally occurring radionuclides Be-7 and K-40 were found in all of the general vegetation samples (Table 10-1). The source of Be-7 is atmospheric deposition. It is continuously formed in the atmosphere by cosmic ray spallation of oxygen, carbon, and nitrogen atoms. Spallation is a process whereby a cosmic ray breaks up the target atom's nucleus producing a radionuclide of lower mass. Be-7 in the vegetation samples had an average of 1.17 ± 0.76 pCi/g. In general vegetation Be-7 concentrations were higher in the fall than in the spring and ranged from 0.42 ± 0.14 to 2.45 ± 0.32 pCi/g. The average Be-7 concentrations in the vegetation increased from May (0.61 ± 0.16 pCi/g) to September (1.73 ± 0.72). In contrast, K-40 is a primordial radionuclide which is incorporated into vegetation from the soil during the growing process. By not being dependent upon seasonal atmospheric variations and plant surface to capture deposition, the vegetation K-40 concentrations from root uptake are more uniform with a range of 2.90 ± 0.48 to 6.50 ± 0.57.

Cs-137 can be present in vegetation via both pathways. Fresh Cs-137 fallout is associated, like Be-7, with deposition on the plant surface. Old fallout from the ‘50s and ‘60s is now being incorporated into growing plants in the same manner as potassium because it is in the same chemical family as potassium. This fallout Cs-137 has been found in firewood ash at many locations in the United States that are far from any nuclear plants (S. Farber, "Cesium-137 in Wood Ash, Results of a Nationwide Survey," 5th Ann. Nat. Biofuels Conf., 10/21/1992).

In 2024, two of the twelve vegetation samples had a positive indication for Cs-137. These occurrences were attributed to the above described mechanism. The only airborne Cs-137 discharged by PBNP occurred in March 2016 when there was no fresh vegetation. In 2017 the airborne Cs-137 release occurred in October after the vegetation and crops were collected. From 2018-2022 there was no airborne Cs-137 released in plant effluents. 2023 had one Cs-137 that occurred in November. In 2024, there was Cs-137 released during the outage in October. This was after the samples had been collected and would not have accounted for the results. Therefore, the Cs-137 has to be the result of uptake via roots. Therefore, it is unlikely that the Cs-137 results indicate an impact from PBNP releases.

There were no positive sample results for Cs-134 or I-131 in vegetation samples. One positive Co-60 at E-20 was detected in the 2024 vegetation samples. This was below the MDC and at the control site.

Based on the 2024 vegetation sampling results, it is concluded that there is little or no effect from PBNP effluents.

## 11.10 Land Use Census (LUC)

In accordance with the requirements of Section 12.2.5 of the ODCM, a visual verification of animals grazing in the vicinity of the PBNP site boundary was completed in 2023. In 2020, changes to the land use surrounding the site due to the installation of solar panels at and around the site boundary were noted. These changes ensure that the use of pasturelands or grazing herds remain conservative, as there is less land near the site boundary for grazing animals and pasture use. Based on this the existing milk-sampling program continues to be acceptable. The nearest dairy (E-21) lies in the SSE sector and it is one of the Point Beach REMP milk sampling sites. Also, the highest $\chi$/Q (1.09E-06) and D/Q (6.23E-09) values occur in these sectors. As demonstrated from the vegetation in the area, there is no measureable plant impact on the environment. Therefore, dose calculations to the maximum exposed hypothetical individual, assumed to reside at the site boundary in the S sector, continues to be conservative for the purpose of calculating doses via the grass-cow-milk and the other ingestion pathways.

The 2023 LUC revealed that one garden location within a 5-mile radius of the site in the N sector required replacement. This garden location was not previously identified in 2020 either. The 2024 LUC also revealed a milking animals location within a 5-mile radius of the site in the NNW sector required replacement. Again, this location was identified in 2020. Two new garden locations were identified in the 2023 LUC for the WNW and W sectors. None of the changes identified in the 2023 LUC necessitate changes to the current REMP, such as the addition of new sampling locations.

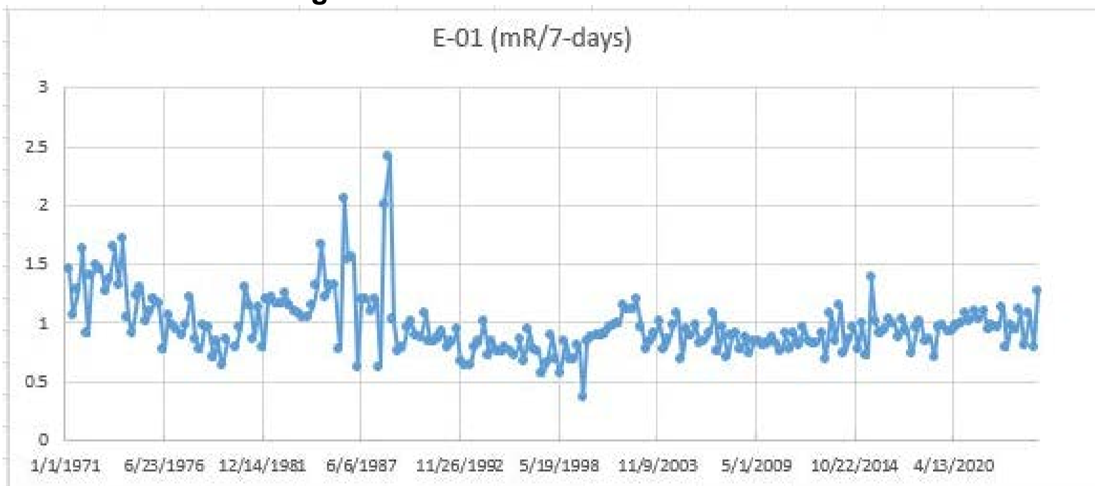
## 11.11 Long Term TLD Trending

To put the 2024 REMP TLD results in perspective, it is instructive to look at long term trends. The following examines the TLD results from 1971 to 2024. The ANSI standard (ANSI/HPS N13.37-2014 "Environmental Dosimetry) states that the data from early vintage dosimetry systems (c. 1970 – 1990) should not be considered comparable to current dosimetry systems in establishing a baseline for environmental TLD results. These problems are evident from the review of our early data as discussed below.

The pre-operational data, 1968 – 1970, are not included. The pre-operational ambient radiation monitoring sites were E-01 (the met tower area) through E-04 (the north boundary). They were monitored using TLDs and ionization chambers. E-04 was used as a background location until E-08 (see Figure 9-1) was added for the operational REMP in 1971. Prior to 1975, a control TLD stored in a lead pig was used for a comparison to those placed in the field. In the pre-operational data, the control TLD could be equal to or higher than the field results and both the field and control TLD results appear erratic compared to the ion-chamber results. Also, the reported TLD results do not have transportation exposures from New Mexico to Wisconsin subtracted. Therefore, only the TLD results beginning in 1971, with the transportation caveat, are used in this analysis of long-term trends.

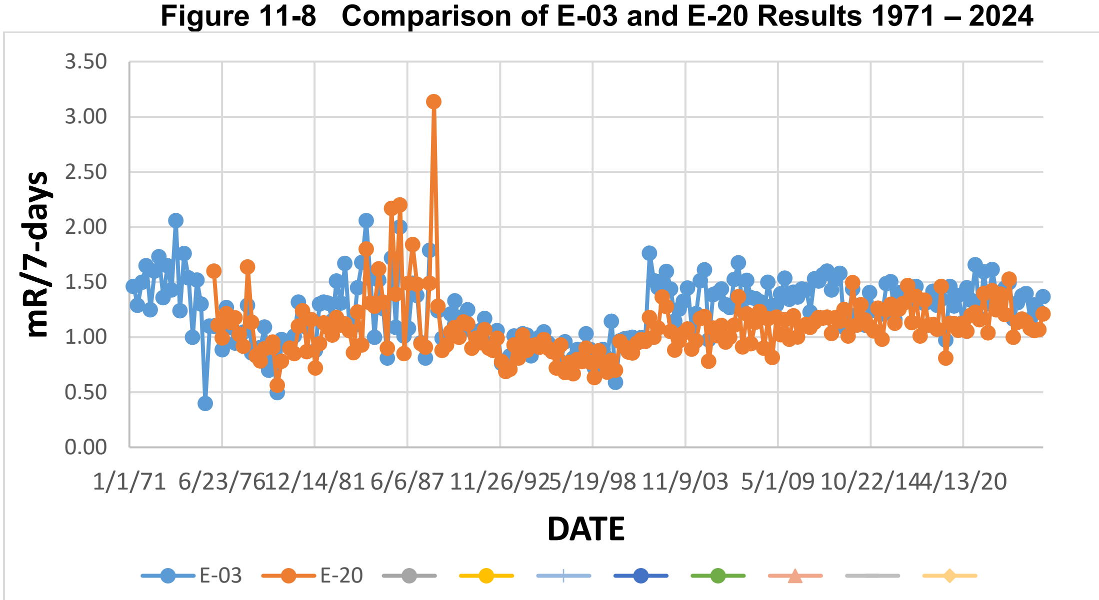
The trend at E-01 (Figure 11-7) shows slowly decreasing *trend* from 1971 to 1979. This may be an artifact. The cause is not known. As previously mentioned, no transportation controls were used until the 4$^{th}$ quarter of 1975, so no transport dose corrections were made prior to that quarter. There is a small increase in 1980 when the current contracted REMP lab began. A slowly decreasing exposure rate occurs from 1980 – 1992 except for the 1984 - 1988 time segments. The erratic results from 1984 – 1988 were traced to a faulty connection in the TLD reader.

**Figure 11-7 E-01 Results 1971 – 2024**




The TLD package from 1980 to 2001 consisted of three LiF chips sealed in a black plastic bag. The magnitude of the error bars indicates the degree of variability of the 1984 - 1988 results from the three chips due to a fault in the TLD reader. The results appear much the same for the E-03 and E-20 results (Figure 11-8). Note that E-20 did not begin until 1976. Again, there is an increase in both the E-20 (the background site) and E-03 (the location nearest the ISFSI) which coincides with the switch from the LiF chips to the Teflon TLD cards. Given that the first twelve casks were loaded December 1995 to September 2000 in which there were no increases in the TLD results, the increase in 2001 indicates that this change is the result of the different response of the new TLDs and not of any effluents or shine from the plant.

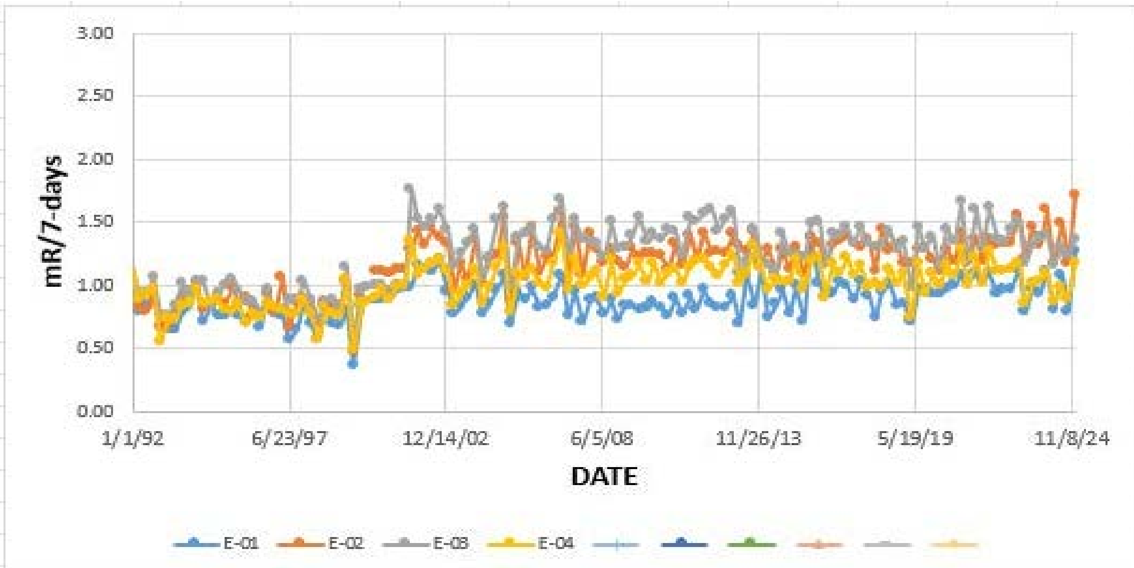
**Figure 11-8 Comparison of E-03 and E-20 Results 1971 – 2024**




Narrowing the time window for the TLD results from 1992 to the present allows for a comparison among the original four TLD locations since the introduction of the ISFSI (Figure 11-9) without the interference by the faulty TLD reader in the mid-

1980s.  Sites E-01 and E-02 are about 1 mile south of the ISFSI.  E-03 is 1200 feet west and E-04 is 4300 feet north.

**Figure 11-9 Comparison of E-01, E-02, E-03 and E-04 (1992 –2024)**




The comparison shows a definite difference between E-01 and the other three locations.  E-01, although approximately the same distance from the ISFSI as E-02 and further away than either E-03 or E-04, is lower than the other three sites.  Therefore, distance is not the determining factor in the difference among the measured exposures.  There are two factors which could cause the observed difference.  The first difference is that E-02, E-03, are surrounded by ploughed fields with solar panels, and E-04 is surrounded by plowed fields whereas the area around E-01 is uncultivated.  Second, E-01 is within 100 feet of the lake.  Therefore, about 50% of the area contributing natural radiation to the location is a combination of sandy soil, beach sand, and lake water.  Since E-01 has a combination of different natural radiation contributors (beach sand, lake water, and soil), that could explain the lower results that are observed at E-01.

The impact of the ISFSI on the ambient radiation levels at its nearest site boundary, the west boundary is shown in Figure 11-10.  The ISFSI impact on ambient exposure levels was addressed briefly in Section 11.1 (see Figure 11-2).

**Figure 11-10 E-03, E-31, E-44 and Background Site E-20 Results 1992 to 2024**

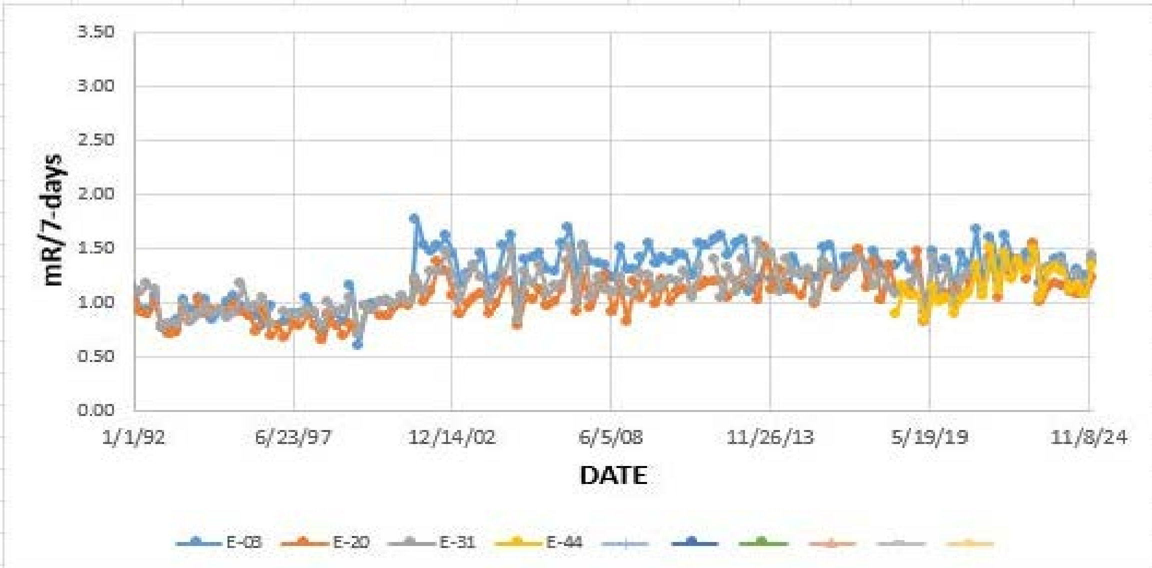



Figure 11-2 shows that beginning with the use of the Teflon TLD cards in the fourth quarter of 2000, the measured exposure levels at E-03 are 2 – 5 mR/7-days lower than the exposures at the west fence of the ISFSI. Figure 11-10 shows that although their individual 95% confidence levels overlap indicating no statistical difference, the quarterly exposures at E-03 (about 1200 feet from the ISFSI) are consistently higher than the exposure at E-31 (at the site boundary about 1400 feet west of E-03). Therefore, the lower values at E-31 compared to E-03 appear to be a real difference as the distance from the ISFSI increases at the west boundary. Because land usage and location are similar at E-03 and E-31, the cause of the previously identified response differences between E-03 and E-01 are not applicable. In 2018, a TLD monitoring location was added at location E-44, directly west of E-03 and E-31 over the site boundary. It can be seen that since 2018, E-44 shows a decreased reading when compared to E-03 and subsequently E-31. Therefore, the lower results at the site boundary location E-31 and E-44 show that the exposures from the ISFSI are dropping off and approaching the lower readings found at the background site E-20.

## 12.0 REMP CONCLUSION

Based on the analytical results from the 757 environmental samples (721 individual samples with an additional 24 quarterly air particulate composites and 12 quarterly lake water composites) together with 132 REMP + 16 ISFSI sets of TLDs that comprised the PBNP REMP for 2024, PBNP effluents had no discernable effect on the surrounding environs. The calculated effluent doses are below the 10 CFR 50, Appendix I dose objectives demonstrating that PBNP continues to have good controls on effluent releases. The control of effluents from PBNP continues to be acceptable pursuant to the ALARA criteria of 10 CFR 50.34a. Additionally, when the TLD results are factored into the overall exposure, the resulting doses are lower than the ISFSI (10 CFR 72.104) and EPA (40 CFR 190) limits of 25 mrem whole body, 75 mrem thyroid, and 25 mrem any other organ.

From the long-term analysis of TLD results, there is no evidence of elevated ambient radiation levels from the operation of Point Beach and the ISFSI except for the slightly higher exposures measured at the site boundary (E-31) compared to the background reference site (E-20) [see Figure 11-10].

# Part D
# GROUNDWATER MONITORING

## 13.0 PROGRAM DESCRIPTION

PBNP monitors groundwater for tritium as part of the Groundwater Protection Program (GWPP). The GWPP supports NEI 07-07, the nuclear industry's groundwater protection initiative. The GWPP also fulfills the requirement of 10 CFR 20.1501(a) to make surveys of areas, including to subsurface in order to comply with Part 20. During 2024 the sampling program consisted of beach drains, intermittent stream and bog locations, drinking water wells, façade wells, yard electrical manholes, ground water monitoring wells, and the subsurface drainage (SSD) system sump located in the U-2 façade.

In the late 1970s, the beach drains entering Lake Michigan were found to contain tritium. The beach drains are the discharge points for yard drainage system, which carries storm water runoff, and are known to be infiltrated by groundwater as observed by discharges even when no rain has occurred. In the 1980s, the source of tritium for this pathway was postulated to be spent fuel pool leakage into the groundwater under the plant. Based on this observation, modifications were made to the pool, and the tritium concentrations decreased below the effluent LLDs. Beach drain effluents continue to be monitored and are accounted for in the monthly effluent quantification process. Because the beach drains are susceptible to groundwater in-leakage from other sources such as the area around the former retention pond which is known to contain tritium, the beach drains are monitored as part of the groundwater monitoring program. In addition to tritium, groundwater beach drain samples also are gamma scanned for the same suite of radionuclides as lake water using the lake water LLDs.

Three intermittent stream locations and the Energy Information Center (EIC) well were added to the groundwater monitoring program in the late 1990s when it was discovered that tritium diffusion from the then operable, earthen retention pond was observable in the intermittent streams which transverse the site in a NW to SE direction. A fourth stream location closer to the plant was added in 2008. These streams pass on the east and west sides of the former retention pond and empty into Lake Michigan about half a mile south of the plant near the meteorological tower. The intermittent stream samples track tritium in the surface groundwater.

The groundwater monitoring program also includes two bogs / ponds on site. One is located about 400 feet SSE of the former retention pond; the other, about 1500 feet N between Warehouses 6 and 7.

In addition to the main plant well, four other drinking water wells are monitored. The Site Boundary Control Center well, located at the plant entrance, the Warehouse 6 well, on the north side of the plant, and the EIC well, located south of the plant. In 2012, a new building (Warehouse 7) was constructed for radwaste. The well for this building was added to the GWPP. These wells do not draw water from the top 20 - 30 feet of soil which is known to contain tritium. These wells monitor the deeper (200 - 600 feet), drinking water aquifer from which the main plant well draws its water. The two soil layers are separated by a gray, very dense till layer of low permeability identified by hydrological studies.

Manholes in the plant yard and for the subsurface drainage (SSD) system under the plant are available for obtaining ground water samples. The plant yard manholes for accessing electrical conduits are susceptible to ground water in-leakage. Therefore, a number of these were sampled. The SSD system was designed to lessen hydrostatic pressure on the foundation by controlling the flow of water under the plant and around the perimeter of the foundation walls. The SSD system flows to a sump in the Unit 2 facade. The sump was sampled twelve times during 2024.

Due to flooding concerns, man-holes and clean-outs for the SSD were sealed in 2014. Therefore, only the SSD sump is now used for sampling.

In the 1990s, two wells were sunk in each unit's façade to monitor the groundwater levels and look for evidence of concrete integrity as part of the ISI IWE Containment Inspection Program. These wells are stand pipes which are sampled periodically for chemical analyses. Façade well sampling has been part of the GWPP since 2007. These wells are sampled quarterly.

In November 2019 repairs to the beach drain access and additional wave run up rip-rap was placed around the shoreline to prevent additional high lake level impacts and beach erosion. These repairs and additions allowed for better access to beach drain sampling in 2020. S-1 and S-3 locations were sampled every month during the year when flow was available, and S-12 was also more accessible throughout the year for sampling. Other beach drain locations were noted as not having flow during the sampling periods.

The groundwater sampling sites (other than the beach drains, SSDs and manholes) are shown in Figure 13-1.

**Figure 13-1 Groundwater Monitoring Locations**

## 14.0 RESULTS AND DISCUSSION

### 14.1 Streams and Bogs

The results from the surface groundwater monitoring associated with the former retention pond are presented in Table 14-1. For the most part the creek results are near the MDC and lower than the results in the beach drain run-off samples. The highest averages are for the East Creek and STP which are in the groundwater flow path from the retention pond area to Lake Michigan. The West Creek is west of the former retention pond, an upstream location with respect to the groundwater flow. The tritium concentration at GW-08, close to the former retention pond, is about one-tenth of the tritium concentrations it had prior to the remediation of the retention pond.

**Table 14-1 Intermittent Streams and Bogs**
**H-3 Concentration (pCi/l)**

| Month | GW-01(E-01) | GW-02 | GW-03 | GW-17 | BOGS | | MDC |
|---|---|---|---|---|---|---|---|
| | Creek Confluence | E. Creek | W. Creek | STP | GW-07 | GW-08 | |
| Jan | 75 ± 85 | 262 ± 94 | 5 ± 80 | 250 ± 94 | | | 170 |
| Feb | 90 ± 94 | 310 ± 104 | 59 ± 92 | 343 ± 106 | | | 179 |
| Mar | 65 ± 85 | 82 ± 86 | 130 ± 88 | 221 ± 93 | | | 175 |
| Apr | 72 ± 83 | 81 ± 84 | 86 ± 84 | 431 ± 102 | | | 170 |
| May | 82 ± 97 | 153 ± 101 | 22 ± 92 | 302 ± 106 | 54 ± 93 | 541 ± 116 | 188 |
| Jun | -22 ± 84 | 146 ± 94 | 119 ± 92 | 474 ± 110 | | | 185 |
| Jul | 20 ± 86 | 242 ± 98 | 29 ± 87 | 224 ± 97 | | | 177 |
| Aug | -28 ± 85 | 114 ± 92 | -1 ± 86 | 217 ± 98 | | | 183 |
| Sep | 93 ± 90 | 302 ± 100 | 76 ± 89 | 161 ± 93 | | | 180 |
| Oct | NS ± NS | NS ± NS | NS ± NS | NS ± NS | | | |
| Nov | 78 ± 91 | 114 ± 93 | -10 ± 86 | 161 ± 93 | | | 185 |
| Dec | NS ± NS | NS ± NS | NS ± NS | NS ± NS | | | |
| Average | 53 ± 65 | 181 ± 68 | 52 ± 44 | 278 ± 76 | | | |

A blank indicates no sample was scheduled. Streams are sampled monthly; bogs, annually.
Values are presented as the measured value and the 95% confidence level counting error.
ND = not statistically different from zero at the 95% confidence level. NS= No sample available

The analyses of these surface water samples show low concentrations of tritium, similar to those observed in the beach drains. The West Creek (GW-03) samples had tritium results right at the MDC in most cases. Small positive tritium concentrations occurred in the samples from the confluence of the two creeks (GW-01), which again are similar to the West Creek concentrations. In contrast, there are more positive results from GW-02 (south end of the East Creek) and GW-17 (located at the north end of the East Creek).

The bog (GW-08) SE of the former retention pond is higher than the bog at GW-07 north of the former retention pond. The GW-08 bog result is increased a little from 2024 (501pCi/L to 541pCi/L), but is down from the 3200 - 3800 pCi/l seen in 1999 before the retention pond was remediated. A gamma analysis of the GW-07 bog sample from May 2024 showed no positive isotopes. Previous years' gamma scans did not show any indications of isotopes either. Tritium results at GW-07 from 2023 showed a detectable result at 344 pCi/L. 2024's result at the same sample point was less than detectable.

## 14.2 Beach Drains

The 2024 results for the beach drains that were sampled are presented in Table 14-2. S-1 collects yard drainage from the north part of the site yard; S-3, from the south. Drains S-8 and S-9 carry water from the lake side yard drains whereas drains S-7 and S-10 are from the turbine building roof. S-12 is a drain from the external SSD which run along the outside northern half of the foundation wall, and S-13 is the south external SSD drain. They are not connected to the internal SSD under the plant which drains to a sump in the U2 façade. Sample points S-7 and S-13 did not have analyzes due to no flow during sample collection. These points are excluded from Table 14-2.

**Table 14-2**
**2024 Beach Drain H-3 Concentration (pCi/l)**

| Month | S-1 | S-3 | S-8 | S-9 | S-10 | S-12 | MDC |
|---|---|---|---|---|---|---|---|
| Jan | 436 ± 102 | 42 ± 81 | NF ± | NF ± | NF ± | 247 ± 93 | 170 |
| Feb | 358 ± 99 | 207 ± 91 | NF ± | NF ± | NF ± | 193 ± 91 | 170 |
| Mar | 394 ± 104 | 115 ± 90 | NF ± | NF ± | NF ± | 181 ± 94 | 175 |
| Apr | 392 ± 102 | 1174 ± 133 | NF ± | 108 ± 91 | 185 ± 91 | 213 ± 93 | 175 |
| May | 321 ± 99 | 141 ± 90 | NF ± | NF ± | NF ± | 283 ± 97 | 174 |
| Jun | 163 ± 94 | 326 ± 102 | NF ± | NF ± | NF ± | 203 ± 96 | 183 |
| Jul | 243 ± 98 | 91 ± 90 | NF ± | NF ± | NF ± | 170 ± 94 | 183 |
| Aug | 156 ± 95 | 190 ± 97 | NF ± | NF ± | NF ± | 117 ± 93 | 181 |
| Sep | 268 ± 100 | 180 ± 96 | NF ± | NF ± | NF ± | 87 ± 91 | 183 |
| Oct | 275 ± 104 | 164 ± 98 | NF ± | NF ± | NF ± | NF ± | 181 |
| Nov | 266 ± 100 | 368 ± 105 | 387 ± 106 | NF ± | NF ± | 156 ± 94 | 185 |
| Dec | 146 ± 93 | 95 ± 90 | NF ± | NF ± | NF ± | 109 ± 91 | 183 |
| Avg = | 285 ± 98 | 258 ± 303 | 387 ± 106 | 108 ± 91 | 185 ± 91 | 178 ± 59 | |

ND = not detected and ≤MDC NS = no sample
NF = no sample due to no flow

The tritium concentrations at S-1, S-3, and S-12 are consistent with results from previous years. Results are similar to those observed at intermittent streams and in manholes around the site, and like in years prior are attributed to tritium recapture.

Gamma scans were performed on the beach drain samples at the LLD used for lake water. A few indications of small, positive concentration values below their MDCs were found for Be-7, Fe-59, Co-60, and Cs-137. Co-58 was found in the S-1 March sample to be above the MDC (3.5 ± 2.3 MDC 3.2). Gaseous effluents would be the most likely cause of a positive hit. There were no gaseous releases with Co-58 in February or March (sample was from 3/7/24), therefore Co-58 was considered a false positive. A higher than expected tritium result in the S-3 sample from April, flagged the sample for extra hard to detect analysis. The analysis resulted in less than detectable results. Recapture could have contributed to the observed positive values, though tritium can be concluded as only PBNP radionuclide positively found in the beach drains.

## 14.3 Electrical Vaults and Other Manholes

Manholes for access to below ground electrical facilities are susceptible to groundwater in-leakage. The manholes on the east side of the plant, between the Turbine building and Lake Michigan have low tritium concentrations (Table 14-3). Z-065A and Z-065B are located on the west side of the pump house. Manholes, Z-066A and Z-067A through Z-066D and Z-067D are between the pump house and the turbine building and run in parallel in the NE section of the yard beginning just north of the Unit 2 truck bay and run from the Unit 2 truck bay north to the EDG building. Z-068 is located just west of the EDG building and north of Z-066/067D. Each of the two A, B, C, and D vaults are side by side.

**Table 14-3**
**2024 East Yard Area Manhole Tritium (pCi/l)**

| MH | Spring | | | Fall | | |
|---|---|---|---|---|---|---|
| Z-065A(M-1) | 278 | ± | 107 | 302 | ± | 100 |
| Z-065B(M-2) | 331 | ± | 110 | 227 | ± | 97 |
| Z-066A | 57 | ± | 96 | 205 | ± | 96 |
| Z-067A | 184 | ± | 103 | 217 | ± | 96 |
| Z-066B | 217 | ± | 104 | 244 | ± | 98 |
| Z-067B | 166 | ± | 102 | 125 | ± | 92 |
| Z-066C | 293 | ± | 108 | 312 | ± | 101 |
| Z-067C | 57 | ± | 96 | 147 | ± | 93 |
| Z-066D | 151 | ± | 101 | 222 | ± | 97 |
| Z-067D | 156 | ± | 101 | 212 | ± | 96 |
| Z-068 | 306 | ± | 109 | 83 | ± | 89 |
| MDC | 188 | | | 180 | | |

Elevated tritium could be attributed to washout from rain/snowmelt as the manholes are outside. Tritium results are similar to what is observed in the subsurface drainage system with no isotopes present.

## 14.4 Façade Wells and Subsurface Drainage System

There are two methods of sampling the groundwater under the plant foundation. The first is a set of four shallow wells, two in each façade. The other is a subsurface drainage system (SSD). The façade wells were installed to monitor for groundwater conditions which may affect the integrity of the concrete and rebar of each unit's foundation. The SSD was designed to relieve hydrostatic pressure on each unit's foundation as well as the Auxiliary and Turbine buildings.

The façade wells are not located symmetrically in the two units. The Unit 1 façade wells are east of the containment in the SE (1Z-361A) and NE (1Z-361B) corners of the façade. However, in Unit 2, there is one well in the NW corner (2Z-361A) and the other rotated approximately 180° in the SW corner (2Z-361B). In each, the well cap is level with the floor. The 2024 façade well tritium results are shown in Table 14-4. The Unit 1 wells consistently have higher tritium concentrations than the U2 wells with 1Z-361A, in the SE corner of the Unit 1 façade, on average having the highest tritium concentrations.

In addition to tritium analysis, the façade wells were analyzed for gamma isotopic activity. As in lake water samples, small positive values below their calculated, minimum detectable concentrations were found for Co-58, Fe-59, Co-60, Zn-65, Cs-137, and Ba-La-140.

**Table 14-4**
**2024 Facade Well Water Tritium (pCi/l)**
**H-3 Concentration (pCi/l)**

| Month | UNIT 1 | | UNIT 2 | | MDC |
|---|---|---|---|---|---|
| | 1Z-361A | 1Z-361B | 2Z-361A | 2Z-361B | |
| Janary | 223 ± 91 | 275 ± 94 | 6 ± 80 | 141 ± 87 | 168 |
| June | 296 ± 101 | 105 ± 91 | -24 ± 84 | 227 ± 97 | 177 |
| September | 256 ± 98 | 93 ± 90 | -80 ± 80 | 171 ± 94 | 180 |
| November | 260 ± 101 | -20 ± 87 | 129 ± 95 | 97 ± 93 | 183 |

To relieve hydrostatic pressure on the foundation, Point Beach has an external and an internal subsurface drainage system (SSD) to drain groundwater away from the foundation.

The internal SSD consist of perforated piping which drains groundwater by gravity to a sump located in the Unit 2 façade. A comparison of the 2020 through 2024 SSD results is presented in Table 14-5. In 2024, the tritium results were similar as to what was observed in 2020-2023.

The SSD samples are scanned for gamma emitters. Two samples had positive values with results greater than the MDC. The sample from February 28, 2024 had Cs-137 (4.4 ± 1.9, MDC <3.9) and the sample from August 31, 2024 had Co-60 (4.6 ± 1.5, MDC <3.0). A few other slightly positive values were found for Co-60, Zn-65, and Cs-137 with all results calculated below the MDC.

**Table 14-5**
**2020 - 2024 Unit 2 Facade SSD Sump H-3 (pCi/l)**

| | 2020 | | | 2021 | | | 2022 | | | 2023 | | | 2024 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | pCi/l | | 2σ | pCi/l | | 2σ | pCi/l | | 2σ | pCi/l | | 2σ | pCi/l | | 2σ |
| Jan | 3557 | ± | 196 | 1185 | ± | 127 | 2547 | ± | 170 | 1697 | ± | 146 | 924 | ± | 123 |
| Feb | 3356 | ± | 187 | 1409 | ± | 135 | 2939 | ± | 186 | 1805 | ± | 149 | 910 | ± | 125 |
| Mar | 1915 | ± | 150 | 1605 | ± | 148 | 1820 | ± | 155 | 1072 | ± | 132 | 1214 | ± | 135 |
| Apr | 1468 | ± | 134 | 1437 | ± | 139 | 1112 | ± | 129 | 1384 | ± | 138 | 900 | ± | 134 |
| May | 1225 | ± | 129 | 1174 | ± | 131 | | NS | | 1392 | ± | 136 | 826 | ± | 125 |
| Jun | 1217 | ± | 130 | 806 | ± | 114 | 962 | ± | 128 | 2339 | ± | 169 | 1062 | ± | 133 |
| Jul | 2136 | ± | 157 | 6496 | ± | 257 | 1473 | ± | 147 | 1120 | ± | 131 | 940 | ± | 131 |
| Aug | 1900 | ± | 150 | 2915 | ± | 180 | 2642 | ± | 174 | 1004 | ± | 123 | 815 | ± | 126 |
| Sep | 1621 | ± | 141 | 2714 | ± | 175 | 1219 | ± | 132 | 1391 | ± | 140 | 687 | ± | 122 |
| Oct | 1419 | ± | 135 | 2654 | ± | 175 | 1611 | ± | 149 | 462 | ± | 104 | 1386 | ± | 145 |
| Nov | 1170 | ± | 130 | 2672 | ± | 175 | 1197 | ± | 128 | 792 | ± | 117 | 838 | ± | 126 |
| Dec | 1241 | ± | 131 | 2439 | ± | 169 | 1110 | ± | 129 | 870 | ± | 120 | 787 | ± | 138 |
| Average | 1852 | ± | 814 | 2292 | ± | 1514 | 1694 | ± | 703 | 1277 | ± | 507 | 941 | ± | 195 |

The external SSD system runs along the external foundation walls for the Unit 1 and Unit 2 facades, the Auxiliary Building, the North Service Building, and the Turbine Hall. It is not connected to the internal SSD system. During 2014, work to mitigate the possibility of external flooding events uncovered the N (S-12) and S (S-13) external SSD outfalls. Both the north and south halves of the external SSD system drain toward the beach. Several samples from SSD S-12 were obtained in 2024 and the results averaged 178 pCi/L, which is lower yet still comparable to the concentrations found in various manholes (Table 14-3) on the east side of the plant during 2024.

## 14.5 Potable Water and Monitoring Wells

Outside of the protected area, ten wells, in addition to the main plant well (Section 11.7), are used for monitoring tritium in groundwater: the four potable water wells, GW-04 (Energy Information Center or EIC), GW-05 (Warehouse 6), GW-18 (Warehouse 7), GW-06 (Site Boundary Control Center), and six tritium groundwater monitoring wells, GW-11 through GW-16 (Figure 13-1).

The potable water wells monitor the deep, drinking water aquifer whereas the monitoring wells penetrate less than 30 feet to monitor the top soil layer. The potable water aquifer is separated from the shallow, surface water aquifer by a thick, clay layer with very low permeability. GW-04 had one positive result for tritium in January 2024. The result was almost statistically no different than zero, and was <MDC. The rest of the potable water wells had no detectable tritium in any of the samples.

GW-04 is analyzed monthly for gamma, and had two slightly positive results each for Mn-54 and Cs-137. Both were less than the MDC. This was determined to be false positives as there were no known spills or effluent release pathways that would have interacted with this location.

**Table 14-6**
**2024 Potable Well Water Tritium Concentration (pCi/l)**

| Month | EIC WELL GW-04 | EIC MDC | Warehouse 6 Well GW-05 | SBCC Well GW-06 | WH 7 GW-18 | GW-05, 06, 18 MDC |
|---|---|---|---|---|---|---|
| Jan | 87 ± 84 | 168 | ND | ND | ND | 168 |
| Feb | ND | 179 | | | | |
| Mar | ND | 175 | | | | |
| Apr | ND | 170 | ND | ND | ND | 175 |
| May | NS* | | | | | |
| Jun | ND | 185 | | | | |
| Jul | ND | 177 | ND | ND | ND | 177 |
| Aug | ND | 181 | | | | |
| Sep | ND | 180 | | | | |
| Oct | ND | 177 | ND | ND | ND | 181 |
| Nov | ND | 185 | | | | |
| Dec | ND | 182 | | | | |

ND= not detected NS* No sample due to May Water Outage

The monitoring well results are similar to those obtained in previous years. The two monitoring wells showing higher and consistently detectable tritium (GW-15, GW-16) are in the flow path from the retention pond area to the lake (Table 14-7). However they are approaching similar levels as observed at the locations nearest the lake such as GW-11 and GW-14. GW-15 duplicate samples were analyzed for gamma. Two positive result were obtained for Cs-137. The first, in June, was

<MDC (4.5 ± 4.3, MDC <9.0). The second, in October, was also <MDC (1.2 ± 1.1, MDC <2.2).

**Table 14-7**
**2024 Quarterly Monitoring Well Tritium (pCi/l)**

| Q | MW-01 GW-11 | MW-02 GW-12 | MW-06 GW-13 | MW-05 GW-14 | MW-04 *GW-15 | MW-03 GW-16 | **MDC** |
|---|---|---|---|---|---|---|---|
| 1 | 107 ± 92 | ND | ND | ND | 145 ± 94 | 155 ± 94 | 174 |
| 2 | ND | ND | ND | 145 ± 93 | ND | 280 ± 100 | 183 |
| 3 | 112 ± 93 | ND | ND | 151 ± 95 | 247 ± 100 | 139 ± 95 | 181 |
| 4 | 89 ± 87 | ND | ND | 104 ± 88 | 148 ± 90 | 150 ± 91 | 177 |

ND= not statistically different from zero and <MDC. NS = no sample available

*Duplicate samples taken, highest value reported.

In summary, the results from monitoring wells GW-15 and GW-16 as well as results from the nearby surface water sample locations (GW-03, the east creek; GW-08, the bog to the SE of the former pond; and GW-17, the surface water on the SE corner of the STP) show that the area around and in the groundwater flow path from the former retention pond remain impacted by the tritium that diffused from the pond into the soil while it was in use.

14.6 Air Conditioning Condensate Samples

The results from the airborne tritium recapture study presented in the 2011 AMR demonstrated that the tritium via precipitation was higher close to the plant than away from the plant. Additionally, it was shown that the condensate from AC units located on building roofs and within the plant contained high concentrations of H-3. Similar results for AC condensate were demonstrated in 2012, 2013, 2014, and 2016. Based on this information AC Condensate samples were moved to a three year periodicity and were obtained in 2022 showing similar results as were previously observed. A comparison of the results is shown in Table 14-8.

**Table 14-8**
**2022 Air Conditioning Tritium Concentration (pCi/l)**

| Location | 2012 H-3 (pCi/l) | | 2σ | 2013 H-3 (pCi/l) | | 2σ | 2014 H-3 (pCi/l) | | 2σ | 2016 H-3 (pCi/l) | | 2σ | 2019 H-3 (pCi/l) | | 2σ | 2022 H-3 (pCi/l) | | 2σ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NSB (4th floor) | 557 | ± | 102 | 478 | ± | 102 | 328 | ± | 101 | NS | | | NS | | | NS | ± | |
| Turbine Bldg 66' | 998 | ± | 118 | 757 | ± | 112 | 527 | ± | 108 | 6096 | ± | 240 | NS | | | 2625 | ± | 175 |
| S Service Bldg Roof | 5822 | ± | 231 | 2606 | ± | 166 | 2690 | ± | 166 | 2911 | ± | 174 | 920 | ± | 114 | 900 | ± | 120 |
| South Gate Roof | 473 | ± | 99 | 217 | ± | 91 | 173 | ± | 95 | 171 | ± | 85 | ND | | | 121 | ± | 84 |
| Turbine Bldg 8' | 602 | ± | 104 | 1055 | ± | 123 | 874 | ± | 119 | NS | | | ND | | | 1054 | ± | 126 |
| Training Bldg Roof | 185 | ± | 86 | 203 | ± | 90 | ND | ± | | ND | | | ND | | | 138 | ± | 86 |

NS = no sample ND = not detected, measured value - 2σ ≤ 0

These results show that the H-3 concentrations continue to be higher in the immediate vicinity of Units 1 and 2 (S. Service Building and Turbine Building) than at the Training Building, which is some 800 feet south. The higher concentrations occurring within the area of the yard drains feeding beach drains support the conclusion that precipitation scavenging and roof drains continue to be a source for the H-3 found in the beach drains.  This was taken from 2022 AMR.

## 15.0 GROUNDWATER SUMMARY

Groundwater monitoring indicates that low levels of tritium continue to occur in the upper soil layer but not in the deep, drinking water aquifer. These results also indicate that the low levels of tritium are restricted to a small, well defined area close to the plant. Results from precipitation analyses (2011 AMR) show that airborne tritium concentrations are higher close to the plant as compared to results at the site boundaries. The observed tritium concentrations in the yard manholes can be explained by the higher tritium in precipitation close to the plant. In addition to tritium captured by precipitation, the beach drains also receive the tritium captured in the AC condensate because the condensate drainage is connected to the yard drain system.

Tritium continues in the soil below the plant foundation as evidenced by results from the subsurface drainage system and from the façade wells.

In conclusion, the groundwater tritium concentrations observed at Point Beach are below the EPA drinking water standards prior to emptying into Lake Michigan where they will undergo further dilution. All analyses to date indicate that the drinking water contains no tritium. None of the tritium in the upper soil layer is migrating off-site toward the surrounding population. This is based on the known west-to-east groundwater flow toward Lake Michigan and the results from the two monitoring wells west of the plant (GW-12 and GW-13, Figure 13-1). Additionally, because no tritium is detected at a value statistically different than zero in either of the four potable water wells closest to the power block or from the drinking water well at the site boundary, none of the tritium observed in the upper soil layer has penetrated into the drinking water aquifer to impact either on-site or off-site personnel.

# APPENDIX 1

Microbac Laboratories Inc.
Final Report for the Point Beach Nuclear Plant
and
Other Analyses
Reporting Period: January – December 2024

85 pages follow

MICROBAC®

MONTHLY
PROGRESS REPORT
NextEra Energy

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

THE POINT BEACH NUCLEAR PLANT
TWO RIVERS, WISCONSIN

PREPARED AND SUBMITTED
BY
Microbac Laboratories Inc.

Project Number: 8006

Reporting Period: January-December, 2024

Reviewed and
Approved by ______________________ Date 2/25/25
A. Banavali, PhD.
Laboratory Director

Distribution: R. Prucha, 1 email, 1 hardcopy

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# 1.0 INTRODUCTION

The following constitutes the current Monthly Progress Report for the Environmental Radiological Monitoring Program conducted at the Point Beach Nuclear Plant, Two Rivers, Wisconsin. Results of completed analyses are presented in the attached tables. Missing entries indicate analyses that are not completed. These results will appear in subsequent reports. Data tables reflect sample analysis results for both Technical Specification requirements and Special Interest locations and samples are randomly selected within the Program monitoring area to provide additional data for cross-comparisons.

For all gamma isotopic analyses, the spectrum is computer scanned from 80 to 2048 KeV. Specifically included are Mn-54, Fe-59, Co-58, Co-60, Zn-65, Zr-95, Nb-95, Ru-103, Ru-106, I-131, Ba-La-140, Cs-134, Cs-137, Ce-141, and Ce-144. Naturally occurring gamma-emitters, such as K-40 and Ra daughters, are frequently detected in soil and sediment samples. Specific isotopes listed are K-40, Tl-208, Pb-212, Bi-214, Ra-226 and Ac-228. The results reported under "Other Gammas" may be Co-60, Ru-103 or any other radionuclide which is indicative of other gammas for the sample type. "Other Gammas" do not include naturally occuring radionuclides.

All concentrations, except gross beta, are decay corrected.

All samples were collected within the scheduled period unless noted otherwise in the Listing of Missed Samples.

POINT BEACH NUCLEAR PLANT

## 2.0 LISTING OF MISSED SAMPLES

| Sample Type | Location | Expected Collection Date | Reason |
|---|---|---|---|
| AP/AI | E-20 | 06-27-24 | No sample due to a power failure at the station. |

# 3.0 Data Tables

Table 1. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131.
Location: E-01, Meteorological Tower
Units: pCi/m$^3$
Collection: Continuous, weekly exchange.

| Date Collected | Vol. (m$^3$) | Gross Beta | I-131 | Date Collected | Vol. (m$^3$) | Gross Beta | I-131 |
|---|---|---|---|---|---|---|---|
| Required LLD | | 0.010 | 0.030 | Required LLD | | 0.010 | 0.030 |
| 01-10-24 | 300 | 0.021 ± 0.004 | < 0.013 | 07-10-24 | 299 | 0.019 ± 0.003 | < 0.007 |
| 01-17-24 | 319 | 0.021 ± 0.003 | < 0.008 | 07-17-24 | 303 | 0.017 ± 0.003 | < 0.006 |
| 01-24-24 | 301 | 0.025 ± 0.004 | < 0.009 | 07-24-24 | 302 | 0.013 ± 0.003 | < 0.008 |
| 01-31-24 | 300 | 0.021 ± 0.004 | < 0.005 | 07-31-24 | 299 | 0.024 ± 0.004 | < 0.008 |
| 02-07-24 | 299 | 0.022 ± 0.004 | < 0.006 | 08-07-24 | 313 | 0.026 ± 0.004 | < 0.007 |
| 02-14-24 | 298 | 0.027 ± 0.004 | < 0.007 | 08-15-24 | 352 | 0.014 ± 0.003 | < 0.007 |
| 02-21-24 | 299 | 0.030 ± 0.004 | < 0.010 | 08-21-24 | 262 | 0.023 ± 0.004 | < 0.015 |
| 02-28-24 | 306 | 0.031 ± 0.004 | < 0.007 | 08-28-24 | 295 | 0.034 ± 0.004 | < 0.006 |
| 03-06-24 | 299 | 0.021 ± 0.004 | < 0.013 | 09-04-24 | 307 | 0.018 ± 0.003 | < 0.010 |
| 03-13-24 | 297 | 0.032 ± 0.004 | < 0.010 | 09-12-24 | 346 | 0.028 ± 0.003 | < 0.008 |
| 03-20-24 | 309 | 0.020 ± 0.003 | < 0.019 | 09-18-24 | 256 | 0.051 ± 0.005 | < 0.011 |
| 03-27-24 | 299 | 0.016 ± 0.003 | < 0.008 | 09-24-24 | 258 | 0.031 ± 0.004 | < 0.017 |
| 04-02-24 | 258 | 0.015 ± 0.003 | < 0.019 | 10-02-24 | 343 | 0.028 ± 0.004 | < 0.008 |
| 1st Quarter Mean ± s.d. | | 0.023 ± 0.005 | < 0.010 | 3rd Quarter Mean ± s.d. | | 0.025 ± 0.010 | < 0.009 |
| 04-09-24 | 305 | 0.010 ± 0.003 | < 0.006 | 10-10-24 | 347 | 0.019 ± 0.003 | < 0.007 |
| 04-17-24 | 345 | 0.018 ± 0.003 | < 0.007 | 10-16-24 | 264 | 0.022 ± 0.004 | < 0.014 |
| 04-23-24 | 265 | 0.022 ± 0.004 | < 0.017 | 10-23-24 | 293 | 0.038 ± 0.004 | < 0.012 |
| 05-01-24 | 367 | 0.017 ± 0.003 | < 0.007 | 10-30-24 | 317 | 0.032 ± 0.004 | < 0.010 |
| 05-08-24 | 304 | 0.010 ± 0.003 | < 0.009 | 11-06-24 | 308 | 0.012 ± 0.003 | < 0.011 |
| 05-15-24 | 312 | 0.011 ± 0.003 | < 0.016 | 11-13-24 | 306 | 0.022 ± 0.004 | < 0.011 |
| 05-23-24 | 340 | 0.015 ± 0.003 | < 0.008 | 11-20-24 | 307 | 0.028 ± 0.004 | < 0.008 |
| 05-30-24 | 306 | 0.015 ± 0.003 | < 0.013 | 11-27-24 | 309 | 0.016 ± 0.003 | < 0.021 |
| 06-05-24 | 260 | 0.026 ± 0.004 | < 0.007 | 12-04-24 | 316 | 0.018 ± 0.003 | < 0.008 |
| 06-12-24 | 308 | 0.009 ± 0.003 | < 0.007 | 12-12-24 | 348 | 0.034 ± 0.004 | < 0.011 |
| 06-19-24 | 282 | 0.020 ± 0.004 | < 0.008 | 12-18-24 | 247 | 0.043 ± 0.005 | < 0.019 |
| 06-27-24 | 340 | 0.012 ± 0.003 | < 0.005 | 12-26-24 | 356 | 0.025 ± 0.003 | < 0.007 |
| 07-03-24 | 260 | 0.013 ± 0.003 | < 0.020 | 01-02-25 | 310 | 0.042 ± 0.004 | < 0.010 |
| 2nd Quarter Mean ± s.d. | | 0.015 ± 0.005 | < 0.010 | 4th Quarter Mean ± s.d. | | 0.027 ± 0.010 | < 0.011 |
| | | | | Cumulative Average | | 0.023 ± 0.009 | < 0.010 |

Table 1. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131.
Location: E-02, Site Boundary Control Center
Units: pCi/m$^3$
Collection: Continuous, weekly exchange.

| Date Collected | Vol. (m$^3$) | Gross Beta | I-131 |
|---|---|---|---|
| Required LLD | | 0.010 | 0.030 |
| 01-10-24 | 300 | 0.024 ± 0.004 | < 0.013 |
| 01-17-24 | 310 | 0.024 ± 0.004 | < 0.008 |
| 01-24-24 | 300 | 0.024 ± 0.004 | < 0.009 |
| 01-31-24 | 302 | 0.023 ± 0.004 | < 0.005 |
| 02-07-24 | 305 | 0.020 ± 0.004 | < 0.006 |
| 02-14-24 | 298 | 0.024 ± 0.004 | < 0.007 |
| 02-21-24 | 294 | 0.032 ± 0.004 | < 0.010 |
| 02-28-24 | 307 | 0.038 ± 0.004 | < 0.007 |
| 03-06-24 | 301 | 0.022 ± 0.004 | < 0.013 |
| 03-13-24 | 293 | 0.035 ± 0.004 | < 0.011 |
| 03-20-24 | 311 | 0.021 ± 0.003 | < 0.019 |
| 03-27-24 | 299 | 0.018 ± 0.003 | < 0.008 |
| 04-02-24 | 263 | 0.018 ± 0.004 | < 0.018 |
| 1st Quarter Mean ± s.d. | | 0.025 ± 0.006 | < 0.010 |
| 04-09-24 | 296 | 0.008 ± 0.003 | < 0.007 |
| 04-17-24 | 354 | 0.020 ± 0.003 | < 0.007 |
| 04-23-24 | 261 | 0.023 ± 0.004 | < 0.017 |
| 05-01-24 | 356 | 0.017 ± 0.003 | < 0.007 |
| 05-08-24 | 313 | 0.012 ± 0.003 | < 0.009 |
| 05-15-24 | 312 | 0.011 ± 0.003 | < 0.016 |
| 05-23-24 | 339 | 0.016 ± 0.003 | < 0.008 |
| 05-30-24 | 311 | 0.016 ± 0.003 | < 0.013 |
| 06-05-24 | 261 | 0.028 ± 0.004 | < 0.007 |
| 06-12-24 | 312 | 0.009 ± 0.003 | < 0.007 |
| 06-19-24 | 310 | 0.025 ± 0.004 | < 0.007 |
| 06-27-24 | 345 | 0.013 ± 0.003 | < 0.005 |
| 07-03-24 | 259 | 0.011 ± 0.003 | < 0.021 |
| 2nd Quarter Mean ± s.d. | | 0.016 ± 0.006 | < 0.010 |

| Date Collected | Vol. (m$^3$) | Gross Beta | I-131 |
|---|---|---|---|
| Required LLD | | 0.010 | 0.030 |
| 07-10-24 | 300 | 0.023 ± 0.004 | < 0.007 |
| 07-17-24 | 297 | 0.019 ± 0.004 | < 0.006 |
| 07-24-24 | 302 | 0.018 ± 0.003 | < 0.008 |
| 07-31-24 | 295 | 0.024 ± 0.004 | < 0.008 |
| 08-07-24 | 311 | 0.025 ± 0.004 | < 0.007 |
| 08-15-24 | 344 | 0.017 ± 0.003 | < 0.007 |
| 08-21-24 | 262 | 0.024 ± 0.004 | < 0.015 |
| 08-28-24 | 302 | 0.037 ± 0.004 | < 0.005 |
| 09-04-24 | 303 | 0.018 ± 0.003 | < 0.010 |
| 09-12-24 | 348 | 0.032 ± 0.004 | < 0.008 |
| 09-18-24 | 258 | 0.061 ± 0.005 | < 0.011 |
| 09-24-24 | 259 | 0.031 ± 0.004 | < 0.017 |
| 10-02-24 | 346 | 0.025 ± 0.003 | < 0.008 |
| 3rd Quarter Mean ± s.d. | | 0.027 ± 0.012 | < 0.009 |
| 10-10-24 | 348 | 0.021 ± 0.003 | < 0.006 |
| 10-16-24 | 266 | 0.024 ± 0.004 | < 0.014 |
| 10-23-24 | 297 | 0.036 ± 0.004 | < 0.012 |
| 10-30-24 | 310 | 0.030 ± 0.004 | < 0.010 |
| 11-06-24 | 305 | 0.012 ± 0.003 | < 0.011 |
| 11-13-24 | 303 | 0.028 ± 0.004 | < 0.011 |
| 11-20-24 | 297 | 0.028 ± 0.004 | < 0.008 |
| 11-27-24 | 308 | 0.017 ± 0.003 | < 0.021 |
| 12-04-24 | 311 | 0.018 ± 0.004 | < 0.008 |
| 12-12-24 | 348 | 0.032 ± 0.004 | < 0.010 |
| 12-18-24 | 250 | 0.041 ± 0.005 | < 0.018 |
| 12-26-24 | 345 | 0.025 ± 0.003 | < 0.007 |
| 01-02-25 | 304 | 0.036 ± 0.004 | < 0.010 |
| 4th Quarter Mean ± s.d. | | 0.027 ± 0.008 | < 0.011 |
| Cumulative Average | | 0.024 ± 0.009 | < 0.010 |

POINT BEACH NUCLEAR PLANT

Table 1. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131.
Location: E-03, West Boundary
Units: pCi/m$^3$
Collection: Continuous, weekly exchange.

| Date Collected | Vol. (m$^3$) | Gross Beta | I-131 | Date Collected | Vol. (m$^3$) | Gross Beta | I-131 |
|---|---|---|---|---|---|---|---|
| Required LLD | | 0.010 | 0.030 | Required LLD | | 0.010 | 0.030 |
| 01-10-24 | 307 | 0.022 ± 0.004 | < 0.013 | 07-10-24 | 301 | 0.022 ± 0.004 | < 0.007 |
| 01-17-24 | 323 | 0.021 ± 0.003 | < 0.008 | 07-17-24 | 298 | 0.020 ± 0.004 | < 0.006 |
| 01-24-24 | 296 | 0.023 ± 0.004 | < 0.010 | 07-24-24 | 306 | 0.014 ± 0.003 | < 0.008 |
| 01-31-24 | 306 | 0.020 ± 0.003 | < 0.005 | 07-31-24 | 303 | 0.025 ± 0.004 | < 0.008 |
| 02-07-24 | 309 | 0.025 ± 0.004 | < 0.006 | 08-07-24 | 312 | 0.028 ± 0.004 | < 0.007 |
| 02-14-24 | 306 | 0.027 ± 0.004 | < 0.007 | 08-15-24 | 353 | 0.014 ± 0.003 | < 0.007 |
| 02-21-24 | 307 | 0.031 ± 0.004 | < 0.010 | 08-21-24 | 265 | 0.026 ± 0.004 | < 0.015 |
| 02-28-24 | 309 | 0.039 ± 0.004 | < 0.007 | 08-28-24 | 299 | 0.042 ± 0.005 | < 0.005 |
| 03-06-24 | 295 | 0.021 ± 0.004 | < 0.013 | 09-04-24 | 305 | 0.018 ± 0.003 | < 0.010 |
| 03-13-24 | 300 | 0.031 ± 0.004 | < 0.010 | 09-12-24 | 349 | 0.028 ± 0.003 | < 0.008 |
| 03-20-24 | 317 | 0.022 ± 0.003 | < 0.019 | 09-18-24 | 256 | 0.055 ± 0.005 | < 0.011 |
| 03-27-24 | 303 | 0.016 ± 0.003 | < 0.008 | 09-24-24 | 259 | 0.031 ± 0.004 | < 0.017 |
| 04-02-24 | 260 | 0.018 ± 0.004 | < 0.019 | 10-02-24 | 353 | 0.029 ± 0.004 | < 0.008 |
| 1st Quarter Mean ± s.d. | | 0.024 ± 0.006 | < 0.010 | 3rd Quarter Mean ± s.d. | | 0.027 ± 0.011 | < 0.009 |
| 04-09-24 | 300 | 0.010 ± 0.003 | < 0.007 | 10-10-24 | 352 | 0.022 ± 0.003 | < 0.006 |
| 04-17-24 | 350 | 0.016 ± 0.003 | < 0.007 | 10-16-24 | 270 | 0.019 ± 0.004 | < 0.014 |
| 04-23-24 | 264 | 0.019 ± 0.004 | < 0.017 | 10-23-24 | 300 | 0.037 ± 0.004 | < 0.012 |
| 05-01-24 | 352 | 0.018 ± 0.003 | < 0.007 | 10-30-24 | 308 | 0.033 ± 0.004 | < 0.010 |
| 05-08-24 | 311 | 0.011 ± 0.003 | < 0.009 | 11-06-24 | 313 | 0.011 ± 0.003 | < 0.011 |
| 05-15-24 | 318 | 0.009 ± 0.003 | < 0.016 | 11-13-24 | 305 | 0.026 ± 0.004 | < 0.011 |
| 05-23-24 | 334 | 0.014 ± 0.003 | < 0.008 | 11-20-24 | 301 | 0.027 ± 0.004 | < 0.008 |
| 05-30-24 | 313 | 0.015 ± 0.003 | < 0.013 | 11-27-24 | 309 | 0.013 ± 0.003 | < 0.021 |
| 06-05-24 | 261 | 0.025 ± 0.004 | < 0.007 | 12-04-24 | 313 | 0.018 ± 0.003 | < 0.008 |
| 06-12-24 | 311 | 0.009 ± 0.003 | < 0.007 | 12-12-24 | 354 | 0.033 ± 0.004 | < 0.010 |
| 06-19-24 | 313 | 0.022 ± 0.003 | < 0.007 | 12-18-24 | 247 | 0.042 ± 0.005 | < 0.018 |
| 06-27-24 | 355 | 0.013 ± 0.003 | < 0.005 | 12-26-24 | 354 | 0.023 ± 0.003 | < 0.007 |
| 07-03-24 | 259 | 0.013 ± 0.003 | < 0.021 | 01-02-25 | 306 | 0.038 ± 0.004 | < 0.010 |
| 2nd Quarter Mean ± s.d. | | 0.015 ± 0.005 | < 0.010 | 4th Quarter Mean ± s.d. | | 0.026 ± 0.010 | < 0.011 |
| | | | | Cumulative Average | | 0.023 ± 0.010 | < 0.010 |

Table 1. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131.
Location: E-04, North Boundary
Units: pCi/$m^3$
Collection: Continuous, weekly exchange.

| Date Collected | Vol. ($m^3$) | Gross Beta | I-131 | Date Collected | Vol. ($m^3$) | Gross Beta | I-131 |
|---|---|---|---|---|---|---|---|
| Required LLD | | 0.010 | 0.030 | Required LLD | | 0.010 | 0.030 |
| 01-10-24 | 310 | 0.022 ± 0.004 | < 0.013 | 07-10-24 | 300 | 0.021 ± 0.003 | < 0.007 |
| 01-17-24 | 308 | 0.020 ± 0.003 | < 0.008 | 07-17-24 | 302 | 0.017 ± 0.003 | < 0.006 |
| 01-24-24 | 325 | 0.022 ± 0.003 | < 0.009 | 07-24-24 | 296 | 0.013 ± 0.003 | < 0.009 |
| 01-31-24 | 306 | 0.023 ± 0.004 | < 0.005 | 07-31-24 | 297 | 0.023 ± 0.003 | < 0.008 |
| 02-07-24 | 307 | 0.022 ± 0.004 | < 0.006 | 08-07-24 | 299 | 0.026 ± 0.004 | < 0.008 |
| 02-14-24 | 311 | 0.024 ± 0.004 | < 0.007 | 08-15-24 | 326 | 0.016 ± 0.003 | < 0.007 |
| 02-21-24 | 304 | 0.031 ± 0.004 | < 0.010 | 08-21-24 | 294 | 0.020 ± 0.004 | < 0.014 |
| 02-28-24 | 308 | 0.030 ± 0.004 | < 0.007 | 08-28-24 | 329 | 0.028 ± 0.004 | < 0.005 |
| 03-06-24 | 300 | 0.025 ± 0.004 | < 0.013 | 09-04-24 | 288 | 0.017 ± 0.003 | < 0.010 |
| 03-13-24 | 303 | 0.035 ± 0.004 | < 0.010 | 09-12-24 | 321 | 0.026 ± 0.003 | < 0.008 |
| 03-20-24 | 316 | 0.024 ± 0.003 | < 0.019 | 09-18-24 | 258 | 0.056 ± 0.005 | < 0.011 |
| 03-27-24 | 300 | 0.013 ± 0.003 | < 0.008 | 09-24-24 | 265 | 0.034 ± 0.004 | < 0.016 |
| 04-02-24 | 254 | 0.017 ± 0.004 | < 0.019 | 10-02-24 | 344 | 0.026 ± 0.004 | < 0.008 |
| 1st Quarter Mean ± s.d. | | 0.024 ± 0.006 | < 0.010 | 3rd Quarter Mean ± s.d. | | 0.025 ± 0.011 | < 0.009 |
| 04-09-24 | 282 | 0.009 ± 0.003 | < 0.007 | 10-10-24 | 323 | 0.018 ± 0.003 | < 0.007 |
| 04-17-24 | 345 | 0.020 ± 0.003 | < 0.007 | 10-16-24 | 287 | 0.018 ± 0.003 | < 0.013 |
| 04-23-24 | 262 | 0.022 ± 0.004 | < 0.017 | 10-23-24 | 266 | 0.036 ± 0.004 | < 0.013 |
| 05-01-24 | 361 | 0.018 ± 0.003 | < 0.007 | 10-30-24 | 309 | 0.035 ± 0.004 | < 0.010 |
| 05-08-24 | 314 | 0.010 ± 0.003 | < 0.009 | 11-06-24 | 310 | 0.015 ± 0.003 | < 0.011 |
| 05-15-24 | 317 | 0.008 ± 0.003 | < 0.016 | 11-13-24 | 286 | 0.019 ± 0.004 | < 0.012 |
| 05-23-24 | 342 | 0.012 ± 0.003 | < 0.008 | 11-20-24 | 287 | 0.025 ± 0.004 | < 0.009 |
| 05-30-24 | 309 | 0.017 ± 0.003 | < 0.013 | 11-27-24 | 305 | 0.016 ± 0.003 | < 0.022 |
| 06-05-24 | 262 | 0.023 ± 0.004 | < 0.007 | 12-04-24 | 346 | 0.021 ± 0.003 | < 0.008 |
| 06-12-24 | 314 | 0.007 ± 0.003 | < 0.007 | 12-12-24 | 333 | 0.031 ± 0.004 | < 0.011 |
| 06-19-24 | 305 | 0.022 ± 0.004 | < 0.008 | 12-18-24 | 242 | 0.038 ± 0.005 | < 0.019 |
| 06-27-24 | 326 | 0.014 ± 0.003 | < 0.005 | 12-26-24 | 324 | 0.024 ± 0.004 | < 0.008 |
| 07-03-24 | 256 | 0.014 ± 0.003 | < 0.021 | 01-02-25 | 338 | 0.035 ± 0.004 | < 0.009 |
| 2nd Quarter Mean ± s.d. | | 0.015 ± 0.006 | < 0.010 | 4th Quarter Mean ± s.d. | | 0.025 ± 0.008 | < 0.012 |
| | | | | Cumulative Average | | 0.022 ± 0.009 | < 0.010 |

Table 1. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131.
Location: E-08, G.J. Francar Residence
Units: pCi/m$^3$
Collection: Continuous, weekly exchange.

| Date Collected | Vol. (m$^3$) | Gross Beta | I-131 | Date Collected | Vol. (m$^3$) | Gross Beta | I-131 |
|---|---|---|---|---|---|---|---|
| Required LLD | | 0.010 | 0.030 | Required LLD | | 0.010 | 0.030 |
| 01-10-24 | 306 | 0.020 ± 0.004 | < 0.013 | 07-10-24 | 299 | 0.025 ± 0.004 | < 0.007 |
| 01-17-24 | 319 | 0.024 ± 0.004 | < 0.008 | 07-17-24 | 298 | 0.017 ± 0.003 | < 0.006 |
| 01-24-24 | 292 | 0.022 ± 0.004 | < 0.010 | 07-24-24 | 306 | 0.015 ± 0.003 | < 0.008 |
| 01-31-24 | 304 | 0.024 ± 0.004 | < 0.005 | 07-31-24 | 300 | 0.023 ± 0.003 | < 0.008 |
| 02-07-24 | 304 | 0.020 ± 0.004 | < 0.006 | 08-07-24 | 304 | 0.025 ± 0.004 | < 0.007 |
| 02-14-24 | 304 | 0.026 ± 0.004 | < 0.007 | 08-15-24 | 351 | 0.016 ± 0.003 | < 0.007 |
| 02-21-24 | 309 | 0.031 ± 0.004 | < 0.010 | 08-21-24 | 258 | 0.021 ± 0.004 | < 0.016 |
| 02-28-24 | 305 | 0.036 ± 0.004 | < 0.007 | 08-28-24 | 301 | 0.034 ± 0.004 | < 0.005 |
| 03-06-24 | 291 | 0.024 ± 0.004 | < 0.013 | 09-04-24 | 302 | 0.017 ± 0.003 | < 0.010 |
| 03-13-24 | 299 | 0.029 ± 0.004 | < 0.010 | 09-12-24 | 347 | 0.029 ± 0.003 | < 0.008 |
| 03-20-24 | 315 | 0.021 ± 0.003 | < 0.019 | 09-18-24 | 261 | 0.058 ± 0.005 | < 0.011 |
| 03-27-24 | 301 | 0.018 ± 0.003 | < 0.008 | 09-24-24 | 256 | 0.032 ± 0.004 | < 0.017 |
| 04-02-24 | 259 | 0.015 ± 0.004 | < 0.019 | 10-02-24 | 348 | 0.033 ± 0.004 | < 0.008 |
| 1st Quarter Mean ± s.d. | | 0.024 ± 0.006 | < 0.010 | 3rd Quarter Mean ± s.d. | | 0.027 ± 0.011 | < 0.009 |
| 04-09-24 | 304 | 0.008 ± 0.003 | < 0.006 | 10-10-24 | 341 | 0.021 ± 0.003 | < 0.007 |
| 04-17-24 | 341 | 0.018 ± 0.003 | < 0.007 | 10-16-24 | 267 | 0.021 ± 0.004 | < 0.014 |
| 04-23-24 | 267 | 0.019 ± 0.004 | < 0.017 | 10-23-24 | 290 | 0.036 ± 0.004 | < 0.012 |
| 05-01-24 | 355 | 0.018 ± 0.003 | < 0.007 | 10-30-24 | 309 | 0.026 ± 0.004 | < 0.010 |
| 05-08-24 | 303 | 0.013 ± 0.003 | < 0.010 | 11-06-24 | 312 | 0.010 ± 0.003 | < 0.011 |
| 05-15-24 | 289 | 0.008 ± 0.003 | < 0.018 | 11-13-24 | 303 | 0.025 ± 0.004 | < 0.011 |
| 05-23-24 | 278 | 0.017 ± 0.004 | < 0.010 | 11-20-24 | 301 | 0.028 ± 0.004 | < 0.008 |
| 05-30-24 | 261 | 0.017 ± 0.003 | < 0.016 | 11-27-24 | 303 | 0.017 ± 0.004 | < 0.022 |
| 06-05-24 | 258 | 0.021 ± 0.004 | < 0.008 | 12-04-24 | 312 | 0.021 ± 0.004 | < 0.008 |
| 06-12-24 | 305 | 0.009 ± 0.003 | < 0.007 | 12-12-24 | 348 | 0.033 ± 0.004 | < 0.010 |
| 06-19-24 | 305 | 0.024 ± 0.004 | < 0.008 | 12-18-24 | 246 | 0.039 ± 0.005 | < 0.019 |
| 06-27-24 | 344 | 0.011 ± 0.003 | < 0.005 | 12-26-24 | 351 | 0.027 ± 0.003 | < 0.007 |
| 07-03-24 | 257 | 0.013 ± 0.003 | < 0.021 | 01-02-25 | 305 | 0.035 ± 0.004 | < 0.010 |
| 2nd Quarter Mean ± s.d. | | 0.015 ± 0.005 | < 0.011 | 4th Quarter Mean ± s.d. | | 0.026 ± 0.008 | < 0.011 |
| | | | | Cumulative Average | | 0.023 ± 0.009 | < 0.010 |
| | | | | **Indicator Locations Annual Mean ± s.d.** | | **0.023 ± 0.009** | **< 0.010** |

Table 1. Airborne particulates and charcoal canisters, analyses for gross beta and iodine-131.
Location: E-20, Silver Lake
Units: pCi/$m^3$
Collection: Continuous, weekly exchange.

| Date Collected | Vol. ($m^3$) | Gross Beta | I-131 |
|---|---|---|---|
| Required LLD | | 0.010 | 0.030 |
| 01-10-24 | 305 | 0.022 ± 0.004 | < 0.013 |
| 01-17-24 | 321 | 0.023 ± 0.003 | < 0.008 |
| 01-24-24 | 299 | 0.021 ± 0.004 | < 0.010 |
| 01-31-24 | 306 | 0.024 ± 0.004 | < 0.005 |
| 02-07-24 | 303 | 0.022 ± 0.004 | < 0.006 |
| 02-14-24 | 306 | 0.029 ± 0.004 | < 0.007 |
| 02-21-24 | 304 | 0.035 ± 0.004 | < 0.010 |
| 02-28-24 | 305 | 0.036 ± 0.004 | < 0.007 |
| 03-06-24 | 293 | 0.026 ± 0.004 | < 0.013 |
| 03-13-24 | 300 | 0.033 ± 0.004 | < 0.010 |
| 03-20-24 | 315 | 0.023 ± 0.003 | < 0.019 |
| 03-27-24 | 300 | 0.016 ± 0.003 | < 0.008 |
| 04-02-24 | 260 | 0.018 ± 0.004 | < 0.019 |
| 1st Quarter Mean ± s.d. | | 0.025 ± 0.006 | < 0.010 |
| 04-09-24 | 295 | 0.009 ± 0.003 | < 0.007 |
| 04-17-24 | 341 | 0.020 ± 0.003 | < 0.007 |
| 04-23-24 | 265 | 0.021 ± 0.004 | < 0.017 |
| 05-01-24 | 352 | 0.015 ± 0.003 | < 0.007 |
| 05-08-24 | 307 | 0.011 ± 0.003 | < 0.009 |
| 05-15-24 | 309 | 0.010 ± 0.003 | < 0.017 |
| 05-23-24 | 339 | 0.013 ± 0.003 | < 0.008 |
| 05-30-24 | 305 | 0.016 ± 0.003 | < 0.013 |
| 06-05-24 | 254 | 0.025 ± 0.004 | < 0.008 |
| 06-12-24 | 311 | 0.011 ± 0.003 | < 0.007 |
| 06-19-24 | 305 | 0.021 ± 0.003 | < 0.008 |
| 06-27-24 | | NS[a] | |
| 07-03-24 | 293 | 0.017 ± 0.003 | < 0.018 |
| 2nd Quarter Mean ± s.d. | | 0.016 ± 0.005 | < 0.010 |

| Date Collected | Vol. ($m^3$) | Gross Beta | I-131 |
|---|---|---|---|
| Required LLD | | 0.010 | 0.030 |
| 07-10-24 | 305 | 0.024 ± 0.004 | < 0.007 |
| 07-17-24 | 302 | 0.020 ± 0.004 | < 0.006 |
| 07-24-24 | 305 | 0.016 ± 0.003 | < 0.008 |
| 07-31-24 | 294 | 0.023 ± 0.003 | < 0.008 |
| 08-07-24 | 308 | 0.024 ± 0.004 | < 0.007 |
| 08-15-24 | 336 | 0.018 ± 0.003 | < 0.007 |
| 08-21-24 | 264 | 0.023 ± 0.004 | < 0.015 |
| 08-28-24 | 295 | 0.035 ± 0.004 | < 0.006 |
| 09-04-24 | 300 | 0.018 ± 0.003 | < 0.010 |
| 09-12-24 | 348 | 0.027 ± 0.003 | < 0.008 |
| 09-18-24 | 262 | 0.055 ± 0.005 | < 0.011 |
| 09-24-24 | 260 | 0.030 ± 0.004 | < 0.017 |
| 10-02-24 | 352 | 0.031 ± 0.004 | < 0.008 |
| 3rd Quarter Mean ± s.d. | | 0.027 ± 0.010 | < 0.009 |
| 10-10-24 | 344 | 0.023 ± 0.003 | < 0.007 |
| 10-16-24 | 268 | 0.018 ± 0.004 | < 0.014 |
| 10-23-24 | 295 | 0.033 ± 0.004 | < 0.012 |
| 10-30-24 | 307 | 0.028 ± 0.004 | < 0.010 |
| 11-06-24 | 313 | 0.012 ± 0.003 | < 0.011 |
| 11-13-24 | 310 | 0.028 ± 0.004 | < 0.011 |
| 11-20-24 | 301 | 0.028 ± 0.004 | < 0.008 |
| 11-27-24 | 313 | 0.016 ± 0.003 | < 0.021 |
| 12-04-24 | 311 | 0.019 ± 0.004 | < 0.008 |
| 12-12-24 | 361 | 0.029 ± 0.004 | < 0.010 |
| 12-18-24 | 247 | 0.044 ± 0.005 | < 0.018 |
| 12-26-24 | 349 | 0.027 ± 0.003 | < 0.007 |
| 01-02-25 | 306 | 0.035 ± 0.004 | < 0.010 |
| 4th Quarter Mean ± s.d. | | 0.026 ± 0.009 | < 0.011 |
| Cumulative Average | | 0.024 ± 0.009 | < 0.010 |
| **Control Annual Mean ± s.d.** | | 0.024 ± 0.009 | < 0.010 |

[a] "NS" = No sample; see Table 2.0, Listing of Missed Samples.

POINT BEACH NUCLEAR PLANT

Table 2. Gamma emitters in quarterly composites of air particulate filters

Units: pCi/m$^3$

| Location | Lab Code | Be-7 | Be-7 | Cs-134 | Cs-134 | Cs-137 | Cs-137 | (Other) Co-60 | (Other) (Co-60) | Volume |
|---|---|---|---|---|---|---|---|---|---|---|
| | Req. LLD | - | MDC | 0.01 | MDC | 0.01 | MDC | ( 0.10 ) | MDC | m$^3$ |
| | | | | | 1st Quarter | | | | | |
| E-01 | EAP- 870 | 0.068 ± 0.016 | - | -0.0005 ± 0.0006 | < 0.0009 | 0.0007 ± 0.0005 | < 0.0009 | -0.0007 ± 0.0008 | < 0.0010 | 3883 |
| E-02 | - 871 | 0.067 ± 0.012 | - | 0.0003 ± 0.0004 | < 0.0006 | 0.0007 ± 0.0005 | < 0.0009 | 0.0001 ± 0.0004 | < 0.0009 | 3883 |
| E-03 | - 872 | 0.063 ± 0.016 | - | -0.0002 ± 0.0005 | < 0.0009 | -0.0002 ± 0.0005 | < 0.0004 | 0.0005 ± 0.0005 | < 0.0008 | 3936 |
| E-04 | - 873 | 0.068 ± 0.013 | - | -0.0002 ± 0.0004 | < 0.0006 | 0.0001 ± 0.0005 | < 0.0010 | 0.0003 ± 0.0006 | < 0.0009 | 3951 |
| E-08 | - 874 | 0.058 ± 0.016 | - | -0.0005 ± 0.0005 | < 0.0008 | -0.0007 ± 0.0005 | < 0.0005 | -0.0007 ± 0.0006 | < 0.0009 | 3909 |
| E-20 | - 875 | 0.062 ± 0.004 | - | -0.0001 ± 0.0001 | < 0.0002 | 0.0004 ± 0.0002 | < 0.0003 | 0.0003 ± 0.0002 | < 0.0003 | 3917 |
| | | | | | 2nd Quarter | | | | | |
| E-01 | EAP- 1762 | 0.062 ± 0.010 | - | 0.0000 ± 0.0003 | < 0.0006 | 0.0006 ± 0.0004 | < 0.0007 | 0.0003 ± 0.0003 | < 0.0007 | 3994 |
| E-02 | - 1763 | 0.074 ± 0.011 | - | 0.0000 ± 0.0003 | < 0.0006 | 0.0002 ± 0.0004 | < 0.0008 | 0.0007 ± 0.0005 | < 0.0009 | 4028 |
| E-03 | - 1764 | 0.077 ± 0.013 | - | 0.0002 ± 0.0003 | < 0.0006 | 0.0003 ± 0.0004 | < 0.0007 | 0.0000 ± 0.0004 | < 0.0007 | 4041 |
| E-04 | - 1766 | 0.066 ± 0.013 | - | 0.0001 ± 0.0004 | < 0.0007 | 0.0003 ± 0.0004 | < 0.0006 | 0.0001 ± 0.0006 | < 0.0010 | 3997 |
| E-08 | - 1767 | 0.065 ± 0.014 | - | 0.0001 ± 0.0004 | < 0.0007 | -0.0001 ± 0.0004 | < 0.0007 | 0.0004 ± 0.0005 | < 0.0009 | 3866 |
| E-20 | - 1768 | 0.063 ± 0.010 | - | -0.0001 ± 0.0003 | < 0.0006 | 0.0006 ± 0.0004 | < 0.0008 | 0.0005 ± 0.0004 | < 0.0008 | 3675 |
| | | | | | 3rd Quarter | | | | | |
| E-01 | EAP- 2760 | 0.076 ± 0.016 | - | -0.0006 ± 0.0005 | < 0.0009 | 0.0000 ± 0.0004 | < 0.0005 | -0.0002 ± 0.0006 | < 0.0005 | 3935 |
| E-02 | - 2761 | 0.108 ± 0.018 | - | -0.0026 ± 0.0007 | < 0.0011 | -0.0004 ± 0.0006 | < 0.0009 | -0.0001 ± 0.0006 | < 0.0007 | 3926 |
| E-03 | - 2762 | 0.087 ± 0.016 | - | 0.0003 ± 0.0005 | < 0.0009 | 0.0002 ± 0.0004 | < 0.0007 | 0.0002 ± 0.0005 | < 0.0006 | 3959 |
| E-04 | - 2763 | 0.081 ± 0.014 | - | -0.0002 ± 0.0005 | < 0.0010 | 0.0002 ± 0.0005 | < 0.0010 | 0.0005 ± 0.0006 | < 0.0011 | 3920 |
| E-08 | - 2764 | 0.070 ± 0.015 | - | -0.0006 ± 0.0005 | < 0.0009 | 0.0005 ± 0.0006 | < 0.0011 | -0.0005 ± 0.0007 | < 0.0005 | 3931 |
| E-20 | - 2765 | 0.096 ± 0.022 | - | -0.0016 ± 0.0007 | < 0.0010 | -0.0006 ± 0.0007 | < 0.0006 | -0.0001 ± 0.0007 | < 0.0010 | 3931 |
| | | | | | 4th Quarter | | | | | |
| E-01 | EAP- 3348 | 0.048 ± 0.012 | - | -0.0001 ± 0.0004 | < 0.0008 | 0.0003 ± 0.0005 | < 0.0009 | 0.0003 ± 0.0006 | < 0.0009 | 4028 |
| E-02 | - 3349 | 0.051 ± 0.012 | - | -0.0008 ± 0.0005 | < 0.0008 | 0.0001 ± 0.0005 | < 0.0009 | 0.0001 ± 0.0007 | < 0.0005 | 3992 |
| E-03 | - 3350 | 0.042 ± 0.013 | - | -0.0004 ± 0.0004 | < 0.0007 | 0.0003 ± 0.0004 | < 0.0008 | 0.0003 ± 0.0005 | < 0.0009 | 4031 |
| E-04 | - 3351 | 0.039 ± 0.011 | - | 0.0000 ± 0.0005 | < 0.0009 | 0.0001 ± 0.0006 | < 0.0012 | 0.0002 ± 0.0005 | < 0.0005 | 3956 |
| E-08 | - 3352 | 0.046 ± 0.016 | - | -0.0002 ± 0.0005 | < 0.0008 | 0.0002 ± 0.0005 | < 0.0005 | 0.0004 ± 0.0004 | < 0.0004 | 3988 |
| E-20 | - 3353 | 0.045 ± 0.012 | - | -0.0009 ± 0.0004 | < 0.0007 | 0.0000 ± 0.0005 | < 0.0008 | 0.0001 ± 0.0005 | < 0.0005 | 4025 |
| **Annual Mean±s.d.** | | **0.066 ± 0.017** | | **-0.0004 ± 0.0006** | **< 0.0008** | **0.0002 ± 0.0004** | **< 0.0008** | **0.0001 ± 0.0004** | **< 0.0007** | |

POINT BEACH NUCLEAR PLANT

Table 3. Radioactivity in milk samples

Collection: Monthly

Sample Description and Concentration (pCi/L)

E-11 Lambert Dairy Farm

| Collection Date | 01-10-24 | MDC | 02-14-24 | MDC | 03-13-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 49 | | EMI- 249 | | EMI- 466 | | |
| Sr-89 | 0.0 ± 0.8 | < 0.8 | 0.4 ± 0.7 | < 0.6 | 0.0 ± 0.6 | < 0.7 | 5.0 |
| Sr-90 | 0.5 ± 0.3 | < 0.6 | 0.6 ± 0.3 | < 0.6 | 0.3 ± 0.3 | < 0.6 | 1.0 |
| I-131 | 0.05 ± 0.20 | < 0.41 | 0.06 ± 0.19 | < 0.37 | -0.09 ± 0.18 | < 0.37 | 0.5 |
| K-40 | 1274 ± 110 | - | 1224 ± 85 | - | 1203 ± 104 | - | |
| Cs-134 | -2.5 ± 2.3 | < 4.2 | -0.9 ± 1.3 | < 2.7 | -1.2 ± 2.2 | < 4.4 | 5.0 |
| Cs-137 | -0.4 ± 2.7 | < 3.4 | -1.1 ± 1.6 | < 2.3 | -1.6 ± 2.4 | < 2.3 | 5.0 |
| Ba-La-140 | -1.4 ± 2.9 | < 3.1 | -1.1 ± 1.6 | < 2.1 | 0.2 ± 2.4 | < 2.9 | 5.0 |
| Other (Co-60) | -0.8 ± 2.4 | < 4.1 | -0.3 ± 1.7 | < 2.2 | -3.9 ± 2.9 | < 3.2 | 15.0 |

| Collection Date | 04-10-24 | MDC | 05-08-24 | MDC | 06-12-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 694 | | EMI- 1087 | | EMI- 1320 | | |
| Sr-89 | 0.3 ± 0.9 | < 1.2 | 0.1 ± 0.7 | < 0.7 | 0.4 ± 0.6 | < 0.7 | 5.0 |
| Sr-90 | -0.2 ± 0.3 | < 0.7 | 0.5 ± 0.3 | < 0.6 | 0.4 ± 0.7 | < 0.5 | 1.0 |
| I-131 | 0.05 ± 0.14 | < 0.25 | 0.18 ± 0.20 | < 0.38 | -0.18 ± 0.16 | < 0.31 | 0.5 |
| K-40 | 1301 ± 67 | - | 1229 ± 88 | - | 1241 ± 63 | - | |
| Cs-134 | -1.1 ± 1.3 | < 2.6 | 0.0 ± 1.5 | < 3.1 | -0.8 ± 1.3 | < 2.6 | 5.0 |
| Cs-137 | -0.2 ± 1.6 | < 2.1 | 2.4 ± 2.0 | < 4.0 | 0.7 ± 1.5 | < 2.2 | 5.0 |
| Ba-La-140 | -1.1 ± 1.5 | < 2.1 | 4.0 ± 6.2 | < 0.8 | 0.4 ± 1.5 | < 2.3 | 5.0 |
| Other (Co-60) | 0.5 ± 1.7 | < 2.3 | 2.0 ± 1.8 | < 3.5 | -0.2 ± 1.5 | < 2.4 | 15.0 |

Table 3. Radioactivity in milk samples

Collection: Monthly

Sample Description and Concentration (pCi/L)

E-11 Lambert Dairy Farm

| Collection Date | 07-10-24 | MDC | 08-14-24 | MDC | 09-11-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 1583 | | EMI- 1946 | | EMI- 2128 | | |
| Sr-89 | 0.1 ± 0.5 | < 0.5 | 0.1 ± 0.6 | < 0.7 | 0.0 ± 0.6 | < 0.7 | 5.0 |
| Sr-90 | 0.6 ± 0.3 | < 0.5 | 0.4 ± 0.3 | < 0.5 | 0.4 ± 0.3 | < 0.6 | 1.0 |
| I-131 | 0.22 ± 0.24 | < 0.45 | 0.09 ± 0.13 | < 0.23 | 0.05 ± 0.14 | < 0.24 | 0.5 |
| K-40 | 1347 ± 102 | - | 1291 ± 116 | - | 1249 ± 121 | - | |
| Cs-134 | 0.8 ± 1.5 | < 2.6 | -1.9 ± 2.5 | < 4.8 | -1.9 ± 2.0 | < 3.9 | 5.0 |
| Cs-137 | 0.4 ± 1.7 | < 2.1 | -1.1 ± 2.7 | < 3.6 | 0.7 ± 2.6 | < 4.8 | 5.0 |
| Ba-La-140 | 1.0 ± 1.4 | < 2.4 | 0.4 ± 2.4 | < 3.0 | 0.5 ± 2.3 | < 4.7 | 5.0 |
| Other (Co-60) | 0.9 ± 2.0 | < 3.1 | -1.1 ± 3.1 | < 5.2 | -0.5 ± 2.8 | < 5.4 | 15.0 |

| Collection Date | 10-09-24 | MDC | 11-13-24 | MDC | 12-11-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 2420 | | EMI- 2906 | | EMI- 3072 | | |
| Sr-89 | 0.3 ± 0.7 | < 0.8 | -0.3 ± 0.7 | < 0.7 | -0.1 ± 0.6 | < 0.6 | 5.0 |
| Sr-90 | 0.5 ± 0.3 | < 0.6 | 0.8 ± 0.3 | < 0.5 | 0.7 ± 0.3 | < 0.5 | 1.0 |
| I-131 | 0.10 ± 0.14 | < 0.25 | -0.08 ± 0.14 | < 0.26 | -0.01 ± 0.20 | < 0.41 | 0.5 |
| K-40 | 1294 ± 94 | - | 1289 ± 105 | - | 1218 ± 90 | - | |
| Cs-134 | -0.8 ± 1.7 | < 3.3 | 0.8 ± 2.0 | < 3.8 | -0.8 ± 1.4 | < 2.9 | 5.0 |
| Cs-137 | 1.4 ± 2.0 | < 3.4 | 2.0 ± 2.4 | < 4.4 | 1.5 ± 1.7 | < 2.8 | 5.0 |
| Ba-La-140 | 1.4 ± 1.6 | < 2.6 | 0.2 ± 1.7 | < 1.0 | -0.3 ± 1.5 | < 2.7 | 5.0 |
| Other (Co-60) | 1.4 ± 2.0 | < 3.3 | -0.3 ± 2.3 | < 3.1 | -2.1 ± 2.1 | < 2.1 | 15.0 |

POINT BEACH NUCLEAR PLANT

Table 3. Radioactivity in milk samples

Collection: Monthly

Sample Description and Concentration (pCi/L)

E-21 Strutz Dairy Farm

| Collection Date | 01-10-24 | MDC | 02-14-24 | MDC | 03-13-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 50 | | EMI- 250 | | EMI- 467 | | |
| Sr-89 | 0.2 ± 0.8 | < 0.9 | 0.3 ± 0.6 | < 0.7 | 0.0 ± 0.6 | < 0.6 | 5.0 |
| Sr-90 | 0.4 ± 0.3 | < 0.6 | 0.2 ± 0.3 | < 0.6 | 0.4 ± 0.3 | < 0.4 | 1.0 |
| I-131 | -0.02 ± 0.19 | < 0.38 | -0.10 ± 0.16 | < 0.34 | 0.06 ± 0.13 | < 0.23 | 0.5 |
| K-40 | 1337 ± 65 | - | 1325 ± 41 | - | 1216 ± 67 | - | |
| Cs-134 | 0.3 ± 1.1 | < 2.0 | 0.3 ± 0.7 | < 1.2 | 1.1 ± 1.2 | < 2.1 | 5.0 |
| Cs-137 | 0.6 ± 1.3 | < 1.9 | 0.2 ± 0.8 | < 1.2 | 0.0 ± 1.3 | < 2.8 | 5.0 |
| Ba-La-140 | 1.1 ± 1.2 | < 3.2 | -0.1 ± 0.7 | < 0.9 | -0.2 ± 1.2 | < 1.7 | 5.0 |
| Other (Co-60) | -0.3 ± 1.3 | < 2.0 | 0.6 ± 0.7 | < 1.2 | -1.8 ± 1.5 | < 1.8 | 15.0 |

| Collection Date | 04-10-24 | MDC | 05-08-24 | MDC | 06-12-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 695 | | EMI- 1088 | | EMI- 1321 | | |
| Sr-89 | -0.3 ± 0.7 | < 0.9 | 0.4 ± 0.6 | < 0.8 | -0.2 ± 0.7 | < 0.8 | 5.0 |
| Sr-90 | 0.2 ± 0.3 | < 0.6 | 0.1 ± 0.3 | < 0.6 | 0.6 ± 0.3 | < 0.6 | 1.0 |
| I-131 | 0.11 ± 0.13 | < 0.23 | 0.14 ± 0.21 | < 0.41 | -0.10 ± 0.15 | < 0.28 | 0.5 |
| K-40 | 1260 ± 49 | - | 1272 ± 73 | - | 1296 ± 38 | - | |
| Cs-134 | 0.3 ± 0.7 | < 1.2 | -0.7 ± 1.1 | < 2.3 | 0.0 ± 0.6 | < 1.2 | 5.0 |
| Cs-137 | 0.5 ± 0.8 | < 1.4 | 0.5 ± 1.3 | < 2.9 | 0.7 ± 0.7 | < 1.3 | 5.0 |
| Ba-La-140 | 0.1 ± 0.6 | < 0.8 | -0.9 ± 1.3 | < 2.7 | -0.1 ± 0.6 | < 1.1 | 5.0 |
| Other (Co-60) | 0.2 ± 0.8 | < 1.3 | 0.6 ± 1.3 | < 2.1 | 0.1 ± 1.6 | < 1.3 | 15.0 |

Table 3. Radioactivity in milk samples

Collection: Monthly

Sample Description and Concentration (pCi/L)

E-21 Strutz Dairy Farm

| Collection Date | 07-10-24 | MDC | 08-14-24 | MDC | 09-11-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 1584 | | EMI- 1947 | | EMI- 2129 | | |
| Sr-89 | 0.0 ± 0.5 | < 0.5 | -0.4 ± 0.6 | < 0.8 | 0.0 ± 0.5 | < 0.5 | 5.0 |
| Sr-90 | 0.5 ± 0.3 | < 0.5 | 0.3 ± 0.3 | < 0.5 | 0.4 ± 0.3 | < 0.5 | 1.0 |
| I-131 | 0.20 ± 0.21 | < 0.39 | 0.04 ± 0.13 | < 0.24 | 0.03 ± 0.14 | < 0.24 | 0.5 |
| K-40 | 1280 ± 80 | - | 1333 ± 87 | - | 1152 ± 72 | - | |
| Cs-134 | 0.8 ± 1.4 | < 2.8 | -0.2 ± 1.5 | < 2.6 | -1.2 ± 1.3 | < 2.4 | 5.0 |
| Cs-137 | 1.8 ± 1.7 | < 3.6 | 0.4 ± 1.8 | < 3.5 | -0.3 ± 1.4 | < 2.3 | 5.0 |
| Ba-La-140 | -1.1 ± 1.2 | < 0.9 | 0.1 ± 1.3 | < 1.6 | -0.2 ± 1.2 | < 2.1 | 5.0 |
| Other (Co-60) | 2.8 ± 1.9 | < 4.0 | -0.8 ± 1.9 | < 3.0 | -0.3 ± 1.6 | < 2.5 | 15.0 |

| Collection Date | 10-09-24 | MDC | 11-13-24 | MDC | 12-11-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 2421 | | EMI- 2907 | | EMI- 3073 | | |
| Sr-89 | 0.0 ± 0.7 | < 0.8 | 0.4 ± 0.6 | < 0.8 | -0.1 ± 0.6 | < 0.6 | 5.0 |
| Sr-90 | 0.4 ± 0.3 | < 0.6 | 0.3 ± 0.3 | < 0.6 | 0.5 ± 0.3 | < 0.6 | 1.0 |
| I-131 | -0.04 ± 0.12 | < 0.23 | -0.09 ± 0.14 | < 0.26 | -0.05 ± 0.16 | < 0.29 | 0.5 |
| K-40 | 1238 ± 55 | - | 1250 ± 115 | - | 1267 ± 95 | - | |
| Cs-134 | -0.7 ± 1.1 | < 2.2 | -0.3 ± 2.6 | < 4.5 | 0.4 ± 1.6 | < 3.0 | 5.0 |
| Cs-137 | -1.4 ± 1.3 | < 2.7 | -4.8 ± 2.8 | < 2.8 | 1.0 ± 1.6 | < 3.0 | 5.0 |
| Ba-La-140 | -0.9 ± 1.2 | < 2.0 | -0.2 ± 2.0 | < 3.0 | -0.9 ± 1.6 | < 2.4 | 5.0 |
| Other (Co-60) | 0.1 ± 1.4 | < 2.0 | 0.1 ± 2.9 | < 4.8 | 0.8 ± 2.0 | < 2.7 | 15.0 |

Table 3. Radioactivity in milk samples

Collection: Monthly

Sample Description and Concentration (pCi/L)

E-40 Barta

| | | MDC | | MDC | | MDC | Required |
|---|---|---|---|---|---|---|---|
| Collection Date | 01-10-24 | | 02-14-24 | | 03-13-24 | | LLD |
| Lab Code | EMI- 51 | | EMI- 251 | | EMI- 468 | | |
| Sr-89 | 0.1 ± 0.7 | < 0.7 | 0.0 ± 0.6 | < 0.6 | -0.4 ± 0.6 | < 0.6 | 5.0 |
| Sr-90 | 0.5 ± 0.3 | < 0.5 | 0.4 ± 0.3 | < 0.5 | 0.4 ± 0.3 | < 0.5 | 1.0 |
| I-131 | -0.04 ± 0.17 | < 0.36 | 0.10 ± 0.18 | < 0.31 | -0.07 ± 0.21 | < 0.48 | 0.5 |
| K-40 | 1355 ± 72 | - | 1410 ± 48 | - | 1406 ± 78 | - | |
| Cs-134 | -0.2 ± 1.2 | < 2.1 | -0.2 ± 0.6 | < 1.2 | -0.5 ± 1.2 | < 2.1 | 5.0 |
| Cs-137 | 0.9 ± 1.3 | < 2.8 | 0.2 ± 0.8 | < 1.4 | 0.9 ± 1.4 | < 2.8 | 5.0 |
| Ba-La-140 | -0.1 ± 1.2 | < 2.3 | -0.3 ± 0.7 | < 1.4 | -0.5 ± 1.2 | < 1.8 | 5.0 |
| Other (Co-60) | 0.7 ± 1.5 | < 3.0 | 0.3 ± 0.9 | < 1.7 | 1.1 ± 1.6 | < 3.2 | 15.0 |

| | | MDC | | MDC | | MDC | Required |
|---|---|---|---|---|---|---|---|
| Collection Date | 04-10-24 | | 05-08-24 | | 06-12-24 | | LLD |
| Lab Code | EMI- 696 | | EMI- 1089 | | EMI- 1322 | | |
| Sr-89 | 0.2 ± 1.1 | < 1.3 | -0.3 ± 0.6 | < 0.7 | -0.3 ± 0.6 | < 0.6 | 5.0 |
| Sr-90 | 0.1 ± 0.4 | < 0.9 | 0.3 ± 0.3 | < 0.5 | 0.5 ± 0.3 | < 0.5 | 1.0 |
| I-131 | 0.13 ± 0.15 | < 0.26 | -0.01 ± 0.17 | < 0.30 | 0.11 ± 0.16 | < 0.29 | 0.5 |
| K-40 | 1403 ± 44 | - | 1354 ± 82 | - | 1452 ± 44 | - | |
| Cs-134 | 0.1 ± 0.6 | < 1.2 | -1.3 ± 1.4 | < 2.6 | 0.0 ± 0.6 | < 1.1 | 5.0 |
| Cs-137 | 0.8 ± 0.8 | < 1.5 | -0.5 ± 1.3 | < 2.4 | 0.5 ± 0.7 | < 1.3 | 5.0 |
| Ba-La-140 | -0.4 ± 0.6 | < 1.1 | 0.4 ± 1.3 | < 2.9 | -0.6 ± 0.7 | < 1.3 | 5.0 |
| Other (Co-60) | 0.4 ± 0.9 | < 1.4 | -2.2 ± 1.9 | < 2.1 | 0.4 ± 0.8 | < 1.3 | 15.0 |

Table 3. Radioactivity in milk samples

Collection: Monthly

Sample Description and Concentration (pCi/L)

E-40 Barta

| Collection Date | 07-10-24 | MDC | 08-14-24 | MDC | 09-11-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 1585 | | EMI- 1948 | | EMI- 2130 | | |
| Sr-89 | -0.2 ± 0.5 | < 0.5 | 0.0 ± 0.7 | < 0.7 | -0.1 ± 0.5 | < 0.6 | 5.0 |
| Sr-90 | 0.6 ± 0.3 | < 0.5 | 0.4 ± 0.3 | < 0.5 | 0.3 ± 0.3 | < 0.4 | 1.0 |
| I-131 | 0.07 ± 0.20 | < 0.39 | -0.01 ± 0.11 | < 0.15 | -0.04 ± 0.15 | < 0.28 | 0.5 |
| K-40 | 1367 ± 126 | - | 1428 ± 97 | - | 1493 ± 89 | - | |
| Cs-134 | 2.5 ± 2.4 | < 4.8 | -1.0 ± 1.5 | < 2.5 | -0.7 ± 1.3 | < 2.2 | 5.0 |
| Cs-137 | -0.9 ± 3.0 | < 3.6 | 0.5 ± 1.6 | < 2.7 | 1.4 ± 1.4 | < 2.8 | 5.0 |
| Ba-La-140 | -1.0 ± 3.1 | < 4.3 | 0.4 ± 1.6 | < 2.3 | 0.7 ± 1.4 | < 2.9 | 5.0 |
| Other (Co-60) | -0.9 ± 3.2 | < 4.5 | 1.7 ± 1.7 | < 2.6 | -1.0 ± 1.6 | < 1.9 | 15.0 |

| Collection Date | 10-09-24 | MDC | 11-13-24 | MDC | 12-11-24 | MDC | Required LLD |
|---|---|---|---|---|---|---|---|
| Lab Code | EMI- 2422 | | EMI- 2908 | | EMI- 3074 | | |
| Sr-89 | -0.1 ± 0.7 | < 0.7 | -0.3 ± 0.6 | < 0.7 | -0.1 ± 0.6 | < 0.6 | 5.0 |
| Sr-90 | 0.5 ± 0.3 | < 0.5 | 0.4 ± 0.3 | < 0.5 | 0.7 ± 0.3 | < 0.5 | 1.0 |
| I-131 | 0.09 ± 0.14 | < 0.25 | -0.08 ± 0.16 | < 0.29 | 0.07 ± 0.15 | < 0.26 | 0.5 |
| K-40 | 1316 ± 121 | - | 1311 ± 102 | - | 1457 ± 105 | - | |
| Cs-134 | -1.0 ± 2.2 | < 3.8 | -0.2 ± 1.8 | < 3.1 | -0.9 ± 1.5 | < 2.7 | 5.0 |
| Cs-137 | 1.6 ± 2.3 | < 4.0 | -0.3 ± 2.0 | < 3.1 | 0.1 ± 1.8 | < 3.1 | 5.0 |
| Ba-La-140 | -1.3 ± 2.2 | < 2.5 | -3.9 ± 2.2 | < 2.2 | -2.0 ± 1.9 | < 3.3 | 5.0 |
| Other (Co-60) | -1.8 ± 2.7 | < 2.5 | -0.4 ± 2.2 | < 3.1 | 0.7 ± 2.0 | < 2.9 | 15.0 |

| | |
|---|---|
| **Sr-89 Annual Mean + s.d.** | **0.0 ± 0.2** |
| **Sr-90 Annual Mean + s.d.** | **0.4 ± 0.2** |
| **I-131 Annual Mean + s.d.** | **0.03 ± 0.09** |
| **K-40 Annual Mean + s.d.** | **1309 ± 80** |
| **Cs-134 Annual Mean + s.d.** | **-0.4 ± 0.9** |
| **Cs-137 Annual Mean + s.d.** | **0.3 ± 1.3** |
| **Ba-La Annual Mean + s.d.** | **-0.2 ± 1.2** |
| **Co-60 Annual Mean + s.d.** | **-0.1 ± 1.3** |

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Table 4. Radioactivity in Well Water Samples, E-10
Collection: Quarterly
Units: pCi/L

| | 1st Qtr. | 2nd Qtr. | 3rd Qtr. | 4th Qtr. | Req. LLD |
|---|---|---|---|---|---|
| Collection Date | 01-17-24 | 04-10-24 | 07-18-24 | 10-09-24 | |
| Lab Code | EWW- 69 | EWW- 701 | EWW- 1686 | EWW- 2415 | |
| Gross Beta | 0.1 ± 1.1 | 0.5 ± 0.9 | 1.1 ± 1.0 | 0.8 ± 1.1 | 4.0 |
| H-3 | 29 ± 81 | 29 ± 83 | -59 ± 81 | -20 ± 89 | 500 |
| Sr-89 | -0.1 ± 0.4 | 0.4 ± 0.5 | 0.0 ± 0.4 | 0.3 ± 0.4 | 5.0 |
| Sr-90 | 0.0 ± 0.2 | 0.0 ± 0.3 | -0.2 ± 0.2 | -0.1 ± 0.2 | 1.0 |
| I-131 | -0.03 ± 0.15 | -0.04 ± 0.13 | 0.11 ± 0.13 | -0.04 ± 0.18 | 0.5 |
| Mn-54 | 1.2 ± 2.5 | 0.3 ± 1.2 | -0.6 ± 0.7 | 0.1 ± 1.5 | 10 |
| Fe-59 | -0.9 ± 4.6 | -1.2 ± 2.2 | 0.6 ± 1.3 | -0.2 ± 2.4 | 30 |
| Co-58 | -0.2 ± 2.0 | 0.1 ± 1.2 | -0.7 ± 0.6 | -0.2 ± 1.3 | 10 |
| Co-60 | -2.5 ± 2.8 | -0.7 ± 1.4 | 0.5 ± 0.8 | -0.4 ± 1.5 | 10 |
| Zn-65 | -10.5 ± 5.8 | 0.1 ± 2.2 | -1.1 ± 1.6 | -0.8 ± 2.7 | 30 |
| Zr-Nb-95 | -13.1 ± 3.3 | -2.1 ± 1.3 | -1.4 ± 0.8 | -6.4 ± 1.7 | 15 |
| Cs-134 | -1.7 ± 2.3 | -0.1 ± 1.2 | -0.1 ± 0.7 | -1.0 ± 1.3 | 10 |
| Cs-137 | -0.2 ± 2.8 | 0.2 ± 1.3 | 2.6 ± 0.8 | 0.2 ± 1.5 | 10 |
| Ba-La-140 | 0.3 ± 3.3 | 0.6 ± 1.5 | -1.5 ± 0.8 | -0.1 ± 1.7 | 15 |
| Other (Ru-103) | -0.6 ± 1.7 | 0.0 ± 1.1 | -0.9 ± 0.7 | 0.2 ± 1.2 | 30 |

MDC Data

| | | | | | |
|---|---|---|---|---|---|
| Collection Date | 01-17-24 | 04-10-24 | 07-18-24 | 10-09-24 | |
| Lab Code | EWW- 69 | EWW- 701 | EWW- 1686 | EWW- 2415 | |
| Gross Beta | < 2.1 | < 1.7 | < 1.9 | < 2.1 | 4.0 |
| H-3 | < 168 | < 175 | < 177 | < 181 | 500 |
| Sr-89 | < 0.5 | < 0.6 | < 0.6 | < 0.5 | 5.0 |
| Sr-90 | < 0.5 | < 0.6 | < 0.5 | < 0.4 | 1.0 |
| I-131 | < 0.27 | < 0.23 | < 0.23 | < 0.36 | 0.5 |
| Mn-54 | < 4.1 | < 1.6 | < 1.1 | < 1.8 | 10 |
| Fe-59 | < 4.5 | < 3.0 | < 2.4 | < 4.1 | 30 |
| Co-58 | < 3.5 | < 2.2 | < 1.0 | < 1.9 | 10 |
| Co-60 | < 2.7 | < 2.0 | < 1.9 | < 1.6 | 10 |
| Zn-65 | < 9.1 | < 3.8 | < 2.9 | < 5.5 | 30 |
| Zr-Nb-95 | < 6.6 | < 2.1 | < 1.5 | < 2.6 | 15 |
| Cs-134 | < 3.6 | < 2.3 | < 1.4 | < 2.3 | 10 |
| Cs-137 | < 3.8 | < 1.6 | < 1.8 | < 2.9 | 10 |
| Ba-La-140 | < 5.6 | < 2.6 | < 1.4 | < 2.3 | 15 |
| Other (Ru-103) | < 3.7 | < 1.9 | < 0.8 | < 1.7 | 30 |

Table 5. Lake water, analyses for gross beta, iodine-131 and gamma emitting isotopes.
Location: E-01 (Meteorological Tower)
Collection: Monthly composites
Units: pCi/L

| | | MDC | | MDC | | MDC | | MDC | |
|---|---|---|---|---|---|---|---|---|---|
| Lab Code | ELW- 38 | | ELW- 246 | | ELW- 433 | | ELW- 698 | | |
| Date Collected | 01-08-24 | | 02-13-24 | | 03-12-24 | | | | Req. LLD |
| Gross beta | 0.8 ± 0.5 | < 0.9 | 1.6 ± 0.6 | < 0.9 | 1.2 ± 0.6 | < 0.9 | 1.2 ± 0.6 | < 0.9 | 4.0 |
| I-131 | 0.10 ± 0.14 | < 0.25 | 0.07 ± 0.19 | < 0.38 | 0.00 ± 0.12 | < 0.21 | 0.06 ± 0.14 | < 0.25 | 0.5 |
| Be-7 | 0.1 ± 6.0 | < 12.7 | 13.3 ± 22.1 | < 30.6 | 7.6 ± 10.4 | < 20.4 | -18.8 ± 18.8 | < 25.0 | |
| Mn-54 | -0.2 ± 0.6 | < 0.9 | 1.9 ± 2.9 | < 4.8 | -0.2 ± 1.2 | < 2.6 | -0.5 ± 2.5 | < 4.6 | 10 |
| Fe-59 | -1.0 ± 1.3 | < 2.4 | 0.2 ± 4.9 | < 4.2 | 0.1 ± 2.3 | < 3.6 | -3.0 ± 5.1 | < 7.8 | 30 |
| Co-58 | -0.1 ± 0.7 | < 1.3 | -0.3 ± 2.6 | < 3.1 | 0.1 ± 1.1 | < 1.9 | -1.8 ± 2.3 | < 1.7 | 10 |
| Co-60 | 0.2 ± 0.7 | < 2.4 | -1.6 ± 3.3 | < 2.7 | 1.7 ± 1.4 | < 2.7 | -2.8 ± 2.7 | < 3.5 | 10 |
| Zn-65 | -1.1 ± 1.5 | < 2.5 | -6.9 ± 7.4 | < 5.9 | 2.3 ± 2.5 | < 4.7 | -3.0 ± 5.6 | < 5.6 | 30 |
| Zr-Nb-95 | -1.3 ± 0.7 | < 1.5 | 0.3 ± 3.0 | < 3.0 | 0.0 ± 1.2 | < 2.1 | -0.4 ± 2.8 | < 5.0 | 15 |
| Cs-134 | 0.3 ± 0.6 | < 1.3 | -4.1 ± 3.3 | < 6.3 | 0.6 ± 1.2 | < 2.2 | -0.8 ± 2.4 | < 4.7 | 10 |
| Cs-137 | -2.0 ± 0.6 | < 2.0 | -2.7 ± 3.0 | < 3.5 | -2.0 ± 0.6 | < 3.1 | 0.4 ± 2.5 | < 2.0 | 10 |
| Ba-La-140 | 0.2 ± 0.7 | < 1.4 | -1.1 ± 2.9 | < 2.5 | -1.3 ± 1.2 | < 1.8 | 3.2 ± 3.1 | < 3.0 | 15 |
| Other (Ru-103) | -0.2 ± 0.7 | < 1.5 | -4.1 ± 2.7 | < 3.0 | -0.8 ± 1.2 | < 2.0 | -2.6 ± 2.2 | < 2.8 | 30 |
| Lab Code | ELW- 1065 | | ELW- 1345 | | ELW- 1586 | | ELW- 1943 | | |
| Date Collected | 05-07-24 | | 06-11-24 | | 07-09-24 | | 08-14-24 | | Req. LLD |
| Gross beta | 1.1 ± 0.6 | < 0.9 | 1.0 ± 0.5 | < 0.9 | 0.9 ± 0.5 | < 0.9 | 2.5 ± 0.8 | < 1.2 | 4.0 |
| I-131 | 0.10 ± 0.16 | < 0.27 | 0.14 ± 0.19 | < 0.32 | 0.04 ± 0.17 | < 0.34 | -0.08 ± 0.11 | < 0.17 | 0.5 |
| Be-7 | 9.5 ± 20.0 | < 27.8 | -11.0 ± 22.6 | < 33.3 | 3.8 ± 14.1 | < 24.3 | 3.1 ± 7.9 | < 15.6 | |
| Mn-54 | -1.9 ± 2.9 | < 4.6 | -2.0 ± 3.3 | < 5.6 | -1.3 ± 1.2 | < 1.4 | 0.5 ± 1.1 | < 1.5 | 10 |
| Fe-59 | 0.5 ± 5.3 | < 3.6 | -1.5 ± 6.5 | < 11.2 | -3.8 ± 3.0 | < 3.0 | -2.2 ± 2.2 | < 1.7 | 30 |
| Co-58 | -0.3 ± 2.4 | < 3.8 | 2.0 ± 2.8 | < 4.2 | -0.8 ± 1.6 | < 2.7 | 0.8 ± 1.1 | < 1.9 | 10 |
| Co-60 | 1.0 ± 2.8 | < 4.5 | -1.7 ± 2.9 | < 3.0 | 0.4 ± 1.8 | < 3.0 | 0.5 ± 1.5 | < 1.8 | 10 |
| Zn-65 | 6.1 ± 5.8 | < 5.2 | -3.5 ± 7.0 | < 7.3 | 1.9 ± 3.4 | < 5.2 | 1.7 ± 2.7 | < 4.9 | 30 |
| Zr-Nb-95 | -0.3 ± 4.1 | < 4.9 | -0.5 ± 3.2 | < 3.7 | 1.2 ± 1.5 | < 2.9 | -0.9 ± 1.3 | < 1.7 | 15 |
| Cs-134 | -1.7 ± 2.3 | < 4.6 | -2.2 ± 2.7 | < 5.4 | -0.4 ± 1.6 | < 3.3 | 0.2 ± 1.2 | < 2.2 | 10 |
| Cs-137 | -0.2 ± 3.0 | < 5.4 | 1.8 ± 3.1 | < 4.4 | 3.7 ± 1.9 | < 3.5 | -0.4 ± 1.3 | < 2.3 | 10 |
| Ba-La-140 | -4.6 ± 2.8 | < 1.4 | -0.1 ± 3.4 | < 2.2 | -1.1 ± 1.6 | < 1.8 | 0.3 ± 1.5 | < 2.3 | 15 |
| Other (Ru-103) | 1.7 ± 2.5 | < 4.0 | 0.9 ± 2.6 | < 4.3 | 0.0 ± 1.6 | < 1.5 | 0.2 ± 0.9 | < 1.7 | 30 |
| Lab Code | ELW- 2144 | | ELW- 2412 | | ELW- 2911 | | ELW- 3075 | | |
| Date Collected | 09-11-24 | | 10-09-24 | | 11-13-24 | | 12-11-24 | | Req. LLD |
| Gross beta | 2.3 ± 0.5 | < 0.6 | 1.9 ± 0.7 | < 1.1 | 1.8 ± 0.6 | < 1.0 | 1.4 ± 0.6 | < 1.0 | 4.0 |
| I-131 | 0.12 ± 0.15 | < 0.26 | 0.12 ± 0.19 | < 0.36 | -0.10 ± 0.14 | < 0.26 | 0.03 ± 0.13 | < 0.24 | 0.5 |
| Be-7 | -9.1 ± 12.4 | < 19.3 | 1.0 ± 10.0 | < 19.7 | 8.9 ± 13.1 | < 23.1 | -3.3 ± 14.8 | < 28.0 | |
| Mn-54 | 0.5 ± 1.3 | < 2.2 | 0.2 ± 1.3 | < 1.7 | 0.6 ± 1.6 | < 1.8 | 2.6 ± 1.7 | < 2.8 | 10 |
| Fe-59 | -1.1 ± 2.9 | < 4.5 | -0.8 ± 2.6 | < 3.4 | -2.1 ± 3.1 | < 3.3 | 0.3 ± 3.6 | < 6.9 | 30 |
| Co-58 | -0.5 ± 1.3 | < 1.5 | 0.3 ± 1.3 | < 2.0 | -0.2 ± 1.7 | < 3.6 | 0.5 ± 1.6 | < 2.6 | 10 |
| Co-60 | -0.2 ± 1.5 | < 2.5 | 0.3 ± 1.7 | < 2.6 | -0.6 ± 1.8 | < 3.0 | 1.6 ± 2.4 | < 3.9 | 10 |
| Zn-65 | -2.3 ± 3.2 | < 2.4 | -0.8 ± 2.8 | < 5.3 | -2.2 ± 3.6 | < 4.3 | -0.8 ± 3.8 | < 4.7 | 30 |
| Zr-Nb-95 | -1.1 ± 1.4 | < 2.0 | -0.8 ± 1.6 | < 2.9 | -1.5 ± 1.6 | < 1.7 | -1.6 ± 2.0 | < 2.6 | 15 |
| Cs-134 | 0.1 ± 1.4 | < 2.7 | -0.6 ± 1.4 | < 2.5 | 0.6 ± 1.5 | < 2.7 | 1.0 ± 1.5 | < 3.0 | 10 |
| Cs-137 | 1.0 ± 1.7 | < 3.2 | 0.2 ± 1.6 | < 3.1 | 2.6 ± 2.1 | < 4.1 | -0.4 ± 2.4 | < 4.4 | 10 |
| Ba-La-140 | 0.6 ± 1.5 | < 2.2 | -3.7 ± 4.0 | < 1.9 | -0.2 ± 1.6 | < 1.8 | -3.1 ± 1.6 | < 1.4 | 15 |
| Other (Ru-103) | -0.2 ± 1.4 | < 2.2 | -1.5 ± 1.2 | < 1.6 | 0.1 ± 1.7 | < 2.6 | 0.0 ± 1.9 | < 3.9 | 30 |

Table 5. Lake water, analyses for gross beta, iodine-131 and gamma emitting isotopes.
Location: E-05 (Two Creeks Park)
Collection: Monthly composites Units: pCi/L

| | | MDC | | MDC | | MDC | | MDC | |
|---|---|---|---|---|---|---|---|---|---|
| Lab Code | ELW- 39 | | ELW- 247 | | ELW- 434 | | ELW- 699 | | |
| Date Collected | 01-08-24 | | 02-13-24 | | 03-12-24 | | 04-10-24 | | Req. LLD |
| Gross beta | 0.4 ± 0.5 | < 0.9 | 2.4 ± 0.6 | < 0.9 | 1.1 ± 0.5 | < 0.9 | 1.5 ± 0.6 | < 0.9 | 4.0 |
| I-131 | -0.02 ± 0.13 | < 0.24 | -0.06 ± 0.20 | < 0.38 | 0.04 ± 0.12 | < 0.21 | 0.08 ± 0.17 | < 0.30 | 0.5 |
| Be-7 | -3.3 ± 4.6 | < 7.9 | -6.3 ± 9.7 | < 16.7 | 0.3 ± 4.9 | < 9.5 | -2.5 ± 8.7 | < 15.4 | |
| Mn-54 | -0.3 ± 0.6 | < 0.8 | 0.5 ± 1.2 | < 2.4 | 0.1 ± 0.6 | < 1.1 | 0.0 ± 1.2 | < 2.0 | 10 |
| Fe-59 | -0.3 ± 1.1 | < 2.8 | -0.4 ± 2.3 | < 3.3 | 0.4 ± 1.2 | < 2.5 | -1.4 ± 2.3 | < 4.1 | 30 |
| Co-58 | 0.0 ± 0.6 | < 1.1 | 0.4 ± 1.3 | < 2.4 | -0.5 ± 0.6 | < 0.9 | -0.2 ± 1.2 | < 1.5 | 10 |
| Co-60 | -0.1 ± 0.6 | < 1.0 | -1.1 ± 1.3 | < 1.6 | -0.1 ± 0.7 | < 1.2 | 0.4 ± 1.3 | < 1.4 | 10 |
| Zn-65 | -0.9 ± 1.2 | < 1.8 | -0.1 ± 1.9 | < 3.8 | 0.0 ± 1.2 | < 2.6 | -3.0 ± 2.5 | < 3.7 | 30 |
| Zr-Nb-95 | -1.2 ± 0.7 | < 1.2 | -0.6 ± 1.3 | < 1.9 | -0.8 ± 0.7 | < 1.3 | -1.5 ± 1.1 | < 1.5 | 15 |
| Cs-134 | -0.4 ± 0.6 | < 1.1 | -1.2 ± 1.3 | < 2.3 | 0.2 ± 0.6 | < 1.2 | 0.5 ± 1.1 | < 2.1 | 10 |
| Cs-137 | 0.0 ± 0.7 | < 1.2 | 1.9 ± 1.4 | < 2.4 | -0.2 ± 0.7 | < 1.1 | 0.8 ± 1.3 | < 2.3 | 10 |
| Ba-La-140 | -0.5 ± 0.7 | < 1.4 | -0.2 ± 1.4 | < 1.8 | 0.0 ± 0.7 | < 1.2 | 0.9 ± 1.1 | < 1.4 | 15 |
| Other (Ru-103) | 0.1 ± 0.5 | < 1.1 | -0.1 ± 1.2 | < 2.2 | 0.2 ± 0.5 | < 1.1 | 0.0 ± 1.0 | < 1.9 | 30 |
| Lab Code | ELW- 1066 | | ELW- 1346 | | ELW- 1587 | | ELW- 1944 | | |
| Date Collected | 05-07-24 | | 06-11-24 | | 07-09-24 | | 08-14-24 | | Req. LLD |
| Gross beta | 0.8 ± 0.5 | < 0.9 | 0.8 ± 0.5 | < 0.8 | 1.3 ± 0.6 | < 0.9 | 2.0 ± 0.7 | < 1.1 | 4.0 |
| I-131 | 0.08 ± 0.20 | < 0.35 | -0.05 ± 0.23 | < 0.47 | 0.00 ± 0.13 | < 0.24 | 0.03 ± 0.15 | < 0.26 | 0.5 |
| Be-7 | -5.9 ± 19.2 | < 21.4 | -4.4 ± 5.8 | < 8.4 | 16.3 ± 21.9 | < 39.9 | -2.5 ± 4.7 | < 7.0 | |
| Mn-54 | 0.6 ± 2.4 | < 5.0 | 0.0 ± 0.8 | < 1.5 | -1.0 ± 2.9 | < 3.7 | -0.2 ± 0.6 | < 0.8 | 10 |
| Fe-59 | 2.0 ± 4.6 | < 7.2 | 0.3 ± 1.5 | < 2.5 | 2.8 ± 6.2 | < 8.8 | 0.4 ± 1.1 | < 2.6 | 30 |
| Co-58 | -0.2 ± 2.1 | < 3.2 | 0.1 ± 0.8 | < 1.6 | 1.1 ± 3.2 | < 4.7 | -0.3 ± 0.6 | < 0.8 | 10 |
| Co-60 | 0.1 ± 2.3 | < 2.9 | -0.3 ± 0.8 | < 1.3 | 0.3 ± 2.9 | < 3.0 | 0.0 ± 0.7 | < 1.1 | 10 |
| Zn-65 | -2.5 ± 4.9 | < 5.1 | -0.6 ± 1.6 | < 2.7 | -6.7 ± 7.3 | < 4.0 | 0.3 ± 1.2 | < 1.8 | 30 |
| Zr-Nb-95 | -0.4 ± 2.4 | < 3.7 | -0.7 ± 0.9 | < 1.6 | 0.1 ± 3.3 | < 4.7 | -1.3 ± 0.7 | < 1.1 | 15 |
| Cs-134 | -0.5 ± 2.4 | < 4.6 | 0.5 ± 0.8 | < 1.5 | -1.0 ± 2.6 | < 5.4 | 0.2 ± 0.6 | < 1.2 | 10 |
| Cs-137 | -0.8 ± 2.6 | < 4.7 | 0.6 ± 0.9 | < 1.9 | 2.6 ± 3.5 | < 3.5 | 0.4 ± 0.7 | < 1.3 | 10 |
| Ba-La-140 | -1.8 ± 3.1 | < 3.4 | -0.3 ± 1.0 | < 1.6 | 2.8 ± 10.6 | < 1.9 | 0.1 ± 0.6 | < 1.2 | 15 |
| Other (Ru-103) | -0.2 ± 2.1 | < 3.1 | -0.6 ± 0.7 | < 1.1 | 1.8 ± 2.9 | < 5.0 | 0.0 ± 0.6 | < 1.2 | 30 |
| Lab Code | ELW- 2145 | | ELW- 2413 | | ELW- 2912 | | ELW- 3076 | | |
| Date Collected | 09-11-24 | | 10-09-24 | | 11-13-24 | | 12-11-24 | | Req. LLD |
| Gross beta | 1.9 ± 0.5 | < 0.7 | 1.3 ± 0.6 | < 1.0 | 1.4 ± 0.6 | < 0.9 | 2.0 ± 0.6 | < 0.9 | 4.0 |
| I-131 | -0.26 ± 0.19 | < 0.43 | 0.10 ± 0.14 | < 0.24 | 0.10 ± 0.18 | < 0.31 | -0.15 ± 0.13 | < 0.25 | 0.5 |
| Be-7 | 5.7 ± 9.4 | < 17.7 | 1.0 ± 17.1 | < 26.7 | -17.7 ± 11.2 | < 15.6 | 6.8 ± 25.6 | < 56.6 | |
| Mn-54 | -0.5 ± 1.2 | < 2.1 | 0.1 ± 1.9 | < 3.0 | 0.7 ± 1.4 | < 2.8 | -0.9 ± 3.3 | < 4.1 | 10 |
| Fe-59 | 0.5 ± 2.3 | < 4.2 | 2.3 ± 3.1 | < 3.4 | -0.1 ± 2.6 | < 3.8 | -3.7 ± 7.3 | < 5.9 | 30 |
| Co-58 | 1.3 ± 1.2 | < 2.2 | 0.2 ± 1.9 | < 2.4 | -1.7 ± 1.5 | < 1.9 | -0.1 ± 3.7 | < 5.7 | 10 |
| Co-60 | 1.2 ± 1.3 | < 2.2 | 2.3 ± 2.2 | < 4.0 | 0.6 ± 1.4 | < 2.0 | -0.4 ± 3.3 | < 4.9 | 10 |
| Zn-65 | 0.2 ± 2.3 | < 3.4 | -3.5 ± 4.8 | < 6.2 | -0.1 ± 3.0 | < 5.6 | -3.7 ± 8.6 | < 9.3 | 30 |
| Zr-Nb-95 | -0.6 ± 1.3 | < 1.6 | -2.2 ± 2.2 | < 2.1 | -1.0 ± 1.6 | < 2.7 | -0.7 ± 3.8 | < 7.2 | 15 |
| Cs-134 | -0.7 ± 1.2 | < 2.3 | 0.6 ± 1.7 | < 3.8 | -1.4 ± 1.4 | < 2.3 | -5.3 ± 3.4 | < 6.0 | 10 |
| Cs-137 | 0.2 ± 1.5 | < 2.5 | 2.7 ± 2.0 | < 4.0 | 1.2 ± 1.6 | < 3.0 | 4.7 ± 3.4 | < 5.3 | 10 |
| Ba-La-140 | -0.5 ± 1.4 | < 2.5 | -0.9 ± 2.7 | < 3.2 | 1.2 ± 1.5 | < 3.8 | -5.6 ± 4.1 | < 5.4 | 15 |
| Other (Ru-103) | 0.4 ± 1.1 | < 2.0 | -1.7 ± 2.2 | < 2.2 | -1.3 ± 1.2 | < 2.1 | 0.8 ± 3.2 | < 5.8 | 30 |

Table 5. Lake water, analyses for gross beta, iodine-131 and gamma emitting isotopes.
Location: E-06 (Coast Guard Station)
Collection: Monthly composites Units: pCi/L

| | | MDC | | MDC | | MDC | | MDC | |
|---|---|---|---|---|---|---|---|---|---|
| Lab Code | ELW- 40 | | ELW- 248 | | ELW- 435 | | ELW- 700 | | |
| Date Collected | 01-08-24 | | 02-13-24 | | 03-12-24 | | 04-10-24 | | Req. LLD |
| Gross beta | 1.1 ± 0.6 | < 1.0 | 1.6 ± 0.6 | < 0.9 | 1.4 ± 0.6 | < 0.9 | 2.0 ± 0.6 | < 0.9 | 4.0 |
| I-131 | -0.03 ± 0.12 | < 0.22 | 0.14 ± 0.23 | < 0.44 | 0.11 ± 0.23 | < 0.48 | -0.06 ± 0.14 | < 0.26 | 0.5 |
| Be-7 | -3.5 ± 4.0 | < 5.7 | 5.0 ± 8.5 | < 17.5 | -0.8 ± 4.1 | < 9.7 | 10.2 ± 7.8 | < 17.5 | |
| Mn-54 | 0.5 ± 0.6 | < 1.2 | -1.0 ± 1.3 | < 1.2 | -0.1 ± 0.6 | < 1.0 | 0.1 ± 1.2 | < 1.6 | 10 |
| Fe-59 | -0.6 ± 1.1 | < 2.5 | 0.5 ± 2.6 | < 4.3 | 0.4 ± 1.2 | < 2.4 | -0.4 ± 2.2 | < 3.4 | 30 |
| Co-58 | 0.6 ± 0.6 | < 0.9 | 0.1 ± 1.3 | < 2.0 | -0.2 ± 0.6 | < 0.8 | -0.1 ± 1.1 | < 1.8 | 10 |
| Co-60 | 0.5 ± 0.7 | < 1.5 | -0.1 ± 1.5 | < 1.3 | 0.7 ± 0.7 | < 1.1 | -0.3 ± 1.5 | < 1.4 | 10 |
| Zn-65 | 1.2 ± 1.3 | < 2.3 | -1.8 ± 3.0 | < 3.3 | -0.4 ± 1.3 | < 2.5 | 0.9 ± 2.6 | < 3.1 | 30 |
| Zr-Nb-95 | -0.5 ± 0.6 | < 1.5 | -1.5 ± 1.7 | < 3.6 | -0.7 ± 0.6 | < 0.9 | -1.5 ± 1.2 | < 1.2 | 15 |
| Cs-134 | -0.6 ± 0.5 | < 1.0 | 0.0 ± 1.2 | < 2.2 | -0.2 ± 0.6 | < 1.1 | 0.8 ± 1.1 | < 1.9 | 10 |
| Cs-137 | 0.7 ± 0.6 | < 1.1 | 0.5 ± 1.5 | < 2.6 | 0.4 ± 0.7 | < 1.6 | 0.0 ± 1.4 | < 2.4 | 10 |
| Ba-La-140 | -1.2 ± 0.7 | < 1.6 | -1.1 ± 1.7 | < 2.6 | -0.3 ± 0.7 | < 1.0 | -1.4 ± 1.4 | < 1.7 | 15 |
| Other (Ru-103) | 0.6 ± 0.5 | < 1.2 | 0.6 ± 1.0 | < 1.5 | -0.3 ± 0.5 | < 0.7 | -0.4 ± 0.9 | < 1.9 | 30 |

| | | MDC | | MDC | | MDC | | MDC | |
|---|---|---|---|---|---|---|---|---|---|
| Lab Code | ELW- 1067 | | ELW- 1347 | | ELW- 1588 | | ELW- 1945 | | |
| Date Collected | 05-07-24 | | 06-11-24 | | 07-09-24 | | 08-14-24 | | Req. LLD |
| Gross beta | 1.2 ± 0.6 | < 0.9 | 1.0 ± 0.5 | < 0.9 | 1.7 ± 0.6 | < 0.9 | 2.2 ± 0.7 | < 1.2 | 4.0 |
| I-131 | 0.16 ± 0.18 | < 0.31 | 0.15 ± 0.24 | < 0.46 | 0.06 ± 0.14 | < 0.24 | 0.03 ± 0.13 | < 0.24 | 0.5 |
| Be-7 | -8.0 ± 8.9 | < 13.9 | 17.7 ± 13.9 | < 29.3 | -1.1 ± 10.4 | < 19.0 | 2.2 ± 4.1 | < 8.9 | |
| Mn-54 | -0.5 ± 1.1 | < 1.7 | 0.2 ± 1.8 | < 3.1 | -0.1 ± 1.4 | < 2.3 | -0.1 ± 0.6 | < 0.9 | 10 |
| Fe-59 | 3.3 ± 1.9 | < 3.6 | 6.0 ± 3.0 | < 5.9 | -1.2 ± 2.4 | < 2.9 | -0.6 ± 1.2 | < 1.2 | 30 |
| Co-58 | 0.9 ± 1.1 | < 2.2 | -1.6 ± 1.8 | < 3.1 | -0.3 ± 1.5 | < 1.8 | 0.2 ± 0.5 | < 1.0 | 10 |
| Co-60 | -0.2 ± 1.2 | < 1.3 | 1.5 ± 1.7 | < 2.5 | -1.0 ± 1.4 | < 1.4 | -0.4 ± 0.7 | < 1.0 | 10 |
| Zn-65 | 2.6 ± 2.3 | < 4.4 | 0.1 ± 3.6 | < 4.4 | 2.2 ± 2.6 | < 4.2 | 0.6 ± 1.2 | < 2.2 | 30 |
| Zr-Nb-95 | -0.8 ± 1.1 | < 1.4 | 0.1 ± 2.8 | < 2.8 | -0.5 ± 1.4 | < 2.4 | 0.0 ± 0.6 | < 1.1 | 15 |
| Cs-134 | 0.1 ± 1.1 | < 2.1 | -1.4 ± 1.6 | < 3.5 | -0.3 ± 1.4 | < 2.6 | 0.0 ± 0.5 | < 1.0 | 10 |
| Cs-137 | 0.3 ± 1.3 | < 2.4 | 0.8 ± 1.9 | < 4.1 | 0.0 ± 1.7 | < 3.1 | -0.1 ± 0.7 | < 1.1 | 10 |
| Ba-La-140 | -0.3 ± 1.3 | < 1.4 | -1.4 ± 2.1 | < 2.7 | -1.0 ± 1.6 | < 2.2 | 0.2 ± 0.7 | < 1.6 | 15 |
| Other (Ru-103) | -0.2 ± 1.0 | < 1.4 | -0.1 ± 1.6 | < 2.7 | -0.1 ± 1.2 | < 0.7 | -0.2 ± 0.5 | < 1.9 | 30 |

| | | MDC | | MDC | | MDC | | MDC | |
|---|---|---|---|---|---|---|---|---|---|
| Lab Code | ELW- 2146 | | ELW- 2414 | | ELW- 2913 | | ELW- 3077 | | |
| Date Collected | 09-11-24 | | 10-09-24 | | 11-13-24 | | 12-11-24 | | Req. LLD |
| Gross beta | 2.0 ± 0.5 | < 0.7 | 1.4 ± 0.6 | < 1.1 | 0.8 ± 0.5 | < 0.9 | 2.6 ± 0.7 | < 0.9 | 4.0 |
| I-131 | 0.13 ± 0.15 | < 0.27 | 0.04 ± 0.15 | < 0.26 | 0.13 ± 0.14 | < 0.23 | 0.01 ± 0.16 | < 0.32 | 0.5 |
| Be-7 | -1.2 ± 9.1 | < 15.4 | -8.3 ± 12.4 | < 16.9 | 5.1 ± 9.2 | < 19.3 | 3.2 ± 11.7 | < 22.8 | |
| Mn-54 | 0.3 ± 1.2 | < 1.9 | 1.3 ± 1.9 | < 3.2 | 1.2 ± 1.3 | < 2.0 | 0.7 ± 1.5 | < 2.7 | 10 |
| Fe-59 | -1.1 ± 2.0 | < 2.3 | 0.8 ± 2.7 | < 4.4 | -1.3 ± 2.3 | < 1.8 | -2.4 ± 2.7 | < 3.6 | 30 |
| Co-58 | 0.2 ± 1.2 | < 1.7 | 0.7 ± 1.6 | < 2.3 | 1.3 ± 1.5 | < 3.0 | 1.0 ± 1.5 | < 2.5 | 10 |
| Co-60 | -0.5 ± 1.5 | < 1.4 | 2.0 ± 1.7 | < 2.5 | 0.9 ± 1.6 | < 2.1 | 1.5 ± 1.5 | < 2.5 | 10 |
| Zn-65 | -1.4 ± 2.3 | < 3.1 | -1.4 ± 3.4 | < 4.4 | 1.4 ± 3.3 | < 5.7 | 1.1 ± 3.1 | < 4.5 | 30 |
| Zr-Nb-95 | -1.3 ± 1.2 | < 1.2 | -2.4 ± 1.9 | < 2.6 | -2.6 ± 1.5 | < 1.7 | -1.5 ± 1.7 | < 3.1 | 15 |
| Cs-134 | -0.6 ± 1.2 | < 2.0 | -1.1 ± 1.9 | < 3.0 | -1.1 ± 1.3 | < 2.1 | -0.6 ± 1.7 | < 2.9 | 10 |
| Cs-137 | 1.3 ± 1.5 | < 2.4 | -0.1 ± 1.8 | < 3.8 | 1.1 ± 1.6 | < 2.7 | -0.6 ± 1.8 | < 3.0 | 10 |
| Ba-La-140 | 0.2 ± 1.7 | < 3.0 | -0.2 ± 1.5 | < 2.0 | -1.3 ± 2.1 | < 2.4 | 0.1 ± 1.9 | < 3.8 | 15 |
| Other (Ru-103) | -0.6 ± 1.0 | < 1.7 | -0.3 ± 1.4 | < 2.1 | 0.2 ± 1.1 | < 2.5 | 1.0 ± 1.4 | < 2.9 | 30 |

**Annual**

**Annual**

| All locations | Mean ± s.d. | | Mean ± s.d. | | Mean ± s.d. |
|---|---|---|---|---|---|
| Gross Beta | 1.5 ± 0.5 | | | | |
| I-131 | 0.04 ± 0.07 | Co-58 | 0.1 ± 0.7 | Cs-134 | -0.4 ± 1.1 |
| Be-7 | 0.3 ± 7.2 | Co-60 | 0.1 ± 0.9 | Cs-137 | 0.4 ± 1.3 |
| Mn-54 | 0.0 ± 0.8 | Zn-65 | -0.5 ± 2.2 | Ba-La-140 | -0.5 ± 1.5 |
| Fe-59 | -0.2 ± 1.7 | Zr-Nb-95 | -0.7 ± 0.8 | Ru-103 | -0.1 ± 0.9 |

POINT BEACH NUCLEAR PLANT

Table 6. Lake water, analyses for tritium, strontium-89 and strontium-90.
Collection: Quarterly composites of weekly grab samples
Units: pCi/L

| Location | E-01 (Meteorological Tower) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Period | 1st Qtr. | **MDC** | 2nd Qtr. | **MDC** | 3rd Qtr. | **MDC** | 4th Qtr. | **MDC** |
| Lab Code | ELW- 446 | | ELW- 1411 | | ELW- 2220 | | ELW- 3080 | |
| H-3 | 43 ± 89 | < 174 | 8 ± 86 | < 183 | 25 ± 86 | < 180 | 67 ± 88 | < 182 |
| Sr-89 | -0.17 ± 0.38 | < 0.48 | -0.05 ± 0.48 | < 0.63 | -0.03 ± 0.49 | < 0.59 | 0.38 ± 0.85 | < 1.15 |
| Sr-90 | 0.20 ± 0.25 | < 0.49 | 0.00 ± 0.26 | < 0.56 | 0.04 ± 0.25 | < 0.53 | -0.17 ± 0.33 | < 0.76 |

| Location | E-05 (Two Creeks Park) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Period | 1st Qtr. | | 2nd Qtr. | | 3rd Qtr. | | 4th Qtr. | |
| Lab Code | ELW- 447 | | ELW- 1413 | | ELW- 2221 | | ELW- 3081 | |
| H-3 | 60 ± 89 | < 174 | 25 ± 87 | < 183 | -46 ± 82 | < 180 | 28 ± 86 | < 182 |
| Sr-89 | 0.10 ± 0.43 | < 0.56 | 0.03 ± 0.46 | < 0.54 | -0.26 ± 0.58 | < 0.66 | -0.55 ± 0.87 | < 1.13 |
| Sr-90 | 0.07 ± 0.27 | < 0.56 | 0.10 ± 0.25 | < 0.51 | 0.29 ± 0.29 | < 0.56 | 0.24 ± 0.36 | < 0.73 |

| Location | E-06 (Coast Guard Station) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Period | 1st Qtr. | | 2nd Qtr. | | 3rd Qtr. | | 4th Qtr. | |
| Lab Code | ELW- 448 | | ELW- 1414 | | ELW- 2222 | | ELW- 3082 | |
| H-3 | 112 ± 92 | < 174 | 8 ± 86 | < 183 | 64 ± 88 | < 180 | 53 ± 88 | < 182 |
| Sr-89 | 0.00 ± 0.36 | < 0.47 | 0.11 ± 0.47 | < 0.57 | -0.66 ± 0.60 | < 0.73 | 0.30 ± 0.78 | < 0.97 |
| Sr-90 | 0.04 ± 0.24 | < 0.50 | 0.06 ± 0.25 | < 0.52 | 0.25 ± 0.32 | < 0.62 | 0.07 ± 0.31 | < 0.66 |

| | |
|---|---|
| **Tritium Annual Mean ± s.d.** | **37 ± 39** |
| **Sr-89 Annual Mean ± s.d.** | **-0.07 ± 0.31** |
| **Sr-90 Annual Mean ± s.d.** | **0.10 ± 0.13** |

Table 7. Fish, analyses for gamma emitting isotopes.
Location: E-13
Collection: Quarterly Units: pCi/g wet

| | Sample Description and Concentration | MDC | | MDC | | MDC | Req. LLD |
|---|---|---|---|---|---|---|---|
| Collection Date | 01-16-24 | | 01-23-24 | | 02-26-24 | | |
| Lab Code | EF- 411 | | EF- 412 | | EF- 413 | | |
| Type | Chinook Salmon | | Lake Trout | | Burbot | | |
| K-40 | 3.05 ± 0.47 | - | 2.68 ± 0.26 | - | 1.75 ± 0.23 | - | |
| Mn-54 | -0.005 ± 0.011 | < 0.020 | 0.001 ± 0.006 | < 0.013 | 0.003 ± 0.006 | < 0.011 | 0.13 |
| Fe-59 | 0.012 ± 0.021 | < 0.081 | -0.005 ± 0.011 | < 0.038 | -0.005 ± 0.010 | < 0.024 | 0.26 |
| Co-58 | 0.007 ± 0.010 | < 0.019 | 0.011 ± 0.006 | < 0.017 | 0.010 ± 0.006 | < 0.015 | 0.13 |
| Co-60 | -0.003 ± 0.012 | < 0.020 | 0.002 ± 0.007 | < 0.009 | 0.001 ± 0.007 | < 0.009 | 0.13 |
| Zn-65 | -0.043 ± 0.029 | < 0.021 | 0.007 ± 0.013 | < 0.023 | 0.003 ± 0.013 | < 0.026 | 0.26 |
| Cs-134 | -0.008 ± 0.011 | < 0.021 | 0.002 ± 0.006 | < 0.010 | 0.000 ± 0.006 | < 0.011 | 0.13 |
| Cs-137 | 0.003 ± 0.012 | < 0.025 | 0.011 ± 0.007 | < 0.013 | 0.021 ± 0.008 | < 0.013 | 0.15 |
| Other (Ru-103) | 0.030 ± 0.009 | < 0.043 | -0.005 ± 0.005 | < 0.019 | 0.003 ± 0.005 | < 0.010 | 0.5 |
| Collection Date | 03-10-24 | | 04-01-24 | | 05-19-24 | | |
| Lab Code | EF- 1302 | | EF- 1301 | | EF- 1303 | | |
| Type | Coho Salmon | | Burbot | | Burbot | | |
| K-40 | 2.78 ± 0.10 | - | 2.55 ± 0.10 | - | 2.53 ± 0.12 | - | |
| Mn-54 | 0.003 ± 0.002 | < 0.006 | 0.000 ± 0.002 | < 0.004 | 0.002 ± 0.003 | < 0.006 | 0.13 |
| Fe-59 | -0.008 ± 0.004 | < 0.042 | -0.001 ± 0.004 | < 0.040 | -0.019 ± 0.006 | < 0.065 | 0.26 |
| Co-58 | -0.002 ± 0.002 | < 0.008 | -0.002 ± 0.002 | < 0.007 | 0.002 ± 0.002 | < 0.013 | 0.13 |
| Co-60 | 0.004 ± 0.002 | < 0.005 | -0.001 ± 0.002 | < 0.003 | 0.004 ± 0.003 | < 0.008 | 0.13 |
| Zn-65 | -0.001 ± 0.005 | < 0.013 | 0.000 ± 0.005 | < 0.013 | -0.005 ± 0.006 | < 0.012 | 0.26 |
| Cs-134 | -0.001 ± 0.002 | < 0.004 | -0.001 ± 0.002 | < 0.004 | 0.000 ± 0.003 | < 0.006 | 0.13 |
| Cs-137 | 0.012 ± 0.004 | < 0.005 | 0.008 ± 0.004 | < 0.005 | 0.017 ± 0.005 | < 0.009 | 0.15 |
| Other (Ru-103) | 0.006 ± 0.002 | < 0.029 | 0.008 ± 0.002 | < 0.022 | -0.009 ± 0.003 | < 0.027 | 0.5 |

Table 7. Fish, analyses for gamma emitting isotopes.
Location: E-13
Collection: Quarterly Units: pCi/g wet

| | Sample Description and Concentration (pCi/g wet) | MDC | | MDC | | MDC | Req. LLD |
|---|---|---|---|---|---|---|---|
| Collection Date | 07-19-24 | | 08-09-24 | | 08-13-23 | | |
| Lab Code | EF- 2125 | | EF- 2126 | | EF- 2127 | | |
| Type | Lake trout | | Burbot | | Rainbow Trout | | |
| K-40 | 2.60 ± 0.12 | - | 2.41 ± 0.12 | - | 3.10 ± 1.30 | | |
| Mn-54 | 0.003 ± 0.002 | < 0.006 | 0.002 ± 0.003 | < 0.005 | 0.003 ± 0.003 | < 0.006 | 0.13 |
| Fe-59 | -0.009 ± 0.005 | < 0.020 | -0.007 ± 0.005 | < 0.022 | -0.005 ± 0.005 | < 0.021 | 0.26 |
| Co-58 | -0.003 ± 0.002 | < 0.005 | 0.000 ± 0.003 | < 0.006 | -0.003 ± 0.002 | < 0.005 | 0.13 |
| Co-60 | 0.008 ± 0.003 | < 0.007 | 0.000 ± 0.003 | < 0.005 | 0.001 ± 0.003 | < 0.005 | 0.13 |
| Zn-65 | 0.000 ± 0.006 | < 0.011 | -0.002 ± 0.006 | < 0.011 | 0.002 ± 0.006 | < 0.014 | 0.26 |
| Cs-134 | -0.002 ± 0.002 | < 0.005 | 0.000 ± 0.003 | < 0.006 | 0.001 ± 0.003 | < 0.005 | 0.13 |
| Cs-137 | 0.016 ± 0.004 | < 0.006 | 0.018 ± 0.005 | < 0.006 | 0.010 ± 0.004 | < 0.006 | 0.15 |
| Other (Ru-103) | 0.006 ± 0.003 | < 0.020 | 0.003 ± 0.002 | < 0.012 | -0.001 ± 0.002 | < 0.010 | 0.5 |
| Collection Date | 11-01-24 | | 11-03-24 | | 11-15-24 | | |
| Lab Code | EF- 3048 | | EF- 3049 | | EF- 3050 | | |
| Type | White Sucker | | Burbot | | Lake Trout | | |
| K-40 | 1.83 ± 0.31 | - | 1.33 ± 0.10 | - | 3.24 ± 0.41 | - | |
| Mn-54 | -0.001 ± 0.010 | < 0.021 | 0.001 ± 0.003 | < 0.006 | 0.002 ± 0.010 | < 0.020 | 0.13 |
| Fe-59 | -0.031 ± 0.017 | < 0.065 | 0.001 ± 0.005 | < 0.024 | 0.024 ± 0.018 | < 0.073 | 0.26 |
| Co-58 | -0.008 ± 0.009 | < 0.021 | 0.003 ± 0.002 | < 0.008 | -0.002 ± 0.009 | < 0.025 | 0.13 |
| Co-60 | 0.007 ± 0.010 | < 0.018 | 0.003 ± 0.003 | < 0.005 | 0.007 ± 0.011 | < 0.015 | 0.13 |
| Zn-65 | 0.003 ± 0.021 | < 0.047 | -0.005 ± 0.006 | < 0.011 | -0.025 ± 0.026 | < 0.032 | 0.26 |
| Cs-134 | 0.004 ± 0.010 | < 0.017 | 0.000 ± 0.003 | < 0.005 | -0.004 ± 0.010 | < 0.017 | 0.13 |
| Cs-137 | 0.004 ± 0.011 | < 0.022 | 0.011 ± 0.003 | < 0.007 | 0.009 ± 0.011 | < 0.018 | 0.15 |
| Other (Ru-103) | 0.009 ± 0.008 | < 0.059 | 0.003 ± 0.002 | < 0.018 | -0.012 ± 0.007 | < 0.020 | 0.5 |

Table 8. Radioactivity in shoreline sediment samples

Collection: Annual

Sample Description and Concentration (pCi/g dry)

| | | MDC | | MDC | | MDC | |
|---|---|---|---|---|---|---|---|
| Collection Date | 10/16/2024 | | 10/16/2024 | | 10/16/2024 | | |
| Lab Code | ESS- 2560 | | ESS- 2561 | | ESS- 2562 | | LLD |
| Location | E-01 | | E-05 | | E-06 | | |
| Be-7 | 0.007 ± 0.033 | < 0.095 | 0.075 ± 0.031 | < 0.118 | 0.121 ± 0.059 | < 0.254 | |
| K-40 | 6.317 ± 0.305 | - | 5.727 ± 0.483 | - | 6.650 ± 0.399 | - | - |
| Cs-134 | 0.002 ± 0.004 | < 0.009 | -0.001 ± 0.004 | < 0.009 | -0.051 ± 0.010 | < 0.016 | 0.15 |
| Cs-137 | 0.011 ± 0.005 | < 0.010 | 0.007 ± 0.005 | < 0.009 | 0.024 ± 0.013 | < 0.015 | 0.15 |
| Tl-208 | 0.041 ± 0.012 | - | 0.041 ± 0.010 | - | 0.055 ± 0.018 | - | - |
| Pb-212 | 0.102 ± 0.013 | - | 0.113 ± 0.013 | - | 0.149 ± 0.018 | - | - |
| Bi-214 | 0.215 ± 0.022 | - | 0.131 ± 0.019 | - | 0.258 ± 0.031 | - | - |
| Ra-226 | 0.256 ± 0.118 | - | 0.253 ± 0.117 | - | 0.277 ± 0.149 | - | - |
| Ac-228 | 0.139 ± 0.043 | - | 0.157 ± 0.031 | - | 0.181 ± 0.059 | - | - |

| | **Annual Mean ±s.d.** |
|---|---|
| **Be-7** | **0.068 ± 0.057** |
| **K-40** | **6.23 ± 0.47** |
| **Cs-134** | **-0.02 ± 0.03** |
| **Cs-137** | **0.014 ± 0.009** |
| **Tl-208** | **0.05 ± 0.01** |
| **Pb-212** | **0.12 ± 0.02** |
| **Bi-214** | **0.20 ± 0.06** |
| **Ra-226** | **0.26 ± 0.01** |
| **Ac-228** | **0.16 ± 0.02** |

## POINT BEACH NUCLEAR PLANT

Table 9. Radioactivity in soil samples

Collection: Annual

Sample Description and Concentration (pCi/g dry)

| | | MDC | | MDC | | MDC | |
|---|---|---|---|---|---|---|---|
| Collection Date | 9/23/2024 | | 9/23/2024 | | 9/23/2024 | | Req. |
| Lab Code | ESO- 2263 | | ESO- 2264 | | ESO- 2265 | | LLD |
| Location | E-01 | | E-02 | | E-03 | | |
| Be-7 | 0.154 ± 0.05 | < 0.14 | 0.088 ± 0.03 | < 0.10 | 0.060 ± 0.04 | < 0.11 | |
| K-40 | 13.32 ± 0.34 | - | 18.70 ± 0.27 | - | 19.55 ± 0.37 | - | - |
| Cs-134 | -0.017 ± 0.00 | < 0.01 | -0.005 ± 0.01 | < 0.01 | -0.010 ± 0.01 | < 0.01 | 0.15 |
| Cs-137 | 0.107 ± 0.01 | < 0.01 | 0.167 ± 0.01 | < 0.01 | 0.025 ± 0.01 | < 0.01 | 0.15 |
| Tl-208 | 0.138 ± 0.02 | - | 0.173 ± 0.01 | - | 0.202 ± 0.02 | - | - |
| Pb-212 | 0.360 ± 0.02 | - | 0.465 ± 0.01 | - | 0.550 ± 0.02 | - | - |
| Bi-214 | 0.377 ± 0.02 | - | 0.549 ± 0.02 | - | 0.501 ± 0.02 | - | - |
| Ra-226 | 0.683 ± 0.15 | - | 1.200 ± 0.10 | - | 1.494 ± 0.31 | - | - |
| Ac-228 | 0.440 ± 0.04 | - | 0.552 ± 0.03 | - | 0.630 ± 0.03 | - | - |
| Collection Date | 9/23/2024 | | 9/23/2024 | | 9/23/2024 | | |
| Lab Code | ESO- 2266 | | ESO- 2267 | | ESO- 2268 | | |
| Location | E-04 | | E-06 | | E-20 | | |
| Be-7 | 0.074 ± 0.03 | < 0.09 | 0.040 ± 0.05 | < 0.16 | 0.150 ± 0.03 | < 0.15 | |
| K-40 | 17.22 ± 0.27 | - | 13.07 ± 0.38 | - | 12.77 ± 0.28 | - | - |
| Cs-134 | -0.008 ± 0.01 | < 0.01 | -0.015 ± 0.01 | < 0.01 | -0.009 ± 0.01 | < 0.01 | 0.15 |
| Cs-137 | 0.242 ± 0.01 | < 0.01 | 0.239 ± 0.01 | < 0.01 | 0.082 ± 0.01 | < 0.01 | 0.15 |
| Tl-208 | 0.139 ± 0.01 | - | 0.048 ± 0.02 | - | 0.154 ± 0.01 | - | - |
| Pb-212 | 0.360 ± 0.01 | - | 0.148 ± 0.01 | - | 0.437 ± 0.01 | - | - |
| Bi-214 | 0.425 ± 0.02 | - | 0.142 ± 0.02 | - | 0.381 ± 0.02 | - | - |
| Ra-226 | 0.860 ± 0.09 | - | 0.306 ± 0.13 | - | 1.219 ± 0.12 | - | - |
| Ac-228 | 0.448 ± 0.04 | - | 0.177 ± 0.04 | - | 0.478 ± 0.05 | - | - |

| | Annual Mean ± s.d. | |
|---|---|---|
| Be-7 | **0.094 ± 0.05** | |
| K-40 | **15.77 ± 3.08** | - |
| Cs-134 | **-0.011 ± 0.00** | 0.15 |
| Cs-137 | **0.14 ± 0.09** | 0.15 |
| Tl-208 | **0.14 ± 0.05** | - |
| Pb-212 | **0.39 ± 0.14** | - |
| Bi-214 | **0.40 ± 0.14** | - |
| Ra-226 | **0.96 ± 0.43** | - |
| Ac-228 | **0.45 ± 0.15** | - |

Table 10. Radioactivity in vegetation samples
Collection: Bi-annual

Sample Description and Concentration (pCi/g wet)

| | | MDC | | MDC | | MDC | |
|---|---|---|---|---|---|---|---|
| Location | E-01 | | E-02 | | E-03 | | |
| Collection Date | 05-24-24 | | 05-24-24 | | 05-24-24 | | |
| Lab Code | EG- 1184 | | EG- 1185 | | EG- 1186 | | Req. LLD |
| Be-7 | 0.63 ± 0.11 | - | 0.71 ± 0.09 | - | 0.46 ± 0.12 | - | - |
| K-40 | 5.89 ± 0.30 | - | 4.69 ± 0.19 | - | 6.05 ± 0.39 | - | - |
| I-131 | 0.004 ± 0.005 | < 0.016 | 0.002 ± 0.004 | < 0.007 | 0.000 ± 0.005 | < 0.014 | 0.060 |
| Cs-134 | -0.004 ± 0.005 | < 0.010 | -0.001 ± 0.004 | < 0.007 | 0.004 ± 0.006 | < 0.013 | 0.060 |
| Cs-137 | 0.008 ± 0.006 | < 0.012 | -0.002 ± 0.005 | < 0.007 | 0.003 ± 0.008 | < 0.007 | 0.080 |
| Other (Co-60) | 0.001 ± 0.006 | < 0.012 | 0.001 ± 0.005 | < 0.006 | 0.001 ± 0.008 | < 0.014 | 0.060 |
| Location | E-04 | | E-06 | | E-20 | | |
| Collection Date | 05-24-24 | | 05-24-24 | | 05-24-24 | | |
| Lab Code | EG- 1187 | | EG- 1188 | | EG- 1189 | | Req. LLD |
| Be-7 | 0.42 ± 0.14 | - | 0.86 ± 0.20 | - | 0.59 ± 0.10 | - | - |
| K-40 | 5.45 ± 0.35 | - | 3.81 ± 0.33 | - | 5.35 ± 0.30 | - | - |
| I-131 | 0.001 ± 0.002 | < 0.005 | 0.005 ± 0.007 | < 0.015 | -0.001 ± 0.004 | < 0.013 | 0.060 |
| Cs-134 | -0.003 ± 0.006 | < 0.010 | -0.001 ± 0.006 | < 0.012 | 0.002 ± 0.005 | < 0.008 | 0.060 |
| Cs-137 | 0.001 ± 0.008 | < 0.008 | 0.118 ± 0.024 | < 0.023 | -0.001 ± 0.005 | < 0.005 | 0.080 |
| Other (Co-60) | -0.002 ± 0.007 | < 0.010 | 0.005 ± 0.008 | < 0.014 | -0.001 ± 0.006 | < 0.008 | 0.060 |

Table 10. Radioactivity in vegetation samples
Collection: Bi-annual

Sample Description and Concentration (pCi/g wet)

| | | MDC | | MDC | | MDC | |
|---|---|---|---|---|---|---|---|
| Location | E-01 | | E-02 | | E-03 | | |
| Collection Date | 09-23-24 | | 09-23-24 | | 09-23-24 | | |
| Lab Code | EG- 2257 | | EG- 2258 | | EG- 2259 | | Req. LLD |
| Be-7 | 0.70 ± 0.17 | - | 1.30 ± 0.15 | - | 2.45 ± 0.32 | - | - |
| K-40 | 4.90 ± 0.34 | - | 4.14 ± 0.32 | - | 6.50 ± 0.57 | - | - |
| I-131 | -0.005 ± 0.007 | < 0.012 | 0.000 ± 0.005 | < 0.015 | -0.004 ± 0.008 | < 0.025 | 0.060 |
| Cs-134 | 0.002 ± 0.006 | < 0.013 | 0.002 ± 0.005 | < 0.010 | -0.005 ± 0.011 | < 0.020 | 0.060 |
| Cs-137 | 0.003 ± 0.008 | < 0.015 | 0.002 ± 0.006 | < 0.011 | -0.008 ± 0.014 | < 0.011 | 0.080 |
| Other (Co-60) | 0.005 ± 0.008 | < 0.014 | 0.004 ± 0.006 | < 0.009 | 0.007 ± 0.014 | < 0.024 | 0.060 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Location | E-04 | | E-06 | | E-20 | | |
| Collection Date | 09-23-24 | | 09-23-24 | | 09-23-24 | | |
| Lab Code | EG- 2260 | | EG- 2261 | | EG- 2262 | | Req. LLD |
| Be-7 | 1.34 ± 0.16 | - | 2.45 ± 0.33 | - | 2.11 ± 0.19 | - | - |
| K-40 | 3.96 ± 0.33 | - | 2.90 ± 0.48 | - | 4.77 ± 0.36 | - | - |
| I-131 | 0.001 ± 0.004 | < 0.013 | 0.000 ± 0.009 | < 0.032 | -0.008 ± 0.006 | < 0.016 | 0.060 |
| Cs-134 | -0.001 ± 0.005 | < 0.010 | 0.001 ± 0.011 | < 0.023 | 0.000 ± 0.005 | < 0.011 | 0.060 |
| Cs-137 | -0.005 ± 0.007 | < 0.012 | 0.037 ± 0.016 | < 0.029 | 0.005 ± 0.007 | < 0.014 | 0.080 |
| Other (Co-60) | 0.007 ± 0.007 | < 0.008 | 0.011 ± 0.015 | < 0.028 | 0.010 ± 0.007 | < 0.013 | 0.060 |

| | |
|---|---|
| **Be-7 Annual Mean ± s.d.** | **1.17 ± 0.76** |
| **K-40 Annual Mean ± s.d.** | **4.87 ± 1.05** |
| **I-131 Annual Mean ± s.d.** | **0.000 ± 0.004** |
| **Cs-134 Annual Mean ± s.d.** | **0.000 ± 0.003** |
| **Cs-137 Annual Mean ± s.d.** | **0.015 ± 0.034** |
| **Co-60 Annual Mean ± s.d.** | **0.004 ± 0.004** |

Table 11. Ambient Gamma Radiation [a]
LLD/7days: < 1mR/TLD

1st. Quarter, 2024

| | | | |
|---|---|---|---|
| Date Annealed: | 12-12-23 | Days in the field | 91 |
| Date Placed: | 01-04-24 | Days from Annealing | |
| Date Removed: | 04-04-24 | to Readout: | 119 |
| Date Read: | 04-09-24 | | |

| Location | Days in Field | Total mR | Net mR | mR/Stnd Qtr (91 days) | Net mR per 7 days |
|---|---|---|---|---|---|
| Indicator | | | | | |
| E-1 | 91 | 15.2 ± 0.9 | 10.4 ± 1.0 | 10.4 ± 1.0 | 0.80 ± 0.07 |
| E-2 | 91 | 19.9 ± 0.3 | 15.1 ± 0.3 | 15.1 ± 0.3 | 1.16 ± 0.03 |
| E-3 | 91 | 19.9 ± 1.0 | 15.1 ± 1.0 | 15.1 ± 1.0 | 1.16 ± 0.08 |
| E-4 | 91 | 16.1 ± 0.7 | 11.3 ± 0.7 | 11.3 ± 0.7 | 0.87 ± 0.05 |
| E-5 | 91 | 17.3 ± 0.4 | 12.5 ± 0.5 | 12.5 ± 0.5 | 0.96 ± 0.04 |
| E-6 | 91 | 16.3 ± 0.6 | 11.5 ± 0.6 | 11.5 ± 0.6 | 0.89 ± 0.05 |
| E-7 | 91 | 17.5 ± 0.5 | 12.7 ± 0.5 | 12.7 ± 0.5 | 0.98 ± 0.04 |
| E-8 | 91 | 15.6 ± 1.0 | 10.8 ± 1.0 | 10.8 ± 1.0 | 0.83 ± 0.08 |
| E-9 | 91 | 16.8 ± 0.1 | 12.0 ± 0.2 | 12.0 ± 0.2 | 0.92 ± 0.02 |
| E-12 | 91 | 12.6 ± 0.2 | 7.8 ± 0.3 | 7.8 ± 0.3 | 0.60 ± 0.02 |
| E-14 | 91 | 19.0 ± 0.2 | 14.2 ± 0.3 | 14.2 ± 0.3 | 1.09 ± 0.02 |
| E-15 | 91 | 19.4 ± 0.4 | 14.6 ± 0.5 | 14.6 ± 0.5 | 1.12 ± 0.04 |
| E-16B | 91 | 20.3 ± 0.7 | 15.5 ± 0.8 | 15.5 ± 0.8 | 1.19 ± 0.06 |
| E-17 | 91 | 19.2 ± 0.4 | 14.4 ± 0.4 | 14.4 ± 0.4 | 1.11 ± 0.03 |
| E-18 | 91 | 18.6 ± 0.5 | 13.8 ± 0.5 | 13.8 ± 0.5 | 1.06 ± 0.04 |
| E-22 | 91 | 17.6 ± 0.5 | 12.8 ± 0.6 | 12.8 ± 0.6 | 0.99 ± 0.04 |
| E-23 | 91 | 21.3 ± 0.4 | 16.5 ± 0.5 | 16.5 ± 0.5 | 1.27 ± 0.04 |
| E-24 | 91 | 18.4 ± 0.4 | 13.6 ± 0.4 | 13.6 ± 0.4 | 1.05 ± 0.03 |
| E-25 | 91 | 18.8 ± 0.2 | 14.0 ± 0.3 | 14.0 ± 0.3 | 1.08 ± 0.02 |
| E-26B | 91 | 18.4 ± 0.3 | 13.6 ± 0.3 | 13.6 ± 0.3 | 1.04 ± 0.03 |
| E-27 | 91 | 17.8 ± 0.3 | 13.0 ± 0.4 | 13.0 ± 0.4 | 1.00 ± 0.03 |
| E-28 | 91 | 13.2 ± 0.3 | 8.4 ± 0.4 | 8.4 ± 0.4 | 0.64 ± 0.03 |
| E-29 | 91 | 14.8 ± 0.3 | 10.0 ± 0.3 | 10.0 ± 0.3 | 0.77 ± 0.03 |
| E-30 | 91 | 18.0 ± 0.4 | 13.2 ± 0.5 | 13.2 ± 0.5 | 1.02 ± 0.03 |
| E-31 | 91 | 19.3 ± 0.3 | 14.5 ± 0.4 | 14.5 ± 0.4 | 1.11 ± 0.03 |
| E-32 | 91 | 22.9 ± 0.2 | 18.1 ± 0.3 | 18.1 ± 0.3 | 1.39 ± 0.02 |
| E-38 | 91 | 19.7 ± 1.3 | 14.9 ± 1.3 | 14.9 ± 1.3 | 1.14 ± 0.10 |
| E-39 | 91 | 20.0 ± 0.7 | 15.2 ± 0.7 | 15.2 ± 0.7 | 1.17 ± 0.06 |
| E-41 | 91 | 19.3 ± 0.3 | 14.5 ± 0.4 | 14.5 ± 0.4 | 1.11 ± 0.03 |
| E-42 | 91 | 18.6 ± 0.2 | 13.8 ± 0.3 | 13.8 ± 0.3 | 1.06 ± 0.02 |
| E-43 | 91 | 19.3 ± 0.7 | 14.5 ± 0.7 | 14.5 ± 0.7 | 1.12 ± 0.05 |
| E-44 | 91 | 19.1 ± 0.6 | 14.3 ± 0.7 | 14.3 ± 0.7 | 1.10 ± 0.05 |
| Control | | | | | |
| E-20 | 91 | 18.9 ± 1.0 | 14.1 ± 1.1 | 14.1 ± 1.1 | 1.08 ± 0.08 |
| Mean±s.d. | | 18.2 ± 2.2 | 13.4 ± 2.2 | 13.4 ± 2.2 | 1.03 ± 0.17 |

| In-Transit Exposure | Date Annealed | Date Read | ITC-1 | ITC-2 |
|---|---|---|---|---|
| | 12-12-23 | 01-11-24 | 4.5 ± 0.2 | 4.4 ± 0.2 |
| | 03-12-24 | 04-09-24 | 5.8 ± 0.2 | 5.1 ± 0.2 |

[a] The $CaSO_4$:Dy dosimeter cards provide four separate readout areas. Values listed represent the mean and standard deviation of the average of the four readings.

## POINT BEACH NUCLEAR PLANT

Table 11. Ambient Gamma Radiation [a]
LLD/7days: < 1mR/TLD

2nd Quarter, 2024

| | | | |
|---|---|---|---|
| Date Annealed: | 03-12-24 | Days in the field | 88 |
| Date Placed: | 04-04-24 | Days from Annealing to Readout: | 115 |
| Date Removed: | 07-01-24 | | |
| Date Read: | 07-05-24 | | |

| Location | Days in Field | Total mR | Net mR | mR/Stnd Qtr (91 days) | Net mR per 7 days |
|---|---|---|---|---|---|
| Indicator | | | | | |
| E-1 | 88 | 18.5 ± 1.1 | 13.5 ± 1.2 | 14.0 ± 1.2 | 1.08 ± 0.09 |
| E-2 | 88 | 23.8 ± 0.9 | 18.8 ± 1.0 | 19.4 ± 1.0 | 1.50 ± 0.08 |
| E-3 | 88 | 21.2 ± 1.7 | 16.3 ± 1.8 | 16.8 ± 1.8 | 1.29 ± 0.14 |
| E-4 | 88 | 17.3 ± 0.3 | 12.3 ± 0.5 | 12.7 ± 0.5 | 0.98 ± 0.04 |
| E-5 | 88 | 20.2 ± 0.5 | 15.2 ± 0.7 | 15.8 ± 0.7 | 1.21 ± 0.05 |
| E-6 | 88 | 16.7 ± 0.4 | 11.7 ± 0.6 | 12.1 ± 0.6 | 0.93 ± 0.04 |
| E-7 | 88 | 17.4 ± 0.2 | 12.5 ± 0.4 | 12.9 ± 0.4 | 0.99 ± 0.03 |
| E-8 | 88 | 18.6 ± 0.8 | 13.6 ± 0.9 | 14.1 ± 0.9 | 1.08 ± 0.07 |
| E-9 | 88 | 17.8 ± 0.3 | 12.8 ± 0.5 | 13.2 ± 0.5 | 1.02 ± 0.04 |
| E-12 | 88 | 14.4 ± 0.8 | 9.4 ± 0.8 | 9.7 ± 0.9 | 0.75 ± 0.07 |
| E-14 | 88 | 20.8 ± 1.8 | 15.9 ± 1.9 | 16.4 ± 1.9 | 1.26 ± 0.15 |
| E-15 | 88 | 19.1 ± 1.2 | 14.1 ± 1.3 | 14.6 ± 1.3 | 1.12 ± 0.10 |
| E-16B | 88 | 20.7 ± 0.5 | 15.7 ± 0.6 | 16.3 ± 0.6 | 1.25 ± 0.05 |
| E-17 | 88 | 17.9 ± 0.6 | 13.0 ± 0.7 | 13.4 ± 0.7 | 1.03 ± 0.05 |
| E-18 | 88 | 20.3 ± 0.4 | 15.4 ± 0.5 | 15.9 ± 0.6 | 1.22 ± 0.04 |
| E-22 | 88 | 20.4 ± 0.5 | 15.4 ± 0.6 | 15.9 ± 0.6 | 1.22 ± 0.05 |
| E-23 | 88 | 22.5 ± 0.2 | 17.5 ± 0.4 | 18.1 ± 0.4 | 1.39 ± 0.03 |
| E-24 | 88 | 18.7 ± 0.8 | 13.7 ± 0.9 | 14.2 ± 0.9 | 1.09 ± 0.07 |
| E-25 | 88 | 19.8 ± 0.6 | 14.9 ± 0.7 | 15.4 ± 0.7 | 1.18 ± 0.05 |
| E-26B | 88 | 18.5 ± 0.1 | 13.5 ± 0.4 | 13.9 ± 0.4 | 1.07 ± 0.03 |
| E-27 | 88 | 19.1 ± 0.4 | 14.2 ± 0.5 | 14.7 ± 0.5 | 1.13 ± 0.04 |
| E-28 | 88 | 15.1 ± 0.3 | 10.2 ± 0.4 | 10.5 ± 0.5 | 0.81 ± 0.04 |
| E-29 | 88 | 14.2 ± 0.2 | 9.3 ± 0.4 | 9.6 ± 0.4 | 0.74 ± 0.03 |
| E-30 | 88 | 16.9 ± 0.2 | 11.9 ± 0.4 | 12.3 ± 0.4 | 0.95 ± 0.03 |
| E-31 | 88 | 20.6 ± 1.0 | 15.7 ± 1.1 | 16.2 ± 1.1 | 1.25 ± 0.09 |
| E-32 | 88 | 23.3 ± 0.5 | 18.3 ± 0.6 | 18.9 ± 0.6 | 1.46 ± 0.05 |
| E-38 | 88 | 18.2 ± 0.4 | 13.2 ± 0.5 | 13.7 ± 0.5 | 1.05 ± 0.04 |
| E-39 | 88 | 19.2 ± 0.4 | 14.2 ± 0.5 | 14.7 ± 0.5 | 1.13 ± 0.04 |
| E-41 | 88 | 20.6 ± 0.2 | 15.6 ± 0.4 | 16.1 ± 0.4 | 1.24 ± 0.03 |
| E-42 | 88 | 20.2 ± 0.4 | 15.2 ± 0.5 | 15.8 ± 0.5 | 1.21 ± 0.04 |
| E-43 | 88 | 21.0 ± 0.6 | 16.0 ± 0.7 | 16.6 ± 0.7 | 1.27 ± 0.06 |
| E-44 | 88 | 19.4 ± 0.4 | 14.4 ± 0.6 | 14.9 ± 0.6 | 1.15 ± 0.04 |
| Control | | | | | |
| E-20 | 88 | 18.3 ± 0.7 | 13.3 ± 0.8 | 13.8 ± 0.8 | 1.06 ± 0.06 |
| Mean±s.d. | | 19.1 ± 2.2 | 14.1 ± 2.2 | 14.6 ± 2.3 | 1.13 ± 0.17 |

| In-Transit Exposure | Date Annealed | Date Read | ITC-1 | ITC-2 |
|---|---|---|---|---|
| | 03-12-24 | 04-09-24 | 5.8 ± 0.2 | 5.1 ± 0.2 |
| | 06-11-24 | 07-05-24 | 4.5 ± 0.2 | 4.5 ± 0.1 |

[a] The $CaSO_4$:Dy dosimeter cards provide four separate readout areas. Values listed represent the mean and standard deviation of the average of the four readings.

Table 11. Ambient Gamma Radiation [a]
LLD/7days: < 1mR/TLD

3rd Quarter, 2024

| | | | |
|---|---|---|---|
| Date Annealed: | 06-04-24 | Days in the field | 98 |
| Date Placed: | 07-01-24 | Days from Annealing | |
| Date Removed: | 10-07-24 [b] | to Readout: | 132 |
| Date Read: | 10-14-24 | | |

| Location | Days in Field | Total mR | Net mR | mR/Stnd Qtr (91 days) | Net mR per 7 days |
|---|---|---|---|---|---|
| Indicator | | | | | |
| E-1 | 98 | 16.8 ± 0.6 | 11.1 ± 0.7 | 10.3 ± 0.7 | 0.79 ± 0.05 |
| E-2 | 98 | 22.2 ± 0.4 | 16.4 ± 0.5 | 15.3 ± 0.5 | 1.17 ± 0.04 |
| E-3 | 98 | 23.0 ± 1.1 | 17.3 ± 1.1 | 16.1 ± 1.0 | 1.23 ± 0.08 |
| E-4 | 98 | 18.1 ± 0.8 | 12.4 ± 0.8 | 11.5 ± 0.8 | 0.89 ± 0.06 |
| E-5 | 98 | 20.4 ± 0.7 | 14.6 ± 0.8 | 13.6 ± 0.7 | 1.05 ± 0.05 |
| E-6 | 98 | 17.2 ± 0.5 | 11.5 ± 0.6 | 10.7 ± 0.6 | 0.82 ± 0.05 |
| E-7 | 97 | 19.6 ± 0.6 | 13.9 ± 0.7 | 13.0 ± 0.7 | 1.00 ± 0.05 |
| E-8 | 97 | 18.3 ± 0.8 | 12.5 ± 0.9 | 11.8 ± 0.8 | 0.90 ± 0.06 |
| E-9 | 97 | 20.3 ± 0.3 | 14.6 ± 0.4 | 13.7 ± 0.4 | 1.05 ± 0.03 |
| E-12 | 97 | 13.3 ± 0.2 | 7.6 ± 0.4 | 7.1 ± 0.4 | 0.55 ± 0.03 |
| E-14 | 97 | 20.7 ± 0.2 | 15.0 ± 0.4 | 14.0 ± 0.4 | 1.08 ± 0.03 |
| E-15 | 97 | 22.2 ± 0.4 | 16.5 ± 0.5 | 15.5 ± 0.5 | 1.19 ± 0.04 |
| E-16B | 98 | 22.8 ± 0.6 | 17.1 ± 0.7 | 15.8 ± 0.6 | 1.22 ± 0.05 |
| E-17 | 98 | 21.6 ± 0.4 | 15.9 ± 0.5 | 14.8 ± 0.5 | 1.14 ± 0.04 |
| E-18 | 98 | 22.2 ± 0.7 | 16.5 ± 0.7 | 15.3 ± 0.7 | 1.18 ± 0.05 |
| E-22 | 98 | 19.7 ± 0.4 | 14.0 ± 0.5 | 13.0 ± 0.5 | 1.00 ± 0.04 |
| E-23 | 97 | 24.0 ± 0.5 | 18.3 ± 0.6 | 17.1 ± 0.5 | 1.32 ± 0.04 |
| E-24 | 97 | 20.4 ± 0.5 | 14.7 ± 0.6 | 13.8 ± 0.6 | 1.06 ± 0.04 |
| E-25 | 97 | 21.1 ± 0.4 | 15.4 ± 0.5 | 14.4 ± 0.5 | 1.11 ± 0.04 |
| E-26B | 97 | 20.9 ± 0.5 | 15.1 ± 0.6 | 14.2 ± 0.6 | 1.09 ± 0.04 |
| E-27 | 97 | 20.4 ± 0.3 | 14.6 ± 0.5 | 13.7 ± 0.4 | 1.06 ± 0.03 |
| E-28 | 97 | 14.4 ± 0.2 | 8.6 ± 0.4 | 8.1 ± 0.4 | 0.62 ± 0.03 |
| E-29 | 97 | 15.8 ± 0.4 | 10.1 ± 0.5 | 9.4 ± 0.5 | 0.73 ± 0.04 |
| E-30 | 98 | 19.8 ± 0.6 | 14.1 ± 0.7 | 13.1 ± 0.7 | 1.01 ± 0.05 |
| E-31 | 97 | 21.3 ± 0.5 | 15.6 ± 0.6 | 14.7 ± 0.6 | 1.13 ± 0.05 |
| E-32 | 97 | 25.6 ± 0.3 | 19.9 ± 0.4 | 18.7 ± 0.4 | 1.44 ± 0.03 |
| E-38 | 97 | 22.2 ± 1.4 | 16.5 ± 1.4 | 15.4 ± 1.3 | 1.19 ± 0.10 |
| E-39 | 97 | 22.5 ± 0.9 | 16.8 ± 0.9 | 15.7 ± 0.9 | 1.21 ± 0.07 |
| E-41 | 97 | 22.5 ± 0.3 | 16.8 ± 0.5 | 15.7 ± 0.4 | 1.21 ± 0.03 |
| E-42 | 98 | 21.4 ± 0.2 | 15.6 ± 0.4 | 14.5 ± 0.4 | 1.12 ± 0.03 |
| E-43 | 97 | 23.4 ± 0.6 | 17.6 ± 0.7 | 16.6 ± 0.7 | 1.27 ± 0.05 |
| E-44 | 97 | 20.4 ± 0.8 | 14.7 ± 0.8 | 13.8 ± 0.8 | 1.06 ± 0.06 |
| Control | | | | | |
| E-20 | 97 | 20.5 ± 0.9 | 14.8 ± 1.0 | 13.9 ± 0.9 | 1.07 ± 0.07 |
| Mean±s.d. | | 20.5 ± 2.7 | 14.7 ± 2.7 | 13.8 ± 2.5 | 1.06 ± 0.19 |

| In-Transit Exposure | Date Annealed | Date Read | ITC-1 | ITC-2 |
|---|---|---|---|---|
| | 06-11-24 | 07-05-24 | 4.5 ± 0.2 | 4.5 ± 0.1 |
| | 09-10-24 | 10-14-24 | 7.5 ± 0.2 | 6.4 ± 0.2 |

[a] The $CaSO_4$:Dy dosimeter cards provide four separate readout areas. Values listed represent the mean and standard deviation of the average of the four readings.

[b] Some samples collected on 10/6, as indicated

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Table 11. Ambient Gamma Radiation[a]
LLD/7days: < 1mR/TLD

4th Quarter, 2024

| | | | |
|---|---|---|---|
| Date Annealed: | 09-10-24 | Days in the field | 88 |
| Date Placed: | 10-07-24 [b] | Days from Annealing | |
| Date Removed: | 01-03-25 | to Readout: | 125 |
| Date Read: | 01-13-25 | | |

| Location | Days in Field | Total mR | Net mR | mR/Stnd Qtr (91 days) | Net mR per 7 days |
|---|---|---|---|---|---|
| Indicator | | | | | |
| E-1 | 88 | 21.6 ± 0.9 | 15.9 ± 1.0 | 16.4 ± 1.0 | 1.26 ± 0.08 |
| E-2 | 88 | 27.2 ± 1.1 | 21.5 ± 1.2 | 22.2 ± 1.2 | 1.71 ± 0.09 |
| E-3 | 88 | 22.9 ± 1.6 | 17.2 ± 1.7 | 17.8 ± 1.7 | 1.37 ± 0.13 |
| E-4 | 88 | 20.5 ± 0.3 | 14.8 ± 0.5 | 15.3 ± 0.5 | 1.18 ± 0.04 |
| E-5 | 88 | 23.3 ± 0.7 | 17.6 ± 0.8 | 18.2 ± 0.8 | 1.40 ± 0.06 |
| E-6 | 88 | 19.7 ± 0.3 | 14.0 ± 0.5 | 14.5 ± 0.5 | 1.11 ± 0.04 |
| E-7 | 89 | 21.2 ± 0.3 | 15.5 ± 0.5 | 15.8 ± 0.5 | 1.22 ± 0.04 |
| E-8 | 89 | 21.6 ± 0.7 | 15.9 ± 0.8 | 16.3 ± 0.8 | 1.25 ± 0.06 |
| E-9 | 89 | 20.4 ± 0.3 | 14.7 ± 0.5 | 15.0 ± 0.5 | 1.16 ± 0.04 |
| E-12 | 89 | 17.3 ± 0.9 | 11.6 ± 1.0 | 11.9 ± 1.0 | 0.91 ± 0.08 |
| E-14 | 89 | 21.7 ± 1.7 | 16.0 ± 1.7 | 16.4 ± 1.8 | 1.26 ± 0.14 |
| E-15 | 89 | 25.8 ± 1.7 | 20.1 ± 1.7 | 20.5 ± 1.8 | 1.58 ± 0.14 |
| E-16B | 88 | 24.3 ± 0.3 | 18.6 ± 0.5 | 19.2 ± 0.5 | 1.48 ± 0.04 |
| E-17 | 89 | 24.1 ± 0.7 | 18.4 ± 0.8 | 18.8 ± 0.8 | 1.45 ± 0.06 |
| E-18 | 89 | 23.6 ± 0.6 | 17.9 ± 0.7 | 18.3 ± 0.7 | 1.41 ± 0.06 |
| E-22 | 88 | 23.4 ± 0.5 | 17.7 ± 0.6 | 18.3 ± 0.7 | 1.41 ± 0.05 |
| E-23 | 89 | 25.6 ± 0.2 | 19.9 ± 0.5 | 20.3 ± 0.5 | 1.56 ± 0.04 |
| E-24 | 89 | 24.4 ± 0.8 | 18.7 ± 0.9 | 19.1 ± 0.9 | 1.47 ± 0.07 |
| E-25 | 89 | 23.1 ± 0.8 | 17.4 ± 0.9 | 17.8 ± 0.9 | 1.37 ± 0.07 |
| E-26B | 89 | 22.9 ± 0.3 | 17.2 ± 0.5 | 17.6 ± 0.5 | 1.35 ± 0.04 |
| E-27 | 89 | 25.2 ± 0.4 | 19.5 ± 0.6 | 19.9 ± 0.6 | 1.53 ± 0.04 |
| E-28 | 89 | 19.1 ± 0.4 | 13.4 ± 0.6 | 13.7 ± 0.6 | 1.05 ± 0.04 |
| E-29 | 89 | 17.8 ± 0.5 | 12.1 ± 0.6 | 12.4 ± 0.7 | 0.95 ± 0.05 |
| E-30 | 89 | 19.7 ± 0.3 | 14.0 ± 0.5 | 14.3 ± 0.5 | 1.10 ± 0.04 |
| E-31 | 89 | 23.8 ± 1.3 | 18.1 ± 1.4 | 18.5 ± 1.4 | 1.42 ± 0.11 |
| E-32 | 89 | 28.3 ± 0.6 | 22.6 ± 0.7 | 23.1 ± 0.7 | 1.78 ± 0.06 |
| E-38 | 89 | 22.1 ± 0.3 | 16.4 ± 0.5 | 16.8 ± 0.5 | 1.29 ± 0.04 |
| E-39 | 89 | 22.7 ± 0.4 | 17.0 ± 0.6 | 17.4 ± 0.6 | 1.34 ± 0.04 |
| E-41 | 89 | 23.4 ± 0.3 | 17.7 ± 0.5 | 18.1 ± 0.5 | 1.39 ± 0.04 |
| E-42 | 88 | 24.0 ± 0.9 | 18.3 ± 1.0 | 18.9 ± 1.0 | 1.46 ± 0.08 |
| E-43 | 89 | 24.9 ± 0.5 | 19.2 ± 0.6 | 19.6 ± 0.7 | 1.51 ± 0.05 |
| E-44 | 89 | 22.7 ± 0.5 | 17.0 ± 0.6 | 17.4 ± 0.7 | 1.34 ± 0.05 |
| Control | | | | | |
| E-20 | 89 | 21.1 ± 0.8 | 15.4 ± 0.9 | 15.7 ± 0.9 | 1.21 ± 0.07 |
| Mean±s.d. | | 22.7 ± 2.5 | 17.0 ± 2.5 | 17.4 ± 2.5 | 1.34 ± 0.19 |

| In-Transit Exposure | Date Annealed | Date Read | ITC-1 | ITC-2 |
|---|---|---|---|---|
| | 09-10-24 | 10-14-24 | 7.5 ± 0.2 | 6.4 ± 0.2 |
| | 12-10-24 | 01-13-25 | 4.5 ± 0.2 | 4.4 ± 0.2 |

[a] The $CaSO_4$:Dy dosimeter cards provide four separate readout areas. Values listed represent the mean and standard deviation of the average of the four readings.

[b] Some TLDs collected on 1/6/25 as indicated.

| | | | | |
|---|---|---|---|---|
| Annual Indicator Mean±s.d. | 20.1 ± 3.0 | 14.8 ± 2.8 | 14.8 ± 2.9 | 1.1 ± 0.2 |
| Annual Control Mean±s.d. | 19.7 ± 1.3 | 14.4 ± 0.9 | 14.4 ± 0.9 | 1.1 ± 0.1 |
| Annual Indicator/Control Mean±s.d. | 20.1 ± 2.9 | 14.8 ± 2.7 | 14.8 ± 2.9 | 1.1 ± 0.2 |

Table 12. Groundwater Tritium Monitoring Program
(Monthly Collections)
Units = pCi/L

## Intermittent Streams

| Sample ID | GW-01 | | | Sample ID | GW-02 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 01-24-24 | EWW- 98 | 75 ± 85 | < 171 | 01-31-24 | EWW- 148 | 262 ± 94 | < 170 |
| 02-21-24 | EWW- 276 | 90 ± 94 | < 179 | 02-21-24 | EWW- 277 | 310 ± 104 | < 179 |
| 03-28-24 | EWW- 546 | 65 ± 85 | < 175 | 03-28-24 | EWW- 547 | 82 ± 86 | < 175 |
| 04-17-24 | EWW- 821 | 72 ± 83 | < 170 | 04-17-24 | EWW- 822 | 81 ± 84 | < 170 |
| 05-14-24 | EWW- 1130 | 82 ± 97 | < 188 | 05-14-24 | EWW- 1131 | 153 ± 101 | < 188 |
| 06-18-24 | EWW- 1372 | -22 ± 84 | < 185 | 06-18-24 | EWW- 1373 | 146 ± 94 | < 185 |
| 07-18-24 | EWW- 1695 | 20 ± 86 | < 177 | 07-18-24 | EWW- 1696 | 242 ± 98 | < 177 |
| 08-22-24 | EWW- 1988 | -28 ± 85 | < 183 | 08-22-24 | EWW- 1989 | 114 ± 92 | < 183 |
| 09-19-24 | EWW- 2226 | 93 ± 90 | < 180 | 09-19-24 | EWW- 2227 | 302 ± 100 | < 180 |
| 10-16-24 | | NF[a] | | 10-16-24 | | NF[a] | |
| 11-20-24 | EWW- 2937 | 78 ± 91 | < 185 | 11-20-24 | EWW- 2938 | 114 ± 93 | < 185 |
| 12-27-24 | | NF[a] | | 12-27-24 | | NF[a] | |
| Mean ± s.d. | | 53 ± 46 | | Mean ± s.d. | | 181 ± 89 | |

| Sample ID | GW-03 | | | Sample ID | GW-17 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 01-31-24 | EWW- 146 | 5 ± 80 | < 170 | 01-24-24 | EWW- 99 | 250 ± 94 | < 171 |
| 02-21-24 | EWW- 278 | 59 ± 92 | < 179 | 02-21-24 | EWW- 280 | 343 ± 106 | < 179 |
| 03-28-24 | EWW- 548 | 130 ± 88 | < 175 | 03-28-24 | EWW- 550 | 221 ± 93 | < 175 |
| 04-17-24 | EWW- 823 | 86 ± 84 | < 170 | 04-17-24 | EWW- 825 | 431 ± 102 | < 170 |
| 05-14-24 | EWW- 1132 | 22 ± 92 | < 188 | 05-14-24 | EWW- 1134 | 302 ± 106 | < 188 |
| 06-18-24 | EWW- 1374 | 119 ± 92 | < 185 | 06-18-24 | EWW- 1375 | 474 ± 110 | < 185 |
| 07-18-24 | EWW- 1697 | 29 ± 87 | < 177 | 07-18-24 | EWW- 1699 | 224 ± 97 | < 177 |
| 08-22-24 | EWW- 1990 | -1 ± 86 | < 183 | 08-22-24 | EWW- 1991 | 217 ± 98 | < 183 |
| 09-19-24 | EWW- 2229 | 76 ± 89 | < 180 | 09-19-24 | EWW- 2230 | 161 ± 93 | < 180 |
| 10-16-24 | | NF[a] | | 10-16-24 | | NF[a] | |
| 11-20-24 | EWW- 2939 | -10 ± 86 | < 185 | 11-20-24 | EWW- 2941 | 131 ± 94 | < 185 |
| 12-27-24 | | NF[a] | | 12-27-24 | | NF[a] | |
| Mean ± s.d. | | 51 ± 50 | | Mean ± s.d. | | 275 ± 112 | |

[a] "NF" = No flow.

## Wells

| Sample ID | GW-04 (EIC Well) | | |
|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC |
| 01-17-24 | EWW- 70 | 87 ± 84 | < 168 |
| 02-21-24 | EWW- 279 | -18 ± 88 | < 179 |
| 03-28-24 | EWW- 549 | 49 ± 84 | < 175 |
| 04-17-24 | EWW- 826 | -2 ± 79 | < 170 |
| 05-14-24 | | NS[a] | |
| 06-18-24 | EWW- 1376 | -39 ± 83 | < 185 |
| 07-18-24 | EWW- 1698 | -51 ± 82 | < 177 |
| 08-21-24 | EWW- 1987 | 57 ± 88 | < 181 |
| 09-19-24 | EWW- 2231 | -4 ± 84 | < 180 |
| 10-16-24 | EWW- 2559 | 4 ± 82 | < 177 |
| 11-20-24 | EWW- 2940 | -127 ± 79 | < 185 |
| 12-27-24 | EWW- 3175 | -37 ± 85 | < 182 |
| Mean ± s.d. | | -7 ± 59 | |

[a] "NS" = Water outage at the facility.

Table 12. Groundwater Tritium Monitoring Program
(Monthly Collections)
Units = pCi/L

## Beach Drains

| Sample ID | S-1 | | | | S-3 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 01-03-24 | ESW- 15 | 436 ± 102 | < 170 | 01-03-24 | ESW- 16 | 42 ± 81 | < 170 |
| 02-07-24 | ESW- 218 | 358 ± 99 | < 170 | 02-07-24 | ESW- 219 | 207 ± 91 | < 170 |
| 03-07-24 | ESW- 419 | 394 ± 104 | < 175 | 03-07-24 | ESW- 420 | 115 ± 90 | < 175 |
| 04-02-24 | ESW- 623 | 392 ± 102 | < 175 | 04-02-24 | [b] ESW- 624 | 1174 ± 133 | < 175 |
| 05-02-24 | ESW- 1029 | 321 ± 99 | < 174 | 05-05-24 | ESW- 1030 | 141 ± 90 | < 174 |
| 06-06-24 | ESW- 1304 | 163 ± 94 | < 183 | 06-06-24 | ESW- 1305 | 326 ± 102 | < 183 |
| 07-01-24 | ESW- 1487 | 243 ± 98 | < 183 | 07-01-24 | ESW- 1488 | 91 ± 90 | < 183 |
| 08-07-24 | EWW- 1898 | 156 ± 95 | < 181 | 08-07-24 | ESW- 1899 | 190 ± 97 | < 181 |
| 09-10-24 | EWW- 2122 | 268 ± 100 | < 183 | 09-10-24 | ESW- 2123 | 180 ± 96 | < 183 |
| 09-30-24 | EWW- 2302 | 275 ± 104 | < 181 | 09-30-24 | ESW- 2303 | 164 ± 98 | < 181 |
| 11-05-24 | EWW- 2815 | 266 ± 100 | < 185 | 11-05-24 | ESW- 2817 | 368 ± 105 | < 185 |
| 12-04-24 | EWW- 3044 | 146 ± 93 | < 183 | 12-04-24 | EWW- 3045 | 95 ± 90 | < 183 |
| Mean ± s.d. | | 285 ± 98 | | Mean ± s.d. | | 258 ± 303 | |

[b] Tritium > 1000 pCi/L. Additional analyses in app. F.

| Sample ID | S-7 | | | | S-8 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 01-03-24 | | NF[a] | | 01-03-24 | | NF[a] | |
| 02-07-24 | | NF[a] | | 02-07-24 | | NF[a] | |
| 03-07-24 | | NF[a] | | 03-07-24 | | NF[a] | |
| 04-02-24 | | NF[a] | | 04-02-24 | | NF[a] | |
| 05-02-24 | | NF[a] | | 05-02-24 | | NF[a] | |
| 06-06-24 | | NF[a] | | 06-06-24 | | NF[a] | |
| 07-01-24 | | NF[a] | | 07-01-24 | | NF[a] | |
| 08-07-24 | | NF[a] | | 08-07-24 | | NF[a] | |
| 09-10-24 | | NF[a] | | 09-10-24 | | NF[a] | |
| 09-30-24 | | NF[a] | | 09-30-24 | | NF[a] | |
| 11-05-24 | | NF[a] | | 11-05-24 | ESW- 2818 | 387 ± 106 | < 185 |
| 12-04-24 | | NF[a] | | 12-04-24 | | NF[a] | |
| Mean ± s.d. | | | | Mean ± s.d. | | | |

| Sample ID | S-9 | | | | S-10 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 01-03-24 | | NF[a] | | 01-03-24 | | NF[a] | |
| 02-07-24 | | NF[a] | | 02-07-24 | | NF[a] | |
| 03-07-24 | | NF[a] | | 03-07-24 | | NF[a] | |
| 04-02-24 | ESW- 628 | 108 ± 91 | < 175 | 04-02-24 | ESW- 626 | 185 ± 91 | < 175 |
| 05-02-24 | | NF[a] | | 05-02-24 | | NF[a] | |
| 06-06-24 | | NF[a] | | 06-06-24 | | NF[a] | |
| 07-01-24 | | NF[a] | | 07-01-24 | | NF[a] | |
| 08-07-24 | | NF[a] | | 08-07-24 | | NF[a] | |
| 09-10-24 | | NF[a] | | 09-10-24 | | NF[a] | |
| 09-30-24 | | NF[a] | | 09-30-24 | | NF[a] | |
| 11-05-24 | | NF[a] | | 11-05-24 | | NF[a] | |
| 12-04-24 | | NF[a] | | 12-04-24 | | NF[a] | |
| Mean ± s.d. | | | | Mean ± s.d. | | | |

[a] "NF" = No flow.

Table 12. Groundwater Tritium Monitoring Program
(Monthly Collections)
Units = pCi/L

## Beach Drains (cont.)

| Sample ID | S-12 | | | | S-13 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 01-03-24 | EWW- 17 | 247 ± 93 | < 170 | 01-03-24 | | NF[a] | |
| 02-07-24 | EWW- 220 | 193 ± 91 | < 170 | 02-07-24 | | NF[a] | |
| 03-07-24 | EWW- 421 | 181 ± 94 | < 175 | 03-07-24 | | NF[a] | |
| 04-02-24 | EWW- 627 | 213 ± 93 | < 175 | 04-02-24 | | NF[a] | |
| 05-02-24 | EWW- 1031 | 283 ± 97 | < 174 | 05-02-24 | | NF[a] | |
| 06-06-24 | EWW- 1306 | 203 ± 96 | < 183 | 06-06-24 | | NF[a] | |
| 07-01-24 | EWW- 1489 | 170 ± 94 | < 183 | 07-01-24 | | NF[a] | |
| 08-07-24 | EWW- 1900 | 117 ± 93 | < 181 | 08-07-24 | | NF[a] | |
| 09-10-24 | EWW- 2124 | 87 ± 91 | < 183 | 09-10-24 | | NF[a] | |
| 09-30-24 | | NF[a] | | 09-30-24 | | NF[a] | |
| 11-05-24 | EWW- 2819 | 156 ± 94 | < 185 | 11-05-24 | | NF[a] | |
| 12-04-24 | EWW- 3046 | 109 ± 91 | < 183 | 12-04-24 | | NF[a] | |
| Mean ± s.d. | | 178 ± 59 | | Mean ± s.d. | | | |

## U2 Façade Subsurface Drain Sump

| Sample ID | U2 Façade Subsurface Drain Sump | | |
|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC |
| 01-31-24 | EW- 227 | 924 ± 123 | < 170 |
| 02-28-24 | EW- 359 | 910 ± 125 | < 175 |
| 03-31-24 | EW- 738 | 1214 ± 135 | < 175 |
| 04-30-24 | EW- 1129 | 900 ± 134 | < 188 |
| 05-31-24 | EW- 1319 | 826 ± 125 | < 185 |
| 06-30-24 | EW- 1680 | 1062 ± 133 | < 177 |
| 07-31-24 | EW- 2002 | 940 ± 131 | < 171 |
| 08-31-24 | EW- 2248 | 815 ± 126 | < 180 |
| 09-30-24 | EW- 2429 | 687 ± 122 | < 181 |
| 10-31-24 | EW- 2964 | 1386 ± 145 | < 185 |
| 11-30-24 | EW- 3139 | 838 ± 126 | < 183 |
| 12-31-24 | EW- 3313 | 787 ± 138 | < 177 |
| Mean ± s.d. | | 941 ± 195 | |

[a] "NF" = No flow.

## POINT BEACH NUCLEAR PLANT

**Beach Drains**

Units: = pCi/L | Gamma isotopic analysis

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 01-03-24 | | 01-03-24 | | 01-03-24 | | 01-03-24 | |
| Lab Code | EW- 15 | MDC | EW- 16 | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | 5.4 ± 9.3 | < 21.1 | -2.9 ± 9.2 | < 18.5 | - | | - | |
| Mn-54 | 1.3 ± 1.3 | < 2.0 | 0.1 ± 1.2 | < 1.3 | - | | - | |
| Fe-59 | 0.5 ± 2.4 | < 4.6 | 0.0 ± 2.4 | < 3.9 | - | | - | |
| Co-58 | 0.0 ± 1.2 | < 1.7 | -1.2 ± 1.4 | < 1.8 | - | | - | |
| Co-60 | 0.6 ± 1.4 | < 1.8 | 0.4 ± 1.5 | < 2.3 | - | | - | |
| Zn-65 | -0.9 ± 2.7 | < 2.3 | -0.9 ± 3.4 | < 5.0 | - | | - | |
| Zr-Nb-95 | -0.2 ± 1.5 | < 1.6 | 1.2 ± 1.6 | < 2.7 | - | | - | |
| Cs-134 | -0.7 ± 1.3 | < 2.4 | 0.2 ± 1.3 | < 2.4 | - | | - | |
| Cs-137 | 0.9 ± 1.5 | < 2.8 | 0.5 ± 1.4 | < 2.7 | - | | - | |
| Ba-La-140 | 0.2 ± 1.2 | < 2.3 | 0.9 ± 1.6 | < 2.5 | - | | - | |

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 01-03-24 | | 01-03-24 | | 01-03-24 | | 01-03-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 17 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | -11.9 ± 9.9 | < 15.7 | - | |
| Mn-54 | - | | - | | 0.3 ± 1.7 | < 3.3 | - | |
| Fe-59 | - | | - | | 2.2 ± 2.5 | < 4.5 | - | |
| Co-58 | - | | - | | 0.7 ± 1.4 | < 2.5 | - | |
| Co-60 | - | | - | | -1.3 ± 1.5 | < 1.6 | - | |
| Zn-65 | - | | - | | -2.1 ± 2.3 | < 3.8 | - | |
| Zr-Nb-95 | - | | - | | -2.5 ± 1.5 | < 1.5 | - | |
| Cs-134 | - | | - | | 0.4 ± 1.4 | < 2.4 | - | |
| Cs-137 | - | | - | | -0.5 ± 1.6 | < 1.7 | - | |
| Ba-La-140 | - | | - | | 0.1 ± 1.6 | < 4.1 | - | |

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 02-07-24 | | 02-07-24 | | 02-07-24 | | 02-07-24 | |
| Lab Code | EW- 218 | MDC | EW- 219 | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | 5.8 ± 4.7 | < 9.9 | -2.4 ± 4.3 | < 7.7 | - | | - | |
| Mn-54 | -0.4 ± 0.6 | < 1.1 | -0.1 ± 0.7 | < 1.0 | - | | - | |
| Fe-59 | 0.3 ± 1.1 | < 2.1 | -1.3 ± 1.1 | < 1.3 | - | | - | |
| Co-58 | -0.4 ± 0.6 | < 1.2 | -0.2 ± 0.6 | < 1.2 | - | | - | |
| Co-60 | 0.0 ± 0.7 | < 0.8 | 0.0 ± 0.7 | < 1.0 | - | | - | |
| Zn-65 | 0.3 ± 1.2 | < 2.7 | -0.8 ± 1.3 | < 2.0 | - | | - | |
| Zr-Nb-95 | -1.2 ± 0.7 | < 1.2 | -1.2 ± 0.7 | < 1.3 | - | | - | |
| Cs-134 | -0.9 ± 0.6 | < 1.1 | -0.6 ± 0.6 | < 1.1 | - | | - | |
| Cs-137 | 0.2 ± 0.7 | < 1.4 | 0.6 ± 0.7 | < 1.5 | - | | - | |
| Ba-La-140 | -0.3 ± 0.7 | < 1.3 | -0.3 ± 0.8 | < 1.4 | - | | - | |

[a] "NF" = No flow.

**Beach Drains (cont.)**

Units: = pCi\L | Gamma isotopic analysis

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 02-07-24 | | 02-07-24 | | 02-07-24 | | 02-07-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 220 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | -1.1 ± 8.2 | < 18.6 | - | |
| Mn-54 | - | | - | | 0.7 ± 1.2 | < 1.5 | - | |
| Fe-59 | - | | - | | -0.6 ± 1.9 | < 2.2 | - | |
| Co-58 | - | | - | | 0.4 ± 1.2 | < 1.9 | - | |
| Co-60 | - | | - | | 0.1 ± 1.3 | < 1.8 | - | |
| Zn-65 | - | | - | | -2.3 ± 2.5 | < 3.1 | - | |
| Zr-Nb-95 | - | | - | | -1.3 ± 1.3 | < 1.6 | - | |
| Cs-134 | - | | - | | 0.3 ± 1.1 | < 1.9 | - | |
| Cs-137 | - | | - | | 0.4 ± 1.4 | < 2.3 | - | |
| Ba-La-140 | - | | - | | -0.4 ± 1.3 | < 2.1 | - | |

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 03-07-24 | | 03-07-24 | | 03-07-24 | | 03-07-24 | |
| Lab Code | EW- 419 | MDC | EW- 420 | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | 3.3 ± 21.9 | < 39.4 | -2.9 ± 9.4 | < 16.9 | - | < | - | |
| Mn-54 | 1.9 ± 2.5 | < 4.5 | -0.6 ± 1.3 | < 1.1 | - | < | - | |
| Fe-59 | -0.4 ± 4.6 | < 5.0 | 0.3 ± 2.2 | < 2.4 | - | < | - | |
| Co-58 | 3.5 ± 2.3 | < 3.2 | -0.4 ± 1.2 | < 2.2 | - | < | - | |
| Co-60 | 0.7 ± 2.5 | < 2.7 | -0.6 ± 1.3 | < 2.1 | - | < | - | |
| Zn-65 | -9.1 ± 6.5 | < 7.2 | 0.6 ± 2.3 | < 3.4 | - | < | - | |
| Zr-Nb-95 | -1.5 ± 2.7 | < 3.3 | -0.7 ± 1.3 | < 2.1 | - | < | - | |
| Cs-134 | -2.7 ± 2.8 | < 5.4 | 0.9 ± 1.2 | < 2.3 | - | < | - | |
| Cs-137 | 0.8 ± 2.9 | < 4.2 | -0.8 ± 1.3 | < 2.0 | - | < | - | |
| Ba-La-140 | 1.2 ± 2.9 | < 2.6 | 0.1 ± 1.3 | < 1.7 | - | < | - | |

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 03-07-24 | | 03-07-24 | | 03-07-24 | | 03-07-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 421 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | -1.5 ± 7.9 | < 15.2 | - | |
| Mn-54 | - | | - | | -0.7 ± 1.3 | < 1.2 | - | |
| Fe-59 | - | | - | | -2.4 ± 2.3 | < 2.2 | - | |
| Co-58 | - | | - | | 0.1 ± 1.3 | < 2.2 | - | |
| Co-60 | - | | - | | 0.1 ± 1.5 | < 2.5 | - | |
| Zn-65 | - | | - | | -1.4 ± 2.8 | < 4.0 | - | |
| Zr-Nb-95 | - | | - | | -2.6 ± 1.4 | < 2.6 | - | |
| Cs-134 | - | | - | | 0.6 ± 1.2 | < 2.1 | - | |
| Cs-137 | - | | - | | 0.8 ± 1.4 | < 3.0 | - | |
| Ba-La-140 | - | | - | | -0.4 ± 1.2 | < 2.1 | - | |

[a] "NF" = No flow.

POINT BEACH NUCLEAR PLANT

**Beach Drains (cont.)**

Units: = pCi\L | Gamma isotopic analysis

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 04-02-24 | | 04-02-24 | | 04-02-24 | | 04-02-24 | |
| Lab Code | EW- 623 | MDC | EW- 624 | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | -7.4 ± 6.5 | < 10.3 | 14.6 ± 24.2 | < 46.0 | - | | - | |
| Mn-54 | -0.7 ± 1.0 | < 1.1 | -1.0 ± 2.8 | < 4.7 | - | | - | |
| Fe-59 | 0.1 ± 1.6 | < 2.8 | -1.6 ± 6.2 | < 9.1 | - | | - | |
| Co-58 | 0.5 ± 0.8 | < 1.8 | -2.0 ± 2.6 | < 3.1 | - | | - | |
| Co-60 | 0.4 ± 1.0 | < 1.7 | 0.1 ± 2.6 | < 3.0 | - | | - | |
| Zn-65 | -2.2 ± 1.8 | < 2.9 | -1.2 ± 5.7 | < 6.7 | - | | - | |
| Zr-Nb-95 | -1.4 ± 0.9 | < 1.7 | 0.4 ± 2.8 | < 4.4 | - | | - | |
| Cs-134 | 0.2 ± 0.9 | < 1.6 | -2.3 ± 2.4 | < 5.0 | - | | - | |
| Cs-137 | -0.1 ± 1.0 | < 1.8 | -2.2 ± 2.5 | < 2.1 | - | | - | |
| Ba-La-140 | 1.0 ± 1.0 | < 2.6 | -2.8 ± 3.5 | < 5.2 | - | | - | |

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 04-02-24 | | 04-02-24 | | 04-02-24 | | 04-02-24 | |
| Lab Code | EW- 628 | MDC | EW- 626 | MDC | EW- 627 | MDC | NF[a] | MDC |
| Be-7 | 17.3 ± 10.4 | < 19.5 | 16.3 ± 9.0 | < 18.0 | -3.7 ± 9.0 | < 16.0 | - | |
| Mn-54 | 1.7 ± 1.4 | < 2.5 | 0.4 ± 1.0 | < 1.7 | -0.6 ± 1.3 | < 2.3 | - | |
| Fe-59 | 2.3 ± 2.3 | < 4.4 | -1.1 ± 1.9 | < 3.9 | 1.5 ± 2.2 | < 4.6 | - | |
| Co-58 | -0.5 ± 1.4 | < 1.7 | 1.3 ± 1.1 | < 2.1 | -0.4 ± 1.2 | < 1.9 | - | |
| Co-60 | 1.7 ± 1.2 | < 1.8 | 1.3 ± 1.3 | < 1.9 | -0.5 ± 1.4 | < 1.8 | - | |
| Zn-65 | 0.6 ± 2.3 | < 2.5 | -2.4 ± 2.5 | < 3.3 | -0.2 ± 2.0 | < 2.7 | - | |
| Zr-Nb-95 | -0.4 ± 1.3 | < 2.0 | -2.3 ± 1.2 | < 1.6 | 0.9 ± 1.2 | < 2.7 | - | |
| Cs-134 | -0.7 ± 1.2 | < 2.0 | -0.2 ± 1.0 | < 1.9 | -0.6 ± 1.3 | < 2.3 | - | |
| Cs-137 | 2.0 ± 1.4 | < 2.5 | -0.2 ± 1.2 | < 2.1 | 0.3 ± 1.5 | < 2.4 | - | |
| Ba-La-140 | -0.6 ± 1.3 | < 2.8 | -0.7 ± 1.3 | < 2.2 | -0.4 ± 1.5 | < 2.9 | - | |

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 05-02-24 | | 05-02-24 | | 05-02-24 | | 05-02-24 | |
| Lab Code | EW- 1029 | MDC | EW- 1030 | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | 0.8 ± 15.3 | < 28.4 | 12.7 ± 24.6 | < 38.8 | - | | - | |
| Mn-54 | 0.4 ± 1.7 | < 2.7 | -2.1 ± 3.1 | < 4.4 | - | | - | |
| Fe-59 | -0.7 ± 3.3 | < 5.4 | 4.6 ± 6.2 | < 8.5 | - | | - | |
| Co-58 | -1.1 ± 1.6 | < 2.3 | -0.9 ± 3.0 | < 5.1 | - | | - | |
| Co-60 | 2.1 ± 1.9 | < 3.3 | 0.4 ± 3.4 | < 2.8 | - | | - | |
| Zn-65 | -1.1 ± 3.5 | < 4.2 | -1.8 ± 6.6 | < 6.3 | - | | - | |
| Zr-Nb-95 | -2.6 ± 1.8 | < 2.0 | 0.1 ± 3.3 | < 6.2 | - | | - | |
| Cs-134 | 0.3 ± 1.6 | < 3.1 | -1.9 ± 2.9 | < 5.8 | - | | - | |
| Cs-137 | 2.1 ± 2.0 | < 3.9 | 3.0 ± 3.4 | < 5.6 | - | | - | |
| Ba-La-140 | -0.7 ± 1.3 | < 1.6 | 1.1 ± 3.4 | < 2.6 | - | | - | |

[a] "NF" = No flow.

Beach Drains (cont.)

Units: = pCi\L

Gamma isotopic analysis

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 05-02-24 | | 05-02-24 | | 05-02-24 | | 05-02-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 1031 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | 4.2 ± 10.8 | < 24.2 | - | |
| Mn-54 | - | | - | | -0.6 ± 1.3 | < 2.3 | - | |
| Fe-59 | - | | - | | 3.1 ± 2.6 | < 4.7 | - | |
| Co-58 | - | | - | | 1.3 ± 1.3 | < 2.7 | - | |
| Co-60 | - | | - | | 0.5 ± 1.4 | < 1.3 | - | |
| Zn-65 | - | | - | | -4.2 ± 2.8 | < 2.8 | - | |
| Zr-Nb-95 | - | | - | | 0.3 ± 1.5 | < 2.7 | - | |
| Cs-134 | - | | - | | 0.0 ± 1.4 | < 2.6 | - | |
| Cs-137 | - | | - | | -0.4 ± 1.6 | < 2.4 | - | |
| Ba-La-140 | - | | - | | -1.0 ± 1.6 | < 2.8 | - | |

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 06-06-24 | | 06-06-24 | | 06-06-24 | | 06-06-24 | |
| Lab Code | EW- 1304 | MDC | EW- 1305 | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | 0.1 ± 10.1 | < 13.4 | -2.7 ± 8.2 | < | - | | - | |
| Mn-54 | 0.3 ± 1.3 | < 2.3 | 1.0 ± 1.1 | < | - | | - | |
| Fe-59 | 1.0 ± 2.6 | < 3.5 | -0.4 ± 2.2 | < | - | | - | |
| Co-58 | -0.6 ± 1.3 | < 1.2 | -0.4 ± 1.1 | < | - | | - | |
| Co-60 | -0.3 ± 1.3 | < 1.3 | -0.8 ± 1.1 | < | - | | - | |
| Zn-65 | -3.9 ± 3.0 | < 2.5 | -2.6 ± 2.3 | < | - | | - | |
| Zr-Nb-95 | -0.1 ± 1.3 | < 2.3 | -0.2 ± 1.1 | < | - | | - | |
| Cs-134 | -1.0 ± 1.2 | < 2.5 | -0.4 ± 1.0 | < | - | | - | |
| Cs-137 | 0.5 ± 1.4 | < 3.0 | -0.7 ± 1.2 | < | - | | - | |
| Ba-La-140 | -0.1 ± 1.5 | < 1.5 | -2.6 ± 1.4 | < | - | | - | |

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 06-06-24 | | 06-06-24 | | 06-06-24 | | 06-06-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 1306 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | -0.8 ± 3.6 | < 7.3 | - | |
| Mn-54 | - | | - | | 0.0 ± 0.5 | < 1.0 | - | |
| Fe-59 | - | | - | | -0.5 ± 0.9 | < 2.0 | - | |
| Co-58 | - | | - | | -0.1 ± 0.5 | < 0.9 | - | |
| Co-60 | - | | - | | 0.6 ± 0.5 | < 1.0 | - | |
| Zn-65 | - | | - | | 0.3 ± 0.9 | < 1.5 | - | |
| Zr-Nb-95 | - | | - | | -1.4 ± 0.5 | < 1.0 | - | |
| Cs-134 | - | | - | | -0.4 ± 0.5 | < 0.9 | - | |
| Cs-137 | - | | - | | 0.1 ± 0.5 | < 0.8 | - | |
| Ba-La-140 | - | | - | | 0.1 ± 0.5 | < 0.9 | - | |

[a] "NF" = No flow.

Beach Drains (cont.)

Units: = pCi\L

Gamma isotopic analysis

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 07-01-24 | | 07-01-24 | | 07-01-24 | | 07-01-24 | |
| Lab Code | EW- 1487 | MDC | EW- 1488 | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | -12.1 ± 24.7 | < 32.8 | 0.7 ± 10.9 | < 19.6 | - | | - | |
| Mn-54 | 0.4 ± 3.4 | < 6.4 | -0.1 ± 1.4 | < 2.1 | - | | - | |
| Fe-59 | 0.5 ± 4.9 | < 5.0 | -0.2 ± 3.0 | < 4.8 | - | | - | |
| Co-58 | 0.3 ± 3.2 | < 4.5 | -0.9 ± 1.4 | < 2.0 | - | | - | |
| Co-60 | -4.1 ± 3.6 | < 3.0 | 0.2 ± 1.6 | < 2.8 | - | | - | |
| Zn-65 | 2.7 ± 9.0 | < 8.4 | 0.1 ± 2.6 | < 2.2 | - | | - | |
| Zr-Nb-95 | -2.3 ± 3.2 | < 4.8 | -0.5 ± 1.5 | < 2.5 | - | | - | |
| Cs-134 | -1.6 ± 3.0 | < 5.6 | 0.0 ± 1.4 | < 2.8 | - | | - | |
| Cs-137 | -0.6 ± 3.4 | < 4.0 | 0.1 ± 1.7 | < 2.5 | - | | - | |
| Ba-La-140 | -1.7 ± 2.5 | < 2.2 | 1.3 ± 1.7 | < 2.8 | - | | - | |

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 07-01-24 | | 07-01-24 | | 07-01-24 | | 07-01-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 1489 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | -3.7 ± 8.9 | < 16.3 | - | |
| Mn-54 | - | | - | | 0.9 ± 1.3 | < 1.4 | - | |
| Fe-59 | - | | - | | -0.2 ± 2.7 | < 3.7 | - | |
| Co-58 | - | | - | | -0.2 ± 1.4 | < 2.0 | - | |
| Co-60 | - | | - | | 0.9 ± 1.2 | < 2.0 | - | |
| Zn-65 | - | | - | | -2.2 ± 3.0 | < 3.6 | - | |
| Zr-Nb-95 | - | | - | | -1.7 ± 1.7 | < 2.2 | - | |
| Cs-134 | - | | - | | 0.0 ± 1.5 | < 2.4 | - | |
| Cs-137 | - | | - | | 0.5 ± 1.7 | < 3.3 | - | |
| Ba-La-140 | - | | - | | -1.9 ± 1.6 | < 2.5 | - | |

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 08-07-24 | MDC | 08-07-24 | MDC | 08-07-24 | MDC | 08-07-24 | MDC |
| Lab Code | EW- 1898 | | EW- 1899 | | NF[a] | | NF[a] | |
| Be-7 | -6.1 ± 9.0 | < 18.0 | 14.2 ± 8.2 | < 19.7 | - | | - | |
| Mn-54 | -0.8 ± 1.3 | < 2.1 | 0.4 ± 1.3 | < 1.9 | - | | - | |
| Fe-59 | -1.1 ± 2.2 | < 3.6 | -0.1 ± 2.2 | < 3.0 | - | | - | |
| Co-58 | -0.3 ± 1.1 | < 1.6 | 1.0 ± 1.1 | < 2.2 | - | | - | |
| Co-60 | 0.3 ± 1.2 | < 1.7 | 1.2 ± 1.5 | < 2.8 | - | | - | |
| Zn-65 | -1.6 ± 2.1 | < 3.1 | 1.1 ± 2.3 | < 3.0 | - | | - | |
| Zr-Nb-95 | -2.0 ± 1.3 | < 1.8 | 0.6 ± 1.2 | < 2.0 | - | | - | |
| Cs-134 | 0.0 ± 1.1 | < 2.0 | 0.0 ± 1.1 | < 2.1 | - | | - | |
| Cs-137 | 0.6 ± 1.4 | < 2.3 | -0.1 ± 1.3 | < 2.4 | - | | - | |
| Ba-La-140 | -0.8 ± 1.2 | < 2.2 | 0.1 ± 3.4 | < 3.7 | - | | - | |

[a] "NF" = No flow.

## POINT BEACH NUCLEAR PLANT

Beach Drains (cont.)

Units: = pCi\L

Gamma isotopic analysis

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 08-07-24 | | 08-07-24 | | 08-07-24 | | 08-07-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 1900 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | 0.5 ± 10.1 | < 21.3 | - | |
| Mn-54 | - | | - | | -0.5 ± 1.1 | < 1.7 | - | |
| Fe-59 | - | | - | | -1.6 ± 2.3 | < 3.8 | - | |
| Co-58 | - | | - | | 0.6 ± 1.1 | < 2.4 | - | |
| Co-60 | - | | - | | 1.9 ± 1.3 | < 2.5 | - | |
| Zn-65 | - | | - | | 1.9 ± 2.4 | < 4.8 | - | |
| Zr-Nb-95 | - | | - | | -0.7 ± 1.1 | < 1.3 | - | |
| Cs-134 | - | | - | | 0.4 ± 1.1 | < 2.2 | - | |
| Cs-137 | - | | - | | 2.0 ± 1.4 | < 2.6 | - | |
| Ba-La-140 | - | | - | | -1.9 ± 1.2 | < 1.5 | - | |

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 09-10-24 | | 09-10-24 | | 09-10-24 | | 09-10-24 | |
| Lab Code | EW- 2122 | MDC | EW- 2123 | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | -9.9 ± 22.9 | < 28.0 | -4.8 ± 11.3 | < 20.7 | - | | - | |
| Mn-54 | -0.1 ± 3.1 | < 3.7 | 1.1 ± 1.4 | < 2.3 | - | | - | |
| Fe-59 | -5.1 ± 6.1 | < 5.5 | 0.4 ± 2.6 | < 2.9 | - | | - | |
| Co-58 | 0.2 ± 2.8 | < 4.4 | -0.5 ± 1.4 | < 1.4 | - | | - | |
| Co-60 | 2.2 ± 2.5 | < 4.3 | 0.4 ± 1.4 | < 2.0 | - | | - | |
| Zn-65 | -3.0 ± 7.0 | < 4.8 | 0.5 ± 2.8 | < 3.8 | - | | - | |
| Zr-Nb-95 | 1.7 ± 2.8 | < 5.2 | -0.1 ± 1.7 | < 2.9 | - | | - | |
| Cs-134 | 0.4 ± 2.9 | < 5.3 | -0.3 ± 1.4 | < 2.5 | - | | - | |
| Cs-137 | 0.5 ± 2.9 | < 4.4 | -0.2 ± 1.6 | < 3.0 | - | | - | |
| Ba-La-140 | -3.6 ± 3.1 | < 4.1 | -1.1 ± 1.7 | < 3.5 | - | | - | |

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 09-10-24 | | 09-10-24 | | 09-10-24 | | 09-10-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 2124 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | 9.3 ± 9.1 | < 20.7 | - | |
| Mn-54 | - | | - | | -0.8 ± 1.4 | < 1.4 | - | |
| Fe-59 | - | | - | | 0.6 ± 2.7 | < 4.1 | - | |
| Co-58 | - | | - | | -0.6 ± 1.3 | < 1.8 | - | |
| Co-60 | - | | - | | 0.7 ± 1.4 | < 1.3 | - | |
| Zn-65 | - | | - | | -1.6 ± 2.6 | < 4.0 | - | |
| Zr-Nb-95 | - | | - | | -1.1 ± 1.4 | < 1.1 | - | |
| Cs-134 | - | | - | | -0.3 ± 1.3 | < 2.2 | - | |
| Cs-137 | - | | - | | 0.4 ± 1.5 | < 2.4 | - | |
| Ba-La-140 | - | | - | | -0.4 ± 1.6 | < 2.8 | - | |

[a] "NF" = No flow.

POINT BEACH NUCLEAR PLANT

Beach Drains (cont.)

Units: = pCi\L

Gamma isotopic analysis

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 09-30-24 | | 09-30-24 | | 09-30-24 | | 09-30-24 | |
| Lab Code | EW- 2302 | MDC | NF[a] | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | 0.7 ± 9.8 | < 22.8 | - | | - | | - | |
| Mn-54 | 0.1 ± 1.4 | < 2.3 | - | | - | | - | |
| Fe-59 | 0.8 ± 2.5 | < 4.6 | - | | - | | - | |
| Co-58 | -0.5 ± 1.3 | < 2.1 | - | | - | | - | |
| Co-60 | 0.6 ± 1.6 | < 1.8 | - | | - | | - | |
| Zn-65 | -0.3 ± 2.6 | < 3.7 | - | | - | | - | |
| Zr-Nb-95 | -0.6 ± 1.5 | < 2.5 | - | | - | | - | |
| Cs-134 | -0.3 ± 1.3 | < 2.4 | - | | - | | - | |
| Cs-137 | -0.4 ± 1.4 | < 2.0 | - | | - | | - | |
| Ba-La-140 | -1.4 ± 4.2 | < 2.9 | - | | - | | - | |

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 09-30-24 | | 09-30-24 | | 09-30-24 | | 09-30-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 2303 [b] | MDC | NF[a] | MDC |
| Be-7 | - | | - | | - | | - | |
| Mn-54 | - | | - | | - | | - | |
| Fe-59 | - | | - | | - | | - | |
| Co-58 | - | | - | | - | | - | |
| Co-60 | - | | - | | - | | - | |
| Zn-65 | - | | - | | - | | - | |
| Zr-Nb-95 | - | | - | | - | | - | |
| Cs-134 | - | | - | | - | | - | |
| Cs-137 | - | | - | | - | | - | |
| Ba-La-140 | - | | - | | - | | - | |

| Location | S-1 | MDC | S-3 | MDC | S-7 | MDC | S-8 | MDC |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 11-05-24 | | 11-05-24 | | 11-05-24 | | 11-05-24 | |
| Lab Code | EW- 2815 | | EW- 2817 | | NF[a] | | EW- 2818 | |
| Be-7 | 8.6 ± 20.4 | < 39.4 | 8.3 ± 14.7 | < 26.4 | - | | 25.4 ± 29.3 | < 27.3 |
| Mn-54 | -1.2 ± 2.0 | < 2.7 | 1.3 ± 1.7 | < 3.1 | - | | -1.0 ± 4.3 | < 7.4 |
| Fe-59 | 2.7 ± 3.7 | < 5.2 | -1.8 ± 3.5 | < 5.7 | - | | -3.8 ± 7.0 | < 5.1 |
| Co-58 | -0.8 ± 2.1 | < 3.4 | -0.3 ± 1.4 | < 1.2 | - | | -3.0 ± 3.7 | < 3.8 |
| Co-60 | 1.5 ± 2.5 | < 4.1 | 0.6 ± 1.9 | < 2.5 | - | | -0.9 ± 3.8 | < 5.3 |
| Zn-65 | -4.4 ± 5.6 | < 6.6 | 1.3 ± 3.4 | < 5.9 | - | | -17.9 ± 12.2 | < 9.9 |
| Zr-Nb-95 | -3.1 ± 2.5 | < 2.4 | -1.8 ± 2.4 | < 3.1 | - | | -1.0 ± 4.6 | < 5.5 |
| Cs-134 | -0.8 ± 2.2 | < 4.1 | -0.6 ± 2.1 | < 3.3 | - | | -10.6 ± 4.4 | < 6.7 |
| Cs-137 | 2.3 ± 2.9 | < 5.5 | -0.7 ± 2.2 | < 3.7 | - | | 1.8 ± 4.1 | < 6.9 |
| Ba-La-140 | 1.5 ± 2.5 | < 3.6 | -1.8 ± 2.2 | < 2.2 | - | | -5.6 ± 4.1 | < 4.2 |

[a] "NF" = No flow.  [b] Sample too small for gamma scan

Units: = pCi\L | Gamma isotopic analysis

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 11-05-24 | | 11-05-24 | | 11-05-24 | | 11-05-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 2819 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | -10.3 ± 12.6 | < 20.3 | - | |
| Mn-54 | - | | - | | -0.6 ± 1.9 | < 2.3 | - | |
| Fe-59 | - | | - | | -3.2 ± 3.5 | < 2.7 | - | |
| Co-58 | - | | - | | -0.6 ± 2.0 | < 1.8 | - | |
| Co-60 | - | | - | | 0.2 ± 1.7 | < 1.5 | - | |
| Zn-65 | - | | - | | -1.1 ± 3.8 | < 5.9 | - | |
| Zr-Nb-95 | - | | - | | 0.3 ± 2.0 | < 2.6 | - | |
| Cs-134 | - | | - | | 0.2 ± 1.8 | < 2.8 | - | |
| Cs-137 | - | | - | | -0.4 ± 1.9 | < 3.2 | - | |
| Ba-La-140 | - | | - | | -0.8 ± 2.0 | < 2.3 | - | |

| Location | S-1 | | S-3 | | S-7 | | S-8 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 12-04-24 | | 12-04-24 | | 12-04-24 | | 12-04-24 | |
| Lab Code | EW- 3044 | MDC | EW- 3045 | MDC | NF[a] | MDC | NF[a] | MDC |
| Be-7 | -5.2 ± 9.8 | < 24.8 | 2.0 ± 13.2 | < 31.0 | - | | - | |
| Mn-54 | -0.3 ± 1.5 | < 2.5 | 0.1 ± 1.7 | < 3.4 | - | | - | |
| Fe-59 | -0.4 ± 2.4 | < 4.0 | -0.9 ± 2.9 | < 5.6 | - | | - | |
| Co-58 | -0.5 ± 1.3 | < 1.7 | -1.3 ± 1.5 | < 2.2 | - | | - | |
| Co-60 | 0.3 ± 1.5 | < 2.2 | 0.2 ± 1.3 | < 1.0 | - | | - | |
| Zn-65 | -0.6 ± 2.6 | < 4.5 | 2.0 ± 3.1 | < 5.3 | - | | - | |
| Zr-Nb-95 | -1.2 ± 1.4 | < 2.5 | -1.5 ± 1.8 | < 4.6 | - | | - | |
| Cs-134 | -0.6 ± 1.4 | < 2.8 | 0.2 ± 1.6 | < 2.8 | - | | - | |
| Cs-137 | 0.4 ± 1.4 | < 2.0 | 0.5 ± 1.6 | < 2.0 | - | | - | |
| Ba-La-140 | -1.2 ± 1.8 | < 6.2 | -3.4 ± 1.9 | < 5.7 | - | | - | |

| Location | S-9 | | S-10 | | S-12 | | S-13 | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 12-04-24 | | 12-04-24 | | 12-04-24 | | 12-04-24 | |
| Lab Code | NF[a] | MDC | NF[a] | MDC | EW- 3046 | MDC | NF[a] | MDC |
| Be-7 | - | | - | | 0.7 ± 9.9 | < 25.2 | - | |
| Mn-54 | - | | - | | 0.3 ± 1.4 | < 2.1 | - | |
| Fe-59 | - | | - | | -0.1 ± 2.6 | < 5.5 | - | |
| Co-58 | - | | - | | 1.2 ± 1.3 | < 2.3 | - | |
| Co-60 | - | | - | | -0.3 ± 1.9 | < 1.6 | - | |
| Zn-65 | - | | - | | -3.9 ± 2.8 | < 1.9 | - | |
| Zr-Nb-95 | - | | - | | -0.9 ± 1.6 | < 3.5 | - | |
| Cs-134 | - | | - | | 0.4 ± 1.5 | < 2.8 | - | |
| Cs-137 | - | | - | | 0.5 ± 1.7 | < 2.8 | - | |
| Ba-La-140 | - | | - | | -2.3 ± 2.7 | < 5.9 | - | |

[a] "NF" = No flow.

Table 12. Groundwater Tritium Monitoring Program
(Quarterly Collections)
Units = pCi/L

## Quarterly Wells

| Sample ID | GW-05 (WH 6 Well) | | | | GW-06 (SBCC Well) | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 01-17-24 | EWW- 71 | -20 ± 78 | < 168 | 01-17-24 | EWW- 72 | 22 ± 80 | < 168 |
| 04-10-24 | EWW- 702 | 37 ± 83 | < 175 | 04-10-24 | EWW- 703 | -21 ± 80 | < 175 |
| 07-18-24 | EWW- 1687 | 51 ± 88 | < 177 | 07-18-24 | EWW- 1688 | 37 ± 87 | < 177 |
| 10-09-24 | EWW- 2416 | -34 ± 88 | < 181 | 10-09-24 | EWW- 2418 | -34 ± 88 | < 181 |
| Mean ± s.d. | | 8 ± 42 | | Mean ± s.d. | | 1 ± 34 | |

| Sample ID | GW-11 (MW-1) | | | | GW-12 (MW-2) | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 03-12-24 | EWW- 487 | 107 ± 92 | < 174 | 03-12-24 | EWW- 488 | -11 ± 86 | < 174 |
| 06-27-24 | EWW- 1501 | 38 ± 87 | < 183 | 06-27-24 | EWW- 1502 | 6 ± 85 | < 183 |
| 07-25-24 | EWW- 1805 | 112 ± 93 | < 181 | 07-25-24 | EWW- 1806 | -41 ± 85 | < 181 |
| 10-20-24 | EWW- 2599 | 89 ± 87 | < 177 | 10-20-24 | EWW- 2600 | 52 ± 85 | < 177 |
| Mean ± s.d. | | 86 ± 34 | | Mean ± s.d. | | 2 ± 39 | |

| Sample ID | GW-13 (MW-6) | | | | GW-14A (MW-05A) | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 03-12-24 | EWW- 489 | 43 ± 89 | < 174 | 03-12-24 | EWW- 490 | 72 ± 90 | < 174 |
| 06-27-24 | EWW- 1503 | 55 ± 88 | < 183 | 06-27-24 | EWW- 1504 | 145 ± 93 | < 183 |
| 07-25-24 | EWW- 1808 | 75 ± 91 | < 181 | 07-25-24 | EWW- 1809 | 151 ± 95 | < 181 |
| 10-20-24 | EWW- 2601 | 62 ± 86 | < 177 | 10-20-24 | EWW- 2602 | 104 ± 88 | < 177 |
| Mean ± s.d. | | 59 ± 13 | | Mean ± s.d. | | 118 ± 37 | |

| Sample ID | GW-15A (MW-4) | | | | GW-15B (MW-4) | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC | Collection Date | Lab Code | Tritium | MDC |
| 03-12-24 | EWW- 491 | 145 ± 94 | < 174 | 03-12-24 | EWW- 492 | 114 ± 92 | < 174 |
| 06-27-24 | EWW- 1505 | 38 ± 87 | < 183 | 06-27-24 | EWW- 1506 | 28 ± 86 | < 183 |
| 07-25-24 | EWW- 1810 | 247 ± 100 | < 181 | 07-25-24 | EWW- 1811 | 58 ± 90 | < 181 |
| 10-20-24 | EWW- 2603 | 106 ± 88 | < 177 | 10-20-24 | EWW- 2604 | 148 ± 90 | < 177 |
| Mean ± s.d. | | 134 ± 88 | | Mean ± s.d. | | 87 ± 54 | |

| Sample ID | GW-16A (MW-3) | | |
|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC |
| 03-12-24 | EWW- 493 | 155 ± 94 | < 174 |
| 06-27-24 | EWW- 1507 | 280 ± 100 | < 183 |
| 07-25-24 | EWW- 1812 | 139 ± 95 | < 181 |
| 10-20-24 | EWW- 2605 | 150 ± 91 | < 177 |
| Mean ± s.d. | | 181 ± 66 | |

Table 12. Groundwater Tritium Monitoring Program
(Quarterly Collections)
Units = pCi/L

## Quarterly Wells (cont.)

Sample ID GW-18 (WH 7 Well)

| Collection Date | Lab Code | Tritium | MDC |
|---|---|---|---|
| 01-18-24 | EWW- 81 | 7 ± 81 | < 171 |
| 04-10-24 | EWW- 704 | -35 ± 79 | < 175 |
| 07-18-24 | EWW- 1700 | -41 ± 82 | < 177 |
| 10-09-24 | EWW- 2419 | -37 ± 88 | < 181 |
| Mean ± s.d. | | -38 ± 23 | |

## Façade Wells

Sample ID GW-09 1Z-361A

| Collection Date | Lab Code | Tritium | MDC |
|---|---|---|---|
| 01-10-24 | EWW- 43 | 223 ± 91 | < 168 |
| 07-09-24 | EWW- 1605 | 296 ± 101 | < 177 |
| 09-19-24 | EWW- 2244 | 256 ± 98 | < 180 |
| 11-30-24 | EWW- 3135 | 260 ± 101 | < 183 |
| Mean ± s.d. | | 259 ± 30 | |

Sample ID GW-09 1Z-361B

| Collection Date | Lab Code | Tritium | MDC |
|---|---|---|---|
| 01-10-24 | EWW- 44 | 275 ± 94 | < 168 |
| 07-09-24 | EWW- 1606 | 105 ± 91 | < 177 |
| 09-19-24 | EWW- 2245 | 93 ± 90 | < 180 |
| 11-30-24 | EWW- 3136 | -20 ± 87 | < 183 |
| Mean ± s.d. | | 113 ± 122 | |

Sample ID GW-10 2Z-361A

| Collection Date | Lab Code | Tritium | MDC |
|---|---|---|---|
| 01-10-24 | EWW- 45 | 6 ± 80 | < 168 |
| 07-09-24 | EWW- 1607 | -24 ± 84 | < 177 |
| 09-19-24 | EWW- 2246 | -80 ± 80 | < 180 |
| 11-30-24 | EWW- 3137 | 129 ± 95 | < 183 |
| Mean ± s.d. | | 8 ± 88 | |

Sample ID GW-10 2Z-361B

| Collection Date | Lab Code | Tritium | MDC |
|---|---|---|---|
| 01-10-24 | EWW- 46 | 141 ± 87 | < 168 |
| 07-09-24 | EWW- 1608 | 227 ± 97 | < 177 |
| 09-19-24 | EWW- 2247 | 171 ± 94 | < 180 |
| 11-30-24 | EWW- 3138 | 97 ± 93 | < 183 |
| Mean ± s.d. | | 159 ± 55 | |

(Annual Collections)
Units = pCi/L

## Bogs

Sample ID GW-07 (North Bog)

| Collection Date | Lab Code | Tritium | MDC |
|---|---|---|---|
| 05-14-24 | EWW- 1135 | 54 ± 93 | < 188 |

Sample ID GW-08 EIC Bog

| Collection Date | Lab Code | Tritium | MDC |
|---|---|---|---|
| 05-14-24 | EWW- 1136 | 541 ± 116 | < 188 |

Table 12. Groundwater Tritium Monitoring Program

Units = pCi/L

## Manholes

| Sample ID | | MH Z-065A | | | | MH Z-065B | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| 04-30-24 | EW- 1075 | 278 ± 107 | < 188 | 04-30-24 | EW- 1077 | 331 ± 110 | < 188 |
| 09-12-24 | EW- 2232 | 302 ± 100 | < 180 | 09-12-24 | EW- 2233 | 227 ± 97 | < 180 |
| Mean ± s.d. | | 290 ± 17 | | Mean ± s.d. | | 279 ± 74 | |

| Sample ID | | MH Z-065C | | | | MH Z-065D | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| Mean ± s.d. | | | | Mean ± s.d. | | | |

| Sample ID | | MH Z-066A | | | | MH Z-066B | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| 04-30-24 | EW- 1078 | 57 ± 96 | < 188 | 05-02-24 | EW- 1079 | 217 ± 104 | < 188 |
| 09-11-24 | EW- 2234 | 205 ± 96 | < 180 | 09-11-24 | EW- 2235 | 244 ± 98 | < 180 |
| Mean ± s.d. | | 131 ± 105 | | Mean ± s.d. | | 230 ± 19 | |

| Sample ID | | MH Z-066C | | | | MH Z-066D | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| 05-02-24 | EW- 1080 | 293 ± 108 | < 188 | 05-02-24 | EW- 1081 | 151 ± 101 | < 188 |
| 09-11-24 | EW- 2236 | 312 ± 101 | < 180 | 09-10-24 | EW- 2237 | 222 ± 97 | < 180 |
| Mean ± s.d. | | 302 ± 13 | | Mean ± s.d. | | 186 ± 50 | |

| Sample ID | | MH Z-067A | | | | MH Z-067B | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| 04-30-24 | EW- 1082 | 184 ± 103 | < 188 | 05-02-24 | EW- 1083 | 166 ± 102 | < 188 |
| 09-11-24 | EW- 2238 | 217 ± 96 | < 180 | 09-11-24 | EW- 2239 | 125 ± 92 | < 180 |
| Mean ± s.d. | | 200 ± 24 | | Mean ± s.d. | | 145 ± 29 | |

## Manholes (cont.)

| Sample ID | MH Z-067C | | | | MH Z-067D | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| 05-02-24 | EW- 1084 | 57 ± 96 | < 188 | 05-02-24 | EW- 1085 | 156 ± 101 | < 188 |
| 09-11-24 | EW- 2240 | 147 ± 93 | < 180 | 09-10-24 | EW- 2241 | 212 ± 96 | < 180 |
| Mean ± s.d. | | 102 ± 63 | | Mean ± s.d. | | 184 ± 40 | |

| Sample ID | MH Z-068 | | | | MH-1 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| 05-02-24 | EW- 1086 | 306 ± 109 | < 188 | | | | |
| 09-10-24 | EW- 2242 | 83 ± 89 | < 180 | | | | |
| Mean ± s.d. | | 194 ± 157 | | Mean ± s.d. | | | |

| Sample ID | MH-4 | | | | MH-6 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| Mean ± s.d. | | | | Mean ± s.d. | | | |

| Sample ID | MH-7 | | | | MH-8 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| Mean ± s.d. | | | | Mean ± s.d. | | | |

| Sample ID | MH-16 | | | | MH-2 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| Mean ± s.d. | | | | Mean ± s.d. | | | |

| Sample ID | MH-5A | | | | MH-9 | | |
|---|---|---|---|---|---|---|---|
| Collection Date | Lab Code | Tritium | MDC (pCi/L) | Collection Date | Lab Code | Tritium | MDC (pCi/L) |
| Mean ± s.d. | | | | Mean ± s.d. | | | |

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# APPENDIX A

## INTERLABORATORY AND INTRALABORATORY COMPARISON PROGRAM RESULTS

NOTE: Appendix A is updated four times a year. The complete appendix is included in March, June, September and December monthly progress reports only.

January, 2024 through December, 2024

# Appendix A

## Interlaboratory/ Intralaboratory Comparison Program Results

Microbac Laboratories - Northbrook (previously Environmental Inc.) has participated in interlaboratory comparison (crosscheck) programs since the formulation of its quality program in December 1971. These programs are operated by agencies and/or companies which supply environmental sample types containing concentrations of radionuclides known to the issuing entity but not to participant laboratories. The purpose of such a program is to provide an independent check on a laboratory's analytical procedures and to alert it of any possible problems.

Participant laboratories measure the concentration of specified radionuclides and report them to the issuing agency. Several months later, the agency reports the known values to the participant laboratories and specifies control limits. Results consistently higher or lower than the known values or outside the control limits indicate a need to check the instruments or procedures used.

Results in Table A-1 were obtained through participation in the RAD PT Study Proficiency Testing Program administered by Environmental Resource Associates, serving as a replacement for studies conducted previously by the U.S. EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

Table A-2 lists results for thermoluminescent dosimeters (TLDs), via irradiation and evaluation by the University of Wisconsin-Madison Radiation Calibration Laboratory at the University of Wisconsin Medical Radiation Research Center.

Table A-3 lists results of the analyses on intralaboratory “spiked” samples for the past twelve months. All samples are prepared using NIST traceable sources. Data for previous years available upon request.

Table A-4 lists results of the analyses on intralaboratory “blank” samples for the past twelve months. Data for previous years available upon request.

Table A-5 lists analytical results from the intralaboratory “duplicate” program for the past twelve months. Acceptance is based on each result being within 25% of the mean of the two results or the two sigma uncertainties of each result overlap.

The results in Table A-6 were obtained through participation in the Mixed Analyte Performance Evaluation Program.

Results in Table A-7 were obtained through participation in the MRAD PT Study Proficiency Testing Program administered by Environmental Resource Associates, serving as a replacement for studies conducted previously by the Environmental Measurement Laboratory Quality Assessment Program (EML).

Attachment A lists the laboratory acceptance criteria for various analyses.

Out-of-limit results are explained directly below the result.

## Attachment A

ACCEPTANCE CRITERIA FOR INTRALABORATORY "SPIKED" SAMPLES

| Analysis | Ratio of lab result to known value. |
|---|---|
| Gamma Emitters | 0.8 to 1.2 |
| Strontium-89, Strontium-90 | 0.8 to 1.2 |
| Potassium-40 | 0.8 to 1.2 |
| Gross alpha | 0.5 to 1.5 |
| Gross beta | 0.8 to 1.2 |
| Tritium | 0.8 to 1.2 |
| Radium-226, Radium-228 | 0.7 to 1.3 |
| Plutonium | 0.8 to 1.2 |
| Iodine-129, Iodine-131 | 0.8 to 1.2 |
| Nickel-63, Technetium-99, Uranium-238 | 0.7 to 1.3 |
| Iron-55 | 0.8 to 1.2 |
| Other Analyses | 0.8 to 1.2 |

TABLE A-1. Interlaboratory Comparison Crosscheck program, Environmental Resource Associates (ERA)[a].

RAD study

| Lab Code | Date | Analysis | Concentration (pCi/L) Laboratory Result | ERA Value | Acceptance Limits | Acceptance |
|---|---|---|---|---|---|---|
| RAD-022724M (study dates 2/27/24 - 3/11/24) | | | | | | |
| ERDW-323 | 10/7/2022 | Ba-133 | 67.3 ± 4.1 | 79.4 | 62.3 - 97.0 | Pass |
| ERDW-323 | 10/7/2022 | Cs-134 | 20.6 ± 2.6 | 30.5 | 18.2 - 42.8 | Pass |
| ERDW-323 | 10/7/2022 | Cs-137 | 221 ± 7 | 212 | 172 - 252 | Pass |
| ERDW-323 | 10/7/2022 | Co-60 | 48.8 ± 4.2 | 51.4 | 37.1 - 65.7 | Pass |
| ERDW-323 | 10/7/2022 | Zn-65 | 82.6 ± 9 | 216 | 167 - 265 | Fail [b] |
| ERDW-325 | 10/7/2022 | Gr. Alpha | 15.4 ± 1.6 | 16.9 | 11.1 - 22.7 | Pass |
| ERDW-325 | 10/7/2022 | G. Beta | 48.2 ± 1.4 | 53.0 | 39.1 - 66.9 | Pass |
| ERDW-321 | 10/7/2022 | Ra-226 | 15.9 ± 0.9 | 19.0 | 16.2 - 21.8 | Fail [c] |
| ERDW-321 | 10/7/2022 | Ra-228 | 3.81 ± 1.04 | 2.33 | 1.04 - 3.60 | Fail [d] |
| ERDW-321 | 10/7/2022 | Uranium | 8.745 ± 1.070 | 8.53 | 7.10 - 10.0 | Pass |
| ERDW-327 | 4/10/2023 | H-3 | 12,740 ± 366 | 12,700 | 10,500 - 14,900 | Pass |
| RAD-137 Study (study dates 4/08/24 - 5/23/24) | | | | | | |
| ERDW-715 | 4/8/2024 | Ba-133 | 71.2 ± 5.5 | 65.9 | 50.1 - 81.7 | Pass |
| ERDW-715 | 4/8/2024 | Cs-134 | 70.4 ± 9.5 | 57.8 | 42.8 - 72.8 | Pass |
| ERDW-715 | 4/8/2024 | Cs-137 | 188 ± 11 | 186 | 149 - 233 | Pass |
| ERDW-715 | 4/8/2024 | Co-60 | 100 ± 10 | 98.8 | 79.7 - 118 | Pass |
| ERDW-715 | 4/8/2024 | Zn-65 | 231 ± 15 | 240 | 188 - 292 | Pass |
| ERDW-713 | 4/8/2024 | Gr. Alpha | 39.4 ± 1.9 | 52.6 | 39.6 - 65.8 | Fail [e] |
| ERDW-713 | 4/8/2024 | G. Beta | 45.5 ± 1.4 | 46.5 | 33.9 - 59.1 | Pass |
| ERDW-711 | 4/8/2024 | Ra-226 | 14.3 ± 0.8 | 13.4 | 11.10 - 15.7 | Pass |
| ERDW-711 | 4/8/2024 | Ra-228 | 6.01 ± 1.19 | 6.24 | 4.2 - 8.3 | Pass |
| ERDW-711 | 4/8/2024 | Uranium | 63.5 ± 2.4 | 59.3 | 52.8 - 65.8 | Pass |
| ERDW-717 | 4/8/2024 | H-3 | 20,400 ± 448 | 21,300 | 18,200 - 24,400 | Pass |
| RAD-138 Study (study dates 7/08/24 - 8/22/24) | | | | | | |
| ERDW-1546 | 7/8/2024 | Ba-133 | 41.4 ± 5.9 | 38.2 | 25.2 - 51.2 | Pass |
| ERDW-1546 | 7/8/2024 | Cs-134 | 18.6 ± 8.0 | 18.9 | 7.81 - 30.0 | Pass |
| ERDW-1546 | 7/8/2024 | Cs-137 | 54.4 ± 13.3 | 57.0 | 32.9 - 81.1 | Pass |
| ERDW-1546 | 7/8/2024 | Co-60 | 82.8 ± 7.1 | 76.8 | 59.9 - 93.7 | Pass |
| ERDW-1546 | 7/8/2024 | Zn-65 | 348 ± 30 | 312 | 253 - 371 | Pass |
| ERDW-1548 | 7/8/2024 | Gr. Alpha | 9.05 ± 1.26 | 13.0 | 7.94 - 18.1 | Pass |
| ERDW-1548 | 7/8/2024 | G. Beta | 17.3 ± 1.0 | 20.6 | 13.2 - 28.0 | Pass |
| ERDW-1552 | 7/8/2024 | Ra-226 | 20.4 ± 1.0 | 17.2 | 14.6 - 19.8 | Fail [f] |
| ERDW-1552 | 7/8/2024 | Ra-228 | 3.72 ± 0.96 | 4.63 | 2.88 - 6.38 | Pass |
| ERDW-1552 | 7/8/2024 | Uranium | 36.2 ± 2.4 | 36.8 | 32.5 - 41.1 | Pass |
| ERDW-1554 | 7/8/2024 | H-3 | 7,840 ± 290 | 7,550 | 5,870 - 9,230 | Pass |
| ERDW-1550 | 7/8/2024 | I-131 | 20.1 ± 0.9 | 27.9 | 24.2 - 31.6 | Fail [g] |

[a] Results obtained by Microbac Laboratories Inc. - Northbrook as a participant in the crosscheck program for proficiency testing in drinking water conducted by Environmental Resource Associates (ERA).

[b] An incorrect reference date was used in the calculation of the gamma emitters. If the correct date was used, all analytes would have passed ERA acceptance criteria. The Zn-65 result would have been 212 ± 30 pCi/L.

[c] No obvious conclusion could be determined for the low result. It's possible that a small leak from the radon bubbler may have allowed radon gas to escape thereby leading to the low result. Subsequent ERA study RAD-137 passed for Ra-226.

[d] The batch recovery value as determined by the EPA method could have been biased artificially low thereby causing the result to have a high bias outside the upper acceptance limit. Subsequent ERA studies RAD-137,138 passed for Ra-228.

[e] Data was reviewed but no obvious issue could be determined. Subsequent ERA study RAD-138 passed for both Gross Alpha and Gross Beta.

[f] The lab continues to investigate the Ra-226 performance issues. The procedure has been revised to more closely follow the EPA method. Results are being compiled and a subsequent ERA study will be ordered to validate the revised procedure.

[g] ERA added stable iodine carrier to the PT sample at a concentration of 0.20 mg/L. The calculation of the results that were submitted for this study did not take this added iodine into account when calculating the chemical yield or recovery. Incorporating the ERA added stable iodine into the calculattions; recoveries dropped from 88.32% and 90.52% to 64.56% and 66.17%. The adjusted results are: 29.42 pCi/L and 28.06 pCi/L which are both within the acceptance range.

TABLE A-2. Thermoluminescent Dosimetry, (TLD, $CaSO_4$: Dy Cards).[a]

| | | | mrem | | | |
|---|---|---|---|---|---|---|
| Lab Code | Irradiation Date | Description | Delivered Dose | Reported[b] Dose | Performance[c] Quotient (P) | |
| Environmental, Inc. | | Group 1 | | | | |
| 2024-25-1 | 1/6/2025 | Spike 1 | 92.0 | 91.8 | 0.00 | |
| 2024-25-1 | 1/6/2025 | Spike 2 | 92.0 | 89.7 | -0.03 | |
| 2024-25-1 | 1/6/2025 | Spike 3 | 92.0 | 92.0 | 0.00 | |
| 2024-25-1 | 1/6/2025 | Spike 4 | 92.0 | 92.9 | 0.01 | |
| 2024-25-1 | 1/6/2025 | Spike 5 | 92.0 | 91.8 | 0.00 | |
| 2024-25-1 | 1/6/2025 | Spike 6 | 92.0 | 98.0 | 0.07 | |
| 2024-25-1 | 1/6/2025 | Spike 7 | 92.0 | 94.6 | 0.03 | |
| 2024-25-1 | 1/6/2025 | Spike 8 | 92.0 | 94.2 | 0.02 | |
| 2024-25-1 | 1/6/2025 | Spike 9 | 92.0 | 95.4 | 0.04 | |
| 2024-25-1 | 1/6/2025 | Spike 10 | 92.0 | 91.3 | -0.01 | |
| 2024-25-1 | 1/6/2025 | Spike 11 | 92.0 | 89.4 | -0.03 | |
| 2024-25-1 | 1/6/2025 | Spike 12 | 92.0 | 97.7 | 0.06 | |
| 2024-25-1 | 1/6/2025 | Spike 13 | 92.0 | 94.1 | 0.02 | |
| 2024-25-1 | 1/6/2025 | Spike 14 | 92.0 | 92.2 | 0.00 | |
| 2024-25-1 | 1/6/2025 | Spike 15 | 92.0 | 92.9 | 0.01 | |
| 2024-25-1 | 1/6/2025 | Spike 16 | 92.0 | 91.7 | 0.00 | |
| 2024-25-1 | 1/6/2025 | Spike 17 | 92.0 | 87.4 | -0.05 | |
| 2024-25-1 | 1/6/2025 | Spike 18 | 92.0 | 94.7 | 0.03 | |
| 2024-25-1 | 1/6/2025 | Spike 19 | 92.0 | 91.0 | -0.01 | |
| 2024-25-1 | 1/6/2025 | Spike 20 | 92.0 | 92.5 | 0.01 | |
| Mean (Spike 1-20) | | | | 92.8 | 0.01 | Pass[d] |
| Standard Deviation (Spike 1-20) | | | | 2.6 | 0.03 | Pass[d] |

a TLD's were irradiated by the University of Wisconsin-Madison Radiation Calibration Laboratory following ANSI N13.37 protocol from a known air kerma rate. TLD's were read and the results were submitted by Microbac Laboratories - Northbrook to the University of Wisconsin-Madison Radiation Calibration Laboratory for comparison to the delivered dose.

b Reported dose was converted from exposure (R) to Air Kerma (cGy) using a conversion of 0.876. Conversion from air kerma to ambient dose equivalent for Cs-137 at the reference dose point $H^*(10)K_a$ = 1.20 . mrem/cGy = 1000.

c Performance Quotient (P) is calculated as ((reported dose - conventionally true value) ÷ conventionally true value) where the conventionally true value is the delivered dose.

d Acceptance is achieved when neither the absolute value of the mean of the P values, nor the standard deviation of the P values exceed 0.15.

TABLE A-2. Thermoluminescent Dosimetry, (TLD, $CaSO_4$: Dy Cards).[a]

| | | | mrem | | | |
|---|---|---|---|---|---|---|
| Lab Code | Irradiation Date | Description | Delivered Dose | Reported Dose[b] | Performance[c] Quotient (P) | |
| Environmental, Inc. | | Group 2 | | | | |
| 2024-25-2 | 1/6/2025 | Spike 21 | 74.0 | 77.5 | 0.05 | |
| 2024-25-2 | 1/6/2025 | Spike 22 | 74.0 | 77.6 | 0.05 | |
| 2024-25-2 | 1/6/2025 | Spike 23 | 74.0 | 73.2 | -0.01 | |
| 2024-25-2 | 1/6/2025 | Spike 24 | 74.0 | 75.4 | 0.02 | |
| 2024-25-2 | 1/6/2025 | Spike 25 | 74.0 | 75.3 | 0.02 | |
| 2024-25-2 | 1/6/2025 | Spike 26 | 74.0 | 77.8 | 0.05 | |
| 2024-25-2 | 1/6/2025 | Spike 27 | 74.0 | 73.1 | -0.01 | |
| 2024-25-2 | 1/6/2025 | Spike 28 | 74.0 | 74.0 | 0.00 | |
| 2024-25-2 | 1/6/2025 | Spike 29 | 74.0 | 75.8 | 0.02 | |
| 2024-25-2 | 1/6/2025 | Spike 30 | 74.0 | 76.5 | 0.03 | |
| 2024-25-2 | 1/6/2025 | Spike 31 | 74.0 | 73.5 | -0.01 | |
| 2024-25-2 | 1/6/2025 | Spike 32 | 74.0 | 75.5 | 0.02 | |
| 2024-25-2 | 1/6/2025 | Spike 33 | 74.0 | 76.5 | 0.03 | |
| 2024-25-2 | 1/6/2025 | Spike 34 | 74.0 | 76.4 | 0.03 | |
| 2024-25-2 | 1/6/2025 | Spike 35 | 74.0 | 75.1 | 0.01 | |
| 2024-25-2 | 1/6/2025 | Spike 36 | 74.0 | 72.8 | -0.02 | |
| 2024-25-2 | 1/6/2025 | Spike 37 | 74.0 | 76.0 | 0.03 | |
| 2024-25-2 | 1/6/2025 | Spike 38 | 74.0 | 74.9 | 0.01 | |
| 2024-25-2 | 1/6/2025 | Spike 39 | 74.0 | 75.4 | 0.02 | |
| 2024-25-2 | 1/6/2025 | Spike 40 | 74.0 | 70.8 | -0.04 | |
| Mean (Spike 21-40) | | | | 75.2 | 0.02 | Pass[d] |
| Standard Deviation (Spike 21-40) | | | | 1.8 | 0.02 | Pass[d] |

a TLD's were irradiated by the University of Wisconsin-Madison Radiation Calibration Laboratory following ANSI N13.37 protocol from a known air kerma rate. TLD's were read and the results were submitted by Microbac Laboratories - Northbrook to the University of Wisconsin-Madison Radiation Calibration Laboratory for comparison to the delivered dose.

b Reported dose was converted from exposure (R) to Air Kerma (cGy) using a conversion of 0.876. Conversion from air kerma to ambient dose equivalent for Cs-137 at the reference dose point $H^*(10)K_a$ = 1.20 . mrem/cGy = 1000.

c Performance Quotient (P) is calculated as ((reported dose - conventionally true value) ÷ conventionally true value) where the conventionally true value is the delivered dose.

d Acceptance is achieved when neither the absolute value of the mean of the P values, nor the standard deviation of the P values exceed 0.15.

TABLE A-3. Intralaboratory "Spiked" Samples

| | | | Concentration[a] | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lab Code[b] | Reference Date | Analysis | Laboratory results 2s, n=1[c] | Known Activity | Control Limits[d] | | Acceptance | Ratio Lab/Known |
| SPDW-60025 | 1/12/2024 | Gr. Alpha | 43.3 ± 2.4 | 47.9 | 24.0 - 57.5 | | Pass | 0.90 |
| SPDW-60025 | 1/12/2024 | Gr. Beta | 28.9 ± 1.3 | 28.6 | 22.9 - 34.3 | | Pass | 1.01 |
| SPDW-60042 | 2/2/2024 | H-3 | 21,225 459 | 22,100 | 17,680 - 26,520 | | Pass | 0.96 |
| SPDW-60059 | 2/14/2024 | Gr. Alpha | 37.6 ± 2.8 | 32.2 | 16.1 - 38.6 | | Pass | 1.17 |
| SPDW-60059 | 2/14/2024 | Gr. Beta | 168 ± 3 | 160 | 128.0 - 192.0 | | Pass | 1.05 |
| SPDW-60067 | 2/13/2024 | H-3 | 20,925 451 | 22,100 | 17,680 - 26,520 | | Pass | 0.95 |
| SPDW-60097 | 2/28/2024 | Gr. Alpha | 27.7 ± 2.1 | 32.2 | 16.1 - 38.6 | | Pass | 0.86 |
| SPDW-60097 | 2/28/2024 | Gr. Beta | 160 ± 3 | 160 | 128.0 - 192.0 | | Pass | 1.00 |
| SPDW-60100 | 2/26/2024 | H-3 | 21,582 ± 462 | 22,100 | 17,680 - 26,520 | | Pass | 0.98 |
| SPDW-60016 | 3/7/2024 | H-3 | 20,572 ± 449 | 22,100 | 17,680 - 26,520 | | Pass | 0.93 |
| SPDW-60133 | 3/14/2024 | Gr. Alpha | 23.6 ± 2.1 | 32.2 | 16.1 - 38.6 | | Pass | 0.73 |
| SPDW-60133 | 3/14/2024 | Gr. Beta | 171 ± 3 | 160 | 128.0 - 192.0 | | Pass | 1.07 |
| SPDW-60150 | 3/22/2024 | H-3 | 20,618 ± 450 | 22,100 | 17,680 - 26,520 | | Pass | 0.93 |
| SPDW-60191 | 3/21/2024 | Ra-226 | 13.2 ± 0.4 | 12.3 | 8.6 - 16.0 | | Pass | 1.07 |
| SPDW-60154 | 3/25/2024 | Ra-228 | 12.7 ± 1.6 | 15.4 | 10.8 - 20.0 | | Pass | 0.82 |
| LCS-W-052924 | 4/8/2024 | Ba-133 | 55.7 ± 4.3 | 65.9 | 52.7 - 79.1 | | Pass | 0.85 |
| LCS-W-052924 | 4/8/2024 | Cs-134 | 50.1 ± 3.4 | 57.8 | 46.2 - 69.4 | | Pass | 0.87 |
| LCS-W-052924 | 4/8/2024 | Cs-137 | 172 ± 6 | 186 | 149 - 223 | | Pass | 0.92 |
| LCS-W-052924 | 4/8/2024 | Co-60 | 95.3 ± 4.0 | 99 | 79.0 - 119 | | Pass | 0.96 |
| LCS-W-052924 | 4/8/2024 | Zn-65 | 224 ± 12 | 240 | 192 - 288 | | Pass | 0.93 |
| SPDW-60184 | 4/9/2024 | Gr. Alpha | 21.0 ± 2.0 | 32.2 | 16.1 - 38.6 | | Pass | 0.65 |
| SPDW-60184 | 4/9/2024 | Gr. Beta | 158 ± 3 | 160 | 128.0 - 192.0 | | Pass | 0.99 |
| SPDW-60198 | 4/15/2024 | H-3 | 20,822 ± 453 | 22,100 | 17,680 - 26,520 | | Pass | 0.94 |
| SPDW-60213 | 4/25/2024 | Ra-228 | 15.4 ± 2.0 | 15.3 | 10.7 - 19.9 | | Pass | 1.01 |
| SPDW-60215 | 4/26/2024 | H-3 | 20,400 ± 447 | 22,100 | 17,680 - 26,520 | | Pass | 0.92 |
| SPDW-60267 | 4/11/2024 | Ra-226 | 10.8 ± 0.3 | 12.3 | 8.6 - 16.0 | | Pass | 0.88 |
| SPDW-60236 | 5/10/2024 | H-3 | 20,415 ± 448 | 22,100 | 17,680 - 26,520 | | Pass | 0.92 |
| SPDW-60253 | 5/16/2024 | Ra-228 | 13.6 ± 1.8 | 15.3 | 10.7 - 19.9 | | Pass | 0.89 |
| SPDW-60302 | 5/29/2024 | Gr. Alpha | 18.1 ± 1.7 | 32.2 | 16.1 - 38.6 | | Pass | 0.56 |
| SPDW-60302 | 5/29/2024 | Gr. Beta | 163 ± 3 | 160 | 128 - 192 | | Pass | 1.02 |
| SPDW-60307 | 5/23/2024 | Ra-226 | 13.0 ± 0.5 | 12.3 | 8.6 - 16.0 | | Pass | 1.05 |
| SPDW-60294 | 5/28/2024 | H-3 | 20,840 ± 463 | 22,100 | 17,680 - 26,520 | | Pass | 0.94 |
| SPDW-60314 | 6/6/2024 | Ra-228 | 11.9 ± 1.6 | 15.3 | 10.7 - 19.9 | | Pass | 0.78 |
| SPDW-60331 | 6/10/2024 | H-3 | 20,602 ± 459 | 22,100 | 17,680 - 26,520 | | Pass | 0.93 |
| SPDW-60357 | 5/30/2024 | Ra-226 | 11.8 ± 0.4 | 12.3 | 8.6 - 16.0 | | Pass | 0.96 |
| SPDW-60361 | 6/27/2024 | Gr. Alpha | 21.7 ± 2.0 | 32.2 | 16.1 - 38.6 | | Pass | 0.67 |
| SPDW-60361 | 6/27/2024 | Gr. Beta | 151 ± 2 | 160 | 128 ± 192 | | Pass | 0.94 |
| SPDW-60425 | 6/24/2024 | Ra-226 | 12.8 ± 0.4 | 12.3 | 8.6 - 16.0 | | Pass | 1.04 |
| SPDW-60393 | 7/10/2024 | H-3 | 20,368 ± 454 | 22,100 | 17,680 - 26,520 | | Pass | 0.92 |

[a] Liquid sample results are reported in pCi/Liter, air filters ( pCi/m3), charcoal (pCi/charcoal canister), and solid samples (pCi/kg).
[b] Laboratory codes : W & SPW (Water), MI (milk), AP (air filter), SO (soil), VE (vegetation), CH (charcoal canister), F (fish), U (urine).
[c] Results are based on single determinations.
[d] Acceptance criteria are listed in Attachment A of this report.

TABLE A-3. Intralaboratory "Spiked" Samples

| | | | Concentration[a] | | | | |
|---|---|---|---|---|---|---|---|
| Lab Code[b] | Reference Date | Analysis | Laboratory results 2s, n=1[c] | Known Activity | Control Limits[d] | Acceptance | Ratio Lab/Known |
| SPDW-60411 | 7/22/2024 | Gr. Alpha | 18.2 ± 1.9 | 32.2 | 16.1 - 38.6 | Pass | 0.57 |
| SPDW-60411 | 7/22/2024 | Gr. Beta | 155 ± 3 | 160 | 128 - 192 | Pass | 0.97 |
| SPDW-60417 | 7/23/2024 | U (Natural) | 8.14 ± 0.92 | 7.36 | 5.15 - 9.57 | Pass | 1.11 |
| SPDW-60452 | 7/31/2024 | Ra-226 | 11.5 ± 0.4 | 12.3 | 8.6 - 16.0 | Pass | 0.93 |
| SPDW-60530 | 8/12/2024 | Ra-226 | 12.3 ± 0.4 | 12.3 | 8.6 - 16.0 | Pass | 1.00 |
| LCS-08/26/24 | 7/8/2024 | Ba-133 | 31.2 ± 4.3 | 38.2 | 30.6 - 45.8 | Pass | 0.82 |
| LCS-08/26/24 | 7/8/2024 | Cs-134 | 22.0 ± 3.0 | 18.9 | 15.1 - 22.7 | Pass | 1.16 |
| LCS-08/26/24 | 7/8/2024 | Cs-137 | 68.0 ± 6.5 | 57.0 | 45.6 - 68.4 | Pass | 1.19 |
| LCS-08/26/24 | 7/8/2024 | Co-60 | 80.8 ± 5.0 | 76.8 | 61.4 - 92.2 | Pass | 1.05 |
| LCS-08/26/24 | 7/8/2024 | Zn-65 | 337 ± 15 | 312 | 250 - 374 | Pass | 1.08 |
| LCS-S-09/04/24 | 3/19/2018 | Ac-228 | 1,122 ± 120 | 1,240 | 992 - 1,488 | Pass | 0.90 |
| LCS-S-09/04/24 | 3/19/2018 | Bi-212 | 1,105 ± 293 | 1,240 | 992 - 1,488 | Pass | 0.89 |
| LCS-S-09/04/24 | 3/19/2018 | Bi-214 | 1,563 ± 49 | 1,760 | 1,408 - 2,112 | Pass | 0.89 |
| LCS-S-09/04/24 | 3/19/2018 | Co-60 | 7,251 ± 94 | 8,060 | 6,448 - 9,672 | Pass | 0.90 |
| LCS-S-09/04/24 | 3/19/2018 | Pb-214 | 1,489 ± 54 | 1,850 | 1,480 - 2,220 | Pass | 0.80 |
| SPDW-60527 | 9/10/2024 | H-3 | 20,297 ± 453 | 22,100 | 17,680 - 26,520 | Pass | 0.92 |
| SPDW-60546 | 9/13/2024 | S-90 | 15.9 ± 1.0 | 15.4 | 12.3 - 18.5 | Pass | 1.03 |
| SPDW-60559 | 9/25/2024 | Gr. Alpha | 7.5 ± 1.1 | 13.0 | 6.5 - 15.6 | Pass | 0.58 |
| SPDW-60559 | 9/25/2024 | Gr. Beta | 21.5 ± 1.3 | 20.6 | 16.5 - 24.7 | Pass | 1.04 |
| SPDW-60584 | 10/9/2024 | H-3 | 20,016 ± 452 | 22,100 | 17,680 - 26,520 | Pass | 0.91 |
| LCS-W-090324 | 4/8/2024 | Ba-133 | 65.5 ± 5.8 | 65.9 | 53 - 79 | Pass | 0.99 |
| LCS-W-090324 | 4/8/2024 | Cs-134 | 54.5 ± 5.1 | 57.8 | 46 - 69 | Pass | 0.94 |
| LCS-W-090324 | 4/8/2024 | Cs-137 | 189 ± 12 | 186 | 149 - 223 | Pass | 1.02 |
| LCS-W-090324 | 4/8/2024 | Co-60 | 101 ± 9 | 98.8 | 79 - 119 | Pass | 1.02 |
| LCS-W-090324 | 4/8/2024 | Zn-65 | 260 ± 25 | 240 | 192 - 288 | Pass | 1.08 |
| LCS-W-10/03/24 | 8/1/2023 | Cs-134 | 288 ± 5 | 305 | 244 - 366 | Pass | 0.94 |
| LCS-W-10/03/24 | 8/1/2023 | Cs-137 | 257 ± 8 | 235 | 188 - 282 | Pass | 1.09 |
| LCS-W-10/03/24 | 8/1/2023 | Co-57 | 550 ± 16 | 521 | 417 - 625 | Pass | 1.06 |
| LCS-W-10/03/24 | 8/1/2023 | Mn-54 | 364 ± 16 | 343 | 274 - 412 | Pass | 1.06 |
| LCS-W-10/03/24 | 8/1/2023 | Zn-65 | 489 ± 28 | 516 | 413 - 619 | Pass | 0.95 |
| LCS-W-10/05/24 | 7/12/2021 | Ba-133 | 42.5 ± 3.5 | 45.5 | 36 - 55 | Pass | 0.93 |
| LCS-W-10/05/24 | 7/12/2021 | Cs-134 | 88.1 ± 6.2 | 87.5 | 70 - 105 | Pass | 1.01 |
| LCS-W-10/05/24 | 7/12/2021 | Cs-137 | 219 ± 6 | 208 | 166 - 250 | Pass | 1.05 |
| LCS-W-10/05/24 | 7/12/2021 | Co-60 | 88.8 ± 5.1 | 87.1 | 70 - 105 | Pass | 1.02 |
| LCS-AP-10/05/24 | 8/1/2022 | Cs-137 | 52.1 ± 2.0 | 47.5 | 38 - 57 | Pass | 1.10 |
| LCS-AP-10/05/24 | 8/1/2022 | Co-57 | 99.8 ± 6.5 | 94.5 | 76 - 113 | Pass | 1.06 |
| LCS-AP-10/05/24 | 8/1/2022 | Co-60 | 59.9 ± 2.1 | 57.0 | 46 - 68 | Pass | 1.05 |
| LCS-AP-10/05/24 | 8/1/2022 | Mn-54 | 61.2 ± 7.7 | 58.9 | 47 - 71 | Pass | 1.04 |
| LCS-AP-10/05/24 | 8/1/2022 | Zn-65 | 43.1 ± 13.5 | 49.4 | 40 - 59 | Pass | 0.87 |

[a] Liquid sample results are reported in pCi/Liter, air filters ( pCi/m3), charcoal (pCi/charcoal canister), and solid samples (pCi/kg).
[b] Laboratory codes : W & SPW (Water), MI (milk), AP (air filter), SO (soil), VE (vegetation), CH (charcoal canister), F (fish), U (urine).
[c] Results are based on single determinations.
[d] Acceptance criteria are listed in Attachment A of this report.

TABLE A-3. Intralaboratory "Spiked" Samples

| | | | Concentration[a] | | | | |
|---|---|---|---|---|---|---|---|
| Lab Code[b] | Reference Date | Analysis | Laboratory results 2s, n=1[c] | Known Activity | Control Limits[d] | Acceptance | Ratio Lab/Known |
| LCS-S-092424 | 3/19/2018 | K-40 | 9,021 ± 385 | 10,600 | 8,480 - 12720 | Pass | 0.85 |
| LCS-S-092424 | 3/19/2018 | Cs-134 | 4,450 ± 235 | 5,330 | 4,264 - 6396 | Pass | 0.83 |
| LCS-S-092424 | 3/19/2018 | Cs-137 | 3,773 ± 55 | 4,210 | 3,368 - 5052 | Pass | 0.90 |
| LCS-S-092424 | 3/19/2018 | Co-60 | 6,958 ± 96 | 8,060 | 6,448 - 9672 | Pass | 0.86 |
| LCS-S-092424 | 3/19/2018 | Pb-214 | 1,638 ± 59 | 1,850 | 1,480 - 2220 | Pass | 0.89 |
| LCS-S-092424 | 3/19/2018 | Bi-214 | 1,608 ± 50 | 1,760 | 1,408 - 2112 | Pass | 0.91 |
| LCS-S-092424 | 3/19/2018 | Ac-228 | 1,105 ± 117 | 1,240 | 992 - 1488 | Pass | 0.89 |
| LCS-S-101424 | 2/1/2024 | Co-60 | 15,340 ± 87 | 17,820 | 14,256 - 21,384 | Pass | 0.86 |
| LCS-S-101424 | 2/1/2024 | Cs-134 | 8,700 ± 62 | 8,694 | 6,955 - 10,433 | Pass | 1.00 |
| LCS-S-101424 | 2/1/2024 | Cs-137 | 37,330 ± 26 | 41,850 | 33,480 - 50,220 | Pass | 0.89 |
| LCS-S-101424 | 2/1/2024 | K-40 | 11,550 ± 411 | 13,095 | 10,476 - 15,714 | Pass | 0.88 |
| LCS-S-101424 | 2/1/2024 | Mn-54 | 8,080 ± 125 | 8,964 | 7,171 - 10,757 | Pass | 0.90 |
| LCS-S-101424 | 2/1/2024 | Zn-65 | 16,260 ± 273 | 18,981 | 15,185 - 22,777 | Pass | 0.86 |
| LCS-W-1014224 | 2/1/2024 | Co-57 | 544 ± 24 | 554 | 443 - 664 | Pass | 0.98 |
| LCS-W-1014224 | 2/1/2024 | Cs-134 | 281 ± 8 | 289 | 231 - 347 | Pass | 0.97 |
| LCS-W-1014224 | 2/1/2024 | Cs-137 | 254 ± 11 | 257 | 205 - 308 | Pass | 0.99 |
| LCS-W-1014224 | 2/1/2024 | Mn-54 | 369 ± 21 | 365 | 292 - 437 | Pass | 1.01 |
| LCS-W-1014224 | 2/1/2024 | Zn-65 | 501 ± 38 | 489 | 391 - 586 | Pass | 1.03 |
| LCS-VE-100524 | 2/1/2024 | Co-57 | 544 ± 5 | 521 | 417 - 625 | Pass | 1.04 |
| LCS-VE-100524 | 2/1/2024 | Cs-134 | 281 ± 8 | 305 | 244 - 366 | Pass | 0.92 |
| LCS-VE-100524 | 2/1/2024 | Cs-137 | 254 ± 11 | 235 | 188 - 282 | Pass | 1.08 |
| LCS-VE-100524 | 2/1/2024 | Zn-65 | 501 ± 38 | 516 | 413 - 619 | Pass | 0.97 |
| LCS-VE-100524 | 2/1/2024 | Mn-54 | 369 ± 21 | 343 | 274 - 411 | Pass | 1.08 |
| SPDW-60583 | 10/9/2024 | H-3 | 20,016 ± 452 | 22,100 | 17,680 - 26,520 | Pass | 0.91 |
| SPDW-60604 | 10/25/2024 | H-3 | 19,814 ± 447 | 22,100 | 17,680 - 26,520 | Pass | 0.90 |
| SPDW-60622 | 11/14/2024 | Gr. Alpha | 12.5 ± 2.9 | 13.0 | 6.5 - 15.6 | Pass | 0.96 |
| SPDW-60622 | 11/14/2024 | Gr. Beta | 17.8 ± 2.3 | 20.6 | 16.5 - 24.7 | Pass | 0.86 |
| SPDW-60635 | 10/10/2024 | Ra-226 | 14.9 ± 0.5 | 12.3 | 8.6 - 16.0 | Pass | 1.21 |
| SPDW-60631 | 12/2/2024 | H-3 | 20,384 ± 453 | 22,100 | 17,680 - 26,520 | Pass | 0.92 |
| SPDW-60641 | 12/17/2024 | H-3 | 21,520 ± 468 | 22,100 | 17,680 - 26,520 | Pass | 0.97 |

[a] Liquid sample results are reported in pCi/Liter, air filters ( pCi/m3), charcoal (pCi/charcoal canister), and solid samples (pCi/kg). vegetation (pCi/sample)

[b] Laboratory codes : W & SPW (Water), MI (milk), AP (air filter), SO (soil), VE (vegetation), CH (charcoal canister), F (fish), U (urine).

[c] Results are based on single determinations.

[d] Acceptance criteria are listed in Attachment A of this report.

TABLE A-4. Intralaboratory "Blank" Samples

| Lab Code[b] | Sample Type | Collection Date | Analysis[c] | Concentration[a] Laboratory results (4.66σ) LLD | Activity[d] | Acceptance Criteria (4.66 σ) |
|---|---|---|---|---|---|---|
| SPDW-60024 | Water | 1/12/2024 | Gr. Alpha | 0.70 | 0.14 ± 0.50 | 2 |
| SPDW-60024 | Water | 1/12/2024 | Gr. Beta | 0.83 | -0.60 ± 0.56 | 4 |
| SPW-3913 | Water | 2/2/2024 | Tc-99 | 11.8 | -12.3 ± 7.0 | 200 |
| SPDW-60041 | Water | 2/2/2024 | H-3 | 177 | 68 ± 96 | 200 |
| SPDW-60058 | Water | 2/14/2024 | Gr. Alpha | 0.51 | -0.10 ± 0.35 | 2 |
| SPDW-60058 | Water | 2/14/2024 | Gr. Beta | 0.71 | 0.19 ± 0.50 | 4 |
| SPDW-60147 | Water | 2/21/2024 | Ra-226 | 0.04 | 0.18 ± 0.03 | 2 |
| SPDW-60099 | Water | 2/26/2024 | H-3 | 179 | -89 ± 84 | 200 |
| SPDW-60097 | Water | 2/28/2024 | Gr. Alpha | 0.53 | 0.29 ± 0.39 | 2 |
| SPDW-60097 | Water | 2/28/2024 | Gr. Beta | 0.79 | -0.42 ± 0.54 | 4 |
| SPDW-60141 | Water | 3/19/2024 | I-131 | 0.18 | -0.10 ± 0.10 | 1 |
| SPDW-60149 | Water | 3/22/2024 | H-3 | 174 | -2 ± 86 | 200 |
| SPDW-60115 | Water | 3/7/2024 | H-3 | 175 | 20 ± 85 | 200 |
| SPDW-60129 | Water | 3/11/2024 | Ra-228 | 0.74 | 0.07 ± 0.35 | 2 |
| SPDW-60132 | Water | 3/14/2024 | Gr. Alpha | 0.51 | -0.20 ± 0.34 | 2 |
| SPDW-60132 | Water | 3/14/2024 | Gr. Beta | 0.75 | -0.07 ± 0.52 | 4 |
| SPDW-60190 | Water | 3/21/2024 | Ra-226 | 0.04 | -0.14 ± 0.03 | 2 |
| SPDW-60155 | Water | 3/25/2024 | Ra-228 | 1.46 | -0.13 ± 0.66 | 2 |
| SPDW-60183 | Water | 4/9/2024 | Gr. Alpha | 0.66 | -0.09 ± 0.46 | 2 |
| SPDW-60183 | Water | 4/9/2024 | Gr. Beta | 0.76 | 0.11 ± 0.54 | 4 |
| SPDW-60266 | Water | 4/11/2024 | Ra-226 | 0.04 | -0.15 ± 0.03 | 2 |
| SPDW-60197 | Water | 4/15/2024 | H-3 | 174 | 53 ± 84 | 200 |
| SPDW-60212 | Water | 4/25/2024 | Ra-228 | 0.90 | 0.03 ± 0.42 | 2 |
| SPDW-60214 | Water | 4/26/2024 | H-3 | 170 | 27 ± 80 | 200 |
| SPDW-60235 | Water | 5/10/2024 | H-3 | 174 | -7 ± 81 | 200 |
| SPDW-60252 | Water | 5/16/2024 | Ra-228 | 0.68 | 0.72 ± 0.39 | 2 |
| SPDW-60294 | Water | 5/28/2024 | H-3 | 188 | -43 ± 88 | 200 |
| SPDW-60295 | Water | 5/28/2024 | Sr-89 | 0.62 | 0.16 ± 0.44 | 5 |
| SPDW-60295 | Water | 5/28/2024 | Sr-90 | 0.66 | -0.20 ± 0.28 | 1 |
| SPDW-60301 | Water | 5/29/2024 | Gr. Alpha | 0.49 | -0.16 ± 0.33 | 2 |
| SPDW-60301 | Water | 5/29/2024 | Gr. Beta | 0.76 | 0.14 ± 0.54 | 4 |
| SPDW-60306 | Water | 5/23/2024 | Ra-228 | 0.17 | -0.30 ± 0.38 | 2 |
| SPDW-60356 | Water | 5/30/2024 | Ra-226 | 0.04 | 0.12 ± 0.03 | 2 |
| SPDW-60313 | Water | 6/6/2024 | Ra-228 | 0.76 | -0.01 ± 0.35 | 2 |
| SPDW-60330 | Water | 6/10/2024 | H-3 | 183 | 12 ± 85 | 200 |
| SPDW-60340 | Water | 6/17/2024 | I-131 | 0.15 | -0.04 ± 0.08 | 1 |
| SPDW-60360 | Water | 6/27/2024 | Gr. Alpha | 0.46 | -0.12 ± 0.31 | 2 |
| SPDW-60360 | Water | 6/27/2024 | Gr. Beta | 0.75 | 0.10 ± 0.53 | 4 |
| SPDW-60424 | Water | 6/24/2024 | Ra-226 | 0.04 | -0.14 ± 0.09 | 2 |

[a] Liquid sample results are reported in pCi/Liter, air filters ( pCi/m$^3$), charcoal (pCi/charcoal canister), and solid samples (pCi/g).
[b] Laboratory codes : W & SPW (Water), MI (milk), AP (air filter), SO (soil), VE (vegetation), CH (charcoal canister), F (fish), U (urine).
[c] I-131(G); iodine-131 as analyzed by gamma spectroscopy.
[d] Activity reported is a net activity result.

TABLE A-4. Intralaboratory "Blank" Samples

| Lab Code[b] | Sample Type | Collection Date | Analysis[c] | Concentration[a] | | |
|---|---|---|---|---|---|---|
| | | | | Laboratory results (4.66σ) | | Acceptance |
| | | | | LLD | Activity[d] | Criteria (4.66 σ) |
| SPDW-60392 | Water | 7/10/2024 | H-3 | 183 | -28 ± 83 | 200 |
| SPDW-60411 | Water | 7/22/2024 | Gr. Alpha | 0.42 | -0.06 ± 0.29 | 2 |
| SPDW-60411 | Water | 7/22/2024 | Gr. Beta | 0.71 | 0.40 ± 0.51 | 4 |
| SPDW-60416 | Water | 7/23/2024 | U (Natural) | 0.56 | -0.16 ± 0.66 | 1 |
| SPDW-60418 | Water | 7/24/2024 | Ra-228 | 0.65 | 0.93 ± 0.40 | 2 |
| SPDW-60451 | Water | 7/31/2024 | Ra-226 | 0.07 | 0.02 ± 0.06 | 2 |
| SPW-1901 | Water | 8/6/2024 | Ni-63 | 87 | -144 ± 51 | 200 |
| SPDW-60462 | Water | 8/16/2024 | Ra-228 | 0.58 | 0.08 ± 0.28 | 2 |
| SPDW-60529 | Water | 8/12/2024 | Ra-226 | 0.04 | -0.07 ± 0.03 | 2 |
| SPDW-60522 | Water | 9/5/2024 | I-131 | 0.11 | -0.09 ± 0.07 | 1 |
| SPDW-60526 | Water | 9/10/2024 | H-3 | 183 | 9 ± 86 | 200 |
| SPDW-60592 | Water | 9/11/2024 | Ra-226 | 0.06 | -0.11 ± 0.05 | 2 |
| SPDW-60545 | Water | 9/13/2024 | Sr-89 | 0.56 | -0.06 ± 0.43 | 5 |
| SPDW-60545 | Water | 9/13/2024 | Sr-90 | 0.52 | 0.06 ± 0.25 | 1 |
| SPDW-60560 | Water | 9/26/2024 | H-3 | 180 | 88 ± 89 | 200 |
| SPDW-60594 | Water | 10/16/2024 | Ra-228 | 0.73 | 0.43 ± 0.39 | 2 |
| SPDW-60634 | Water | 10/10/2024 | Ra-226 | 0.05 | -0.07 ± 0.04 | 2 |
| MB-102124 | Water | 10/21/2024 | Co-57 | 4.76 | 0.87 ± 2.53 | 10 |
| MB-102124 | Water | 10/21/2024 | Cs-134 | 3.88 | -3.36 ± 2.68 | 10 |
| MB-102124 | Water | 10/21/2024 | Cs-137 | 5.73 | 1.08 ± 2.64 | 10 |
| MB-102124 | Water | 10/21/2024 | Mn-54 | 5.17 | 0.03 ± 2.65 | 10 |
| MB-102124 | Water | 10/21/2024 | Zn-65 | 6.83 | -1.76 ± 5.61 | 10 |
| SPDW-60614 | Water | 11/8/2024 | H-3 | 185 | -29 ± 84 | 200 |
| SPDW-60630 | Water | 12/2/2024 | H-3 | 184 | -12 ± 86 | 200 |
| MB-120924 | Water | 12/9/2024 | Co-57 | 1.08 | 0.04 ± 0.66 | 10 |
| MB-120924 | Water | 12/9/2024 | Cs-134 | 1.06 | 0.22 ± 0.61 | 10 |
| MB-120924 | Water | 12/9/2024 | Cs-137 | 1.39 | 0.65 ± 0.68 | 10 |
| MB-120924 | Water | 12/9/2024 | Mn-54 | 0.93 | 0.07 ± 0.55 | 10 |
| MB-120924 | Water | 12/9/2024 | Zn-65 | 2.28 | 0.33 ± 1.12 | 10 |
| MB-121224 | Water | 12/12/2024 | Co-57 | 1.56 | -1.64 ± 1.28 | 10 |
| MB-121224 | Water | 12/12/2024 | Cs-134 | 1.85 | -2.84 ± 1.36 | 10 |
| MB-121224 | Water | 12/12/2024 | Cs-137 | 1.39 | -0.10 ± 1.44 | 10 |
| MB-121224 | Water | 12/12/2024 | Mn-54 | 2.56 | 1.81 ± 1.30 | 10 |
| MB-121224 | Water | 12/12/2024 | Zn-65 | 3.05 | -6.22 ± 2.99 | 10 |
| SPDW-60638 | Water | 12/12/2024 | I-131 | 0.17 | -0.19 ± 0.08 | 1 |
| SPDW-60641 | Water | 12/17/2024 | H-3 | 182 | 3 ± 85 | 200 |

[a] Liquid sample results are reported in pCi/Liter, air filters ( pCi/m$^3$), charcoal (pCi/charcoal canister), and solid samples (pCi/g).
[b] Laboratory codes : W & SPW (Water), MI (milk), AP (air filter), SO (soil), VE (vegetation), CH (charcoal canister), F (fish), U (urine).
[c] I-131(G); iodine-131 as analyzed by gamma spectroscopy.
[d] Activity reported is a net activity result.

TABLE A-5. Intralaboratory "Duplicate" Samples

| | | | Concentration[a] | | | |
|---|---|---|---|---|---|---|
| Lab Code[b] | Collection Date | Analysis | First Result | Second Result | Averaged Result | Acceptance |
| DW-60006 | 1/5/2024 | Gr. Alpha | 2.03 ± 0.83 | 1.59 ± 0.83 | 1.81 ± 0.59 | Pass |
| DW-60006 | 1/5/2024 | Gr. Beta | 1.36 ± 0.58 | 1.22 ± 0.62 | 1.29 ± 0.42 | Pass |
| W-41 | 1/5/2024 | Ra-226 | 1.67 ± 0.35 | 1.03 ± 0.35 | 1.35 ± 0.25 | Pass |
| W-41 | 1/5/2024 | Ra-228 | 4.19 ± 0.85 | 3.45 ± 0.83 | 3.82 ± 0.59 | Pass |
| W-62 | 1/8/2024 | Ra-226 | 0.54 ± 0.30 | 0.12 ± 0.41 | 0.33 ± 0.25 | Pass |
| DW-60018 | 1/16/2024 | Gr. Alpha | 1.75 ± 0.74 | 0.98 ± 0.80 | 1.37 ± 0.54 | Pass |
| W-125,126 | 1/16/2024 | Ra-226 | 0.37 ± 0.18 | 0.66 ± 0.27 | 0.52 ± 0.16 | Pass |
| DW-60034,60035 | 1/29/2024 | Gr. Alpha | 2.10 ± 0.74 | 1.41 ± 0.79 | 1.76 ± 0.54 | Pass |
| DW-60034,60035 | 1/29/2024 | Gr. Beta | 1.13 ± 0.57 | 0.57 ± 0.57 | 0.85 ± 0.40 | Pass |
| DW-60049,60050 | 2/5/2024 | Gr. Alpha | 0.61 ± 1.02 | 1.20 ± 0.87 | 0.90 ± 0.67 | Pass |
| DW-60049,60050 | 2/5/2024 | Gr. Beta | 0.99 ± 0.64 | 1.19 ± 0.07 | 1.09 ± 0.32 | Pass |
| DW-60054,60055 | 2/8/2024 | Gr. Beta | 0.25 ± 0.53 | 0.62 ± 0.61 | 0.44 ± 0.40 | Pass |
| DW-60071,60072 | 2/16/2024 | Ra-226 | 2.33 ± 0.21 | 1.73 ± 0.17 | 2.03 ± 0.14 | Pass |
| DW-60071,60072 | 2/16/2024 | Ra-228 | 0.48 ± 0.42 | 0.60 ± 0.45 | 0.54 ± 0.31 | Pass |
| DW-60107,60108 | 3/2/2024 | Gr. Alpha | 1.26 ± 0.98 | 1.59 ± 0.99 | 1.42 ± 0.70 | Pass |
| DW-60107,60108 | 3/2/2024 | Gr. Beta | 0.63 ± 0.57 | 0.14 ± 0.59 | 0.38 ± 0.41 | Pass |
| DW-60120,60121 | 3/8/2024 | Gr. Beta | 1.15 ± 0.56 | 1.04 ± 0.58 | 1.10 ± 0.40 | Pass |
| LW-582,583 | 3/19/2024 | Be-7 | 3.80 ± 0.70 | 1.76 ± 0.60 | 2.78 ± 0.46 | Pass |
| SWT-708,709 | 3/26/2024 | H-3 | 186 ± 90 | 136 ± 87 | 161 ± 62 | Pass |
| SW-624,625 | 4/2/2024 | H-3 | 1,174 ± 133 | 1,302 ± 138 | 1,238 ± 96 | Pass |
| AP-865,866 | 4/3/2024 | Be-7 | 0.040 ± 0.007 | 0.053 ± 0.008 | 0.047 ± 0.005 | Pass |
| DW-60180,60181 | 4/5/2024 | Ra-226 | 0.97 ± 0.25 | 1.30 ± 0.21 | 1.135 ± 0.16 | Pass |
| DW-60180,60181 | 4/5/2024 | Ra-228 | 0.85 ± 0.48 | 1.34 ± 0.54 | 1.095 ± 0.36 | Pass |
| WW-949,950 | 4/16/2024 | H-3 | 229 ± 94 | 136 ± 90 | 183 ± 65 | Pass |
| S-886,887 | 4/18/2024 | Pb-214 | 0.93 ± 0.04 | 0.94 ± 0.04 | 0.93 ± 0.03 | Pass |
| S-886,887 | 4/18/2024 | Ac-228 | 0.82 ± 0.08 | 0.83 ± 0.06 | 0.82 ± 0.05 | Pass |
| DW-60206,60207 | 4/19/2024 | Ra-226 | 2.35 ± 0.27 | 3.49 ± 0.25 | 2.92 ± 0.18 | Pass |
| DW-60203,60204 | 4/19/2024 | Gr. Alpha | 2.12 ± 0.64 | 1.74 ± 0.73 | 1.93 ± 0.49 | Pass |
| DW-60206,60207 | 4/19/2024 | Ra-228 | 0.50 ± 0.59 | -0.21 ± 0.53 | 0.15 ± 0.40 | Pass |
| WW-1075,1076 | 4/30/2024 | H-3 | 278 ± 107 | 311 ± 109 | 294 ± 76 | Pass |
| SG-1017,1018 | 5/1/2024 | Gr. Alpha | 27.2 ± 4.00 | 32.0 ± 4.00 | 29.6 ± 2.83 | Pass |
| SG-1017,1018 | 5/1/2024 | Gr. Beta | 25.7 ± 1.80 | 24.5 ± 1.90 | 25.1 ± 1.31 | Pass |
| SG-1017,1018 | 5/1/2024 | Pb-214 | 3.28 ± 0.14 | 4.61 ± 0.11 | 3.95 ± 0.09 | Pass |
| SG-1017,1018 | 5/1/2024 | Ac-228 | 4.86 ± 0.18 | 4.98 ± 0.37 | 4.92 ± 0.21 | Pass |
| DW-60273,60274 | 5/21/2024 | Ra-228 | 2.12 ± 0.63 | 1.33 ± 0.45 | 1.73 ± 0.39 | Pass |
| XW-1138,1139 | 5/31/2024 | H-3 | 732 ± 124 | 688 ± 122 | 710 ± 87 | Pass |

TABLE A-5. Intralaboratory "Duplicate" Samples

| | | | Concentration[a] | | | |
|---|---|---|---|---|---|---|
| Lab Code[b] | Collection Date | Analysis | First Result | Second Result | Averaged Result | Acceptance |
| AP-060324A,B | 6/3/2024 | Gr. Beta | 0.021 ± 0.005 | 0.018 ± 0.005 | 0.020 ± 0.003 | Pass |
| AP-061224A,B | 6/12/2024 | Gr. Beta | 0.009 ± 0.003 | 0.011 ± 0.003 | 0.010 ± 0.002 | Pass |
| AP-061724A,B | 6/17/2024 | Gr. Beta | 0.031 ± 0.005 | 0.023 ± 0.005 | 0.027 ± 0.004 | Pass |
| AP-062524A,B | 6/25/2024 | Gr. Beta | 0.033 ± 0.003 | 0.034 ± 0.003 | 0.034 ± 0.002 | Pass |
| SG-1432,1433 | 6/24/2024 | Ra-226 | 2.36 ± 0.09 | 2.36 ± 0.08 | 2.36 ± 0.06 | Pass |
| SG-1432,1433 | 6/24/2024 | Ra-228 | 1.67 ± 0.14 | 1.69 ± 0.15 | 1.68 ± 0.10 | Pass |
| SG-1472,1473 | 7/1/2024 | Gr. Alpha | 36.0 ± 4.5 | 36.8 ± 4.5 | 36.4 ± 3.2 | Pass |
| SG-1472,1473 | 7/1/2024 | Gr. Beta | 30.4 ± 2.1 | 31.2 ± 2.2 | 30.8 ± 1.5 | Pass |
| SG-1472,1473 | 7/1/2024 | Pb-214 | 2.64 ± 0.11 | 3.11 ± 0.09 | 2.88 ± 0.07 | Pass |
| SG-1472,1473 | 7/1/2024 | Ac-228 | 5.55 ± 0.21 | 5.79 ± 0.25 | 5.67 ± 0.16 | Pass |
| SG-1474,1475 | 7/1/2024 | Gr. Alpha | 43.6 ± 5.7 | 37.5 ± 5.4 | 40.6 ± 3.9 | Pass |
| SG-1474,1475 | 7/1/2024 | Gr. Beta | 40.6 ± 2.8 | 34.2 ± 2.7 | 37.4 ± 1.9 | Pass |
| SG-1474,1475 | 7/1/2024 | Pb-214 | 3.58 ± 0.10 | 3.93 ± 0.10 | 3.76 ± 0.07 | Pass |
| SG-1474,1475 | 7/1/2024 | Ac-228 | 4.21 ± 0.15 | 4.13 ± 0.16 | 4.17 ± 0.11 | Pass |
| AP-070324A,B | 7/3/2024 | Gr. Beta | 0.013 ± 0.003 | 0.014 ± 0.003 | 0.013 ± 0.002 | Pass |
| W-1592,1593 | 7/9/2024 | Gr. Alpha | 1.23 ± 0.67 | 0.36 ± 0.54 | 0.80 ± 0.43 | Pass |
| W-1592,1593 | 7/9/2024 | Gr. Beta | 1.45 ± 0.60 | 0.60 ± 0.53 | 1.03 ± 0.40 | Pass |
| AP-071024A,B | 7/10/2024 | Gr. Beta | 0.024 ± 0.003 | 0.025 ± 0.003 | 0.024 ± 0.002 | Pass |
| S-1613,1614 | 7/11/2024 | Pb-214 | 197 ± 1 | 200 ± 1 | 199 ± 1 | Pass |
| S-1613,1614 | 7/11/2024 | Ac-228 | 134 ± 1 | 143 ± 1 | 139 ± 1 | Pass |
| AP-071724A,B | 7/17/2024 | Gr. Beta | 0.038 ± 0.001 | 0.032 ± 0.003 | 0.035 ± 0.001 | Pass |
| SG-1722,1723 | 7/22/2024 | Gr. Beta | 16.4 ± 3.4 | 17.5 ± 3.4 | 16.9 ± 2.4 | Pass |
| SG-1722,1723 | 7/22/2024 | Gr. Alpha | 25.5 ± 6.9 | 17.5 ± 6.0 | 21.5 ± 4.6 | Pass |
| SG-1722,1723 | 7/22/2024 | K-40 | 6.99 ± 1.04 | 5.75 ± 0.86 | 6.37 ± 0.67 | Pass |
| SG-1722,1723 | 7/22/2024 | Pb-214 | 7.62 ± 0.18 | 8.10 ± 0.25 | 7.86 ± 0.15 | Pass |
| SG-1722,1723 | 7/22/2024 | Ac-228 | 4.72 ± 0.34 | 4.76 ± 0.36 | 4.74 ± 0.24 | Pass |
| DW-60413,60414 | 7/22/2024 | Gr. Alpha | 1.71 ± 0.79 | 0.93 ± 0.81 | 1.32 ± 0.56 | Pass |
| DW-60413,60414 | 7/22/2024 | Gr. Beta | 1.18 ± 0.58 | 1.26 ± 0.59 | 1.22 ± 0.41 | Pass |
| AP-080524A,B | 8/5/2024 | Gr. Beta | 0.025 ± 0.003 | 0.025 ± 0.003 | 0.025 ± 0.002 | Pass |
| AP-081324A,B | 8/13/2024 | Gr. Beta | 0.030 ± 0.004 | 0.028 ± 0.004 | 0.029 ± 0.003 | Pass |
| AP-082124A,B | 8/21/2024 | Gr. Beta | 0.034 ± 0.003 | 0.030 ± 0.003 | 0.032 ± 0.002 | Pass |
| AP-082824A,B | 8/28/2024 | Gr. Beta | 0.033 ± 0.003 | 0.034 ± 0.003 | 0.033 ± 0.002 | Pass |
| AP-090924A,B | 9/9/2024 | Gr. Beta | 0.025 ± 0.005 | 0.026 ± 0.005 | 0.026 ± 0.003 | Pass |
| SO-2132,2133 | 9/9/2024 | Be-7 | 0.39 ± 0.11 | 0.53 ± 0.22 | 0.46 ± 0.12 | Pass |
| SO-2132,2133 | 9/9/2024 | K-40 | 14.78 ± 0.27 | 14.52 ± 0.52 | 14.65 ± 0.29 | Pass |
| SO-2132,2133 | 9/9/2024 | Cs-137 | 0.10 ± 0.01 | 0.08 ± 0.02 | 0.09 ± 0.01 | Pass |
| SO-2132,2133 | 9/9/2024 | Tl-208 | 0.44 ± 0.03 | 0.43 ± 0.02 | 0.44 ± 0.02 | Pass |
| SO-2132,2133 | 9/9/2024 | Bi-212 | 1.40 ± 0.34 | 1.25 ± 0.15 | 1.32 ± 0.19 | Pass |
| SO-2132,2133 | 9/9/2024 | Bi-214 | 1.01 ± 0.03 | 0.90 ± 0.04 | 0.95 ± 0.02 | Pass |
| SO-2132,2133 | 9/9/2024 | Pb-212 | 1.29 ± 0.02 | 1.18 ± 0.03 | 1.24 ± 0.02 | Pass |
| SO-2132,2133 | 9/9/2024 | Pb-214 | 0.88 ± 0.03 | 1.07 ± 0.03 | 0.98 ± 0.02 | Pass |

TABLE A-5. Intralaboratory "Duplicate" Samples

| | | | Concentration[a] | | | |
|---|---|---|---|---|---|---|
| Lab Code[b] | Collection Date | Analysis | First Result | Second Result | Averaged Result | Acceptance |
| SO-2132,2133 | 9/9/2024 | Ra-226 | 2.38 ± 0.36 | 2.31 ± 0.16 | 2.34 ± 0.20 | Pass |
| SO-2132,2133 | 9/9/2024 | Ac-228 | 1.33 ± 0.10 | 1.33 ± 0.06 | 1.33 ± 0.06 | Pass |
| | | | | | | |
| SS-2206,2207 | 9/17/2024 | Be-7 | 0.29 ± 0.06 | 0.23 ± 0.10 | 0.26 ± 0.06 | Pass |
| SS-2206,2207 | 9/17/2024 | K-40 | 6.54 ± 0.29 | 6.19 ± 0.20 | 6.37 ± 0.18 | Pass |
| SS-2206,2207 | 9/17/2024 | Tl-208 | 0.20 ± 0.02 | 0.22 ± 0.02 | 0.21 ± 0.01 | Pass |
| SS-2206,2207 | 9/17/2024 | Bi-212 | 0.65 ± 0.14 | 0.69 ± 0.19 | 0.67 ± 0.12 | Pass |
| SS-2206,2207 | 9/17/2024 | Bi-214 | 0.68 ± 0.02 | 0.61 ± 0.02 | 0.65 ± 0.02 | Pass |
| SS-2206,2207 | 9/17/2024 | Pb-212 | 0.51 ± 0.02 | 0.59 ± 0.02 | 0.55 ± 0.01 | Pass |
| SS-2206,2207 | 9/17/2024 | Pb-214 | 0.73 ± 0.03 | 0.63 ± 0.02 | 0.68 ± 0.02 | Pass |
| SS-2206,2207 | 9/17/2024 | Ra-226 | 1.12 ± 0.12 | 1.25 ± 0.19 | 1.18 ± 0.11 | Pass |
| SS-2206,2207 | 9/17/2024 | Ac-228 | 0.66 ± 0.05 | 0.65 ± 0.06 | 0.66 ± 0.04 | Pass |
| VE-2111,2112 | 9/10/2024 | Be-7 | 0.56 ± 0.17 | 0.59 ± 0.18 | 0.58 ± 0.12 | Pass |
| VE-2111,2112 | 9/10/2024 | K-40 | 4.62 ± 0.40 | 5.21 ± 0.41 | 4.91 ± 0.29 | Pass |
| | | | | | | |
| AP-091624A,B | 9/16/2024 | Gr. Beta | 0.044 ± 0.004 | 0.043 ± 0.004 | 0.044 ± 0.002 | Pass |
| SS-2206,2207 | 9/17/2024 | Be-7 | 0.29 ± 0.06 | 0.23 ± 0.10 | 0.26 ± 0.06 | Pass |
| SS-2206,2207 | 9/17/2024 | K-40 | 6.54 ± 0.29 | 6.19 ± 0.20 | 6.37 ± 0.18 | Pass |
| SS-2206,2207 | 9/17/2024 | Tl-208 | 0.20 ± 0.02 | 0.22 ± 0.02 | 0.21 ± 0.01 | Pass |
| SS-2206,2207 | 9/17/2024 | Bi-212 | 0.65 ± 0.14 | 0.69 ± 0.19 | 0.67 ± 0.12 | Pass |
| SS-2206,2207 | 9/17/2024 | Bi-214 | 0.68 ± 0.02 | 0.61 ± 0.02 | 0.65 ± 0.02 | Pass |
| SS-2206,2207 | 9/17/2024 | Pb-212 | 0.51 ± 0.02 | 0.59 ± 0.02 | 0.55 ± 0.01 | Pass |
| SS-2206,2207 | 9/17/2024 | Pb-214 | 0.73 ± 0.03 | 0.63 ± 0.02 | 0.68 ± 0.02 | Pass |
| SS-2206,2207 | 9/17/2024 | Ra-226 | 1.12 ± 0.12 | 1.25 ± 0.19 | 1.18 ± 0.11 | Pass |
| SS-2206,2207 | 9/17/2024 | Ac-228 | 0.66 ± 0.05 | 0.65 ± 0.06 | 0.66 ± 0.04 | Pass |
| VE-2111,2112 | 9/10/2024 | Be-7 | 0.56 ± 0.17 | 0.59 ± 0.18 | 0.58 ± 0.12 | Pass |
| VE-2111,2112 | 9/10/2024 | K-40 | 4.62 ± 0.40 | 5.21 ± 0.41 | 4.91 ± 0.29 | Pass |
| AP-092524A,B | 9/25/2024 | Gr. Beta | 0.036 ± 0.003 | 0.033 ± 0.003 | 0.035 ± 0.002 | Pass |
| AP-2773,2774 | 9/30/2024 | Be-7 | 0.067 ± 0.008 | 0.075 ± 0.066 | 0.071 ± 0.033 | Pass |
| | | | | | | |
| SG-2353,2354 | 10/3/2024 | K-40 | 3.68 ± 0.34 | 2.79 ± 0.59 | 3.24 ± 0.34 | Pass |
| SG-2353,2354 | 10/3/2024 | Tl-208 | 0.13 ± 0.01 | 0.14 ± 0.03 | 0.13 ± 0.01 | Pass |
| SG-2353,2354 | 10/3/2024 | Pb-212 | 0.36 ± 0.02 | 0.27 ± 0.03 | 0.32 ± 0.02 | Pass |
| SG-2353,2354 | 10/3/2024 | Pb-214 | 1.64 ± 0.05 | 1.21 ± 0.08 | 1.43 ± 0.05 | Pass |
| SG-2353,2354 | 10/3/2024 | Bi-214 | 1.56 ± 0.05 | 1.32 ± 0.10 | 1.44 ± 0.06 | Pass |
| SG-2353,2354 | 10/3/2024 | Ac-228 | 2.62 ± 0.09 | 2.20 ± 0.19 | 2.41 ± 0.11 | Pass |
| SG-2362,2363 | 10/4/2024 | Gr. Alpha | 31.50 ± 3.70 | 23.00 ± 3.30 | 27.25 ± 2.48 | Pass |
| SG-2362,2363 | 10/4/2024 | Gr. Beta | 24.70 ± 1.70 | 19.60 ± 1.60 | 22.15 ± 1.17 | Pass |
| SG-2362,2363 | 10/4/2024 | Ra-226 | 4.08 ± 0.23 | 4.03 ± 0.18 | 4.06 ± 0.15 | Pass |
| SG-2362,2363 | 10/4/2024 | Ra-228 | 5.90 ± 0.41 | 5.85 ± 0.34 | 5.88 ± 0.27 | Pass |
| S-2541,2542 | 10/11/2024 | K-40 | 14.20 ± 0.44 | 14.82 ± 0.44 | 14.51 ± 0.31 | Pass |
| S-2541,2542 | 10/11/2024 | Cs-137 | 0.08 ± 0.01 | 0.10 ± 0.01 | 0.09 ± 0.01 | Pass |
| S-2541,2542 | 10/11/2024 | Tl-208 | 0.26 ± 0.02 | 0.27 ± 0.02 | 0.27 ± 0.01 | Pass |
| S-2541,2542 | 10/11/2024 | Pb-212 | 0.75 ± 0.03 | 0.54 ± 0.03 | 0.64 ± 0.02 | Pass |

TABLE A-5. Intralaboratory "Duplicate" Samples

| | | | Concentration[a] | | | |
|---|---|---|---|---|---|---|
| Lab Code[b] | Collection Date | Analysis | First Result | Second Result | Averaged Result | Acceptance |
| S-2541,2542 | 10/11/2024 | Bi-212 | 1.17 ± 0.29 | 0.83 ± 0.16 | 1.00 ± 0.16 | Pass |
| S-2541,2542 | 10/11/2024 | Pb-214 | 1.28 ± 0.05 | 1.07 ± 0.05 | 1.17 ± 0.04 | Pass |
| S-2541,2542 | 10/11/2024 | Ac-228 | 0.88 ± 0.08 | 0.85 ± 0.08 | 0.86 ± 0.06 | Pass |
| S-2752,2753 | 10/24/2024 | K-40 | 15.24 ± 0.33 | 15.54 ± 0.31 | 15.39 ± 0.22 | Pass |
| S-2752,2753 | 10/24/2024 | Cs-137 | 0.09 ± 0.09 | 0.10 ± 0.09 | 0.09 ± 0.06 | Pass |
| S-2752,2753 | 10/24/2024 | Tl-208 | 0.33 ± 0.01 | 0.34 ± 0.01 | 0.34 ± 0.01 | Pass |
| S-2752,2753 | 10/24/2024 | Pb-212 | 0.93 ± 0.02 | 0.98 ± 0.02 | 0.96 ± 0.01 | Pass |
| S-2752,2753 | 10/24/2024 | Bi-212 | 1.15 ± 0.12 | 1.13 ± 0.12 | 1.14 ± 0.08 | Pass |
| S-2752,2753 | 10/24/2024 | Pb-214 | 1.33 ± 0.03 | 1.19 ± 0.03 | 1.26 ± 0.02 | Pass |
| S-2752,2753 | 10/24/2024 | Bi-214 | 1.37 ± 0.04 | 1.19 ± 0.03 | 1.28 ± 0.03 | Pass |
| S-2752,2753 | 10/24/2024 | Ra-226 | 2.61 ± 0.36 | 2.28 ± 0.15 | 2.45 ± 0.20 | Pass |
| S-2752,2753 | 10/24/2024 | Ac-228 | 1.10 ± 0.07 | 1.10 ± 0.04 | 1.10 ± 0.04 | Pass |
| F-2899,2900 | 11/6/2024 | K-40 | 2.38 ± 0.35 | 3.06 ± 0.13 | 2.72 ± 0.18 | Pass |
| SW-2815,2816 | 11/5/2024 | H-3 | 265 ± 100 | 214 ± 97 | 240 ± 70 | Pass |
| SW-3046,3047 | 12/4/2024 | H-3 | 109 ± 91 | 178 ± 94 | 144 ± 65 | Pass |
| W-3067,3068 | 12/3/2024 | H-3 | 206 ± 96 | 329 ± 102 | 268 ± 70 | Pass |
| AP-3335,3336 | 12/30/2024 | Be-7 | 0.034 ± 0.005 | 0.050 ± 0.005 | 0.042 ± 0.003 | Pass |

Note: Duplicate analyses are performed on every twentieth sample received. Results are not listed for those analyses with activities that measure below the LLD.

[a] Results are reported in units of pCi/L, except for air filters (pCi/Filter or pCi/m3), food products, vegetation, soil and sediment (pCi/g).

[b] AP (Air Particulate), AV (Aquatic Vegetation), BS (Bottom Sediment), CF (Cattle Feed), CH (Charcoal Canister), DW (Drinking Water), E (Egg), F (Fish), G (Grass), LW (Lake Water), MI (Milk), P (Precipitation), PM (Powdered Milk), S (Solid), SG (Sludge), SO (Soil), SS (Shoreline Sediment), SW (Surface Water), SWT (Surface Water Treated), SWU (Surface Water Untreated), U (Urine), VE (Vegetation), W (Water), WW (Well Water).

TABLE A-6. Department of Energy's Mixed Analyte Performance Evaluation Program (MAPEP).

| | | | | Concentration[a] | | |
|---|---|---|---|---|---|---|
| Lab Code [b] | Reference Date | Analysis | Laboratory result | Known Activity | Acceptance Range [c] | Acceptance |
| MADW-429 | 2/1/2024 | Gross Alpha | 0.641 ± 0.048 | 1.01 | 0.30 - 1.72 | Pass |
| MADW-429 | 2/1/2024 | Gross Beta | 4.71 ± 0.08 | 5.6 | 2.79 - 8.36 | Pass |
| MADW-457 | 2/1/2024 | Cs-134 | 0.09 ± 0.19 | 0 | NA [c] | Pass |
| MADW-457 | 2/1/2024 | Cs-137 | 11.1 ± 0.4 | 9.7 | 6.8 - 12.6 | Pass |
| MADW-457 | 2/1/2024 | Co-57 | 26.4 ± 0.4 | 25.4 | 17.8 - 33.0 | Pass |
| MADW-457 | 2/1/2024 | Co-60 | 11.2 ± 0.3 | 10.27 | 7.19 - 13.35 | Pass |
| MADW-457 | 2/1/2024 | Mn-54 | 8.23 ± 0.39 | 7.36 | 5.15 - 9.57 | Pass |
| MADW-457 | 2/1/2024 | Zn-65 | 0.10 ± 0.30 | 0 | NA [c] | Pass |
| MADW-457 | 2/1/2024 | K-40 | 3.16 ± 2.49 | 0 | NA [c] | Pass |
| MADW-457 | 2/1/2024 | Ra-226 | 0.46 ± 0.07 | 0.310 | 0.217 - 0.403 | Fail [d] |
| MAAP-459 | 2/1/2024 | Cs-134 | 0.03 ± 0.03 | 0 | NA [c] | Pass |
| MAAP-459 | 2/1/2024 | Cs-137 | 1.30 ± 0.07 | 1.48 | 1.04 - 1.92 | Pass |
| MAAP-459 | 2/1/2024 | Co-57 | 0.58 ± 0.03 | 0.819 | 0.573 - 1.065 | Pass |
| MAAP-459 | 2/1/2024 | Co-60 | 1.30 ± 0.06 | 1.64 | 1.15 - 2.13 | Pass |
| MAAP-459 | 2/1/2024 | Mn-54 | 0.51 ± 0.05 | 0.555 | 0.389 - 0.722 | Pass |
| MAAP-459 | 2/1/2024 | Zn-65 | 0.27 ± 0.07 | 0.332 | NA [e] | Pass |
| MASO-461 | 2/1/2024 | Cs-134 | 345 ± 2 | 404 | 283 - 525 | Pass |
| MASO-461 | 2/1/2024 | Cs-137 | 1539 ± 7 | 1550 | 1085 - 2015 | Pass |
| MASO-461 | 2/1/2024 | Co-57 | 355 ± 4 | 401 | 281 - 521 | Pass |
| MASO-461 | 2/1/2024 | Co-60 | 619 ± 4 | 660 | 462 - 858 | Pass |
| MASO-461 | 2/1/2024 | Mn-54 | 332 ± 13 | 332 | 232 - 432 | Pass |
| MASO-461 | 2/1/2024 | Zn-65 | 543 ± 9 | 703 | 492 - 914 | Pass |
| MASO-461 | 2/1/2024 | K-40 | 510 ± 20 | 485 | 340 - 631 | Pass |
| MAVE-464 | 2/1/2024 | Cs-134 | 2.97 ± 0.08 | 3.67 | 2.57 - 4.77 | Pass |
| MAVE-464 | 2/1/2024 | Cs-137 | 2.36 ± 0.15 | 2.57 | 1.80 - 3.34 | Pass |
| MAVE-464 | 2/1/2024 | Co-57 | 1.78 ± 0.09 | 2.53 | 1.77 - 3.29 | Pass |
| MAVE-464 | 2/1/2024 | Co-60 | 2.61 ± 0.13 | 2.96 | 2.07 - 3.85 | Pass |
| MAVE-464 | 2/1/2024 | Mn-54 | 0.03 ± 0.07 | 0 | NA [c] | Pass |
| MAVE-464 | 2/1/2024 | Zn-65 | 6.41 ± 0.30 | 8.02 | 5.61 - 10.43 | Pass |

TABLE A-6. Department of Energy's Mixed Analyte Performance Evaluation Program (MAPEP).

| | | | Concentration[a] | | | |
|---|---|---|---|---|---|---|
| Lab Code [b] | Reference Date | Analysis | Laboratory result | Known Activity | Acceptance Range [c] | Acceptance |
| MADW-2185 | 8/1/2024 | Gross Alpha | 0.88 ± 0.01 | 1.29 | 0.39 - 2.19 | Pass |
| MADW-2185 | 8/1/2024 | Gross Beta | 4.35 ± 0.01 | 5.09 | 2.55 - 7.64 | Pass |
| MASO-2187 | 8/1/2024 | Cs-134 | 330 ± 4 | 417 | 292 - 542 | Pass |
| MASO-2187 | 8/1/2024 | Cs-137 | 1650 ± 11 | 1650 | 1155 - 2145 | Pass |
| MASO-2187 | 8/1/2024 | Co-57 | 311 ± 5 | 330 | 231 - 429 | Pass |
| MASO-2187 | 8/1/2024 | Co-60 | 669 ± 7 | 700 | 490 - 910 | Pass |
| MASO-2187 | 8/1/2024 | Mn-54 | 116 ± 5 | 113 | 79 - 147 | Pass |
| MASO-2187 | 8/1/2024 | Zn-65 | 330 ± 8 | 415 | 291 - 540 | Pass |
| MASO-2187 | 8/1/2024 | K-40 | 531 ± 31 | 525 | 368 - 683 | Pass |
| MADW-2183 | 8/1/2024 | Cs-134 | 19.9 ± 0.3 | 22.3 | 15.6 - 29.0 | Pass |
| MADW-2183 | 8/1/2024 | Cs-137 | 0.99 ± 0.29 | 0 | NA [c, e] | Fail |
| MADW-2183 | 8/1/2024 | Co-57 | 25.3 ± 0.4 | 26.4 | 18.5 - 34.3 | Pass |
| MADW-2183 | 8/1/2024 | Co-60 | 14.7 ± 0.4 | 15.0 | 10.5 - 19.5 | Pass |
| MADW-2183 | 8/1/2024 | Mn-54 | 0.12 ± 0.16 | 0 | NA [c] | Pass |
| MADW-2183 | 8/1/2024 | Zn-65 | 20.6 ± 1.0 | 22.8 | 16.00 - 29.60 | Pass |
| MADW-2183 | 8/1/2024 | K-40 | 8.92 ± 1.23 | 0 | NA [c, e] | Fail |
| MAAP-2191 | 8/1/2024 | Cs-134 | 0.254 ± 0.030 | 0.334 | 0.234 - 0.434 | Pass |
| MAAP-2191 | 8/1/2024 | Cs-137 | 0.260 ± 0.046 | 0.269 | 0.188 - 0.350 | Pass |
| MAAP-2191 | 8/1/2024 | Co-57 | -0.0003 ± 0.0126 | 0 | NA [c] | Pass |
| MAAP-2191 | 8/1/2024 | Co-60 | 0.333 ± 0.045 | 0.361 | 0.253 - 0.469 | Pass |
| MAAP-2191 | 8/1/2024 | Mn-54 | -0.003 ± 0.022 | 0 | NA [c] | Pass |
| MAAP-2191 | 8/1/2024 | Zn-65 | -0.002 ± 0.054 | 0 | NA [c] | Pass |
| MAVE-2189 | 8/1/2024 | Cs-134 | 2.10 ± 0.07 | 2.89 | 2.02 - 3.76 | Pass |
| MAVE-2189 | 8/1/2024 | Cs-137 | 1.53 ± 0.11 | 1.91 | 1.34 - 2.48 | Pass |
| MAVE-2189 | 8/1/2024 | Co-57 | 0.003 ± 0.023 | 0 | NA [c] | Pass |
| MAVE-2189 | 8/1/2024 | Co-60 | 1.54 ± 0.08 | 2.01 | 1.41 - 2.61 | Pass |
| MAVE-2189 | 8/1/2024 | Mn-54 | 2.89 ± 0.15 | 3.53 | 2.47 - 4.59 | Pass |
| MAVE-2189 | 8/1/2024 | Zn-65 | 7.14 ± 0.29 | 9.13 | 6.39 - 11.87 | Pass |

[a] Results are reported in units of Bq/kg (soil), Bq/L (water) or Bq/total sample (filters, vegetation).

[b] Laboratory codes as follows: MAW (water), MADW (water), MAAP (air filter), MASO (soil) and MAVE (vegetation).

[c] MAPEP results are presented as the known values and expected laboratory precision (1 sigma, 1 determination) and control limits as defined by the MAPEP. A known value of "zero" indicates an analysis was included in the testing series as a "false positive". MAPEP does not provide an acceptance range.

[d] No conclusive reason for the failure could be determined. The uncertainty overlapped the known activity (reference value).

[e] False positive detections could have occurred due to a combination of an inadequate background subtraction for this sample geometry compounded by a very long analysis time.

TABLE A-7. Interlaboratory Comparison Crosscheck Program, Environmental Resource Associates (ERA)[a].

MRAD-40 Study

| Lab Code [b] | Concentration [a] | | | | | |
|---|---|---|---|---|---|---|
| | Date | Analysis | Laboratory Result | ERA Value [c] | Acceptance Limits [d] | Acceptance |
| ERAP-574 | 3/18/2024 | Cs-134 | 291 ± 4 | 273 | 177 - 335 | Pass |
| ERAP-574 | 3/18/2024 | Cs-137 | 131 ± 6 | 106 | 87 - 139 | Pass |
| ERAP-574 | 3/18/2024 | Co-60 | 1240 ± 8 | 1120 | 952 - 1420 | Pass |
| ERAP-574 | 3/18/2024 | Mn-54 | < 3.1 | < 35.0 | 0.00 - 35.0 | Pass |
| ERAP-574 | 3/18/2024 | Zn-65 | 102 ± 9 | 77.2 | 63.3 - 118 | Pass |
| ERAP-574 | 3/18/2024 | Sr-90 | 173 ± 5 | 158 | 99.9 - 215 | Pass |
| ERAP-600 | 3/18/2024 | Gross Alpha | 110 ± 3 | 95.9 | 50.1 - 158 | Pass |
| ERAP-600 | 3/18/2024 | Gross Beta | 31.7 ± 1.6 | 22.2 | 13.5 - 33.5 | Pass |

[a] Results obtained by Microbac Laboratories - Northbrook as a participant in the crosscheck program for proficiency testing administered by Environmental Resource Associates, serving as a replacement for studies conducted previously by the Environmental Measurements Laboratory Quality Assessment Program (EML).

[b] Laboratory code ERAP (air filter). Results are reported in units of (pCi/Filter).

[c] The ERA Assigned values for the air filter standards are equal to 100% of the parameter present in the standard as determined by the gravimetric and/or volumetric measurements made during standard preparation as applicable.

[d] The acceptance limits are established per the guidelines contained in the Department of Energy (DOE) report EML-564, Analysis of Environmental Measurements Laboratory (EML) Quality Assessment Program (QAP) Data Determination of Operational Criteria and Control Limits for Performance Evaluation Purposes or ERA's SOP for the generation of Performance Acceptance Limits.

Appendix B

Data Reporting Conventions

# APPENDIX B. DATA REPORTING CONVENTIONS

## Data Reporting Conventions

1.0. All activities, except gross alpha and gross beta, are decay corrected to collection time or the end of the collection period.

2.0. Single Measurements

Each single measurement is reported as follows: $x \pm s$

where: $x$ = value of the measurement;

$s = 2\sigma$ counting uncertainty (corresponding to the 95% confidence level).

In cases where the activity is less than the lower limit of detection L, it is reported as: < L, where L = the lower limit of detection based on $4.66\sigma$ uncertainty for a background sample.

3.0. Duplicate analyses

If duplicate analyses are reported, the convention is as follows. :

3.1 Individual results: For two analysis results; $x_1 \pm s_1$ and $x_2 \pm s_2$

Reported result: $x \pm s$; where $x = (1/2)(x_1 + x_2)$ and $s = (1/2)\sqrt{s_1^2 + s_2^2}$

3.2. Individual results: $< L_1$, $< L_2$ Reported result: $< L$, where L = lower of $L_1$ and $L_2$

3.3. Individual results: $x \pm s$, $< L$ Reported result: $x \pm s$ if $x \ge L$; $< L$ otherwise.

4.0. Computation of Averages and Standard Deviations

4.1 Averages and standard deviations listed in the tables are computed from all of the individual measurements over the period averaged; for example, an annual standard deviation would not be the average of quarterly standard deviations. The average $\bar{x}$ and standard deviation "s" of a set of n numbers $x_1, x_2 \ldots x_n$ are defined as follows:

$$\bar{x} = \frac{1}{n} \sum x \qquad s = \sqrt{\frac{\sum (x-\bar{x})^2}{n-1}}$$

4.2 Values below the highest lower limit of detection are not included in the average.

4.3 If all values in the averaging group are less than the highest LLD, the highest LLD is reported.

4.4 If all but one of the values are less than the highest LLD, the single value x and associated two sigma error is reported.

4.5 In rounding off, the following rules are followed:

4.5.1. If the number following those to be retained is less than 5, the number is dropped, and the retained numbers are kept unchanged. As an example, 11.443 is rounded off to 11.44.

4.5.2. If the number following those to be retained is equal to or greater than 5, the number is dropped and the last retained number is raised by 1. As an example, 11.445 is rounded off to 11.45.

# APPENDIX C

## Sampling Program and Locations

| Sample Type | Locations No. | Locations Codes (and Type)[a] | Collection Type (and Frequency)[b] | Analysis (and Frequency)[b] |
|---|---|---|---|---|
| Airborne Filters | 6 | E-1-4, 8, 20 | Weekly | GB, GS, on QC for each location |
| Airborne Iodine | 6 | E-1-4, 8, 20 | Weekly | I-131 |
| Ambient Radiation (TLD's) | 22 | E-1-9, 12, 14-18, 20, 22-32, 34-36, 38,39 | Quarterly | Ambient Gamma |
| Lake Water | 5 | E-1, 5, 6, 33 | Monthly | GB, GS, I-131 on MC H-3, Sr-89-90 on QC |
| Well Water | 1 | E-10 | Quarterly | GB, GS, H-3, Sr-89-90, I-131 |
| Vegetation | 8 | E-1-4, 6, 20 | 2x / year as available | GS |
| Shoreline Silt | 5 | E-1, 5, 6 | Annual | GS |
| Soil | 8 | E-1-4, 6, 20 | Annual | GS |
| Milk | 3 | E-11, 40, 21 | Monthly | GS, I-131, Sr-89-90 |
| Fish | 1 | E-13 | 2x / year as available | GS (in edible portions) |

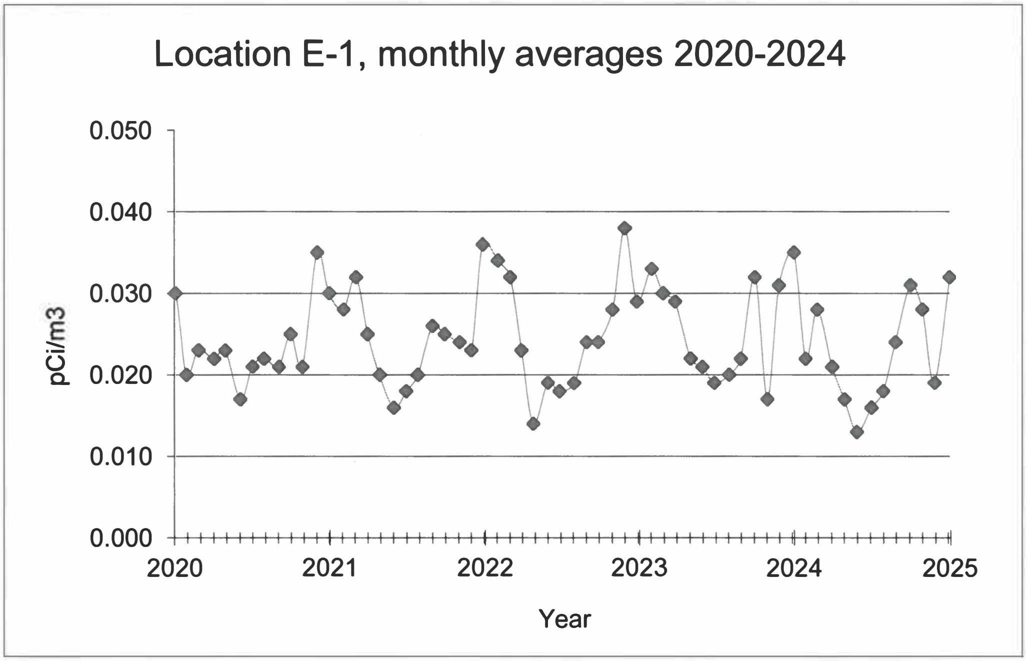
[a] Locations codes are defined in Table 2. Control Stations are indicated by (C). All other stations are indicators.

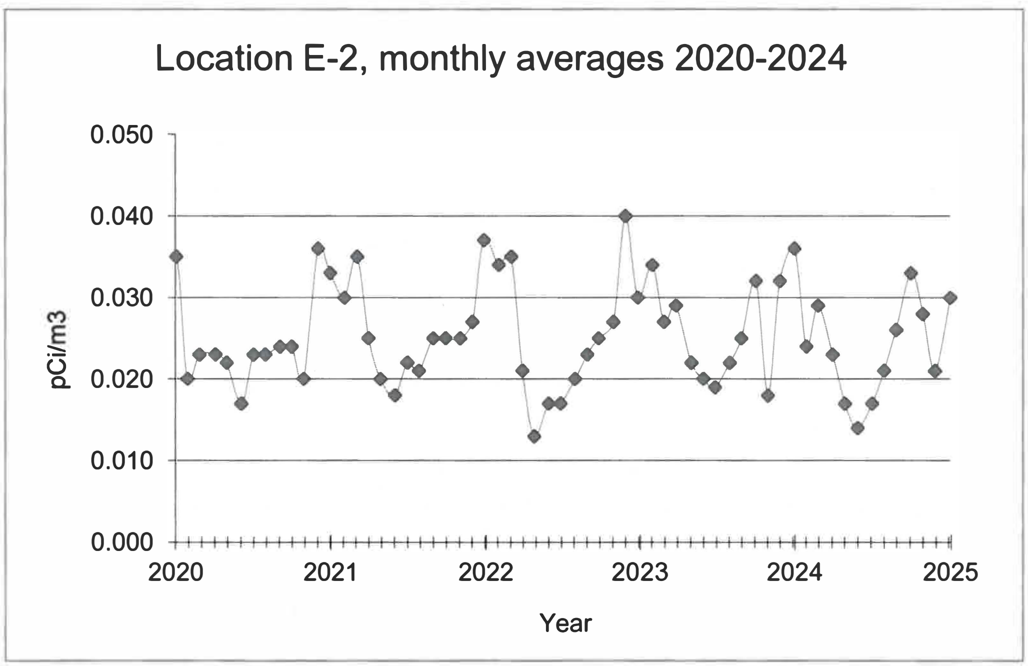
[b] Analysis type is coded as follows: GB = gross beta, GA = gross alpha, GS = gamma spectroscopy, H-3 = tritium, Sr-89 = strontium-89, Sr-90 = strontium-90, I-131 = iodine-131. Analysis frequency is coded as follows: MC = monthly composite, QC = quarterly composite.

# APPENDIX D

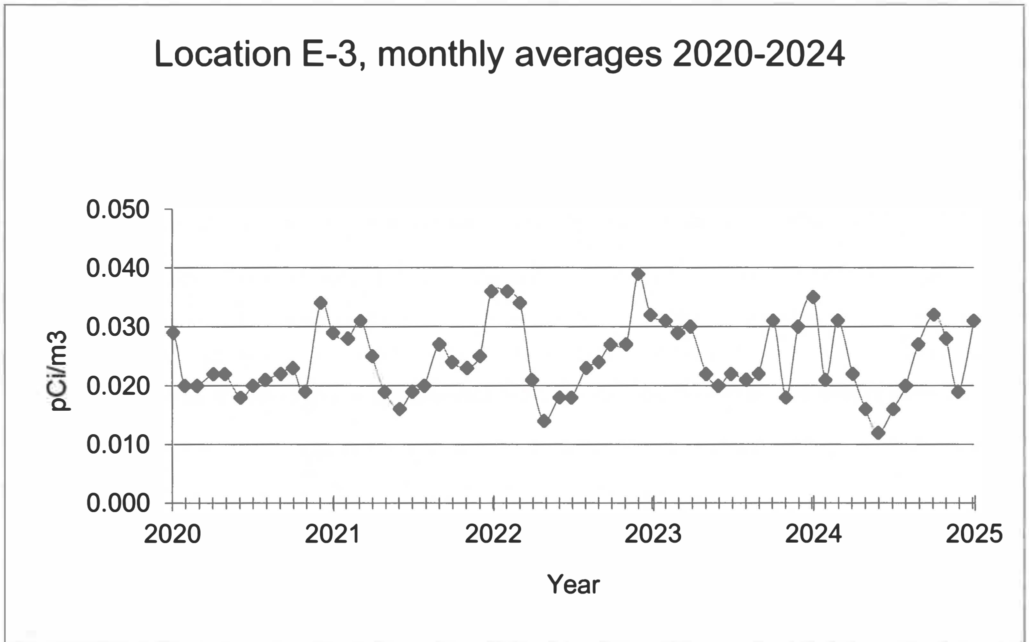
## Graphs of Data Trends

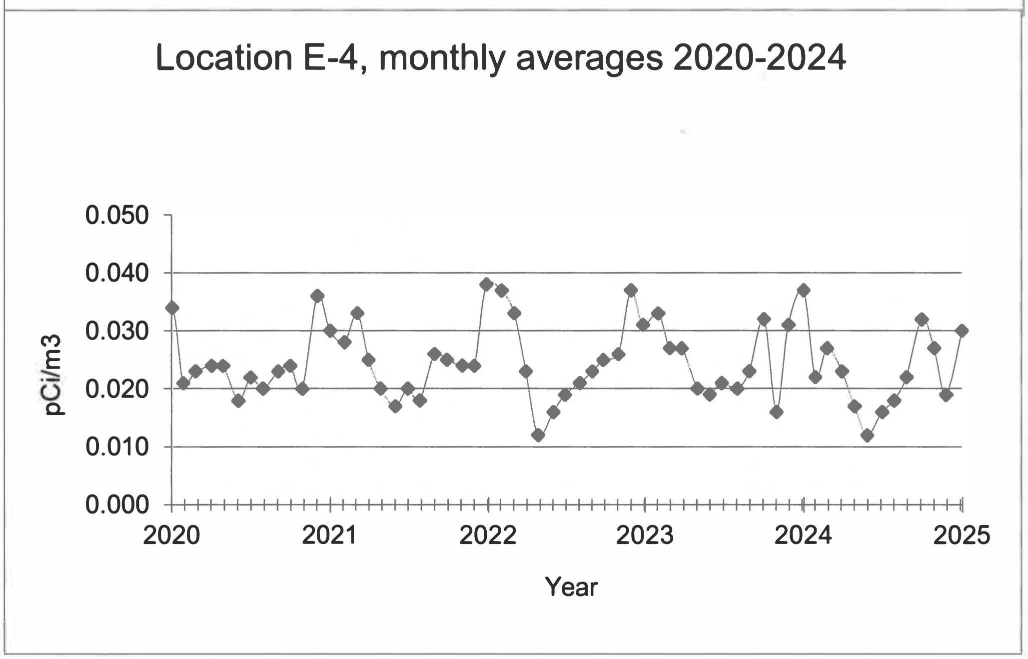
## Air Particulates - Gross Beta



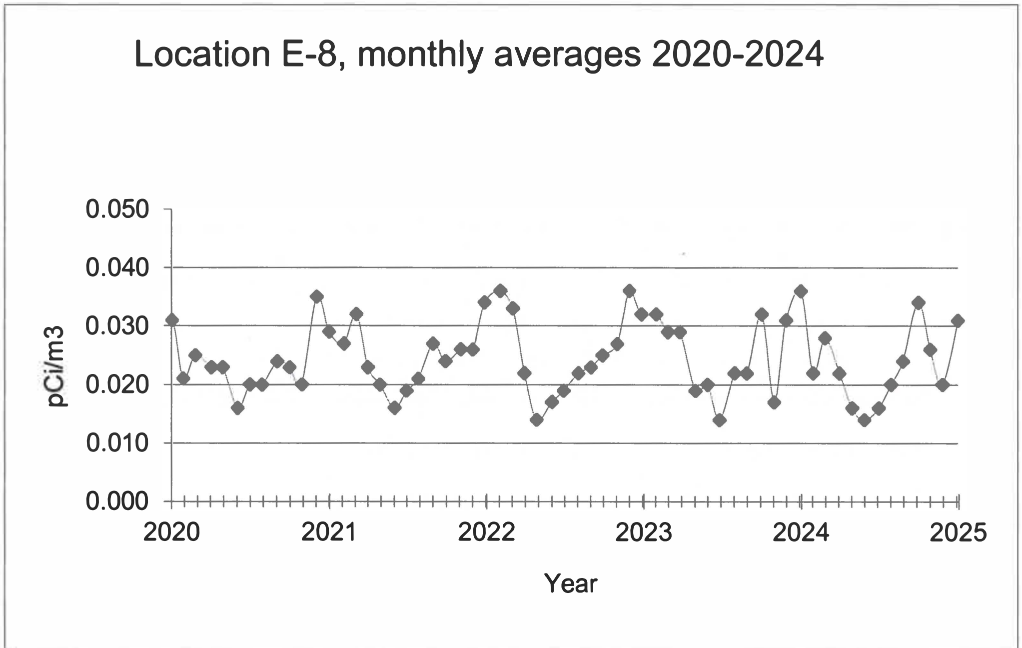



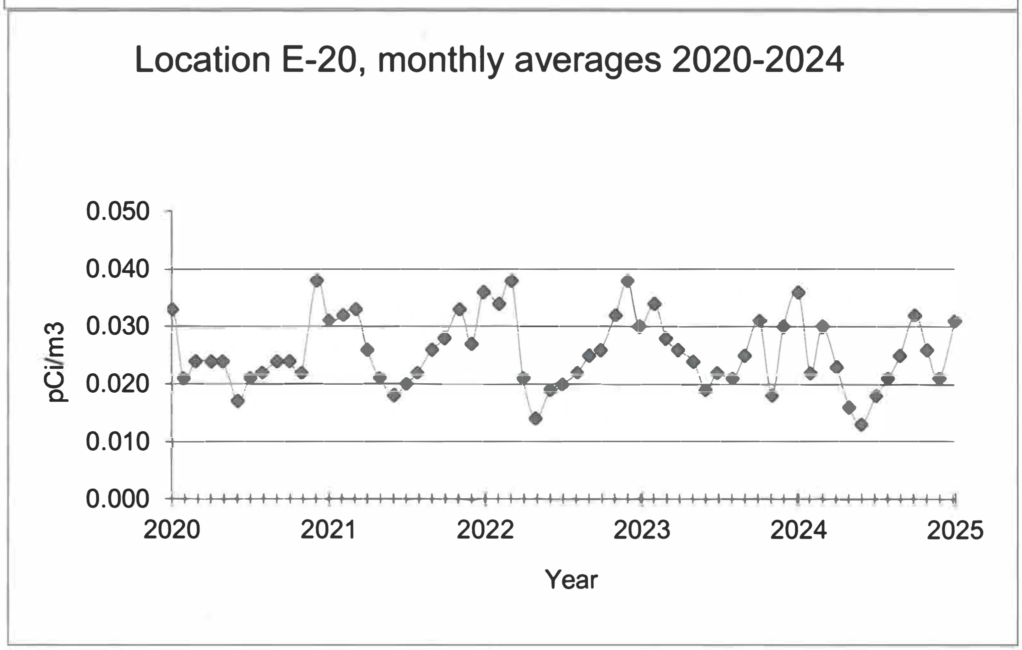
## Air Particulates - Gross Beta



## Air Particulates - Gross Beta



# APPENDIX E

## Supplemental Analyses

POINT BEACH NUCLEAR PLANT

Facade Wells

Units: = pCi\L

Gamma isotopic analysis

| Location | GW-09 1Z-361A | | GW-09 1Z-361B | | GW-10 2Z-361A | | GW-10 2Z-361B | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 01-09-24 | | 01-09-24 | | 01-09-24 | | 01-09-24 | |
| Lab Code | EWW- 43 | MDC | EWW- 44 | MDC | EWW- 45 | MDC | EWW- 46 | MDC |
| Be-7 | -5.3 ± 24.5 | < 51.6 | 2.2 ± 18.7 | < 38.8 | -2.3 ± 15.9 | < 26.4 | 3.5 ± 11.4 | < 23.4 |
| Mn-54 | -2.4 ± 3.3 | < 4.5 | 0.1 ± 2.3 | < 4.1 | 1.4 ± 1.6 | < 3.7 | 0.1 ± 1.5 | < 3.2 |
| Fe-59 | -1.1 ± 4.9 | < 7.5 | -1.7 ± 3.6 | < 6.0 | 1.3 ± 3.3 | < 5.9 | -1.0 ± 2.6 | < 3.5 |
| Co-58 | 1.2 ± 3.2 | < 5.8 | 1.3 ± 2.3 | < 3.3 | -0.5 ± 1.6 | < 3.2 | 0.2 ± 1.4 | < 2.9 |
| Co-60 | 2.4 ± 4.0 | < 7.6 | 1.9 ± 2.4 | < 4.6 | 3.3 ± 1.8 | < 6.0 | -2.0 ± 1.6 | < 3.0 |
| Zn-65 | 0.3 ± 7.6 | < 13.3 | -0.1 ± 4.0 | < 6.7 | -5.3 ± 3.5 | < 4.3 | -3.5 ± 2.9 | < 5.0 |
| Zr-Nb-95 | -0.4 ± 4.1 | < 7.3 | -2.6 ± 2.9 | < 4.8 | -3.8 ± 1.8 | < 3.6 | -2.1 ± 1.7 | < 3.7 |
| Cs-134 | -4.2 ± 3.9 | < 6.8 | -2.2 ± 2.4 | < 4.1 | -1.0 ± 1.7 | < 3.2 | -1.3 ± 1.5 | < 2.7 |
| Cs-137 | 1.0 ± 3.5 | < 6.0 | 2.3 ± 2.7 | < 4.7 | 3.9 ± 1.9 | < 5.2 | 0.8 ± 1.7 | < 3.0 |
| Ba-La-140 | 3.8 ± 4.0 | < 6.2 | -0.8 ± 2.4 | < 6.4 | -0.1 ± 1.8 | < 4.9 | -0.7 ± 1.6 | < 3.7 |

| Location | GW-09 1Z-361A | | GW-09 1Z-361B | | GW-10 2Z-361A | | GW-10 2Z-361B | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 07-09-24 | | 07-09-24 | | 07-09-24 | | 07-09-24 | |
| Lab Code | EWW- 1605 | MDC | EWW- 1606 | MDC | EWW- 1607 | MDC | EWW- 1608 | MDC |
| Be-7 | -4.6 ± 19.9 | < 39.3 | -12.9 ± 34.6 | < 54.2 | 7.0 ± 11.8 | < 24.7 | 9.2 ± 30.6 | < 71.0 |
| Mn-54 | 0.8 ± 2.5 | < 4.1 | -0.9 ± 4.5 | < 7.4 | 0.7 ± 1.4 | < 2.3 | 2.6 ± 3.8 | < 6.0 |
| Fe-59 | -0.7 ± 4.4 | < 10.0 | -3.2 ± 8.9 | < 12.4 | 2.8 ± 2.4 | < 5.9 | -0.6 ± 7.8 | < 13.6 |
| Co-58 | -0.7 ± 2.4 | < 4.0 | 0.8 ± 4.6 | < 9.0 | 1.0 ± 1.4 | < 2.8 | 1.6 ± 3.7 | < 4.2 |
| Co-60 | 1.8 ± 2.4 | < 4.7 | 1.3 ± 4.4 | < 9.0 | 0.8 ± 1.5 | < 3.0 | 0.8 ± 4.2 | < 8.4 |
| Zn-65 | 2.7 ± 4.9 | < 9.1 | -3.8 ± 10.2 | < 14.2 | 2.4 ± 2.8 | < 5.0 | -3.5 ± 9.1 | < 12.8 |
| Zr-Nb-95 | -3.4 ± 2.7 | < 5.4 | -2.2 ± 4.3 | < 8.0 | -1.0 ± 1.6 | < 3.0 | 0.1 ± 4.1 | < 5.1 |
| Cs-134 | -1.4 ± 2.3 | < 4.3 | -6.0 ± 4.1 | < 7.8 | 0.7 ± 1.5 | < 2.9 | 0.4 ± 3.7 | < 7.0 |
| Cs-137 | -3.6 ± 2.6 | < 3.3 | -2.2 ± 5.0 | < 5.2 | 0.2 ± 1.8 | < 2.8 | 0.8 ± 4.1 | < 6.7 |
| Ba-La-140 | -1.4 ± 3.0 | < 5.9 | 0.4 ± 4.7 | < 7.3 | -2.9 ± 1.7 | < 2.6 | -1.5 ± 4.6 | < 4.5 |

| | GW-09 1Z-361A | | GW-09 1Z-361B | | GW-10 2Z-361A | | GW-10 2Z-361B | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 09-19-24 | | 09-19-24 | | 09-19-24 | | 09-19-24 | |
| Lab Code | EWW- 2244 | MDC | EWW- 2245 | MDC | EWW- 2246 | MDC | 2247 | MDC |
| Be-7 | -1.5 ± 19.7 | < 46.0 | -11.2 ± 13.9 | < 20.6 | 2.1 ± 11.5 | < 28.8 | 3.5 ± 20.1 | < 38.6 |
| Mn-54 | 0.0 ± 2.4 | < 4.3 | 1.8 ± 1.5 | < 2.7 | 0.5 ± 1.5 | < 3.1 | 0.7 ± 2.5 | < 3.8 |
| Fe-59 | 0.4 ± 4.9 | < 5.6 | -0.3 ± 3.0 | < 5.2 | -3.3 ± 2.4 | < 2.8 | 0.8 ± 5.0 | < 9.3 |
| Co-58 | -0.3 ± 2.3 | < 4.5 | 0.6 ± 1.4 | < 3.0 | 0.1 ± 1.4 | < 2.6 | 4.9 ± 2.6 | < 5.1 |
| Co-60 | -3.7 ± 2.9 | < 3.0 | 1.1 ± 2.0 | < 4.3 | 0.6 ± 1.5 | < 2.6 | 1.8 ± 3.3 | < 4.9 |
| Zn-65 | -4.0 ± 5.7 | < 6.1 | -2.2 ± 3.3 | < 4.4 | 4.5 ± 2.8 | < 5.4 | -1.1 ± 5.4 | < 9.1 |
| Zr-Nb-95 | -3.0 ± 2.4 | < 2.6 | 0.2 ± 1.7 | < 3.1 | -3.3 ± 1.6 | < 3.1 | -4.8 ± 3.0 | < 3.9 |
| Cs-134 | -2.3 ± 2.4 | < 4.6 | -1.1 ± 1.5 | < 3.0 | -0.3 ± 1.4 | < 2.7 | 0.1 ± 2.5 | < 4.8 |
| Cs-137 | 1.9 ± 2.6 | < 5.2 | 1.1 ± 2.6 | < 3.9 | 1.0 ± 1.6 | < 2.7 | 1.0 ± 3.0 | < 4.6 |
| Ba-La-140 | -5.0 ± 2.7 | < 8.3 | -1.1 ± 1.7 | < 4.0 | 1.0 ± 1.7 | < 3.4 | -4.4 ± 3.4 | < 3.6 |

## POINT BEACH NUCLEAR PLANT

Units: = pCi\L

Gamma isotopic analysis

| Location | GW-09 1Z-361A | | GW-09 1Z-361B | | GW-10 2Z-361A | | GW-10 2Z-361B | |
|---|---|---|---|---|---|---|---|---|
| Collection Date | 11-30-24 | | 11-30-24 | | 11-30-24 | | 11-30-24 | |
| Lab Code | EWW- 3135 | MDC | EWW- 3136 | MDC | EWW- 3137 | MDC | EWW- 3138 | MDC |
| Be-7 | 5.3 ± 6.4 | < 20.2 | -1.1 ± 8.8 | < 26.1 | -0.9 ± 9.2 | < 27.7 | -6.3 ± 9.7 | < 29.1 |
| Mn-54 | 0.7 ± 0.8 | < 1.7 | 1.0 ± 1.1 | < 2.4 | 0.2 ± 1.2 | < 2.0 | 1.3 ± 1.2 | < 2.3 |
| Fe-59 | -1.4 ± 1.3 | < 2.5 | -1.5 ± 2.1 | < 6.3 | -1.1 ± 2.0 | < 5.8 | 1.9 ± 2.1 | < 7.2 |
| Co-58 | -0.3 ± 0.7 | < 1.5 | 0.6 ± 1.1 | < 6.0 | 0.7 ± 1.1 | < 2.9 | 0.0 ± 1.1 | < 2.1 |
| Co-60 | 0.3 ± 0.8 | < 1.3 | 0.3 ± 1.2 | < 2.1 | -0.7 ± 1.2 | < 2.3 | 1.4 ± 1.1 | < 2.1 |
| Zn-65 | -0.9 ± 1.5 | < 2.4 | -1.1 ± 2.2 | < 3.8 | 0.4 ± 2.1 | < 4.6 | -2.9 ± 2.3 | < 4.5 |
| Zr-Nb-95 | -3.5 ± 0.9 | < 2.7 | -10.8 ± 1.3 | < 4.2 | -9.8 ± 1.4 | < 3.9 | -6.3 ± 1.4 | < 3.0 |
| Cs-134 | -1.2 ± 0.8 | < 1.4 | 0.8 ± 1.1 | < 2.3 | -0.5 ± 1.1 | < 2.3 | -0.2 ± 1.2 | < 2.4 |
| Cs-137 | 0.5 ± 0.9 | < 1.6 | 0.8 ± 1.3 | < 2.3 | 0.3 ± 1.3 | < 2.1 | 0.0 ± 1.4 | < 2.2 |
| Ba-La-140 | -0.7 ± 0.9 | < 5.2 | -5.9 ± 1.3 | < 13.4 | 7.5 ± 3.8 | < 11.1 | -5.3 ± 1.3 | < 6.8 |

POINT BEACH NUCLEAR PLANT

Supplemental Analyses

Units: = pCi/L

Gamma isotopic analysis

| Location | GW-04 | | GW-18 | | U2FSSDS | |
|---|---|---|---|---|---|---|
| Collection Date | 01-17-24 | | 01-18-24 | | 01-31-24 | |
| Lab Code | EW- 70 | MDC | EW- 81 | MDC | EW- 227 | MDC |
| Be-7 | -11.4 ± 15.6 | < 15.7 | 7.7 ± 16.9 | < 29.3 | 18.8 ± 22.0 | < 56.2 |
| Mn-54 | -1.9 ± 2.1 | < 3.5 | 1.2 ± 1.6 | < 2.6 | 1.0 ± 2.8 | < 5.1 |
| Fe-59 | 2.0 ± 3.9 | < 4.1 | 2.1 ± 3.6 | < 3.7 | -0.6 ± 5.8 | < 13.8 |
| Co-58 | -0.8 ± 1.9 | < 2.3 | 1.3 ± 1.7 | < 2.7 | -1.6 ± 2.6 | < 5.3 |
| Co-60 | 1.6 ± 2.6 | < 6.5 | 2.1 ± 2.3 | < 5.9 | 1.7 ± 3.1 | < 7.3 |
| Zn-65 | -1.3 ± 3.9 | < 3.3 | 0.3 ± 3.8 | < 5.1 | -8.2 ± 6.3 | < 4.6 |
| Zr-Nb-95 | -4.6 ± 2.6 | < 4.7 | -4.2 ± 2.2 | < 3.3 | -0.3 ± 2.8 | < 6.4 |
| Cs-134 | -0.6 ± 2.0 | < 3.6 | -1.1 ± 1.7 | < 3.4 | -3.1 ± 2.7 | < 5.3 |
| Cs-137 | 3.5 ± 2.3 | < 5.9 | 1.7 ± 2.2 | < 5.9 | -2.1 ± 3.2 | < 5.8 |
| Ba-La-140 | -1.2 ± 2.3 | < 2.1 | -0.4 ± 1.8 | < 2.4 | -6.6 ± 3.1 | < 11.7 |

| Location | GW-04 | | U2FSSDS | | GW-15A,B | |
|---|---|---|---|---|---|---|
| Collection Date | 02-21-24 | | 02-28-24 | | 03-15-24 | |
| Lab Code | EW- 279 | MDC | EW- 359 | MDC | EW- 494 | MDC |
| Be-7 | 1.9 ± 4.0 | < 8.4 | -1.2 ± 14.2 | < 23.1 | -8.9 ± 18.7 | < 28.8 |
| Mn-54 | 0.2 ± 0.6 | < 1.0 | 0.7 ± 1.4 | < 2.3 | -1.0 ± 2.4 | < 4.3 |
| Fe-59 | 1.0 ± 1.1 | < 2.4 | -0.1 ± 3.0 | < 3.3 | -3.2 ± 4.9 | < 9.2 |
| Co-58 | 0.2 ± 0.6 | < 1.1 | -0.4 ± 1.3 | < 2.1 | 1.1 ± 2.2 | < 5.0 |
| Co-60 | 0.5 ± 0.7 | < 1.3 | 2.8 ± 1.6 | < 3.6 | 1.2 ± 2.5 | < 5.9 |
| Zn-65 | 0.0 ± 1.3 | < 2.6 | -1.7 ± 3.3 | < 5.1 | -10.6 ± 6.2 | < 8.9 |
| Zr-Nb-95 | -0.3 ± 0.6 | < 1.1 | -0.8 ± 1.6 | < 3.2 | 0.6 ± 2.4 | < 4.2 |
| Cs-134 | -0.2 ± 0.6 | < 1.1 | -0.5 ± 1.5 | < 3.0 | -3.3 ± 2.5 | < 4.6 |
| Cs-137 | 0.6 ± 0.7 | < 1.4 | 4.4 ± 1.9 | < 3.9 | -0.3 ± 2.7 | < 4.9 |
| Ba-La-140 | 0.2 ± 0.7 | < 1.4 | -1.5 ± 1.7 | < 3.6 | -0.8 ± 2.7 | < 6.4 |

| Location | GW-04 | | U2FSSDS | | GW-18 | |
|---|---|---|---|---|---|---|
| Collection Date | 03-28-24 | MDC | 03-31-24 | MDC | 04-10-24 | MDC |
| Lab Code | EW- 549 | | EWW- 738 | | EWW- 704 | |
| Be-7 | 1.9 ± 4.6 | < 12.2 | -0.5 ± 7.0 | < 17.3 | 3.8 ± 8.3 | < 18.8 |
| Mn-54 | 0.3 ± 0.6 | < 1.4 | 0.1 ± 0.9 | < 1.4 | 0.1 ± 1.2 | < 2.0 |
| Fe-59 | 0.8 ± 1.1 | < 2.5 | -0.7 ± 1.5 | < 5.2 | -2.5 ± 2.0 | < 1.8 |
| Co-58 | 0.5 ± 0.6 | < 1.3 | 0.0 ± 0.9 | < 2.2 | -0.8 ± 1.1 | < 0.8 |
| Co-60 | -0.1 ± 0.7 | < 1.2 | 0.9 ± 1.0 | < 1.6 | -0.3 ± 1.2 | < 1.7 |
| Zn-65 | -0.1 ± 1.2 | < 2.1 | -2.0 ± 1.6 | < 2.7 | -2.1 ± 2.4 | < 3.8 |
| Zr-Nb-95 | -1.4 ± 0.7 | < 1.6 | -2.3 ± 0.9 | < 2.9 | -1.2 ± 1.1 | < 1.5 |
| Cs-134 | -0.1 ± 0.6 | < 1.1 | 0.0 ± 0.9 | < 1.7 | -0.8 ± 1.1 | < 1.9 |
| Cs-137 | 0.0 ± 0.7 | < 1.3 | 1.3 ± 1.0 | < 1.9 | -0.1 ± 1.2 | < 2.0 |
| Ba-La-140 | -0.3 ± 0.6 | < 1.4 | -0.8 ± 1.0 | < 4.9 | -0.6 ± 1.3 | < 1.6 |

POINT BEACH NUCLEAR PLANT

Supplemental Analyses

Units: = pCi\L | Gamma isotopic analysis

| Location | GW-04 | | U2FSSDS | | GW-04 | |
|---|---|---|---|---|---|---|
| Collection Date | 04-17-24 | | 04-30-24 | | 05-14-24 | |
| Lab Code | EW- 826 | MDC | EW- 1129 | MDC | EW- 1133 NS[a] | MDC |
| Be-7 | 2.3 ± 9.9 | < 20.0 | -18.6 ± 19.1 | < 49.7 | - | |
| Mn-54 | 0.8 ± 1.4 | < 2.5 | 0.5 ± 2.4 | < 4.5 | - | |
| Fe-59 | 0.3 ± 2.5 | < 3.6 | 0.1 ± 4.9 | < 6.3 | - | |
| Co-58 | -0.3 ± 1.5 | < 2.1 | -2.4 ± 2.4 | < 3.0 | - | |
| Co-60 | 0.4 ± 1.9 | < 2.5 | 0.3 ± 2.5 | < 4.3 | - | |
| Zn-65 | 0.6 ± 3.0 | < 4.2 | -3.0 ± 5.1 | < 5.4 | - | |
| Zr-Nb-95 | -0.2 ± 1.6 | < 2.7 | 2.3 ± 2.3 | < 6.6 | - | |
| Cs-134 | -0.5 ± 1.4 | < 2.7 | -0.9 ± 2.4 | < 4.6 | - | |
| Cs-137 | 1.6 ± 1.6 | < 3.1 | -0.9 ± 2.7 | < 3.3 | - | |
| Ba-La-140 | 0.2 ± 1.6 | < 2.9 | -8.1 ± 3.2 | < 12.6 | - | |

| Location | GW-07 | | U2FSSDS | | GW-04 | |
|---|---|---|---|---|---|---|
| Collection Date | 05-14-24 | | 05-31-24 | | 06-18-24 | |
| Lab Code | EW- 1135 | MDC | EW- 1319 | MDC | EW- 1376 | MDC |
| Be-7 | 0.5 ± 9.5 | < 15.7 | 5.6 ± 17.1 | < 41.2 | -8.8 ± 24.8 | < 32.3 |
| Mn-54 | 0.7 ± 1.1 | < 1.8 | 1.1 ± 2.2 | < 4.6 | -2.3 ± 3.2 | < 3.6 |
| Fe-59 | -1.6 ± 2.2 | < 3.2 | 0.3 ± 4.2 | < 9.8 | 3.0 ± 5.7 | < 5.0 |
| Co-58 | -0.4 ± 1.1 | < 1.8 | -0.2 ± 2.1 | < 4.1 | 0.1 ± 3.5 | < 3.7 |
| Co-60 | -0.5 ± 1.3 | < 2.4 | 0.6 ± 2.5 | < 5.3 | 0.3 ± 3.0 | < 3.6 |
| Zn-65 | -2.4 ± 2.0 | < 3.6 | -8.7 ± 4.8 | < 5.8 | -4.7 ± 8.1 | < 7.0 |
| Zr-Nb-95 | -1.1 ± 1.3 | < 2.5 | -0.1 ± 2.3 | < 4.5 | -1.8 ± 3.7 | < 3.3 |
| Cs-134 | 0.2 ± 1.1 | < 2.2 | -2.5 ± 2.3 | < 4.4 | -0.2 ± 3.1 | < 6.4 |
| Cs-137 | 0.7 ± 1.2 | < 2.3 | -0.2 ± 2.6 | < 5.3 | -2.2 ± 3.5 | < 3.9 |
| Ba-La-140 | -0.5 ± 1.2 | < 1.6 | -7.2 ± 7.5 | < 6.3 | -2.6 ± 3.9 | < 2.4 |

| Location | GW-15A,B | | U2FSSDS | | GW-04 | |
|---|---|---|---|---|---|---|
| Collection Date | 06-27-24 | | 06-30-24 | | 07-18-24 | |
| Lab Code | EW- 1508 | MDC | EW- 1680 | MDC | EW- 1698 | MDC |
| Be-7 | -10.3 ± 29.6 | < 63.7 | -5.5 ± 10.7 | < 21.2 | -0.3 ± 4.7 | < 11.2 |
| Mn-54 | -0.9 ± 3.0 | < 3.9 | 0.6 ± 1.3 | < 2.5 | -0.1 ± 0.6 | < 0.6 |
| Fe-59 | -9.5 ± 6.3 | < 6.1 | 0.5 ± 2.4 | < 5.9 | 1.5 ± 1.0 | < 2.4 |
| Co-58 | 2.5 ± 2.9 | < 5.8 | 0.1 ± 1.3 | < 2.7 | -0.2 ± 0.6 | < 1.0 |
| Co-60 | 0.8 ± 4.4 | < 7.7 | 0.3 ± 1.4 | < 2.9 | 0.9 ± 0.6 | < 1.0 |
| Zn-65 | -4.2 ± 7.4 | < 9.9 | -3.8 ± 2.7 | < 5.2 | -0.5 ± 1.2 | < 2.1 |
| Zr-Nb-95 | -2.1 ± 3.1 | < 4.0 | -5.7 ± 1.6 | < 4.3 | -1.3 ± 0.7 | < 1.2 |
| Cs-134 | 3.2 ± 3.5 | < 6.4 | 0.8 ± 1.3 | < 2.4 | -0.4 ± 0.6 | < 1.1 |
| Cs-137 | 4.5 ± 4.3 | < 9.0 | -0.1 ± 1.5 | < 2.7 | 0.5 ± 0.7 | < 1.0 |
| Ba-La-140 | 8.1 ± 12.6 | < 7.3 | -5.4 ± 1.6 | < 8.7 | -0.5 ± 0.7 | < 0.8 |

[a] No sample, water outage.

Supplemental Analyses

Units: = pCi\L

Gamma isotopic analysis

| Location | GW-18 | | GW-15A,B | | U2FSSDS | |
|---|---|---|---|---|---|---|
| Collection Date | 07-18-24 | | 07-25-24 | | 07-31-24 | |
| Lab Code | EW- 1700 | MDC | EW- 1813 | MDC | EW- 2002 | MDC |
| Be-7 | -0.8 ± 10.5 | < 18.7 | 7.2 ± 4.6 | < 16.6 | -3.1 ± 10.8 | < 21.7 |
| Mn-54 | 0.3 ± 1.2 | < 1.6 | 0.0 ± 0.6 | < 1.2 | -0.7 ± 1.3 | < 2.6 |
| Fe-59 | -0.4 ± 2.3 | < 3.8 | 0.5 ± 0.1 | < 3.0 | -0.3 ± 2.4 | < 5.9 |
| Co-58 | 0.3 ± 1.1 | < 2.2 | 0.1 ± 0.5 | < 1.4 | -1.6 ± 1.3 | < 1.8 |
| Co-60 | -0.6 ± 1.4 | < 1.6 | 0.4 ± 0.6 | < 1.3 | 0.8 ± 1.5 | < 3.1 |
| Zn-65 | -0.4 ± 2.5 | < 3.6 | -0.7 ± 1.1 | < 2.4 | -1.0 ± 2.7 | < 5.9 |
| Zr-Nb-95 | -1.3 ± 1.4 | < 2.4 | -2.8 ± 0.6 | < 1.7 | -5.1 ± 1.6 | < 4.9 |
| Cs-134 | -0.2 ± 1.3 | < 2.5 | 0.6 ± 0.6 | < 1.1 | -1.5 ± 1.4 | < 2.8 |
| Cs-137 | 0.2 ± 1.5 | < 2.6 | 0.5 ± 0.7 | < 1.1 | 1.2 ± 1.5 | < 2.2 |
| Ba-La-140 | 0.1 ± 1.5 | < 2.7 | -3.1 ± 2.0 | < 14.5 | -7.6 ± 1.6 | < 8.9 |

| Location | GW-04 | | U2FSSDS | | GW-04 | |
|---|---|---|---|---|---|---|
| Collection Date | 08-21-24 | | 08-31-24 | | 09-19-24 | |
| Lab Code | EW- 1987 | MDC | EW- 2248 | MDC | EW- 2231 | MDC |
| Be-7 | -0.6 ± 6.8 | < 17.7 | 0.3 ± 10.0 | < 25.3 | -24.8 ± 18.8 | < 24.4 |
| Mn-54 | 1.3 ± 0.9 | < 1.8 | 0.6 ± 1.3 | < 2.6 | -0.3 ± 2.7 | < 3.9 |
| Fe-59 | 0.3 ± 1.7 | < 3.1 | -3.5 ± 2.4 | < 4.7 | 2.6 ± 5.0 | < 8.1 |
| Co-58 | 0.0 ± 0.8 | < 1.5 | -0.3 ± 1.2 | < 2.5 | -2.4 ± 2.6 | < 2.5 |
| Co-60 | -0.4 ± 0.9 | < 0.9 | 4.6 ± 1.5 | < 3.0 | -0.9 ± 2.3 | < 3.6 |
| Zn-65 | 0.6 ± 1.7 | < 3.0 | 3.9 ± 2.6 | < 5.2 | -4.1 ± 5.8 | < 5.1 |
| Zr-Nb-95 | -1.5 ± 1.0 | < 1.9 | -7.5 ± 1.5 | < 4.4 | -0.2 ± 2.7 | < 4.2 |
| Cs-134 | -0.6 ± 0.9 | < 1.5 | 0.0 ± 1.3 | < 2.6 | -1.6 ± 2.3 | < 4.5 |
| Cs-137 | 0.7 ± 1.0 | < 1.7 | 0.8 ± 1.4 | < 2.6 | -1.8 ± 2.6 | < 2.2 |
| Ba-La-140 | 0.6 ± 1.0 | < 2.6 | 0.1 ± 1.5 | < 6.4 | -1.1 ± 2.7 | < 3.9 |

| Location | U2FSSDS | | GW-18 | | GW-04 | |
|---|---|---|---|---|---|---|
| Collection Date | 09-30-24 | | 10-09-24 | | 10-16-24 | |
| Lab Code | EW- 2429 | MDC | EW- 2419 | MDC | EW- 2559 | MDC |
| Be-7 | -6.1 ± 9.4 | < 23.9 | 7.6 ± 7.7 | < 14.7 | -4.4 ± 11.5 | < 25.5 |
| Mn-54 | 0.9 ± 1.1 | < 2.0 | -0.4 ± 1.2 | < 1.6 | -0.2 ± 1.8 | < 1.4 |
| Fe-59 | -1.4 ± 2.0 | < 4.6 | -0.4 ± 2.1 | < 3.1 | -2.6 ± 3.5 | < 3.7 |
| Co-58 | -0.6 ± 1.2 | < 2.4 | -0.1 ± 1.0 | < 1.1 | 1.5 ± 1.8 | < 3.0 |
| Co-60 | 0.4 ± 1.3 | < 2.2 | -1.6 ± 1.5 | < 1.2 | -0.2 ± 2.0 | < 2.5 |
| Zn-65 | -0.5 ± 2.3 | < 4.8 | -2.4 ± 2.5 | < 2.1 | 0.9 ± 3.9 | < 6.8 |
| Zr-Nb-95 | -3.8 ± 1.4 | < 3.0 | -0.9 ± 1.2 | < 1.3 | -3.1 ± 1.9 | < 1.6 |
| Cs-134 | -1.0 ± 1.2 | < 2.3 | -0.4 ± 1.2 | < 1.8 | -0.5 ± 1.7 | < 2.9 |
| Cs-137 | -0.6 ± 1.4 | < 1.4 | 0.4 ± 1.3 | < 2.3 | 1.5 ± 2.1 | < 3.8 |
| Ba-La-140 | -1.9 ± 1.3 | < 2.4 | 1.1 ± 1.4 | < 2.8 | -0.4 ± 2.2 | < 3.1 |

# POINT BEACH NUCLEAR PLANT

Supplemental Analyses

Units: = pCi\L Gamma isotopic analysis

| Location | GW-15A,B | | U2FSSDS | | GW-04 | |
|---|---|---|---|---|---|---|
| Collection Date | 10-20-24 | | 10-31-24 | | 11-20-24 | |
| Lab Code | EW- 2607 | MDC | EW- 2964 | MDC | EW- 2940 | MDC |
| Be-7 | 2.2 ± 7.6 | < 17.5 | 6.2 ± 7.9 | < 21.9 | -4.0 ± 10.9 | < 16.5 |
| Mn-54 | 1.0 ± 1.0 | < 1.9 | -0.2 ± 0.9 | < 1.6 | 0.7 ± 1.8 | < 2.3 |
| Fe-59 | 0.7 ± 1.7 | < 3.7 | 0.5 ± 1.7 | < 4.9 | -0.3 ± 3.0 | < 3.6 |
| Co-58 | -0.8 ± 0.9 | < 1.9 | -0.3 ± 0.9 | < 2.4 | -0.6 ± 1.5 | < 1.4 |
| Co-60 | 1.0 ± 1.2 | < 2.5 | 0.1 ± 1.1 | < 1.8 | 1.1 ± 2.0 | < 2.6 |
| Zn-65 | -0.5 ± 1.9 | < 3.9 | -0.7 ± 1.8 | < 3.0 | 0.8 ± 3.5 | < 2.8 |
| Zr-Nb-95 | -0.7 ± 1.0 | < 2.3 | -4.0 ± 1.1 | < 3.6 | -2.0 ± 1.7 | < 5.3 |
| Cs-134 | -0.8 ± 1.0 | < 1.8 | -1.1 ± 1.0 | < 1.7 | -0.2 ± 1.5 | < 2.3 |
| Cs-137 | 1.2 ± 1.1 | < 2.2 | -0.1 ± 1.1 | < 1.9 | 0.4 ± 2.0 | < 3.3 |
| Ba-La-140 | 0.9 ± 1.0 | < 3.0 | -3.5 ± 1.1 | < 10.3 | -1.0 ± 2.0 | < 2.4 |

| Location | U2FSSDS | | GW-04 | | U2FSSDS | |
|---|---|---|---|---|---|---|
| Collection Date | 11-30-24 | | 12-27-24 | | 12-31-24 | |
| Lab Code | EW- 3139 | MDC | EW- 3175 | MDC | EW- 3313 | MDC |
| Be-7 | 4.4 ± 12.9 | < 25.7 | 2.5 ± 13.8 | < 29.4 | 13.8 ± 22.7 | < 46.1 |
| Mn-54 | 1.1 ± 1.5 | < 2.7 | -0.4 ± 1.7 | < 2.7 | 0.1 ± 2.8 | < 5.4 |
| Fe-59 | 0.6 ± 2.6 | < 5.2 | 1.4 ± 3.1 | < 5.3 | -2.8 ± 5.4 | < 10.1 |
| Co-58 | -0.2 ± 1.5 | < 3.4 | 1.2 ± 1.6 | < 3.2 | 3.4 ± 2.5 | < 4.2 |
| Co-60 | 0.5 ± 1.5 | < 2.4 | -0.4 ± 1.9 | < 3.5 | 0.1 ± 3.2 | < 3.7 |
| Zn-65 | -0.9 ± 3.1 | < 6.6 | -4.0 ± 3.8 | < 2.8 | -1.5 ± 6.7 | < 11.6 |
| Zr-Nb-95 | -4.0 ± 1.8 | < 4.1 | 0.3 ± 1.7 | < 3.1 | -6.2 ± 3.2 | < 6.7 |
| Cs-134 | -1.4 ± 1.6 | < 2.8 | -0.1 ± 1.4 | < 3.1 | -1.4 ± 2.9 | < 4.9 |
| Cs-137 | 1.1 ± 1.9 | < 3.7 | 1.2 ± 2.1 | < 3.5 | -0.5 ± 3.4 | < 6.2 |
| Ba-La-140 | 0.9 ± 1.7 | < 6.1 | 0.3 ± 1.3 | < 2.1 | 2.2 ± 3.1 | < 9.4 |

# APPENDIX F

## Special Analyses

Additional Analyses

| Units pCi/L | | |
|---|---|---|
| Location | S-3 | **MDC** |
| Collection Date | 04-02-24 | |
| Lab Code | EW- 624 | |
| Fe-55 | 194.7 ± 287.3 | < 456.3 |
| Ni-63 | -20.45 ± 49.4 | < 81.967 |
| Sr-89 | 0.18 ± 0.8 | < 0.98 |
| Sr-90 | -0.03 ± 0.3 | < 0.72 |
| Tc-99 | -6.3 ± 7.2 | < 12.04 |

# ODCM

# OFFSITE DOSE CALCULATION MANUAL

| | |
|---|---|
| **DOCUMENT TYPE:** | Controlled Reference |
| **CLASSIFICATION:** | N/A |
| **REVISION:** | 26 |
| **REVIEWER:** | Onsite Review Group |
| **APPROVAL AUTHORITY:** | Plant Manager |
| **PROCEDURE OWNER (title):** | Group Head |
| **OWNER GROUP:** | Chemistry |

Verified Current Copy: ______________________ ____________ ____________
Signature Date Time

List pages used for Partial Performance

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Controlling Work Document Numbers

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**FIGURES**

## 1.0 RECORD OF REVISIONS

Per TS 5.5.1.C, licensee initiated changes to the Offsite Dose Calculation Manual (ODCM) shall be documented and records of reviews performed shall be retained. This documentation shall contain sufficient information to support the changes(s) together with the appropriate analyses or evaluations justifying the changes(s), and a determination that the change(s) maintain the levels of radioactive effluent control required by 10 CFR 20.1302, 40 CFR 190, 10 CFR 50.36a, and 10 CFR 50, Appendix I, and do not adversely impact the accuracy or reliability of effluent, dose, or setpoint calculations. These changes shall become effective after receiving concurrence from the Onsite Review Group (ORG) and approval of the Plant General Manager, and shall be submitted to the NRC in the form of a complete, legible copy of the entire ODCM as a part of or concurrent with the Annual Monitoring Report for the period of the report in which any change in the ODCM was made. Each change shall be identified by markings in the affected pages, clearly indicating the area of the page that was changed, and shall indicate the date (i.e. month and year) the change was implemented. PBF-7072 ODCM Change Documentation form shall be used to document ODCM changes and included with records of review for retention in addition to the ORG package.

# 2.0 INTRODUCTION

## 2.1 Purpose

The PBNP Offsite Dose Calculation Manual contains the current methodology and parameters for the calculation of offsite doses due to radioactive gaseous and liquid effluents. This manual describes a methodology for demonstrating compliance with 10 CFR 50, Appendix I dose limits. Compliance with Appendix I is demonstrated by periodic calculation of offsite doses based on actual plant releases and comparison to Appendix I dose limits.

The manual also details the methodology for the determination of gaseous and liquid effluent monitor alarm setpoints. The PBNP Radiation Monitoring System (RMS) effluent monitor alarm setpoints are established to ensure that controlled releases of liquid and gaseous radioactive effluents are maintained as low as is reasonably achievable. The setpoints also are established to ensure that the dose rate from radioactive material released in effluents to the atmosphere do not exceed 500 mrem/yr at the site boundary and to ensure that the concentrations of radioactive materials released in liquid effluents to the unrestricted area conform to (do not exceed) 10 times the concentration values in Table 2, Column 2 of Appendix B to 10 CFR 20 as specified in TS 5.5.4.g.

The manual also details the methodology for evaluating the radiological impact of sewage treatment sludge disposal. This methodology addresses the commitments made to the United States Nuclear Regulatory Commission in our application dated October 8, 1987 (NRC-87-104) and accepted by the USNRC in a letter dated January 13, 1988 (NPC-30260). This application was submitted in accordance with the provisions of 10 CFR 20.302(a). Dose limits are established in the application to ensure the health and safety of the maximally exposed member of the general public and the inadvertent intruder. 10 CFR 50, Appendix I dose limits do not apply to sewage treatment sludge disposal.

## 2.2 Guidance

The following sources provided guidance for this document:

U. S. Nuclear Regulatory Commission, Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR50, Appendix I”, Revision 1, October 1977.

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.113, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I”, Revision 1, April 1977.

U.S. Nuclear Regulatory Commission, Regulatory Guide 1.21, “Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste”, Revision 2, June 2009.

U. S. Nuclear Regulatory Commission, NUREG-0133, "Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants", Revision 2, May 1982.

U.S. Nuclear Regulatory Commission, NUREG-1301, "Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors", April 1991.

2.3 General Responsibilities

The primary responsibility for the implementation of the PBNP offsite dose calculation program and for any actions required by the program resides with Chemistry. Chemistry will provide the technical, regulatory, licensing, and administrative support necessary to fulfill the requirements of this manual. The calculation of offsite doses and analysis of data are Chemistry responsibilities.

The Plant General Manager, PBNP is responsible for assuring that Radiation Monitoring System alarm setpoints are established and maintained in accordance with the methodologies outlined in this manual. The Plant General Manager, PBNP is also responsible for assuring the performance of periodic release summaries for the purpose of demonstrating compliance with PBNP effluent release limits.

2.4 Audits

Audits of the activities encompassed by the ODCM, the Radiological Effluent Control Program (Section 13.0 of this manual), and the Radiological Environmental Monitoring Program (Section 12.0 of this manual) and its implementing procedures shall be scheduled, performed, and reported in accordance with the Quality Assurance Topical Report.

2.5 Definitions

**ABNORMAL RELEASE**

An ABNORMAL RELEASE is an unplanned or uncontrolled emission of an effluent containing plant related, licensed radioactive material.

**ACTION**

ACTION shall be that part of a specification that prescribes remedial measures required under designated conditions.

**BATCH RELEASE**

A BATCH RELEASE is a release of a discrete liquid volume from a tank or any isolatable containment containing radionuclide(s) whose inputs to the volume were secured prior to sampling for discharge and remains secured until the discharge is completed.

**CHANNEL CALIBRATION**

A CHANNEL CALIBRATION is the adjustment, as necessary, of the channel such that it responds within the required range and accuracy to known values of input. The CHANNEL CALIBRATION SHALL encompass the entire channel including the sensors and alarm, interlock and/or trip functions and may be performed by any series of sequential, overlapping, or total channel steps such that the entire channel is calibrated.

**CHANNEL CHECK**

CHANNEL CHECK is a qualitative determination of acceptable FUNCTIONALITY made by observing channel behavior during operation. This shall include, where possible, comparison of the channel with other independent instrumentation channels measuring the same parameter.

**CONTINUOUS RELEASE**

A CONTINUOUS RELEASE is a discharge of liquid or gaseous radioactive effluents of a non-discrete volume from a source containing radionuclide(s) that usually has make-up flow during the release.

**DISCHARGE**

A DISCHARGE is a radioactive effluent that enters an unrestricted area.

**FUNCTIONAL – FUNCTIONALITY**

FUNCTIONALITY is an attribute of an SSC(s) that is not controlled by TSs. An SSC not controlled by TSs is FUNCTIONAL or has FUNCTIONALITY when it is capable of performing its function(s) as set forth in the CLB. These CLB function(s) may include the capability to perform a necessary and related support function for an SSC(s) controlled by TSs.

**FUNCTIONAL TEST**

FUNCTIONAL TEST is the injection of a simulated signal into the channel to verify that it is FUNCTIONAL, including alarm and/or trip initiating action. This shall include, where possible, a comparison of the channel with other independent channels measuring the same variable.

**GASEOUS RADWASTE TREATMENT SYSTEM**

The GASEOUS RADWASTE TREATMENT SYSTEM consists of those components or devices utilized to reduce radioactive material in effluents released to the atmosphere. The system consists of the following:

- Gas decay tanks,
- Drumming area ventilation exhaust duct filter assembly (F-26),
- Unit 1 and 2 containment purge exhaust filter assemblies (1/2 F-11A/B),
- Air ejector decay duct filter assembly (F-30),
- Auxiliary building ventilation filter assembly (F-25, nominal 11,214 CFM exhaust pathway),
- Chemistry laboratory exhaust duct filter assembly (F-21),
- Service building ventilation exhaust duct filter assembly (F-20),
- Auxiliary building ventilation filter assemblies (F-23, F-29, nominal 34,150 CFM exhaust pathway).

**LIQUID RADWASTE TREATMENT SYSTEM**

The LIQUID RADWASTE TREATMENT SYSTEM consists of those components or devices used to reduce radioactive material in liquid effluent. The system consists of the following:

- Waste evaporator,
- Polishing demineralizers,
- Advanced Liquid Processing System (ALPS)
- Boric acid evaporator feed and condensate demineralizers

**MEMBER OF THE PUBLIC (10 CFR 20)**

MEMBER OF THE PUBLIC as defined by 10 CFR 20.1003: Means any individual except when that individual is receiving an occupational dose. (TRM 4.1)

**MEMBER OF THE PUBLIC (40 CFR 190)**

MEMBER OF THE PUBLIC as defined by 40 CFR 190.02: Means any individual that can receive a radiation dose in the general environment, whether he may or may not also be exposed to radiation in an occupation associated with a nuclear fuel cycle. However, an individual is not considered a member of the public during any period in which the individual is engaged in carrying out any operation which is part of the nuclear fuel cycle. (TRM 4.1)

**NUCLEAR FUEL CYCLE**

NUCLEAR FUEL CYCLE as defined by 40 CFR 190.02: Means the operations defined to be associated with the production of electrical power for public use by any fuel cycle through the use of nuclear energy.

**OPERABLE-OPERABILITY**

A system, subsystem, train, component or device shall be OPERABLE or have OPERABILITY when it is capable of performing its *specified safety functions(s)*, and when all necessary attendant instrumentation, controls, normal or emergency electrical power, cooling or seal water, lubrication and other auxiliary equipment that are required for the system, subsystem, train, component or device to perform its specified safety function(s) are also capable of performing their related support function(s).

**PURGE-PURGING**

PURGE or PURGING is any controlled process of discharging air or gas from a confinement to maintain temperature, pressure, humidity, concentration or other operating condition, in such a manner that replacement air or gas is required to purify the confinement.

**RELEASE**

A RELEASE is an effluent from the plant regardless of where the effluent is deposited.

**SITE BOUNDARY**

The SITE BOUNDARY shall be that line beyond which the land is neither owned, nor leased, nor otherwise controlled by the licensee.

**SOURCE CHECK**

A SOURCE CHECK shall be the qualitative assessment of channel response when the channel sensor is exposed to a source of increased radioactivity.

**SPECIFIED FUNCTION/SPECIFIED SAFETY FUNCTION**

The definition of operability refers to the capability to perform the "specified function" at non-improved TSs plants or "specified safety function" at improved TSs plants. The specified safety function(s) in the CLB for the facility.

In addition to providing the specified safety function, an SSC is expected to perform as designed, tested and maintained. When system capability is degraded to a point where it cannot perform with reasonable expectation or reliability, the SSC should be judged inoperable, even if at this instantaneous point in time the SSC(s) could provide the specified safety function.

**UNRESTRICTED AREA**

An UNRESTRICTED AREA is any area at or beyond the SITE BOUNDARY access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. (TRM 4.1)

**URANIUM FUEL CYCLE**

The URANIUM FUEL CYCLE is defined in 40 CFR Part 190.02(b) as: "The operation of milling of uranium ore, chemical conversion of uranium, isotopic enrichment of uranium, fabrication of uranium fuel, generation of electricity by a light-water-cooled nuclear power plant using uranium fuel, and reprocessing of spent uranium fuel, to the extent that these directly support the production of electrical power for public use utilizing nuclear energy, but excludes mining operations, operations at wasted disposal sites, transportation of any radioactive material in support of these operations, and the use of recovered non-uranium special nuclear and by-product materials from the cycle".

**VENTILATION EXHAUST TREATMENT SYSTEM**

A VENTILATION EXHAUST TREATMENT SYSTEM is any system designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in effluents by passing ventilation or vent exhaust gases through charcoal absorbers and/or HEPA filters for the purpose of removing iodines or particulates from the gaseous exhaust stream prior to the release to the environment. Such a system is not considered to have any effect on noble gas effluents. Engineered Safety Features Atmospheric Cleanup Systems are not considered to be VENTILATION EXHAUST TREATMENT SYSTEM components.

**VENTING**

VENTING is the controlled process of discharging air or gas form a confinement to maintain temperature, pressure, humidity, concentration, or other operating condition, in such a manner that replacement air or gas is not provided or required during VENTING. Vent, used in system names, does not imply a VENTING process.

## 3.0 REPORTING REQUIREMENTS

### 3.1 Annual Monitoring Report

In accordance with TS 5.6.2, the Annual Monitoring Report covering the operation of the units shall be submitted in accordance with 10 CFR 50.36a. The annual monitoring report shall be submitted by April 30 of each calendar year to the administrator of the appropriate Regional NRC office or designee and shall include:

a. A summary of the quantities of radioactive liquid and gaseous effluents released from the plant with data summarized on a quarterly and annual basis. The material provided shall be consistent with the objectives outlined in Sections 6.2, 7.2 and 7.3 of the ODCM and in conformance with 10 CFR 50, Appendix I, Section IV.B.1. In the event that some results are not available for inclusion with the report, the report shall be submitted noting and explaining the reasons for the missing results. The missing data shall be submitted in a supplementary report as soon as possible.

b. An assessment of the radiation doses from radioactive effluents released from the plant during the previous calendar year. All assumptions used in making these assessments (i.e., specific activity, exposure time and location) shall be included in the report.

c. The air doses and the doses to the hypothetical maximum exposed individual calculated following the ODCM methodology shall be reported.

d. The following information for solid waste shipped offsite during the report period:

- Total amount of solid waste shipped, buried or stored (in cubic feet)
- Estimated total isotopic content (in curies) determined by scaling factors, gamma isotopic and/or other suitable analyses
- Dates of shipment and burial site, if applicable quantity
- Type of waste (e.g., spent resin, dry activated waste, evaporator bottoms, filters, scrap metal, asbestos, etc.),
- Type of container (e.g., LSA, Type A, Type B, Large Quantity), and
- Solidification agent (e.g., cement, urea formaldehyde), if applicable

e. The following information for liquid releases during the report period.

- Total radioactivity in curies released and average diluted discharge concentrations of the following release categories: Fission & Activation Products (not including tritium, gases, and alpha), tritium, gross alpha, and dissolved/entrained gases.
- Total volume (in gallons) of liquid waste released into circulating water discharge.

- Total volume (in gallons) of dilution water used.
- Quarterly and annual totals of quantities of individual radionuclides, as determined by isotopic analyses.

f. The following information for gaseous releases during the report period.

- Total gross radioactivity (in Curies), by quarter, released of:
  - Fission and Activation Gases (Noble Gases)
  - Iodines
  - Particulates
  - Tritium
  - Average release rate for period
- Estimated quarterly total radioactivity (in Curies) released, by nuclide, for I-131, I-133, H-3, and radioactive particulates with half-lives greater than eight days, based on representative analyses performed by beta and by gamma isotopic analyses.
- Annual totals of isotopic radionuclide quantities.

g. Identification of ABNORMAL RELEASES from the site in gaseous and liquid effluents in the AMR.

h. Summaries, interpretations, and analyses of trends of the results of the radiological environmental monitoring program for the reporting period. The material provided shall be consistent with the objectives outlined in ODCM Section 12.0 and in 10 CFR 50, Appendix I, Sections IV.B.2, IV.B.3, and IV.C. See Section 12.1.2.a.6 for REMP specific reporting requirements.

i. If the calculated dose from the release of radioactive materials in liquid or gaseous effluents exceeds twice the limits of 10 CFR 50, Appendix I, the Annual Monitoring Report shall also include an assessment of radiation doses to the most likely exposed member of the general public from reactor releases and other nearby uranium fuel cycle sources (including doses from primary effluent pathways and direct radiation) for the previous 12 consecutive months to show compliance with 40 CFR 190, Environmental Radiation Protection Standards for Nuclear Power Operation.

j. A description (including cause, response and prevention of reoccurrence) of occurrences and circumstances when fewer than the sampling frequency, minimum analysis frequency, or lower limit of detection requirement specified in Table 6-2 and Table 7-1 are met.

k. The Annual Monitoring Report shall include a description of all deviations from the radiological environmental sample collection and analysis frequency contained in Table 12-3.

l. The Annual Monitoring Report shall include a description of occurrences when fewer than the minimum required radioactive liquid and/or gaseous effluent monitoring instrumentation channels were FUNCTIONAL **OR** OPERABLE as required in Table 6-2 and Table 7-2.

m. The quantity of each of the principal radionuclides released to the environment in liquid and gaseous effluents during the previous 12 months of operation for the ISFSI. Other information required by the Commission to estimate maximum potential radiation dose commitment to the public resulting from effluent releases should be included in the report.

n. Licensee initiated changes to the ODCM in the form of a complete legible copy of the entire ODCM as a part of or concurrent with the Annual Monitoring Report for the period of the report in which the change in the ODCM was made. Each change shall be identified by markings in the margin of the affected pages clearly indicating the area of the page that was changed.

3.2 Record Retention Requirements

Records of reviews performed for changes made to the ODCM shall be kept for the duration of the operating licenses of Units 1 and 2 of the Point Beach Nuclear Plant. (TS 5.5.1)

Meteorological data shall be kept on file, on site for review by the NRC, upon request. The data available will include wind speed, wind direction and atmospheric stability. The data will be in the form of hour-by-hour averages stored in electronic form for each of the parameters.

## 4.0 RADIATION MONITORING SYSTEM AND RELEASE ACCOUNTING

A computerized Radiation Monitoring System (RMS) is installed at Point Beach Nuclear Plant (PBNP). The RMS includes area, process, and effluent monitors. A description of those monitors used for liquid and gaseous effluents is presented in Table 4-1 and Table 4-2. The liquid and gaseous waste processing flow paths, equipment, and monitoring systems are depicted in Figure 4-1 and Figure 4-2. Calibration of the RMS detectors is accomplished in accordance with the PBNP instrument and control procedures. The setpoint methodology is described in Section 9.1 and Section 10.1 of the ODCM.

The RMS is designed to detect and measure liquid and gaseous releases from the plant effluent pathways. The RMS will initiate isolation and control functions on certain effluent streams identified in Table 4-1 and Table 4-2. Complete monitoring and accounting of nuclides released in liquid and gaseous effluents is accomplished with the RMS together with the characterization of nuclide distributions by laboratory analysis of grab samples. Sampling frequencies and analysis requirements are described for liquids in Table 6-1 and gases in Table 7-1.

The RMS is not used for normal operational release quantification. Release quantification is based on the analysis of actual samples and the known discharge rate. The main liquid releases (Ci) occur via batch releases. The continuous releases via SGBD and waste water effluents have a greater volume but very little licensed material. The major continuous release points are the vents from the Auxiliary Building, the Drumming Area, and the Gas Stripper. The Combined Air Ejector is a minor release source in terms of activity and volume during normal operation. The batch releases from the gas decay tanks occur through the Aux. Building vent stack.

TABLE 4-1
RADIOACTIVE LIQUID WASTE EFFLUENT MONITORS

| CHANNEL NUMBER | NAME | CONTROL FUNCTION | DETECTOR TYPE |
|---|---|---|---|
| 1 (2) RE-216 | Containment Fan Coolers Liquid Monitors | None | Scintillation |
| RE-218 | Waste Disposal System Liquid Monitor | Shuts waste liquid overboard | Scintillation |
| 1 (2) RE-219 | Steam Generator Blowdown Line Liquid Monitors | Shuts steam generator blowdown isolation valves, blowdown tank outlet valves and steam generator sample valves | Scintillation |
| RE-220 | Spent Fuel Pool Liquid Monitor | None | Scintillation |
| 1 (2) RE-222 | Steam Generator Blowdown Tank Outlet Monitor | Shuts steam generator blowdown isolation valves and blowdown tank outlet valves | GM Tube |
| RE-223 | Waste Distillate Overboard Liquid Monitor | Shuts waste distillate overboard isolation valve | Scintillation |
| 1 (2) RE-229 | Service Water Discharge Monitors | None | Scintillation |
| RE-230 | Waste Water Effluent Monitor | None | Scintillation |

TABLE 4-2
RADIOACTIVE GASEOUS WASTE EFFLUENT MONITORS

| CHANNEL NUMBER | NAME | CONTROL FUNCTION | DETECTOR TYPE |
|---|---|---|---|
| 1 (2) RE-212 | Containment Noble Gas Monitor | Actuates containment ventilation isolation | Scintillation |
| RE-214 | Auxiliary Building Exhaust Ventilation Noble Gas Monitor | Shuts gas release valve and shifts auxiliary building exhaust through carbon filters | Scintillation |
| 1 (2) RE-215 | Condenser Air Ejector Noble Gas Monitors | None | Scintillation |
| RE-221 | Drumming Area Vent Noble Gas Monitor | None | Scintillation |
| RE-224 | Gas Stripper Building Exhaust Noble Gas Monitor | None | Scintillation |
| RE-225 | Combined Air Ejector Low-Range Noble Gas Monitor | None | Scintillation |
| 1 (2) RE-305 | Unit 1 and 2 Purge Exhaust Noble Gas Monitors (Channel 5 on SPING Units No. 21 and No. 22) | Containment ventilation isolation | Scintillation |
| RE-315 | Auxiliary Building Exhaust Ventilation Noble Gas Monitor (Channel 5 on SPING Unit No. 23) | None | Scintillation |
| RE-325 | Drumming Area Ventilation Noble Gas Monitor (Channel 5 on SPING Unit No. 24) | None | Scintillation |

FIGURE 4-1
RADIOACTIVE LIQUID WASTE EFFLUENT MONITORS

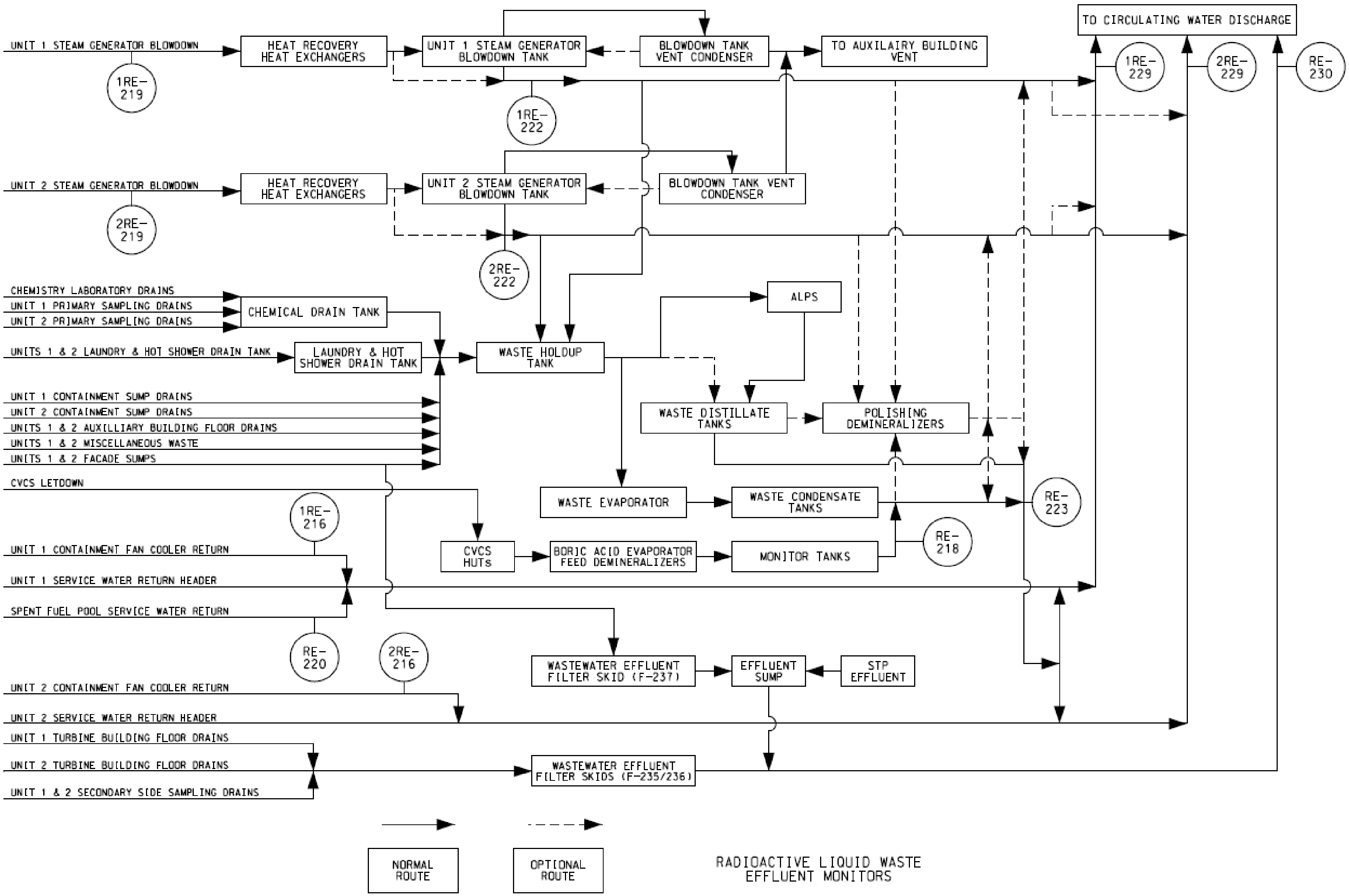
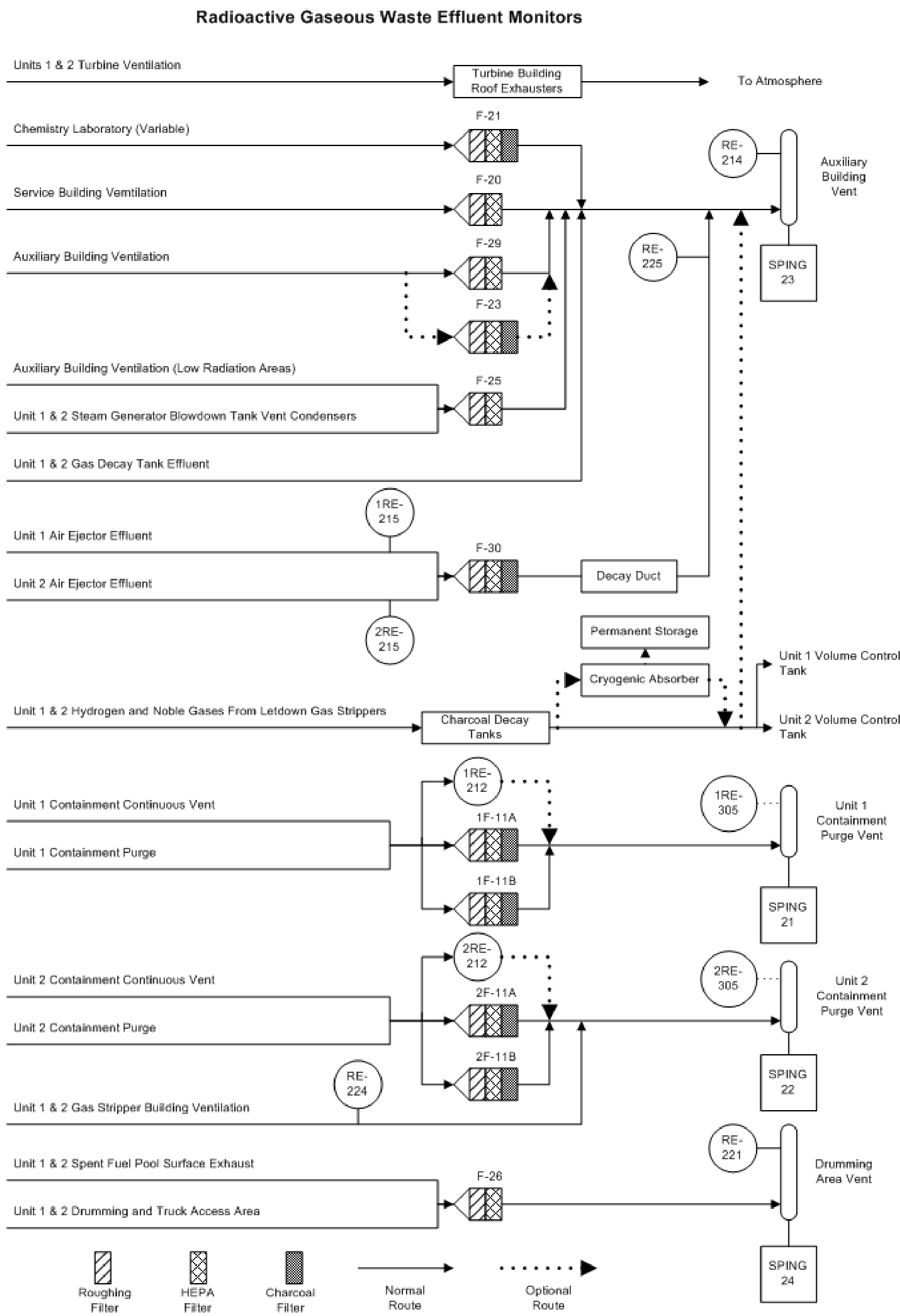


FIGURE 4-2
RADIOACTIVE GASEOUS WASTE EFFLUENT MONITORS



## 5.0 SPECIFICATIONS AND SURVEILLANCE REQUIREMENTS

### 5.1 Specifications

Compliance with the specifications contained in the succeeding text is required during the conditions specified therein. Upon failure to meet the specification, either during the performance of the surveillance, or between performances, the associated ACTION requirement shall be met.

Noncompliance with a specification shall exist when its requirements and associated ACTION requirements are not met within the specified time period. If the specification is restored prior to expiration of the specified time intervals, completion of the ACTION requirements is not required.

### 5.2 Surveillance Requirements

Surveillance Requirements shall be met during the conditions specified for individual specifications unless otherwise stated in an individual surveillance requirement. The provisions of SR 3.0.2 and 3.0.3 are applicable to the surveillance frequency of the Radioactive Effluent Controls Program in accordance with TS 5.5.4.

# 6.0 LIQUID EFFLUENT SPECIFICATIONS AND SURVEILLANCE REQUIREMENTS

## 6.1 Concentration

### 6.1.1 Specifications

In accordance with PBNP TS 5.5.4.b, the concentration of radioactive materials in liquid effluents to the unrestricted area is limited to ten times the concentration value in Appendix B, Table 2, Column 2 to 10 CFR 20. For dissolved and entrained noble gases, the concentration shall be limited to 2.0 E-04 µCi/mL total activity.

### 6.1.2 Applicability

At all times

### 6.1.3 Action

a. During release of radioactive liquid effluents, at least one condenser circulating water pump shall be in operation and the service water return header shall be lined up only to the unit whose circulating water pump is operating.

b. When the concentration of radioactive material released in liquid effluents to UNRESTRICTED AREAS exceeds the limits identified in Section 6.1.1, immediately restore the concentration to within the above limits.

c. Report all deviations in the Annual Monitoring Report

### 6.1.4 Surveillance Requirement

a. The concentration of radioactivity in liquid waste shall be determined by sampling and analysis in accordance with Table 6-1.

b. The results of radioactive analysis shall be used in accordance with the methodology of Section 9.1 to assure that the concentrations at the point of release are maintained within the limits of Section 6.1.1.

6.1.5 Basis

This specification is provided to ensure that the concentration of radioactive materials released in liquid waste effluents from the site to UNRESTRICTED AREAS will be less than 10X the concentration levels specified in 10 CFR Part 20, Appendix B, Table 2, Column 2. This limitation provides additional assurance that the levels of radioactive materials in bodies of water outside the site will not result in exposures exceeding (1) the Section II.A design objectives of Appendix I, 10 CFR Part 50, to a MEMBER OF THE PUBLIC and (2) the limits of 10 CFR Part 20.1301(a)(1) to the population. The concentration limit for dissolved or entrained noble gases is based upon the NRC's evaluation and assumption that Xe-135 is the controlling radioisotope and its limit in air (submersion) has been converted to an equivalent concentration in water using the methods described in International Commission on Radiological Protection (ICRP) Publication 2.
The required detection capabilities for radioactive materials in liquid waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits can be found in Currie, L. A., "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," NUREG/CR-4007 (September 1984).

Note: Hard-to-detect (HTD) radionuclides are radionuclides, such as alpha emitters and pure beta emitters which can be detected only by chemical extraction followed by alpha or beta counting, and therefore cannot be detected before a release using gamma spectroscopy. Analyses for HTDs are accomplished by obtaining aliquots of sample streams and sending the samples to a contracted laboratory for analyses. Their release quantities and doses are assessed after analytical results are obtained and then included in the monthly effluent quantification. The HTDs specifically identified by the Point Beach RETS were Sr-89/90 and alpha emitters. Fe-55 identified in NUREG-0472 was not included in the Point Beach RETS. Pursuant to regulatory guidance, reviews of the Part 61 analyses have been undertaken and, as a good practice, the following HTDs (other than the ones specifically required) have been added to the analytical list: C-14, Fe-55, Ni-63, and Tc-99. NRC guidance (Reg Guide 1.21, Rev 2, June 2009) does not require analysis for C-14 in liquids because the airborne C-14 far outweighs the amount discharged in liquids. Therefore, C-14 analyses may be discontinued in the future based on the results from the Part 61 analyses. The list of required radionuclides and the additional HTDs are listed in Table 6-1.

## TABLE 6-1
## RADIOACTIVE LIQUID WASTE SAMPLING AND ANALYSIS PROGRAM

| LIQUID RELEASE TYPE[5] | SAMPLING FREQUENCY | MINIMUM ANALYSIS FREQUENCY | TYPE OF ACTIVITY ANALYSIS | LOWER LEVEL OF DETECTION[1] (µCI/CC) |
|---|---|---|---|---|
| 1. Batch Releases[2]<br>a. Waste Condensate Tank<br>b. Waste Distillate Tank<br>c. Monitor Tanks<br>d. Other tanks containing radioactivity to be discharged | Prior to release | Prior to release | Gamma emitters | 5 E-07 |
| | | | I-131 | 1 E-06 |
| | | | Tritium | 1 E-05 |
| | | Monthly on composites obtained from batches released during the current month | Gross alpha<br>Fe-55, Ni-63,<br>Tc-99, C-14 | 1 E-07<br>1E-06<br>1E-06 |
| | | Quarterly on composites obtained from batches released during the current quarter | Sr-89/90 | 5 E-08 |
| 2. Continuous Releases[3, 5]<br>a. Steam Generator Blowdown<br>b. Service Water | Grab samples twice weekly | Twice weekly | Gamma emitters | 5E-07 |
| | | | I-131 | 1E-06 |
| | | | Tritium | 1E-05 |
| | | Monthly on grab composites | Gross alpha<br>Fe-55, Ni-63, Tc-99, C-14 | 1E-07<br>1E-06<br>1E-06 |
| | | Quarterly on grab composites | Sr-89/90 | 5E-08 |
| 3. Waste Water Effluent[5] | Continuous Composite[4] | Weekly | Gamma emitters | 5E-07 |
| | | | I-131 | 1E-06 |
| | | | Tritium | 1E-05 |
| | | Monthly on weekly composite | Gross alpha<br>Fe-55, Ni-63, Tc-99, C-14 | 1E-07<br>1E-06<br>1E-06 |
| | | Quarterly on monthly composite | Sr-89/90 | 5E-08 |

**NOTE 1:** **The principal gamma emitter for which the gamma isotopic LLD applies is Cs-137. Because gamma isotopic analyses are performed, the LLDs for all other gamma emitters are inherently determined by the operating characteristics of the counting system. All positively identified gamma emitters will be reported in the Annual Monitoring Report**

**NOTE 2:** **A BATCH RELEASE is defined in Section 2.5. Prior to sampling for analysis, each batch shall be isolated and mixed to assure representative sampling.**

**NOTE 3:** **A CONTINUOUS RELEASE is defined in Section 2.5.**

**NOTE 4:** **A continuous composite is one in which the method of sampling employed results in a specimen that is representative of the liquids released.**

**NOTE 5:** **For compensatory analyses required by Table 6-2 only the analyses performed by the out-of-service monitor need to be performed.**

6.2 Dose

6.2.1 Specifications

In accordance with PBNP TS 5.5.4.d, the dose or dose commitment to a MEMBER OF THE PUBLIC from radioactive materials in liquid effluents released to UNRESTRICTED AREAS shall not exceed:

a. 3 mrem to the total body or 10 mrem to any organ, total from both units, during any calendar quarter, and

b. 6 mrem to the total body or 20 mrem to any organ, total from both units, during any calendar year.

6.2.2 Applicability

At all times

6.2.3 Action

If the calculated dose from radioactive material actually released in liquid effluents exceeds any of the above limits, a special report shall be prepared and submitted to the Commission within 30 days of determination of the release quantity. The report shall include, as appropriate:

- The cause(s) for exceeding the limits,
- The corrective action(s) taken to reduce the release, and
- The proposed corrective action(s) to be taken to assure that subsequent releases will be in compliance with the above limits.

If the dose to any MEMBER OF THE PUBLIC exceeds 75 mrem to the thyroid or 25 mrem to the whole body or an organ other than the thyroid, pursuant to 40 CFR 190, the report shall also contain a request for a variance from this standard pursuant to 40 CFR 190.11.

6.2.4 Surveillance Requirement

Cumulative dose contributions from radioactive effluents shall be determined for the current calendar quarter and current calendar year in accordance with the methodology described in Section 9.2 at least once every 31 days.

6.2.5 Basis

This specification is provided to implement the requirements of Sections II.A, III.A, and IV.A of Appendix I, 10 CFR Part 50. The Limiting Condition for Operation implements the guides set forth in Section II.A of Appendix I. The ACTION statements provide operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the releases of radioactive material in liquid effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable". Also, for fresh water sites with drinking water supplies that can be potentially affected by plant operations, there is reasonable assurance that the operation of the facility will not result in radionuclide concentrations in the finished drinking water that are in excess of the requirements of 40 CFR Part 141. The dose calculation methodology in Section 9.2 implements the requirements of Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The equations specified in Section 9.2 for calculating the doses due to the actual release rates of radioactive materials in liquid effluents are consistent with the methodology provided in Regulatory Guide 1.109 and Regulatory Guide 1.113.

## 6.3 <u>Liquid Radwaste Treatment System</u>

6.3.1 Specifications

In accordance with PBNP TS 5.5.4.f, the LIQUID RADWASTE TREATMENT SYSTEM shall be used to reduce the radioactive materials in liquid wastes prior to discharge when the projected doses, due to the liquid effluent, to UNRESTRICTED AREAS would exceed 0.12 mrem to the total body or 0.4 mrem to any organ (2% of the annual Appendix I dose objective) in a 31 day period.

6.3.2 Applicability

At all times

6.3.3 Action

With radioactive liquid waste being discharged without treatment and in excess of the above limits and any portion of the LIQUID RADWASTE TREATMENT SYSTEM not in operation, prepare and submit to the Commission within 30 days a special report that includes the following information:

- Identification of the non-functional equipment or subsystem and the reason for non-functionality.
- Actions taken to restore the non-functional equipment to FUNCTIONAL status.
- Summary description of actions taken to prevent a recurrence.

6.3.4 Surveillance Requirement

Doses due to liquid releases shall be projected at least once per 31 days in accordance with the methodology and parameters in Section 9.3.

6.3.5 Basis

The requirement that the appropriate portions of this system be used, when specified, provides assurance that the releases of radioactive materials in liquid effluents will be kept “as low as is reasonably achievable”. This specification implements the requirements of 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and the design objective given in Section II.D of Appendix I to 1o CFR Part 50. The specified limits governing the use of appropriate portions of the LIQUID RADWASTE TREATMENT SYSTEM were specified as a suitable fraction of the dose design objectives set forth in Section II.A of Appendix I, 10 CFR Part 50, for liquid effluents.

6.4 Liquid Effluent Monitoring Instrumentation

6.4.1 Specifications

a. In accordance with PBNP TS 5.5.4, the radioactive liquid monitoring instrumentation channels listed in Table 6-2 shall be FUNCTIONAL and alarm or trip setpoints established such that effluent releases do not exceed the values described in Section 6.1.1.

b. The alarm or trip setpoints of the monitoring instrumentation channels shall be determined in accordance with the methodology in Section 9.1.

6.4.2 Applicability

During releases using the monitored pathway

6.4.3 Action

a. If a radioactive effluent monitoring instrumentation channel alarm or trip setpoint is found less conservative than required by Section 6.4.1, immediately suspend the release of radioactive liquid effluents monitored by the affected channel, or declare the channel non-functional, or change the setpoint so it is acceptably conservative.

b. If fewer than the minimum number of radioactive effluent monitoring channels is FUNCTIONAL, the appropriate ACTION should be taken for the instrument as listed in Table 6-2. Best effort shall be made to return the non-functional channel to a FUNCTIONAL status within 30 days. If this cannot be accomplished, the circumstances of the instrument failure and schedule for repair shall be reported in the Annual Monitoring Report.

c. Report all deviations in the Annual Monitoring Report.

6.4.4 Surveillance Requirement

Each radioactive effluent monitoring instrumentation channel shall be demonstrated FUNCTIONAL by performance of the CHANNEL CHECK, calibration, FUNCTIONAL TEST, and SOURCE CHECK at the frequencies described in Table 6-3.

6.4.5 Basis

The radioactive liquid effluent monitoring instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in liquid effluents during actual or potential releases of liquid effluents. The Alarm/Trip Setpoint for these instruments SHALL be calculated and adjusted in accordance with the methodologies and parameters in Section 9.1 of the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of TS 5.5.4.6. The FUNCTIONALITY and use of the instrumentation is consistent with the requirements of General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50 and Point Beach General Design Criteria 17 and 70.

TABLE 6-2
RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION

| INSTRUMENT | MINIMUM CHANNELS FUNCTIONAL | ACTION |
|---|---|---|
| 1. Liquid Radwaste System | | |
| a. RE-223, Waste Distillate Tank Discharge | 1 | Note 1 |
| b. RE-218, Waste Condensate Tank Discharge | 1 | Note 1 |
| c. Waste Condensate Tank Discharge Flow Meter | 1 | Note 2 |
| d. Waste Distillate Tank Flow Rate Recorder | 1 | Note 2 |
| 2. Steam Generator Blowdown System | | |
| a. For each unit: RE-219, Steam Generator Blowdown Liquid Discharge, or RE-222, Blowdown Tank Monitor, or RE-229, Service Water Discharge | 1 | Note 3 |
| b. Steam Generator Blowdown Flow Indicating Transmitters (1 per steam generator) | 1 | Note 4 |
| 3. Service Water System | | |
| a. RE-229, Service Water Discharge (for applicable unit) | 1 | Note 5 |
| b. For each unit: RE-216, Containment Cooling Fan Service Water Return, or RE-229, Service Water Discharge | 1 | Note 5 |
| c. RE-220, Spent Fuel Pool Heat Exchanger Service Water Outlet or RE-229, Service Water Discharge (for applicable unit) | 1 | Note 5 |
| 4. Waste Water Effluent | | |
| a. RE-230, Waste Water Effluent | 1 | Note 5 |
| b. Waste Water Effluent Composite Sampler | 1 | Note 6 |
| c. Waste Water Effluent Flow Determination | N/A | Note 7 |

**NOTE 1:** **If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided that 1) prior to initiating a batch release, two separate samples are analyzed by two technically qualified people in accordance with the applicable part of Tables 6-1 and 6-2, 2) the release rate is reviewed by two technically qualified people, and 3) at a minimum, one grab sample is obtained during the discharge, and once every 12 hours through the duration of the release. Otherwise, suspend release of radioactive effluents via this pathway (reference TRM 3.3.1).**

**NOTE 2:** **If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided the flow rate is estimated at least once every four hours during actual liquid batch releases.**

**NOTE 3:** **If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided grab samples are analyzed for gamma radioactivity in accordance with Table 6-1 at least once every 24 hours when the secondary coolant specific activity is less than 0.01 µCi/cc dose equivalent I-131 or once every 12 hours when the activity is greater than 0.01 µCi/cc dose equivalent I-131.**

**NOTE 4:** **If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided the flow is estimated or determined with auxiliary indication at least once every 24 hours.**

**NOTE 5:** **If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided that at least once every 12 hours grab samples are collected and analyzed in accordance with Table 6-1.**

**NOTE 6:** **If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided grab samples are collected twice per week and analyzed in accordance with Table 6-1.**

**NOTE 7:** **Waste water effluent flow may be determined from the waste water effluent flow meter**

TABLE 6-3
RADIOACTIVE LIQUID EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE REQUIREMENTS

| INSTRUMENT DESCRIPTION | CHANNEL CHECK | CALIB. | FUNCTION TEST | SOURCE CHECK |
|---|---|---|---|---|
| 1. Liquid Radwaste System | | | | |
| a. RE-223, Waste Distillate Tank | D | R | Q | P |
| b. RE-218, Waste Condensate Tank Discharge | D | R | Q | P |
| c. Waste Condensate Tank Discharge Flow Meter | P/D | R | N/A | N/A |
| d. Waste Distillate Tank Flow Rate Recorder | P/D | R | N/A | N/A |
| 2. Steam Generator Blowdown System | | | | |
| a. RE-219, Steam Generator Blowdown Liquid Discharge (1 per unit) | D | R | Q | M |
| b. RE-222, Blowdown Tank Monitor (1 per unit) | D | R | Q | M |
| c. Steam Generator Blowdown Flow Indicating Transmitters (1 per steam generator) | D | R | N/A | N/A |
| 3. Service Water System | | | | |
| a. RE-229, Service Water Discharge (1 per unit) | D | R | Q | M |
| b. RE-216, Containment Cooling Fan Service Water Return | D | R | Q | M |
| c. RE-220, Spent Fuel Pool Heat Exchanger Service Water Outlet | D | R | Q | M |
| 4. Waste Water Effluent | | | | |
| a. RE-230, Waste Water Effluent | D | R | Q | M |
| b. Waste Water Effluent Composite Sampler | W | N/A | N/A | N/A |
| c. Waste Water Effluent Flow Meter | W | R | N/A | N/A |

Legend:
- D = Daily
- W = Weekly
- M = Monthly
- Q = Quarterly
- R = Once per 18 months, typically during refueling
- P/D = Prior to or immediately upon initiation of a release or daily if a release continues for more than one day
- N/A = Not applicable

# 7.0 GASEOUS EFFLUENT SPECIFICATIONS AND SURVEILLANCE REQUIREMENTS

## 7.1 Dose Rate

### 7.1.1 Specifications

In accordance with PBNP TS 5.5.4.g, the dose rate resulting from radioactive material released in gaseous effluents from the site areas at or beyond the SITE BOUNDARY shall be limited to the following:

a. For noble gases: a dose rate ≤ 500 mrem/yr to the whole body and a dose rate ≤ 3000 mrem/yr to the skin, and

b. For iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than eight days: a dose rate ≤ 1500 mrem/yr to any organ.

### 7.1.2 Applicability

At all times.

### 7.1.3 Action

With the dose rate(s) exceeding the above limits, immediately restore the release rate within the above limit(s).

### 7.1.4 Surveillance Requirement

a. The dose rate due to noble gases in gaseous effluents shall be determined to be within the above limits in accordance with the methodology and parameters in Section 10.3 of this manual.

b. The dose rate due to iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than 8 days in gaseous effluents shall be determined to be within the above limits in accordance with the methodology and parameters in Section 10.4 of this manual by obtaining representative samples and performing analyses in accordance with the sampling and analysis program specified in Table 7-1.

7.1.5 Basis

This specification is provided to ensure that the dose rate at the SITE BOUNDARY averaged over a time period of no greater than one hour due to gaseous effluents from all units on the site will be within the annual dose limits of 10 CFR Part 20 for UNRESTRICTED AREAS. These limits provide reasonable assurance that radioactive material discharged in gaseous effluents will not result in the exposure of a MEMBER OF THE PUBLIC in an UNRESTRICTED AREA, either within or outside the SITE BOUNDARY, to annual average concentrations exceeding the limits specified in Appendix B, Table 2 of 10 CFR Part 20. For MEMBERS OF THE PUBLIC who may at times be within the SITE BOUNDARY, the occupancy of the MEMBER OF THE PUBLIC will usually be sufficiently low to compensate for any increase in the atmospheric diffusion factor above that for the SITE BOUNDARY. The specified release rate limits restrict, at all times, the corresponding gamma and beta dose rates above background to a MEMBER OF THE PUBLIC at or beyond the SITE BOUNDARY to less than or equal to 500 mrem/yr to the total body or to less than or equal to 3000 mrem/year to the skin. These release rate limits also restrict, at all times, the corresponding thyroid dose rate above background to less than or equal to 1500 mrem/year. The required detection capabilities for radioactive material in gaseous waste samples are tabulated in terms of the lower limits of detection (LLDs). Detailed discussion of the LLD, and other detection limits can be found in Currie, L. A., "Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements," NUREG/CR-4007 (September 1984).

Hard-to-detect (HTD) radionuclides are radionuclides, such as alpha emitters and pure beta emitters which can be detected only by chemical extraction followed by alpha or beta counting. HTD analyses are accomplished by a contracted laboratory on representative waste stream samples. Their release quantities and doses are assessed after analytical results are obtained and then included in the monthly effluent quantification. The HTDs specifically identified by the Point Beach RETS were Sr-89/90 and alpha emitters. Fe-55 identified in NUREG-0472 was not included in the Point Beach RETS. Pursuant to regulatory guidance, reviews of the Part 61 analyses have been undertaken, and, as a good practice, the following HTDs (other than the ones specifically required) have been added to the analytical list: Fe-55, Ni-63, and Tc-99. Airborne C-14 is calculated. The list of required radionuclides and the additional HTDs are listed in Table 7-1.

TABLE 7-1
RADIOACTIVE GASEOUS WASTE SAMPLING AND ANALYSIS PROGRAM

| GASEOUS RELEASE TYPE | SAMPLING FREQUENCY | MINIMUM FREQUENCY ANALYSIS | TYPE OF ACTIVITY ANALYSIS | LOWER LEVEL OF DETECTION[1] (µCi/cc) |
|---|---|---|---|---|
| 1. Gas Decay Tank | Prior to release | Prior to release | Gamma emitters | 1E-04 |
| 2. Containment Purge or Continuous Vent | Prior to Purge[2] or vent | Prior to purge or vent | Gamma emitters | 1E-04 |
| | | | Tritium | 1E-06 |
| 3. Continuous Releases<br>a. Unit 1 Containment Purge and Vent<br>b. Unit 2 Containment Purge and Vent<br>c. Drumming Area vent<br>d. Gas Stripper Building Vent<br>e. Auxiliary Building Vent | Continuous[3] | Weekly analysis of charcoal and particulate samples | Gamma emitters | 1E-11 |
| | | | I-131 | 1E-12 |
| | | Monthly composite of particulate sample | Gross alpha | 1E-11 |
| | | Quarterly composite of particulate sample | Sr-89/90 | 1E-11 |
| | | | Fe-55, Ni-63, Tc-99 | Per industry standards[5] |
| | | Noble gas monitor | Noble gases – gross beta or gamma | 1E-06 |
| | Monthly[4] (grab) | Monthly | Gamma emitters | 1E-04 |
| | | | Tritium | 1E-06 |

**NOTE 1:** **The principal gamma emitters for which LLD specification applies are Cs-137 in particulates and Xe-133 in gases. Because gamma isotopic analyses are performed, the LLDs for all other gamma emitters are inherently determined by the operating characteristics of the counting system. All identifiable gamma emitters will be reported in the Annual Monitoring Report.**

**NOTE 2:** **Tritium grab samples will be taken every 24 hours when the refueling cavity is flooded.**

**NOTE 3:** **The ratio of the sample flow rate to the release flow rate shall be known or estimated for the time period covered by each sampling interval. (Reference RAM 5.2)**

**NOTE 4:** **Tritium grab samples will be taken every seven days from the drumming area ventilation exhaust/spent fuel pool area whenever there is spent fuel in the spent fuel pool.**

**NOTE 5:** **LLDs for Fe-55, Ni-63 and Tc-99 are not prescribed in NUREG 1301. LLDs should be consistent with laboratory capabilities and industry standards for nuclide detection.**

## 7.2 Dose – Noble Gases

### 7.2.1 Specifications

In accordance with PBNP TS 5.5.4.e & 5.5.4.h, the air dose from noble gases released in gaseous effluents to areas beyond the SITE BOUNDARY shall not exceed:

a. 10 mrad for gamma radiation or 20 mrad for beta radiation, per calendar quarter, and

b. 20 mrad for gamma radiation or 40 mrad for beta radiation, per calendar year.

### 7.2.2 Applicability

At all times.

### 7.2.3 Action

If the calculated air dose from radioactive noble gases actually released in gaseous effluents exceeds any of the above limits, a special report shall be prepared and submitted to the Commission within 30 days of determination of the release quantity. The report shall include, as appropriate:

- The cause(s) for exceeding the limits,
- The corrective action(s) taken to reduce the release, and
- The proposed corrective action(s) to be taken to assure that subsequent releases will be in compliance with the above limits.

If the dose to any MEMBER OF THE PUBLIC exceeds 75 mrem to the thyroid or 25 mrem to the whole body or an organ other than the thyroid, pursuant to 40 CFR 190, the report shall also contain a request for a variance from this standard pursuant to 40 CFR 190.11.

### 7.2.4 Surveillance Requirement

Cumulative dose contributions from noble gases in radioactive effluents shall be determined for the current calendar quarter and current calendar year in accordance with the methodology described in Section 10.5, at least every 31 days.

7.2.5 Basis

This specification is provided to implement the requirements of Section II.B, III.A and IV.A of Appendix I, 10 CFR Part 50. The Limiting Conditions for Operation implement the guides set forth in Section II.B of Appendix I. The ACTION statement provides the required operating flexibility and at the same time implements the guides set forth in Section IV.A of Appendix I to assure that the release of radioactive material in gaseous effluents will be kept "as low as reasonably achievable". The Surveillance Requirements implement the requirements of Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology of Section 10.3 for calculating the doses due to the actual release rate of radioactive noble gases in gaseous effluents are consistent with the methodology provided in Regulatory Guide 1.109 and Regulatory Guide 1.111. The equations of Section 10.5 provided for determining the air doses at and beyond the SITE BOUNDARY are based upon the historical average atmospheric conditions.

Consistent with the approach for limiting gaseous effluents in 10CFR50 App. I, meeting the air dose limits for gamma and beta radiation under most all site conditions provides a *de facto* compliance with the total body (5 mrem per unit) and skin (15 mrem per unit) dose limits. For PBNP, the air dose limits are met at the site boundary at the location with the highest $\chi/Q$, which is a very conservative assessment when compared to the location of any real person. Furthermore, PBNP TS section 5.5.4.h. requires compliance with only the air dose limits. Therefore, compliance with the gamma and beta air dose limits provides for compliance with the total body and skin dose limits.

7.3 Dose – I-131, I-133, H-3 and Radionuclides in Particulate Form

7.3.1 Specifications

In accordance with PBNP TS 5.5.4.i, the annual or quarterly dose to a MEMBER OF THE PUBLIC from iodine-131, iodine-133, tritium, and all radionuclides in particulate form with half-lives greater than eight days in gaseous effluents release to areas beyond the SITE BOUNDARY shall be limited to:

a. ≤ 15 mrem to any organ per calendar quarter, and

b. ≤ 30 mrem to any organ per calendar year.

7.3.2 Applicability

At all times.

7.3.3 Action

If the calculated dose from the release of iodine-131, iodine-133, tritium, and radionuclides in particulate form with half-lives greater than eight days, in gaseous effluents exceeds any of the above limits, a special report shall be prepared and submitted to the Commission within 30 days of determination of the release quantity. The report shall include, as appropriate:

- The cause(s) for exceeding the limits,
- The corrective action(s) taken to reduce the release, and
- The proposed corrective action(s) to be taken to assure that subsequent releases will be in compliance with the above limits.

If the dose to any MEMBER OF THE PUBLIC exceeds 75 mrem to the thyroid or 25 mrem to the whole body or an organ other than the thyroid, pursuant to 40 CFR 190, the report shall also contain a request for a variance from this standard pursuant to 40 CFR 190.11.

7.3.4 Surveillance Requirement

Cumulative dose contributions from iodine-131, iodine-133, tritium, and particulates with half-lives greater than eight days in radioactive effluents shall be determined for the current calendar quarter and current calendar year in accordance with the methodology described in Section 10.6, at least every 31 days.

7.3.5 Basis

This specification is provided to implement the requirements of Section II.C, III.A and IV.A of Appendix I, 10 CFR Part 50. The Limiting Conditions for Operation are the guides set forth in Section II.C of Appendix I. The ACTION statements provide the required operating flexibility and at the same time implement the guides set forth in Section IV.A of Appendix I to assure that the release of radioactive materials in gaseous effluents to UNRESTRICTED AREAS will be kept "as low as is reasonably achievable". The Surveillance Requirements implement the requirements of Section III.A of Appendix I that conformance with the guides of Appendix I be shown by calculational procedures based on models and data such that the actual exposure of a MEMBER OF THE PUBLIC through appropriate pathways is unlikely to be substantially underestimated. The dose calculation methodology of Section 10.4 for calculating the doses due to the actual release rates of the subject materials are consistent with the methodology provided in Regulatory Guide 1.109 and Regulatory Guide 1.111. These equations also provide for determining the actual doses based upon the historical average atmospheric conditions. The release rate controls for iodine-131, iodine-133, tritium, and radionuclides in particulate form with half-lives greater than eight days are dependent upon the existing radionuclide pathways to man at and beyond the SITE BOUNDARY. The pathways that were examined in the development of the calculations were: (1) individual inhalation of airborne radionuclides, (2) deposition of radionuclides onto green leafy vegetation with subsequent consumption by man, (3) deposition onto grassy areas where milk animals and meat producing animals graze with consumption of the milk and meat by man, and (4) deposition on the ground with subsequent exposure of man.

7.4 Gaseous Radwaste Treatment System

7.4.1 Specifications

In accordance with PBNP TS 5.5.4.f, the GASEOUS RADWASTE TREATMENT SYSTEM shall be used to reduce radioactive materials in gaseous waste prior to discharge when the 31-day projected gaseous effluent air doses due to the gaseous effluents to UNRESTRICTED AREAS would exceed 0.4 mrad from noble gas gamma radiation, 0.8 mrad from noble gas beta radiation, and 0.6 mrem to any organ from I-131, I-133, H-3 and radioactive material in particulate form whose half-life is > 8 days, from both units (2% of the Appendix I annual dose objectives).

7.4.2 Applicability

At all times.

7.4.3 Action

If radioactive gases are being discharged for a period of 31 consecutive days without use of the effluent treatment system to meet the release limits specified above, a special report shall be prepared and submitted to the Commission within thirty days which includes the following information:

- Identification of the non-functional equipment or subsystem and the reason for non-functionality.
- Actions taken to restore the non-functional equipment to FUNCTIONAL status.
- Summary description of actions taken to prevent a recurrence.

The following portions of the gaseous radioactive effluent treatment system shall be used to reduce the release of radioactivity:

- For noble gases, a gas decay tank(s) (GDTs) shall be operated when required to maintain gaseous releases within the specified limits, described above.
- During a GDT discharge through the Auxiliary Building vent, at least one exhaust fan shall be in operation (FSAR 11.2.3).
- For iodine-131, iodine-133, tritium, and particulates with half-lives greater than eight days, the auxiliary building ventilation exhaust charcoal filter and/or air ejector charcoal filter shall be operated when required to maintain gaseous releases within the specified limits, described above.

7.4.4 Surveillance Requirement

Projected dose contributions from radioactive effluents shall be determined for the current calendar quarter and current calendar year in accordance with the methodology described Sections 9.3 and 10.7 at least every 31 days.

7.4.5 Basis

The requirement that the appropriate portions of these systems be used, when specified, provides reasonable assurance that the release of radioactive materials in gaseous effluents will be kept “as low as is reasonably achievable”. This specification implements the requirements of PBNP GDC 70, 10 CFR Part 50.36a, General Design Criterion 60 of Appendix A to 10 CFR Part 50 and the design objective given in Section II.D of Appendix I to 1o CFR Part 50. The specified limits governing the use of appropriate portions of the GASEOUS RADWASTE TREATMENT SYSTEM were specified as a suitable fraction (2%) of the annual dose design objectives set forth in Sections II.B and II.C of Appendix I, 10 CFR Part 50, for gaseous effluents.

7.5 Gaseous Effluent Monitoring Instrumentation

7.5.1 Specification

a. In accordance with PBNP TS 5.5.4.a, the radioactive gaseous monitoring instrumentation channels listed in Table 7-2 shall be FUNCTIONAL and alarm or trip setpoints established such that effluent releases do not exceed the values described in Section 7.1.1.

1. All monitors are defined by the term FUNCTIONAL – FUNCTIONALITY, **EXCEPT** 1(2) RE-212 Containment Noble Gas Monitor which is defined by the term OPERABLE – OPERABILITY.

2. **IF** the ability of 1(2) RE-212, Containment Noble Gas Monitor, to perform its function is questioned,
**THEN** the Operability Determination process is applicable.
(LCO 3.4.15, RCS Leakage Detection Instrumentation)

b. The alarm or trip setpoints of the monitoring instrumentation channels shall be determined in accordance with the methodology in Section 10.1 of the ODCM.

7.5.2 Applicability

During releases via the monitored pathway.

7.5.3 Action

a. If a radioactive effluent monitoring instrumentation channel alarm or trip setpoint is found less conservative than required by Section 7.5.1, immediately suspend the release of radioactive gaseous effluents monitored by the affected channel, or declare the channel non-functional, or change the setpoint so it is acceptably conservative.

b. If fewer than the minimum number of radioactive effluent monitoring channels is FUNCTIONAL, the appropriate ACTION should be taken for the instrument as listed in. Best effort shall be made to return the non-functional channel to a FUNCTIONAL status within 30 days. If the number of channels FUNCTIONAL is not restored to the minimum required for any release pathway within 30 days, the circumstances of the instrument failures and schedule for repair shall be reported in the Annual Monitoring Report.

c. Report all deviations in the Annual Monitoring Report

7.5.4 Surveillance Requirement

Each radioactive effluent monitoring instrumentation channel shall be demonstrated FUNCTIONAL by performance of the CHANNEL CHECK, calibration, FUNCTIONAL TEST, and SOURCE CHECK at the frequencies described in Table 7-3.

7.5.5 Basis

The radioactive gaseous effluent monitoring instrumentation is provided to monitor and control, as applicable, the releases of radioactive materials in gaseous effluents during actual or potential releases of gaseous effluents. The Alarm/Trip Setpoint for these instruments SHALL be calculated and adjusted in accordance with the methodologies and parameters in the ODCM to ensure that the alarm/trip will occur prior to exceeding the limits of 10 CFR Part 20. The FUNCTIONALITY and use of the instrumentation is consistent with the requirements of Point Beach General Design Criteria 17 and 70 and General Design Criteria 60, 63, and 64 of Appendix A to 10 CFR Part 50.

# TABLE 7-2
# GASEOUS EFFLUENT MONITORING INSTRUMENTATION

| INSTRUMENT | MINIMUM CHANNELS FUNCTIONAL | ACTION |
|---|---|---|
| 1. Gas Decay Tank System | | |
| a. RE-214 , Noble Gas (Auxiliary Building Vent Stack), or RE-315, Noble Gas (Auxiliary Building Vent SPING) | 1 | Note 1 |
| b. Gas Decay Tank Flow Measuring Meter | 1 | Note 2 |
| 2. Auxiliary Building Ventilation | | |
| a. RE-214, Noble Gas (Auxiliary Building Vent Stack), or RE-315, Noble Gas (Auxiliary Building Vent SPING) | 1 | Note 3 |
| b. Isokinetic Iodine and Particulate Continuous Air Sampling System or SPING 23 | 1 | Note 4 |
| 3. Condenser Air Ejector System | | |
| a. RE-225, Noble Gas (Combined Air Ejector Discharge Monitor), or RE-215, Noble Gas (Air Ejector Monitors – 1 per unit), or RE-214, Noble Gas (Auxiliary Building Vent Stack); or RE-315, Noble Gas (Auxiliary Building Vent SPING) | 1 | Note 3 |
| b. Flow Rate Monitor – Air Ejectors | 1 | Note **5** |
| 4. Containment Purge and Vent System | | |
| a. RE-212, Noble Gas Monitors (1 per unit); or RE-305, Noble Gas (Purge Exhaust SPING – 1 per unit) | 1 | Note 3 |
| b. 30 cfm Forced Vent Path Flow Indicators | 1 | Note **5** |
| c. Iodine and Particulate – Continuous Air Samplers | 1 | Note 4 |
| d. Sampler Flow Rate Measuring Device | 1 | Note **5** |
| 5. Fuel Storage and Drumming Area Ventilation | | |
| a. RE-221, Noble Gas (Drumming Area Stack), or RE-325, Noble Gas (Drumming Area SPING) | 1 | Note 3 |
| b. Isokinetic Iodine and Particulate Continuous Air Sampling System or SPING 24 | 1 | Note 4 |
| 6. Gas Stripper Building Ventilations | | |
| a. RE-224, Noble Gas (Gas Stripper Building), or RE-305, Unit 2 Purge Exhaust SPING | 1 | Note 3 |
| b. Iodine and Particulate – Continuous Air Sampler or SPING 22 | 1 | Note 4 |
| c. Sampler Flow Rate Measuring Device | 1 | Note **5** |

**NOTE 1: If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided that prior to initiating a release, two separate samples are analyzed by two technically qualified people in accordance with the applicable part of Table 7-1 and the release rate is reviewed by two technically qualified people.**

**NOTE 2: If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided the flow rate is estimated at least once every four hours during actual gaseous releases.**

**NOTE 3: If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided grab samples are collected at least once per 12 hours and are analyzed in accordance with Table 7-1. (Reference Step 7.5.1 for additional information regarding RE-212)**

**NOTE 4: If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via the affected pathway may continue provided samples are continuously collected with auxiliary sampling equipment, (e.g., any low volume sampler which meets the requirements of Table 7-1).**

**NOTE 5: If the number of channels FUNCTIONAL is fewer than the minimum required, effluent releases via this pathway may continue provided the flow is estimated or determined with auxiliary indication at least once every 24 hours.**

# TABLE 7-3
# RADIOACTIVE GASEOUS EFFLUENT MONITORING INSTRUMENTATION SURVEILLANCE REQUIREMENTS

| INSTRUMENT DESCRIPTION | CHANNEL CHECK | CALIB. | FUNCT. TEST | SOURCE CHECK |
|---|---|---|---|---|
| 1. Gas Decay Tank System | | | | |
| a. RE-214, Noble Gas (Auxiliary Building Vent Stack) | D | R | Q | M |
| b. Gas Decay Tank Flow Measuring Device | P | R | N/A | N/A |
| 2. Auxiliary Building Ventilation System | | | | |
| a. RE-214, Noble Gas (Auxiliary Building Vent Stack | D | R | Q | M |
| b. RE-315, Noble Gas (Auxiliary Building SPING) | D | R | Q | M |
| c. Isokinetic Iodine and Particulate Continuous Air Sampling System | W | R | N/A | N/A |
| 3. Condenser Air Ejector System | | | | |
| a. RE-225, Noble Gas (Combined Air Ejector Discharge) | D | R | Q | M |
| b. RE-215, Noble Gas (Air Ejectors – 1 per unit) | D | R | Q | M |
| c. Flow Rate Monitor – Air Ejectors (1 per unit) | D | R | N/A | N/A |
| 4. Containment Purge and Vent System | | | | |
| a. RE-212, Noble Gas (1 per unit) | D | R | Q | M[1] |
| b. 30 cfm Vent Path Flow Indication | P/D | R | N/A | N/A |
| c. RE-305, Noble Gas (Purge Exhaust SPING – 1 per unit) | D | R | Q | M[1] |
| d. Iodine and Particulate Continuous Air Sampler | P/W | N/A | N/A | N/A |
| e. Sampler Flow Rate Measuring Device | P/D | R | N/A | N/A |
| 5. Fuel Storage and Drumming Area Ventilation Stack | | | | |
| a. RE-221, Noble Gas (Drumming Area Vent Stack) | D | R | Q | M |
| b. RE-325, Noble Gas (Drumming Area SPING) | D | R | Q | M |
| c. Isokinetic Iodine and Particulate Continuous Air Sampling System | W | R | N/A | N/A |
| 6. Gas Stripper Building Ventilation System | | | | |
| a. RE-224, Noble Gas | D | R | Q | M |
| b. Iodine and Particulate Continuous Air Sampler | W | N/A | N/A | N/A |
| c. Sampler Flow Rate Measuring Device | W | R | N/A | N/A |

Legend: D = Daily R = Once per 18 months, typically during refueling

W = Weekly P/D(W) = Prior to or immediately upon initiation of a release or daily (weekly) if a release continues for more than one day (week)

M = Monthly Q = Quarterly N/A = Not applicable

**NOTE 1: SOURCE CHECK required prior to containment purge**

# 8.0 TOTAL DOSE

## 8.1 Specification

The annual (calendar year) dose or dose commitment to any MEMBER OF THE PUBLIC due to releases of radioactivity and to radiation from URANIUM FUEL SOURCES shall be limited to less than or equal to 25 mrem to the total body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem.

## 8.2 Applicability

At all times.

## 8.3 Action

a. With the calculated doses from the release or radioactive materials in liquid or gaseous effluents exceeding twice the limits of Sections 6.2.1, 7.2.1, or 7.3.1, calculations should be made including direct radiation contributions from the site to determine whether the above limits have been exceeded. If the limits are exceeded, a special report shall be prepared and submitted to the Commission within 30 days in lieu of a License Event Report, that includes the following:

- the corrective action(s) taken to reduce subsequent releases to prevent recurrence of exceeding the above limits and includes the schedule for achieving conformance with the above limits.
- An analysis that estimates the radiation exposure (dose) to a MEMBER OF THE PUBLIC from URANIUM FUEL CYCLE sources, including all effluent pathways and direct radiation, for the calendar year that includes the release(s) covered by this report, as defined in 10 CFR 20.2203.
- A description of the levels of radiation and concentrations of radioactive material involved, and the cause of the exposure levels or concentrations.

b. If the estimated dose(s) exceeds the above limits, and if the release condition resulting in violation of 40 CFR Part 190 has not already been corrected, a request for a variance in accordance with the provisions of 40 CFR Part 190 shall be made. Submittal of the report is considered a timely request, and a variance is granted until staff action on the request is complete.

## 8.4 Surveillance Requirements

8.4.1 Cumulative dose contributions from liquid and gaseous effluents shall be determined in accordance with Surveillance Requirements 6.2.4, 7.2.4, and 7.3.4 and in accordance with the methodology of Sections 9.2, 10.5, and 10.6, respectively.

8.4.2 Cumulative dose contributions from direct radiation from the reactor units shall be determined using the procedure outlined in Section 11.0. This application is applicable only under the conditions set forth in ACTION 7.1.3.

8.5 Basis

This specification is provided to meet the dose limitations of 40 CFR Part 190 that have been incorporated into 10 CFR Part 20 by 46 FR 18525. The specification requires the preparation and submittal of a special report whenever the calculated doses due to releases of radioactivity and to radiation from the URANIUM FUEL CYCLE sources exceed 25 mrem to the whole body or any organ, except the thyroid, which shall be limited to less than or equal to 75 mrem. For sites containing up to four reactors, it is highly unlikely that the resultant dose to a MEMBER OF THE PUBLIC will exceed the dose limits of 40 CFR 190 if the individual reactors remain within twice the dose design objectives of Appendix I and if direct radiation doses from the units (including outside storage tanks, the ISFSI, etc.) are kept small. The special report will describe a course of action that should result in the limitation of the annual dose to a MEMBER OF THE PUBLIC to within 40 CFR 190 limits. For the purposes of the special report, it may be assumed that the dose commitment to a MEMBER OF THE PUBLIC from other URANIUM FUEL CYCLE sources is negligible, with the exception that dose contributions from other nuclear fuel cycle facilities at the same site or within a radius of 8 km must be considered.

The Kewaunee Nuclear Power Plant (KNPP) is within a radius of 8 Km of Point Beach. KNPP is now shut down. However, should there be any stored licensed material on that site which is released to the environment; the dose contribution from that release would have to be considered when evaluating Point Beach compliance with 40 CFR 190 limits.

If the dose to any MEMBER OF THE PUBLIC is estimated to exceed the requirements of 40CFR190, the special report with a request for a variance (provided the release conditions resulting in violation of 40CFR190 have not already been corrected), in accordance with the provisions of 40CFR190.11 and 10CFR20.2203(a)(4), is considered to be a timely request and fulfills the requirements of 40CFR190 until NRC staff action is completed. The variance only relates to the limits of 40CFR190, and does not apply in any way to the other requirements for dose limitation of 10CFR20, as addressed in Sections 6.2, 7.2 and 7.3. An individual is not considered a MEMBER OF THE PUBLIC during any period in which he/she is engaged in carrying out any operation that is part of the nuclear fuel cycle.

# 9.0 LIQUID EFFLUENT CALCULATIONS

## 9.1 Monitor Alarm Setpoint Determination

The effluent monitor setpoints are established to ensure that controlled releases of liquid radioactive effluents are maintained as low as is reasonably achievable, to ensure releases result in concentrations to unrestricted areas within the limits specified in Section 6.1 and to ensure that the dose limits of 10 CFR 50, Appendix I are not exceeded.

The computerized PBNP Radiation Monitoring System (RMS) permits each effluent radiation monitor to be programmed to alarm at two distinct setpoints. The alert setpoint, typically twice the steady-state reading, is intended to delineate a changing plant condition, and is established for evaluation purposes only. The high alarm or trip setpoint either will actuate a control function as applicable or will require corrective action to be initiated.

Alert Setpoint Guidelines

The alert setpoint of each effluent monitor normally will be set to alarm at two times the established steady-state reading. The alert setpoint is normally set at concentrations well below the alarm setpoint value and is never to be set in excess of the alarm setpoint. Certain situations during the course of plant operations may require a deviation from the two times steady-state value. The intent of this setpoint is to warn of changing plant conditions, which may warrant an evaluation to determine the cause of the increased reading. If the increased level is actually due to an increased radiation inventory within the system being monitored, as opposed to an increased background radiation field in the vicinity of the detector, an evaluation should be made to determine the impact of the release. The alert setpoint may be adjusted with prior approval. Alert setpoint adjustments are to be made in accordance with the PBNP RMS Alarm Setpoint and Response Book (Ref. OM 4.1.7).

High Alarm or Trip Setpoint Guidelines

In accordance with TS 5.5.4 and as stated in Section 6.1, the high alarm or trip setpoint for effluent monitors shall be established to annunciate at concentrations that would result in an UNRESTRICTED AREA concentration equal to or greater than 10x the applicable maximum effluent concentration (MEC) for a single radionuclide. For a mixture of radionuclides, the setpoint shall be established so that the sum of fractions (SOF), as defined in Appendix B of 10 CFR 20, is less than or equal to one. If the setpoints listed in Table 9-1 exceed the monitor's saturation or fail high level, the setpoint may be set at a value ≤70% of the fail high level (MSSM No. 93-01). These monitors are indicated by an asterisk (*) in Table 9-1. The appropriate detailed response to an effluent alarm is described in the PBNP RMS Alarm Setpoint and Response Book.

The effluent monitor setpoints are established to ensure that controlled releases of liquid radioactive effluent are maintained as low as is reasonably achievable, to ensure releases result in concentrations to UNRESTRICTED AREAS within the specified limits described in Section 6.1.1 and to ensure that the dose limits of 10 CFR50, Appendix 1 are not exceeded.

The following equation must be satisfied to meet the liquid effluent restriction:

$$c \leq \frac{C(F+f)}{f} \quad [9\text{-}1]$$

*Where:*

- $c$ = *The setpoint of the radioactivity monitor measuring the radioactivity concentration in the effluent line prior to dilution and subsequent release; the setpoint, which is inversely proportional to the volumetric flow of the dilution stream plus the effluent stream, represents a value which, if exceeded, would result in concentration exceeding the TS limits of 10x the 10 CFR 20 values in the UNRESTRICTED AREA (µCi/mL)*
- $C$ = *10x the effluent concentration limit from 10 CFR 20, Appendix B, Table 2 Column 2 (see section* 6.1.1*) (µCi/mL)*
- $f$ = *the flow rate at the radiation monitor location (volume/time)*
- $F$ = *The dilution water flow rate as measured prior to the release point (volume/time)*

*Note: If no dilution is provided, then $c \leq C$. Also if F is large compared to f, then $(F+f) \approx F$*

The liquid monitor setpoints are based on 10x the 10CFR20, Appendix B, Table 2, Column 2 maximum effluent concentration (MEC) values as allowed by the Point Beach TS. For a mixture of radionuclides, the setpoint is calculated so that the summation of fractions (SOF) will not exceed unity, i.e.

$$SOF = \sum \frac{C_i}{MEC_i} \leq 1 \quad [9\text{-}2]$$

*Where:*

- $C_i$ = *The concentration of radionuclide i in the liquid effluent (µCi/mL)*
- $MEC_i$ = *10 times the Maximum Effluent Concentration value corresponding to radionuclide "i" from 10 CFR Part 20, Appendix B, Column 2 (µCi/mL),*

The SOF meeting the ≤1 criterion means that the discharge concentration could have been higher by a factor of 1/SOF such that the effective maximum effluent concentration (EMEC) for the mixture could have been

$$EMEC = \frac{\sum C_i}{\sum \frac{C_i}{MEC_i}} \quad [9\text{-}3]$$

The setpoints for liquid effluent monitors are determined by the following equation:

$$EMEC \leq \frac{\sum (C_i) \times \beta cf}{\sum \frac{C_i}{10\ MEC_i} \times \beta cf} \qquad [9\text{-}4]$$

$$SP \leq \frac{EMEC\ CW \times Sen}{RR} \qquad [9\text{-}5]$$

*Where:*

| | | |
|---|---|---|
| *SP* | = | *Setpoint of the radiation monitor (cpm or μCi/mL, depending upon the specific monitor),* |
| *EMEC* | = | *The effective MEC value for the mixture of radionuclides in the effluent stream (μCi/mL)* |
| *CW* | = | *the circulating water flow rate (dilution water flow) at the time of the release (gpm)* |
| $C_i$ | = | *The concentration of radionuclide i in the liquid effluent (μCi/mL)* |
| *RR* | = | *The liquid effluent release rate (gpm)* |
| *βcf* | = | *Beta correction factor to account for pure beta emitters such as H-3 which are not detected by the monitors* |

*Note: The EMEC includes pure beta emitting radionuclides that may are not be detected by the monitors (i.e., non-gamma emitters). See Appendix A for a discussion of this factor.*

If the nuclide specific sensitivity is unavailable, the default sensitivity based upon system calibration should be used. The default sensitivity is based upon the monitor response to the 2000 – 2010 average liquid isotopic distribution, as presented in Appendix A.

$$Default\ Sensitivity = \frac{Monitor\ Response}{\sum (\mu Ci/cc_i)} \qquad [9\text{-}6]$$

*Where:*

| | | |
|---|---|---|
| *Monitor Response* | = | *the counts per minute registered by the monitor exposed to a calibration source* |
| $\Sigma(\mu Ci/cc_i)$ | = | *total concentration of radionuclides in the 2000 - 2010 average liquid effluent isotopic distribution.* |

In the event that an alarm setpoint, based upon the concentration limits of Section 6.1.1, is exceeded during any release of liquid effluents, an evaluation of compliance with the concentration limits may be performed using the following equation:

$$\sum \left[ \frac{C_i}{10\ MEC_i} \times \frac{RR}{CW} \right] \leq 1 \qquad [9\text{-}7]$$

*Where:*

| | | |
|---|---|---|
| $C_i$ | = | *the concentration of radionuclide "i" in the liquid effluent (μCi/mL),* |
| *RR* | = | *the liquid effluent release rate (gpm)* |

*CW* = *the circulating water flow rate (dilution water flow) at the time of the release (gpm),*

Default Monitor Setpoints

A default alarm setpoint for each liquid monitor is based upon the 2000 – 2010 average radionuclide concentration in the effluent discharged to the UNRESTRICTED AREA. The concentration in the release is calculated assuming a minimum circulating water flow rate of 243,000 gpm and the physical maximum flow rate of the individual liquid effluent waste stream. Maximum waste discharge flow rates, the monitors associated with each liquid effluent pathway and the maximum TS default setpoints are listed in Table 9-1. The isotopic distribution of the waste system is obtained from the historical PBNP release data for the eleven years mentioned above. This information can be found in Appendix A.

As indicated in Table 9-1, several liquid RMS monitors fail high before reaching the TS high alarm setpoint. For these monitors, as described above, the ≤ 70% of the fail high value will be applied to the monitor in lieu of the calculated default setpoint.

Additionally, RE-230, Waste Water Effluent Monitor, is impacted by a PBNP EP requirement for EAL declaration, therefore the application of the ≤70% of the fail high value is not an acceptable option. To fulfill the EAL requirement, RE-230 must be capable of reading 2x the ODCM setpoint on the liquid radiation monitor. As a result, the alarm setpoint as described in this section cannot be implemented for RE-230, Waste Water Effluent Monitor.

Therefore, instead of utilizing the TS limit of 10x the 10 CFR 20, Appendix B, Table 2, Column 2, concentrations, the ODCM (Revision 18) RE-230 setpoint of 1.03E-03 µCi/cc value will be used as the basis for the new setpoint. This setpoint is based on 1x the current 10 CFR 20, Appendix B, Table 2, Column 2, concentrations **AND** the old circulating water minimum flow rate of 206 Kgal/min. The ODCM (Revision 18) setpoint will be modified by the ratio of the current minimum circulating water flow rate of 243 Kgal/min to the old minimum circulating water flow rate. The flow augmentation factor is 1.18E+00 (243/206 = 1.18E+00). The application of this flow factor results in an RE-230 setpoint of 1.22E-03 µCi/cc.

TABLE 9-1
LIQUID EFFLUENT PATHWAYS

| LIQUID EFFLUENT PATHWAY | PATHWAY MONITOR[3] | | DISCHARGE FLOWRATE (GPM) | CALCULATED DEFAULT SETPOINT[1] (µCi/cc) |
|---|---|---|---|---|
| Recirculation Water | None | 1 pump, either unit | 243,000 | N/A |
| | | 2 pumps, either unit | 394,000 | N/A |
| | | 1 pump, each unit | 484,000 | N/A |
| | | 1 pump, one unit & 2 pumps, other unit | 619,000 | N/A |
| | | 2 pumps, each unit | 744,000 | N/A |
| Service Water Return (normal cool down per pump) | 1(2)RE-229 | 2 pumps @ 7500 gpm | 15,000 | |
| | | 3 pumps @ 6300 gpm | 18,900 | |
| | | 4 pumps @ 5100 gpm | 20,400 | |
| | | 5 pumps @ 4300 gpm | 21,500 | |
| | | 6 pumps @ 3700 gpm | 22,200 | 1.14E-03 |
| Steam Generator Blowdown | 1(2)RE-219* & 1 (2)RE-222 | Max Flow Rate | 200 | 1.26E-01 |
| Waste Water Effluent[2] | RE-230 | Max Flow Rate (both filter skids running in parallel) | 700 | 1.22E-03 |
| Spent Fuel Pool | RE-220* | Max Flow Rate | 700 | 3.61E-02 |
| Waste Distillate & Condensate Storage Tank Discharge | RE-218* & RE-223* | Max Flow Rate | 100 | 2.53E-01 |
| Containment Fan Cooler Return | 1(2)RE-216* | Max Flow Rate (per Containment) | 4000 | 6.32E-03 |

**NOTE 1: Setpoints except for RE-230 are based on 10x the MEC values listed in 10CFR20, Appendix B, Table 2, Column 2. PBNP TS Section 5.5.4.b allows concentrations of radioactive material released to unrestricted areas to be 10x the MEC values.**

**NOTE 2: RE-230 setpoint explanation can be found in Section 9.1, Default Monitor Setpoints.**

**NOTE 3: Monitors marked with an asterisk (*) have a calculated default alarm setpoint above the monitors fail high or saturation level. See Section 9.1, High Alarm or Trip Setpoint Guidelines for further explanation.**

## 9.2 Liquid Dose Calculations

Section 6.2.1 establishes dose or dose commitment limits to members of the public from radioactive materials in liquid effluents.

The following equation may be used to determine the dose or dose commitment to members of the public due to these releases:

$$\bar{A}_{h\bar{A}\ \bar{A}\bar{A}\bar{A}\bar{A}} = \sum_{\bar{A}} \bar{A}_{\bar{A}h\bar{A}\ \bar{A}\bar{A}\bar{A}\bar{A}}$$

And [9-8]

$$\bar{A}_{\bar{A}\bar{A}\bar{A}\ \bar{A}\bar{A}} = \sum_{h} \bar{A}_{h\bar{A}\ \bar{A}\bar{A}\bar{A}\bar{A}}$$

*Where:*

$D_{hmarAP}$ = *Receptor Location(h) Release Mode(m) Age Group(a) Receptor(r) Calendar Period or Permit Dose due to ALL enabled Pathways, ALL Nuclides and ALL applicable Discharge Points (mrem)*

$D_{marAP}$ = *Max Release Mode(m) Age Group(a) Receptor(r) Calendar Period or Permit Dose due to ALL Nuclides, ALL enabled Pathways, ALL applicable Discharge Points, and ALL applicable Receptor Locations (mrem)*

$D_{zhmarAP}$ = *Discharge Point(z) Receptor Location(h) Release Mode(m) Age Group(a) Receptor(r) Nuclide(i) Calendar Period or Permit Dose due to ALL enabled pathways (mrem)*

The PBNP site-specific liquid dose commitment is derived using guidance from Regulatory Guide 1.109 and NUREG-0133. NUREG-0133 states that the maximum exposed individual's cumulative dose contribution should consider consumption of fish, invertebrates (not applicable to Point Beach), shoreline exposure (not applicable to Point Beach), and potable water as appropriate. The NUREG goes on to state that the adult is normally the maximum exposed individual although all age groups are calculated. The formulas and input parameters are described in detail in Appendix B. A summary of the liquid effluent sub-pathways applicable to Point Beach is described below in Table 9-2.

TABLE 9-2
LIQUID EFFLUENT SUB-PATHWAYS

| LIQUID EFFLUENT SUB-PATHWAY | APPLICABLE | JUSTIFICATION | LOCATION |
|---|---|---|---|
| Aquatic Foods (fish) | Yes | Fish assumed to be caught at PBNP discharge | PBNP discharge |
| Aquatic Foods (invertebrates) | No | No invertebrates are consumed from Lake Michigan | N/A |
| Irrigated Foods (meat from watered cattle) | No | In the area of PBNP, only well water is used to irrigate crops or water animals. Lake Michigan water is not used. | N/A |
| Irrigated Foods (milk from watered cattle) | No | In the area of PBNP, only well water is used to irrigate crops or water animals. Lake Michigan water is not used. | N/A |
| Potable Water | Yes | Assumed drinking water obtained from Two Rivers facility, 11 miles south of PBNP. | Two Rivers |
| Shoreline Deposits | No | Although shoreline deposits could be considered, NUREG-0133 provides guidance that the dose consequence of this pathway is generally negligible. | N/A |

## 9.3 Dose Projections

As required by TS 5.5.4.e and TS 5.5.4.f dose projections shall be made at least once every 31 days. As described in Section 6.3.1, when the projected doses in a period of 31 days would exceed 2% of the guidelines for the annual dose or dose commitment, appropriate portions of the liquid effluent treatment system should be used to reduce releases of radioactivity to within the allowable limits. The following equations should be used to perform dose projections:

$$Ā_{ĀĀĀ} = \sum ĀĀĀĀĀĀĀĀĀ\ ĀĀĀĀĀĀĀĀ\hbar Ā\ ĀĀĀĀ31\ ĀĀĀĀ \qquad [9\text{-}9]$$

$$Ā_{ĀĀĀ\ Ā} = \sum Ā\ ĀĀ\ ĀĀĀĀĀ\ ĀĀĀĀĀĀĀĀ\hbar Ā\ ĀĀĀĀ31\ ĀĀĀĀ \qquad [9\text{-}10]$$

*Where:*

$D_{tbp}$ = *total body dose projection (mrem)*

$D_{tb}$ = *total body dose as determined by Equation 9-8 (mrem)*

$D_{maxp}$ = *maximum organ dose projection (mrem)*

$D_{max}$ = *maximum organ dose as determined by Equation 9-8 (mrem)*

# 10.0 GASEOUS EFFLUENT CALCULATIONS

## 10.1 Monitor Alarm Setpoint Determination

The computerized PBNP radiation monitoring system permits each effluent radiation monitor to be programmed to alarm at two distinct setpoints. The alert setpoint, typically twice the steady state reading, is intended to delineate a changing plant condition, and is established for evaluation purposes only. The high alarm or trip setpoint either will actuate a control function as applicable or will require corrective action to be initiated.

### Alert Setpoint Guidelines

The alert setpoint of each effluent monitor will normally be set to alarm at two times the established steady-state reading. The alert setpoint is normally set at concentrations well below the alarm setpoint value and is never to be set in excess of the alarm setpoint. Certain situations during the course of plant operations may require a deviation from the two times steady-state value. The intent of this setpoint is to warn of changing plant conditions, which may warrant an evaluation to determine the cause of the increased reading. If the increased level is actually due to an increased radiation inventory with the system being monitored, as opposed to an increased background radiation field in the vicinity of the detector, an evaluation should be made to determine the impact of the release. The alert setpoint may be adjusted with prior approval. Alert setpoint adjustments are to be made in accordance with the PBNP RMS Alarm Setpoint and Response Book (Ref. OM 4.1.7). The appropriate detailed response to an effluent alarm also is described in the PBNP RMS Alarm Setpoint and Response Book.

### High Alarm or Trip Setpoint Guidelines

In accordance with PBNP TS 5.5.4.a, alarm setpoints shall be established for the gaseous effluent monitoring instrumentation to ensure that the release rate of noble gases does not exceed the instantaneous dose rate limits of Section 7.1.1. These limits correspond to a dose rate at or beyond the SITE BOUNDARY of 500 mrem/yr to the total body or 3000 mrem/yr to the skin.

Certain airborne effluent monitors cannot reach the calculated setpoint because they fail high at a lower value. These monitors are indicated by an asterisk (*) in Table 10-1. It is plant operational practice to set these monitors at ≤ 70% of the fail high value (MSSM No. 93-01). The following mid-range SPING monitors can read the calculated default setpoints: SPING 21, 1RE-307; SPING22, 2RE-307; SPING 23, RE-317; and SPING 24, RE-327.

The radiation monitoring alarm setpoints are established using the following equations:

$$SP_{TB} \leq \frac{\sum C_i * 500}{472 * \chi/Q_{NG} * VF * \sum(C_i * K_i)} * AF$$

$$SP_S \leq \frac{\sum C_i * 3000}{472 * \chi/Q_{NG} * VF * \sum[C_i * (L_i + 1.1 M_i)]} * AF \qquad [10\text{-}1]$$

*Where:*

| | | |
|---|---|---|
| $SP_{TB}$ | = | *monitor setpoint corresponding to the release rate limit for the total body dose rate of 500 mrem/yr (μCi/cc)* |
| $SP_S$ | = | *monitor setpoint corresponding to the release rate limit for the skin dose rate of 3000 mrem/yr (μCi/cc)* |
| 500 | = | *total body dose rate limit (mrem/yr)* |
| 3000 | = | *skin dose rate limit (mrem/yr)* |
| $\chi/Q_{NG}$ | = | *atmospheric dispersion for direct exposure to noble gas at or beyond the SITE BOUNDARY (sec/m$^3$see Table 10-2)* |
| VF | = | *ventilation flow rate for the applicable release point and monitor (ft$^3$/min)* |
| $C_i$ | = | *concentration of noble gas radionuclide "i" as determined by radioanalysis of grab sample (μCi/cc)* |
| $K_i$ | = | *total body dose conversion factor for noble gas radionuclide "i" (mrem/yr per μCi/m$^3$, see Table 10-3)* |
| $L_i$ | = | *beta skin dose conversion factor for noble gas radionuclide "i" (mrem/yr per μCi/m$^3$, see Table 10-3)* |
| $M_i$ | = | *gamma air dose conversion factor for noble gas radionuclide "i" (mrad/yr per μCi/m$^3$, see Table 10-3)* |
| 1.1 | = | *mrem skin dose per mrad gamma air dose (mrem/mrad),* |
| 472 | = | *28317 (cc/ft$^3$) x 1/60 (min/sec)* |
| AF | = | *additional reduction factor of 0.25 applied to the four release point monitors(RE-214,-221, -224, and -225) to ensure that the maximum allowable SITE BOUNDARY dose rates will not be exceeded in the event simultaneous release from these points occur* |

The lesser value of $SP_{TB}$ and $SP_S$ is used to establish the monitor setpoint.

Default Monitor Setpoints

Default setpoints are established to eliminate the potential of periodically having to adjust the setpoint to reflect slight variations in the radionuclide distribution and variations in release flow rates. Using activities obtained from the 2000-2010 average annual atmospheric releases (see Appendix C for a detailed discussion), the highest annual $\chi/Q$, and the maximum ventilation flow rates for each pathway, default setpoints can be determined using Equations 10-1 and 10-2.
Gaseous effluent pathway discharge flow rates, the monitors associated with each pathway and default setpoints are listed in Table 10-1. If the default setpoints listed in Table 10-1 exceed the monitors' saturation or fail high levels, the MSS has approved (MSSM No. 93-01) the use of a setpoint which is set at ≤ 70% of that monitor's fail high level. The current alarm levels are recorded in the RMS Alarm Setpoint and Response Book.

Adjustments may be made to the alarm setpoints for release periods if actual flow rates are reduced to less than the maximum values or the actual $\chi/Q$ values are calculated. This is not typical under conditions with elevated levels in containment or the waste gas decay tank. Alarm setpoint adjustments which result in values higher than the default values are to be made in accordance with the provisions and methodologies of the PBNP RMS Alarm Setpoint and Response Book.

To maintain the inequality of Equations 10-1 and 10-2 during the release, the release rate (or release of gaseous effluents) may be adjusted. If at any time the monitor response is greater than that anticipated for the gaseous release (i.e., above the alert alarm setpoint), the activity should be re-evaluated. This re-evaluation will may include resampling of the applicable waste stream.

With the setpoints being calculated based on TS release limits, some monitors fail high below the calculated default alarm setpoint. This value is the TS limit that will be reached at the sector of the site boundary with the highest X/Q and D/Q values. For the current airborne monitors, one of the associated SPING monitors has the range required to encompass the default alarm setpoint.

TABLE 10-1
GASEOUS EFFLUENT PATHWAYS

| GASEOUS EFFLUENT PATHWAY | MONITORS | DISCHARGE FLOW RATE (cfm) | CALCULATED DEFAULT SETPOINT (μCi/cc) |
|---|---|---|---|
| 1. Auxiliary Building Vent | RE-214* & SPING 23 | 66,400 (1500[1]) | 6.75E-04 |
| 2. Combined Air Ejector | RE-225* | 20 | 2.24E+00 |
| 3. Unit Air Ejector | 1(2) RE-215* | 10 | 1.79E+01 |
| 4. Containment Purge/Vent | | | |
| Unit 1 | 1RE-212* & SPING 21 | 25,000[2] | 7.17E-03 |
| Unit 2 | 2RE-212* & SPING 22 | 38,000[3] | 4.72E-03 |
| Unit 1(2) | 1(2) RE-212* | 35[4] | 5.12E+00 |
| 5. Gas Stripper Building | RE-224* | 13,000 (250[1]) | 3.45E-03 |
| 6. Drumming Area Vent | RE-221* & SPING 24 | 43,100 (500[1]) | 1.04E-03 |

**NOTE 1:** **From RAM 5.1, Radioactive Airborne Effluent Releases, Table 2, convective flow with fans off**

**NOTE 2:** **Two fans of 12,500 cfm**

**NOTE 3:** **Two fans + 13,000 cfm from gas stripper bldg.**

**NOTE 4:** **Forced vent with nominal 35 cfm flow rate**

**NOTE 5:** **Monitors marked with an asterisk (*) have a calculated default alarm setpoint above the monitors fail high or saturation level. See Section 10.1, High Alarm or Trip Setpoint Guidelines for further explanation and designation of SPING monitors that can be set at the calculated default setpoint.**

TABLE 10-2
CONTROLLING LOCATIONS, PATHWAYS AND ATMOSPHERIC DISPERSION FOR DOSE CALCULATIONS

| ODCM SECTION | LOCATION | DISTANCE AND DIRECTION | PATHWAY(S) | $\chi/Q$[1] (sec/m$^3$) | D/Q (m$^{-2}$) |
|---|---|---|---|---|---|
| 7.1.1.a | Site boundary | SSE, 1220 meters[2] | Noble gases<br>Direct exposure | 1.09E-06 | N/A |
| 7.1.1.b | Site boundary | SSE, 1220 meters | Inhalation | 1.09E-06 | N/A |
| 7.2.1 | Site boundary | SSE, 1220 meters | Gamma-air<br>Beta-air | 1.09E-06 | N/A |
| 7.3.1 | Residence/dairy | SSW, 1290 meters[3] | Inhalation, milk, meat, produce, leafy vegetables and ground plane. | 7.15E-07 | 5.90E-9 |

**NOTE 1:** **Atmospheric dispersion and deposition data taken from *Point Beach Annual Meteorological and Atmospheric Dispersion Report for 2009*, Report No. R-2330244-001, December 2010.**

**NOTE 2:** **Location corresponds to site boundary distance and sector with the greatest $\chi$/Q and D/Q values.**

**NOTE 3:** **The nearest residence/dairy is in the SSW sector. The distance is conservatively assumed to be at the site boundary.**

## 10.2 Carbon-14

Carbon-14 is a constituent of a nuclear power plants atmospheric effluent that requires specific attention and evaluation. $^{14}C$ is a pure, low-energy beta emitter (0.156 MeV) that historically has not been a focus of ODCM and nuclear power plant radiological effluent evaluations. The low beta energy means that $^{14}C$ is not detected by installed effluent monitors, and can only be quantified with sensitive, in-laboratory equipment. Historically, $^{14}C$ has not been identified as a significant contributor to the effluent source term, on either an activity or dose basis. However, the continued reduction in total effluent releases has increased the relative importance of $^{14}C$, with respect to both the activity released and dose consequence. The PBNP methodology for estimating the activity of $^{14}C$ released and the dose consequence of the release is described in the sections below.

### 10.2.1 Carbon-14 Effluent Activity

The annual release rate of $^{14}C$ in gaseous effluents is calculated in accordance with the methodology described in EPRI Technical Report 1021106 "Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents" (EPRI, 2010). $^{14}C$ is primarily generated in a nuclear power plant by one of 2 reactions:

$^{17}O(n,\alpha)^{14}C$ or

$^{14}N(n,p)^{14}C$

The $^{14}C$ production rate is determined by the following equation:

$$Prod.\ Rate = \frac{N \times (\sigma_{th} \times \varphi_{th} + \sigma_{i+f} \times \varphi_{i+f}) \times 1.0E-24 \times \lambda}{3.7E-04} \quad [10\text{-}2]$$

*Where:*

| | | |
|---|---|---|
| *Prod. Rate* | = | *Production rate of C-14 production (μCi/s-kgfrom $^{17}O$ and μCi/s-kg-ppm N from $^{14}N$)* |
| *N* | = | *Atoms*<br>*$^{17}O$ = 1.27E+22 atoms $^{17}O$/kg $H_2O$*<br>*$^{14}N$ = 4.284E+19 atoms $^{14}N$/kg-ppm N* |
| $\sigma_{th}$ | = | *"effective" thermal cross-section (b)*<br>*$^{17}O$ = 0.121*<br>*$^{14}N$ = 0.951 (from EPRI TR-1021106)* |
| $\varphi_{th}$ | = | *Thermal neutron flux (n/cm$^2$-s)*<br>*=3.55E13 n/cm$^2$-s at BOC (from EPRI TR-1021106)* |
| $\sigma_{i+f}$ | = | *"effective" intermediate + fast cross-section (b)*<br>*$^{17}O$ = 0.0479*<br>*$^{14}N$ = 0.0392 (from EPRI TR-1021106)* |
| $\varphi_{i+f}$ | = | *Intermediate + fast neutron flux (n/cm$^2$-s)*<br>*=3.51E17 n/cm$^2$-s at BOC (from EPRI TR-1021106)* |
| *1.0E-24* | = | *(cm$^2$/b)* |
| $\lambda$ | = | *$^{14}C$ decay constant, 3.833E-12 s$^{-1}$* |
| *3.7E-04* | = | *d/s-μCi* |

Using the above formula and example PWR data values (for neutron flux, water mass in the active core and nitrogen content) from the EPRI report, the calculated $^{14}C$ generation rate is 0.349 µCi/s from the $^{17}O$ reaction and 2.96E-3 µCi/s from the $^{14}N$ reaction. This results in a total $^{14}C$ production rate of 11.1 Ci/year. According to the EPRI report, the atmospheric release rate is approximately 90-98% of the production rate. The remainder is effectively released via solid waste. For PWRs virtually all of the released C-14 is in the non-$CO_2$ form, a form which does not contributes to ingestion dose. Based on measurements at Ginna (a Westinghouse plant the same vintage as PBNP), approximately 10% is release as $CO_2$ (Kunz, "Measurement of $^{14}C$ Production and Discharge From the Ginna Nuclear Power Plant, June 1982, p. 20)

The neutron flux values listed in the formulae above are based on an assumed 3548 $MW_{th}$ Westinghouse PWR operating continuously at full power. Annual $^{14}C$ production and release values can be determined based on actual reactor operating performance at PBNP. As needed, the neutron flux data are obtained from ENG-Fuel/JB each year to estimate the year's $^{14}C$ production. An evaluation of plant conditions and operating data will be considered to determine if adjustments are needed to the assumed production rate of $^{14}C$.

10.2.2 Carbon-14 Vegetation Concentration

The concentration of $^{14}C$ incorporated in vegetation from $^{14}CO$ or $^{14}CO_2$ is calculated as described in Regulatory Guide 1.109 (Rev 1) Appendix C, equation C-8:

$$C^{V}_{C-14}(r,\theta) = 3.17E+07 \times p \times Q_{C-14}\left[\chi/Q\right](r,\theta)\frac{0.11}{0.16} \qquad [10\text{-}3]$$

*Where:*

$C^{V}_{C-14}(r,\theta)$ = *the concentration of carbon-14 in vegetation grown at location $(r,\Theta)$ in pCi/kg*

3.17E+07 = *conversion factor equivalent to (1E+12 pCi/Ci)($1x10^3$ g/kg)/(3.15E+07 sec/year)*

$p$ = *Fractional equilibrium ratio = 1 for continuous releases (from RG 1.109, page 26)*

0.11/0.16 = *total plant mass as natural carbon (0.11) divided the concentration of natural carbon in the atmosphere (0.16 $g/m^3$)*

$Q_{C-14}$ = *the annual release rate of $^{14}C$ (Ci/year)*

$\chi/Q\ (r,\theta)$ = *the annual average atmospheric dispersion factor, in $sec/m^3$ for the point of interest defined by $(r,\Theta)$.*

The concentration calculated above is then used to determine the concentration in meat and milk, no different from other radionuclides. The resultant dose is calculated in the same fashion as listed in the applicable sections below.

## 10.3 Dose Rate Calculations – Noble Gases

PBNP TS 5.5.4.g limits the instantaneous dose rate at the SITE BOUNDARY due to noble gas releases to:

- ≤ 500 mrem/yr to the total body
- ≤ 3000 mrem/yr to the skin

Radiation monitor alarm setpoints are established to ensure that these release limits are not exceeded. If the alarm setpoint is exceeded by any gaseous release from the station, and evaluation of the SITE BOUNDARY dose rate resulting from the release shall be performed using the following equations:

$$\vec{Ā}_{ĀĀ} = Ā/Ā * \sum_{Ā} (Ā_{Ā} * \vec{Ā}_{Ā}) \quad [10\text{-}4]$$

$$\vec{Ā}_{Ā} = Ā/Ā * \sum_{Ā} \left[ (Ā_{Ā} + 1.1 Ā_{Ā}) * \vec{Ā}_{Ā} \right] \quad [10\text{-}5]$$

*Where:*

| | | |
|---|---|---|
| $\dot{D}_{tb}$ | = | *the total body dose rate (mrem/yr),* |
| $\vec{Ā}_{Ā}$ | = | *the skin dose rate (mrem/yr),* |
| $\chi/Q$ | = | *the atmospheric dispersion to the controlling SITE BOUNDARY location (sec/m$^3$, see Table 10-2)* |
| $\vec{Ā}_{Ā}$ | = | *the average release rate of radionuclide "i" over the release period under evaluation, not to exceed one hour (µCi/sec)* |
| $K_i$ | = | *total body dose conversion factor for noble gas radionuclide "i" (mrem/yr per µCi/m$^3$ see Table 10-3)* |
| $L_i$ | = | *beta skin dose conversion factor for noble gas radionuclide "i" (mrem/yr per µCi/m$^3$ see Table 10-3)* |
| $M_i$ | = | *gamma air dose conversion factor for noble gas radionuclide "i" (mrad/yr per µCi/m$^3$ see Table 10-3)* |
| *1.1* | = | *mrem skin dose per mrad gamma air dose (mrem/mrad)* |

TABLE 10-3
DOSE FACTORS FOR NOBLE GASES

| **RADIONUCLIDE** | **TOTAL BODY DOSE FACTOR $K_i$ (mrem/yr per μCi/m$^3$)** | **SKIN DOSE FACTOR $L_i$ (mrem/yr per μCi/m$^3$)** | **GAMMA AIR DOSE FACTOR $M_i$ (mrad/yr per μCi/m$^3$)** | **BETA AIR DOSE FACTOR $N_i$ (mrad/yr per μCi/m$^3$)** |
|---|---|---|---|---|
| Kr-83m | 7.56E-02 | --- | 1.93 E+01 | 2.88 E+02 |
| Kr-85m | 1.17 E+03 | 1.46 E+03 | 1.23 E+03 | 1.97 E+03 |
| Kr-85 | 1.61 E+01 | 1.34 E+03 | 1.72 E+01 | 1.95 E+03 |
| Kr-87 | 5.92 E+03 | 9.73 E+03 | 6.17 E+03 | 1.03 E+04 |
| Kr-88 | 1.47 E+04 | 2.37 E+03 | 1.52 E+04 | 2.93 E+03 |
| Kr-89 | 1.66 E+04 | 1.01 E+04 | 1.73 E+04 | 1.06 E+04 |
| Kr-90 | 1.56 E+04 | 7.29 E+03 | 1.63 E+04 | 7.83 E+03 |
| Xe-131m | 9.15 E+01 | 4.76 E+02 | 1.56 E+02 | 1.11 E+03 |
| Xe-133m | 2.51 E+02 | 9.94 E+02 | 3.27 E+02 | 1.48 E+03 |
| Xe-133 | 2.94 E+02 | 3.06 E+02 | 3.53 E+02 | 1.05 E+03 |
| Xe-135m | 3.12 E+03 | 7.11 E+02 | 3.36 E+03 | 7.39 E+02 |
| Xe-135 | 1.81 E+03 | 1.86 E+03 | 1.92 E+03 | 2.46 E+03 |
| Xe-137 | 1.42 E+03 | 1.22 E+04 | 1.51 E+03 | 1.27 E+04 |
| Xe-138 | 8.83 E+03 | 4.13 E+03 | 9.21 E+03 | 4.75 E+03 |
| Ar-41 | 8.84 E+03 | 2.69 E+03 | 9.30 E+03 | 3.28 E+03 |

Source: Reg. Guide 1.109, Table B-1

## 10.4 Dose Rate Calculations – Radioiodine, Tritium, Particulates

PBNP TS 5.5.4.g limits the instantaneous dose rate to 1500 mrem/yr to any organ for I-131, I-133, tritium, and particulates with half-lives greater than eight days. To demonstrate compliance with this limit, an evaluation may be performed at a frequency no greater than that corresponding to the sampling and analysis time period for CONTINUOUS RELEASES and for BATCH RELEASES on the time period over which any BATCH RELEASE is to occur when conditions depart from bounding conditions of the previous year. The following equation shall be used for the dose rate evaluation:

***Highest of:***

$$DR_{pORGAN} = \sum_{i} RR_{wip} * MAX_{r}(DF_{irCINH}) * DISP_{zhNG} * BR_{c} * 10^{6}$$

**OR** [10-6]

$$DR_{pORGAN} = MAX_{r}\left(\sum_{i} RR_{wip} * DF_{irCINH} * DISP_{zhNG} * BR_{c} * 10^{6}\right)$$

*Where:*

| | | |
|---|---|---|
| $DR_{pORGAN}$ | = | *the average organ dose rate over the sampling time period (mrem/yr)* |
| $RR_{wip}$ | = | *Release Permit(p) Nuclide(i) Release Rate due to Waste (uCi/sec)* |
| $DF_{irCINH}$ | = | *Nuclide(i) Receptor(r) Child Inhalation Dose Factor* |
| $DISP_{zhNG}$ | = | *the atmospheric dispersion to the controlling SITE BOUNDARY location (sec/$m^3$, see Table 10-2)* |
| $BR_{c}$ | = | *Child Breathing Rate* |
| $10^{6}$ | = | *Conversion Factor* |
| $MAX_{r}$ | = | *Maximum Receptor(r) Dose Factor or Calculated Dose Rate for the applicable formula. All receptors specified for the Particulate, Iodine and Tritium Organ Dose Rate evaluation are evaluated to determine the maximum.* |

## 10.5 Dose Calculations – Noble Gases

PBNP TS 5.5.4.h requires that dose contributions due to the release of noble gases should be determined at least once every 31 days in order to evaluate compliance with the quarterly dose limits of < 5 mrad, gamma-air and < 10 mrad, beta-air and annual dose limits of < 10 mrad, gamma-air and < 20 mrad, beta-air. The following equations shall be used to calculate the gamma-air and beta-air doses:

$$\text{Ā}_{\text{Ā}} = 3.17\text{Ā} - 08 * \text{Ā}/\text{Ā} * \sum_{\text{Ā}} (\text{Ā}_{\text{Ā}} * \text{Ā}_{\text{Ā}}) \quad [10\text{-}7]$$

$$\text{Ā}_{\text{Ā}} = 3.17\text{Ā} - 08 * \text{Ā}/\text{Ā} * \sum_{\text{Ā}} (\text{Ā}_{\text{Ā}} * \text{Ā}_{\text{Ā}}) \quad [10\text{-}8]$$

*Where:*

| | | |
|---|---|---|
| $D_\gamma$ | = | *air dose due to gamma emissions for noble gas radionuclides (mrad),* |
| $D_\beta$ | = | *air dose due to beta emissions for noble gas radionuclides (mrad),* |
| $\chi/Q$ ($DISP_{zhNG}$) | = | *atmospheric dispersion to the controlling SITE BOUNDARY location (sec/$m^3$ , see Table 10-2)* |
| $Q_i$ | = | *cumulative release of noble gas radionuclide "i" over the period of interest (µCi)* |
| $M_i$ | = | *air dose factor due to gamma emissions form noble gas radionuclide "i" (mrad/yr per µCi /$m^3$, see Table 10-3)* |
| $N_i$ | = | *air dose factor due to beta emissions form noble gas radionuclide "i" (mrad/yr per µCi /$m^3$, see Table 10-3)* |
| *3.17E-08* | = | *yr/sec* |

## 10.6 Dose Calculations – Radioiodine, Tritium, Particulates

PBNP TS 5.5.4.i requires that dose contributions due to the release of I-131, I-133, tritium, and/or particulates with half-lives greater than eight days should be determined at least once every 31 days in order to evaluate compliance with the quarterly dose limit of < 7.5 mrem and annual dose limit of < 15 mrem to any organ, per unit. For the two unit PBNP site, the limit is 15 mrem per quarter and 30 mrem per year. The following equation shall be used to evaluate the maximum organ dose:

$$\text{ĀĀĀ}_{h\text{ĀĀ}} = \text{Ā}_{h\text{ĀĀĀĀ}} + \text{Ā}_{h\text{ĀĀĀĀ}} + \sum_{\text{Ā}} \text{Ā}_{h\text{ĀĀĀ}} + \sum_{\text{Ā}} \text{Ā}_{h\text{ĀĀĀ}} + \text{Ā}_{h\text{ĀĀĀĀĀ}}$$

**AND** [10-9]

$$\text{ĀĀĀ}_{\text{Ā ĀĀ}} = \text{Ā ĀĀ}_{h\text{Ā}}(\text{ĀĀĀ}_{h\text{Ā}})$$

*Where:*

| | | |
|---|---|---|
| $DAP_{hra}$ | = | *dose for age group to organ, via pathway (mrem),* |
| $DAP_{MAX}$ | = | *Maximum Dose for any Receptor Location(h) Age Group(a) due to ALL pathways. (mrem)* |
| $D_{hraINH}$ | = | *Organ Dose due to Inhalation* |
| $D_{hraGP}$ | = | *Organ Dose due to Ground Plane Exposure* |
| $D_{hraA}$ | = | *Organ Dose due to Consumption of Animal Media A. A may be cow/goat/sheep milk/meat* |
| $D_{hraV}$ | = | *Organ Dose due to Consumption of Vegetation Media V. V may be stored/fresh vegetation* |
| $D_{hraCLD}$ | = | *Organ Dose due to Noble Cloud Dose* |

In general, the infant or child is expected to be the controlling age group for gaseous exposures.

## 10.7 Gaseous Dose Projection

As required by TS 5.5.4.e and TS 5.5.4.f dose projections shall be made at least once every 31 days. As described in Section 7.4.1, when the projected doses in a period of 31 days would exceed 2% of the guidelines for the annual dose or dose commitment, appropriate portions of the gaseous effluent treatment system should be used to reduce releases of radioactivity to within the allowable limits. The following equations should be used to perform dose projections:

$$\text{Ā}_{\text{ĀĀ}} = \sum \text{ĀĀĀĀ Ā} - \text{ĀĀĀĀĀĀĀĀĀĀĀ}h\text{Ā ĀĀĀĀ}31 \text{ ĀĀĀĀ} \quad [10\text{-}10]$$

$$\text{Ā}_{\text{ĀĀ}} = \sum \text{ĀĀĀ} - \text{ĀĀĀĀĀĀĀĀĀĀĀ}h\text{Ā ĀĀĀĀ}31 \text{ ĀĀĀĀ} \quad [10\text{-}11]$$

$$\text{Ā}_{\text{ĀĀĀ Ā}} = \sum \text{Ā ĀĀ ĀĀĀĀĀ ĀĀĀĀĀĀĀĀ}h\text{Ā ĀĀĀĀ}31 \text{ ĀĀĀĀ} \quad [10\text{-}12]$$

*Where:*

| | | |
|---|---|---|
| $D_{\gamma p}$ | = | *projected 31-day gamma-air dose (mrad)* |
| $D_{\beta p}$ | = | *projected 31-day beta-air dose (mrad)* |
| $D_{maxp}$ | = | *maximum organ dose projection (mrem)* |

TABLE 10-4
INHALATION PATHWAY DOSE FACTORS - ADULT
**(mrem/pCi/inhaled)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Ag-110m | 1.35E-06 | 1.25E-06 | 7.43E-07 | | 2.46E-06 | 5.79E-04 | 3.78E-05 |
| Am-241 | 1.01E+00 | 4.59E-01 | 6.71E-02 | | 5.04E-01 | 6.06E-02 | 4.60E-05 |
| As-76 | 1.22E-07 | 3.26E-07 | 2.74E-06 | 1.19E-07 | 3.63E-07 | 1.26E-05 | 1.07E-05 |
| Ba-139 | 1.17E-10 | 8.32E-14 | 3.42E-12 | | 7.78E-14 | 4.70E-07 | 1.12E-07 |
| Ba-140 | 4.88E-06 | 6.13E-09 | 3.21E-07 | | 2.09E-09 | 1.59E-04 | 2.73E-05 |
| Ba-141 | 1.25E-11 | 9.41E-15 | 4.20E-13 | | 8.75E-15 | 2.42E-07 | 1.45E-17 |
| Ba-142 | 3.29E-12 | 3.38E-15 | 2.07E-13 | | 2.86E-15 | 1.49E-07 | 1.96E-26 |
| Br-82 | | | 1.69E-06 | | | | 1.30E-06 |
| Br-83 | | | 3.01E-08 | | | | 2.90E-08 |
| Br-84 | | | 3.91E-08 | | | | 2.05E-13 |
| Br-85 | | | 1.60E-09 | | | | |
| C-14 | 2.27E-06 | 4.26E-07 | 4.26E-07 | | 4.26E-07 | 4.26E-07 | 4.26E-07 |
| Ce-141 | 2.49E-06 | 1.69E-06 | 1.91E-07 | | 7.83E-07 | 4.52E-05 | 1.50E-05 |
| Ce-143 | 2.33E-08 | 1.72E-08 | 1.91E-09 | | 7.60E-09 | 9.97E-06 | 2.83E-05 |
| Ce-144 | 4.29E-04 | 1.79E-04 | 2.30E-05 | | 1.06E-04 | 9.72E-04 | 1.02E-04 |
| Co-57 | | 8.65E-08 | 8.39E-08 | | | 4.62E-05 | 3.93E-06 |
| Co-58 | | 1.98E-07 | 2.59E-07 | | | 1.16E-04 | 1.33E-05 |
| Co-60 | | 1.44E-06 | 1.85E-06 | | | 7.46E-04 | 3.56E-05 |
| Cr-51 | | | 1.25E-08 | 7.44E-09 | 2.85E-09 | 1.80E-06 | 4.15E-07 |
| Cs-134 | 4.66E-05 | 1.06E-04 | 9.10E-05 | | 3.59E-05 | 1.22E-05 | 1.30E-06 |
| Cs-134m | 1.59E-08 | 3.20E-08 | 1.72E-08 | | 1.83E-08 | 2.93E-09 | 7.92E-09 |
| Cs-136 | 4.88E-06 | 1.83E-05 | 1.38E-05 | | 1.07E-05 | 1.50E-06 | 1.46E-06 |
| Cs-137 | 5.98E-05 | 7.76E-05 | 5.35E-05 | | 2.78E-05 | 9.40E-06 | 1.05E-06 |
| Cs-138 | 4.14E-08 | 7.76E-08 | 4.05E-08 | | 6.00E-08 | 6.07E-09 | 2.33E-13 |
| Cu-64 | | 1.83E-10 | 7.69E-11 | | 5.78E-10 | 8.48E-07 | 6.12E-06 |
| Eu-152 | 2.38E-05 | 5.40E-05 | 4.76E-05 | | 3.35E-04 | 3.43E-04 | 1.59E-05 |
| F-18 | 4.71E-07 | | 5.19E-08 | | | | 9.24E-09 |
| Fe-55 | 3.07E-06 | 2.12E-06 | 4.93E-07 | | | 9.01E-06 | 7.54E-07 |
| Fe-59 | 1.47E-06 | 3.47E-06 | 1.32E-06 | | | 1.27E-04 | 2.35E-05 |
| H-3 | | 1.58E-07 | 1.58E-07 | 1.58E-07 | 1.58E-07 | 1.58E-07 | 1.58E-07 |
| I-129 | 2.48E-06 | 2.11E-06 | 6.91E-06 | 5.54E-03 | 4.53E-06 | | 2.22E-07 |
| I-130 | 5.72E-07 | 1.68E-06 | 6.60E-07 | 1.42E-04 | 2.61E-06 | | 9.61E-07 |
| I-131 | 3.15E-06 | 4.47E-06 | 2.56E-06 | 1.49E-03 | 7.66E-06 | | 7.85E-07 |
| I-132 | 1.45E-07 | 4.07E-07 | 1.45E-07 | 1.43E-05 | 6.48E-07 | | 5.08E-08 |
| I-133 | 1.08E-06 | 1.85E-06 | 5.65E-07 | 2.69E-04 | 3.23E-06 | | 1.11E-06 |

TABLE 10-4
INHALATION PATHWAY DOSE FACTORS - ADULT
**(mrem/pCi/inhaled)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| I-134 | 8.05E-08 | 2.16E-07 | 7.69E-08 | 3.73E-06 | 3.44E-07 | | 1.26E-10 |
| I-135 | 3.35E-07 | 8.73E-07 | 3.21E-07 | 5.60E-05 | 1.39E-06 | | 6.56E-07 |
| La-140 | 4.30E-08 | 2.17E-08 | 5.73E-09 | | | 1.70E-05 | 5.73E-05 |
| La-142 | 8.54E-11 | 3.88E-11 | 9.65E-12 | | | 7.91E-07 | 2.64E-07 |
| Mn-54 | | 4.95E-06 | 7.87E-07 | | 1.23E-06 | 1.75E-04 | 9.67E-06 |
| Mn-56 | | 1.55E-10 | 2.29E-11 | | 1.63E-10 | 1.18E-06 | 2.53E-06 |
| Mo-99 | | 1.51E-08 | 2.87E-09 | | 3.64E-08 | 1.14E-05 | 3.10E-05 |
| Na-22 | 1.30E-05 | 1.30E-05 | 1.30E-05 | 1.30E-05 | 1.30E-05 | 1.30E-05 | 1.30E-05 |
| Na-24 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 | 1.28E-06 |
| Nb-95 | 1.76E-06 | 9.77E-07 | 5.26E-07 | | 9.67E-07 | 6.31E-05 | 1.30E-05 |
| Nb-97 | 2.78E-11 | 7.03E-12 | 2.56E-12 | | 8.18E-12 | 3.00E-07 | 3.02E-08 |
| Nd-147 | 6.59E-07 | 7.62E-07 | 4.56E-08 | | 4.45E-07 | 2.76E-05 | 2.16E-05 |
| Ni-63 | 5.40E-05 | 3.93E-06 | 1.81E-06 | | | 2.23E-05 | 1.67E-06 |
| Ni-65 | 1.92E-10 | 2.62E-11 | 1.14E-11 | | | 7.00E-07 | 1.54E-06 |
| Np-239 | 2.87E-08 | 2.82E-09 | 1.55E-09 | | 8.75E-09 | 4.70E-06 | 1.49E-05 |
| P-32 | 1.65E-04 | 9.64E-06 | 6.26E-06 | | | | 1.08E-05 |
| Pm-147 | 8.37E-05 | 7.87E-06 | 3.19E-06 | | 1.49E-05 | 6.60E-05 | 5.54E-06 |
| Pm-149 | 3.44E-08 | 4.87E-09 | 1.99E-09 | | 9.19E-09 | 7.21E-06 | 2.50E-05 |
| Pr-143 | 1.17E-06 | 4.69E-07 | 5.80E-08 | | 2.70E-07 | 3.51E-05 | 2.50E-05 |
| Pr-144 | 3.76E-12 | 1.56E-12 | 1.91E-13 | | 8.81E-13 | 1.27E-07 | 2.69E-18 |
| Rb-86 | | 1.69E-05 | 7.37E-06 | | | | 2.08E-06 |
| Rb-88 | | 4.84E-08 | 2.41E-08 | | | | 4.18E-19 |
| Rb-89 | | 3.20E-08 | 2.12E-08 | | | | 1.16E-21 |
| Rh-105 | 9.88E-11 | | 3.89E-11 | | 1.27E-10 | 1.37E-06 | 6.02E-06 |
| Ru-103 | 1.91E-07 | | 8.23E-08 | | 7.29E-07 | 6.31E-05 | 1.38E-05 |
| Ru-105 | 9.88E-11 | | 3.89E-11 | | 1.27E-10 | 1.37E-06 | 6.02E-06 |
| Ru-106 | 8.64E-06 | | 1.09E-06 | | 1.67E-05 | 1.17E-03 | 1.14E-04 |
| Sb-122 | 2.37E-07 | 1.85E-07 | 3.70E-06 | 8.15E-08 | 9.63E-08 | 2.04E-05 | 1.44E-05 |
| Sb-124 | 3.90E-06 | 7.36E-08 | 1.55E-06 | 9.44E-09 | | 3.10E-04 | 5.08E-05 |
| Sb-125 | 6.67E-06 | 7.44E-08 | 1.58E-06 | 6.75E-09 | | 2.18E-04 | 1.26E-05 |
| Sb-127 | 3.30E-08 | 7.22E-10 | 1.27E-08 | 3.97E-10 | | 2.05E-05 | 3.77E-05 |
| Sc-46 | 5.51E-05 | 1.07E-04 | 3.11E-05 | | 9.99E-05 | | 2.69E-05 |
| Sm-151 | 8.59E-05 | 1.48E-05 | 3.55E-05 | | 1.66E-05 | 4.45E-05 | 3.25E-06 |
| Sm-153 | 1.70E-08 | 1.42E-08 | 1.04E-09 | | 4.59E-09 | 4.14E-06 | 1.58E-05 |
| Sn-113 | 3.37E-06 | 1.26E-06 | 1.00E-05 | 7.04E-07 | 6.67E-07 | 7.04E-05 | 7.78E-06 |

TABLE 10-4
INHALATION PATHWAY DOSE FACTORS - ADULT
**(mrem/pCi/inhaled)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Sn-117m | 3.48E-06 | 1.85E-07 | 8.89E-06 | 8.89E-08 | 8.89E-08 | 7.04E-05 | 6.67E-06 |
| Sr-89 | 3.80E-05 | | 1.09E-06 | | | 1.75E-04 | 4.37E-05 |
| Sr-90 | 1.24E-02 | | 7.62E-04 | | | 1.20E-03 | 9.02E-05 |
| Sr-91 | 7.74E-09 | | 3.13E-10 | | | 4.56E-06 | 2.39E-05 |
| Sr-92 | 8.43E-10 | | 3.64E-11 | | | 2.06E-06 | 5.38E-06 |
| Tc-101 | 5.22E-15 | 7.52E-15 | 7.38E-14 | | 1.35E-13 | 4.99E-08 | 1.36E-21 |
| Tc-99 | 3.13E-08 | 4.64E-08 | 1.25E-08 | | 5.85E-07 | 1.01E-04 | 7.54E-06 |
| Tc-99m | 1.29E-13 | 3.64E-13 | 4.63E-12 | | 5.52E-12 | 9.55E-08 | 5.20E-07 |
| Te-125m | 4.27E-07 | 1.98E-07 | 5.84E-08 | 1.31E-07 | 1.55E-06 | 3.92E-05 | 8.83E-06 |
| Te-127 | 1.75E-10 | 8.03E-11 | 3.87E-11 | 1.32E-10 | 6.37E-10 | 8.14E-07 | 7.17E-06 |
| Te-127m | 1.58E-06 | 7.21E-07 | 1.96E-07 | 4.11E-07 | 5.72E-06 | 1.20E-04 | 1.87E-05 |
| Te-129 | 6.22E-12 | 2.99E-12 | 1.55E-12 | 4.87E-12 | 2.34E-11 | 2.42E-07 | 1.96E-08 |
| Te-129m | 1.22E-06 | 5.84E-07 | 1.98E-07 | 4.30E-07 | 4.57E-06 | 1.45E-04 | 4.79E-05 |
| Te-131 | 1.39E-12 | 7.44E-13 | 4.49E-13 | 1.17E-12 | 5.46E-12 | 1.74E-07 | 2.30E-09 |
| Te-131m | 8.74E-09 | 5.45E-09 | 3.63E-09 | 6.88E-09 | 3.86E-08 | 1.82E-05 | 6.95E-05 |
| Te-132 | 3.25E-08 | 2.69E-08 | 2.02E-08 | 2.37E-08 | 1.82E-07 | 3.60E-05 | 6.37E-05 |
| Te-134 | 3.84E-12 | 3.22E-12 | 1.57E-12 | 3.44E-12 | 2.18E-11 | 4.34E-07 | 2.97E-11 |
| U-235 | 1.00E-02 | | 6.07E-04 | | 2.34E-03 | 4.90E-02 | 4.84E-05 |
| U-238 | 9.58E-03 | | 5.67E-04 | | 2.18E-03 | 4.58E-02 | 3.41E-05 |
| W-187 | 1.06E-09 | 8.85E-10 | 3.10E-10 | | | 3.63E-06 | 1.94E-05 |
| Y-90 | 2.61E-07 | | 7.01E-09 | | | 2.12E-05 | 6.32E-05 |
| Y-91 | 5.78E-05 | | 1.55E-06 | | | 2.13E-04 | 4.81E-05 |
| Y-91m | 3.26E-11 | | 1.27E-12 | | | 2.40E-07 | 1.66E-10 |
| Y-92 | 1.29E-09 | | 3.77E-11 | | | 1.96E-06 | 9.19E-06 |
| Y-93 | 1.18E-08 | | 3.26E-10 | | | 6.06E-06 | 5.27E-05 |
| Zn-65 | 4.05E-06 | 1.29E-05 | 5.82E-06 | | 8.62E-06 | 1.08E-04 | 6.68E-06 |
| Zn-69 | 4.23E-12 | 8.14E-12 | 5.65E-13 | | 5.27E-12 | 1.15E-07 | 2.04E-09 |
| Zn-69m | 1.02E-09 | 2.45E-09 | 2.24E-10 | | 1.48E-09 | 2.38E-06 | 1.71E-05 |
| Zr-95 | 1.34E-05 | 4.30E-06 | 2.91E-06 | | 6.77E-06 | 2.21E-04 | 1.88E-05 |
| Zr-97 | 1.21E-08 | 2.45E-09 | 1.13E-09 | | 3.71E-09 | 9.84E-06 | 6.54E-05 |

TABLE 10-5
INHALATION PATHWAY DOSE FACTORS - TEEN
**(mrem/pCi inhaled)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Ag-110m | 1.73E-06 | 1.64E-06 | 9.99E-07 | | 3.13E-06 | 8.44E-04 | 3.41E-05 |
| Am-241 | 1.06E+00 | 4.07E-01 | 7.10E-02 | | 5.32E-01 | 1.05E-01 | 4.88E-05 |
| As-76 | 1.44E-07 | 4.07E-07 | 3.26E-06 | 1.37E-07 | 4.44E-07 | 1.48E-05 | 1.30E-05 |
| Ba-139 | 1.67E-10 | 1.18E-13 | 4.87E-12 | | 1.11E-13 | 8.08E-07 | 8.06E-07 |
| Ba-140 | 6.84E-06 | 8.38E-09 | 4.40E-07 | | 2.85E-09 | 2.54E-04 | 2.86E-05 |
| Ba-141 | 1.78E-11 | 1.32E-14 | 5.93E-13 | | 1.23E-14 | 4.11E-07 | 9.33E-14 |
| Ba-142 | 4.62E-12 | 4.63E-15 | 2.84E-13 | | 3.92E-15 | 2.39E-07 | 5.99E-20 |
| Br-82 | | | 2.28E-06 | | | | |
| Br-83 | | | 4.30E-08 | | | | |
| Br-84 | | | 5.41E-08 | | | | |
| Br-85 | | | 2.29E-09 | | | | |
| C-14 | 3.25E-06 | 6.09E-07 | 6.09E-07 | 6.09E-07 | 6.09E-07 | 6.09E-07 | 6.09E-07 |
| Ce-141 | 3.55E-06 | 2.37E-06 | 2.71E-07 | | 1.11E-06 | 7.67E-05 | 1.58E-05 |
| Ce-143 | 3.32E-08 | 2.42E-08 | 2.70E-09 | | 1.08E-08 | 1.63E-05 | 3.19E-05 |
| Ce-144 | 6.11E-04 | 2.53E-04 | 3.28E-05 | | 1.51E-04 | 1.67E-03 | 1.08E-04 |
| Co-57 | | 1.18E-07 | 1.15E-07 | | | 7.35E-05 | 3.93E-06 |
| Co-58 | | 2.59E-07 | 3.47E-07 | | | 1.68E-04 | 1.19E-05 |
| Co-60 | | 1.89E-06 | 2.48E-06 | | | 1.09E-03 | 3.24E-05 |
| Cr-51 | | | 1.69E-08 | 9.37E-09 | 3.84E-09 | 2.62E-06 | 3.75E-07 |
| Cs-134 | 6.28E-05 | 1.41E-04 | 6.86E-05 | | 4.69E-05 | 1.83E-05 | 1.22E-06 |
| Cs-134m | 2.20E-08 | 4.35E-08 | 2.35E-08 | | 2.54E-08 | 4.56E-09 | 2.02E-08 |
| Cs-136 | 6.44E-06 | 2.42E-05 | 1.71E-05 | | 1.38E-05 | 2.22E-06 | 1.36E-06 |
| Cs-137 | 8.38E-05 | 1.06E-04 | 3.89E-05 | | 3.80E-05 | 1.51E-05 | 1.06E-06 |
| Cs-138 | 5.82E-08 | 1.07E-07 | 5.58E-08 | | 8.28E-08 | 9.84E-09 | 3.38E-11 |
| Cu-64 | | 2.54E-10 | 1.06E-10 | | 8.01E-10 | 1.39E-06 | 7.68E-06 |
| Eu-152 | 2.96E-04 | 7.19E-05 | 6.30E-05 | | 3.34E-04 | 5.01E-04 | 1.35E-05 |
| F-18 | 6.52E-07 | | 7.10E-08 | | | | 3.89E-08 |
| Fe-55 | 4.18E-06 | 2.98E-06 | 6.93E-07 | | | 1.55E-05 | 7.99E-07 |
| Fe-59 | 1.99E-06 | 4.62E-06 | 1.79E-06 | | | 1.91E-04 | 2.23E-05 |
| H-3 | | 1.59E-07 | 1.59E-07 | 1.59E-07 | 1.59E-07 | 1.59E-07 | 1.59E-07 |
| I-129 | 3.53E-06 | 2.94E-06 | 4.90E-06 | 3.66E-03 | 5.26E-06 | | 2.29E-07 |
| I-130 | 7.80E-07 | 2.24E-06 | 8.96E-07 | 1.86E-04 | 3.44E-06 | | 1.14E-06 |
| I-131 | 4.43E-06 | 6.14E-06 | 3.30E-06 | 1.83E-03 | 1.05E-05 | | 8.11E-07 |
| I-132 | 1.99E-07 | 5.47E-07 | 1.97E-07 | 1.89E-05 | 8.65E-07 | | 1.59E-07 |
| I-133 | 1.52E-06 | 2.36E-06 | 7.78E-07 | 3.65E-04 | 4.49E-06 | | 1.29E-06 |

TABLE 10-5
INHALATION PATHWAY DOSE FACTORS - TEEN
**(mrem/pCi inhaled)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| I-134 | 1.11E-07 | 2.90E-07 | 1.05E-07 | 4.94E-06 | 4.58E-07 | | 2.55E-09 |
| I-135 | 4.62E-07 | 1.18E-06 | 4.36E-07 | 7.76E-05 | 1.86E-06 | | 8.69E-07 |
| La-140 | 5.99E-08 | 2.95E-08 | 7.82E-09 | | | 2.68E-05 | 6.09E-05 |
| La-142 | 1.20E-10 | 5.31E-11 | 1.32E-11 | | | 1.27E-06 | 1.50E-06 |
| Mn-54 | | 6.39E-06 | 1.05E-06 | | 1.59E-06 | 2.48E-04 | 8.35E-06 |
| Mn-56 | | 2.12E-10 | 3.15E-11 | | 2.24E-10 | 1.90E-06 | 7.18E-06 |
| Mo-99 | | 2.11E-08 | 4.03E-09 | | 5.14E-08 | 1.92E-05 | 3.36E-05 |
| Na-22 | 1.30E-05 | 1.30E-05 | 1.30E-05 | 1.30E-05 | 1.30E-05 | 1.30E-05 | 1.30E-05 |
| Na-24 | 1.72E-06 | 1.72E-06 | 1.72E-06 | 1.72E-06 | 1.72E-06 | 1.72E-06 | 1.72E-06 |
| Nb-95 | 2.32E-06 | 1.29E-06 | 7.08E-07 | | 1.25E-06 | 9.39E-05 | 1.21E-05 |
| Nb-97 | 3.92E-11 | 9.72E-12 | 3.55E-12 | | 1.14E-11 | 4.91E-07 | 2.71E-07 |
| Nd-147 | 9.83E-07 | 1.07E-06 | 6.41E-08 | | 6.28E-07 | 4.65E-05 | 2.28E-05 |
| Ni-63 | 7.25E-05 | 5.43E-06 | 2.47E-06 | | | 3.84E-05 | 1.77E-06 |
| Ni-65 | 2.73E-10 | 3.66E-11 | 1.59E-11 | | | 1.17E-06 | 4.59E-06 |
| Np-239 | 4.23E-08 | 3.99E-09 | 2.21E-09 | | 1.25E-08 | 8.11E-06 | 1.65E-05 |
| P-32 | 2.36E-04 | 1.37E-05 | 8.95E-06 | | | | 1.16E-05 |
| Pm-147 | 1.15E-04 | 1.10E-05 | 4.50E-06 | | 2.10E-05 | 1.14E-04 | 5.87E-06 |
| Pm-149 | 4.91E-08 | 6.89E-09 | 2.84E-09 | | 1.31E-08 | 1.24E-05 | 2.79E-05 |
| Pr-143 | 1.67E-06 | 6.64E-07 | 8.28E-08 | | 3.86E-07 | 6.04E-05 | 2.67E-05 |
| Pr-144 | 5.37E-12 | 2.20E-12 | 2.72E-13 | | 1.26E-12 | 2.19E-07 | 2.94E-14 |
| Rb-86 | | 2.38E-05 | 1.05E-05 | | | | 2.21E-06 |
| Rb-88 | | 6.82E-08 | 3.40E-08 | | | | 3.65E-15 |
| Rb-89 | | 4.40E-08 | 2.91E-08 | | | | 4.22E-17 |
| Rh-105 | 1.32E-09 | 9.48E-10 | 6.24E-10 | | 4.04E-09 | 4.09E-06 | 1.23E-05 |
| Ru-103 | 2.63E-07 | | 1.12E-07 | | 9.29E-07 | 9.79E-05 | 1.36E-05 |
| Ru-105 | 1.40E-10 | | 5.42E-11 | | 1.76E-10 | 2.27E-06 | 1.13E-05 |
| Ru-106 | 1.23E-05 | | 1.55E-06 | | 2.38E-05 | 2.01E-03 | 1.20E-04 |
| Sb-122 | 2.52E-07 | 2.30E-07 | 4.81E-06 | 9.26E-08 | 1.19E-07 | 2.48E-05 | 1.74E-05 |
| Sb-124 | 5.38E-06 | 9.92E-08 | 2.10E-06 | 1.22E-08 | | 4.81E-04 | 4.98E-05 |
| Sb-125 | 9.23E-06 | 1.01E-07 | 2.15E-06 | 8.80E-09 | | 3.42E-04 | 1.24E-05 |
| Sb-127 | 4.64E-08 | 9.92E-10 | 1.75E-08 | 5.21E-10 | | 3.31E-05 | 3.94E-05 |
| Sc-46 | 7.24E-05 | 1.41E-04 | 4.18E-05 | | 1.35E-04 | | 2.48E-05 |
| Sm-151 | 1.07E-04 | 2.10E-05 | 4.86E-06 | | 2.27E-05 | 7.68E-05 | 3.53E-06 |
| Sm-153 | 2.43E-08 | 2.01E-08 | 1.47E-09 | | 6.56E-09 | 7.11E-06 | 1.77E-05 |
| Sn-113 | 3.52E-06 | 1.56E-06 | 1.19E-05 | 8.15E-07 | 8.15E-07 | 8.52E-05 | 9.26E-06 |

TABLE 10-5
INHALATION PATHWAY DOSE FACTORS - TEEN
**(mrem/pCi inhaled)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Sn-117m | 3.41E-06 | 2.33E-07 | 1.15E-05 | 1.07E-07 | 1.15E-07 | 8.89E-05 | 7.78E-06 |
| Sr-89 | 5.43E-05 | | 1.56E-06 | | | 3.02E-04 | 4.64E-05 |
| Sr-90 | 1.35E-02 | | 8.35E-04 | | | 2.06E-03 | 9.56E-05 |
| Sr-91 | 1.10E-08 | | 4.39E-10 | | | 7.59E-06 | 3.24E-05 |
| Sr-92 | 1.19E-09 | | 5.08E-11 | | | 3.43E-06 | 1.49E-05 |
| Tc-101 | 7.40E-15 | 1.05E-14 | 1.03E-13 | | 1.90E-13 | 8.34E-08 | 1.09E-16 |
| Tc-99 | 4.48E-08 | 6.58E-08 | 1.79E-08 | | 8.35E-07 | 1.74E-04 | 7.99E-06 |
| Tc-99m | 1.73E-13 | 4.83E-13 | 6.24E-12 | | 7.20E-12 | 1.44E-07 | 7.66E-07 |
| Te-125m | 6.10E-07 | 2.80E-07 | 8.34E-08 | 1.75E-07 | | 6.70E-05 | 9.38E-06 |
| Te-127 | 2.51E-10 | 1.14E-10 | 5.52E-11 | 1.77E-10 | 9.10E-10 | 1.40E-06 | 1.01E-05 |
| Te-127m | 2.25E-06 | 1.02E-06 | 2.73E-07 | 5.48E-07 | 8.17E-06 | 2.07E-04 | 1.99E-05 |
| Te-129 | 8.87E-12 | 4.22E-12 | 2.20E-12 | 6.48E-12 | 3.32E-11 | 4.12E-07 | 2.02E-07 |
| Te-129m | 1.74E-06 | 8.23E-07 | 2.81E-07 | 5.72E-07 | 6.49E-06 | 2.47E-04 | 5.06E-05 |
| Te-131 | 1.97E-12 | 1.04E-12 | 6.30E-13 | 1.55E-12 | 7.72E-12 | 2.92E-07 | 1.89E-09 |
| Te-131m | 1.23E-08 | 7.51E-09 | 5.03E-09 | 9.06E-09 | 5.49E-08 | 2.97E-05 | 7.76E-05 |
| Te-132 | 4.50E-08 | 3.63E-08 | 2.74E-08 | 3.07E-08 | 2.44E-07 | 5.61E-05 | 5.79E-05 |
| Te-134 | 5.31E-12 | 4.35E-12 | 3.64E-12 | 4.46E-12 | 2.91E-11 | 6.75E-07 | 1.37E-09 |
| U-235 | 1.42E-02 | | 8.67E-04 | | 3.34E-03 | 8.44E-02 | 5.13E-05 |
| U-238 | 1.36E-02 | | 8.10E-04 | | 3.12E-03 | 7.89E-02 | 3.62E-05 |
| W-187 | 1.50E-09 | 1.22E-09 | 4.29E-10 | | | 5.92E-06 | 2.21E-05 |
| Y-90 | 3.73E-07 | | 1.00E-08 | | | 3.66E-05 | 6.99E-05 |
| Y-91 | 8.26E-05 | | 2.21E-06 | | | 3.67E-04 | 5.11E-05 |
| Y-91m | 4.63E-11 | | 1.77E-12 | | | 4.00E-07 | 3.77E-09 |
| Y-92 | 1.84E-09 | | 5.36E-11 | | | 3.35E-06 | 2.06E-05 |
| Y-93 | 1.69E-08 | | 4.65E-10 | | | 1.04E-05 | 7.24E-05 |
| Zn-65 | 4.82E-06 | 1.67E-05 | 7.80E-06 | | 1.08E-05 | 1.55E-04 | 5.83E-06 |
| Zn-69 | 6.04E-12 | 1.15E-11 | 8.07E-13 | | 7.53E-12 | 1.98E-07 | 3.56E-08 |
| Zn-69m | 1.44E-09 | 3.39E-09 | 3.11E-10 | | 2.06E-09 | 3.92E-06 | 2.14E-05 |
| Zr-95 | 1.82E-05 | 5.73E-06 | 3.94E-06 | | 8.42E-06 | 3.36E-04 | 1.86E-05 |
| Zr-97 | 1.72E-08 | 3.40E-09 | 1.57E-09 | | 5.15E-09 | 1.62E-05 | 7.88E-05 |

TABLE 10-6
INHALATION PATHWAY DOSE FACTORS - CHILD
(mrem/pCi inhaled)

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Ag-110m | 4.56E-06 | 3.08E-06 | 2.47E-06 | | 5.74E-06 | 1.48E-03 | 2.71E-05 |
| Am-241 | 1.74E+00 | 7.85E-01 | 1.24E-01 | | 7.63E-01 | 2.02E-01 | 4.73E-05 |
| As-76 | 4.44E-07 | 1.11E-06 | 8.15E-06 | 4.07E-07 | 1.11E-06 | 2.52E-05 | 4.44E-05 |
| Ba-139 | 4.98E-10 | 2.66E-13 | 1.45E-11 | | 2.33E-13 | 1.56E-06 | 1.56E-05 |
| Ba-140 | 2.00E-05 | 1.75E-08 | 1.17E-06 | | 5.71E-09 | 4.71E-04 | 2.75E-05 |
| Ba-141 | 5.29E-11 | 2.95E-14 | 1.72E-12 | | 2.56E-14 | 7.89E-07 | 7.44E-08 |
| Ba-142 | 1.35E-11 | 9.73E-15 | 7.54E-13 | | 7.87E-15 | 4.44E-07 | 7.41E-10 |
| Br-82 | | | 5.66E-06 | | | | |
| Br-83 | | | 1.28E-07 | | | | |
| Br-84 | | | 1.48E-07 | | | | |
| Br-85 | | | 6.84E-09 | | | | |
| C-14 | 9.70E-06 | 1.82E-06 | 1.82E-06 | 1.82E-06 | 1.82E-06 | 1.82E-06 | 1.82E-06 |
| Ce-141 | 1.06E-05 | 5.28E-06 | 7.83E-07 | | 2.31E-06 | 1.47E-04 | 1.53E-05 |
| Ce-143 | 9.89E-08 | 5.37E-08 | 7.77E-09 | | 2.26E-08 | 3.12E-05 | 3.44E-05 |
| Ce-144 | 1.83E-03 | 5.72E-04 | 9.77E-05 | | 3.17E-04 | 3.23E-03 | 1.05E-04 |
| Co-57 | | 2.44E-07 | 2.88E-07 | | | 1.37E-04 | 3.58E-06 |
| Co-58 | | 4.79E-07 | 8.55E-07 | | | 2.99E-04 | 9.29E-06 |
| Co-60 | | 3.55E-06 | 6.12E-06 | | | 1.91E-03 | 2.60E-05 |
| Cr-51 | | | 4.17E-08 | 2.31E-08 | 6.57E-09 | 4.59E-06 | 2.93E-07 |
| Cs-134 | 1.76E-04 | 2.74E-04 | 6.07E-05 | | 8.93E-05 | 3.27E-05 | 1.04E-06 |
| Cs-134m | 6.33E-08 | 8.92E-08 | 6.12E-08 | | 4.94E-08 | 8.35E-09 | 7.92E-08 |
| Cs-136 | 1.76E-05 | 4.62E-05 | 3.14E-05 | | 2.58E-05 | 3.93E-06 | 1.13E-06 |
| Cs-137 | 2.45E-04 | 2.23E-04 | 3.47E-05 | | 7.63E-05 | 2.81E-05 | 9.78E-07 |
| Cs-138 | 1.71E-07 | 2.27E-07 | 1.50E-07 | | 1.68E-07 | 1.84E-08 | 7.29E-08 |
| Cu-64 | | 5.39E-10 | 2.90E-10 | | 1.63E-09 | 2.59E-06 | 9.92E-06 |
| Eu-152 | 7.42E-04 | 1.37E-04 | 1.61E-04 | | 5.73E-04 | 9.00E-04 | 1.14E-05 |
| F-18 | 1.88E-06 | | 1.85E-07 | | | | 3.37E-07 |
| Fe-55 | 1.28E-05 | 6.80E-06 | 2.10E-06 | | | 3.00E-05 | 7.75E-07 |
| Fe-59 | 5.59E-06 | 9.04E-06 | 4.51E-06 | | | 3.43E-04 | 1.91E-05 |
| H-3 | | 3.04E-07 | 3.04E-07 | 3.04E-07 | 3.04E-07 | 3.04E-07 | 3.04E-07 |
| I-129 | 1.05E-05 | 6.40E-06 | 5.71E-06 | 4.28E-03 | 1.08E-05 | | 2.15E-07 |
| I-130 | 2.21E-06 | 4.43E-06 | 2.28E-06 | 4.99E-04 | 6.61E-06 | | 1.38E-06 |
| I-131 | 1.30E-05 | 1.30E-05 | 7.37E-06 | 4.39E-03 | 2.13E-05 | | 7.68E-07 |
| I-132 | 5.72E-07 | 1.10E-06 | 5.07E-07 | 5.23E-05 | 1.69E-06 | | 8.65E-07 |
| I-133 | 4.48E-06 | 5.49E-06 | 2.08E-06 | 1.04E-03 | 9.13E-06 | | 1.48E-06 |

TABLE 10-6
INHALATION PATHWAY DOSE FACTORS - CHILD
(mrem/pCi inhaled)

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| I-134 | 3.17E-07 | 5.84E-07 | 2.69E-07 | 1.37E-05 | 8.92E-07 | | 2.58E-07 |
| I-135 | 1.33E-06 | 2.36E-06 | 1.12E-06 | 2.14E-04 | 3.62E-06 | | 1.20E-06 |
| La-140 | 1.74E-07 | 6.08E-08 | 2.04E-08 | | | 4.94E-05 | 6.10E-05 |
| La-142 | 3.50E-10 | 1.11E-10 | 3.49E-11 | | | 2.35E-06 | 2.05E-05 |
| Mn-54 | | 1.16E-05 | 2.57E-06 | | 2.71E-06 | 4.26E-04 | 6.19E-06 |
| Mn-56 | | 4.48E-10 | 8.43E-11 | | 4.52E-10 | 3.55E-06 | 3.33E-05 |
| Mo-99 | | 4.66E-08 | 1.15E-08 | | 1.06E-07 | 3.66E-05 | 3.42E-05 |
| Na-22 | 4.41E-05 | 4.41E-05 | 4.41E-05 | 4.41E-05 | 4.41E-05 | 4.41E-05 | 4.41E-05 |
| Na-24 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 | 4.35E-06 |
| Nb-95 | 6.35E-06 | 2.48E-06 | 1.77E-06 | | 2.33E-06 | 1.66E-04 | 1.00E-05 |
| Nb-97 | 1.16E-10 | 2.08E-11 | 9.74E-12 | | 2.31E-11 | 9.23E-07 | 7.52E-06 |
| Nd-147 | 2.92E-06 | 2.36E-06 | 1.84E-07 | | 1.30E-06 | 8.87E-05 | 2.22E-05 |
| Ni-63 | 2.22E-04 | 1.25E-05 | 7.56E-06 | | | 7.43E-05 | 1.71E-06 |
| Ni-65 | 8.08E-10 | 7.99E-11 | 4.44E-11 | | | 2.21E-06 | 2.27E-05 |
| Np-239 | 1.26E-07 | 9.04E-09 | 6.35E-09 | | 2.63E-08 | 1.57E-05 | 1.73E-05 |
| P-32 | 7.04E-04 | 3.09E-05 | 2.67E-05 | | | | 1.14E-05 |
| Pm-147 | 3.52E-04 | 2.52E-05 | 1.36E-05 | | 4.45E-05 | 2.20E-04 | 5.70E-06 |
| Pm-149 | 1.47E-07 | 1.56E-08 | 8.45E-09 | | 2.75E-08 | 2.40E-05 | 2.92E-05 |
| Pr-143 | 4.99E-06 | 1.50E-06 | 2.47E-07 | | 8.11E-07 | 1.17E-04 | 2.63E-05 |
| Pr-144 | 1.61E-11 | 4.99E-12 | 8.10E-13 | | 2.64E-12 | 4.23E-07 | 5.32E-08 |
| Rb-86 | | 5.36E-05 | 3.09E-05 | | | | 2.16E-06 |
| Rb-88 | | 1.52E-07 | 9.90E-08 | | | | 4.66E-09 |
| Rb-89 | | 9.33E-08 | 7.83E-08 | | | | 5.11E-10 |
| Rh-105 | 3.91E-09 | 2.10E-09 | 1.79E-09 | | 8.39E-09 | 7.82E-06 | 1.33E-05 |
| Ru-103 | 7.55E-07 | | 2.90E-07 | | 1.90E-06 | 1.79E-04 | 1.21E-05 |
| Ru-105 | 4.13E-10 | | 1.50E-10 | | 3.63E-10 | 4.30E-06 | 2.69E-05 |
| Ru-106 | 3.68E-05 | | 4.57E-06 | | 4.97E-05 | 3.87E-03 | 1.16E-04 |
| Sb-122 | 7.04E-07 | 5.56E-07 | 1.04E-05 | 2.33E-07 | 3.00E-07 | 3.70E-05 | 6.30E-05 |
| Sb-124 | 1.55E-05 | 2.00E-07 | 5.41E-06 | 3.41E-08 | | 8.76E-04 | 4.43E-05 |
| Sb-125 | 2.66E-05 | 2.39E-07 | 5.59E-06 | 2.46E-08 | | 6.27E-04 | 1.09E-05 |
| Sb-127 | 1.36E-07 | 2.09E-09 | 4.70E-08 | 1.51E-09 | | 6.17E-05 | 3.82E-05 |
| Sc-46 | 1.97E-04 | 2.70E-04 | 1.04E-04 | | 2.39E-04 | | 2.04E-05 |
| Sm-151 | 3.14E-04 | 4.75E-05 | 1.49E-05 | | 4.89E-05 | 1.48E-04 | 3.43E-06 |
| Sm-153 | 7.24E-08 | 4.51E-08 | 4.35E-09 | | 1.37E-08 | 1.37E-05 | 1.87E-05 |
| Sn-113 | 9.63E-06 | 3.19E-06 | 2.15E-05 | 2.07E-06 | 1.89E-06 | 1.41E-04 | 3.04E-05 |

TABLE 10-6
INHALATION PATHWAY DOSE FACTORS - CHILD
(mrem/pCi inhaled)

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Sn-117m | 1.11E-05 | 4.81E-07 | 1.70E-05 | 2.81E-07 | 2.85E-07 | 1.19E-04 | 2.67E-05 |
| Sr-89 | 1.62E-04 | | 4.66E-06 | | | 5.83E-04 | 4.52E-05 |
| Sr-90 | 2.73E-02 | | 1.74E-03 | | | 3.99E-03 | 9.28E-05 |
| Sr-91 | 3.28E-08 | | 1.24E-09 | | | 1.44E-05 | 4.70E-05 |
| Sr-92 | 3.54E-09 | | 1.42E-10 | | | 6.49E-06 | 6.55E-05 |
| Tc-101 | 2.19E-14 | 2.30E-14 | 2.91E-13 | | 3.92E-13 | 1.58E-07 | 4.41E-09 |
| Tc-99 | 1.34E-07 | 1.49E-07 | 5.35E-08 | | 1.75E-06 | 3.37E-04 | 7.75E-06 |
| Tc-99m | 4.81E-13 | 9.41E-13 | 1.56E-11 | | 1.37E-11 | 2.57E-07 | 1.30E-06 |
| Te-125m | 1.82E-06 | 6.29E-07 | 2.47E-07 | 5.20E-07 | | 1.29E-04 | 9.13E-06 |
| Te-127 | 7.49E-10 | 2.57E-10 | 1.65E-10 | 5.30E-10 | 1.91E-09 | 2.71E-06 | 1.52E-05 |
| Te-127m | 6.72E-06 | 2.31E-06 | 8.16E-07 | 1.64E-06 | 1.72E-05 | 4.00E-04 | 1.93E-05 |
| Te-129 | 2.64E-11 | 9.45E-12 | 6.44E-12 | 1.93E-11 | 6.94E-11 | 7.93E-07 | 6.89E-06 |
| Te-129m | 5.19E-06 | 1.85E-06 | 8.22E-07 | 1.71E-06 | 1.36E-05 | 4.76E-04 | 4.91E-05 |
| Te-131 | 5.87E-12 | 2.28E-12 | 1.78E-12 | 4.59E-12 | 1.59E-11 | 5.55E-07 | 3.60E-07 |
| Te-131m | 3.63E-08 | 1.60E-08 | 1.37E-08 | 2.64E-08 | 1.08E-07 | 5.56E-05 | 8.32E-05 |
| Te-132 | 1.30E-07 | 7.36E-08 | 7.12E-08 | 8.58E-08 | 4.79E-07 | 1.02E-04 | 3.72E-05 |
| Te-134 | 1.53E-11 | 8.81E-10 | 9.40E-12 | 1.24E-11 | 5.71E-11 | 1.23E-06 | 4.87E-07 |
| U-235 | 4.27E-02 | | 2.59E-03 | | 7.01E-03 | 1.63E-01 | 4.98E-05 |
| U-238 | 4.09E-02 | | 2.42E-03 | | 6.55E-03 | 1.53E-01 | 3.51E-05 |
| W-187 | 4.41E-09 | 2.61E-09 | 1.17E-09 | | | 1.11E-05 | 2.46E-05 |
| Y-90 | 1.11E-06 | | 2.99E-08 | | | 7.07E-05 | 7.24E-05 |
| Y-91 | 2.47E-04 | | 6.59E-06 | | | 7.10E-04 | 4.97E-05 |
| Y-91m | 1.37E-10 | | 4.98E-12 | | | 7.60E-07 | 4.64E-07 |
| Y-92 | 5.50E-09 | | 1.57E-10 | | | 6.46E-06 | 6.46E-05 |
| Y-93 | 5.04E-08 | | 1.38E-09 | | | 2.01E-05 | 1.05E-04 |
| Zn-65 | 1.15E-05 | 3.06E-05 | 1.90E-05 | | 1.93E-05 | 2.69E-04 | 4.41E-06 |
| Zn-69 | 1.81E-11 | 2.61E-11 | 2.41E-12 | | 1.58E-11 | 3.84E-07 | 2.75E-06 |
| Zn-69m | 4.26E-09 | 7.28E-09 | 8.59E-10 | | 4.22E-09 | 7.36E-06 | 2.71E-05 |
| Zr-95 | 5.13E-05 | 1.13E-05 | 1.00E-05 | | 1.61E-05 | 6.03E-04 | 1.65E-05 |
| Zr-97 | 5.07E-08 | 7.34E-09 | 4.32E-09 | | 1.05E-08 | 3.06E-05 | 9.49E-05 |

TABLE 10-7
INHALATION PATHWAY DOSE FACTORS - INFANT
**(mrem/pCi inhaled)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Ag-110m | 7.13E-06 | 5.16E-06 | 3.57E-06 | | 7.80E-06 | 2.62E-03 | 2.36E-05 |
| Am-241 | 1.84E+00 | 8.44E-01 | 1.31E-01 | | 7.94E-01 | 4.06E-01 | 4.78E-05 |
| As-76 | 2.56E-06 | 6.67E-06 | 1.89E-05 | 2.56E-06 | 6.67E-06 | 5.56E-05 | 7.04E-05 |
| Ba-139 | 1.06E-09 | 7.03E-13 | 3.07E-11 | | 4.23E-13 | 4.25E-06 | 3.64E-05 |
| Ba-140 | 4.00E-05 | 4.00E-08 | 2.07E-06 | | 9.59E-09 | 1.14E-03 | 2.74E-05 |
| Ba-141 | 1.12E-10 | 7.70E-14 | 3.55E-12 | | 4.64E-14 | 2.12E-06 | 3.39E-06 |
| Ba-142 | 2.84E-11 | 2.36E-14 | 1.40E-12 | | 1.36E-14 | 1.11E-06 | 4.95E-07 |
| Br-82 | | | 9.49E-06 | | | | |
| Br-83 | | | 2.72E-07 | | | | |
| Br-84 | | | 2.86E-07 | | | | |
| Br-85 | | | 1.46E-08 | | | | |
| C-14 | 1.89E-05 | 3.79E-06 | 3.79E-06 | 3.79E-06 | 3.79E-06 | 3.79E-06 | 3.79E-06 |
| Ce-141 | 1.98E-05 | 1.19E-05 | 1.42E-06 | | 3.75E-06 | 3.69E-04 | 1.54E-05 |
| Ce-143 | 2.09E-07 | 1.38E-07 | 1.58E-08 | | 4.03E-08 | 8.30E-05 | 3.55E-05 |
| Ce-144 | 2.28E-03 | 8.65E-04 | 1.26E-04 | | 3.84E-04 | 7.03E-03 | 1.06E-04 |
| Co-57 | | 4.65E-07 | 4.58E-07 | | | 2.71E-04 | 3.47E-06 |
| Co-58 | | 8.71E-07 | 1.30E-06 | | | 5.55E-04 | 7.95E-06 |
| Co-60 | | 5.73E-06 | 8.41E-06 | | | 3.22E-03 | 2.28E-05 |
| Cr-51 | | | 6.39E-08 | 4.11E-08 | 9.45E-09 | 9.17E-06 | 2.55E-07 |
| Cs-134 | 2.83E-04 | 5.02E-04 | 5.32E-05 | | 1.36E-04 | 5.69E-05 | 9.53E-07 |
| Cs-134m | 1.32E-07 | 2.10E-08 | 1.11E-07 | | 8.50E-08 | 2.00E-08 | 1.16E-07 |
| Cs-136 | 3.45E-05 | 9.61E-05 | 3.78E-05 | | 4.03E-05 | 8.40E-06 | 1.02E-06 |
| Cs-137 | 3.92E-04 | 4.37E-04 | 3.25E-05 | | 1.23E-04 | 5.09E-05 | 9.53E-07 |
| Cs-138 | 3.61E-07 | 5.58E-07 | 2.84E-07 | | 2.93E-07 | 4.67E-08 | 6.26E-07 |
| Cu-64 | | 1.34E-09 | 5.53E-10 | | 2.84E-09 | 6.64E-06 | 1.07E-05 |
| Eu-152 | 7.83E-04 | 1.77E-04 | 1.72E-04 | | 5.94E-04 | 1.48E-03 | 9.88E-06 |
| F-18 | 3.92E-06 | | 3.33E-07 | | | | 6.10E-07 |
| Fe-55 | 1.41E-05 | 8.39E-06 | 2.38E-06 | | | 6.21E-05 | 7.82E-07 |
| Fe-59 | 9.69E-06 | 1.68E-05 | 6.77E-06 | | | 7.25E-04 | 1.77E-05 |
| H-3 | | 4.62E-07 | 4.62E-07 | 4.62E-07 | 4.62E-07 | 4.62E-07 | 4.62E-07 |
| I-129 | 2.16E-05 | 1.59E-05 | 1.16E-05 | 1.04E-02 | 1.88E-05 | | 2.12E-07 |
| I-130 | 4.54E-06 | 9.91E-06 | 3.98E-06 | 1.14E-03 | 1.09E-05 | | 1.42E-06 |
| I-131 | 2.71E-05 | 3.17E-05 | 1.40E-05 | 1.06E-02 | 3.70E-05 | | 7.56E-07 |
| I-132 | 1.21E-06 | 2.53E-06 | 8.99E-07 | 1.21E-04 | 2.82E-06 | | 1.36E-06 |
| I-133 | 9.46E-06 | 1.37E-05 | 4.00E-06 | 2.54E-03 | 1.60E-05 | | 1.54E-06 |

TABLE 10-7
INHALATION PATHWAY DOSE FACTORS - INFANT
**(mrem/pCi inhaled)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| I-134 | 6.58E-07 | 1.34E-06 | 4.75E-07 | 3.18E-05 | 1.49E-06 | | 9.21E-07 |
| I-135 | 2.76E-06 | 5.43E-06 | 1.98E-06 | 4.97E-04 | 6.05E-06 | | 1.31E-06 |
| La-140 | 3.61E-07 | 1.43E-07 | 3.68E-08 | | | 1.20E-04 | 6.06E-05 |
| La-142 | 7.36E-10 | 2.69E-10 | 6.46E-11 | | | 5.87E-06 | 4.25E-05 |
| Mn-54 | | 1.81E-05 | 3.56E-06 | | 3.56E-06 | 7.14E-04 | 5.04E-06 |
| Mn-56 | | 1.10E-09 | 1.58E-10 | | 7.86E-10 | 8.95E-06 | 5.12E-05 |
| Mo-99 | | 1.18E-07 | 2.31E-08 | | 1.89E-07 | 9.63E-05 | 3.48E-05 |
| Na-22 | 7.37E-05 | 7.37E-05 | 7.37E-05 | 7.37E-05 | 7.37E-05 | 7.37E-05 | 7.37E-05 |
| Na-24 | 7.54E-06 | 7.54E-06 | 7.54E-06 | 7.54E-06 | 7.54E-06 | 7.54E-06 | 7.54E-06 |
| Nb-95 | 1.12E-05 | 4.59E-06 | 2.70E-06 | | 3.37E-06 | 3.42E-04 | 9.05E-06 |
| Nb-97 | 2.44E-10 | 5.21E-11 | 1.88E-11 | | 4.07E-11 | 2.37E-06 | 1.92E-05 |
| Nd-147 | 5.67E-06 | 5.81E-06 | 3.57E-07 | | 2.25E-06 | 2.30E-04 | 2.23E-05 |
| Ni-63 | 2.42E-04 | 1.46E-05 | 8.29E-06 | | | 1.49E-04 | 1.73E-06 |
| Ni-65 | 1.71E-09 | 2.03E-10 | 8.79E-11 | | | 5.80E-06 | 3.58E-05 |
| Np-239 | 2.65E-07 | 2.37E-08 | 1.34E-08 | | 4.73E-08 | 4.25E-05 | 1.78E-05 |
| P-32 | 1.45E-03 | 8.03E-05 | 5.53E-05 | | | | 1.15E-05 |
| Pm-147 | 3.91E-04 | 3.07E-05 | 1.56E-05 | | 4.93E-05 | 4.55E-04 | 5.75E-06 |
| Pm-149 | 3.10E-07 | 4.08E-08 | 1.78E-08 | | 4.96E-08 | 6.50E-05 | 3.01E-05 |
| Pr-143 | 1.00E-05 | 3.74E-06 | 4.99E-07 | | 1.41E-06 | 3.09E-04 | 2.66E-05 |
| Pr-144 | 3.42E-11 | 1.32E-11 | 1.72E-12 | | 4.80E-12 | 1.15E-06 | 3.06E-06 |
| Rb-86 | | 1.36E-04 | 6.30E-05 | | | | 2.17E-06 |
| Rb-88 | | 3.98E-07 | 2.05E-07 | | | | 2.42E-07 |
| Rb-89 | | 2.29E-07 | 1.47E-07 | | | | 4.87E-08 |
| Rh-105 | 8.26E-09 | 5.41E-09 | 3.63E-09 | | 1.50E-08 | 2.08E-05 | 1.37E-05 |
| Ru-103 | 1.44E-06 | | 4.85E-07 | | 3.03E-06 | 3.94E-04 | 1.15E-05 |
| Ru-105 | 8.74E-10 | | 2.93E-10 | | 6.42E-10 | 1.12E-05 | 3.46E-05 |
| Ru-106 | 6.20E-05 | | 7.77E-06 | | 7.61E-05 | 8.26E-03 | 1.17E-04 |
| Sb-122 | 1.70E-06 | 1.52E-06 | 3.07E-05 | 5.93E-07 | 8.15E-07 | 8.15E-05 | 2.26E-04 |
| Sb-124 | 2.71E-05 | 3.97E-07 | 8.56E-06 | 7.18E-08 | | 1.89E-03 | 4.22E-05 |
| Sb-125 | 3.69E-05 | 3.41E-07 | 7.78E-06 | 4.45E-08 | | 1.17E-03 | 1.05E-05 |
| Sb-127 | 2.82E-07 | 5.04E-09 | 8.76E-06 | 3.60E-09 | | 1.54E-04 | 3.78E-05 |
| Sc-46 | 3.75E-04 | 5.41E-04 | 1.69E-04 | | 3.56E-04 | | 1.82E-05 |
| Sm-151 | 3.38E-04 | 6.45E-05 | 1.63E-05 | | 5.24E-05 | 2.98E-04 | 3.46E-06 |
| Sm-153 | 1.53E-07 | 1.18E-07 | 9.06E-09 | | 2.47E-08 | 3.70E-05 | 1.93E-05 |
| Sn-113 | 2.00E-05 | 6.67E-06 | 4.81E-05 | 4.44E-06 | 4.44E-06 | 2.85E-04 | 1.04E-04 |

TABLE 10-7
INHALATION PATHWAY DOSE FACTORS - INFANT
**(mrem/pCi inhaled)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GILLI |
|---|---|---|---|---|---|---|---|
| Sn-117m | 2.33E-05 | 1.19E-06 | 3.70E-05 | 7.04E-07 | 7.78E-07 | 2.37E-04 | 9.63E-05 |
| Sr-89 | 2.84E-04 | | 8.15E-06 | | | 1.45E-03 | 4.57E-05 |
| Sr-90 | 2.92E-02 | | 1.85E-03 | | | 8.03E-03 | 9.36E-05 |
| Sr-91 | 6.83E-08 | | 2.47E-09 | | | 3.76E-05 | 5.24E-05 |
| Sr-92 | 7.50E-09 | | 2.79E-10 | | | 1.70E-05 | 1.00E-04 |
| Tc-101 | 4.65E-14 | 5.88E-14 | 5.80E-13 | | 6.99E-13 | 4.17E-07 | 6.03E-07 |
| Tc-99 | 2.09E-07 | 2.68E-07 | 8.85E-08 | | 2.49E-06 | 6.77E-04 | 7.82E-06 |
| Tc-99m | 9.98E-13 | 2.06E-12 | 2.66E-11 | | 2.22E-11 | 5.79E-07 | 1.45E-06 |
| Te-125m | 3.40E-06 | 1.42E-06 | 4.70E-07 | 1.16E-06 | | 3.19E-04 | 9.22E-06 |
| Te-127 | 1.59E-09 | 6.81E-10 | 3.49E-10 | 1.32E-09 | 3.47E-09 | 7.39E-06 | 1.74E-05 |
| Te-127m | 1.19E-05 | 4.93E-06 | 1.48E-06 | 3.48E-06 | 2.68E-05 | 9.37E-04 | 1.95E-05 |
| Te-129 | 5.63E-11 | 2.48E-11 | 1.34E-11 | 4.82E-11 | 1.25E-10 | 2.14E-06 | 1.88E-05 |
| Te-129m | 1.01E-05 | 4.35E-06 | 1.59E-06 | 3.91E-06 | 2.27E-05 | 1.20E-03 | 4.93E-05 |
| Te-131 | 1.24E-11 | 5.87E-12 | 3.57E-12 | 1.13E-11 | 2.85E-11 | 1.47E-06 | 5.87E-06 |
| Te-131m | 7.62E-08 | 3.93E-08 | 2.59E-08 | 6.38E-08 | 1.89E-07 | 1.42E-04 | 8.51E-05 |
| Te-132 | 2.66E-07 | 1.69E-07 | 1.26E-07 | 1.99E-07 | 7.39E-07 | 2.43E-04 | 3.15E-05 |
| Te-134 | 3.18E-11 | 2.04E-11 | 1.68E-11 | 2.91E-11 | 9.59E-11 | 2.93E-06 | 2.53E-06 |
| U-235 | 5.01E-02 | | 3.30E-03 | | 1.01E-02 | 3.28E-01 | 5.02E-05 |
| U-238 | 4.79E-02 | | 3.29E-03 | | 9.40E-03 | 3.06E-01 | 3.54E-05 |
| W-187 | 9.26E-09 | 6.44E-09 | 2.23E-09 | | | 2.83E-05 | 2.54E-05 |
| Y-90 | 2.35E-06 | | 6.30E-08 | | | 1.92E-04 | 7.43E-05 |
| Y-91 | 4.20E-04 | | 1.12E-05 | | | 1.75E-03 | 5.02E-05 |
| Y-91m | 2.91E-10 | | 9.90E-12 | | | 1.99E-06 | 1.68E-06 |
| Y-92 | 1.17E-08 | | 3.29E-10 | | | 1.75E-05 | 9.04E-05 |
| Y-93 | 1.07E-07 | | 2.91E-09 | | | 5.46E-05 | 1.19E-04 |
| Zn-65 | 1.38E-05 | 4.47E-05 | 2.22E-05 | | 2.32E-05 | 4.62E-04 | 3.67E-05 |
| Zn-69 | 3.85E-11 | 6.91E-11 | 5.13E-12 | | 2.87E-11 | 1.05E-06 | 9.44E-06 |
| Zn-69m | 8.98E-09 | 1.84E-08 | 1.67E-09 | | 7.45E-09 | 1.91E-05 | 2.92E-05 |
| Zr-95 | 8.24E-05 | 1.99E-05 | 1.45E-05 | | 2.22E-05 | 1.25E-03 | 1.55E-05 |
| Zr-97 | 1.07E-07 | 1.83E-08 | 8.36E-09 | | 1.85E-08 | 7.88E-05 | 1.00E-04 |

TABLE 10-8
INGESTION PATHWAY DOSE FACTORS - ADULT
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Ag-110m | 1.600E-07 | 1.480E-07 | 8.790E-08 | | 2.910E-07 | | 6.040E-05 |
| Am-241 | 8.910E-04 | 2.880E-04 | 5.410E-05 | | 4.070E-04 | | 7.420E-05 |
| As-76 | 4.070E-07 | 1.190E-06 | 5.926E-06 | 3.560E-07 | 1.440E-06 | 3.700E-07 | 5.190E-05 |
| Ba-139 | 9.700E-08 | 6.910E-11 | 2.840E-09 | | 6.460E-11 | 3.920E-11 | 1.720E-07 |
| Ba-140 | 2.030E-05 | 2.550E-08 | 1.330E-06 | | 8.670E-09 | 1.460E-08 | 4.180E-05 |
| Ba-141 | 4.710E-08 | 3.560E-11 | 1.590E-09 | | 3.310E-11 | 2.020E-11 | 2.220E-17 |
| Ba-142 | 2.130E-08 | 2.190E-11 | 1.340E-09 | | 1.850E-11 | 1.240E-11 | 3.000E-26 |
| Br-82 | | | 2.260E-06 | | | | 2.590E-06 |
| Br-83 | | | 4.020E-08 | | | | 5.790E-08 |
| Br-84 | | | 5.210E-08 | | | | 4.090E-13 |
| Br-85 | | | 2.140E-09 | | | | |
| C-14 | 2.840E-06 | 5.680E-07 | 5.680E-07 | 5.680E-07 | 5.680E-07 | 5.680E-07 | 5.680E-07 |
| Ce-141 | 9.360E-09 | 6.330E-09 | 7.180E-10 | | 2.940E-09 | | 2.420E-05 |
| Ce-143 | 1.650E-09 | 1.220E-06 | 1.350E-10 | | 5.370E-10 | | 4.560E-05 |
| Ce-144 | 4.880E-07 | 2.040E-07 | 2.620E-08 | | 1.210E-07 | | 1.650E-04 |
| Co-57 | | 1.750E-07 | 2.910E-07 | | | | 4.440E-06 |
| Co-58 | | 7.450E-07 | 1.670E-06 | | | | 1.510E-05 |
| Co-60 | | 2.140E-06 | 4.720E-06 | | | | 4.020E-05 |
| Cr-51 | | | 2.660E-09 | 1.590E-09 | 5.860E-10 | 3.530E-09 | 6.690E-07 |
| Cs-134 | 6.220E-05 | 1.480E-04 | 1.210E-04 | | 4.790E-05 | 1.590E-05 | 2.590E-06 |
| Cs-134m | 2.130E-08 | 4.480E-08 | 2.290E-08 | | 2.430E-08 | 3.830E-09 | 1.580E-08 |
| Cs-136 | 6.510E-06 | 2.570E-05 | 1.850E-05 | | 1.430E-05 | 1.960E-06 | 2.920E-06 |
| Cs-137 | 7.970E-05 | 1.090E-04 | 7.140E-05 | | 3.700E-05 | 1.230E-05 | 2.110E-06 |
| Cs-138 | 5.520E-08 | 1.090E-07 | 5.400E-08 | | 8.010E-08 | 7.910E-09 | 4.650E-13 |
| Cu-64 | | 8.330E-08 | 3.910E-08 | | 2.100E-07 | | 7.100E-06 |
| Eu-152 | 1.970E+07 | 4.440E-08 | 3.900E-08 | | 2.750E-07 | | 2.560E-05 |
| F-18 | 6.240E-07 | | 6.920E-08 | | | | 1.850E-08 |
| Fe-55 | 2.750E-06 | 1.900E-06 | 4.430E-07 | | | 1.060E-06 | 1.090E-06 |
| Fe-59 | 4.340E-06 | 1.020E-05 | 3.910E-06 | | | 2.850E-06 | 3.400E-05 |
| H-3 | | 1.050E-07 | 1.050E-07 | 1.050E-07 | 1.050E-07 | 1.050E-07 | 1.050E-07 |
| I-129 | 3.270E-06 | 2.810E-06 | 9.210E-06 | 7.230E-03 | 6.040E-06 | | 4.440E-07 |
| I-130 | 7.560E-07 | 2.230E-06 | 8.800E-07 | 1.890E-04 | 3.480E-06 | | 1.920E-06 |
| I-131 | 4.160E-06 | 5.950E-06 | 3.410E-06 | 1.950E-03 | 1.020E-05 | | 1.570E-06 |
| I-132 | 2.030E-07 | 5.430E-07 | 1.900E-07 | 1.900E-05 | 8.650E-07 | | 1.020E-07 |
| I-133 | 1.420E-06 | 2.470E-06 | 7.530E-07 | 3.630E-04 | 4.310E-06 | | 2.220E-06 |
| I-134 | 1.060E-07 | 2.880E-07 | 1.030E-07 | 4.990E-06 | 4.580E-07 | | 2.510E-10 |
| I-135 | 4.430E-07 | 1.160E-06 | 4.280E-07 | 7.650E-05 | 1.860E-06 | | 1.310E-06 |
| La-140 | 2.500E-09 | 1.260E-09 | 3.330E-10 | | | | 9.250E-05 |
| La-142 | 1.280E-10 | 5.820E-11 | 1.450E-11 | | | | 4.250E-07 |
| Mn-54 | | 4.570E-06 | 8.720E-07 | | 1.360E-06 | | 1.400E-05 |
| Mn-56 | | 1.150E-07 | 2.040E-08 | | 1.460E-07 | | 3.670E-06 |

TABLE 10-8
INGESTION PATHWAY DOSE FACTORS - ADULT
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Mo-99 | | 4.310E-06 | 8.200E-07 | | 9.760E-06 | | 9.990E-06 |
| Na-22 | 1.740E-05 | 1.740E-05 | 1.740E-05 | 1.740E-05 | 1.740E-05 | 1.740E-05 | 1.740E-05 |
| Na-24 | 1.700E-06 | 1.700E-06 | 1.700E-06 | 1.700E-06 | 1.700E-06 | 1.700E-06 | 1.700E-06 |
| Nb-95 | 6.220E-09 | 3.460E-09 | 1.860E-09 | | 3.420E-09 | | 2.100E-05 |
| Nb-97 | 5.220E-11 | 1.320E-11 | 4.820E-12 | | 1.540E-11 | | 4.870E-08 |
| Nd-147 | 6.290E-09 | 7.270E-09 | 4.350E-10 | | 4.250E-09 | | 3.490E-05 |
| Ni-63 | 1.300E-04 | 9.010E-06 | 4.360E-06 | | | | 1.880E-06 |
| Ni-65 | 5.280E-07 | 6.860E-08 | 3.130E-08 | | | | 1.740E-06 |
| Np-239 | 1.190E-09 | 1.170E-10 | 6.450E-11 | | 3.650E-10 | | 2.400E-05 |
| P-32 | 1.930E-04 | 1.200E-05 | 7.460E-06 | | | | 2.170E-05 |
| Pm-147 | 7.540E-08 | 7.090E-09 | 2.870E-09 | | 1.340E-08 | | 8.930E-06 |
| Pm-149 | 1.520E-09 | 2.150E-10 | 8.780E-11 | | 4.060E-10 | | 4.030E-05 |
| Pr-143 | 9.200E-09 | 3.690E-09 | 4.560E-10 | | 2.130E-09 | | 4.030E-05 |
| Pr-144 | 3.010E-11 | 1.250E-11 | 1.530E-12 | | 7.050E-12 | | 4.330E-18 |
| Rb-86 | | 2.110E-05 | 9.830E-06 | | | | 4.160E-06 |
| Rb-88 | | 6.050E-08 | 3.210E-08 | | | | 8.360E-19 |
| Rb-89 | | 4.010E-08 | 2.820E-08 | | | | 2.330E-21 |
| Rh-103m | 1.850E-07 | | 7.970E-08 | | 7.060E-07 | | 2.160E-05 |
| Rh-105 | 1.220E-07 | 8.850E-08 | 5.830E-08 | | 3.760E-07 | | 1.410E-05 |
| Rh-106 | 2.750E-06 | | 3.480E-07 | | 5.310E-06 | | 1.780E-04 |
| Ru-103 | 1.850E-07 | | 7.970E-08 | | 7.060E-07 | | 2.160E-05 |
| Ru-105 | 1.540E-08 | | 6.080E-09 | | 1.990E-07 | | 9.420E-06 |
| Ru-106 | 2.750E-06 | | 3.480E-07 | | 5.310E-06 | | 1.780E-04 |
| Sb-122 | 6.670E-07 | 3.670E-07 | 6.296E-06 | 7.780E-08 | 2.590E-07 | 1.000E-07 | 6.670E-05 |
| Sb-124 | 2.800E-06 | 5.290E-08 | 1.110E-06 | 6.790E-09 | | 2.180E-06 | 7.950E-05 |
| Sb-125 | 1.790E-06 | 2.000E-08 | 4.260E-07 | 1.820E-09 | | 1.380E-06 | 1.970E-05 |
| Sb-126 | 1.150E-06 | 2.340E-08 | 4.150E-07 | 7.040E-09 | | 7.050E-07 | 9.400E-05 |
| Sb-127 | 2.580E-07 | 5.650E-09 | 9.900E-08 | 3.100E-09 | | 1.530E-07 | 5.900E-05 |
| Sc-46 | 5.510E-09 | 1.070E-08 | 3.110E-09 | | 9.990E-09 | | 5.210E-05 |
| Se-75 | 7.660E-06 | 3.460E-06 | 9.620E-06 | 4.180E-06 | 3.460E-06 | 6.140E-06 | 3.460E-06 |
| Sm-151 | 6.900E-08 | 1.190E-08 | 2.850E-09 | | 1.330E-08 | | 5.250E-06 |
| Sm-153 | 8.570E-10 | 7.150E-10 | 5.220E-11 | | 2.310E-10 | | 2.550E-05 |
| Sn-113 | 9.630E-07 | 1.630E-07 | 2.704E-06 | 8.520E-08 | 2.220E-07 | 1.000E-07 | 2.900E-05 |
| Sn-117m | 1.850E-06 | 6.300E-08 | 2.630E-06 | 1.260E-08 | 9.630E-08 | 2.000E-08 | 2.960E-05 |
| Sr-89 | 3.080E-04 | | 8.840E-06 | | | | 4.940E-05 |
| Sr-90 | 7.580E-03 | | 1.860E-03 | | | | 2.190E-04 |
| Sr-91 | 5.670E-06 | | 2.290E-07 | | | | 2.700E-05 |
| Sr-92 | 2.150E-06 | | 9.300E-08 | | | | 4.260E-05 |
| Tc-101 | 2.540E-10 | 3.660E-10 | 3.590E-09 | | 6.590E-09 | 1.870E-10 | 1.100E-21 |
| Tc-99 | 1.250E-07 | 1.860E-07 | 5.020E-08 | | 2.340E-06 | 1.580E-08 | 6.080E-06 |
| Tc-99m | 2.470E-10 | 6.980E-10 | 8.890E-09 | | 1.060E-08 | 3.420E-10 | 4.130E-07 |

TABLE 10-8
INGESTION PATHWAY DOSE FACTORS - ADULT
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Te-123m | 7.880E-06 | 1.150E-06 | 5.660E-07 | 1.730E-06 | 1.310E-05 | | 1.080E-05 |
| Te-125m | 2.680E-06 | 9.710E-07 | 3.590E-07 | 8.060E-07 | 1.090E-05 | | 1.070E-05 |
| Te-127 | 1.100E-07 | 3.950E-08 | 2.380E-08 | 8.150E-08 | 4.480E-07 | | 8.680E-06 |
| Te-127m | 6.770E-06 | 2.420E-06 | 8.250E-07 | 1.730E-06 | 2.750E-05 | | 2.270E-05 |
| Te-129 | 3.140E-08 | 1.180E-08 | 7.650E-09 | 2.410E-08 | 1.320E-07 | | 2.370E-08 |
| Te-129m | 1.150E-05 | 4.290E-06 | 1.820E-06 | 3.950E-06 | 4.800E-05 | | 5.790E-05 |
| Te-131 | 1.970E-08 | 8.230E-09 | 6.220E-09 | 1.620E-08 | 8.630E-08 | | 2.790E-09 |
| Te-131m | 1.730E-06 | 8.460E-07 | 7.050E-07 | 1.340E-06 | 8.570E-06 | | 8.400E-05 |
| Te-132 | 2.520E-06 | 1.630E-06 | 1.530E-06 | 1.800E-06 | 1.570E-05 | | 7.710E-05 |
| U-235 | 8.010E-04 | | 4.860E-05 | | 1.870E-04 | | 7.810E-05 |
| U-238 | 7.670E-04 | | 1.175E-03 | | 1.870E-04 | | 7.810E-05 |
| W-187 | 1.030E-07 | 8.610E-08 | 3.010E-08 | | | | 2.820E-05 |
| Y-90 | 9.620E-09 | | 2.580E-10 | | | | 1.020E-04 |
| Y-91 | 1.410E-07 | | 3.770E-09 | | | | 7.760E-05 |
| Y-91m | 9.090E-11 | | 3.520E-12 | | | | 2.670E-10 |
| Y-92 | 8.450E-10 | | 2.470E-11 | | | | 1.480E-05 |
| Y-93 | 2.680E-09 | | 7.400E-11 | | | | 8.500E-05 |
| Zn-65 | 4.840E-06 | 1.540E-05 | 6.960E-06 | | 1.030E-05 | | 9.700E-06 |
| Zn-69 | 1.030E-08 | 1.970E-08 | 1.370E-09 | | 1.280E-08 | | 2.960E-09 |
| Zn-69m | 1.700E-07 | 4.080E-07 | 3.730E-08 | | 2.470E-07 | 2.470E-07 | 2.490E-05 |
| Zr-95 | 3.040E-08 | 9.750E-09 | 6.600E-09 | | 1.530E-08 | | 3.090E-05 |
| Zr-97 | 1.680E-09 | 3.390E-10 | 1.550E-10 | | 5.120E-10 | | 1.050E-04 |

TABLE 10-9
INGESTION PATHWAY DOSE FACTORS - TEEN
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Ag-110m | 2.050E-07 | 1.940E-07 | 1.180E-07 | | 3.700E-07 | | 5.450E-05 |
| Am-241 | 8.620E-04 | 3.290E-04 | 5.750E-05 | | 4.310E-04 | | 7.870E-05 |
| As-76 | 4.810E-07 | 1.520E-06 | 7.410E-06 | 4.440E-07 | 1.780E-06 | 4.440E-07 | 6.670E-05 |
| Ba-139 | 1.390E-07 | 9.780E-11 | 4.050E-09 | | 9.220E-11 | 6.740E-11 | 1.240E-06 |
| Ba-140 | 2.840E-05 | 3.480E-08 | 1.830E-06 | | 1.180E-08 | 2.340E-08 | 4.380E-05 |
| Ba-141 | 6.710E-08 | 5.010E-11 | 2.240E-09 | | 4.650E-11 | 3.430E-11 | 1.430E-13 |
| Ba-142 | 2.990E-08 | 2.990E-11 | 1.840E-09 | | 2.530E-11 | 1.990E-11 | 9.180E-20 |
| Br-82 | | | 3.040E-06 | | | | |
| Br-83 | | | 5.740E-08 | | | | |
| Br-84 | | | 7.220E-08 | | | | |
| Br-85 | | | 3.050E-09 | | | | |
| C-14 | 4.060E-06 | 8.120E-07 | 8.120E-07 | 8.120E-07 | 8.120E-07 | 8.120E-07 | 8.120E-07 |
| Ce-141 | 1.330E-08 | 8.880E-09 | 1.020E-09 | | 4.180E-09 | | 2.540E-05 |
| Ce-143 | 2.350E-09 | 1.710E-06 | 1.910E-10 | | 7.670E-10 | | 5.140E-05 |
| Ce-144 | 6.960E-07 | 2.880E-07 | 3.740E-08 | | 1.720E-07 | | 1.750E-04 |
| Co-57 | | 2.380E-07 | 3.990E-07 | | | | 4.440E-06 |
| Co-58 | | 9.720E-07 | 2.240E-06 | | | | 1.340E-05 |
| Co-60 | | 2.810E-06 | 6.330E-06 | | | | 3.660E-05 |
| Cr-51 | | | 3.600E-09 | 2.000E-09 | 7.890E-10 | 5.140E-09 | 6.050E-07 |
| Cs-134 | 8.370E-05 | 1.970E-04 | 9.140E-05 | | 6.260E-05 | 2.390E-05 | 2.450E-06 |
| Cs-134m | 2.940E-08 | 6.090E-08 | 3.130E-08 | | 3.390E-08 | 5.950E-09 | 4.050E-08 |
| Cs-136 | 8.590E-06 | 3.380E-05 | 2.270E-05 | | 1.840E-05 | 2.900E-06 | 2.720E-06 |
| Cs-137 | 1.120E-04 | 1.490E-04 | 5.190E-05 | | 5.070E-05 | 1.970E-05 | 2.120E-06 |
| Cs-138 | 7.760E-08 | 1.490E-07 | 7.450E-08 | | 1.100E-07 | 1.280E-08 | 6.760E-11 |
| Cu-64 | | 1.150E-07 | 5.410E-08 | | 2.910E-07 | | 8.920E-06 |
| Eu-152 | 2.450E-07 | 5.900E-08 | 5.200E-08 | | 2.470E-07 | | 2.170E-05 |
| F-18 | 8.640E-07 | | 9.470E-08 | | | | 7.780E-08 |
| Fe-55 | 3.780E-06 | 2.680E-06 | 6.250E-07 | | | 1.700E-06 | 1.160E-06 |
| Fe-59 | 5.870E-06 | 1.370E-05 | 5.290E-06 | | | 4.320E-06 | 3.240E-05 |
| H-3 | | 1.060E-07 | 1.060E-07 | 1.060E-07 | 1.060E-07 | 1.060E-07 | 1.060E-07 |
| I-129 | 4.660E-06 | 3.920E-06 | 6.540E-06 | 4.770E-03 | 7.010E-06 | | 4.570E-07 |
| I-130 | 1.030E-06 | 2.980E-06 | 1.190E-06 | 2.430E-04 | 4.590E-06 | | 2.290E-06 |
| I-131 | 5.850E-06 | 8.190E-06 | 4.400E-06 | 2.390E-03 | 1.410E-05 | | 1.620E-06 |
| I-132 | 2.790E-07 | 7.300E-07 | 2.620E-07 | 2.460E-05 | 1.150E-06 | | 3.180E-07 |
| I-133 | 2.010E-06 | 3.410E-06 | 1.040E-06 | 4.760E-04 | 5.980E-06 | | 2.580E-06 |
| I-134 | 1.460E-07 | 3.870E-07 | 1.390E-07 | 6.450E-06 | 6.100E-07 | | 5.100E-09 |
| I-135 | 6.100E-07 | 1.570E-06 | 5.820E-07 | 1.010E-04 | 2.480E-06 | | 1.740E-06 |
| La-140 | 3.480E-09 | 1.710E-09 | 4.550E-10 | | | | 9.820E-05 |
| La-142 | 1.790E-10 | 7.950E-11 | 1.980E-11 | | | | 2.420E-06 |
| Mn-54 | | 5.900E-06 | 1.170E-06 | | 1.760E-06 | | 1.210E-05 |
| Mn-56 | | 1.580E-07 | 2.810E-08 | | 2.000E-07 | | 1.040E-05 |

TABLE 10-9
INGESTION PATHWAY DOSE FACTORS - TEEN
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Mo-99 | | 6.030E-06 | 1.150E-06 | | 1.380E-05 | | 1.080E-05 |
| Na-22 | 2.340E-05 | 2.340E-05 | 2.340E-05 | 2.340E-05 | 2.340E-05 | 2.340E-05 | 2.340E-05 |
| Na-24 | 2.300E-06 | 2.300E-06 | 2.300E-06 | 2.300E-06 | 2.300E-06 | 2.300E-06 | 2.300E-06 |
| Nb-95 | 8.220E-09 | 4.560E-09 | 2.510E-09 | | 4.420E-09 | | 1.950E-05 |
| Nb-97 | 7.370E-11 | 1.830E-11 | 6.680E-12 | | 2.140E-11 | | 4.370E-07 |
| Nd-147 | 9.380E-09 | 1.020E-08 | 6.110E-10 | | 5.990E-09 | | 3.680E-05 |
| Ni-63 | 1.770E-04 | 1.250E-05 | 6.000E-06 | | | | 1.990E-06 |
| Ni-65 | 7.490E-07 | 9.570E-08 | 4.360E-08 | | | | 5.190E-06 |
| Np-239 | 1.760E-09 | 1.660E-10 | 9.220E-11 | | 5.210E-10 | | 2.670E-05 |
| P-32 | 2.760E-04 | 1.710E-05 | 1.070E-05 | | | | 2.320E-05 |
| Pm-147 | 1.050E-07 | 9.960E-09 | 4.060E-09 | | 1.900E-08 | | 9.470E-06 |
| Pm-149 | 2.170E-09 | 3.050E-10 | 1.250E-10 | | 5.810E-10 | | 4.490E-05 |
| Pr-143 | 1.310E-08 | 5.230E-09 | 6.520E-10 | | 3.040E-09 | | 4.310E-05 |
| Pr-144 | 4.300E-11 | 1.760E-11 | 2.180E-12 | | 1.010E-11 | | 4.740E-14 |
| Rb-86 | | 2.980E-05 | 1.400E-05 | | | | 4.410E-06 |
| Rb-88 | | 8.520E-08 | 4.540E-08 | | | | 7.300E-15 |
| Rb-89 | | 5.500E-08 | 3.890E-08 | | | | 8.430E-17 |
| Rh-105 | 1.730E-07 | 1.250E-07 | 8.200E-08 | | 5.310E-07 | | 1.590E-05 |
| Ru-103 | 2.550E-07 | | 1.090E-07 | | 8.990E-07 | | 2.130E-05 |
| Ru-105 | 2.180E-08 | | 8.460E-09 | | 2.750E-07 | | 1.760E-05 |
| Ru-106 | 3.920E-06 | | 4.940E-07 | | 7.560E-06 | | 1.880E-04 |
| Sb-122 | 7.040E-07 | 4.810E-07 | 7.780E-06 | 9.630E-08 | 3.500E-07 | 1.300E-07 | 8.150E-05 |
| Sb-124 | 3.870E-06 | 7.130E-08 | 1.510E-06 | 8.780E-09 | | 3.380E-06 | 7.800E-05 |
| Sb-125 | 2.480E-06 | 2.710E-08 | 5.800E-07 | 2.370E-09 | | 2.180E-06 | 1.930E-05 |
| Sb-126 | 1.590E-06 | 3.250E-08 | 5.710E-07 | 8.990E-09 | | 1.140E-06 | 9.410E-05 |
| Sb-127 | 3.630E-07 | 7.760E-09 | 1.370E-07 | 4.080E-09 | | 2.470E-07 | 6.160E-05 |
| Sc-46 | 7.240E-09 | 1.410E-08 | 4.180E-09 | | 1.350E-08 | | 4.800E-05 |
| Se-75 | 7.660E-06 | 3.460E-06 | 9.620E-06 | 4.180E-06 | 3.460E-06 | 6.140E-06 | 3.460E-06 |
| Sm-151 | 8.730E-08 | 1.680E-08 | 3.940E-09 | | 1.840E-08 | | 5.700E-06 |
| Sm-153 | 1.220E-09 | 1.010E-09 | 7.430E-11 | | 3.300E-10 | | 2.850E-05 |
| Sn-113 | 1.040E-06 | 2.070E-07 | 3.410E-06 | 1.000E-07 | 2.700E-07 | 1.220E-07 | 3.670E-05 |
| Sn-117m | 1.890E-06 | 8.150E-08 | 3.260E-06 | 1.520E-08 | 1.150E-07 | 2.780E-08 | 3.670E-05 |
| Sr-89 | 4.400E-04 | | 1.260E-05 | | | | 5.240E-05 |
| Sr-90 | 8.300E-03 | | 2.050E-03 | | | | 2.330E-04 |
| Sr-91 | 8.070E-06 | | 3.210E-07 | | | | 3.660E-05 |
| Sr-92 | 3.050E-06 | | 1.300E-07 | | | | 7.770E-05 |
| Tc-101 | 3.600E-10 | 5.120E-10 | 5.030E-09 | | 9.260E-09 | 3.120E-10 | 8.750E-17 |
| Tc-99 | 1.790E-07 | 2.630E-07 | 7.170E-88 | | 3.340E-06 | 2.720E-08 | 6.440E-06 |
| Tc-99m | 3.320E-10 | 9.260E-10 | 1.200E-08 | | 1.380E-08 | 5.140E-10 | 6.080E-07 |
| Te-123m | 1.130E-05 | 1.630E-06 | 7.890E-07 | 2.300E-06 | 1.870E-05 | | 1.150E-05 |
| Te-125m | 3.830E-06 | 1.380E-06 | 5.120E-07 | 1.070E-06 | | | 1.130E-05 |

TABLE 10-9
INGESTION PATHWAY DOSE FACTORS - TEEN
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Te-127 | 1.580E-07 | 5.600E-08 | 3.400E-08 | 1.090E-07 | 6.400E-07 | | 1.220E-05 |
| Te-127m | 9.670E-06 | 3.430E-06 | 1.150E-06 | 2.300E-06 | 3.920E-05 | | 2.410E-05 |
| Te-129 | 4.480E-08 | 1.670E-08 | 1.090E-08 | 3.200E-08 | 1.880E-07 | | 2.450E-07 |
| Te-129m | 1.630E-05 | 6.050E-06 | 2.580E-06 | 5.260E-06 | 6.820E-05 | | 6.120E-05 |
| Te-131 | 2.790E-08 | 1.150E-08 | 8.720E-09 | 2.150E-08 | 1.220E-07 | | 2.290E-09 |
| Te-131m | 2.440E-06 | 1.170E-06 | 9.760E-07 | 1.760E-06 | 1.220E-05 | | 9.390E-05 |
| Te-132 | 3.490E-06 | 2.210E-06 | 2.080E-06 | 2.330E-06 | 2.120E-05 | | 7.000E-05 |
| Te-134 | 4.470E-08 | 2.870E-08 | 3.000E-08 | 3.670E-08 | 2.740E-07 | | 1.660E-09 |
| U-235 | 1.140E-03 | | 6.940E-05 | | 2.670E-04 | | 8.280E-05 |
| U-238 | 1.090E-03 | | 6.490E-05 | | 2.500E-04 | | 5.850E-05 |
| W-187 | 1.460E-07 | 1.190E-07 | 4.170E-08 | | | | 3.220E-05 |
| Y-90 | 1.370E-08 | | 3.690E-10 | | | | 1.130E-04 |
| Y-91 | 2.010E-07 | | 5.390E-09 | | | | 8.240E-05 |
| Y-91m | 1.290E-10 | | 4.930E-12 | | | | 6.090E-09 |
| Y-92 | 1.210E-09 | | 3.500E-11 | | | | 3.320E-05 |
| Y-93 | 3.830E-09 | | 1.050E-10 | | | | 1.170E-04 |
| Zn-65 | 5.760E-06 | 2.000E-05 | 9.330E-06 | | 1.280E-05 | | 8.470E-06 |
| Zn-69 | 1.470E-08 | 2.800E-08 | 1.960E-09 | | 1.830E-08 | | 5.160E-08 |
| Zn-69m | 2.400E-07 | 5.660E-07 | 5.190E-08 | | 3.440E-07 | | 3.110E-05 |
| Zr-95 | 4.120E-08 | 1.300E-08 | 8.940E-09 | | 1.910E-08 | | 3.000E-05 |
| Zr-97 | 2.370E-09 | 4.690E-10 | 2.160E-10 | | 7.110E-10 | | 1.270E-04 |

TABLE 10-10
INGESTION PATHWAY DOSE FACTORS - CHILD
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Ag-110m | 5.390E-07 | 3.640E-07 | 2.910E-07 | | 6.780E-07 | | 4.330E-05 |
| Am-241 | 1.430E-03 | 6.400E-04 | 1.020E-04 | | 6.230E-04 | | 7.640E-05 |
| As-76 | 1.330E-06 | 3.700E-06 | 2.150E-05 | 1.260E-06 | 4.070E-06 | 1.260E-06 | 1.930E-04 |
| Ba-139 | 4.140E-07 | 2.210E-10 | 1.200E-08 | | 1.930E-10 | 1.300E-10 | 2.390E-05 |
| Ba-140 | 8.310E-05 | 7.280E-08 | 4.850E-06 | | 2.370E-08 | 4.340E-08 | 4.210E-05 |
| Ba-141 | 2.000E-07 | 1.120E-10 | 6.510E-09 | | 9.690E-11 | 6.580E-10 | 1.140E-07 |
| Ba-142 | 8.740E-08 | 6.290E-11 | 4.880E-09 | | 5.090E-11 | 3.700E-11 | 1.140E-09 |
| Br-82 | | | 7.550E-06 | | | | |
| Br-83 | | | 1.710E-07 | | | | |
| Br-84 | | | 1.980E-07 | | | | |
| Br-85 | | | 9.120E-09 | | | | |
| C-14 | 1.210E-05 | 2.420E-06 | 2.420E-06 | 2.420E-06 | 2.420E-06 | 2.420E-06 | 2.420E-06 |
| Ce-141 | 3.970E-08 | 1.980E-08 | 2.940E-09 | | 8.680E-09 | | 2.470E-05 |
| Ce-143 | 6.990E-09 | 3.790E-06 | 5.490E-10 | | 1.590E-09 | | 5.550E-05 |
| Ce-144 | 2.080E-06 | 6.520E-07 | 1.110E-07 | | 3.610E-07 | | 1.700E-04 |
| Co-57 | | 4.930E-07 | 9.980E-07 | | | | 4.040E-06 |
| Co-58 | | 1.800E-06 | 5.510E-06 | | | | 1.050E-05 |
| Co-60 | | 5.290E-06 | 1.560E-05 | | | | 2.930E-05 |
| Cr-51 | | | 8.900E-09 | 4.940E-09 | 1.350E-09 | 9.020E-09 | 4.720E-07 |
| Cs-134 | 2.340E-04 | 3.840E-04 | 8.100E-05 | | 1.190E-04 | 4.270E-05 | 2.070E-06 |
| Cs-134m | 8.440E-08 | 1.250E-07 | 8.160E-08 | | 6.590E-08 | 1.090E-08 | 1.580E-07 |
| Cs-136 | 2.350E-05 | 6.460E-05 | 4.180E-05 | | 3.440E-05 | 5.130E-06 | 2.270E-06 |
| Cs-137 | 3.270E-04 | 3.130E-04 | 4.620E-05 | | 1.020E-04 | 3.670E-05 | 1.960E-06 |
| Cs-138 | 2.280E-07 | 3.170E-07 | 2.010E-07 | | 2.230E-07 | 2.400E-08 | 1.460E-07 |
| Cu-64 | | 2.450E-07 | 1.480E-07 | | 5.920E-07 | | 1.150E-05 |
| Eu-152 | 6.150E-07 | 1.120E-07 | 1.330E-07 | | 4.730E-07 | | 1.840E-05 |
| F-18 | 2.490E-06 | | 2.470E-07 | | | | 6.470E-07 |
| Fe-55 | 1.150E-05 | 6.100E-06 | 1.890E-06 | | | 3.450E-06 | 1.130E-06 |
| Fe-59 | 1.650E-05 | 2.670E-05 | 1.330E-05 | | | 7.740E-06 | 2.780E-05 |
| H-3 | | 2.030E-07 | 2.030E-07 | 2.030E-07 | 2.030E-07 | 2.030E-07 | 2.030E-07 |
| I-129 | 1.390E-05 | 8.530E-06 | 7.620E-06 | 5.580E-03 | 1.440E-05 | | 4.290E-07 |
| I-130 | 2.920E-06 | 5.900E-06 | 3.040E-06 | 6.500E-04 | 8.820E-06 | | 2.760E-06 |
| I-131 | 1.720E-05 | 1.730E-05 | 9.830E-06 | 5.720E-03 | 2.840E-05 | | 1.540E-06 |
| I-132 | 8.000E-07 | 1.470E-06 | 6.760E-07 | 6.820E-05 | 2.250E-06 | | 1.730E-06 |
| I-133 | 5.920E-06 | 7.320E-06 | 2.770E-06 | 1.360E-03 | 1.220E-05 | | 2.950E-06 |
| I-134 | 4.190E-07 | 7.780E-07 | 3.580E-07 | 1.790E-05 | 1.190E-06 | | 5.160E-07 |
| I-135 | 1.750E-06 | 3.150E-06 | 1.490E-06 | 2.790E-04 | 4.830E-06 | | 2.400E-06 |
| La-140 | 1.010E-08 | 3.530E-09 | 1.190E-09 | | | | 9.840E-05 |
| La-142 | 5.240E-10 | 1.670E-10 | 5.230E-11 | | | | 3.310E-05 |
| Mn-54 | | 1.070E-05 | 2.850E-06 | | 3.000E-06 | | 8.980E-06 |
| Mn-56 | | 3.340E-07 | 7.540E-08 | | 4.040E-07 | | 4.840E-05 |

TABLE 10-10
INGESTION PATHWAY DOSE FACTORS - CHILD
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Mo-99 | | 1.330E-05 | 3.290E-06 | | 2.840E-05 | | 1.100E-05 |
| Na-22 | 5.880E-05 | 5.880E-05 | 5.880E-05 | 5.880E-05 | 5.880E-05 | 5.880E-05 | 5.880E-05 |
| Na-24 | 5.800E-06 | 5.800E-06 | 5.800E-06 | 5.800E-06 | 5.800E-06 | 5.800E-06 | 5.800E-06 |
| Nb-95 | 2.250E-08 | 8.760E-09 | 6.260E-09 | | 8.230E-09 | | 1.620E-05 |
| Nb-97 | 2.170E-10 | 3.920E-11 | 1.830E-11 | | 4.350E-11 | | 1.210E-05 |
| Nd-147 | 2.790E-08 | 2.260E-08 | 1.750E-09 | | 1.240E-08 | | 3.580E-05 |
| Ni-63 | 5.380E-04 | 2.880E-05 | 1.830E-05 | | | | 1.940E-06 |
| Ni-65 | 2.220E-06 | 2.090E-07 | 1.220E-07 | | | | 2.560E-05 |
| Np-239 | 5.250E-09 | 3.770E-10 | 2.650E-10 | | 1.090E-09 | | 2.790E-05 |
| P-32 | 8.250E-04 | 3.860E-05 | 3.180E-05 | | | | 2.280E-05 |
| Pm-147 | 3.180E-07 | 2.270E-08 | 1.220E-08 | | 4.010E-08 | | 9.190E-06 |
| Pm-149 | 5.490E-09 | 6.900E-10 | 3.740E-10 | | 1.220E-09 | | 4.710E-05 |
| Pr-143 | 3.930E-08 | 1.180E-08 | 1.950E-09 | | 6.390E-09 | | 4.240E-05 |
| Pr-144 | 1.290E-10 | 3.990E-11 | 6.490E-12 | | 2.110E-11 | | 8.590E-08 |
| Rb-86 | | 6.700E-05 | 4.120E-05 | | | | 4.310E-06 |
| Rb-88 | | 1.900E-07 | 1.320E-07 | | | | 9.320E-09 |
| Rb-89 | | 1.170E-07 | 1.040E-07 | | | | 1.020E-09 |
| Rh-105 | 5.140E-07 | 2.760E-07 | 2.360E-07 | | 1.100E-06 | | 1.710E-05 |
| Ru-103 | 7.310E-07 | | 2.810E-07 | | 1.840E-06 | | 1.890E-05 |
| Ru-105 | 6.450E-08 | | 2.340E-08 | | 5.670E-07 | | 4.210E-05 |
| Ru-106 | 1.170E-05 | | 1.460E-06 | | 1.580E-05 | | 1.820E-04 |
| Sb-122 | 2.040E-06 | 1.220E-06 | 2.260E-05 | 2.670E-07 | 7.410E-07 | 3.480E-07 | 2.440E-04 |
| Sb-124 | 1.110E-05 | 1.440E-07 | 3.890E-06 | 2.450E-08 | | 6.160E-06 | 6.940E-05 |
| Sb-125 | 7.160E-06 | 5.520E-08 | 1.500E-06 | 6.630E-09 | | 3.990E-06 | 1.710E-05 |
| Sb-126 | 4.400E-06 | 6.730E-08 | 1.580E-06 | 2.580E-08 | | 2.100E-06 | 8.870E-05 |
| Sb-127 | 1.060E-05 | 1.640E-08 | 3.680E-07 | 1.180E-08 | | 4.600E-07 | 5.970E-05 |
| Sc-46 | 1.970E-08 | 2.700E-08 | 1.040E-08 | | 2.390E-08 | | 3.950E-05 |
| Se-75 | 7.660E-06 | 3.460E-06 | 9.620E-06 | 4.180E-06 | 3.460E-06 | 6.140E-06 | 3.460E-06 |
| Sm-151 | 2.560E-07 | 3.810E-08 | 1.200E-08 | | 3.940E-08 | | 5.530E-06 |
| Sm-153 | 3.650E-09 | 2.270E-09 | 2.190E-10 | | 6.910E-10 | | 3.020E-05 |
| Sn-113 | 2.930E-06 | 6.300E-07 | 9.630E-06 | 2.520E-07 | 6.670E-07 | 3.150E-07 | 1.070E-04 |
| Sn-117m | 5.930E-06 | 2.810E-07 | 9.260E-06 | 4.440E-08 | 2.850E-07 | 8.150E-08 | 1.070E-04 |
| Sr-89 | 1.320E-03 | | 3.770E-05 | | | | 5.110E-05 |
| Sr-90 | 1.700E-02 | | 4.310E-03 | | | | 2.290E-04 |
| Sr-91 | 2.400E-05 | | 9.060E-07 | | | | 5.300E-05 |
| Sr-92 | 9.030E-06 | | 3.620E-07 | | | | 1.710E-04 |
| Tc-101 | 1.070E-09 | 1.120E-09 | 1.420E-08 | | 1.910E-08 | 5.920E-10 | 3.560E-09 |
| Tc-99 | 5.350E-07 | 5.960E-07 | 2.140E-07 | | 7.020E-06 | 5.270E-08 | 6.250E-06 |
| Tc-99m | 9.230E-10 | 1.810E-09 | 3.000E-08 | | 2.630E-08 | 9.190E-10 | 1.030E-06 |
| Te-123m | 3.360E-05 | 3.710E-06 | 2.350E-06 | 6.920E-06 | 3.930E-05 | | 1.120E-05 |
| Te-125m | 1.140E-05 | 3.090E-06 | 1.520E-06 | 3.200E-06 | | | 1.100E-05 |

TABLE 10-10
INGESTION PATHWAY DOSE FACTORS - CHILD
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Te-127 | 4.710E-07 | 1.270E-07 | 1.010E-07 | 3.260E-07 | 1.340E-06 | | 1.840E-05 |
| Te-127m | 2.890E-05 | 7.780E-06 | 3.430E-06 | 6.910E-06 | 8.240E-05 | | 2.340E-05 |
| Te-129 | 1.340E-07 | 3.740E-08 | 3.180E-08 | 9.560E-08 | 3.920E-07 | | 8.340E-06 |
| Te-129m | 4.870E-05 | 1.360E-05 | 7.560E-06 | 1.570E-05 | 1.430E-04 | | 5.940E-05 |
| Te-131 | 8.300E-08 | 2.530E-08 | 2.470E-08 | 6.350E-08 | 2.510E-07 | | 4.360E-07 |
| Te-131m | 7.200E-06 | 2.490E-06 | 2.650E-06 | 5.120E-06 | 2.410E-05 | | 1.010E-04 |
| Te-132 | 1.010E-05 | 4.470E-06 | 5.400E-06 | 6.510E-06 | 4.150E-05 | | 4.500E-05 |
| Te-134 | 1.290E-07 | 5.800E-08 | 7.740E-08 | 1.020E-07 | 5.370E-07 | | 5.890E-07 |
| U-235 | 3.420E-03 | | 2.070E-04 | | 5.610E-04 | | 8.030E-05 |
| U-238 | 3.270E-03 | | 1.940E-04 | | 5.240E-04 | | 5.660E-05 |
| W-187 | 4.290E-07 | 2.540E-07 | 1.140E-07 | | | | 3.570E-05 |
| Y-90 | 4.110E-08 | | 1.100E-09 | | | | 1.170E-04 |
| Y-91 | 6.020E-07 | | 1.610E-08 | | | | 8.020E-05 |
| Y-91m | 3.820E-10 | | 1.390E-11 | | | | 7.480E-07 |
| Y-92 | 3.600E-09 | | 1.030E-10 | | | | 1.040E-04 |
| Y-93 | 1.140E-08 | | 3.130E-10 | | | | 1.700E-04 |
| Zn-65 | 1.370E-05 | 3.650E-05 | 2.270E-05 | | 2.300E-05 | | 6.410E-06 |
| Zn-69 | 4.380E-08 | 6.330E-08 | 5.850E-09 | | 3.840E-08 | | 3.990E-06 |
| Zn-69m | 7.100E-07 | 1.210E-06 | 1.430E-07 | | 7.030E-07 | | 3.940E-05 |
| Zr-95 | 1.160E-07 | 2.550E-08 | 2.270E-08 | | 3.650E-08 | | 2.660E-05 |
| Zr-97 | 6.990E-09 | 1.010E-09 | 5.960E-10 | | 1.450E-09 | | 1.530E-04 |

TABLE 10-11
INGESTION PATHWAY DOSE FACTORS - INFANT
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Ag-110m | 9.960E-07 | 7.270E-07 | 4.810E-07 | | 1.040E-06 | | 3.770E-05 |
| Am-241 | 1.530E-03 | 7.180E-04 | 1.090E-04 | | 6.550E-04 | | 7.700E-05 |
| As-76 | 8.148E-06 | 2.150E-05 | 3.700E-05 | 8.148E-06 | 2.260E-05 | 8.150E-06 | 2.370E-04 |
| Ba-139 | 8.810E-07 | 5.840E-10 | 2.550E-08 | | 3.510E-10 | 3.540E-10 | 5.580E-05 |
| Ba-140 | 1.710E-04 | 1.710E-07 | 8.810E-06 | | 4.060E-08 | 1.050E-07 | 4.200E-05 |
| Ba-141 | 4.250E-07 | 2.910E-10 | 1.340E-08 | | 1.750E-10 | 1.770E-10 | 5.190E-06 |
| Ba-142 | 1.840E-07 | 1.530E-10 | 9.060E-09 | | 8.810E-11 | 9.260E-11 | 7.590E-07 |
| Br-82 | | | 1.270E-05 | | | | |
| Br-83 | | | 3.630E-07 | | | | |
| Br-84 | | | 3.820E-07 | | | | |
| Br-85 | | | 1.940E-08 | | | | |
| C-14 | 2.370E-05 | 5.060E-06 | 5.060E-06 | 5.060E-06 | 5.060E-06 | 5.060E-06 | 5.060E-06 |
| Ce-141 | 7.870E-08 | 4.800E-08 | 5.650E-09 | | 1.480E-08 | | 2.480E-05 |
| Ce-143 | 1.480E-08 | 9.820E-06 | 1.120E-09 | | 2.860E-09 | | 5.730E-05 |
| Ce-144 | 2.980E-06 | 1.220E-06 | 1.670E-07 | | 4.930E-07 | | 1.710E-04 |
| Co-57 | | 1.150E-06 | 1.870E-06 | | | | 3.920E-06 |
| Co-58 | | 3.600E-06 | 8.980E-06 | | | | 8.970E-06 |
| Co-60 | | 1.080E-05 | 2.550E-05 | | | | 2.570E-05 |
| Cr-51 | | | 1.410E-08 | 9.200E-09 | 2.010E-09 | 1.790E-08 | 4.110E-07 |
| Cs-134 | 3.770E-04 | 7.030E-04 | 7.100E-05 | | 1.810E-04 | 7.420E-05 | 1.910E-06 |
| Cs-134m | 1.760E-07 | 2.930E-07 | 1.480E-07 | | 1.130E-07 | 2.600E-08 | 2.320E-07 |
| Cs-136 | 4.590E-05 | 1.350E-04 | 5.040E-05 | | 5.380E-05 | 1.100E-05 | 2.050E-06 |
| Cs-137 | 5.220E-04 | 6.110E-04 | 4.330E-05 | | 1.640E-04 | 6.640E-05 | 1.910E-06 |
| Cs-138 | 4.810E-07 | 7.820E-07 | 3.790E-07 | | 3.900E-07 | 6.090E-08 | 1.250E-06 |
| Cu-64 | | 6.090E-07 | 2.820E-07 | | 1.030E-06 | | 1.250E-05 |
| Eu-152 | 6.740E-07 | 1.790E-07 | 1.510E-07 | | 5.030E-07 | | 1.590E-05 |
| F-18 | 5.190E-06 | | 4.430E-07 | | | | 1.220E-06 |
| Fe-55 | 1.390E-05 | 8.980E-06 | 2.400E-06 | | | 4.390E-06 | 1.140E-06 |
| Fe-59 | 3.080E-05 | 5.380E-05 | 2.120E-05 | | | 1.590E-05 | 2.570E-05 |
| H-3 | | 3.080E-07 | 3.080E-07 | 3.080E-07 | 3.080E-07 | 3.080E-07 | 3.080E-07 |
| I-129 | 2.860E-05 | 2.120E-05 | 1.550E-05 | 1.360E-02 | 2.510E-05 | | 4.240E-07 |
| I-130 | 6.000E-06 | 1.320E-05 | 5.300E-06 | 1.480E-03 | 1.450E-05 | | 2.830E-06 |
| I-131 | 3.590E-05 | 4.230E-05 | 1.860E-05 | 1.390E-02 | 4.940E-05 | | 1.510E-06 |
| I-132 | 1.660E-06 | 3.370E-06 | 1.200E-06 | 1.580E-04 | 3.760E-06 | | 2.730E-06 |
| I-133 | 1.250E-05 | 1.820E-05 | 5.330E-06 | 3.310E-03 | 2.140E-05 | | 3.080E-06 |
| I-134 | 8.690E-07 | 1.780E-06 | 6.330E-07 | 4.150E-05 | 1.990E-06 | | 1.840E-06 |
| I-135 | 3.640E-06 | 7.240E-06 | 2.640E-06 | 6.490E-04 | 8.070E-06 | | 2.620E-06 |
| La-140 | 2.110E-08 | 8.320E-09 | 2.140E-09 | | | | 9.770E-05 |
| La-142 | 1.100E-09 | 4.040E-10 | 9.670E-11 | | | | 6.860E-05 |
| Mn-54 | | 1.990E-05 | 4.510E-06 | | 4.410E-06 | | 7.310E-06 |
| Mn-56 | | 8.180E-07 | 1.410E-07 | | 7.030E-07 | | 7.430E-05 |

TABLE 10-11
INGESTION PATHWAY DOSE FACTORS - INFANT
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Mo-99 | | 3.400E-05 | 6.630E-06 | | 5.080E-05 | | 1.120E-05 |
| Na-22 | 9.830E-05 | 9.830E-05 | 9.830E-05 | 9.830E-05 | 9.830E-05 | 9.830E-05 | 9.830E-05 |
| Na-24 | 1.010E-05 | 1.010E-05 | 1.010E-05 | 1.010E-05 | 1.010E-05 | 1.010E-05 | 1.010E-05 |
| Nb-95 | 4.200E-08 | 1.730E-08 | 1.000E-08 | | 1.240E-08 | | 1.460E-05 |
| Nb-97 | 4.590E-10 | 9.790E-11 | 3.530E-11 | | 7.650E-11 | | 3.090E-05 |
| Nd-147 | 5.530E-08 | 5.680E-08 | 3.480E-09 | | 2.190E-08 | | 3.600E-05 |
| Ni-63 | 6.340E-04 | 3.920E-05 | 2.200E-05 | | | | 1.950E-06 |
| Ni-65 | 4.700E-06 | 5.320E-07 | 2.420E-07 | | | | 4.050E-05 |
| Np-239 | 1.110E-08 | 9.930E-10 | 5.610E-10 | | 1.980E-09 | | 2.870E-05 |
| P-32 | 1.700E-03 | 1.000E-04 | 6.590E-05 | | | | 2.300E-05 |
| Pm-147 | 3.880E-07 | 3.270E-08 | 1.590E-08 | | 4.880E-08 | | 9.270E-06 |
| Pm-149 | 1.380E-08 | 1.810E-09 | 7.900E-10 | | 2.200E-09 | | 4.860E-05 |
| Pr-143 | 8.130E-08 | 3.040E-08 | 4.030E-09 | | 1.130E-08 | | 4.290E-05 |
| Pr-144 | 2.740E-10 | 1.060E-10 | 1.380E-11 | | 3.840E-11 | | 4.930E-06 |
| Rb-86 | | 1.700E-04 | 8.400E-05 | | | | 4.350E-06 |
| Rb-88 | | 4.980E-07 | 2.730E-07 | | | | 4.850E-07 |
| Rb-89 | | 2.860E-07 | 1.970E-07 | | | | 9.740E-08 |
| Rh-105 | 1.090E-06 | 7.130E-07 | 4.790E-07 | | 1.980E-06 | | 1.770E-05 |
| Ru-103 | 1.480E-06 | | 4.950E-07 | | 3.080E-06 | | 1.800E-05 |
| Ru-105 | 1.360E-07 | | 4.580E-08 | | 1.000E-06 | | 5.410E-05 |
| Ru-106 | 2.410E-05 | | 3.010E-06 | | 2.850E-05 | | 1.830E-04 |
| Sb-122 | 7.778E-06 | 5.190E-06 | 6.670E-05 | 1.556E-06 | 2.480E-06 | 1.780E-06 | 7.040E-04 |
| Sb-124 | 2.140E-05 | 3.150E-07 | 6.630E-06 | 5.680E-08 | | 1.340E-05 | 6.600E-05 |
| Sb-125 | 1.230E-05 | 1.190E-07 | 2.530E-06 | 1.540E-08 | | 7.720E-06 | 1.640E-05 |
| Sb-126 | 8.060E-06 | 1.580E-07 | 2.910E-06 | 6.190E-08 | | 5.070E-06 | 8.350E-05 |
| Sb-127 | 2.230E-06 | 3.980E-08 | 6.900E-07 | 2.840E-08 | | 1.150E-06 | 5.910E-05 |
| Sc-46 | 3.750E-08 | 5.400E-08 | 1.690E-08 | | 3.560E-08 | | 3.530E-05 |
| Se-75 | 7.660E-06 | 3.460E-06 | 9.620E-06 | 4.180E-06 | 3.460E-06 | 6.140E-06 | 3.460E-06 |
| Sm-151 | 2.900E-07 | 6.670E-08 | 1.440E-08 | | 4.530E-08 | | 5.580E-06 |
| Sm-153 | 7.720E-09 | 5.970E-09 | 4.580E-10 | | 1.250E-09 | | 3.120E-05 |
| Sn-113 | 1.074E-05 | 2.150E-06 | 2.890E-05 | 1.140E-06 | 2.150E-06 | 1.440E-06 | 3.190E-04 |
| Sn-117m | 2.111E-05 | 8.520E-07 | 2.850E-05 | 2.407E-07 | 7.410E-07 | 3.480E-07 | 3.260E-04 |
| Sr-89 | 2.510E-03 | | 7.200E-05 | | | | 5.160E-05 |
| Sr-90 | 1.850E-02 | | 4.710E-03 | | | | 2.310E-04 |
| Sr-91 | 5.000E-05 | | 1.810E-06 | | | | 5.920E-05 |
| Sr-92 | 1.920E-05 | | 7.130E-07 | | | | 2.070E-04 |
| Tc-101 | 2.270E-09 | 2.860E-09 | 2.830E-08 | | 3.400E-08 | 1.560E-09 | 4.860E-07 |
| Tc-99 | 1.080E-06 | 1.460E-06 | 4.550E-07 | | 1.230E-05 | 1.420E-07 | 6.310E-06 |
| Tc-99m | 1.920E-09 | 3.960E-09 | 5.100E-08 | | 4.260E-08 | 2.070E-09 | 1.150E-06 |
| Te-123m | 6.810E-05 | 9.240E-06 | 4.860E-06 | 1.690E-05 | 6.860E-05 | | 1.120E-05 |
| Te-125m | 2.330E-05 | 7.790E-06 | 3.150E-06 | 7.840E-06 | | | 1.110E-05 |

TABLE 10-11
INGESTION PATHWAY DOSE FACTORS - INFANT
**(mrem/pCi ingested)**

| NUCLIDE | BONE | LIVER | TOTAL BODY | THYROID | KIDNEY | LUNG | GI-LLI |
|---|---|---|---|---|---|---|---|
| Te-127 | 1.000E-06 | 3.350E-07 | 2.150E-07 | 8.140E-07 | 2.440E-06 | | 2.100E-05 |
| Te-127m | 5.850E-05 | 1.940E-05 | 7.080E-06 | 1.690E-05 | 1.440E-04 | | 2.360E-05 |
| Te-129 | 2.840E-07 | 9.790E-08 | 6.630E-08 | 2.380E-07 | 7.070E-07 | | 2.270E-05 |
| Te-129m | 1.000E-04 | 3.430E-05 | 1.540E-05 | 3.840E-05 | 2.500E-04 | | 5.970E-05 |
| Te-131 | 1.760E-07 | 6.500E-08 | 4.940E-08 | 1.570E-07 | 4.500E-07 | | 7.110E-06 |
| Te-131m | 1.520E-05 | 6.120E-06 | 5.050E-06 | 1.240E-05 | 4.210E-05 | | 1.030E-04 |
| Te-132 | 2.080E-05 | 1.030E-05 | 9.610E-06 | 1.520E-05 | 6.440E-05 | | 3.810E-05 |
| Te-134 | 2.670E-07 | 1.340E-07 | 1.380E-07 | 2.390E-07 | 9.030E-07 | | 3.060E-06 |
| U-235 | 4.670E-03 | | 3.560E-04 | | 9.930E-04 | | 8.100E-05 |
| U-238 | 4.470E-03 | | 3.330E-04 | | 9.280E-04 | | 5.710E-05 |
| W-187 | 9.030E-07 | 6.280E-07 | 2.170E-07 | | | | 3.690E-05 |
| Y-90 | 8.690E-08 | | 2.330E-09 | | | | 1.200E-04 |
| Y-91 | 1.130E-06 | | 3.010E-08 | | | | 8.100E-05 |
| Y-91m | 8.100E-10 | | 2.760E-11 | | | | 2.700E-06 |
| Y-92 | 7.650E-09 | | 2.150E-10 | | | | 1.460E-04 |
| Y-93 | 2.430E-08 | | 6.620E-10 | | | | 1.920E-04 |
| Zn-65 | 1.840E-05 | 6.310E-05 | 2.910E-05 | | 3.060E-05 | | 5.330E-05 |
| Zn-69 | 9.330E-08 | 1.680E-07 | 1.250E-08 | | 6.980E-08 | | 1.370E-05 |
| Zn-69m | 1.500E-06 | 3.060E-06 | 2.790E-07 | | 1.240E-06 | | 4.240E-05 |
| Zr-95 | 2.060E-07 | 5.020E-08 | 3.560E-08 | | 5.410E-08 | | 2.500E-05 |
| Zr-97 | 1.480E-08 | 2.540E-09 | 1.160E-09 | | 2.560E-09 | | 1.620E-04 |

TABLE 10-12
GROUND PLANE PATHWAY DOSE FACTORS
**(mrem/hr per pCi/m$^2$)**

| NUCLIDE | TOTAL BODY AND ORGANS | | NUCLIDE | TOTAL BODY AND ORGANS | | NUCLIDE | TOTAL BODY AND ORGANS |
|---|---|---|---|---|---|---|---|
| Ag-110m | 1.80E-08 | | I-133 | 3.70E-09 | | Sc-46 | 2.57E-08 |
| Am-241 | 3.67E-10 | | I-134 | 1.60E-08 | | Sm-151 | 5.24E-13 |
| As-76 | 5.65E-09 | | I-135 | 1.20E-08 | | Sm-153 | 1.02E-09 |
| Ba-139 | 2.40E-09 | | La-140 | 1.50E-08 | | Sn-113 | 2.84E-10 |
| Ba-140 | 2.10E-09 | | La-142 | 1.50E-08 | | Sn-117m | 2.01E-09 |
| Ba-141 | 4.30E-09 | | Mn-54 | 5.80E-09 | | Sr-89 | 5.60E-13 |
| Ba-142 | 7.90E-09 | | Mn-56 | 1.10E-08 | | Sr-90 | 3.79E-12 |
| Br-82 | 3.40E-08 | | Mo-99 | 1.90E-09 | | Sr-91 | 7.10E-09 |
| Br-83 | 6.40E-11 | | Na-22 | 2.80E-08 | | Sr-92 | 9.00E-09 |
| Br-84 | 1.20E-08 | | Na-24 | 2.50E-08 | | Tc-101 | 2.70E-09 |
| C-14 | 0.00E+00 | | Nb-95 | 5.10E-09 | | Tc-99 | 1.04E-12 |
| Ce-141 | 5.50E-10 | | Nb-97 | 8.60E-09 | | Tc-99m | 9.60E-10 |
| Ce-143 | 2.20E-09 | | Nd-147 | 1.00E-09 | | Te-125m | 3.50E-11 |
| Ce-144 | 3.20E-10 | | Ni-65 | 3.70E-09 | | Te-127 | 1.00E-11 |
| Co-57 | 1.53E-09 | | Np-239 | 9.50E-10 | | Te-127m | 1.10E-12 |
| Co-58 | 7.00E-09 | | Pm-147 | 6.13E-14 | | Te-129 | 7.10E-10 |
| Co-60 | 1.70E-08 | | Pm-149 | 1.54E-10 | | Te-129m | 7.70E-10 |
| Cr-51 | 2.20E-10 | | Pr-144 | 2.00E-10 | | Te-131 | 2.20E-09 |
| Cs-134 | 1.20E-08 | | Rb-86 | 6.30E-10 | | Te-131m | 8.40E-09 |
| Cs-134m | 3.45E-10 | | Rb-88 | 3.50E-09 | | Te-132 | 1.70E-09 |
| Cs-136 | 1.50E-08 | | Rb-89 | 1.50E-08 | | Te-134 | 1.07E-08 |
| Cs-137 | 4.20E-09 | | Rh-103m | 4.65E-11 | | U-235 | 1.97E-09 |
| Cs-138 | 2.10E-08 | | Rh-105 | 1.02E-09 | | U-238 | 7.35E-12 |
| Cu-64 | 1.50E-09 | | Rh-106 | 3.32E-09 | | W-187 | 3.10E-09 |
| Eu-152 | 1.47E-08 | | Ru-103 | 3.60E-09 | | Y-90 | 2.20E-12 |
| F-18 | 1.35E-08 | | Ru-105 | 4.50E-09 | | Y-91 | 2.40E-11 |
| Fe-59 | 8.00E-09 | | Ru-106 | 1.50E-09 | | Y-91m | 3.80E-09 |
| H-3 | 0.00E+00 | | Sb-122 | 5.81E-09 | | Y-92 | 1.60E-09 |
| I-129 | 9.97E-10 | | Sb-124 | 2.28E-08 | | Y-93 | 5.70E-10 |
| I-130 | 1.40E-08 | | Sb-125 | 5.67E-09 | | Zn-65 | 4.00E-09 |
| I-131 | 2.80E-09 | | Sb-126 | 8.90E-09 | | Zn-69m | 5.49E-09 |
| I-132 | 1.70E-08 | | Sb-127 | 1.16E-08 | | Zr-95 | 5.00E-09 |
| | | | | | | Zr-97 | 5.50E-09 |

## 11.0 DETERMINATION OF TOTAL DOSE

The purpose of this section is to describe the method used to calculate the cumulative dose contributions from liquid and gaseous effluents in accordance with PBNP Technical Specifications for total dose. This method can also be used to demonstrate compliance with the Environmental Protection Agency (EPA) 40CFR190, “Environmental Standards for the Uranium Fuel Cycle”.

Compliance with the PBNP Technical Specification dose objectives for the maximum individual demonstrates compliance with the EPA limits to any MEMBER OF THE PUBLIC, since the design dose objectives from 10CFR50, Appendix I are much lower than the 40CFR190 dose limits to the general public. With the calculated doses from the releases of radioactive materials in liquid or gaseous effluents exceeding twice the limits outlined in Sections 6.2.1, 7.2.1 and 7.3.1, a special analysis shall be performed. The purpose of this analysis is to demonstrate if the total dose to any MEMBER OF THE PUBLIC (real individual) from all URANIUM FUEL CYCLE sources (including direct radiation contributions from the reactor units and from outside storage areas and from all real pathways) is limited to less than or equal to 25 mrem per year to the total body or any organ, except the thyroid, which is limited to 75 mrem per year.

If required, the total dose to a MEMBER OF THE PUBLIC will be calculated for all significant effluent release points for all real pathways including direct radiation. As necessary, effluent releases from Kewaunee Nuclear Power Plant must also be considered due to its proximity. Calculations will be based on the equations in Sections 9.2, 10.5, 10.6 with the exception that usage factors and other site specific parameters may be modified using more realistic assumptions, where appropriate.

The direct radiation component from the facility can be determined using environmental TLD results. These results will be corrected for natural background and for actual occupancy time of any areas accessible to the general public at the location of maximum direct radiation. It is recognized that by including the results from the environmental TLDs into the sum of total dose component, the direct radiation dose may be overestimated. The TLD measurements may include the exposure from noble gases, ground plane deposition, and shoreline deposition, which have already been included in the summation of the significant dose pathways to the general public. However, this conservative method can be used, if required, as well as any other method for estimating the direct radiation dose form contained radioactive sources within the facility. The methodology used to incorporate the direct radiation component into total dose estimates will be outlined whenever total doses are reported.

Therefore, the total dose will be determined based on the most realistic site specific data and parameters to assess the real dose to any MEMBER OF THE PUBLIC.

# 12.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

## 12.1 REMP Administration

### 12.1.1 Definition and Basis

Radiological environmental monitoring is the measurement of radioactivity in samples collected from the atmospheric, aquatic and terrestrial environment around the Point Beach Nuclear Plant (PBNP). Monitoring radioactivity in effluent streams at or prior to the point of discharge to the environment is not part of the Radiological Environmental Monitoring Program (REMP).

The REMP is designed to fulfill the requirements of 10 CFR 20.1302, PBNP GDC 17, and Sections IV.B.2 and IV.B.3 of Appendix I to 10 CFR 50. Technical Specification 5.5.1.b requires the Offsite Dose Calculation Manual (ODCM) to contain the radiological environmental monitoring activities.

No significant radionuclide concentrations of plant origin are expected in the plant environs because radioactivity in plant effluent is continuously monitored to ensure that releases are well below levels which are considered safe upper limits. The REMP is conducted to demonstrate compliance with applicable standards, to assess the radiological environmental impact of PBNP operations, and to monitor the efficacy of in plant effluent controls. The REMP, as outlined in Table 12-2 through Table 12-3 is designed to provide sufficient sample types and locations to detect and to evaluate changes in environmental radioactivity.

Radioactivity is released in liquid and gaseous effluents. Air samplers and thermoluminescent dosimeters placed at various locations provide means of detecting changes in environmental radioactivity as a result of plant releases to the atmosphere. Sampling of vegetation is conducted to determine changes in radiological conditions at the base of the food chain because the land around PBNP is used for farming. Sampling of area-produced milk is conducted because dairy farming is a major industry in the area. Land in the vicinity of PBNP is used for farming, dairy purposes, and solar power projects.

Water and fish are analyzed to monitor radionuclide levels in Lake Michigan in the vicinity of PBNP. Because of the migratory behavior of fish, fish sampling is of minimal value for determining radiological impact specifically related to the operation of the Point Beach Nuclear Plant. However, fish sampling is carried out in order to monitor the status of radioactivity in fish in the vicinity of Point Beach.

Vegetation and fish sampling frequencies are qualified on an "as available" basis recognizing that certain biological samples may occasionally be unavailable due to environmental conditions.

12.1.2 Responsibilities

a. Chemistry Functions

Chemistry together with Regulatory Affairs (RA) provides the Plant Manager with the technical, regulatory, licensing, and administrative support necessary for the implementation of the program. The Chemistry administrative functions relating to the REMP fall into the six broad areas outlined below.

1. Program Scope

The scope of the REMP is determined by the cognizant Chemist based on radiological principles for the fulfillment of PBNP Technical Specifications (TS) and the applicable Federal Regulations. Based on the scope, the ODCM is written to accomplish the collection and analyses of the necessary environmental samples, and revised as necessary to conform to changes in procedures and scope. Chemistry monitors the REMP effectiveness and compliance with TS and with the procedures and directives in the ODCM. In order to verify compliance with TS, Nuclear Oversight arranges for program audits and Supplier Assessments of the contracted radioanalytical laboratory. Chemistry reviews the REMP annually via the Annual Monitoring Report.

2. Record Keeping

The monthly radioanalytical results from the contracted laboratory are reviewed by Chemistry and one copy of the monthly radioanalytical results from the contracted laboratory is kept for the lifetime of the plant. The vendors monthly reports are cumulative (e.g. The September report contains all the results from January-September). The cognizant Chemist reviews the current months results and sends the reviewed report to plants records for retention.

3. Data Monitoring

Chemistry reviews the monthly analytical results from the vendor. Trends, if any, are noted. Any resulting corrections, modifications and additions to the data are made by Chemistry. Inconsistencies are investigated by Chemistry with the cooperation of Radiation Protection (RP) and contractor personnel, as required. Radioactivity levels in excess of administrative notification levels would be evaluated and notifications made, as appropriate, in accordance with applicable fleet policies and procedures (LI-AA-102-1001).

4. Data Summary

Pursuant to TS 5.6.2, REMP results shall be summarized annually for inclusion in the PBNP Annual Monitoring Report. This summary advises the Plant Manager of the radiological status of the environment in the vicinity of PBNP. The summary shall include the numbers and types of samples as well as the averages, statistical confidence limits and the ranges of analytical results. Methods used in summarizing data are at the discretion of Chemistry.

5. Contractor Communications

Communication with the contractor regarding data, analytical procedures, lower limits of detection, notification levels and contractual matters are normally conducted by Chemistry. Communication regarding sample shipment may be done by either RP or Chemistry as appropriate.

6. Reportable Items

Chemistry shall generate reports related to the operation of the REMP. The material included shall be sufficient to fulfill the objectives outlined in Sections IV.B.2 and IV.B.3 of Appendix I to 10 CFR 50. The following items specific to the REMP are required to be reported in the PBNP Annual Monitoring Report:

(a) Summary and discussion of monitoring results including number and type of samples and measurements, and all detected radionuclides, except for naturally occurring radionuclides;

(b) Unavailable, missing, and lost samples and plans to prevent recurrence and comments on any significant portion of the REMP not conducted as indicated in Table 12-3.

(c) New or relocated sampling locations and reason for change;

(d) LLDs that are higher than specified in Table 12-1 and factors contributing to inability to achieve specified LLDs;

(e) Notification that the analytical laboratory does not participate in an interlaboratory comparison program and corrective action taken to preclude a recurrence; and

(f) Results of the annual milk sampling program land use census "milk survey" to visually verify that the location of grazing animals in the vicinity of the PBNP site boundary so as to ensure that the milk sampling program remains as conservative as practicable.

(g) The annual results from the contracted REMP analytical laboratory as well as the laboratory's analytical QA/QC results, in-house blanks, interlaboratory comparisons, etc., shall be submitted to the NRC, via the Annual Monitoring Report.

b. Non-Chemistry Functions

The primary responsibility for the implementation of the PBNP REMP and for any actions to be taken at PBNP, based on the results of the program, resides with the Plant Manager.

1. Manual control and distribution

The distribution of the PBNP Offsite Dose Calculation Manual is the responsibility of Document Control.

2. Program coordination

The daily operation of the program is conducted by PBNP Radiation Protection personnel, and other qualified personnel as required, under the supervision of an RP staff member who consults, as needed, with Chemistry. The daily administrative functions of the RP Management Employee address those functions required for the effective operation of the PBNP Radiological Environmental Monitoring Program. These administrative functions include the following:

(a) Ensuring that samples are obtained in accordance with the type and frequency in Table 12-3 following procedures outlined in this manual;

(b) Ensuring adequate sampling supplies and calibrated, functional equipment are available at all times;

(c) Ensuring that air sampling pumps are maintained, repaired and calibrated as required and that an adequate number of backup pumps are readily available at all times;

(d) Reporting lost or unavailable samples, as well as other potential deviations from the sampling regime in Table 12-3 will be documented via the radiological environmental sampling checklist forms and Corrective Action Program. Deviations are to be communicated to the cognizant Chemist.

(e) As a courtesy to the State of Wisconsin, Point Beach assists in obtaining samples at co-located and other sampling sites (this is not a TS requirement); and

(f) Assisting Chemistry, as necessary, with investigations into elevated radioactivity levels in environmental samples.

12.1.3 Quality Assurance / Quality Control

Quality assurance is an integral part of PBNP's Radiological Environmental Monitoring Program. The QATR commits PBNP to Reg. Guide 4.15, Quality Assurance for Radiological Monitoring Programs (Inception through Normal Operation to License Termination) – Effluent Streams and the Environment. The REMP involves the interaction of Chemistry and the contracted analytical laboratory. The contracted vendor shall participate in an interlaboratory comparison program. The laboratory is audited periodically, either by PBNP or by an independent third party.

Quality control for the PBNP portion of the Radiological Environmental Monitoring Program is achieved by following the procedures contained in this manual. Radiation Protection Technologists (RPTs) collect, package and ship environmental samples under the supervision of Radiation Protection supervisors. They are advised by Radiation Protection Management who has immediate responsibility for the overall technical operation of the environmental sampling functions. The RPTs receive classroom training as well as on-the-job training in carrying out these procedures.

An audit of the PBNP Radiological Environmental Monitoring Program and its results shall be completed periodically as a means of monitoring program effectiveness and assuring compliance with program directives. The audit shall be performed in accordance with Section 2.4.

## 12.2 REMP Implementation

### 12.2.1 Program Overview

a. Purpose

No significant or unexpected radionuclide concentrations of plant origin are expected because each normal effluent pathway at PBNP is monitored at or before the release point. However, the REMP is conducted to verify that plant operations produce no significant radiological impact on the environment and to demonstrate compliance with applicable standards.

b. Samples

Samples for the REMP are obtained from the aquatic, terrestrial and atmospheric environment. The sample types represent key indicators or critical pathways which have been identified by applying radiological principles from NRC and other guidance documents to the PBNP environment.

c. Monitoring Sensitivity

The effectiveness of the REMP in fulfilling its purpose depends upon the ability to accurately determine the nature and origins of fluctuations in low levels of environmental radioactivity. This requires a high degree of sensitivity so that it is possible to correctly discriminate between fluctuations in background radiation levels and levels of radioactivity that may be attributable to the operation of PBNP. Therefore, personnel actively participating in the monitoring program should make every effort to minimize the possibility of contaminating environmental samples and to obtain samples of the appropriate size.

### 12.2.2 Program Parameters

a. Contamination Avoidance

Contamination prevents the accurate quantification of environmental radioactivity and the correct differentiation between fluctuating background radioactivity and levels of radioactivity attributable to the operation of PBNP. Therefore, it is necessary that all personnel associated with collecting and handling radiological environmental samples take the appropriate precautions to minimize the possibility of contaminating the samples. Some of the precautions that should be taken and which will help to minimize contamination are listed below:

1. Equipment which has been in the radiologically controlled area, even if released clean, should not normally be used in conjunction with radiological environmental monitoring. An exception to this is the Health Physics Test Instrument (HPTI) equipment used to calibrate the air flow calibrator.

2. Store sampling equipment in radiologically clean areas only;

3. Store radiological environmental samples only in radiologically clean areas when samples cannot be shipped to the contractor on the same day they are collected;

4. Treat each sample as a possible source of contamination for other samples so as to minimize the possibility of cross-contamination;

5. Radiological environmental monitoring equipment should be repaired in clean-side shops;

6. Avoid entering contaminated areas prior to collecting environmental samples.

b. Lower Limit of Detection

The sensitivity required for a specific analysis of an environmental sample is defined in terms of the lower limit of detection (LLD). The LLD is the smallest concentration of radioactive material in a sample that will yield a net count, above system background, that will be detected with a 95% probability and have only a 5% probability of falsely concluding that a blank observation represents a real signal. Mathematically, the LLD is defined by the formula:

$$LLD = \frac{4.66 S_b}{E \times V \times 2.22 \times Y \times e^{-\lambda \Delta T}} \quad [12\text{-}1]$$

*Where:*

| | | | |
|---|---|---|---|
| | *LLD* | = | *The a priori lower limit of detection in picocuries per unit volume or mass, as applicable* |
| | $S_b$ | = | *The standard deviation of the background counting rate or the counting rate of a blank sample, as appropriate, in counts per minutes* |
| | *E* | = | *counting efficiency in counts per disintegration;* |
| | *V* | = | *sample size in units of volume or mass, as applicable;* |
| | *2.22* | = | *number of disintegrations per minute per picocurie;* |
| | *Y* | = | *the fractional chemical yield as applicable;* |
| | $\lambda$ | = | *the radioactive decay constant for the particular radionuclide; and* |
| | $\Delta T$ | = | *the elapsed time between sample collection, or the end of the collection period, and the time of counting.* |

Typical values of E, V, Y, and ΔT are used to calculate the LLD. As defined, the LLD is an *a priori* limit representing the capability of a measuring system and not an *a posteriori* limit for a particular measurement.

The required analysis for each environmental sample and the highest acceptable LLD associated with each analysis are listed in Table 12-1. Whenever LLD values lower than those specified in Table 12-1 are reasonably achievable, the analytical contractor for the radiological environmental samples will do so. When the LLDs listed in Table 12-1 are not achieved, a description of the factors contributing to the higher LLD shall be reported in the next PBNP Annual Monitoring Report.

c. Notification Levels

The Notification Level (NL) is that measured quantity of radioactivity in an environmental sample which, when exceeded, requires a notification of such an occurrence be made to the appropriate party. Regulatory and administrative notification levels are listed in Table 12-1.

1. Regulatory notification levels

The regulatory notification levels listed in Table 12-1 represent the concentration levels at which NRC notification is required. If a measured level of radioactivity in any radiological environmental monitoring program sample exceeds the regulatory notification level listed in Table 12-1, resampling and/or reanalysis for confirmation shall be completed within 30 days of the determination of the anomalous result. If the confirmed measured level of radioactivity remains above the notification level, a written report shall be submitted to the NRC. If more than one of the radionuclides listed in Table 12-1 are detected in any environmental medium, a weighted sum calculation shall be performed if the measured concentration of a detected radionuclide is greater than 25% of the notification levels. For those radionuclides with LLDs in excess of 25% of the notification level, a weighted sum calculation needs to be performed only if the reported value exceeds the LLD. Radionuclide concentration levels, called Weighted Sum Action Levels, which trigger a weighted sum calculation, are listed in Table 12-1.

The weighted sum is calculated as follows:

$$\frac{\text{ĀĀĀĀĀĀ ĀĀĀĀĀĀĀ (1)}}{\text{ĀĀĀĀĀĀĀĀĀĀĀ ĀĀĀĀĀ(1)}} + \frac{\text{ĀĀĀĀĀĀ ĀĀĀĀĀĀĀ (2)}}{\text{ĀĀĀĀĀĀĀĀĀĀĀ ĀĀĀĀĀ(2)}} + \ldots = \text{Ā ĀĀĀ}h\text{ĀĀĀ ĀĀĀ} \qquad [12\text{-}2]$$

If the calculated weighted sum is equal to or greater than 1, resampling and/or reanalysis for confirmation shall be completed within 30 days of the determination of the anomalous result. If the confirmed calculated weighted sum remains equal to or greater than 1, see Section 12.1.2.a.3 for notification guidance. This calculation requirement and report is not required if the measured level of radioactivity was not the result of plant effluents.

2. Administrative notification levels

The administrative notification levels are the concentration levels at which the contracted analytical laboratory promptly notifies the cognizant Chemistry Specialist by phone, followed by a formal written communication. The administrative notification levels are lower than the NRC regulatory notification levels and lower than, or equal to, the weighted sum action levels so the nature and origin of the increased level of environmental radioactivity may be ascertained and corrective actions taken, if required.

d. Sampling Locations

A list of sampling locations and the corresponding location codes appear in Table 12-2. The locations are shown in Figure 12-1 through Figure 12-3. If samples become unavailable from specified sample locations, new locations for obtaining replacement samples shall be identified and added to the Radiological Environmental Monitoring Program. If milk or vegetation samples become unavailable from the specified sampling locations, new sampling locations will be identified within 30 days. The specific locations where samples were unavailable may be deleted from the monitoring program in accordance with established provisions for assessing changes. Any significant changes in existing sampling location and the criteria for the change shall be reported in the Annual Monitoring Report for the period in which the change occurred. Additional sampling locations may be designated if deemed necessary by cognizant company personnel. Figures and tables in this manual shall be revised to reflect the changes.

e. Sampling Media and Frequency

The minimum sampling frequency for the environmental media required by the PBNP REMP is found in Table 12-3. Additional samples may be collected in response to plant conditions as determined by the cognizant Chemistry Analyst. Additionally, the REMP also includes the sampling of soil and shoreline sediment, which were not part of the PBNP RETS but kept for continuity with the preoperational monitoring program.

Samples are collected pursuant to HPIP 3.58.1, Radiological Environmental Sampling, which uses a monthly checklist to ensure that all the samples for the month are collected. The checklists also identify the schedule for the annual milk survey.

It is recognized that on occasions samples will be lost or that samples cannot be collected at the specified frequency because of hazardous conditions, seasonable unavailability, automatic sampling equipment malfunctions and other legitimate reasons. Reasonable efforts will be made to recover lost or missed samples if warranted and appropriate. If samples are not obtained at the indicated frequency or location, the reasons or explanations for deviations from the sampling frequency specified in Table 12-3 shall be documented in an AR and reported in the AMR.

f. Sample Analyses and Frequency

The PBNP REMP samples shall be analyzed for designated parameters at the frequency listed in Table 12-3. Additional samples may be collected in response to plant conditions. Gamma isotopic analysis means the identification and quantification of gamma-emitting radionuclides that may be attributable to effluents from PBNP. Typically, this entails the scanning of the spectrum from 80 to 2048 KeV and decay correcting identified radionuclides to the time of collection. The analysis specifically includes, but is not limited to, Mn-54, Fe-59, Zn-65, Co-58, Co-60, Zr/Nb-95, Ru-103, I-131, Cs-134, Cs-137, Ba/La-140, Ce-141, and Ce-144.

g. Analytical Laboratory

The contracted laboratory performs the analyses in such a manner as to attain the desired LLDs. The contracted laboratory participates in an inter-laboratory comparison crosscheck program.

The laboratory is responsible for providing prompt notification to the cognizant Chemist regarding any samples found to exceed the administrative notification levels as identified in Table 12-1.

12.2.3 Assistance to the State of Wisconsin (Non-Technical Specification Activity)

As a courtesy and convenience, PBNP personnel obtain certain environmental samples for the Section of Radiation Protection, Department of Health and Family Services of the State of Wisconsin.

12.2.4 Specification of Sampling Procedures

General radiological environmental sampling procedures follow the directives presented in Sections 12.1 and 12.2. Station procedures provide the specific information for the collection of the following samples:

- Vegetation
- Thermoluminescent Dosimeters (TLDs)
- Lake water
- Well water
- Air
- Milk
- Fish
- Soil (not part of PBNP RETS,10-3-1985)
- Shoreline sediment (not part of PBNP RETS,10-3-1985)

12.2.5 Milk Survey

The milk sampling program is reviewed annually, including a visual verification of animal grazing in the vicinity of the site boundary, to ensure that sampling locations remain as conservative as practicable. The verification is conducted each summer by cognizant PBNP personnel. Because it is already assumed that milk animals may graze up to the site boundary, it is only necessary to verify that these animals have not moved onto the site. No animal census is required. Upon completion of the visual check, a memo will be generated to document the review and the memo sent to file. To ensure performance of the annual verification, "milk review" is identified on the sampling checklist.

12.2.6 Land Use Census

A land use census is conducted in the vicinity of PBNP on a periodic basis, approximately every 3 years. The land use census is conducted during the growing season. The objective of the land use census is to determine if there have been any changes in land use, receptor locations, or if there are new exposure pathways.

TABLE 12-1
SAMPLE TYPES AND ASSOCIATED LOWER LEVEL OF DETECTION (LLD) AND NOTIFICATION LEVEL VALUES

| SAMPLE TYPE | REPORTING UNIT | PARAMETER | LLD[1] | NOTIFICATION LEVELS | |
|---|---|---|---|---|---|
| | | | | NRC | PBNP[2] (ADMIN.) |
| Vegetation | pCi/g (wet) | Cs-137 | 0.08 | 2 | 0.40 |
| | | Cs-134 | 0.06 | 1 | 0.20 |
| | | I-131 | 0.06 | 0.1 | 0.06 |
| | | Other[3] | 0.25 | --- | 2.0 |
| Shoreline Sediment and Soil[5] | pCi/g (dry) | Cs-134/137 | 0.15/0.18 | --- | 20 |
| | | Other[3] | 0.15 | --- | 20 |
| Fish | pCi/g (wet) | Cs-137 | 0.15 | 2 | 0.40 |
| | | Cs-134 | 0.13 | 1 | 0.20 |
| | | Co-58 | 0.13 | 30 | 3 |
| | | Co-60 | 0.13 | 10 | 1 |
| | | Mn-54 | 0.13 | 30 | 3 |
| | | Fe-59 | 0.26 | 10 | 1 |
| | | Zn-65 | 0.26 | 20 | 2 |
| | | Other[3] | 0.5 | --- | 6 |
| Milk | pCi/L | Sr-89[5] | 5 | --- | 100 |
| | | Sr-90[5] | 1 | --- | 100 |
| | | I-131 | 0.5[7] | 3 | 0.5 |
| | | Cs-134 | 15 (5) | 60 | 15 |
| | | Cs-137 | 18 (5) | 70 | 18 |
| | | Ba-La-140 | 15 (5) | 300 | 30 |
| | | Other[3] | 15 | --- | 30 |
| Air Filter[6] | $pCi/m^3$ | Gross beta | 0.01 | --- | 1.0 |
| | | I-131 | 0.07 (0.03) | 0.9 | 0.09 |
| | | Cs-137 | 0.06 | 20 | 2.0 |
| | | Cs-134 | 0.05 | 10 | 1.0 |
| | | Other[3] | 0.1 | --- | 1.0 |
| TLDs | mR/7 days | Gamma | 1mR/TLD | --- | 5mR/7 days |

TABLE 12-1
SAMPLE TYPES AND ASSOCIATED LOWER LEVEL OF DETECTION (LLD) AND NOTIFICATION LEVEL VALUES

| SAMPLE TYPE | REPORTING UNIT | PARAMETER | LLD[1] | NOTIFICATION LEVELS | |
|---|---|---|---|---|---|
| | | | | NRC | PBNP[2] (ADMIN.) |
| Lakewater[4] and Well Water | pCi/L from Total Solids | Gross beta | 4 | --- | 100 |
| | pCi/L | Cs-134 | 15 (10) | 30 | 15 |
| | | Cs-137 | 18 (10) | 50 | 18 |
| | | Fe-59 | 30 | 400 | 40 |
| | | Zn-65 | 30 | 300 | 30 |
| | | Zr-Nb-95 | 15 | 400 | 40 |
| | | Ba-La-140 | 15 | 200 | 20 |
| | | Co-58 | 15 (10) | 1,000 | 100 |
| | | Co-60 | 15 (10) | 300 | 30 |
| | | Mn-54 | 15 (10) | 1,000 | 100 |
| | | I-131 | 1 (0.5) | 2 | 2 |
| | | Other[3] | 30 | --- | 100 |
| | | H-3[4] (Lakewater) | 3,000 (200) | 30,000 | 3,000 |
| | | H-3 (Well Water) | 2,000 (200) | 20,000 | 3,000 |
| | | Sr-89[5] | 10 (5) | --- | 50 |
| | | Sr-90[5] | 2 (1) | --- | 20 |

**NOTE 1:** **The LLDs in this column are the maximum acceptable values. The values in parentheses are the administrative LLDs.**

**NOTE 2:** **Values in this column are not technical specifications.**

**NOTE 3:** **"Other" refers to non-specified identifiable gamma emitters resulting from the operation of PBNP. Naturally occurring radionuclides are not included.**

**NOTE 4:** **No drinking water.**

**NOTE 5:** **Items not required by PBNP RETS (10-3-1985) or NUREG-1301 but kept in the REMP for comparison to pre-operational and historical data.**

**NOTE 6:** **All particulate filters shall be allowed to decay for at least 24 hours after sampling to allow for radon and radon-daughter decay prior to gross β analysis.**

**NOTE 7:** **Lower than NUREG-1301 value 1 pCi/L to support PBNP's sampling frequency.**

TABLE 12-2
RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATIONS

| LOCATION CODE | LOCATION DESCRIPTION |
|---|---|
| E-01 | Primary Meteorological Tower, South of the plant |
| E-02 | Site Boundary Control Center - East Side of Building |
| E-03 | Tapawingo Road, about 0.4 Miles West of Lakeshore Road |
| E-04 | North Boundary |
| E-05 | Two Creeks Park, the TLD is on South side of Two Creeks Road, West of Lakeshore Road on first pole West of Lakeshore. |
| E-06 | Point Beach State Park - Water and shoreline sediment samples near the Coast Guard Station; soil and vegetation from the Point Beach State Park campground area N of the Coast Guard Station and on the West side of County Road O; TLD located South of lighthouse on telephone pole. |
| E-07 | WPSC Substation on County Rt. V, about 0.5 Miles West of Hwy. 42 |
| E-08 | G. J. Francar Property, at the SE Corner of the Intersection of Cty. B and Zander Road |
| E-09 | Nature Conservancy, East side of Hwy 42. Corner of Hwy 42 and Cty. BB. On pole North side of Entrance. |
| E-10 | PBNP Site Well |
| E-11 | Lambert Dairy Farm, 1523 Tapawingo Road, 0.5 miles West of Saxonburg Road |
| E-12 | Discharge Flume / Pier, U-1 side |
| E-13 | Pumphouse |
| E-14 | South Boundary, about 0.2 miles East of Site Boundary Control Center |
| E-15 | SW Corner of Site, N side of Nuclear Rd at junction with Twin Elder Rd. |
| E-16b | Pole #2124 23L17, Third pole (beside white underground cable post) N of old E-16 pole at residence 14427 Hwy 42 |
| E-17 | North of Mishicot, Cty. B and Assman Road, NE Corner of Intersection |
| E-18 | NW of Two Creeks at Zander and Tannery Roads |
| E-20 | Reference Location, 17 miles SW, at Holy Family Convent Property |
| E-21 | Local Dairy Farm just South of Site (R. Strutz) on Lakeshore and Irish Roads |
| E-22 | West Side of Hwy. 42, about 0.25 miles North of Johanek Road |
| E-23 | Greenfield Lane, about 4.5 Miles South of Site, 0.5 Miles East of Hwy. 42 |
| E-24 | North Side of County Rt. V, near intersection of Saxonburg Road |
| E-25 | South Side of County Rt. BB, about 0.5 miles West of Norman/Saxonberg Road |

TABLE 12-2
RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATIONS

| LOCATION CODE | LOCATION DESCRIPTION |
|---|---|
| E-26b | 804 Tapawingo Road, Pole #2124 18L17, Second Pole East of Cty. B. North Side of Road |
| E-27 | NE corner of Saxonburg and Nuclear Roads, about 4 Miles WSW |
| E-28 | TLD on westernmost pole between the 2nd and 3rd parking lots, |
| E-29 | On microwave tower fence |
| E-30 | NE corner at Intersection of Tapawingo and Lakeshore Roads. |
| E-31 | On utility pole North side of Tapawingo Road closest to the gate at the West property line |
| E-32 | On a conduit/pole located near the junction of property lines, about 500 feet east of the west gate in line with first designated treeline on Tapawingo Road and about 1200 feet south of Tapawingo Road. The location is almost under the power lines between the blue and gray transmission towers. (The conduit/pole is about 6 feet high). |
| E-38 | On tree West of former Retention Pond site |
| E-39 | On tree East of former Retention Pond site |
| E-40 | Local Dairy Farm (Barta), about 1.8 miles north of intersection of Highway 42 and Nuclear Road (Manitowoc County), on West side of Highway 42. |
| E-41 | NW corner of Woodside and Nuclear Roads (Kewaunee Co.) |
| E-42 | NW corner of Church and Division, East of Mishicot |
| E-43 | West Side of Tannery Road South of Elmwood (7th pole South of Elmwood) |
| E-44 | Utility Pole N side of Tapawingo Rd near house at 5011 |
| E-TC | Transportation Control; Reserved for TLDs |

TABLE 12-3
PBNP RADIOLOGICAL ENVIRONMENTAL SAMPLE COLLECTION AND ANALYSIS FREQUENCY

| SAMPLE TYPE | SAMPLE CODES | ANALYSES | FREQUENCY |
|---|---|---|---|
| Environmental Radiation Exposure | E-01, -02, -03, -04, -05, -06, -07, -08, -09, -12, -14, -15, -16b, -17, -18, -20, -22, -23, -24, -25, -26b, -27, -28, -29, -30, -31, -32, -38, -39, -41, -42, -43, -44, -TC | TLD | Quarterly |
| Vegetation (Grass and Weeds) | E-01, -02, -03, -04, -06, -20 | Gamma isotopic | 2x/yr as available |
| Fish (edible portions only) | E-13 | Gamma isotopic | 4x/yr as available |
| Well Water | E-10 | Gross beta, H-3 | Quarterly |
| | | Sr-89, 90, I-131 | |
| | | Gamma isotopic | |
| Lake Water | E-01, -05, -06 | Gross beta | Monthly |
| | | H-3, Sr-89, 90 | Quarterly composite of monthly collections |
| | | I-131 | Monthly |
| | | Gamma isotopic | Monthly |
| Milk | E-11, -21, -40 | Sr-89, 90 | Monthly |
| | | I-131 | |
| | | Gamma isotopic | |
| Air Filters | E-01, -02, -03, -04, -08, -20 | Gross beta | Weekly (particulate) |
| | | I-131 | Weekly (charcoal) |
| | | Gamma isotopic | Quarterly (on composite particulate filters) |
| Soil | E-01, -02, -03, -04, -06, -20, | Gamma isotopic | 1x/yr |
| Shoreline Sediment | E-01, -05, -06 | Gamma isotopic Analysis | 1x/yr |

FIGURE 12-1
RADIOACTIVE ENVIRONMENTAL SAMPLING LOCATIONS

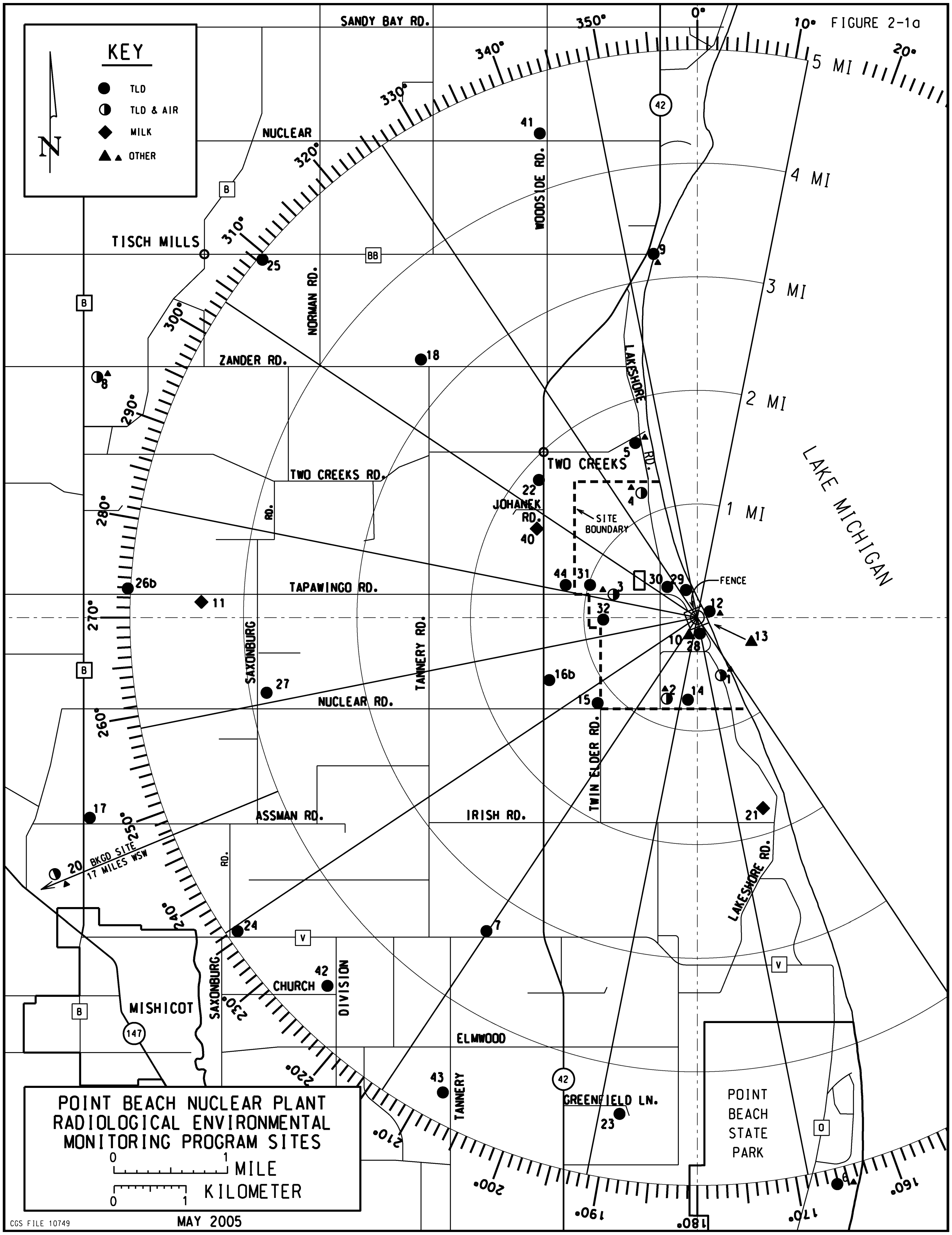


FIGURE 12-2
RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATIONS

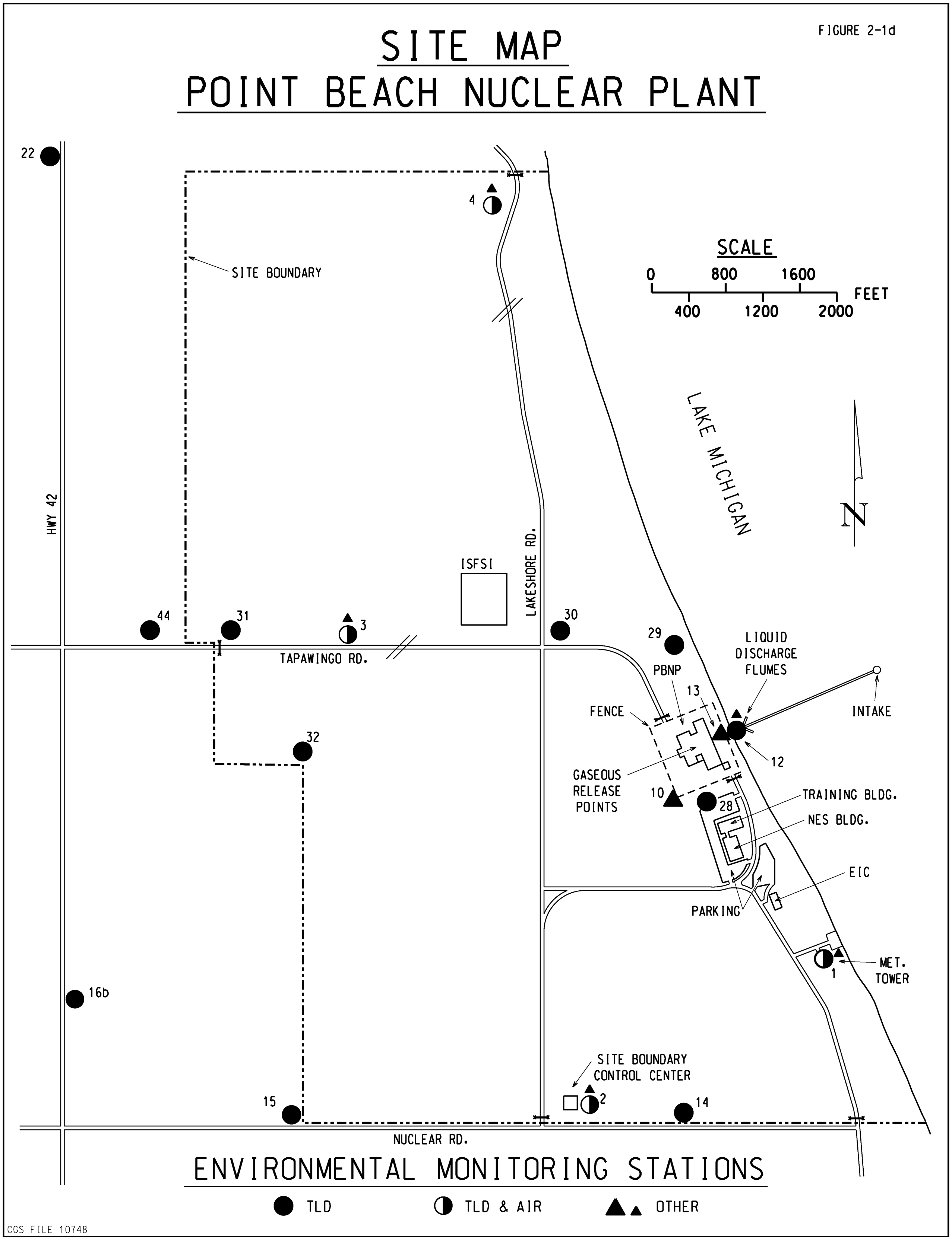
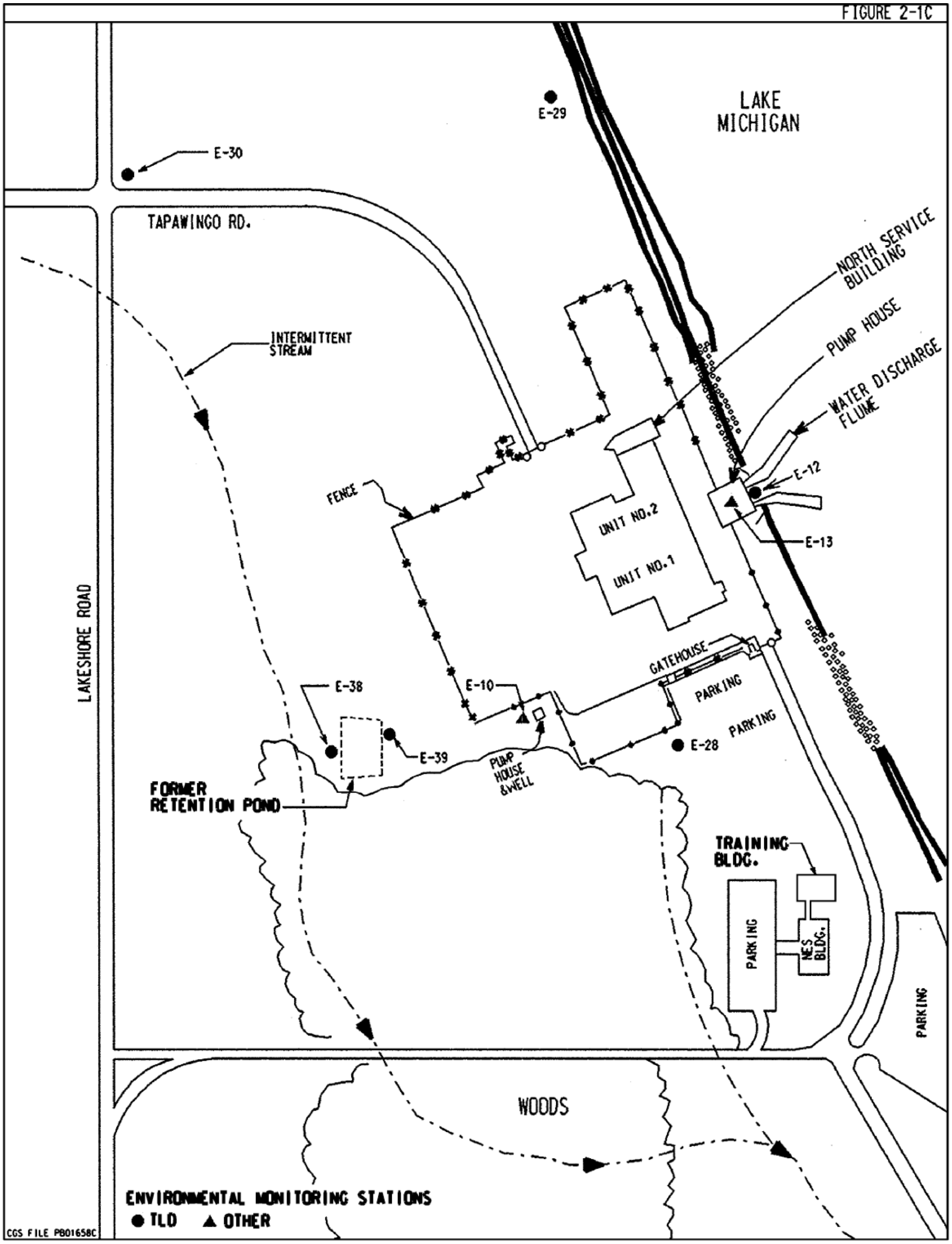


FIGURE 12-3
RADIOLOGICAL ENVIRONMENTAL SAMPLING LOCATIONS

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# 13.0 RADIOLOGICAL EFFLUENT CONTROLS PROGRAM

## 13.1 Radiological Effluent Controls Program

### 13.1.1 Basis

The Radiological Effluent Control Program (RECP) shall conform to 10 CFR 50.36a for the control of radioactive effluents and maintaining doses to members of the public from radioactive effluents as low as reasonably achievable (ALARA). The RECP also is established to control the amount and concentrations of radioactivity in PBNP effluent pursuant to the following documents:

- 10 CFR 50.34a-Design objectives for equipment to control releases of radioactive material in effluents-nuclear power reactors,
- 10 CFR 50, Appendix A, Criterion 60-Control of releases of radioactive material to the environment,
- 10 CFR 50, Appendix A, Criterion 63-Monitoring fuel and waste storage,
- 10 CFR 50, Appendix A, Criterion 64-Monitoring radioactivity releases,
- 10 CFR 20.1302-Compliance with dose limits for individual members of the public,
- 10 CFR 20.1501-General,
- PBNP General Design Criterion 17-Monitoring Radioactivity Releases, and
- PBNP General Design Criterion 70-Control of releases of radioactivity to the environment

### 13.1.2 Basis Statement

Liquid effluent from the radioactive waste disposal system is diluted by the circulating water system prior to release to Lake Michigan. With two pumps operating per unit, the flow of the circulating water system is approximately 390,000 gpm per unit. Operation of a single circulating water pump per unit reduces the nominal flow rate by about 35%. Liquid waste from the waste disposal system may be discharged to the circulating water system of either unit via the service water return header. Because of the low radioactivity levels in the circulating water discharge, the concentrations of liquid radioactive effluents at this point are not measured directly. Instead, the concentrations in the circulating water discharge are calculated from the measured concentration of the liquid effluent, the discharge flow rate of the effluent and the nominal flow in the circulating water system.

The release of radioactive materials in liquid effluents to unrestricted areas is monitored and controlled to conform to the dose objectives in Section II.A of Appendix I to 10 CFR 50 and will be ALARA in accordance with the requirements of 10 CFR Parts 50.34a and 50.36a. The monitoring and control also is undertaken to keep the concentrations of radionuclides in PBNP liquid effluent released to unrestricted areas conforming to ten times the maximum effluent concentration (MEC) values specified in Table 2, Column 2 of Appendix B to 10 CFR 20. Furthermore, the appropriate portions of the liquid radwaste treatment systems will be used as required to keep the releases ALARA.

These actions provide reasonable assurance that the resulting average annual dose or dose commitment from liquid effluent from each unit of the Point Beach Nuclear Plant for any individual in an unrestricted area from all pathways of exposure will not exceed the 10 CFR 50, Appendix I dose objectives. Thus, discharge of liquid wastes not exceeding these release limits will not result in significant exposure to members of the public because of consumption of drinking water from the lake, even if the effect of potable water treatment systems on reducing radioactive concentrations of the water supply is conservatively neglected.

Prior to release to the atmosphere, gaseous wastes are mixed in the auxiliary building vent with the flow from at least one of two auxiliary building exhaust fans. Further dilution then occurs in the atmosphere. Release of radionuclides to the atmosphere is monitored and controlled so that effluents to unrestricted areas conform to the dose objectives of Sections II.B and C of Appendix I to 10 CFR 50. Monitoring and control also is undertaken to ensure that at the point of maximum ground concentration at the site boundary, the radionuclide concentrations in the atmosphere will conform to the limits specified in Table 2, Column 1 of Appendix B to 10 CFR 20. Furthermore, the appropriate portions of the gaseous radwaste treatment system are used as required to keep the radioactive releases to the atmosphere ALARA.

In order to achieve the dose objectives of Appendix I to 10 CFR 50 and the aforementioned concentration limits, the setpoints for releases to the atmosphere and to Lake Michigan utilize the methodology found in the Offsite Dose Calculation Manual. Setpoints for releases to the atmosphere are based on conforming to the TS instantaneous dose rate limits using the dilution provided by building vents as well as the highest annual average $\chi/Q$ at the site boundary. Setpoints for releases to Lake Michigan are based only on dilution by circulation water. Together, control and monitoring provide reasonable assurance that the annual dose from each unit's effluents, to an individual in an unrestricted area will not exceed the dose objectives of Appendix I to 10 CFR 50.

Implementation of the RECP will keep average annual releases of radioactive material in PBNP effluents and their resultant committed effective dose equivalents at small percentages of the dose limits specified in 10 CFR 20.1301. At the same time, the methodology of implementing the RECP permits the flexibility of operation, compatible with considerations of health and safety, to assure that the public is provided with a dependable source of power even under unusual operating conditions which may temporarily result in releases higher than such numerical guides for design objectives set forth in Appendix I but still within levels that assure that the average population exposure is equivalent to small fractions of doses from natural background radiation.

Compliance with the provisions of Appendix I to 10 CFR Part 50 constitutes adequate demonstration of conformance to the standards set forth in 40 CFR Part 190 regarding the dose commitment to individuals from the uranium fuel cycle.

13.1.3 Other RECP Reportable Events

a. Radioactive Effluent Non-Treatment

If the effluent treatment system for radioactive liquids or for releases to the atmosphere is non-functional and effluents are being discharged for 31 consecutive days without the treatment required to meet the release limits specified in Section 6.1 and Section 7.1, a special report shall be prepared and submitted to the Commission within thirty days which includes the following information:

1. Identification of the non-functional equipment or subsystem and the reason for non-functionality.

2. Actions taken to restore the non-functional equipment to FUNCTIONAL status.

3. Summary description of actions taken to prevent a recurrence.

b. Exceeding Radioactive Effluent Release Limits

If the quantity of radioactive material actually released in liquid or gaseous effluents during any calendar quarter exceeds twice the quarterly limit as specified in Sections 6.2, 7.2 or 7.3, a special report shall be prepared and submitted to the Commission within thirty days of determination of the release quantity.

The report must describe the extent of exposure of individuals to radiation and radioactive material, including as appropriate:

1. corrective action(s) to be taken to reduce subsequent releases to prevent recurrence of exceeding the limits, including the schedule for achieving conformance with applicable limits, ALARA constraints, generally applicable environmental standards, and associated license conditions,

2. estimates of exposures to a member of the public, including the dose from any external storage units, such as the ISFSI and the SGSF, for compliance with 40 CFR 190 limits,

3. levels of radiation and concentrations of radioactive materials involved, and

4. cause of the elevated exposures, dose rates, or concentrations.

If the dose to any member of the public exceeds 75 mrem to the thyroid or 25 mrem to the whole body or any organ other than the thyroid, pursuant to 40 CFR 190, the report shall also contain a request for a variance from this standard pursuant to 40 CFR 190.11.

c. Major Change to Radioactive Liquid, Gaseous and Solid Waste Treatment Systems

Licensee initiated major changes to the radioactive waste treatment systems (liquid, gaseous, and solid) shall be reported to the U.S. Nuclear Regulatory Commission with the periodic update to the FSAR for the period for which the updates are submitted. The discussion of each change shall include:

1. A summary of the evaluation that led to the determination that the change could be made in accordance with 10 CFR Part 50.59;

2. Information necessary to support the reason for the change;

3. A description of the equipment, components and processes involved and the interfaces with other plant systems;

4. An evaluation of the change, which shows how the predicted releases of radioactive materials in liquid effluents and gaseous effluents and/or quantity of solid waste will differ from those previously predicted in the license application and amendments thereto;

5. An evaluation of the change, which shows the expected maximum exposures to an individual in the unrestricted area and to the general population that differ from those previously estimated in the license application and amendments thereto;

6. An estimate of the exposure to plant operating personnel because of the change

d. Audits

The activities of the Radiological Effluent Controls Program as described in this manual and its implementing procedures shall be audited in accordance with Section 2.4.

## 13.2 Radioactive Effluent Control and Accountability

### 13.2.1 Radiation Monitoring System

a. Description

The computerized Radiation Monitoring System (RMS) at Point Beach Nuclear Plant consists of area and process monitors. The effluent monitors are those process monitors that are designed to detect and measure radioactivity in liquid and gaseous releases from PBNP. A description of the liquid and gaseous effluent monitors and associated isolation and control functions are presented in ODCM Sections 9.1 and 10.1.

b. Calibration

Calibration of the RMS detectors is accomplished according to the PBNP instrument and control procedures.

c. Setpoints

The methodology for determining effluent RMS detector setpoints is described in the ODCM Sections 9.1 and 10.1.

d. Alarms

Response to alarms received from RMS effluent detectors is described in the PBNP RMS Alarm Setpoint and Response Book.

e. Effluent Detector Functionality and Surveillance

Detector functionality and surveillance requirements are addressed in Sections 6.0 and 7.0 of this manual.

13.2.2 Release Accountability

Control and accountability of radioactivity in PBNP effluents is accomplished by the RMS in conjunction with the characterization of radionuclide distributions by laboratory analyses of grab samples from the various waste streams. Sampling frequencies and analysis requirements are set forth in Sections 6.1.4 and 7.1.4 of this manual. Additional aspects of grab sampling and release accountability are described in the PBNP Release Accountability Manual

13.3 Radioactive Effluent Monitoring Instrumentation Functionality Requirements

13.3.1 Objective

The functionality of detectors is specified in order to ensure that liquid and gaseous radioactive effluents are adequately monitored and to ensure that alarm or trip setpoints are established such that effluent releases do not exceed the values cited in Sections 6.1.1, 6.2.1, 7.1.1, 7.2.1, 7.3.1 and 8.1.

13.3.2 Functionality Specifications

a. The radioactive effluent monitoring instrumentation channels listed in Table 6-2 and Table 7-2 shall be functional. The alarm or trip setpoints of these channels shall be determined and adjusted in accordance with the methodology and parameters in the ODCM.

   1. All monitors are defined by the term FUNCTIONAL – FUNCTIONALITY, **EXCEPT** 1(2) RE-212 Containment Noble Gas Monitor which is defined by the term OPERABLE – OPERABILITY.

   2. **IF** the ability of 1(2) RE-212, Containment Noble Gas Monitor, to perform its function is questioned,
      **THEN** the Operability Determination process is applicable.
      (LCO 3.4.15, RCS Leakage Detection Instrumentation)

b. If fewer than the minimum number of radioactive effluent monitoring channels are functional, the action statement listed in either Table 6-2 or Table 7-2 shall be taken. Best effort shall be made to return a non-functional channel to functional status within 30 days.

c. If the channel is not returned to a functional status within 30 days, the circumstances of the instrument failure and schedule for repair shall be reported to the NRC Resident Inspector.

d. If a radioactive effluent monitoring instrumentation channel alarm or trip setpoint is found less conservative than required by the ODCM, the channel shall be declared non-functional
**OR** the setpoint shall be changed to the ODCM value or a more conservative value.

13.4 Solid Radioactive Waste

The solid radwaste system shall be used in accordance with the Process Control Program to process radioactive wastes to meet all shipping and burial ground requirements. If the provisions of the Process Control Program are not satisfied, shipments of defectively processed or defectively packaged radioactive waste from the site will be suspended. The Process Control Program shall be used to verify solidification of radwaste.

## 14.0 REFERENCES

14.1 10 CFR Part 50, “Domestic Licensing of Production and Utilization Facilities,” U.S. Nuclear Regulatory Commission, Washington DC.

14.2 Regulatory Guide 1.109, “Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Demonstrating Compliance with 10 CFR Part 50, Appendix I,” U.S. Nuclear Regulatory Commission, Washington, DC.

14.3 Regulatory Guide 1.113, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I,” U.S. Nuclear Regulatory Commission, Washington, DC.

14.4 Regulatory Guide 1.21, “Measuring, Evaluating, and Reporting Radioactive Material in Liquid and Gaseous Effluents and Solid Waste,” U.S. Nuclear Regulatory Commission, Washington, DC.

14.5 NUREG-0133, “Preparation of Radiological Effluent Technical Specifications for Nuclear Power Plants,” October 1978.

14.6 NUREG-1301, “Offsite Dose Calculation Manual Guidance: Standard Radiological Effluent Controls for Pressurized Water Reactors,” April 1991.

14.7 EPRI Technical Report 1021106 “Estimation of Carbon-14 in Nuclear Power Plant Gaseous Effluents”, 2010.

14.8 Report No. R-2330244-001, Point Beach Annual Meteorological and Atmospheric Dispersion Report for 2009, December 2010.

14.9 Regulatory Guide 4.1, “Radiological Environmental Monitoring for Nuclear Power Plants,” June 2008, Rev. 2, USNRC, Washington, DC.

14.10 NUREG-0172, Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake, November 1977

14.11 EPA-520/1-88-020, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion", September 1988

14.12 Radiological Effluent Administration System (RADEAS) Design Configuration Parameters, ABS Consulting, September 2019 (MSI 26937)

**NOTE: The NRC documents (References 14.2 - 14.6, and 14.9-14.11) are presented for informational purposes and do not constitute a NextEra Energy Point Beach commitment to these documents.**

# APPENDIX A
# LIQUID PATHWAY EMEC FOR USE IN SETPOINT CALCULATIONS

The effective maximum effluent concentration (EMEC) is calculated from the annual liquid releases for the years 2000 through 2010 (Table A-1). The EMEC is the total concentration of radionuclides which can be discharged without having the summation of concentration fractions exceed unity. To obtain this value, the average annual total radionuclide concentration is divided by the sum of the ratio of each average individual radionuclide concentration divided by 10x its maximum effluent concentration listed in 10CFR20, Appendix B, Table 2, Col 2. The EMEC formula (Equation 9-3) is:

$$EMEC = \frac{\sum C_i}{\sum \frac{C_i}{MEC_i}} \quad \text{or} \quad EMEC = \frac{\sum C_i}{SOF} \qquad \text{[B-1]}$$

*Where:* *SOF* = *Sum of fractions*
*$C_i$* = *Annual average concentration of radionuclide "i"*
*$MEC_i$* = *10x the maximum effluent concentration from 10CFR20, Appendix B, Table 2, Column 2. Also referred to as the Effluent Concentration Limit (ECL)*

The 2000 – 2010 liquid effluent data are used for calculating the annual averages and EMEC (see Table A-1). C-14, Ni-63 and Tc-99 were added to the analytical requirements for liquid wastes in 2009, so each of these three radionuclides is averaged only over the two years of available data.

The annual average concentration is based on the volume for all of the eleven years. In calculating the annual average concentrations, the annual liquid waste effluent volumes were not used because they were four orders of magnitude lower than the dilution volume and would have but a minor effect on the resulting concentrations.

The calculated value for the EMEC is 9.89E-03 µCi/cc. The NaI detectors do not measure pure β-emitters such as H-3, C-14, Fe-55, Ni-63, Sr-90, and Tc-99. Therefore, a β-correction factor (βCF) is used to correct for these radionuclides to correct for these isotopes not being detected by the monitors. Additional conservatism is realized when calculating individual liquid effluent monitor setpoints because the minimum dilution flow is used. PBNP technical specifications allow liquid discharge concentrations at ten times the concentrations set forth in 10CFR20, Appendix B, Table 2, Column 2.

The EMEC is the maximum concentration allowed at the point of discharge. Therefore, in addition to a βCF, a dilution scaling factor (SF) is applied to determine the monitor setpoint which is the maximum allowable discharge concentration. The SF is the ratio of the circ water flow rate (CW) to the release rate (RR) [ODCM formula 9-5]. Therefore the SP = EMEC * SF * βCF. The SF is calculated from the minimum circ water flow (243,000 gpm) and the maximum effluent release rate (Table 9-1).

## TABLE A-1
## LIQUID EFFLUENT VOLUMES

| | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | TOTAL | AVE. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Discharge Vol. (cc) | 4.94E+11 | 4.15E+11 | 4.72E+11 | 3.96E+11 | 4.15E+11 | 3.59E+11 | 3.77E+11 | 3.84E+11 | 4.12E+11 | 4.80E+11 | 6.24E+11 | 4.83E+12 | 4.39E+11 |
| Dilution Vol. (cc) | 1.06E+15 | 1.04E+15 | 1.03E+15 | 1.00E+15 | 1.04E+15 | 8.64E+14 | 1.12E+15 | 1.10E+15 | 1.70E+15 | 1.07E+15 | 1.11E+15 | 1.21E+16 | 1.103E+15 |

## TABLE A-2
## LIQUID EFFLUENT RELEASES

| | MEC (µCi/cc) | 2000 (Ci/yr) | 2001 (Ci/yr) | 2002 (Ci/yr) | 2003 (Ci/yr) | 2004 (Ci/yr) | 2005 (Ci/yr) | 2006 (Ci/yr) | 2007 (Ci/yr) | 2008 (Ci/yr) | 2009 (Ci/yr) | 2010 (Ci/yr) | Total (Ci) | Ave. (Ci/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H-3 | 1.00E-03 | 8.04E+02 | 5.88E+02 | 5.60E+02 | 7.48E+02 | 6.08E+02 | 5.53E+02 | 6.07E+02 | 5.88E+02 | 5.34E+02 | 6.37E+02 | 5.59E+02 | 6.79E+03 | 6.17E+02 |
| C-14 | 3.00E-05 | | | | | | | | | | 1.97E-02 | 3.39E-03 | 2.31E-02 | 1.15E-02 |
| F-18 | 7.00E-04 | 2.26E-04 | 9.90E-04 | 3.31E-04 | 1.08E-03 | 1.30E-03 | 1.20E-03 | 2.52E-03 | 2.45E-03 | 1.97E-03 | 3.81E-03 | 5.66E-03 | 2.15E-02 | 1.96E-03 |
| Na-22 | 6.00E-06 | | | | | | | | | | 5.58E-06 | | 5.58E-06 | 5.07E-07 |
| Na-24 | 5.00E-05 | | | | | | | | | 5.50E-06 | | | 5.50E-06 | 5.00E-07 |
| Cr-51 | 5.00E-04 | 8.24E-03 | 9.08E-03 | 1.41E-02 | 8.23E-03 | 4.25E-04 | 2.55E-03 | 7.82E-03 | 3.10E-03 | 2.06E-02 | 8.63E-03 | 4.88E-03 | 8.77E-02 | 7.97E-03 |
| Mn-54 | 3.00E-05 | 4.53E-04 | 1.52E-03 | 4.42E-04 | 1.06E-03 | 1.21E-04 | 6.97E-04 | 4.39E-04 | 1.24E-04 | 6.62E-04 | 9.10E-04 | 1.42E-04 | 6.57E-03 | 5.97E-04 |
| Mn-56 | 7.00E-05 | | | | | | | 1.92E-06 | | | | | 1.92E-06 | 1.75E-07 |
| Fe-55 | 1.00E-04 | 1.12E-02 | 8.80E-03 | 6.82E-03 | 7.21E-03 | 3.85E-03 | 3.23E-03 | 3.06E-03 | 6.22E-03 | 5.50E-03 | 4.62E-03 | 4.92E-03 | 6.54E-02 | 5.95E-03 |
| Fe-59 | 1.00E-05 | 1.23E-04 | 2.18E-04 | 1.85E-03 | 3.11E-04 | 5.61E-05 | 1.04E-05 | 1.09E-04 | 1.93E-04 | 5.21E-04 | 1.49E-04 | 3.66E-04 | 3.91E-03 | 3.55E-04 |
| Ni-63 | 1.00E-04 | | | | | | | | | | 9.94E-03 | 2.26E-03 | 1.22E-02 | 6.10E-03 |
| Co-57 | 6.00E-05 | 1.29E-04 | 1.03E-03 | 1.11E-04 | 1.29E-04 | 1.06E-05 | 3.04E-05 | 5.50E-06 | | 2.72E-04 | 9.13E-05 | 5.60E-05 | 1.86E-03 | 1.69E-04 |
| Co-58 | 2.00E-05 | 5.56E-02 | 9.01E-02 | 3.39E-02 | 1.04E-01 | 4.12E-03 | 4.92E-03 | 3.58E-03 | 6.26E-03 | 3.70E-02 | 1.36E-02 | 4.28E-02 | 3.96E-01 | 3.60E-02 |
| Co-60 | 3.00E-06 | 7.33E-03 | 1.35E-02 | 3.61E-03 | 1.27E-02 | 2.13E-03 | 8.02E-03 | 9.94E-03 | 5.45E-03 | 1.10E-02 | 2.17E-02 | 3.96E-03 | 9.93E-02 | 9.03E-03 |
| Zn-65 | 5.00E-06 | 1.44E-04 | 1.76E-04 | 4.57E-05 | 6.35E-05 | 3.73E-06 | 8.13E-05 | 4.38E-05 | 4.62E-06 | 1.55E-04 | 3.50E-04 | 9.33E-06 | 1.08E-03 | 9.79E-05 |
| As-76 | 1.00E-05 | | | | 2.07E-05 | 1.27E-05 | 1.97E-05 | 1.84E-05 | 1.99E-05 | 7.09E-06 | 9.33E-05 | 8.59E-09 | 1.92E-04 | 1.74E-05 |
| Sr-89 | 8.00E-06 | 3.41E-06 | | | | | | | | | 7.69E-05 | | 8.03E-05 | 7.30E-06 |
| Sr-90 | 5.00E-07 | 3.04E-04 | 8.79E-05 | 2.14E-04 | 1.57E-05 | | | 1.71E-06 | 9.36E-05 | 1.03E-05 | 1.95E-05 | | 7.47E-04 | 6.79E-05 |
| Sr-92 | 4.00E-05 | | 1.36E-06 | 4.25E-05 | 5.54E-06 | | | | | | 1.76E-06 | 1.61E-06 | 5.27E-05 | 4.79E-06 |
| Nb-95 | 3.00E-05 | 1.07E-03 | 3.86E-03 | 1.67E-03 | 1.73E-03 | 1.83E-04 | 1.62E-03 | 9.38E-04 | 2.71E-04 | 3.92E-03 | 1.57E-03 | 6.09E-04 | 1.74E-02 | 1.59E-03 |
| Nb-97 | 3.00E-04 | 2.93E-05 | 1.92E-05 | 9.20E-06 | 1.92E-05 | 1.50E-05 | 7.07E-06 | 9.10E-06 | 1.83E-06 | 1.50E-05 | 6.36E-06 | 1.13E-05 | 1.43E-04 | 1.30E-05 |

TABLE A-2
LIQUID EFFLUENT RELEASES

| | MEC (µCi/cc) | 2000 (Ci/yr) | 2001 (Ci/yr) | 2002 (Ci/yr) | 2003 (Ci/yr) | 2004 (Ci/yr) | 2005 (Ci/yr) | 2006 (Ci/yr) | 2007 (Ci/yr) | 2008 (Ci/yr) | 2009 (Ci/yr) | 2010 (Ci/yr) | Total (Ci) | Ave. (Ci/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Zr-95 | 2.00E-05 | 5.11E-04 | 1.69E-03 | 7.02E-03 | 8.89E-04 | 5.26E-05 | 6.85E-04 | 4.97E-04 | 4.53E-05 | 2.12E-03 | 8.17E-04 | 3.38E-04 | 1.47E-02 | 1.33E-03 |
| Zr-97 | 9.00E-06 | | 1.65E-06 | 5.31E-08 | 7.14E-06 | 0.00E+00 | 0.00E+00 | 2.86E-06 | | | | 6.67E-06 | 1.84E-05 | 1.67E-06 |
| Mo-99 | 2.00E-05 | | 1.96E-06 | | 8.72E-06 | | | | | | | | 1.07E-05 | 9.71E-07 |
| Tc-99 | 6.00E-05 | | | | | | | | | | 6.46E-04 | 6.60E-04 | 1.31E-03 | 6.53E-04 |
| Tc-99m | 1.00E-03 | | 6.34E-06 | | 8.45E-06 | | | | | | | | 1.48E-05 | 1.34E-06 |
| Ru-103 | 3.00E-05 | | | 9.58E-06 | | | | | 2.68E-06 | 2.05E-05 | | | 3.28E-05 | 2.98E-06 |
| Ru-105 | 7.00E-05 | | | 1.68E-05 | | | | | | | | | 1.68E-05 | 1.52E-06 |
| Ru-106 | 3.00E-06 | | | 2.31E-05 | 3.13E-05 | | | | 2.49E-04 | | | | 3.03E-04 | 2.76E-05 |
| Ag-110m | 6.00E-06 | 2.92E-03 | 4.66E-03 | 2.80E-03 | 3.85E-03 | 5.45E-04 | 3.29E-03 | 2.46E-03 | 4.74E-03 | 2.67E-03 | 1.06E-03 | 2.95E-03 | 3.19E-02 | 2.90E-03 |
| Sn-113 | 3.00E-05 | 1.20E-04 | 3.51E-04 | 6.91E-04 | 4.17E-04 | 3.23E-05 | 1.64E-04 | 7.81E-05 | 1.17E-04 | 1.22E-03 | 4.34E-04 | 2.88E-04 | 3.91E-03 | 3.56E-04 |
| Sn-117m | 3.00E-05 | 3.47E-04 | 5.83E-04 | 1.32E-03 | 1.45E-03 | 1.29E-03 | 2.45E-03 | 1.24E-03 | 2.27E-03 | 4.34E-03 | 3.68E-03 | 1.70E-03 | 2.07E-02 | 1.88E-03 |
| Sb-122 | 1.00E-05 | 5.90E-06 | | 3.14E-06 | 4.25E-06 | | 5.75E-06 | 3.49E-06 | 1.33E-05 | | 5.66E-07 | | 3.64E-05 | 3.31E-06 |
| Sb-124 | 7.00E-06 | 2.03E-04 | 4.31E-04 | 6.09E-04 | 4.71E-04 | 1.76E-03 | 4.76E-05 | 2.01E-04 | 2.90E-04 | 1.20E-03 | 7.59E-04 | 1.06E-03 | 7.03E-03 | 6.39E-04 |
| Sb-125 | 3.00E-05 | 5.70E-03 | 6.65E-04 | 2.06E-03 | 1.30E-02 | 6.69E-03 | 2.40E-02 | 9.15E-04 | 4.88E-02 | 2.64E-02 | 8.90E-03 | 1.57E-03 | 1.39E-01 | 1.26E-02 |
| Te-131 | 8.00E-05 | | | | | | | 3.49E-06 | | | | | 3.49E-06 | 3.17E-07 |
| Te-132 | 9.00E-06 | 2.73E-05 | | 3.73E-05 | 1.17E-04 | 1.07E-05 | | | 2.32E-05 | 1.38E-05 | | | 2.29E-04 | 2.09E-05 |
| I-131 | 1.00E-06 | 1.65E-04 | | 9.30E-05 | 1.97E-06 | 2.50E-06 | | | 3.74E-05 | 9.32E-07 | | 1.21E-05 | 3.13E-04 | 2.85E-05 |
| I-132 | 1.00E-04 | | | | | | | | | 1.10E-05 | | | 1.10E-05 | 1.00E-06 |
| I-133 | 7.00E-06 | 2.68E-06 | | | | | 1.74E-05 | 4.22E-05 | 2.06E-05 | 1.53E-06 | | 2.10E-05 | 1.05E-04 | 9.58E-06 |
| Cs-134 | 9.00E-07 | | | | | | | 2.70E-06 | | | | | 2.70E-06 | 2.45E-07 |
| Cs-134m | 2.00E-03 | | | 4.09E-06 | | | | | | | | | 4.09E-06 | 3.72E-07 |
| Cs-136 | 6.00E-06 | 1.73E-05 | 1.60E-05 | 6.94E-06 | 6.83E-06 | | 1.51E-06 | | | | 5.67E-06 | 2.42E-06 | 5.67E-05 | 5.15E-06 |
| Cs-137 | 1.00E-06 | 9.15E-04 | 9.31E-05 | 2.84E-05 | 7.83E-05 | 3.57E-05 | 2.62E-04 | 5.13E-04 | 1.04E-04 | 9.35E-05 | 2.45E-03 | 1.17E-05 | 4.58E-03 | 4.16E-04 |
| Ba-139 | 2.00E-04 | 5.37E-07 | | | | | | | | | | | 5.37E-07 | 4.88E-08 |
| Ba-140 | 8.00E-06 | | 9.31E-06 | | | | | 3.66E-05 | 1.79E-05 | | | | 6.38E-05 | 5.80E-06 |
| La-140 | 9.00E-06 | 1.45E-04 | | 8.21E-06 | | | | | | | | | 1.53E-04 | 1.39E-05 |
| Ce-141 | 3.00E-05 | 0.00E+00 | 2.18E-06 | | | | | | | | | | 2.18E-06 | 1.99E-07 |
| W-187 | 3.00E-05 | | | | | | | 1.12E-05 | | | | | 1.12E-05 | 1.02E-06 |

TABLE A-3
LIQUID EFFLUENT CONCENTRATIONS
(The pure β emitters are highlighted)

| | MEC (µCi/cc) | Ann. Average (µCi/cc) | $C_i/10xMEC_i$ |
|---|---|---|---|
| H-3 | 1.00E-03 | 5.59E-07 | 5.59E- 05 |
| C-14 | 3.00E-05 | 1.05E-11 | 3.49E- 08 |
| F-18 | 7.00E-04 | 1.77E-12 | 2.54E-10 |
| Na-22 | 6.00E-06 | 4.60E-16 | 7.66E-12 |
| Na-24 | 5.00E-05 | 4.53E-16 | 9.07E-13 |
| Cr-51 | 5.00E-04 | 7.23E-12 | 1.45E-09 |
| Mn-54 | 3.00E-05 | 5.41E-13 | 1.80E-09 |
| Mn-56 | 3.00E-05 | 1.58E-16 | 2.26E-13 |
| Fe-55 | 1.00E-04 | 5.39E-12 | 5.39E-09 |
| Fe-59 | 1.00E-05 | 3.22E-13 | 3.22E-09 |
| Ni-63 | 1.00E-04 | 5.53E-12 | 5.53E-09 |
| Co-57 | 6.00E-05 | 1.53E-13 | 2.56E-10 |
| Co-58 | 2.00E-05 | 3.26E-11 | 1.63E-07 |
| Co-60 | 3.00E-06 | 8.19E-12 | 2.73E-07 |
| Zn-65 | 5.00E-06 | 8.87E-14 | 1.77E-09 |
| As-76 | 1.00E-05 | 1.58E-14 | 1.58E-10 |
| Sr-89 | 8.00E-06 | 6.62E-15 | 8.27E-11 |
| Sr-90 | 5.00E-07 | 6.16E-14 | 1.23E-08 |
| Sr-92 | 4.00E-05 | 4.35E-15 | 1.09E-11 |
| Nb-95 | 3.00E-05 | 1.44E-12 | 4.79E-09 |
| Nb-97 | 3.00E-04 | 1.18E-14 | 3.92E-12 |
| Zr-95 | 2.00E-05 | 1.21E-12 | 6.04E-09 |
| Zr-97 | 9.00E-06 | 1.51E-15 | 1.68E-11 |
| Mo-99 | 2.00E-05 | 8.80E-16 | 4.40E-12 |
| Tc-99 | 6.00E-05 | 5.92E-13 | 9.86E-10 |
| Tc-99m | 1.00E-03 | 1.22E-15 | 1.22E-13 |
| Ru-103 | 3.00E-05 | 2.70E-15 | 9.00E-12 |
| Ru-105 | 7.00E-05 | 1.38E-15 | 1.97E-12 |
| Ru-106 | 3.00E-06 | 2.50E-14 | 8.33E-10 |
| Ag-110m | 6.00E-06 | 2.63E-12 | 4.39E-08 |
| Sn-113 | 3.00E-05 | 3.22E-13 | 1.07E-09 |
| Sn-117m | 3.00E-05 | 1.70E-12 | 5.68E-09 |
| Sb-122 | 1.00E-05 | 3.00E-15 | 3.00E-11 |
| Sb-124 | 7.00E-06 | 5.80E-13 | 8.28E-09 |
| Sb-125 | 3.00E-05 | 1.14E-11 | 3.81E-08 |
| Te-131 | 8.00E-08 | 2.88E-16 | 3.60E-13 |
| Te-132 | 9.00E-06 | 1.89E-14 | 2.10E-10 |
| I-131 | 1.00E-06 | 2.58E-14 | 2.58E-09 |
| I-132 | 1.00E-04 | 9.07E-16 | 9.07E-13 |

TABLE A-3(CONT'D)
LIQUID EFFLUENT CONCENTRATIONS

| | MEC (µCi/cc) | Ann. Average (µCi/cc) | $C_i/10xMEC_i$ |
|---|---|---|---|
| I-133 | 7.00E-06 | 8.69E-15 | 1.24E-10 |
| Cs-134 | 9.00E-07 | 2.23E-16 | 2.47E-11 |
| Cs-134m | 2.00E-03 | 3.37E-16 | 1.69E-14 |
| Cs-136 | 6.00E-06 | 4.67E-15 | 7.79E-11 |
| Cs-137 | 1.00E-06 | 3.77E-13 | 3.77E-08 |
| Ba-139 | 2.00E-04 | 4.43E-17 | 2.21E-14 |
| Ba-140 | 8.00E-06 | 5.26E-15 | 6.57E-11 |
| La-140 | 9.00E-06 | 1.26E-14 | 1.40E-10 |
| Ce-141 | 3.00E-05 | 1.80E-16 | 6.00E-13 |
| W-187 | 3.00E-05 | 9.23E-16 | 3.08E-12 |
| **TOTAL** | | **5.59E-07** | **5.66E-05** |
| **TOTAL γ** | | **7.07E-11** | **5.95E-07** |
| **Total β** | | **5.59E-07** | **5.60E-05** |

The βCF is based on the condition that the total summation of fraction or ΣSOF ≤ 1.
Therefore, at the setpoint, the β and γ SOF fractions of the total SOF (ΣSOF) must satisfy the condition

$$1 = SOF\beta / \Sigma SOF + SOF\gamma / \Sigma SOF.$$

Because the monitors detect only the gamma fraction of the ΣSOF, the EMEC is multiplied by the ratio SOFγ/ ΣSOF which is the βCF. Using the above Table A-3 SOF values, the

$$\beta CF = SOF\gamma / \Sigma SOF = 5.95E\text{-}07/5.66E\text{-}05 = 1.05E\text{-}02.$$

TABLE A-4
BETA CORRECTED SETPOINTS

| Beta Corrected Set Point = EMEC x SF x βCF | | | |
|---|---|---|---|
| Monitor | MAX GPM | SF (CW/RR) | β-Corrected SP(µCi/cc) |
| 1/2RE-229 | 22200 | 1.09E+01 | 1.14E-03 |
| 1/2RE-219/222 | 200 | 1.22E+03 | 1.26E-01 |
| RE-230 | 700 | 3.47E+02 | 3.61E-02 |
| RE-220 | 700 | 3.47E+02 | 3.61E-02 |
| RE-218/223 | 100 | 2.43E+03 | 2.53E-01 |
| 1/2RE-216 | 4000 | 6.08E+01 | 6.32E-03 |

# APPENDIX B
# LIQUID DOSE TECHNICAL BASIS

The dose factors for each liquid effluent pathway are calculated using the following equations:

Aquatic Foods (Fish)

$$\text{Ā}_{\text{Ā}h\text{Ā ĀĀĀĀĀ}} = \frac{\text{ĀĀĀ} * \text{Ā}_{\text{ĀĀĀ}} * \text{Ā}_{\text{ĀĀĀ}} * \text{ĀĀ}_{\text{ĀĀĀĀĀ Ā}} * 10^9}{\text{ĀĀĀ}_{\text{Ā}h\text{ĀĀ}} * 8760} * exp\left[\frac{-\ln(2) * \text{Ā}_{\text{Ā}}}{\text{Ā}_{\text{Ā}}}\right] \qquad \text{[B-1]}$$

*Where:*

| | | |
|---|---|---|
| *ECD* | = | *Effluent Concentration Duration (uCi-hr/ml)* |
| $DF_{ariING}$ | = | *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)* |
| : $DIL_{zhAF}$ | = | *the mixing ratio (reciprocal of the dilution factor) at the point of harvest of aquatic food*<br>*= 0.1136 (Point of harvest of the fresh fish is taken at a point 1000m downstream. The plume centerline dilution factor at this location is 8.8 using RG 1.113 methodology. The factor of 2 allowed for current reversals was not used. See Appendix E.)* |
| $U_{aAF}$ | = | *annual fish consumption rate for age group "a" (kg/yr)*<br>*= 0 kg/yr for infant*<br>*= 6.9 kg/yr for child*<br>*= 16 kg/yr for teen*<br>*= 21 kg/yr for adult (see RG 1.109, Table E-5 for maximum exposed individual)* |
| $B_{iAF}$ | = | *the equilibrium bioaccumulation factor for radionuclide "i" in pathway "p", expressed as the ratio of the concentration in biota (in pCi/kg) to the radionuclide concentration in water (pCi/l). (L/kg, see RG 1.109, Table A-1)* |
| $T_i$ | = | *the radioactive decay constant of nuclide "i", in day$^{-1}$* |
| $T_T$ | = | *the average transit time required for nuclides to reach the point of exposure. For internal dose, $t_p$ is the total time elapsed between release of the nuclides and the ingestion of the water*<br>*= 0.5 d* |
| $10^9$ | = | *conversion factor 1000 ml/L) * ($10^6$ pCi/uCi)* |
| *8760* | = | *Hours/year* |

Potable water

$$\text{Ā}_{\text{ĀhĀ ĀĀĀĀĀ}} = \frac{\text{ĀĀĀ} * \text{Ā}_{\text{ĀĀĀ}} * \text{ĀĀ}_{\text{ĀĀĀĀĀĀ}} * 10^{9}}{\text{ĀĀĀ}_{\text{ĀhĀĀ}} * 8760} * exp\left[\frac{-\ln(2) * \text{Ā}_{\text{Ā}}}{\text{Ā}_{\text{Ā}}}\right] \quad \text{[B-2]}$$

*ECD* = *Effluent Concentration Duration (uCi-hr/ml)*

*Where:*

*$DIL_{zhDW}$* = *mixing ratio (reciprocal of the dilution factor) at the point of withdrawal of drinking water*
*= 0.0384 (Withdrawal point is taken as the Two Rivers municipal water intake located a distance of 12 miles downstream. The plume centerline dilution factor at this location is 26 using RG 1.113 methodology.)*

*$U_{aDW}$* = *a usage factor that specifies the drinking water intake rate for an individual of age group "a" associated with pathway "p";*
*= 330 L/yr for infant*
*= 510 L/yr for child*
*= 510 L/yr for teen*
*= 730 L/yr for adult (see RG 1.109, Table E-5)*

*$D_{ariING}$* = *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)*

*$T_i$* = *radioactive decay constant of nuclide "i"*

*$T_T$* = *average transit time required for nuclides to reach the point of exposure. (d)*
*= 2 d (12.2 cm/s plus 12 hours to reflect the transport of the water through the water purification plant and distribution system)*

*$10^9$* = *conversion factor (1000 ml/L) * ($10^6$ pCi/uCi)*

*8760* = *Hours/year*

Effluent Concentration Duration

$$\text{ĀĀĀ}_{\text{ĀĀĀ}} = \text{ĀĀ}_{\text{Ā ĀĀ}} * \Delta\text{Ā}_{\text{ĀĀ}} \quad \text{[B-3]}$$

*Where:*

*$EC_{wip}$* = *Release Permit(p) Nuclide(i) Effluent Concentration due to Waste*

*$\Delta T_{pc}$* = *Release Permit (p) Release Duration (hours)*

| The following equations B – 4 through B – 8 are included to comply with Appendix F through J. They are currently not used. |
|---|

<u>Irrigated Foods (Meat/Milk )</u>

$$\bar{A}_{\bar{A}h\bar{A}\ \bar{A}\bar{A}\bar{A}\bar{A}} = \frac{\bar{A}_{\bar{A}\bar{A}}\bar{A}_{\bar{A}\bar{A}} \cdot \bar{A}\bar{A}\bar{A}_{\bar{A}} \cdot \bar{A}^{-\bar{A}_{\bar{A}}\bar{A}_{\bar{A}}} \cdot \bar{A}\bar{A}_{\bar{A}\bar{A}\bar{A}\bar{A}\bar{A}}}{\bar{A}\bar{A}\bar{A}_{\bar{A}h}}$$

$$\left\{1.14\bar{A}5 \cdot \bar{A}_{\bar{A}} + 31.7\bar{A}_{\bar{A}} \cdot \bar{A}_{\bar{A}}\bar{A}^{-\bar{A}_{\bar{A}}\bar{A}_h}\left[\frac{\bar{A}\left(1-\bar{A}^{-\bar{A}_{\bar{A}\bar{A}}\bar{A}_{\bar{A}}}\right)}{\bar{A}_{\bar{A}}\bar{A}_{\bar{A}\bar{A}}} + \frac{\bar{A}_{\bar{A}} \cdot \bar{A}_{\bar{A}\bar{A}}\left(1-\bar{A}^{-\bar{A}_{\bar{A}}\bar{A}_{\bar{A}}}\right)}{\bar{A}\bar{A}_{\bar{A}}}\right]\right\} \quad [B-4]$$

*Where:*

| | | |
|---|---|---|
| $DIL_{zh}$ | = | *Dilution Factor between Discharge Point(z) to irrigation water extraction point.* |
| $U_{ap}$ | = | *Meat (kg/yr)*<br>*= 0 kg/yr for infant*<br>*= 41 kg/yr for child*<br>*= 65 kg/yr for teen*<br>*= 110 kg/yr for adult (see RG 1.109, Table E-5 for maximum exposed individual)*<br><br>*Milk*<br>*= 330 L/yr for infant*<br>*= 330 L/yr for child*<br>*= 400 L/yr for teen*<br>*= 310 L/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)* |
| $F_{iA}$ | = | *Stable element transfer coefficient from feed to animal* |
| *ECD* | = | *Effluent Concentration Duration (uCi-hr/ml)* |
| $Q_w$ | = | *consumption rate of contaminated water by an animal (L/d) = 60 L/day (see RG 1.109, Table E-3)* |
| $Q_F$ | = | *Consumption of contaminated feed by animal, kg/day = 50 kg/day (see RG 1.109, Table E-3)* |
| $F_i$ | = | *Fraction of year crops are irrigated* |
| $DFI_{ariING}$ | = | *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)* |
| $\lambda_i$ | = | *the radioactive decay constant of nuclide "i", in* $sec^{-1}$ |
| $t_s$ | = | *time from slaughter to consumption (d) = 20d (see RG 1.109, Table E-15)* |
| *114000* | = | *conversion factor (pCi/µCi * mL/L per hr/yr)* |
| $T_t$ | = | *Transit time from discharge to irrigation, s* |
| *31.7* | = | *Units Conversion (103 ml/L)*(106 pCi/uCi)/(3153600 s/yr)** |
| $I_p$ | = | *Irrigation rate for vegetation pathway(p), l/m2-hr* |
| $T_h$ | = | *Time from harvest to consumption, s* |
| *r* | = | *Fraction of deposition retained on crops* |
| $\lambda_{Ei}$ | = | *Effective removal rate constant, s-1* |
| $T_e$ | = | *Time crops are exposed to contamination during growing season, s* |
| $Y_v$ | = | *Agricultural productivity,* $kg/m^2$ |
| $B_{iv}$ | = | *Soil-vegetation concentration factor for isotope(i)* |
| $T_b$ | = | *Soil exposure time, s* |
| *P* | = | *Effective surface density of soil,* $kg/m^2$ |

Tritium in Irrigated Foods (Milk /Meat)

$$\text{Ā}_{\text{Ā}h\text{ĀĀĀ ĀĀĀĀ}} = \frac{1.14\text{Ā}5\text{Ā}_{\text{ĀĀ}} \cdot \text{ĀĀĀ}_{\text{Ā}} \cdot \text{ĀĀ}_{\text{ĀĀĀĀĀĀ}} \cdot \text{Ā}_{\text{ĀĀ}} \cdot (\text{Ā}_{\text{Ā}} + \text{Ā}_{\text{Ā}})}{\text{ĀĀĀ}_{\text{Ā}h}} \qquad [B\text{-}5]$$

*Where:* $U_{ap}$ =

| Meat (kg/yr) | Milk |
|---|---|
| = 0 kg/yr for infant | = 330 L/yr for infant |
| = 41 kg/yr for child | = 330 L/yr for child |
| = 65 kg/yr for teen | = 400 L/yr for teen |
| = 110 kg/yr for adult (see RG 1.109, Table E-5 for maximum exposed individual) | = 310 L/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual) |

$ECD_i$ = *Effluent Concentration Duration (uCi-hr/ml*

$Q_F$ = *consumption rate of contaminated food by an animal (L/d) = 50 /dkgay (see RG 1.109, Table E-3)*

$Q_w$ = *consumption rate of contaminated water by an animal (L/d) = 60 L/day (see RG 1.109, Table E-3)*

$F_{ia}$ = *stable element transfer coefficients (d/L, from RG 1.109, Table E-1)*

$DF_{ariING}$ = *ingestion dose factor for age group "a", radionuclide "i" and organ "o", from Reg. Guide 1.109 (mrem/pCi)*

$DIL_{zh}$ = *Dilution Factor between Discharge Point(z) to irrigation water extraction point(h)*

*114000* = *conversion factor (pCi/μCi * mL/L per hr/yr)*

Tritium in Irrigated Foods (Vegetables)

$$\text{Ā}_{\text{Ā}h\text{ĀĀĀ ĀĀĀĀ}} = \frac{1.14\text{Ā}5\text{Ā}_{\text{ĀĀ}} \cdot \text{ĀĀĀ}_{\text{Ā}} \cdot \text{ĀĀ}_{\text{ĀĀĀĀĀĀ}}}{\text{ĀĀĀ}_{\text{Ā}h}} \qquad [B\text{-}6]$$

*Where:* $U_{ap}$ =

| Produce (kg/yr) | Leafy |
|---|---|
| = 0 kg/yr for infant | = 0 kg/yr for infant |
| = 520 kg/yr for child | = 26 kg/yr for child |
| = 630 kg/yr for teen | = 42 kg/yr for teen |
| = 520 kg/yr for adult (see RG 1.109, Table E-5 for maximum exposed individual) | = 64 kg/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual) |

$ECD_i$ = *Effluent Concentration Duration (uCi-hr/ml*

$DF_{ariING}$ = *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 - 10-11)*

$DIL_{zh}$ = *Dilution Factor between Discharge Point(z) to irrigation water extraction point(h)*

*114000* = *conversion factor (pCi/μCi * mL/L per hr/yr)*

Shoreline Deposits

$$\text{Ā}_{\text{Ā}h\text{Ā ĀĀĀĀĀ}} = \frac{\text{ĀĀĀ} * \text{Ā}_{\text{ĀĀĀ}} * \text{ĀĀ}_{\text{ĀĀĀĀ}} * 10^9 * 100 * \text{Ā} * \text{Ā}_{\text{Ā}}}{\text{ĀĀĀ}_{\text{Ā}h\text{ĀĀĀ}} * 8760 * 86400} * \left(1 - \exp\left[\frac{-\ln(2) * \text{Ā}_{\text{ĀĀ}}}{\text{Ā}_{\text{Ā}}}\right]\right) * exp\left[\frac{-\ln(2) * \text{Ā}_{\text{Ā}}}{\text{Ā}_{\text{Ā}}}\right] \quad \text{[B-7]}$$

*Where:*

| | | | |
|---|---|---|---|
| | $DIL_{zhSLE}$ | = | *the mixing ratio (reciprocal of the dilution factor) at the point of exposure;*<br>*= 0.01821 (Point of exposure is taken as the Point Beach State Park beach which is located 8000 meters downstream. The plume shoreline dilution factor at this location is 54.9 using RG 1.113 methodology. The factor of 2 allowed for current reversals was not used. See Appendix E)* |
| | $U_{aSL}$ | = | *Annual recreation for age group "a" and pathway "p" (h/yr)*<br>*= 0 hr/yr for infant*<br>*= 14 hr/yr for child*<br>*= 67 hr/yr for teen*<br>*= 12 hr/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)* |
| | $W$ | = | *the shoreline width factor;*<br>*= 0.3 (from RG 1.109, Table A-2)* |
| | $T_i$ | = | *radioactive half-life of radionuclide "i" (s)* |
| | $DF_{RiGP}$ | = | *the external dose factor for nuclide "i", in mrem/hr per pCi/$m^2$, taken from Table E-6 of RG 1.109* |
| | $T_T$ | = | *the average transit time required for nuclides to reach the point of exposure (s)*<br>*= 43200 (0.5 d)* |
| | $10^9$ | | *Units Conversion ($10^3$ ml/L) * ($10^6$ pCi/uCi)* |
| | *100* | | *Water to Sediment Transfer Coefficient* |
| | *8760* | | *Units Conversion (8760 hr/year)* |
| | *84600* | | *Conversion Factor (sec/day)* |
| | $T_{SE}$ | = | *time period of long-term buildup for activity in sediment or soil (s)*<br>*= 4.73 E8 s (15 yr, see RG 1.109, Table E-15)* |

Irrigated Foods (Leafy Vegetables, Produce)

$$D_{ahr\ ipm} = \frac{31.7 U_{ap} \cdot I_p \cdot EDC_i \cdot DF_{ariING} e^{-\lambda_i (T_h + t_t)}}{DIL_{zh}} \left[ \frac{r\left(1 - e^{-\lambda_{Et} T_e}\right)}{Y_v \lambda_{Et}} + \frac{F_i \cdot B_{iv}\left(1 - e^{-\lambda_i t_b}\right)}{P \lambda_i} \right] \qquad \text{[B-8]}$$

*Where:*

| | | | |
|---|---|---|---|
| 31.7 | = | *Units Conversion (103 ml/L)*(106 pCi/uCi)/(3153600 s/yr)* | |
| $U_{ap}$ | = | *annual vegetable consumption for age group "a" and pathway "p" (kg/yr)<br>= 0 kg/yr for infant<br>= 26 kg/yr for child= 42 kg/yr for teen<br>= 64 kg/yr for adult<br>(from RG 1.109, Table E-5 for maximum exposed individual* | *annual produce consumption for age group "a" and pathway "p" (kg/yr)<br>= 0 kg/yr for infant<br>= 520 kg/yr for child<br>= 630 kg/yr for teen<br>= 520 kg/yr for adult<br>(from RG 1.109, Table E-5 for maximum exposed individual* |
| $I_p$ | = | *Irrigation rate for vegetation pathway(p), l/m2-hr* | |
| $EDC_i$ | = | *Effluent Concentration Duration (uCi-hr/ml)for isotope(i)(ECDiczm for Calendar Period dose, ECDip for Permit dose)* | |
| $DF_{ariING}$ | = | *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)* | |
| $\lambda_i$ | = | *the radioactive decay constant of nuclide "i", in* $sec^{-1}$ | |
| $T_h$ | = | *Time from harvest to consumption, s* | |
| $t_t$ | = | *Transit time from discharge to irrigation, s* | |
| $DIL_{zh}$ | = | *Dilution Factor between Discharge Point(z) to irrigation water extraction point(h) (If zero or non-existent, then dose equals zero.)* | |
| $r$ | = | *Fraction of deposition retained on crops, dimensionless* | |
| $\lambda_{Et}$ | = | *Effective removal rate constant, s-1* | |
| $T_e$ | = | *Time crops are exposed to contamination during growing season, s* | |
| $t_b$ | = | *Soil exposure time, s* | |
| $F_i$ | = | *Fraction of year crops are irrigated* | |
| $B_{iv}$ | = | *Soil-vegetation concentration factor for isotope(i), dimensionless* | |
| $Y_v$ | = | *Agricultural productivity, kg/m2* | |
| $P$ | = | *Effective surface density of soil, kg/m2* | |

## APPENDIX C
## GASEOUS PATHWAY SETPOINT CALCULATIONS

The calculation of the setpoints for airborne effluents is based on the tech spec requirement that the noble gas dose rate at the site boundary nearest the closest residence must be ≤500 mrem/yr total body or ≤ 3000 mrem/yr to the skin of the whole body. The calculation proceeds in a manner similar to the liquid EMEC calculation. First the average noble gas emission rate for each identified noble gas is calculated from the average annual effluent discharge. Next, the site boundary concentrations are calculated by multiplying the release rates by the dispersion coefficient, $\chi/Q$. Then the product of the individual noble gas concentrations and its dose factor is summed to determine the total dose rate from this noble gas mixture. Dividing this dose rate into the dose rate limit determines factor by which the average total site boundary noble concentration must be multiplied in order to achieve the concentration which will yield the limiting dose rate. Finally, based on the flow rate of an individual stack and applying the dispersion factor, the alarm setpoint for that stack monitor is calculated.

The parameters for calculating the setpoints are shown in the spreadsheet below and the setpoints are calculated using either equation 10-1(total body) or equation 10-2 (skin).

TABLE C-1
NOBLE GAS RELEASES

| | 2000 (Ci/yr) | 2001 (Ci/yr) | 2002 (Ci/yr) | 2003 (Ci/yr) | 2004 (Ci/yr) | 2005 (Ci/yr) | 2006 (Ci/yr) | 2007 (Ci/yr) | 2008 (Ci/yr) | 2009 (Ci/yr) | 2010 (Ci/yr) | Avg. (Ci/yr) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ar-41 | 1.35E+00 | 9.28E-01 | 1.87E+00 | 7.77E-01 | 8.47E-01 | 4.61E-01 | 5.45E-01 | 4.98E-01 | 1.55E+00 | 7.67E-01 | 7.74E-01 | 8.52E-01 |
| Kr-85 | 0.00E+00 | 0.00E+00 | 4.87E-03 | 3.95E-04 | 0.00E+00 | 2.63E-04 | 0.00E+00 | 0.00E+00 | 1.37E-03 | 8.66E-03 | 0.00E+00 | 1.41E-03 |
| Kr-85m | 1.47E-02 | 4.42E-04 | 4.67E-02 | 0.00E+00 | 2.84E-03 | 3.71E-03 | 1.43E-04 | 2.07E-04 | 8.47E-04 | 7.60E-03 | 9.73E-03 | 7.90E-03 |
| Kr-87 | 3.51E-02 | 1.76E-03 | 1.68E-01 | 0.00E+00 | 7.27E-03 | 8.80E-03 | 0.00E+00 | 4.64E-04 | 2.10E-03 | 1.86E-02 | 2.35E-02 | 2.41E-02 |
| Kr-88 | 3.52E-02 | 2.02E-03 | 1.61E-01 | 0.00E+00 | 7.62E-03 | 9.12E-03 | 0.00E+00 | 2.02E-02 | 6.50E-03 | 1.80E-02 | 2.33E-02 | 2.57E-02 |
| Xe-131m | 0.00E+00 | 1.15E-04 | 0.00E+00 | 7.00E-05 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.70E-03 | 8.04E-04 | 0.00E+00 | 2.44E-04 |
| Xe-133 | 9.86E-01 | 4.95E-01 | 2.37E-01 | 1.12E-01 | 3.70E-01 | 9.14E-02 | 4.13E-02 | 9.95E-02 | 3.32E-04 | 5.43E-02 | 2.83E-01 | 2.52E-01 |
| Xe-133m | 2.89E-03 | 4.72E-04 | 0.00E+00 | 8.37E-04 | 9.67E-04 | 5.19E-04 | 3.65E+00 | 3.74E-04 | 2.77E-01 | 9.40E-04 | 2.11E-03 | 3.58E-01 |
| Xe-135 | 1.75E-01 | 3.20E-02 | 4.10E-01 | 1.59E-04 | 1.97E-02 | 2.26E-02 | 9.32E-02 | 4.79E-03 | 4.05E-03 | 4.28E-02 | 6.14E-02 | 7.88E-02 |
| Xe-135m | 6.07E-02 | 0.00E+00 | 1.79E-01 | 3.46E-04 | 1.18E-02 | 1.74E-02 | 1.48E-02 | 9.53E-04 | 0.00E+00 | 3.36E-02 | 5.38E-02 | 3.38E-02 |
| Xe-138 | 1.50E-01 | 8.77E-03 | 7.57E-01 | 0.00E+00 | 3.25E-02 | 4.43E-02 | 3.89E-02 | 2.17E-03 | 1.14E-02 | 9.17E-02 | 1.16E-01 | 1.14E-01 |

TABLE C-2
AVERAGE ANNUAL DISCHARGE VOLUME

| MONITOR | VENT STACK | CFM | CC/MIN | CC/YR |
|---|---|---|---|---|
| RE-214 | ABVS | 66,400 | 1.880E+09 | 9.883E+14 |
| RE-225 | CAE | 20 | 5.663E+05 | 2.977E+11 |
| 1/2RE-215 | CAE | 10 | 2.832E+05 | 1.488E+11 |
| 1RE-212 | U1 | 25,000 | 7.079E+08 | |
| 2RE-212 | U2 | 38,000 | 1.076E+09 | |
| 1/2RE-212 | U1/2 | 35 | 9.911E+05 | 5.209E+11 |
| RE-224 | GSVS | 13,000 | 3.681E+08 | 1.935E+14 |
| RE-221 | DAVS | 43,100 | 1.220E+09 | 6.415E+14 |
| | | | **Total (cc/yr)** | **1.823E+15** |

The average annual discharge volume is based on the flow from the four pathways monitored by RE-214, RE-221, RE-224, and RE-225. A random check of monthly effluent calculations show that over a span of one year, only the Aux. Bldg. Vent Stack, the Gas Stripper, and the Drumming Area Vent are important. The containment vents typically are about 35 cfm. The purges at 25,000 cfm occur during outages at a time when there no noble gas is detected in containment as all results are <MDA. Therefore, including the purge volumes would result in a less conservative calculated concentration by adding to the total volume at a time when no noble gases would be contributed to the total annual noble gas discharge. Also, not included are the GDT discharges. Their volumes are negligible in comparison to the main stack discharge volumes.

TABLE C-3
NOBLE GAS SETPOINT PARAMETER CALCULATION

| | **Avg. (Ci/yr)** | **$C_i$ (µCi/cc)** | **$K_i$ (Whole Body)** | **$L_i$ (skin)** | **$M_i$ (γ-air)** | **$C_i \times K_i$** | **$C_i \times (L_i + 1.1M_i)$** |
|---|---|---|---|---|---|---|---|
| Ar-41 | 8.52E-01 | 4.670E-10 | 8.84E+03 | 2.69E+03 | 9.30E+03 | 4.129E-06 | 6.034E-08 |
| Kr-85 | 1.41E-03 | 7.758E-13 | 1.61E+01 | 1.34E+03 | 1.72E+01 | 1.249E-11 | 1.054E-09 |
| Kr-85m | 7.90E-03 | 4.335E-12 | 1.17E+03 | 1.46E+03 | 1.23E+03 | 5.072E-09 | 1.219E-08 |
| Kr-87 | 2.41E-02 | 1.324E-11 | 5.92E+03 | 9.73E+03 | 6.17E+03 | 7.839E-08 | 2.187E-07 |
| Kr-88 | 2.57E-02 | 1.411E-11 | 1.47E+04 | 2.37E+03 | 1.52E+04 | 2.074E-07 | 2.694E-07 |
| Xe-131m | 2.44E-04 | 1.341E-13 | 9.15E+01 | 4.76E+02 | 1.56E+02 | 1.227E-11 | 6.613E-11 |
| Xe-133 | 2.52E-01 | 1.383E-10 | 2.94E+02 | 3.06E+02 | 3.53E+02 | 4.065E-08 | 9.600E-08 |
| Xe-133m | 3.58E-01 | 1.963E-10 | 2.51E+02 | 9.94E+02 | 3.27E+02 | 4.927E-08 | 2.657E-07 |
| Xe-135 | 7.88E-02 | 4.319E-11 | 1.81E+03 | 1.86E+03 | 1.92E+03 | 7.818E-08 | 1.716E-07 |
| Xe-135m | 3.38E-02 | 1.857E-11 | 3.12E+03 | 7.11E+02 | 3.36E+03 | 5.792E-08 | 8.182E-08 |
| Xe-138 | 1.14E-01 | 6.247E-11 | 8.83E+03 | 4.13E+03 | 9.21E+03 | 5.516E-07 | 8.909E-07 |
| **TOTAL** | | | | | | **5.197E-06** | **8.042E-06** |

Inserting these calculated totals and this sector's χ/Q into equations 10-1 and 10-2, the equations reduce to the following:

$$SP_{TB}\ (\mu Ci/cc) = 1.79E{+}02 AF/VF \quad \text{and} \quad SP_S\ (\mu Ci/cc) = 6.95E{+}03 AF/VF \text{ , or}$$
$$SP_{TB}\ (\mu Ci/cc) = 1.95E{-}04 AF/(VF * \chi/Q) \quad \text{and} \quad SP_S\ (\mu Ci/cc) = 7.58E{-}04 AF/(VF * \chi/Q) \text{ .}$$

From this it is seen that the limiting setpoints are derived using the total body dose rate restriction. The resulting setpoints are shown in Table C-4 where AF is applied only to RE-214, RE-221, RE-224, and RE-225.

TABLE C-4
RMS AIRBORNE ALARM SETPOINTS

| GASEOUS EFFLUENT PATHWAY | MONITORS | DISCHARGE FLOW RATE (cfm) | DEFAULT SETPOINT (μCi/cc) |
|---|---|---|---|
| 1. Auxiliary Building Vent | RE-214 & SPING 23 | 66,400 | 6.75E-04 |
| 2. Combined Air Ejector | RE-225 | 20 | 2.24E+00 |
| 3. Unit Air Ejector | 1(2) RE-215 | 10 | 1.79E+01 |
| 4. Containment Purge Vent | | | |
| Unit 1 | 1RE-212 & SPING 21 | 25,000[1] | 7.17E-03 |
| Unit 2 | 2RE-212 & SPING 22 | 38,000[2] | 4.72E-03 |
| Unit 1(2) | 1(2) RE-212 | 35[3] | 5.12E+00 |
| 5. Gas Stripper Building | RE-224 | 13,000 | 3.45E-03 |
| 6. Drumming Area Vent | RE-221 & SPING 24 | 43,100 | 1.04E-03 |

**Note 1: Two fans of 12,500 cfm**

**Note 2: Two fans + 13,000 cfm from gas stripper bldg.**

**Note 3: Forced vent with nominal 35 cfm flow rate**

APPENDIX D
GASEOUS DOSE TECHNICAL BASIS

TECHNICAL BASIS FOR PBNP SITE-SPECIFIC GASEOUS DOSE

The dose factors for each gaseous effluent pathway are calculated using the following equations:

Inhalation Pathway

$$\bar{A}_{\bar{A}h\bar{A}\bar{A}\bar{A}\bar{A}\bar{A}} = 3.17\bar{A} - 8 * 1\bar{A}6 * \bar{A}\bar{A}\bar{A}\bar{A}_{\bar{A}h\bar{A}\bar{A}\bar{A}} * \bar{A}\bar{A}_{\bar{A}} * \bar{A}\bar{A}_{\bar{A}} * \bar{A}\bar{A}_{\bar{A}\bar{A}\bar{A}\bar{A}\bar{A}} \quad [D\text{-}1]$$

*Where:* | | |
---|---|---
*$BR_a$* | = | *breathing rate for age group "a" ($m^3$/yr):*<br>*Infant = 1400*<br>*Child = 3700*<br>*Teen & Adult = 8000 (from RG 1.109, Table E-5 for maximum exposed individual)*
*$DFI_{iraINH}$* | = | *Inhalation dose factor to the total body or any age group "a" for receptor "r" and nuclide "i" (Tables 10-4 – 10-7)*
*3.17E-8* | = | *Inverse of the number of seconds in a year*
*1E6* | = | *Conversion factor for pCi/μCi*
*$DISP_{zhPIT}$* | = | *Dispersion Factor (X/Q)*
*$AR_i$* | = | *Nuclide(i) Activity Released (uCi)*

Ground Plane Pathway

$$\bar{A}_{\bar{A}h\bar{A}\bar{A}\bar{A}\bar{A}\bar{A}} = \bar{A}\bar{A}_{\bar{A}} * \bar{A}\bar{A}\bar{A}_{\bar{A}h\bar{A}\bar{A}\bar{A}} * 3.17\bar{A} - 8 * 1\bar{A}6 * 8760 * \bar{A}\bar{A}\bar{A}\bar{A} * \bar{A}\bar{A}_{\bar{A}\bar{A}\bar{A}\bar{A}\bar{A}} * \left( \frac{1 - \bar{A}^{-\frac{\ln(2) * \bar{A}_{\bar{A}\bar{A}\bar{A}}}{A_{\bar{A}}}}}{\frac{\bar{A}\bar{A}(2)}{A_{\bar{A}}}} \right) \quad [D\text{-}2]$$

*Where:* | | |
---|---|---
*$AR_i$* | = | *Nuclide(i) Activity Released (uCi))*
*$DEP_{zhPIT}$* | = | *Deposition Factor (D/Q)*
*3.17E-8* | = | *Inverse of the number of seconds in a year*
*$DF_{iraGP}$* | = | *ground plane dose factor for age group "a", receptor "r" and nuclide "i", (Table 10-12)*
*$T_i$* | = | *the radioactive half life of nuclide "i", in $sec^{-1}$*
*$T_{GPE}$* | = | *the exposure period (sec)*<br>*= 9.47E+08 s (30 yr, half of the60 year operating life from RG 1.109, App. C.1)*
*8.76E+09* | = | *conversion factor for pCi/μCi and hr/yr*
*SHFR* | = | *shielding factor*<br>*= 0.7 (see RG 1.109, Table E-15 for maximum exposed individual)*

Grass-Cow-Milk and Meat Pathway

The dose from the grass-cow-milk and meat pathways is determined according to following equations for all particulates and iodines, EXCEPT H-3 and C-14. Form (a) of the equation is used when on pasture, and form (b) when on stored feed.

$$\text{Ā}_{\text{Ā}h\text{ĀĀĀ}-\text{ĀĀĀ}} = \text{ĀĀ}_{\text{Ā}} * \text{ĀĀĀ}_{\text{Ā}h\text{ĀĀĀ}} * 3.17\text{Ā} - 2 * \text{ĀĀ}_{\text{Ā}} * \text{Ā}_{\text{ĀĀ}} * \text{ĀĀĀ}_{\text{ĀĀ}} * \text{ĀĀĀ}_{\text{Ā}} * \text{ĀĀ}_{\text{ĀĀĀĀĀ Ā}} * \left(\frac{\text{ĀĀĀ}_{\text{Ā}}}{\text{ĀĀĀĀ}} + \frac{(1-\text{ĀĀĀ}_{\text{Ā}}) * \text{Ā}^{-\frac{\text{ĀĀ}(2)*\text{ĀĀ}_{\text{ĀĀĀĀ}}}{\text{Ā}_{\text{Ā}}}}}{\text{ĀĀĀĀ}}\right) * \text{Ā}^{-\frac{\text{ĀĀ}(2)*\text{ĀĀ}_{\text{ĀĀĀĀ}}}{\text{Ā}_{\text{Ā}}}} * \left(\frac{\text{ĀĀ}(2)}{\text{Ā}_{\text{Ā}}} + \text{Ā ĀĀ}\right)^{-1} \quad (\text{Ā})$$

$$\text{Ā}_{\text{Ā}h\text{ĀĀĀ}-\text{ĀĀĀ}} = \text{ĀĀ}_{\text{Ā}} * \text{ĀĀĀ}_{\text{Ā}h\text{ĀĀĀ}} * 3.17\text{Ā} - 2 * \text{ĀĀ}_{\text{Ā}} * \text{Ā}_{\text{ĀĀ}} * \text{ĀĀĀ}_{\text{ĀĀ}} * \text{ĀĀĀ}_{\text{Ā}} * \text{ĀĀ}_{\text{ĀĀĀĀĀ Ā}} * \left(\frac{\text{Ā}^{-\frac{\text{ĀĀ}(2)*\text{ĀĀ}_{\text{ĀĀĀĀ}}}{\text{Ā}_{\text{Ā}}}}}{\text{ĀĀĀĀ}}\right) * \text{Ā}^{-\frac{\text{ĀĀ}(2)*\text{ĀĀ}_{\text{ĀĀĀĀ}}}{\text{Ā}_{\text{Ā}}}} * \left(\frac{\text{ĀĀ}(2)}{\text{Ā}_{\text{Ā}}} + \text{Ā ĀĀ}\right)^{-1} \quad (\text{Ā}) \qquad [\text{D-3}]$$

*Where:*

| | | |
|---|---|---|
| $AR_i$ | = | *Nuclide(i) Activity Released (uCi))* |
| $DEP_{zhPIT}$ | = | *Deposition Factor (D/Q)* |
| *3.17E-2* | = | *Conversion Factor (pCi/uCi)*(sec/yr)* |
| $CR_a$ | = | *cow feed consumption rate (kg/d)*<br>*= 50 kg/d (from RG 1.109, Table E-3)* |
| $U_{ap}$ | = | *annual cow's milk consumption rate for age group "a" and milk pathway "p" (L/yr)*<br>*= 330 L/yr for infant*<br>*= 330 L/yr for child*<br>*= 400 L/yr for teen*<br>*= 310 L/yr for adult*<br>*(from RG 1.109, Table E-5 for maximum exposed individual)*<br><br>*annual meat consumption rate for age group "a" and meat pathway "p" (kg/yr)*<br>*= 0 kg/yr for infant*<br>*= 41 kg/yr for child*<br>*= 65 kg/yr for teen*<br>*= 110 kg/yr for adult (see RG 1.109, Table E-5 for maximum exposed individual)* |
| $SET_{im}$ | = | *stable element transfer coefficients (d/L, from RG 1.109, Table E-1)* |
| $DF_{iraING}$ | = | *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)* |
| $T_i$ | = | *Half life of radionuclide "i" (sec$^{-1}$)* |
| $TT_{ARPF}$ | = | *transport time from pasture to cow, to milk, to receptor (sec)*<br>*= 1.73E+05 s (2d, from RG 1.109, Table E-15)* |
| $f_p$ | = | *fraction of the year that cow is on pasture*<br>*= 0.5 (from June 1976 Appendix I submittal to NRC. Doc. Number NPC-27397)* |

| | | |
|---|---|---|
| $FFP_a$ | = | *fraction of cow feed that is pasture grass while cow is on pasture*<br>*= 0.5 (from June 1976 Appendix I submittal to NRC. Doc. Number NPC-27397)* |
| $Ln(2)$ | = | *Natural log of 2 (0.693….)* |
| $FRF_i$ | = | *fraction of deposited activity retained on cow's feed grass*<br>*= 0.5 for radioiodines (Using Reg Guide 1.109 elemental fraction)*<br>*= 0.2 for particulates (see RG 1.109, Table E-15)* |
| $TT_{ARSF}$ | = | *transport time from pasture, to harvest, to cow, to milk to receptor (sec)*<br>*= 7.78E+06 s (90d, see RG 1.109, Table E-15)* |
| WRC | = | *decay constant for removal of activity on leaf and plant surfaces by weathering* ($sec^{-1}$)<br>*=* 5.73E-07 $sec^{-1}$ *(corresponds to a 14 day half-life, see RG 1.109, Table E-15)* |
| APPF | = | *agricultural productivity by unit area of pasture feed grass* ($kg/m^2$)<br>*= 0.7* $kg/m^2$ *(from RG 1.109, Table E-15)* |
| APSF | = | *Agricultural productivity by unit area of stored feed*<br>*1.0* |

For carbon-14, the milk and meat pathway dose is calculated according to the following equation:

$$Ā_{ĀhĀĀĀĀ-Ā} = ĀĀ_{Ā} * ĀĀĀĀ_{ĀhĀĀĀ} * 31.7 * Ā_{ĀĀ} * ĀĀ_{ĀĀĀĀĀ Ā} * \frac{ĀĀĀ * ĀĀ}{24 * ĀĀĀ}$$ [D-4]

*Where:*

*$AR_C$* = *Activity Released (Carbon-14 Only) (uCi)*

*$DISP_{zhPIT}$* = *Dispersion Factor (X/Q)*

*0.16* = *concentration of natural carbon in the atmosphere (see RG 1.109, eqn, C-8) 0.16*

*31.7* = *Conversion Factor (pCi/uCi)* (gm/kg)*(sec/yr)*

*$U_{ap}$* = *annual cow's milk consumption rate for age group "a" and milk pathway "p" (L/yr)*
*= 330 L/yr for infant*
*= 330 L/yr for child*
*= 400 L/yr for teen*
*= 310 L/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)*

*annual meat consumption rate for age group "a" and meat pathway "p" (kg/yr)*
*= 0 kg/yr for infant*
*= 41 kg/yr for child*
*= 65 kg/yr for teen*
*= 110 kg/yr for adult (see RG 1.109, Table E-5 for maximum exposed individual)*

*$DF_{iraING}$* = *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)*

*VCF* = *concentration of natural carbon in the atmosphere (see RG 1.109, eqn, C-8)*
*0.11*

*DH* = *Daylight Hours*
*=14*

24 = *Hours/day*

*NCC* = *Natural Carbon Concentration,*
*0.16*

For hydrogen-3, the milk and meat pathway dose is calculated according to the following equation:

$$\bar{A}_{\bar{A}h\bar{A}\bar{A}\bar{A}\bar{A}-\bar{A}} = \bar{A}\bar{A}_{\bar{A}} * \bar{A}\bar{A}\bar{A}\bar{A}_{\bar{A}h\bar{A}\bar{A}\bar{A}} * 31.7 * \bar{A}\bar{A}\bar{A}_{\bar{A}\bar{A}} * \bar{A}\bar{A}_{\bar{A}} * \bar{A}_{\bar{A}\bar{A}} * \bar{A}\bar{A}_{\bar{A}\bar{A}\bar{A}\bar{A}\bar{A}\bar{A}} * \frac{0.75 * 0.5}{\bar{A}\bar{A}\bar{A}} \quad [D\text{-}5]$$

*Where:*

- $AR_i$ = *Activity Released (Tritium Only) (uCi)*
- $DISP_{zhPIT}$ = *Dispersion Factor (X/Q)*
- *31.7* = *Conversion Factor(pCi/uCi)*(gm/kg)*(sec/yr)*
- $SET_{iM}$ = *stable element transfer coefficients (d/L, from RG 1.109, Table E-1)*
- $CR_A$ = *cow feed consumption rate (kg/d)*
  *= 50 kg/d (from RG 1.109, Table E-3)*
- $U_{ap}$ = *annual cow's milk consumption rate for age group "a" and milk pathway "p" (L/yr)*
  *= 330 L/yr for infant*
  *= 330 L/yr for child*
  *= 400 L/yr for teen*
  *= 310 L/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)*
  
  *annual meat consumption rate for age group "a" and meat pathway "p" (kg/yr)*
  *= 0 kg/yr for infant*
  *= 41 kg/yr for child*
  *= 65 kg/yr for teen*
  *= 110 kg/yr for adult (see RG 1.109, Table E-5 for maximum exposed individual)*
- $DF_{iraING}$ = *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)*
- *0.75* = *fraction of plant mass that is water (see RG 1.109, eqn. C-9)*
- *0.5* = *ratio of tritium concentration in plant water to tritium concentration in atmospheric water (see RG 1.109, eqn, C-9)*
- *AAH* = *absolute humidity at the location of interest* ($g/m^3$)
  *=* $5.5\ g/m^3$ *(from E. L. Entier (1980), Health Physics 39:318-320)*
- $t_h$ = *time interval between harvest and consumption of milk (sec)*
  *= 1.73E+05 sec (2 d, RG 1.109, Table E-15 )*

Fruit, Grain, Non-Leafy Vegetable (Produce) and Leafy Vegetable Pathways

The dose from the fruit, grain, non-leafy vegetable (produce) and leafy vegetable pathways is determined according to the following equation for all particulates and iodines, EXCEPT H-3 and C-14:

$$Ā_{ĀhĀĀĀĀ-ĀĀĀ} = ĀĀ_{Ā} * ĀĀĀ_{ĀhĀĀĀ} * 3.17Ā - 2 * ĀĀĀ_{Ā} * ĀĀ_{ĀĀĀĀĀ Ā} * \left( Ā_{ĀĀĀ} * ĀĀĀ_{ĀĀ} * Ā^{-\frac{ĀĀ(2)*Ā ĀĀ_{ĀĀ}}{Ā_{Ā}}} + \right.$$

$$\left. Ā_{ĀĀĀ} * ĀĀĀ_{ĀĀ} * Ā^{-\frac{ĀĀ(2)*Ā ĀĀ_{ĀĀ}}{Ā_{Ā}}} \right) \left[ ĀĀĀ * \left( \frac{ĀĀ(2)}{Ā_{Ā}} + Ā ĀĀ \right) \right]^{-1} \quad [D-6]$$

| | | | |
|---|---|---|---|
| *Where:* $AR_i$ | = | Activity Released | |
| $DEP_{zhPIT}$ | = | Deposition Factor (D/Q) | |
| *3.17e-2* | = | Conversion Factor (pCi/uCi)*(sec/yr) | |
| $FRF_i$ | = | *fraction of deposited activity remaining on crops*<br>*= 0.5 for radioiodines (Using Reg Guide 1.109 elemental fraction)*<br>*= 0.2 for other particulates (from RG 1.109, Table E-15)* | |
| $DF_{iraING}$ | = | *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)* | |
| $U_{aCSV}$, $U_{aCFV}$ | = | *annual produce usage rate (consumption rate) for age group "a" and produce pathway "p" (kg/yr)*<br>*= 0 kg/yr for infant*<br>*= 520 kg/yr for child*<br>*= 630 kg/yr for teen*<br>*= 520 kg/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)* | *annual produce usage rate (consumption rate) for age group "a" and leafy vegetable pathway "p" (kg/yr)*<br>*= 0 kg/yr for infant*<br>*= 26 kg/yr for child*<br>*= 42 kg/yr for teen*<br>*= 64 kg/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)* |
| $FAI_{FV}$ | = | *fraction of ingestion taken from the garden of interest*<br>*= 1 (from NUREG-0133, page 36)* | |
| $FAI_{SV}$ | = | *fraction of ingestion stored from the garden of interest*<br>*= 0.76 (from NUREG-0133, page 36)* | |
| *Ln(2)* | = | *Natural log of 2 (0.693….)* | |
| $HTC_{FV}$ | = | *Ingestion of produce (Reg Guide 1.109, Table E-15)*<br>*= 8.16 E+4 (sec)* | |
| $HTC_{SV}$ | = | *Ingestion of produce (Reg Guide 1.109, Table E-15)*<br>*= 5.18 E+6 (sec)* | |
| *Ti* | = | *Radioactive Half Life* | |
| *VAD* | = | *agricultural productivity by unit area (kg/m$^2$)*<br>*= 2.0 kg/m$^2$ (from RG 1.109, Table E-15)* | |

WRC = *decay constant for removal of activity on leaf and plant surfaces by weathering, (sec$^{-1}$)*
*= 5.73E-07 sec$^{-1}$ (14 day half-life, from RG 1.109, Table E-15)*

For carbon-14, the Produce and Leafy Vegetable dose is calculated according to the following equations:

$$Ā_{Āh ĀĀĀĀ-Ā} = ĀĀ_{Ā} * ĀĀĀĀ_{Āh ĀĀĀ} * 31.7 * (Ā_{ĀĀĀĀ} * ĀĀĀ_{ĀĀĀ} + Ā_{ĀĀĀĀ} * ĀĀĀ_{ĀĀĀ}) * ĀĀ_{ĀĀĀĀĀĀ} * \frac{ĀĀĀ * ĀĀ}{24 * ĀĀĀ} \qquad [D-7]$$

*Where:*

$AR_c$ = Carbon 14 released (uCi)

$DISP_{zhPIT}$ = *Dispersion Factor (X/Q)*

*31.7* = *Conversion Factor(pCi/uCi)*(gm/kg)*(sec/yr)*

$FAI_{CSV}$ = *fraction of leafy vegetables taken from the garden of interest*
*= 1.0 (from NUREG-0133, page 36)*

$FAI_{CFV}$ = *fraction of produce taken from the garden of interest*
*= 0.76 (from NUREG-0133, page 36)*

$U_{aCSV}$, $U_{aCFV}$ =

*annual produce usage rate (consumption rate) for age group "a" and produce pathway "p" (kg/yr)*
*= 0 kg/yr for infant*
*= 520 kg/yr for child*
*= 630 kg/yr for teen*
*= 520 kg/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)*

*annual produce usage rate (consumption rate) for age group "a" and leafy vegetable pathway "p" (kg/yr)*
*= 0 kg/yr for infant*
*= 26 kg/yr for child*
*= 42 kg/yr for teen*
*= 64 kg/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)*

$DF_{iraING}$ = *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)*

*VCF* = *Vegetation Carbon Fraction*
*0.11 (from Reg. Guide 1.109)*

*DH* = *Daylight Hours*
*14*

*NCC* = *Natural Carbon Concentration in Atmosphere (gm/m$^3$)*
*0.16 (from Reg. Guide 1.109)*

For hydrogen-3, the Produce and Leafy Vegetable dose is calculated according to the following equation:

$$Ā_{ĀhĀĀĀĀ-Ā} = ĀĀ_{Ā} * ĀĀĀĀ_{ĀhĀĀĀ} * 31.7 * (Ā_{ĀĀĀ} * ĀĀĀ_{ĀĀ} + Ā_{ĀĀĀ} * ĀĀĀ_{ĀĀ}) * ĀĀ_{ĀĀĀĀĀ} * \frac{0.75 * 0.5}{ĀĀĀ} \quad \text{[D-8]}$$

*Where:*

- $AR_i$ = *Activity Released (Tritium Only) (uCi)*
- $DISP_{zhPIT}$ = *Dispersion Factor (X/Q)*
- *31.7* = *Conversion Factor(pCi/uCi)*(gm/kg)*(sec/yr)*
- $U_{aSV}$, $U_{aFV}$ = *annual produce usage rate (consumption rate) for age group "a" and produce pathway "p" (kg/yr)*
  *= 0 kg/yr for infant*
  *= 520 kg/yr for child*
  *= 630 kg/yr for teen*
  *= 520 kg/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)*

  *annual produce usage rate (consumption rate) for age group "a" and leafy vegetable pathway "p" (kg/yr)*
  *= 0 kg/yr for infant*
  *= 26 kg/yr for child*
  *= 42 kg/yr for teen*
  *= 64 kg/yr for adult (from RG 1.109, Table E-5 for maximum exposed individual)*
- $FAI_{SV}$ = *fraction of leafy vegetables taken from the garden of interest*
  *= 1.0 (from NUREG-0133, page 36)*
- $FAI_{FV}$ = *fraction of produce taken from the garden of interest*
  *= 0.76 (from NUREG-0133, page 36)*
- $DR_{iarING}$ *Ingestion dose factor to the total body or any age group "a" for receptor "r" and nuclide "I" (Tables 10-8 – 10-11)*
- *0.75* = *fraction of plant mass that is water (see RG 1.109, eqn. C-9)*
- *0.5* = *ratio of tritium concentration in plant waer to tritium concentration in atmospheric water (see RG 1.109, eqn, C-9)*
- *AAH* = *absolute humidity at the location of interest* ($g/m^3$)
  *= 5.5* $g/m^3$ *(from E. L. Entier (1980), Health Physics 39:318-320)*

# APPENDIX E
# DERIVATION OF DILUTION FACTORS USING REGULATORY GUIDE 1.113

## E.1 Liquid Effluent Dilution Factor Calculations

### E.1.1 Methodology

The dilution factors used for calculating the doses from liquid effluent released to Lake Michigan were calculated using the methodology of Regulatory Guide 1.113, "Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I." The parameters used in the calculation and the results of the calculation are given in Table E-1. The results are presented graphically in Figure E-1.

The centerline and shoreline values were calculated using Reg Guide 1.113 formulae 17 and 18 which apply to discharges to the Great Lakes. (The formulae are not presented here. See Appendix I Section 5 of the PBNP FSAR for the formulae and origin of values used.) These results are applied as calculated for fish caught near PBNP. But for other pathways, an extra factor of two (2) is applied to account for current reversals which occur in Lake Michigan as described in the Appendix I, Section 5, of the PBNP FSAR.

TABLE E-1
SURFACE DILUTION FACTORS FOR LIQUID EFFLUENTS IN A LARGE LAKE

| DOWNSTREAM DISTANCE (meters) | PLUME CENTERLINE | SHORELINE |
|---|---|---|
| 10 | 8.81 | |
| 20 | 8.81 | |
| 30 | 8.81 | |
| 40 | 8.81 | |
| 50 | 8.81 | |
| 60 | 8.81 | |
| 70 | 8.81 | |
| 80 | 8.81 | |
| 90 | 8.81 | |
| 100 | 8.81 | |
| 200 | 8.81 | |
| 300 | 8.81 | |
| 400 | 8.81 | |
| 500 | 8.81 | |
| 600 | 8.81 | |
| 700 | 8.81 | |
| 800 | 8.81 | |

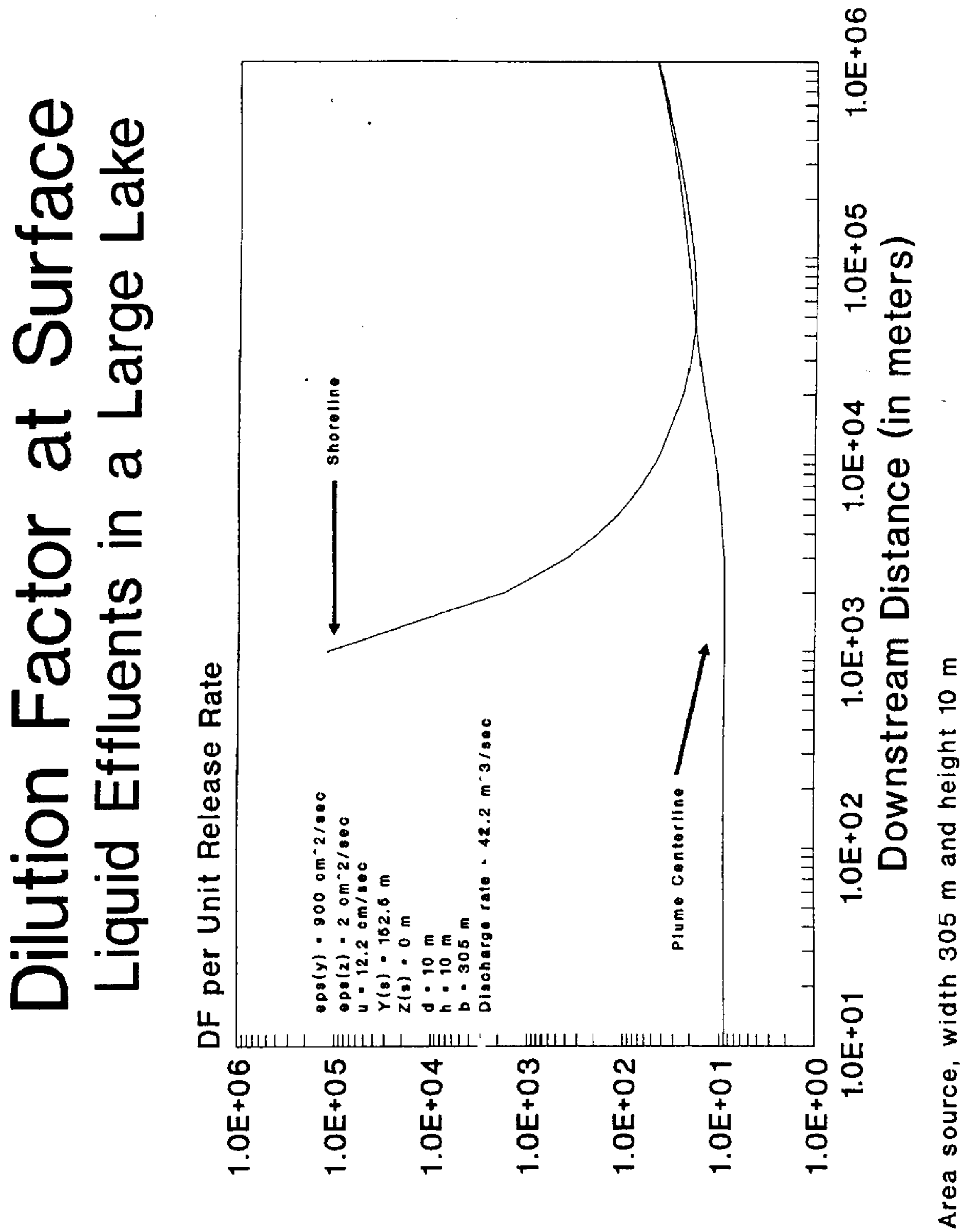
TABLE E-1
SURFACE DILUTION FACTORS FOR LIQUID EFFLUENTS IN A LARGE LAKE

| DOWNSTREAM DISTANCE (meters) | PLUME CENTERLINE | SHORELINE |
|---|---|---|
| 900 | 8.81 | |
| 1000 | 8.81 | 122000 |
| 2000 | 8.86 | 1758 |
| 3000 | 9.01 | 401 |
| 4000 | 9.25 | 186 |
| 5000 | 9.53 | 116 |
| 6000 | 9.85 | 83.8 |
| 7000 | 10.2 | 65.9 |
| 8000 | 10.5 | 54.9 |
| 9000 | 10.8 | 47.4 |
| 10000 | 11.1 | 42.1 |
| 20000 | 14.0 | 24.0 |
| 30000 | 16.1 | 20.1 |
| 40000 | 17.7 | 18.7 |
| 50000 | 18.8 | 18.3 |
| 60000 | 19.6 | 18.2 |
| 70000 | 20.3 | 18.3 |
| 80000 | 20.9 | 18.6 |
| 90000 | 21.4 | 18.9 |
| 100000 | 21.9 | 19.2 |
| 200000 | 25.9 | 23.2 |
| 300000 | 29.2 | 26.9 |
| 400000 | 32.3 | 30.3 |
| 500000 | 35.2 | 33.3 |
| 600000 | 37.8 | 36.0 |
| 700000 | 40.2 | 38.6 |
| 800000 | 42.6 | 41.0 |
| 900000 | 44.8 | 43.3 |
| 1000000 | 46.9 | 45.5 |

**NOTE 1: These values were calculated using the equation described in Section 5.2 of the PBNP FSAR and the following values:**

$\in_y$ = 900 $cm^2$/sec  $z_s$ = 0 meters
$\in_z$ = 2 $cm^2$/sec  d = 10 meters
U = 12.2 cm/sec  h = 10 meters
$y_s$ = 152.5 meters  b = 305 meters
Discharge rate = 42.2 $m^3$/sec

FIGURE E-1
DILUTION FACTORS AT SURFACE



## E.1.2 Dilution Factor Twelve Miles Downstream: Two Rivers Water Intake

The dilution factors used at the Two Rivers water intake twelve miles downstream from PBNP included the factor of two described in Section E.1.1. However, instead of using the straight centerline dilution factor shown in Table 1, the weighted average dilution factor calculated over the width of the plume was used.

The approach was used for the following reasons. First, the path that the current takes to reach the Two Rivers water intake is not straight. In order to reach Two Rivers, the water must flow southeast around Point Beach State Park, which juts into Lake Michigan, and then curves back 90 degrees towards Two Rivers. As a result of this deviation from straight line flow, any part of the plume or possibly none of the plume would impinge upon the intake structure.

Second, there is a difference in the distance offshore of the PBNP discharge and the Two Rivers water intake. The Two Rivers water intake is located 5080 feet offshore. By contrast, PBNP discharges close to the shoreline through two flumes, one directed north and one directed south, and is modeled as a source that extends 1000 feet out into the lake from the shoreline.

Based on these two considerations, it was concluded that the weighted average dilution across the width of the plume as it diverges while flowing south would constitute a better estimate of the dilution factor instead of the calculated for the centerline of an area source as is assumed for the FSAR calculation. The calculation and the values used are shown below.

The average dilution factor at 12 miles downstream was calculated in the following manner:

The standard deviation of the radionuclide concentration in the y direction at 12 miles downstream on the surface of the lake is 168.8 meters. This calculation used the following formula:

$$\sigma_y = \sqrt{\frac{2 \times \varepsilon_y \times x}{u}} \qquad \text{[E-1]}$$

*Where:*

$\sigma_y$ = *Standard deviation of the radionuclide concentration in the y direction*

$\varepsilon_y$ = *Lateral turbulent diffusion coefficient (cm²/sec) = 900 cm²/sec*

$x$ = *Downstream distance (cm) =1.93E+06 cm*

$u$ = *Current (cm/sec) = 12.2 cm/sec*

At distances of 0.1σ, 0.2σ, etc. off the plume centerline, the dilution factor was calculated using the equation shown in Appendix I Section 5.2 of the PBNP FSAR. The distances off the plume centerline, the calculated dilution factor, and the fraction of the area under the normal distribution curve is listed below.

TABLE E-2
DILUTION FACTORS

| STANDARD DEVIATION | DISTANCE (meters) | FRACTION OF AREA UNDER CURVE[1] | DILUTION FACTOR |
|---|---|---|---|
| 0.1σ | 16.9 | 0.080 | 13.8 |
| 0.2σ | 33.8 | 0.080 | 14.0 |
| 0.3σ | 50.6 | 0.078 | 14.3 |
| 0.4σ | 67.5 | 0.075 | 14.7 |
| 0.5σ | 84.4 | 0.072 | 15.2 |
| 0.6σ | 101.3 | 0.068 | 15.8 |
| 0.7σ | 118.1 | 0.065 | 16.6 |
| 0.8σ | 135.0 | 0.060 | 17.6 |
| 0.9σ | 151.9 | 0.056 | 18.8 |
| 1.0σ | 168.8 | 0.051 | 20.2 |
| 1.1σ | 185.6 | 0.046 | 21.9 |
| 1.2σ | 202.5 | 0.042 | 23.9 |
| 1.3σ | 219.4 | 0.037 | 26.3 |
| 1.4σ | 236.3 | 0.032 | 29.2 |
| 1.5σ | 253.2 | 0.028 | 32.6 |
| 1.75σ | 295.4 | 0.053 | 44.7 |
| 2.0σ | 337.6 | 0.035 | 64.7 |
| 2.25σ | 379.8 | 0.021 | 98.4 |
| 2.5σ | 421.9 | 0.012 | 158.4 |
| 3.0σ | 506.3 | 0.010 | 482 |
| | **TOTAL** | **1.000** | |

**NOTE:** **It is assumed that the standard deviation of the radionuclide concentrations across the plume can be represented by a normal distribution curve. The fraction of the total area under the curve is that fraction of the area under the curve that lies between, for example, the interval 0.1σ and 0.2σ which also includes the area of the curve in the interval -0.1σ and -0.2σ.**
**The average dilution factor over the width of the plume was calculated by multiplying the dilution factor at each of the locations off of the plume centerline by the fraction of the total area of the curve occupied by that interval and then summing over all the intervals. An average dilution factor of 29 was calculated.**

APPENDIX F
RADIOLOGICAL IMPACT OF SEWAGE TREATMENT SLUDGE DISPOSAL

**NOTE: Appendix F is for historical reference. Land disposal of sewage sludge is no longer used at Point Beach**

The methodology for determining the radiological impact of land application of contaminated sewage treatment sludge is presented in this section. The evaluation must be made prior to every land application of sewage treatment plant (STP) sludge that contains licensed material. Sludge and other STP material which does not contain licensed material may be disposed of by any legal method without prior radiological analysis.

F.1 Basis, Commitments and Actions

F.1.1 Basis

With the discovery that the PBNP STP sludge contained licensed material, Wisconsin Electric applied for NRC approval to dispose of the sludge by land application on land within the PBNP site boundary pursuant to 10 CFR 20.302(a). Wisconsin Electric committed to gamma isotopic analysis (GIA) of the sludge to measure the concentrations of licensed material in the STP sludge and to compare the results to concentration limits prior to each disposal [letter dated October 8, 1987 (VPNPD-87-430, NRC-87-104)] (See Appendix G). In addition, the dose to the maximally exposed individual of the general public and to the inadvertent intruder would be evaluated for the appropriate exposure pathways.

F.1.2 Basis for NRC Commitment Modification

Pursuant to NRC guidance, the sludge is clean if no licensed materials are found when analyzed under conditions necessary to achieve the environmental LLDs (NRC HPPOS 221). Clean sludge is not under NRC jurisdiction and may be disposed of by any legal method without prior radioanalyses. Therefore, if the sludge is clean and there is no pathway to the STP from the RCA, or pathways are administratively controlled to prevent the transfer of licensed materials to the STP, there is no need to analyze the sludge prior to any disposal.

Since the 1987 commitment, engineering modifications and administrative controls have eliminated the pathways from the RCA to the STP. Three subsequent sludge GIAs (a total of eight STP samples) utilizing the analytical parameters required to achieve environmental lower limit of detection (LLD) found only naturally occurring radionuclides. In each analysis, the licensed materials were below the minimum detectable activity for the particular measurement and below the required LLDs. These results verify the efficiency of the modifications and administrative controls in eliminating pathways from the RCA to the STP. Therefore, because there is no longer any reason to believe that the PBNP STP sewage contains licensed material and there are no pathways from the RCA to the STP, the sewage may be disposed of by any legal method without GIA prior to each disposal.

### F.1.3 Modification

Periodic gamma isotopic analyses (GIA) of the STP sludge shall occur at a frequency set forth in the Chemistry Analytical Methods & Procedures (CAMP). This may include analyses prior to disposal depending on the results from the periodic analyses. The GIA of the STP sludge shall meet the LLD criteria of normal liquid effluents. The detection of any licensed material in the sludge during the periodic GIA shall necessitate returning to the GIA prior to disposal in order to evaluate the radiological consequences of the disposal. The GIA prior to each disposal shall continue until such time that the sludge can be shown, using environmental LLD criteria, not to contain licensed material.

Also, re-initiation of the 1987 commitment to analyze the STP sludge prior to each disposal shall be required if plant conditions change in a manner which would lead one to believe that the STP sludge may be contaminated. An example of such a condition is the opening of valve STP-009 which is controlled by a tag. Again, reversion to a CAMP controlled frequency can occur only upon verification that no licensed material is in the sludge pursuant to the environmental LLD criteria.

### F.1.4 Exposure Evaluations

If the sludge contains licensed material, the 1987 commitment requires that the appropriate exposure pathways be evaluated prior to each application of sludge to insure that the dose to the maximally exposed member of the general public is maintained at less than 1 mrem/year and that to the inadvertent intruder, at less than 5 mrem/year. Also, the measured concentration shall be compared to the liquid maximum effluent concentrations of Appendix B to 10 CFR 20.

The exposure pathways evaluated for the maximally exposed individual are the following:

1. External whole body exposure due to a ground plane source of radionuclides.
2. Milk ingestion pathway from cows fed alfalfa grown on plot.
3. Meat ingestion pathway from cows fed alfalfa grown on plot.
4. Vegetable ingestion pathway from vegetables grown on plot.
5. Inhalation of radioactivity resuspended in air above plot.
6. Pathways associated with a release to Lake Michigan. These pathways are ingestion of potable water at the Two Rivers, Wisconsin municipal water supply, ingestion of fish from edge of initial mixing zone of radionuclide release, ingestion of fresh and stored vegetables irrigated with water from Lake Michigan, ingestion of milk and meat from cows utilizing Lake Michigan as drinking water source, swimming and boating activities at the edge of the initial mixing zone, and shoreline deposits.

The exposure pathways evaluated for the inadvertent intruder are the same as items 1, 4, 5, and 6 identified above for the maximally exposed individual.

F.2 Procedure

The following steps are to be performed by the responsible Chemistry Specialist for each contaminated sewage treatment sludge disposal.

1. Determine the radionuclide concentrations in each representative sewage treatment sludge sample. The minimum number of representative samples required is three from each sludge storage tank. The average of all statistically valid concentration determinations will be utilized in determining the sludge storage tank concentration values.

2. Verify that the concentration of each radionuclide meets the concentration and activity limit criteria. The methodology for determining compliance with the concentration and activity limit criteria are contained in Wisconsin Electric letter VPNPD 87-430.

3. Verify that the proposed disposal of the sewage treatment sludge will maintain doses within the applicable limits. This calculation will include radionuclides disposed of in previous sludge applications. The activity from these prior disposals will be corrected for radiological decay prior to performing dose calculations for the meat, milk, and vegetable ingestion pathways, the inhalation of resuspended radionuclides, and all pathways associated with a potential release to Lake Michigan. The residual radioactivity will be corrected, if applicable, for the mixing of radionuclides in the soil prior to performing external exposure calculations.

   Microshield, a nationally recognized computer code, will be used to calculate the dose rate due to standing on a plot of land utilized for sludge disposal in which the radionuclides from prior disposals have been incorporated into the plot by plowing. This calculated dose rate will be used to assess the radiological consequences from prior disposals with the consequences of proposed future disposals. The total radiological dose consequence of the past and the proposed disposal will be compared to the applicable limits to insure the dose is maintained at or below the limits.

   The methodology for calculating the radiological impact of the sewage treatment sludge disposal is contained in Wisconsin Electric letter VPNPD 87-430.

4. Inform the appropriate Chemistry Specialist that the sewage treatment sludge disposal may proceed after verifying that the sewage treatment sludge meets the concentration, activity, and dose limits.

5. All calculations shall be included with the sewage treatment sludge disposal record.

F.3 Administrative Requirements

The following steps are to be performed by the responsible Chemistry Specialist for each contaminated sewage treatment sludge disposal.

1. Complete records of each contaminated disposal shall be kept as follows:

   a. Radionuclide concentration of the sludge
   b. Total volume of the sludge disposed
   c. The identity of the plot used for the disposal
   d. Dose calculation results
   e. Results of annual chemical composition determination

2. Modifications to the WE application as documented in the October 8, 1987, letter shall be processed in accordance with NP 5.1.7, Regulatory Commitment Management. (CCE 001-013)

   a. Commitment Change - 1

      Section 3.2 of Attachment II of the submittal states that physical and chemical properties of the sludge would be determined prior the each land application. Pursuant to a change in the PBNP WPDES Permit, non-radiological properties are now determined annually instead of per application. The frequency for radiological characterization did not change. (See Appendix H and CCE 2002-002)

   b. Commitment Change - 2

      In Section 3.3 of Attachment II of the submittal letter, the annual disposal rate was…" limited to 4,000 gallons/acre, provided WDNR chemical composition, NRC dose guidelines and activity limits are maintained...." Modification 2 removes the 4,000 gallon limit and makes the application unlimited provided the WDNR and NRC constraints are met. (See Appendix I and CCE 2002-004)

c. Commitment Change - 3

In Section 3.2 of Attachment II of NRC submittal letter dated October 8, 1987, Wisconsin Electric committed to gamma isotopic analysis (GIA) to determine the concentration of licensed material in sewage treatment plant (STP) sludge prior to each disposal. Pursuant to NRC HPPOS-221 guidance, the sludge has been shown to be clean on three different occasions after pathways from the RCA to the STP were eliminated by plant modifications and administrative controls. Pursuant to HPPOS, the sludge analyses were done under the conditions necessary to achieve the environmental LLDs. Only naturally occurring radionuclides were found and licensed material was below the minimum detectable concentration. This indicates that the former pathways from the RCA to the STP had been eliminated. Therefore, there is no need to continue the analyses because there is no RCA to STP pathway and there is no reason to believe that the sewage contains licensed material. Hence, the commitment to analyze STP sludge prior to every disposal is modified and replaced with periodic analyses at a frequency set by CAMP 914. However, if plant conditions change in a manner which places the STP sewage outside the guidance parameters which allowed for the discontinuance of analyses, the sewage must be analyzed prior to each disposal until it again is shown not to contain licensed material. (See Appendix J and CCE-2002-3)

# APPENDIX G
## VPNPD-87-430, NRC-87-104

Wisconsin Electric submittal to the United States Nuclear Regulatory Commission, dated October 8, 1987 (VPNPD-87-430, NRC-87-104)

The submittal consists of the letter and two Attachments. Attachment II contains Appendices A-G.

Pursuant to the NRC letter of January 13, 1988 (NPC-30260), a copy of the submittal (VPNPD-87-430, NRC-87-104) must be permanently incorporated into the ODCM as an Appendix and future modifications of the letter be reported to the NRC in accordance with commitments regarding ODCM changes.

Wisconsin Electric POWER COMPANY
231 W. MICHIGAN, P.O. BOX 2046, MILWAUKEE, WI 53201
(414) 277-2345

VPNPD-87-430
NRC-87-104

October 8, 1987

Plant 12010100 gen. (cr. 05160000) file for commitment made for additional sampling & analysis prior to discharge (Attach II, ILF page 2)

U.S. NUCLEAR REGULATORY COMMISSION
Document Control Desk
Washington, D.C. 20555

Gentlemen:

DOCKET NOS. 50-266 AND 50-301
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
FOR 10 CFR 20.302 APPLICATION
POINT BEACH NUCLEAR PLANT

On July 14, 1987, Wisconsin Electric Power Company submitted an application, under the provisions of 10 CFR 20.302, for approval of a proposed procedure to dispose of sewage treatment sludge containing minute quantities of radioactive materials. Subsequent to the application, Mr. Ted Quay of the NRC staff requested additional information regarding the environmental characteristics of the area surrounding the Point Beach Nuclear Plant. The responses to this request were furnished in our submittal dated August 6, 1987.

By letter dated September 9, 1987, the NRC has requested Wisconsin Electric supply additional information in order to complete the review of our application. This Request for Additional Information (RAI) contains ten specific items which require responses or commitments from Wisconsin Electric. In addition, the NRC requests the previously submitted information and the information supplied in response to the RAI be compiled into "one complete, extensive, and self-contained package". To facilitate your review, Attachment I is included to provide direct responses to the ten items contained in the RAI. Attachment II is provided as the complete application, including the information from our letters dated July 14, 1987, and August 6, 1987, and information supplied in response to the NRC RAI.

We request that you complete your review of this complete, self-contained package and issue an approval of our application

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NRC Document Control Desk
October 8, 1987
Page 2

as soon as possible. In order to facilitate your review and to expedite processing, we would be pleased to discuss these matters or provide additional information by telephone. Please feel free to contact us.

Very truly yours,

C. W. Fay
Vice President
Nuclear Power

bjm

Attachments

Copies to NRC Resident Inspector
NRC Regional Administrator, Region III

Blind copies to Britt/Gorske/Finke, Burstein, Charnoff, Fay, Krieser, Lipke, Newton, Zach

# ATTACHMENT I

## RESPONSES TO QUESTIONS CONTAINED IN THE REQUEST FOR ADDITIONAL INFORMATION (RAI) ON POINT BEACH 1 AND 2 REQUEST FOR DISPOSAL OF LOW LEVEL RADIOACTIVITY CONTAMINATED SEWAGE SLUDGE BY LAND APPLICATION WISCONSIN ELECTRIC POWER COMPANY UNDER 10 CFR 20.302(a)

The numbering system used in these responses corresponds directly to numbering used in the NRC RAI, dated September 9, 1987.

1. a. This request is for multiple applications, approximately 2 to 4 per year.
   b. This request is for multiple years, expiration to coincide with conclusion of decommissioning activities associated with retirement of PBNP Units 1 & 2.
   c. Please refer to the response to question number 10.

2. The pathways used to determine doses to both the maximally exposed individual and the inadvertent intruder are documented in Attachment II, Appendices D and E.

   Due to the extremely low concentrations of radionuclides in the sewage sludge and the associate low doses, Wisconsin Electric will control access to the disposal sites by conditions of use defined in lease agreements with the lease. Use of the land is not controlled beyond the conditions of the lease, thereby not restraining a casual visitor from the disposal site. However continuous occupancy would be readily observed, and remedial action would be taken.

3. Information contained in previous submittals has been included in Attachment II with modifications to provide specific commitments to the NRC.

4. Please refer to the response to question number 10.

5. Site maps have been updated and are included in Attachment II, Appendix C.

6. The direct grazing of cattle on the proposed disposal sites is controlled by restrictions contained in the lease agreement.

   There will be no restrictions placed on fishermen on Lake Michigan. Calculations of doses due to all pathways associated with a release to Lake Michigan (Attachment II, Appendix E) do not indicate a need to apply restrictions to fishermen.

7. Please refer to revised site maps included in Attachment II, Appendix C. Site number 5 is located on company owned land beyond the PBNP site boundary. All other sites are within the PBNP site boundary area.

8. a. Please refer to Attachment II, Section 3.2, Disposal Procedure.
   b. Please refer to Attachment II, Section 3.2, Disposal Procedure.
   c. Please refer to Attachment II, Section 3.2, Disposal Procedure.
   d. Please refer to Attachment II, Appendix A.

9. Please refer to Attachment II, including Appendix D and Appendix E for additional pathways analyzed for this submittal. These identified pathways will be analyzed prior to all subsequent disposals to insure doses are maintained within prescribed limits, i.e., 1 mrem/year to the maximally exposed individual and 5 mrem/year to the inadvertent intruder.

10. A limiting concentration level for the sludge contained in the storage tank is discussed, in Attachment II, Appendix F. Since this application is for multiple applications over multiple years, Attachment II, Appendix F also addresses an activity limit.

# ATTACHMENT II

## COMPLETE ANALYSIS AND EVALUATION
## POINT BEACH NUCLEAR PLANT
## 10 CFR 20.302(a) APPLICATION

1.0 Purpose

By this submittal Wisconsin Electric Power Company requests approval of the U.S. Nuclear Regulatory Commission for a proposed procedure to dispose of sewage treatment sludge containing trace quantities of radionuclides generated at the Point Beach Nuclear Plant. This request is submitted in accordance with the provisions of 10 CFR 20.302(a).

2.0 Waste Description

The waste involved in this disposal process consists of the residual solids remaining in solution upon completion of the aerobic digestion sewage treatment process utilized at PBNP. The PBNP sewage treatment plant is used to process waste water from the plant sanitary and potable water systems. These systems produce non-radioactive waste streams with the possible exception of wash basins located in the radiologically controlled area of the plant. These wash basins are believed to be the primary source of the extremely small quantities of radionuclides in the sludge.

The sewage sludge generated at PBNP is allowed to accumulate in the sewage plant digestor and aeration basin. Two to four times annually, depending on work activities and corresponding work force at PBNP, the volume of the sludge in the digestor and aeration basin needs to be reduced to allow continued efficient operation of the treatment facility. The total volume of sludge removed during each disposal operation is typically on the order of 15,000 gallons. The maximum capacity for the entire PBNP treatment facility and hence the maximum disposal volume is about 30,000 gallons. In the case of a maximum capacity disposal, doses would not necessarily increase in proportion to the volume, since more than one disposal site may be used.

Trace amounts of radionuclides have been identified in PBNP sludge currently being stored awaiting disposal. The radionuclides identified and their concentrations in the sludge are summarized below:

| Nuclide | Concentration (µCi/cc) |
|---|---|
| Co-60 | 2.33E-07 |
| Cs-137 | 1.50E-07 |

The total activity of the radionuclides in the stored sludge, based on the identified concentrations and a total volume of 15,000 gallons of sewage sludge, are as follows:

| Nuclide | Activity (µCi) |
|---|---|
| Co-60 | 13.2 |
| Cs-137 | 8.5 |

These concentrations and activities are consistent with expected values based on prior analyses of sewage sludge. The radionuclide concentration in the sewage sludge has remained relatively constant during sampling conducted since December 30, 1983. A detailed summary of the results of this sampling program are contained in Appendix A for your review.

In addition to monitoring for the radionuclide content of the sludge, the WDNR requires several other physical and chemical properties of the sludge to be determined. These properties are the percent total solids, percent total nitrogen, percent ammonium nitrogen, pH, percent total phosphorus, percent total potassium, cadmium, copper, lead, nickel, mercury, zinc, and boron. An example of a typical sludge sample analysis is included in Appendix B

## 3.0 Disposal Method

In the context of this application, Wisconsin Electric commits to the following methodology. No distinction is made or intended between "shall" or "will", as used in the descriptions contained in this section.

## 3.1 Transport of Sludge

The method used to dispose of the sludge shall utilize a technique approved by the WDNR. The process of transporting the sewage sludge for disposal involves pumping the sludge from the PBNP sewage treatment plant storage tanks into a truck mounted tank. The truck mounted tank shall be required to be maintained tightly closed to prevent spillage while in transit to the disposal site. The sludge shall be transported to one or more of the six sites approved by the WDNR for land application of the sewage sludge from PBNP.

### 3.2 Disposal Procedure

The radionuclide concentrations in the sludge shall be determined prior to each disposal by obtaining three representative samples from each of the sludge storage tanks. The sludge contained in the sludge tanks is prevented from going septic by a process known as complete mix and continuous aeration. This process completely mixes the sludge allowing for representative samples to be obtained.

The samples shall be counted utilizing a GeLi detector and multi-channel analyzer with appropriate geometry. The detection system is routinely calibrated and checked to ensure the lower limits of detection are within values specified in the Radiological Effluent Technical Specifications (RETS).

To insure the samples are representative of the overall concentration in the storage tanks, the radionuclide concentration determination for each of the three samples shall be analyzed to insure each sample is within two standard deviations of the average value of the three samples. If this criteria is not met, additional samples will be obtained and analyzed to insure a truly representative radionuclide concentration is utilized for dose calculations and concentration limit determinations. The average of all statistically valid concentration determinations will be utilized in determining the storage tank concentration values.

Prior to disposal the waste stream will be monitored to determine the physical and chemical properties of the sludge, as discussed in the last paragraph of Section 2.0, Waste Description. The results will be compared to State of Wisconsin limits to insure the sludge does not pose a chemical hazard to people or to the environment.

The radionuclides identified in the sludge, along with their respective concentrations, will be compared to concentration limits prior to disposal. The methodology discussed in Appendix F will be used in determining compliance with the proposed concentration limit. The total activity of the proposed disposal will be compared to the proposed activity limit as described in Appendix F.

If the concentration and activity limit criteria are met, the appropriate exposure pathways (as described in Appendix D) will be evaluated prior to each application of sludge. These exposures will be evaluated to insure the dose to the maximally exposed individual will be maintained less than 1 mrem/year and the dose to the inadvertent intruder is maintained less than 5 mrem/year. The exposures will be calculated utilizing the methodology used in Appendix E, including the current activity to be landspread along with the activity from all prior disposal. The remaining radioactivity from prior disposals will be corrected for radiological decay prior to performing dose calculations for the meat, milk, and vegetable ingestion pathways, the inhalation of resuspended radionuclides, and all pathways associated with a release to Lake Michigan. The residual radioactivity will be corrected for radiological decay and, if appropriate, the mixing of the radionuclides in the soil by plowing prior to performing external exposure calculations.

The sewage sludge is applied on the designated area of land utilizing the WDNR approved technique and adhering to the following requirements of WPDES Permit Number WI-0000957-3.

- Discharge to the land disposal system shall be limited so that during surface spreading all of the sludge and any precipitation falling onto or flowing onto the disposal field shall not overflow the perimeter of the system.
- Sludge shall not be land spread on land with a slope greater than 12%. During the period from December 15 through March 31 sludge shall not be land spread on land with a slope greater than 6% unless the wastes are injected immediately into the soil.
- Sludge shall not be surface spread closer than 500 feet from the nearest inhabited dwelling except that this distance may be reduced with the dwelling owner's written consent.
- Sludge shall not be spread closer than 1,000 feet from a public water supply well or 250 feet from a private water supply well.
- Sludge shall not be land spread within 200 feet of any surface water unless a egetative buffer strip is maintained between the surface watercourse and the land spreading system, in which case a minimum separation distance of at least 100 feet is required between the system and the surface watercourse.

- Depth to groundwater and bedrock shall be greater than 3 feet from the land surface elevation during use of any site.
- Sludge shall not be land spread in a floodway.
- Sludge shall not be land spread within 50 feet of a property line road or ditch unless the sludge is incorporated with the soil, in which case a minimum separation distance of at least 25 feet is required.
- The pH of the sludge-soil mixture shall be maintained at 6.5 or higher.
- Low areas of the approved fields, subject to seasonally high ground-water levels, are excluded from the sludge application.
- Crops for human consumption shall not be grown on the land for up to one year following the application of the sludge.
- The sludge shall be plowed, disked, injected or otherwise incorporated into the surface soil layer at appropriate intervals.

The flexibility implied in the latter provision for soil incorporation is intended to allow for crops which require more than a one year cycle. For the Point Beach disposal sites, alfalfa is a common crop which is harvested for several years after a single planting. Sludge disposal on an alfalfa plot constitutes good fertilization, but the plot cannot be plowed without destroying the crop. The alfalfa in this case aids in binding the layer of sludge on the surface of the plot. At a minimum, however, plowing (or disking or other method of injection and mixing to a nominal depth of 6 inches) shall be done prior to planting any new crop, regardless of the crop.

### 3.3 Administrative Procedures

Complete records of each disposal will be maintained. These records will include the concentration of radionuclides in the sludge, the total volume of sludge disposed, the total activity, the plot on which the sludge was applied, the results of the chemical composition determinations, and all dose calculations.

The annual disposal rate for each of the approved land spread sites will be limited to 4,000 gallons/acre, provided WDNR chemical composition, NRC dose guidelines, and concentration and activity limits are maintained within the appropriate values.

The farmer leasing the site used for the disposal will be notified of the applicable restrictions placed on the site due to the land spreading of sewage sludge.

## 4.0 Evaluation of Environmental Impact

### 4.1 Site Characteristics

#### 4.1.1 Site Topography

The disposal sites are located in the Town of Two Creeks in the northeast corner of Manitowoc County, Wisconsin, on the west shore of Lake Michigan about 30 miles southeast of the center of the city of Green Bay, and 90 miles NNE of Milwaukee. This site is located at longitude 87° 32.5'W and latitude 44° 17.0'N. The six sites are on property owned and controlled by Wisconsin Electric and are within or directly adjacent to the Point Beach site boundary. The sites are described below and are outlined on the map contained in Appendix C as Figure 3.

Site No. PB-01 - The approximately 15 acres located in the NE 1/4 of the NE 1/4 of Section 23, T. 21N - R. 24E.

Site No. PB-02 - The approximately 20 acres located in the SE 1/4 of the SE 1/4 of Section 14, T. 21N - R. 24E.

Site No. PB-03 - The approximately 5 acres located in the NW 1/4 of Section 24, T. 21N - R. 24E.

Site No. PB-04 - The approximately 5 acres located in the NW 1/4 of the SW 1/4 of Section 24, T. 21N - R. 24E.

Site No. PB-05 - The approximately 5 acres located in the NE 1/4 of the NW 1/4 of Section 25, T. 21N - R. 24E.

Site No. PB-06 - The approximately 5 acres located in the NE 1/4 of the SW 1/4 of Section 14, T. 21N - R. 24E.

The overall ground surface at the site of the Point Beach Nuclear Plant is gently rolling to flat with elevations varying from 5 to 60 feet above the level of Lake Michigan. Subdued knob and kettle topography is visible from aerial photographs. The land surface slopes gradually toward the lake from the higher glacial moraine areas west of the site. Higher ground adjacent to the lake, however, diverts the drainage to the north and south.

The major surface drainage features are two small creeks which drain to the north and south. One creek discharges into the lake about 1500 feet above the northern corner of the site and the other near the center of the site. During the spring, ponds of water may occupy the shallow depressions. As mentioned in Section 3.2, Disposal Procedure, these low areas are excluded from the sludge application.

A site topographic map covering details out to a 5 mile radius may be found in the FSAR at Figure 2.2-3 and is included in Appendix C as Figure 2.

The disposal of sewage sludge at these six sites will have no impact on the topography of this area.

4.1.2 <u>Site Geology</u>

Prior to construction of the Point Beach Nuclear Plant, an evaluation of the geological characteristics of the area in and surrounding the site was made. The geologic structure of the region is essentially simple. Gently dipping sedimentary rock strata of Paleozoic age outcrop in a horseshoe pattern around a shield of Precambrian crystalline rock which occupies the western part of the region. The site is located on the western flank of the Michigan Basin, which is a broad downwarp ringed by discontinuous outcrops of more resistant formations. The bedrock formations are principally limestones, dolomites, and sandstones with subordinate shale layers. The rocks form a succession of extensive layers that are relatively uniform in thickness. The bedrock strata dip very gently towards Lake Michigan at rates from 15 to 35 feet per mile.

The uppermost bedrock under the site is Niagara Dolomite. Bedrock does not outcrop on the site but is covered by glacial till and lake deposits. The soils contain expansive clay minerals and have moderately high base exchange capacity.

In the area of the site, the overburden soils are approximately 70 to 100 feet in thickness. Although the character of the glacial deposits may vary greatly within relatively short distances, a generalized section through the overburden soils adjacent to Lake Michigan at the site consists of the following sequence:

1. An upper layer of brown clay silt topsoil underlain with several feet of brown silty clay with layers of silty sand;

2. A layer of 20 feet of reddish-brown silty clay with some sand and gravel and occasional lenses of silt;

3. A layer of 25 feet of reddish-brown silty clay with layers of silty sand and lenses of silt;

4. A layer of 50 feet of reddish-brown silty clay with some sand and gravel, the lower portion of which contains gravels, cobbles, and boulders resting on a glacial eroded surface of Niagara dolomite bedrock.

Site drainage is poor due to the high clay content of the soil combined with the pock-marked surface. Additional information on site geology may be found in Section 2.8 of the FSAR.

The use of these sites for disposal of sewage sludge will not impact the geology of the area.

## 4.2 Area Characteristics

### 4.2.1 Meteorology

The climate of the site region is influenced by the general storms which move eastward along the northern tier of the United States and by those which move northeastward from the south-western part of the country to the Great Lakes. This conti-nental type of climate is modified by Lake Michigan. During spring, summer, and fall months the lake temperature differs markedly from the air temperature. Wind shifts from westerly to easterly directions produce marked cooling of day-time temperatures in spring and summer. In autumn the relatively warm water to the lake prevents night-time temperatures from falling as low as they do a few miles inland from the shoreline. Summer time temperatures exceed 90°F for six days on the average. Freezing temperatures occur 147 days and below zero on 14 days of the winter on the average. Rainfall averages about 28 inches per year with 55 percent falling in the months of May through September. Snowfall averages about 45 inches per year. Sludge spreading shall be managed such that the surface spreading together with any precipitation falling on the field shall not overflow the perimeter of the field. Additional information on site meteorology may be found in Section 2.6 of the FSAR.

There will be no impact on the meteorology of the area due to the disposal of the sewage sludge.

4.2.2 Hydrology

The dominant hydrological feature of this site is Lake Michigan, one of the largest of the Great Lakes. The normal water level in Lake Michigan is approximately 580 feet above mean sea level. In the general vicinity of the site, the 30 foot depth contour is between 1 and 1-1/2 miles offshore and the 60 foot contour is 3 to 3-1/2 miles off shore. The disposal sites are twenty or more feet above the normal lake level. There is no record that the sites have been flooded by the lake during modern times. There are no rivers or large streams which could create a flood hazard at or near the sites.

The subsurface water table at the Point Beach site has a definite slope eastward toward the lake. The gradient indicated by test drilling on the site is approximately 30 feet per mile. It is therefore extremely unlikely that any release of radioactivity on the site could spread inland. Furthermore, the rate of subsurface flow is small due to the relative impervious nature of the soil and will not promote the spread of releases. Further information on site hydrology is detailed in the PBNP FSAR Section 2.5.

There will be no adverse impact on hydrology of the area due to disposal of sewage sludge by land spreading.

4.3 Water Usage

4.3.1 Surface Water

Lake Michigan is used as the source of potable water supplies in the vicinity of the site for the cities of Two Rivers (12 miles south), Manitowoc (16 miles sourth), Sheboygan (40 miles south), and Green Bay (intake at Rostok 1 mile north of Kewaunee, 13 miles north). No other potable water uses are recorded within 50 miles of the site along the lake shore. All public water supplies drawn from Lake Michigan are treated in purification plants. The nearest surface water used for drinking other than Lake Michigan are the Fox River 30 miles NW and

Lake Winnebago 40 miles W of the site.

Lake Michigan is also utilized by various recreational activities, including fishing, swimming and boating.

There will be no impact on surface water usage due to the disposal of sewage sludge.

4.3.2 Ground Water

Ground water provides the remaining population with potable supplies. Public ground water supplies within a 20 mile radius of the site are listed in Table 2.5-3 of the FSAR. Additional wells for private use are in existence throughout the region. The location of private wells within a two mile radius of PBNP are indicated on Figure 3, Appendix C.

The potable water for use at the Point Beach Nuclear Plant is drawn from a 257 feet deep well located at the southwest corner of the plant yard. Water from this well is routinely sampled as part of the environmental monitoring program.

There will be no adverse impact on ground water usage due to the disposal of sewage sludge.

4.4 Land Usage

Manitowoc County, in which the site is located, and the adjacent counties of Kewaunee, Brown, Calumet, and Sheboygan are predominantly rural. Agricultural pursuits account for approximately 90% of the total county acreage. With the exception of the Kewaunee Nuclear Plant located 4.5 miles north, the region within a radius of five miles of the site is presently devoted exclusively to agriculture. Dairy products and livestock account for 85% of the counties' farm production, with field crops and vegetables accounting for most of the remainder. The principal crops are grain corn, silage corn, oats, barley, hay, potatoes, green peas, lima beans, snap beans, beets, cabbage, sweet corn, cucumbers, and cranberries. Within the township of Two Creeks surrounding the site (15 sq. miles), there are about 800 producing cows on about 40 dairy farms. Some beef cattle are raised 2.5 miles north of the site. Cows are on pasture from the first of June to late September or early October. During the winter, cows are fed on locally produced hay and silage. Of the milk produced in this area, about 25 percent is consumed as fluid milk and 50 percent is converted to cheese, with the remainder being used in butter making and other by-products.

It has been the policy of Wisconsin Electric to permit the controlled use of crop land and pasture land on company owned property. No direct grazing of dairy or beef cattle or other animals is permitted on these company owned properties. Crops intended for human consumption shall not be grown on the disposal sites for at least one year following the application of the sludge.

The proposed land application of sewage sludge will not have any direct effect on the adjacent facilities. Additional land use information may be found in Section 2.4 of the FSAR.

## 4.5 Radiological Impact

The rate of sewage sludge application on each of the six proposed sites will be monitored to insure doses are maintained within applicable limits. These limits are based on NRC Nuclear Reactor Regulation (NRR) staff proposed guidance (described in AIF/NESP-037, August, 1986). These limits require doses to the maximally exposed member of the general public to be maintained less than 1 mrem/year due to the disposal material. In addition, NRR guidance requires doses of less than 5 mrem/year to an inadvertent intruder.

To assess the doses received by the maximally exposed individual and the inadvertent intruder, six credible pathways have been identified for the maximally exposed individual and four credible pathways for the inadvertent intruder. The identified credible pathways are described in Appendix D.

Calculations detailed in Appendix E demonstrate the disposal of the currently stored PBNP sewage sludge would remain below these limits. The total annual exposure to the maximally exposed individual based on the identified exposure pathways is equal to 0.072 mrem. The dose to a hypothetical intruder assuming an overly conservative occupancy factor of 100% is calculated to be 0.115 mrem/year. By definition, the inadvertent intruder would not be exposed to the processed food pathways (meat and milk).

The calculational methodology used in determining doses for the proposed disposal of sludge stored at PBNP shall be utilized prior to each additional land application to insure doses are maintained less than those proposed by NRR. This calculation will include radionuclides disposed of in previous sludge applications. The activity from these prior disposals will be corrected for radiological decay prior to performing dose calculations for the meat, milk, and vegetable ingestion pathways, the inhalation of resuspended radionuclides, and all pathways associated with a potential release to Lake Michigan. The residual radioactivity will be corrected for radiological decay and, if applicable, the mixing of radionuclides in the soil prior to performing external exposure calculations. In addition, the dose to a farmer potentially leasing more than one application site will be addressed by summing the doses received from the external exposure from a ground plane source and resuspension inhalation pathways for each leased site. In addition, the maximum site specific dose due to the other pathways identified in Appendix D, will be utilized in the total exposure estimation.

## 5.0 Radiation Protection

The disposal operation will follow the applicable PBNP procedures to maintain doses as low as reasonably achievable. Technical review and guidance will be provided by the PBNP Superintendent - Health Physics.

# APPENDIX A

## SUMMARY OF RADIOLOGICAL ANALYSES OF SEWAGE SLUDGE SINCE DECEMBER 30, 1983

| Sample Date | Tank | Tank Volume (Gallons) | Radionuclide | Concentration (µCi/cc) |
|---|---|---|---|---|
| 12-30-83 | Digester | 8400 | Co-58 | 5.58E-07 |
| | | | Co-60 | 1.87E-06 |
| | | | Cr-51 | 4.88E-07 |
| | | | Cs-134 | 1.59E-07 |
| | | | Cs-137 | 3.57E-07 |
| 4-05-84 | Digester | 7560 | Co-60 | 7.89E-07 |
| | Aeration | 6667 | Co-60 | 1.87E-07 |
| 12-05-84 | Digester | 7560 | Co-58 | 1.75E-07 |
| | Aeration | 6667 | Co-60 | 8.29E-07 |
| 6-03-85 | Digester | 7560 | Co-60 | 8.29E-07 |
| | | | Cs-137 | 2.46E-07 |
| | Aeration | 6700 | Co-60 | 3.27E-07 |
| | | | Cs-137 | 1.33E-07 |
| 4-10-86 | Digester | 7560 | Co-60 | 6.79E-07 |
| | | | Cs-137 | 1.72E-07 |
| | | | Mn-54 | 4.91E-08 |
| | | | Co-60 | 1.65E-07 |
| 11-04-86 | Digester | 7560 | Co-58 | 8.04E-08 |
| | Aeration & Clarifier | 25100 | Co-58 | 1.37E-07 |
| | | | Co-60 | 2.18E-07 |
| | | | Cs-137 | 1.64E-07 |

# APPENDIX B

## CHEMICAL COMPOSITION ANALYSIS OF SEWAGE SLUDGE

STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES

**SLUDGE CHARACTERISTIC**
Wisconsin Statute 147.02(1) and
Wisconsin Administrative Code NR 110.27(6)
FORM 3400-49 REV. 10-80

Sewage Treatment Plant Sludge

Please complete this form and send to the Department of Natural Resources appropriate District/Area Office. Keep one copy for your records.
For additional forms, please contact your appropriate District/Area Office.

| | |
|---|---|
| PERMITTEE: Wisconsin Electric Power Company | WPDES PERMIT NUMBER: WI 00 0 0 9 5 7 |
| STREET OR ROUTE: 231 W. Michigan Street | COUNTY: Milwaukee |
| CITY, STATE, ZIP CODE: Milwaukee, WI 53203 | TELEPHONE NUMBER (INCLUDE AREA CODE): 414-277-2153 |

1. Please report laboratory testing results for the following parameters:

| *Parameter | Abbreviation | Result | *Parameter | Abbreviation | Result |
|---|---|---|---|---|---|
| Total Solids, % | – | 1.6[illegible] | Chromium, ppm | Cr | [illegible] |
| Total Nitrogen, % | TOT N | 1.0 | Copper, ppm | Cu | 2200 |
| Ammonium Nitrogen, % | $NH_4^+$–N | 0.34 | Lead, ppm | Pb | 190 |
| Total Phosphorous, % | P | < 0.01 | Mercury, ppm | Hg | 5.6 |
| Total Potassium, % | K | 0.25 | Nickel, ppm | Ni | 12 |
| Arsenic, ppm | As | 1.0 | Zinc, ppm | Zn | 2300 |
| Cadmium, ppm | Cd | 12. | pH | – | 7.0 |

*Suggested analysis procedures for the above parameters can be found in NR 219, analytical tests and procedures, Wisconsin Administrative Code. All parameters other than percent solids and pH shall be reported on a dry weight basis.

2. What is the name of the laboratory that did the analysis and when was it performed?

Laboratory Name: Wisconsin Electric Power Co. Laboratory Services Division Date sent to lab: April 12, 1983

3. Where at the treatment plant was the sample taken? From sludge holding tank prior to hauling

4. When was the sample taken? April 12, 1983

| SIGNATURE | TITLE | DATE |
|---|---|---|
| [illegible] | Water Quality Engineer | [illegible] |

# APPENDIX C

# SITE MAPS

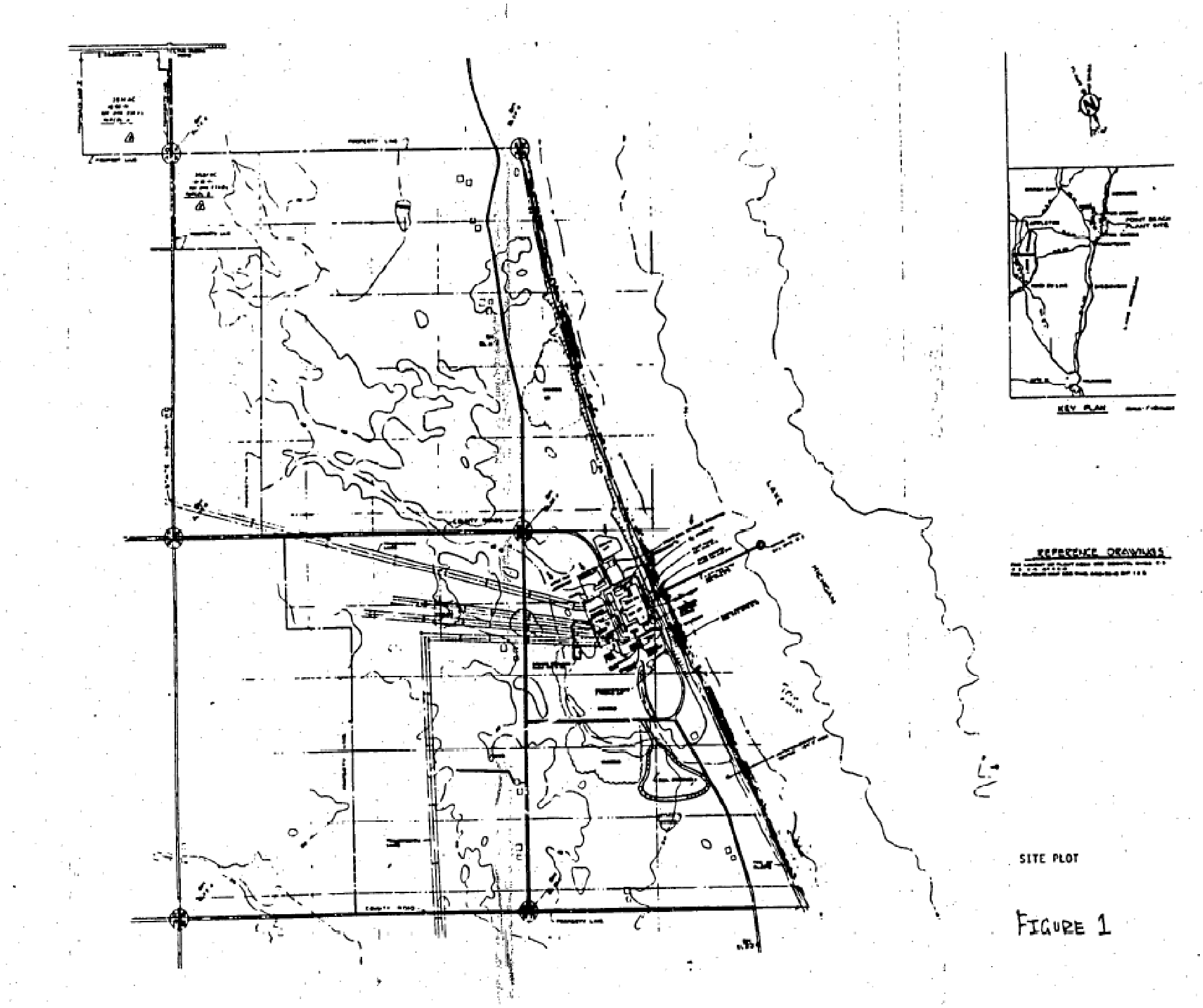
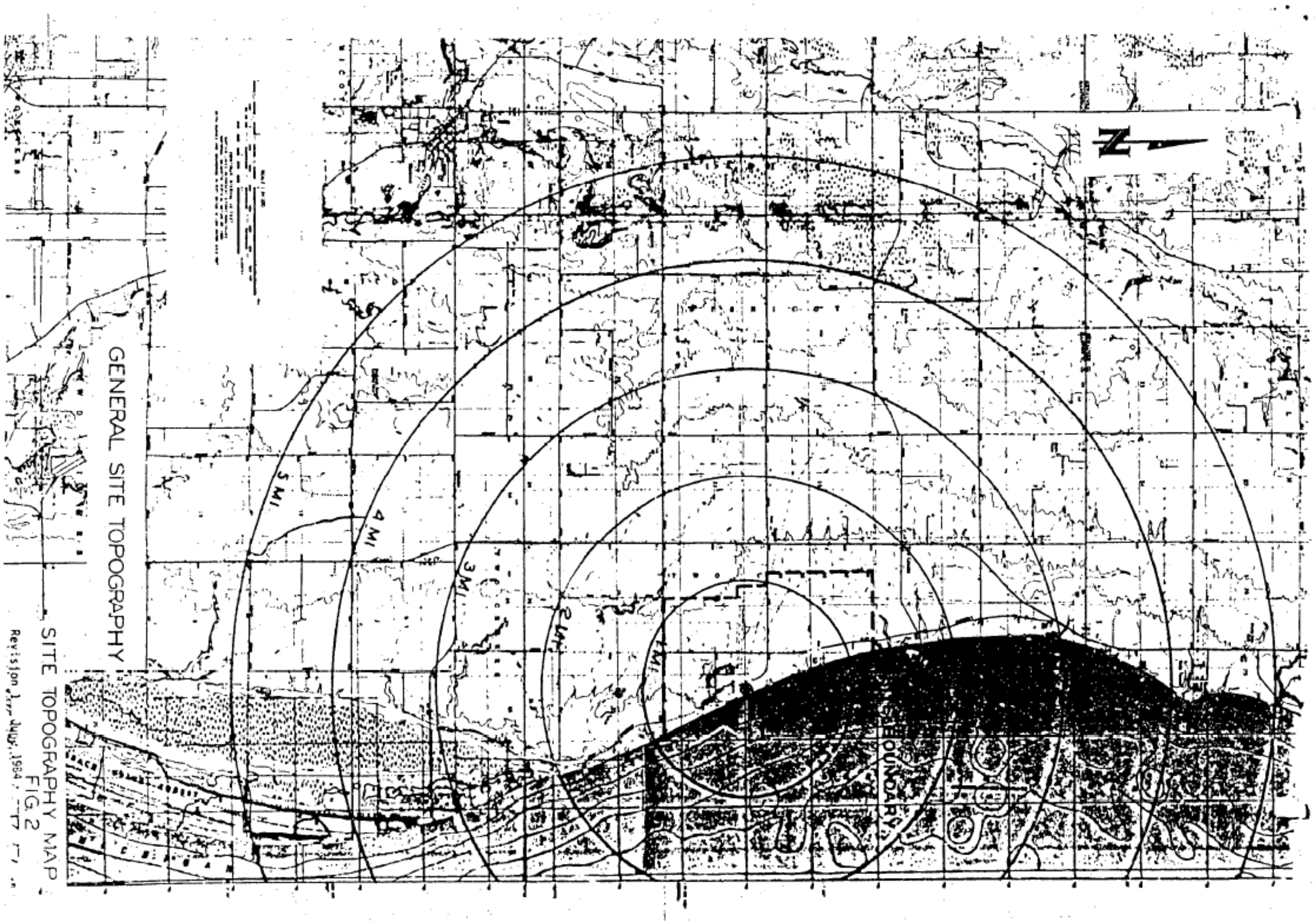
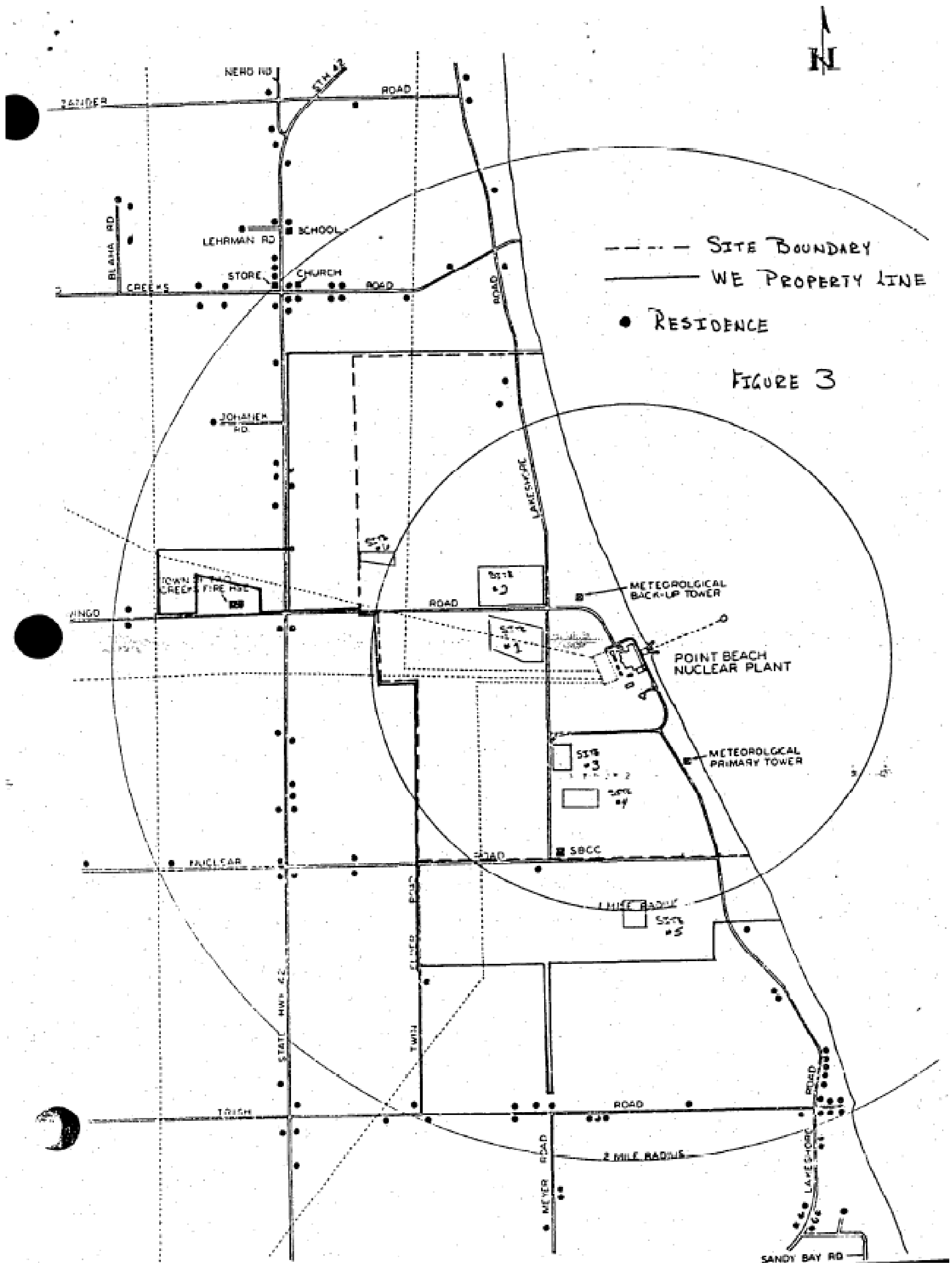



FIGURE 1


GENERAL SITE TOPOGRAPHY
5 MI
4 MI
3 MI
2 MI
1 MI
SITE TOPOGRAPHY MAP
FIG. 2


N
SITE BOUNDARY
WE PROPERTY LINE
RESIDENCE
FIGURE 3
ZANDER
ROAD
NERO RD
STH 42
BLAHA RD
LEHRMAN RD
SCHOOL
STORE
CHURCH
CREEKS
ROAD
JOHANEK RD
LAKESHORE
TOWN OF TWO CREEKS FIRE HSE
VINGO
ROAD
METEOROLGICAL BACK-UP TOWER
POINT BEACH NUCLEAR PLANT
METEOROLGICAL PRIMARY TOWER
SBCC
NUCLEAR
ROAD
1 MILE RADIUS
STATE HWY 42
TWIN ELMER ROAD
IRISH
ROAD
MEYER ROAD
2 MILE RADIUS
LAKESHORE
SANDY BAY RD

# APPENDIX D

# EXPOSURE PATHWAYS

## I. EXPOSURE PATHWAYS - MAXIMALLY EXPOSED INDIVIDUAL

1. External whole body exposure due to a ground plane source of radionuclides.
2. Milk ingestion pathway from cows fed alfalfa grown on plot.
3. Meat ingestion pathway from cows fed alfalfa grown on plot.
4. Vegetable ingestion pathway from vegetables grown on plot.
5. Inhalation of radioactivity resuspended in air above application site.
6. Pathways associated with a release to Lake Michigan. Ingestion of potable water at Two Rivers, Wisconsin municipal water supply, ingestion of fish from edge of initial mixing zone of radionuclide release, ingestion of fresh and stored vegetables irrigated with water source as Lake Michigan, ingestion of milk and meat from cows utilizing Lake Michigan as drinking water source, swimming and boating activities at edge of initial mixing zone, and shoreline deposits.

## II. EXPOSURE PATHWAYS - INADVERTENT INTRUDER

1. External whole body exposure due to a ground plane source of radionuclides.
2. Vegetable ingestion pathway from vegetables grown on plot.
3. Inhalation of radioactivity resuspended in air above application site.
4. Pathways associated with a release to Lake Michigan. Ingestion of potable water at Two Rivers, Wisconsin municipal water supply, ingestion of fish from edge of initial mixing zone of radionuclide release, ingestion of fresh and stored vegetables irrigated with water source as Lake Michigan, ingestion of milk and meat from cows utilizing Lake Michigan as drinking water source, swimming and boating activities at edge of initial mixing zone, and shoreline deposits.

The milk and meat pathways are not included in calculating the dose to the inadvertent intruder. The doses due to these pathways are calculated based on feeding the cows alfalfa grown on the sludge applied land. Since direct grazing on these lands is prohibited, the alfalfa must be cropped prior to being used as feed. This effectively removes the availability of these pathways to the inadvertent intruder, who by definition occupies the sludge applied land continuously.

## III. GROUND WATER PATHWAY

The ingestion of groundwater is not a credible exposure pathway. The two factors contributing to this determination are as follows:

1. The site map in Appendix C, Figure 3 details the spatial relationship between the proposed disposal sites and the local ground water wells. The flow gradient of ground water was determined for the PBNP FSAR to be towards Lake Michigan. Reviewing the sites and local wells shows no private well located in the path of radionuclide migration towards Lake Michigan.

   The PBNP site well is located on the plant site, potentially in a path of radionuclide migration. The PBNP well is routinely sampled as a requirement of the PBNP environmental monitoring program.

2. The cation exchange capacity (CEC) of the soils at each site has been determined.

| Site | Cation Exchange Capacity (MEQ/100g) |
|---|---|
| 1 | 16 |
| 2 | 11 |
| 3 | 11 |
| 4 | 10 |
| 5 | 8 |
| 6 | 9 |

The cation exchange capacity of soil is dependent on the valance of the radionuclides and is determined by the relation:

$$MEQ = \frac{\text{ATOMIC WEIGHT}}{\text{VALANCE}} * 1.0E-03$$

| Radionuclide | Valance | CEC (MEQ/100g) |
|---|---|---|
| Co-60 | +2 | 3.00E-02 |
| Co-58 | +2 | 2.90E-02 |
| Cs-137 | +1 | 1.37E-01 |
| Mn-54 | +2 | 2.70E-02 |
| Cr-51 | +3 | 1.70E-02 |
| Cs-134 | +1 | 1.34E-01 |

Using the values for Cs-137 and site 5 which has the lowest CEC, the total exchange capacity of the soil is

$$\frac{1.10 \text{ grams of Cs-137}}{100 \text{ grams of soil}}$$

Calculating the specific activity of Cs-137,

$$\text{Specific Activity} = \frac{3.578E+05}{T_{1/2}(\text{yrs.}) \cdot \text{ATOMIC MASS}} = \frac{3.578E+05}{30 \cdot 137}$$

$$= 87.1 \text{ Ci/gram}$$

The cation exchange capacity of the soil expressed in the number of Curies of radionuclide per 100 grams of soil is

$$\frac{95.8 \text{ Ci Cs-137}}{100 \text{ grams of soil}}$$

Since the proposed disposal of sewage sludge contains quantities of radionuclides on the order of 10-100 μCi the soil at each site has the capacity to effectively eliminate the migration of the radionuclide to ground water.

# APPENDIX E

## EXPOSURE ANALYSIS

## GENERAL ASSUMPTIONS

1. Sewage sludge is uniformly applied over plot acreage.

2. Sewage sludge is applied to one of the 5 acre plots, site PB-03, PB-04, PB-05, or PB-06. (Assuming the smallest site size is conservative for the calculation methodology herein.)

3. Based on the sewage sludge currently stored at PBNP, the following data is used in the calculations.

| Radionuclide | Sludge Volume (Gallons) | Sludge Volume ($cm^3$) | Activity ($\mu Ci$) | Concentration ($\mu Ci/cm^3$) | Ground Plane Concentration ($\mu Ci/cm^2$) |
|---|---|---|---|---|---|
| Co-60 | 15,000 | 5.68E+07 | 13.2 | 2.33E-07 | 6.53E-08 |
| Cs-137 | 15,000 | 5.68E+07 | 8.5 | 1.50E-07 | 4.21E-08 |

## I. CALCULATION OF EXTERNAL EXPOSURES

### A. Specific Assumptions

1. Conservatively assume radioactivity remains on surface of land plot. Calculation ignores any plowing or mixing of radioactivity within soil. Calculations for the proposed disposal will therefore ignore self absorption or shielding from soil.

   The external exposure at the application site due to prior disposals will be calculated utilizing the methodology in Appendix G and added to that calculated for the proposed disposal.

2. The plots are owned by Wisconsin Electric and have been approved by the Wisconsin Department of Natural Resources (DNR) as disposal sites. The land is leased and potentially farmed. Occupancy of the land can be realistically expected only during plowing, planting and harvesting. Occupancy has been estimated to be 64 hours per year.

### B. Summary of Calculational Methodology

1. Calculate ground plane radionuclide concentrations in $pCi/cm^2$.

2. The dose from a plane of uniformly deposited radionuclides is calculated using Regulatory Guide 1.109, Revision 1, Appendix C, Formula C-2.

3. Dose rates were calculated assuming continuous occupancy then adjusted for realistic occupancy factors.

C. External Exposure Rate Calculations

The dose from a plane of uniformly deposited radionuclides is calculated using Regulatory Guide 1.109, Revision 1, Appendix C, formula C-2

$$D_j^G(r,\theta) = 8760\ S_F \sum_i C_i^G(r,\theta)\ DFG_{ij}$$

where

$D_j^G(r,\theta)$ = yearly dose

8760 = hours per year

$S_F$ = 1.0, since no dose reduction due to residential shielding is applicable.

$C_i^G(r,\theta)$ = ground plane radionuclide concentration (pCi/m²)

DFG(i,j) = external dose factor for standing on contaminated ground as given in Table E-6 of Regulatory Guide 1.109, Revision 1.

| Radionuclide | γ Dose Factor (mrem/hr per pCi/m²) | Ground Plane Concentration (µCi/cm²) | Ground Plane Concentration (pCi/m²) | γ Dose Rate (mrem/yr) |
|---|---|---|---|---|
| Co-60 | 1.70E-08 | 6.53E-08 | 6.53E+02 | 9.72E-02 |
| Cs-137 | 4.20E-09 | 4.21E-08 | 4.21E+02 | 1.55E-02 |

TOTAL: 1.13E-01 mrem/year

These calculated dose rates assume continuous occupancy. In reality, these sites will be occupied only during plowing, planting, and harvesting. Assuming an occupancy of 2 hours per day, 1 day per week, and 32 weeks (8 month growing season) per year, the occupancy factor becomes

2 hr/day * 1 day/week * 32 weeks/yr * 1/8760 hours/yr = 7.3E-03.

EXTERNAL EXPOSURE DOSE RATE (mrem/year)

| Radionuclide | Continuous Occupancy | Realistic Occupancy |
|---|---|---|
| Co-60 | 9.72E-02 | 7.10E-04 |
| Cs-137 | 1.55E-02 | 1.13E-04 |
| TOTAL: | 1.13E-01 | 8.23E-04 |

## II. CALCULATION OF MEAT AND MILK INGESTION PATHWAY EXPOSURES

### A. Specific Assumptions

1. All feed consumed by cow is grown on sludge applied acreage.
2. All meat and milk consumed by human is from cattle exclusively fed feed from sludge applied land.
3. Stable element transfer coefficients ($B_{iv}$) are utilized from Regulatory Guide 1.109 to estimate the fraction of radioactivity which is transferred from the soil to the feed.

| Radionuclide | $B_{iv}$ |
|---|---|
| Co-60 | 9.4E-03 |
| Cs-137 | 1.0E-02 |

4. Alfalfa has typically been grown on the plots. Soil tests have indicated a minimum alfalfa yield of 4.1 tons per acre can be expected.

### B. Summary of Calculational Methodology

1. The concentration of radionuclides in feed grown on the disposal plots is estimated. Transfer coefficients ($B_{iv}$) from Table E-1 of Regulatory Guide 1.109 were used to estimate the fraction of radionuclide which may be expected to transfer to the feed from the soil.
2. Concentrations of radionuclides in milk and meat were estimated using Formula A-11 from Regulatory Guide 1.109.
3. Ingestion dose rates were estimated using Formula A-12 from Regulatory Guide 1.109.

### C. Milk and Meat Ingestion Pathway Dose Rate Calculation

1. Concentration in feed.

Activity in Feed = $B_{iv}$ * Activity in Soil

Concentration in Feed = Activity in Feed/($\frac{\text{kg of Feed}}{\text{Acre}}$ * 5 Acres)

| Radionuclide | Activity in Soil (μCi) | Activity in Feed (μCi) | Radionuclide Concentration in Feed (pCi/kg) |
|---|---|---|---|
| Co-60 | 13.2 | 1.24E-01 | 6.67E+00 |
| Cs-137 | 8.5 | 8.50E-02 | 4.57E+00 |

2. Concentration in Milk and Meat

Calculate concentrations of radionuclides in milk and meat using

Formula A-11 in Regulatory Guide 1.109, Revision 1 which is

$$C_{iA} = F_{iA} * C_{iF} * Q_F$$

where $C_{iA}$ = radionuclide concentration of i in component A
$F_{iA}$ = stable element transfer coefficient whose values are in Table E-1 of the Regulatory Guide
$C_{iF}$ = radionuclide concentration in feed
$Q_F$ = consumption rate of feed = 50 kg/d (wet weight) from Regulatory Guide 1.109

Use the following Regulatory Guide 1.109 values for $F_{iA}$

| Element | $F_{iA}=_m$ (d/l) for milk | $F_{iA}=F_f$ (d/kg) for meat |
|---|---|---|
| Co | 1.0E-03 | 1.3E-02 |
| Cs | 1.2E-02 | 4.0E-03 |

| Radionuclide | Concentration in Milk (pCi/l) | Concentration in Meat (pCi/kg) |
|---|---|---|
| Co-60 | 3.34E-01 | 4.34E+00 |
| Cs-137 | 2.74E+00 | 9.14E-01 |

3. Calculated Dose rates

The formula for total dose from eating animal products fed vegetation (alfalfa) grown on PBNP sludge applied land is given by Regulatory Guide 1.109, Revision 1, Formula A-12, page 1.109-16. But, as noted following equation A-13, it is necessary to compute separately the milk and meat portions of the dose.

$$DOSE = \Sigma(U_{ap} * D_{iapg} * \exp(-\lambda_i t_s))$$

where $U_{ap}$ = consumption rate of animal product
$C_{iA}$ = conc of radionuclide i in animal product A
$D_{iapg}$ = dose factor
$t_s$ = average time between milking or slaughtering and consumption

| | $U_{ap}$ by Age Group | | | |
|---|---|---|---|---|
| | Infant | Child | Teenager | Adult |
| Milk (l/yr) | 330 | 330 | 400 | 310 |
| Meat (kg/yr) | - | 41 | 65 | 110 |

$C_{iA}$ = concentration calculated above

$D_{iapg}$ = DF whole body dose factors, Regulatory Guide 1.109, Revision 1.

**Whole Body Dose Factors (mrem/pCi Ingested)**

| Nuclide | Infant Ingestion | Child Ingestion | Teenager Ingestion | Adult Ingestion |
|---|---|---|---|---|
| Co-60 | 2.55E-05 | 1.56E-05 | 6.33E-06 | 4.72E-06 |
| Cs-137 | 4.33E-05 | 4.62E-05 | 5.19E-05 | 7.14E-05 |

$T_s$ = 0 for milk (assume consumption on farm)
= 20 days for meat (Regulatory Guide 1.109, Revision 1, Table E-15)

**MILK INGESTION DOSE RATE (mrem/year)**

| Radionuclide | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| Co-60 | 2.81E-03 | 1.72E-03 | 8.46E-04 | 4.89E-04 |
| Cs-137 | 3.92E-02 | 4.18E-02 | 5.69E-02 | 6.06E-02 |
| TOTALS: | 4.20E-02 | 4.35E-02 | 5.77E-02 | 6.11E-02 |

**MEAT INGESTION DOSE RATE (mrem/year)**

| Radionuclide | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| Co-60 | - | 2.76E-03 | 1.77E-03 | 2.24E-03 |
| Cs-137 | - | 1.73E-03 | 3.08E-03 | 7.18E-03 |
| TOTALS: | - | 4.49E-03 | 4.85E-03 | 9.42E-03 |

**MEAT AND MILK INGESTION PATHWAY DOSE RATES (mrem/year)**

Infant - 4.20E-02
Child - 4.80E-02
Teenager - 6.26E-02
Adult - 7.05E-02

## III. CALCULATION OF VEGETABLE INGESTION PATHWAY EXPOSURES

### A. Specific Assumptions

1. The WPDES permit issued to PBNP for the disposal of sewage sludge prohibits the growing of crops for human consumption for one year following the application of the sewage sludge. Therefore, prior to planting vegetables on the application site, the soil would be plowed. Plowing is assumed to uniformly mix the top 6 inches of soil.

2. The soil density is assumed to be 1.3 grams/cm³.

3. All vegetables consumed by the individual of interest are grown on the sludge applied acreage.

4. Stable element transfer coefficients ($B_{iv}$) from Regulatory Guide 1.109 are used to estimate the fraction of radioactivity transfered from the soil to the vegetables.

| Radionuclide | $B_{iv}$ |
|---|---|
| Co-60 | 9.4E-03 |
| Cs-137 | 1.0E-02 |

5. The consumption factors of food medium ($U_{ap}$) and the mass basis distributions from Regulatory Guide 1.109, Table E-5 are used to determine annual consumption of vegetables.

$U_{ap}$ by Age Group*

| Infant | Child | Teen | Adult |
|---|---|---|---|
| - | 280 kg/yr | 340 kg/yr | 280 kg/yr |

*Based on 54% vegetable consumption by mass of fruit, vegetable, and grain.

6. The Ingestion Dose Factors by age group are from Regulatory Guide 1.109, Tables E-11, E-12, E-13, and E-14.

Whole Body Ingestion Dose Factors (mrem/pCi ingested)

| Radionuclide | Infant | Child | Teen | Adult |
|---|---|---|---|---|
| Co-60 | 2.55E-05 | 1.56E-05 | 6.33E-06 | 4.72E-06 |
| Cs-137 | 4.33E-05 | 4.62E-05 | 5.19E-05 | 7.14E-05 |

7. Radiological decay of the radionuclides applied to the plot is not taken into account in these calculations.

B. Summary of Calculational Methodology

1. The radionuclide concentration in the soil is calculated in units of pCi/kg based on uniform application over 5 acre plot, plowing to a depth of 6 inches, and a soil density of 1.3 g/cm³.

2. The $B_{iv}$ values are applied to the soil concentration values to obtain the radionuclide concentration in the vegetables.

3. The consumption factors ($U_{ap}$) for each age group are then used to determine the annual radionuclide intake by age group due to eating these vegetables.

4. Finally, the age dependent ingestion dose factors are used to obtain annual doses by age group.

C. Vegetable Pathway Ingestion Dose Rate Calculations

1. Concentration in soil

| Radionuclide | Activity Applied (μCi) | Soil Volume ($cm^3$) | Soil Mass (kg) | Concentration In Soil (pCi/kg) |
|---|---|---|---|---|
| Co-60 | 13.2 | 3.08E+09 | 4.00E+06 | 3.30E+00 |
| Cs-137 | 8.5 | 3.08E+09 | 4.00E+06 | 2.13E+00 |

2. Concentration in vegetables

| Radionuclide | Concentration In Soil (pCi/kg) | $B_{iv}$ | Concentration In Vegetables (pCi/kg) |
|---|---|---|---|
| Co-60 | 3.30E+00 | 9.4E-03 | 3.10E-02 |
| Cs-137 | 2.13E+00 | 1.0E-02 | 2.13E-02 |

3. Calculated Dose Rates

The dose rate for direct ingestion of vegetables grown on the sludge applied land is given by the equation.

$$\text{DOSE RATE} = \Sigma\, U_{ap} * D_{iapj} * \text{EXP}(-\lambda_i t) * C_i$$

where

$U_{ap}$ = consumption rate of food medium
$D_{iapj}$ = dose factor for radionuclide, i
$\lambda_i$ = radiological decay constant
t = time between harvest and consumption
$C_i$ = concentration of radionuclide, i, in food medium.

t, the time between harvest and ingestion, is assumed to be zero for this calculation.

VEGETABLE INGESTION DOSE RATE (mrem/year)

| Radionuclide | Infant | Child | Teen | Adult |
|---|---|---|---|---|
| Co-60 | - | 1.35E-04 | 6.67E-05 | 4.10E-05 |
| Cs-137 | - | 2.76E-04 | 3.76E-04 | 4.26E-04 |
| TOTAL | - | 4.11E-04 | 4.43E-04 | 4.67E-04 |

## IV. CALCULATION OF INHALATION OF RESUSPENDED RADIONUCLIDES PATHWAY EXPOSURE

### A. Specific Assumptions

1. The model used to determine the radionuclide concentration in air above the sludge applied land is taken from WASH-1400, USNRC, Reactor Safety Study - An Assessment of Accident Risks in Commercial Nuclear Power Plants, Appendix VI.

2. The radionuclide concentration in air remains constant for year of interest, i.e., radiological decay and decrease in resuspension factor are not taken into account for this calculation.

3. The maximally exposed member of the general public is assumed to be the farmer using the plot of land with an occupancy of 64 hours per year.

4. The inadvertent intruder is assumed to occupy the plot of land for the entire year.

5. The Inhalation Dose Factors by age group are from Regulatory Guide 1.109, Tables E-7, E-8, E-9, and E-10.

WHOLE BODY INHALATION DOSE FACTORS (mrem/pCi inhaled)

| Radionuclide | Infant | Child | Teen | Adult |
|---|---|---|---|---|
| Co-60 | 8.41E-06 | 6.12E-06 | 2.48E-06 | 1.85E-06 |
| Cs-137 | 3.25E-05 | 3.47E-05 | 3.89E-05 | 5.35E-05 |

LUNG INHALATION DOSE FACTORS (mrem/pCi inhaled)

| Radionuclide | Infant | Child | Teen | Adult |
|---|---|---|---|---|
| Co-60 | 3.22E-03 | 1.91E-03 | 1.09E-03 | 7.46E-04 |
| Cs-137 | 5.09E-05 | 2.81E-05 | 1.51E-05 | 9.40E-06 |

6. The age dependent inhalation rates are obtained from Regulatory Guide 1.109, Table E-5.

Inhalation Rates ($m^3$/yr)

| Infant | Child | Teen | Adult |
|---|---|---|---|
| 1400 | 3700 | 8000 | 8000 |

B. <u>Summary of Calculational Methodology</u>

1. The ground plane radionuclide concentrations in pCi/m².

2. Calculate the resuspension factor utilizing equation given in WASH-1400.

3. Obtain the radionuclide concentration in air (pCi/m³) above plot utilizing methodology in WASH-1400.

4. Using parameters contained in Regulatory Guide 1.109, calculate annual dose for continuous occupancy and for realistic occupancy.

C. <u>Inhalation of Resuspended Radionuclides in Air Pathway Dose Rate Calculations - Resuspension of Radionuclide in Air</u>

1. Ground plane radionuclide concentration

| Radionuclide | Ground Plane Concentration (µCi/cm²) | Ground Plane Concentration (pCi/m²) |
|---|---|---|
| Co-60 | 6.53E-08 | 6.53E+02 |
| Cs-137 | 4.21E-08 | 4.21E+02 |

2. Calculation of resuspension factor, K ($m^{-1}$)

From WASH-1400,
K(t) = 1.0E-09 + 1.0E-05 * EXP [-0.6769 * t]

where t = time since radionuclides were deposited on ground surface.

t is assumed to be 0 for these calculations, thereby maximizing the resuspension factor.

Therefore,

K = 1.0E-05 $m^{-1}$

3. Calculate radionuclide concentration (pCi/m³) in air.

From WASH-1400,

$$K(m^{-1}) = \frac{\text{air concentration (pCi/m}^2)}{\text{surface deposit (pCi/m}^2)}$$

or

Air Concentration (pCi/m³) = surface deposit (pCi/m²) * K($m^{-1}$)

<u>AIR CONCENTRATIONS</u>

| Radionuclide | Air Concentrations (pCi/m³) |
|---|---|
| Co-60 | 6.53E-03 |
| Cs-137 | 4.21E-03 |

4. Dose Rate Calculations

Dose Rate (mrem/yr) = Inhalation Rate (m³/yr) * Air Conc. (pCi/m³) * Dose Conversion Factor (mrem/pCi)

WHOLE BODY INHALATION DOSE RATE (mrem/year)

| Radionuclide | Infant | Child | Teen | Adult |
|---|---|---|---|---|
| Co-60 | 7.69E-05 | 1.48E-04 | 1.30E-04 | 9.66E-05 |
| Cs-137 | 1.92E-04 | 5.41E-04 | 1.31E-03 | 1.80E-03 |
| TOTAL | 2.69E-04 | 6.89E-04 | 1.44E-03 | 1.90E-03 |

LUNG INHALATION DOSE RATE (mrem/year)

| Radionuclide | Infant | Child | Teen | Adult |
|---|---|---|---|---|
| Co-60 | 2.94E-02 | 4.61E-02 | 5.69E-02 | 3.90E-02 |
| Cs-137 | 3.00E-04 | 4.38E-04 | 5.09E-04 | 3.17E-04 |
| TOTAL | 2.97E-02 | 4.65E-02 | 5.74E-02 | 3.93E-02 |

INHALATION OF RESUSPENDED RADIONUCLIDES IN AIR DOSE RATES

WHOLE BODY DOSE RATE (mrem/year)

| Occupancy | Infant | Child | Teen | Adult |
|---|---|---|---|---|
| Continuous | 2.69E-04 | 6.89E-04 | 1.44E-03 | 1.90E-03 |
| Realistic | 1.96E-06 | 5.03E-06 | 1.05E-05 | 1.39E-05 |

LUNG DOSE RATE (mrem/year)

| Occupancy | Infant | Child | Teen | Adult |
|---|---|---|---|---|
| Continuous | 2.97E-02 | 4.65E-02 | 5.74E-02 | 3.93E-02 |
| Realistic | 2.17E-04 | 3.39E-04 | 4.19E-04 | 2.87E-04 |

V. CALCULATION OF WHOLE BODY EXPOSURES DUE TO RELEASE TO LAKE MICHIGAN

A. Specific Assumptions

1. The methodology contained in the PBNP Offsite Dose Calculation Manual (ODCM) is used to perform this calculation.

2. The entire activity contained in the sludge is released into Lake Michigan.

3. The exposure pathways addressed by the ODCM methodology are ingestion of potable water from Two Rivers, WI water supply, ingestion of fish at edge of initial mixing zone, ingestion of fresh and stored vegetables, irrigated with Lake Michigan as source of water, ingestion of milk and meat from cows utilizing Lake Michigan as drinking water source, swimming and boating activities at edge of initial mixing zone, and shoreline deposits.

B. Summary of Calculational Methodology

1. The activity released in the sludge is converted into Co-60 dose equivalent Curies.

2. The annual design release limit from the ODCM is 94.7 Co-60 equivalent curies.

3. The annual design release limit is based on a limiting dose of 6 mrem adult whole body. The annual dose due to sewage sludge is calculated by a ratio of calculated release compared to release limit.

C. Whole Body Exposure Calculations

1. Co-60 equivalent Curies

| Radionuclide | Activity (μCi) | $DF_i/DF_{Co-60}$ | Co-60 eq. Activity (μCi) |
|---|---|---|---|
| Co-60 | 13.2 | 1.00E+00 | 13.2 |
| Cs-137 | 8.5 | 1.51E+01 | 128.4 |
| | | TOTAL | 141.6μCi Co-60 equivalent |

2. Ratio of dose limit to annual design release limit

$$\frac{6\text{ mrem}}{94.7\text{ Co-60 equivalent curies}}$$

3. Whole Body Dose Calculation

$$\frac{\text{Dose}}{141.6\mu\text{Ci}} = \frac{6\text{ mrem}}{94.7\times10^6\mu\text{Ci}}$$

Dose = 8.97E-06 mrem

WHOLE BODY DOSE RATE (mrem/year)

8.97E-06

## DOSE SUMMARY

### Maximally Exposed Individual

The identified credible exposure pathways for the maximally exposed individual are:

1.) External exposure from ground plane source (realistic occupancy)
2.) Milk ingestion pathway
3.) Meat ingestion pathway
4.) Vegetable ingestion pathway
5.) Resuspension inhalation pathway (realistic occupancy)
6.) Pathways identified due to release to Lake Michigan.

| | AGE GROUP | | | |
|---|---|---|---|---|
| Pathway | Infant | Child | Teen | Adult |
| External | 8.23E-04 | 8.23E-04 | 8.23E-04 | 8.23E-04 |
| Milk | 4.20E-02 | 4.35E-02 | 5.77E-02 | 6.11E-02 |
| Meat | - | 4.49E-03 | 4.85E-03 | 9.42E-03 |
| Vegetable | - | 4.11E-04 | 4.43E-04 | 4.67E-04 |
| Inhalation | 1.96E-06 | 5.03E-06 | 1.05E-05 | 1.39E-05 |
| Water | 8.97E-06 | 8.97E-06 | 8.97E-06 | 8.97E-06 |
| TOTAL: (mrem/year) | 0.043 | 0.049 | 0.064 | 0.072 |

### Inadvertent Intruder

The identified credible exposure pathways for the inadvertent intruder are:

1.) External exposure from ground plane source (continuous occupancy)
2.) Vegetable ingestion pathway
3.) Resuspension inhalation pathway (continuous occupancy)
4.) Pathways identified due to release to Lake Michigan.

| | AGE GROUP | | | |
|---|---|---|---|---|
| Pathway | Infant | Child | Teen | Adult |
| External | 1.13E-01 | 1.13E-01 | 1.13E-01 | 1.13E-01 |
| Vegetable | - | 4.11E-04 | 4.43E-04 | 4.67E-04 |
| Inhalation | 2.96E-04 | 6.89E-04 | 1.44E-03 | 1.90E-03 |
| Water | 8.97E-06 | 8.97E-06 | 8.97E-06 | 8.97E-06 |
| TOTAL: (mrem/year) | 0.113 | 0.114 | 0.115 | 0.115 |

Reviewing these tables, the calculated limiting doses for both the maximally exposed individual and the inadvertent intruder occur for the adult age group. These doses are:

Maximally Exposed Individual: 0.072 mrem/year
Inadvertent Intruder: 0.115 mrem/year

# APPENDIX F

## BASIS FOR SETTING CONCENTRATION LIMITS AND ACTIVITY LIMIT FOR DISPOSAL OF SLUDGE

Analyses of previously disposed sewage sludge have identified six different radionuclides in the sludge. All six radionuclides did not occur in each disposal. Therefore, it is difficult to determine a single concentration limit for regulating the disposal of the sludge from the storage tanks.

To provide a basis to regulate the disposal of the sewage sludge based on identified radionuclide concentrations, the following relation is proposed.

$$\sum_{i=1}^{N} \frac{C_i}{0.1 * MPC_i} \leq 1$$

where

N = number of different radionuclides identified in the sewage sludge.

$C_i$ = concentration of the ith radionuclide in the sewage sludge.

$MPC_i$ = the MPC value of the ith radionuclide in the sewage sludge, as listed in 10 CFR Part 20 Appendix B, Table II, Column 2.

If this criteria is met, the sewage sludge may be disposed of by land spreading provided the dose calculations (as identified in Appendix E) indicate dose rates within the prescribed limits.

The attachment to this Appendix details calculations performed to determine doses from four radionuclides identified in the sludge. The calculations are based on an identified concentration equal to 10% of the 10 CFR Part 20, Appendix B, Table II, Column 2 valves. The calculations use the methodology in Appendix E along with the exposure pathways identified in Appendix D to determine the dose rates. These calculations indicate the use of this methodology will maintain radiation doses within the appropriate limits.

The maximum allowable activity disposed of per year per acre is calculated utilizing 10% of the MPC value, 10 CFR Part 20, Appendix B, Table II, Column 2, for Co-58. Volume limit per acre has been proposed at 4,000 gallons/acre/year. Then,

$$1.0E-05\ \mu Ci/cc * 4,000\ gallons/acre/year \times 3.785.43\ cc/gallon$$
$$= 151.4\ \mu Ci/acre/year$$

Cs-134

Concentration in Sludge: 9.0E-07 mCi/ml

| Sludge Volume (Gallons) | (cm³) | Concentration (μCi/cm³) | Activity (μCi) | Ground Plane Concentration (μCi/cm²) |
|---|---|---|---|---|
| 15000 | 5.68E+07 | 9.00E-07 | 5.11E+01 | 2.53E-07 |

External Exposure

| γ Dose Factor (mrem/hr. per pCi/m²) | Ground Plane Concentration (pCi/m²) | γ Dose Rate (mrem/year) |
|---|---|---|
| 1.20E-08 | 2.53E+03 | 2.66E-01 |

Continuous Occupancy: 2.66E-01 mrem/year
Realistic Occupancy: 1.94E-03 mrem/year

Meat & Milk Pathway

| Activity in Soil (μCi) | Activity in Feed (μCi) | Concentration in Feed (pCi/Kg) | Concentration in Milk (pCi/ℓ) | Concentration in Meat (pCi/kg) |
|---|---|---|---|---|
| 5.22E+01 | 5.11E-01 | 2.75E+01 | 1.65E+01 | 5.50E+00 |

Milk Dose Rates (mrem/year)

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| 3.87E-01 | 4.41E-01 | 6.03E-01 | 6.19E-01 |

Meat Dose Rate (mrem/year)

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| - | 1.83E-02 | 3.27E-02 | 7.32E-02 |

Vegetable Pathway

| Activity (μCi) | Soil Volume (Cm³) | Soil Mass (Kg) | Concentration in Soil (pCi/Kg) | Concentration in Vegetables (pCi/Kg) |
|---|---|---|---|---|
| 5.11E+01 | 3.08E+09 | 4.00E+06 | 1.28E+01 | 1.28E-01 |

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**Vegetable Pathway Dose Rates (mrem/year)**

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| - | 2.90E-03 | 3.98E-03 | 4.34E-03 |

**Inhalation Pathway**

| Ground Plane Concentration (pCi/m²) | $K_1$ ($m^{-1}$) | Air Concentration (pCi/m³) |
|---|---|---|
| 2.53E+03 | 1.0E-05 | 2.53E-02 |

**Inhalation Pathway Dose Rates (mrem/year)**

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| Continuous Occupancy | 1.88E-03 | 5.68E-03 | 1.39E-02 | 1.84E-02 |
| Realistic Occupancy | 1.38E-05 | 4.15E-05 | 1.01E-04 | 1.35E-04 |

**Release to Lake Michigan**

| Activity (μCi) | $DF_i/DF_{Co-60}$ | Co-60 eq. activity (μCi) |
|---|---|---|
| 5.11E+01 | 2.56E+01 | 1.31E+03 |

$$\frac{6\ \text{mrem}}{94.7\ \text{Ci}} * 1.31E+03 * \frac{1\ \text{Ci}}{1.0E+06\ \mu\text{Ci}} = 8.29E-05\ \text{mrem}$$

**Maximally Exposed Individual**

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| External | 1.94E-03 | 1.94E-03 | 1.94E-03 | 1.94E-03 |
| Milk | 3.87E-01 | 4.41E-01 | 6.03E-01 | 6.19E-01 |
| Meat | - | 1.83E-02 | 3.27E-02 | 7.32E-02 |
| Vegetable | - | 2.90E-03 | 3.98E-03 | 4.34E-03 |
| Inhalation | 1.38E-05 | 4.15E-05 | 1.01E-04 | 1.35E-04 |
| Water | 8.29E-05 | 8.29E-05 | 8.29E-05 | 8.29E-05 |
| Totals: | 3.89E-01 | 4.64E-01 | 6.42E-01 | 6.99E-01 |

**Inadvertent Intruder**

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| External | 2.66E-01 | 2.66E-01 | 2.66E-01 | 2.66E-01 |
| Vegetable | - | 2.90E-03 | 3.98E-03 | 4.34E-03 |
| Inhalation | 1.88E-03 | 5.68E-03 | 1.39E-02 | 1.84E-02 |
| Water | 8.29E-05 | 8.29E-05 | 8.29E-05 | 8.29E-05 |
| Totals: | 2.68E-01 | 2.75E-01 | 2.84E-01 | 2.89E-01 |

Cs-134-2

Cs-137

Concentration in Sludge: 2.0E-06 µCi/ml

| Sludge Volume (Gallons) | Sludge Volume ($cm^3$) | Concentration ($\mu Ci/cm^3$) | Activity (µCi) | Ground Plane Concentration ($\mu Ci/cm^2$) |
|---|---|---|---|---|
| 15000 | 5.68E+07 | 2.00E-06 | 1.14E+02 | 5.62E-07 |

External Exposure

| γ Dose Factor (mrem/hr. per $pCi/m^2$) | Ground Plane Concentration ($pCi/m^2$) | γ Dose Rate (mrem/year) |
|---|---|---|
| 4.20E-09 | 5.62E+03 | 2.07E-01 |

Continuous Occupancy: 2.07E-01 mrem/year
Realistic Occupancy: 1.51E-03 mrem/year

Meat & Milk Pathway

| Activity in Soil (µCi) | Activity in Feed (µCi) | Concentration in Feed (pCi/Kg) | Concentration in Milk (pCi/ℓ) | Concentration in Meat (pCi/kg) |
|---|---|---|---|---|
| 1.14E+02 | 1.14E+00 | 6.13E+01 | 3.68E+01 | 1.23E+01 |

Milk Dose Rates (mrem/year)

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| 5.26E-00 | 5.61E-01 | 7.64E-01 | 8.15E-01 |

Meat Dose Rate (mrem/year)

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| - | 2.33E-02 | 4.15E-02 | 9.66E-02 |

Vegetable Pathway

| Activity (µCi) | Soil Volume ($Cm^3$) | Soil Mass (Kg) | Concentration in Soil (pCi/Kg) | Concentration in Vegetables (pCi/Kg) |
|---|---|---|---|---|
| 1.14E+02 | 3.08E+09 | 4.00E+06 | 2.85E+01 | 2.85E-01 |

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**Vegetable Pathway Dose Rates (mrem/year)**

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| - | 3.69E-03 | 5.03E-03 | 5.70E-03 |

**Inhalation Pathway**

| Ground Plane Concentration (pCi/m²) | $K_{-1}$ ($m^{-1}$) | Air Concentration (pCi/m³) |
|---|---|---|
| 5.62E+03 | 1.0E-05 | 5.62E-02 |

**Inhalation Pathway Dose Rates (mrem/year)**

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| Continuous Occupancy | 2.56E-03 | 7.22E-03 | 1.75E-02 | 2.41E-02 |
| Realistic Occupancy | 1.87E-05 | 5.27E-05 | 1.28E-04 | 1.76E-04 |

**Release to Lake Michigan**

| Activity (μCi) | $DF_i/DF_{Co-60}$ | Co-60 eq. activity (μCi) |
|---|---|---|
| 1.14E+02 | 1.51E+01 | 1.72E+03 |

$$\frac{6\ \text{mrem}}{94.7\ \text{Ci}} * 1.72E{+}03 * \frac{1\ \text{Ci}}{1.0E{+}06\ \mu\text{Ci}} = 1.09E{-}04\ \text{mrem}$$

**Maximally Exposed Individual**

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| External | 1.51E-03 | 1.51E-03 | 1.51E-03 | 1.51E-03 |
| Milk | 5.26E-01 | 5.61E-01 | 7.64E-01 | 8.15E-01 |
| Meat | - | 2.33E-02 | 4.15E-02 | 5.70E-03 |
| Vegetable | - | 3.69E-03 | 5.03E-03 | 5.70E-03 |
| Inhalation | 1.87E-05 | 5.27E-05 | 1.28E-04 | 1.76E-04 |
| Water | 1.09E-04 | 1.09E-04 | 1.09E-04 | 1.09E-04 |
| Totals: | 5.28E-01 | 5.90E-01 | 8.12E-01 | 9.19E-01 |

**Inadvertent Intruder**

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| External | 2.07E-01 | 2.07E-01 | 2.07E-01 | 2.07E-01 |
| Vegetable | - | 3.69E-03 | 5.03E-03 | 5.70E-03 |
| Inhalation | 2.56E-03 | 7.22E-03 | 1.75E-02 | 2.41E-02 |
| Water | 1.09E-04 | 1.09E-04 | 1.09E-04 | 1.09E-04 |
| Totals: | 2.10E-01 | 2.18E-01 | 2.30E-01 | 2.37E-01 |

## Co-58

Concentration in Sludge: 1.00E-05 μCi/ml

| Sludge Volume (Gallons) | (cm³) | Concentration (μCi/cm³) | Activity (μCi) | Ground Plane Concentration (μCi/cm²) |
|---|---|---|---|---|
| 15000 | 5.68E+07 | 1.00E-05 | 5.68E+02 | 2.81E-06 |

### External Exposure

| γ Dose Factor (mrem/hr. per pCi/m²) | Ground Plane Concentration (pCi/m²) | γ Dose Rate (mrem/year) |
|---|---|---|
| 7.00E-09 | 2.81E+04 | 1.72E+00 |

Continuous Occupancy: 1.72E+00 mrem/year
Realistic Occupancy: 1.26E-02 mrem/year

### Meat & Milk Pathway

| Activity in Soil (μCi) | Activity in Feed (μCi) | Concentration in Feed (pCi/Kg) | Concentration in Milk (pCi/ℓ) | Concentration in Meat (pCi/kg) |
|---|---|---|---|---|
| 5.68E+02 | 5.34E+00 | 2.87E+02 | 1.44E+01 | 1.87E+02 |

Milk Dose Rates (mrem/year)

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| 4.27E-02 | 2.62E-02 | 1.29E-02 | 7.45E-03 |

Meat Dose Rate (mrem/year)

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| - | 4.22E-02 | 2.72E-02 | 3.44E-02 |

### Vegetable Pathway

| Activity (μCi) | Soil Volume (Cm³) | Soil Mass (Kg) | Concentration in Soil (pCi/Kg) | Concentration in Vegetables (pCi/Kg) |
|---|---|---|---|---|
| 5.68E+02 | 3.08E+09 | 4.00E+06 | 1.42E-04 | 1.33E+00 |

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**Vegetable Pathway Dose Rates (mrem/year)**

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| - | 2.05E-03 | 1.01E-03 | 6.22E-04 |

**Inhalation Pathway**

| Ground Plane Concentration ($pCi/m^2$) | $K_1$ ($m^{-1}$) | Air Concentration ($pCi/m^3$) |
|---|---|---|
| 2.81E+04 | 1.0E-05 | 2.81E-01 |

**Inhalation Pathway Dose Rates (mrem/year)**

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| Continuous Occupancy | 5.11E-04 | 8.89E-04 | 7.80E-04 | 5.82E-04 |
| Realistic Occupancy | 3.74E-06 | 6.49E-06 | 5.70E-06 | 4.25E-06 |

**Release to Lake Michigan**

| Activity (μCi) | $DF_i/DF_{Co-60}$ | Co-60 eq. activity (μCi) |
|---|---|---|
| 5.68E+02 | 3.54E-01 | 2.01E+02 |

$$\frac{6\ mrem}{94.7\ Ci} * 2.01E{+}02\ \mu Ci * \frac{1\ Ci}{1.0E{+}06\ \mu Ci} = 1.27E{-}05\ mrem$$

**Maximally Exposed Individual**

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| External | 1.26E-02 | 1.26E-02 | 1.26E-02 | 1.26E-02 |
| Milk | 4.27E-02 | 2.62E-02 | 1.29E-02 | 7.45E-03 |
| Meat | - | 4.22E-02 | 2.72E-02 | 3.44E-02 |
| Vegetable | - | 2.05E-03 | 1.01E-03 | 6.22E-04 |
| Inhalation | 3.74E-06 | 6.49E-06 | 5.70E-06 | 4.25E-06 |
| Water | 1.27E-05 | 1.27E-05 | 1.27E-05 | 1.27E-05 |
| Totals: | 5.53E-02 | 8.31E-02 | 5.37E-02 | 5.51E-02 |

**Inadvertent Intruder**

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| External | 1.72E+00 | 1.72E+00 | 1.72E+00 | 1.72E+00 |
| Vegetable | - | 2.05E-03 | 1.01E-03 | 6.22E-04 |
| Inhalation | 5.11E-04 | 8.89E-04 | 7.80E-04 | 5.82E-04 |
| Water | 1.27E-05 | 1.27E-05 | 1.27E-05 | 1.27E-05 |
| Totals: | 1.72E+00 | 1.72E+00 | 1.72E+00 | 1.72E+00 |

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Co-60

Concentration in Sludge: 5.0E-06 μCi/ml

| Sludge Volume (Gallons) | Sludge Volume (cm³) | Concentration (μCi/cm³) | Activity (μCi) | Ground Plane Concentration (μCi/cm²) |
|---|---|---|---|---|
| 15000 | 5.68E+07 | 5.00E-06 | 2.84E+02 | 1.41E-06 |

External Exposure

| γ Dose Factor (mrem/hr. per pCi/m²) | Ground Plane Concentration (pCi/m²) | γ Dose Rate (mrem/year) |
|---|---|---|
| 1.70E-08 | 1.41E+04 | 2.09E+00 |

Continuous Occupancy: 2.09E+00 mrem/year
Realistic Occupancy: 1.53E-02 mrem/year

Meat & Milk Pathway

| Activity in Soil (μCi) | Activity in Feed (μCi) | Concentration in Feed (pCi/Kg) | Concentration in Milk (pCi/ℓ) | Concentration in Meat (pCi/kg) |
|---|---|---|---|---|
| 2.84E+02 | 2.67E+00 | 1.44E+02 | 7.18E+00 | 9.33E+01 |

Milk Dose Rates (mrem/year)

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| 6.04E-02 | 3.70E-02 | 1.82E-02 | 1.05E-02 |

Meat Dose Rate (mrem/year)

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| - | 5.97E-02 | 3.84E-02 | 4.84E-02 |

Vegetable Pathway

| Activity (μCi) | Soil Volume (Cm³) | Soil Mass (Kg) | Concentration in Soil (pCi/Kg) | Concentration in Vegetables (pCi/Kg) |
|---|---|---|---|---|
| 2.84E+02 | 3.08E+09 | 4.00E+06 | 7.10E+01 | 6.67E-01 |

Co-60-1

### Vegetable Pathway Dose Rates (mrem/year)

| Infant | Child | Teenager | Adult |
|---|---|---|---|
| - | 2.91E-03 | 1.44E-03 | 8.82E-04 |

### Inhalation Pathway

| Ground Plane Concentration ($pCi/m^2$) | $K_1$ ($m^{-1}$) | Air Concentration ($pCi/m^3$) |
|---|---|---|
| 1.41E+04 | 1.0E-05 | 1.41E-01 |

### Inhalation Pathway Dose Rates (mrem/year)

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| Continuous Occupancy | 1.66E-03 | 3.19E-03 | 2.80E-03 | 2.09E-03 |
| Realistic Occupancy | 1.21E-05 | 2.33E-05 | 2.05E-05 | 1.53E-05 |

### Release to Lake Michigan

| Activity (μCi) | $DF_i/DF_{Co-60}$ | Co-60 eq. activity (μCi) |
|---|---|---|

$$\frac{6\ \text{mrem}}{94.7\ \text{Ci}} * 2.84E{+}02\mu\text{Ci} * \frac{1\ \text{Ci}}{1.0E{+}06\ \mu\text{Ci}} = 1.80E{-}05\ \text{mrem}$$

### Maximally Exposed Individual

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| External | 1.53E-02 | 1.53E-02 | 1.53E-02 | 1.53E-02 |
| Milk | 6.04E-02 | 3.70E-02 | 1.82E-02 | 1.05E-02 |
| Meat | - | 5.97E-02 | 3.84E-02 | 4.84E-02 |
| Vegetable | - | 2.91E-03 | 1.44E-03 | 8.82E-04 |
| Inhalation | 1.21E-05 | 2.33E-05 | 2.05E-05 | 1.53E-05 |
| Water | 1.80E-05 | 1.80E-05 | 1.80E-05 | 1.80E-05 |
| Totals: | 7.57E-02 | 1.15E-01 | 7.34E-02 | 7.51E-02 |

### Inadvertent Intruder

| | Infant | Child | Teenager | Adult |
|---|---|---|---|---|
| External | 2.09E+00 | 2.09E+00 | 2.09E+00 | 2.09E+00 |
| Vegetable | - | 2.91E-03 | 1.44E-03 | 8.82E-04 |
| Inhalation | 1.66E-03 | 3.19E-03 | 2.80E-03 | 2.09E-03 |
| Water | 1.80E-05 | 1.80E-05 | 1.80E-03 | 1.80E-03 |
| Totals: | 2.09E+00 | 2.10E+00 | 2.10E+00 | 2.09E+00 |

Co-60-2

# APPENDIX G

## CALCULATIONAL METHODOLOGY FOR DETERMINING EXTERNAL DOSE RATES FROM RADIONUCLIDES AFTER INCORPORATION INTO SOIL

Wisconsin Electric utilizes QAD, a nationally recognized computer code, to perform shielding and dose rate analyses. The QAD computer code utilizes a point kernel methodology to calculate the dose rate at a specified point due to a given source of radiation.

QAD will be used to calculate the dose rate due to standing on a plot of land utilized for sludge disposal after the radionuclides have been incorporated into the plot by plowing. The following parameters will be used in the calculation:

- The total activity from all previous disposals will be corrected for radiological decay and used as the radionuclide source term.
- Appropriate values will be used to represent the surface area of the plot.
- The radionuclides will be assumed to be incorporated uniformly into the top six inches of soil.
- The dose rate will be calculated at a height of 1 meter above the ground plane at a depth of 5 centimeters in tissue. (Regulatory Guide 1.109 values).
- The density of the soil will be assumed to be 1.3 grams/cubic centimeter.

This calculated dose rate will be used to assess the radiological consequences of past disposals in conjunction with the consequences of proposed future disposals. The total radiological dose consequence of the past and the proposed disposal will be compared to the applicable limits to insure the dose is maintained at or below the limits.

# APPENDIX H
# MODIFICATION #1 TO NRC SUBMITTAL

Modifications to the Wisconsin Electric submittal to the United States Nuclear Regulatory Commission dated October 8, 1987 (VPNPD-87-430, NRC-87-104), Disposal by Land Application of Sewage Sludge Containing Minute Quantities Of Radioactive Material.

MODIFICATION #1 TO NRC SUBMITTAL

CHANGE TO ORIGINAL SUBMITTAL

Section 3.2, Disposal Procedure (page 3)

Section 3.3, Administrative Procedure (page 4)

The requirements for sludge characterization (the determination of the chemical and physical properties of the sludge) contained in the sections referenced above are modified to allow characterization of the sludge on an annual basis.

BASIS/EXPLANATION

The October 8, 1987 submittal to the USNRC for permission to dispose of sewage treatment sludge containing minute quantities of radioactive material requires that, "prior to disposal the waste stream will be monitored to determine the physical and chemical properties of the sludge…". Subsequent to the submittal and the approval by the NRC, a new Wisconsin Pollutant Discharge Elimination System (WPDES) permit was issued to the Point Beach Nuclear Plant by the Wisconsin Department of Natural Resources on November 30, 1988. Both the new WPDES permit and the Point Beach Nuclear Plant Sludge Management Plan specify an annual required frequency for the evaluation of the sludge characteristics.

The original requirement to perform the characterization of the chemical and physical properties of the sewage sludge prior to each disposal has proven time consuming and costly for Wisconsin Electric Lab Services. Preparation of special analytical standards are required to complete the characterization study. The preparation of these standards, sample preparation, and the actual analyses are all manpower intensive and difficult to perform on a timely basis. This has led to requiring overtime for Lab Services personnel and support from outside companies. In order to better utilize the resources of Lab Services while maintaining the requirements of the WPDES permit, the frequency of sludge characterization in the October 8, 1987 submittal to the NRC should be changed to an annual requirement.

This change in the required frequency for determination of the sludge characteristics does not change the requirement to analyze the sewage sludge for radionuclide content or perform dose evaluations prior to each disposal.

# APPENDIX I
## MODIFICATION #2 TO NRC SUBMITTAL

Modifications to the Wisconsin Electric submittal to the United States Nuclear Regulatory Commission dated October 8, 1987 (VPNPD-87-430, NRC-87-104), Disposal by Land Application of Sewage Sludge Containing Minute Quantities Of Radioactive Material.

MODIFICATION #2

CHANGE TO ORIGINAL SUBMITTAL

Section 3.3, Administrative Procedures (Page E-10)

The limitation on the annual volume of sludge disposal per acre contained in the section referenced above is modified to allow unlimited disposal provided the other requirements of this submittal are met.

BASIS/EXPLANATION

The October 8, 1987, submittal to the USNRC for permission to dispose of sewage treatment sludge containing minute quantities of radioactive material requires that "the annual disposal rate for each of the approved land spread sites will be limited to 4,000 gallons/acre, provided WDNR chemical composition, NRC dose guidelines, and concentration and activity limits are maintained with the appropriate values".

The original requirement to limit sewage sludge disposal to 4,000 gallons per acre is based on the assumption that the sewage sludge is contaminated with Co-58 at a concentration that is ten percent of the 10 CFR Part 20 Appendix B Table 2 Column 2 value. Past sewage sludge disposal experience has shown that the sludge may or may not be contaminated and, if it is, at concentrations far below ten percent of the performed prior to each sewage sludge disposal. With the removal of some of the land spread sites due to their use as a storage site for dry storage of spent fuel, this requirement is limiting our ability to dispose of the sewage sludge on the remaining approved land spread sites.

This removal of the annual volume of sewage sludge that may be disposed of per acre on approved land spread sites does not change the requirement to analyze the sewage sludge for radionuclide content or perform dose evaluation prior to each disposal.

This change was evaluation under SER 95-057, "Removal of licensee Commitment Involved With Sewage Sludge Disposal", 4/20/95.

MODIFICATION #2

- Depth to groundwater and bedrock shall be greater than 3 feet from the land surface elevation during use of any site.
- Sludge shall not be land spread in a floodway.
- Sludge shall not be land spread within 50 feet of a property line road or ditch unless the sludge is incorporated with the soil, in which case a minimum separation distance of at least 25 feet is required.
- The pH of the sludge-soil mixture shall be maintained at 6.5 or higher.
- Low areas of the approved fields, subject to seasonally high groundwater levels, are excluded from the sludge application.
- Crops for human consumption shall not be grown on the land for up to one year following the application of the sludge.
- The sludge shall be plowed, disked, injected or otherwise incorporated into the surface soil layer at appropriate intervals.

The flexibility implied in the latter provision for soil incorporation is intended to allow for crops which require more than a one year cycle. For the Point Beach disposal sites, alfalfa is a common crop which is harvested for several years after a single planting. Sludge disposal on an alfalfa plot constitutes good fertilization, but the plot cannot be plowed without destroying the crop. The alfalfa in this case aids in binding the layer of sludge on the surface of the plot. At a minimum, however, plowing (or disking or other method of injection and mixing to a nominal depth of 6 inches) shall be done prior to planting any new crop, regardless of the crop.

### 3.3 Administrative Procedures

Complete records of each disposal will be maintained. These records will include the concentration of radionuclides in the sludge, the total volume of sludge disposed, the total activity, the plot on which the sludge was applied, the results of the chemical composition determinations, and all dose calculations.

The annual disposal rate for each of the approved land spread sites will be unlimited ~~limited to 4,000 gallons/acre~~, provided WDNR chemical composition, NRC dose guidelines, and concentration and activity limits are maintained within the appropriate values.

The farmer leasing the site used for the disposal will be notified of the applicable restrictions placed on the site due to the land spreading of sewage sludge.

## 4.0 Evaluation of Environmental Impact

### 4.1 Site Characteristics

#### 4.1.1 Site Topography

The disposal sites are located in the Town of Two Creeks in the northeast corner of Manitowoc County, Wisconsin, on the

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# APPENDIX J
# MODIFICATION #3 TO NRC SUBMITTAL

Modifications to the Wisconsin Electric submittal to the United States Nuclear Regulatory Commission dated October 8, 1987 (VPNPD-87-430, NRC-87-104), Disposal by Land Application of Sewage Sludge Containing Minute Quantities Of Radioactive Material.

## MODIFICATION #3 TO NRC SUBMITTAL

### CHANGE TO ORIGINAL SUBMITTAL

Section 3.2 of Attachment II of the October 8, 1987 letter to the NRC contains the commitment to perform a gamma isotopic analysis of sewage sludge samples prior to every sludge disposal on land surrounding PBNP. The analytical results are to be used to evaluate the dose consequences of the radionuclides entering the environmental via this disposal pathway. As described in ODCM Section 7, the requirement for a radioisotopic analysis of the sewage sludge prior to every disposal on land surrounding PBNP is modified if the sludge has been shown to be clean and there is no reason to believe that the sludge is contaminated.

### BASIS/EXPLANATION

Small μCi quantities of PBNP licensed materials (Co-58/60, Cs-134/137, Cr-51, and Mn-54) were found in PBNP sewage treatment plant (STP) sludge. Pursuant to of 10 CFR 20.302(a), Wisconsin Electric applied to the NRC for permission to dispose of the licensed material by applying the sludge to Wisconsin Electric land surrounding PBNP. In the October 8, 1987 application letter, Wisconsin Electric committed to gamma isotopic analysis of the sludge prior to every disposal in order to evaluate the dose consequences of this disposal and to compare radionuclide concentrations to the 10 CFR 20, Appendix B, maximum effluent concentrations. However, such analysis are not required if the sludge does not contain licensed material. It there is no reason to believe that the sludge is contaminated and if there is no pathway from the RCA to the STP, then there is no reason to analyze the sludge for radionuclides once it has been shown to be clean. Administrative controls and engineering modifications to PBNP have removed the pathway from the RCA to the STP as verified by subsequent analyses of the sludge under conditions required to obtain the environmental LLDs. These analyses have not revealed radionuclides attributable to PBNP. Pursuant to NRC HPPOS-221, a substance is clean if analyses under analytical parameters necessary to achieve the environmental LLDs does not reveal any licensed material. These LLDs define how hard you have to look. Below this detection level, "…the probability of undetected radioactivity is negligible and can be disregarded when considering the practicality of detecting such potential radioactivity from natural background…" (Docket No. 50-206, letter to J. E. Dyer from L. J. Cunningham dated September 6, 1991). Therefore the NRC criteria are met and there is no longer any reason to believe that the STP sludge is contaminated. However if plant conditions should change in a manner compromising the NRC criteria, radiological analysis must be made prior to each STP sludge land application until such time that the clean criteria are satisfied pursuant to subsequent NRC guidance.