Tennessee Valley Authority, Sequoyah Nuclear Plant, P.O. Box 2000, Soddy Daisy, Tennessee 37384

May 5, 2020

10 CFR 50.4

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

Sequoyah Nuclear Plant, Units 1 and 2
Renewed Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327, 50-328, 72-034

Subject: **Annual Radiological Environmental Operating Report**

Enclosed is the Annual Radiological Environmental Operating Report for the period of January 1 to December 31, 2019. This report is being submitted as required by the respective Sequoyah Nuclear Plant (SQN), Units 1 and 2, Technical Specification 5.6.1 and SQN's Offsite Dose Calculation Manual Administrative Control Section 5.1, each of which specifies that the report be submitted prior to May 15th of each year.

There are no regulatory commitments contained in this letter. If you have any questions concerning this matter, please contact Mr. Jeffrey Sowa, SQN Licensing Manager, at (423) 843-8129.

Respectfully,

Matthew Rasmussen
Site Vice President
Sequoyah Nuclear Plant

Enclosure:
Annual Radiological Environmental Operating Report, Sequoyah Nuclear Plant, 2019

cc (Enclosure):

NRC Regional Administrator – Region II
NRC Resident Inspector – Sequoyah Nuclear Plant

ENCLOSURE

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT
SEQUOYAH NUCLEAR PLANT
2019

2019 Annual Radiological Environmental Operating Report

Tennessee Valley Authority Sequoyah Nuclear Plant

May 2020

Prepared under contract by
Chesapeake Nuclear Services, Inc. and GEL Laboratories, LLC

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EXECUTIVE SUMMARY

This report describes the Radiological Environmental Monitoring Program (REMP) conducted by the Tennessee Valley Authority (TVA) near the Sequoyah Nuclear Plant (SQN) during the 2019 monitoring period. The program is conducted in accordance with regulatory requirements to monitor the environment per 10 CFR 20, 10 CFR 50, applicable NUREGs (U.S. NRC, 1991) and TVA procedures (TVA, 2018). The REMP includes the collection and subsequent determination of radioactive material content in environmental samples. Various types of samples are collected within the vicinity of the plant, including air, water, food crops, soil, fish, and shoreline sediment; and direct radiation levels are measured. The radiation levels of these samples are measured and compared with results from control stations, which are located outside the plant's near vicinity, and with environmental data collected at Sequoyah Nuclear Plant prior to operations (preoperational data). This report contains an evaluation of the results from this monitoring program and resulting potential impact of SQN operations on the environment and the general public.

All environmental samples in support of the REMP were collected by TVA and/or contractor personnel. All environmental media were analyzed by GEL Laboratories, LLC except for environmental dosimeters, which were analyzed by Landauer. The evaluation of all results and the generation of this report were performed by Chesapeake Nuclear Services, Inc. and GEL Laboratories.

The radioactivity measured in environmental samples in the SQN program can mostly be attributed to naturally occurring radioactive materials. There is no indication that SQN activities increased the background direct radiation levels normally observed in the areas surrounding the plant, as measured by environmental dosimeters. In 2019, trace quantities of cesium-137 (Cs-137) were measured in most soil samples from both indicator and control locations. The concentrations were typical of the levels expected to be present in the environment from past nuclear weapons testing. The fallout from accidents at the Chernobyl plant in the Ukraine in 1986 and the Fukushima plant in Japan in 2011 may have also contributed to the low levels of Cs-137 and Sr-90 measured in environmental samples. There was no identified increase in Cs-137 and Sr-90 levels attributed to Sequoyah.

Tritium (H-3) was detected in 2 of 21 total surface water samples, but only from control locations. The measured tritium levels were very low and a small fraction (less than 0.1%) of the EPA drinking water limit. For public drinking water, low levels of gross beta were identified in 4 indicator samples out of 55 total samples. Some control location ground water well samples were positive for gross beta, which can be attributed to natural radioactivity. Only naturally occurring radioactivity was identified in milk, fish and food products samples.

In summary, the measured levels of radioactivity in the environmental samples were typical of background levels; there was no detectable increase in exposure to members of the public attributable to the operations of the Sequoyah Nuclear Plant.

INTRODUCTION

This report describes and summarizes the results of radioactivity measurements made in the vicinity of SQN and laboratory analyses of samples collected in the area. The measurements are made to comply with the requirements of 10 CFR 50, Appendix A, Criterion 64 and 10 CFR 50, Appendix I, Section IV.B.2, IV.B.3 and IV.C to determine potential effects on public health and safety. This report satisfies the annual reporting requirements of SQN Technical Specification 5.6.1 and Offsite Dose Calculation Manual (ODCM) Administrative Control 5.1. In addition to reporting the data prescribed by specific requirements, other information is included to correlate the significance of results measured by this monitoring program to the levels of environmental radiation resulting from naturally occurring radioactive materials.

Naturally Occurring and Background Radioactivity

Most materials in our world today contain trace amounts of naturally occurring, primordial radioactivity. Potassium-40 (K-40), with a half-life of 1.3 billion years, is a common radioactive element found naturally in our environment. Approximately 0.01 percent of all potassium is radioactive potassium-40. Other examples of naturally occurring radioactivity are beryllium-7 (Be-7), bismuth-212 and 214 (Bi-212 and Bi-214), lead-210 and 214 (Pb-210 and Pb-214), thallium-208 (Tl-208), actinium-228 (Ac-228), uranium-235 and uranium-238 (U-235 and U-238), thorium-234 (Th-234), radium-226 (Ra-226), radon-220 and radon-222 (Rn-220 and Rn-222), carbon-14 (C-14), and hydrogen-3 (H-3, commonly called tritium). These naturally occurring radioactive elements are in the soil, our food, our drinking water, and our bodies. Radiation emitted from these materials make up part of low-level natural background radiation exposures. Radiation emitted from cosmic rays is the remainder.

It is possible to get an idea of the relative hazard of different types of radiation sources by evaluating the amount of radiation the U.S. population receives from each general type of radiation source. The information in Table 1 is primarily adapted from the U.S. Nuclear Regulatory Commission (U.S. NRC, February 1996) and National Council on Radiation Protection (NCRP, March 2009).

Table 1 - U.S. General Population Average Dose Equivalent Estimates

Source	millirem (mrem)[i] per year per person
Natural Background Dose Equivalent	
Cosmic	33
Terrestrial	21
In the body	29
Radon	228
Total	311
Medical (effective dose equivalent)	300
Nuclear energy	0.28
Consumer Products	13
TOTAL	624.28

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[i] One-thousandth of a Roentgen Equivalent Man (rem). By comparison, the NRC's annual radiation dose limit for the public from any licensed activity, such as a nuclear plant, is 100 mrem.

As can be seen from the data presented above, natural background radiation dose equivalent to the U.S. population exceeds that normally received from nuclear plants by several thousand times. This illustrates that routine nuclear plant operations result in population radiation doses that are insignificant compared to the dose from natural background radiation. As Table 1 shows, the use of radiation and radioactive materials for medical uses results in an effective dose equivalent on average to the U.S. population that is essentially the same as that caused by natural background cosmic and terrestrial radiation.

Electric Power Production

Nuclear power plants are similar in many respects to conventional coal burning (or other fossil fuel) electrical generating plants. The basic process behind electrical power production in power plants is that fuel is used to heat water to produce steam, which provides the force to turn turbines and generators. In a nuclear power plant, the fuel is uranium and the heat is produced in the reactor through the fission of the uranium. Nuclear plants include many complex systems to control the nuclear fission process and to safeguard against the possibility of reactor malfunction. The nuclear reactions produce radionuclide byproducts, commonly referred to as fission and activation products. Very small amounts of these fission and activation products are released into the plant systems. This radioactive material can be transported throughout plant systems and some of it may be released to the environment in an authorized and controlled manner.

Paths through which radioactivity from a nuclear power plant is routinely released are monitored. Liquid and gaseous effluent monitors record the radiation levels for each release. These monitors also provide alarm mechanisms to prompt termination of any abnormal releases before limits are exceeded.

Releases are monitored at the onsite points of release. The radiological environmental monitoring program, which measures the environmental radiation in areas around the plant, provides a confirmation that releases are being properly controlled and monitored in the plant and that any resulting levels in the environment are within the established regulatory limits and a small fraction of the natural background radiation levels. In this way, the release of radioactive materials from the plant is tightly controlled, and verification is provided that the public is not exposed to significant levels of radiation or radioactive materials as the result of plant operations.

The SQN ODCM, which describes the program required by the plant technical specifications, prescribes limits for the release of radioactive effluents, as well as limits for doses to the general public from the release of these effluents.

The NRC's annual dose limit to a member of the public for all licensees is 100 mrem. The NRC's regulations for nuclear power plants require implementing a philosophy of "as low as reasonably achievable," where the dose to a member of the public from radioactive materials released from nuclear power plants to unrestricted areas is further limited on a per unit operating basis to the following:

Liquid Effluents	
Total body	≤ 3 mrem/yr
Any organ	≤ 10 mrem/yr
Gaseous Effluents	
Noble gases:	
Total body	≤ 5 mrem/yr
Gamma air	≤ 10 mrad/yr
Beta air	≤ 20 mrad/yr
Particulates:	
Any organ	≤ 15 mrem/yr

In addition to NRC's regulations, the EPA standard for the total dose to the public in the vicinity of a nuclear power plant, established in the Environmental Dose Standard of 40 CFR 190, is as follows:

Total body	≤ 25 mrem/yr
Thyroid	≤ 75 mrem/yr
Any other organ	≤ 25 mrem/yr

Table E-1 of this report presents a comparison of the nominal lower limits of detection (LLD) for the SQN monitoring program with the regulatory limits for maximum annual average concentration released to unrestricted areas. The table also includes the concentrations of radioactive materials in the environment that would require a special report to the NRC. It should be noted that the levels of radioactive materials in the environmental samples are typically not detected, being below the required detection level, with only naturally occurring radionuclides having measurable levels.

SITE AND PLANT DESCRIPTION

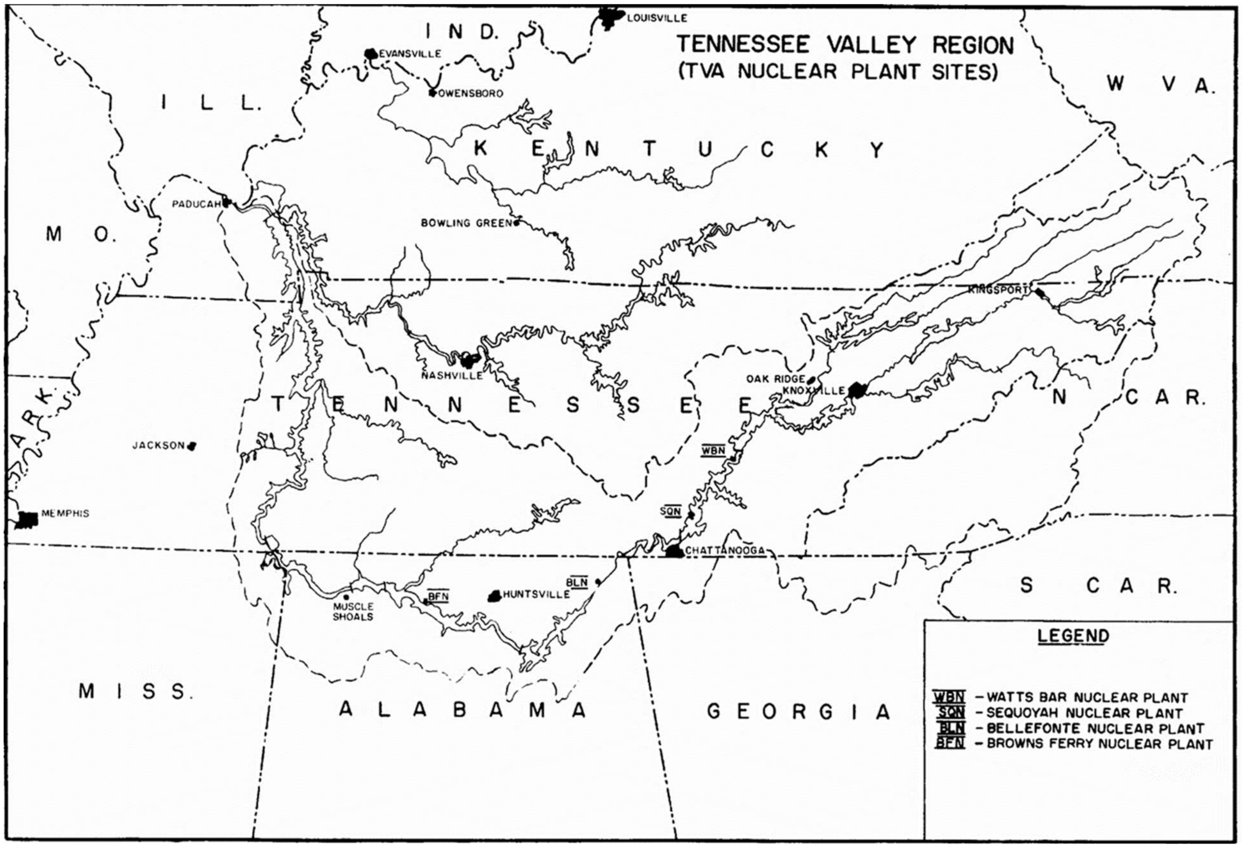
Sequoyah is located on a site near the geographical center of Hamilton County, Tennessee, on a peninsula on the western shore of Chickamauga Lake at Tennessee River Mile (TRM) 484.5. Figure 1 shows the site in relation to other TVA projects. The SQN site, containing approximately 525 acres, is approximately 7.5 miles northeast of the nearest city limit of Chattanooga, Tennessee, 14 miles west-northwest of Cleveland, Tennessee, and approximately 31 miles south-southwest of TVA's Watts Bar Nuclear Plant (WBN) site.

Population is distributed unevenly within 10 miles of the SQN site. Approximately 60 percent of the population is in the general area between 5 and 10 miles from the plant in the sectors ranging from the south, clockwise, to the northwest sector. This concentration is a reflection of suburban Chattanooga and the town of Soddy-Daisy. This area is characterized by considerable open land with scattered residential subdivisions. Residential subdivision growth has continued within the 10-mile radius of the plant. There is also some small-scale farming located within 5 miles of the plant.

Chickamauga Reservoir is one of a series of highly controlled multiple-use reservoirs located on the Tennessee River whose primary uses are flood control, navigation, and the generation of electric power. Secondary uses include industrial and public water supply, commercial fishing, and recreation. Public access areas, boat docks, and residential subdivisions have been developed along the reservoir shoreline.

SQN consists of two pressurized water reactors. Fuel was loaded in Unit 1 on March 1, 1980, and the unit achieved criticality on July 5, 1980. Fuel was loaded in Unit 2 in July 1981, and the unit achieved initial criticality on November 5, 1981.

Figure 1 – Tennessee Valley Region



RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

By design, the radiation and radioactive materials generated in a nuclear reactor are contained within the reactor and plant support systems. There are planned routine releases from these plant systems, but plant effluent radiation monitors are designed to monitor these releases to the environment. Environmental monitoring is a final verification that the systems are performing as designed and planned. The monitoring program is designed to monitor the pathways between the plant and the people in the immediate vicinity of the plant. Sample types are chosen so that the potential for detection of radioactivity in the environment will be maximized. The Radiological Environmental Monitoring Program (REMP) and sampling locations for SQN are outlined in Appendix A.

There are two primary pathways by which radioactivity can move through the environment to humans: air and water (reference Figure 2). The air pathway can be separated into two components: the direct (airborne) pathway and the indirect (ground or terrestrial) pathway. The direct airborne pathway consists of direct radiation and inhalation by humans. In the terrestrial pathway, radioactive materials may be deposited on the ground, with direct exposure to individuals, and/or uptake by plants and the subsequently ingested by animals and/or humans. Human exposure through the liquid pathway may result from drinking water, eating fish, or by direct exposure at the shoreline. The types of samples collected in this program are designed to monitor these pathways.

Many factors were considered in determining the locations for collecting environmental samples. The locations for the atmospheric monitoring stations were determined from a critical pathway analysis based on weather patterns, dose projections, population distribution, and land use. Terrestrial sampling stations were selected after reviewing the local land uses, including the locations of dairy animals and gardens in conjunction with the air pathway analysis. Liquid pathway stations were selected based on dose projections, water use information, and availability of media such as fish and sediment. Table A-2 lists the sampling stations and the types of samples collected. Modifications made to the SQN monitoring program in 2019 are reported in Appendix B. Deviations to the sampling program during 2019 are included in Appendix C.

To determine the amount of radioactivity in the environment prior to the operation of SQN, a preoperational radiological environmental monitoring program was initiated in 1971 and operated until the plant began operation in 1980. Measurements of the same types of radioactive materials that are measured currently were assessed during the preoperational phase to establish normal background levels for various radionuclides in the environment.

The preoperational monitoring program is a very important part of the overall program. During the 1950s, 1960s, and 1970s, atmospheric nuclear weapons testing released radioactive material to the environment causing increases in background radiation levels. Knowledge of preexisting radionuclide patterns in the environment permits a determination, through comparison and trending analyses, of any increase attributable to SQN operation.

The determination of environmental impact during the operating phase also examines changes in the background that may be attributable to sources other than SQN. This potential contribution is determined with control stations that have been established in the environment outside any likely influence from the plant. Results of environmental samples taken at control stations (far from the plant) are compared with those from indicator stations (near the plant) to aid in the determination of any contribution from SQN operation.

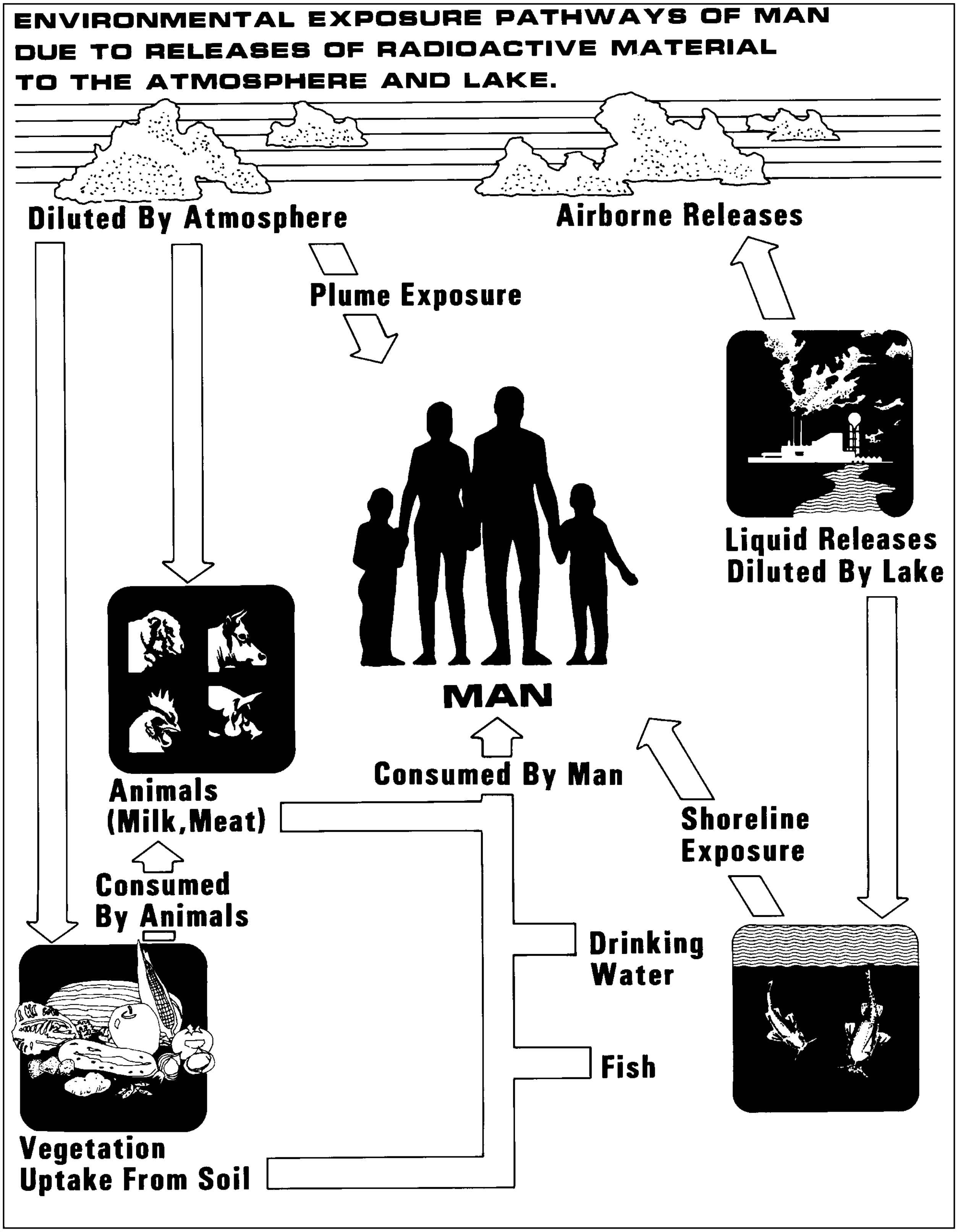
In 2019 the sample analyses were performed by the contracted laboratory, GEL Laboratories, LLC, based in Charleston, SC. Analyses were conducted in accordance with written and approved procedures and are based on industry established standard analytical methods. A summary of the analysis techniques and methodology is presented in Appendix D.

As shown in Table E-1, the analytical methods used to determine the radionuclide content of samples collected in the environment are very sensitive and capable of detecting small amounts of radioactivity. The sensitivity of the measurement process is defined in terms of the lower limit of detection (LLD). A description of the nominal LLDs for the Radioanalytical Laboratory is presented in Appendix E.

The laboratory applies a comprehensive quality assurance/quality control program to monitor laboratory performance throughout the year. One of the key purposes of the QA/QC program is to provide early identification of any problems in the measurement process so they can be corrected in a timely manner. This program includes instrument checks, to ensure that the radiation measurement instruments are working properly, and the analysis of quality control samples. As part of an interlaboratory comparison program, the laboratory participates in a blind sample program administrated by Eckert & Ziegler Analytics. A complete description of the quality control program is presented in Appendix F.

An annual land use census is conducted for the purpose of identifying changes in the land uses around the plant and potential for changes in exposure pathways and locations. Appendix G contains the results of the annual land use census. Data tables summarizing the sample analysis results are presented in Appendix H. Finally, Appendix I contains any errata from previous AREORs.

Figure 2 – Environmental Exposure Pathways



DIRECT RADIATION MONITORING

Direct radiation levels are measured at various monitoring points around the plant site. These measurements include contributions from cosmic radiation, radioactivity in the ground, fallout from atmospheric nuclear weapons tests conducted in the past, and any radioactivity that may be present from plant operations. The plant contribution to the total direct radiation component is small compared to that from background. Therefore, an in-depth analysis, comparing the variation in measurements and the background fluctuation, is undertaken to identify any significant plant contribution. This process is further described below.

Measurement Techniques

The Landauer InLight environmental dosimeter is used in the radiological environmental monitoring program for the measurement of direct radiation. This dosimeter contains four elements consisting of aluminum oxide detectors with open windows as well as plastic and copper filters. The dosimeter is processed using optically stimulated luminescence (OSL) technology to determine the amount of radiation exposure.

The dosimeters are placed approximately one meter above the ground, with two at each monitoring location. Sixteen monitoring points are located around the plant near the site boundary, one location in each of the 16 compass sectors. One monitoring point is also located in each of the 16 compass sectors at approximately four to five miles from the plant.

Dosimeters are also placed at additional monitoring locations out to approximately 32 miles from the site. The dosimeters are exchanged every three months. The dosimeters are sent to Landauer for processing and results reporting. The values are corrected for transit and shielded background exposure. An average of the two dosimeter results is calculated for each monitoring point. The system meets or exceeds the performance specifications outlined in American National Standards Institute (ANSI) N545-1975 and ANSI N13.37-2014 for environmental applications of dosimeters.

Results

For reporting dose, all results for environmental dosimeter measurements are normalized to a standard quarter (91 days). The monitoring locations are grouped according to the distance from the plant. The first group consists of all monitoring points within 2 miles of the plant. The second group is made up of all locations greater than 2 miles from the plant. For purposes of this report, monitoring points 2 miles or less from the plant are identified as “onsite” stations and locations greater than 2 miles are considered “offsite.”

The quarterly and annual gamma radiation levels determined from the dosimeters deployed around SQN in 2019 are summarized in Table 2. For comparison purposes, the average direct radiation measurements made in the preoperational phase of the monitoring program are also shown.

Table 2 - Average External Gamma Radiation Levels at Various Distances from Sequoyah Nuclear Plant for Each Quarter – 2019

	Average External Gamma Radiation Levels					
	Q1 [a] (mrem/qtr)	Q2 (mrem/qtr)	Q3 (mrem/qtr)	Q4 (mrem/qtr)	Annual (mrem/yr)	Preoperational (mR/yr)
Average 0-2 miles (onsite)[a]	15.0	12.5	14.0	14.4	56.0	79
Average >2 miles (offsite)[a]	13.6	12.3	13.2	13.4	52.4	63

NOTES

a. Average of the individual measurements in the set

The data in Table 2 indicate that the average quarterly direct radiation levels at the SQN onsite stations are approximately 0.9 mrem/quarter higher than levels at the offsite stations. This equates to 3.5 mrem/year increase at the onsite locations, which is less than the difference observed during the preoperational program. Even considering this 3.5 mrem/yr as a potential increase for onsite locations attributable to plant operations, it falls well below the 25 mrem total body limit for 40 CFR 190. The difference in onsite and offsite averages is consistent with levels measured for the preoperational and construction phases of TVA nuclear power plant sites where the average levels onsite were slightly higher than levels offsite. Figure 3 compares plots of the data from the onsite stations with those from the offsite stations over the period from 1977 through 2019. Landauer InLight Optically Stimulated Luminescence (OSL) dosimeters have been deployed since 2007, replacing the Panasonic UD-814 dosimeters used during the previous years. Beginning with 2018, the methodology for evaluating and reporting the environmental direct radiation exposure was modified, to reflect recommendations contained in ANSI N13.37-2014. A study was performed to determine the dose received by dosimeters that are used as unexposed controls to account for the transit dose to all dosimeters and the shielded storage dose to the unexposed control dosimeters. This in turn was used to correctly account for the extraneous dose that should be removed from the gross measurements as measured by the field dosimeters.

Figure 3 - Average Direct Radiation

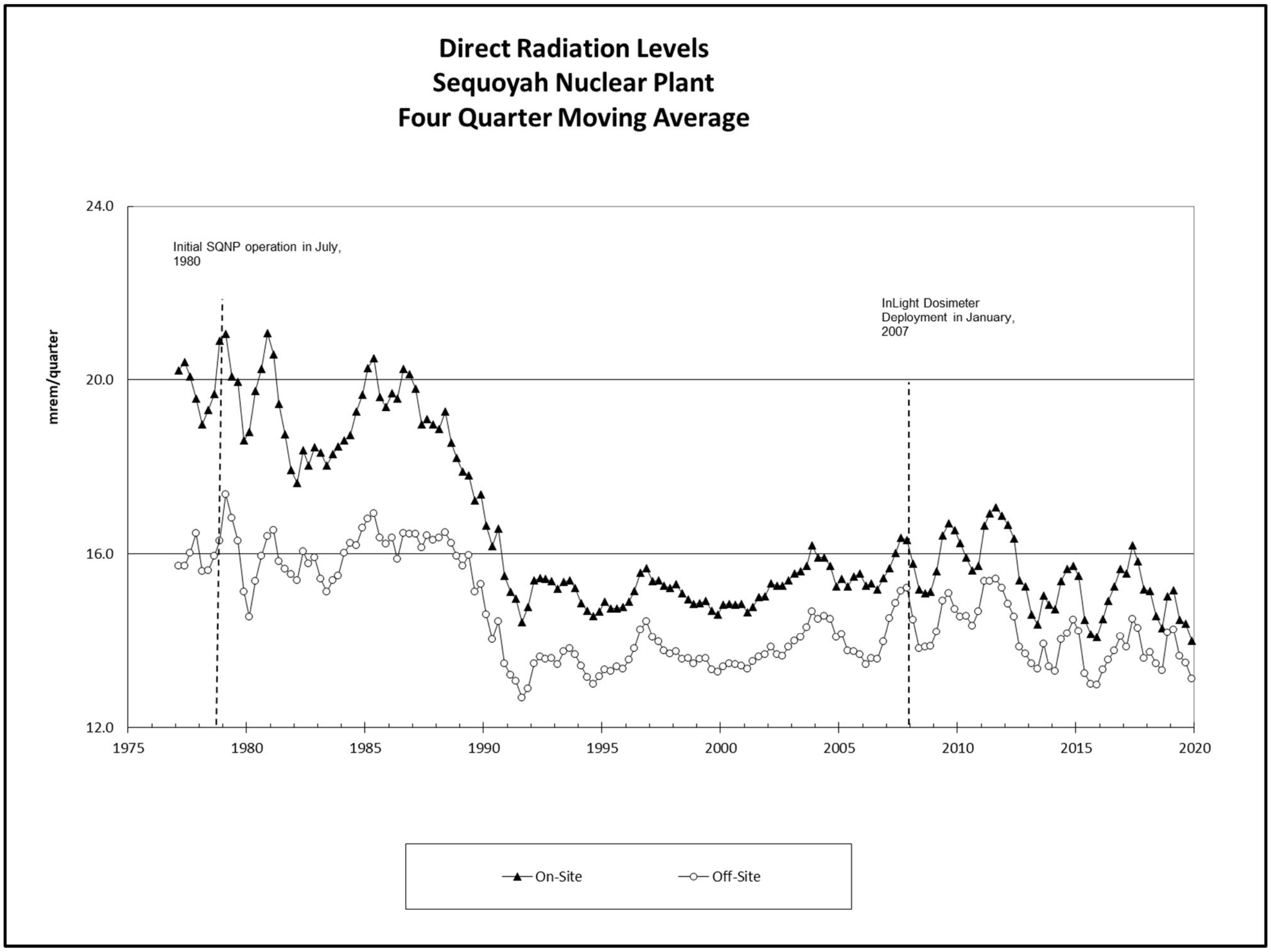


Table H-1 contains the results of the individual monitoring stations. The results reported in 2019, with on-site locations measuring higher than offsite, are consistent with historical and preoperational results indicating that there is no measurable increase in direct radiation levels in the offsite environment attributable to the operation of SQN.

ATMOSPHERIC MONITORING

The atmospheric monitoring network is divided into three groups identified as local, perimeter, and remote. Four local air monitoring stations are located on or adjacent to the plant site in the general directions of highest wind frequency. Four perimeter air monitoring stations are located between 6 to 11 miles from the plant, and two air monitors are located out to 15 miles and used as control or baseline stations. The monitoring program and the locations of monitoring stations are identified in the tables and figures of Appendix A.

Results from the analysis of samples in the atmospheric pathway are presented in Table H-2 through Table H-4. Radioactivity levels identified in this reporting period are consistent with background and preoperational program data. There is no indication of an increase in atmospheric radioactivity due to SQN operations.

Sample Collection and Analysis

Air particulates are collected by continuously sampling air at a flow rate of approximately 2 cubic feet per minute (cfm) through a 2-inch glass fiber filter. The sampling system consists of a Vacuum Florescent Display (VFD), a brushless motor, and a precision-machined mechanical differential pressure flow sensor. It is equipped with automatic flow control, on-board data storage, and various alarm notifications. This system is housed in a weather resistant environmental enclosure approximately 3 feet by 2 feet by 4 feet. The filter is contained in a sampling head mounted on the outside of the monitoring building. The filter is replaced weekly. Each filter is analyzed for gross beta activity at least 3 days after collection to allow time for the naturally occurring radon daughters to decay. Monthly composites of the filters from each location are analyzed by gamma spectroscopy.

Atmospheric radioiodine is sampled using a commercially available cartridge containing triethylenediamine (TEDA)-impregnated charcoal. This system is designed to collect iodine in both the elemental form and as organic compounds. The cartridge is in the same sampling head and downstream of the air particulate filter. The cartridge is changed at the same time as the particulate filter and samples the same volume of air. Each cartridge is analyzed for I-131 by gamma spectroscopy.

Results

The results from the analysis of air particulate samples are summarized in Table H-2. Gross beta activity in 2019 was consistent with levels reported in previous years. The average gross beta activity measured for air particulate samples was 0.037 pCi/m^3 for indicator locations and 0.037pCi/m^3 for control locations. The annual averages of the gross beta activity in air particulate filters at these stations for the period 1977-2019 are presented in Figure H-1. Increased levels due to fallout from atmospheric nuclear weapons testing are evident in the years prior to 1981 and a small increase from the Chernobyl accident can be seen in 1986. These patterns are consistent with data from monitoring programs conducted by TVA at other nuclear power plant sites. In 2017, GEL Laboratories, LLC took over radiochemistry analysis for the SQN REMP program. Since that change, the air filter gross beta results increased from a long-term average of approximately 0.02 pCi/m^3 to approximately 0.03 pCi/m^3. This is the result of the new laboratory using a different calibration source (Tc-99) than the prior laboratory (Sr-90), which resulted in a slightly higher correlation of the instrument measurement to the corresponding calculated air concentration. The current results are consistent between indicator and control samples, and consistent with results from other TVA nuclear facilities.

As shown in Table H-3, I-131 was not detected in any charcoal cartridge samples. Only natural radioactive materials were identified by the monthly gamma spectral analysis of the air particulate samples collected in 2019 (see Table H-4).

TERRESTRIAL MONITORING

Terrestrial monitoring is accomplished by collecting samples of environmental media representing the transport of radioactive material from the atmosphere to humans. For example, radioactive material may be deposited on vegetation and be ingested by consuming vegetables or it may be deposited on pasture grass where dairy cattle are grazing. When the cow ingests the radioactive material, some of it may be transferred to the milk and consumed by humans who drink the milk. Therefore, samples of milk, soil, and food crops are collected and analyzed to determine potential impacts from exposure through these pathways. The results from the analysis of these samples are shown in Table H-6 and Table H-7.

A land use census is conducted annually between April and October to identify the location of the nearest milk animal, the nearest residence, and the nearest garden of greater than 500 square feet producing fresh leafy vegetables in each of 16 meteorological sectors within 5 miles from the plant. This land use census satisfies the requirements 10 CFR 50, Appendix I, Section IV.B.3. The results of the 2019 land use census are presented in Appendix G.

Sample Collection and Analysis

There is no milk pathway currently applicable to SQN. In previous years, there was a milk consumption pathway at one location applicable to SQN and was monitored via milk or vegetation samples at the location. Beginning in July 2019, wet vegetation samples in lieu of milk samples were taken from two control locations. There are no indicator samples, as there is no actual milk pathway in 2019. The land use census will continue to monitor if the milk pathway becomes applicable to SQN again.

Soil samples are collected annually from the area surrounding each air monitoring station. The samples are collected with either a "cookie cutter" or an auger type sampler. After drying and grinding, the sample is analyzed by gamma spectroscopy. When the gamma analysis is complete, the sample is analyzed for Sr-89 and Sr- 90.

Samples representative of food crops raised in the area near the plant are obtained from individual gardens. Types of foods may vary from year to year due to changes in the local vegetable gardens. Samples of green beans, corn, tomatoes, potatoes, cabbage and apples were collected from local vegetable gardens and/or farms. Samples of the same food products grown in areas that would not be affected by the plant were obtained from area produce markets as control samples. The edible portion of each sample is analyzed by gamma spectroscopy.

Results

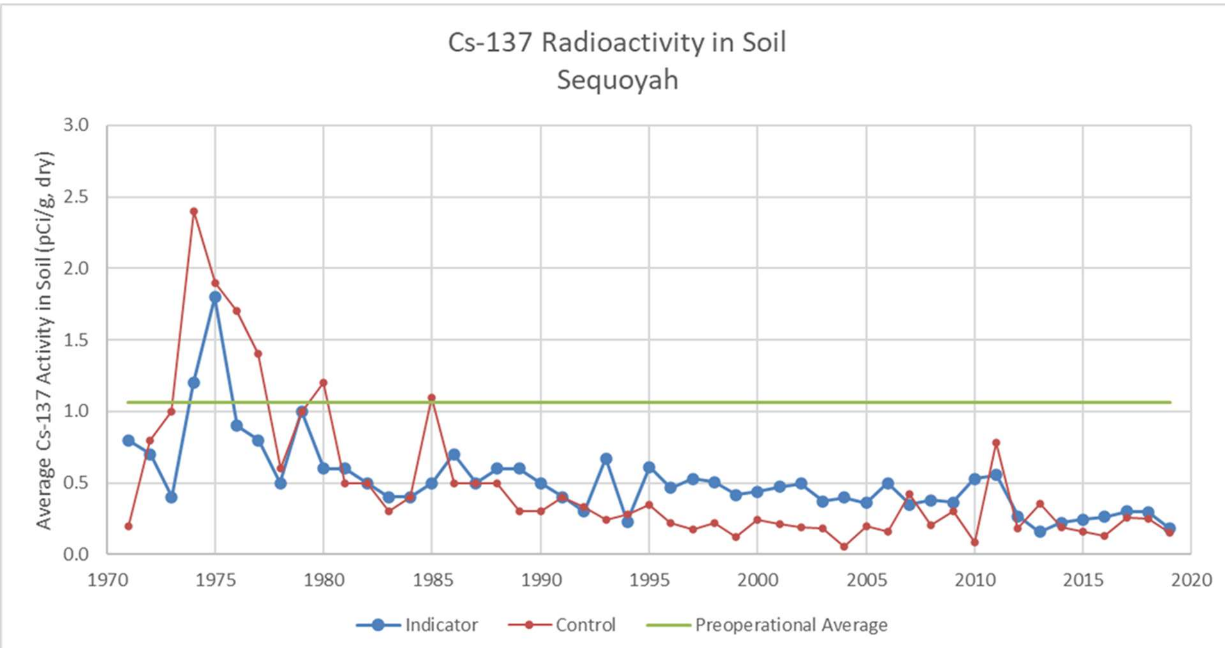
The wet vegetation (milk substitute) samples collected in 2019 did not identify any plant related radionuclides. The vegetation results are provided in Table H-5.

The gamma analysis of soil samples detected trace levels of Cs-137. The concentrations of Cs-137 are consistent with levels previously reported from fallout. No samples were positive for Sr-89/90 in 2019. All other radionuclides reported were naturally occurring isotopes. The soil analysis data are provided in Table H-6. The single highest soil radioactivity was from a control location sample (RM-2, Dayton, TN).

A plot of the annual average Cs-137 concentrations in soil is presented in Figure 4. The concentrations of Cs-137 in soil are steadily decreasing due to the cessation of weapons testing in the atmosphere, the 30-year half-life of Cs-137 and transport through the environment.

Radionuclides reported in food samples were all naturally occurring. Analysis of these samples indicated no contribution from plant activities. The results are reported in Table H-7.

Figure 4 - Average Cs-137 Soil Radioactivity



LIQUID PATHWAY MONITORING

Potential exposures from the liquid pathway can occur from drinking water, ingestion of edible fish, or from direct radiation exposure from radioactive materials deposited in shoreline sediment. The monitoring program includes the collection of samples of surface water, groundwater, drinking water supplies, fish, and shoreline sediment. Samples from the reservoir are collected both upstream and downstream from the plant.

Sample Collection and Analysis

Samples of surface water are collected from the Tennessee River downstream and upstream of the plant using automatic sampling systems. A timer turns on the system at least once every 2 hours and the sample collects into a composite jug. A 1-gallon sample is removed from the composite jug each month and the remaining water in the jug is discarded. The monthly composite sample is analyzed by gamma spectroscopy and gross beta analysis. A quarterly composite sample is analyzed for tritium.

Samples are collected by an automatic sampling system at the first downstream drinking water intake and at the water intake for the city of Dayton located approximately 20 miles upstream. At other selected locations, grab samples are collected from drinking water systems which use the Tennessee River as their source. These monthly samples are analyzed by gamma spectroscopy and gross beta analysis. A quarterly composite sample from each station is analyzed for tritium. Additional tritium analyses are performed on samples from two of the locations that are shared with the Watts Bar monitoring program. The sample collected at the water intake for the city of Dayton also serves as control sample for surface water.

Groundwater is sampled from an onsite well using an automatic composite sampler; and a grab sample is collected quarterly from a private well in an area unaffected by SQN. Samples from the wells are collected every month and analyzed by gamma spectroscopy. A quarterly composite sample is analyzed for tritium and gross beta activity.

Samples of commercial and game fish species are collected semiannually from each of two reservoirs: the reservoir on which the plant is located (Chickamauga Reservoir) and the upstream reservoir (Watts Bar Reservoir). The samples are collected using a combination of netting techniques and electrofishing. Samples are prepared from filleted fish. After drying and grinding, the samples are analyzed by gamma spectroscopy.

Samples of shoreline sediment are collected from two downstream recreational use areas and one upstream location. The samples are dried and ground and analyzed by gamma spectroscopy.

Results

There were no fission or activation product radionuclides identified from the gamma spectroscopy analyses performed on surface water samples. Tritium activity above the nominal LLD value was measured in some samples of surface water. The tritium concentrations in two monthly samples from the control location averaged 448 pCi/liter. These tritium concentrations represent a small fraction of the Environmental Protection Agency (EPA) drinking water limit of 20,000 pCi/liter. The values were consistent with previously reported values. A summary table of the results is shown in Table H-8.

There were no fission or activation products identified by the gamma spectroscopy of drinking water samples. Tritium activity above the nominal LLD value was measured in some drinking water samples. The tritium concentrations in two samples from the control location averaged 448 pCi/liter. These tritium levels represented a small fraction of the EPA drinking water limit of 20,000 pCi/liter. The values were consistent with previously reported values. Some indicator samples were positive for gross beta, averaging 4.10 pCi/liter. The gross beta results are consistent with past samples, where occasionally these samples are positive for gross beta, and not necessarily indicative of a contribution from the power plant. The results are shown in Table H-9.

No fission or activation products were detected by the gamma spectroscopy analyses performed on groundwater samples from the REMP monitoring locations. Tritium was not detected in any collected ground water samples. No gross beta activity was detected for indicator location samples, but gross beta was identified in the offsite well control location, averaging 12.1 pCi/liter. These gross beta levels are representative of the levels typically found in groundwater. The results from the analysis of groundwater samples are presented in Table H-10.

In 2019, game fish (largemouth bass) and commercial fish (channel catfish and blue catfish) were sampled and analyzed from both control and indicator locations. No fission or activation products were identified in any of the samples. The results are summarized in Table H-11.

No fission or activation products were detected by the gamma spectroscopy performed on shoreline sediment samples from the REMP monitoring locations. All other radionuclides reported were naturally occurring isotopes. Results from the analysis of shoreline sediment samples are shown in Table H-12.

ASSESSMENT AND EVALUATION

Results

As stated earlier in this report, the estimated increase in radiation dose equivalent to the general public resulting from the operation of SQN is negligible when compared to the dose from natural background radiation. The results from environmental samples are compared with the concentrations from the corresponding control stations as well as appropriate preoperational and background data to determine influences from the plant. Measurable levels of Cs-137 (at a very low level) were detected in soil. The Cs-137 concentrations are consistent with levels identified previously that are the result of fallout from past atmospheric nuclear weapons testing. The low levels of tritium measured in water samples represent concentrations that were significantly lower than the EPA drinking water limit.

Conclusions

The 2019 radiological environmental monitoring program results demonstrate that exposures to members of the general public, which may have been attributable to SQN, are small fractions of regulatory limits and essentially indistinguishable from the natural background radiation. The radioactivity reported herein is primarily the result of fallout or natural background. Any activity, which may be present in the environment as a result of plant operations, does not represent a significant contribution to the exposure of members of the public. The results confirm that radioactive effluents from the plant are controlled, maintaining releases as low as reasonably achievable (ALARA) and to a small fraction of the limits for doses to members of the public.

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APPENDIX A RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM AND SAMPLING LOCATIONS

Table A-1 - Sequoyah Radiological Environmental Monitoring Program

Exposure Pathway and/or Sample	Number of Samples and Locations[a]	Sampling and Collection Frequency	Type and Frequency of Analysis
1. AIRBORNE			
a. Particulates	4 samples from locations (in different sectors) at or near the site boundary (LM-2, 3, 4 and 5) 4 samples from communities approximately 6-10 miles from plant (PM-2, 3, 8 and 9) 4 samples from control locations > 10 miles from the plant (RM-1, 2, 3 and 4)	Continuous sampler operation with sample collection weekly (more frequently if required by dust loading)	Analyze for gross beta radioactivity ≥ 24 hours following filter change. Perform gamma isotopic analysis on each sample if gross beta > 10 times yearly mean of control sample. Composite at least once per 31 days (by location) for gamma spectroscopy.
b. Radioiodine	Samples from same locations as air particulates	Continuous sample operation with filter collection weekly.	I-131 by gamma spectroscopy on each sample.
c. Soil	Samples from same location as air particulates	Annually	Gamma spectroscopy, Sr-89, Sr-90 annually
2. DIRECT			
a. Dosimeters	2 or more dosimeters placed at or near the site boundary in each of the 16 sectors. 2 or more dosimeters placed at stations located approximately 4 to 5 miles from the plant in each of the 16 sectors. 2 or more dosimeters in other locations of special interest.	Quarterly (once per 92 days)	Gamma dose quarterly (at least once per 92 days)

Table A-1 - Sequoyah Radiological Environmental Monitoring Program (Continued)

Exposure Pathway and/or Sample	Number of Samples and Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
3. WATERBORNE			
a. Surface Water	TRM 503.8 TRM 483.4	Collected by automatic sequential-type sampler[b] with composite samples collected over a period of approximately 31 days.	Gross beta and gamma spectroscopy on each sample. Composite for tritium analysis at least once per 92 days.
b. Ground water	1 sample adjacent to the plant (Well #6) 1 sample from ground water source up gradient (Farm HW).	Quarterly (Once per 92 days)	Gross beta, gamma spectroscopy, and tritium analysis of each sample.
c. Drinking Water	1 sample at the first potable surface water supplies, downstream from the plant (TRM 473.0). 1 sample at the next 2 downstream potable water systems (greater than 10 miles downstream) (TRM 469.9 and TRM 465.3) 1 sample at a control location (TRM 503.8)[c]	Monthly (once per 31 days)	Gross beta and gamma scan of each sample. Composite for tritium once per 92 days.
d. Shoreline Sediment	TRM 485 TRM 480 TRM 479	Semi-Annually (at least once per 184 days)	Gamma spectroscopy of each sample

Table A-1 - Sequoyah Radiological Environmental Monitoring Program (Continued)

Exposure Pathway and/or Sample	Number of Samples and Locations	Sampling and Collection Frequency	Type and Frequency of Analysis
4. INGESTION			
a. Milk	N/A. As of 2017, the milk pathway is not applicable to SQN.	Once per 15 days	I-131 and gamma spectroscopy on each sample. Sr-89 and Sr-90 quarterly.
b. Fish	One sample of commercially important species and one sample of recreationally important species. One sample of each species from Chickamauga and Watts Bar Reservoirs.	Semi-Annually (at least once per 184 days)	Gamma spectroscopy on edible portions
c. Vegetation[d] (Pasturage and grass)	Samples from farms producing milk but not providing a milk sample	Monthly (at least once per 31 days)	I-131 analysis and gamma spectroscopy of each sample
d. Food Products	1 sample of each principal food products grown at private gardens and/or farms in the immediate vicinity of the plant. 1 sample of each of the same foods grown at greater than 10 miles distance from the plant.	Annually at time of harvest. The types of foods available for sampling will vary. Typically available foods may include: • Cabbage • Corn • Green Beans • Potatoes • Tomatoes	Gamma spectroscopy on edible portions

[a] Sample locations are shown on Figure A-1 through Figure A-3.
[b] Samples shall be collected by collecting an aliquot at intervals not exceeding 2 hours
[c] The samples collected at TRMs 503.8 are taken from the raw water supply, therefore, the upstream surface water sample will be considered the control sample for drinking water
[d] Vegetation sampling is applicable only for farms that meet the criteria for milk sampling and when milk sampling cannot be performed

Table A-2 - Sequoyah REMP Sampling Locations

Map Location Number[a]	Station	Sector	Distance (miles)	Indicator (I) or Control (C)	Samples Collected[b]
2	LM-2	N	0.7	I	AP,CF,S
3	LM-3	SSW	2.0	I	AP,CF,S
4	LM-4	NE	1.5	I	AP,CF,S
5	LM-5	NNE	1.8	I	AP,CF,S
7	PM-2	SW	3.8	I	AP,CF,S
8	PM-3	W	5.6	I	AP,CF,S
9	PM-8	SSW	8.7	I	AP,CF,S
10	PM-9	WSW	2.6	I	AP,CF,S
11	RM-1	SW	16.7	C	AP,CF,S
12	RM-2	NNE	17.8	C	AP,CF,S
13	RM-3	ESE	11.3	C	AP,CF,S
14	RM-4	NW	20.0	C	AP,CF,S
19	Farm HW	NW	1.2	I	W[c]
24	Well No. 6	NNE	0.15	I	W
31	TRM 473.0 (East Side Utilities)[c]	--	10.7[d]	I	PW
32	TRM 469.9 (E. I. DuPont)	--	13.8[d]	I	PW
33	TRM 465.3 (Chattanooga)	--	18.4[d]	I	PW
35	TRM 503.8 (Dayton)	--	20.1[d]	C	PW,SW
37	TRM 485.0	--	1.3[d]	C	SS
38	TRM 483.4	--	0.3[d]	I	SW
40	TRM 479.0	--	4.7[d]	I	SS
44	TRM 480.0	--	3.7[d]	I	SS
46	Chickamauga Reservoir (TRM 471-530)	--	--	I	F
47	Watts Bar Reservoir (TRM 530-602)	--	--	C	F

[a] See Figure A-1 through Figure A-3

[b] Sample Codes:

AM =	Atmospheric moisture	PW =	Public water	SS =	Shoreline sediment
AP =	Air particulate filter	V =	Vegetation	SW =	Surface water
F =	Fish	S =	Soil	W =	Well water
CF =	Charcoal Filter	M =	Milk		

[c] A control for well water

[d] Distance from plant discharge (TRM 483.7)

Table A-3 - Sequoyah Environmental Dosimeter Locations

Map Location Number[a]	Station	Sector	Distance (miles)	Onsite or Offsite[b]
3	SSW-1C	SSW	2.0	off
4	NE-1A	NE	1.5	onsite
5	NNE-1	NNE	1.8	onsite
7	SW-2	SW	3.8	off
8	W-3	W	5.6	off
9	SSW-3	SSW	8.7	off
10	WSW-2A	WSW	2.6	off
11	SW-3	SW	16.7	off
12	NNE-4	NNE	17.8	off
13	ESE-3	ESE	11.3	off
14	NW-3	NW	20.0	off
49	N-1	N	0.6	onsite
50	N-2	N	2.1	off
51	N-3	N	5.2	off
52	N-4	N	10.0	off
53	NNE-2	NNE	5.3	off
55	NE-1	NE	2.4	off
56	NE-2	NE	4.1	off
57	ENE-1	ENE	0.2	onsite
58	ENE-2	ENE	5.1	off
59	E-1	E	1.2	onsite
60	E-2	E	5.2	off
62	ESE-1	ESE	1.2	onsite
63	ESE-2	ESE	4.9	off
66	SE-1	SE	1.4	onsite
67	SE-2	SE	1.9	onsite
68	SE-4	SE	5.2	off
69	SSE-1	SSE	1.6	onsite
70	SSE-2	SSE	4.6	off
71	S-1	S	1.5	onsite
72	S-2	S	4.7	off
73	SSW-1	SSW	0.6	onsite
74	SSW-2	SSW	4.0	off
75	SW-1	SW	0.7	onsite
76	WSW-1	WSW	0.9	onsite
77	WSW-2	WSW	2.5	off
78	WSW-3	WSW	5.7	off
79	WSW-4	WSW	7.8	off
81	W-1	W	0.6	onsite
82	W-2	W	4.3	off
83	WNW-1	WNW	0.4	onsite

Table A-3 - Sequoyah Environmental Dosimeter Locations (Continued)

Map Location Number	Station	Sector	Distance (miles)	Onsite or Offsite
84	WNW-2	WNW	5.3	Off
85	NW-1	NW	0.4	onsite
86	NW-2	NW	5.2	off
87	NNW-1	NNW	0.6	onsite
88	NNW-2	NNW	1.7	onsite
89	NNW-3	NNW	5.3	off
90	SSW-1B	SSW	1.5	onsite

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[a] See Figure A-1 through Figure A-3

[b] Dosimeters designated "onsite" are located 2 miles or less from the plant; "offsite" are located more than 2 miles from the plant

Figure A-1 - Radiological Environmental Sampling Locations Within 1 Mile of the Plant

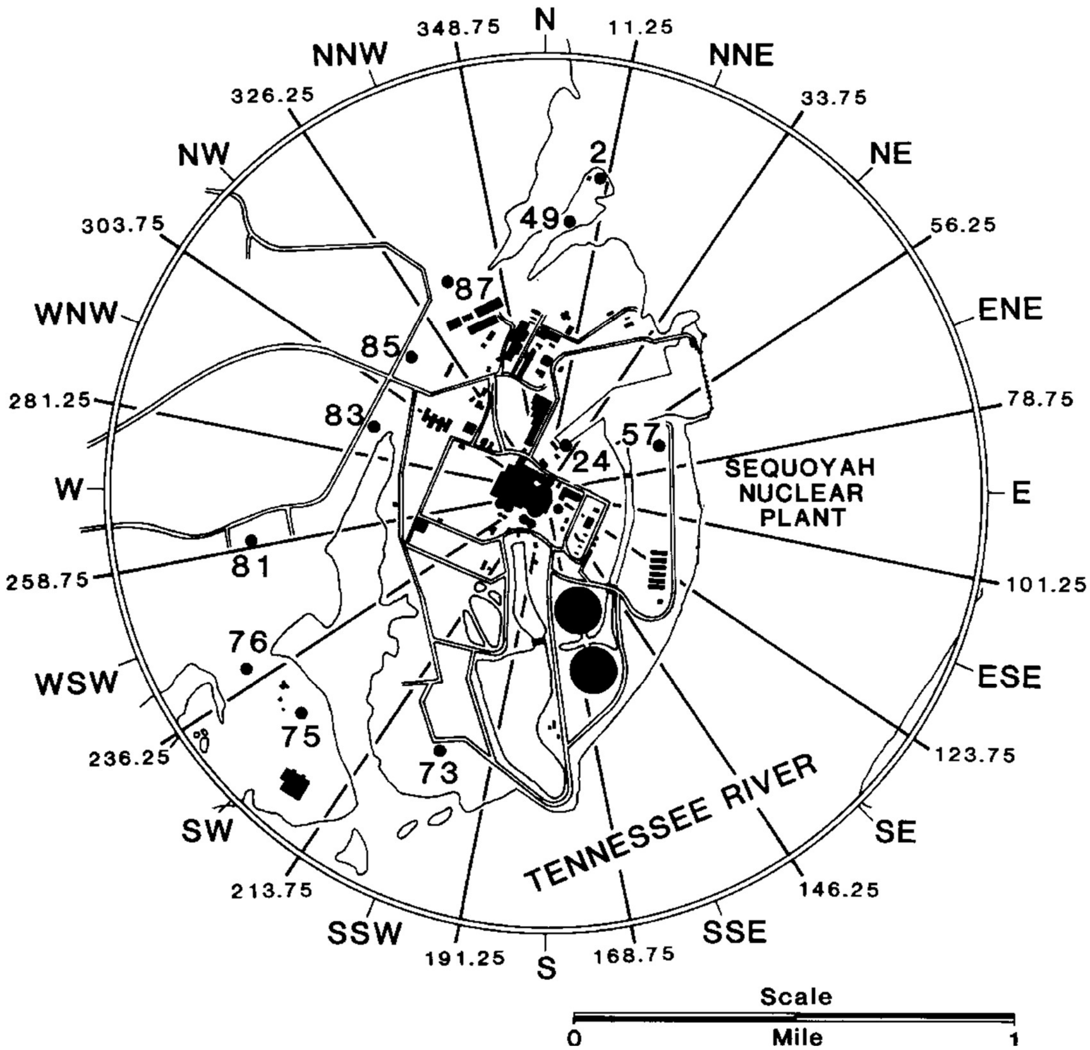


Figure A-2 - Radiological Environmental Sampling Locations from 1 to 5 Miles from the Plant

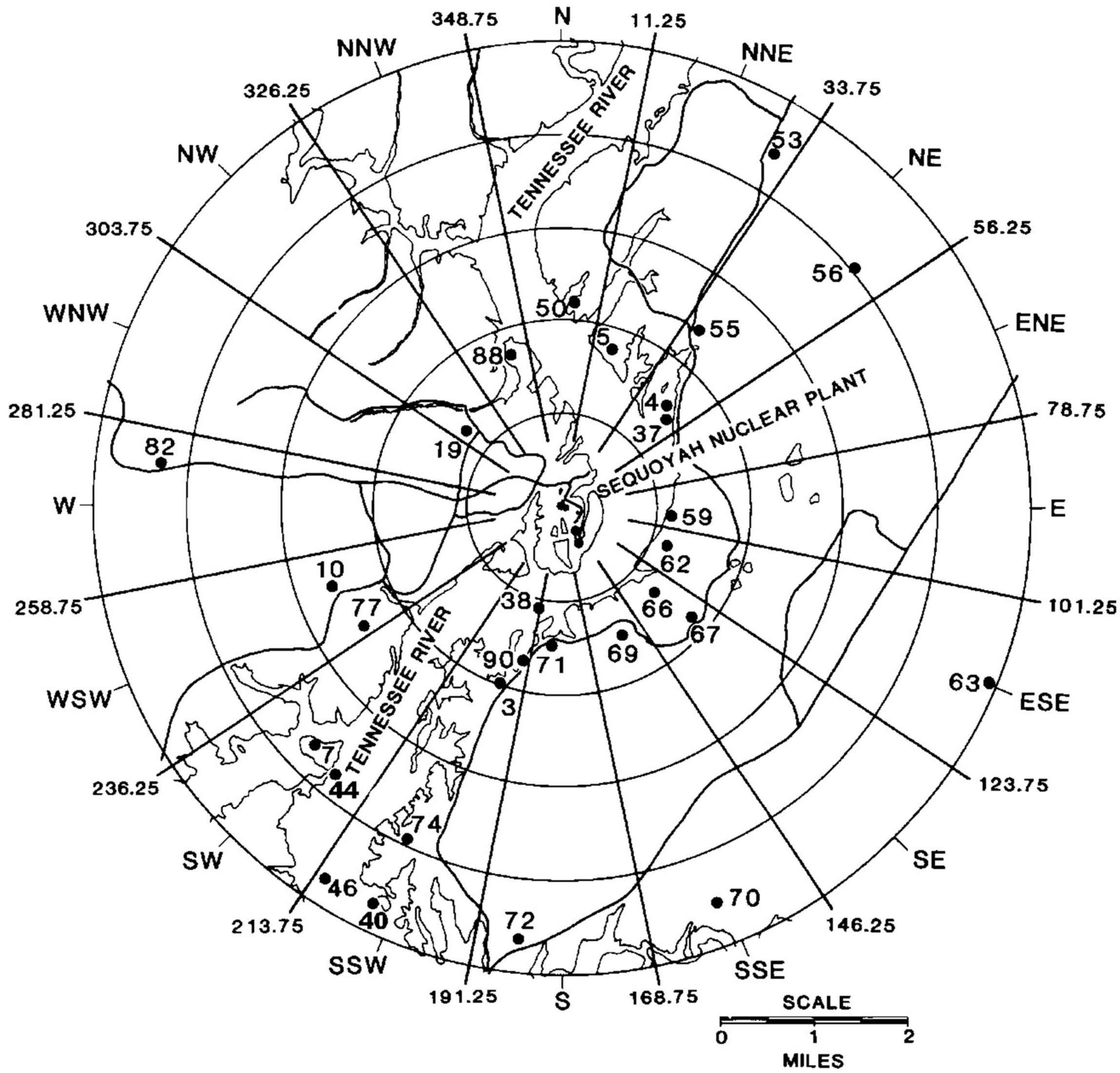
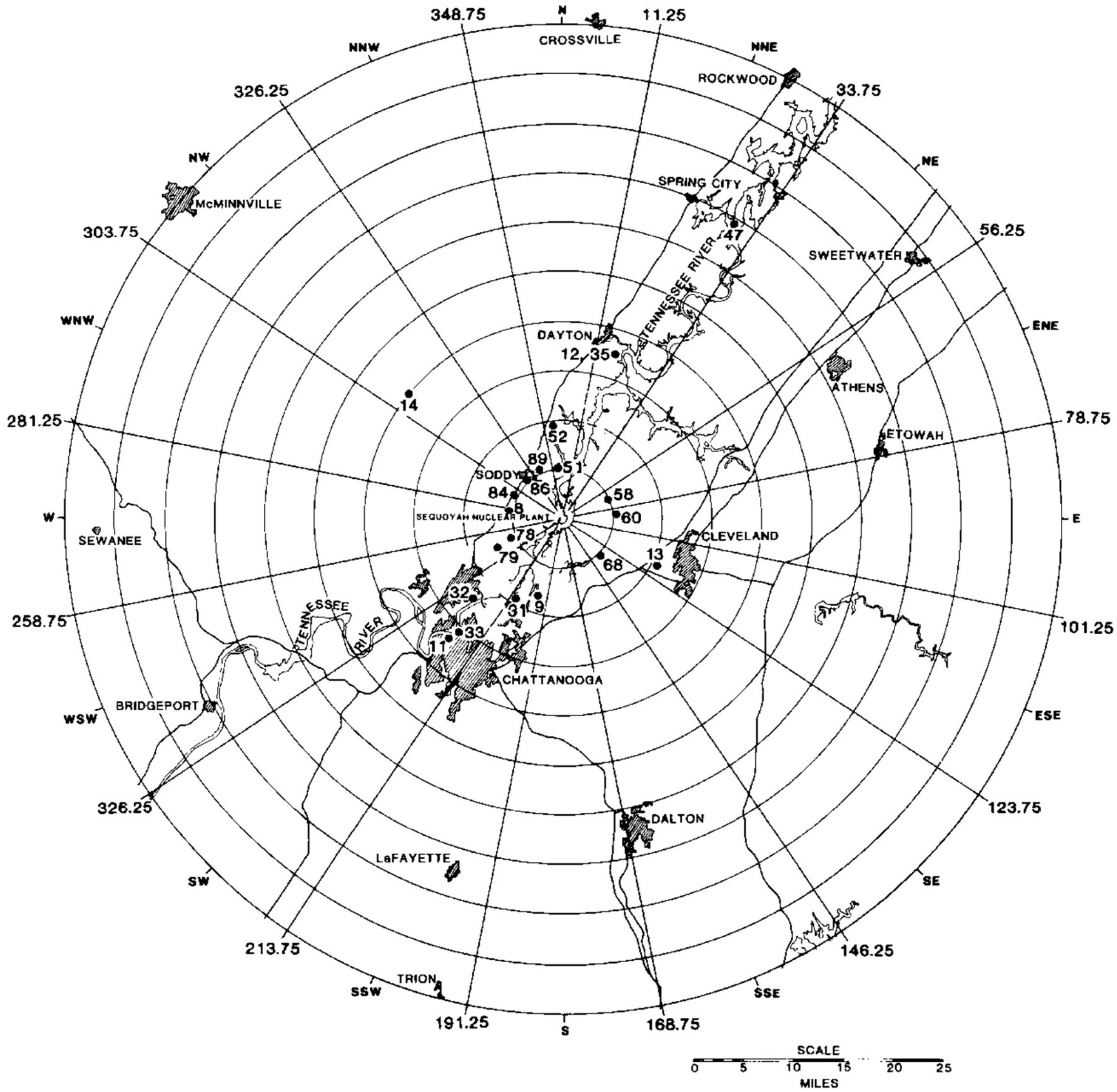


Figure A-3 - Radiological Environmental Sampling Locations Greater Than 5 Miles from the Plant



APPENDIX B PROGRAM MODIFICATIONS

Radiological Environmental Monitoring Program Modifications

In 2019, there was one change to the Sequoyah REMP.

Beginning in July 2019, monthly vegetation samples were collected as a substitute for milk sampling, in order to comply with requirements in Table 9.1 of the ODCM (TVA, 2018). There is currently no milk sampling location or pathway applicable to Sequoyah, and the vegetation samples are all from control locations.

APPENDIX C PROGRAM DEVIATIONS

Program Deviations

Media	Location	Date	CR	Issue
Air Filter Charcoal Filter	RM-2 (3298)	1/1/19 1/8/19 1/15/19	1495778	Station did not have power. CR initiated in 2018.
Direct Radiation	SSE-1 (40A and 40B)	Q2	1546936	OSLDs 40A and 40B were changed in the field, but not received by the vendor lab. Lost at an unknown point in the transit process.

APPENDIX D ANALYTICAL PROCEDURES

Analytical Procedures

Analyses of environmental samples are performed by GEL Laboratories, LLC in Charleston, SC. Analysis of environmental dosimeters are performed by Landauer, Inc. in Glenwood, IL. Analysis procedures are based on accepted methods and summarized below.

The gross beta measurements are made with an automatic low background counting system. Normal counting times are 50 minutes. Water samples are prepared by evaporating 400 milliliter (mL) of samples to near dryness, transferring to a stainless steel planchet, and completing the evaporation process. Air particulate filters are counted directly in a shallow planchet.

Gamma analyses are performed in various counting geometries depending on the sample type and volume. All gamma counts are obtained with germanium type detectors interfaced with a high resolution gamma spectroscopy system. All samples requiring gamma analysis are analyzed in this manner.

The necessary efficiency values, weight-efficiency curves, and geometry tables are established and maintained on each detector and counting system. A series of daily and periodic quality control checks are performed to monitor counting instrumentation. System logbooks and control charts are used to document the results of the quality control checks.

The specific analysis of I-131 in milk is performed by first isolating and purifying the iodine by radiochemical separation and then counting the final precipitate on a beta-gamma coincidence counting system. The normal count time is 480 minutes. Then the I-131 is counted by gamma spectroscopy utilizing high resolution Ge detectors.

After a radiochemical separation, milk samples analyzed for Sr-89 and Sr-90 are counted on a low background beta counting system. The sample is counted a second time after a minimum ingrowth period of six days. From the two counts, the Sr-89 and Sr-90 concentrations can be determined.

Water samples are analyzed for tritium content by first distilling a portion of the sample and then counting by liquid scintillation. A commercially available scintillation cocktail is used.

The Landauer InLight Environmental Dosimetry System is used for measuring direct radiation in the REMP. Landauer has performed type testing of this system in accordance with ANSI N13.37-2014 standards.

APPENDIX E LOWER LIMITS OF DETECTION

Lower Limits of Detection

Many factors influence the Lower Limit of Detection (LLD) for a specific analysis method, including sample size, count time, counting efficiency, chemical processes, radioactive decay factors, and interfering isotopes encountered in the sample. Nominal LLD values for the environmental monitoring program are calculated based on system parameter values for each of the components as identified above, in accordance with the methodology prescribed in the ODCM. The current nominal LLD values achieved by the radioanalytical lab are listed in Table E-2 and Table E-3. For comparison, the maximum values for the lower limits of detection specified in the ODCM are given in Table E-4.

Table E-1 - Comparison of Program Lower Limits of Detection with the Regulatory Limits for Maximum Annual Average Effluent Concentration Released to Unrestricted Areas and Reporting Levels

	Concentrations in Water (pCi/Liter)			Concentrations in Air (pCi/m^3)		
Analysis	10 CFR 20 Effluent Concentration Limit[a]	Reporting Level[b, c]	Lower Limit of Detection[d]	10 CFR 20 Effluent Concentration Limit[a]	Reporting Level[b, c]	Lower Limit of Detection[d]
H-3	1,000,000	20,000	270	100,000	--	--
Cr-51	500,000	--	45	30,000	--	0.02
Mn-54	30,000	1000	5	1,000	--	0.005
Fe-59	10,000	400	10	500	--	0.005
Co-58	20,000	1000	5	1,000	--	0.005
Co-60	3,000	300	5	50	--	0.005
Zn-65	5,000	300	10	400	--	0.005
Sr-89	8,000	--	--	1,000	--	--
Sr-90	500	--	--	6	--	--
Nb-95	30,000	400	5	2,000	--	0.0005
Zr-95	20,000	400	10	400	--	0.005
Ru-103	30,000	--	5	900	--	0.005
Ru-106	3,000	--	40	20	--	0.02
I-131	1,000	2	0.4	200	0.9	0.03
Cs-134	900	30	5	200	10	0.005
Cs-137	1,000	50	5	200	20	0.005
Ce-144	3,000	--	30	40	--	0.01
Ba-140	8,000	200	25	2,000	--	0.015
La-140	9,000	200	10	2,000	--	0.01

[a] Source: Table 2 of Appendix B to 10 CFR 20.1001-20.2401
[b] For those reporting levels and lower limits of detection that are blank, no value is given in the reference
[c] Source: SQN Offsite Dose Calculation Manual, Table 2.3-2
[d] Source: Table E-2 and Table E-3 of this report

Table E-2 - Nominal LLD Values - Radiochemical

Analysis	Airborne Particulate or Gases (pCi/m^3)	Water (pCi/L)	Milk (pCi/L)	Wet Vegetation (pCi/kg, wet)	Sediment and Soil (pCi/kg, dry)
Gross beta	0.002	1.9	--	--	--
H-3	3.0	270	--	--	--
I-131	--	0.4	0.4	6.0	--
Sr-89	--	--	3.5	--	1.6
Sr-90	--	--	2.0	--	0.4

Table E-3 - Nominal LLD Values – Gamma Analysis

Analysis	Airborne Particulate (pCi/m^3)	Charcoal Filter (pCi/m^3)	Water and Milk (pCi/L)	Wet Vegetation (pCi/kg, wet)	Sediment and Soil (pCi/kg, dry)	Fish (pCi/kg, wet)	Food Products (pCi/kg, wet)
Ce-141	0.005	0.02	10	35	0.10	0.07	20
Ce-144	0.01	0.07	30	115	0.20	0.15	60
Cr-51	0.02	0.15	45	200	0.35	0.30	95
I-131	0.005	0.03	10	60	0.25	0.20	20
Ru-103	0.005	0.02	5	25	0.03	0.03	25
Ru-106	0.02	0.12	40	190	0.20	0.15	90
Cs-134	0.005	0.02	5	30	0.03	0.03	10
Cs-137	0.005	0.02	5	25	0.03	0.03	10
Zr-95	0.005	0.03	10	45	0.05	0.05	45
Nb-95	0.005	0.02	5	30	0.04	0.25	10
Co-58	0.005	0.02	5	20	0.03	0.03	10
Mn-54	0.005	0.02	5	20	0.03	0.03	10
Zn-65	0.005	0.03	10	45	0.05	0.05	45
Co-60	0.005	0.02	5	20	0.03	0.03	10
K-40	0.04	0.30	100	400	0.75	0.40	250
Ba-140	0.015	0.07	25	130	0.30	0.30	50
La-140	0.01	0.04	10	50	0.20	0.20	25
Fe-59	0.005	0.04	10	40	0.05	0.08	25
Be-7	0.02	0.15	45	200	0.25	0.25	90
Pb-212	0.005	0.03	15	40	0.10	0.04	40
Pb-214	0.005	0.07	20	80	0.15	0.10	80

Table E-3 - Nominal LLD Values – Gamma Analysis (continued)

Analysis	Airborne Particulate (pCi/m^3)	Charcoal Filter (pCi/m^3)	Water and Milk (pCi/L)	Wet Vegetation (pCi/kg, wet)	Sediment and Soil (pCi/kg, dry)	Fish (pCi/kg, wet)	Food Products (pCi/kg, wet)
Bi-214	0.005	0.05	20	55	0.15	0.10	40
Bi-212	0.02	0.20	50	250	0.45	0.25	130
Tl-208	0.002	0.02	10	30	0.06	0.03	30
Ra-224	--	--	--	--	0.75	--	--
Ra-226	--	--	--	--	0.15	--	--
Ac-228	0.01	0.07	20	70	0.25	0.10	50
Pa-234m	--	--	800	--	4.0	--	--

Table E-4 - Maximum Values for Lower Limits of Detection (LLD)

Analysis	Water (pCi/L)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/L)	Food Products (pCi/kg, wet)	Sediment (pCi/kg, dry)
Gross beta	4	0.01	--	--	--	--
H-3	2000[a]	--	--	--	--	--
Mn-54	15	--	130	--	--	--
Fe-59	30	--	260	--	--	--
Co-58, 60	15	--	130	--	--	--
Zn-65	30	--	260	--	--	--
Zr-95	30	--	--	--	--	--
Nb-95	15	--	--	--	--	--
I-131	1[b]	0.07	--	1	60	--
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-140	60	--	--	60	--	--
La-140	15	--	--	15	--	--

Notes

a. If no drinking water pathway exists, a value of 3000 pCi/L may be used
b. If no drinking water pathway exists, a value of 15 pCi/L may be used.

APPENDIX F QUALITY ASSURANCE / QUALITY CONTROL PROGRAM

Quality Assurance / Quality Control Program

A quality assurance program is employed by the offsite vendor laboratory to ensure that the environmental monitoring data are reliable. This program includes the use of written, approved procedures in performing the work, provisions for staff training and certification, internal self-assessments of program performance, audits by various external organizations, and a laboratory quality control program.

The quality control program employed by the radioanalytical laboratory is designed to ensure that the sampling and analysis process is working as intended. The program includes equipment checks and the analysis of quality control samples, along with routine field samples. Instrument quality control checks include background count rate and counts reproducibility. In addition to these two general checks, other quality control checks are performed on the variety of detectors used in the laboratory. The exact nature of these checks depends on the type of device and the method it uses to detect radiation or store the information obtained.

Quality control samples of a variety of types are used by the laboratory to verify the performance of different portions of the analytical process. These quality control samples include blanks, field duplicates, process duplicates, matrix spikes, laboratory control samples, and independent cross-checks.

Blanks are samples which contain no measurable radioactivity of the type being measured. Such samples are analyzed to determine whether there is any contamination or cross-contamination of equipment, reagents, processed samples, or interferences from isotopes other than the ones being measured.

Duplicate field samples are generated at random by the sample computer program which schedules the collection of the routine samples. For example, if the routine program calls for four milk samples every week, on a random basis each farm might provide an additional sample several times a year. These duplicate samples are analyzed along with other routine samples. They provide information about the variability of radioactive content in the various sample media. If enough sample is available for a particular analysis, the laboratory staff can split the sample taking two individual aliquots, known as process duplicates. Duplicate samples provide information about the variability of the entire sampling and analytical process.

Matrix spikes are field samples that have been spiked with known low levels of specific target isotopes. Recovery of the known amount allow the analyst to determine if any interferences are exhibited from the field sample's matrix.

Laboratory control samples are another type of quality control sample. A known amount of radioactivity is added to a sample medium and processed along with the other QC and field samples in the analytical batch. Laboratory control samples provide the assurance that all aspects of the process have been successfully completed within the criteria established by Standard Operating Procedure.

Another category of quality control samples is cross-check samples. The laboratory procures single-blind performance evaluation samples from Eckert & Ziegler Analytics to verify the analysis of sample matrices processed at the laboratory. Samples are received on a quarterly basis. The laboratory's Third-Party Cross-Check Program provides environmental matrices encountered in a typical nuclear utility REMP. Once performance evaluation samples have been prepared in accordance with the instructions from the performance evaluator provider, samples are managed and analyzed in the same manner as environmental samples. These samples have a known amount of radioactivity added and are presented to the lab staff labeled as cross-check samples. The laboratory does not know the amount of radioactivity added to the sample. Such samples test the best performance of the laboratory by determining if the laboratory can find the "right answer." These samples provide information about the accuracy of the measurement process. Further information is available about the variability of the process if multiple analyses are requested on the same sample. Like matrix spikes or laboratory control samples, these samples can also be spiked with low levels of activity to test detection limits. The analysis results for internal cross-check samples met program performance goals for 2019.

The quality control data are routinely collected, examined and reported to laboratory supervisory personnel. They are checked for trends, problem areas, or other indications that a portion of the analytical process needs correction or improvement. The result is a measurement process that provides reliable and verifiable data and is sensitive enough to measure the presence of radioactivity far below the levels which could be harmful to humans.

Per the GEL 2019 Annual Environmental Quality Assurance (QA) Report (GEL, 2019), forty-five (45) radioisotopes associated with seven (7) matrix types (air filter, cartridge, water, milk, soil, liquid and vegetation) were analyzed under GEL's Performance Evaluation program in participation with ERA, Department of Energy Mixed Analyte Performance Evaluate Program (MAPEP), and Eckert & Ziegler Analytics. Matrix types were representative of client analyses performed during 2019. Of the four hundred twenty-five (425) total results, 97.2% (413 of 425) were found to be acceptable within the PT providers three sigma or other statistical criteria. For the Eckert & Ziegler Analytics Environmental Cross Check Program, GEL was provided eighty-nine (89) individual environmental analyses. The accuracy of each result reported to Eckert & Ziegler Analytics, Inc. is measured by the ratio of GEL's result to the known value. All results fell within GEL's acceptance criteria (100% within acceptance).

The radioanalytical lab performance in 2019 meets the criteria described in Reg. Guide 4.15 and ANSI/HPS N13.37-2014.

APPENDIX G LAND USE CENSUS

Land Use Census

A land use census is conducted annually to identify the location of the nearest milk producing animal, the nearest residence, and the nearest garden of greater than 500 square feet producing fresh leafy vegetables in each of 16 meteorological sectors within 5 miles (8,047 meters) from the plant.

The land use census is conducted between April 1 and October 1 using appropriate techniques such as door-to-door survey, mail survey, telephone survey, aerial survey, or information from local agricultural authorities or other reliable sources.

The location of the nearest resident was updated in one meteorological sector. This updated location did not result in a change in the required sampling locations or sampling media; new location is summarized below:

Table G-1 - 2019 Updated Nearest Residence

Sector	2018 Nearest Resident Distance (meters)	2019 Nearest Resident Distance (meters)
E	1685	1732

The location of the nearest garden greater than 500 ft^2 was changed or updated in three sectors. These updated locations did not result in any changes in the required sampling locations or sampling media; new locations are summarized below:

Table G-2 - 2019 Updated Nearest Garden

Sector	2018 Nearest Resident Distance (meters)	2019 Nearest Resident Distance (meters)
S	4137	4010
SSW	4532	4363
NNW	1975	2502

In 2019, no milk locations were identified within 8-km (5 mile) radius of the site. Results of the 2019 Land Use Census did not identify the need for any changes to the sampling locations or sampling media as currently required by the SQN REMP.

Table G-3 - Sequoyah Land Use Census Results

Meteorological Sector	Nearest Resident (meters)	Nearest Garden (meters)	Nearest Milk Production (meters)
N	1389	4329	-
NNE	2456	3770	-
NE	3400	6230	-
ENE	2127	5220	-

Meteorological Sector	Nearest Resident (meters)	Nearest Garden (meters)	Nearest Milk Production (meters)
E	**1732**	5370	-
ESE	1693	1861	-
SE	1721	3406	-
SSE	2073	6190	-
S	1764	**4010**	-
SSW	2129	**4363**	-
SW	2502	4920	-
WSW	1036	1152	-
W	982	3050	-
WNW	1331	5363	-
NW	1316	1316	-
NNW	864	**2502**	-

APPENDIX H DATA TABLES AND FIGURES

Table H-1 - Individual Dosimeter Stations at Sequoyah Nuclear Plant

Map Loc. No.	Station Number	Dir. (degrees)	Distance (miles)	Q1 2019	Q2 2019	Q3 2019	Q4 2019	Annual Exposure (mrem/yr)
				(mrem/qtr)				
3	SSW-1C	198	2.0	13.1	10.4	13.3	12.6	49.4
4	NE-1A	50	1.5	13.0	13.9	14.2	14.7	55.7
5	NNE-1	13	1.8	18.5	16.7	15.1	18.5	68.9
7	SW-2	227	3.8	13.4	14.3	11.2	12.3	51.3
8	W-3	280	5.6	13.0	8.2	10.0	12.3	43.5
9	SSW-3	203	8.7	15.0	13.8	14.8	15.3	58.9
10	WSW-2A	250	2.6	12.9	11.4	11.2	12.9	48.4
11	SW-3	228	16.7	13.5	15.3	16.7	16.9	62.4
12	NNE-4	32	17.8	15.4	17.2	14.8	19.0	66.3
13	ESE-3	117	11.3	15.0	9.6	11.7	13.1	49.4
14	NW-3	320	20.0	13.5	7.7	9.8	12.0	43.0
49	N-1	3	0.6	19.5	11.3	14.3	15.4	60.5
50	N-2	4	2.1	14.0	10.7	13.6	13.9	52.1
51	N-3	358	5.2	11.0	15.6	12.2	11.4	50.2
52	N-4	355	10.0	16.5	14.1	14.1	13.0	57.7
53	NNE-2	31	5.3	10.0	10.2	13.1	13.9	47.2
55	NE-1	38	2.4	15.0	13.2	15.0	12.3	55.5
56	NE-2	51	4.1	11.5	8.7	8.8	10.1	39.1
57	ENE-1	73	0.2	13.1	9.4	12.4	13.1	48.0
58	ENE-2	66	5.1	11.0	12.2	14.6	12.3	50.0
59	E-1	96	1.2	10.0	10.5	9.6	11.7	41.7
60	E-2	87	5.2	13.5	12.2	18.9	12.5	57.0
62	ESE-1	110	1.2	16.0	12.0	14.3	12.8	55.0
63	ESE-2	112	4.9	15.5	15.1	16.0	14.9	61.6
66	SE-1	131	1.4	9.5	11.0	9.1	10.1	39.7
67	SE-2	129	1.9	14.4	11.5	13.3	12.8	52.0
68	SE-4	136	5.2	16.5	12.7	15.5	15.6	60.3
69	SSE-1	154	1.6	10.5	N/A[a]	9.6	12.3	32.3
70	SSE-2	158	4.6	19.0	17.6	17.4	16.0	70.0
71	S-1	183	1.5	16.5	17.0	17.6	17.1	68.1
72	S-2	185	4.7	10.0	10.0	10.5	11.2	41.7
73	SSW-1	203	0.6	18.7	12.0	15.9	15.3	61.9
74	SSW-2	204	4.0	19.0	18.0	17.1	18.7	72.8
75	SW-1	228	0.7	17.0	16.3	17.0	16.0	66.2
76	WSW-1	241	0.9	19.0	14.8	16.3	16.2	66.3
77	WSW-2	238	2.5	14.5	10.4	6.9	10.6	42.4
78	WSW-3	248	5.7	12.5	13.5	16.3	16.0	58.3
79	WSW-4	244	7.8	13.0	11.1	11.5	12.8	48.3
81	W-1	260	0.6	21.5	18.7	18.9	19.7	78.8
82	W-2	275	4.3	8.5	7.5	10.7	11.2	37.9
83	WNW-1	292	0.4	17.0	14.8	14.6	14.9	61.3
84	WNW-2	295	5.3	12.0	9.9	9.0	10.9	41.8
85	NW-1	315	0.4	16.5	15.8	17.0	16.0	65.2
86	NW-2	318	5.2	15.5	13.3	14.8	11.4	55.1
87	NNW-1	344	0.6	15.0	13.2	14.6	14.4	57.2
88	NNW-2	342	1.7	11.5	10.9	12.2	11.2	45.7
89	NNW-3	334	5.3	10.0	11.4	12.6	12.3	46.3
90	SSW-1B	192	1.5	10.5	9.9	11.0	11.5	42.9

NOTES

a. Dosimeters at location SSE-1 during Q2 were lost in the field.

Table H-2 - Weekly Airborne Particulate Gross Beta

Sample Pathway (Measurement Unit)	Type and Number of Analysis Performed	Lower Limit of Detection (LLD)[a]	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
				Name, Distance and Direction	Mean (Range)		
Air Filter Inhalation (pCi/m³)	Gross Beta 622	0.01	0.037 (416/416) (0.012 – 0.091)	RM-1, 16.7 Mi. SW[b]	0.039 (52/52) (0.020 – 0.083)	0.037 (206/206) (0.018 – 0.086)	0

NOTES

a. LLD is the a priori limit as prescribed by the ODCM.

b. The location with the highest annual mean is a control location.

Figure H-1 - Average Beta Activity in Air Filters

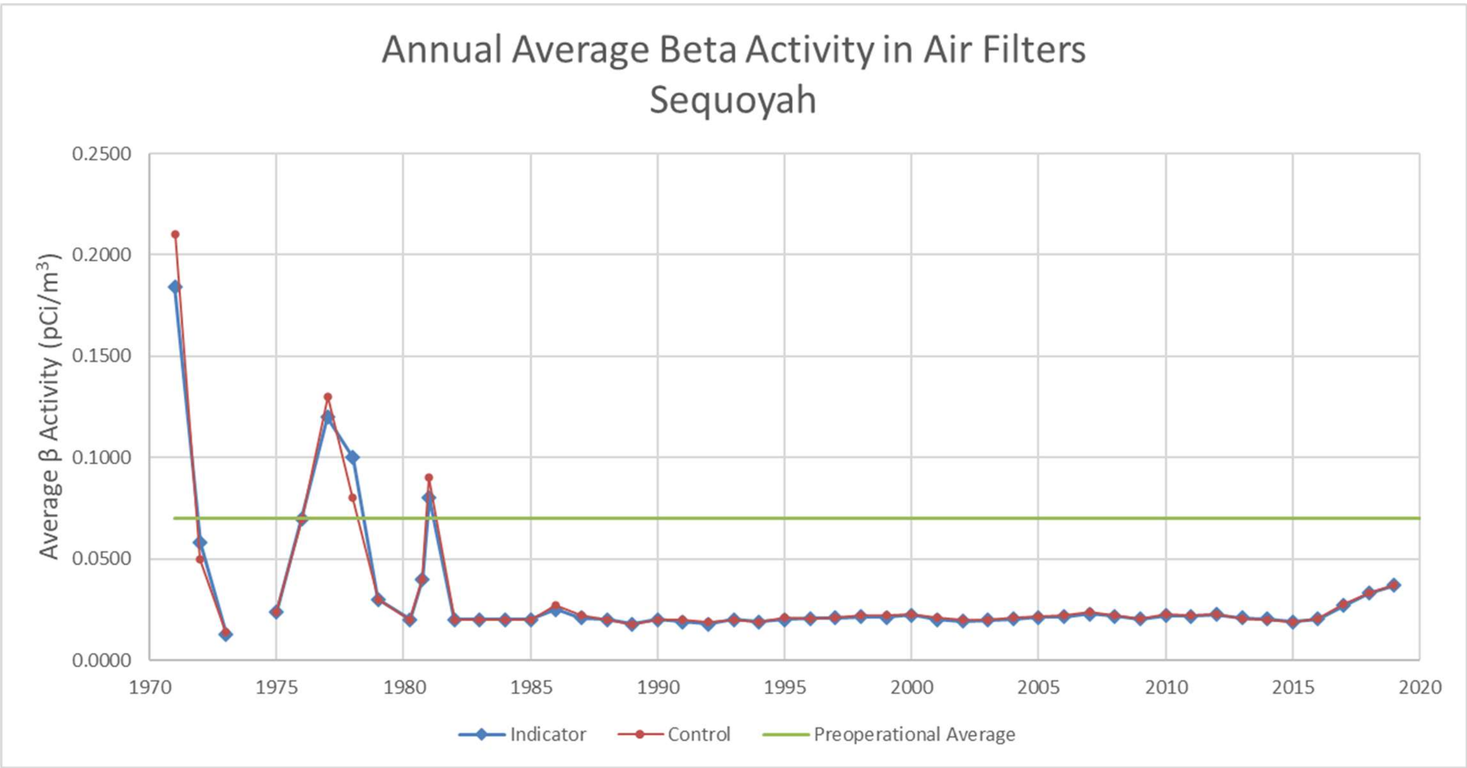


Table H-3 - Weekly Airborne I-131 Radioactivity

Sample Pathway [a] (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Activated Charcoal Inhalation (pCi/m³)	I-131	622	0.07	< LLD[a] (0/416)	< LLD	< LLD	< LLD (0/206)	0

NOTES
a. The term "< LLD" as used means that results had no identified activity above the minimum detectable.

Table H-4 - Quarterly Airborne Composite Particulate Gamma Radioactivity

Sample Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Air Filter Inhalation (pCi/m³)	Gamma Isotopic [a]	156	Various	< LLD[a] (0/104)	< LLD	< LLD	< LLD (0/52)	0

NOTES
a. Natural occurring radionuclides were observed in quarterly composite air samples in 2019.
b. See Table E-1 through Table E-4 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

Table H-5 – Monthly Vegetation Gamma Radioactivity

Sample Pathway [a] (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Vegetation Ingestion (pCi/m^3)	Gamma Isotopic [a]	12	Various	N/A	< LLD	< LLD	< LLD (0/12)	0

NOTES
a. Natural occurring radionuclides were observed in vegetation samples in 2019.

Table H-6 - Annual Soil Radioactivity

Sample Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Soil Direct Radiation (pCi/g)	Gamma Isotopic [a]	12	Various	< LLD[a] (0/8)	< LLD	< LLD	< LLD (0/4)	0
	Cs-137[b]	12	180	182 (5/8) 80 - 321	RM-2, 17.8 Mi. NNE[c]	333 (1/1) 333 – 333	156 (4/4) 80 - 333	0
	Sr-89	12	1.6	< LLD (0/8)	< LLD	< LLD	< LLD (0/4)	0
	Sr-90	12	0.4	< LLD (0/8)	< LLD	< LLD	< LLD (0/4)	0

NOTES
a. Natural occurring radionuclides were observed in soil samples in 2019.
b. Cs-137 is the only non-natural radionuclide positively identified as part of the gamma isotopic analysis
c. The location with the highest annual mean is a control location.

Table H-7 - Annual Local Crop Radioactivity

Sample Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Cabbage Ingestion (pCi/g)	Gamma Isotopic [a]	2	Various [b]	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Apples Ingestion (pCi/g)	Gamma Isotopic [a]	1	Various [b]	< LLD (0/2)	< LLD	< LLD	N/A	0
Pears Ingestion (pCi/g)	Gamma Isotopic [a]	2	Various [b]	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0
Potatoes Ingestion (pCi/g)	Gamma Isotopic [a]	2	Various [b]	N/A	< LLD	< LLD	< LLD (0/1)	0
Green Beans Ingestion (pCi/g)	Gamma Isotopic [a]	1	Various [b]	< LLD (0/2)	< LLD	< LLD	N/A	0
Tomatoes Ingestion (pCi/g)	Gamma Isotopic [a]	1	Various [b]	< LLD (0/1)	< LLD	< LLD	N/A	0

NOTES

a. Natural occurring radionuclides were observed in local crop samples in 2019.
b. See Table E-1 through Table E-4 for the required and nominal LLDs for individual radionuclides via gamma isotopic analysis.

Table H-8 - Monthly Surface Water Radioactivity

Sample Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Surface Water Direct Exposure (pCi/L)	Gamma Isotopic [a]	26	Various	< LLD (0/13)	< LLD	< LLD	< LLD (0/13)	0
	Tritium[b]	21	2000	< LLD (0/4)	TRM 503.8 [c]	448 (2/17) 348 - 547	448 (2/17) 348 - 547	0

NOTES
a. Natural occurring radionuclides were observed in surface water samples in 2019.
b. SQN ODCM requires quarterly tritium samples on surface water samples
c. The location with the highest annual mean is a control location.

Table H-9 - Monthly Public Drinking Water Radioactivity

Sample Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Drinking Water Ingestion (pCi/L)	Gross Beta	55	4.0	4.10 (4/42) 1.98 – 5.04	TRM 473.0	5.04 (1/16) 5.04 – 5.04	< LLD (0/13)	0
	Gamma Isotopic [a]	55	Various	< LLD[a] (0/42)	N/A	N/A	< LLD (0/13)	0
	Tritium	42	2000	< LLD (0/25)	TRM 503.8[b]	448 (2/17) 348 - 547	448 (2/17) 348 - 547	0

NOTES
a. Natural occurring radionuclides were observed in drinking water samples in 2019.
b. The location with the highest annual mean is the control location

Table H-10 - Quarterly Well (Ground) Water Radioactivity

Sample Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Ground Water Ingestion (pCi/L)	Gross Beta	8	4.0	< LLD (0/4)	Farm HW, 1.2 Mi., NW[b]	12.1 (4/4) 6.72 – 20.2	12.1 (4/4) 6.72 – 20.2	0
	Gamma Isotopic [a]	8	Various	< LLD[a] (0/4)	< LLD	< LLD	< LLD (0/4)	0
	Tritium	8	2000	< LLD (0/4)	< LLD	< LLD	< LLD (0/4)	0

NOTES

a. Natural occurring radionuclides were observed in ground water samples in 2019.

b. The location with the highest annual mean is a control location

Table H-11 - Semi-Annual Fish Radioactivity

Sample Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Game Fish – Large Mouth Bass Ingestion (pCi/kg)	Gamma Isotopic [a]	4	Various	< LLD[a] (0/2)	< LLD	< LLD	< LLD (0/2)	0
Commercial Fish - Channel Catfish Ingestion (pCi/kg)	Gamma Isotopic	4	Various	< LLD (0/3)	< LLD	< LLD	< LLD (0/1)	0
Commercial Fish – Blue Catfish Ingestion (pCi/kg)	Gamma Isotopic	2	Various	< LLD (0/1)	< LLD	< LLD	< LLD (0/1)	0

NOTES

a. Natural occurring radionuclides were observed in fish samples in 2019

Table H-12 - Semi-Annual Shoreline Sediment Radioactivity

Sample Pathway (Measurement Unit)	Type and Number of Analysis Performed		Lower Limit of Detection (LLD)	All Indicator Locations Mean (Count) Range	Location with Highest Annual Mean		All Control Locations Mean (Count) Range	Non-routine Reported Measurements
					Name, Distance and Direction	Mean (Range)		
Shoreline Sediment Direct Radiation (pCi/kg)	Gamma Isotopic [a]	6	Various	< LLD[a] (0/4)	< LLD	< LLD	< LLD (0/2)	0

NOTES

a. Natural occurring radionuclides were observed in shoreline sediment samples in 2019.

APPENDIX I ERRATA TO PREVIOUS ANNUAL ENVIRONMENTAL OPERATING REPORTS

Errata to Previous AREORs

The 2018 SQN Annual Radiological Environmental Operating Report (AREOR) incorrectly referenced BFN (Browns Ferry) instead of SQN in the discussion of the atmospheric monitoring results. On Page 13, the sentence should read:

"In 2017, GEL Laboratories, LLC took over radiochemistry analysis for the SQN REMP program."

This error was identified in CR#1524089.