



Barbara E. Dotson
Manager, Regulatory Assurance
Palisades Nuclear Plant
269-764-2265

PNP 2022-004

Technical Specification 5.6.2

May 12, 2022

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

Subject: 2021 Radiological Environmental Operating Report

Palisades Nuclear Plant
Docket 50-255
Renewed Facility License No. DPR-20

Dear Sir or Madam:

Entergy Nuclear Operations, Inc. is submitting the enclosed Radiological Environmental Operating Report for the Palisades Nuclear Plant. This report was prepared in accordance with the requirements of Technical Specification 5.6.2. The period covered by the enclosed report is January 1, 2021, through December 31, 2021.

If you have any questions regarding this submittal, please contact Bill Turco, Chemistry Manager, at 269-764-2537.

This letter contains no new commitments and no revision to existing commitments.

Respectfully,

A handwritten signature in black ink that reads 'Barbara E. Dotson'.

BED / mrp

Enclosure: Annual Radiological Environmental Operating Report

cc: Administrator, Region III, USNRC
Project Manager, Palisades, USNRC
Resident Inspector, Palisades, USNRC

ENCLOSURE

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT
PNP 2022-004



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Annual Radiological Environmental Operating Report**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 Palisades Radiological Environmental Monitoring Program (REMP) for the period January 1 through December 31, 2021. This report fulfills the requirements of Palisades Technical Specification 5.6.2.

No measurable levels of radiation above baseline levels attributable to Palisades operation were detected in the vicinity of Palisades in 2021. The 2021 REMP thus substantiated the adequacy of source control and effluent monitoring at Palisades with no observed impact of plant operations on the environment.

Palisades established the REMP prior to the station becoming operational to provide data on background radiation and radioactivity normally present in the area. Palisades has continued to monitor the environment by sampling air, water, sediment, broad leaf vegetation, fish, and food products, as well as measuring direct radiation. Palisades also samples milk if milk-producing animals used for human consumption are present within five miles (8 km) of the plant. All analyses have required, nuclide specific, lower limit of detections (LLDs) which must be achieved. The requirements of the REMP are formally described in the offsite dose calculation manual (ODCM), a site specific regulatory document.

The REMP includes sampling indicator and control locations. 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. Palisades personnel compare indicator results with control and preoperational results to assess any impact Palisades operation might have had on the surrounding environment.

In 2021, REMP samples were collected for radiological analysis. The results of indicator locations were compared with control locations and previous studies. All 2021 REMP results support the conclusion that the surrounding environment is not affected by Palisades' effluents. No activity in any REMP sample from 2021 was attributed to Palisades' effluents.

1.2 Reporting Levels

No samples equaled or exceeded reporting levels.

1.3 Sample Deviations

During 2021, environmental sampling was performed for eight media types (airborne, surface water, drinking water, offsite groundwater, sediment, broad leaf vegetation, fish, and food products) and analyzed for direct radiation. All REMP samples were obtained as required by the ODCM in 2021 with the exception of 3 instances of sample deviations which are further discussed in Attachment 1 Table 8.

1.4 Program Modifications

There were no program modifications during the reporting period.

Annual Radiological Environmental Operating Report**2.0 INTRODUCTION****2.1 Radiological Environmental Monitoring Program**

Palisades established the REMP, as defined in the ODCM, to fulfill 10 CFR Part 50 Appendix I Section IV.B.2. The REMP supplements the radiological effluent monitoring program by verifying that the concentrations of radioactive materials and levels of radiation are not higher than expected on the basis of the effluent measurements and the modeling of the environmental exposure pathways.

2.2 Pathways Monitored

The airborne, direct radiation, waterborne and ingestion pathways are monitored as required by Palisades ODCM. These requirements are also listed in this report in Table 1 through Table 4.

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

2.3 Land Use Census

Palisades conducts a land use census annually to identify changes in uses of land within five miles of the site that would require modifications to the REMP and the ODCM. The purpose of this census is to identify critical receptor pathways for the purpose of effluent modeling and REMP sampling.

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
<p><u>RADIOIODINE AND PARTICULATES</u></p> <p>Six samples total. Four samples from within 6 km (3.7 miles) of the site boundary in different sectors. One sample from the vicinity of a community having the highest calculated annual average ground level deposition factor. One control sample in the least prevalent wind direction (considering practical direction and distance).</p>	<ul style="list-style-type: none"> • A8 (0.595 miles NE) - onsite near state park • A19 (0.423 miles SSE) - onsite near Bluestar Hwy • A9 (1.525 miles SSW) - offsite near blue star highway • A4 (3.882 miles SE) - offsite in Covert township • A5 (3.590 miles ESE) - offsite in Covert township • A10 (50.765 miles NE) - offsite near Grand Rapids 	<p>Continuous sampler operation with sample collection every week, or more frequently if required by dust loading.</p>	<p>I-131 analysis weekly for each filter change.</p> <p>Gross beta radioactivity analysis weekly for each filter change.</p> <p>Gamma isotopic analysis quarterly for a composite of all filters collected.</p> <p>IF filter gross beta is greater than 10 times the yearly mean of the control sample THEN gamma isotopic is performed on the filter.</p>

Table 2, Exposure Pathway – Direct Radiation

Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
<p><u>TLDS</u></p> <p>23 routine monitoring stations either with two or more dosimeters or with one instrument for measuring and recording dose rate continuously, placed as follows:</p> <p>One onsite TLD in the vicinity of the plant. An inner ring of stations consisting of one in each overland meteorological sector, one in the general area of the state park camping area in the NE sector, and one in the general area of the site boundary.</p> <p>An outer ring of stations one in each overland meteorological sector within the 12 km range from the site.</p> <p>Three control stations sufficiently far from the plant as to not be affected from the plant.</p>	<ul style="list-style-type: none"> • TLD-1 (0.213 miles E) - onsite inner ring TLD • TLD-8 (0.602 miles NE)- inner ring TLD • TLD-13 (0.530 miles NNE) - inner ring TLD • TLD-14 (0.551 miles NE)- inner ring TLD • TLD-15 (0.834 miles ENE)- inner ring TLD • TLD-16 (0.804 miles E)- inner ring TLD • TLD-17 (0.572 miles ESE) - inner ring TLD • TLD-18 (0.469 miles SE) - inner ring TLD • TLD-19 (0.443 miles SSE)- inner ring TLD • TLD-20 (0.412 miles S)- inner ring TLD • TLD-21 (0.382 miles SSW) - inner ring TLD 	<p>Quarterly</p>	<p>Gamma dose (units of milliRoentgen, abbreviated mR) quarterly</p>

Table 2, Exposure Pathway – Direct Radiation

Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
	<ul style="list-style-type: none"> • TLD-2 (5.560 miles SE) - outer ring TLD • TLD-3 (5.684 miles SSE) - outer ring TLD • TLD-4 (3.668 miles S) - outer ring TLD • TLD-5 - (3.475 miles ESE) - outer ring TLD • TLD-6 - (5.314 miles NE) - outer ring TLD • TLD-7 (4.115 miles NNE) - outer ring TLD • TLD-9 (1.670 miles SSW) - outer ring TLD • TLD-23 (3.189 miles ENE) - outer ring TLD • TLD-24 (6.021 miles E) - outer ring TLD • TLD-10 (50.746 miles NE) - control TLD • TLD-11 (39.472 miles E) - control TLD • TLD-12 (27.971 miles SSE) - control TLD 	Quarterly	Gamma dose (units of milliRoentgen, abbreviated mR) quarterly

Table 3, Exposure Pathway – Waterborne

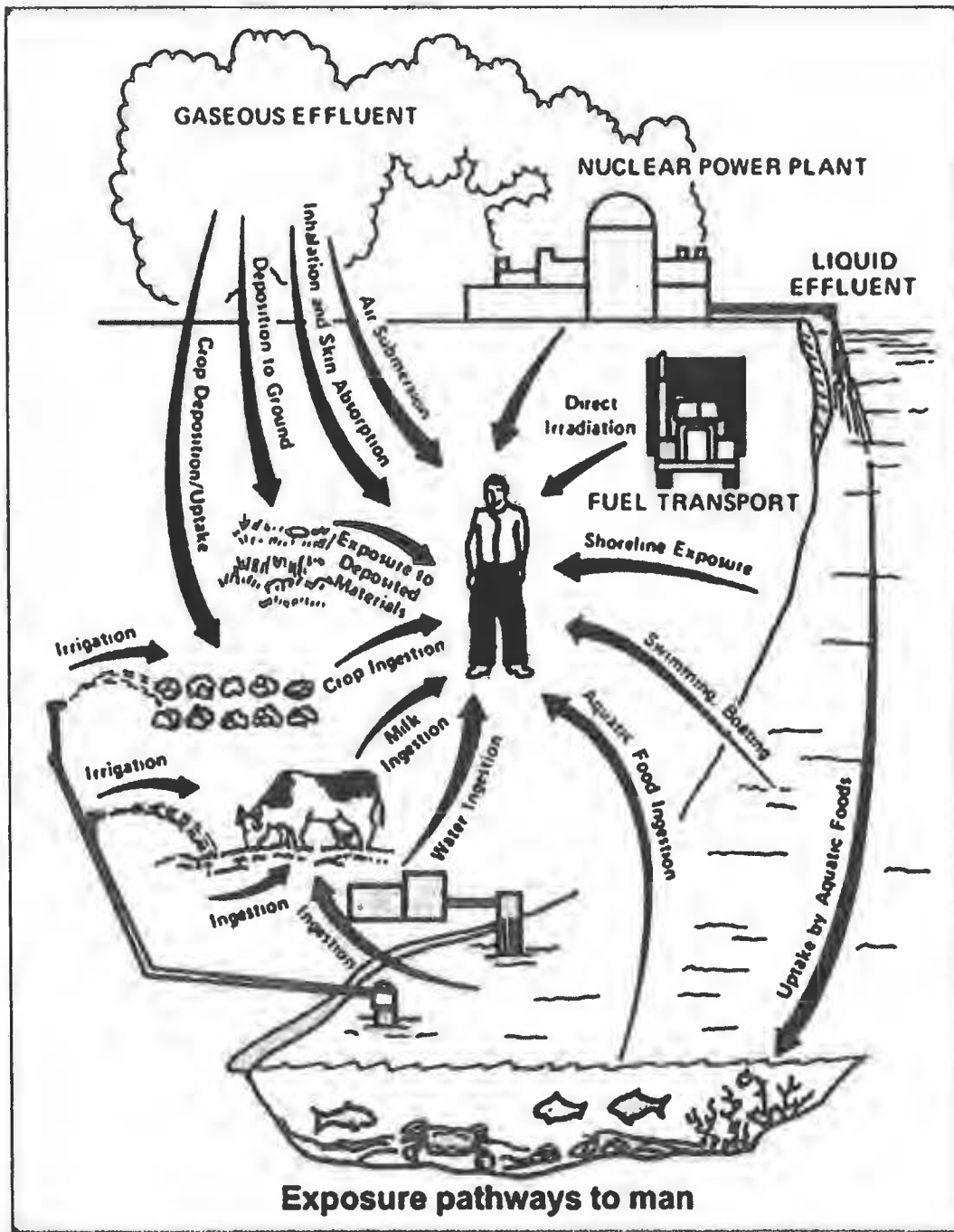
Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
<p><u>SURFACE WATER</u> Lake in (plant intake lake water)</p>	<p>Lake in - Lake Michigan intake water used in plant systems. Sample is collected onsite.</p>	<p>Daily samples are used to make a monthly composite sample.</p>	<p>Gamma isotopic, gross beta (not ODCM required), and tritium analysis monthly</p>
<p><u>DRINKING WATER</u> South Haven drinking water Palisades Park (Pal Park) community drinking water is sampled when in operation (summer months) Domestic water (not ODCM required) is sampled onsite.</p>	<p>City of South Haven drinking water intake structure (5.6 miles NNE of Palisades) Pal Park community drinking water (0.7 miles SSW of Palisades) Domestic water is sampled onsite from any potable water source, typically an eye wash station.</p>	<p>Daily South Haven drinking water samples are used to make a monthly composite sample. 1 grab sample of Palisades Park (Pal Park) community drinking water is sampled monthly when in operation (summer months). Daily samples are used to make a monthly composite.</p>	<p>Gamma isotopic, gross beta, and tritium analysis monthly Gamma isotopic, gross beta (not ODCM required), and tritium analysis monthly when operational Gamma isotopic, gross beta, and tritium analysis monthly</p>
<p><u>Surface Water and Drinking Water Control</u> Lake water from Ludington Pump-house is analyzed as a control sample for drinking and surface water.</p>	<p>Ludington Control - Lake Michigan intake water from Ludington Pump-house (201 km North of Palisades).</p>	<p>Daily samples are used to make a monthly composite sample.</p>	<p>Gamma isotopic, gross beta, and tritium analysis monthly</p>
<p><u>OFFSITE GROUNDWATER</u> Palisades Park (Pal Park) commercial water is sampled when in operation (summer months). This sample is not ODCM required.</p>	<p>0.7 miles S of Palisades</p>	<p>1 grab sample is sampled monthly when in operation (summer months)</p>	<p>Gamma isotopic, gross beta, and tritium analysis monthly</p>
<p><u>SEDIMENT FROM SHORELINE</u> North sediment sample South sediment sample (not ODCM required)</p>	<p>1 sample between the north site boundary and Van Buren State Park beach, approximately 1/2 mile north of the plant discharge. 1 sample from beach near south boundary of site property</p>	<p>Semiannually Semiannually</p>	<p>Gamma isotopic analysis semiannually. Gamma isotopic analysis semiannually.</p>

Table 4, Exposure Pathway – Ingestion

Requirement	Sample Point Description Distance and Direction	Sampling and Collection Frequency	Type and Frequency Of Analyses
<p><u>MILK</u></p> <p>Samples from milking animals in 3 locations between 5-8km distance</p> <p>1 sample from milking animals at a control location.</p>	<p>For 2021 goat milk samples were not available to be sampled from the indicator locations. Therefore no control samples were obtained, and broad leaf vegetation was sampled as described below.</p>	<p>Monthly</p>	<p>Gamma isotopic and I-131 monthly</p>
<p><u>Broad leaf Vegetation</u></p> <p>Samples of three different kinds of broad leaf vegetation grown nearest each of two different offsite locations of highest predicted annual average ground level deposition and one sample of each of the similar broad leaf vegetation grown 15-30 km distance in the least prevalent wind direction IF milk sample is not performed.</p>	<p>0.7 miles SE from Palisades.</p> <p>0.4 miles SSE from Palisades.</p> <p>13.6 miles NNE from Palisades.</p>	<p>Monthly during growing season</p>	<p>Gamma isotopic and I-131 monthly during growing season</p>
<p><u>FISH</u></p> <p>Sample 2 species of commercially and/or recreationally important species in the vicinity of the plant discharge area.</p> <p>1 sample of the same species in areas not influenced by plant discharge.</p>	<p>The indicator sample is obtained from Lake Michigan onsite within a few hundred feet of the main liquid discharge point.</p> <p>The control sample is obtained from Lake Michigan near Ludington MI (201 km North of Palisades).</p>	<p>Semiannually</p>	<p>Gamma isotopic analysis semiannually</p>
<p><u>FOOD PRODUCTS</u></p> <p>1 sample of each of two principal fruit crops (blueberries and apples).</p>	<p>(blueberries) 3.7 to 4.7 miles SE or ESE from Palisades</p> <p>(apples) 3.5 to 3.7 miles E or SE from Palisades</p>	<p>Annually at time of harvest</p>	<p>Gamma isotopic and I-131 annually</p>

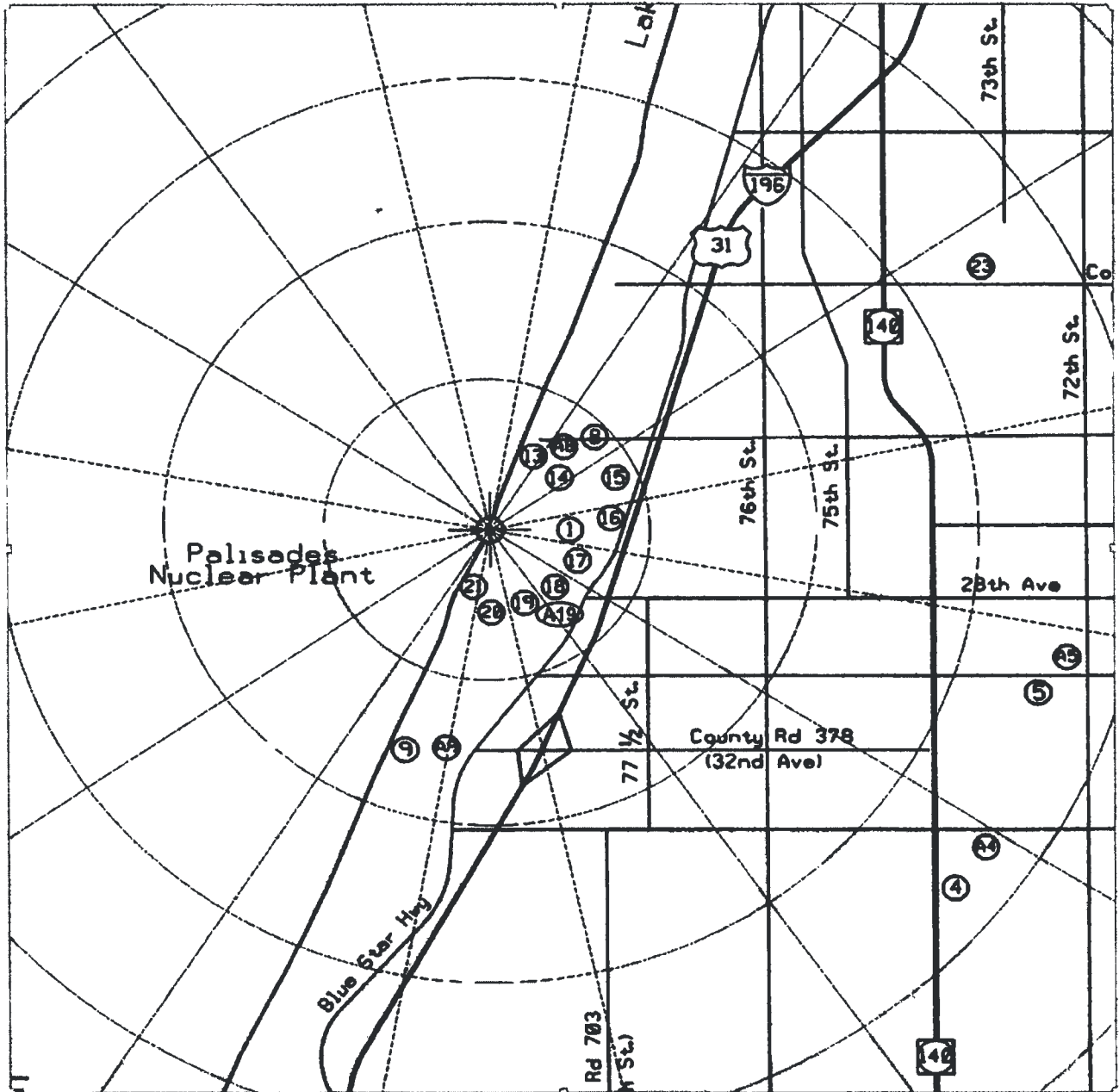
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Figure 1, Exposure Pathway



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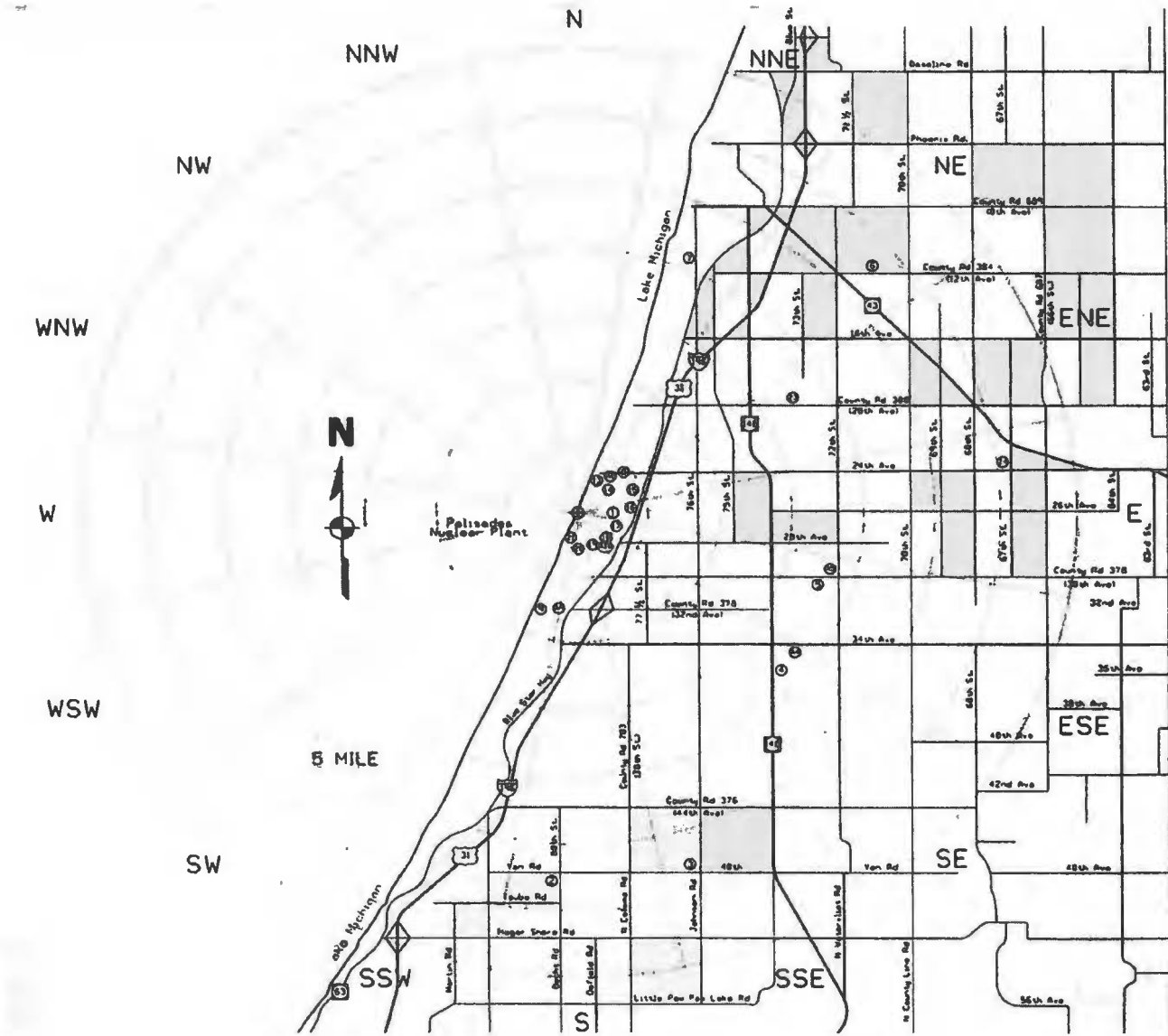
Figure 2, Sample Collection Sites –Near Field



The locations in Figure 2 correspond to the TLD and Air Sampler locations in Table 1 and Table 2.

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Figure 3, Sample Collection Sites - Far Field



The locations in Figure 3 correspond to the TLD and Air Sampler locations in Table 1 and Table 2.

Annual Radiological Environmental Operating Report**4.0 INTERPRETATION AND TRENDS OF RESULTS****4.1 Air Particulate and Radioiodine Sample**

There were 318 air samples collected and analyzed for gross beta and I-131 during 2021. Three of the air samples were not used in the analytical results in this report. This is discussed in Attachment 1 Table 8. Air iodine and particulate samples are collected weekly from six air-sampling locations. Air is metered into the sampling unit through a 47-mm air filter (for particulate) and an air iodine cartridge. The filters are in series with one another and housed within the same filter holder. An "as found" and "as left" leak test is performed at each station during each sample collection. Weekly samples were sent to Teledyne Brown Engineering Environmental Services for analysis.

Analysis of the airborne particulate sample data, between the five near-site indicator locations and the control location, indicate no difference between indicator and control locations. The average concentration of gross beta activity among all indicator locations was $2.69\text{E-}02$ pCi/m³ and was $2.52\text{E-}02$ pCi/m³ for the control location. All I-131 activity results, for both indicator and control locations, were below the minimum detectable activity (MDA). Gamma isotopic analysis is performed quarterly on a quarterly composite of the filter papers. All radionuclides detected (Be-7, K-40,) were naturally occurring radionuclides which are not attributed to plant effluents.

Palisades' pre-operational environmental study showed naturally occurring gross beta radiation between 0.03 and 3.0 pCi/m³ with a similar trend between stations onsite, in the surrounding community, and control stations. The activity results from 2021 indicate there is no measurable change between pre-operational airborne gross beta activity and present day airborne gross beta activity.

There was five REMP deviations in 2021 involving air sampling. Two of the deviations involved the as-found leak test at an air sample station. The other three deviations involved a failed air sample station sampling pump. All REMP air sampling pumps are replaced at least once every 2 years to minimize pump failures. These instances are discussed in more detail in Attachment 1 Table 8.

In the absence of plant-related gamma radionuclides, gross beta activity is attributed to naturally occurring radionuclides. The air sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2021. This conclusion is that the surrounding environment is not affected by Palisades' effluents. No REMP air samples from 2021 contained measurable radiological materials attributed to Palisades' effluents.

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4.2 Thermoluminescent Dosimetry (TLD) Sample Results

Palisades reports measured dose as net exposure (subtracting transit reading) normalized to 92 days. TLDs are oriented in an inner ring, outer ring, and control locations. The inner ring consists of 11 TLDs, the outer ring consists of 9 TLDs, and there are 3 control locations. This orientation allows for monitoring all 9 overland compass sectors surrounding Palisades. To assess the effect of direct and shine radiation from Palisades to the environment the inner ring, outer ring, and control TLDs are compared to one another. Additionally, each individual TLD location is compared to a baseline of data which was created from a comprehensive review of data from 2011 through 2016. The high and low values for the baseline are based upon two standard deviations for each data point from 2011 through 2016. If a value is measured outside the baseline additional follow-up investigation is performed to evaluate the cause. During 2021 all TLDs trended normal and no TLDs were outside the baseline. This evaluation identified no noticeable trend that would indicate that the ambient radiation levels are being affected by plant operations. Table 5 shows the consistent trend of average inner ring, outer ring, and control TLDs.

TLD measurements taken as part of Palisades' pre-operational environmental study used different instrumentation which had difficulty in achieving desired sensitivity and accuracy. A more sensitive type of TLD was implemented in 1971 and the present day TLD device used is the industry standard. TLD data has trended consistently throughout the several most recent independent spent fuel storage installation (ISFSI) loading campaigns which indicates these loading campaigns have had no measurable effect on the environment.

Activity from TLD measurements in the environment is attributed to naturally occurring background radiation and not from Palisades' direct or shine radiation.

Table 5, Direct Radiation Annual Summary

Year	Inner Ring (mR/Qtr)	Outer Ring (mR/Qtr)	Control Location (mR/Qtr)
2014	9.1	10.9	10.7
2015	9.5	11.2	10.9
2016	9.6	11.3	11.2
2017	9.3	11.2	10.9
2018	9.3	11.1	11.0
2019	9.4	11.2	11.0
2020	9.3	11.2	11.1
2021	9.3	11.3	11.1

Annual Radiological Environmental Operating Report**4.3 Waterborne Sample Results**

During 2021 Palisades implemented the REMP in accordance with the ODCM for collection of surface, drinking, and groundwater. For all surface, drinking, and groundwater indicator samples, the same control sample is used as a baseline for comparison. That control sample is referred to as the "Ludington Control" and is collected 201 km north of Palisades. The Ludington Control sample is analyzed monthly and is a composite of daily samples. The Ludington Control sample is analyzed for gamma radionuclide, tritium, and gross beta activity. In 2021 the only radionuclide activity detected in Ludington Control water was naturally occurring isotopes (K-40 and Th-228). Of the twelve Ludington Control samples collected in 2021, five contained detectable gross beta with an average value of 3.08 pCi/L. The gross beta activity is a result of naturally occurring radionuclide and is not attributed to Palisades' effluents.

4.3.1 Surface Water

The indicator surface water samples collected and analyzed for the REMP include "Lake In" water. This sample is Lake Michigan water after it has traveled through the Palisades' intake structure and traveling screens. This sample is collected daily and composited into a monthly sample which is analyzed for gamma radionuclide and tritium onsite. This sample is also analyzed by Teledyne Brown Engineering Environmental Services for gamma, tritium, and gross beta activity. All radionuclide detected (Th-228) were naturally occurring and are not attributed to Palisades' effluents. Five out of the twelve monthly samples contained measurable gross beta with the average detectable gross beta activity at 3.29 pCi/L. The gross beta activity is attributed to naturally occurring radionuclide.

Palisades' pre-operational environmental study established a baseline of gross beta activity for the site before Palisades was operational. The study results for surface water showed consistently measurable results for gross beta activity between 11 - 18 (+/- 5) pCi/L.

The surface water sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2021. This conclusion is that the surrounding environment is not affected by Palisades' effluents. No REMP surface water samples from 2021 contained measurable radiological materials attributed to Palisades' effluents.

4.3.2 Drinking Water

The indicator drinking water samples collected and analyzed for the REMP include "Domestic Water", "South Haven Drinking Water", and "Palisades Park Community Water". All samples are analyzed for gamma, tritium, and gross beta by Teledyne Brown Engineering Environmental Services.

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Domestic Water is collected onsite from a potable water system. This sample is collected daily and composited into a monthly sample which is analyzed for gamma radionuclide and tritium onsite. All radionuclide detected (Ra-226) were naturally occurring and are not attributed to Palisades' effluents. Four out of the twelve monthly samples contained measurable gross beta activity with the average detectable gross beta activity at 2.88 pCi/L. The gross beta activity is attributed to naturally occurring radionuclide. Domestic water is not required by the ODCM for the REMP. This sample is collected as part of the NRC bulletin 80-10 commitments and is included in this report because the data strengthens the REMP.

South Haven Drinking Water is collected from the City of South Haven Water Treatment facility located in South Haven. All radionuclide detected (Th-228 and Ra-226) were naturally occurring and are not attributed to Palisades' effluents. Two out of the twelve monthly samples contained measurable gross beta with the average detectable gross beta activity at 2.51 pCi/L. The gross beta activity is attributed to naturally occurring radionuclide.

Palisades Park Community Water is collected once per month as a grab sample from a community just south of Palisades while the facility is operational (summer months). This sample is analyzed for gamma, tritium, and gross beta activity. No radionuclide were detected from gamma spectroscopy or tritium analysis. One out of the six monthly samples contained measurable gross beta activity with an activity of 3.05 pCi/L. The gross beta activity is attributed to naturally occurring radionuclide. Gross beta activity is not required by the ODCM for this sample but is performed for trending purposes and to strengthen the REMP.

Palisades' pre-operational environmental study established a baseline of gross beta activity for the site before Palisades was operational. The study results relied upon as a baseline for drinking water analysis are the same results as with surface water, that being consistent gross beta activity between 11 - 18 (+/- 5) pCi/L.

The drinking water sample results collected, in accordance with the REMP, support the conclusions of the effluents monitoring program for 2021. This conclusion is that the surrounding environment is not affected by Palisades' effluents. No REMP drinking water samples from 2021 contained measurable radiological materials attributed to Palisades' effluents.

Annual Radiological Environmental Operating Report**4.3.3 Groundwater**

Palisades implements an extensive groundwater monitoring program in accordance with NEI-0707, "Industry Ground Water Protection Initiative - Final Guidance Document". This program is designed to identify onsite leaks to groundwater to allow for prompt repair or isolation of the leak. The results of the onsite groundwater program are described in the Annual Radioactive Effluent Release Report (ARERR). Palisades samples one offsite groundwater location. This sample is not required by Palisades' ODCM but is procedurally implemented to strengthen the program overall. The REMP groundwater sample is the "Palisades Park Commercial Well Water" sample. This sample is collected once per month as a grab sample from a community just south of Palisades while the facility is operational (summer months). This sample is analyzed for gamma, tritium, and gross beta activity by Teledyne Brown Engineering Environmental Services. No radionuclide were detected from gamma spectroscopy or tritium analysis. Four out of the Six monthly samples contained measurable gross beta with the average detectable gross beta activity at 4.93 pCi/L. The gross beta activity is attributed to naturally occurring radionuclide.

Palisades' pre-operational environmental study established a baseline of gross beta activity for the site before Palisades was operational. The study results were that five well water samples from Palisades contained gross beta activity above 5 pCi/L with the highest value being 16 pCi/L. Two samples from Covert Park well water contained gross beta activity at 6 and 7 pCi/L.

The groundwater sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2021. This conclusion is that the surrounding environment is not affected by Palisades' effluents. No REMP groundwater samples from 2021 contained measurable radiological materials attributed to Palisades' effluents.

Annual Radiological Environmental Operating Report**4.4 Sediment Sample Results**

Sediment samples are collected two times per year north and south of the plant from the beach on Lake Michigan. One sample is collected at the southern edge of the property and a second sample is collected approximately 0.5 miles north of the plant. The sample south of the plant is not required by the ODCM but is collected and analyzed to strengthen the REMP. Both the north and south sediment samples are analyzed for gamma radionuclide. In 2021, the only radionuclides detected (K-40, Th-228, Th-232, and Ac-228) were naturally occurring isotopes which are not attributed to Palisades' effluents. In accordance with the ODCM, no control sample is collected for this sample type.

Soil samples were not specifically part of the Palisades' pre-operational environmental study however a study of Cs-137 found in soil (due to global events such as historical atomic testing and fallout) was performed by Palisades in 2011. Analysis was performed of soil in the surrounding area (Southwest Michigan) which showed Cs-137 concentrations between $1.41\text{E-}08$ uCi/g and $5.68\text{E-}07$ uCi/g with an average of $2.68\text{E-}07$ uCi/g. Considering similar studies performed by other utilities, a conservative (low) background of $1.8\text{E-}07$ uCi/g Cs-137 in soil is assumed to be due to global fallout.

The sediment sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2021. This conclusion is that the surrounding environment is not affected by Palisades' effluents. No REMP sediment samples from 2021 contained measurable radiological materials attributed to Palisades' effluents.

4.5 Ingestion Sample Results**4.5.1 Milk Sample Results**

Indicator milk samples were not available to be collected during 2021. In accordance with Palisades ODCM, broadleaf sampling is performed when milk sampling is not performed.

Annual Radiological Environmental Operating Report**4.5.2 Broad leaf Sample Results**

In accordance with Palisades ODCM three different kinds of broad leaf vegetation is sampled from two onsite (indicator) locations and one offsite (control) location due to the fact that milk sampling is not performed. Broad leaf samples are collected once per month during the growing season and analyzed for gamma radionuclides including iodine-131. Naturally occurring radionuclide detected in broad leaf vegetation (Be-7 and K-40) are not attributed to Palisades' effluents. Cs-137 detected in broad leaf vegetation was attributed to historical global atomic testing and biological uptake. Cs-137 was detected at location BV1 (0.4 miles SSE) for four out of the five monthly samples. Cs-137 was detected in BV2 for one out of five monthly samples. The average concentration of Cs-137 among all indicator locations was 59.8 pCi/kg. Cs-137 was detected in none of the samples from location BVC. It is not abnormal to detect Cs-137 in broad leaf samples. Palisades procedurally implements a conservative administrative action value to perform additional reviews if the activity of broad leaf samples exceeds 146 pCi/kg Cs-137. This administrative action value was developed in 2013 based upon Cs-137 trends in broadleaf samples. The absence of other more prominent radionuclides measured in the plant effluent and coolant systems further support that the Cs-137 detected in broadleaf is not a result of Palisades activity.

The pre-operational environmental study consisted in part of Cs-137 and Sr-90 analysis for crops and milk. These (and broadleaf) sample results are a result of historical global atomic testing and biological uptake. The pre-operational study identified Cs-137 in milk samples ranging from 2 to 70 pCi/L and Sr-90 ranging from 5 to 15 pCi/L. For crop samples, gross gamma activity was generally between 0.11 and 0.22 pCi/g and gross beta activity was generally between 0.72 to 3.31 pCi/g.

The broad leaf sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2021. This conclusion is that the surrounding environment is not affected by Palisades' effluents. No REMP broadleaf samples from 2021 contained measurable radiological materials attributed to Palisades' effluents.

4.5.3 Fish Sample Results

Indicator and Control fish samples are collected and analyzed twice per year. The filet of the fish is analyzed for gamma radionuclide. The indicator fish are collected near Palisades lake-out discharge point. At least 2 species of commercial or recreational importance are collected and analyzed. At least one sample of the same species is collected as a control sample. The control fish are collected 201 km north of Palisades near Ludington, MI. In 2021, the only radionuclides detected among all fish samples were naturally occurring radionuclides (K-40) which were not attributed to Palisades' effluents.

Palisades' pre-operational environmental study established a baseline for radiological material in fish. The study established that gross beta activity is generally between 2 and 4 pCi/g and gross gamma activity is generally between 0.04 and 0.4 pCi/g in fish. Cs-137 and Sr-90 were measured in the pre-operational study and were expected to be measured due to known worldwide contamination from historical global atomic testing. Cs-137 detected was generally between 0.10 and 0.25 pCi/g and Sr-90 detected was generally between 0.01 to 0.04 pCi/g in the pre-operational environmental study.

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The fish sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2021. This conclusion is that the surrounding environment is not affected by Palisades' effluents. No REMP fish water samples from 2021 contained measurable radiological materials attributed to Palisades' effluents.

4.5.4 Food Product Sample Results

Two principal fruit crops are collected once per year and analyzed for gamma radionuclides including Iodine-131 in accordance with the REMP. The two crops sampled in 2021 were blueberries and apples. The results of all sample analysis show that only naturally occurring radionuclides (K-40) were present. In accordance with the ODCM, no control sample is collected for this sample type.

Palisades' pre-operational environmental study performed radiological analysis on a variety of crop samples. Gross gamma activity was generally between 0.11 and 0.22 pCi/g and gross beta activity was generally between 0.72 to 3.31 pCi/g.

The fruit sample results collected in accordance with the REMP support the conclusions of the effluents monitoring program for 2021. This conclusion is that the surrounding environment is not affected by Palisades' effluents. No REMP fruit samples from 2021 contained measurable radiological materials attributed to Palisades' effluents.

4.6 Land Use Census Results

The latest land use census (performed in 2021) did not identify any new locations that prompt a change to the REMP or to the atmospheric dispersion or deposition factors used for offsite dose modeling. The sectors in Table 6 include all overland compass sectors.

Table 6, Land Use Census –2021 Nearest Residence Within Five Miles

Sector	Direction	Residence	Garden	Beef Cattle	Dairy Cow	Goat
2	NNE	1.67	2.52	> 5	> 5	> 5
3	NE	1.14	2.76	> 5	> 5	> 5
4	ENE	1.19	2.11	2.29	> 5	>5
5	E	1.62	2.46	3.51	> 5	3.46
6	ESE	1.35	1.66	2.04	> 5	2.04
7	SE	0.87	2.20	3.88	> 5	3.88
8	SSE	0.80	0.70	> 5	> 5	> 5
9	S	0.51	3.51	> 5	> 5	> 5
10	SSW	0.48	>5	> 5	> 5	> 5

Annual Radiological Environmental Operating Report**4.7 Interlaboratory Comparison Results**

Attachment 3 contains result summary for Interlaboratory Comparison program for Teledyne Brown Engineering.

5.0 RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SUMMARY

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

Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses	LLD ^[Note 1]	Indicator Locations Mean (F) ^[Note 2] [Range]	Location ^[Note 3] [Highest Annual Mean]	Mean (F) ^[Note 2] [Range]	Control Locations Mean (F) ^[Note 2] [Range]	Number of Non-Routine Results ^[Note 4]
Air (pCi/m ³)	GB / 315	0.01	2.69E-02 (262/262) [1.19E-02 - 4.82E-02]	Station 8SP (0.595 miles NE)	3.25E-02 (53/53) [1.46E-02 - 4.82E-02]	2.52E-02 (53/53) [1.22E-02 - 4.01E-02]	0
	I-131 / 315	0.07	<MDA (0/259)	N/A	N/A	<MDA (0/52)	0
	Cs-134 / 24	0.05	<MDA (0/20)	N/A	N/A	<MDA (0/4)	0
	Cs-137 / 24	0.06	<MDA (0/20)	N/A	N/A	<MDA (0/4)	0
Inner Ring TLDs (mR/Qtr)	Gamma / 56	Sensitivity of 3 mR	9.28 (44/44) [7.26 - 11.22]	Station 1 (onsite 0.213 miles E)	10.68 (4/4) [10.44 - 11.22]	11.14 (12/12) [9.84 - 12.80]	0 0
Outer Ring TLDs (mR/Qtr)	Gamma / 48	Sensitivity of 3 mR	11.26 (36/36) [9.20 - 15.54]	Station 2 (5.560 miles S)	14.12 (4/4) [13.14 - 15.54]	11.14 (12/12) [9.84 - 12.80]	0

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Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses	LLD [Note 1]	Indicator Locations Mean (F) ^[Note 2] [Range]	Location [Note 3] [Highest Annual Mean]	Mean (F) ^[Note 2] [Range]	Control Locations Mean (F) ^[Note 2] [Range]	Number of Non-Routine Results [Note 4]
Surface Water (pCi/L)	Gross Beta / 24	4.0	3.29 (5 / 12) [2.52 - 5.20]	Lake In (Plant lake intake)	3.29 (5 / 12) [2.52 - 5.20]	2.29 (4 / 12) [2.05 - 2.68]	0
	H-3 / 24	2000	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Mn-54 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Fe-59 / 24	30	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Co-58 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Co-60 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Zn-65 / 24	30	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Zr-95 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Nb-95 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Cs-134 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Cs-137 / 24	18	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
	Ba-140 / 24	60	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0
La-140 / 24	15	<MDA (0 / 12)	N/A	N/A	<MDA (0 / 12)	0	

Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses	LLD ^[Note 1]	Indicator Locations Mean (F) ^[Note 2] [Range]	Location ^[Note 3] [Highest Annual Mean]	Mean (F) ^[Note 2] [Range]	Control Locations Mean (F) ^[Note 2] [Range]	Number of Non-Routine Results ^[Note 4]
Drinking Water (pCi/L)	Gross Beta / 42	4	2.80 (7 / 30) [2.40 - 3.42]	Pal Park Community(0.7 miles SSW)	3.05 (1 / 6) [3.05 - 3.05]	2.29 (4 / 12) [2.05 - 2.68]	0
	H-3 / 42	2000	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Mn-54 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Fe-59 / 42	30	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Co-58 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Co-60 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Zn-65 / 42	30	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Zr-95 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Nb-95 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Cs-134 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Cs-137 / 42	18	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	Ba-140 / 42	60	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
	La-140 / 42	15	<MDA (0 / 30)	N/A	N/A	<MDA (0 / 12)	0
Fish (pCi/kg)	Mn-54 / 10	130	<MDA (0 / 6)	N/A	N/A	<MDA (0 / 4)	0
	Fe-59 / 10	260	<MDA (0 / 6)	N/A	N/A	<MDA (0 / 4)	0
	Co-58 / 10	130	<MDA (0 / 6)	N/A	N/A	<MDA (0 / 4)	0
	Co-60 / 10	130	<MDA (0 / 6)	N/A	N/A	<MDA (0 / 4)	0
	Zn-65 / 10	260	<MDA (0 / 6)	N/A	N/A	<MDA (0 / 4)	0
	Cs-134 / 10	130	<MDA (0 / 6)	N/A	N/A	<MDA (0 / 4)	0
	Cs-137 / 10	150	<MDA (0 / 6)	N/A	N/A	<MDA (0 / 4)	0

Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses	LLD ^[Note 1]	Indicator Locations Mean (F) ^[Note 2] [Range]	Location ^[Note 3] [Highest Annual Mean]	Mean (F) ^[Note 2] [Range]	Control Locations Mean (F) ^[Note 2] [Range]	Number of Non-Routine Results ^[Note 4]
Food Products (pCi/kg)	I-131 / 2	60	<MDA (0 / 2)	N/A	N/A	Control sample not required	0
	Cs-134 / 2	60	<MDA (0 / 2)	N/A	N/A		0
	Cs-137 / 2	80	<MDA (0 / 2)	N/A	N/A		0
Broad leaf Vegetation (pCi/kg)	I-131 / 15	60	<MDA (0 / 10)	N/A	N/A	<MDA (0 / 5)	0
	Cs-134 / 15	60	<MDA (0 / 10)	N/A	N/A	<MDA (0 / 5)	0
	Cs-137 / 15	80	59.8 (5 / 10) [35.9 - 81.6]	BV2 (onsite 0.7 miles SE)	76.4 (1 / 5) [76.4 - 76.4]	<MDA (0 / 5) [N/A]	0
Sediment (pCi/kg)	Cs-134 / 4	150	<MDA (0 / 4)	N/A	N/A	Control sample not required	0
	Cs-137 / 4	180	<MDA (0 / 4)	N/A	N/A		0

Table 7, Radiological Environmental Monitoring Program Summary

Sample Type (Units)	Type / Number of Analyses	LLD [Note 1]	Indicator Locations Mean (F) ^[Note 2] [Range]	Location ^[Note 3] [Highest Annual Mean]	Mean (F) ^[Note 2] [Range]	Control Locations Mean (F) ^[Note 2] [Range]	Number of Non-Routine Results ^[Note 4]
Offsite Groundwater (Pal Park Commercial Well) (pCi/L)	Gross Beta / 18	4	4.93 (4 / 6) [3.94 - 6.25]	Pal Park Commercial Well (0.7 miles S)	4.93 (4 / 6) [3.94 - 6.25]	2.29 (4 / 12) [2.05 - 2.68]	0
	H-3 / 18	2000	<MDA (0 / 6)	N/A	N/A	N/A	0
	Mn-54 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Fe-59 / 18	30	<MDA (0 / 6)	N/A	N/A	N/A	0
	Co-58 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Co-60 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Zn-65 / 18	30	<MDA (0 / 6)	N/A	N/A	N/A	0
	Zr-95 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Nb-95 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Cs-134 / 18	15	<MDA (0 / 6)	N/A	N/A	N/A	0
	Cs-137 / 18	18	<MDA (0 / 6)	N/A	N/A	N/A	0
	Ba-140 / 18	60	<MDA (0 / 6)	N/A	N/A	N/A	0
La-140 / 18	15	<MDA (0 / 6)	<MDA (0 / 6)	N/A	N/A	N/A	0

[Note 1] – LLD = Required lower limit of detection

[Note 2] – Mean and range based upon detectable measurements only. Fraction of detectable measurements at specified locations is indicated in parenthesis (F).

[Note 3] – Locations are specified (1) by name and (2) compass sector relative to reactor site.

[Note 4] – A reportable occurrence is a situation in which an NRC report was submitted in accordance with the requirements in Palisades ODCM.

Sample Deviations

Table 8, Sample Deviations Table

Comment No.	Sample Media Affected	Sample Location	Date	Problem	Evaluation / Actions
1	Air Sample	A9	01/18/21	As-found leak test did not pass	During normal weekly sample collection (on 01/18/21) the as-found leak test did not pass. An as-found and as-left leak test is performed to ensure all sample volume is being pulled through the filter media. The sample results (2.85E-02 pCi/m ³) trended normal for the station. It is unknown how much of the sample volume by-passed the filter media and therefore the sample results were not included in this report.
2	Air Sample	A9	02/02/21	As-found leak test did not pass	During normal weekly sample collection (on 02/02/21) the as-found leak test did not pass. An as-found and as-left leak test is performed to ensure all sample volume is being pulled through the filter media. The sample results (1.59E-02 pCi/m ³) trended lower but still within the minimum to maximum annual range for the station. It is unknown how much of the sample volume by-passed the filter media and therefore the sample results were not included in this report. A suspected degraded fitting was replaced on the inlet tubing to the sample pump and this has corrected the issue.
3	Air Sample	A19	01/18/21	Sample Pump Failure	During normal weekly sample collection (on 01/18/21) the GFCI outlet the sampling pump is plugged into was found tripped off. The outlet was reset and the pump did not turn back on. The pump was replaced the same day the condition was discovered, and flow was restored to the monitoring station. The sample volume was very low for the filter paper and iodine cartridge collected indicating that the pump was not running for approximately 6.5 of the previous 7 days. Therefore, the results of the filter paper and iodine cartridge analysis were not included in this report.

Sample Deviations

Table 8, Sample Deviations Table

Comment No.	Sample Media Affected	Sample Location	Date	Problem	Evaluation / Actions
4	Air Sample	A8	02/08/21	Sample Pump Failure	During normal weekly sample collection (on 02/08/21) the GFCI outlet the sampling pump is plugged into was found tripped off. The outlet was reset and the pump did not turn back on. The pump was replaced the same day the condition was discovered, and flow was restored to the monitoring station. The sample volume was about 75% of what is typically observed for this location indicating the sample pump was not running for approximately 2 days. These sample results were included in this report because all analysis requirements were met.
5	Air Sample	A4	06/14/21	Sample Pump Failure	During normal weekly sample collection (on 06/14/21) the sampling pump was found seized. The pump was replaced the same day the condition was discovered, and flow was restored to the monitoring station. The sample volume was about 60% of what is typically observed for this location indicating the sample pump was not running for approximately 3 days. These sample results were included in this report because all analysis requirements were met.

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Monitoring Results Tables

Table 9, Air Gross Beta Data Summary Table

Analysis: Gross Beta				Units: pCi/m ³			
Start Date	End Date	Station A4 (Indicator)	Station A5 (Indicator)	Station A8 ^[Note 1] (Indicator)	Station A9 (Indicator)	Station A19 (Indicator)	Station A10 ^[Note 2] (Control)
REQUIRED LLD →		1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
12/28/20	1/5/21	2.09E-02	2.48E-02	2.68E-02	1.91E-02	2.71E-02	2.44E-02
1/5/21	1/11/21	3.33E-02	2.55E-02	3.18E-02	2.63E-02	3.02E-02	3.20E-02
1/11/21	1/18/21	3.49E-02	3.47E-02	3.13E-02	2.85E-02 [Note 3]	1.41E-01 [Note 3]	2.94E-02
1/18/21	1/25/21	1.84E-02	1.56E-02	1.93E-02	1.62E-02	1.50E-02	1.61E-02
1/25/21	2/2/21	1.70E-02	2.10E-02	1.96E-02	1.59E-02 [Note 3]	1.71E-02	1.62E-02
2/2/21	2/8/21	2.53E-02	2.62E-02	2.87E-02 [Note 3]	2.77E-02	2.42E-02	1.88E-02
2/8/21	2/15/21	2.21E-02	2.20E-02	3.17E-02	2.82E-02	2.31E-02	2.23E-02
2/15/21	2/22/21	3.17E-02	3.24E-02	4.48E-02	3.00E-02	2.65E-02	3.86E-02
2/22/21	3/1/21	2.41E-02	2.25E-02	2.99E-02	1.91E-02	2.12E-02	1.56E-02
3/1/21	3/8/21	2.10E-02	2.25E-02	2.38E-02	1.69E-02	2.17E-02	2.15E-02
3/8/21	3/15/21	1.82E-02	2.63E-02	3.27E-02	2.06E-02	2.09E-02	2.70E-02
3/15/21	3/22/21	2.72E-02	2.72E-02	3.87E-02	2.30E-02	2.82E-02	1.83E-02
3/29/21	4/5/21	3.07E-02	2.84E-02	4.14E-02	3.08E-02	2.98E-02	2.48E-02
3/22/21	3/29/21	1.81E-02	2.08E-02	2.69E-02	2.07E-02	1.99E-02	2.77E-02
4/5/21	4/12/21	1.73E-02	2.25E-02	1.98E-02	1.73E-02	1.72E-02	2.74E-02
4/12/21	4/19/21	1.83E-02	1.53E-02	2.12E-02	1.35E-02	1.73E-02	1.70E-02
4/19/21	4/26/21	2.60E-02	2.78E-02	3.11E-02	2.60E-02	2.03E-02	2.75E-02
4/26/21	5/3/21	2.24E-02	2.28E-02	3.38E-02	2.48E-02	1.95E-02	2.58E-02
5/3/21	5/11/21	1.19E-02	1.64E-02	1.46E-02	1.50E-02	1.26E-02	1.22E-02
5/11/21	5/17/21	2.25E-02	2.16E-02	2.23E-02	2.13E-02	1.95E-02	1.94E-02
5/17/21	5/24/21	2.57E-02	3.04E-02	3.28E-02	2.07E-02	2.56E-02	3.09E-02
5/24/21	6/1/21	2.12E-02	2.09E-02	2.86E-02	2.19E-02	2.05E-02	1.87E-02
6/1/21	6/8/21	2.58E-02	3.24E-02	3.75E-02	2.83E-02	2.89E-02	3.35E-02
6/8/21	6/14/21	2.55E-02 ^[Note 3]	2.59E-02	3.47E-02	2.53E-02	2.49E-02	2.02E-02
6/14/21	6/21/21	1.77E-02	2.52E-02	2.94E-02	2.14E-02	2.21E-02	1.91E-02

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Table 9, Air Gross Beta Data Summary Table

Analysis: Gross Beta				Units: pCi/m ³			
Start Date	End Date	Station A4 (Indicator)	Station A5 (Indicator)	Station A8 ^[Note 1] (Indicator)	Station A9 (Indicator)	Station A19 (Indicator)	Station A10 ^[Note 2] (Control)
6/21/21	6/28/21	1.93E-02	1.62E-02	2.33E-02	1.49E-02	1.61E-02	1.68E-02
6/28/21	7/6/21	2.29E-02	2.80E-02	2.94E-02	2.14E-02	2.13E-02	2.12E-02
7/6/21	7/12/21	2.24E-02	1.99E-02	2.71E-02	1.99E-02	2.00E-02	2.52E-02
7/12/21	7/19/21	2.67E-02	2.79E-02	3.05E-02	2.26E-02	2.38E-02	2.26E-02
7/19/21	7/26/21	2.88E-02	3.18E-02	3.79E-02	2.74E-02	2.88E-02	2.88E-02
7/26/21	8/2/21	2.39E-02	2.40E-02	3.05E-02	2.35E-02	2.59E-02	1.85E-02
8/2/21	8/9/21	2.94E-02	3.29E-02	3.84E-02	2.76E-02	2.80E-02	2.63E-02
8/9/21	8/17/21	1.66E-02	1.74E-02	2.27E-02	1.50E-02	1.65E-02	2.28E-02
8/17/21	8/23/21	3.39E-02	3.49E-02	4.58E-02	3.37E-02	3.64E-02	3.54E-02
8/23/21	8/30/21	3.02E-02	3.37E-02	3.80E-02	2.56E-02	2.56E-02	3.46E-02
8/30/21	9/7/21	2.65E-02	2.93E-02	3.59E-02	2.51E-02	3.06E-02	2.43E-02
9/7/21	9/13/21	2.95E-02	3.85E-02	4.46E-02	3.28E-02	3.11E-02	3.71E-02
9/13/21	9/20/21	3.08E-02	3.02E-02	4.53E-02	3.02E-02	3.20E-02	2.62E-02
9/20/21	9/27/21	2.32E-02	2.67E-02	2.98E-02	2.11E-02	2.28E-02	2.23E-02
9/27/21	10/4/21	3.39E-02	3.36E-02	4.63E-02	3.92E-02	3.45E-02	3.03E-02
10/4/21	10/11/21	2.95E-02	3.46E-02	4.34E-02	3.01E-02	2.93E-02	3.17E-02
10/11/21	10/18/21	2.86E-02	2.78E-02	3.94E-02	2.75E-02	2.76E-02	2.90E-02
10/18/21	10/25/21	2.49E-02	2.83E-02	3.12E-02	2.89E-02	2.93E-02	2.49E-02
10/25/21	11/2/21	1.60E-02	2.00E-02	2.37E-02	1.95E-02	2.05E-02	1.97E-02
11/2/21	11/8/21	2.99E-02	3.69E-02	4.68E-02	3.57E-02	2.90E-02	2.72E-02
11/8/21	11/16/21	2.68E-02	2.83E-02	3.75E-02	2.58E-02	2.76E-02	2.34E-02
11/16/21	11/22/21	2.73E-02	2.90E-02	3.40E-02	2.54E-02	2.37E-02	2.93E-02
11/22/21	11/29/21	2.04E-02	2.38E-02	3.28E-02	2.28E-02	1.99E-02	1.92E-02
11/29/21	12/6/21	1.87E-02	2.43E-02	2.58E-02	2.35E-02	2.15E-02	2.52E-02
12/6/21	12/13/21	2.99E-02	3.15E-02	3.65E-02	3.08E-02	3.21E-02	2.42E-02
12/13/21	12/21/21	2.97E-02	3.01E-02	2.52E-02	2.84E-02	2.37E-02	3.17E-02
12/21/21	12/27/21	4.06E-02	4.82E-02	4.82E-02	4.80E-02	4.03E-02	4.01E-02

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Table 10, Air Radioiodine Data Table Summary

Analysis: I-131				Units: pCi/m ³			
Start Date	End Date	Station A4 (Indicator)	Station A5 (Indicator)	Station A8 (Indicator)	Station A9 (Indicator)	Station A19 (Indicator)	Station A10 ^[Note 1] (Control)
11/16/21	11/22/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
11/22/21	11/29/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
11/29/21	12/6/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
12/6/21	12/13/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
12/13/21	12/21/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
12/21/21	12/27/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
12/27/21	1/4/22	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA

[Note 1] – The sample date range is accurate to plus or minus 2 days for station A10

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

Table 11, Air Sample Gamma Isotopic

Analysis: Gamma Isotopic			Units: pCi/m ³			
Location	Start Date	End Date	Cs-134	Cs-137	Be-7 ^[Note 1]	K-40 ^[Note 1]
REQUIRED LLD →			0.05	0.06	NA	NA
Station A4	12/28/2021	3/29/2021	<MDA	<MDA	1.54E-01	<MDA
Station A4	3/29/2021	6/28/2021	<MDA	<MDA	1.17E-01	<MDA
Station A4	6/28/2021	9/27/2021	<MDA	<MDA	1.65E-01	<MDA
Station A4	9/27/2021	1/4/2022	<MDA	<MDA	1.05E-01	<MDA
Station A5	12/28/2021	3/29/2021	<MDA	<MDA	1.29E-01	<MDA
Station A5	3/29/2021	6/28/2021	<MDA	<MDA	1.69E-01	<MDA
Station A5	6/28/2021	9/27/2021	<MDA	<MDA	1.14E-01	<MDA
Station A5	9/27/2021	1/4/2022	<MDA	<MDA	1.17E-01	<MDA
Station A8	12/28/2021	3/29/2021	<MDA	<MDA	1.61E-01	<MDA
Station A8	3/29/2021	6/28/2021	<MDA	<MDA	1.92E-01	<MDA
Station A8	6/28/2021	9/27/2021	<MDA	<MDA	1.95E-01	<MDA
Station A8	9/27/2021	1/4/2022	<MDA	<MDA	1.40E-01	<MDA
Station A9	12/28/2021	3/29/2021	<MDA	<MDA	1.02E-01	<MDA
Station A9	3/29/2021	6/28/2021	<MDA	<MDA	1.53E-01	2.21E-02
Station A9	6/28/2021	9/27/2021	<MDA	<MDA	1.17E-01	<MDA
Station A9	9/27/2021	1/4/2022	<MDA	<MDA	1.20E-01	<MDA
Station A19	12/28/2021	3/29/2021	<MDA	<MDA	1.18E-01	<MDA
Station A19	3/29/2021	6/28/2021	<MDA	<MDA	1.70E-01	<MDA
Station A19	6/28/2021	9/27/2021	<MDA	<MDA	1.16E-01	<MDA
Station A19	9/27/2021	1/4/2022	<MDA	<MDA	1.01E-01	<MDA

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Station A10	12/28/2021	3/29/2021	<MDA	<MDA	1.44E-01	<MDA
Station A10	3/29/2021	6/28/2021	<MDA	<MDA	1.82E-01	<MDA
Station A10	6/28/2021	9/27/2021	<MDA	<MDA	1.45E-01	<MDA
Station A10	9/27/2021	1/4/2022	<MDA	<MDA	1.07E-01	<MDA

[Note 1] - This nuclide is naturally occurring and there is no ODCM required LLD.

Table 12, Thermoluminescent Dosimeters – Inner Ring

Analysis: Gamma Dose			Units: mR		
Station	1 st Qtr 2020	2 nd Qtr 2020	3 rd Qtr 2020	4 th Qtr 2020	Annual Mean
1 ^[Note 1]	10.44	10.51	11.22	10.56	10.68
8	9.44	9.72	10.9	9.82	9.97
13	9.81	9.06	10.16	9.21	9.56
14	8.21	7.26	9	7.86	8.08
15	8.86	8.14	10.15	8.49	8.91
16	8.96	8.19	10.14	8.51	8.95
17	8.74	8.1	9.27	8.03	8.54
18	9.13	9.17	10.8	9.2	9.58
19	8.84	8.72	10.14	8.89	9.15
20	8.74	8.78	10.33	8.83	9.17
21	9.08	9.35	10.1	9.38	9.48

[Note 1] – Station with highest annual mean.

Table 13, Thermoluminescent Dosimeters – Outer Ring

Analysis: Gamma Dose			Units: mR		
Station	1 st Qtr 2020	2 nd Qtr 2020	3 rd Qtr 2020	4 th Qtr 2020	Annual Mean
2 ^[Note 1]	13.14	14.14	15.54	13.66	14.12
3	10.75	10.81	11.9	10.65	11.03
4	11.43	12.26	12.99	11.81	12.12

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Table 15, Surface Water – Gamma Isotopic

Analysis: Gamma Isotopic							Units: pCi/L								
Location	Start Date	End Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95 and Zr-95	Cs-134	Cs-137	Ba-140	La-140	K-40	Th-228	Ra-226
Ludington Control	11/01/21	12/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
Ludington Control	12/01/21	01/01/22	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA

[Note 1] - This nuclide is naturally occurring and there is no ODCM required LLD.

Table 16, Surface Water – Tritium and Gross Beta

Analysis: Tritium and Gross Beta			Units: pCi/L	
Location	Start Date	End Date	Tritium	Gross Beta
REQUIRED LLD →			2000	4.00
Lake In	01/01/21	02/01/21	<MDA	<MDA
Lake In	02/01/21	03/01/21	<MDA	<MDA
Lake In	03/01/21	04/01/21	<MDA	<MDA
Lake In	04/01/21	05/01/21	<MDA	2.87
Lake In	05/01/21	06/01/21	<MDA	<MDA
Lake In	06/01/21	07/01/21	<MDA	<MDA
Lake In	07/01/21	08/01/21	<MDA	3.21
Lake In	08/01/21	09/01/21	<MDA	2.63
Lake In	09/01/21	10/01/21	<MDA	2.52
Lake In	10/01/21	11/01/21	<MDA	2.68
Lake In	11/01/21	12/01/21	<MDA	<MDA
Lake In	12/01/21	01/01/22	<MDA	<MDA
Ludington Control	01/01/21	02/01/21	<MDA	2.05

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Table 17, Drinking Water –Gamma Isotopic

Analysis: Gamma Isotopic							Units: pCi/L								
Location	Start Date	End Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Nb-95	Zr-95	Cs-134	Cs-137	Ba-140	La-140	Th-228	RA-226
REQUIRED LLD →			15	15	30	15	30	15	15	15	18	60	15	[Note 1]	[Note 1]
South Haven	02/01/21	03/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	03/01/21	04/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	04/01/21	05/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	05/01/21	06/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	06/01/21	07/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	07/01/21	08/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	08/01/21	09/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	09/01/21	10/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	10/01/21	11/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA
South Haven	11/01/21	12/01/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3.15	<MDA
South Haven	12/01/21	01/01/22	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	74.0

[Note 1] - This nuclide is naturally occurring and there is no ODCM required LLD.

Table 18, Drinking Water – Tritium and Gross Beta

Analysis: Tritium and Gross Beta			Units: pCi/L	
Location	Start Date	End Date	Tritium	Gross Beta
REQUIRED LLD →			2000	4.00
Domestic Water	01/01/21	02/01/21	<MDA	2.63

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Table 18, Drinking Water – Tritium and Gross Beta

Analysis: Tritium and Gross Beta		Units: pCi/L		
Location	Start Date	End Date	Tritium	Gross Beta
Domestic Water	02/01/21	03/01/21	<MDA	2.91
Domestic Water	03/01/21	04/01/21	<MDA	<MDA
Domestic Water	04/01/21	05/01/21	<MDA	<MDA
Domestic Water	05/01/21	06/01/21	<MDA	<MDA
Domestic Water	06/01/21	07/01/21	<MDA	<MDA
Domestic Water	07/01/21	08/01/21	<MDA	<MDA
Domestic Water	08/01/21	09/01/21	<MDA	<MDA
Domestic Water	09/01/21	10/01/21	<MDA	2.55
Domestic Water	10/01/21	11/01/21	<MDA	3.42
Domestic Water	11/01/21	12/01/21	<MDA	<MDA
Domestic Water	12/01/21	01/01/22	<MDA	<MDA
Pal Park Community	05/17/21	NA ^[Note 1]	<MDA	3.05
Pal Park Community	06/14/21	NA ^[Note 1]	<MDA	<MDA
Pal Park Community	07/15/21	NA ^[Note 1]	<MDA	<MDA
Pal Park Community	08/17/21	NA ^[Note 1]	<MDA	<MDA
Pal Park Community	09/20/21	NA ^[Note 1]	<MDA	<MDA
Pal Park Community	10/04/21	NA ^[Note 1]	<MDA	<MDA
South Haven	01/01/21	02/01/21	<MDA	<MDA
South Haven	02/01/21	03/01/21	<MDA	<MDA
South Haven	03/01/21	04/01/21	<MDA	<MDA
South Haven	04/01/21	05/01/21	<MDA	<MDA
South Haven	05/01/21	06/01/21	<MDA	<MDA

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Table 20, Fish									
Analysis: Gamma Isotopic				Units: pCi/kg					
Location / species	Collection Date	Mn-54	Co-58	Fe-59	Co-60	Zn-65	Cs-134	Cs-137	K-40
Ludington / Shad	8/15/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2873
Ludington / Trout	5/5/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3397
Ludington / Walleye	5/30/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3593
Palisades / Carp	5/18/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2665
Palisades / Drum	5/27/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2792
Palisades / Shad	7/7/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2282
Palisades / Walleye	5/27/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	4090
Palisades / White Bass	5/27/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	3214
Palisades / White perch	7/7/21	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	<MDA	2936

[Note 1] – This nuclide is naturally occurring and there is no ODCM required LLD.

Table 21, Food Products					
Analysis: I-131, Gamma Isotopic		Units: pCi/kg			
Sample / Location	Collection Date	I-131	Cs-134	Cs-137	K-40
REQUIRED LLD →		60	60	80	[Note 1]
Blueberries / Covert MI	07/06/21	<MDA	<MDA	<MDA	966
Apples / Covert MI	09/28/21	<MDA	<MDA	<MDA	1629

[Note 1] – This nuclide is naturally occurring and there is no ODCM required LLD.

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Table 23, Offsite Groundwater – Tritium and Gross Beta			
Analysis: Tritium and Gross Beta		Units: pCi/L	
Location	Collection Date	Tritium	Gross Beta
REQUIRED LLD →		2000	4.00
Pal Park Commercial Well	05/17/21	<MDA	5.29
Pal Park Commercial Well	06/14/21	<MDA	4.24
Pal Park Commercial Well	07/15/21	<MDA	<MDA
Pal Park Commercial Well	08/17/21	<MDA	3.94
Pal Park Commercial Well	09/20/21	<MDA	6.25
Pal Park Commercial Well	10/04/21	<MDA	<MDA

Table 24, Broad Leaf Vegetation						
Analysis: I-131, Gamma Isotopic		Units: pCi/kg				
Location	Collection Date	I-131	Cs-134	Cs-137	K-40	Be-7
REQUIRED LLD →		60	60	80	[Note 1]	[Note 1]
Location BV1, 0.4 miles SSE	05/14/21	<MDA	<MDA	40.3	3053	1115
Location BV1, 0.4 miles SSE	06/14/21	<MDA	<MDA	35.9	2265	603
Location BV1, 0.4 miles SSE	07/15/21	<MDA	<MDA	<MDA	2881	2760
Location BV1, 0.4 miles SSE	08/17/21	<MDA	<MDA	64.5	1679	5438
Location BV1, 0.4 miles SSE	09/20/21	<MDA	<MDA	81.6	1814	3152
Location BV2, 0.7 miles SSE	05/14/21	<MDA	<MDA	<MDA	3850	1278

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Table 24, Broad Leaf Vegetation						
Analysis: I-131, Gamma Isotopic		Units: pCi/kg				
Location	Collection Date	I-131	Cs-134	Cs-137	K-40	Be-7
Location BV2, 0.7 miles SSE	06/15/21	<MDA	<MDA	76.4	3720	422
Location BV2, 0.7 miles SSE	07/15/21	<MDA	<MDA	<MDA	4332	1953
Location BV2, 0.7 miles SSE	08/17/21	<MDA	<MDA	<MDA	3833	5529
Location BV2, 0.7 miles SSE	09/20/21	<MDA	<MDA	<MDA	3421	2680
Location BVC, 13.6 miles SSE	05/14/21	<MDA	<MDA	<MDA	4208	592
Location BVC, 13.6 miles SSE	06/14/21	<MDA	<MDA	<MDA	3941	274
Location BVC, 13.6 miles SSE	07/15/21	<MDA	<MDA	<MDA	5225	1784
Location BVC, 13.6 miles SSE	08/17/21	<MDA	<MDA	<MDA	4237	1558
Location BVC, 13.6 miles SSE	09/20/21	<MDA	<MDA	<MDA	2847	1285

[Note 1] – This nuclide is naturally occurring and there is no ODCM required LLD.

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Interlaboratory Comparison Program Results

1.0 Summary

Teledyne Brown Engineering (TBE) laboratory participates in three overlapping interlaboratory cross check programs, those being, Analytics Environmental Cross Check Program, Department of Energy (DOE) Mixed Analyte Performance Evaluation Program (MAPEP), and Environmental Resource Associates (ERA). Each program has its own grading criteria for pass or fail. All failures are tracked by TBE with a non-conformance report to determine the cause of the failure. The interlaboratory program is one indicator that the REMP results are accurate.

A total of 27 nuclides associated with six media types (air filter, charcoal, milk, soil, vegetation, and water) were analyzed. From all cross-check analyses in 2021 seven non-conformance reports (NCR's) were initiated.

NCR 21-01 – MRAD water Fe-55 result of 579 pCi/L was not within the acceptance criteria of 162 - 400 pCi/L. The likely cause for the high result was sample loss in the plating process. Coaching was provided to lab and count-room technicians to more closely inspect plates for possible sample loss.

NCR 21-02 – MAPEP air particulate gross alpha result of 0.371 Bq/sample was not within the acceptance criteria of 0.53 to 3.01 Bq/sample. After investigation it was determined that the sample filter was sent to the lab upside down in the container. The sample is marked to indicate which side is spiked upon receipt and when the sample was reanalyzed facing the other direction the result passed testing. This is not likely to affect a real sample since real samples are dark on the side collecting the sample.

NCR 21-03 – MAPEP soil Ni-63 result of 310 Bq/kg was not within acceptance criteria of 482 - 896 Bq/kg. The cause could be due to interferences not completely removed in the separation process. The procedure for soils was re-evaluated against other national standards and re-written to better remove known interferences in samples and to ensure that there is limited loss of Ni during the process.

NCR 21-10 – ERA gross beta in water result of 63.0 pCi/L was outside the acceptance criteria of 38.1 - 62.6 pCi/L. Considering other QA acceptance criteria and the 2 sigma uncertainty of the analysis no corrective actions for this result were pursued other than repeating the analysis with a new unknown cross-check.

NCR 21-11 – ERA tritium in water result of 13,800 pCi/L was outside acceptance criteria of 15,000 - 18,900 pCi/L. This was the first "not acceptable" for tritium on record. Although ERA deemed the result as "not acceptable" the result falls within Teledyne Browns passing QC standard. Considering other QA acceptance criteria and the 2 sigma uncertainty of the analysis no corrective actions for this result were pursued other than repeating the analysis with a new unknown cross-check.

NCR 21-13 – MAPEP Ni-63 result in soil result of 546 Bq/kg was outside the acceptance criteria range of 896 - 1664 Bq/kg. It is believed interferences in the cross-check sample are affecting the results, so a procedure change was made to matrix spike all client samples of this type.

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Interlaboratory Comparison Program Results

NCR 21-14 – ERA gross beta in water result of 47.6 pCi/L was outside the range of 26.4 - 47.3 pCi/L. Considering other QA acceptance criteria and the 2 sigma uncertainty of the analysis no corrective actions for this result were pursued other than repeating the analysis using a different detector which yielded results within the ERA acceptance criteria.

Thermoluminescent dosimeters (TLDs) are analyzed by an offsite vendor, "Environmental Dosimetry Company" (EDC). The TLDs used are Panasonic 814 Environmental dosimeters. EDC implements an internal quality assurance program and audits the program annually. Some of EDC's vendors also perform independent testing on the TLDs accuracy and precision. During 2021 100% (72/72) of the individual dosimeters met the criterion for accuracy and precision (plus or minus 12.8%). Also, 100% (12/12) of the dosimeter sets evaluated met EDC acceptance criteria for mean bias and precision and 100% (6/6) of independent testing passed the performance criteria. One internal assessment was performed in 2021. There were no findings identified.