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GGNS TS 5.6.2

GNRO2022-00014

April 21, 2022

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

SUBJECT: Grand Gulf Nuclear Station Annual Radiological Environmental Operating Report  
(AREOR)

Grand Gulf Nuclear Station, Unit 1  
Docket No. 50-416  
License No. NPF-29

In accordance with Grand Gulf Nuclear Station Unit 1 Technical Specification 5.6.2, attached is the Annual Radiological Environmental Operating Report (AREOR) for the time-period of January 1, 2021 through December 31, 2021.

There are no commitments contained in this submittal. If you have any questions or need additional information, please contact Jeff Hardy at 802-380-5124.

Sincerely,

A handwritten signature in blue ink, appearing to read 'JH/ram'.

JH/ram

cc: NRC Senior Resident Inspector  
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Washington, DC 20555-0001



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	<b>YEAR: 2021</b>
<b>Document Number: GNRO 2022-00014</b>	
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## **1.0 EXECUTIVE SUMMARY**

### **1.1 Radiological Environmental Monitoring Program**

The Annual Radiological Environmental Operating Report presents data obtained through analyses of environmental samples collected for Grand Gulf Nuclear Station (GGNS) Radiological Environmental Monitoring Program (REMP) for the period January 1 through December 31, 2021. This report fulfills the requirements of Grand Gulf Nuclear Station Technical Specification 5.6.2.

All required lower limit of detection (LLD) capabilities were achieved in all sample analyses during 2021, as required by the GGNS Offsite Dose Calculation Manual (ODCM) Specifications Table 6.12.1-3. No measurable levels of radiation above baseline levels attributable to GGNS operation were detected in the vicinity of GGNS. The 2021 Radiological Environmental Monitoring Program thus substantiated the adequacy of source control and effluent monitoring at GGNS with no observed impact of plant operations on the environment.

GGNS established the REMP in 1978 prior to the station's becoming operational (1985) to provide data on background radiation and radioactivity normally present in the area. GGNS has continued to monitor the environment by sampling air, water, sediment, fish and food products, as well as measuring direct radiation. GGNS also samples milk if milk-producing animals used for human consumption are present within five miles (8 km) of the plant.

The REMP includes sampling indicator and control locations within an approximate 20-mile radius of the plant. The REMP utilizes indicator locations near the site to show any increases or buildup of radioactivity that might occur due to station operation and control locations farther away from the site to indicate the presence of only naturally occurring radioactivity. GGNS personnel compare indicator results with control and preoperational results to assess any impact GGNS operation might have had on the surrounding environment.

In 2021, environmental samples were collected for radiological analysis. The results of indicator locations were compared with control locations and previous studies. It was concluded that no significant relationship exists between GGNS operation and effect on the area around the plant. The review of 2021 data showed radioactivity levels in the environment were undetectable in many locations and near background levels in significant pathways.

### **1.2 Reporting Levels**

When averaged over any calendar quarter, no environmental samples equaled or exceeded reporting levels for radioactivity as outlined in ODCM Specifications Table 6.12.1-2; the analytical results did not trigger any Radiological Monitoring Program Special Reports.

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### **1.3 Comparison to State and/or Federal Program**

GGNS personnel compared REMP data to state monitoring programs as results became available. Historically, the programs used for comparison have included the U.S. Nuclear Regulatory Commission (NRC) Thermoluminescent Dosimeter (TLD) Direct Radiation Monitoring Network and the Mississippi State Department of Health (MSDH), Division of Radiological Health monitoring program.

The NRC TLD Network Program was discontinued in 1998. Historically these results have compared to those from the GGNS REMP. GGNS TLD results continue to remain similar to the historical average and continue to verify that plant operation is not affecting the ambient radiation levels in the environment.

The MSDH and the GGNS REMP entail similar radiological environmental monitoring program requirements. These programs include collecting air samples and splitting or sharing sample media such as water, sediment, and fish. Both programs have obtained similar results over previous years.

### **1.4 Sample Deviations**

During 2021, environmental sampling was performed for 5 media types addressed in the ODCM and for direct radiation. A total of 369 samples of the 377 scheduled were obtained. Of the scheduled samples, 98 percent were collected and analyzed in accordance with the requirements specified in the ODCM. Attachment 1 contains the listing of sample deviations and actions taken.

### **1.5 Program Modifications**

There were no program modifications during the reporting period.

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## **2.0 INTRODUCTION**

### **2.1 Radiological Environmental Monitoring Program**

GGNS established the REMP to ensure that plant operating controls properly function to minimize any associated radiation endangerment to human health or the environment. The REMP is designed for:

Analyzing applicable pathways for anticipated types and quantities of radionuclides released into the environment.

- Considering the possibility of a buildup of long-lived radionuclides in the environment and identifying physical and biological accumulations that may contribute to human exposures.
- Considering the potential radiation exposure to plant and animal life in the environment surrounding GGNS.
- Correlating levels of radiation and radioactivity in the environment with radioactive releases from station operation.

### **2.2 Pathways Monitored**

The airborne, direct radiation, waterborne and ingestion pathways are monitored as required by GGNS ODCM Table 6.12.1-1. A description of the REMP utilized to monitor the exposure pathways is described in the attached Tables and Figures.

Section 4.0 of this report provides a discussion of 2021 sampling results with Section 5.0 providing a summary of results for the monitored exposure pathways.

### **2.3 Land Use Census**

GGNS conducts a land use census biennially, as required by Section 6.12.2 of the ODCM. The purpose of this census is to identify changes in uses of land within five miles of GGNS that would require modifications to the REMP and the ODCM. The most important criteria during this census are to determine the location in each sector of the nearest occupied residence, unoccupied residence, garden, and milking animal.

### 3.0 RADIOLOGICAL ENVIRONMENTAL SAMPLING PROGRAM REQUIREMENTS

**Table 1, Exposure Pathway – Airborne**

Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
<b><u>RADIOIODINE AND PARTICULATES</u></b> 1 sample close to the SITE BOUNDARY having the highest calculated annual average ground level D/Q.	AS-7 (Sector H, 0.5 miles) – South-southeast of GGNS at the IBEW Union Hall	7 days, or more frequently if required by dust loading.	<ul style="list-style-type: none"> <li>• Radioiodine Canisters – I-131 analysis every 7 days</li> <li>• Air Particulate – Gross beta radioactivity analysis following filter change</li> <li>• Air Particulate – Gamma Isotopic composite (by location) every 92 days</li> </ul>
<b><u>RADIOIODINE AND PARTICULATES</u></b> 1 sample from the vicinity of a community having the highest calculated annual average ground level D/Q.	AS-1 (Sector G, 5.5 miles) – Southeast of GGNS at the Port Gibson City Barn		
<b><u>RADIOIODINE AND PARTICULATES</u></b> 1 sample from the vicinity of a community having the highest calculated annual average ground level D/Q.	AS-20 (Sector L, 0.9 miles) – South-southeast of GGNS at the former Glodjo residence		
<b><u>RADIOIODINE AND PARTICULATES</u></b> 1 sample from a control location 15 - 30 km distance.	AS-3 (Sector B, 18 miles) – North of the Vicksburg Airport		

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**Table 2, Exposure Pathway – Direct Radiation**

<b>Requirement</b>	<b>Sample Point Description Distance and Direction</b>	<b>Sampling and Collection Frequency</b>	<b>Type and Frequency Of Analyses</b>
<b><u>TLDS</u></b> An inner ring of stations in the general areas of the SITE BOUNDARY.	<ul style="list-style-type: none"> <li>• <b>M-16 (Sector A, Radius 0.9 Miles)</b> – Meteorological Tower.</li> <li>• <b>M-19 (Sector E, Radius 0.5 Miles)</b> – Eastern SITE BOUNDARY Property line, North-northeast of HWSA.</li> <li>• <b>M-21 (Sector J, Radius 0.4 Miles)</b> – Near Former Training Center Building on Bald Hill Road.</li> <li>• <b>M-22 (Sector G, Radius 0.5 Miles)</b> – Former RR Entrance Crossing On Bald Hill Road.</li> <li>• <b>M-23 (Sector Q, Radius 0.5 Miles)</b> – Gin Lake Road 50 Yards North of Heavy Haul Road on Power Pole.</li> <li>• <b>M-25 (Sector N, Radius 1.6 Miles)</b> – Radial Well Number 1.</li> <li>• <b>M-28 (Sector L, Radius 0.9 Miles)</b> – Bald Hill Road.</li> <li>• <b>M-94 (Sector R, Radius 0.8 Miles)</b> – Sector R Near Meteorological Tower.</li> <li>• <b>M-95 (Sector F, Radius 0.5 mi)</b> – Spoils Area, fence of old storage area, near entrance gate</li> </ul>	92 days	Gamma dose; 92 days

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**Table 2, Exposure Pathway – Direct Radiation**

<b>Requirement</b>	<b>Sample Point Description Distance and Direction</b>	<b>Sampling and Collection Frequency</b>	<b>Type and Frequency Of Analyses</b>
<b><u>TLDS</u></b> An inner ring of stations in the general areas of the SITE BOUNDARY.	<ul style="list-style-type: none"> <li>• <b>M-96 (Sector B, Radius 0.7 mi.)</b> – North Gate Fence</li> <li>• <b>M-97 (Sector D, Radius 0.8 mi.)</b> – Grand Gulf Road entrance gate to spoils area</li> <li>• <b>M-98 (Sector H, Radius 0.5 mi.)</b> – Bald Hill Road, across from Union Hall, in curve</li> <li>• <b>M-99 (Sector K, Radius 0.4 mi.)</b> – North Fence of old Ball Field near utility pole</li> <li>• <b>M-100 (Sector C, Radius 0.6 mi.)</b> – Grand Gulf Road</li> </ul>	92 days	Gamma dose; 92 days

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**Table 2, Exposure Pathway – Direct Radiation**

<b>Requirement</b>	<b>Sample Point Description Distance and Direction</b>	<b>Sampling and Collection Frequency</b>	<b>Type and Frequency Of Analyses</b>
<b><u>TLDS</u></b> An outer ring of stations approximately 3 to 5 miles from the site.	<ul style="list-style-type: none"> <li>• <b>M-36 (Sector P, Radius 5.0 Miles)</b> – Curve on HW 608, Point Nearest GGNS at Power Pole.</li> <li>• <b>M-40 (Sector M, Radius 2.3 Miles)</b> – Headly Drive, Near River Port Entrance.</li> <li>• <b>M-48 (Sector K, Radius 4.8 Miles)</b> – 0.4 Miles South on Mont Gomer Road on West Side.</li> <li>• <b>M-49 (Sector H, Radius 4.5 Miles)</b> – Fork in Bessie Weathers Road/Shafter Road.</li> <li>• <b>M-50 (Sector B, Radius 5.3 Miles)</b> – Panola Hunting Club Entrance.</li> <li>• <b>M-55 (Sector D, Radius 5.0 Miles)</b> – Near Ingelside Karnac Ferry Road/Ashland Road Intersection.</li> <li>• <b>M-57 (Sector F, Radius 4.5 Miles)</b> – Hwy 61, Behind the Welcome to Port Gibson Sign at Glensdale Subdivision.</li> </ul>	92 days	Gamma dose; 92 days

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**Table 2, Exposure Pathway – Direct Radiation**

<b>Requirement</b>	<b>Sample Point Description Distance and Direction</b>	<b>Sampling and Collection Frequency</b>	<b>Type and Frequency Of Analyses</b>
<b><u>TLDS</u></b> Additional stations in special interest areas such as population centers, nearby residences, schools, and in 1 or 2 areas to serve as control locations.	<ul style="list-style-type: none"> <li>• <b>M-01 (Sector E, Radius 3.5 Miles)</b> – Across the road from Lake Claiborne Entry Gate. (Special)</li> <li>• <b>M-07 (Sector G, Radius 5.5 Miles)</b> – AS-1 PG, Port Gibson City Barn. (Special)</li> <li>• <b>M-09 (Sector D, Radius 3.5 Miles)</b> – Warner Tully Y-Camp. (Special)</li> <li>• <b>M-10 (Sector A, Radius 1.5 Miles)</b> – Grand Gulf Military Park. (Special)</li> <li>• <b>M-14 (Sector B, Radius 18.0 Miles)</b> – AS-3-61VA, Hwy 61, North of Vicksburg Airport. (Control)</li> <li>• <b>M-33 (Sector P, Radius 12.5 Miles)</b> – Newellton, Louisiana Water Tower. (Control)</li> <li>• <b>M-38 (Sector M, Radius 9.5 Miles)</b> – Lake Bruin State Park, Entrance Road. (Special)</li> <li>• <b>M-39 (Sector M, Radius 13.0 Miles)</b> – St. Joseph, Louisiana, Auxiliary Water Tank. (Special)</li> </ul>	92 days	Gamma dose; 92 days



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**Table 3, Exposure Pathway – Waterborne**

<b>Requirement</b>	<b>Sample Point Description Distance and Direction</b>	<b>Sampling and Collection Frequency</b>	<b>Type and Frequency Of Analyses</b>
<b><u>SURFACE WATER</u></b> 1 sample upstream and 1 sample downstream.	<ul style="list-style-type: none"> <li>• <b>MRUP (Sector R, Radius 1.8 Miles)</b> - At least 4500 ft upstream of the GGNS discharge point into the Mississippi River to allow adequate mixing of the Mississippi and Big Black Rivers.</li> <li>• <b>MRDOWN (Sector N, Radius 1.6 Miles)</b> - At least 5000 ft downstream of the GGNS discharge point in the Mississippi River near Radial Well No. 1.</li> </ul>	92 days	Gamma isotopic and tritium analysis; 92 days
1 sample downstream during a Liquid Radwaste Discharge.	<ul style="list-style-type: none"> <li>• <b>MRDOWN (Sector P, Radius 1.3 Miles)</b> – Downstream of the GGNS discharge point in the Mississippi River near Radial Well No. 5.</li> </ul>	366 days	Gamma isotopic and tritium analysis; 366 days
1 sample from Outfall 007	<ul style="list-style-type: none"> <li>• <b>OUTFALL 007 (Sector N, Radius 0.2 Miles)</b> – Storm Drain System</li> </ul>	31 days	Tritium; 31 days
<b><u>GROUNDWATER</u></b> Samples from 2 sources	<ul style="list-style-type: none"> <li>• <b>PGWELL (Sector G, Radius 5.0 Miles)</b> - Port Gibson Wells – Taken from distribution system or one of the five wells.</li> <li>• <b>CONSTWELL (Sector Q, Radius 0.4 Miles)</b> – GGNS Construction Water Well – Taken from distribution system or the well.</li> </ul>	366 days	Gamma isotopic and tritium analysis; 366 days

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**Table 3, Exposure Pathway – Waterborne**

<b>Requirement</b>	<b>Sample Point Description Distance and Direction</b>	<b>Sampling and Collection Frequency</b>	<b>Type and Frequency Of Analyses</b>
<u><b>SEDIMENT FROM SHORELINE</b></u> 1 sample from downstream area and 1 sample from upstream area	<ul style="list-style-type: none"> <li>• <b>SEDHAM (Sector N, Radius 1.6 Miles)</b> – Downstream of the GGNS discharge point in the Mississippi River near Hamilton Lake outlet.</li> <li>• <b>SEDCONT (Minimum of 100 yds)</b> – Upstream of the GGNS discharge point in the Mississippi River.</li> </ul>	366 days	Gamma isotopic; 366 days

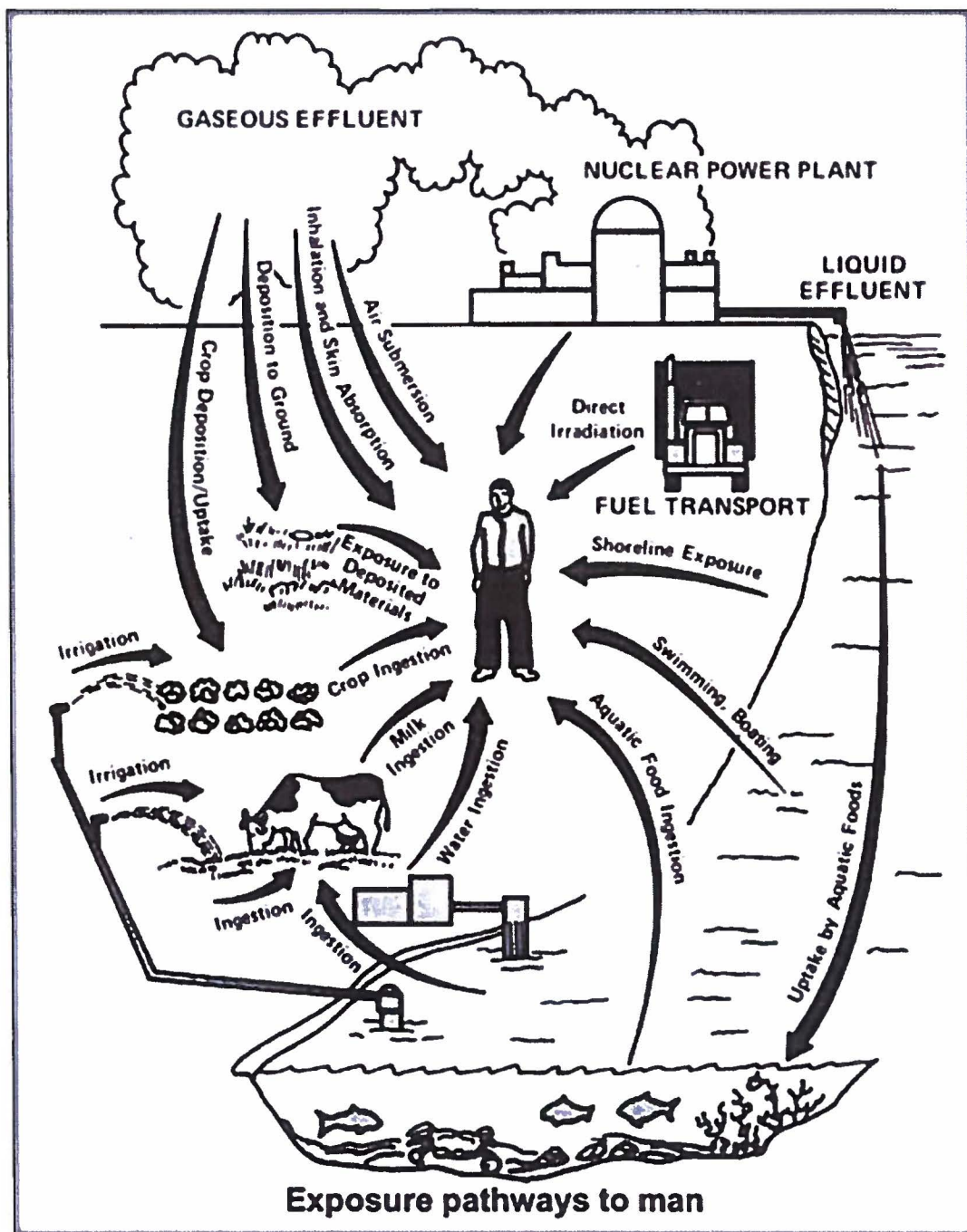
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**Table 4, Exposure Pathway – Ingestion**

<b>Requirement</b>	<b>Sample Point Description Distance and Direction</b>	<b>Sampling and Collection Frequency</b>	<b>Type and Frequency Of Analyses</b>
<b><u>MILK</u></b> <ul style="list-style-type: none"> <li>If commercially available, 1 sample from milking animals within 8 km distant</li> <li>1 sample from milking animals at a control location &gt;8 km distant when an indicator location exists.</li> </ul>	<ul style="list-style-type: none"> <li>Currently, no available milking animals within 8 km of GGNS.</li> <li><b>ALCONT (Sector K, Radius 10.5 Miles)</b> - Located South-southwest of GGNS at Alcorn State University. (Control)</li> </ul>	92 days when required	Gamma isotopic and I-131; 92 days
<b><u>FISH AND INVERTEBRATES</u></b> <ul style="list-style-type: none"> <li>1 sample in vicinity of GGNS discharge point.</li> <li>1 sample uninfluenced by GGNS discharge.</li> </ul>	<ul style="list-style-type: none"> <li><b>FISHDOWN</b> – Downstream of the GGNS discharge point into the Mississippi River</li> <li><b>FISHUP</b> – Upstream of the GGNS discharge point into the Mississippi River uninfluenced by plant operations.</li> </ul>	366 days	Gamma isotopic on edible portions; 366 days
<b><u>FOOD PRODUCTS</u></b> <ul style="list-style-type: none"> <li>1 sample of broadleaf vegetation grown in one of two different offsite locations with highest anticipated annual average ground level D/Q if milk sampling is not performed.</li> <li>1 sample of similar vegetation grown 15 – 30 km distant if milk sampling is not performed.</li> </ul>	<ul style="list-style-type: none"> <li><b>VEG-J (Sector J, Radius 0.4 Miles)</b> – South of GGNS near former Training Center on Bald Hill Road.</li> <li><b>VEG-CONT (Sector K, Radius 10.5 Miles)</b> – Alcorn State University south-southwest of GGNS when available, otherwise a location 15-30 km distant. (Control)</li> </ul>	92 days when available	Gamma isotopic and I-131; 92 days

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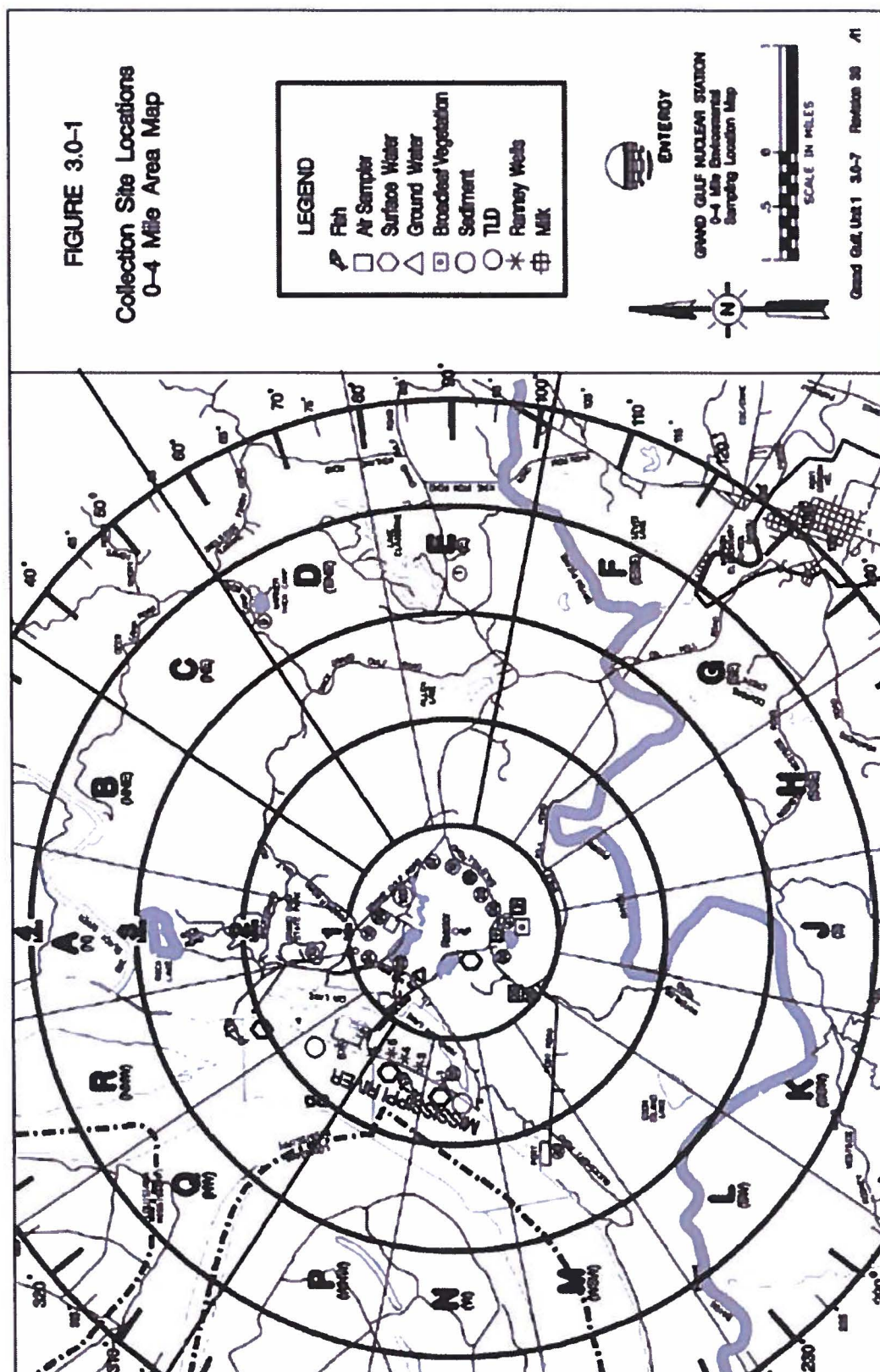
Figure 1, Exposure Pathway





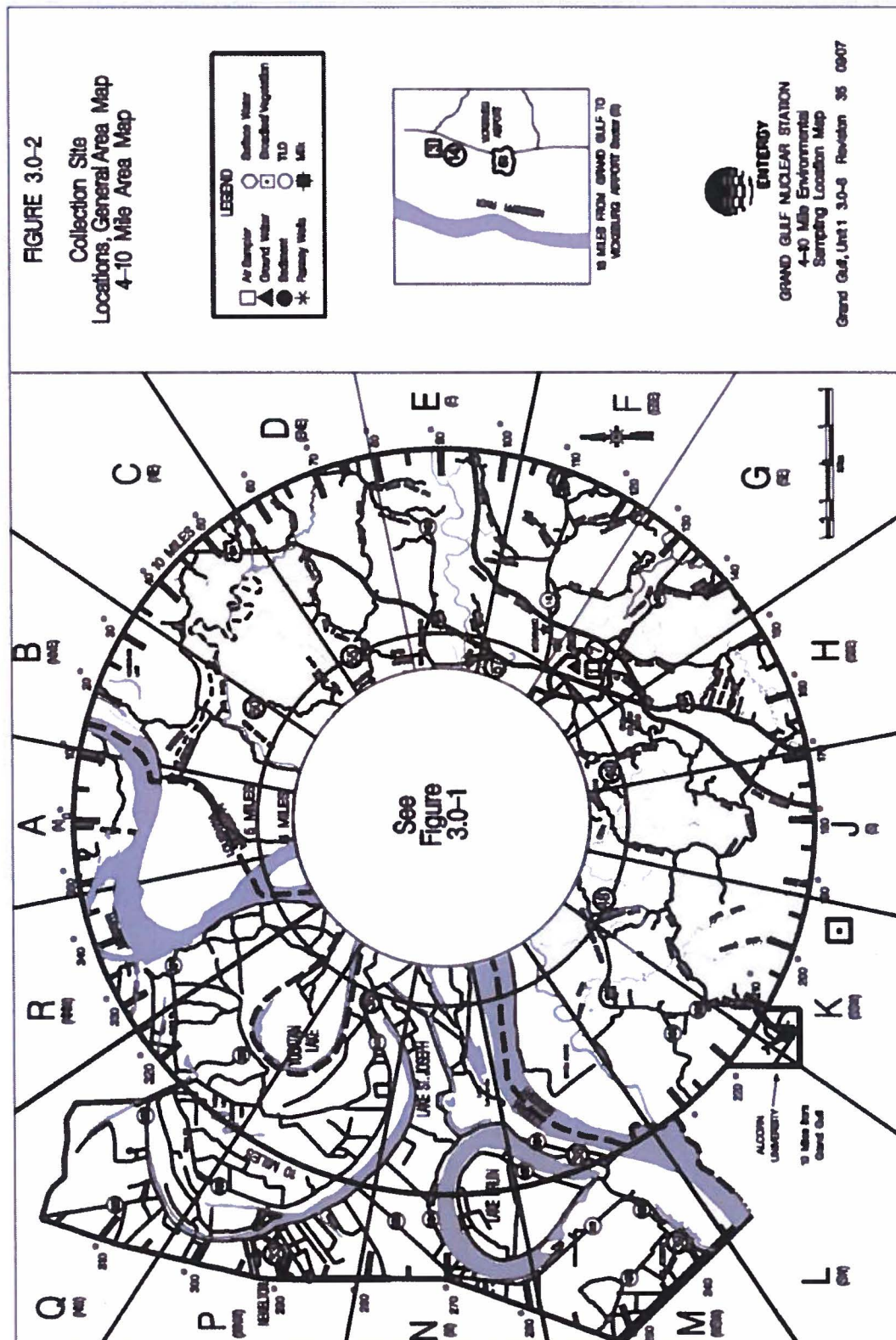
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Figure 2, Sample Collection Sites –Near Field



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Figure 3, Sample Collection Sites - Far Field



#### 4.0 INTERPRETATION AND TRENDS OF RESULTS

##### 4.1 Air Particulate and Radioiodine Sample Results

GGNS did not detect any plant related gamma emitting radionuclides in the quarterly air particulate composites. The REMP had previously detected airborne radioactivity attributable to other sources in this pathway. These sources include the Chinese nuclear test in 1980 and the accident at the Chernobyl Nuclear Power Plant in 1986. The GGNS REMP detected radioactivity released from the Fukushima Dai-ichi Nuclear Power Plant following the March 11, 2011, Tohoku earthquake.

In 2021 there were no samples above the LLD for I-131. Indicator gross beta air particulate results for 2021 were comparable to results obtained from 2011-2020 of the operational REMP. Also, the 2021 gross beta annual average was less than the average for preoperational levels. Results are reported as annual average picocuries per cubic meter (pCi/m<sup>3</sup>).

<u>Monitoring Period</u>	<u>Result</u>
2011 – 2020 (Minimum Value)	0.008
2021 Average Value	0.020
2011 – 2020 (Maximum Value)	0.041
Preoperational	0.032

In the absence of plant-related gamma radionuclides, gross beta activity is attributed to naturally occurring radionuclides. Table 3.1, which include gross beta concentrations and provide a comparison of the indicator and control means and ranges emphasizes the consistent trends seen in this pathway to support the presence of naturally occurring activity. Therefore, it can be concluded that the airborne pathway continues to be unaffected by Grand Gulf Nuclear Station operations.



#### 4.2 Thermoluminescent Dosimetry (TLD) Sample Results

Grand Gulf Nuclear Station reports measured dose as net exposure (field reading less transit reading) normalized to 92 days and relies on comparison of the indicator locations to the control as a measure of plant impact. Grand Gulf Nuclear Station's comparison of the inner ring and special interest area TLD results to the control, as seen in Table 7, identified no noticeable trend that would indicate that the ambient radiation levels are being affected by plant operations. In addition, the inner ring value of 9.9 millirem/quarter (mR/Qtr) shown in Table 7 for 2021 is within the historical bounds of 2011 – 2020 annual average results, which have ranged from 9.3 to 10.0 mrem. Overall, Grand Gulf Nuclear Station concluded that the ambient radiation levels are not being affected by plant operations.

**Table 5, Direct Radiation Annual Summary**

Year	Inner Ring (mR/Qtr)	Outer Ring (mR/Qtr)	Control Location (mR/Qtr)
2011	10.0	10.2	11.4
2012	9.5	9.7	11.0
2013	9.8	9.7	10.8
2014	10.0	9.9	11.0
2015	9.6	9.5	10.8
2016	9.3	9.3	10.7
2017	9.9	9.9	11.3
2018	9.7	9.8	10.6
2019	10.0	9.7	10.7
2020	9.6	9.4	10.7
2021	9.9	10.2	11.7

#### 4.3 Waterborne Sample Results

Analytical results for 2021 surface water and drinking water samples were similar to those reported in previous years. Gamma radionuclides analytical results for 2021 surface water samples were similar to those reported in previous years. Tritium in Grand Gulf Nuclear Station surface water indicator samples continues to be detected, but is attributed to washout and entrainment of normal, previously monitored gaseous effluents. These results are further explained below.

##### 4.3.1 Surface Water

Samples were collected from two indicator locations (Outfall 007, MRDOWN) and one control location (MRUP) and analyzed for gamma emitting radionuclides and tritium. Plant related gamma emitting radionuclides and tritium remained undetectable in the upstream and downstream Mississippi River locations, which is consistent with previous operational years. Storm waters contribute to Outfall 007 and can include tritium as a result of washout and



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entrainment of normal, previously monitored gaseous effluents. As a result, tritium is occasionally observed. Tritium was measured at during February (926 pCi/L), May (2080 pCi/L), September (1010 pCi/L), October (6300 pCi/L), November (2230 pCi/L), and December (3510 pCi/L) at the Outfall 007 location. Tritium was also measured in the duplicate samples collected during February (1390 pCi/L), May (2380 pCi/L), September (1160 pCi/L), October (6530 pCi/L), November (2460 pCi/L), and December (3860 pCi/L). Tritium was not observed in the remaining Outfall 007 samples collected during 2021. Results are reported as annual average pCi/L.

<u>Monitoring Period</u>	<u>Result</u>
2011 – 2020 (Minimum Value)	905
2021 Average Value	2820
2011 – 2020 (Maximum Value)	3283
Preoperational	2739

In addition to the tritium samples required by the REMP, five special surface water samples for gamma emitting radionuclides were collected at the Outfall 007 location. Plant related gamma emitting radionuclides remained undetectable in these samples.

Grand Gulf Nuclear Station personnel have noted no definable increasing trends associated with the tritium levels at the discharge location (Outfall 007). Levels detected during 2021 and previous operational years have been well below regulatory reporting limits. Therefore, the operation of Grand Gulf Nuclear Station had no definable impact on this waterborne pathway during 2021 and levels of radionuclides remain similar to those obtained in previous operational years.

#### 4.3.2 Drinking Water

Drinking water samples were collected from two locations, CONSTWELL (indicator) and PGWELL (control). Drinking water samples were analyzed for I-131, gamma radionuclides and tritium. During 2021, gamma radionuclides, I-131, and tritium concentrations were below the LLD limits at the indicator and control locations, which is consistent with previous operational years. Results are reported as annual average pCi/L.

<u>Radionuclide</u>	<u>2021</u>	<u>2011 – 2020</u>	<u>Preoperational</u>
Gross Beta	< LLD	< LLD	<LLD
Iodine-131	< LLD	< LLD	< LLD
Gamma	< LLD	< LLD	< LLD
Tritium	< LLD	< LLD	<LLD

Grand Gulf Nuclear Station personnel have noted no definable trends associated with drinking water results at the indicator location. Therefore, the operation of Grand Gulf Nuclear Station had no definable impact on this waterborne pathway during 2021 and levels of radionuclides remain similar to those obtained in previous operational years. Results from 2021 are summarized in Table 7.

#### 4.3.3 Groundwater

Groundwater monitoring data collected during administration of the Groundwater Protection Initiative (GPI) site program are included in the Annual Radioactive Effluent Release Report.

#### 4.4 Soil Sample Results

Sediment samples were collected from two locations in 2021 and analyzed for gamma radionuclides. Listed below is a comparison of 2021 indicator results to the 2011 – 2020 operational years. Grand Gulf Nuclear Station operations had no significant impact on the environment or public by this waterborne pathway. Results are reported as pCi/kg.

<u>Monitoring Period</u>	<u>Result</u>
2011 – 2020 (Minimum Value)	<LLD
2021 Value	< LLD
2011 – 2020 (Maximum Value)	40.3
Preoperational	295.0

#### 4.5 Ingestion Sample Results

##### 4.5.1 Milk Sample Results

Milk samples were not collected during 2021 due to the unavailability of indicator locations within five miles of Grand Gulf Nuclear Station.

##### 4.5.2 Fish Sample Results

Fish samples were collected from two locations and analyzed for gamma radionuclides. In 2021, gamma radionuclides were below detectable limits which are consistent with preoperational and operational years. Therefore, based on these measurements, Grand Gulf Nuclear Station operations had no significant radiological impact upon the environment or public by this ingestion pathway.

##### 4.5.3 Food Product Sample Results

The REMP has detected radionuclides prior to 1990 that are attributable to other sources. These include the radioactive plume release due to reactor core degradation at Chernobyl Nuclear Power Plant in 1986 and atmospheric weapons testing.

In 2021, food product samples were collected from two locations and analyzed for plant related Iodine-131 and gamma radionuclides. The 2021 levels remained undetectable, as has been the case in previous years. Therefore, based on these measurements, Grand Gulf Nuclear Station operations had no significant radiological impact upon the environment or public by this ingestion pathway.

#### 4.6 Land Use Census Results

The latest land use census, performed in 2020, did not identify any new locations that yielded a calculated dose or dose commitment greater than those currently calculated.

The land use census identified no milk-producing animals within a five-mile radius of the plant site. In accordance with ODCM Section 6.12.1, Grand Gulf Nuclear Station personnel sampled broadleaf vegetation.

**Table 6, Land Use Census – 2020 Nearest Residence Within Five Miles**

Sector	Direction	Nearest Residence (miles)	Nearest Garden (miles)
A	N	1.02	1.02
B	NNE	1.51	1.52
C	NE	0.70	4.14
D	ENE	2.60	4.50
E	E	0.83	0.91
F	ESE	2.25	4.51
G	SE	3.72	4.20
H	SSE	1.10	4.31
J	S	3.14	3.16
K	SSW	2.20	2.18
L	SW	0.89	0.89
M	WSW	none within 5 miles	none within 5 miles
N	W	none within 5 miles	none within 5 miles
P	WNW	none within 5 miles	none within 5 miles
Q	NW	none within 5 miles	none within 5 miles
R	NNW	1.44	none within 5 miles

The next land use census is scheduled to be conducted in 2022.

#### 4.7 Interlaboratory Comparison Results

Teledyne Brown Engineering and Stanford Dosimetry analyzed interlaboratory comparison samples to fulfill the requirements of ODCM Specification 6.12.1. The results are shown in Attachment 3.

#### 5.0 **RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY**

1. Table 7, Radiological Environmental Monitoring Program Summary, summarizes data for the 2021 REMP program.

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**Table 7, Radiological Environmental Monitoring Program Summary**

Sample Type (Units)	Type / Number of Analyses [Note 1]	LLD [Note 2]	Indicator Locations Mean (F)[Note 3] [Range]	Location with the Highest Annual Mean		Control Locations Mean (F)[Note 3] [Range]	Number of Non-Routine Results [Note 5]
				Location [Note 4]	Mean (F)[Note 3] [Range]		
Air Particulates (pCi/m <sup>3</sup> )	GB / 207	0.01	0.0199 (156 / 156) [0.0090 – 0.0388]	AS-1 PG (Sector G, 5.5 mi)	0.0203 (52 / 52) [0.0107 - 0.0388]	0.0205 (52 / 52) [0.0099 - 0.0356]	0
	GS / 16	0.05	<LLD	N/A	N/A	<LLD	0
	Cs-134 CS-137	0.06	<LLD	N/A	N/A	<LLD	0
Airborne Iodine (pCi/ m <sup>3</sup> )	I-131 / 207	0.07	< LLD	N/A	N/A	< LLD	0
Inner Ring TLDs (mR/Qtr)	Gamma / 54	[Note 6]	9.86 (54 / 54) [6.2 – 13.8]	M-99 (Sector J, 0.4 mi.)	12.5 (4 / 4) [12.0 – 13.8]	N/A	0
Outer Ring TLDs (mR/Qtr)	Gamma / 26	[Note 6]	10.19 (26 / 26) [5.1 – 13.2]	M-55 (Sector D, 5.0 mi.)	11.7 (4 / 4) [11.0 – 13.2]	N/A	0
Special Interest TLDs (mR/Qtr)	Gamma / 27	[Note 6]	10.2 (27 / 27) [7.4 – 12.9]	M-01 (Sector E, 3.5 mi.)	12.0 (4 / 4) [11.0 – 12.9]	N/A	0
Control TLD (mR/Qtr)	Gamma / 4	[Note 6]	N/A	N/A	N/A	11.7 (4 / 4) [10.2 – 13.1]	0

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Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses [Note 1]	LLD [Note 2]	Indicator Locations Mean (F) [Note 3] [Range]	Location with the Highest Annual Mean		Control Locations Mean (F) [Note 3] [Range]	Number of Non-Routine Results [Note 5]
				Location [Note 4]	Mean (F) [Note 3] [Range]		
Surface Water (pCi/l)	H-3 / 39	3000	2820 (12 / 32) [926 – 6530]	Outfall 007 (Sector N, 0.2 mi.)	2820 (12 / 23) [926 – 6530]	< LLD	0
	GS / 16						
	Mn-54	15	< LLD	N/A	N/A	< LLD	0
	Fe-59	30	< LLD	N/A	N/A	< LLD	0
	Co-58	15	< LLD	N/A	N/A	< LLD	0
	Co-60	15	< LLD	N/A	N/A	< LLD	0
	Zn-65	30	< LLD	N/A	N/A	< LLD	0
	Zr-95	30	< LLD	N/A	N/A	< LLD	0
	Nb-95	15	< LLD	N/A	N/A	< LLD	0
	I-131	15	< LLD	N/A	N/A	< LLD	0
	Cs-134	15	< LLD	N/A	N/A	< LLD	0
	Cs-137	18	< LLD	N/A	N/A	< LLD	0
	Ba-140	60	< LLD	N/A	N/A	< LLD	0
	La-140	15	< LLD	N/A	N/A	< LLD	0

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Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses [Note 1]	LLD [Note 2]	Indicator Locations Mean (F)[Note 3] [Range]	Location with the Highest Annual Mean		Control Locations Mean (F)[Note 3] [Range]	Number of Non-Routine Results [Note 5]
				Location [Note 4]	Mean (F)[Note 3] [Range]		
Drinking Water (pCi/l)	I-131 / 6	1	< LLD	N/A	N/A	< LLD	0
	H-3 / 6	2000	< LLD	N/A	N/A	< LLD	0
	GS / 6						
	Mn-54	15	< LLD	N/A	N/A	< LLD	0
	Fe-59	30	< LLD	N/A	N/A	< LLD	0
	Co-58	15	< LLD	N/A	N/A	< LLD	0
	Co-60	15	< LLD	N/A	N/A	< LLD	0
	Zn-65	30	< LLD	N/A	N/A	< LLD	0
	Zr-95	30	< LLD	N/A	N/A	< LLD	0
	Nb-95	15	< LLD	N/A	N/A	< LLD	0
	Cs-134	15	< LLD	N/A	N/A	< LLD	0
	Cs-137	18	< LLD	N/A	N/A	< LLD	0
	Ba-140	60	< LLD	N/A	N/A	< LLD	0
	La-140	15	< LLD	N/A	N/A	< LLD	0
Sediment (pCi/kg)	GS / 4	150	< LLD	N/A	N/A	N/A	0
	Cs-134 Cs-137	180	< LLD	N/A	N/A	N/A	0

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Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses [Note 1]	LLD [Note 2]	Indicator Locations Mean (F) [Note 3] [Range]	Location with the Highest Annual Mean		Control Locations Mean (F) [Note 3] [Range]	Number of Non-Routine Results [Note 5]
				Location [Note 4]	Mean (F) [Note 3] [Range]		
Fish (pCi/kg)	GS / 4						
	Mn-54	130	< LLD	N/A	N/A	< LLD	0
	Fe-59	260	< LLD	N/A	N/A	< LLD	0
	Co-58	130	< LLD	N/A	N/A	< LLD	0
	Co-60	130	< LLD	N/A	N/A	< LLD	0
	Zn-65	260	< LLD	N/A	N/A	< LLD	0
	Cs-134	130	< LLD	N/A	N/A	< LLD	0
	Cs-137	150	< LLD	N/A	N/A	< LLD	0
Food Products (pCi/kg)	I-131 / 12	60	< LLD	N/A	N/A	N/A	0
	GS / 12						
	Cs-134	60	< LLD	N/A	N/A	N/A	0
	Cs-137	80	< LLD	N/A	N/A	N/A	0

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Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses [Note 1]	LLD [Note 2]	Indicator Locations Mean (F)[Note 3] [Range]	Location with the Highest Annual Mean		Control Locations Mean (F)[Note 3] [Range]	Number of Non-Routine Results [Note 5]
				Location [Note 4]	Mean (F)[Note 3] [Range]		
Surface Water (Special) (pCi/l)	GS / 7						
	Mn-54	15	< LLD	N/A	N/A	< LLD	0
	Fe-59	30	< LLD	N/A	N/A	< LLD	0
	Co-58	15	< LLD	N/A	N/A	< LLD	0
	Co-60	15	< LLD	N/A	N/A	< LLD	0
	Zn-65	30	< LLD	N/A	N/A	< LLD	0
	Zr-95	30	< LLD	N/A	N/A	< LLD	0
	Nb-95	15	< LLD	N/A	N/A	< LLD	0
	Cs-134	15	< LLD	N/A	N/A	< LLD	0
	Cs-137	18	< LLD	N/A	N/A	< LLD	0
	Ba-140	60	< LLD	N/A	N/A	< LLD	0
	La-140	15	< LLD	N/A	N/A	< LLD	0



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Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses [Note 1]	LLD [Note 2]	Indicator Locations Mean (F)[Note 3] [Range]	Location with the Highest Annual Mean		Control Locations Mean (F)[Note 3] [Range]	Number of Non-Routine Results [Note 5]
				Location [Note 4]	Mean (F)[Note 3] [Range]		
Meat (Special) (pCi/kg)	GS / 1						
	Mn-54	130	< LLD	N/A	N/A	< LLD	0
	Fe-59	260	< LLD	N/A	N/A	< LLD	0
	Co-58	130	< LLD	N/A	N/A	< LLD	0
	Co-60	130	< LLD	N/A	N/A	< LLD	0
	Zn-65	260	< LLD	N/A	N/A	< LLD	0
	Cs-134	130	< LLD	N/A	N/A	< LLD	0
	Cs-137	150	< LLD	N/A	N/A	< LLD	0

**LEGEND:**

[Note 1] - GB = Gross beta; I-131 = Iodine-131; H-3 = Tritium; GS = Gamma scan.

[Note 2] - LLD = Required lower limit of detection based on ODCM Table 6.12.1-3.

[Note 3] - Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parenthesis (F).

[Note 4] - Where applicable, locations are specified (1) by name, (2) distance from reactor site, and (3) meteorological sector.

[Note 5] - Non-routine results are those which exceed ten times the control station value. If no control station value is available, the result is considered non-routine if it exceeds ten times the preoperational value for the location.

[Note 6] - LLD is not defined in ODCM Table 6.12.1-3.

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Sample Deviations

Table 8, Sample Deviations Table

Comment No.	Sample Media Affected	Sample Location	Date	Problem	Evaluation / Actions
1	Air	AS-1, AS-3, AS-7, AS-20	02/23/21	Air Sampler Power Outage	Air sample locations AS-1, AS-3, AS-7, and AS-20 had reduced runtimes due to weather related power outages (ice storm). Due to low sample volume, the required LLDs for AS-20 gross beta and I-131 were not met. The AS-20 data was excluded from data summary calculations, and the analytical results are included in data tables for information only. CR-GGN-2021-01470 documents the condition.
2	TLD	M-25	04/05/21	Inaccessible TLD	During collection of 1st quarter 2021 TLDs, monitoring location M-25 was inaccessible due to high Mississippi River water level. CR-GGN-2021-02653 documents the condition.
3	TLD	M-40	04/02/21	Lost TLD	During collection of 1st quarter 2021 TLDs, monitoring location M-40 was lost due to road construction activities. A new TLD was installed at the location. CR-GGN-2021-02616 documents the condition.
4	TLD	M-25	07/06/21	Inaccessible TLD	During collection of 2nd quarter 2021 TLDs, monitoring location M-25 was inaccessible due to high Mississippi River water level. CR-GGN-2021-05178 documents the condition.
5	TLD	M-33	07/06/21	Lost TLD	During collection of 2nd quarter 2021 TLDs, monitoring location M-33 was lost due to building construction activities. A new TLD was installed at the location. CR-GGN-2021-05174 documents the condition.
6	TLD	M-40	10/04/21	Lost TLD	During collection of 3rd quarter 2021 TLDs, monitoring location M-40 was lost. The cause for the missing TLD was not determined. A new TLD was installed at the location. CR-GGN-2021-07512 documents the condition.

## Monitoring Results Tables

Table 9, Air Particulate Data Summary Table

Analysis: Gross Beta				Units: pCi/m <sup>3</sup>	
Start Date	End Date	Station AS-1 (Indicator)	Station AS-7 (Indicator)	Station AS-20 (Indicator)	Station AS-3 <sup>[Note 1]</sup> (Control)
<b>REQUIRED LLD →</b>		<b>0.01</b>	<b>0.01</b>	<b>0.01</b>	<b>0.01</b>
12/29/20	01/05/21	0.01580	0.01520	0.01100	0.01420
01/05/21	01/12/21	0.02040	0.01870	0.01720	0.02080
01/12/21	01/19/21	0.02420	0.02040	0.02360	0.02120
01/19/21	01/26/21	0.01720	0.01840	0.01860	0.02220
01/26/21	02/02/21	0.02240	0.01790	0.02340	0.02370
02/02/21	02/09/21	0.01450	0.01960	0.01910	0.01740
02/09/21	02/17/21	0.02080	0.02160	0.01870	0.02590
02/17/21	02/23/21	0.03500	0.02230	0.22800 <sup>[Note 2]</sup>	0.02310
02/23/21	03/02/21	0.01850	0.01670	0.01700	0.02060
03/02/21	03/09/21	0.01520	0.01200	0.01570	0.01580
03/09/21	03/16/21	0.01500	0.01410	0.01540	0.01400
03/16/21	03/23/21	0.01760	0.01460	0.01700	0.01370
03/23/21	03/30/21	0.01620	0.01580	0.01550	0.01440
03/30/21	04/06/21	0.02180	0.02030	0.02750	0.02240
04/06/21	04/13/21	0.01930	0.01840	0.01810	0.02050
04/13/21	04/20/21	0.01240	0.01570	0.01870	0.01750
04/20/21	04/27/21	0.01910	0.02120	0.01950	0.01800
04/27/21	05/04/21	0.01950	0.01970	0.02170	0.01670
05/04/21	05/11/21	0.01600	0.01790	0.01690	0.01800
05/11/21	05/18/21	0.01910	0.01740	0.01800	0.01450
05/18/21	05/25/21	0.01750	0.01850	0.01640	0.01380
05/25/21	06/01/21	0.01370	0.01260	0.01130	0.01380
06/01/21	06/08/21	0.01290	0.01390	0.01400	0.01510
06/08/21	06/15/21	0.01430	0.01460	0.01490	0.01530
06/15/21	06/22/21	0.01810	0.01920	0.01670	0.01910
06/22/21	06/29/21	0.01140	0.01190	0.01440	0.00993
06/29/21	07/06/21	0.01500	0.01330	0.01600	0.01350

## Monitoring Results Tables

Table 9, Air Particulate Data Summary Table

Analysis: Gross Beta				Units: pCi/m <sup>3</sup>	
Start Date	End Date	Station AS-1 (Indicator)	Station AS-7 (Indicator)	Station AS-20 (Indicator)	Station AS-3 <sup>[Note 1]</sup> (Control)
<b><u>REQUIRED LLD →</u></b>		<b><u>0.01</u></b>	<b><u>0.01</u></b>	<b><u>0.01</u></b>	<b><u>0.01</u></b>
07/06/21	07/13/21	0.01200	0.00899	0.01110	0.01270
07/13/21	07/20/21	0.01380	0.01280	0.01490	0.01740
07/20/21	07/27/21	0.01920	0.01960	0.01870	0.02130
07/27/21	08/03/21	0.02520	0.02870	0.02580	0.02500
08/03/21	08/10/21	0.02930	0.02560	0.02770	0.02960
08/10/21	08/17/21	0.01070	0.01070	0.01100	0.01290
08/17/21	08/24/21	0.01490	0.01390	0.01690	0.01300
08/24/21	08/31/21	0.01460	0.01990	0.01540	0.01700
08/31/21	09/07/21	0.02030	0.01740	0.01880	0.02160
09/07/21	09/14/21	0.02400	0.02030	0.02420	0.02600
09/14/21	09/21/21	0.01070	0.00898	0.00997	0.01090
09/21/21	09/28/21	0.03000	0.02940	0.02630	0.02990
09/28/21	10/05/21	0.01410	0.01590	0.01390	0.01570
10/05/21	10/12/21	0.02630	0.02470	0.03010	0.03560
10/12/21	10/19/21	0.01840	0.01720	0.02320	0.01780
10/19/21	10/26/21	0.03360	0.03240	0.03130	0.03450
10/26/21	11/02/21	0.02060	0.01940	0.01810	0.02230
11/02/21	11/09/21	0.03350	0.03280	0.03220	0.02970
11/09/21	11/16/21	0.02780	0.02700	0.02580	0.02830
11/16/21	11/23/21	0.03110	0.02760	0.02720	0.03250
11/23/21	11/30/21	0.02980	0.02950	0.02580	0.02920
11/30/21	12/07/21	0.03880	0.03000	0.02940	0.03350
12/07/21	12/14/21	0.02560	0.02400	0.02780	0.02840
12/14/21	12/21/21	0.01850	0.02130	0.02080	0.01620
12/21/21	12/28/21	0.03130	0.02970	0.03190	0.02880

[Note 1] – Station with highest annual mean.

[Note 2] – Reference Attachment 1, Sample Deviations, Table 8, Sample Deviations Table, Comment 1



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## Monitoring Results Tables

Table 10, Radioiodine Cartridge Data Table Summary

Analysis: I-131				Units: pCi/m <sup>3</sup>	
Start Date	End Date	AS-1 (Indicator)	AS-7 (Indicator)	AS-20 (Indicator)	AS-3 (Control)
<b>REQUIRED LLD →</b>		<b>0.07</b>	<b>0.07</b>	<b>0.07</b>	<b>0.07</b>
12/29/20	01/05/21	<0.03013	<0.0303	<0.02909	<0.0298
01/05/21	01/12/21	<0.02497	<0.02548	<0.02548	<0.01659
01/12/21	01/19/21	<0.04214	<0.0427	<0.04236	<0.04205
01/19/21	01/26/21	<0.02385	<0.02393	<0.02356	<0.02314
01/26/21	02/02/21	<0.03603	<0.03614	<0.0363	<0.03533
02/02/21	02/09/21	<0.04267	<0.04397	<0.04278	<0.04195
02/09/21	02/17/21	<0.03102	<0.03074	<0.03169	<0.03043
02/17/21	02/23/21	<0.04697	<0.05151	<0.5912 <sup>[Note 1]</sup>	<0.03936
02/23/21	03/02/21	<0.03366	<0.03342	<0.03403	<0.03255
03/02/21	03/09/21	<0.01734	<0.01765	<0.01754	<0.01697
03/09/21	03/16/21	<0.03579	<0.03491	<0.0359	<0.03431
03/16/21	03/23/21	<0.04056	<0.03999	<0.04098	<0.03952
03/23/21	03/30/21	<0.02661	<0.02551	<0.02676	<0.02616
03/30/21	04/06/21	<0.03081	<0.03025	<0.03077	<0.02926
04/06/21	04/13/21	<0.01585	<0.01585	<0.01603	<0.01512
04/13/21	04/20/21	<0.02191	<0.02163	<0.02209	<0.02104
04/20/21	04/27/21	<0.03618	<0.03685	<0.03782	<0.03433
04/27/21	05/04/21	<0.03003	<0.02984	<0.03025	<0.02886
05/04/21	05/11/21	<0.03864	<0.04593	<0.04535	<0.03887
05/11/21	05/18/21	<0.02855	<0.02835	<0.02949	<0.02295
05/18/21	05/25/21	<0.03047	<0.02965	<0.03073	<0.02946
05/25/21	06/01/21	<0.02841	<0.02783	<0.02861	<0.02703
06/01/21	06/08/21	<0.04667	<0.04649	<0.04712	<0.04446
06/08/21	06/15/21	<0.03657	<0.03636	<0.03704	<0.03464
06/15/21	06/22/21	<0.01935	<0.01902	<0.01959	<0.0184
06/22/21	06/29/21	<0.036	<0.03608	<0.0363	<0.03598
06/29/21	07/06/21	<0.03461	<0.03492	<0.03482	<0.03557

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## Monitoring Results Tables

Table 10, Radioiodine Cartridge Data Table Summary

Analysis: I-131				Units: pCi/m <sup>3</sup>	
Start Date	End Date	AS-1 (Indicator)	AS-7 (Indicator)	AS-20 (Indicator)	AS-3 (Control)
<b>REQUIRED LLD →</b>		<b>0.07</b>	<b>0.07</b>	<b>0.07</b>	<b>0.07</b>
07/06/21	07/13/21	<0.0362	<0.03638	<0.03711	<0.03674
07/13/21	07/20/21	<0.03198	<0.0319	<0.03281	<0.03285
07/20/21	07/27/21	<0.0365	<0.03649	<0.03694	<0.03739
07/27/21	08/03/21	<0.03974	<0.04204	<0.04247	<0.04108
08/03/21	08/10/21	<0.03643	<0.03729	<0.03754	<0.03754
08/10/21	08/17/21	<0.02693	<0.0275	<0.01421	<0.02802
08/17/21	08/24/21	<0.0203	<0.02076	<0.02118	<0.02098
08/24/21	08/31/21	<0.02636	<0.03662	<0.0336	<0.02791
08/31/21	09/07/21	<0.01963	<0.02017	<0.02035	<0.0195
09/07/21	09/14/21	<0.03342	<0.03266	<0.03367	<0.03379
09/14/21	09/21/21	<0.052	<0.05059	<0.05248	<0.05269
09/21/21	09/28/21	<0.03201	<0.03162	<0.0329	<0.03276
09/28/21	10/05/21	<0.03764	<0.03742	<0.03904	<0.03873
10/05/21	10/12/21	<0.02707	<0.02686	<0.02806	<0.02806
10/12/21	10/19/21	<0.04026	<0.04024	<0.04188	<0.04145
10/19/21	10/26/21	<0.01589	<0.03117	<0.03261	<0.03318
10/26/21	11/02/21	<0.04283	<0.04378	<0.04517	<0.04455
11/02/21	11/09/21	<0.02977	<0.03028	<0.03139	<0.03123
11/09/21	11/16/21	<0.02321	<0.02345	<0.02443	<0.0244
11/16/21	11/23/21	<0.04294	<0.04343	<0.04505	<0.04439
11/23/21	11/30/21	<0.02842	<0.02899	<0.0299	<0.02969
11/30/21	12/07/21	<0.02915	<0.02984	<0.03092	<0.03056
12/07/21	12/14/21	<0.02772	<0.02841	<0.02919	<0.02894
12/14/21	12/21/21	<0.02194	<0.02229	<0.02306	<0.02327
12/21/21	12/28/21	<0.02833	<0.02855	<0.01403	<0.02891

[Note 1] - Reference Attachment 1, Sample Deviations, Table 8, Sample Deviations Table, Comment 1

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Monitoring Results Tables

Table 11, Air Gamma Quarterly Composite

Analysis: Gamma Isotopic		Units: pCi/cu.m	
Location	Date	CS-134	CS-137
<b><u>REQUIRED LLD →</u></b>		<b>0.05</b>	<b>0.06</b>
AS-1	02/12/21	<0.002278	<0.001452
AS-3		<0.001326	<0.001052
AS-7		<0.001495	<0.00126
AS-20		<0.002218	<0.001994
AS-1	05/14/21	<0.002422	<0.001861
AS-3		<0.0021	<0.001923
AS-7		<0.001928	<0.001669
AS-20		<0.002531	<0.001925
AS-1	08/13/21	<0.002446	<0.001978
AS-3		<0.003193	<0.002981
AS-7		<0.002989	<0.00209
AS-20		<0.002875	<0.001924
AS-1	11/12/21	<0.001645	<0.001512
AS-3		<0.002066	<0.001946
AS-7		<0.002402	<0.00254
AS-20		<0.001307	<0.001228

Monitoring Results Tables

Table 12, Thermoluminescent Dosimeters – Inner Ring

Analysis: Gamma Dose				Units: mrem	
Station	1 <sup>st</sup> Qtr 2021	2 <sup>nd</sup> Qtr 2021	3 <sup>rd</sup> Qtr 2021	4 <sup>th</sup> Qtr 2021	Annual Mean 2021
M-16	10.2	11.0	10.3	12.0	10.9
M-19	8.7	9.5	9.2	11.1	9.6
M-21	11.6	12.3	12.3	13.4	12.4
M-22	8.1	8.5	8.3	9.4	8.6
M-23	8.4	7.4	8.3	9.6	8.4
M-25	Lost <sup>[Note 2]</sup>	Lost <sup>[Note 3]</sup>	8.4	9.3	8.8
M-28	10.1	10.8	10.9	12.1	11.0
M-94	9.8	10.1	9.9	11.6	10.4
M-95	6.4	6.2	7.4	7.4	6.9
M-96	8.0	8.0	8.1	9.1	8.3
M-97	7.5	7.7	7.4	8.1	7.6
M-98	11.0	11.1	12.2	12.8	11.8
M-99 <sup>[Note 1]</sup>	12.1	12.2	12.0	13.8	12.5
M-100	10.5	11.1	9.8	10.1	10.4

[Note 1] – Station with highest annual mean.

[Note 2] - Reference Attachment 1, Sample Deviations, Table 8, Sample Deviations Table, Comment 2

[Note 3] - Reference Attachment 1, Sample Deviations, Table 8, Sample Deviations Table, Comment 3



## Monitoring Results Tables

Table 13, Thermoluminescent Dosimeters – Outer Ring

Analysis: Gamma Dose			Units: mrem		
Station	1 <sup>st</sup> Qtr 2021	2 <sup>nd</sup> Qtr 2021	3 <sup>rd</sup> Qtr 2021	4 <sup>th</sup> Qtr 2021	Annual Mean 2021
M-36	7.8	8.2	8.9	9.8	8.7
M-40	Lost <sup>[Note 2]</sup>	5.1	Lost <sup>[Note 3]</sup>	6.7	5.9
M-48	9.5	9.7	10.3	11.6	10.3
M-49	10.5	10.5	11.4	12.1	11.1
M-50	9.0	9.1	10.2	11.6	9.9
M-55 <sup>[Note 1]</sup>	11.0	11.1	11.3	13.2	11.6
M-57	10.4	11.5	11.9	12.7	11.6

[Note 1] – Station with highest annual mean.

[Note 2] - Reference Attachment 1, Sample Deviations, Table 8, Sample Deviations Table, Comment 4

[Note 3] - Reference Attachment 1, Sample Deviations, Table 8, Sample Deviations Table, Comment 5

Table 14, Thermoluminescent Dosimeters – Special Interest Areas

Analysis: Gamma Dose			Units: mrem		
Station	1 <sup>st</sup> Qtr 2021	2 <sup>nd</sup> Qtr 2021	3 <sup>rd</sup> Qtr 2021	4 <sup>th</sup> Qtr 2021	Annual Mean 2021
M-01 <sup>[Note 1]</sup>	11.0	11.8	12.2	12.9	12.0
M-07	9.8	11.2	10.5	12.0	10.9
M-09	9.9	10.2	10.2	11.4	10.4
M-10	8.5	9.1	9.3	10.0	9.2
M-33	7.4	Lost <sup>[Note 2]</sup>	10.6	12.5	10.2
M-38	9.0	9.0	10.0	11.3	9.8
M-39	8.6	8.6	8.8	9.9	9.0

[Note 1] – Station with highest annual mean.

[Note 2] - Reference Attachment 1, Sample Deviations, Table 8, Sample Deviations Table, Comment 6

Table 15, Thermoluminescent Dosimeters – Control

Analysis: Gamma Dose			Units: mrem		
Station	1 <sup>st</sup> Qtr 2021	2 <sup>nd</sup> Qtr 2021	3 <sup>rd</sup> Qtr 2021	4 <sup>th</sup> Qtr 2021	Annual Mean 2021
M-14	10.2	11.6	11.8	13.1	11.7

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**Monitoring Results Tables**

**Table 16, Surface Water – Gamma**

Analysis: Gamma Isotopic			Units: pCi/L										
Location	Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
<b>REQUIRED LLD →</b>		<b>15</b>	<b>15</b>	<b>30</b>	<b>15</b>	<b>30</b>	<b>15</b>	<b>30</b>	<b>15</b>	<b>15</b>	<b>18</b>	<b>60</b>	<b>15</b>
MRDOWN (Indicator)	02/03/21	<6.201	<6.632	<16.6	<8.541	<13.31	<7.019	<10.62	<13.52	<6.236	<7.916	<32.51	<9.547
MRUP (Control)	02/03/21	<6.482	<6.426	<15.64	<5.432	<14.45	<5.764	<11.24	<10.8	<6.424	<6.57	<34.02	<10.49
MRDOWN GG (Indicator)	02/03/21	<5.218	<4.648	<11.29	<5.684	<8.778	<6.114	<10.25	<5.066	<3.486	<5.967	<21.16	<7.571
MRUP GG (Control)	02/03/21	<6.837	<7.163	<18.15	<7.568	<14.67	<6.171	<16.26	<12.97	<8.71	<8.027	<33.93	<13.4
MRDOWN (Indicator)	05/06/21	<6.85	<4.679	<7.035	<6.344	<14.75	<5.909	<11.77	<9.349	<6.609	<5.879	<28.98	<6.834
MRUP (Control)	05/06/21	<5.971	<6.029	<11.1	<5.331	<8.992	<6.62	<13.44	<10.87	<6.653	<6.028	<30.2	<9.968
MRDOWN (Indicator)	08/05/21	<6.702	<5.864	<16.34	<6.761	<14.77	<6.765	<9.605	<9.598	<7.23	<6.831	<26.41	<10.64
MRUP (Control)	08/05/21	<5.31	<4.57	<9.425	<3.78	<7.811	<5.264	<9.009	<7.18	<5.017	<5.236	<19.81	<6.566
MRDOWN GG (Indicator)	08/05/21	<6.336	<3.929	<11.39	<5.367	<12.61	<6.212	<10.41	<10.93	<6.409	<5.386	<24.44	<9.467
MRUP GG (Control)	08/05/21	<4.782	<4.873	<12.95	<5.66	<14.17	<5.686	<10.87	<8.573	<5.54	<4.87	<28.01	<11.81

## Monitoring Results Tables

Table 16, Surface Water – Gamma

Analysis: Gamma Isotopic			Units: pCi/L										
Location	Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
<b>REQUIRED LLD →</b>		<b>15</b>	<b>15</b>	<b>30</b>	<b>15</b>	<b>30</b>	<b>15</b>	<b>30</b>	<b>15</b>	<b>15</b>	<b>18</b>	<b>60</b>	<b>15</b>
MRDOWN (Indicator)	11/04/21	<7.981	<7.422	<13.36	<8.663	<13.68	<8.994	<15.44	<13.71	<7.654	<7.234	<44.92	<8.26
MRUP (Control)	11/04/21	<4.718	<4.659	<8.575	<6.252	<10.52	<7.18	<9.698	<8.449	<5.909	<5.379	<28	<9.834
MRDOWN GG (Indicator)	11/04/21	<4.786	<4.381	<9.244	<5.787	<8.606	<5.173	<9.034	<8.28	<4.559	<4.794	<25.36	<8.551
MRUP GG (Control)	11/04/21	<4.763	<5.559	<11.75	<5.224	<10.82	<7.552	<8.232	<9.537	<4.481	<5.713	<27.9	<5.973
MRDOWN* (Indicator)	11/05/21	<5.674	<5.355	<11.44	<4.803	<9.748	<7.021	<9.153	<14.09	<5.658	<7.214	<36.48	<10.4
MRDOWN GG* (Indicator)	11/05/21	<6.314	<5.688	<11.8	<5.94	<12.94	<5.398	<10.46	<13.39	<5.434	<6.174	<37.33	<9.397

GG - indicates duplicate sample

\* - indicates annual sample collected during liquid effluent discharge

Monitoring Results Tables

Table 17, Surface Water – Tritium

Analysis: H-3		Units: pCi/L
Location	Date	H-3
<b><u>REQUIRED LLD →</u></b>		<b><u>3000</u></b>
OUTFALL 007	01/19/21	<512
OUTFALL 007 GG	01/19/21	<502
MRDOWN	02/03/21	<505
MRUP	02/03/21	<504
MRDOWN GG	02/03/21	<501
MRUP GG	02/03/21	<496
OUTFALL 007	02/23/21	926
OUTFALL 007 GG	02/23/21	1390
OUTFALL 007	03/12/21	<479
OUTFALL 007 GG	03/12/21	<472
OUTFALL 007	04/20/21	<527
OUTFALL 007 GG	04/20/21	<555
MRDOWN	05/06/21	<522
MRUP	05/06/21	<551
OUTFALL 007	05/18/21	2080
OUTFALL 007 GG	05/18/21	2380
OUTFALL 007	06/15/21	<574
OUTFALL 007 GG	06/15/21	<573
OUTFALL 007	07/20/21	<525
MRDOWN	08/05/21	<531
MRUP	08/05/21	<525
MRDOWN GG	08/05/21	<535
MRUP GG	08/05/21	<528
OUTFALL 007	08/18/21	<523
OUTFALL 007 GG	08/18/21	<514

Monitoring Results Tables

Table 17, Surface Water – Tritium

Analysis: H-3		Units: pCi/L
Location	Date	H-3
OUTFALL 007	09/14/21	1010
OUTFALL 007 GG	09/14/21	1160
OUTFALL 007	10/19/21	6300
OUTFALL 007 GG	10/19/21	6530
MRDOWN	11/04/21	<508
MRUP	11/04/21	<477
MRDOWN GG	11/04/21	<558
MRUP GG	11/04/21	<498
MRDOWN*	11/05/21	<501
MRDOWN GG*	11/05/21	<536
OUTFALL 007	11/16/21	2230
OUTFALL 007 GG	11/16/21	2460
OUTFALL 007	12/14/21	3510
OUTFALL 007 GG	12/14/21	3860

GG - indicates duplicate sample

\* - indicates Annual Sample collected during liquid discharge

## Monitoring Results Tables

Table 18, Drinking Water - Gamma, I-131

Analysis: Gamma Isotopic, I-131						Units: pCi/L							
Location	Date	I-131	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140
<b>REQUIRED LLD →</b>		<b>1</b>	<b>15</b>	<b>15</b>	<b>30</b>	<b>15</b>	<b>30</b>	<b>15</b>	<b>30</b>	<b>15</b>	<b>18</b>	<b>60</b>	<b>15</b>
CONSTWELL 3	11/10/21	<0.589	<6.701	<5.942	<11.72	<7.329	<14.73	<6.888	<10.48	<6.098	<7.104	<24.74	<8.693
CONSTWELL 3 GG	11/10/21	<0.589	<6.411	<6.63	<9.803	<5.568	<12.14	<5.061	<11.1	<7.99	<6.766	<22.16	<9.491
CONSTWELL 4	11/10/21	<0.757	<6.481	<5.714	<14.77	<4.974	<14.22	<6.539	<10.79	<6.475	<6.679	<21.58	<6.832
CONSTWELL 4 GG	11/10/21	<0.824	<5.15	<5.835	<11.16	<8.789	<11.83	<6.149	<11.06	<7.52	<7.034	<23.01	<6.461
PGWELL	11/10/21	<0.656	<7.054	<9.511	<21.7	<8.799	<16.92	<8.871	<13.24	<9.107	<9.181	<26.98	<8.97
PGWELL GG	11/10/21	<0.909	<6.665	<5.543	<13.43	<5.349	<15.2	<7.414	<9.914	<6.34	<5.246	<20.25	<8.286

GG - indicates duplicate sample

Monitoring Results Tables

Table 19, Drinking Water – Tritium

Analysis: H-3		Units: pCi/L
Location	Date	H-3
<b><u>REQUIRED LLD →</u></b>		<b><u>2000</u></b>
CONSTWELL 3	11/10/21	<495
CONSTWELL 3 GG	11/10/21	<516
CONSTWELL 4	11/10/21	<487
CONSTWELL 4 GG	11/10/21	<482
PGWELL	11/10/21	<483
PGWELL GG	11/10/21	<486

GG - indicates duplicate sample

Table 20, Sediment

Analysis: Gamma Isotopic		Units: pCi/kg	
Location	Date	Cs-134	Cs-137
<b><u>REQUIRED LLD →</u></b>		<b>150</b>	<b>180</b>
SEDHAM	09/07/21	<72.71	<62.09
SEDHAM GG	09/07/21	<64.31	<51.98
SEDCONT	09/07/21	<65.2	<50.24
SEDCONT GG	09/07/21	<72.73	<65.1

GG - indicates duplicate sample



Monitoring Results Tables

Table 21, Fish

Analysis: Gamma Isotopic				Units: pCi/kg				
Location	Collection Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Cs-134	Cs-137
<b>REQUIRED LLD →</b>		130	130	260	130	260	130	150
FISHDOWN	09/01/21	<68.33	<60.12	<124.3	<65.91	<107.6	<45.78	<55.18
FISHDOWN GG	09/01/21	<56.8	<56.56	<113.9	<51.67	<81.87	<61.77	<61.47
FISHUP	09/01/21	<46.14	<41.1	<124	<49.72	<100.7	<54.75	<46.29
FISHUP GG	09/01/21	<48.42	<66.81	<111.7	<62.27	<76.07	<48.4	<45.79

Table 22, Food Products

Analysis: Gamma Isotopic, I-131		Units: pCi/kg		
Location	Collection Date	I-131	Cs-134	Cs-137
<b>REQUIRED LLD →</b>		60	60	80
VEG-CONT	02/24/21	<23.11	<27.31	<24.57
VEG-J	02/24/21	<28.87	<28.45	<27.19
VEG-CONT	05/19/21	<32.61	<36.51	<30.85
VEG-CONT GG	05/19/21	<36.55	<33.88	<32.78
VEG-J	05/19/21	<28.1	<28.86	<29.78
VEG-J GG	05/19/21	<23.79	<27.16	<26.95
VEG-CONT	08/12/21	<20.62	<21.37	<17.34
VEG-J	08/12/21	<30.16	<32.72	<33.34
VEG-CONT	11/17/21	<24.01	<18.4	<11.09
VEG-CONT GG	11/17/21	<21.72	<15.77	<17.09
VEG-J	11/21/21	<12.83	<15.62	<13.43
VEG-J GG	11/21/21	<19.32	<19.43	<16.75

GG - indicates duplicate sample



## Monitoring Results Tables

Table 23, Special Samples, Surface Water

Analysis: Gamma Isotopic			Units: pCi/L										
Location	Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	I-131	Cs-134	Cs-137	Ba-140	La-140
<b>REQUIRED LLD →</b>		15	15	30	15	30	15	30	15	15	18	60	15
OUTFALL 007	03/12/21	<6.329	<6.532	<15.59	<5.738	<11.15	<7.518	<10.86	<12.7	<6.925	<6.113	<35.49	<14.07
OUTFALL 007 GG	03/12/21	<6.134	<6.008	<12.3	<6.492	<10.62	<6.813	<9.705	<13.36	<6.623	<6.735	<30.64	<9.914
OUTFALL 007	06/08/21	<6.186	<5.977	<12.83	<6.325	<11.45	<5.224	<11.6	<11.47	<6.618	<7.302	<31.91	<11.52
OUTFALL 007	09/29/21	<5.922	<6.955	<16.05	<5.948	<15.46	<8.641	<12.7	<13.84	<7.815	<9.872	<36.25	<13.59
OUTFALL 007 GG	09/29/21	<5.887	<8.354	<17.98	<8.933	<13.78	<7.078	<14.76	<10.67	<5.528	<7.64	<28.4	<11.33
OUTFALL 007	12/14/21	<5.195	<5.707	<11.04	<6.656	<16.26	<4.628	<11.31	<10.42	<6.429	<7.487	<29.63	<10.88
OUTFALL 007 GG	12/14/21	<5.317	<6.459	<11.75	<5.249	<11.86	<6.467	<9.237	<10.8	<5.582	<6.162	<24.65	<10.82

GG - indicates duplicate sample

Table 24, Special Samples, Meat

Analysis: Gamma Isotopic			Units: pCi/kg					
Location	Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Cs-134	Cs-137
<b>REQUIRED LLD →</b>		130	130	260	130	260	130	150
DEER	12/20/21	<96.5	<74.6	<162	<98.69	<200.5	<78.52	<95.03

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### **ATTACHMENT 3**

#### **INTERLABORATORY COMPARISON RESULTS**

Quality control data from the offsite environmental laboratories are summarized in the following pages.

Information from Teledyne Brown Engineering is presented first, followed by Environmental Dosimetry Company / Stanford Dosimetry.

## TELEDYNE BROWN ENGINEERING

### 1.0 Summary

The TBE Laboratory analyzed Performance Evaluation (PE) samples of air particulate (AP), air iodine, milk, soil, vegetation, and water matrices for various analytes. The PE samples supplied by Analytics Inc., Environmental Resource Associates (ERA) and Department of Energy (DOE) Mixed Analyte Performance Evaluation Program (MAPEP), were evaluated against the following pre-set acceptance criteria:

#### A. Analytics Evaluation Criteria

Analytics' evaluation report provides a ratio of TBE's result and Analytics' known value. Since flag values are not assigned by Analytics, TBE evaluates the reported ratios based on internal QC requirements based on the DOE MAPEP criteria.

#### B. ERA Evaluation Criteria

ERA's evaluation report provides an acceptance range for control and warning limits with associated flag values. ERA's acceptance limits are established per the US EPA, National Environmental Laboratory Accreditation Conference (NELAC), state-specific Performance Testing (PT) program requirements or ERA's SOP for the Generation of Performance Acceptance Limits, as applicable. The acceptance limits are either determined by a regression equation specific to each analyte or a fixed percentage limit promulgated under the appropriate regulatory document.

#### C. DOE Evaluation Criteria

MAPEP's evaluation report provides an acceptance range with associated flag values. MAPEP defines three levels of performance:

- Acceptable (flag = "A") - result within  $\pm 20\%$  of the reference value
- Acceptable with Warning (flag = "W") - result falls in the  $\pm 20\%$  to  $\pm 30\%$  of the reference value
- Not Acceptable (flag = "N") - bias is greater than 30% of the reference value

*Note: The Department of Energy (DOE) Mixed Analyte Performance Evaluation Program (MAPEP) samples are created to mimic conditions found at DOE sites which do not resemble typical environmental samples obtained at commercial nuclear power facilities.*

For the TBE laboratory, 126 out of 133 analyses performed met the specified acceptance criteria. Seven analyses did not meet the specified acceptance criteria for the following reasons and were addressed through the TBE Corrective Action Program. A summary is found below:

1. The MAPEP February 2020 AP U-233/234 and U-238 results were evaluated as *Not Acceptable*. The reported value for U-233/234 was  $0.0416 \pm 0.0102$  Bq/sample and the known result was 0.075 Bq/sample (acceptance range 0.053 - 0.098). The reported value for U-238 was  $0.0388 \pm 0.00991$  Bq/sample and the known result was 0.078 Bq/sample (acceptance range 0.055 - 0.101). This sample was run as the workgroup duplicate and had RPD's of 10.4% (U-234) and 11.7% (U-238). After the known results were obtained, the sample was relogged. The filter was completely digested with tracer added originally; the R1 results were almost identical. It was concluded that the recorded tracer amount was actually double, causing the results to be skewed. Lab worksheets have been modified to verify actual tracer amount vs. LIMS data. TBE changed vendors for this cross-check to ERA MRAD during the 2<sup>nd</sup> half of 2020. Results were acceptable at 97.8% for U-234 and 106% for U-238. (NCR 20-13)
2. The Analytics September 2020 milk Sr-89 result was evaluated as *Not Acceptable*. The reported value was 62.8 pCi/L and the known result was 95.4 (66%). All QC data was reviewed and there were no anomalies. This was the first failure for milk Sr-89 since 2013 and there have only been 3 upper/lower boundary warnings since that time. It is believed that there may have been some Sr-89 loss during sample prep. The December 2020 result was at 92% of the known. (NCR 20-19)
3. The ERA October 2020 water I-131 result was evaluated as *Not Acceptable*. The reported value was 22.9 pCi/L and the known result was 28.2 (acceptance range 23.5 - 33.1). The reported result was 81% of the known, which passes TBE QC criteria. This was the first failure for water I-131. (NCR 20-17)
4. The ERA October 2020 water Gross Alpha and Gross Beta results were evaluated as *Not Acceptable*. The reported/acceptable values and ranges are as follows:

	<u>Reported</u>	<u>Known</u>	<u>Range</u>
Gross Alpha	40.0	26.2	13.3 - 34.7
Gross Beta	47.5	69.1	48.0 - 76.0

All QC data was reviewed with no anomalies and a cause for failure could not be determined. This was the first failure for water Gross Beta. A Quick Response follow-up cross-check was analyzed as soon as possible with acceptable results at 96.8% for Gross Alpha and 102% for Gross Beta. (NCR 20-18)
5. The MAPEP August 2020 soil Ni-63 result was evaluated as *Not Acceptable*. The reported value was  $438 \pm 21.1$  Bq/kg and the known result was 980 Bq/kg (acceptance range 686 - 1274). It is believed that some Ni-63 loss occurred during the sample prep step. (NCR 20-20)

The Inter-Laboratory Comparison Program provides evidence of "in control" counting systems and methods, and that the laboratories are producing accurate and reliable data.

**ENVIRONMENTAL DOSIMETRY COMPANY**

**ANNUAL QUALITY ASSURANCE STATUS REPORT**

**January - December 2021**

Prepared By: Jim Smith Date: 3/16/22

Approved By: Michael Stanford Date: 3/16/22

**Environmental Dosimetry Company  
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## EXECUTIVE SUMMARY

Routine quality control (QC) testing was performed for dosimeters issued by the Environmental Dosimetry Company (EDC) .

During this annual period 100% (72/72) of the individual dosimeters, evaluated against the EDC internal performance acceptance criteria (high-energy photons only), met the criterion for accuracy and 100% (72/72) met the criterion for precision (Table 1). In addition, 100% (12/12) of the dosimeter sets evaluated against the internal tolerance limits met EDC acceptance criteria (Table 2) and 100% (6/6) of independent testing passed the performance criteria (Table 3). Trending graphs, which evaluate performance statistic for high-energy photon irradiations and co-located stations are given in Appendix A.

One internal assessment was performed in 2021. There were no findings.



## I. INTRODUCTION

The TLD systems at the Environmental Dosimetry Company (EDC) are calibrated and operated to ensure consistent and accurate evaluation of TLDs. The quality of the dosimetric results reported to EDC clients is ensured by in-house performance testing and independent performance testing by EDC clients, and both internal and client directed program assessments.

The purpose of the dosimetry quality assurance program is to provide performance documentation of the routine processing of EDC dosimeters. Performance testing provides a statistical measure of the bias and precision of dosimetry processing against a reliable standard, which in turn points out any trends or performance changes. Two programs are used:

### A. QC Program

Dosimetry quality control tests are performed on EDC Panasonic 814 Environmental dosimeters. These tests include: (1) the in-house testing program coordinated by the EDC QA Officer and (2) independent test perform by EDC clients. In-house test are performed using six pairs of 814 dosimeters, a pair is reported as an individual result and six pairs are reported as the mean result. Results of these tests are described in this report.

Excluded from this report are instrumentation checks. Although instrumentation checks represent an important aspect of the quality assurance program, they are not included as process checks in this report. Instrumentation checks represent between 5-10% of the TLDs processed.

### B. QA Program

An internal assessment of dosimetry activities is conducted annually by the Quality Assurance Officer (Reference 1). The purpose of the assessment is to review procedures, results, materials or components to identify opportunities to improve or enhance processes and/or services.

## II. PERFORMANCE EVALUATION CRITERIA

### A. Acceptance Criteria for Internal Evaluations

#### 1. Bias

For each dosimeter tested, the measure of bias is the percent deviation of the reported result relative to the delivered exposure. The percent deviation relative to the delivered exposure is calculated as follows:

$$\frac{(H'_i - H_i)}{H_i} 100$$

where:

$H'_i$  = the corresponding reported exposure for the  $i^{\text{th}}$  dosimeter (i.e., the reported exposure)

$H_i$  = the exposure delivered to the  $i^{\text{th}}$  irradiated dosimeter (i.e., the delivered exposure)

## 2. Mean Bias

For each group of test dosimeters, the mean bias is the average percent deviation of the reported result relative to the delivered exposure. The mean percent deviation relative to the delivered exposure is calculated as follows:

$$\sum \left( \frac{(H'_i - H_i)}{H_i} \right) 100 \left( \frac{1}{n} \right)$$

where:

$H'_i$  = the corresponding reported exposure for the  $i^{\text{th}}$  dosimeter (i.e., the reported exposure)

$H_i$  = the exposure delivered to the  $i^{\text{th}}$  irradiated test dosimeter (i.e., the delivered exposure)

$n$  = the number of dosimeters in the test group

## Precision

For a group of test dosimeters irradiated to a given exposure, the measure of precision is the percent deviation of individual results relative to the mean reported exposure. At least two values are required for the determination of precision. The measure of precision for the  $i^{\text{th}}$  dosimeter is:

$$\left( \frac{(H'_i - \bar{H})}{\bar{H}} \right) 100$$

where:

$H'_i$  = the reported exposure for the  $i^{\text{th}}$  dosimeter (i.e., the reported exposure)

$\bar{H}$  = the mean reported exposure; i.e.,  $\bar{H} = \sum H'_i \left( \frac{1}{n} \right)$

$n$  = the number of dosimeters in the test group

## 3. EDC Internal Tolerance Limits

All evaluation criteria are taken from the "EDC Quality System Manual," (Reference 2). These criteria are only applied to individual test dosimeters irradiated with high-energy photons (Cs-137) and are as follows for Panasonic Environmental dosimeters:  $\pm 15\%$  for bias and  $\pm 12.8\%$  for precision.

B. QC Investigation Criteria and Result Reporting

EDC Quality System Manual (Reference 2) specifies when an investigation is required due to a QC analysis that has failed the EDC bias criteria. The criteria are as follows:

1. No investigation is necessary when an individual QC result falls outside the QC performance criteria for accuracy.
2. Investigations are initiated when the mean of a QC processing batch is outside the performance criterion for bias.

C. Reporting of Environmental Dosimetry Results to EDC Customers

1. All results are to be reported in a timely fashion.
4. If the QA Officer determines that an investigation is required for a process, the results shall be issued as normal. If the QC results prompting the investigation have a mean bias from the known of greater than  $\pm 20\%$ , the results shall be issued with a note indicating that they may be updated in the future, pending resolution of a QA issue.
5. Environmental dosimetry results do not require updating if the investigation has shown that the mean bias between the original results and the corrected results, based on applicable correction factors from the investigation, does not exceed  $\pm 20\%$ .

III. DATA SUMMARY FOR ISSUANCE PERIOD JANUARY-DECEMBER 2021

A. General Discussion

Results of performance tests conducted are summarized and discussed in the following sections. Summaries of the performance tests for the reporting period are given in Tables 1 through 3 and Figures 1 through 4.

Table 1 provides a summary of individual dosimeter results evaluated against the EDC internal acceptance criteria for high-energy photons only. During this period 100% (72/72) of the individual dosimeters, evaluated against these criteria, met the tolerance limits for accuracy and 100% (72/72) met the criterion for precision. A graphical interpretation is provided in Figures 1 and 2.

Table 2 provides the bias and standard deviation results for each group (N=6) of dosimeters evaluated against the internal tolerance criteria. Overall, 100% (12/12) of the dosimeter sets, evaluated against the internal tolerance performance criteria, met these criteria. A graphical interpretation is provided in Figure 3.

Table 3 presents the independent blind spike results for dosimeters processed during this annual period. All results passed the performance acceptance criterion. Figure 4 is a graphical interpretation of Seabrook Station blind co-located station results.

B. Result Trending

One of the main benefits of performing quality control tests on a routine basis is to identify trends or performance changes. The results of the Panasonic environmental dosimeter performance tests are presented in Appendix A. The results are evaluated against each of the performance criteria listed in Section II, namely: individual dosimeter accuracy, individual dosimeter precision, and mean bias.

All of the results presented in Appendix A are plotted sequentially by processing date.

IV. STATUS OF EDC CONDITION REPORTS (CR)

No condition reports were issued during this annual period.

V. STATUS OF AUDITS/ASSESSMENTS

1. Internal

EDC Internal Quality Assurance Assessment was conducted during the fourth quarter 2021. There were no findings identified.

2. External

None.

VI. PROCEDURES AND MANUALS REVISED DURING JANUARY - DECEMBER 2021

Several procedures were reissued with no changes as part of the 5 year review cycle.

VII. CONCLUSION AND RECOMMENDATIONS

The quality control evaluations continue to indicate the dosimetry processing programs at the EDC satisfy the criteria specified in the Quality System Manual. The EDC demonstrated the ability to meet all applicable acceptance criteria.

VIII. REFERENCES

1. EDC Quality Control and Audit Assessment Schedule, 2021.
2. EDC Manual 1, Quality System Manual, Rev. 4, September 28, 2020.

TABLE 1

**PERCENTAGE OF INDIVIDUAL DOSIMETERS THAT PASSED EDC INTERNAL CRITERIA  
JANUARY – DECEMBER 2021<sup>(1), (2)</sup>**

Dosimeter Type	Number Tested	% Passed Bias Criteria	% Passed Precision Criteria
Panasonic Environmental	72	100	100

<sup>(1)</sup>This table summarizes results of tests conducted by EDC.

<sup>(2)</sup>Environmental dosimeter results are free in air.

TABLE 2

**MEAN DOSIMETER ANALYSES (N=6)  
JANUARY – DECEMBER 2021<sup>(1), (2)</sup>**

Process Date	Exposure Level	Mean Bias %	Standard Deviation %	Tolerance Limit +/-15%
5/04/2021	33	0.6	0.9	Pass
5/06/2021	120	-0.2	1.4	Pass
5/26/2021	53	-3.8	1.6	Pass
7/27/2021	67	2.8	1.4	Pass
8/04/2021	91	-1.8	2.3	Pass
9/14/2021	47	-0.2	2.3	Pass
11/01/2021	28	3.7	0.6	Pass
11/03/2021	74	1.9	1.9	Pass
11/09/2021	103	1.1	1.1	Pass
01/26/2022	37	2.6	1.9	Pass
01/30/2022	85	-4.2	1.1	Pass
02/06/2022	58	2.9	1.2	Pass

<sup>(1)</sup>This table summarizes results of tests conducted by EDC for TLDs issued in 2021.

<sup>(2)</sup>Environmental dosimeter results are free in air.

**TABLE 3  
SUMMARY OF INDEPENDENT DOSIMETER TESTING  
JANUARY – DECEMBER 2021<sup>(1), (2)</sup>**

Issuance Period	Client	Mean Bias %	Standard Deviation %	Pass / Fail
1 <sup>st</sup> Qtr. 2021	SONGS	-3.8	1.4	Pass
1 <sup>st</sup> Qtr. 2021	SONGS	-4.7	1.1	Pass
2 <sup>nd</sup> Qtr. 2021	Seabrook	3.1	1.0	Pass
3 <sup>rd</sup> Qtr. 2021	Millstone	-4.7	1.4	Pass
4 <sup>th</sup> Qtr. 2021	PSEG(PNNL) 50mR	1.3	0.8	Pass
4 <sup>th</sup> Qtr. 2021	PSEG(PNNL) 100mR	1.8	0.8	Pass
4 <sup>th</sup> Qtr. 2021	PSEG(PNNL) 150mR	-0.6	0.5	Pass
4 <sup>th</sup> Qtr. 2021	PSEG(PNNL) 200mR	-2.6	2.0	Pass
4 <sup>th</sup> Qtr. 2021	Seabrook	2.6	1.4	Pass

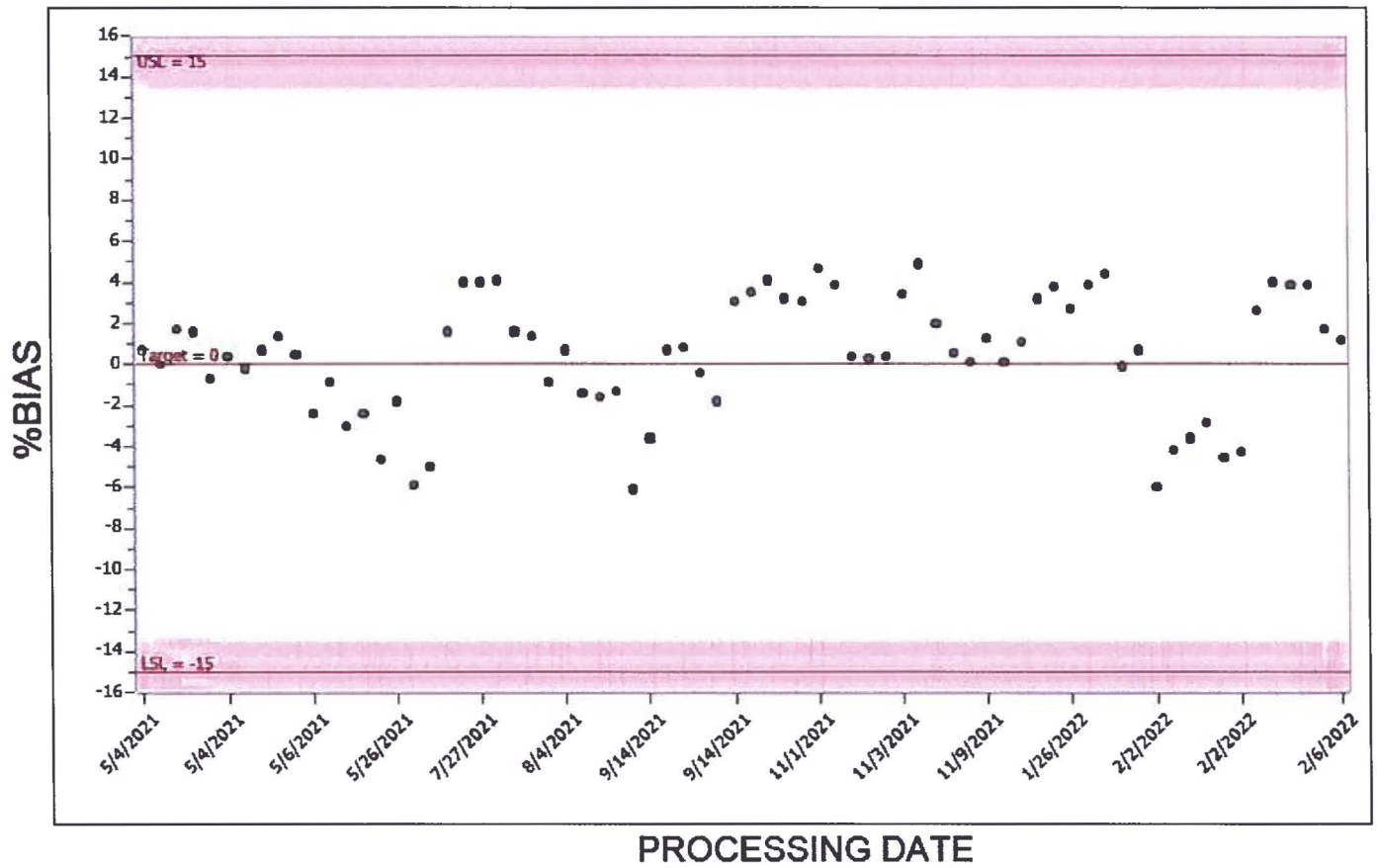
<sup>(1)</sup>Performance criteria are +/- 15%.

<sup>(2)</sup>Blind spike irradiations using Cs-137

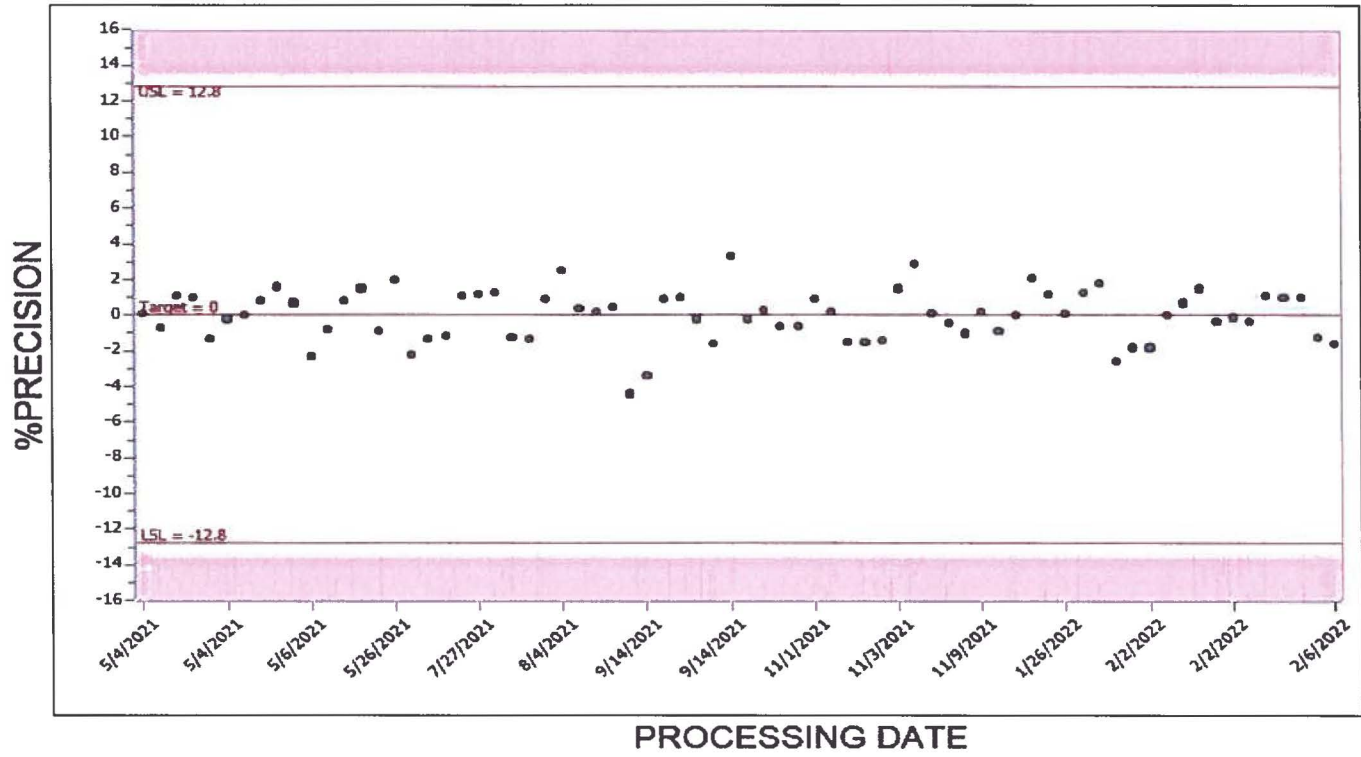
APPENDIX A  
DOSIMETRY QUALITY CONTROL TRENDING GRAPHS  
ISSUE PERIOD JANUARY - DECEMBER 2021



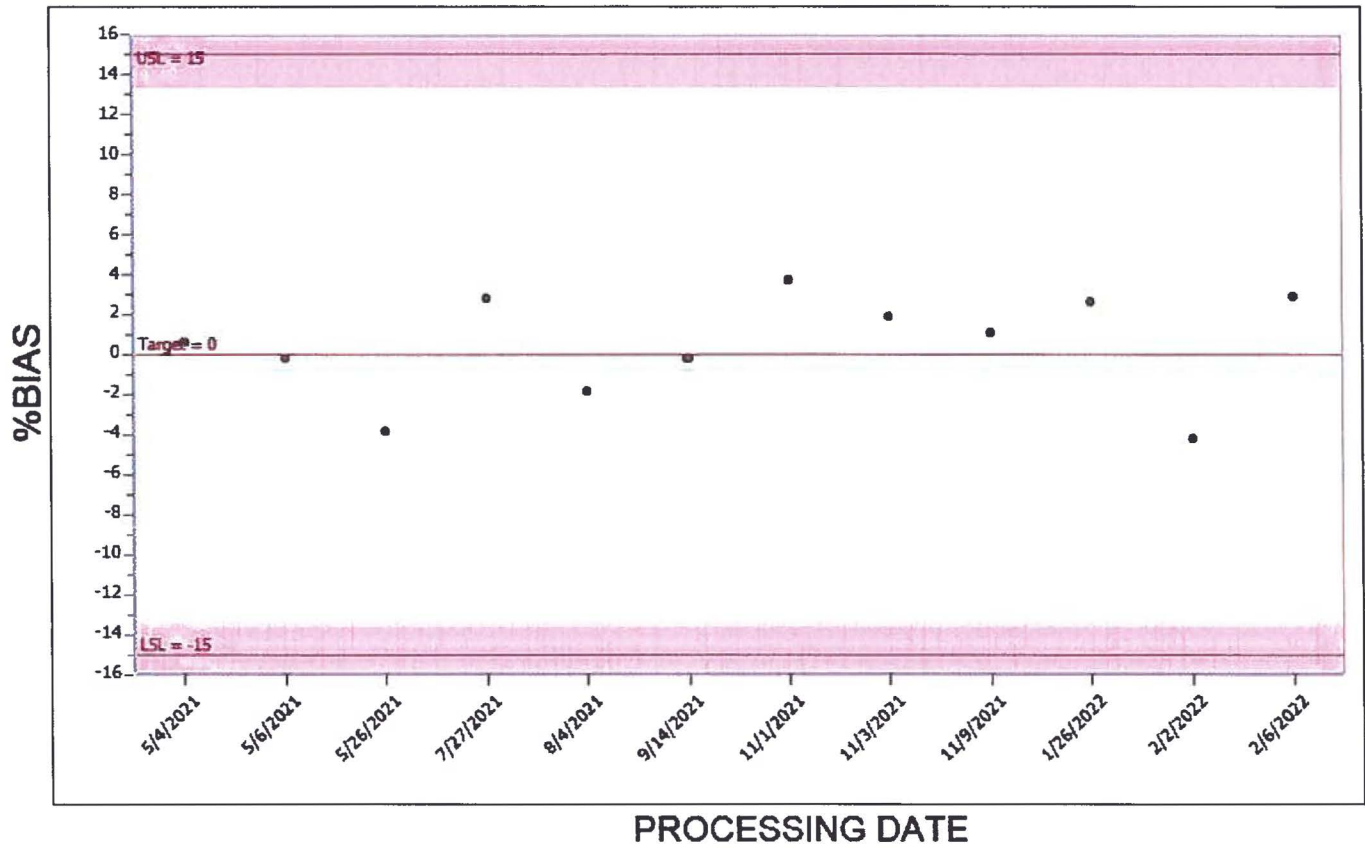
INDIVIDUAL ACCURACY ENVIRONMENTAL  
FIGURE 1



INDIVIDUAL PRECISION ENVIRONMENTAL  
FIGURE 2



MEAN ACCURACY ENVIRONMENTAL  
FIGURE 3



SEABROOK CO-LOCATE ACCURACY  
FIGURE 4

