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JUN 29 1990

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
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Gentlemen:

In the Matter of the Application of	)	Docket Nos. 50-390
Tennessee Valley Authority	)	50-391

WATTS BAR NUCLEAR PLANT (WBN) - ANNUAL RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT - 1989

Enclosed is a copy of the preoperational 1989 Annual Radiological Environmental Monitoring Report. This report was prepared by TVA and is being provided to you as information pertaining to environmental monitoring at WBN.

If there are any questions, please telephone R. J. Stevens of WBN Site Licensing at (615) 365-8650.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

for R. H. Shell

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Enclosure
cc: See page 2

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U.S. Nuclear Regulatory Commission

JUN 29 1990

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ANNUAL RADIOLOGICAL ENVIRONMENTAL MONITORING REPORT

WATTS BAR NUCLEAR PLANT

1989

TENNESSEE VALLEY AUTHORITY

NUCLEAR ASSURANCE AND SERVICES

CHEMISTRY AND RADIOLOGICAL SERVICES

May 1989

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EXECUTIVE SUMMARY

This report describes the preoperational environmental radiological monitoring program conducted by TVA in the vicinity of the Watts Bar Nuclear Plant (WBN) in 1989. The program includes the collection of samples from the environment and the determination of the concentrations of radioactive materials in the samples. Samples are taken from stations in the general area of the plant and from areas that will not be influenced by plant operations. Station locations are selected after careful consideration of the weather patterns and projected radiation doses to the various areas around the plant. Material sampled includes air, water, milk, foods, vegetation, soil, fish, sediment, and direct radiation levels. During plant operations, results from stations near the plant will be compared with concentrations from control stations and with preoperational measurements to determine potential impacts to the public.

The exposures calculated from environmental samples were contributed by naturally occurring radioactive materials, from materials commonly found in the environment as a result of atmospheric fallout, or from the operation of other nuclear facilities in the area. Since WBN has not operated, there has been no contribution of radioactivity from the plant to the environment.

INTRODUCTION

This report describes and summarizes a large volume of data, the results of thousands of measurements and laboratory analyses. The measurements are made to determine the existing background radioactivity levels in the area of WBN. Some of the data presented are prescribed by specific requirements, while other data are included which may be useful or interesting to individuals who do not work with this material routinely.

Naturally Occurring and Background Radioactivity

Most materials in our world contain trace amounts of naturally occurring radioactivity, and naturally occurring radioactive materials have always been in our environment. Approximately 0.01 percent of all potassium is radioactive potassium-40. Potassium-40 (K-40), with a half-life of 1.3 billion years, is one of the major types of radioactive materials found naturally in our environment. An individual weighing 150 pounds contains about 140 grams of potassium (reference 1). This is equivalent to approximately 100,000 pCi of K-40 which delivers a dose of 15 to 20 mrem per year to the bone and soft tissue of the body. Other examples of naturally occurring radioactive materials are bismuth-212 and 214, lead-212 and 214, thallium-208, actinium-228, uranium-238, uranium-235, thorium-234, radium-226, radon-222, carbon-14, and hydrogen-3 (generally called tritium). These naturally occurring radioactive materials are in the soil, our food, our drinking water, and our bodies.

The radiation from these materials makes up a part of the low-level natural background radiation. The remainder of the natural background radiation comes from outer space. We are all exposed to this natural radiation 24 hours per day.

The average dose equivalent at sea level resulting from radiation from outer space (part of natural background radiation) is about 27 mrem/year. This essentially doubles with each 6600-foot increase in altitude in the lower atmosphere. Another part of natural background radiation comes from naturally occurring radioactive materials in the soil and rocks. Because the quantity of naturally occurring radioactive material varies according to geographical location, the part of the natural background radiation coming from this radioactive material also depends upon the geographical location. Most of the remainder of the natural background radiation comes from the radioactive materials within each individual's body. We absorb these materials from the food we eat which contains naturally occurring radioactive materials from the soil. An example of this is K-40 as described above. Even building materials affect the natural background radiation levels in the environment. Living or working in a building which is largely made of earthen material, such as concrete or brick, will generally result in a higher natural background radiation level than would exist if the same structure were made of wood. This is due to the naturally occurring radioisotopes in the concrete or brick, such as trace amounts of uranium, radium, thorium, etc.

Because the city of Denver, Colorado, is over 5000 feet in altitude and the soil and rocks there contain more radioactive material than the U.S. average,

the people of Denver receive around 350 mrem/year total natural background radiation dose equivalent compared to about 295 mrem/year for the national average. People in some locations of the world receive over 1000 mrem/year natural background radiation dose equivalent, primarily because of the greater quantity of radioactive materials in the soil and rocks in those locations. Scientists have never been able to show that these levels of radiation have caused harmful effects to anyone.

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 below is primarily adapted from references 2 and 3.

U.S. GENERAL POPULATION AVERAGE DOSE EQUIVALENT ESTIMATES

Source	Millirem/Year Per Person	
Natural background dose equivalent		
Cosmic	27	
Cosmogenic	1	
Terrestrial	28	
In the body	39	
Radon	200	
Total		295
Release of radioactive material in natural gas, mining, milling, etc.		5
Medical (effective dose equivalent)		53
Nuclear weapons fallout		less than 1
Nuclear energy		0.28
Consumer products		0.03
Total		355 (approximately)

As can be seen from the table, natural background radiation dose equivalent to the U.S. population normally exceeds that from nuclear plants by several

hundred times. This indicates that nuclear plant operations normally result in a population radiation dose equivalent which is insignificant compared to that which results from natural background radiation.

Significant discussion recently has centered around exposures from radon. Radon is an inert gas given off as a result of the decay of naturally occurring radium-226 in soil. When dispersed in the atmosphere, radon concentrations are relatively low. However, when the gas is trapped in closed spaces, it can build up until concentrations become significant. The National Council of Radiation Protection and Measurements (reference 2) has estimated that the average annual effective dose equivalent from radon in the United States is approximately 200 mrem/year. This estimated dose is approximately twice the average dose equivalent from all other natural background sources.

SITE/PLANT DESCRIPTION

The WBN site is located in Rhea county, Tennessee, on the west bank of the Tennessee River at Tennessee River Mile (TRM) 528. Figure 1 shows the site in relation to other TVA projects. The WBN site, containing approximately 1770 acres on Chickamauga Lake, is about 1.25 miles south of the Watts Bar Dam and approximately 31 miles north-northeast of TVA's Sequoyah Nuclear Plant (SQN) site. Also located within the reservation are the Watts Bar Dam and Hydro-Electric Plant, the Watts Bar Steam Plant, and the Watts Bar Resort Area.

Approximately 12,000 to 15,000 people live within 10 miles of the WBN site. More than 80 percent of these live between 5 and 10 miles from the site. Two small towns, Spring City and Decatur, are located in this area. Spring City, with a population of approximately 2,000, is northwest and north-northwest from the site, while Decatur, with about 1,000 people, is south and south-southwest from the plant. The remainder of the area within 10 miles of the site is sparsely populated, consisting primarily of small farms.

The area between 10 and 50 miles from the site includes portions of the cities of Chattanooga and Knoxville. The largest urban concentration in this area is the city of Chattanooga, located to the southwest and south-southwest. The Chattanooga urbanized area has a population of over 250,000, with approximately 80 percent located between 40 and 50 miles from the site and the remainder located beyond 50 miles. The city of Knoxville is located to the east-northeast, with not more than 10 percent of its 200,000 plus people living within 50 miles of the site. Three smaller urban areas of greater than

20,000 people are located between 30 and 40 miles from the site. Oak Ridge is approximately 40 miles to the northeast, the twin cities of Alcoa and Maryville are located 45 to 50 miles to the east-northeast, and Cleveland is located about 30 miles to the south.

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

The WBN consists of two pressurized water reactors: each unit is rated at 1160 megawatts (electrical). Fuel load is currently scheduled for September 1991 for unit 1.

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM

The unique environmental concern associated with a nuclear power plant is its production of radioactive materials and radiation. The vast majority of this radiation and radioactivity is contained within the reactor itself or one of the other plant systems designed to keep the material in the plant. The retention of the materials in each level of control is achieved by system engineering, design, construction, and operation. Environmental monitoring is a final verification that the systems are performing as planned. The monitoring program is designed to most efficiently 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 environmental radiological monitoring program is outlined in appendix A.

There are two primary pathways by which radioactivity can move through the environment to humans: air and water (see 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 or on plants and 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.

To determine the amount of radioactivity in the environment prior to the operation of WBN, a preoperational environmental radiological monitoring program was initiated in December 1976 and continues to operate today. Measurements of the same types of radioactive materials that are expected from an operating plant are assessed during the preoperational phase to establish normal background levels for various radionuclides in the environment. This is very important in that during the 1950s, 60s, and 70s, atmospheric nuclear weapons testing occurred which released radioactive material to the environment causing fluctuations in the natural background radiation levels. This radioactive material is the same type as that which will be produced in the WBN reactors. Preoperational knowledge of natural radionuclide patterns in the environment will permit a determination, through comparison and trending analyses, of whether the operation of WBN is impacting the environment and thus the surrounding population. The determination of impact during the operating phase also considers the presence of control stations that have been established in the environment. Results of environmental samples taken at control stations (far from the plant) will be compared with those from indicator stations (near the plant) to aid in the determination of the impacts from WBN after the plant becomes operational.

A number of 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 such things as 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 from each. Modifications made to the program in 1989 are described in appendix B and exceptions to the sampling and analysis schedule are presented in appendix C.

All samples are analyzed by the radioanalytical laboratory of TVA's Environmental Radiological Monitoring and Instrumentation Department located at the Western Area Radiological Laboratory (WARL) in Muscle Shoals, Alabama. Analyses are conducted in accordance with written and approved procedures and are based on accepted methods. A summary of the analysis techniques and methodology is presented in appendix D. Data tables summarizing the sample analysis results are presented in appendix H.

The sophisticated radiation detection devices used to determine the radionuclide content of samples collected in the environment are generally quite sensitive to small amounts of radioactivity. In the field of radiation measurement, the sensitivity of the measurement process is discussed 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 radioanalytical laboratory employs a comprehensive quality assurance/ quality control program to monitor laboratory performance throughout the year. The program is intended to detect any problems in the measurement process as soon as possible so they can be corrected. This program includes

equipment checks to ensure that the complex radiation detection devices are working properly and the analysis of special samples which are included alongside routine environmental samples. A complete description of the program is presented in appendix F.

A land use survey is conducted periodically 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 a distance of 5 miles from the plant. From these data, radiation doses are projected for individuals living near the plant. Doses from breathing air (air submersion) are calculated for the nearest resident in each sector, while doses from drinking milk or eating foods produced near the plant are calculated for the areas with milk-producing animals and gardens, respectively. The doses projected as a result of the most recent (1986) land use survey are presented in appendix G.

DIRECT RADIATION MONITORING

Direct radiation levels are measured at a number of stations 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 as a result of plant operations. Because of the relatively large variations in background radiation as compared to the small levels from the plant, contributions from the plant may be difficult to distinguish.

Radiation levels measured in the area around the WBN site in 1989 were consistent with levels from previous years and with levels measured at other locations in the region.

Measurement Techniques

Direct radiation measurements are made with thermoluminescent dosimeters (TLDs). When certain materials are exposed to ionizing radiation, many of the electrons which become displaced are trapped in the crystalline structure of the material. They remain trapped for long periods of time as long as the material is not heated. When heated, the electrons are released, along with a pulse of light. A measurement of the intensity of the light is directly proportional to the radiation to which the material was exposed. Materials which display these characteristics are used in the manufacture of TLDs.

Since 1971 TVA has used a manganese activated calcium fluoride (Ca_2F:Mn) TLD material encased in a glass bulb. The bulb is placed in an energy

compensating shield to correct for energy dependence of the material. TLDs are placed approximately 1 meter above the ground, with two TLDs at each station. Sixteen stations are located around the plant near the site boundary, at least one station in each of the 16 sectors. Dosimeters are also placed at the perimeter and remote air monitoring sites and at 22 additional stations out to approximately 15 miles from the site. The TLDs are exchanged every 3 months and read with a Victoreen Model 2810 TLD reader. The values are corrected for gamma response, self-irradiation, and fading, with individual gamma response calibrations and self-irradiation factors determined for each TLD. The system meets or exceeds the performance specifications outlined in Regulatory Guide 4.13 for environmental applications of TLDs.

In 1989, TVA began the process of changing from the Victoreen dosimeter to the Panasonic Model UD-814 dosimeter. This dosimeter contains four elements consisting of one lithium borate and three calcium sulfate phosphors. The calcium sulfate phosphors are shielded by approximately 1000 mg/cm^2 plastic and lead to compensate for the over-response of the detector to low energy radiation. These dosimeters are deployed in the same manner as the bulb detectors described above. The accumulated exposure on the detectors is read with a Panasonic Model UD-710A automatic reader interfaced with a Hewlett Packard Model 9000 computer system. Since the calcium sulfate phosphor is much more sensitive than the lithium borate, the measured exposure is taken as the median of the results obtained from the nine calcium sulfate phosphors in three detectors. The values are corrected for gamma response, system variations, and transit exposure, with individual gamma response calibrations for each element. This system also meets or exceeds the performance

specifications outlined in Regulatory Guide 4.13 for environmental applications of TLDs.

Results

Results are normalized to a standard quarter (91.25 days or 2190 hours). The stations are grouped according to the distance from the plant. The first group consists of stations within 1 mile of the plant. The second group lies between 1 and 2 miles, the third group between 2 and 4 miles, the fourth between 4 and 6 miles, and the fifth group is made up of stations greater than 6 miles from the plant. Past data have shown that the results from stations greater than 2 miles from the plant are essentially the same. Therefore, for purposes of this report, stations 2 miles or less from the plant are identified as "onsite" stations and all others are considered "offsite."

The quarterly gamma radiation levels determined from the TLDs deployed around WBN in 1989 are given in table H-1. The rounded average annual exposures are shown below. For comparison purposes, the average direct radiation measurements made in the preoperational monitoring program are also shown.

Annual Average
Direct Radiation Levels
WBN
mR/year

	1989		Preoperational
	Victoreen	Panasonic	Average
Onsite Stations	75	62	81
Offsite Stations	67	55	69

The data in table H-1 indicate that the average quarterly radiation levels at the WBN onsite stations are approximately 2-4 mR/quarter higher

than levels at the offsite stations. This difference is also noted in the preoperational monitoring at the Browns Ferry and Sequoyah Nuclear Plants and at other nonoperating TVA nuclear power plant construction sites where the average levels onsite are generally 2-6 mR/quarter higher than levels offsite. The causes of these differences have not been isolated; however, it is postulated that the differences are probably attributable to combinations of influences such as natural variations in environmental radiation levels, earth-moving activities onsite, and the mass of concrete employed in the construction of the plant. Other undetermined influences may also play a part.

Figure H-1 compares plots of the data from the onsite or site boundary stations with those from the offsite stations over the period from 1977 through 1988. To reduce the variations present in the data sets, a 4-quarter moving average was constructed for each data set. Figure H-2 presents a trend plot of the direct radiation levels as defined by the moving averages. The data follow the same general trend as the raw data, but the curves are smoothed considerably.

The procedures for the handling and readout of the Panasonic dosimeters and calculating the exposure from the raw data generated by the dosimeters were being developed during the year. The data from the Panasonic dosimeters during the last two quarters of 1989 vary with the exposures calculated from the Victoreen dosimeters by 5 to 13 percent.

The results reported in 1989 are consistent with direct radiation levels reported in previous years.

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 areas of greatest wind frequency. Four perimeter air monitoring stations are located in communities out to about 12 miles from the plant, and two remote air monitors are located out to 20 miles. The remote stations are used as control or baseline stations. The program is designed to include samples of air particulates, gaseous radioiodine, heavy particle fallout, and rainwater.

As a result of delays in the scheduled fuel load date for WBN, the atmospheric monitoring program was discontinued for calendar year 1989. The annual averages of the gross beta activity in air particulate filters for the years 1977-1988 are presented in figure H-3. Increased levels due to fallout from atmospheric nuclear weapons testing are evident, especially in 1977, 1978, and 1981. Evidence of a small increase resulting from the Chernobyl accident can also be seen in 1986.

The full program was restarted in January 1990. The results from this program will be reported in the 1990 Annual Environmental Radiological Monitoring Report.

TERRESTRIAL MONITORING

Terrestrial monitoring is accomplished by collecting samples of environmental media that may transport radioactive material from the atmosphere to humans. For example, radioactive material may be deposited on a vegetable garden and be ingested along with the 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 in the milk and consumed by humans who drink the milk. Therefore, samples of milk, vegetation, soil, and food crops are collected and analyzed to determine potential impacts from exposure to this pathway. The results from the analysis of these samples are shown in tables H-2 through H-7.

Sample Collection and Analysis

Milk samples are purchased every 4 weeks from four indicator dairies and from at least one of three control dairies. Two of the control stations, which are also a part of the Sequoyah Nuclear Plant (SQN) monitoring program, are sampled every two weeks. Milk samples are placed on ice for transport to the radioanalytical laboratory. Gamma spectral, I-131, Sr-89, and Sr-90 analyses are performed on each sample.

Samples of vegetation are collected quarterly for I-131, gamma, and strontium analysis. For the first seven months of the year, samples were collected from the same locations as milk samples and from selected air monitoring stations. For the last five months, samples were collected from two of the farms. Samples were collected monthly from one control station, which is also a part

of the SQN monitoring program. The samples are collected by cutting or breaking enough vegetation to provide between 100 and 200 grams of sample. Care is taken not to include any soil with the vegetation. The sample is placed in a container with 1650 ml of 0.5 N NaOH for transport back to the radioanalytical laboratory. A second sample of between 750 and 1000 grams is also collected from each location. After drying and grinding, this sample is analyzed by gamma spectroscopy. Once each quarter, the sample is ashed after the gamma analysis is completed and analyzed for Sr-89,90.

Soil samples are collected annually from the air monitoring locations. 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 ashed and analyzed for Sr-89,90.

Samples representative of food crops raised in the area near the plant are obtained from individual gardens, corner markets, or cooperatives. Types of foods may vary from year to year as a result of changes in the local vegetable gardens. In 1989 samples of green beans and tomatoes were collected from local vegetable gardens. In addition, samples of apples were also obtained from the area. The edible portion of each sample is prepared as if it were to be eaten and is analyzed by gamma spectroscopy. After drying, grinding, and ashing, the sample is analyzed for gross beta activity.

Results

The results from the analysis of milk samples are presented in table H-2. All I-131 results were less than the established nominal LLD of 0.2 pCi/liter.

Cesium-137 was identified in two samples at levels up to 2 times the LLD. Strontium-90 was found in more than half of the samples. These levels are consistent with concentrations measured in samples collected in TVA's preoperational environmental radiological monitoring programs and with concentrations reported in milk as a result of fallout from atmospheric nuclear weapons tests (reference 1). The average Sr-90 concentration reported from indicator stations was 4.7 pCi/liter. An average of 2.4 pCi/liter was identified in samples from control stations. By far the predominate isotope reported in milk samples was the naturally occurring K-40. An average of approximately 1250 pCi/liter of K-40 was identified in all milk samples.

As has been noted in the environmental radiological monitoring reports for SQN, the levels of Sr-90 in milk samples from farms producing milk for private consumption only are up to six times the levels found in milk from commercial dairy farms. Samples of feed and water supplied to the animals were analyzed in 1979 in an effort to determine the source of the strontium. Analysis of dried hay samples indicated levels of Sr-90 slightly higher than those encountered in routine vegetation samples. Analysis of pond water indicated no significant strontium activity.

This phenomenon was observed during the preoperational radiological monitoring near SQN and near the Bellefonte Nuclear Plant at farms where only one or two cows were being milked for private consumption of the milk. It is postulated that the feeding practices of these small farms differ from those of the larger dairy farmers to the extent that fallout from atmospheric nuclear weapons testing may be more concentrated in these instances.

Similarly, Hansen, et al. (reference 4), reported an inverse relationship between the levels of Sr-90 in milk and the quality of fertilization and land management.

Results from the analysis of vegetation samples are presented in table H-3. Seven samples had I-131 values slightly higher than the nominal LLD. Cesium-137 was identified in one sample at a concentration of 27.7 pCi/kg. Strontium-90 levels averaged 108 pCi/kg from indicator stations and 237 pCi/kg from control stations. Again, the largest concentrations identified were for the naturally occurring isotopes K-40 and Be-7.

The only fission product identified in soil samples was Cs-137. The maximum concentration of Cs-137 was 1.4 pCi/g. This value is consistent with levels previously reported from fallout. All other radionuclides reported were naturally occurring isotopes (table H-4).

All radionuclides reported in food samples were naturally occurring. The maximum K-40 value was 2,190 pCi/kg in tomatoes. Gross beta concentrations for all indicator samples were consistent with the control values. The results are reported in tables H-5 through H-7.

AQUATIC MONITORING

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

Results from the analysis of aquatic samples are presented in tables H-8 through H-17. Radioactivity levels in water, fish, sediment, and clams were consistent with background and/or fallout levels previously reported.

Sample Collection and Analysis

Samples of surface water are collected from the Tennessee River using automatic sampling pumps from two downstream stations and one upstream station. A timer turns on the pump at least once every 2 hours. The line is flushed and a sample collected into a composite container. A 1-gallon sample is removed from the container at 4-week intervals and the remaining water is discarded. The samples are composited quarterly and analyzed by gamma spectroscopy and for gross beta and tritium activity.

Samples are also collected by an automatic sampling pump at the first downstream drinking water intake. These samples are collected in the same manner as the surface water samples. These quarterly composites are analyzed

by gamma spectroscopy and for gross beta, Sr-89, Sr-90, and tritium activity. The downstream stations are also analyzed for I-131 content. The samples collected by the automatic pumping device are taken directly from the river at the intake structure. Since the sample at this point is raw water, not water processed through the water treatment plant, the control sample should also be unprocessed water. Therefore, the upstream surface water sample is also considered as a control sample for drinking water.

Groundwater is sampled from an onsite well and from a private well in an area unaffected by WBN. The samples are analyzed quarterly by gamma spectroscopy and for tritium content.

Samples of commercial and game fish species are collected semiannually from each of three reservoirs: the reservoir on which the plant is located (Chickamauga Reservoir), the upstream reservoir (Watts Bar Reservoir), and the downstream reservoir (Nickajack Reservoir). The samples are collected using a combination of netting techniques and electrofishing. Most of the fish are filleted, but one group is processed whole for analysis. After drying and grinding, the samples are analyzed by gamma spectroscopy. The sample is then ashed and analyzed for gross beta activity.

Bottom sediment is collected semiannually from selected TRM locations using a dredging apparatus. Samples of shoreline sediment are also taken from recreation areas in the vicinity of the plant. The samples are dried and ground and analyzed by gamma spectroscopy. After this analysis is complete, the samples are ashed and analyzed for Sr-89,90.

Samples of Asiatic clams are collected semiannually from three of the same locations as the bottom sediment. The clams are usually collected in the dredging process with the sediment. However, at times the clams are difficult to find and divers must be used. Even then, sufficient quantities of clams are not always found. When available, enough clams are collected to produce approximately 50 grams of wet flesh. The flesh is separated from the shells, and the dried flesh samples are analyzed by gamma spectroscopy.

Results

Tritium was identified in two surface water samples. Gross beta activity was present in most samples. A trend plot of the gross beta activity in surface water samples from 1977 through 1989 is presented in figure H-4. Strontium-89 was identified in three samples. With a half-life of approximately 60 days, Sr-89 cannot be present in the environment as a result of plant operations or previous nuclear weapons testing. The positive identification of Sr-89 is an artifact of the calculational process and the low concentrations the laboratory is attempting to detect. A summary table of the results is shown in table H-8.

For public water, average gross beta activity was 2.7 pCi/liter at the downstream stations and 2.8 pCi/liter at the control stations. Tritium was identified in one sample at a concentration slightly above the LLD. Sr-89 was also identified in three samples. As noted earlier, the positive identification of Sr-89 is an artifact of the calculational process and the low concentrations the laboratory is attempting to detect.

The results are shown in table H-9 and a trend plot of the gross beta activity in drinking water from 1977 to the present is presented in figure H-5.

Concentrations of fission and activation products in ground water were all below the LLDs. Only naturally occurring radionuclides were identified in these samples. The results are presented in table H-10.

Cesium-137 was identified in 5 fish samples. The downstream samples contained a maximum of 0.10 pCi/g, while the upstream sample had a maximum of 0.21 pCi/g. Other radioisotopes found in fish were naturally occurring, with the most notable being K-40. The concentrations of K-40 ranged from 4.0 pCi/g to 17.2 pCi/g. These results, which are summarized in tables H-11, H-12, H-13, and H-14, indicate that the Cs-137 activity is probably a result of fallout or other upstream effluents.

Radionuclides of the types produced by nuclear power plant operations were identified in sediment samples. The materials identified were Cs-137 and Co-60. In bottom sediment samples the average levels of Cs-137 were 0.50 pCi/g in downstream samples and 2.78 pCi/g upstream. In shoreline sediment, Cs-137 levels were 0.19 and 0.17 pCi/g, respectively, in downstream and upstream samples. These values are consistent with previously identified levels. Trend plots of the average Cs-137 and Co-60 concentrations in bottom sediment samples are presented in figures H-6 and H-7, respectively.

In bottom sediment, Co-60 concentrations in downstream samples averaged 0.05 pCi/g while levels in upstream samples averaged 0.08 pCi/g. Co-60 was not identified in shoreline sediment samples. Strontium-90 was also identified in one shoreline sediment sample at a level slightly above the LLD. Results from the analysis of bottom sediment and shoreline sediment samples are shown in tables H-15 and H-16 respectively.

Only naturally occurring radioisotopes were identified in clam flesh samples. The concentrations are shown in table H-17.

ASSESSMENT AND EVALUATION

For operating nuclear power plants, potential doses to the public are estimated from measured effluents using computer models. These models were developed by TVA and are based on guidance provided by the NRC in Regulatory Guide 1.109 for determining the potential dose to individuals and populations living in the vicinity of the plant.

The area around the plant is analyzed to determine the pathways through which the public may receive an exposure. As indicated in figure 2, the two major ways by which radioactivity is introduced into the environment are through liquid and gaseous effluents.

For liquid effluents, the public can be exposed to radiation from three sources: drinking water from the Tennessee River, eating fish caught in the Tennessee River, and direct exposure to radioactive material due to activities on the banks of the river (recreational activities). For gaseous effluents, the public can be exposed to radiation from several sources: direct radiation from the radioactivity in the air, direct radiation from radioactivity deposited on the ground, inhalation of radioactivity in the air, ingestion of vegetation which contains radioactivity deposited from the atmosphere, and ingestion of milk or meat from animals which consumed vegetation containing deposited radioactivity.

The results from each sample are compared with the concentrations from the corresponding control stations to establish the relationship between these

stations during the preoperational phase of the monitoring program. During this report period, Cs-137 and Sr-90 were found in milk and vegetation samples from both indicator and control stations. Cesium-137 was also identified in all soil samples. Co-60 and Cs-137 were seen in aquatic media. Cs-137 in fish and sediment is consistent with fallout levels identified in samples both upstream and downstream from the plant. Co-60 was identified in sediment samples upstream and downstream from the plant. No increases of radioactivity have been seen in water samples.

Dose estimates were made from concentrations of radioactivity found in samples of environmental media. Media evaluated include, but are not limited to, air, milk, food products, drinking water, and fish. Inhalation and ingestion doses estimated for persons at the indicator locations were essentially identical to those determined for persons at control stations. Concentrations of Sr-90 and Cs-137 are consistent with levels measured in TVA's preoperational environmental radiological monitoring programs.

Conclusions

Since WBN has not achieved criticality, there has been no contribution of radioactivity from the plant to the environment. The levels of radioactivity reported in this document are due to natural background radiation, fallout from nuclear weapons testing, fallout from the Chernobyl nuclear power station accident, or other nuclear operations in the area.

REFERENCES

1. Merril Eisenbud, Environmental Radioactivity, Academic Press, Inc., New York, NY, 1987.

2. National Council on Radiation Protection and Measurements, Report No. 93, "Ionizing Radiation Exposure of the Population of the United States," September 1987.

3. United States Nuclear Regulatory Commission, Regulatory Guide 8.29, "Instruction Concerning Risks From Occupational Radiation Exposure," July 1981.

4. Hansen, W. G., Campbell, J. E., Fooks, J. H., Mitchell, H. C., and Eller, C. H., Farming Practices and Concentrations of Emission Products in Milk, U.S. Department of Health, Education, and Welfare; Public Health Service Publication No. 999-R-6, May 1964.

Table 1

MAXIMUM PERMISSIBLE CONCENTRATIONS

FOR NONOCCUPATIONAL EXPOSURE

	MPC	
	In Water pCi/l*	In Air pCi/m^3*
Gross beta	3,000	100
H-3	3,000,000	200,000
Cs-137	20,000	500
Ru-103,106	10,000	200
Ce-144	10,000	200
Zr-95 - Nb-95	60,000	1,000
Ba-140 - La-140	20,000	1,000
I-131	300	100
Zn-65	100,000	2,000
Mn-54	100,000	1,000
Co-60	30,000	300
Sr-89	3,000	300
Sr-90	300	30
Cr-51	2,000,000	80,000
Cs-134	9,000	400
Co-58	90,000	2,000

*1 pCi = 3.7×10^{-2} Bq.

Source: 10 CFR, Part 20, Appendix B, Table II.

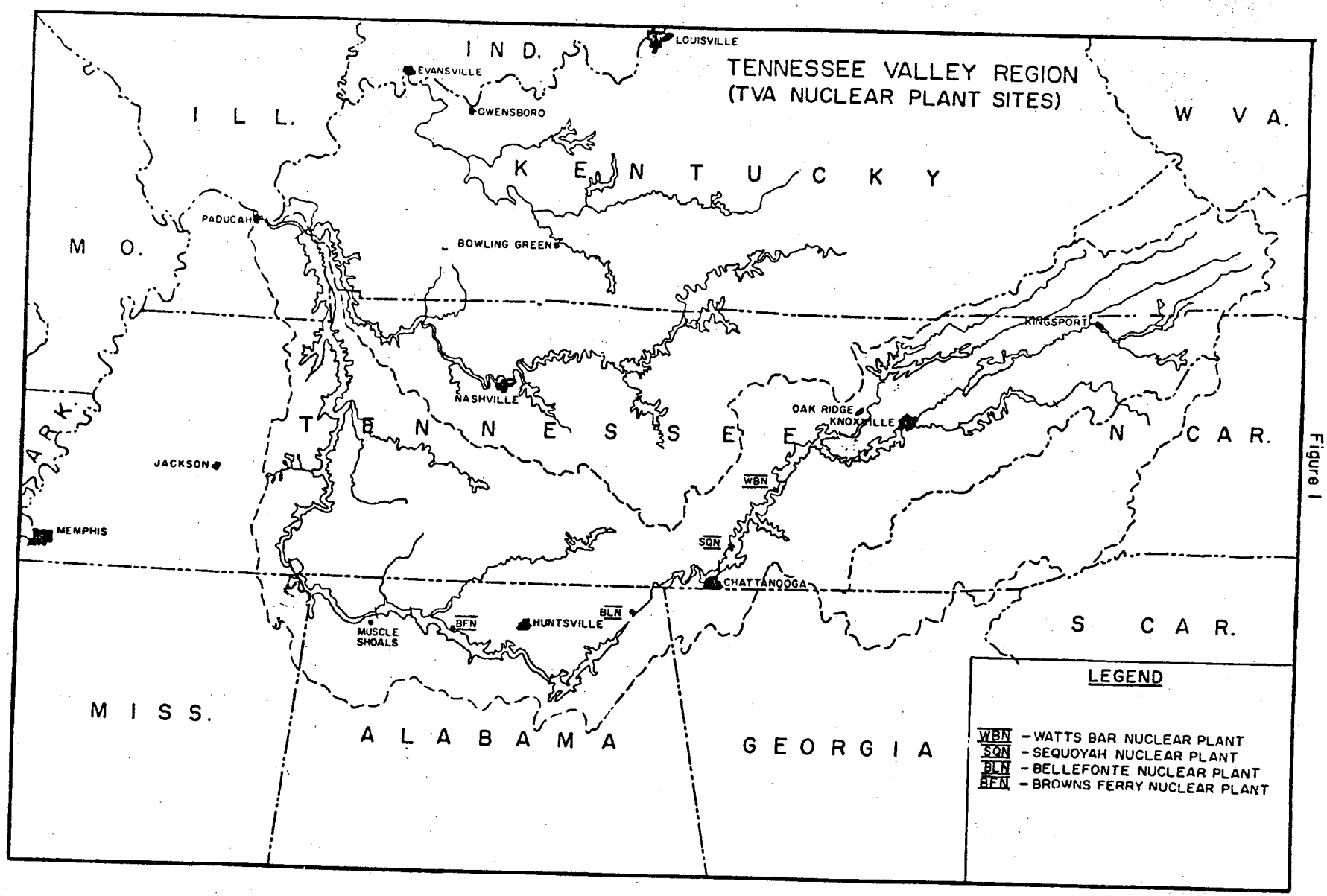
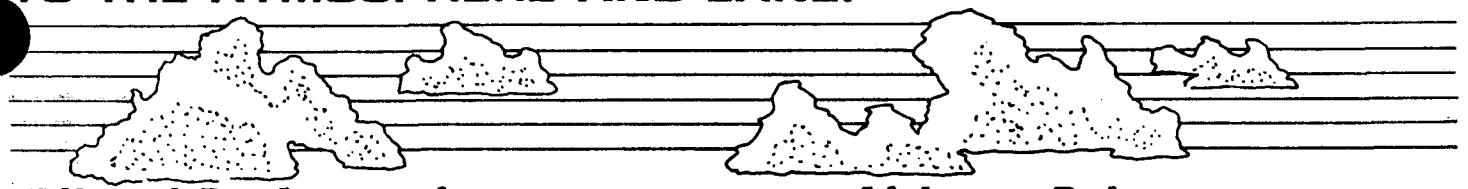

TENNESSEE VALLEY REGION
(TVA NUCLEAR PLANT SITES)
LOUISVILLE
EVANSVILLE
OWENSBORO
PADUCAH
BOWLING GREEN
KINGSPORT
NASHVILLE
OAK RIDGE
KNOXVILLE
JACKSON
MEMPHIS
WBN
SQN
CHATTANOOGA
MUSCLE SHOALS
BFN
HUNTSVILLE
BLN
IND.
ILL.
W VA.
KENTUCKY
MO.
ARK.
TENNESSEE
N CAR.
S CAR.
MISS.
ALABAMA
GEORGIA
LEGEND
WBN - WATTS BAR NUCLEAR PLANT
SQN - SEQUOYAH NUCLEAR PLANT
BLN - BELLEFONTE NUCLEAR PLANT
BFN - BROWNS FERRY NUCLEAR PLANT

Figure 1

ENVIRONMENTAL EXPOSURE PATHWAYS OF MAN DUE TO RELEASES OF RADIOACTIVE MATERIAL TO THE ATMOSPHERE AND LAKE.

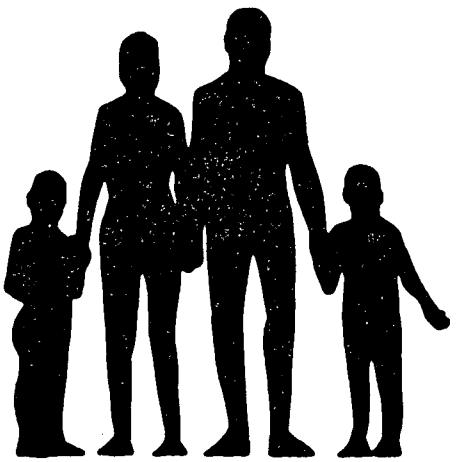


Diluted By Atmosphere

Airborne Releases

Plume Exposure

Liquid Releases Diluted By Lake



MAN

Animals (Milk,Meat)

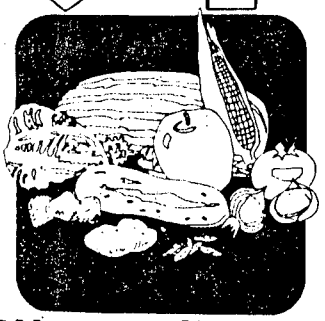
Consumed By Man

Shoreline Exposure

Consumed By Animals

Drinking Water

Fish



Vegetation Uptake From Soil

APPENDIX A

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM AND

SAMPLING LOCATIONS

Table A-1

WATTS BAR NUCLEAR PLANT
ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM[a]

Exposure Pathway and/or Sample	Number of Samples and Locations[b]	Sampling and Collection Frequency	Type and Frequency of Analysis
1. AIRBORNE			
a. As a result of delays in the scheduled fuel load date, collection of air particulate, radioiodine, fallout, and rainwater samples was discontinued for 1989.			
b. Soil	Samples from same locations as air particulates	Once per year	Gamma scan, Sr-89, Sr-90 once per year
2. DIRECT	Two or more dosimeter at a location on or near site boundary in each of the 16 metrological sectors and at two local atmospheric monitoring stations (LM-3 and LM-4)	At least once per 92 days	Gamma dose at least once per 92 days
	Two or more dosimeters at each of the perimeter and remote atmospheric monitoring stations (PM-2, PM-3, PM-4, PM-5, RM-2 and RM-3)		
	Two or more dosimeters in at least 20 additional locations of special interest.		
3. WATERBORNE			
a. Surface	Two samples downstream from plant discharge (TRM 517.9 and TRM 523.1)	Collected by automatic sequential-type sampler[c] with composite sample collected quarterly	Gross beta, gamma scan, Sr-89, Sr-90, and tritium on each composite.
	One sample at a control location upstream from plant discharge (TRM 529.3)		
b. Ground	One sample adjacent to plant (well No. 1)	Collected by automatic sequential-type sampler[c] with composite sample collected quarterly	Gamma scan and tritium on each sample.
	One sample from ground water source upgradient (Farm L)	Grab sample quarterly days	

Table A-1 (Continued)

WATTS BAR NUCLEAR PLANT
ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM[a]

Exposure Pathway and/or Sample	Number of Samples and Locations[b]	Sampling and Collection Frequency	Type and Frequency of Analysis
c. Drinking	One sample at the first two potable surface water supplies downstream from the plant (TRM 503.8 and TRM 473.0 One sample at a control location (TRM 529.3[d])	Collected by automatic sequential-type sampler[c] with composite sample analyzed at least quarterly[e]	Gross beta, I-131, and gamma scan on each composite. Quarterly composite also analyzed for tritium, Sr-89, and Sr-90
4. AQUATIC			
a. Sediment	One sample in the immediate downstream area of plant discharge (TRM 527.4) One additional sample downstream of plant discharge (TRM 496.5) One sample at a control location upstream from plant discharge (TRM 532.1)	At least once per 184 days	Gamma scan, Sr-89, and Sr-90 analyses of each sample
b. Sediment from shoreline	One sample downstream from plant discharge (TRM 513.0) One sample from a control location upstream from plant discharge (TRM 530.2)	At least once per 184 days	Gamma scan, Sr-89 and Sr-90 analyses on each sample

Table A-1 (Continued)

WATTS BAR NUCLEAR PLANT
ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM[a]

Exposure Pathway and/or Sample	Number of Samples and Locations[b]	Sampling and Collection Frequency	Type and Frequency of Analysis
5. INGESTION			
a. Milk	Four samples from farms and/or dairies in the immediate vicinity of the plant (Farms L, H., Mo, and Mu)	Monthly	Gamma scan, I-131, Sr-89, and Sr-90 analysis on each sample
	One or more samples from control locations Farm B	Monthly	Gamma scan, I-131, Sr-89, and Sr-90 analysis on each sample
	Farms C and/or S (Also used at SQN)	Every 2 weeks	Gamma scan and I-131 analysis on each sample. Sr-89 and Sr-90 monthly.
b. Fish	One sample each of a commercially and a recreationally important species from Nickajack, Chickamauga, and Watts Bar Reservoirs	At least once per 184 days. At least two of the following species shall be sampled: Channel Catfish, Crappie Small Mouth Buffalo	Gamma scan on edible portions.
c. Clams	One sample in the immediate downstream area of the plant discharge (TRM 527.4) One additional sample downstream of the plant discharge (TRM 496.5) One sample at a control location upstream from the plant discharge (TRM 532.1)	At least once per 184 days	Gamma scan on flesh only

Table A-1 (Continued)

WATTS BAR NUCLEAR PLANT
ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM[a]

Exposure Pathway and/or Sample	Number of Samples and Locations[b]	Sampling and Collection Frequency	Type and Frequency of Analysis
d. Vegetation (Pasturage and grass)	One samples from two locations of milk-producing animals (Farms L and Mo)	At least quarterly	Gamma scan, I-131, Sr-89, and Sr-90 on each sample
	One sample from a control location (Farm S; also used for SQN)	Monthly	Gamma scan and I-131 on each sample Sr-89, Sr-90 analyses at least once per 92 days
e. Food Products	One sample each of principal food products grown at private gardens and/or farms in the immediate vicinity of the plant One sample of each of the same foods grown at distances of greater than 10 miles from the plant	Annually at time of harvest. The types of foods available for sampling will vary. Following is a list of typical foods which may be available: Cabbage and/or Lettuce Corn Green Beans Potatoes Tomatoes	Gamma scan on edible portion

a. The sampling program outlined in this table is that which was in effect at the end of 1989.
b. Sample locations are shown on Figures A-1, A-2, and A-3.
c. Samples shall be collected by collecting an aliquot at intervals not exceeding 2 hours.
d. The sample collected at TRM 503.8 is taken from the raw water supply, therefore, the upstream surface water sample will be considered the control sample for drinking water.
e. The two downstream sampling stations are also part of the Sequoyah Nuclear Plant (SQN) monitoring program. Samples from these stations were analyzed monthly.

Table A-2

WATTS BAR NUCLEAR PLANT
ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM
SAMPLING LOCATIONS

Map[a] Location Number	Station	Sector	Approximate Distance (miles)	Indicator (I) or Control (C)	Samples Collected[b]
2	PM-2	NW	7.0	I	S
3	PM-3	NNE	10.4	I	S
4	PM-4	NE/ENE[d]	7.6	I	S
5	PM-5	S	6.2	I	S
6	RM-2	SW	15.0	C	S
7	RM-3	NNW	15.0	C	S,V[c]
8	LM-1	SSW	0.5	I	S,V[c]
9	LM-2	N	0.5	I	S,V[c]
10	LM-3	NNE	1.9	I	S,V[c]
11	LM-4	SE	0.9	I	S,V[c]
12	Farm L	SSW	1.3	I[e]	M,V,W
13	Farm Mo	NW	4.6	I	M,V
14	Farm H	W	4.8	I	M,V[c]
15	Farm B	E	15.0	C	M
16	Farm C	SSW	16.0	C	M
17	Farm S	SW	19.5	C	M,V
18	Well #1	S	0.6	I	W
19	Farm Mu	ESE	3.7	I	M,V[c]
25	TRM 517.9	--	9.9[f]	I	SW
26	TRM 523.1	--	4.7[f]	I	SW
27	TRM 529.3	--	1.5[f]	C	SW
28	TRM 532.1	--	4.3[f]	C	CL,SD
29	TRM 527.4	--	0.4[f]	I	CL,SD
31	TRM 473.0 (C.F. Industries)	--	54.8[f]	I	PW
32	TRM 513.0	--	14.8[f]	I	SS
33	TRM 530.2	--	2.4[f]	C	SS
35	TRM 503.8 (Dayton)	--	24.0[f]	I	PW
36	TRM 496.5	--	31.3[f]	I	CL,SD
37	TRM 425-471 (Nickajack Lake)	--	--	I	F

Table A-2 (Continued)

WATTS BAR NUCLEAR PLANT
ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM
SAMPLING LOCATIONS

Map[a] Location Number	Station	Sector	Approximate Distance (miles)	Indicator (I) or Control (C)	Samples Collected[b]
38	TRM 471-530 (Chickamauga Lake)	--	--	I	F
39	TRM 530-602 (Watts Bar Lake)	--	--	C	F

a. See figures A-1, A-2, and A-3.
b. Sample codes:

AP = Air particulate filter	R = Rainwater
CF = Charcoal filter	S = Soil
CL = Clams	SD = Sediment
F = Fish	SS = Shoreline sediment
FO = Fallout	SW = Surface water
M = Milk	V = Vegetation
PW = Public water	W = Well water

c. Vegetation sampling discontinued in August 1989.
d. Station located on boundary between these sectors.
e. A control for well water.
f. Distance from plant discharge (TRM 527.8).

Table A-3

WATTS BAR NUCLEAR PLANT
THERMOLUMINESCENT DOSIMETER (TLD) LOCATIONS

Map[a] Location Number	Station	Sector	Approximate Distance (miles)	Onsite (On)[b] or Offsite (Off)
2	NW-3	NW	7.0	Off
3	NNE-3	NNE	10.4	Off
4	ENE-3	ENE	7.6	Off
5	S-3	S	6.2	Off
6	SW-3	SW	15.0	Off
7	NNW-4	NNW	15.0	Off
10	NNE-1A	NNE	1.9	Off
11	SE-1A	SE	0.9	On
12	SSW-2	SSW	1.3	On
14	W-2	W	4.8	Off
15	E-3	E	15.0	Off
40	N-1	N	1.2	On
41	N-2	N	4.7	Off
42	NNE-1	NNE	1.2	On
43	NNE-2	NNE	4.1	Off
44	NE-1	NE	0.9	On
45	NE-2	NE	2.9	Off
46	NE-3	NE	6.1	Off
47	ENE-1	ENE	0.7	On
48	ENE-2	ENE	5.8	Off
49	E-1	E	1.3	On
50	E-2	E	5.0	Off
51	ESE-1	ESE	1.2	On
52	ESE-2	ESE	4.4	Off
53	SE-1	SE	0.6	On
54	SE-2	SE	5.3	Off
55	SSE-1	SSE	0.6	On
56	SSE-2	SSE	5.8	Off
57	S-1	S	0.7	On
58	S-2	S	4.8	Off
59	SSW-1	SSW	0.8	On
60	SSW-3	SSW	5.0	Off
62	SW-1	SW	0.8	On
63	SW-2	SW	5.3	Off
64	WSW-1	WSW	0.9	On
65	WSW-2	WSW	3.9	Off
66	W-1	W	0.9	On
67	WNW-1	WNW	0.9	On

Table A-3 (Continued)

WATTS BAR NUCLEAR PLANT
THERMOLUMINESCENT DOSIMETER (TLD) LOCATIONS

Map[a] Location Number	Station	Sector	Approximate Distance (miles)	Onsite (On)[b] or Offsite (Off)
68	WNW-2	WNW	4.9	Off
69	NW-1	NW	1.1	On
70	NW-2	NW	4.7	Off
71	NNW-1	NNW	1.0	On
72	NNW-2	NNW	4.5	Off
73	NNW-3	NNW	7.0	Off

a. See figures A-1, A-2, and A-3.
b. TLDs designated onsite are those located 2 miles or less from the plant. TLDs designated offsite are those located more than 2 miles from the plant.

Figure A-1

Environmental Radiological Sampling Locations
Within 1 Mile of Plant

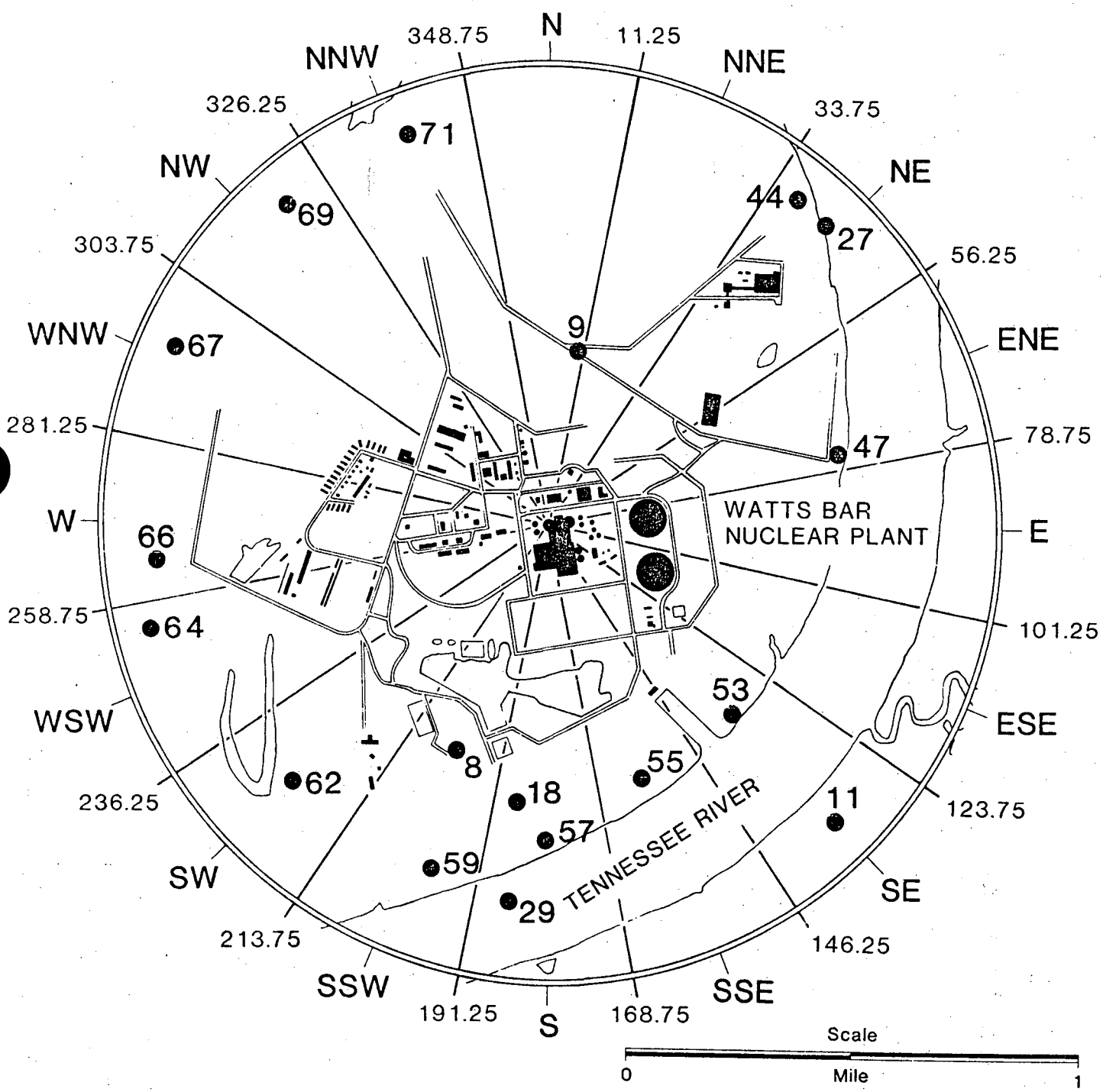


Figure A-2

Environmental Radiological Sampling Locations
From 1 to 5 Miles From The Plant

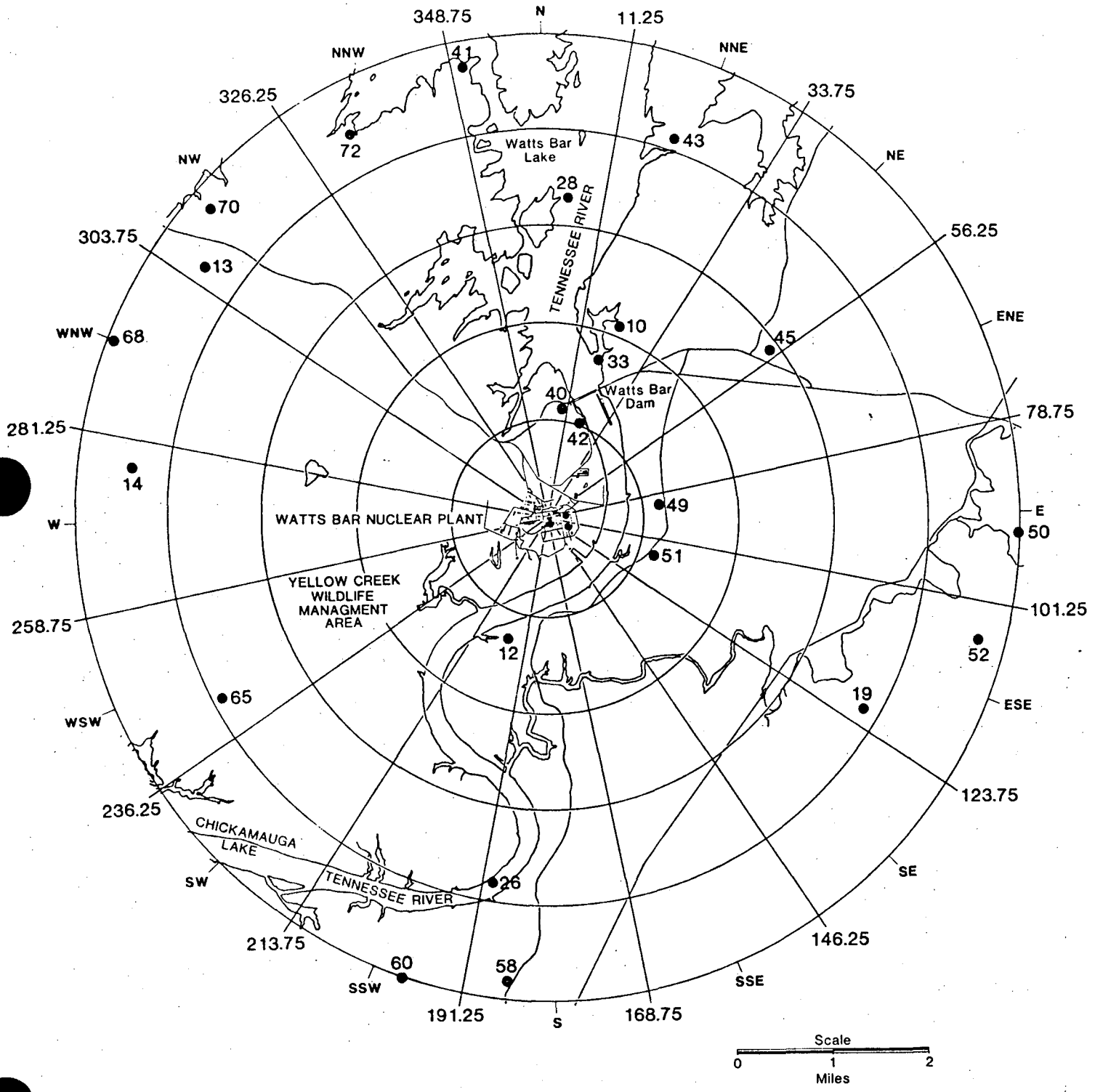
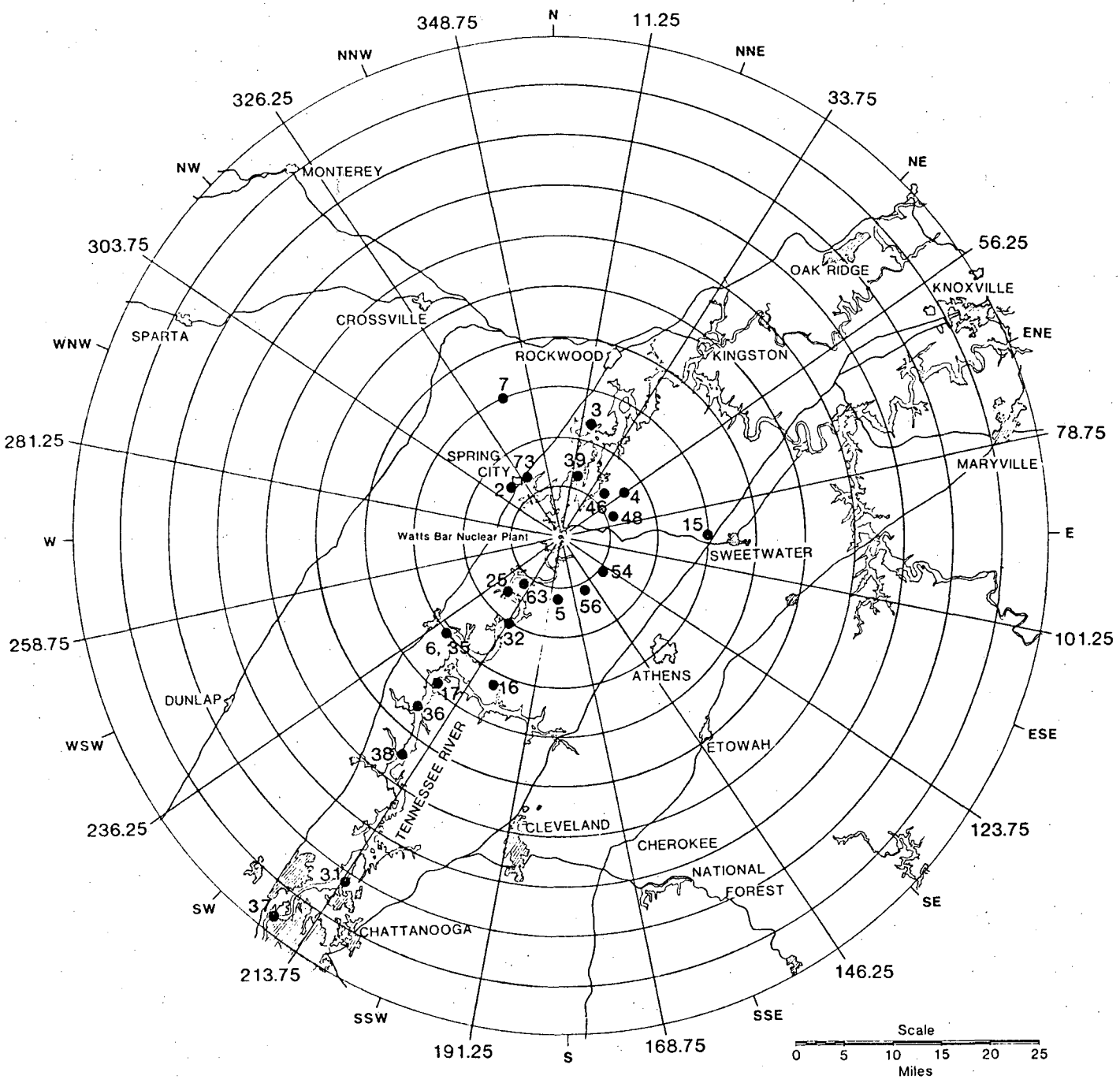


Figure A-3

Environmental Radiological Sampling Locations
Greater Than 5 Miles From The Plant



APPENDIX B

1989 PROGRAM MODIFICATIONS

Appendix B

1989 Program Modifications

During 1989, significant modifications were made in the WBN environmental radiological monitoring program as a result of delays in the scheduled date for loading fuel into the reactors. The collection of all atmospheric samples was discontinued, the frequency for collecting milk samples was reduced from semimonthly to monthly, and the frequency of all sampling previously performed monthly was reduced to quarterly. All quarterly, semiannual, and annual sampling continued as before. The full monitoring program was resumed January 1, 1990.

In addition, the number of vegetation (grass) samples was reduced. Results from the program over the past several years indicate that air and milk samples provide an earlier indication of changes in envrionemntal concentrations than do the vegetation samples. Therefore, vegetation sampling has been discontinued at all but three stations.

Table B-1

WATTS BAR NUCLEAR PLANT
Environmental Radiological Monitoring Program Modifications
1990

Date	Sample Type	Station(s)	Modification
1/1/89	Air Particulate Charcoal Filter Fallout Rainwater	All	Discontinue the collection of these samples for calendar year 1989.
1/1/89	Surface Water Well Water	All	Sampling frequency changed from monthly to quarterly.
1/1/89	Milk	Farm L Farm Mo Farm H Farm B Farm Mu	Sampling frequency changed from once per 2 weeks to once per 4 weeks.
1/1/89	Vegetation	All	Sampling frequency changed from monthly to quarterly.
8/3/89	Vegetation	LM- 1-4 RM- 3 Farm H Farm Mu	Sampling discontinued at these stations.

APPENDIX C

MISSED SAMPLES AND ANALYSES

Appendix C

Missed Samples and Analyses

During the 1989 sampling period, a small number of samples were not collected and several analyses were not completed on some collected samples. These occurrences resulted in deviations from the scheduled program.

The missed samples and analyses were the result of sample unavailability, the scarcity of sample media, and the loss of sample fractions as a result of insufficient chemical recovery during the separation process. A list of missed samples, analyses, causes, and remedies to prevent recurrence, where applicable, are found in table C-1.

Table C-1

Missed Samples and Analyses

Date	Station	Location	Remarks
2/8/89	Farm Mo	4.6 miles NW	Milk sample collected - Sample fraction lost when labware broke during strontium analysis.
4/4/89	Farm Mu	3.7 miles ESE	Milk sample collected - Sample fraction lost when inadvertently transferred to wrong container during strontium analysis.
8/23/89	Farm L	1.3 miles SSW	Vegetation sample collected - Sample fraction lost as a result of low chemical yield during I-131 analysis.
6/9/89	TRM 503.8	24.0 miles downstream	Drinking water sample collected. Additional volume used for I-131 analysis. Insufficient sample remained for gross beta analysis.
6/13/89	TRM 473.0	54.8 miles downstream	Drinking water sample collected. Additional volume used for I-131 analysis. Insufficient sample remained for gross beta analysis.
4/25/89	TRM 532.1	4.3 miles upstream	Insufficient clams available for sample. Clam population diminishing.
4/26/89	TRM 496.5	31.3 miles downstream	
11/9/89	TRM 527.4	0.4 miles downstream	Insufficient clams available for sample. Clam population diminishing.
12/1/89	TRM 496.5	31.3 miles downstream	

a. See table A-2 for locations.

APPENDIX D

ANALYTICAL PROCEDURES

APPENDIX D

Analytical Procedures

All analyses are performed by the radioanalytical laboratory located at the Western Area Radiological Laboratory facility in Muscle Shoals. All analysis procedures are based on accepted methods. A summary of the analysis techniques and methodology follows.

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 500 ml of samples to near dryness, transfering to a stainless steel planchet and completing the evaporation process. For solid samples, a specified amount of the sample is packed into a deep stainless steel planchet.

The specific analysis of I-131 in milk, water, or vegetation samples 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 100 minutes. With the beta-gamma coincidence counting system, background counts are virtually eliminated and extremely low levels of detection can be obtained.

After a radiochemical separation, samples analyzed for Sr-89,90 are counted on a low background beta counting system. The sample is counted a second time after a 7-day ingrowth period. 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 commerically available scintillation cocktail is used.

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 computer based multichannel analyzer system. Spectral data reduction is performed by the computer program HYPERMET.

All of 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.

APPENDIX E

NOMINAL LOWER LIMITS OF DETECTION (LLD)

Appendix E

Nominal Lower Limits of Detection

Sensitive radiation detection devices can give a signal or reading even when no radioactivity is present in a sample being analyzed. This signal may come from trace amounts of radioactivity in the components of the device, from cosmic rays, from naturally occurring radon gas, or from machine noise. Thus, there is always some sort of signal on these sensitive devices. The signal registered when no activity is present in the sample is called the background.

The point at which the signal is determined to represent radioactivity in the sample is called the critical level. This point is based on statistical analysis of the background readings from any particular device. However, any sample measured over and over in the same device will give different readings; some higher than others. The sample should have some well-defined average reading, but any individual reading will vary from that average. In order to determine the activity present in a sample that will produce a reading above the critical level, additional statistical analysis of the background readings is required. The hypothetical activity calculated from this analysis is called the lower limit of detection (LLD). A listing of typical LLD values that a laboratory publishes is a guide to the sensitivity of the analytical measurements performed by the laboratory.

Every time an activity is calculated for a sample, the machine background must be subtracted from the sample signal. For the very low levels encountered in environmental monitoring, the sample signals are often very close to the background. The measuring equipment is being used at the limit of its capability. For a sample with no measureable activity, which often happens, about half the time its signal should fall below the average machine background and half the time it should be above the background. If a signal above the background is present, the calculated activity is compared to the calculated LLD to determine if there is really activity present or if the number is an artifact of the way radioactivity is measured.

A number of factors influence the LLD, including sample size, count time, counting efficiency, chemical processes, radioactive decay factors, and interfering isotopes encountered in the sample. The most likely values for these factors have been evaluated for the various analyses performed in the environmental monitoring program. The nominal LLDs calculated from these values are presented in the following table.

Table E-1

Nominal LLD Values
A. Radiochemical Procedures

	Air Filters (pCi/m^3)	Charcoal Filters (pCi/m^3)	Water (pCi/L)	Milk (pCi/L)	Fish Flesh (pCi/g dry)	Whole Fish (pCi/g dry)	Food Crops (pCi/kg wet)	Sediment and Soil (pCi/g dry)
Gross Beta	0.002		1.7				9	
Tritium			250					
Iodine-131		.020	1.0	0.2				
Strontium-89	0.0006		3.0	2.5	0.3	0.7		1.0
Strontium-90	0.0003		1.4	2.0	0.04	0.09		0.3

	Wet Vegetation (pCi/kg Wet)	Clam Flesh (pCi/g Dry)	Meat (pCi/kg Wet)
Gross Beta		0.2	15
Iodine-131	4		
Strontium-89	140		
Strontium-90	60		

Table E-1

Nominal LLD Values
B. Gamma Analyses (GeLi)

	Air Particulates pCi/m3	Water and Milk pCi/L	Vegetation and Grain pCi/g, dry	Wet Vegetation pCi/kg, wet	Soil and Sediment pCi/g, dry	Fish pCi/g, dry	Clam Flesh pCi/g, dry	Foods, Tomatoes Potatoes, etc. pCi/kg, wet	Meat and Poultry pCi/kg, wet
Ce-141	.005	10	.07	28	.02	.07	.15	10	25
Ce-144	.01	33	.25	100	.06	.25	.50	33	50
Cr-51	.02	45	.45	180	.10	.45	.94	45	90
I-131	.005	10	.09	36	.02	.09	.18	10	20
Ru-103	.005	5	.05	20	.01	.05	.11	5	15
Ru-106	.02	40	.48	190	.09	.48	.95	40	95
Cs-134	.005	5	.07	28	.01	.07	.11	5	15
Cs-137	.005	5	.06	24	.01	.06	.10	5	15
Zr-95	.005	10	.11	44	.02	.11	.19	10	25
Nb-95	.005	5	.06	24	.01	.06	.11	5	15
Co-58	.005	5	.05	20	.01	.05	.10	5	15
Mn-54	.005	5	.05	20	.01	.05	.10	5	15
Zn-65	.005	10	.11	44	.01	.11	.21	10	25
Co-60	.005	5	.07	28	.01	.07	.11	5	15
K-40	.04	150	1.00	400	.20	1.00	2.00	150	300
Ba-140	.01	25	.23	92	.05	.23	.47	25	50
La-140	.005	8	.11	44	.02	.11	.17	8	20
Fe-59	.005	5	.10	40	.01	.10	.13	5	15
Be-7	.02	45	.50	200	.10	.50	.90	45	100
Pb-212	.005	20	.10	40	.02	.10	.25	20	40
Pb-214	.005	20	.20	80	.02	.20	.25	20	40
Bi-214	.005	20	.12	48	.04	.12	.25	20	40
Bi-212		53	.40	40	.25	.40		53	
Tl-208	.001	7	.03	26	.02	.03	.35	7	
Ra-224					.30				
Ra-226					.05				
Ac-228	.014	25	.10	80	.10	.10	1.00	22	22
Pa-234m		700			3.00				

APPENDIX F

QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

Appendix F

Quality Assurance/Quality Control Program

A thorough quality assurance program is employed by the laboratory to ensure that the environmental monitoring data are reliable. This program includes the use of written, approved procedures in performing the work, a nonconformance and corrective action tracking system, systematic internal audits, a complete training and retraining system, 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 special samples along with routine samples.

Radiation detection devices are complex and can be tested in a number of ways. There are two primary tests which are performed on all devices. In the first type, the device is operated without a sample on the detector to determine the background count rate. The background counts are usually low values and are due to machine noise, cosmic rays, or trace amounts of radioactivity in the materials used to construct the detector. Charts of background counts are kept and monitored to ensure that no unusually high or low values are encountered.

In the second test, the device is operated with a known amount of radioactivity present. The number of counts registered from such a

radioactive standard should be very reproducible. These reproduciblity checks are also monitored to ensure that they are neither higher nor lower than expected. When counts from either test fall outside the expected range, the device is inspected for malfunction or contamination. It is not placed into service until it is operating properly.

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 answer questions about the performance of the different portions of the analytical process. These quality control samples may be blanks, replicate samples, blind samples, or cross-checks.

Blanks are samples which contain no measureable radioactivity or no activity of the type being measured. Such samples are analyzed to determine whether there is any contamination of equipment or commercial laboratory chemicals, cross-contamination in the chemical process, or interference from isotopes other than the one being measured.

Duplicate samples are generated at random by the same 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 the other routine samples. They provide information about the variability of radioactive content in the various sample media.

There is another kind of replicate sample. From time to time, if enough sample is available for a particular analysis, the laboratory analyst can split it into two portions. Such a sample can provide information about the variability of the analytical process since two identical portions of material are analyzed side by side.

Analytical knowns are another category of quality control sample. A known amount of radioactivity is added to a sample medium by the quality control staff or by the analysts themselves. The analysts are told the radioactive content of the sample. Whenever possible, the analytical knowns contain the same amount of radioactivity each time they are run. In this way, the analysts have immediate knowledge of the quality of the measurement process. A portion of these samples are also blanks.

Blind spikes are samples containing radioactivity which are introduced into the analysis process disguised as ordinary environmental samples. The analyst does not know they contain radioactivity. Since the bulk of the ordinary workload of the environmental laboratory contains no measureable activity or only naturally occurring radioisotopes, blind spikes can be used to test the detection capability of the laboratory or they can be used to test the data review process. If an analysis routinely generates numerous zeroes for a particular isotope, the presence of the isotope is brought to the attention

of the laboratory supervisor in the daily review process. Blind spikes test this process since they contain radioactivity at levels high enough to be detected. Furthermore, the activity can be put into such samples at the extreme limit of detection to determine whether or not the laboratory can find any unusual radioactivity whatsoever.

At present, 5 percent of the laboratory workload is in the category of internal cross-checks. These samples have a known amount of radioactivity added and are presented to the analysts labeled as cross-check samples. This means that the quality control staff knows the radioactive content or "right answer" but the analysts do not. They are aware they are being tested. Such samples test the best performance of the laboratory by determining if the analysts 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. Internal cross-checks can also tell if there is a difference in performance between two analysts. Like blind spikes or analytical knowns, these samples can also be spiked with low levels of activity to test detection limits.

A series of cross-checks is produced by the EPA in Las Vegas. These interlaboratory comparison samples or "EPA cross-checks" are considered to be the primary indicator of laboratory performance. They provide an independent check of the entire measurement process that cannot be easily provided by the laboratory itself. That is, unlike internally produced cross-checks, EPA cross-checks test the calibration of the laboratory detection devices since

different radioactive standards produced by individuals outside TVA are used in the cross-checks. The results of the analysis of these samples are reported back to EPA which then issues a report of all the results of all participants. These reports are examined very closely by laboratory supervisory and quality control personnel. They indicate how well the laboratory is doing compared to others across the nation. Like internal cross-checks, the EPA cross-checks provide information to the laboratory about the precision and accuracy of the radioanalytical work it does. The results of TVA's participation in the EPA Interlaboratory Comparison Program are presented in table F-1.

TVA splits certain environmental samples with laboratories operated by the States of Alabama and Tennessee and the EPA Eastern Environmental Radiation Facility in Montgomery, Alabama. When radioactivity has been present in the environment in measureable quantities, such as following atmospheric nuclear weapons testing, following the Chernobyl incident, or as naturally occurring radionuclides, the split samples have provided TVA with yet another level of information about laboratory performance. These samples demonstrate performance on actual environmental sample matrices rather than on the constructed matrices used in cross-check programs.

All 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 help or improvement. The end result is a measurement process that provides accurate data and is sensitive enough to measure the presence of radioactivity far below the levels which could be harmful to humans.

Table F-1

RESULTS OBTAINED IN INTERLABORATORY COMPARISON PROGRAM

A. Air Filter (pCi/Filter)

Date	Gross Alpha EPA Value (±3σ)	Gross Alpha TVA Avg.	Gross Beta EPA Value (±3σ)	Gross Beta TVA Avg.	Strontium-90 EPA Value (±3σ)	Strontium-90 TVA Avg.	Cesium-137 EPA Value (±3σ)	Cesium-137 TVA Avg.
3/89	21±9	23	62±9	65	20±2.6	a	20±9	20
8/89	6±9	9					10±9	10

B. Radiochemical Analysis of Water (pCi/L)

Date	Gross Beta EPA Value (±3σ)	Gross Beta TVA Avg.	Strontium-89 EPA Value (±3σ)	Strontium-89 TVA Avg.	Strontium-90 EPA Value (±3σ)	Strontium-90 TVA Avg.	Tritium EPA Value (±3σ)	Tritium TVA Avg.	Iodine-131 EPA Value (±3σ)	Iodine-131 TVA Avg.
1/89	4±9	2	40±9	30[b]	25±2.6	23				
2/89							2754±617	2690	106±19	98
3/89										
4/89[c]			8±9	8	8±2.6	7				
4/89										
5/89	50±9	47	6±9	<5	6±2.6	6				
6/89							4503±779	4100		
7/89										
8/89									83±14	77
9/89	6±9	9								
10/89							3496±630	3353		
10/89[c]			15±9	15	7±2.6	6				
11/89										
12/89										

Table F-1

RESULTS OBTAINED IN INTERLABORATORY COMPARISON PROGRAM (Continued)

C. Gamma-Spectral Analysis of Water (pCi/L)

Date	Barium-133 or Chromium-51		Cobalt-60		Zinc-65		Ruthenium-106		Cesium-134		Cesium-137	
	EPA Value (±3σ)	TVA Avg.	EPA Value (±3σ)	TVA Avg.	EPA Value (±3σ)	TVA Avg.	EPA Value (±3σ)	TVA Avg.	EPA Value (±3σ)	TVA Avg.	EPA Value (±3σ)	TVA Avg.
2/89	235±42	235	10±9	11	159±28	159	178±31	166	10±9	10	10±9	11
4/89[c]									20±9	19	20±9	20
6/89	49± 9	49	31±9	31	165±29	171	128±23	124	39±9	38	20±9	21
10/89	59±10	58	30±9	30	129±23	129	161±28	150	29±9	26	59±9	59
10/89[c]									5±9	5	5±9	6

D. Milk (pCi/L)

Date	Strontium-89		Strontium-90		Iodine-131		Cesium-137		Potassium-40[d]	
	EPA Value (±3σ)	TVA Avg.	EPA Value (±3σ)	TVA Avg.	EPA Value (±3σ)	TVA Avg.	EPA Value (±3σ)	TVA Avg.	EPA Value (±3σ)	TVA Avg.
4/88	39±9	24[b]	55±5	53			50±9	49	1600±139	1633

Footnotes for Table F-1

Results Obtained in Interlaboratory Comparison Program

a. Change in sample matrix resulted in lost analysis - Procedure revision in progress to accomodate new matrix.

b. The low strontium result was investigated. A definitive cause for the low result could not be identified. Further evaluation of the strontium radioanalytical procedure continues.

c. Laboratory Performance Evaluation Study.

d. Units are milligram of total potassium per liter rather than picrocuries of K-40 per liter.

APPENDIX G

LAND USE SURVEY

APPENDIX G

Land Use Survey

A land use survey is conducted periodically 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 a distance of 5 miles from the plant.

The land use survey is usually 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 most recent land use survey was performed in 1986. From the data of that survey, radiation doses were projected for individuals near the plant. Doses from breathing air (air submersion) were calculated for the nearest resident in each sector, while doses from drinking milk or eating foods produced near the plant were calculated for the areas with milk producing animals and gardens, respectively. These doses were calculated using design basis source terms and historical meteorological data.

Doses calculated for 1986 for air submersion were unchanged from those projected for 1985.

Doses calculated for 1986 for ingestion of home-grown foods changed in one sector. A garden was identified in the ENE sector 0.7 mile nearer the plant.

Doses calculated for the ingestion of milk at those locations with milk producing animals were unchanged with one exception. At one location (Farm Bn) children were identified where previously there were none. Consequently, the projected dose was somewhat higher.

Tables G-1, G-2, and G-3 show the comparative calculated doses for 1985 and 1986.

Table G-1

Watts Bar Nuclear Plant
Projected Annual Air Submersion Dose to the Nearest Resident
Within 5 Miles of Plant

mrem/year/reactor

Sector	Distance (Miles)	1986 Annual Dose	1985 Annual Dose
N	1.3	0.14	.14
NNE	1.7	0.10	.10
NE	2.1	0.04	.04
ENE	1.4	0.12	.12
E	2.0	0.08	.08
ESE	2.9	0.03	.03
SE	0.9	0.53	.53
SSE	1.0	0.36	.36
S	1.0	0.23	.23
SSW	1.2	0.15	.15
SW	2.7	0.02	.02
WSW	1.3	0.16	.16
W	1.9	0.05	.05
WNW	1.0	0.07	.07
NW	1.9	0.03	.03
NNW	2.8	0.02	.02

Table G-2

Watts Bar Nuclear Plant
Projected Annual Intestion Dose to Child's Critical
Organ from Intestion of Home-Grown Foods
Nearest Garden Within 5 Miles of Plant

mrem/year/reactor

	1986		1985	
Sector	Distance (Miles)	Annual Dose (Bone)	Distance (Miles)	Annual Dose (Bone)
N	2.8	0.81	2.8	0.81
NNE	2.3	1.47	2.3	1.47
NE	2.1	1.38	2.1	1.38
ENE	1.4	3.56	2.1	1.66
E	2.0	2.45	2.0	2.45
ESE	2.9	1.00	2.9	1.00
SE	1.9	3.17	1.9	3.17
SSE	1.0	10.70	1.0	10.70
S	1.4	2.86	1.4	2.86
SSW	1.3	3.27	1.3	3.27
SW	*	*	*	*
SWS	1.5	3.61	1.5	3.61
W	1.9	1.62	1.9	1.62
WNW	1.6	0.65	1.6	0.65
NW	2.6	0.46	2.6	0.46
NNW	2.8	0.59	2.8	0.59

*Garden not identified in this sector.

Table G-3

Watts Bar Nuclear Plant
Projected Annual Dose to Reactor Thyroid from Ingestion of Milk
(Nearest Milk-Producing Animal Within 5 Miles of Plant)

mrem/year/reactor

Sector	Location	Approximate Distance (Miles)	Annual Dose 1986	Annual Dose 1985
N	a	-	-	-
NNE	a	-	-	-
NE	Farm Bn[b,c]	2.1	1.14	0.36
ENE	a	-	-	-
E	Farm W	4.5	0.03	0.03
ESE	Farm Mu[d]	3.7	0.19	0.19
SE	a	-	-	-
SSE	a	-	-	-
S	Farm Ho[e]	1.5	0.53	0.53
SSW	Farm L[d]	1.3	0.89	0.89
SW	Farm L[d]	1.5	0.56	0.56
WSW	Farm He	5.0	0.07	0.07
W	Farm H[f]	4.4	0.02	0.02
WNW	Farm P	3.4	0.06	0.06
WN	Farm Mo[f]	4.6	0.01	0.01
NNW	a	-	-	-

a. Milk-producing animals not identified in this sector.
b. Children identified at this location in 1986.
c. Milk was not available in sufficient quantities for sampling until January 1987. Samples were collected until animals went "dry" in June 1987 when the animals were disposed of. Vegetation samples were collected from January 1985 until September 1987.
d. Milk and vegetation samples collected at this location.
e. Owner unwilling to provide samples.
f. Milk samples collected at this station.

APPENDIX H

DATA TABLES

Table H-1

DIRECT RADIATION LEVELS

Average External Gamma Radiation Levels at Various Distances from Watts Bar Nuclear Plant for Each Quarter - 1990
mR/Quarter[a]

Distance Miles	Average External Gamma Radiation Levels[b]							
	1st Quarter (Dec 88-Feb 89)		2nd Quarter (Mar-May 89)		3rd Quarter (Jun-Aug 89)		4th Quarter (Sep-Nov 89)	
	Victoreen	Panasonic	Victoreen	Panasonic	Victoreen	Panasonic	Victoreen	Panasonic
0-1	19.6 ± 1.4	14.4 ± 1.2	18.6 ± 3.6	14.2 ± 1.5	18.5 ± 2.2	17.8 ± 1.5	17.7 ± 1.8	15.4 ± 1.4
1-2	20.3 ± 1.6	14.7 ± 1.1	19.9 ± 1.1	14.7 ± 0.9	19.1 ± 1.6	18.1 ± 0.8	17.2 ± 1.3	15.6 ± 0.9
2-4	18.0 ± 0.6	12.7 ± 0.8	15.9 ± 3.3	12.9 ± 0.4	16.6 ± 0.9	15.5 ± 1.1	16.2 ± 1.5	13.9 ± 1.0
4-6	18.2 ± 2.6	13.5 ± 1.4	17.6 ± 2.7	13.4 ± 1.7	17.6 ± 2.3	16.3 ± 1.7	16.3 ± 1.3	14.2 ± 1.7
> 6	17.0 ± 2.8	12.0 ± 1.9	14.8 ± 3.4	11.6 ± 2.3	16.7 ± 2.8	14.8 ± 2.2	14.9 ± 2.4	12.7 ± 2.0
Average, 0-2 miles (onsite)	19.8 ± 1.5	14.5 ± 1.2	19.0 ± 3.0	14.4 ± 1.3	18.8 ± 2.0	17.9 ± 1.3	17.5 ± 1.6	15.5 ± 1.2
Average, greater than 2 miles (offsite)	17.8 ± 2.6	12.9 ± 1.7	16.5 ± 3.2	12.6 ± 2.0	17.2 ± 2.4	15.7 ± 2.0	15.8 ± 1.8	13.7 ± 1.9

a. Data normalized to one quarter (2190 hours).
b. Averages of the individual measurements in the set ±1 standard deviation of the set.

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN MILK
PCI/L - 0.037 BQ/L

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
IODINE-131						
117	2.00E-01	52 VALUES < LLD			65 VALUES < LLD	
GAMMA SCAN (GELI)						
117						
AC-228	2.50E+01	52 VALUES < LLD	LAYMAN FARM 1.3 MILES SW	13 VALUES < LLD	3.02E+01(1/ 65) 3.02E+01- 3.02E+01	
BI-214	2.00E+01	8.27E+01(8/ 52) 3.35E+01- 3.31E+02	LAYMAN FARM 1.3 MILES SW	1.33E+02(3/ 13) 3.35E+01- 3.31E+02	4.37E+01(7/ 65) 2.93E+01- 6.58E+01	
CS-137	5.00E+00	7.47E+00(2/ 52) 5.74E+00- 9.19E+00	MOFFETT FARM 4.6 MILES NW	7.47E+00(2/ 13) 5.74E+00- 9.19E+00	65 VALUES < LLD	
K-40	1.50E+02	1.25E+03(51/ 52) 5.20E+02- 1.65E+03	MULLINS FARM 3.7 M. ESE	1.35E+03(12/ 13) 1.28E+03- 1.53E+03	1.29E+03(65/ 65) 4.93E+02- 1.58E+03	
PB-214	2.00E+01	8.15E+01(8/ 52) 3.30E+01- 3.30E+02	LAYMAN FARM 1.3 MILES SW	1.34E+02(3/ 13) 3.30E+01- 3.30E+02	4.53E+01(6/ 65) 2.64E+01- 7.14E+01	
SR 89						
89	2.50E+00	3.14E+00(3/ 50) 2.75E+00- 3.47E+00	HOUSLEY FARM 4.4 MILES W	3.33E+00(2/ 13) 3.19E+00- 3.47E+00	3.73E+00(1/ 39) 3.73E+00- 3.73E+00	
SR 90						
89	2.00E+00	4.70E+00(28/ 50) 2.07E+00- 1.09E+01	HOUSLEY FARM 4.4 MILES W	5.73E+00(11/ 13) 2.73E+00- 1.09E+01	2.36E+00(13/ 39) 2.03E+00- 4.15E+00	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN WET VEGETATION
PCI/KG - 0.037 BQ/KG (WET WT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
IODINE-131						
34						
	4.00E+00	5.72E+00(1/ 19)	LM-3 WB	5.72E+00(1/ 2)	4.67E+00(6/ 15)	
		5.72E+00- 5.72E+00	2.1 MILES NNE	5.72E+00- 5.72E+00	4.18E+00- 6.12E+00	
GAMMA SCAN (GELI)						
35						
AC-228	8.00E+01	8.96E+01(3/ 20)	LM-4 WB	1.01E+02(1/ 2)	15 VALUES < LLD	
		8.07E+01- 1.01E+02	0.9 MILES SE	1.01E+02- 1.01E+02		
BE-7	2.00E+02	3.17E+03(20/ 20)	LM-4 WB	5.58E+03(2/ 2)	2.76E+03(15/ 15)	
		3.15E+02- 1.01E+04	0.9 MILES SE	1.30E+03- 9.86E+03	2.64E+02- 1.46E+04	
BI-212	4.00E+01	1.45E+02(1/ 20)	LAYMAN FARM	1.45E+02(1/ 4)	15 VALUES < LLD	
		1.45E+02- 1.45E+02	1.3 MILES SW	1.45E+02- 1.45E+02		
BI-214	4.80E+01	8.62E+01(4/ 20)	MOFFETT FARM	1.04E+02(1/ 2)	15 VALUES < LLD	
		7.01E+01- 1.04E+02	4.6 MILES NW	1.04E+02- 1.04E+02		
CS-137	2.40E+01	2.77E+01(1/ 20)	LAYMAN FARM	2.77E+01(1/ 4)	15 VALUES < LLD	
		2.77E+01- 2.77E+01	1.3 MILES SW	2.77E+01- 2.77E+01		
K-40	4.00E+02	4.87E+03(20/ 20)	LAYMAN FARM	6.34E+03(4/ 4)	5.15E+03(15/ 15)	
		1.32E+03- 9.16E+03	1.3 MILES SW	4.71E+03- 8.53E+03	2.02E+03- 8.07E+03	
PB-212	4.00E+01	6.50E+01(3/ 20)	LAYMAN FARM	8.08E+01(1/ 4)	4.22E+01(2/ 15)	
		5.51E+01- 8.08E+01	1.3 MILES SW	8.08E+01- 8.08E+01	4.18E+01- 4.26E+01	
PB-214	8.00E+01	1.00E+02(1/ 20)	HOUSLEY FARM	1.00E+02(1/ 2)	15 VALUES < LLD	
		1.00E+02- 1.00E+02	4.4 MILES W	1.00E+02- 1.00E+02		
TL-208	2.60E+01	3.11E+01(2/ 20)	LAYMAN FARM	3.43E+01(1/ 4)	15 VALUES < LLD	
		2.80E+01- 3.43E+01	1.3 MILES SW	3.43E+01- 3.43E+01		
SR 89						
26						
	1.40E+02	20 VALUES < LLD			6 VALUES < LLD	
SR 90						
26						
	6.00E+01	1.08E+02(6/ 20)	MULLINS FARM	1.81E+02(1/ 4)	2.37E+02(2/ 6)	
		6.02E+01- 1.81E+02	3.7 M. ESE	1.81E+02- 1.81E+02	1.45E+02- 3.29E+02	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN SOIL
PCI/GM - 0.037 BQ/G (DRY WEIGHT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GAMMA SCAN (GELI)						
11						
AC-228	1.00E-01	9.40E-01(8/ 8)	LM-4 WB	1.32E+00(1/ 1)	7.46E-01(3/ 3)	
		6.56E-01- 1.32E+00	0.9 MILES SE	1.32E+00- 1.32E+00	5.54E-01- 9.28E-01	
BI-212	2.50E-01	9.75E-01(8/ 8)	LM1 ENV DATA STA	1.37E+00(1/ 1)	7.26E-01(3/ 3)	
		6.54E-01- 1.37E+00	0.5 MILES SSW	1.37E+00- 1.37E+00	4.98E-01- 9.56E-01	
BI-214	4.00E-02	7.41E-01(8/ 8)	LM-3 WB	9.46E-01(1/ 1)	6.23E-01(3/ 3)	
		5.75E-01- 9.46E-01	2.1 MILES NNE	9.46E-01- 9.46E-01	5.70E-01- 7.03E-01	
CS-137	1.00E-02	5.01E-01(8/ 8)	LM2 N. WBSP GATE	1.36E+00(1/ 1)	2.66E-01(3/ 3)	
		7.92E-02- 1.36E+00	0.5 MILES N	1.36E+00- 1.36E+00	1.34E-01- 3.91E-01	
K-40	2.00E-01	8.70E+00(8/ 8)	LM-4 WB	2.52E+01(1/ 1)	4.27E+00(3/ 3)	
		2.80E+00- 2.52E+01	0.9 MILES SE	2.52E+01- 2.52E+01	3.18E+00- 5.70E+00	
PA-234M	3.00E+00	3.91E+00(1/ 8)	LM-4 WB	3.91E+00(1/ 1)	3 VALUES < LLD	
		3.91E+00- 3.91E+00	0.9 MILES SE	3.91E+00- 3.91E+00		
PB-212	2.00E-02	8.85E-01(8/ 8)	LM1 ENV DATA STA	1.19E+00(1/ 1)	6.75E-01(3/ 3)	
		6.43E-01- 1.19E+00	0.5 MILES SSW	1.19E+00- 1.19E+00	5.41E-01- 7.52E-01	
PB-214	2.00E-02	8.04E-01(8/ 8)	LM1 ENV DATA STA	1.01E+00(1/ 1)	6.56E-01(3/ 3)	
		6.15E-01- 1.01E+00	0.5 MILES SSW	1.01E+00- 1.01E+00	5.80E-01- 7.49E-01	
RA-224	3.00E-01	9.21E-01(5/ 8)	LM-4 WB	1.26E+00(1/ 1)	7.93E-01(3/ 3)	
		5.97E-01- 1.26E+00	0.9 MILES SE	1.26E+00- 1.26E+00	6.35E-01- 9.11E-01	
RA-226	5.00E-02	7.41E-01(8/ 8)	LM-3 WB	9.46E-01(1/ 1)	6.23E-01(3/ 3)	
		5.75E-01- 9.46E-01	2.1 MILES NNE	9.46E-01- 9.46E-01	5.70E-01- 7.03E-01	
TL-208	2.00E-02	3.06E-01(8/ 8)	LM1 ENV DATA STA	4.30E-01(1/ 1)	2.31E-01(3/ 3)	
		2.12E-01- 4.30E-01	0.5 MILES SSW	4.30E-01- 4.30E-01	1.82E-01- 2.69E-01	
SR 89						
11						
	1.00E+00	8 VALUES < LLD			3 VALUES < LLD	
SR 90						
11						
	3.00E-01	8 VALUES < LLD			3 VALUES < LLD	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1.
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN APPLES
PCI/KG - 0.037 BQ/KG (WET WT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMEN
GROSS BETA						
2	9.00E+00	1.91E+03(1/ 1) 1.91E+03- 1.91E+03	2.0 MILES WNW	1.91E+03(1/ 1) 1.91E+03- 1.91E+03	1.50E+03(1/ 1) 1.50E+03- 1.50E+03	
GAMMA SCAN (GELI)						
2						
K-40	1.50E+02	8.06E+02(1/ 1) 8.06E+02- 8.06E+02	2.0 MILES WNW	8.06E+02(1/ 1) 8.06E+02- 8.06E+02	6.86E+02(1/ 1) 6.86E+02- 6.86E+02	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN TOMATOES
PCI/KG - 0.037 BQ/KG (WET WT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GROSS BETA						
2	9.00E+00	3.45E+03(1/ 1) 3.45E+03- 3.45E+03	SHIRLEY REED FARM 1.5 MILES WSW	3.45E+03(1/ 1) 3.45E+03- 3.45E+03	3.50E+03(1/ 1) 3.50E+03- 3.50E+03	
GAMMA SCAN (GELI)						
2						
K-40	1.50E+02	2.19E+03(1/ 1) 2.19E+03- 2.19E+03	SHIRLEY REED FARM 1.5 MILES WSW	2.19E+03(1/ 1) 2.19E+03- 2.19E+03	1.77E+03(1/ 1) 1.77E+03- 1.77E+03	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN TURNIP GREENS
PCI/KG - 0.037 BQ/KG (WET WT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMEN
GROSS BETA						
2	9.00E+00	3.02E+03(1/ 1) 3.02E+03- 3.02E+03	SHIRLEY REED FARM 1.5 MILES WSW	3.02E+03(1/ 1) 3.02E+03- 3.02E+03	3.93E+03(1/ 1) 3.93E+03- 3.93E+03	
GAMMA SCAN (GELI)						
2						
BE-7	4.50E+01	4.77E+01(1/ 1) 4.77E+01- 4.77E+01	SHIRLEY REED FARM 1.5 MILES WSW	4.77E+01(1/ 1) 4.77E+01- 4.77E+01	1.04E+02(1/ 1) 1.04E+02- 1.04E+02	
K-40	1.50E+02	1.29E+03(1/ 1) 1.29E+03- 1.29E+03	SHIRLEY REED FARM 1.5 MILES WSW	1.29E+03(1/ 1) 1.29E+03- 1.29E+03	1.83E+03(1/ 1) 1.83E+03- 1.83E+03	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN SURFACE WATER(Total)
PCI/L - 0.037 BQ/L

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE
DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GROSS BETA						
12	1.70E+00	3.07E+00(5/ 8)	TRM 523.1	3.33E+00(4/ 4)	2.75E+00(3/ 4)	
		2.05E+00- 4.21E+00	4.7 MILES DOWNSTREA	2.21E+00- 4.21E+00	2.48E+00- 3.02E+00	
GAMMA SCAN (GELI)						
12	3.00E+00	8 VALUES < LLD			4 VALUES < LLD	
SR 89						
12	3.00E+00	3.14E+00(1/ 8)	TRM 517.9	3.14E+00(1/ 4)	4.52E+00(2/ 4)	
		3.14E+00- 3.14E+00	9.9 MILES DOWNSTREA	3.14E+00- 3.14E+00	4.51E+00- 4.53E+00	
SR 90						
12	1.40E+00	8 VALUES < LLD			4 VALUES < LLD	
TRITIUM						
12	2.50E+02	2.76E+02(1/ 8)	TRM 517.9	2.76E+02(1/ 4)	3.23E+02(1/ 4)	
		2.76E+02- 2.76E+02	9.9 MILES DOWNSTREA	2.76E+02- 2.76E+02	3.23E+02- 3.23E+02	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN PUBLIC WATER(Total)
PCI/L - 0.037 BQ/L

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE
DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GROSS BETA						
28	1.70E+00	2.72E+00(24/ 24)	DAYTON, TN	2.90E+00(12/ 12)	2.75E+00(3/ 4)	
		1.75E+00- 3.93E+00	17.75 MILES NNE	2.27E+00- 3.93E+00	2.48E+00- 3.02E+00	
IODINE-131						
26	1.00E+00	26 VALUES < LLD			0 VALUES < LLD	
GAMMA SCAN (GELI)						
30						
BI-214	2.00E+01	3.08E+01(1/ 26)	DAYTON, TN	3.08E+01(1/ 13)	4 VALUES < LLD	
		3.08E+01- 3.08E+01	17.75 MILES NNE	3.08E+01- 3.08E+01		
SR 89						
12	3.00E+00	3.90E+00(1/ 8)	CF INDUSTRIES	3.90E+00(1/ 4)	4.52E+00(2/ 4)	
		3.90E+00- 3.90E+00	TRM 473.0	3.90E+00- 3.90E+00	4.51E+00- 4.53E+00	
SR 90						
12	1.40E+00	8 VALUES < LLD			4 VALUES < LLD	
TRITIUM						
12	2.50E+02	8 VALUES < LLD	DAYTON, TN	4 VALUES < LLD	3.23E+02(1/ 4)	
			17.75 MILES NNE		3.23E+02- 3.23E+02	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN WELL WATER(Total)
PCI/L - 0.037 BQ/L

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390.391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GAMMA SCAN (GELI)						
8						
BI-214	2.00E+01	4 VALUES < LLD	WBN WELL #1 ONSITE S	4 VALUES < LLD	3.62E+01(1/ 4) 3.62E+01- 3.62E+01	
PB-214	2.00E+01	4 VALUES < LLD	WBN WELL #1 ONSITE S	4 VALUES < LLD	4.12E+01(1/ 4) 4.12E+01- 4.12E+01	
TRITIUM						
8						
	2.50E+02	4 VALUES < LLD			4 VALUES < LLD	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN FISH-FLESH-CC
PCI/GM - 0.037 BQ/G (DRY WEIGHT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GAMMA SCAN (GELI) 6						
CS-137	6.00E-02	4 VALUES (LLD	NICKAJACK RES TRM 425-471	2 VALUES (LLD	7.59E-02(2/ 2) 6.48E-02- 8.70E-02	
K-40	1.00E+00	1.05E+01(4/ 4) 9.83E+00- 1.11E+01	NICKAJACK RES TRM 425-471	1.08E+01(2/ 2) 1.04E+01- 1.11E+01	1.10E+01(2/ 2) 1.06E+01- 1.14E+01	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN FISH-FLESH-WC
PCI/GM - 0.037 BQ/G (DRY WEIGHT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GAMMA SCAN (GELI) 6						
CS-137	6.00E-02	1.04E-01(1/ 4)	NICKAJACK RES	1.04E-01(1/ 2)	1.43E-01(2/ 2)	
		1.04E-01- 1.04E-01	TRM 425-471	1.04E-01- 1.04E-01	7.94E-02- 2.06E-01	
K-40	1.00E+00	1.16E+01(4/ 4)	CHICKAMAUGA RES	1.20E+01(2/ 2)	1.67E+01(2/ 2)	
		6.40E+00- 1.67E+01	TRM 471-530	7.34E+00- 1.67E+01	1.63E+01- 1.72E+01	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN FISH-FLESH-SB
PCI/GM - 0.037 BQ/G (DRY WEIGHT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GAMMA SCAN (GELI)						
6						
K-40	1.00E+00	8.52E+00(4/ 4)	NICKAJACK RES	9.33E+00(2/ 2)	9.80E+00(2/ 2)	
		6.78E+00- 1.19E+01	TRM 425-471	6.78E+00- 1.19E+01	7.07E+00- 1.25E+01	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN FISH-WHOLE-SB
PCI/GM - 0.037 BQ/G (DRY WEIGHT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GAMMA SCAN (GELI)						
6						
K-40	1.00E+00	5.50E+00(4/ 4) 3.98E+00- 9.26E+00	NICKAJACK RES TRM 425-471	6.95E+00(2/ 2) 4.64E+00- 9.26E+00	5.76E+00(2/ 2) 4.45E+00- 7.07E+00	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN SEDIMENT
PCI/GM - 0.037 BQ/G (DRY WEIGHT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GAMMA SCAN (GELI)						
AC-228 6	1.00E-01	1.33E+00(4/ 4)	TRM 527.4	1.43E+00(2/ 2)	1.05E+00(2/ 2)	
		1.14E+00- 1.73E+00	0.4 MILES DOWNSTREA	1.14E+00- 1.73E+00	1.04E+00- 1.07E+00	
BE-7	1.00E-01	3.13E-01(1/ 4)	TRM 496.50	3.13E-01(1/ 2)	1.39E-01(1/ 2)	
		3.13E-01- 3.13E-01		3.13E-01- 3.13E-01	1.39E-01- 1.39E-01	
BI-212	2.50E-01	1.39E+00(4/ 4)	TRM 527.4	1.49E+00(2/ 2)	1.08E+00(2/ 2)	
		1.20E+00- 1.73E+00	0.4 MILES DOWNSTREA	1.24E+00- 1.73E+00	9.64E-01- 1.20E+00	
BI-214	4.00E-02	8.75E-01(4/ 4)	TRM 527.4	9.10E-01(2/ 2)	7.28E-01(2/ 2)	
		7.33E-01- 1.09E+00	0.4 MILES DOWNSTREA	7.33E-01- 1.09E+00	6.34E-01- 8.22E-01	
CO-60	1.00E-02	5.20E-02(2/ 4)	TRM 496.50	5.20E-02(2/ 2)	7.80E-02(2/ 2)	
		4.30E-02- 6.09E-02		4.30E-02- 6.09E-02	7.76E-02- 7.84E-02	
CS-137	1.00E-02	5.04E-01(4/ 4)	TRM 496.50	9.70E-01(2/ 2)	2.78E+00(2/ 2)	
		3.25E-02- 9.83E-01		9.57E-01- 9.83E-01	2.12E+00- 3.44E+00	
K-40	2.00E-01	1.22E+01(4/ 4)	TRM 496.50	1.34E+01(2/ 2)	1.26E+01(2/ 2)	
		1.04E+01- 1.37E+01		1.31E+01- 1.37E+01	1.20E+01- 1.32E+01	
PB-212	2.00E-02	1.25E+00(4/ 4)	TRM 527.4	1.37E+00(2/ 2)	9.75E-01(2/ 2)	
		1.09E+00- 1.65E+00	0.4 MILES DOWNSTREA	1.10E+00- 1.65E+00	9.41E-01- 1.01E+00	
PB-214	2.00E-02	9.40E-01(4/ 4)	TRM 527.4	9.75E-01(2/ 2)	7.71E-01(2/ 2)	
		8.04E-01- 1.15E+00	0.4 MILES DOWNSTREA	8.04E-01- 1.15E+00	6.84E-01- 8.57E-01	
RA-224	3.00E-01	1.38E+00(3/ 4)	TRM 527.4	1.49E+00(2/ 2)	1.09E+00(2/ 2)	
		1.14E+00- 1.83E+00	0.4 MILES DOWNSTREA	1.14E+00- 1.83E+00	1.08E+00- 1.10E+00	
RA-226	5.00E-02	8.75E-01(4/ 4)	TRM 527.4	9.10E-01(2/ 2)	7.28E-01(2/ 2)	
		7.33E-01- 1.09E+00	0.4 MILES DOWNSTREA	7.33E-01- 1.09E+00	6.34E-01- 8.22E-01	
TL-208	2.00E-02	4.29E-01(4/ 4)	TRM 527.4	4.69E-01(2/ 2)	3.43E-01(2/ 2)	
		3.75E-01- 5.63E-01	0.4 MILES DOWNSTREA	3.75E-01- 5.63E-01	3.27E-01- 3.58E-01	
SR 89 6	1.00E+00	4 VALUES < LLD			2 VALUES < LLD	
SR 90 6	3.00E-01	4 VALUES < LLD			2 VALUES < LLD	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
RADIOLOGICAL CONTROL
ENVIRONMENTAL RADIOLOGICAL MONITORING AND INSTRUMENTATION DEPT.
WESTERN AREA RADIOLOGICAL LABORATORY
ENVIRONMENTAL MONITORING REPORTING SYSTEM
RADIOACTIVITY IN SHORELINE SEDIMENT
PCI/GM - 0.037 BQ/G (DRY WEIGHT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMENT
GAMMA SCAN (GELI)						
4						
AC-228	1.00E-01	1.48E+00(2/ 2)	COTTON PORT MARINA	1.48E+00(2/ 2)	9.65E-01(2/ 2)	
		1.32E+00- 1.65E+00	TRM 513	1.32E+00- 1.65E+00	3.56E-01- 1.57E+00	
BI-212	2.50E-01	1.58E+00(2/ 2)	COTTON PORT MARINA	1.58E+00(2/ 2)	1.08E+00(2/ 2)	
		1.44E+00- 1.72E+00	TRM 513	1.44E+00- 1.72E+00	3.66E-01- 1.80E+00	
BI-214	4.00E-02	6.70E-01(2/ 2)	COTTON PORT MARINA	6.70E-01(2/ 2)	7.03E-01(2/ 2)	
		6.04E-01- 7.36E-01	TRM 513	6.04E-01- 7.36E-01	2.76E-01- 1.13E+00	
CS-137	1.00E-02	1.90E-01(1/ 2)	COTTON PORT MARINA	1.90E-01(1/ 2)	1.71E-02(1/ 2)	
		1.90E-01- 1.90E-01	TRM 513	1.90E-01- 1.90E-01	1.71E-02- 1.71E-02	
K-40	2.00E-01	2.51E+01(2/ 2)	COTTON PORT MARINA	2.51E+01(2/ 2)	3.68E+00(2/ 2)	
		2.11E+01- 2.90E+01	TRM 513	2.11E+01- 2.90E+01	8.02E-01- 6.55E+00	
PB-212	2.00E-02	1.42E+00(2/ 2)	COTTON PORT MARINA	1.42E+00(2/ 2)	9.02E-01(2/ 2)	
		1.26E+00- 1.57E+00	TRM 513	1.26E+00- 1.57E+00	3.36E-01- 1.47E+00	
PB-214	2.00E-02	7.37E-01(2/ 2)	COTTON PORT MARINA	7.37E-01(2/ 2)	7.75E-01(2/ 2)	
		6.33E-01- 8.40E-01	TRM 513	6.33E-01- 8.40E-01	3.12E-01- 1.24E+00	
RA-224	3.00E-01	1.52E+00(2/ 2)	COTTON PORT MARINA	1.52E+00(2/ 2)	1.48E+00(1/ 2)	
		1.22E+00- 1.82E+00	TRM 513	1.22E+00- 1.82E+00	1.48E+00- 1.48E+00	
RA-226	5.00E-02	6.70E-01(2/ 2)	COTTON PORT MARINA	6.70E-01(2/ 2)	7.03E-01(2/ 2)	
		6.04E-01- 7.36E-01	TRM 513	6.04E-01- 7.36E-01	2.76E-01- 1.13E+00	
TL-208	2.00E-02	4.77E-01(2/ 2)	COTTON PORT MARINA	4.77E-01(2/ 2)	3.13E-01(2/ 2)	
		4.28E-01- 5.25E-01	TRM 513	4.28E-01- 5.25E-01	1.17E-01- 5.10E-01	
SR 89						
4						
	1.00E+00	2 VALUES < LLD			2 VALUES < LLD	
SR 90						
4						
	3.00E-01	4.65E-01(1/ 2)	COTTON PORT MARINA	4.65E-01(1/ 2)	2 VALUES < LLD	
		4.65E-01- 4.65E-01	TRM 513	4.65E-01- 4.65E-01		

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

TENNESSEE VALLEY AUTHORITY
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RADIOACTIVITY IN CLAM FLESH
PCI/GM - 0.037 BQ/G (DRY WEIGHT)

NAME OF FACILITY: WATTS BAR NUCLEAR PLANT
LOCATION OF FACILITY: RHEA TENNESSEE

DOCKET NO.: 50-390,391
REPORTING PERIOD: 1989

TYPE AND TOTAL NUMBER OF ANALYSIS PERFORMED	LOWER LIMIT OF DETECTION (LLD) SEE NOTE 1	ALL INDICATOR LOCATIONS MEAN (F) RANGE SEE NOTE 2	LOCATION WITH HIGHEST ANNUAL MEAN NAME DISTANCE AND DIRECTION	MEAN (F) RANGE SEE NOTE 2	CONTROL LOCATIONS MEAN (F) RANGE SEE NOTE 2	NUMBER OF NONROUTINE REPORTED MEASUREMEN
GAMMA SCAN (GELI) 2						
BI-214	2.50E-01	1 VALUES < LLD	TRM 527.4 0.4 MILES DOWNSTREA	1 VALUES < LLD	9.30E-01(1/ 1) 9.30E-01- 9.30E-01	
K-40	2.00E+00	1 VALUES < LLD	TRM 527.4 0.4 MILES DOWNSTREA	1 VALUES < LLD	2.69E+00(1/ 1) 2.69E+00- 2.69E+00	

NOTE: 1. NOMINAL LOWER LIMIT OF DETECTION (LLD) AS DESCRIBED IN TABLE E-1 .
NOTE: 2. MEAN AND RANGE BASED UPON DETECTABLE MEASUREMENTS ONLY. FRACTION OF DETECTABLE MEASUREMENTS AT SPECIFIED LOCATIONS IS INDICATED IN PARENTHESES (F).

Figure H-1

Direct Radiation Levels
Watts Bar Nuclear Plant

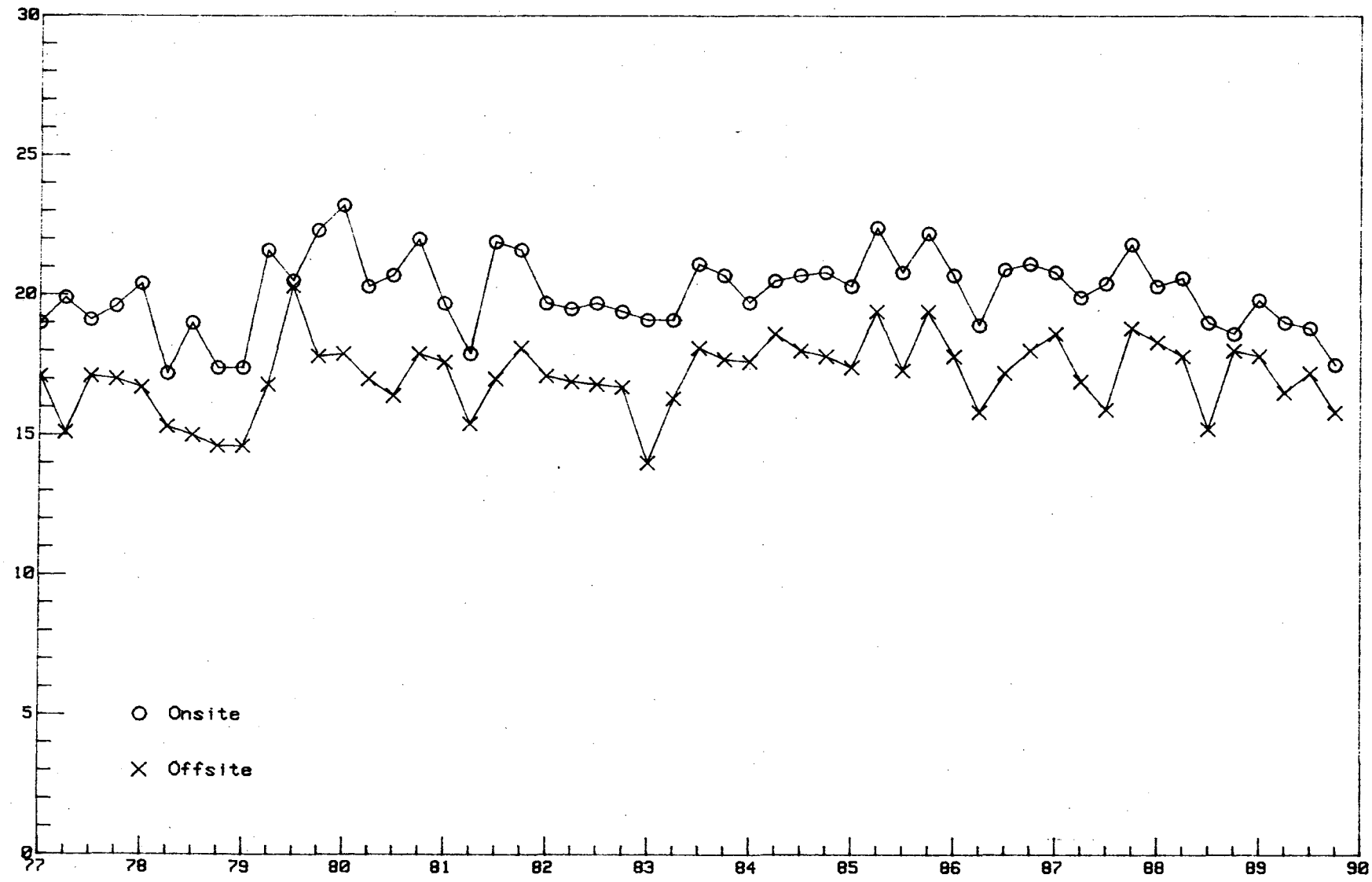


Figure H-2

Direct Radiation Levels
Watts Bar Nuclear Plant
4-Quarter Moving Average

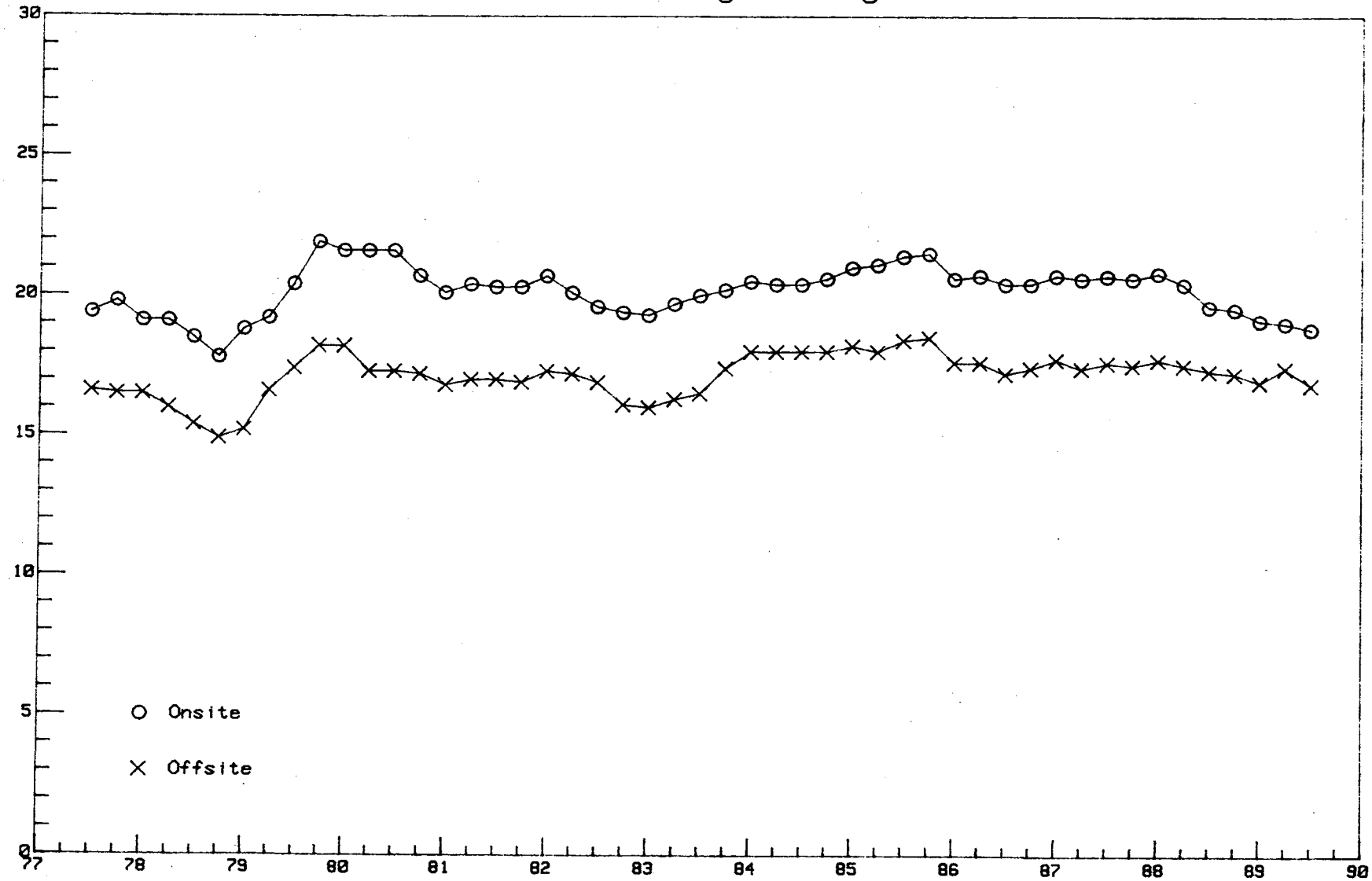


Figure H-3

Annual Average Gross Beta Activity
Air Filters (pCi/Cubic Meter)
Watts Bar Nuclear Plant

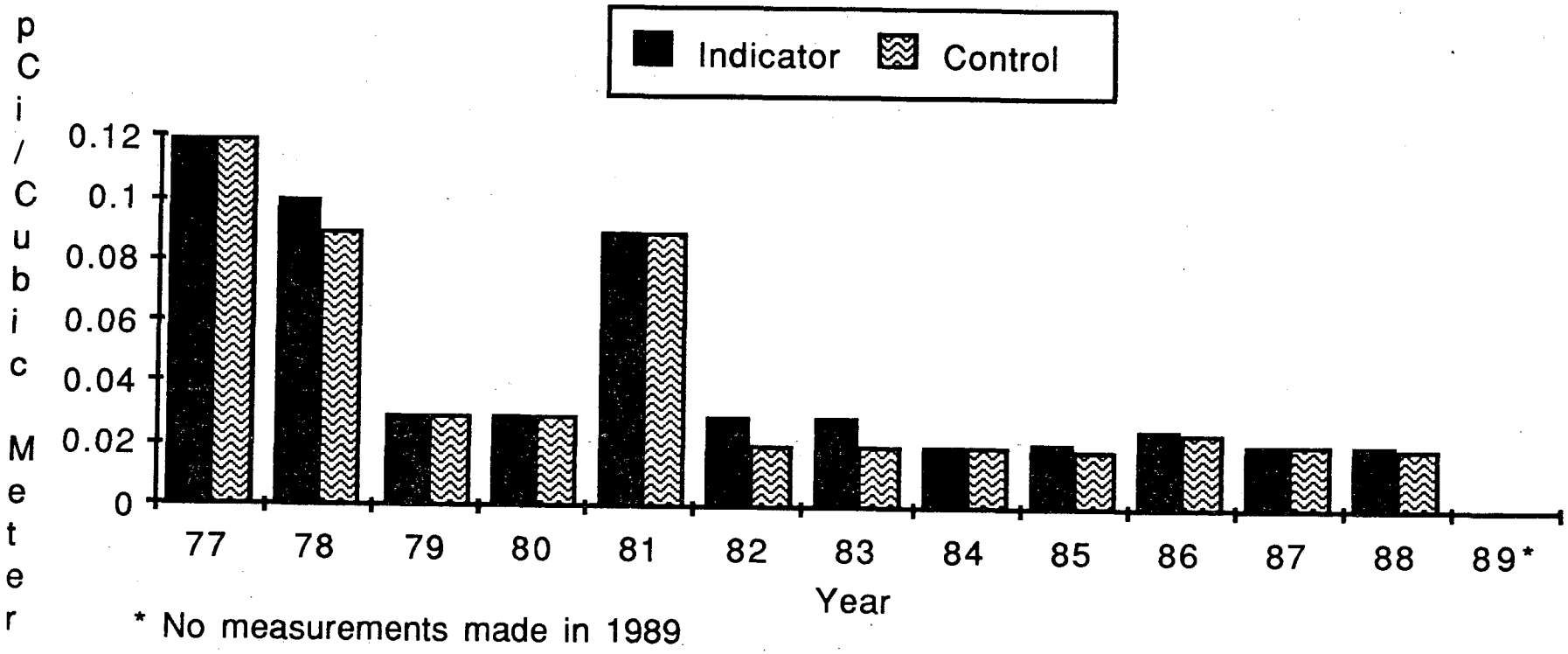
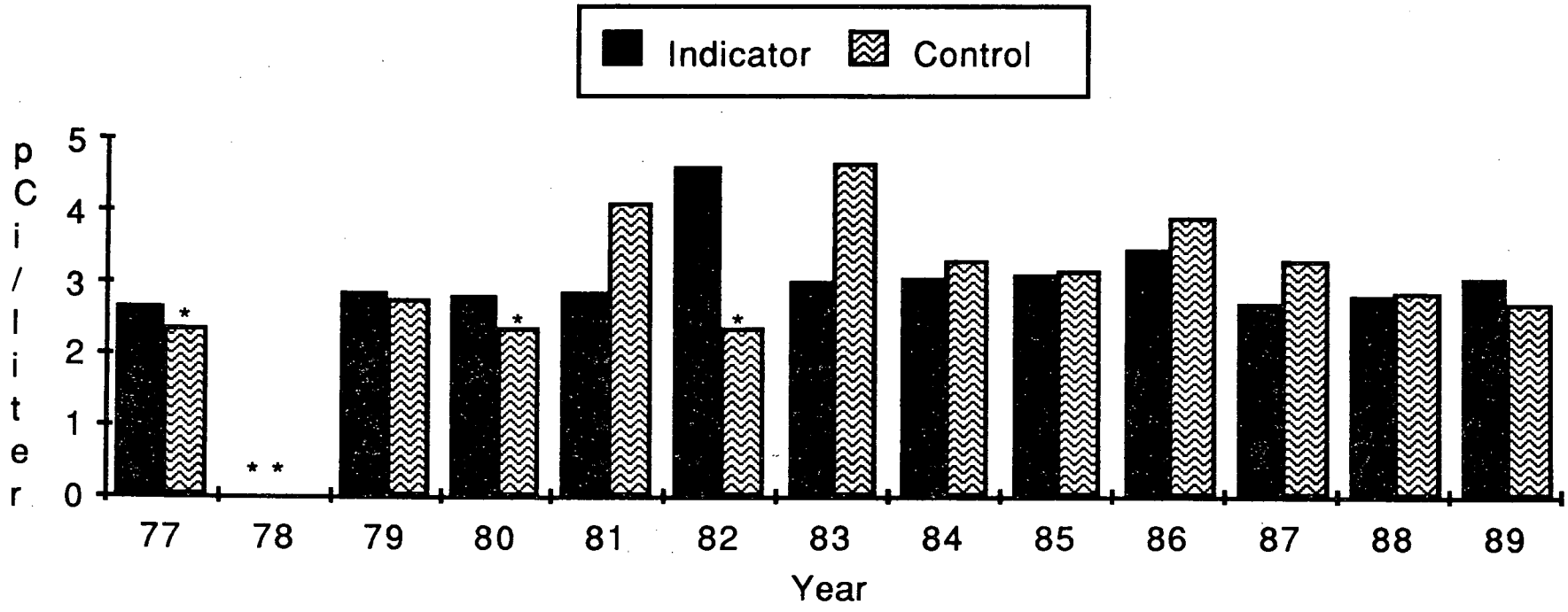


Figure H-4

Annual Average Gross Beta Activity
Surface Water (pCi/liter)
Watts Bar Nuclear Plant



* Less than LLD (2.4 pCi/liter)

** No measurements made in 1978.

Figure H-5

Annual Average Gross Beta Activity
Drinking Water (pCi/liter)
Watts Bar Nuclear Plant

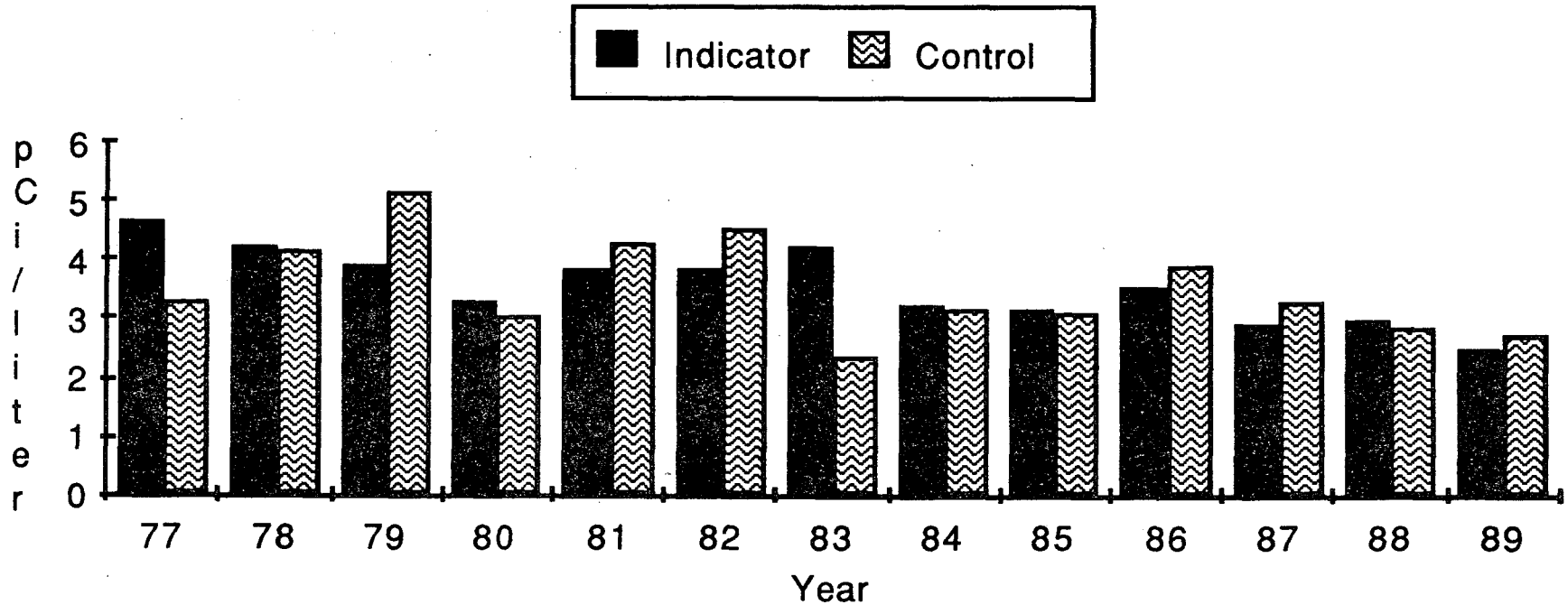


Figure H-6

Annual Average Cs-137 Activity
Sediment (pCi/g dry weight)
Watts Bar Nuclear Plant

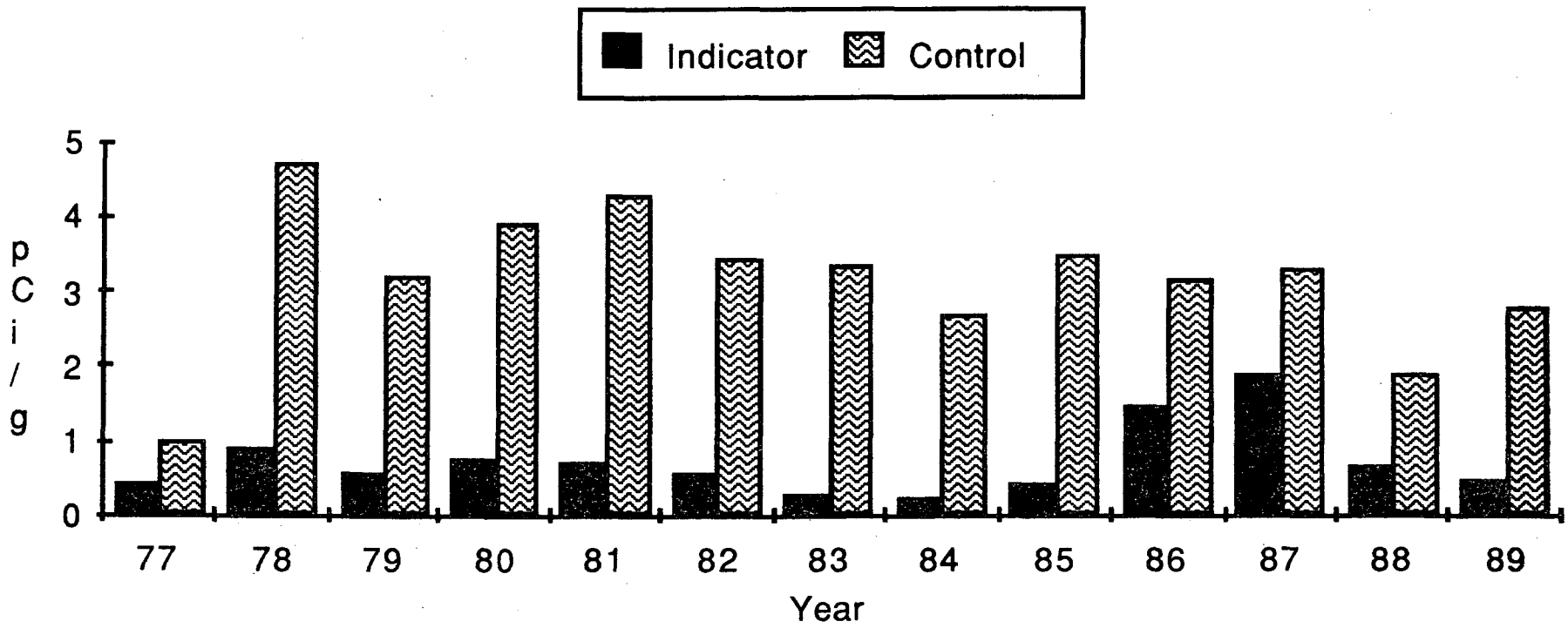
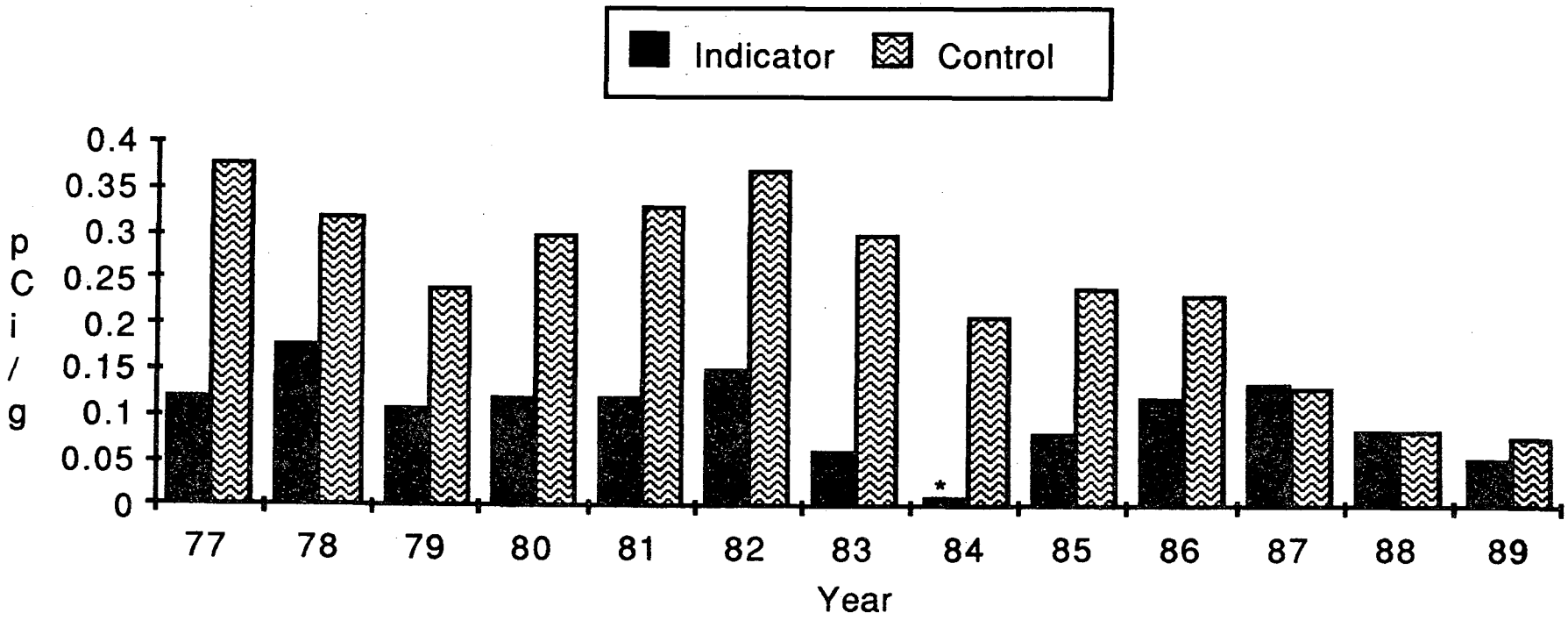


Figure H-7

Annual Average Co-60 Activity
Sediment (pCi/g dry weight)
Watts Bar Nuclear Plant



* Less than LLD (0.01 pCi/g)