Frank O'Donnell

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OAK RIDGE NATIONAL LABORATORY

UNION CARBIDE

OPERATED BY
UNION CARBIDE CORPORATION
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ENVIRONMENTAL MONITORING REPORTS

UNITED STATES DEPARTMENT OF ENERGY OAK RIDGE FACILITIES

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NUCLEAR DIVISION

UNION CARBIDE

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ENVIRONMENTAL MONITORING REPORT

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OAK RIDGE FACILITIES

Calendar Year 1982

UNION CARBIDE CORPORATION - NUCLEAR DIVISION

Office of Health, Safety, and Environmental Affairs
Post Office Box Y
Oak Ridge, Tennessee 37830

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INTRODUCTION

Oak Ridge is located in East Tennessee in a broad valley which lies between the Cumberland Mountains on the northwest and the Great Smoky Mountains on the southeast. The Department of Energy (DOE) Reservation is located in the Valley and Ridge physiographic province which is characterized by parallel ridges of sandstone, shale, and cherty dolomite, separated by valleys of less weather-resistant limestone and shale. The ridges are oriented southwest-northeast. Topography of the area is due to differential erosion of severely folded and faulted rocks ranging in age from Early Cambrian to Early Mississippian. Elevations range from 226 to 415 meters above mean sea level with a maximum relief of 189 meters. The area includes gently sloping valleys and rolling to steep slopes and ridges. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar Reservoirs on the Clinch River form the southern and western boundaries of the Reservation while the City of Oak Ridge (approximately 28,000 population) is on the northern boundary.

The local climate is noticeably influenced by topography. Prevailing winds are usually either up-valley, from west to southwest, or down-valley, from east to northeast. During periods of light winds, daytime winds are usually southwesterly and nighttime winds usually northeasterly. Wind velocities are somewhat decreased by the mountains and ridges, and tornadoes rarely occur. In winter, the Cumberland Mountains have a moderating influence on the local climate by retarding the flow of cold air from the north and west. Temperatures of 38°C or higher and -18°C or below are unusual. Low-level temperature inversions occur during approximately 56 percent of the hourly observations. Winter and early spring are the seasons of heaviest precipitation with the monthly maximum normally occurring during January to March. The mean annual precipitation is approximately 137 centimeters.

The topography of the Oak Ridge area is such that all drainage from the DOE Reservation flows into the Clinch River which has its headwaters in southwestern Virginia and flows southwest to its mouth near Kingston, Tennessee. The Clinch River flow is regulated by several dams which provide reservoirs for flood control, electric power generation, and recreation. The principal tributaries through which liquid effluents from the plant areas reach the Clinch River are White Oak Creek, East Fork Poplar Creek, and Poplar Creek.

With the exception of the City of Oak Ridge, the land within 8 kilometers of the DOE Reservation is predominantly rural being utilized largely for residences, small farms, and pasturage for cattle. Fishing, boating, water skiing, and swimming are favorite recreational activities in the area. The approximate location and population of the towns nearest the DOE Reservation are: Oliver Springs (pop. 3600) 11 kilometers to the northwest; Clinton (pop. 5400) 16 kilometers to the northeast; Lenior City (pop. 5400) 11 kilometers to the southeast; Kingston (pop. 4400) 11 kilometers to the southwest; and Harriman (pop. 8300) 13 kilometers to the west. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 kilometers to the east and has a population of approximately 183,000. A directional 80-kilometer population distribution, which is used for population dose calculations later in this report, is shown in Table 1.

The DOE Reservation contains three major operating facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Gaseous Diffusion Plant (ORGDP), and the Y-12 Plant; all of which are operated by Union Carbide Corporation, Nuclear Division. In addition, two smaller DOE facilities are in the area: the Comparative Animal Research Laboratory, and the Oak Ridge Associated Universities, both of which are operated by Oak Ridge Associated Universities.

The Oak Ridge National Laboratory is a large multipurpose research laboratory whose basic mission is the discovery of new knowledge, both basic and applied, in all areas related to energy. To accomplish this mission, the Laboratory conducts research in all fields of modern science and technology. The Laboratory's facilities consist of nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, and support facilities.

The Oak Ridge Gaseous Diffusion Plant (ORGDP) is a complex of production, research, development, and support facilities located west of the city of Oak Ridge. While the primary function of ORGDP is the enrichment of uranium hexafluoride (UF_6) in the uranium-235 isotope, extensive efforts are also expended on research and development activities associated with both the gaseous diffusion and gas centrifuge processes. In addition, the barrier material used by all three Department of Energy-owned gaseous diffusion plants is manufactured at ORGDP. Numerous other activities (maintenance, nitrogen production, steam production, uranium recovery, fluorine production, water treatment, laboratory analysis, administration, etc.) lend support to these primary functions and are thus essential to the operation of this plant.

The Oak Ridge Y-12 Plant which is located immediately adjacent to the City of Oak Ridge has five major responsibilities: (1) production of nuclear weapon components, (2) processing of source and special nuclear materials, (3) support to the weapon design laboratories, (4) support to other UCC-ND installations, and (5) support to other government agencies. Activities associated with these functions include the production of lithium compounds, the recovery of enriched uranium from unirradiated scrap material, and the fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

Operations associated with the DOE research and production facilities in Oak Ridge give rise to several types of waste materials.

Radioactive waste are generated from nuclear research activities, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, uranium enrichment, and uranium processing operations. Nonradioactive wastes are generated by normal industrial-type support operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plant operations, and steam plant operations.

Nonradioactive solid wastes are buried in a centralized sanitary landfill or designated burial areas. Radioactive solid wastes are buried in solid waste storage areas and placed in retrievable storage either above or below ground depending upon the type and quantity of radioactive material present and the economic value involved.

Gaseous wastes generally are treated by filtration, electrostatic precipitation, and/or chemical scrubbing techniques prior to release to the atmosphere. The major gaseous waste streams are released through stacks to provide atmosphere dilution for materials which may remain in the stream following treatment.

Liquid radioactive wastes are not released but are concentrated and contained in tanks for ultimate disposal. Process water which may contain small quantities of radioactive or chemical pollutants is discharged, after treatment, to White Oak Creek, Poplar Creek, East Fork Poplar Creek, and Bear Creek, which are small tributaries to the Clinch River.

SUMMARY

The Environmental Monitoring Program for the Oak Ridge area includes sampling and analysis of air, water from surface streams, creek sediments, biota, and soil for both radioactive and nonradioactive materials. This report presents a summary of the results of the program for calendar year 1982.

Surveillance of radioactivity in the Oak Ridge environs indicates that atmospheric concentrations of radioactivity were not significantly different from other areas in East Tennessee. Concentrations of radioactivity in the Clinch River and in fish collected from the river were less than one percent of the permissible concentration and intake guides for individuals in the offsite environment. While some radioactivity was released to the environment from plant operations, the concentrations in all of the media sampled were well below established standards.

The total body dose to a "hypothetical maximum exposed individual" at the site boundary was calculated to be 4.9 millirem/yr (49 microsieverts) which is one percent of the DOE Order 5480.1A standard. The maximum 50-year dose commitment to the critical organ of an individual from the aquatic food chain was calculated to be 21 millirem (210 microsieverts) to the bone which is 1.4 percent of the allowable annual standard. The maximum dose commitment to individuals living nearest the site boundary from airborne releases, assuming continuous residence, was 1.9 millirem (19 microsieverts) to the total body and 8.7 millirem (87 microsieverts) to the lung. These doses are 0.4 percent and 0.6 percent, respectively, of the annual standards. The average total body dose to an Oak Ridge resident was estimated to be 0.09 millirem (0.9 microsieverts) as compared to approximately 100 millirem/yr (1000 microsieverts/yr) from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.44 millirem (4.4 microsieverts). The cumulative total body dose to the population within an 80-kilometer radius of the Oak Ridge facilities resulting from 1982 effluents was calculated to be 50 man-rem (0.5 man-sieverts). This dose may be compared to an estimated 87,000 man-rem (870 man-sieverts) to the same population resulting from natural background radiation.

Surveillance of nonradioactive materials in the Oak Ridge environs shows that established limits were not exceeded for those materials possibly present in the air as a result of plant operations.

The chemical water quality data in surface streams obtained from the water sampling program indicated that average concentrations resulting from plant effluents were in compliance with State stream guidelines with the exception of fluoride at monitoring Station E-1 which was 110 percent of the guideline and nitrate at Station B-1 which was 100 percent of the guideline.

National Pollutant Discharge Elimination System (NPDES) permit compliance information has been included in this report.

During 1982 there were no spills of oil and/or hazardous materials from the Oak Ridge installations reported to the National Response Center.

MONITORING DATA COLLECTION, ANALYSIS, AND EVALUATION

Environmental monitoring data for calendar year 1982 are summarized in Tables 2 through 34. In general, the data tables show the number of samples collected at each location, the maximum concentration, the minimum concentration, the average concentration, the relevant standard, and percent of standard for the average of each parameter. Averages are usually accompanied by plus-or-minus ($\pm$) values which represent the 95 percent confidence limits. The 95 percent confidence

limits which are calculated from the standard deviation of the average, assuming a normal frequency distribution, are predictions of the variability in the range of concentrations based on a limited number of measurements. They do not represent the conventional error in the average of repeated measurements on identical samples. Data which are below the minimum detectable limit are expressed as less than (<) the minimum detectable value. In computing average values, sample results below the detection limit are assigned the detection limit value with the resulting average value being expressed as less than (<) the computed value.

Average environmental concentrations are compared with applicable standards, where such standards have been established, as a means of evaluating the impact of effluent releases. Potential radiation dose to members of the public and/or environmental concentrations of radioactivity are compared with the dose standards and environmental concentration guides contained in DOE Order 5480.1A[1]

The concentration guide (CG) is a number derived for the most part from the dose standards recommended by the International Commission on Radiological Protection (ICRP) and the National Council on Radiological Protection (NCRP) and contained in DOE Order 5480.1A. The concentration guides for a particular radionuclide are those concentrations in air or water which can be inhaled or ingested each day by a "standard man" for a period of 50 years without exceeding the committed dose equivalent specified in the dose standards.

The "standard man" is described by the ICRP in terms of body proportions of various elements found in the body; average consumption rates of food, air, and water; average excretion rates; weight of each body organ; and a number of other factors such as the size distribution of dust particles trapped in the respiratory tract and their fate in the body.

Stream concentrations of nonradoactive pollutants have been compared with Tennessee State Health Department stream guidelines.

Liquid effluent monitoring data have been compared to the limits specified in the National Pollutant Discharge Elimination System (NPDES) permits issued to the Oak Ridge facilities by the Environmental Protection Agency (EPA).

There is a movement currently in some scientific communities to use the International System of Units (SI) for radioactive measurements. This report contains data in both units; the non-SI units used previously, followed by the SI units in parentheses.

Air Monitoring

Radioactive - Atmospheric concentrations of radioactive materials occuring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of nine stations (HP-31 through HP-39) which encircle the perimeter of the Oak Ridge area and provides data for evaluating releases from Oak Ridge facilities to the immediate environment, Figure 1. A second system consists of seven stations (HP-51 through HP-53 and HP-55 through HP-58) encircling the Oak Ridge area at distances of from 19 to 121 kilometers, Figure 2. This system provides background data to aid in evaluating local conditions. Sampling for radioactive particulates is carried out by passing air continuously through filter papers. Filter papers are evaluated weekly by gross beta and gross alpha counting techniques and composited by system quarterly for specific radionuclide analysis. More frequent detailed analyses are performed if concentrations in the environment are significantly above normal. Airborne radioactive iodine is monitored in the immediate environment at the perimeter stations by passing air continuously through cartridges containing activated charcoal. Charcoal cartridges are evaluated for radioactive iodine by gamma spectrometry.

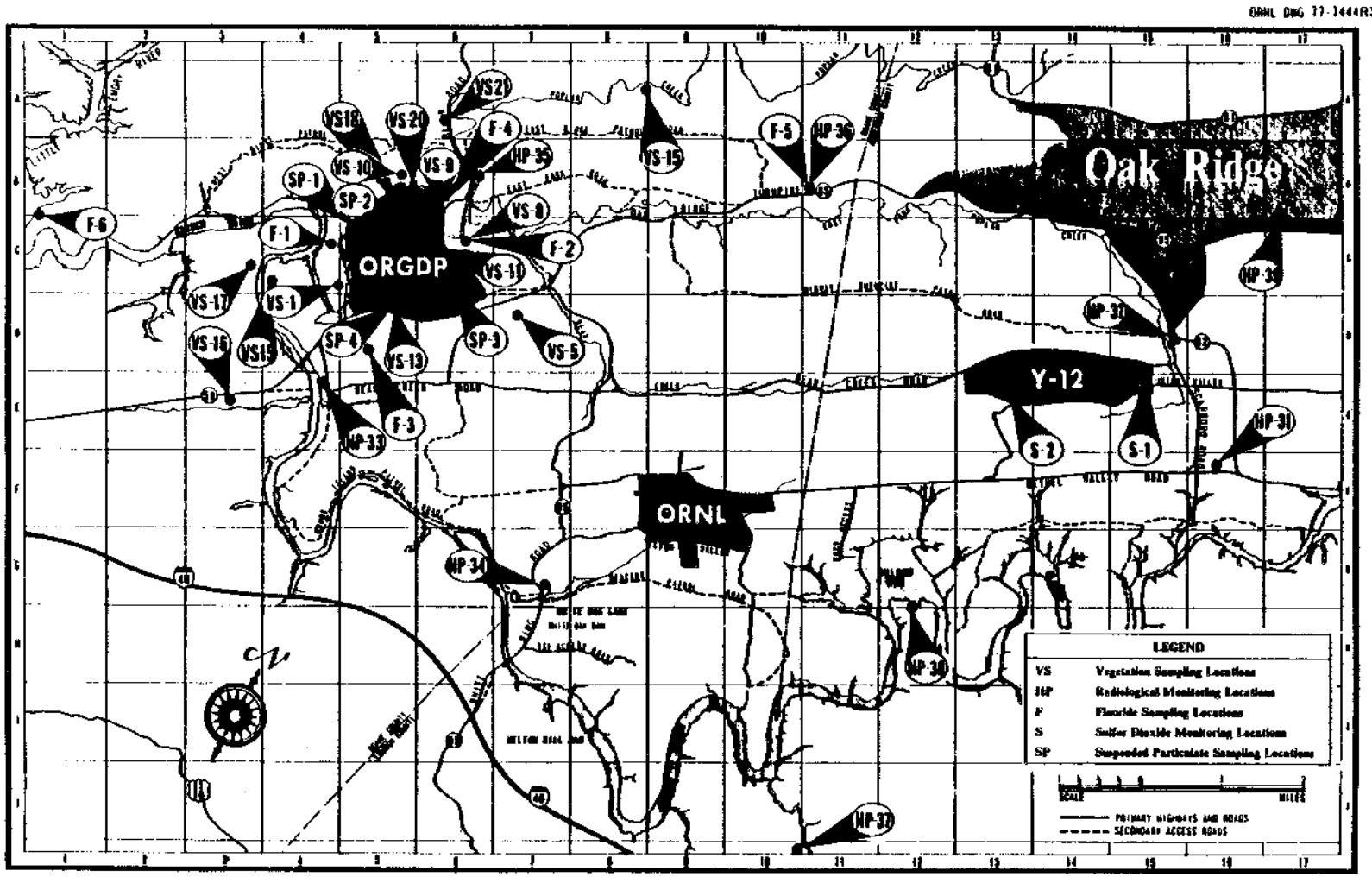

Figure 1
AIR, VEGETATION, AND SOIL SAMPLING LOCATIONS

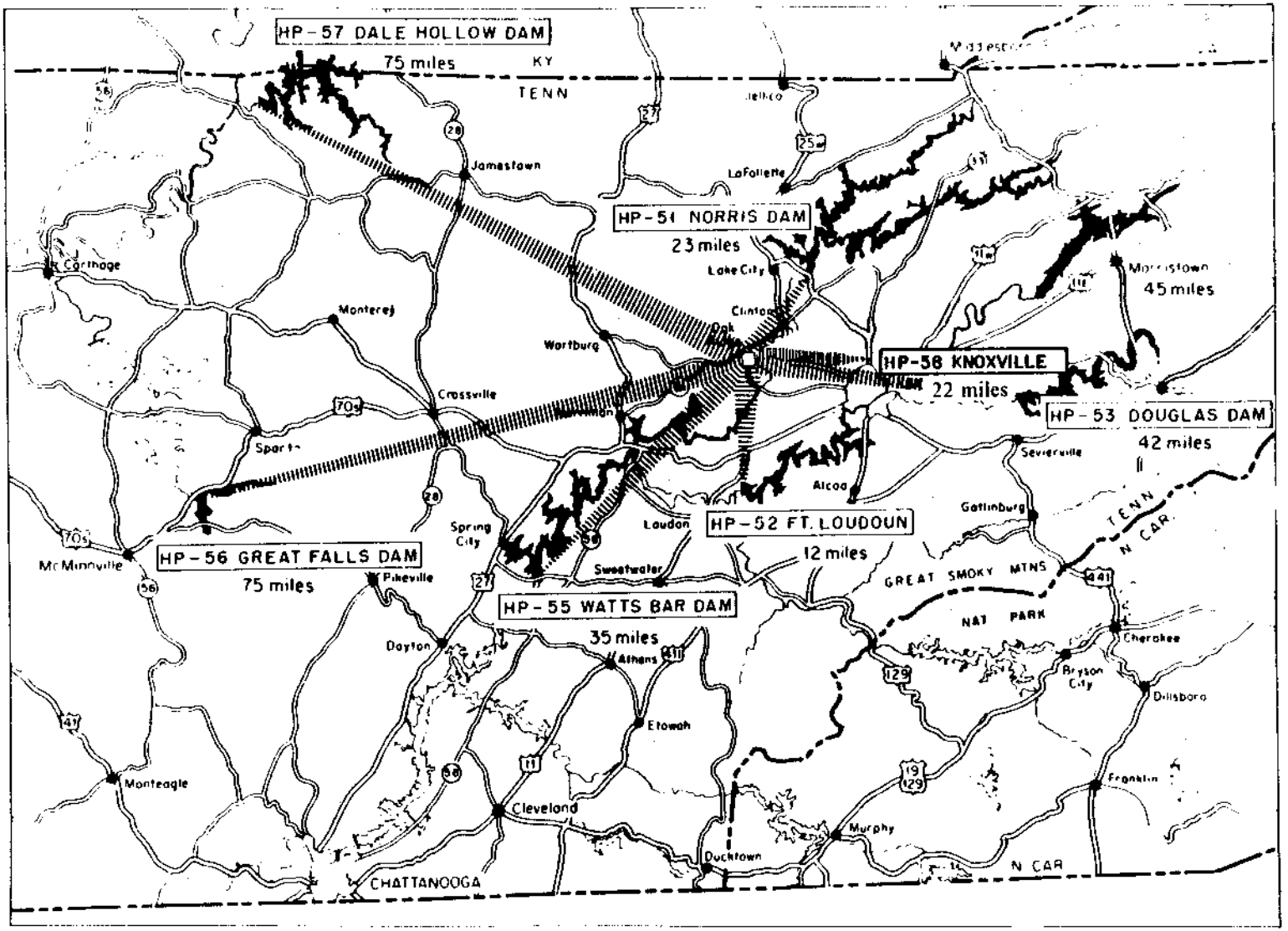

Figure 2
REMOTE AIR MONITORING LOCATIONS

Data on the concentrations of radioactive materials in air and the quantities of radioactive materials released to the atmosphere in the Oak Ridge and surrounding areas are given in Tables 2 through 6.

The average gross beta concentrations of radioactivity from particulates in air measured by both the perimeter and remote monitoring systems were 0.02 and 0.02 percent, respectively, of the applicable concentration guide (CG) as specified in the DOE Order 5480.1A, Chapter XI for individuals in uncontrolled areas (Table 2).

The average gross alpha concentrations in the perimeter and remote monitoring systems were 0.02 and 0.02 percent, respectively, of the CG for a mixture of uranium isotopes (Table 3).

The results of specific radionuclide analyses of composited filters are given in Table 4. The environmental concentrations tabulated are all at least a thousand times less than the applicable DOE concentration guides for the radionuclides detected. In general, activity levels were less than those of the previous year, this change being attributed to the decrease in world-wide fallout.

The concentration of ^{131}I as measured by the perimeter air monitoring system was <0.01 percent of the inhalation concentration guide for individuals in uncontrolled areas (Table 5).

While some radioactivity was released to the atmosphere (Table 6), measurements in the Oak Ridge area show that environmental levels were well below established standards.

Nonradioactive - Environmental air samples are taken for the determination of fluorides, suspended particulates, and sulfur dioxide.

Sampling locations for fluorides are indicated by F-1 through F-6, Figure 1. The current sampling procedure is to obtain six-day samples collected on potassium carbonate treated paper and to analyze weekly by specific ion electrode. The six-day analyses are then averaged to obtain 30-day values.

Suspended particulates are measured at locations SP-1 through SP-4, Figure 1. The method for the determination of suspended particulates is the high volume method recommended by EPA. Particulates are collected by drawing air through weighed filter paper. The filter paper is allowed to equilibrate in a humidity controlled atmosphere and the filter is reweighed. From the weight of particulates, the sampling time, and the air flow rate, the particulate concentration in micrograms per cubic meter is calculated. The sampling period is 24 hours.

The two continuous monitoring stations (S-1 and S-2) in the Y-12 Plant are used for measurement of ambient sulfur dioxide concentrations. Each station consists of a pulsed ultraviolet fluorescence analyzer and recorder with associated equipment located in a temperature-controlled shelter. Sulfur dioxide concentrations are interpreted on an hourly basis and averaged for 24-hour, monthly, and annual periods.

Air monitoring data for fluorides, suspended particulates, and sulfur dioxide are presented in Tables 7 through 9. The data indicate that measured environmental concentrations of fluorides, suspended particulates, and sulfur dioxide were in compliance with applicable standards.[2]

The Y-12 steam plant is being upgraded to operate more efficiently at higher steam load levels. The current electrostatic precipitator installation is not adequate to meet emission limits at higher steam load levels. Construction has commenced on the installation of pollution control equipment to meet emission limits under higher operating load conditions.

External Gamma Radiation Monitoring

External gamma radiation background measurements are made routinely at the perimeter air monitoring stations and at the remote monitoring stations using calcium fluoride thermoluminescent dosimeters suspended one meter above the ground. Dosimeters at the perimeter stations are collected and analyzed monthly. Those at the remote stations are collected and analyzed semiannually.

Data on the average external gamma radiation background are given in Table 10. A considerable variation in background levels is normally experienced in East Tennessee depending upon elevation, topography, and geological character of the surrounding soil.[3]

External gamma radiation measurements were made along the bank of the Clinch River from the mouth of White Oak Creek several hundred yards downstream to evaluate gamma radiation levels resulting from effluent releases and "sky shine" from an experimental cesium plot located near the river bank. Measurements were made using scintillation detectors and/or thermoluminescent dosimeters suspended one meter above the ground surface. The average background level determined at the remote stations was subtracted from the measured gamma radiation levels to determine the incremental increases resulting from plant operations.

The external gamma radiation levels along the bank of the Clinch River ranged from 2 to 20 μR/h (0.5 E-09 to 5.2 E-09 C/kg/h) above background. Potential doses to individuals in the environment from these elevated gamma radiation levels were calculated and are included, where significant, in the dose assessment section of the report.

Water Monitoring

Radioactive - Water samples are collected in the Clinch River for radioactivity analyses at Melton Hill Dam (Station C-2) 3.7 kilometers above White Oak Creek outfall, at the ORGDP sanitary water intake (Station C-3) 10 kilometers downstream from the entry of White Oak Creek, at the ORGDP recirculating water intake (Station C-4) downstream from the Poplar Creek outfall, and near Brashear Island (Station C-6). A sample is also collected from the Water Plant (Station C-5) near Kingston, Tennessee, Figure 3. Samples are collected continuously at Stations C-2, and C-3. A weekly 24-hour composite sample is collected at Station C-4 and a weekly grab sample is collected at Station C-6. A daily grab sample is collected at Station C-5. Samples are composited for monthly or quarterly analysis depending upon location.

Water samples also are collected for radioactivity analyses at the mouth of White Oak Creek (Station W-1), at the outlet of New Hope Pond on East Fork Poplar Creek (Station E-1), in Bear Creek (Station B-1), and in Poplar Creek (Stations P-1 and P-2), Figure 3. The samples collected at Stations W-1, E-1, and B-1 are continuous samples. Grab samples are collected at Stations P-1 and P-2 on a weekly basis. Water samples are collected also at White Oak Dam. All samples are composited for monthly analysis.

The concentrations of fission product radionuclides present in detectably significant amounts are determined by specific radionuclide analysis and gamma spectrometry. Uranium analysis is by the fluorometric method. Transuranic alpha emitters are determined by ion exchange and alpha range analysis. The concentration of each radionuclide is compared with its respective concentration guide (CG) value as specified in the DOE Order 5480.1A and percent of concentration guide for a known mixture of radionuclides is calculated in accordance with the method given in the Order.

Data on the concentrations of radionuclides measured in the surface streams are given in Table 11. Data on the concentrations of uranium in surface streams and the quantities of radioactivity release to surface streams are given in Tables 12 and 13.

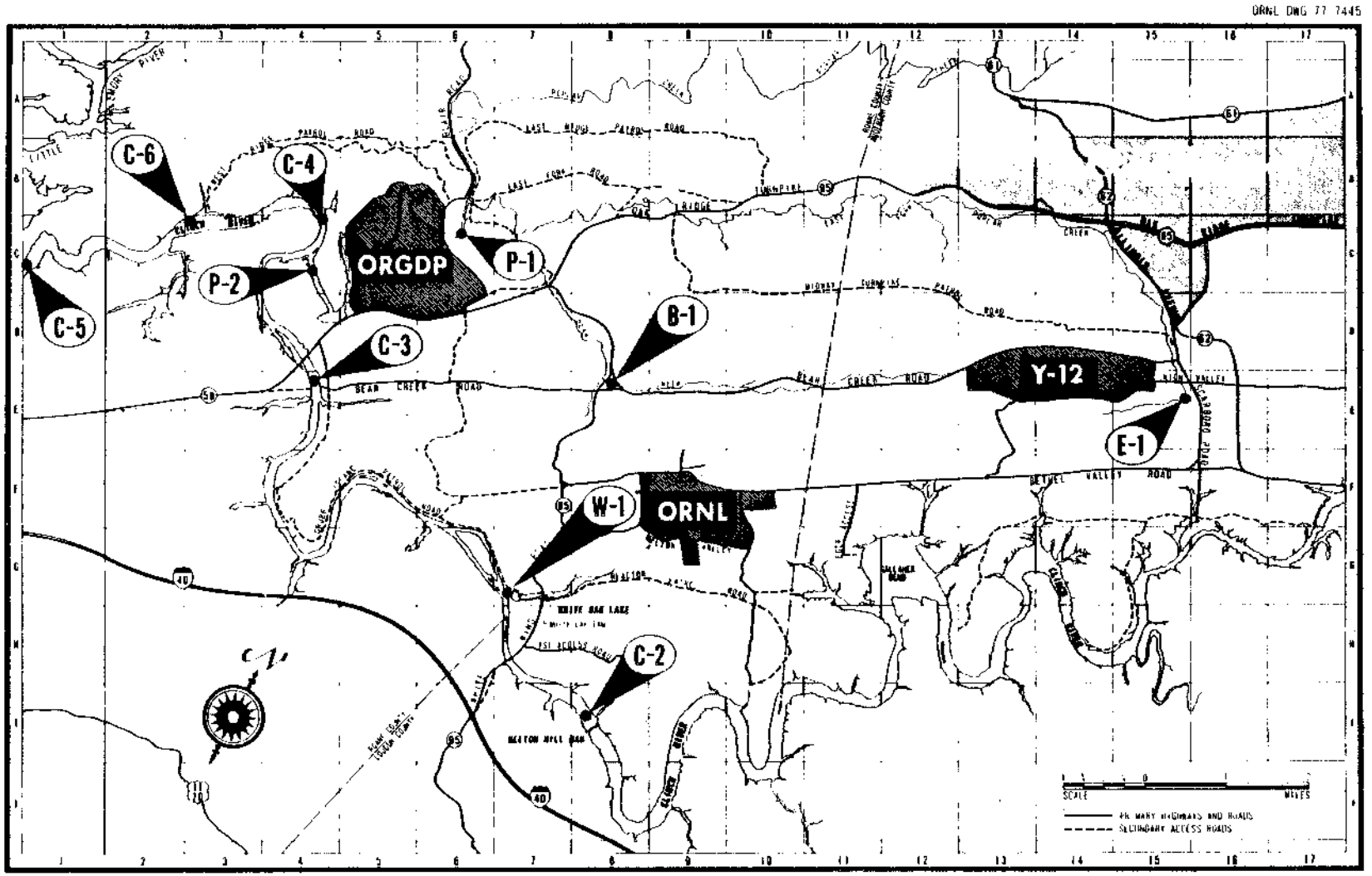

Figure 3
STREAM MONITORING LOCATIONS

Analysis of water samples collected in the mouth of White Oak Creek (Station W-1) indicated that the yearly average concentration of radionuclides was approximately 26 percent of the applicable concentration guide for uncontrolled areas. The calculated average concentration of radionuclides in the Clinch River, based on the analysis of water samples collected at White Oak Dam and the dilution afforded by the river, assuming complete mixing, was determined to be 0.3 percent of the applicable concentration guide for uncontrolled areas. The average dilution factor for 1982, based on the flow of White Oak Creek and the Clinch River, was 463. The measured average concentrations of radionuclides in the Clinch River upstream and downstream of White Oak Creek outfall were less than one percent of the applicable concentration guide.

The calculated average concentration of transuranic alpha emitters in the Clinch River resulting from effluent releases was 0.86 E-11 μCi/mL (0.33 mBq/L), which is about 0.03 percent of the concentration guide for water containing a known mixture of radionuclides.

Trends in water discharges and calculated percent concentration guide levels in the Clinch River are presented in Figures 4 and 5. Discharges of ^{90}Sr and ^{3}H are shown in Figure 4 as these nuclides contribute the majority of the radiological dose downstream.

Rainwater - The gross beta activity in rainwater was analyzed; the results are shown in Table 14. The fluctuations among the stations for both the perimeter and remote networks are due to statistical random variation. It is noted that the average radioactivity is greater for the remote stations than the perimeter stations.

Nonradioactive - Water samples are collected for the analysis of nonradioactive substances at the same locations discussed previously under radioactive water sampling. All samples are composited for monthly analysis. Samples are analyzed for a variety of water quality parameters related to process release potential and background information needs by analytical procedures recommended by the Environmental Protection Agency.[4] Samples from Station C-2 were not analyzed for nonradioactive pollutants during 1982.

Data on chemical concentrations in surface streams are given in Tables 15 through 22. The average concentrations of all substances analyzed were in compliance with Tennessee stream guidelines[5, 6] except for fluoride at Station E-1 and nitrate at Station B-1 which were 110 and 100 percent of the guidelines, respectively.

National Pollution Discharge Elimination System (NPDES) permits were issued by the Environmental Protection Agency (EPA) for each of the Oak Ridge facilities operated by Union Carbide Corporation - Nuclear Division in 1975. The permits established a number of discharge locations at each installation and listed specific concentration limits and/or monitoring requirements for a number of parameters at each discharge location. Table 23 shows the discharge locations at each installation, the parameters at each location for which limits have been established, the permit limits for each parameter, and the percentage compliance experienced.

Biological Monitoring

Milk - Raw milk is monitored for ^{131}I and ^{90}Sr by the collection and analysis of samples from 10 sampling stations located within a radius of 80 kilometers of Oak Ridge. Samples are normally collected weekly at each of six stations located near the Oak Ridge area. Four stations, located more remotely with respect to Oak Ridge operations, are sampled at a rate of one station each week. Milk sampling locations for all stations are shown in Figures 6 and 7. Samples are analyzed by ion exchange and gamma spectrometry; results are compared to intake guides specified by the Federal Radiation Council (FRC).[7]

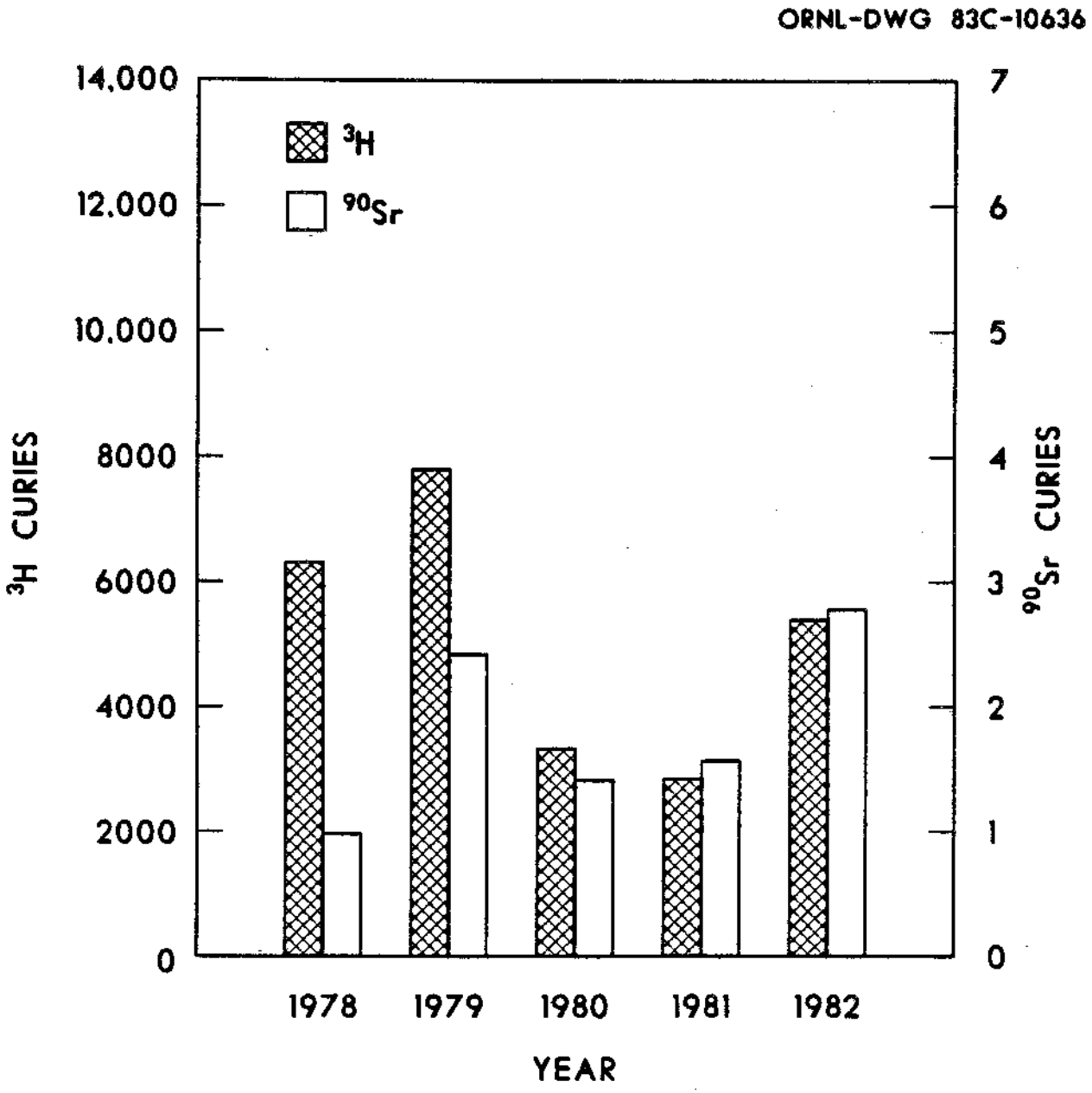

Figure 4
CURIES DISCHARGED OVER WHITE OAK DAM

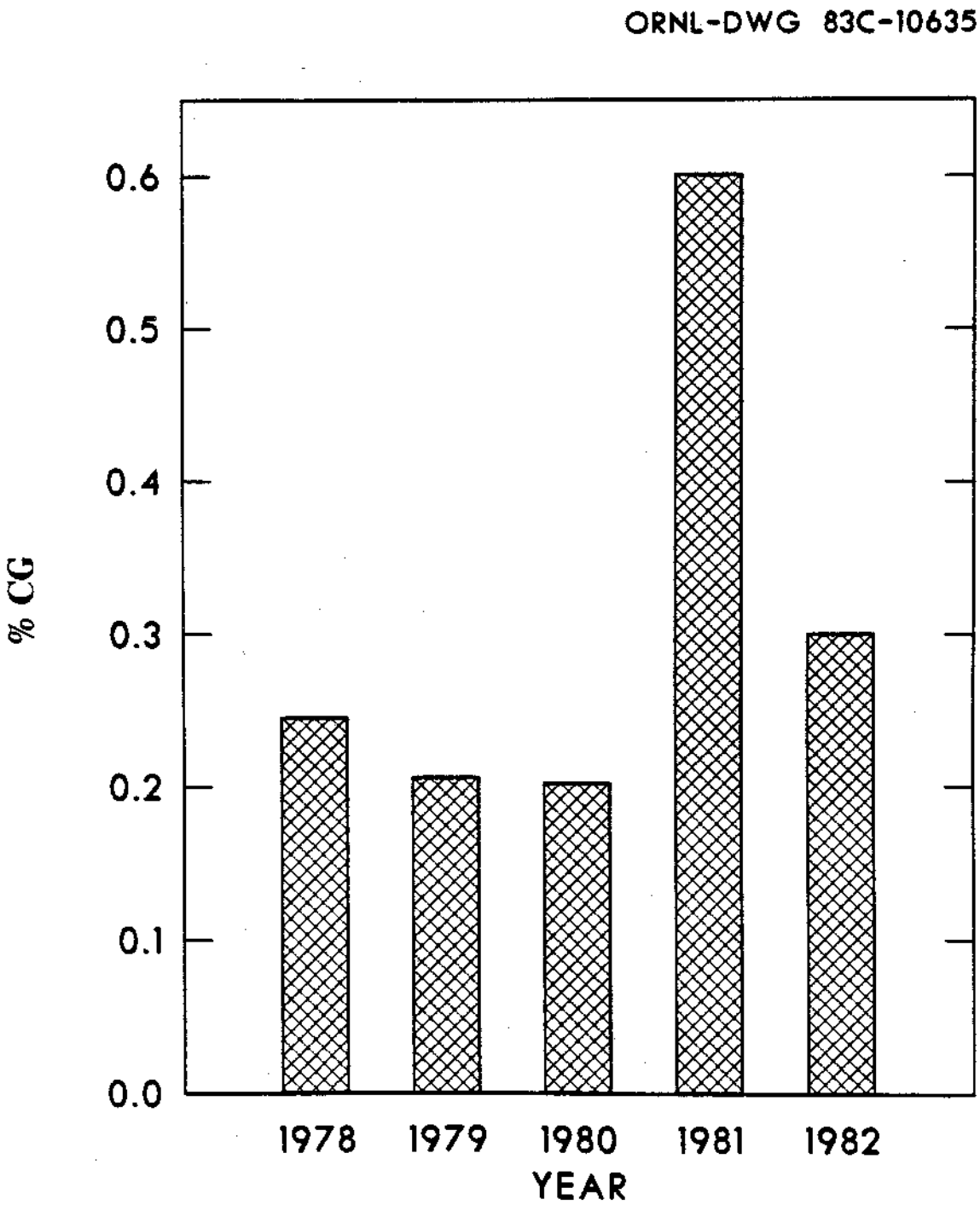

Figure 5
PERCENTAGE CONCENTRATION GUIDE LEVELS IN THE CLINCH RIVER (VALUES GIVEN ARE CALCULATED VALUES BASED ON THOSE CONCENTRATIONS MEASURED AT WHITE OAK DAM AND DILUTION AFFORDED BY THE CLINCH RIVER

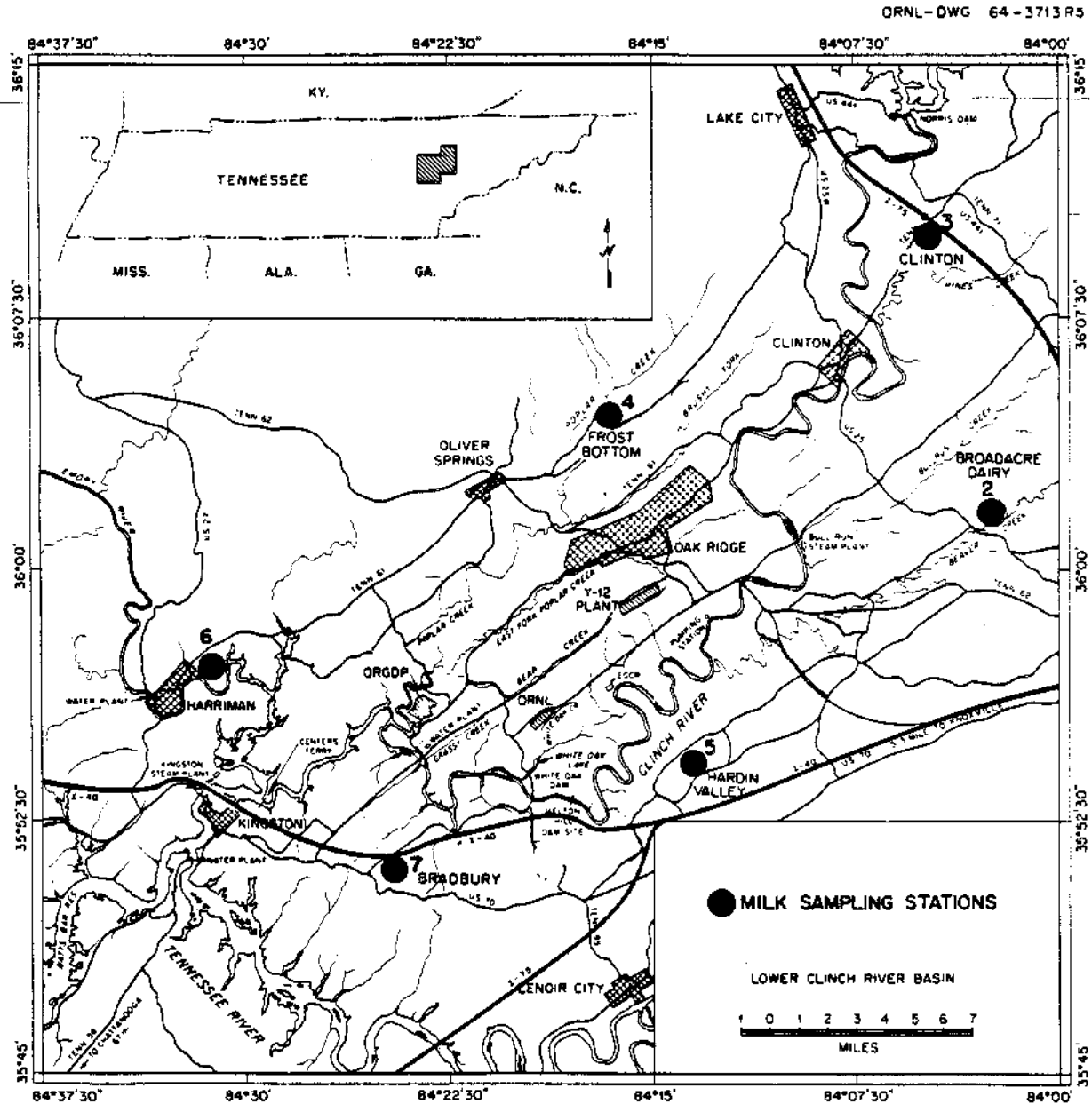

Figure 6
IMMEDIATE ENVIRONS MILK SAMPLING LOCATIONS

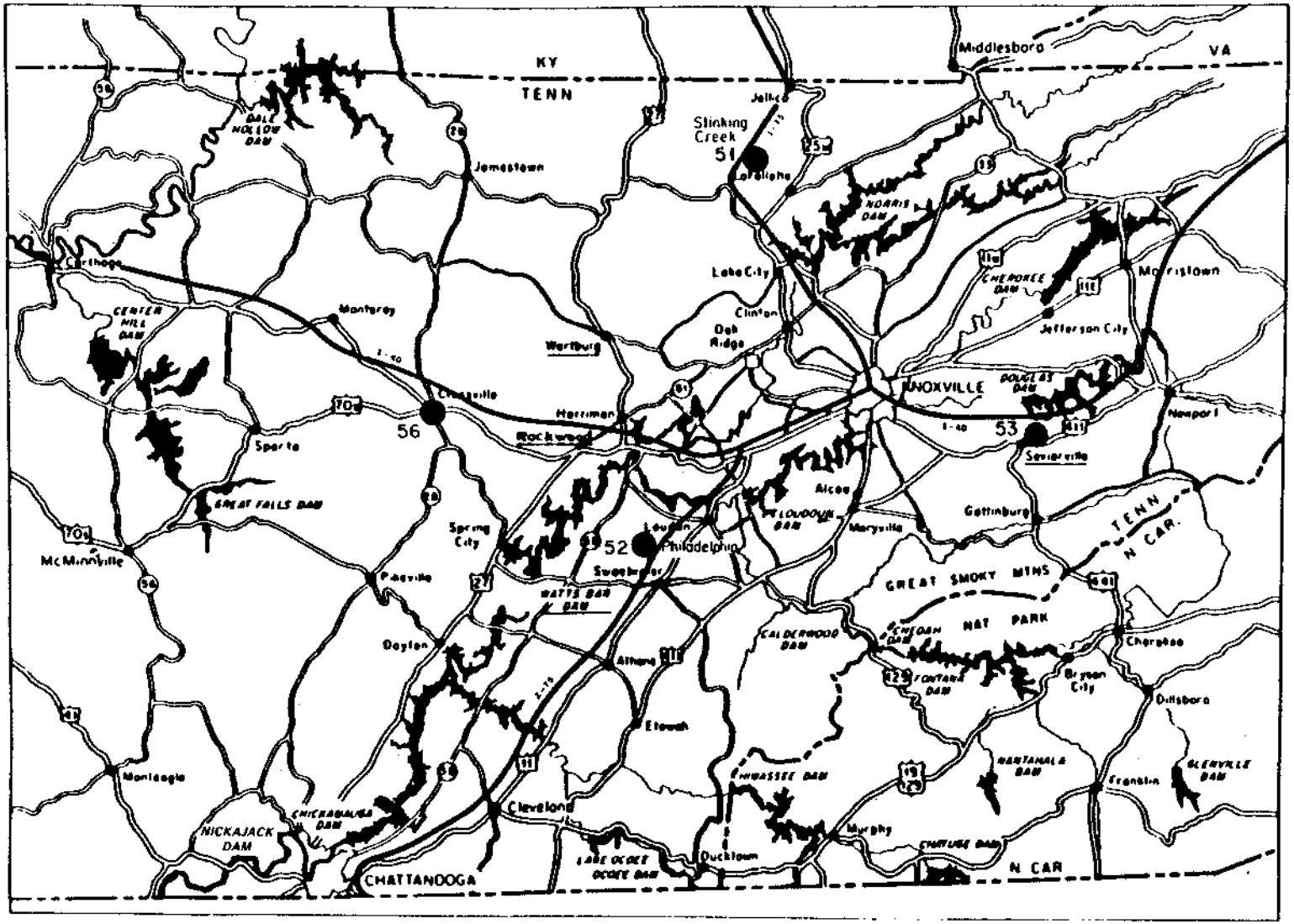

Figure 7
REMOTE ENVIRONS MILK SAMPLING LOCATIONS

The average concentrations of ^{131}I and ^{90}Sr in raw milk are given in Tables 24 and 25, respectively. If one assumes the average intake of milk per individual to be one liter per day, the average concentrations of ^{131}I in milk in both the immediate environs of the Oak Ridge area and in the environs remote from Oak Ridge were below the detection limit for ^{131}I, 0.45 E-09 μCi/mL (0.017 Bq/L). The average concentrations of ^{90}Sr in milk from both the immediate and remote environs were within the FRC Range 1.

Fish Sampling - Several species of fish which are commonly caught are taken from the Clinch River each year. The scales, head, and entrails are removed from the fish before ashing. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometry and radiochemical techniques for the critical radionuclides which may contribute significantly to the potential radiation dose to man.

Data on the concentration of radionuclides in Clinch River fish are given in Tables 26 and 27. Consumption of 16.8 kilograms of bluegill per year[8] taken from the river near White Oak Creek outfall results in approximately 0.6 percent of the maximum permissible intake, which represents the highest dose potential to the public from fish consumption. The maximum permissible intake is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of the radionuclides in question. Mercury concentrations in the fish samples collected were less than the Food and Drug Administration (FDA) proposed action level (Table 28).

Deer - Frequently, deer are killed by automobiles on the DOE Reservation. Forty-eight deer samples were analyzed during 1982. Summary data of the ^{137}Cs content in deer samples are presented in Table 29. The deer with the highest concentration of ^{137}Cs would result in a dose of 0.1 millirem (one microsievert) to the total body and 0.14 millirem (1.4 microsieverts) to the liver (critical organ) if one assumes the consumption of one kilogram of meat. It should be noted that no hunting is allowed on the Reservation.

Vegetation - Samples of pine needles and grass are collected semiannually from 14 areas (Figure 1) and analyzed for uranium and fluoride content. Fluorometric analysis is used for the determination of uranium and colorimetric analysis is used for the determination of fluorides.

Data on the uranium and fluoride content in vegetation are presented in Table 30. The fluoride concentration in grass at all sampling points was below the 30 $\mu g/g$ level considered to produce no adverse effects when ingested by cattle.[9] Uranium concentrations were below levels of environmental concern.

Additionally, samples of grass were collected semiannually from the perimeter and annually from the remote air-sampling stations (see Figures 1 and 2). At each station, all the grass from five 1/5 meter-squared plots was collected. One plot was taken beside the station, and the other four were taken at 15 m from the station at 90° directions from each other. The grass from each station was then composited and analyzed by gamma spectrometry and radiochemical techniques for a variety of radionuclides. Data on the radionuclide concentrations in grass are presented in Table 31.

Soil and Sediment Monitoring

Soil - Soil samples are also collected semiannually from near the perimeter and annually from the remote stations. The same five 1/5 meter-squared plots used for grass analysis were also used for soil determinations. Two cores, 8 cm in diameter and 5 cm in depth, were taken from each plot; a composite of 10 cores was used for each station. These samples were also analyzed by gamma spectrometry and radiochemical techniques.

Data on specific radionuclide concentrations in soil are given in Table 32. The plutonium concentrations found were comparable to the value of 0.05 pCi/g (0.002 Bq/g) considered to be a representative concentration of plutonium in U.S. surface soil.[10]

Sediment - A sediment sampling program was initiated at ORGDP in 1975 to determine the concentrations of various metallic ions in the sediment of Poplar Creek. The current sampling program consists of 8 sampling locations (Figure 8) which should be generally representative of plant effluents. Samples are collected twice during the year and analyzed by atomic absorption.

The concentrations of metals in the stream sediment samples, Table 33, generally exceed background levels for metals in remote streams. An examination of the effluent sources indicates that only very small quantities of any of these metals are currently being released, suggesting that present concentrations found in sediment samples are residual metals from earlier Oak Ridge plant operations.

Calculation of Potential Radiation Dose to the Public

Potential radiation doses resulting from plant effluents were calculated for a number of dose reference points within the Oak Ridge environs. All significant sources and modes of exposure were examined, and a number of general assumptions were used in making the calculations.

The site boundary for the Oak Ridge Complex was defined as the perimeter of the DOE controlled area.

Gaseous effluents are discharged from several locations within each of the three Oak Ridge facilities. For calculational purposes, the gaseous discharges are assumed to occur from only one vent from each site. Since the release points at ORGDP and the Y-12 Plant do not physically approximate an elevated stack, their discharges are assumed to be from 10 meters above ground level; releases from ORNL are through elevated stacks. The meteorological data collected at the ORNL site were used for dispersion calculations. Concentrations of radionuclides contained in the air and deposited on the ground were estimated at distances up to 80 kilometers from the Oak Ridge facilities with the Gaussian plume model developed by Pasquill[11] and Gifford[12] incorporated in a computer program.[13] The concentration has been averaged over the crosswind direction to give the estimated ground level concentration downwind of the source of emission.[14] The deposition velocities used in the calculations were 0.0 cm/s for krypton and xenon, 0.2 cm/s for iodine, and 0.1 cm/s for particulates.[15] Meteorological data are shown in Figure 9; the length of the bars indicates the percentage of time the wind is blowing in that direction.

Potential pathways of exposure to man from radioactive effluents released by the Oak Ridge operations that are considered in the dose estimates are presented in Figure 10. The pathways shown in the figure are not exhaustive, but they include the principal pathways of exposure based on experience.

Exposures to radionuclides that originate in the effluents released from the Oak Ridge facilities were converted to estimates of radiation dose to individuals using models and data presented in publications of the International Commission on Radiological Protection,[16-21] other recognized literature on radiation protection,[22-24] personal communication,[25] and computer programs incorporating some of these models and data.[26, 27] Radioactive material taken into the body by inhalation or ingestion will continuously irradiate the body until removed by processes of metabolism and radioactive decay; thus the estimates for internal dose are called "dose commitments," they are obtained by integrating over the assumed remaining lifetime (50 years) of the exposed individual.

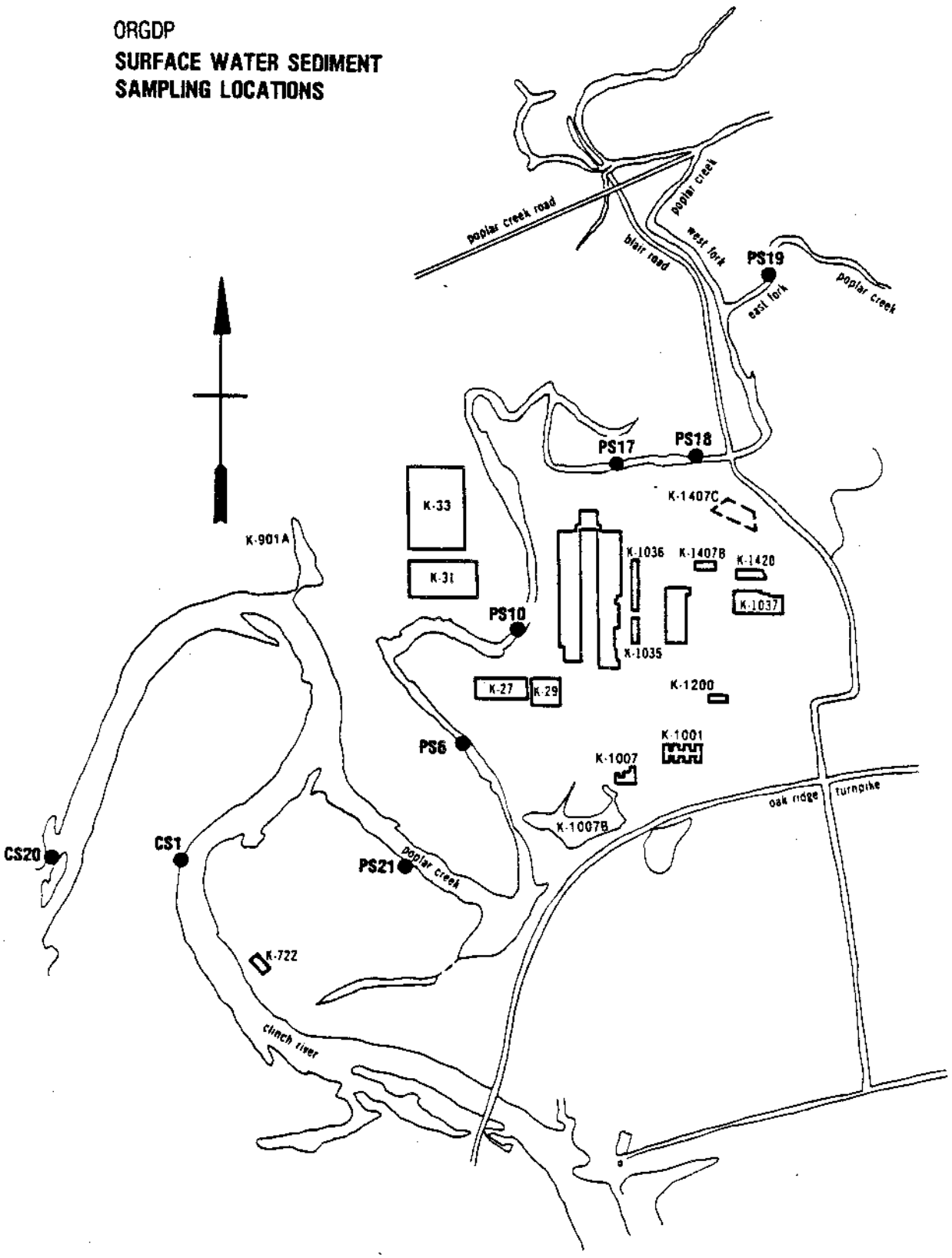

Figure 8
OAK RIDGE GASEOUS DIFFUSION PLANT SEDIMENT SAMPLING LOCATIONS

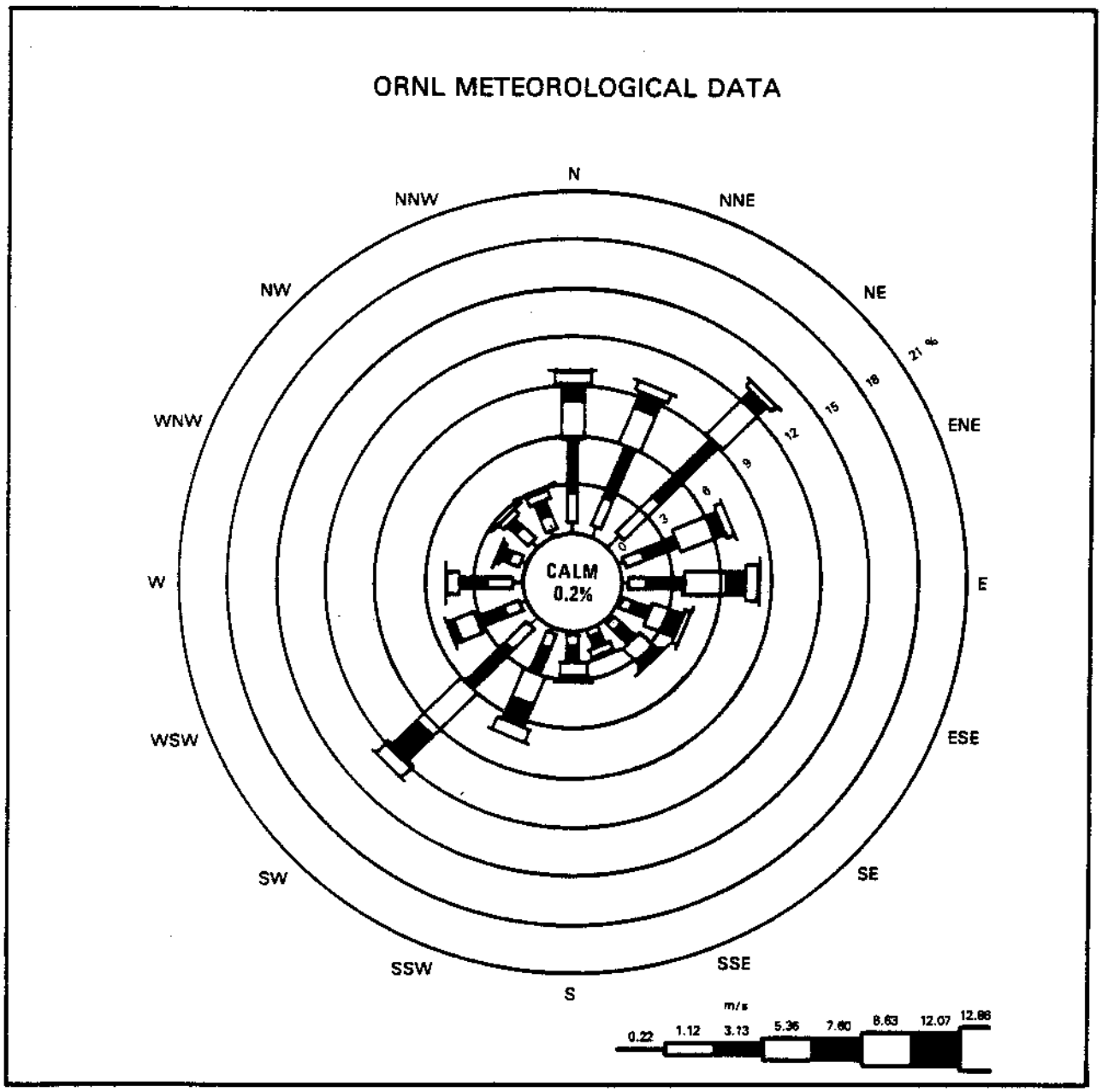

Figure 9
METEOROLOGICAL DATA FOR THE OAK RIDGE RESERVATION

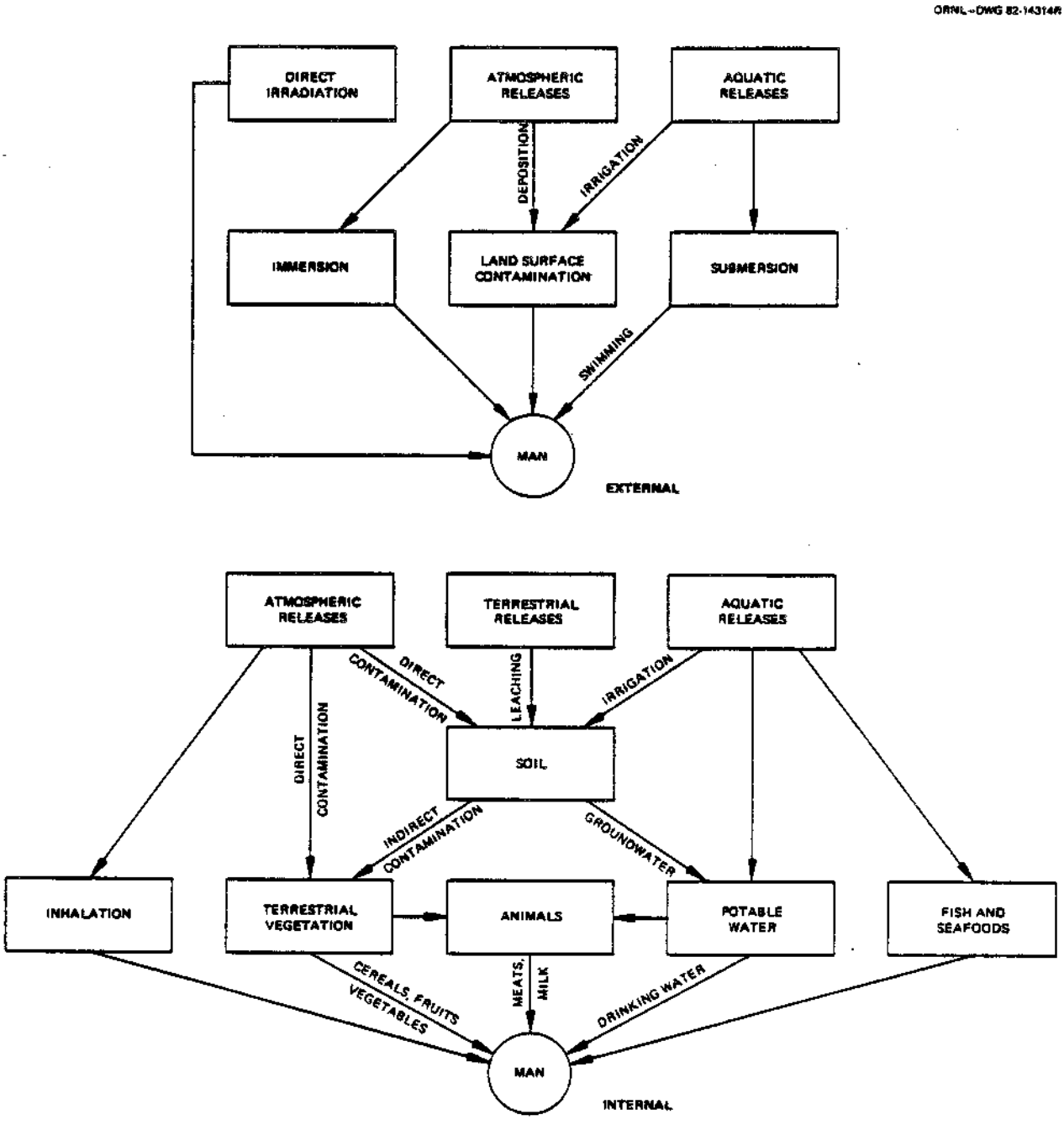

Figure 10
EXPOSURE PATHWAYS

The radiation doses to the total body and to internal organs from external exposures to penetrating radiation are approximately equal, but they may vary considerably for internal exposures because some radionuclides concentrate in certain organs of the body. For this reason, estimates of radiation dose to the total body, thyroid, lungs, bone, liver, kidneys, and gastrointestinal tract were considered for various pathways of exposure. These estimates were based on parameters applicable to an average adult.[16, 21] The population dose estimate in man-rem (man-sieverts) is the sum of the total body doses to exposed individuals within an 80-kilometer radius of the Oak Ridge facilities.

Maximum Potential Exposure - The point of maximum potential ("fence-post" dose) on the site boundary is located along the bank of the Clinch River adjacent to a cesium field experimental plot and is due primarily to "sky-shine" from the plot. A maximum potential total body exposure of 178 millirem/yr (1780 microsieverts/yr) was calculated for this location assuming that an individual remained at this point for 24 hours/day for the entire year. The calculated maximum potential exposure is 36 percent of the allowable standard.[1] This is an atypical exposure location and the probability of an exposure of the magnitude calculated is considered remote since access is only by boat.

The total body dose to a "hypothetical maximum exposed individual" at the same location was calculated using a more realistic residence time of 240 hours/yr. The calculated dose under these conditions was 4.9 millirem/yr (49 microsieverts) which is one percent of the allowable standard[1] and represents what is considered a probable upper limit of exposure.

A more probable exposure might be considered to occur at other locations beyond the site boundary as a result of airborne or liquid effluent releases.

The dose commitment to an individual continuously occupying the residence nearest the site boundary would result from inhalation and is based on an inhalation rate for the average adult of 2 E+04 liters/day. The calculated dose commitments at this location were 8.7 millirem (87 microsieverts) to the lung (the critical organ) and 1.9 millirem (19 microsieverts) to the total body; ^{234}U is the important radionuclide contributing to this dose. These levels are 0.6 percent and 0.4 percent, respectively, of the allowable annual standard. Due to inherent uncertainties in the meteorological data,[28] stack sampling data and calculational techniques, the calculated doses may be in error as much as 300 percent.

An important contribution to dose from radioactivity within the terrestrial food-chain is by the atmosphere-pasture-cow-milk food-chain pathway. Measurements of the two principal radionuclides entering into this pathway, ^{131}I and ^{90}Sr (see Tables 24 and 25), indicate that the maximum dose to an individual in the immediate environs from ingestion of one liter of milk per day is less than 0.02 millirem (0.2 microsieverts) to the thyroid and 1.2 millirem (12 microsieverts) to the bone. The average concentrations for the remote stations were assumed to be background and were subtracted from the perimeter station data in making the calculations.

The public water supply closest to the liquid discharges from the Oak Ridge facilities is located approximately 26 kilometers downstream at Kingston, Tennessee. The intake to the water filtration plant is located on the Tennessee River approximately one-half mile upstream from the confluence of the Clinch and Tennessee Rivers. Normally, Tennessee River water is used for the Kingston water supply but under certain conditions of power generation backflow can occur. Under backflow conditions, Clinch River water may move upstream in the Tennessee River and be used as the source of water for the Kingston filtration plant. Measurements of treated river water samples taken at the Kingston filtration plant indicate that the maximum dose commitment resulting from

the ingestion of the daily adult requirement (about two liters per day) is 6.7 millirem (67 microsieverts) to the bone and 0.13 millirem (1.3 microsieverts) to the total body. Treated water from Melton Hill Lake (background) contained about the same levels of radioactivity as the Kingston treated water.

Estimates of the 50-year dose commitment to an adult were calculated for consumption of 16.8 kilograms of fish per year from the Clinch River. The consumption of 16.8 kilograms[8] is about 2.5 times the national average fish consumption[29] and is used because of the popularity of fishing in East Tennessee. From the analysis of edible parts of the fish examined (see Table 26 and 27), the maximum possible organ dose commitment to an individual from the highest quarterly bluegill sample taken from Clinch River Mile (CRM) 20.8 is estimated to be 21 millirem (210 microsieverts) to the bone from ^{90}Sr. The maximum total body dose to an individual was calculated to be 0.43 millirem (4.3 microsieverts).

A more probable dose commitment, based on the annual average concentration of ^{90}Sr in bluegill samples taken from CRM 20.8, was calculated to be 9.6 millirem (96 microsieverts) to the bone and 0.4 millirem (4 microsieverts) to the total body. These dose commitments are about 0.6 percent and 0.08 percent, respectively, of the allowable annual standards. Fish samples taken from Melton Hill Lake were analyzed to determine background conditions. Fish caught and consumed from other locations in the Clinch River would result in significantly less dose than the maximum calculated for CRM 20.8, see Tables 26 and 27.

Summaries are given in Table 34 of the potential radiation doses to adult members of the general public at the points of highest potential exposure from gaseous and liquid effluents from the Oak Ridge facilities.

Dose to the Population - The Oak Ridge population received the largest average individual total body dose as a population group. The average total body dose to an Oak Ridge resident was estimated to be 0.09 millirem (0.9 microsieverts) as compared to approximately 100 millirem/yr (1000 microsieverts/yr) from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.44 millirem (4.4 microsieverts). The maximum potential dose commitment to an Oak Ridge resident was calculated to be 8.7 millirem (87 microsieverts) to the lung. This calculated dose is 0.6 percent of the allowable annual standard.[1]

The cumulative total body dose to the population within an 80-kilometer radius of the Oak Ridge facilities resulting from 1982 plant effluents was calculated to be 50.2 man-rem (0.5 man-sieverts). This cumulative dose was calculated using the population distribution given in Table 1 for ORNL atmospheric effluents; similar population distributions were used for the Y-12 and ORGDP releases. This dose may be compared to an estimated 87,000 man-rem (870 man-sieverts) to the same population resulting from natural background radiation. About 10 percent of the collective dose from the effluents of the Oak Ridge facilities is estimated to be to the Oak Ridge population.

Table 1
INCREMENTAL POPULATION TABLE IN THE VICINITY OF ORNL[a]

DISTANCE, MILES DISTANCE, KM	0-1 0-1.6	1-2 1.6-3.2	2-3 3.2-4.8	3-4 4.8-6.4	4-5 6.4-8.0	5-10 8-16	10-20 16-32	20-30 32-48	30-40 48-64	40-50 64-80
Direction										
E	0	0	0	0	0	2,615	50,183	113,337	16,826	16,354
ENE	0	0	0	0	0	0	39,418	79,791	18,513	15,796
NE	0	0	0	0	0	7,336	13,865	9,518	7,239	7,152
NNE	0	0	0	0	874	14,789	7,922	11,412	16,554	9,100
N	0	0	0	0	1,887	4,793	1,971	3,732	5,106	6,545
NNW	0	0	0	0	0	3,187	2,426	2,246	6,830	6,156
NW	0	0	0	0	0	1,964	2,717	2,340	3,303	6,315
WNW	0	0	0	0	0	1,364	4,559	2,336	3,385	4,431
W	0	0	0	0	0	1,804	13,807	5,707	10,627	9,922
WSW	0	0	0	0	0	2,078	9,447	6,387	6,808	4,690
SW	0	0	0	0	0	1,066	2,257	3,422	6,691	13,983
SSW	0	0	0	0	0	1,307	3,321	10,843	24,040	13,900
S	0	0	0	0	0	4,704	7,719	7,810	6,861	3,750
SSE	0	0	0	0	329	4,554	5,451	4,180	1,461	2,590
SE	0	0	0	0	0	3,519	6,739	20,096	1,000	1,689
ESE	0	0	0	0	0	3,740	12,447	37,001	6,319	10,958
TOTAL	0	0	0	0	3,090	58,820	184,249	320,158	141,563	133,331
CUMULATIVE TOTAL	0	0	0	0	3,090	61,910	246,159	566,317	707,880	841,211

[a]Based on 1980 Census Data.

Table 2
CONTINUOUS AIR MONITORING DATA
Long-Lived Gross Beta Activity of Particulates in Air
1982

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-13 μCi/mL (mBq/m^3)			% CG[c]
		MAXIMUM[a]	MINIMUM[b]	AVERAGE	
		Perimeter Area[d]			
HP-31	52	0.62 (2.3)	0.01 (0.03)	0.23 (0.85) ± 0.03	0.02
HP-32	52	1.1 (4.2)	0.03 (0.10)	0.30 (1.1) ± 0.05	0.03
HP-33	52	0.86 (3.2)	0.02 (0.07)	0.30 (1.1) ± 0.04	0.03
HP-34	52	0.49 (1.8)	0.06 (0.22)	0.24 (0.88) ± 0.02	0.02
HP-35	52	0.43 (1.6)	0.03 (0.12)	0.24 (0.88) ± 0.02	0.02
HP-36	51	0.49 (1.8)	0.01 (0.03)	0.19 (0.70) ± 0.02	0.02
HP-37	52	0.38 (1.4)	0.01 (0.03)	0.20 (0.75) ± 0.02	0.02
HP-38	52	0.54 (2.0)	0.01 (0.03)	0.25 (0.92) ± 0.02	0.03
HP-39	52	0.43 (1.6)	0.05 (0.19)	0.20 (0.75) ± 0.02	0.02
Average				0.24 (0.88) ± 0.01	0.02
		Remote Area[e]			
HP-51	36	0.38 (1.4)	0.11 (0.42)	0.24 (0.90) ± 0.02	0.02
HP-52	43	0.32 (1.2)	0.01 (0.03)	0.19 (0.70) ± 0.02	0.02
HP-53	51	0.41 (1.5)	0.01 (0.03)	0.22 (0.81) ± 0.02	0.02
HP-55	51	0.49 (1.8)	0.01 (0.03)	0.21 (0.77) ± 0.02	0.02
HP-56	50	0.46 (1.7)	0.01 (0.03)	0.22 (0.81) ± 0.02	0.02
HP-57	52	0.43 (1.6)	0.02 (0.07)	0.26 (0.95) ± 0.02	0.03
HP-58	38	0.41 (1.5)	0.08 (0.30)	0.20 (0.75) ± 0.02	0.02
Average				0.22 (0.81) ± 0.01	0.02

[a]Maximum weekly average concentration.

[b]Minimum weekly average concentration-minimum detectable level is 1 E-15 μCi/mL (0.037 mBq/m^3).

[c]CG is 1 E-10 μCi/mL (3.7 E+03 mBq/m^3) for unidentified radionuclides (DOE Order 5480.1A, Chapter XI, Attachment XI-1, Table II).

[d]See Figure 1.

[e]See Figure 2.

Table 3
CONTINUOUS AIR MONITORING DATA
Long-Lived Gross Alpha Activity of Particulates in Air
1982

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-15 μCi/mL (μBq/m^3)			% CG[c]
		MAXIMUM[a]	MINIMUM[b]	AVERAGE	
		Perimeter Area[d]			
HP-31	52	2.1 (78)	0.27 (10)	0.92 (34) ± 0.14	0.02
HP-32	52	3.8 (140)	0.35 (13)	1.1 (41) ± 0.19	0.03
HP-33	52	3.2 (120)	0.32 (12)	1.1 (41) ± 0.21	0.03
HP-34	52	3.8 (140)	0.30 (11)	0.97 (36) ± 0.20	0.02
HP-35	52	4.3 (160)	0.22 (8.1)	1.0 (37) ± 0.22	0.03
HP-36	51	4.6 (170)	0.24 (8.9)	0.81 (30) ± 0.23	0.02
HP-37	52	3.2 (120)	0.30 (11)	0.78 (29) ± 0.19	0.02
HP-38	52	3.0 (110)	0.27 (10)	1.4 (52) ± 1.1	0.04
HP-39	52	2.3 (86)	0.27 (10)	0.86 (32) ± 0.17	0.02
Average				0.99 (37) ± 0.06	0.02
		Remote Area[e]			
HP-51	36	2.7 (100)	0.26 (9.5)	0.95 (35) ± 0.22	0.02
HP-52	43	2.1 (78)	0.25 (9.3)	0.81 (30) ± 0.15	0.02
HP-53	51	3.2 (120)	0.32 (12)	0.97 (36) ± 0.22	0.02
HP-55	51	3.2 (120)	0.30 (11)	1.1 (41) ± 0.24	0.03
HP-56	50	3.0 (110)	0.32 (12)	1.0 (37) ± 0.21	0.03
HP-57	52	3.0 (110)	0.27 (10)	1.1 (41) ± 0.18	0.03
HP-58	58	2.3 (86)	0.30 (11)	0.68 (25) ± 0.15	0.02
Average				0.94 (35) ± 0.06	0.02

[a]Maximum weekly average concentration.

[b]Minimum weekly average concentration-minimum detectable level is 1 E-16 μCi/mL (3.7 μBq/m^3)

[c]CG is 40 E-13 μCi/mL (1.48 E+05 μBq/m^3) for a mixture of uranium isotopes (DOE Order 5480.1A, Chapter XI, Attachment XI-1, Table II).

[d]See Figure 1.

[e]See Figure 2.

Table 4
CONTINUOUS AIR-MONITORING DATA
Specific Radionuclides in Air
(Composite Samples)
1982
Units of E-15 μCi/mL (μBq/m^3)

	PERIMETER STATIONS						REMOTE STATIONS					
NUCLIDE	Quarterly Maximum		Quarterly Minimum		Yearly Average		Quarterly Maximum		Quarterly Minimum		Yearly Average	
^{54}Mn	0.050	(1.86)	0.014	(0.52)	0.030	(1.11)	0.043	(1.58)	0.017	(0.63)	0.032	(1.19)
^{90}Sr	0.244	(9.01)	0.065	(2.42)	0.150	(5.56)	0.537	(19.86)	0.041	(1.51)	0.248	(9.17)
^{95}Nb	0.132	(4.87)	0.015	(0.56)	0.076	(2.81)	0.109	(4.05)	0.024	(0.89)	0.070	(2.60)
^{95}Zr	0.052	(1.93)	0.046	(1.70)	0.049	(1.81)	0.048	(1.78)	0.035	(1.30)	0.042	(1.54)
^{103}Ru	0.031	(1.13)	0.031	(1.13)	0.031	(1.13)	0.024	(0.89)	0.024	(0.89)	0.024	(0.89)
^{106}Ru	0.893	(33.0)	0.080	(2.96)	0.404	(14.94)	0.651	(24.09)	0.135	(4.98)	0.383	(14.17)
^{125}Sb	0.179	(6.61)	0.046	(1.70)	0.102	(3.78)	0.120	(4.44)	0.048	(1.78)	0.080	(2.94)
^{137}Cs	0.487	(18.02)	0.043	(1.58)	0.236	(8.73)	0.407	(15.06)	0.043	(1.58)	0.195	(7.22)
^{141}Ce	0.031	(1.13)	0.031	(1.13)	0.031	(1.13)	0.048	(1.78)	0.048	(1.78)	0.048	(1.78)
^{144}Ce	1.36	(50.32)	0.147	(5.42)	0.802	(29.67)	0.997	(36.89)	0.096	(3.56)	0.649	(24.01)
^{228}Th	0.100	(3.70)	0.027	(1.02)	0.060	(2.22)	0.043	(1.58)	0.026	(1.07)	0.036	(1.32)
^{230}Th	0.057	(2.12)	0.018	(0.07)	0.036	(1.33)	0.029	(1.08)	0.019	(0.70)	0.023	(0.84)
^{232}Th	0.080	(2.96)	0.024	(0.90)	0.050	(1.86)	0.036	(1.33)	0.026	(1.07)	0.030	(1.10)
^{234}U	0.304	(11.25)	0.053	(1.98)	0.211	(7.81)	0.381	(14.11)	0.047	(1.73)	0.159	(5.89)
^{235}U	0.033	(1.23)	0.003	(0.11)	0.020	(0.74)	0.025	(0.93)	0.006	(0.21)	0.012	(0.44)
^{238}U	0.214	(7.91)	0.045	(1.68)	0.157	(5.82)	0.404	(14.95)	0.038	(1.42)	0.130	(4.83)
^{238}Pu	0.003	(0.11)	0.0002	(0.007)	0.0009	(0.035)	0.001	(0.04)	0.0002	(0.007)	0.0007	(0.025)
^{239}Pu	0.005	(0.19)	0.0007	(0.025)	0.0021	(0.078)	0.003	(0.11)	0.0004	(0.014)	0.0018	(0.068)

Table 5
CONCENTRATION OF ^{131}I IN AIR MEASURED BY THE PERIMETER AIR MONITORING STATIONS[a]
1982

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-14 μCi/mL (μBq/m^3)			% CG[d]
		MAXIMUM[b]	MINIMUM[c]	AVERAGE	
HP-31	52	0.24 (89)	0.01 (3.7)	0.10 (37) ± 0.01	<0.01
HP-32	52	0.19 (70)	0.02 (7.4)	0.11 (41) ± 0.02	<0.01
HP-33	52	0.26 (98)	0.02 (7.4)	0.12 (44) ± 0.02	<0.01
HP-34	52	0.20 (74)	<0.01 (3.7)	<0.09 (33) ± 0.01	<0.01
HP-35	52	0.16 (59)	0.02 (7.4)	0.09 (33) ± 0.01	<0.01
HP-36	52	0.17 (63)	0.01 (3.7)	0.10 (37) ± 0.01	<0.01
HP-37	52	0.17 (63)	0.02 (7.4)	0.10 (37) ± 0.01	<0.01
HP-38	52	0.22 (81)	0.02 (7.4)	0.10 (37) ± 0.01	<0.01
HP-39	52	0.16 (59)	0.02 (7.4)	0.10 (37) ± 0.01	<0.01
AVERAGE				0.10 (37) ± 0.01	<0.01

[a]See Figure 1.

[b]Maximum weekly average concentration.

[c]Minimum weekly average concentration-minimum detectable amount of ^{131}I is 1 E-16 μCi/mL (3.7 μBq/m^3).

[d]CG is 1 E-10 μCi/mL (3.7 E+06 μBq/m^3) (DOE Order 5480.1A, Chapter XI, Attachment XI-1, Table II).

Table 6
DISCHARGES OF RADIOACTIVITY TO THE ATMOSPHERE
1982

RADIONUCLIDE	QUANTITY DISCHARGED	
	Ci	UNITS OF E+10 Bq
Uranium[a]	0.11	0.4
^{131}I	< 0.13	< 0.5
^{3}H	19,000	70,300
$^{133}Xe^{b}$	<57,100	<211,300
$^{85}Kr^{b}$	<11,700	< 43,300
^{99}Tc	0.03	0.11
Alpha[c]	< 2.7 E-06	< 1.0 E-05

[a]Uranium of varying enrichments - curie quantities calculated using the appropriate specific activity for material released.

[b]Upper limit values based on direct radiation measurements in the stack gas stream and an assumed mixture of noble gases.

[c]Unidentified alpha.

Table 7
AIR MONITORING DATA - FLUORIDES
1982

Location[a]	Number of Samples	Maximum Concentration for Averaging Interval $\mu g/m^3$		Number of Times Standard Exceeded[b]		Annual Average $\mu g/m^3$
	6 Day	6 Day	30 Day	7 Day	30 Day	
F-1	48	0.1	< 0.1	0	0	< 0.1 ± 0.01
F-2	48	0.2	0.1	0	0	< 0.1 ± 0.02
F-3	49	0.3	0.2	0	0	< 0.1 ± 0.02
F-4	48	0.2	< 0.1	0	0	< 0.1 ± 0.01
F-5	49	0.1	< 0.1	0	0	< 0.1 ± 0.01
F-6[c]	48	0.1	< 0.1	0	0	< 0.1 ± 0.01

[a]See Figure 1.

[b]Tennessee Air Pollution Control Regulations -

3.7 $\mu g/m^3$ for 12 hour averaging interval
2.9 $\mu g/m^3$ for 24 hour averaging interval
1.6 $\mu g/m^3$ for 7 day averaging interval
1.2 $\mu g/m^3$ for 30 day averaging interval

All values are maximum--not to be exceeded more than once per year.

[c]Station F-6 approximately 8 kilometers from ORGDP upwind of the predominant prevailing wind direction, thus may be considered representative of general ambient background concentration.

NOTE: Data not amendable to comparison with 12-hour or 24-hour standard. Six-day sample compared to 7 day averaging interval.

Table 8
AIR MONITORING DATA - SUSPENDED PARTICULATES
1982

LOCATION[a]	NUMBER OF SAMPLES	CONCENTRATION, $\mu g/m^3$)			% STD.[b]
		MAXIMUM	MINIMUM	AVERAGE	
SP-1	46	83	1	34 ± 6	45
SP-2	53	88	2	34 ± 6	45
SP-3	47	103	2	32 ± 8	43
SP-4	50	119	1	28 ± 8	37

[a]See Figure 1.

[b]Tennessee Ambient Air Standards - Primary Standard.

Maximum 24 hr. Average — 260 $\mu g/m^3$
Annual Geometric Mean — 75 $\mu g/m^3$

Table 9
SULFUR DIOXIDE MONITORING DATA
1982

MONTH	MAXIMUM 24 HR. AVERAGE (ppm)		MONTHLY AVERAGE (ppm)	
	STATION S-1	STATION S-2	STATION S-1	STATION S-2
January	0.045	0.022	0.013	0.006
February	0.028	0.016	0.013	0.009
March	0.030	0.015	0.012	0.009
April	0.021	0.013	0.010	0.009
May	0.014	0.007	0.006	0.003
June	0.014	0.008	0.006	0.003
July	0.017	0.002	0.008	0.002
August	0.018	0.006	0.009	0.002
September	0.018	0.006	0.009	0.003
October	0.018	0.003	0.008	0.002
November	0.021	0.012	0.012	0.005
December	0.021	0.010	0.004	0.003
Annual Arithmetic Mean			0.009	0.005

Tennessee Ambient Standards
Maximum 24 hr. Average — 0.14 ppm
Annual Arithmetic Mean — 0.03 ppm

Minimum Detectable Limit — 0.002 ppm

Table 10
EXTERNAL GAMMA RADIATION MEASUREMENTS
1982

STATION NUMBER	NUMBER OF MEASUREMENTS	BACKGROUND	
		UNITS OF μR/h	UNITS OF E-09 C/kg/h
	Perimeter Stations[a]		
HP-31	12	8.0 ± 1.0	2.1 ± 0.2
HP-32	10	12.5 ± 2.8	3.3 ± 0.8
HP-33	12	10.0 ± 1.7	2.6 ± 0.4
HP-34	12	17.3 ± 4.0	4.5 ± 1.0
HP-35	12	10.3 ± 4.0	2.7 ± 1.0
HP-36	12	9.5 ± 2.6	2.4 ± 0.6
HP-37	12	9.6 ± 2.2	2.5 ± 0.6
HP-38	12	10.6 ± 4.0	2.7 ± 1.0
HP-39	12	12.1 ± 4.2	3.1 ± 1.0
Average		11.1 ± 1.9	2.9 ± 0.5
	Remote Stations[b]		
HP-51	2	5.8 ± 1.6	1.5 ± 0.4
HP-52	2	7.3 ± 1.8	1.9 ± 0.4
HP-53	2	7.5 ± 2.0	1.9 ± 0.6
HP-55	2	6.8 ± 2.0	1.7 ± 0.6
HP-56	1	5.2	1.3
HP-57	2	7.2 ± 3.0	1.9 ± 0.8
HP-58	2	10.9 ± 2.6	2.8 ± 0.6
Average		7.2 ± 1.4	1.9 ± 0.4

[a]See Figure 1.

[b]See Figure 2.

Table 11
RADIONUCLIDES OF PRIMARY CONCERN IN SURFACE STREAMS
1982

SAMPLING LOCATION	NUMBER OF SAMPLES	RANGE	UNITS OF E-09 μCi/mL (Bq/L)			UNITS OF E-06 μCi/mL (kBq/L)	%
			^{90}Sr	^{137}Cs	^{60}Co	^{3}H	CG[a]
C-2	4	Max.	3.2 (0.12)	0.43 (0.016)	0.27 (0.010)	2.20 (0.081)	
		Min.	0.6 (0.02)	0.05 (0.002)	0.08 (0.003)	0.20 (0.007)	
		Avg.	1.4 (0.05)	0.22 (0.008)	0.18 (0.006)	0.91 (0.034)	.48
C-3	4	Max.	4.6 (0.17)	1.90 (0.072)	1.60 (0.060)	7.60 (0.281)	
		Min.	0.5 (0.02)	0.19 (0.007)	0.11 (0.004)	0.62 (0.023)	
		Avg.	1.8 (0.07)	0.67 (0.025)	0.60 (0.022)	3.40 (0.126)	.71
C-5[b]	4	Max.	1.6 (0.06)	0.32 (0.012)	0.27 (0.010)	1.30 (0.050)	
		Min.	0.8 (0.03)	0.05 (0.002)	0.08 (0.003)	0.23 (0.008)	
		Avg.	1.1 (0.04)	0.17 (0.006)	0.16 (0.006)	0.71 (0.026)	.39
W-1[c]	12	Max.	250 (9.25)	49 (1.81)	540 (20)	280 (11)	
		Min.	1.1 (0.04)	0.3 (0.01)	0.3 (0.01)	30 (1.1)	
		Avg.	67 (2.48)	15 (0.55)	55 (2)	100 (3.7)	26

[a]Most restrictive concentration guide for each isotope used for calculating percent concentration guide. The method for calculating percent of concentration guide for a known mixture of radionuclides is given in DOE Order 5480.1A, Chapter XI, Attachment XI-1.[1]

[b]Kingston Water Plant (treated water).

[c]Mouth of White Oak Creek.

Table 12
URANIUM CONCENTRATION IN SURFACE STREAMS
1982

STATION NUMBER[a]	NUMBER OF SAMPLES	UNITS OF E-08 μCi/mL (Bq/L)						% CG[b]
		MAXIMUM		MINIMUM		AVERAGE		
P-1	12	0.67	(0.25)	< 0.07	(0.03)	< 0.23 (0.09)	± 0.13	< 0.4
P-2	12	0.67	(0.25)	< 0.07	(0.03)	< 0.32 (0.12)	± 0.15	< 0.5
C-3	12	0.60	(0.23)	< 0.07	(0.03)	< 0.13 (0.05)	± 0.10	< 0.2
C-4	12	0.40	(0.15)	< 0.07	(0.03)	< 0.13 (0.05)	± 0.08	< 0.2
C-6	12	0.27	(0.10)	< 0.07	(0.03)	< 0.11 (0.04)	± 0.05	< 0.2
E-1	12	4.1	(1.5)	0.5	(0.19)	2.1 (0.8)	± 1.0	3.5
B-1	12	6.8	(2.5)	1.3	(0.48)	4.1 (1.5)	± 1.6	6.8

[a]See Figure 3.

[b]CG used 6 E-07 μCi/mL (22.2 Bq/L) for soluble ^{238}U (DOE Order 5480.1A, Chapter XI, Attachment XI-1, Table II).

Table 13
DISCHARGES OF RADIOACTIVITY TO SURFACE STREAMS
1982

RADIONUCLIDE	QUANTITY DISCHARGED	
	Ci	UNITS OF E+10 Bq
^{137}Cs	1.45	5.37
^{60}Co	0.96	3.55
^{3}H	5,370	19,870
^{131}I	0.06	0.22
^{90}Sr	2.74	10.14
^{99}Tc	1.70	6.29
Uranium[a]	0.67	2.48
^{232}Th	0.009	0.03
Transuranics[b]	0.034	0.13
^{237}Np	0.002	0.007

[a]Uranium of varying enrichments - curie quantities calculated using the appropriate specific activity for material released.

[b]Upper limit values based on alpha emitter analysis.

Table 14
LONG-LIVED GROSS BETA ACTIVITY IN RAINWATER
1982

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF	
		E-08 μCi/mL[a]	Bq/L
		Perimeter Area[b]	
HP-31	44	0.51 ± 0.11	0.19 ± 0.04
HP-32	43	0.43 ± 0.13	0.16 ± 0.05
HP-33	47	0.65 ± 0.15	0.24 ± 0.06
HP-34	46	0.45 ± 0.13	0.17 ± 0.05
HP-35	42	0.57 ± 0.26	0.21 ± 0.10
HP-36	43	0.42 ± 0.11	0.16 ± 0.04
HP-37	43	0.25 ± 0.07	0.09 ± 0.03
HP-38	45	0.70 ± 0.13	0.26 ± 0.05
HP-39	44	1.5 ± 2.3	0.56 ± 0.08
Average		0.61 ± 0.12	0.23 ± 0.05
		Remote Area[c]	
HP-51	43	1.1 ± 0.27	0.41 ± 0.10
HP-52	29	0.74 ± 0.22	0.27 ± 0.08
HP-53	43	0.99 ± 0.17	0.37 ± 0.06
HP-55	40	0.79 ± 0.19	0.29 ± 0.07
HP-56	41	0.95 ± 0.23	0.35 ± 0.09
HP-57	43	0.94 ± 0.22	0.35 ± 0.08
HP-58	37	0.77 ± 0.18	0.28 ± 0.07
Average		0.90 ± 0.24	0.33 ± 0.02

[a]Weekly average concentration.

[b]See Figure 1.

[c]See Figure 2.

Table 15
CHEMICAL WATER QUALITY DATA - WHITE OAK DAM
1982

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cr	11	0.02	< 0.01	< 0.01 ± 0.002	0.05	< 20
Zn	11	0.04	< 0.02	< 0.02 ± 0.004	0.1	< 20
NO_3(N)	10	18	0.07	7.2 ± 1.8	10	72
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20

[a]Tennessee Stream Guidelines.

Table 16
CHEMICAL WATER QUALITY DATA - ORGDP SANITARY WATER PUMPING STATION
(Location C-3, Figure 3)
1982

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L			STD.[a]	% STD.
		MAXIMUM	MINIMUM	AVERAGE		
Cd	12	< 0.002	< 0.002	< 0.002	0.01	< 20
Cr	12	0.03	< 0.01	< 0.01 ± 0.004	0.05	< 20
CN	12	< 0.002	< 0.002	< 0.002	0.01	< 20
$NO_3(N)$	12	0.8	0.3	0.5 ± 0.1	10	5
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	12	25	3	21 ± 4	250	8
T.D.S.	12	154	130	142 ± 5	500	28
Zn	12	0.05	< 0.02	< 0.03 ± 0.007	0.1	< 30
F^-	12	0.2	< 0.1	< 0.1 ± 0.01	1	< 10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	< 0.01	< 0.01	< 0.01	0.1	< 10

[a]Tennessee Stream Guidelines.

Table 17
CHEMICAL WATER QUALITY DATA - ORGDP RECIRCULATING WATER PUMPING STATION
(Location C-4, Figure 3)
1982

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.002	< 0.002	< 0.002	0.01	< 20
Cr	12	0.03	< 0.01	< 0.01 ± 0.004	0.05	< 25
CN	12	< 0.002	< 0.002	< 0.002	0.01	< 20
$NO_3(N)$	12	1	0.3	0.6 ± 0.1	10	6
Pb	12	0.02	< 0.01	< 0.01 ± 0.002	0.05	< 20
$SO_4^=$	12	34	21	26 ± 2	250	10
T.D.S.	12	194	90	146 ± 20	500	29
Zn	12	0.04	< 0.02	< 0.04 ± 0.02	0.1	< 40
F^-	12	0.2	< 0.1	< 0.1 ± 0.03	1	< 10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	0.02	< 0.01	< 0.01 ± 0.002	0.1	< 10

[a]Tennessee Stream Guidelines.

Table 18
CHEMICAL WATER QUALITY DATA - CLINCH RIVER DOWNSTREAM OF ORGDP
(Location C-6, Figure 3)
1982

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L												STD.[a]	% STD.
		MAXIMUM			MINIMUM			AVERAGE							
Cd	12	<	0.002		<	0.002		<	0.002					0.01	< 20
Cr	12		0.03		<	0.01		<	0.01	±	0.004			0.05	< 20
CN	12	<	0.002		<	0.002		<	0.002					0.01	< 20
NO_3(N)	12		1			0.3			0.5	±	0.1			10	5
Pb	12		0.02		<	0.01		<	0.01	±	0.002			0.05	< 20
$SO_4^=$	12		42			4			24	±	5			250	10
T.D.S.	12		160			79			134	±	14			500	27
Zn	12		0.1		<	0.02		<	0.03	±	0.02			0.1	< 30
F^-	12		0.2		<	0.1		<	0.1	±	0.02			1	< 10
Hg	12	<	0.001		<	0.001		<	0.001					0.005	< 20
Ni	12		0.04		<	0.01		<	0.01	±	0.006			0.1	< 10

[a]Tennessee Stream Guidelines.

Table 19
CHEMICAL WATER QUALITY DATA - EAST FORK POPLAR CREEK
(Location E-1, Figure 3)
1982

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.002	< 0.002	< 0.002	0.01	< 20
Cl^-	11	15	< 2	< 12 ± 4	250	< 5
Cr	12	0.01	< 0.01	< 0.01	0.05	< 20
F^-	12	1.3	0.8	1.1 ± 0.2	1	110
Hg	12	0.007	< 0.001	< 0.002 ± 0.002	0.005	< 40
$NO_3(N)$	12	6.4	2.6	4.3 ± 1.1	10	43
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	11	74	40	54 ± 10	250	22
T.D.S.	12	370	180	239 ± 56	500	48
Zn	12	0.09	< 0.02	< 0.03 ± 0.02	0.1	< 30

[a]Tennessee Stream Guidelines.

Table 20
CHEMICAL WATER QUALITY DATA - BEAR CREEK
(Location B-1, Figure 3)
1982

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.002	< 0.002	< 0.002	0.01	< 20
Cl^-	12	9	< 2	< 5 ± 2	250	< 2
F^-	12	0.4	0.1	0.3 ± 0.1	1	30
$NO_3(N)$	12	23	8	10 ± 6	10	100
Zn	11	0.03	< 0.02	< 0.02 ± 0.003	0.1	< 20
$SO_4^=$	12	31	< 10	< 16 ± 7	250	< 6

[a]Tennessee Stream Guidelines.

Table 21
CHEMICAL WATER QUALITY DATA - POPLAR CREEK ABOVE BLAIR BRIDGE
(Location P-1, Figure 3)
1982

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.002	< 0.002	< 0.002	0.01	< 20
Cr	12	0.02	< 0.01	< 0.01 ± 0.002	0.05	< 20
CN	12	< 0.002	< 0.002	< 0.002	0.01	< 20
NO_3(N)	12	0.5	0.2	0.3 ± 0.08	10	3
Pb	12	0.03	< 0.01	< 0.01 ± 0.003	0.05	< 20
$SO_4^=$	12	48	29	40 ± 3	250	16
T.D.S.	12	196	68	132 ± 25	500	26
Zn	12	0.04	< 0.02	< 0.02 ± 0.004	0.1	< 20
F^-	12	0.2	< 0.1	< 0.1 ± 0.02	1	< 10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	0.2	< 0.01	< 0.02 ± 0.02	0.1	< 20

[a]Tennessee Stream Guidelines.

Table 22
CHEMICAL WATER QUALITY DATA - POPLAR CREEK NEAR CLINCH RIVER
(Location P-2, Figure 3)
1982

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.002	< 0.002	< 0.002	0.01	< 20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	< 20
CN	12	0.003	< 0.002	< 0.002 ± 0.0002	0.01	< 20
NO_3(N)	12	1	0.3	0.7 ± 0.2	10	7
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	12	45	20	34 ± 4	250	14
T.D.S.	12	232	91	146 ± 24	500	29
Zn	12	0.07	< 0.02	< 0.02 ± 0.009	0.1	< 20
F^-	12	0.3	0.1	0.2 ± 0.05	1	20
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	0.04	< 0.01	< 0.01 ± 0.006	0.1	< 10

[a]Tennessee Stream Guidelines.

Table 23
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) EXPERIENCE
1982

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/L	EFFLUENT LIMITS DAILY MAXIMUM mg/L	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
ORNL				
001				
(White Oak Creek)	Dissolved Oxygen (min.)	5	--	100
	Dissolved Solids	--	2000	100
	Oil and Grease	10	15	85
	Chromium (Total)	--	0.05	100
	pH (pH units)	--	6.0 - 9.0	99
002				
(Melton Branch)	Chromium (Total)	--	0.05	100
	Dissolved Solids	--	2000	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 - 9.0	99
003				
(Main Sanitary	Ammonia (N)	--	5	35
Treatment Facility)	BOD	--	20	73
	Chlorine Residual	--	0.5 - 2.0	97
	Fecal Coliform Bact. (No/100 mL)	200[b]	400[c]	83
	pH (pH units)	--	6.0 - 9.0	100
	Suspended Solids	--	30	98
	Settleable Solids (mL/L)	--	0.5	96
004				
(7900 Area Sanitary	BOD	--	30	No Discharges
Treatment Facility)	Chlorine Residual	--	0.5 - 2.0	From This
	Fecal Coliform Bact. (No/100 mL)	200[b]	400[c]	Facility
	pH (pH units)	--	6.0 - 9.0	
	Suspended Solids	--	30	
	Settleable Solids (mL/L)	--	0.5	
Y-12 PLANT				
001				
(Kerr Hollow	Dissolved Solids	--	2000	100
Quarry)	Lithium	--	5	100
	pH (pH units)	--	6.0 - 9.0	100
	Suspended Solids	--	50	100
	Zirconium	--	3	100

Table 23
(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/L	EFFLUENT LIMITS DAILY MAXIMUM mg/L	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
002				
(Rogers Quarry)	**pH (pH units)**	**--**	**6.0 - 9.0**	**100**
	Suspended Solids[a]	**30**	**50**	**100**
	Settleable Solids (mL/L)[a]	**--**	**0.5**	**100**
003				
(New Hope Pond)	**Ammonia (N)**	**--**	**1.6**	**100**
	Chromium	**0.05**	**0.08**	**100**
	Dissolved Oxygen (min.)	**5**	**--**	**99**
	Dissolved Solids	**--**	**2000**	**100**
	Fluoride	**1.5**	**2.0**	**96**
	Lithium	**--**	**5**	**100**
	Oil and Grease	**10**	**15**	**92**
	pH (pH units)	**--**	**6.0 - 9.0**	**100**
	Phosphate (as MBAS)	**5**	**8**	**100**
	Suspended Solids[a]	**--**	**20**	**100**
	Settleable Solids (mL/L)[a]	**--**	**0.5**	**100**
	Total Nitrogen (N)	**--**	**20**	**100**
	Zinc	**0.1**	**0.2**	**96**
004				
(Bear Creek)	**Oil and Grease**	**10**	**15**	**100**
	pH (pH units)	**--**	**6.0 - 8.5**	**100**
ORGDP				
001				
(K-1700 Discharge)	Aluminum	--	1.0	99
	Chromium (Total)	0.05	0.08	100
	Nitrate	--	20	100
	Suspended Solids	30	50	100
	Oil and Grease	10	15	100
	pH(pH units)	--	6.0 - 9.0	99
002				
(K-1410 Metal	Cyanide	--	None Detectable	Did Not
Plating Facility)	Oil and Grease	10	15	Operate In
	pH (pH units)	--	6.0 - 9.0	1982
004				
(K-1131) Steam	pH (pH units)	--	6.0 - 9.0	100
Condensate	Flow (MGD)	0.005	0.008	100
Discharge)				

Table 23
(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/L	EFFLUENT LIMITS DAILY MAXIMUM mg/L	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
005				
(K-1203 Sanitary	Ammonia (N)	5[b]	7[c]	100
Treatment Facility)	BOD	15[b]	20[c]	100
	Chlorine Residual	--	0.5 - 2.0	99
	Dissolved Oxygen (min.)	5	--	100
	Fecal Coliform Bact. (No/100mL)	200[b]	400[c]	100
	pH (pH units)	--	6.0 - 9.0	100
	Suspended Solids	30[b]	45[c]	99
	Settleable Solids (mL/L)	--	0.5	99
006				
(K-1007B Holding	COD	20	25	100
Pond)	Chromium	--	0.05	100
	Dissolved Oxygen (min.)	5	--	100
	Fluoride	1.0	1.5	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 - 9.0	100
	Suspended Solids[a]	30	50	100
007				
(K-901A Holding	Chromium (Total)	--	0.05	99
Pond)	Fluoride	1.0	1.5	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 - 10	100
	Suspended Solids	30	50	100
008[d]				
(K-710 Sanitary	BOD	30[b]	45[c]	No Discharges
Treatment Facility)	Suspended Solids	30[b]	45[c]	From This
	Fecal Coliform Bact. (No/100 mL)	200[b]	400[c]	Facility
	pH (pH units)	--	6.0 - 9.0	
	Chlorine Residual	--	0.5 - 2.0	
	Settleable Solids (mL/L)	--	0.1	
009				
(Sanitary Water	Suspended Solids[a]	30	50	100
Plant)	Aluminum	--	250	100
	Sulphate	--	1400	100
	pH (pH units)	--	6.0 - 9.0	100

[a]Limit applicable only during normal operations. Not applicable during periods of increased discharge due to surface run-off resulting from precipitation.

[b]Monthly Average.

[c]Weekly Average.

[d]Due to the small flow rates at the K-710 Sanitary Treatment Facility, a rapid sand filter was installed May 1, 1978 eliminating the surface discharge and monitoring requirements.

Table 24
CONCENTRATION OF ^{131}I IN MILK[a]
1982

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-09 μCi/mL (Bq/L)			COMPARISON WITH STANDARD[c]
		MAXIMUM	MINIMUM[b]	AVERAGE	
		Immediate Environs[d]			
2	46	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
3	45	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
4	45	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
5	27	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
6	39	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
7	45	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
Average				<0.45 (0.017)	
		Remote Environs[e]			
51	4	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
52	3	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
53	5	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
56	3	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
Average				<0.45 (0.017)	

[a]Raw milk samples, except for Station 2 which is a dairy.

[b]Minimum detectable concentration of ^{131}I is 0.45 E-09 μCi/mL (0.017 Bq/L).

[c]Applicable FRC standard, assuming 1 liter per day intake:

Range I 0 to 1 E-08 μCi/mL (0.37 Bq/L) —Adequate surveillance required to confirm calculated intakes.

Range II 1 E-08 μCi/mL (0.37 Bq/L) to 1 E-07 μCi/mL (3.7 Bq/L) —Active surveillance required.

Range III 1 E-07 μCi/mL (3.7 Bq/L) to 1 E-06 μCi/mL (37 Bq/L) —Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[d]See Figure 6.

[e]See Figure 7.

Table 25
CONCENTRATION OF ^{90}Sr IN MILK[a]
1982

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-09 μCi/mL (Bq/L)			COMPARISON WITH STANDARD[c]
		MAXIMUM	MINIMUM[b]	AVERAGE	
		Immediate Environs[d]			
2	46	1.6 (0.059)	0.8 (0.030)	1.1 (0.042) ± 0.08	Range I
3	44	1.9 (0.070)	0.5 (0.019)	1.2 (0.044) ± 0.11	Range I
4	44	3.0 (0.110)	0.8 (0.030)	1.7 (0.063) ± 0.14	Range I
5	27	1.9 (0.070)	0.5 (0.019)	1.3 (0.047) ± 0.11	Range I
6	38	2.7 (0.100)	0.8 (0.030)	1.6 (0.059) ± 0.13	Range I
7	44	2.7 (0.100)	0.5 (0.019)	1.4 (0.052) ± 0.14	Range I
Average				1.4 (0.052) ± 0.03	
		Remote Environs[e]			
51	4	1.9 (0.070)	0.8 (0.030)	1.5 (0.055) ± 0.47	Range I
52	3	2.2 (0.080)	0.8 (0.030)	1.4 (0.052) ± 0.78	Range I
53	5	4.9 (0.180)	0.5 (0.019)	1.7 (0.063) ± 1.61	Range I
56	3	0.8 (0.030)	0.5 (0.019)	0.6 (0.023) ± 0.18	Range I
Average				1.4 (0.052) ± 0.56	

[a]Raw milk samples, except for Station 2 which is a dairy.

[b]Minimum detectable concentration of ^{90}Sr is 0.5 E-09 μCi/mL (0.019 Bq/L).

[c]Applicable FRC standard, assuming 1 liter per day intake:

Range I 0 to 2 E-08 μCi/mL (0.74 Bq/L) —Adequate surveillance required to confirm calculated intakes.

Range II 2 E-08 μCi/mL (0.74 Bq/L) to 2 E-07 μCi/mL (7.4 Bq/L) —Active surveillance required.

Range III 2 E-07 μCi/mL (7.4 Bq/L) to 2 E-06 μCi/mL (74 Bq/L) —Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[d]See Figure 6.

[e]See Figure 7.

Table 26
RADIONUCLIDE CONTENT IN CLINCH RIVER FISH
ALPHA EMITTERS
1982
pCi/kg (mBq/kg) Wet Weight

LOCATION	Species[a]	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U
CRM 5.0	Bass	0.021 (0.8)	0.027 (1.0)	0.87 (32)	0.15 (6)	0.39 (14)
	Blue Gill	0.030 (1.1)	0.027 (1.0)	0.99 (37)	0.20 (7)	1.3 (48)
	Carp	0.014 (0.5)	0.024 (0.9)	0.88 (33)	0.35 (13)	1.7 (63)
	Shad	0.005 (0.2)	0.032 (1.2)	4.8 (180)	0.32 (12)	7.0 (259)
	Crappie	0.019 (0.7)	0.011 (0.4)	0.30 (11)	0.14 (5)	0.79 (29)
CRM 10.0	Bass	0.035 (1.3)	0.035 (1.3)	0.42 (16)	0.21 (8)	0.81 (30)
	Blue Gill	0.073 (2.7)	0.017 (0.6)	0.97 (36)	0.16 (6)	1.9 (70)
	Carp	0.024 (0.9)	0.021 (0.8)	0.93 (35)	0.04 (2)	1.0 (37)
	Shad	0.11 (4.1)	0.26 (9.6)	7.6 (280)	0.92 (34)	9.2 (340)
	Crappie	0.027 (1.0)	0.004 (0.1)	0.35 (13)	0.35 (13)	0.88 (33)
CRM 12.0	Bass	0.021 (0.8)	0.014 (0.5)	0.70 (26)	0.31 (11)	1.7 (63)
	Blue Gill	0.027 (1.0)	0.019 (0.7)	2.3 (87)	0.57 (21)	3.6 (130)
	Carp	0.024 (0.9)	0.021 (0.8)	2.5 (94)	0.18 (7)	4.2 (160)
	Shad	0.027 (1.0)	0.024 (0.9)	21 (780)	5.0 (190)	33 (1220)
	Crappie	0.019 (0.7)	0.004 (0.1)	0.57 (21)	0.25 (9)	0.83 (31)
CRM 20.8[b]	Bass	0.027 (1.0)	0.036 (1.3)	0.61 (23)	0.20 (7)	1.3 (48)
	Blue Gill	0.036 (1.3)	0.031 (1.2)	0.67 (25)	0.20 (7)	1.2 (44)
	Carp	0.014 (0.5)	0.014 (0.5)	0.61 (23)	0.28 (10)	1.3 (48)
	Shad	0.57 (21)	0.17 (6.3)	3.5 (130)	0.58 (21)	5.5 (200)
	Crappie[c]	0.032 (1.2)	0.027 (1.0)	0.61 (23)	0.13 (5)	1.4 (52)
CRM 25.0	Bass	0.030 (1.1)	0.008 (0.3)	0.49 (18)	0.034 (1)	0.64 (24)
	Blue Gill	0.023 (0.9)	0.023 (0.9)	1.3 (48)	0.46 (17)	2.4 (89)
	Carp	0.017 (0.6)	0.017 (0.6)	0.55 (20)	0.32 (12)	1.1 (41)
	Shad	0.017 (0.6)	0.034 (1.3)	2.1 (78)	0.62 (23)	2.9 (108)

[a]Composite of ten fish in each species.

[b]Average of quarterly samples.

[c]Average of three quarterly samples. Crappie were not collected in the second quarter.

Table 27
RADIONUCLIDE CONTENT IN CLINCH RIVER FISH
BETA-GAMMA EMITTERS
1982
pCi/kg (Bq/kg) Wet Weight

LOCATION	Species[a]	^{137}Cs		^{60}Co		^{90}Sr		% MPI[b]
CRM 5.0	Bass	33	(1.2)	0.7	(0.026)	19	(0.71)	0.14
	Blue Gill	60	(2.2)	1.9	(0.072)	9.1	(0.34)	0.07
	Carp	63	(2.3)	0.7	(0.026)	12	(0.46)	0.10
	Shad	70	(2.6)	4.2	(0.16)	26	(0.96)	0.21
	Crappie	72	(2.7)	1.0	(0.038)	4.5	(0.17)	0.04
CRM 10.0	Bass	330	(12)	4.2	(0.16)	1.4	(0.052)	0.05
	Blue Gill	69	(2.6)	5.7	(0.21)	16	(0.60)	0.12
	Carp	53	(2.0)	2.4	(0.089)	20	(0.75)	0.15
	Shad	86	(3.2)	8.6	(0.32)	38	(1.4)	0.30
	Crappie	84	(3.1)	1.8	(0.065)	7.0	(0.26)	0.06
CRM 12.0	Bass	77	(2.9)	2.5	(0.091)	4.6	(0.17)	0.04
	Blue Gill	18	(0.7)	2.3	(0.084)	2.6	(0.098)	0.03
	Carp	46	(1.7)	1.4	(0.052)	16	(0.60)	0.13
	Shad	44	(1.6)	3.8	(0.14)	2.8	(0.10)	0.12
	Crappie	86	(3.2)	1.5	(0.056)	2.6	(0.098)	0.03
CRM 20.8[c]	Bass	1000	(38)	19	(0.71)	13	(0.49)	0.20
	Blue Gill	1100	(42)	41	(1.5)	69	(2.6)	0.61
	Carp	400	(15)	31	(1.1)	25	(0.94)	0.22
	Shad	390	(14)	33	(1.2)	24	(0.90)	0.23
	Crappie[d]	340	(13)	7.5	(0.28)	13	(0.49)	0.13
CRM 25.0	Bass	6	(0.2)	1.1	(0.042)	3.4	(0.13)	0.03
	Blue Gill	27	(1.0)	0.9	(0.034)	13	(0.49)	0.10
	Carp	3	(0.1)	0.7	(0.026)	4.9	(0.18)	0.04
	Shad	7	(0.3)	1.1	(0.042)	9.6	(0.36)	0.08

[a]Composite of ten fish in each species.

[b]Percent maximum permissible intake for all radionuclides in both Table 26 and 27. See text for definition of maximum permissible intake.

[c]Average of quarterly samples.

[d]Average of three quarterly samples. Crappie were not collected in the second quarter.

Table 28
MERCURY CONTENT IN CLINCH RIVER FISH
1982

LOCATION	Species[a]	CONCENTRATION ng/g - Wet Weight	% A.L.[b]
CRM 5.0	Bass	120	12
	Blue Gill	170	17
	Carp	280	28
	Shad	30	3
	Crappie	59	6
CRM 10.0	Bass	200	20
	Blue Gill	150	15
	Carp	210	21
	Shad	29	3
	Crappie	99	10
CRM 12.0	Bass	220	22
	Blue Gill	560	56
	Carp	530	53
	Shad	190	19
	Crappie	180	18
CRM 20.8[c]	Bass	99	10
	Blue Gill	160	16
	Carp	240	24
	Shad	19	2
	Crappie[d]	43	4
CRM 25.0	Bass	13	1
	Blue Gill	34	3
	Carp	97	10
	Shad	7	1

[a]Composite of ten fish in each species.

[b]Percent of proposed FDA mercury in fish action level of 1000 ng/g.

[c]Average of quarterly samples.

[d]Average of three quarterly samples. Crappie were not collected in the second quarter.

Table 29
^{137}Cs CONCENTRATION IN DEER SAMPLES
1982
pCi/g (Bq/kg) - Wet Weight

SAMPLE NUMBER	MUSCLE		LIVER		SAMPLE NUMBER	MUSCLE		LIVER	
D-1	0.054	(2.0)	0.010	(0.37)	D-54	0.029	(1.1)	0.021	(0.78)
D-2	0.10	(3.7)	0.27	(10.0)	D-55	1.9	(70.3)	0.64	(23.7)
D-3	0.062	(2.3)	-	-	D-56	0.46	(17.0)	0.094	(3.5)
D-6	0.19	(7.0)	0.078	(2.9)	D-60	0.32	(11.8)	0.13	(4.8)
D-7	0.17	(6.3)	0.076	(2.8)	D-61	1.2	(44.4)	0.26	(9.6)
D-8	-	-	-	-	D-62	0.76	(28.1)	0.20	(7.4)
D-20	0.059	(2.2)	0.046	(1.7)	D-63	0.024	(0.89)	0.087	(3.2)
D-21	0.011	(0.41)	-	-	D-66[b]	0.79	(29.2)	0.16	(5.9)
D-22	0.05	(1.9)	0.030	(1.1)	D-67	0.071	(2.6)	0.037	(1.4)
D-24	0.038	(1.4)	0.032	(1.2)	D-70	0.29	(10.7)	0.11	(4.1)
D-28	0.014	(0.5)	0.010	(0.37)	D-73	0.029	(1.1)	-	-
D-30	0.062	(2.3)	0.035	(1.3)	D-75[c]	2.4	(88.8)	0.56	(20.7)
D-31	0.023	(0.85)	0.008	(0.30)	D-77	0.66	(24.4)	0.17	(6.3)
D-32	0.057	(2.1)	0.038	(1.4)	D-80	0.31	(11.5)	0.073	(2.7)
D-34	0.012	(0.44)	-	-	D-81	0.32	(11.8)	0.057	(2.1)
D-35	0.020	(0.74)	0.016	(0.59)	D-82	0.047	(1.74)	0.13	(4.8)
D-40	0.030	(1.1)	0.014	(0.52)	D-88	0.089	(3.3)	0.028	(1.0)
D-41	0.036	(1.3)	0.029	(1.1)	D-89[d]	0.42	(15.5)	0.14	(5.2)
D-45	0.010	(0.37)	0.005	(0.19)	D-93	0.23	(8.5)	0.075	(2.8)
D-47	0.022	(0.81)	0.008	(0.30)	D-94	0.24	(8.9)	0.074	(2.7)
D-49	0.011	(0.41)	-	-	D-95	0.18	(6.7)	0.043	(1.6)
D-51	0.028	(1.0)	0.090	(3.3)	D-98	0.13	(4.8)	0.054	(2.0)
D-52	0.29	(10.7)	0.11	(4.1)	D-105	0.31	(11.5)	0.064	(2.4)
D-53	0.73	(27.0)	0.32	(11.8)	D-108	0.054	(2.0)	0.025	(0.93)

[a]Entries with a dash (-) indicate a concentration level <0.01 pCi/g (<0.4 Bq/kg).

[b]Cobalt-60 (Liver) = 0.021 pCi/g (0.78 Bq/kg).

[c]Cobalt-60 (Liver) = 0.18 pCi/g (6.7 Bq/kg).

[d]Cobalt-60 (Liver) = 0.0004 pCi/g (0.014 Bq/kg).

Table 30
VEGETATION SAMPLING DATA
1982

STATION NUMBER[a]	F^- CONCENTRATION[b] µg/g (ppm)		U (TOTAL) CONCENTRATION[b] µg/g (ppm)	
	GRASS	PINE NEEDLES	GRASS	PINE NEEDLES
1	6	-	0.2	-
5	3	4	0.3	0.1
8	5	7	0.2	0.2
9	3	8	0.1	0.05
10	6.0	< 4	0.2	0.4
11	10.0	5	0.4	0.1
13	5.0	-	0.6	-
15	4.0	-	< 0.1	-
16	< 4.0	< 4	0.2	0.08
17	4.0	< 4	0.1	0.09
18	9.0	-	0.1	-
19	9.0	-	8.2	-
20	8.0	-	4.1	-
21	4.0	-	0.03	-

[a]See Figure 1.

[b]Average concentration of two sample collections, January and July. Analytical results are on a dry weight basis.

NOTE: Applicable guides for flora have not been established. However, for comparison the **American Industrial Hygiene Association Journal** for January-February 1969 (pp. 98-101) states that dairy cattle is the species of livestock most sensitive to fluorides in grasses. For comparative purposes the following fluoride concentrations and their effect on dairy cattle are given.

30 ppm	-	no adverse effects
30 to 40 ppm	-	borderline chronic
40 to 60 ppm	-	moderate chronic
60 to 110 ppm	-	severe chronic
above 250 ppm	-	acute

Table 31
RADIOACTIVITY IN GRASS SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS
1982
Units of pCi/g (Bq/kg) - Dry Weight

SAMPLING LOCATION[a]	^{90}Sr	^{137}Cs	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U
Perimeter[b]							
HP-31	0.30 (11)	0.06 (2.2)	0.0003 (0.01)	0.0013 (0.05)	0.092 (3.4)	0.018 (0.67)	0.16 (6.0)
HP-32	0.23 (9)	0.10 (3.7)	0.0006 (0.02)	0.0005 (0.02)	0.100 (3.7)	0.018 (0.67)	0.23 (8.5)
HP-33	0.15 (6)	0.16 (6.0)	0.0013 (0.05)	0.0019 (0.07)	0.038 (1.4)	0.006 (0.21)	0.04 (1.5)
HP-34	0.35 (13)	0.12 (4.4)	0.0007 (0.03)	0.0004 (0.02)	0.035 (1.3)	0.005 (0.19)	0.04 (1.5)
HP-35	0.14 (5)	0.08 (3.0)	0.0005 (0.02)	0.0004 (0.02)	0.020 (0.75)	0.006 (0.23)	0.03 (1.2)
HP-36	0.51 (19)	0.07 (2.6)	0.0005 (0.02)	0.0006 (0.02)	0.035 (1.3)	0.009 (0.33)	0.04 (1.5)
HP-37	0.22 (8)	0.13 (4.8)	0.0011 (0.04)	0.0004 (0.02)	0.019 (0.70)	0.003 (0.10)	0.02 (0.9)
HP-38	0.26 (10)	0.10 (3.7)	0.0008 (0.03)	0.0009 (0.03)	0.051 (1.9)	0.005 (0.20)	0.04 (1.5)
HP-39	0.30 (11)	0.10 (3.7)	0.0003 (0.01)	0.0004 (0.02)	0.27 (10)	0.006 (0.21)	0.10 (3.7)
Average	0.27 (10)	0.10 (3.7)	0.0006 (0.02)	0.0007 (0.03)	0.074 (2.7)	0.008 (0.30)	0.08 (3.0)
Remote[c]							
HP-51	1.5 (56)	0.20 (7.4)	0.0005 (0.02)	0.0005 (0.02)	0.012 (0.44)	0.013 (0.48)	0.043 (1.6)
HP-52	0.49 (18)	0.05 (1.8)	0.0005 (0.02)	0.0005 (0.02)	0.005 (0.20)	0.010 (0.37)	0.026 (1.0)
HP-53	0.22 (8)	0.08 (3.0)	0.0008 (0.03)	0.0008 (0.03)	0.008 (0.31)	0.001 (0.04)	0.011 (0.4)
HP-55	0.26 (10)	0.04 (1.5)	0.0003 (0.01)	0.0009 (0.03)	0.019 (0.70)	0.012 (0.44)	0.008 (0.3)
HP-56	0.38 (14)	0.15 (5.6)	0.0019 (0.07)	0.0008 (0.03)	0.017 (0.63)	0.008 (0.30)	0.041 (1.5)
HP-57	0.14 (5)	0.05 (2.0)	0.0003 (0.01)	0.0003 (0.01)	0.008 (0.28)	0.001 (0.04)	0.026 (1.0)
HP-58	0.51 (19)	0.14 (5.2)	0.0003 (0.01)	0.0013 (0.05)	0.006 (0.23)	0.006 (0.23)	0.021 (0.8)
Average	0.50 (19)	0.10 (3.7)	0.0006 (0.02)	0.0007 (0.03)	0.011 (0.40)	0.007 (0.27)	0.025 (0.9)

[a]See Figures 1 and 2.

[b]Average of two samples.

[c]One sample.

Table 32
RADIOACTIVITY IN SOIL SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS
1982
Units of pCi/g (Bq/kg) - Dry Weight

SAMPLING LOCATION[a]	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{239}Pu	^{238}Pu	^{238}U
				Perimeter[b]			
HP-31	0.68 (25)	1.0 (37)	1.1 (41)	0.13 (4.8)	0.020 (0.73)	0.0003 (0.011)	0.62 (23)
HP-32	0.17 (6)	0.9 (33)	0.43 (16)	0.043 (1.6)	0.018 (0.67)	0.0014 (0.052)	0.35 (13)
HP-33	0.15 (6)	1.6 (60)	0.35 (13)	0.043 (1.6)	0.032 (1.2)	0.0014 (0.052)	0.24 (9)
HP-34	0.41 (15)	1.5 (56)	0.24 (9)	0.027 (1.0)	0.025 (0.93)	0.0017 (0.063)	0.17 (6)
HP-35	0.09 (3)	1.2 (44)	0.43 (16)	0.068 (2.5)	0.026 (0.96)	0.0004 (0.015)	0.30 (11)
HP-36	0.32 (12)	1.2 (44)	0.38 (14)	0.049 (1.8)	0.023 (0.85)	0.0007 (0.025)	0.30 (11)
HP-37	0.22 (8)	0.6 (22)	0.27 (10)	0.076 (2.8)	0.014 (0.52)	0.0003 (0.011)	0.18 (7)
HP-38	0.35 (13)	1.1 (41)	0.26 (10)	0.022 (0.8)	0.022 (0.81)	0.0003 (0.011)	0.19 (7)
HP-39	0.13 (5)	1.3 (48)	0.89 (33)	0.21 (7.8)	0.030 (1.1)	0.0009 (0.033)	0.73 (27)
Average	0.28 (10)	1.2 (44)	0.48 (18)	0.074 (2.7)	0.023 (0.85)	0.0008 (0.029)	0.34 (13)
				Remote[c]			
HP-51	0.10 (4)	0.7 (25)	0.22 (8)	0.092 (3.4)	0.014 (0.52)	0.0004 (0.015)	0.22 (8)
HP-52	0.30 (11)	1.4 (52)	0.54 (20)	0.081 (3.0)	0.022 (0.81)	0.0004 (0.015)	0.51 (19)
HP-53	0.24 (9)	0.7 (25)	0.62 (23)	0.081 (3.0)	0.010 (0.37)	0.0007 (0.025)	0.57 (21)
HP-55	0.43 (16)	1.6 (60)	0.43 (16)	0.041 (1.5)	0.023 (0.85)	0.0003 (0.011)	0.38 (14)
HP-56	0.27 (10)	1.6 (60)	0.43 (16)	0.011 (0.4)	0.035 (1.3)	0.0076 (0.28)	0.38 (14)
HP-57	0.12 (4)	1.9 (70)	0.54 (20)	0.046 (1.7)	0.032 (1.20)	0.0010 (0.037)	0.46 (17)
HP-58	0.16 (6)	1.0 (37)	0.38 (14)	0.086 (3.2)	0.014 (0.52)	0.0003 (0.011)	0.35 (13)
Average	0.23 (9)	1.3 (47)	0.45 (17)	0.063 (2.3)	0.021 (0.79)	0.0015 (0.055)	0.41 (15)

[a]See Figures 1 and 2.

[b]Average of two samples.

[c]One sample.

Table 33
STREAM SEDIMENT SAMPLES
August/December 1982
Average Concentration (μg/g dry weight basis)

STATION	U	Hg	Pb	Ni	Cu	Zn	Cr	Mn	Al
CS1	1	3	18	28	40	59	30	1301	26,500
PS6	6	10	17	73	59	110	102	442	38,000
PS10	10	19	17	76	79	96	85	418	26,000
PS17	59	9	42	186	105	169	86	731	44,500
PS18	13	9	28	64	104	105	58	473	29,500
PS19	10	8	30	58	73	97	53	445	51,000
PS21	8	51	30	113	72	129	86	668	38,500
CS20	1	3	17	23	35	49	26	522	24,000

Table 34
SUMMARY OF THE ESTIMATED RADIATION DOSE TO AN ADULT INDIVIDUAL DURING 1982 AT LOCATIONS OF MAXIMUM EXPOSURE

PATHWAY	LOCATION	DOSE IN MILLIREM (μSv) TOTAL BODY		CRITICAL ORGAN	
Gaseous Effluents		1.9	(19)	8.7	(87) (lung)
Inhalation plus direct radiation from air, ground, and food chains	Nearest resident to site boundary				
Terrestrial food chain (milk only)	Milk sampling stations (^{90}Sr)	0.02	(0.2)	1.2	(12) (bone)
Liquid Effluents					
Aquatic food chain (fish)	Clinch-Tennessee River System (^{90}Sr)	0.43	(4.3)	21	(210) (bone)
Drinking water[a]	Kingston, Tennessee (^{90}Sr)	0.13	(1.3)	6.7	(67) (bone)
Direct radiation along water, shores, and mud flats[b]	Downstream from White Oak Creek near experimental Cs field plots	4.9	(49)	4.9	(49) (total body)

[a]Based on the analysis of treated water.

[b]Assuming a residence time of 240 h/yr.

NOTE: Average background total body dose in the U.S.[30] is 106 mrem/yr (1060 μSv/yr).

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APPENDIX A
QUALITY ASSURANCE

Radiological

The Environmental Surveillance and Evaluation Section at Oak Ridge National Laboratory has initiated a quality assurance program to ensure that a high degree of accuracy and reliability is maintained in its surveillance activities. The program in effect at ORNL consists of quality control of techniques and procedures, and includes the establishment of a detailed written description of all activities pertaining to the Environmental Surveillance and Evaluation Section. This includes:

1. Operating procedures for each activity.
2. Inspection lists of operating and maintenance activities.
3. Check-off frequency lists for all quality assurance steps, such as schedules for equipment inspection and test control.
4. Documentation of compliance of quality assurance procedures.
5. Participation in intralaboratory and interlaboratory sample-exchange programs.
6. Evaluation of the adequacy of sample preparation work and data analysis.
7. Identification of the role, responsibilities, and authority of each staff member as related to quality assurance.

A schematic diagram showing a flow chart of this quality assurance program is given in Figure A1. A more detailed discussion of the ORNL QA program is given in Ref. (A1) and (A2).

Chemical

A Nuclear Division Committee on Environmental Analysis established an interlaboratory quality control program in 1977. The purpose of this program is to provide quality control data for environmental analysis within the Nuclear Division. A unified Environmental and Effluent Analysis Manual was issued in March of 1977 which currently contains 108 analytical procedures; EPA-certified analytical methods are used wherever possible.

All Nuclear Division analytical laboratories maintain internal measurement control programs that are part of planned and systematic actions taken to prevent incorrect results. Standard samples containing many parameters measured are purchased and submitted to the laboratories for analysis. Standard samples of known values are processed along with routine samples and the results are recorded and examined to determine if they fall within prescribed limits. Analytical results are transmitted to the Y-12 Plant Quality Division for satistical review and a semi-annual report is provided to the analytical laboratories.

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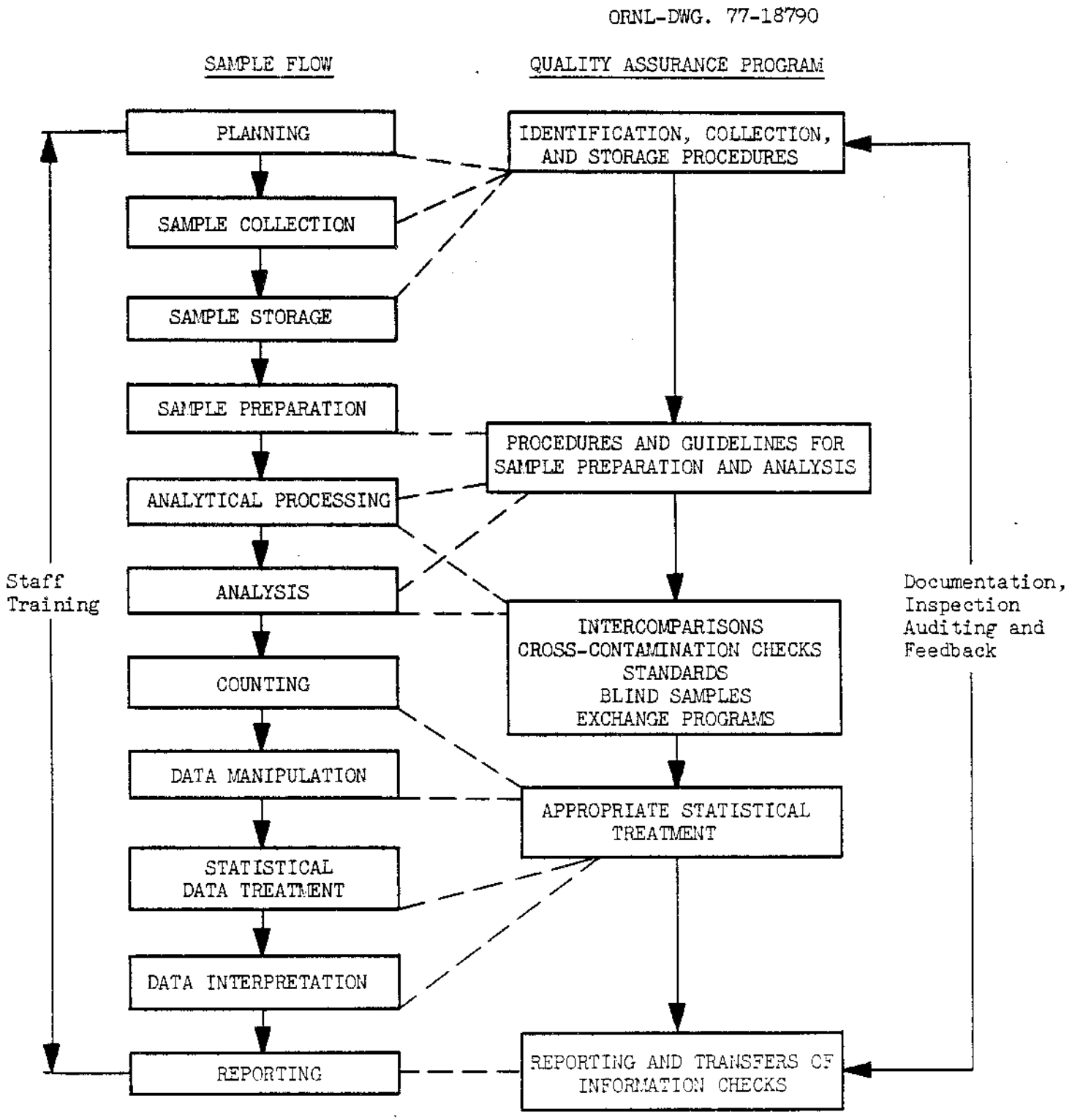

Figure A1
FLOW CHART OF QA PROGRAM

APPENDIX B
UNITS, PREFIXES, AND ABBREVIATIONS

Radiation Units

Curie (Ci) and Becquerel (Bq) - Units of radioactivity which are a measure of those spontaneous, energy-emitting, atomic tranformations that involve changes in the state of the nuclei of radioactive atoms.
1 Ci = 3.7 E+10 Bq

Roentgen (R) and Coulombs per kilogram (C/kg) - Units of exposure to radioactivity.
1 R = 2.58 E-04 C/kg

Rad (rad) and Gray (Gy) - Units of absorbed dose in an medium.
1 rad = 1 E-02 Gy

Roentgen Equivalent Man (rem) and Sievert (Sv) - Units of dose equivalent which account for the relative biological effectiveness of a given absorbed dose. 1 rem = 1 E-02 Sv

Table of Unit Prefixes

Factor	Prefix	Symbol
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10^{1}	deka	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

Abbreviations

Elements and Compounds

Al	Aluminum
Cd	Cadmium
Ce	Cerium
Cl^-	Chloride
CN	Cyanide
Co	Cobalt
Cr	Chromium
Cs	Cesium
Cu	Copper
F^-	Fluoride
^3H	Tritium
Hg	Mercury
I	Iodine
Kr	Krypton
Mn	Manganese
Nb	Niobium
$NH_3(N)$	Ammonia Nitrogen
Ni	Nickel
Pb	Lead
Pu	Plutonium
Ru	Ruthenium
Sb	Antimony
$SO_4^=$	Sulfate
Sr	Strontium
Tc	Technetium
Th	Thorium
U	Uranium

Radiation Units

Bq	Becquerel
C/kg	Coulombs per kilogram
Ci	Curie
R	Roentgen
rem	Roentgen Equivalent Man
Sv	Sievert

Other

A.L.	Allowable limit
BOD	Biological Oxygen Demand
CG	Concentration Guide
COD	Chemical Oxygen Demand
cm	Centimeter
CRM	Clinch River Mile
d	day
g	gram
h	hour
L	liter
m	meter
m^3	cubic meter
MGD	Million gallons per day
min	Minute
MPI	Maximum permissible intake
ppm	parts per million
s	second
STD	Standard
T.S.D.	Total Dissolved Solids
yr	year

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NUCLEAR DIVISION

UNION CARBIDE

ENVIRONMENTAL MONITORING REPORT
UNITED STATES
DEPARTMENT OF ENERGY

OAK RIDGE FACILITIES

Calendar Year 1981

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Office of Health, Safety, and Environmental Affairs
Post Office Box Y
Oak Ridge, Tennessee 37830

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INTRODUCTION

Oak Ridge is located in East Tennessee in a broad valley which lies between the Cumberland Mountains on the northwest and the Great Smoky Mountains on the southeast. The Department of Energy (DOE) Reservation is located in the Valley and Ridge physiographic province which is characterized by parallel ridges of sandstone, shale, and cherty dolomite, separated by valleys of less weather-resistant limestone and shale. The ridges are oriented southwest-northeast. Topography of the area is due to differential erosion of severely folded and faulted rocks ranging in age from Early Cambrian to Early Mississippian. Elevations range from 226 to 415 meters above mean sea level with a maximum relief of 189 meters. The area includes gently sloping valleys and rolling to steep slopes and ridges. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar Reservoirs on the Clinch River form the southern and western boundaries of the Reservation while the City of Oak Ridge (approximately 28,000 population) is on the northern boundary.

The local climate is noticeably influenced by topography. Prevailing winds are usually either up-valley, from west to southwest, or down-valley, from east to northeast. During periods of light winds, daytime winds are usually southwesterly and nighttime winds usually northeasterly. Wind velocities are somewhat decreased by the mountains and ridges, and tornadoes rarely occur. In winter, the Cumberland Mountains have a moderating influence on the local climate by retarding the flow of cold air from the north and west. Temperatures of 38°C or higher and -18°C or below are unusual. Low-level temperature inversions occur during approximately 56 percent of the hourly observations. Winter and early spring are the seasons of heaviest precipitation with the monthly maximum normally occurring during January to March. The mean annual precipitation is approximately 137 centimeters.

The topography of the Oak Ridge area is such that all drainage from the DOE Reservation flows into the Clinch River which has its headwaters in southwestern Virginia and flows southwest to its mouth near Kingston, Tennessee. The Clinch River flow is regulated by several dams which provide reservoirs for flood control, electric power generation, and recreation. The principal tributaries through which liquid effluents from the plant areas reach the Clinch River are White Oak Creek, East Fork Poplar Creek, and Poplar Creek.

With the exception of the City of Oak Ridge, the land within 8 kilometers of the DOE Reservation is predominantly rural being utilized largely for residences, small farms, and pasturage for cattle. Fishing, boating, water skiing, and swimming are favorite recreational activities in the area. The approximate location and population of the towns nearest the DOE Reservation are: Oliver Springs (pop. 3600) 11 kilometers to the northwest; Clinton (pop. 5400) 16 kilometers to the northeast; Lenior City (pop. 5400) 11 kilometers to the southeast; Kingston (pop. 4400) 11 kilometers to the southwest; and Harriman (pop. 8300) 13 kilometers to the west. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 kilometers to the east and has a population of approximately 183,000. A directional 80-kilometer population distribution, which is used for population dose calculations later in this report, is shown in Table 1.

The DOE Reservation contains three major operating facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Gaseous Diffusion Plant (ORGDP), and the Y-12 Plant; all of which are operated by Union Carbide Corporation, Nuclear Division. In addition, two smaller DOE facilities are in the area: the Comparative Animal Research Laboratory, and the Oak Ridge Associated Universities, both of which are operated by Oak Ridge Associated Universities.

The Oak Ridge National Laboratory is a large multipurpose research laboratory whose basic mission is the discovery of new knowledge, both basic and applied, in all areas related to energy. To accomplish this mission, the Laboratory conducts research in all fields of modern science and technology. The Laboratory's facilities consist of nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, and support facilities.

The Oak Ridge Gaseous Diffusion Plant (ORGDP) is a complex of production, research, development, and support facilities located west of the city of Oak Ridge. While the primary function of ORGDP is the enrichment of uranium hexafluoride (UF_6) in the uranium-235 isotope, extensive efforts are also expended on research and development activities associated with both the gaseous diffusion and gas centrifuge processes. In addition, the barrier material used by all three Department of Energy-owned gaseous diffusion plants is manufactured at ORGDP. Numerous other activities (maintenance, nitrogen production, steam production, uranium recovery, fluorine production, water treatment, laboratory analysis, administration, etc.) lend support to these primary functions and are thus essential to the operation of this plant.

The Oak Ridge Y-12 Plant which is located immediately adjacent to the City of Oak Ridge has five major responsibilities: (1) production of nuclear weapon components, (2) processing of source and special nuclear materials, (3) support to the weapon design laboratories, (4) support to other UCC-ND installations, and (5) support to other government agencies. Activities associated with these functions include the production of lithium compounds, the recovery of enriched uranium from unirradiated scrap material, and the fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

Operations associated with the DOE research and production facilities in Oak Ridge give rise to several types of waste materials.

Radioactive wastes are generated from nuclear research activities, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, uranium enrichment, and uranium processing operations. Nonradioactive wastes are generated by normal industrial-type support operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plant operations, and steam plant operations.

Nonradioactive solid wastes are buried in a centralized sanitary landfill or designated burial areas. Radioactive solid wastes are buried in solid waste storage areas and placed in retrievable storage either above or below ground depending upon the type and quantity of radioactive material present and the economic value involved.

Gaseous wastes generally are treated by filtration, electrostatic precipitation, and/or chemical scrubbing techniques prior to release to the atmosphere. The major gaseous waste streams are released through stacks to provide atmosphere dilution for materials which may remain in the stream following treatment.

Liquid radioactive wastes are not released but are concentrated and contained in tanks for ultimate disposal. Process water which may contain small quantities of radioactive or chemical pollutants is discharged, after treatment, to White Oak Creek, Poplar Creek, East Fork Poplar Creek, and Bear Creek, which are small tributaries to the Clinch River.

SUMMARY

The Environmental Monitoring Program for the Oak Ridge area includes sampling and analysis of air, water from surface streams, creek sediments, biota, and soil for both radioactive and nonradioactive materials. This report presents a summary of the results of the program for calendar year 1981.

Surveillance of radioactivity in the Oak Ridge environs indicates that atmospheric concentrations of radioactivity were not significantly different from other areas in East Tennessee. Concentrations of radioactivity in the Clinch River and in fish collected from the river were less than 2 percent of the permissible concentration and intake guides for individuals in the offsite environment. While some radioactivity was released to the environment from plant operations, the concentrations in all of the media sampled were well below established standards.

The total body dose to a "hypothetical maximum exposed individual" at the site boundary was calculated to be 5.9 millirem/yr (59 microsieverts) which is 1.1 percent of the DOE Manual Chapter 0524 standard. The maximum 50-year dose commitment to the critical organ of an individual from the aquatic food chain was calculated to be 71 millirem (710 microsieverts) to the bone which is 4.7 percent of the allowable annual standard. The maximum dose commitment to individuals living nearest the site boundary from airborne releases, assuming continuous residence, was 0.38 millirem (3.8 microsieverts) to the total body and 9.2 millirem (92 microsieverts) to the lung. These doses are 0.08 percent and 0.6 percent, respectively, of the annual standards. The average total body dose to an Oak Ridge resident was estimated to be 0.09 millirem (0.9 microsieverts) as compared to approximately 100 millirem/yr (1000 microsieverts/yr) from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.55 millirem (5.5 microsieverts). The cumulative total body dose to the population within an 80-kilometer radius of the Oak Ridge facilities resulting from 1981 effluents was calculated to be 31.5 man-rem (0.3 man-sieverts). This dose may be compared to an estimated 87,000 man-rem (870 man-sieverts) to the same population resulting from natural background radiation.

Surveillance of nonradioactive materials in the Oak Ridge environs shows that established limits were not exceeded for those materials possibly present in the air as a result of plant operations.

The chemical water quality data in surface streams obtained from the water sampling program indicated that average concentrations resulting from plant effluents were in compliance with State stream guidelines with the exception of fluoride at monitoring Station E-1 which was 120 percent of the guideline and nitrate at Station B-1 which was 150 percent of the guideline.

National Pollutant Discharge Elimination System (NPDES) permit compliance information has been included in this report.

During 1981 there were no spills of oil and/or hazardous materials from the Oak Ridge installations reported to the National Response Center.

MONITORING DATA COLLECTION, ANALYSIS, AND EVALUATION

Environmental monitoring data for calendar year 1981 are summarized in Table 2 through 35. In general, the data tables show the number of samples collected at each location, the maximum concentration, the minimum concentration, the average concentration, the relevant standard, and percent of standard for the average of each parameter. Averages are usually accompanied by plus-or-minus ($\pm$) values which represent the 95 percent confidence limits. The 95 percent confidence

limits which are calculated from the standard deviation of the average, assuming a normal frequency distribution, are predictions of the variability in the range of concentrations based on a limited number of measurements. They do not represent the conventional error in the average of repeated measurements on identical samples. Data which are below the minimum detectable limit are expressed as less than (<) the minimum detectable value. In computing average values, sample results below the detection limit are assigned the detection limit value with the resulting average value being expressed as less than (<) the computed value.

Average environmental concentrations are compared with applicable standards where such standards have been established as a means of evaluating the impact of effluent releases. In some cases, for lack of an official standard, stream concentrations of nonradioactive pollutants have been compared with Tennessee State Health Department stream guidelines.

Liquid effluent monitoring data have been compared to the limits specified in the National Pollutant Discharge Elimination System (NPDES) permits issued to the Oak Ridge facilities by the Environmental Protection Agency (EPA).

There is a movement currently in some scientific communities to use the International System of Units (SI) for radioactive measurements. This report will be converted to SI units for radioactive measurements following a familiarization and transition period. During the transition period the report will contain data in both units; the non-SI units used previously followed by the SI units in parentheses.

Air Monitoring

Radioactive - Atmospheric concentrations of radioactive materials occuring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of nine stations (HP-31 through HP-39) which encircle the perimeter of the Oak Ridge area and provides data for evaluating releases from Oak Ridge facilities to the immediate environment, Figure 1. A second system consists of seven stations (HP-51 through HP-53 and HP-55 through HP-58) encircling the Oak Ridge area at distances of from 19 to 121 kilometers, Figure 2. This system provides background data to aid in evaluating local conditions. Sampling for radioactive particulates is carried out by passing air continuously through filter papers. Filter papers are evaluated weekly by gross beta and gross alpha counting techniques and composited by system quarterly for specific radionuclide analysis. More frequent detailed analyses are performed if concentrations in the environment are significantly above normal. Airborne radioactive iodine is monitored in the immediate environment at the perimeter stations by passing air continuously through cartridges containing activated charcoal. Charcoal cartridges are evaluated for radioactive iodine by gamma spectrometry.

Data on the concentrations of radioactive materials in air and the quantities of radioactive materials released to the atmosphere in the Oak Ridge and surrounding areas are given in Tables 2 through 6.

The average gross beta concentrations of radioactivity from particulates in air measured by both the perimeter and remote monitoring systems were 0.07 and 0.07 percent, respectively, of the applicable concentration guide (CG) as specified in the DOE Manual, Appendix 0524[1] for individuals in uncontrolled areas (Table 2). The increase in activity levels compared to 1980 measurements was attributed to the presence of weapons test debris in the atmosphere during the first half of 1981.

The average gross alpha concentrations in the perimeter and remote monitoring systems were 0.02 and 0.03 percent, respectively, of the CG for a mixture of uranium isotopes (Table 3).

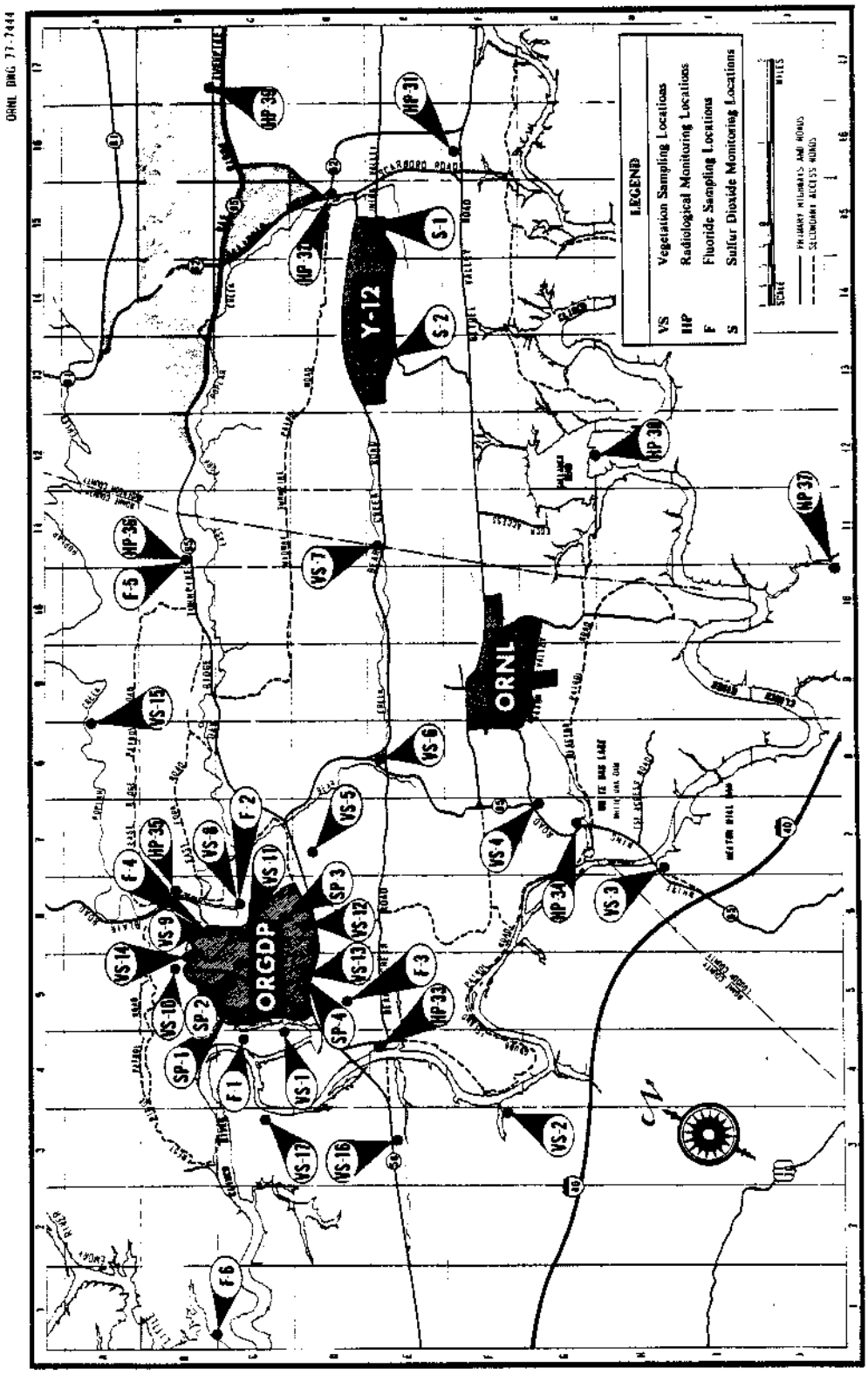

Figure 1
AIR, VEGETATION, AND SOIL SAMPLING LOCATIONS

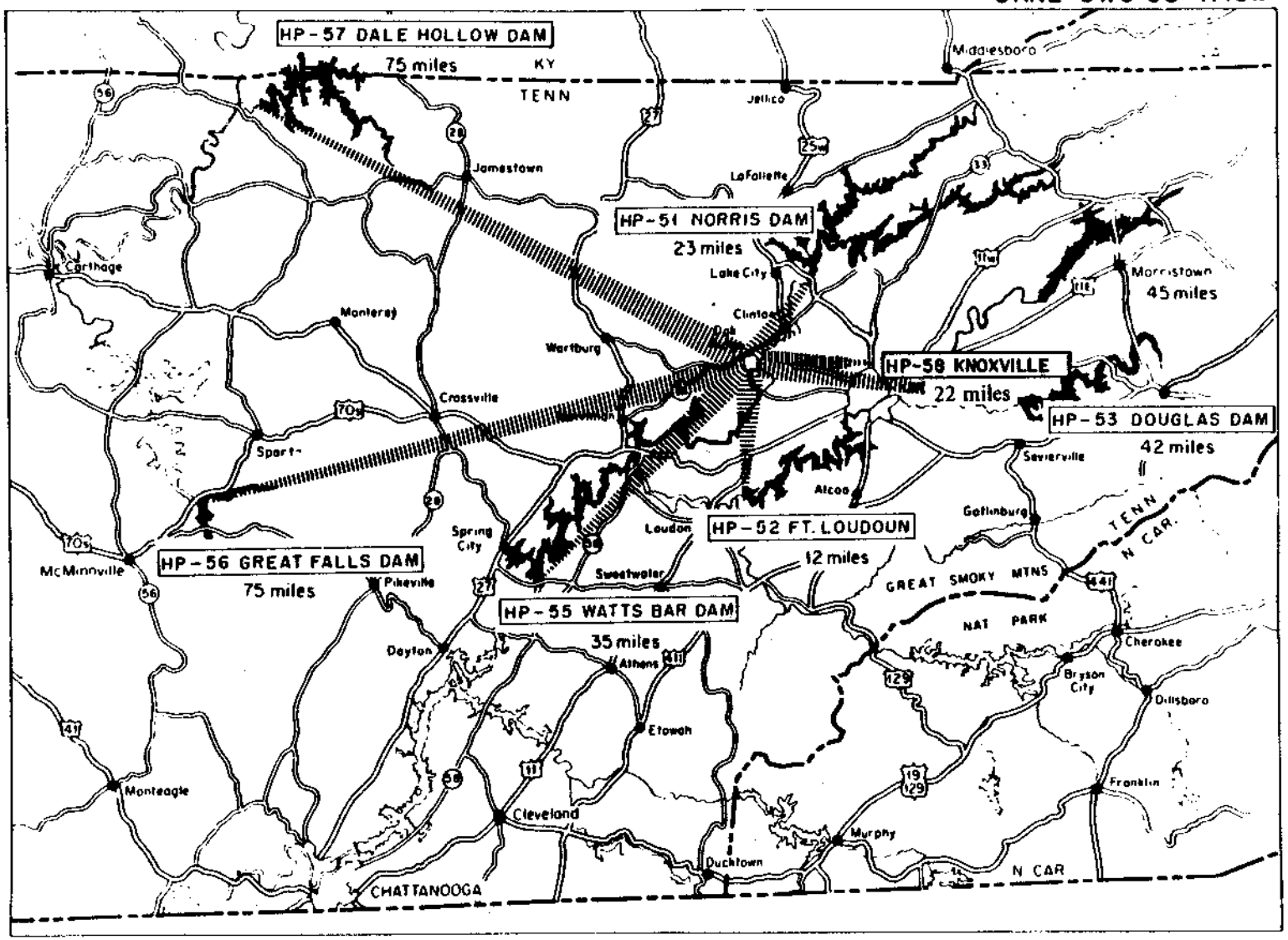

Figure 2
REMOTE AIR MONITORING LOCATIONS

The results of specific radionuclide analyses of composited filters are given in Table 4. The environmental concentrations tabulated are all at least a thousand times less than the applicable DOE concentration guides for the radionuclides detected.

The concentration of ^{131}I as measured by the perimeter air monitoring system was <0.01 percent of the inhalation concentration guide for individuals in uncontrolled areas (Table 5).

While some radioactivity was released to the atmosphere (Table 6), measurements in the Oak Ridge area show that environmental levels were well below established standards.

Nonradioactive - Environmental air samples are taken for the determination of fluorides, suspended particulates, and sulfur dioxide.

Sampling locations for fluorides are indicated by F-1 through F-6, Figure 1. The current sampling procedure is to obtain six-day samples collected on potassium carbonate treated paper and to analyze weekly by specific ion electrode. The six-day analyses are then averaged to obtain 30-day values.

Suspended particulates are measured at locations SP-1 through SP-4, Figure 1. The method for the determination of suspended particulates is the high volume method recommended by EPA. Particulates are collected by drawing air through weighed filter paper. The filter paper is allowed to equilibrate in a humidity controlled atmosphere and the filter is reweighed. From the weight of particulates, the sampling time, and the air flow rate, the particulate concentration in micrograms per cubic meter is calculated. The sampling period is 24 hours.

The two continuous monitoring stations (S-1 and S-2) in the Y-12 Plant are used for measurement of ambient sulfur dioxide concentrations. Each station consists of a pulsed ultraviolet fluorescence analyzer and recorder with associated equipment located in a temperature-controlled shelter. Sulfur dioxide concentrations are interpreted on an hourly basis and averaged for 24-hour, monthly, and annual periods.

Air monitoring data for fluorides, suspended particulates, and sulfur dioxide are presented in Tables 7 through 9. The data indicate that measured environmental concentrations of fluorides, suspended particulates, and sulfur dioxide were in compliance with applicable standards.[2]

The Y-12 steam plant is being upgraded to operate more efficiently at higher steam load levels. The current electrostatic precipitator installation is not adequate to meet emission limits at higher steam load levels. Funds have been approved and preliminary design has been commenced for the installation of pollution control equipment to meet emission limits under higher operating load conditions.

External Gamma Radiation Monitoring

External gamma radiation background measurements are made routinely at the perimeter air monitoring stations and at the remote monitoring stations using calcium fluoride thermoluminescent dosimeters suspended one meter above the ground. Dosimeters at the perimeter stations are collected and analyzed monthly. Those at the remote stations are collected and analyzed semiannually.

Data on the average external gamma radiation background are given in Table 10. A considerable variation in background levels is normally experienced in East Tennessee depending upon elevation, topography, and geological character of the surrounding soil.[3]

External gamma radiation measurements were made along the bank of the Clinch River from the mouth of White Oak Creek several hundred yards downstream to evaluate gamma radiation levels resulting from effluent releases and "sky shine" from an experimental cesium plot located near the river bank. Measurements were made using scintillation detectors and/or thermoluminescent dosimeters suspended one meter above the ground surface. The average background level determined at the remote stations was subtracted from the measured gamma radiation levels to determine the incremental increases resulting from plant operations.

The external gamma radiation levels along the bank of the Clinch River ranged from 4 to 25 μR/hr (1 E-09 to 6.5 E-09 C/kg/h) above background. Potential doses to individuals in the environment from these elevated gamma radiation levels were calculated and are included, where significant, in the dose assessment section of the report.

Water Monitoring

Radioactive - Water samples are collected in the Clinch River for radioactivity analyses at Melton Hill Dam (Station C-2) 3.7 kilometers above White Oak Creek outfall, at the ORGDP sanitary water intake (Station C-3) 10 kilometers downstream from the entry of White Oak Creek, at the ORGDP recirculating water intake (Station C-4) downstream from the Poplar Creek outfall, and near Brashear Island (Station C-6). A sample is also collected from the Tennessee River at the Water Plant (Station C-5) near Kingston, Tennessee, Figure 3. Samples are collected continuously at Stations C-2, C-3, and C-5. A weekly 24-hour composite sample is collected at Station C-4 and a weekly grab sample is collected at Station C-6. Samples are composited for monthly or quarterly analysis depending upon location.

Water samples also are collected for radioactivity analyses at the mouth of White Oak Creek (Station W-1), at the outlet of New Hope Pond on East Fork Poplar Creek (Station E-1), in Bear Creek (Station B-1), and in Poplar Creek (Stations P-1 and P-2), Figure 3. The samples collected at Stations W-1, E-1, and B-1 are continuous samples. Grab samples are collected at Stations P-1 and P-2 on a weekly basis. Water samples are collected also at White Oak Dam. All samples are composited for monthly analysis.

The concentrations of fission product radionuclides present in detectably significant amounts are determined by specific radionuclide analysis and gamma spectrometry. Uranium analysis is by the fluorometric method. Transuranic alpha emitters are determined by ion exchange and alpha range analysis. The concentration of each radionuclide is compared with its respective concentration guide (CG) value as specified in the DOE Manual, Appendix 0524, and percent of concentration guide for a known mixture of radionuclides is calculated in accordance with the method given in Appendix 0524.

Data on the concentrations of radionuclides measured in the surface streams are given in Table 11. Data on the concentrations of uranium in surface streams and the quantities of radioactivity release to surface streams are given in Tables 12 and 13.

Analysis of water samples collected in the mouth of White Oak Creek (Station W-1) indicated that the yearly average concentration of radionuclides was approximately 28 percent of the applicable concentration guide for uncontrolled areas. The calculated average concentration of radionuclides in the Clinch River, based on the analysis of water samples collected at White Oak Dam and the

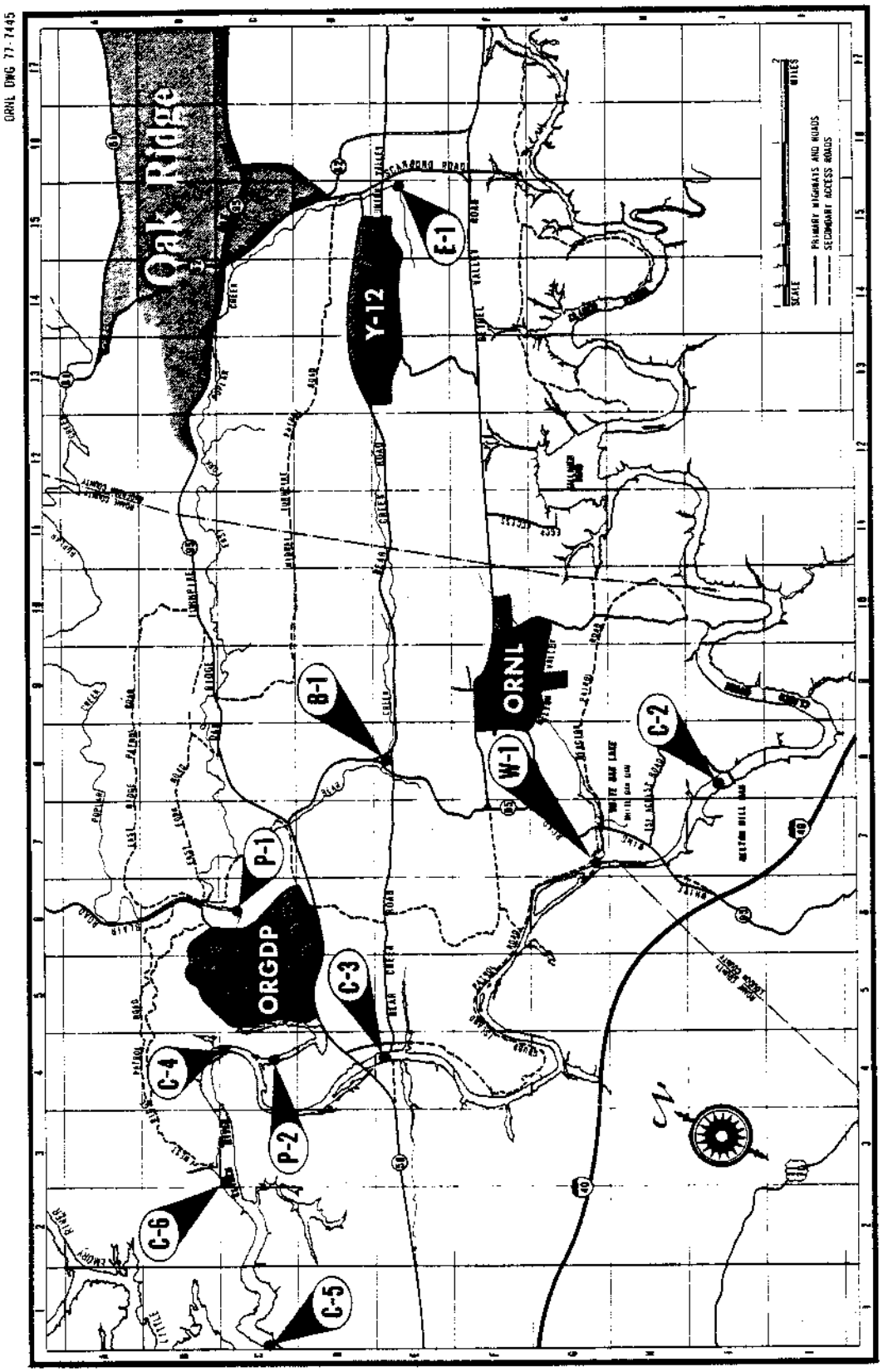

Figure 3
STREAM MONITORING LOCATIONS

dilution afforded by the river, assuming complete mixing, was determined to be 0.6 percent of the applicable concentration guide for uncontrolled areas. The average dilution factor for 1981, based on the flow of White Oak Creek and the Clinch River, was 371. The measured average concentrations of radionuclides in the Clinch River upstream and downstream of White Oak Creek outfall were less than 1 percent of the applicable concentration guide.

The calculated average concentration of transuranic alpha emitters in the Clinch River resulting from effluent releases was 3.7 E-11 μCi/mL (1.4 mBq/L), which is about 0.12 percent of the concentration guide for water containing a known mixture of radionuclides.

Trends in water discharges and calculated percent concentration guide levels in the Clinch River are presented in Figures 4 and 5. Discharges of ^{90}Sr and ^{3}H are shown in Figure 4 as these nuclides contribute the majority of the radiological dose downstream. While the discharges of ^{90}Sr and ^{3}H were essentially the same in 1980 and 1981, the percent MPCw calculated for the Clinch River increased significantly in 1981 (Figure 5). This increase was attributed to low flow in the Clinch River with the resulting dilution being about a factor of three less than last year.

Rainwater - The gross beta activity in rainwater was analyzed; the results are shown in Table 14. The fluctuations among the stations for both the perimeter and remote networks are due to statistical random variation. It is noted that the average radioactivity is greater for the remote stations than the perimeter stations.

Nonradioactive - Water samples are collected for the analysis of nonradioactive substances at the same locations discussed previously under radioactive water sampling. All samples are composited for monthly analysis. Samples are analyzed for a variety of water quality parameters related to process release potential and background information needs by analytical procedures recommended by the Environmental Protection Agency.[4]

Data on chemical concentrations in surface streams are given in Tables 15 through 23. The average concentrations of all substances analyzed were in compliance with Tennessee stream guidelines[5, 6] except for fluoride at Station E-1 and nitrate at Station B-1 which were 120 and 150 percent of the guidelines, respectively.

National Pollution Discharge Elimination System (NPDES) permits were issued by the Environmental Protection Agency (EPA) for each of the Oak Ridge facilities operated by Union Carbide Corporation - Nuclear Division in 1975. The permits established a number of discharge locations at each installation and listed specific concentration limits and/or monitoring requirements for a number of parameters at each discharge location. Table 24 contains the discharge locations at each installation, the parameters at each location for which limits have been established, the permit limits for each parameter, and the percentage compliance experienced.

Biological Monitoring

Milk - Raw milk is monitored for ^{131}I and ^{90}Sr by the collection and analysis of samples from 12 sampling stations located within a radius of 80 kilometers of Oak Ridge. Samples are normally collected weekly at each of seven stations located near the Oak Ridge area. Five stations, located more remotely with respect to Oak Ridge operations, are sampled at a rate of one station each week. Milk sampling locations for all stations are shown in Figures 6 and 7. Samples are analyzed by ion exchange and gamma spectrometry; results are compared to intake guides specified by the Federal Radiation Council (FRC).[7]

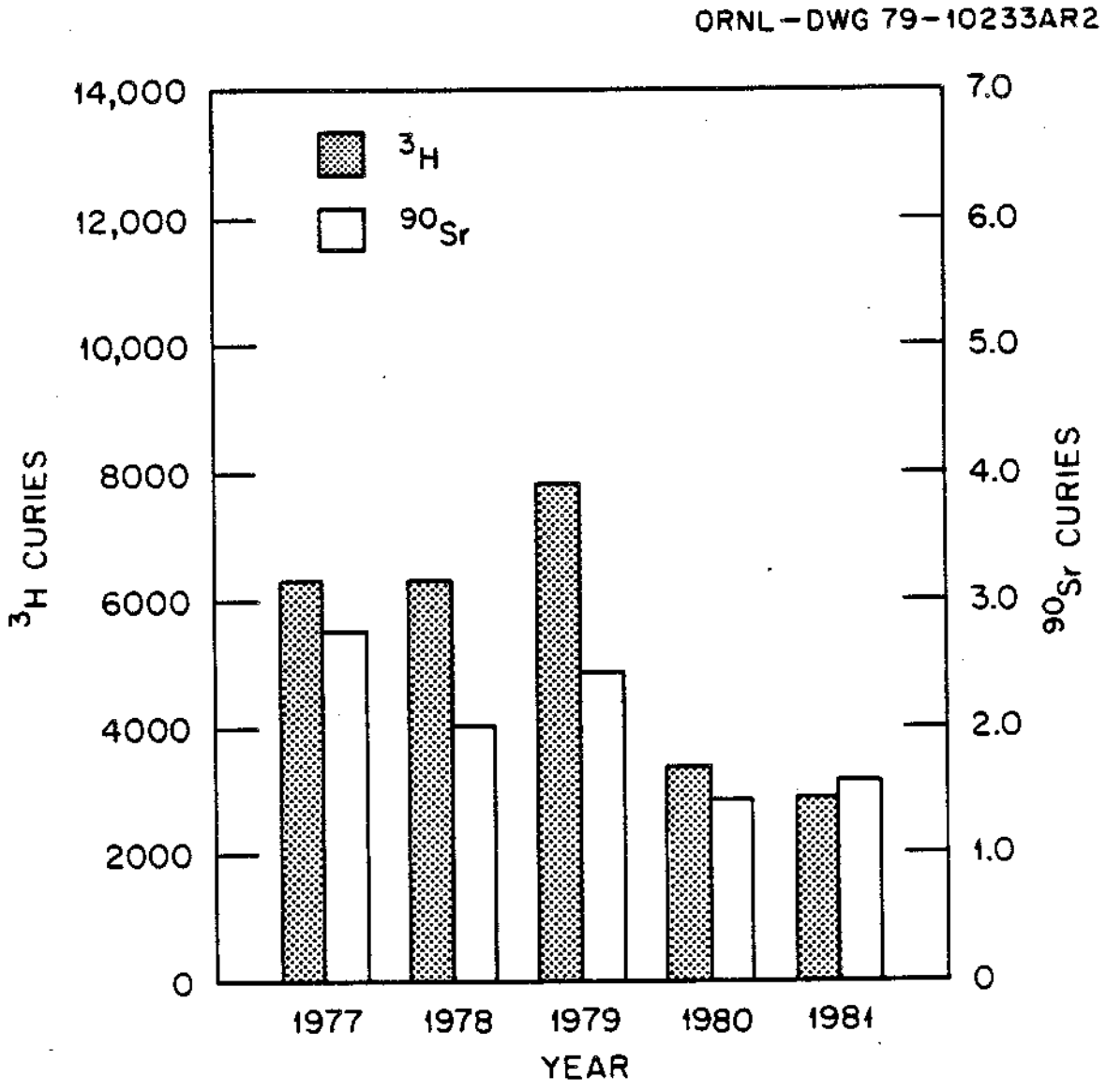

Figure 4
CURIES DISCHARGED OVER WHITE OAK DAM

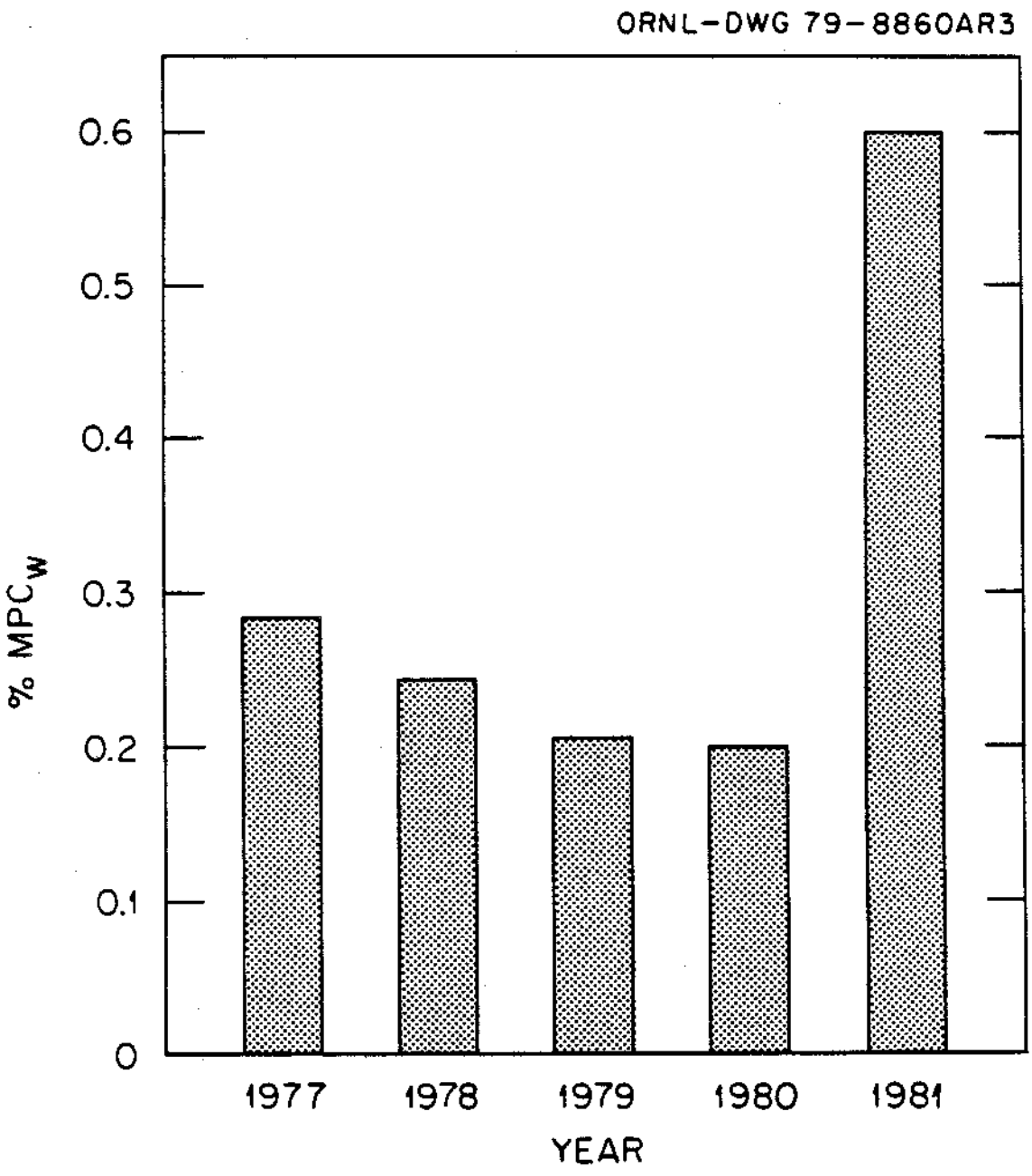

Figure 5
PERCENTAGE CONCENTRATION GUIDE LEVELS IN THE CLINCH RIVER (VALUES GIVEN ARE CALCULATED VALUES BASED ON THOSE CONCENTRATIONS MEASURED AT WHITE OAK DAM AND DILUTION AFFORDED BY THE CLINCH RIVER

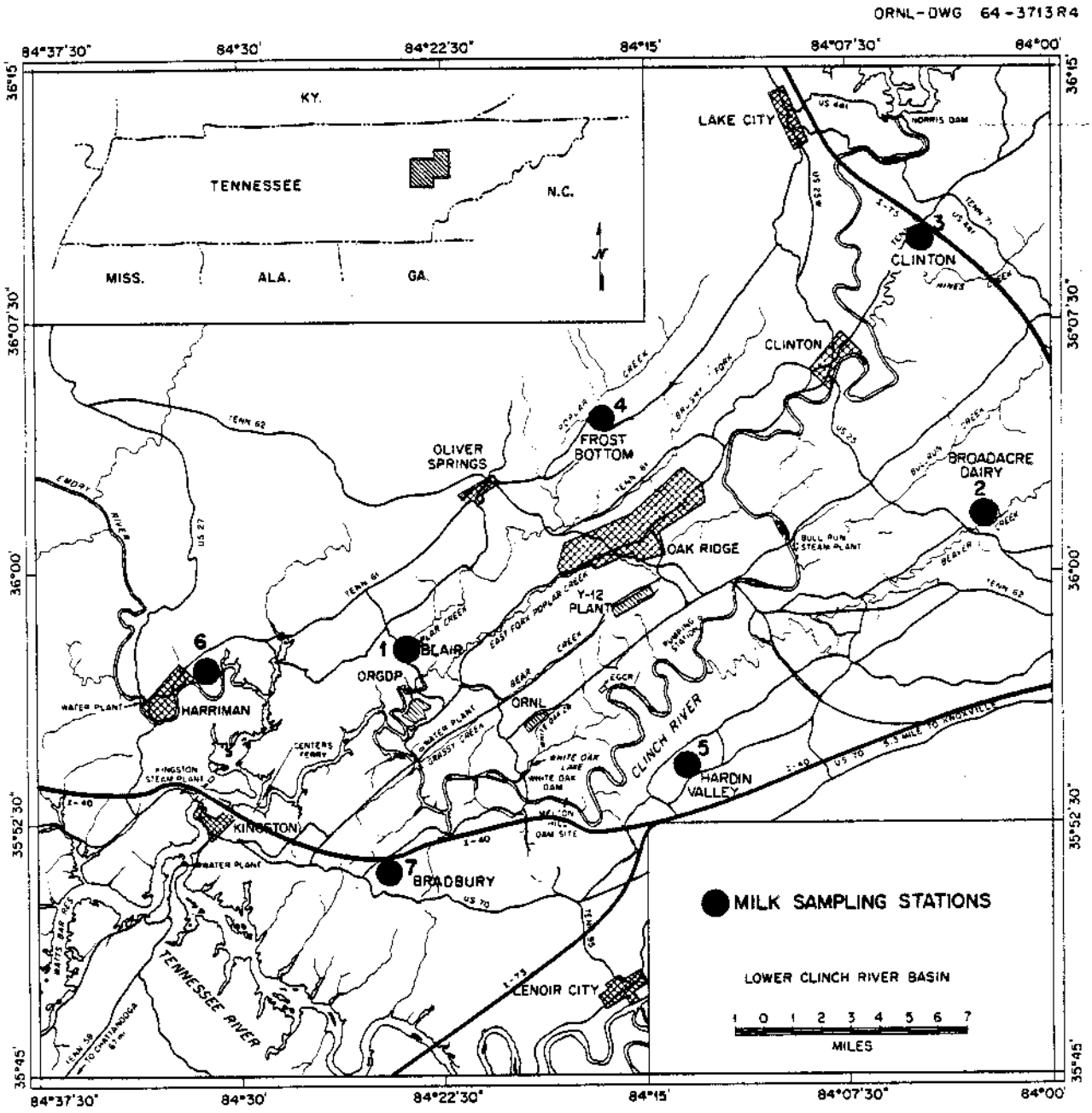

Figure 6
IMMEDIATE ENVIRONS MILK SAMPLING LOCATIONS

ORNL DWG 76-12775RAR2

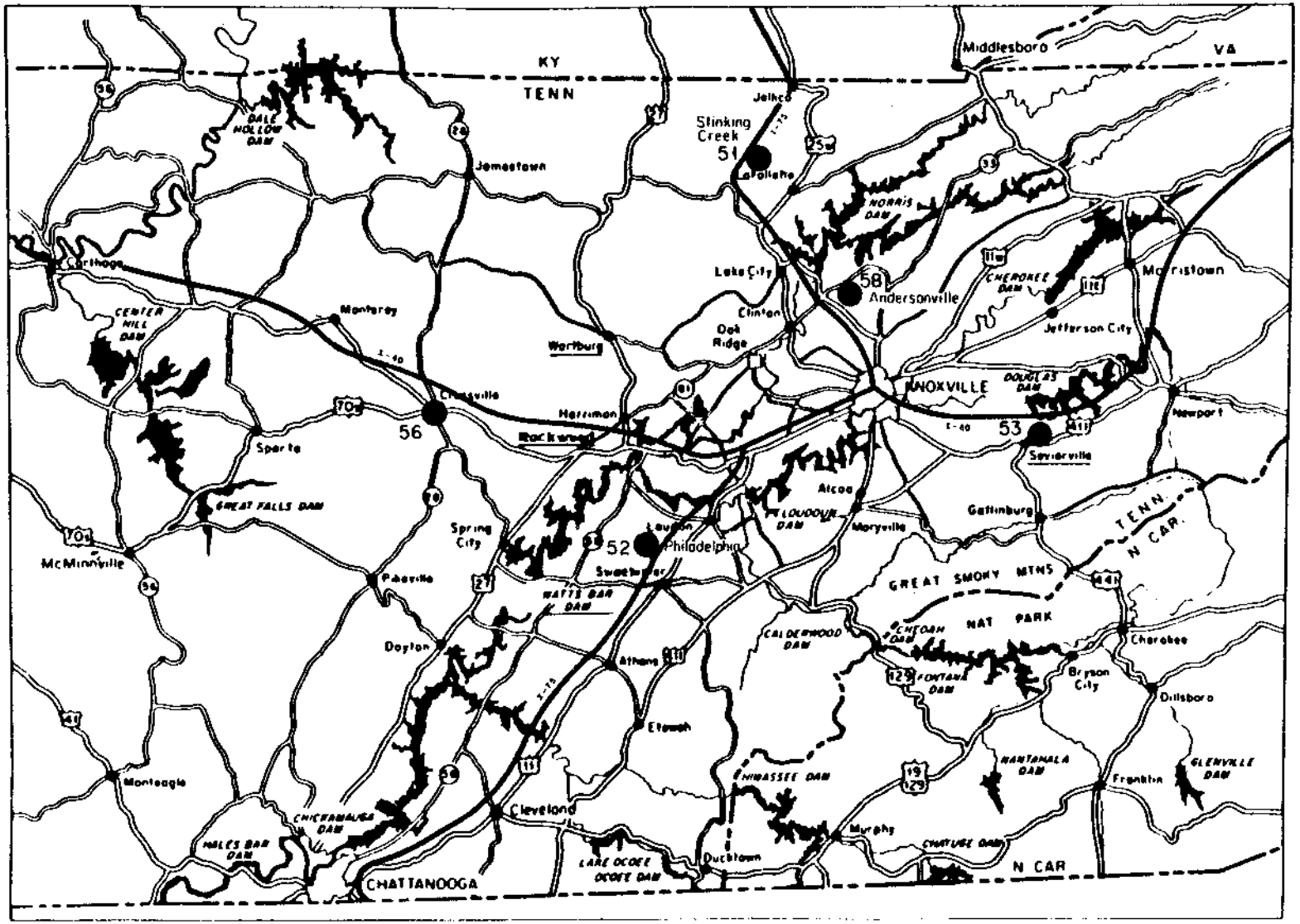

Figure 7
REMOTE ENVIRONS MILK SAMPLING LOCATIONS

The average concentrations of ^{131}I and ^{90}Sr in raw milk are given in Tables 25 and 26, respectively. If one assumes the average intake of milk per individual to be one liter per day, the average concentration of ^{131}I in milk in both the immediate environs of the Oak Ridge area and in the environs remote from Oak Ridge were within FRC Range 1. The average concentrations ^{90}Sr in milk from both the immediate and remote environs were within the FRC Range 1.

Fish Sampling - Several species of fish which are commonly caught are taken from the Clinch River each year. The scales, head, and entrails are removed from the fish before ashing. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometry and radiochemical techniques for the critical radionuclides which may contribute significantly to the potential radiation dose to man.

Data on the concentration of radionuclides in Clinch River fish are given in Tables 27 and 28. Consumption of 16.8 kilograms of bluegill per year[8] taken from the river near White Oak Creek outfall results in approximately 2 percent of the maximum permissible intake, which represents the highest dose potential to the public from fish consumption. The maximum permissible intake is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of the radionuclides in question. Mercury concentrations in the fish samples collected were less than the FDA proposed action level (Table 29), except for the carp collected at Clinch River Mile 12.0 which was 115 percent of the action level.

Deer - Frequently, deer are killed by automobiles on the DOE Reservation. Thirty nine deer samples were analyzed during 1981. Summary data of the ^{137}Cs content in deer samples are presented in Table 30. The deer with the highest concentration of ^{137}Cs would result in a dose of 0.04 millirem (0.4 microsieverts) to the total body and 0.07 millirem (0.7 microsieverts) to the liver (critical organ) if one assumes the consumption of 1 kilogram of meat. It should be noted that no hunting is allowed on the Reservation.

Vegetation - Samples of pine needles and grass are collected semiannually from 17 areas (Stations VS-1 through VS-17, Figure 1) and analyzed for uranium and fluoride content. Fluorometric analysis is used for the determination of uranium and colorimetric analysis is used for the determination of fluorides.

Data on the uranium and fluoride content in vegetation are presented in Table 31. The fluoride concentration in grass at all sampling points was below the 30 $\mu g/g$ level considered to produce no adverse effects when ingested by cattle.[9] Uranium concentrations were below levels of environmental concern.

Additionally, samples of grass were collected semiannually from the perimeter and annually from the remote air-sampling stations (see Figure 1 and 2). At each station, all the grass from five 1/5 meter-squared plots was collected. One plot was taken beside the station, and the other four were taken at 15 m from the station at 90° directions from each other. The grass from each station was then composited and analyzed by gamma spectrometry and radiochemical techniques for a variety of radionuclides. Data on the radionuclide concentrations in grass are presented in Table 32.

Soil and Sediment Monitoring

Soil - Soil samples are also collected semiannually from near the perimeter and annually from the remote stations. The same five 1/5 meter-squared plots used for grass analysis were also used for soil determinations. Two cores, 8 cm in diameter and 5 cm in depth, were taken from each plot; a composite of 10 cores was used for each station. These samples were also analyzed by gamma spectrometry and radiochemical techniques.

Data on specific radionuclide concentrations in soil are given in Table 33. The plutonium concentrations found were comparable to the value of 0.05 pCi/g (0.002 Bq/g) considered to be a representative concentration of plutonium in U.S. surface soil.[10]

Sediment - A sediment sampling program was initiated at ORGDP in 1975 to determine the concentrations of various metallic ions in the sediment of Poplar Creek. The current sampling program consists of 14 sampling locations (Figure 8) which should be generally representative of plant effluents. Samples are collected twice during the year and analyzed by atomic absorption.

The concentrations of metals in the stream sediment samples, Table 34, generally exceed background levels for metals in remote streams. An examination of the effluent sources indicates that only very small quantities of any of these metals are currently being released, suggesting that present concentrations found in sediment samples are residual metals from earlier Oak Ridge plant operations.

Calculation of Potential Radiation Dose to the Public

Potential radiation doses resulting from plant effluents were calculated for a number of dose reference points within the Oak Ridge environs. All significant sources and modes of exposure were examined, and a number of general assumptions were used in making the calculations.

The site boundary for the Oak Ridge Complex was defined as the perimeter of the DOE controlled area.

Gaseous effluents are discharged from several locations within each of the three Oak Ridge facilities. For calculational purposes, the gaseous discharges are assumed to occur from only one vent from each site. Since the release points at ORGDP and the Y-12 Plant do not physically approximate an elevated stack, their discharges are assumed to be from 10 meters above ground level; releases from ORNL are through elevated stacks. The meteorological data collected at the ORNL site were used for dispersion calculations. Concentrations of radionuclides contained in the air and deposited on the ground were estimated at distances up to 80 kilometers from the Oak Ridge facilities with the Gaussian plume model developed by Pasquill[11] and Gifford[12] incorporated in a computer program.[13] The concentration has been averaged over the crosswind direction to give the estimated ground level concentration downwind of the source of emission.[14] The deposition velocities used in the calculations were 0.0 cm/sec for krypton and xenon, 0.2 cm/sec for iodine, and 0.1 cm/sec for particulates.[15] Meteorological data are shown in Figure 9; the length of the bars indicates the percentage of time the wind is blowing in that direction.

Potential pathways of exposure to man from radioactive effluents released by the Oak Ridge operations that are considered in the dose estimates are presented in Figure 10. The pathways shown in the figure are not exhaustive, but they include the principal pathways of exposure based on experience.

Exposures to radionuclides that originate in the effluents released from the Oak Ridge facilities were converted to estimates of radiation dose to individuals using models and data presented in publications of the International Commission on Radiological Protection,[16-21] other recognized literature on radiation protection,[22-24] personal communication,[25] and computer programs incorporating some of these models and data.[26, 27] Radioactive material taken into the body by inhalation or ingestion will continuously irradiate the body until removed by processes of metabolism and radioactive decay; thus the estimates for internal dose are called "dose commitments," they are obtained by integrating over the assumed remaining lifetime (50 years) of the exposed individual.

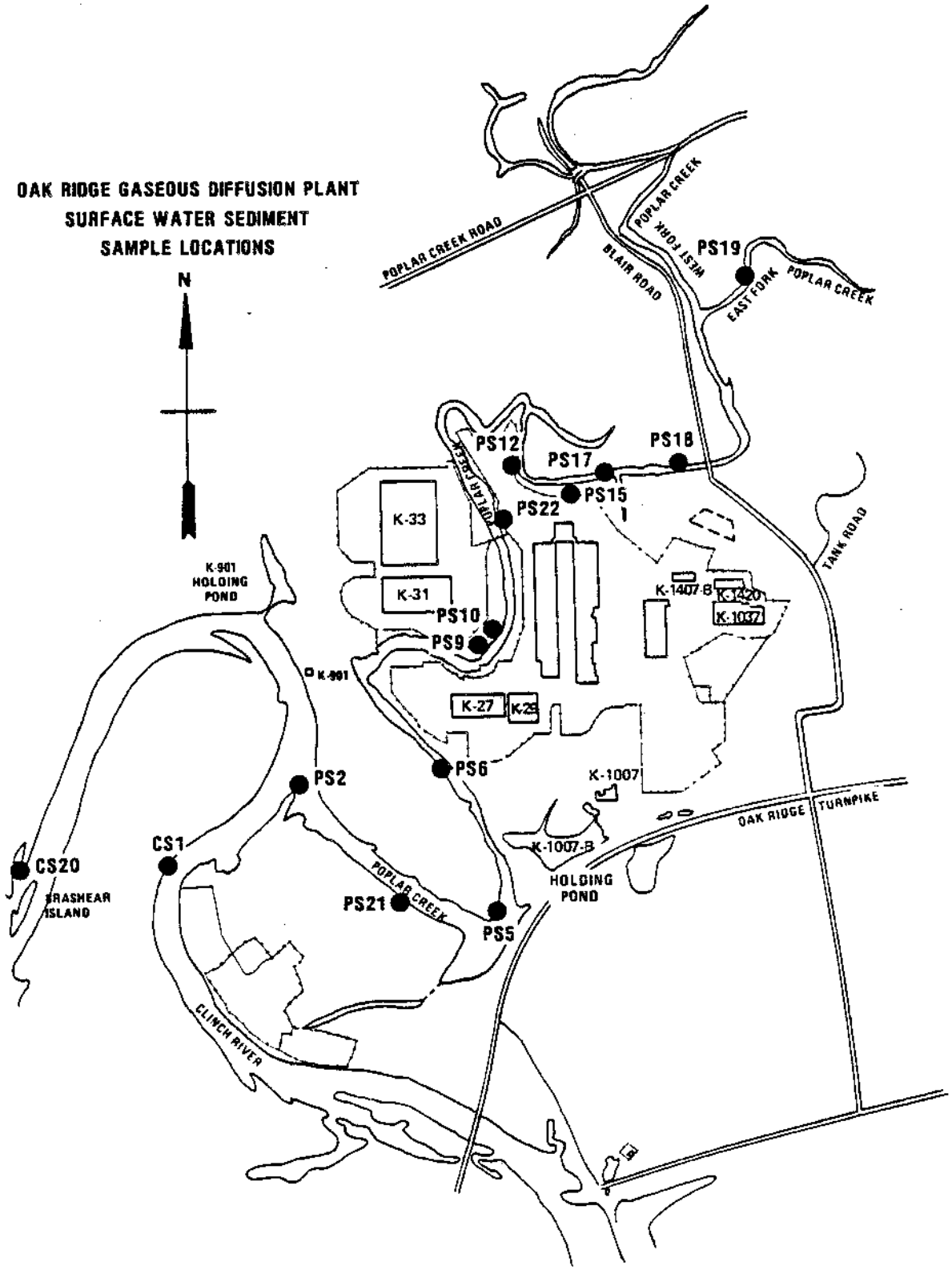

Figure 8
OAK RIDGE GASEOUS DIFFUSION PLANT SEDIMENT SAMPLING LOCATIONS

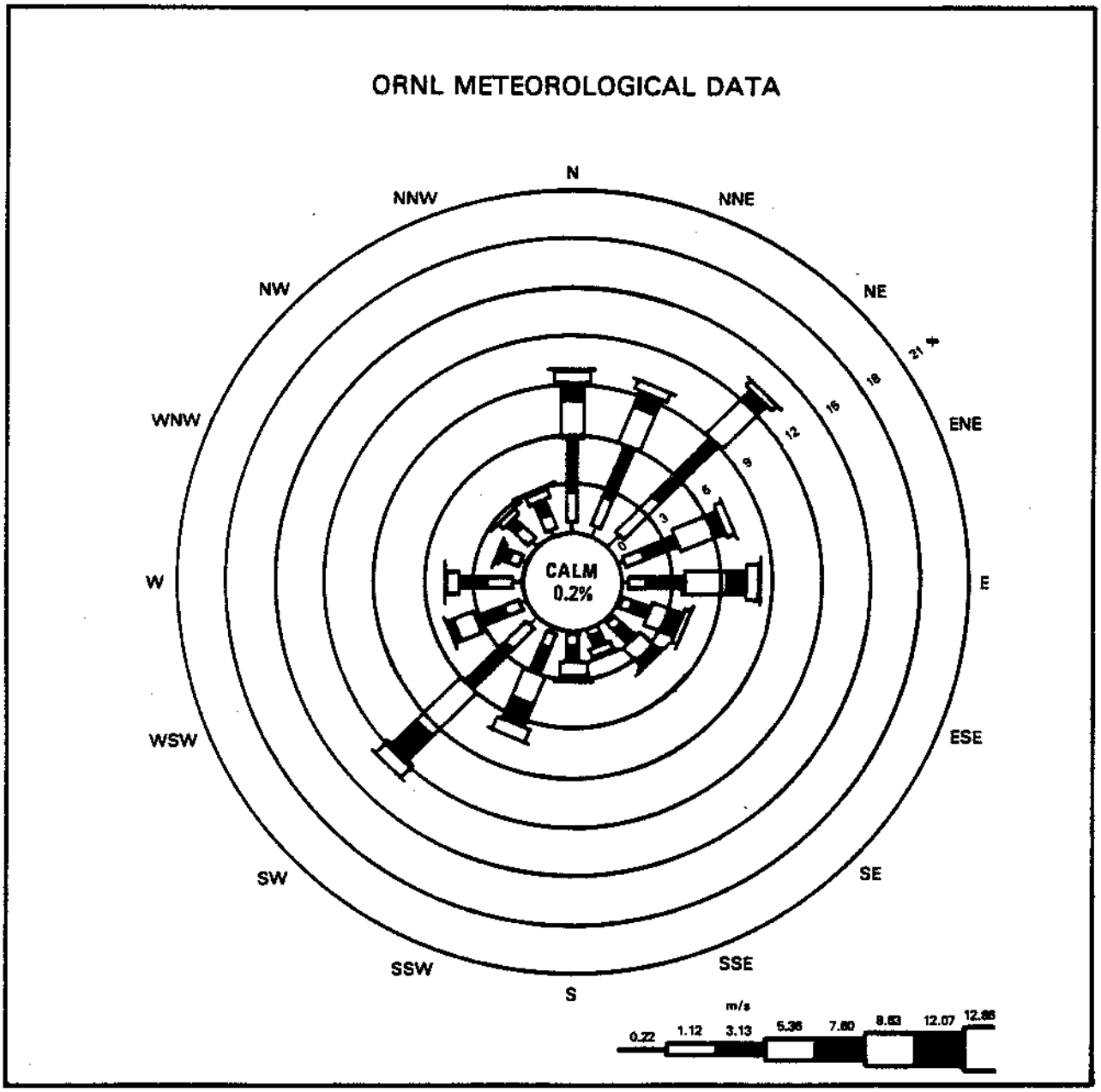

Figure 9
METEOROLOGICAL DATA FOR THE OAK RIDGE RESERVATION

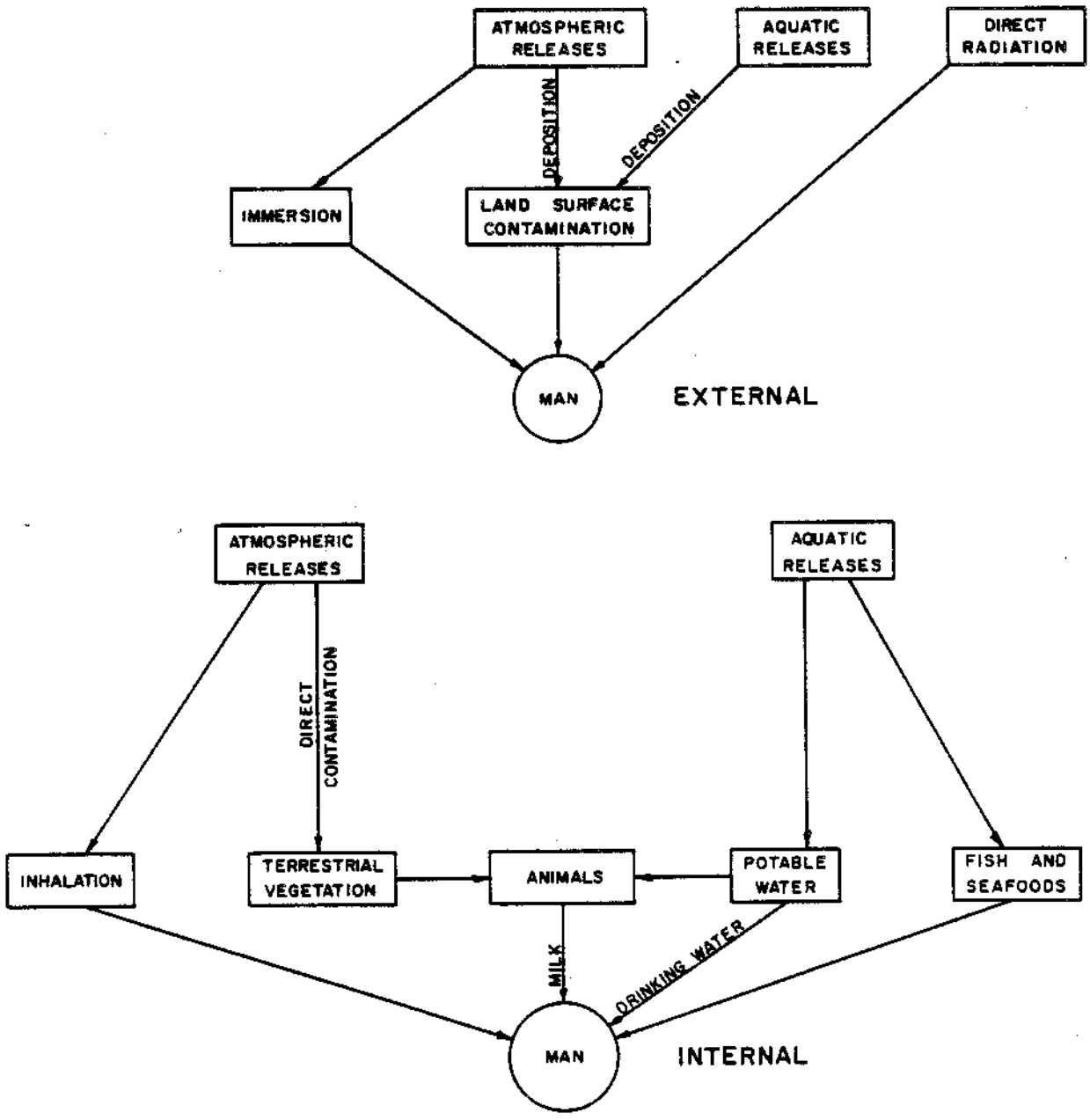

Figure 10
EXPOSURE PATHWAYS

The radiation doses to the total body and to internal organs from external exposures to penetrating radiation are approximately equal, but they may vary considerably for internal exposures because some radionuclides concentrate in certain organs of the body. For this reason, estimates of radiation dose to the total body, thyroid, lungs, bone, liver, kidneys, and gastrointestinal tract were considered for various pathways of exposure. These estimates were based on parameters applicable to an average adult.[16, 21] The population dose estimate in man-rem (man-sieverts) is the sum of the total body doses to exposed individuals within an 80-kilometer radius of the Oak Ridge facilities.

Maximum Potential Exposure - The point of maximum potential ("fence-post" dose) on the site boundary is located along the bank of the Clinch River adjacent to a cesium field experimental plot and is due primarily to "sky-shine" from the plot. A maximum potential total body exposure of 215 millirem/yr (2150 microsieverts/yr) was calculated for this location assuming that an individual remained at this point for 24 hours/day for the entire year. The calculated maximum potential exposure is 43 percent of the allowable standard.[1] This is an atypical exposure location and the probability of an exposure of the magnitude calculated is considered remote since access is only by boat.

The total body dose to a "hypothetical maximum exposed individual" at the same location was calculated using a more realistic residence time of 240 hours/yr. The calculated dose under these conditions was 5.9 millirem/yr (59 microsieverts) which is 1.1 percent of the allowable standard[1] and represents what is considered a probable upper limit of exposure.

A more probable exposure might be considered to occur at other locations beyond the site boundary as a result of airborne or liquid effluent releases.

The dose commitment to an individual continuously occupying the residence nearest the site boundary would result from inhalation and is based on an inhalation rate for the average adult of 2 E+04 liters/day. The calculated dose commitments at this location were 9.2 millrem (92 microsieverts) to the lung (the critical organ) and 0.38 millirem (3.8 microsieverts) to the total body; ^{234}U is the important radionuclide contributing to this dose. These levels are 0.6 percent and 0.08 percent, respectively, of the allowable annual standard. Due to inherent uncertainties in the meteorological data,[28] stack sampling data and calculational techniques, the calculated doses may be in error as much as 300 percent.

The most important contribution to dose from radioactivity within the terrestrial food-chain is by the atmosphere-pasture-cow-milk food-chain pathway. Measurements of the two principal radionuclides entering into this pathway, ^{131}I and ^{90}Sr (see Tables 25 and 26), indicate that the maximum dose to an individual in the immediate environs from ingestion of one liter of milk per day is 0.02 millirem (0.2 microsieverts) to the thyroid and 2.7 millirem (27 microsieverts) to the bone. The average concentrations for the remote stations were assumed to be background and were subtracted from the perimeter station data in making the calculations.

The public water supply closest to the liquid discharges from the Oak Ridge facilities is located approximately 26 kilometers downstream at Kingston, Tennessee. The intake to the water filtration plant is located on the Tennessee River approximately one-half mile upstream from the confluence of the Clinch and Tennessee Rivers. Normally, Tennessee River water is used for the Kingston water supply but under certain conditions of power generation, backflow can occur. Under backflow conditions, Clinch River water may move upstream in the Tennessee River and be used as the source of water for the Kingston filtration plant. Measurements of untreated river water samples taken at the Kingston filtration plant intake indicate that the maximum dose commitment

resulting from the ingestion of the daily adult requirement (about two liters per day) is 10.9 millirem (109 microsieverts) to the bone and 0.22 millirem (2.2 microsieverts) to the total body. The average concentrations in Melton Hill Dam water (background) were subtracted from the values obtained at Kingston.

Estimates of the 50-year dose commitment to an adult were calculated for consumption of 16.8 kilograms of fish per year from the Clinch River. The consumption of 16.8 kilograms[8] is about 2.5 times the national average fish consumption[29] and is used because of the popularity of fishing in East Tennessee. From the analysis of edible parts of the fish examined (see Table 27 and 28), the maximum possible organ dose commitment to an individual from the highest quarterly bluegill sample taken from CRM 20.8 is estimated to be 71 millirem (710 microsieverts) to the bone from ^{90}Sr. The maximum total body dose to an individual was calculated to be 2.9 millirem (29 microsieverts).

A more probable dose commitment, based on the annual average concentration of ^{90}Sr in bluegill samples taken from CRM 20.8, was calculated to be 23 millirem (230 microsieverts) to the bone and 1 millirem (10 microsieverts) to the total body. These dose commitments are about 1.5 percent and 0.2 percent, respectively, of the allowable annual standards. Fish samples taken from Melton Hill Lake were analyzed to determine background conditions. Fish caught and consumed from other locations in the Clinch River would result in significantly less dose than the maximum calculated for CRM 20.8, see Tables 27 and 28.

Summaries are given in Table 35 of the potential radiation doses to adult members of the general public at the points of highest potential exposure from gaseous and liquid effluents from the Oak Ridge facilities.

Dose to the Population - The Oak Ridge population received the largest average individual total body dose as a population group. The average total body dose to an Oak Ridge resident was estimated to be 0.09 millirem (0.9 microsieverts) as compared to approximately 100 millirem/yr (1000 microsieverts/yr) from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 0.55 millirem (5.5 microsieverts). The maximum potential dose commitment to an Oak Ridge resident was calculated to be 9.2 millirem (92 microsieverts) to the lung. This calculated dose is 0.6 percent of the allowable annual standard.[1]

The cumulative total body dose to the population within an 80-kilometer radius of the Oak Ridge facilities resulting from 1981 plant effluents was calculated to be 31.5 man-rem (0.3 man-sieverts). This cumulative dose was calculated using the population distribution given in Table 1 for ORNL atmospheric effluents; similar population distributions were used for the Y-12 and ORGDP releases. This dose may be compared to an estimated 87,000 man-rem (870 man-sieverts) to the same population resulting from natural background radiation. About 7.6 percent of the collective dose from the effluents of the Oak Ridge facilities is estimated to be to the Oak Ridge population.

Table 1
INCREMENTAL POPULATION TABLE IN THE VICINITY OF ORNL[a]

DISTANCE, MILES DISTANCE, KM	0-1 0-1.6	1-2 1.6-3.2	2-3 3.2-4.8	3-4 4.8-6.4	4-5 6.4-8.0	5-10 8-16	10-20 16-32	20-30 32-48	30-40 48-64	40-50 64-80
Direction										
E	0	0	0	0	0	3,059	44,880	100,500	11,790	12,390
ENE	0	0	0	0	0	0	27,460	74,690	18,720	13,870
NE	0	0	0	0	0	9,713	12,480	7,167	4,392	7,476
NNE	0	0	0	0	1,461	13,780	4,362	11,190	12,670	6,119
N	0	0	0	0	1,490	5,578	2,177	1,441	2,223	4,508
NNW	0	0	0	0	0	1,495	0	1,152	4,559	4,676
NW	0	0	0	0	0	1,073	4,804	1,538	1,896	7,552
WNW	0	0	0	0	0	587	2,971	1,543	0	4,151
W	0	0	0	0	0	666	13,100	4,595	9,038	7,318
WSW	0	0	0	0	0	622	9,862	3,495	4,562	4,204
SW	0	0	0	0	0	733	1,840	1,909	3,962	8,578
SSW	0	0	0	0	0	721	2,055	7,897	21,580	10,530
S	0	0	0	0	0	943	8,742	7,309	6,560	1,222
SSE	0	0	0	0	1,374	7,277	1,290	4,091	469	0
SE	0	0	0	0	0	1,167	4,304	15,010	46	0
ESE	0	0	0	0	0	6,096	5,343	36,020	4,132	6,840
TOTAL	0	0	0	0	4,325	53,510	145,670	279,547	106,599	99,434
CUMULATIVE TOTAL	0	0	0	0	4,325	57,835	203,505	483,052	589,651	689,085

[a]Based on 1970 Census Data.

Table 2
CONTINUOUS AIR MONITORING DATA
Long-Lived Gross Beta Activity of Particulates in Air
1981

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-13 μCi/mL (mBq/m³)			% CG[c]
		MAXIMUM[a]	MINIMUM[b]	AVERAGE	
		Perimeter Area[d]			
HP-31	52	3.3 (12)	0.11 (0.42)	0.68 (2.5) ± 0.19	0.07
HP-32	52	3.0 (11)	0.06 (0.21)	0.73 (2.7) ± 0.18	0.07
HP-33	51	3.1 (12)	0.09 (0.34)	0.68 (2.5) ± 0.19	0.07
HP-34	52	3.8 (14)	0.13 (0.47)	0.85 (3.2) ± 0.22	0.09
HP-35	52	3.2 (12)	0.08 (0.31)	0.72 (2.7) ± 0.18	0.07
HP-36	51	2.6 (10)	0.05 (0.18)	0.59 (2.2) ± 0.16	0.06
HP-37	52	2.6 (10)	0.05 (0.17)	0.60 (2.2) ± 0.16	0.06
HP-38	52	3.6 (13)	0.11 (0.40)	0.81 (3.0) ± 0.21	0.08
HP-39	52	2.7 (10)	0.04 (0.15)	0.57 (2.1) ± 0.17	0.06
Average				0.69 (2.6) ± 0.17	0.07
		Remote Area[e]			
HP-51	52	3.7 (14)	0.16 (0.58)	0.73 (2.7) ± 0.19	0.07
HP-52	52	3.4 (13)	0.06 (0.21)	0.74 (2.7) ± 0.18	0.07
HP-53	52	3.7 (14)	0.07 (0.26)	0.68 (2.5) ± 0.19	0.07
HP-55	52	1.9 (7)	0.04 (0.15)	0.55 (2.0) ± 0.12	0.05
HP-56	52	2.2 (8)	0.03 (0.11)	0.64 (2.4) ± 0.15	0.06
HP-57	52	4.0 (15)	0.15 (0.57)	0.86 (3.2) ± 0.22	0.09
HP-58	50	2.9 (11)	0.04 (0.15)	0.64 (2.4) ± 0.18	0.06
Average				0.70 (2.6) ± 0.18	0.07

[a]Maximum weekly average concentration.

[b]Minimum weekly average concentration-minimum detectable level is 1 E-15 μCi/mL (0.037 mBq/m³).

[c]CG is 1 E-10 μCi/mL (3.7 E+3 mBq/m³) for unidentified radionuclides (DOE Manual, Appendix 0524, Annex A, Table II).

[d]See Figure 1.

[e]See Figure 2.

Table 3
CONTINUOUS AIR MONITORING DATA
Long-Lived Gross Alpha Activity of Particulates in Air
1981

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-15 μCi/mL (μBq/m^3)			% CG[c]
		MAXIMUM[a]	MINIMUM[b]	AVERAGE	
		Perimeter Area[d]			
HP-31	52	2.5 (93)	0.1 (4)	0.79 (29) ± 0.17	0.02
HP-32	52	3.5 (130)	0.1 (4)	1.1 (41) ± 0.23	0.03
HP-33	51	2.8 (100)	0.1 (4)	0.85 (31) ± 0.17	0.02
HP-34	52	3.2 (120)	0.1 (4)	0.92 (34) ± 0.20	0.02
HP-35	52	2.4 (89)	0.1 (4)	0.89 (33) ± 0.15	0.02
HP-36	51	2.4 (89)	0.1 (4)	0.82 (30) ± 0.15	0.02
HP-37	52	2.7 (100)	0.1 (4)	0.92 (34) ± 0.18	0.02
HP-38	52	2.9 (110)	0.1 (4)	0.86 (32) ± 0.19	0.02
HP-39	52	3.2 (120)	0.1 (4)	0.84 (31) ± 0.18	0.02
Average				0.89 (33) ± 0.18	0.02
		Remote Area[e]			
HP-51	52	4.1 (150)	0.1 (4)	1.0 (37) ± 0.21	0.03
HP-52	52	3.2 (120)	0.1 (4)	0.96 (36) ± 0.21	0.02
HP-53	52	2.7 (100)	0.1 (4)	1.1 (41) ± 0.21	0.03
HP-55	52	5.6 (210)	0.1 (4)	1.3 (48) ± 0.29	0.03
HP-56	52	4.4 (160)	0.1 (4)	1.2 (44) ± 0.24	0.03
HP-57	52	2.9 (110)	0.1 (4)	0.99 (37) ± 0.19	0.02
HP-58	50	2.7 (100)	0.1 (4)	0.84 (31) ± 0.16	0.02
Average				1.1 (41) ± 0.22	0.03

[a]Maximum weekly average concentration.

[b]Minimum weekly average concentration-minimum detectable level is 1 E-16 μCi/mL (3.7 μBq/ m^3)

[c]CG is 40 E-13 μCi/mL (1.48 E+05 μBq/m^3) for a mixture of uranium isotopes (DOE Manual, Appendix 0524, Annex A, Table II).

[d]See Figure 1.

[e]See Figure 2.

Table 4
CONTINUOUS AIR-MONITORING DATA
Specific Radionuclides in Air
(Composite Samples)
1981
Units of E-15 μCi/mL (μBq/m^3)

NUCLIDE	PERIMETER STATIONS						REMOTE STATIONS					
	Quarterly Maximum		Quarterly Minimum		Yearly Average		Quarterly Maximum		Quarterly Minimum		Yearly Average	
^{54}Mn	1.1	(41)	0.06	(2.2)	0.43	(16)	1.1	(41)	0.04	(1.5)	0.4	(15)
^{90}Sr	0.84	(31)	0.15	(5.6)	0.46	(17)	0.95	(35)	0.05	(1.9)	0.4	(15)
^{95}Nb	56	(2050)	0.41	(15)	23	(860)	49	(1830)	0.39	(14)	21	(790)
^{95}Zr	27	(1000)	0.17	(6.3)	11	(410)	25	(930)	0.08	(3.0)	11	(420)
^{103}Ru	20	(720)	0.03	(1.1)	7.1	(260)	27	(1000)	0.03	(1.1)	8.9	(330)
^{106}Ru	7.4	(270)	0.83	(31)	4.4	(160)	5.4	(200)	0.56	(21)	3.3	(120)
^{125}Sb	1.8	(67)	0.11	(4.1)	0.76	(28)	1.5	(55)	0.10	(3.7)	0.6	(22)
^{137}Cs	3.0	(110)	0.24	(8.9)	1.2	(44)	2.9	(110)	0.23	(8.5)	1.1	(41)
^{141}Ce	39	(1440)	0.03	(1.1)	11	(410)	33	(1210)	0.04	(1.5)	9.2	(340)
^{144}Ce	8.9	(330)	1.3	(49)	5.5	(200)	8.9	(330)	1.2	(44)	4.6	(170)
^{228}Th	0.07	(2.6)	0.04	(1.5)	0.05	(1.9)	0.08	(3.0)	0.03	(1.1)	0.04	(1.5)
^{230}Th	0.07	(2.6)	0.02	(0.7)	0.04	(1.5)	0.02	(0.7)	0.01	(0.4)	0.02	(0.7)
^{232}Th	0.04	(1.5)	0.02	(0.7)	0.03	(1.1)	0.02	(0.7)	0.02	(0.7)	0.02	(0.7)
^{234}U	0.47	(17)	0.26	(9.6)	0.40	(15)	0.09	(3.3)	0.05	(1.9)	0.06	(2.2)
^{235}U	0.07	(2.6)	0.009	(0.3)	0.04	(1.5)	0.02	(0.7)	0.006	(0.2)	0.01	(0.4)
^{238}U	0.35	(13)	0.18	(6.7)	0.28	(10)	0.06	(2.2)	0.03	(1.1)	0.05	(1.9)
^{238}Pu	0.0009	(0.03)	0.0002	(0.007)	0.0004	(0.014)	0.0008	(0.03)	0.0002	(0.007)	0.0006	(0.02)
^{239}Pu	0.03	(1.1)	0.002	(0.07)	0.01	(0.4)	0.03	(1.1)	0.003	(0.11)	0.01	(0.4)

Table 5

CONCENTRATION OF ^{131}I IN AIR MEASURED BY THE PERIMETER AIR MONITORING STATIONS[a]

1981

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-14 μCi/mL (μBq/m^3)			% CG[d]
		MAXIMUM[b]	MINIMUM[c]	AVERAGE	
HP-31	52	0.24 (89)	0.03 (11)	0.13 (48) ± 0.02	<0.01
HP-32	52	0.22 (81)	0.03 (11)	0.13 (48) ± 0.02	<0.01
HP-33	52	0.24 (89)	0.01 (4)	0.14 (52) ± 0.02	<0.01
HP-34	52	0.23 (85)	0.03 (11)	0.13 (48) ± 0.02	<0.01
HP-35	52	0.22 (81)	0.03 (11)	0.13 (48) ± 0.02	<0.01
HP-36	52	0.31 (115)	0.01 (4)	0.12 (44) ± 0.02	<0.01
HP-37	52	0.20 (74)	0.03 (11)	0.12 (44) ± 0.01	<0.01
HP-38	52	0.20 (74)	0.03 (11)	0.13 (48) ± 0.01	<0.01
HP-39	52	0.33 (122)	0.03 (11)	0.13 (48) ± 0.02	<0.01
AVERAGE				0.13 (48) ± 0.02	<0.01

[a]See Figure 1.

[b]Maximum weekly average concentration.

[c]Minimum weekly average concentration-minimum detectable amount of ^{131}I is 1 E-16 μCi/mL (3.7 μBq/m^3).

[d]CG is 1 E-10 μCi/mL (3.7 E+06 μBq/m^3) (DOE Manual, Appendix 0524, Annex A, Table II).

Table 6
DISCHARGE OF RADIOACTIVITY TO THE ATMOSPHERE
1981

RADIONUCLIDE	QUANTITY DISCHARGED Ci	QUANTITY DISCHARGED UNITS OF E+10 Bq
Uranium[a]	0.13	0.5
^{131}I	< 0.5	< 1.9
^{3}H	11,300	41,800
^{133}Xe[b]	<32,400	<119,900
^{85}Kr[b]	< 6,700	< 24,800
^{99}Tc	0.04	0.15
Alpha[c]	< 7.8 E-08	< 2.9 E-07

[a]Uranium of varying enrichments - curie quantities calculated using the appropriate specific activity for material released.

[b]Upper limit values based on direct radiation measurements in the stack gas stream and an assumed mixture of noble gases.

[c]Unidentified alpha.

Table 7
AIR MONITORING DATA - FLUORIDES
1981

Location[a]	Number of Samples	Maximum Concentration for Averaging Interval $\mu g/m^3$		Number of Times Standard Exceeded[b]		Annual Average $\mu g/m^3$
	6 Day	6 Day	30 Day	7 Day	30 Day	
F-1	53	0.2	0.1	0	0	< 0.1 ± 0.01
F-2	51	0.4	0.3	0	0	< 0.1 ± 0.03
F-3	53	0.2	0.2	0	0	< 0.1 ± 0.02
F-4	53	0.2	< 0.1	0	0	< 0.1 ± 0.01
F-5	52	0.1	< 0.1	0	0	< 0.1 ± 0.01
F-6[c]	52	0.1	< 0.1	0	0	< 0.1 ± 0.01

[a]See Figure 1.

[b]Tennessee Air Pollution Control Regulations -

3.7 $\mu g/m^3$ for 12 hour averaging interval
2.9 $\mu g/m^3$ for 24 hour averaging interval
1.6 $\mu g/m^3$ for 7 day averaging interval
1.2 $\mu g/m^3$ for 30 day averaging interval

All values are maximum--not to be exceeded more than once per year.

[c]Station F-6 approximately 8 kilometers from ORGDP upwind of the predominant prevailing wind direction, thus may be considered representative of general ambient background concentration.

NOTE: Data not amenable to comparison with 12-hour or 24-hour standard. Six-day sample compared to 7 day averaging interval.

Table 8
AIR MONITORING DATA - SUSPENDED PARTICULATES
1981

LOCATION[a]	NUMBER OF SAMPLES	CONCENTRATION, $\mu g/m^3$)			% STD.[b]
		MAXIMUM	MINIMUM	AVERAGE	
SP-1	49	98	1	29 ± 8	39
SP-2	55	96	2	30 ± 7	40
SP-3	53	130	1	37 ± 8	49
SP-4	53	110	1	32 ± 8	43

[a]See Figure 1.

[b]Tennessee Ambient Air Standards - Primary Standard.

Maximum 24 hr. Average — 260 $\mu g/m^3$
Annual Geometric Mean — 75 $\mu g/m^3$

Table 9
SULFUR DIOXIDE MONITORING DATA
1981

MONTH	MAXIMUM 24 HR. AVERAGE (PPM)		MONTHLY AVERAGE (PPM)	
	STATION S-1	STATION S-2	STATION S-1	STATION S-2
January	0.030	0.042	0.007	0.011
February	0.033	0.026	0.009	0.009
March	0.024	0.016	0.005	0.005
April	0.029	0.006	0.013	0.003
May	0.019	0.016	0.008	0.003
June	0.013	0.013	0.005	0.005
July	0.015	0.013	0.004	0.007
August	0.016	0.002	0.004	0.002
September	0.007	0.134	0.002	0.021
October	0.005	0.010	0.002	0.007
November	0.024	0.043	0.008	0.005
December	0.032	0.019	0.011	0.006
Annual Arithmetic Mean			0.007	0.007

Tennessee Ambient Standards
Maximum 24 hr. Average — 0.14 ppm
Annual Arithmetic Mean — 0.03 ppm

Minimum Detectable Limit — 0.002 ppm

Table 10
EXTERNAL GAMMA RADIATION MEASUREMENTS
1981

STATION NUMBER	NUMBER OF MEASUREMENTS	BACKGROUND	
		UNITS OF μR/h	UNITS OF E-09 C/kg/h
	Perimeter Stations[a]		
HP-31	12	9.7 ± 0.5	2.5 ± 0.1
HP-32	12	11.7 ± 0.6	3.0 ± 0.2
HP-33	12	.7 ± 0.6	2.5 ± 0.2
HP-34	12	17.8 ± 2.5	4.6 ± 0.7
HP-35	12	8.5 ± 0.5	2.2 ± 0.1
HP-36	12	8.1 ± 0.6	2.1 ± 0.1
HP-37	12	7.9 ± 1.0	2.0 ± 0.3
HP-38	12	8.5 ± 0.6	2.2 ± 0.2
HP-39	12	9.0 ± 0.7	2.3 ± 0.2
Average		10.1 ± 2.0	2.6 ± 0.5
	Remote Stations[b]		
HP-51	2	5.8 ± 0.9	1.5 ± 0.2
HP-52	2	7.3 ± 1.7	1.9 ± 0.4
HP-53	2	7.7 ± 1.1	2.0 ± 0.3
HP-55	2	6.5 ± 1.0	1.7 ± 0.4
HP-56	2	7.3 ± 0.1	1.9 ± 0.1
HP-57	2	7.7 ± 1.2	2.0 ± 0.3
HP-58	2	10.9 ± 0.5	2.8 ± 0.1
Average		7.6 ± 1.1	2.0 ± 0.3

[a]See Figure 1.

[b]See Figure 2.

Table 11
RADIONUCLIDES OF PRIMARY CONCERN IN SURFACE STREAMS
1981

SAMPLING LOCATION	NUMBER OF SAMPLES	RANGE	UNITS OF E-09 μCi/mL (Bq/L)			UNITS OF E-06 μCi/mL (kBg/L)	%
			^{90}Sr	^{137}Cs	^{60}Co	^{3}H[a]	CG[b]
C-2	4	Max.	2.70 (0.10)	.11 (0.004)	.54 (0.020)	3.73 (0.14)	
		Min.	0.54 (0.02)	.05 (0.002)	.05 (0.002)	0.14 (0.005)	
		Avg.	1.30 (0.05)	.07 (0.003)	.20 (0.008)	1.42 (0.05)	0.48
C-3	4	Max.	2.97 (0.11)	.22 (0.008)	.14 (0.005)	3.62 (0.13)	
		Min.	0.27 (0.01)	.03 (0.001)	.05 (0.002)	0.14 (0.005)	
		Avg.	1.44 (0.05)	.12 (0.004)	.10 (0.004)	1.64 (0.06)	0.54
C-5[c]	4	Max.	5.41 (0.20)	.19 (0.007)	.22 (0.008)	2.03 (0.08)	
		Min.	0.54 (0.02)	.05 (0.002)	.08 (0.003)	0.68 (0.03)	
		Avg.	3.11 (0.12)	.14 (0.005)	.16 (0.006)	1.20 (0.04)	1.08
W-1[d]	12	Max.	116 (4.29)	43.3 (1.60)	91.9 (3.40)	1080 (40)	
		Min.	17.6 (0.65)	1.7 (0.06)	10.8 (0.40)	16 (0.6)	
		Avg.	61.9 (2.29)	10.0 (0.37)	32.9 (1.22)	203 (7.5)	27.5

[a]Three tritium samples only from the river and Kingston Water Plant.

[b]Most restrictive concentration guide for each isotope used for calculating percent concentration guide. The method for calculating percent of concentration guide for a known mixture of radionuclides is given in DOE Manual, Appendix 0524, Annex A.(1)

[c]Kingston Water Plant.

[d]Mouth of White Oak Creek.

Table 12
URANIUM CONCENTRATION IN SURFACE STREAMS
1981

STATION NUMBER[a]	NUMBER OF SAMPLES	UNITS OF E-08 μCi/mL (Bq/L)			% CG[b]
		MAXIMUM	MINIMUM	AVERAGE	
P-1	12	1.0 (0.37)	0.07 (0.03)	0.5 (0.19) ± 0.2	< 0.1
P-2	12	1.1 (0.41)	0.20 (0.07)	0.6 (0.22) ± 0.2	0.1
C-3	12	0.3 (0.11)	< 0.07 (0.03)	< 0.1 (0.04) ± 0.05	< 0.1
C-4	12	0.4 (0.15)	< 0.07 (0.03)	< 0.1 (0.04) ± 0.06	< 0.1
C-6	12	0.4 (0.15)	< 0.07 (0.03)	< 0.2 (0.04) ± 0.06	< 0.1
E-1	12	15 (5.6)	1.4 (0.52)	4.1 (1.5) ± 4.1	0.1
B-1	12	5.5 (2.0)	1.6 (0.59)	3.6 (1.3) ± 1.3	0.1

[a]See Figure 3.

[b]CG is 3 E-05 μCi/mL (11 E+02 Bg/L) for a mixture of uranium isotopes (DOE Manual, Appendix 0524, Annex A, Table II).

Table 13
DISCHARGES OF RADIOACTIVITY TO SURFACE STREAMS
1981

RADIONUCLIDE	QUANTITY DISCHARGED	
	Ci	UNITS OF E+10 Bq
^{137}Cs	0.23	0.85
^{60}Co	0.66	2.44
^{3}H	2,880	10,660
^{131}I	0.04	0.15
^{90}Sr	1.51	5.59
^{99}Tc	3.54	13.1
Uranium[a]	0.87	3.21
^{232}Th	0.008	0.03
Transuranics[b]	0.043	0.16

[a]Uranium of varying enrichments - curie quantities calculated using the appropriate specific activity for material released.

[b]Upper limit values based on alpha emitter analysis.

Table 14
LONG-LIVED GROSS BETA ACTIVITY IN RAINWATER
1981

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF	
		E-08 μCi/mL[a]	Bq/L
		Perimeter Area[b]	
HP-31	42	2.5 ± 0.6	0.93 ± 0.2
HP-32	42	2.3 ± 0.7	0.85 ± 0.3
HP-33	44	3.1 ± 0.7	1.1 ± 0.3
HP-34	41	2.3 ± 0.7	0.85 ± 0.2
HP-35	43	2.5 ± 0.6	0.93 ± 0.2
HP-36	44	2.6 ± 0.7	0.96 ± 0.2
HP-37	42	2.5 ± 2.0	0.93 ± 0.6
HP-38	41	3.6 ± 1.0	1.3 ± 0.3
HP-39	45	2.9 ± 1.0	1.1 ± 0.5
Average		2.7 ± 0.8	1.0 ± 0.3
		Remote Area[c]	
HP-51	42	5.4 ± 1.8	2.0 ± 0.7
HP-52	38	3.7 ± 0.9	1.4 ± 0.3
HP-53	46	5.6 ± 1.6	2.1 ± 0.6
HP-55	35	3.4 ± 0.9	1.3 ± 0.3
HP-56	47	3.7 ± 1.0	1.4 ± 0.4
HP-57	39	4.8 ± 1.3	1.8 ± 0.5
HP-58	37	3.1 ± 0.8	1.1 ± 0.3
Average		4.2 ± 1.2	1.6 ± 0.4

[a]Weekly average concentration.

[b]See Figure 1.

[c]See Figure 2.

Table 15
CHEMICAL WATER QUALITY DATA - WHITE OAK DAM
1981

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cr	4	< 0.01	< 0.01	< 0.01	0.05	< 20
Zn	5	< 0.02	< 0.02	< 0.02	0.1	< 20
$NO_3(N)$	5	8.3	3.6	6.1 ± 1.7	10	61
Hg	5	0.002	< 0.001	< 0.001	0.005	< 20

[a]Tennessee Steam Guidelines.

Table 16
CHEMICAL WATER QUALITY DATA - MELTON HILL DAM
(Location C-2, Figure-3)
1981

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cr	4	< 0.01	< 0.01	< 0.01	0.05	< 20
Zn	5	< 0.02	< 0.02	< 0.02	0.1	< 20
$NO_3(N)$	5	0.98	0.63	0.86 ± 0.1	10	8.6
Hg	6	< 0.001	< 0.001	< 0.001	0.005	< 20

[a]Tennessee Steam Guidelines.

Table 17
CHEMICAL WATER QUALITY DATA - ORGDP SANITARY WATER PUMPING STATION
(Location C-3, Figure 3)
1981

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.002	< 0.002	< 0.002	0.01	< 20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	< 20
CN	12	< 0.002	< 0.002	< 0.002	0.01	< 20
$NO_3(N)$	12	0.6	< 0.1	< 0.3 ± 0.1	10	< 3
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	12	36	19	25 ± 3	250	10
T.D.S.	12	240	110	170 ± 26	500	34
Zn	12	0.08	< 0.02	< 0.05 ± 0.01	0.1	< 50
F^-	12	0.1	< 0.1	< 0.1	1	< 10
Hg	12	0.01	< 0.001	< 0.002 ± 0.002	0.005	< 40
Ni	12	< 0.01	< 0.01	< 0.01	0.1	< 10

[a]Tennessee Steam Guidelines.

Table 18
CHEMICAL WATER QUALITY DATA - ORGDP RECIRCULATING WATER PUMPING STATION
(Location C-4, Figure 3)
1981

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.003	< 0.002	< 0.002 ± 0.0002	0.01	< 20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	< 20
CN	12	< 0.002	< 0.002	< 0.002	0.01	< 20
$NO_3(N)$	12	0.6	0.1	0.32 ± 0.08	10	3
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^{=}$	12	32	21	27 ± 2	250	11
T.D.S.	12	250	150	180 ± 21	500	36
Zn	12	0.1	0.03	0.07 ± 0.02	0.1	70
F^-	12	0.3	< 0.1	< 0.1 ± 0.04	1	< 13
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	< 0.01	< 0.01	< 0.01	0.1	< 10

[a]Tennessee Stream Guidelines.

Table 19
CHEMICAL WATER QUALITY DATA - CLINCH RIVER DOWNSTREAM OF ORGDP
(Location C-6, Figure 3)
1981

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.002	< 0.002	< 0.002	0.01	< 20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	< 20
CN	12	< 0.002	< 0.002	< 0.002	0.01	< 20
$NO_3(N)$	12	0.5	< 0.1	< 0.3 ± 0.09	10	< 3
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	12	31	22	26 ± 2	250	11
T.D.S.	12	210	110	170 ± 19	500	34
Zn	12	0.03	< 0.02	< 0.02 ± 0.002	0.1	< 20
F^-	12	0.2	< 0.1	< 0.1 ± 0.01	1	< 10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	< 0.01	< 0.01	< 0.01	0.1	< 10

[a]Tennessee Stream Guidelines.

Table 20
CHEMICAL WATER QUALITY DATA - EAST FORK POPLAR CREEK
(Location E-1, Figure 3)
1981

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	< 0.002	< 0.002	< 0.002	0.01	< 20
Cl^-	12	17	< 2	< 10 ± 6	250	< 4
Cr	12	0.01	< 0.01	< 0.01	0.05	< 20
F^-	12	1.7	0.6	1.2 ± 0.3	1	120
Hg	12	0.002	< 0.001	< 0.002 ± 0.001	0.005	< 40
$NO_3(N)$	12	3.6	0.5	3.0 ± 0.8	10	30
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	12	71	38	52 ± 10	250	21
T.D.S.	12	260	170	230 ± 30	500	46
Zn	12	0.07	< 0.02	< 0.04 ± 0.02	0.1	< 40

[a]Tennessee Stream Guidelines.

Table 21
CHEMICAL WATER QUALITY DATA - BEAR CREEK
(Location B-1, Figure 3)
1981

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.005	< 0.002	< 0.002 ± 0.001	0.01	< 20
Cl^-	12	12	< 2	< 5 ± 4	250	< 2
F^-	12	0.5	< 0.1	< 0.3 ± 0.1	1	< 30
$NO_3(N)$	12	27	1.2	15 ± 10	10	150
Zn	12	0.08	< 0.02	< 0.03 ± 0.02	0.1	< 30
SO_4^-	12	28	< 10	< 16 ± 6	250	< 6

[a]Tennessee Stream Guidelines.

Table 22
CHEMICAL WATER QUALITY DATA - POPLAR CREEK ABOVE BLAIR BRIDGE
(Location P-1, Figure 3)
1981

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.003	< 0.002	< 0.002 ± 0.0002	0.01	< 20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	< 20
CN	12	< 0.002	< 0.002	< 0.002	0.01	< 20
NO_3(N)	12	2	0.2	0.8 ± 0.3	10	8
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	12	86	39	52 ± 10	250	21
T.D.S.	12	330	140	250 ± 41	500	50
Zn	12	0.2	< 0.02	< 0.04 ± 0.03	0.1	< 40
F^-	12	0.5	0.1	0.3 ± 0.07	1	30
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	0.02	< 0.01	< 0.01 ± 0.002	0.1	< 10

[a]Tennessee Stream Guidelines.

Table 23
CHEMICAL WATER QUALITY DATA - POPLAR CREEK NEAR CLINCH RIVER
(Location P-2, Figure 3)
1981

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/L				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.004	< 0.002	< 0.002 ± 0.0004	0.01	< 20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	< 20
CN	12	< 0.002	< 0.002	< 0.002	0.01	< 20
$NO_3(N)$	12	1	0.3	0.6 ± 0.1	10	6
Pb	12	< 0.01	< 0.01	< 0.01	0.05	< 20
$SO_4^=$	12	66	30	40 ± 7	250	16
T.D.S.	12	330	120	200 ± 38	500	40
Zn	12	0.3	< 0.02	< 0.1 ± 0.05	0.1	< 100
F^-	12	0.3	< 0.1	< 0.2 ± 0.04	1	< 18
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	0.02	< 0.01	< 0.01 ± 0.002	0.1	< 10

[a]Tennessee Stream Guidelines.

Table 24
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) EXPERIENCE
1981

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/L	EFFLUENT LIMITS DAILY MAXIMUM mg/L	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
ORNL				
001				
(White Oak Creek)	Dissolved Oxygen (min.)	5	--	100
	Dissolved Solids	--	2000	92
	Oil and Grease	10	15	92
	Chromium (Total)	--	0.05	98
	pH (pH units)	--	6.0 - 9.0	99
002				
(Melton Branch)	Chromium (Total)	--	0.05	100
	Dissolved Solids	--	2000	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 - 9.0	99
003				
(Main Sanitary	Ammonia (N)	--	5	17
Treatment Facility)	BOD	--	20	60
	Chlorine Residual	--	0.5 - 2.0	93
	Fecal Coliform Bact. (No/100 mL)	200[b]	400[c]	100
	pH (pH units)	--	6.0 - 9.0	100
	Suspended Solids	--	30	100
	Settleable Solids (mL/L)	--	0.5	94
004				
(7900 Area Sanitary	BOD	--	30	No Discharges
Treatment Facility)	Chlorine Residual	--	0.5 - 2.0	From This
	Fecal Coliform Bact. (No/100 mL)	200[b]	400[c]	Facility
	pH (pH units)	--	6.0 - 9.0	
	Suspended Solids	--	30	
	Settleable Solids (mL/L)	--	0.5	
Y-12 PLANT				
001				
(Kerr Hollow	Dissolved Solids	--	2000	100
Quarry)	Lithium	--	5	100
	pH (pH units)	--	6.0 - 9.0	100
	Suspended Solids	--	50	100
	Zirconium	--	3	100

Table 24
(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/L	EFFLUENT LIMITS DAILY MAXIMUM mg/L	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
002				
(Rogers Quarry)	pH (pH units)	--	6.0 - 9.0	100
	Suspended Solids[a]	30	50	100
	Settleable Solids (mL/L)[a]	--	0.5	100
003				
(New Hope Pond)	Ammonia (N)	--	1.6	100
	Chromium	0.05	0.08	100
	Dissolved Oxygen (min.)	5	--	100
	Dissolved Solids	--	2000	100
	Fluoride	1.5	2.0	92
	Lithium	--	5	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 - 9.0	100
	Phosphate (as MBAS)	5	8	100
	Suspended Solids[a]	--	20	100
	Settleable Solids (mL/L)[a]	--	0.5	100
	Total Nitrogen (N)	--	20	100
	Zinc	0.1	0.2	96
004				
(Bear Creek)	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 - 8.5	100
ORGDP				
001				
(K-1700 Discharge)	Aluminum	--	1.0	92
	Chromium (Total)	0.05	0.08	100
	Nitrate	--	20	100
	Suspended Solids	30	50	100
	Oil and Grease	10	15	100
	pH(pH units)	--	6.0 - 9.0	98
002				
(K-1410 Metal	Cyanide	--	None Detectable	100
Plating Facility)	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 - 9.0	100
004				
(K-1131) Steam	pH (pH units)	--	6.0 - 9.0	100
Condensate	Flow (MGD)	0.005	0.008	100
Discharge)				

Table 24
(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/L	EFFLUENT LIMITS DAILY MAXIMUM mg/L	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
005				
(K-1203 Sanitary Treatment Facility)	Ammonia (N)	5[b]	7[c]	100
	BOD	15[b]	20[c]	99
	Chlorine Residual	--	0.5 - 2.0	99
	Dissolved Oxygen (min.)	5	--	100
	Fecal Coliform Bact. (No/100mL)	200[b]	400[c]	100
	pH (pH units)	--	6.0 - 9.0	100
	Suspended Solids	30[b]	45[c]	99
	Settleable Solids (mL/L)	--	0.5	99
006				
(K-1007B Holding Pond)	COD	20	25	100
	Chromium	--	0.05	100
	Dissolved Oxygen (min.)	5	--	100
	Fluoride	1.0	1.5	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 - 9.0	100
	Suspended Solids[a]	30	50	100
007				
(K-901A Holding Pond)	Chromium (Total)	--	0.05	100
	Fluoride	1.0	1.5	100
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 - 10	100
	Suspended Solids	30	50	100
008[d]				
(K-710 Sanitary Treatment Facility)	BOD	30[b]	45[c]	No Discharges From This Facility
	Suspended Solids	30[b]	45[c]	
	Fecal Coliform Bact. (No/100 mL)	200[b]	400[c]	
	pH (pH units)	--	6.0 - 9.0	
	Chlorine Residual	--	0.5 - 2.0	
	Settleable Solids (mL/L)	--	0.1	
009				
(Sanitary Water Plant)	Suspended Solids[a]	30	50	100
	Aluminum	--	250	100
	Sulphate	--	1400	100
	pH (pH units)	--	6.0 - 9.0	100

[a]Limit applicable only during normal operations. Not applicable during periods of increased discharge due to surface run-off resulting from precipitation.

[b]Monthly Average.

[c]Weekly Average.

[d]Due to the small flow rates at the K-710 Sanitary Treatment Facility, a rapid sand filter was installed May 1, 1978 eliminating the surface discharge and monitoring requirements.

Table 25
CONCENTRATION OF ^{131}I IN MILK[a]
1981

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-09 μCi/mL (Bq/L)			COMPARISON WITH STANDARD[c]
		MAXIMUM	MINIMUM[b]	AVERAGE	
		Immediate Environs[d]			
1	22	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
2	47	0.7 (0.026)	<0.45 (0.017)	<0.45 (0.017) ± 0.01	Range I
3	46	0.5 (0.019)	<0.45 (0.017)	<0.45 (0.017) ± 0.01	Range I
4	47	1.1 (0.04)	<0.45 (0.017)	<0.45 (0.017) ± 0.03	Range I
5	46	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
6	43	3.6 (0.133)	<0.45 (0.017)	<0.45 (0.017) ± 0.15	Range I
7	47	0.8 (0.030)	<0.45 (0.017)	<0.45 (0.017) ± 0.02	Range I
Average				<0.45 (0.017) ± 0.04	
		Remote Environs[e]			
51	6	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
52	3	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
53	3	0.5 (0.019)	<0.45 (0.017)	<0.45 (0.017) ± 0.06	Range I
56	7	<0.45 (0.017)	<0.45 (0.017)	<0.45 (0.017)	Range I
58	4	1.3 (0.048)	<0.45 (0.017)	<0.45 (0.017) ± 0.48	Range I
Average				<0.45 (0.017) ± 0.10	

[a]Raw milk samples, except for Station 2 which is a dairy.

[b]Minimum detectable concentration of ^{131}I is 0.45 E-09 μCi/mL (0.017 Bq/L).

[c]Applicable FRC standard, assuming 1 liter per day intake:
Range I 0 to 1 E-08 μCi/mL (0.37 Bq/L) — Adequate surveillance required to confirm calculated intakes.
Range II 1 E-08 μCi/mL (0.37 Bq/L) to 1 E-07 μCi/mL (3.7 Bq/L) — Active surveillance required.
Range III 1 E-07 μCi/mL (3.7 Bq/L) to 1 E-06 μCi/mL (37 Bq/L) — Positive control action required.
Note: Upper limit of Range II can be considered the concentration guide.

[d]See Figure 6.

[e]See Figure 7.

Table 26
CONCENTRATION OF ^{90}Sr IN MILK[a]
1981

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF E-09 μCi/mL (Bq/L)			COMPARISON WITH STANDARD[c]
		MAXIMUM	MINIMUM[b]	AVERAGE	
			Immediate Environs[d]		
1	17	1.8 (0.066)	0.9 (0.033)	1.3 (0.048) ± 0.13	Range I
2	47	2.4 (0.089)	0.8 (0.030)	1.4 (0.052) ± 0.11	Range I
3	44	3.2 (0.118)	0.7 (0.026)	1.5 (0.056) ± 0.14	Range I
4	44	4.5 (0.166)	1.1 (0.041)	2.2 (0.081) ± 0.24	Range I
5	46	2.6 (0.096)	0.7 (0.026)	1.5 (0.056) ± 0.12	Range I
6	40	3.2 (0.118)	0.8 (0.030)	1.7 (0.063) ± 0.18	Range I
7	46	2.6 (0.096)	0.7 (0.026)	1.6 (0.059) ± 0.11	Range I
Average				1.6 (0.059) ± 0.15	
			Remote Environs[e]		
51	6	2.4 (0.089)	0.7 (0.026)	1.5 (0.056) ± 0.51	Range I
52	3	1.3 (0.048)	1.1 (0.041)	1.2 (0.044) ± 0.16	Range I
53	3	0.9 (0.033)	0.5 (0.019)	0.8 (0.030) ± 0.27	Range I
56	7	1.6 (0.059)	0.7 (0.026)	1.0 (0.037) ± 0.29	Range I
58	4	2.2 (0.081)	1.1 (0.041)	1.7 (0.063) ± 0.46	Range I
Average				1.3 (0.048) ± 0.36	

[a]Raw milk samples, except for Station 2 which is a dairy.

[b]Minimum detectable concentration of ^{90}Sr is 0.5 E-09 μCi/mL (0.019 Bq/L).

[c]Applicable FRC standard, assuming 1 liter per day intake:
Range I 0 to 2 E-08 μCi/mL (0.74 Bq/L) — Adequate surveillance required to confirm calculated intakes.
Range II 2 E-08 μCi/mL (0.74 Bq/L) to 2 E-07 μCi/mL (7.4 Bq/L) — Active surveillance required.
Range III 2 E-07 μCi/mL (7.4 Bq/L) to 2 E-06 μCi/mL (74 Bq/L) — Positive control action required.
Note: Upper limit of Range II can be considered the concentration guide.

[d]See Figure 6.

[e]See Figure 7.

Table 27
RADIONUCLIDE CONTENT IN CLINCH RIVER FISH
ALPHA EMITTERS
1981
pCi/kg (mBq/kg) Wet Weight

LOCATION	Species[a]	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U
CRM 5.0	Bass	0.011 (0.4)	0.0076 (0.3)	0.26 (10)	0.14 (5)	0.26 (9)
	Blue Gill	0.008 (0.3)	0.057 (2.1)	0.77 (29)	0.41 (15)	1.82 (68)
	Carp	0.011 (0.4)	0.011 (0.4)	2.21 (82)	0.81 (30)	15.8 (590)
	Shad	0.014 (0.5)	0.014 (0.5)	7.80 (290)	1.61 (59)	11.9 (440)
	Crappie	0.011 (0.4)	0.0070 (0.3)	0.27 (10)	0.12 (4)	0.53 (19)
CRM 10.0	Bass	0.011 (0.4)	0.011 (0.4)	0.25 (9)	0.16 (6)	0.68 (25)
	Blue Gill	0.032 (1.2)	0.041 (1.5)	12.2 (450)	2.15 (80)	19.8 (740)
	Carp	0.011 (0.4)	0.012 (0.4)	1.02 (38)	0.67 (25)	2.32 (86)
	Shad	0.10 (3.7)	0.023 (0.9)	4.41 (160)	1.56 (58)	6.89 (260)
	Crappie	0.014 (0.5)	0.0018 (0.07)	0.27 (10)	0.25 (9)	1.02 (38)
CRM 12.0	Bass	0.011 (0.4)	0.0038 (0.1)	0.29 (11)	0.026 (1)	0.49 (18)
	Blue Gill	0.081 (3.0)	0.10 (3.7)	3.24 (120)	2.23 (83)	13.8 (510)
	Carp	0.025 (0.9)	0.018 (0.7)	0.28 (11)	0.066 (3)	0.42 (16)
	Shad	0.064 (2.4)	0.0092 (0.3)	5.51 (200)	0.50 (19)	8.72 (320)
	Crappie	0.020 (0.7)	0.0070 (0.2)	0.98 (36)	0.17 (6)	1.44 (53)
CRM 20.8[b]	Bass	0.026 (1.0)	0.011 (0.4)	0.79 (29)	0.23 (9)	1.78 (66)
	Blue Gill	0.028 (1.0)	0.053 (2.0)	0.69 (26)	0.38 (14)	1.94 (72)
	Carp	0.014 (0.5)	0.021 (0.8)	0.46 (17)	0.28 (10)	1.12 (42)
	Shad	0.17 (6.0)	0.073 (3.0)	3.72 (140)	0.50 (19)	5.92 (220)
	Crappie	0.007 (0.3)	0.007 (0.3)	0.46 (17)	0.11 (4)	1.12 (42)
CRM 25.0	Bass	0.019 (0.7)	0.008 (0.3)	0.95 (35)	0.42 (15)	1.51 (56)
	Blue Gill	0.008 (0.3)	0.012 (0.4)	1.17 (44)	0.89 (33)	3.16 (120)
	Carp	0.007 (0.3)	0.007 (0.3)	1.44 (53)	0.42 (16)	5.62 (210)
	Shad	0.005 (0.2)	0.007 (0.3)	0.69 (26)	0.60 (22)	0.78 (29)
	Crappie	0.007 (0.3)	0.007 (0.3)	1.82 (68)	0.56 (21)	2.56 (95)

[a]Composite of ten fish in each species.

[b]Average of quarterly samples.

Table 28
RADIONUCLIDE CONTENT IN CLINCH RIVER FISH
BETA-GAMMA EMITTERS
1981
pCi/kg (mBq/kg) Wet Weight

LOCATION	Species[a]	^{137}Cs		^{60}Co		^{90}Sr		% MPI[b]
CRM 5.0	Bass	98.3	(3.6)	3.78	(0.14)	3.7	(0.14)	0.04
	Blue Gill	72.9	(2.7)	4.05	(0.15)	6.5	(0.24)	0.05
	Carp	77.2	(2.9)	3.86	(0.14)	18.3	(0.68)	0.14
	Shad	119	(4.4)	6.89	(0.26)	24.3	(0.90)	0.18
	Crappie	98.3	(3.6)	3.51	(0.13)	8.1	(0.30)	0.07
CRM 10.0	Bass	106	(3.9)	1.51	(0.056)	3.8	(0.14)	0.04
	Blue Gill	56.7	(2.1)	3.24	(0.12)	8.9	(0.33)	0.07
	Carp	63.2	(2.3)	3.51	(0.13)	26.7	(0.99)	0.19
	Shad	119	(4.4)	5.97	(0.22)	14.7	(0.54)	0.12
	Crappie	70.2	(2.6)	2.11	(0.078)	3.9	(0.14)	0.03
CRM 12.0	Bass	215	(8.0)	2.27	(0.084)	4.5	(0.17)	0.05
	Blue Gill	72.9	(2.7)	8.10	(0.30)	6.9	(0.26)	0.05
	Carp	25.9	(0.96)	2.11	(0.078)	4.6	(0.17)	0.03
	Shad	96.4	(3.6)	4.59	(0.17)	3.8	(0.14)	0.03
	Crappie	98.2	(3.6)	1.76	(0.065)	4.6	(0.17)	0.04
CRM 20.8[c]	Bass	878	(33)	140	(5.18)	27.6	(1.0)	0.29
	Blue Gill	1371	(51)	51.0	(1.89)	172.5	(6.4)	1.35
	Carp	270	(10)	27.4	(1.01)	52.3	(1.9)	0.39
	Shad	693	(26)	53.2	(1.97)	32.6	(1.2)	0.30
	Crappie	770	(29)	9.48	(0.35)	34.1	(1.3)	0.32
CRM 25.0	Bass	10.6	(0.39)	3.78	(0.14)	4.54	(0.17)	0.03
	Blue Gill	12.6	(0.47)	2.43	(0.09)	17.8	(0.66)	0.13
	Carp	3.51	(0.13)	3.51	(0.13)	56.2	(2.08)	0.39
	Shad	5.05	(0.19)	4.59	(0.17)	8.26	(0.31)	0,06
	Crappie	10.9	(0.40)	3.51	(0.13)	3.51	(0.13)	0.03

[a]Composite of ten fish in each species.

[b]Percent maximum permissible intake for all radionuclides in both Table 27 and 28. See text for definition of maximum permissible intake.

[c]Average of quarterly samples.

Table 29
MERCURY CONTENT IN CLINCH RIVER FISH
1981

LOCATION	Species[a]	CONCENTRATION ng/g - Wet Weight	% A.L.[b]
CRM 5.0	Bass	133	27
	Blue Gill	86	17
	Carp	289	58
	Shad	73	15
	Crappie	401	80
CRM 10.0	Bass	237	47
	Blue Gill	257	51
	Carp	487	97
	Shad	44	9
	Crappie	131	26
CRM 12.0	Bass	43	9
	Blue Gill	18	4
	Carp	575	115
	Shad	23	5
	Crappie	102	20
CRM 20.8[c]	Bass	144	29
	Blue Gill	117	23
	Carp	108	22
	Shad	44	9
	Crappie	253	51
CRM 25.0	Bass	16	3
	Blue Gill	57	11
	Carp	124	25
	Shad	12	2
	Crappie	30	6

[a]Composite of ten fish in each species.

[b]Percent of proposed FDA mercury in fish action level of 500 ng/g.

[c]Average of quarterly samples.

Table 30
^{137}Cs CONCENTRATION IN DEER SAMPLES
1981
pCi/g (Bq/kg) - Wet Weight

SAMPLE NUMBER	MUSCLE		LIVER		SAMPLE NUMBER	MUSCLE		LIVER	
D-1	0.078	(2.9)	-	-[a]	D-25	0.16	(6.0)	0.051	(1.9)
D-2P	-	-	-	-	D-26	0.15	(5.6)	0.059	(2.2)
D-3	-	-	-	-	D-27	0.95	(35.0)	0.22	(8.2)
D-4	0.027	(1.0)	0.059	(2.2)	D-28	0.35	(13.0)	0.17	(6.3)
D-5	0.062	(2.3)	0.049	(1.8)	D-29	0.62	(23.0)	0.14	(5.2)
D-6	0.032	(1.2)	-	-	D-30	0.17	(6.3)	0.15	(5.6)
D-7	0.035	(1.3)	-	-	D-31	0.19	(7.0)	0.084	(3.1)
D-8P	0.016	(0.6)	-	-	D-32	0.086	(3.2)	0.054	(2.0)
D-9	0.027	(1.0)	-	-	D-33	0.27	(10.0)	0.65	(24.0)
D-10	0.030	(1.1)	-	-	D-34	NA	NA	0.059	(2.2)
D-11	0.024	(0.9)	NA	NA	D-35[d]	0.20	(7.4)	0.065	(2.4)
D-12	-	-	0.030	(1.1)	D-36	0.25	(9.1)	0.12	(4.4)
D-13	0.041	(1.5)	-	-	D-37	0.057	(2.1)	0.016	(0.6)
D-14	0.027	(1.0)	-	-	D-38	0.14	(5.2)	0.059	(2.2)
D-16[b]	0.92	(34)	0.38	(14.0)	D-39	0.19	(7.0)	0.068	(2.5)
D-17	0.032	(1.2)	-	-	D-41	0.20	(7.4)	0.043	(1.6)
BL-1	0.11	(4.2)	-	-	D-42	0.095	(3.5)	0.076	(2.8)
BL-2	-	-	-	-	D-43	0.27	(10.0)	-	-
D-22	0.045	(1.8)	0.019	(0.7)	D-44	0.14	(5.2)	0.051	(1.9)
D-23[c]	0.016	(0.6)	0.014	(0.5)	D-45	0.11	(4.2)	0.027	(1.0)
D-24	0.070	(2.6)	0.043	(1.6)	D-46	0.073	(2.7)	-	-

[a]Entries with a dash (-) indicate a concentration level <0.01 pCi/g (<0.4 Bq/kg).

[b]Also 0.005 pCi/g (0.2 Bq/kg) ^{60}Co in muscle; 0.2 pCi/g (7.4 Bq/kg) ^{60}Co in liver.

[c]Also 0.02 pCi/g (0.7 Bq/kg) ^{60}Co in muscle.

[d]Also 0.01 pCi/g (0.4 Bq/kg) ^{60}Co in muscle.

NOTE: NA - Not Analyzed.

Table 31
VEGETATION SAMPLING DATA
1981

STATION NUMBER[a]	F^- CONCENTRATION[b] µg/g (ppm)		U (TOTAL) CONCENTRATION[b] µg/g (ppm)	
	GRASS	PINE NEEDLES	GRASS	PINE NEEDLES
1	9	-	0.6	-
2	7	< 5	1.6	0.2
3	< 5	7	1.2	0.3
4	5	7	0.7	0.2
5	6	7	0.7	0.5
6	< 5	< 5	0.6	0.3
7	5	5	0.5	0.2
8	8	10	0.6	0.4
9	7	< 5	0.7	0.2
10	5	6	0.5	0.1
11	11	9	1.7	1.1
12	10	7	0.4	0.4
13	13	-	1.1	-
14	8	-	-	-
15	11	-	-	-
16	17	-	-	-
17	12	-	-	-

[a]See Figure 1.

[b]Average concentration of two sample collections, January and July. Analytical results are on a dry weight basis.

NOTE: Applicable guides for flora have not been established. However, for comparison the **American Industrial Hygiene Association Journal** for January-February 1969 (pp. 98-101) states that dairy cattle is the species of livestock most sensitive to fluorides in grasses. For comparative purposes the following fluoride concentrations and their effect on dairy cattle are given.

30 ppm	-	no adverse effects
30 to 40 ppm	-	borderline chronic
40 to 60 ppm	-	moderate chronic
60 to 110 ppm	-	severe chronic
above 250 ppm	-	acute

Table 32
RADIOACTIVITY IN GRASS SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS
1981
Units of pCi/g (Bq/kg) - Dry Weight

SAMPLING LOCATION[a]	^{90}Sr	^{137}Cs	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U
Perimeter[b]							
HP-31	0.38 (14)	0.18 (6.7)	0.0089 (0.33)	0.0018 (0.07)	0.09 (3.5)	0.015 (0.56)	0.17 (6.3)
HP-32	0.43 (16)	0.07 (2.6)	0.0008 (0.03)	0.0004 (0.02)	0.11 (4.1)	0.021 (0.78)	0.39 (14)
HP-33	0.47 (17)	0.10 (3.7)	0.0022 (0.08)	0.0007 (0.03)	0.04 (1.5)	0.005 (0.19)	0.07 (2.6)
HP-34	0.57 (21)	0.08 (3.0)	0.0010 (0.04)	0.0011 (0.04)	0.03 (1.1)	0.010 (0.37)	0.07 (2.6)
HP-35	0.47 (17)	0.06 (2.2)	0.0017 (0.06)	0.0008 (0.03)	0.05 (1.9)	0.014 (0.52)	0.12 (4.3)
HP-36	0.82 (30)	0.04 (1.5)	0.0008 (0.03)	0.0007 (0.03)	0.03 (1.1)	0.010 (0.37)	0.05 (1.9)
HP-37	0.55 (20)	0.15 (5.6)	0.0005 (0.02)	0.0007 (0.03)	0.02 (0.7)	0.006 (0.22)	0.05 (1.9)
HP-38	0.49 (18)	0.35 (13.0)	0.0014 (0.05)	0.0009 (0.04)	0.03 (1.1)	0.007 (0.26)	0.05 (1.9)
HP-39	0.62 (23)	0.15 (5.6)	0.0026 (0.10)	0.0018 (0.07)	0.08 (3.0)	0.071 (2.6)	0.16 (5.9)
Average	0.58 (21)	0.13 (4.8)	0.0023 (0.09)	0.0011 (0.04)	0.08 (3.0)	0.020 (0.74)	0.16 (5.9)
Remote[c]							
HP-51	0.95 (35)	0.09 (3.3)	0.0049 (0.18)	0.0005 (0.02)	0.03 (1.1)	0.018 (0.67)	0.06 (2.3)
HP-52	0.76 (28)	0.13 (4.8)	0.0002 (0.01)	0.0049 (0.18)	0.06 (2.2)	0.054 (2.0)	0.17 (6.3)
HP-53	0.95 (35)	0.08 (3.0)	0.0002 (0.01)	0.0022 (0.08)	0.03 (1.1)	0.013 (0.48)	0.05 (1.9)
HP-55	0.59 (22)	NA NA	0.0001 (<0.01)	<0.0001 (<0.01)	0.03 (1.1)	0.025 (0.93)	0.07 (2.6)
HP-56	0.62 (23)	NA NA	0.0041 (0.15)	0.0002 (0.01)	0.10 (4.0)	0.013 (0.48)	0.08 (3.0)
HP-57	0.38 (14)	NA NA	0.0014 (0.05)	0.0002 (0.01)	0.01 (0.4)	0.003 (0.11)	0.03 (1.1)
HP-58	0.54 (20)	0.06 (2.2)	0.0014 (0.05)	0.0008 (0.03)	0.02 (1.0)	0.017 (0.63)	0.07 (2.6)
Average	0.68 (25)	0.09 (3.4)	0.0018 (0.06)	0.0017 (0.06)	0.04 (1.5)	0.020 (0.74)	0.07 (2.6)

[a]See Figures 1 and 2.

[b]Average of two samples.

[c]One sample.

NOTE: NA - Not analyzed.

Table 33
RADIOACTIVITY IN SOIL SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS
1981
Units of pCi/g (Bq/kg) - Dry Weight

SAMPLING LOCATION[a]	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}Pu	^{239}Pu	^{238}U
				Perimeter[b]			
HP-31	0.3 (11)	1.0 (37)	0.7 (26)	0.05 (1.9)	0.012 (0.44)	0.03 (1.1)	0.3 (11)
HP-32	0.2 (7)	1.1 (41)	1.3 (48)	0.03 (1.1)	0.002 (0.07)	0.03 (1.1)	0.9 (33)
HP-33	0.4 (15)	1.1 (41)	0.4 (15)	0.02 (0.7)	0.002 (0.07)	0.04 (1.5)	0.2 (7)
HP-34	0.5 (19)	1.5 (56)	0.3 (11)	0.02 (0.7)	0.002 (0.07)	0.03 (1.1)	0.3 (11)
HP-35	0.4 (15)	1.7 (63)	0.5 (19)	0.03 (1.1)	0.003 (0.11)	0.04 (1.5)	0.4 (15)
HP-36	0.2 (7)	1.4 (52)	0.5 (19)	0.03 (1.1)	0.004 (0.15)	0.02 (0.7)	0.3 (11)
HP-37	0.7 (26)	0.8 (30)	0.2 (7)	0.02 (0.7)	0.004 (0.15)	0.04 (1.5)	0.3 (11)
HP-38	0.6 (22)	0.9 (33)	0.3 (11)	0.02 (0.7)	0.003 (0.11)	0.04 (1.5)	0.2 (7)
HP-39	0.2 (7)	2.3 (85)	0.9 (33)	0.06 (2.2)	0.004 (0.15)	0.06 (2.2)	0.9 (33)
Average	0.4 (15)	1.3 (48)	0.6 (22)	0.03 (1.1)	0.004 (0.15)	0.04 (1.5)	0.4 (15)
				Remote[c]			
HP-51	0.3 (11)	0.5 (19)	0.4 (15)	0.04 (1.5)	0.002 (0.07)	0.02 (0.7)	0.4 (15)
HP-52	0.2 (7)	1.0 (37)	0.5 (19)	0.03 (1.1)	0.007 (0.26)	0.08 (3.0)	0.3 (11)
HP-53	0.3 (11)	1.9 (70)	0.9 (33)	0.04 (1.5)	0.008 (0.30)	0.19 (7.0)	0.7 (26)
HP-55	0.1 (4)	1.4 (52)	0.6 (22)	0.04 (1.5)	0.002 (0.07)	0.05 (1.9)	0.5 (19)
HP-56	0.2 (7)	0.8 (30)	0.7 (26)	0.05 (1.9)	0.007 (0.26)	0.09 (3.3)	0.6 (22)
HP-57	0.3 (11)	3.5 (130)	0.5 (19)	0.03 (1.1)	0.001 (0.04)	0.06 (2.2)	0.4 (15)
HP-58	0.1 (4)	0.8 (30)	0.3 (11)	0.01 (0.4)	0.005 (0.19)	0.04 (1.5)	0.3 (11)
Average	0.2 (7)	1.4 (52)	0.6 (22)	0.03 (1.1)	0.004 (0.15)	0.08 (3.0)	0.5 (19)

[a]See Figures 1 and 2.

[b]Average of two samples.

[c]One sample.

Table 34
STREAM SEDIMENT SAMPLES
July/November 1981
Average Concentration (μg/g dry weight basis)

STATION	U	Hg	Pb	Ni	Cu	Zn	Cr	Mn	Al
CS1	1	1	29	28	21	72	34	2135	36,000
PS2	7	6	40	70	78	120	110	580	60,000
PS5	6	4	37	57	36	126	84	825	50,000
PS6	11	10	44	83	51	187	221	824	50,000
PS9	3	3	30	44	31	85	49	1380	40,000
PS10	18	10	24	56	33	109	52	502	30,000
PS12	9	6	28	78	42	121	52	710	30,000
PS15	31	10	54	112	86	181	93	1050	60,000
PS17	13	3	35	97	38	103	47	1058	30,000
PS18	6	6	24	42	23	78	37	422	30,000
PS19	12	9	36	39	48	110	63	754	40,000
PS21	1	3	17	19	16	41	23	571	20,000
PS22	7	2	42	73	101	125	98	562	70,000
CS20	11	46	31	71	53	135	108	670	40,000

Table 35
SUMMARY OF THE ESTIMATED RADIATION DOSE TO AN ADULT INDIVIDUAL DURING 1981 AT LOCATIONS OF MAXIMUM EXPOSURE

PATHWAY	LOCATION	DOSE IN MILLIREM (μSv)			
		TOTAL BODY		CRITICAL ORGAN	
Gaseous Effluents		0.38	(3.8)	9.2	(92) (lung)
Inhalation plus direct radiation from air and ground	Nearest resident to site boundary				
Terrestrial food chains	Milk sampling stations (^{90}Sr)	0.02	(0.2)	2.7	(27) (bone)
Liquid Effluents					
Aquatic food chains	Clinch-Tennessee River System (^{90}Sr)	2.9	(29)	71	(710) (bone)
Drinking water[a]	Kingston, Tennessee (^{90}Sr)	0.22	(2.2)	10.9	(109) (bone)
Direct radiation along water, shores, and mud flats[b]	Downstream from White Oak Creek near experimental Cs field plots	5.9	(59)	5.9	(59) (total body)

[a]Based on the analysis of raw (unprocessed) water.

[b]Assuming a residence time of 240 hr/yr.

NOTE: Average background total body dose in the U.S.[30] is 106 mrem/yr (1060 μSv/yr).

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APPENDIX A
QUALITY ASSURANCE

Radiological

The Environmental Surveillance and Evaluation Section at Oak Ridge National Laboratory has initiated a quality assurance program to ensure that a high degree of accuracy and reliability is maintained in its surveillance activities. The program in effect at ORNL consists of quality control of techniques and procedures, and includes the establishment of a detailed written description of all activities pertaining to the Environmental Surveillance and Evaluation Section. This includes:

1. Operating procedures for each activity.
2. Inspection lists of operating and maintenance activities.
3. Check-off frequency lists for all quality assurance steps, such as schedules for equipment inspection and test control.
4. Documentation of compliance of quality assurance procedures.
5. Participation in intralaboratory and interlaboratory sample-exchange programs.
6. Evaluation of the adequacy of sample preparation work and data analysis.
7. Identification of the role, responsibilities, and authority of each staff member as related to quality assurance.

A schematic diagram showing a flow chart of this quality assurance program is given in Figure A1. A more detailed discussion of the ORNL QA program is given in Ref. (A1) and (A2).

Chemical

A Nuclear Division Committee on Environmental Analysis established an interlaboratory quality control program in 1977. The purpose of this program is to provide quality control data for environmental analysis within the Nuclear Division. A unified Environmental and Effluent Analysis Manual was issued in March of 1977 which currently contains 105 analytical procedures; EPA-certified analytical methods are used wherever possible.

All Nuclear Division analytical laboratories maintain internal measurement control programs that are part of planned and systematic actions taken to prevent incorrect results. Standard samples containing many parameters measured are purchased and submitted to the laboratories for analysis. Standard samples of known values are processed along with routine samples and the results are recorded and examined to determine if they fall within prescribed limited. Analytical results are transmitted to the Y-12 Plant Quality Division for satistical review and a semi-annual report is provided to the analytical laboratories.

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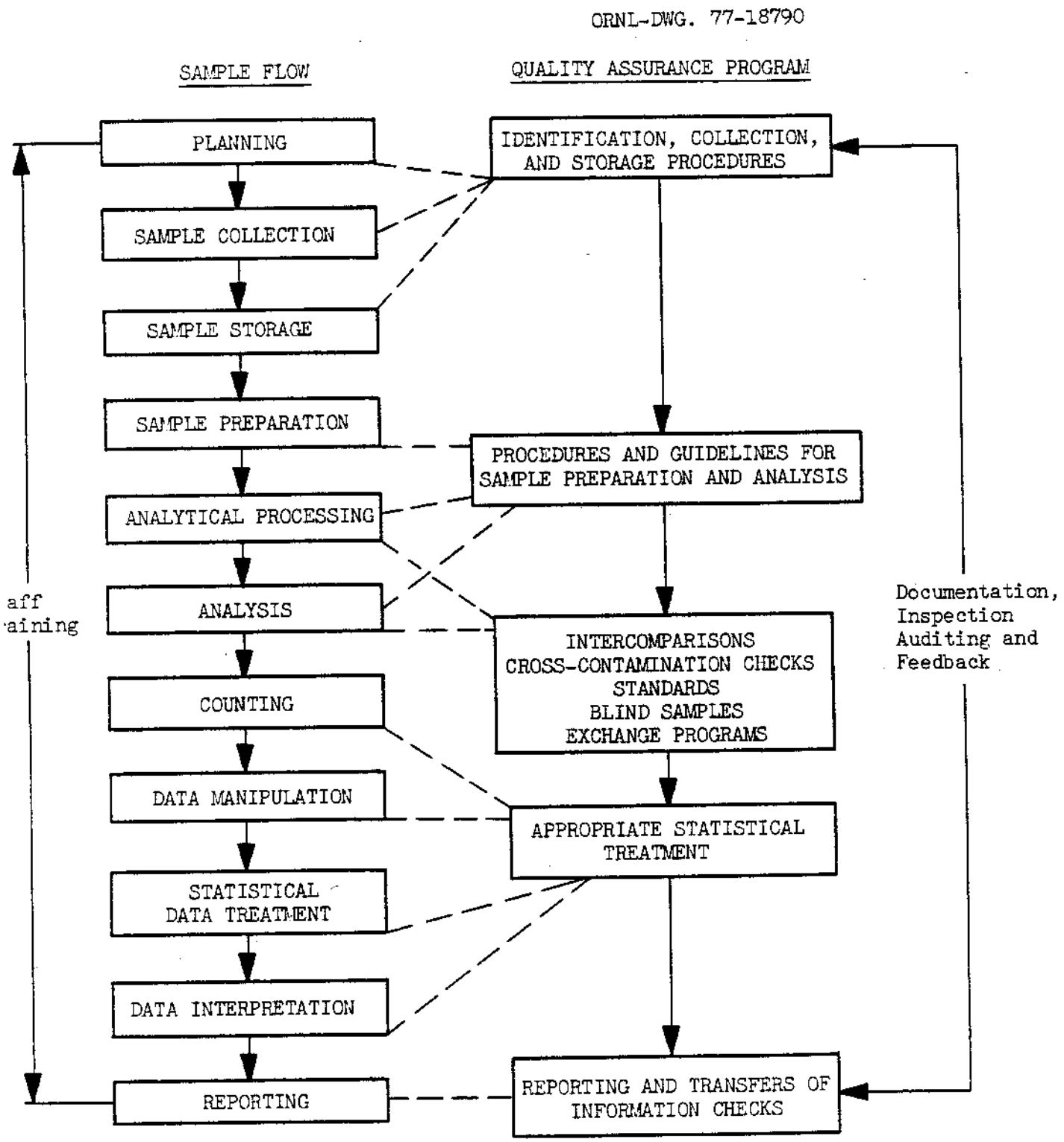

Figure A1
FLOW CHART OF QA PROGRAM

EXTERNAL DISTRIBUTION

Director, Division of Industrial and Radiological Health,
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Director, Tennessee State Health Department
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UCC-ND

NUCLEAR DIVISION

UNION CARBIDE

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FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ENVIRONMENTAL MONITORING REPORT

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE FACILITIES

Calendar Year 1980

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Oak Ridge Gaseous Diffusion Plant

Oak Ridge National Laboratory

Oak Ridge Y-12 Plant

Office of Health, Safety, and Environmental Affairs

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Oak Ridge, Tennessee 37830

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INTRODUCTION

Oak Ridge is located in East Tennessee in a broad valley which lies between the Cumberland Mountains on the northwest and the Great Smoky Mountains on the southeast. The Department of Energy (DOE) Reservation is located in the Valley and Ridge physiographic province which is characterized by parallel ridges of sandstone, shale, and cherty dolomite, separated by valleys of less weather-resistant limestone and shale. The ridges are oriented southwest-northeast. Topography of the area is due to differential erosion of severely folded and faulted rocks ranging in age from Early Cambrian to Early Mississippian. Elevations range from 226 meters to 415 meters above mean sea level with a maximum relief of 189 meters. The area includes gently sloping valleys and rolling to steep slopes and ridges. The Tennessee Valley Authority's (TVA) Melton Hill and Watts Bar Reservoirs on the Clinch River form the southern and western boundaries of the Reservation while the City of Oak Ridge (approximately 28,000 population) is on the northern boundary.

The local climate is noticeably influenced by topography. Prevailing winds are usually either up-valley, from west to southwest, or down-valley, from east to northeast. During periods of light winds, daytime winds are usually southwesterly and nighttime winds usually northeasterly. Wind velocities are somewhat decreased by the mountains and ridges, and tornadoes rarely occur. In winter, the Cumberland Mountains have a moderating influence on the local climate by retarding the flow of cold air from the north and west. Temperatures of 38°C or higher and-18°C or below are unusual. Low-level temperature inversions occur during approximately 56 percent of the hourly observations. Winter and early spring are the seasons of heaviest precipitation with the monthly maximum normally occuring during January to March. The mean annual precipitation is approximately 137 centimeters.

The topography of the Oak Ridge Area is such that all drainage from the DOE Reservation flows into the Clinch River which has its headwaters in southwestern Virginia and flows southwest to its mouth near Kingston, Tennessee. The Clinch River flow is regulated by several dams which provide reservoirs for flood control, electric power generation, and recreation. The principal tributaries through which liquid effluents from the plant areas reach the Clinch River are White Oak Creek, East Fork Poplar Creek, and Poplar Creek.

With the exception of the City of Oak Ridge, the land within 8 kilometers of the DOE Reservation is predominantly rural being utilized largely for residences, small farms, and pasturage for cattle. The approximate location and population of the towns nearest the DOE Reservation are: Oliver Springs (pop. 3400) 11 kilometers to the northwest; Clinton (pop. 4800) 16 kilometers to the northeast; Lenior City (pop. 5300) 11 kilometers to the southeast; Kingston (pop. 4100) 11 kilometers to the southwest; and Harriman (pop. 8700) 13 kilometers to the west. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 40 kilometers to the east and has a population of approximately 175,000. A directional 80-kilometer population distribution, which is used for population dose calculations later in this report, is shown in Table 1.

The DOE Reservation contains three major operating facilities: the Oak Ridge National Laboratory (ORNL), the Oak Ridge Gaseous Diffusion Plant (ORGDP), and the Y-12 Plant; all of which are operated by Union Carbide Corporation, Nuclear Division. In addition, two smaller DOE facilities are in the area: the Comparative Animal Research Laboratory, and the Oak Ridge Associated Universities.

The Oak Ridge National Laboratory is a large multipurpose research laboratory whose basic mission is the discovery of new knowledge, both basic and applied, in all areas related to energy. To accomplish this mission, the Laboratory conducts research in all fields of modern science and technology. The Laboratory's facilities consist of nuclear reactors, chemical pilot plants, research laboratories, radioisotope production laboratories, and support facilities.

The Oak Ridge Gaseous Diffusion Plant (ORGDP) is a complex of production, research, development, and support facilities located west of the city of Oak Ridge. While the primary function of ORGDP is the enrichment of uranium hexafluoride (UF_6) in the uranium-235 isotope, extensive efforts are also expended on research and development activities associated with both the gaseous diffusion and gas centrifuge processes. In addition, the barrier material used by all three Department of Energy-owned gaseous diffusion plants is manufactured at ORGDP. Numerous other activities (maintenance, nitrogen production, steam production, uranium recovery, fluorine production, water treatment, laboratory analysis, administration, etc.) lend support to these primary functions and are thus essential to the operation of this plant.

The Oak Ridge Y-12 Plant which is located immediately adjacent to the City of Oak Ridge has five major responsibilities: (1) production of nuclear weapon components, (2) processing of source and special nuclear materials, (3) support to the weapon design laboratories, (4) support to other UCC-ND installations, and (5) support to other government agencies. Activities associated with these functions include the production of lithium compounds, the recovery of enriched uranium from unirradiated scrap material, and the fabrication of uranium and other materials into finished parts and assemblies. Fabrication operations include vacuum casting, arc melting, powder compaction, rolling, forming, heat treating, machining, inspection, and testing.

Operations associated with the DOE research and production facilities in Oak Ridge give rise to several types of waste materials.

Radioactive wastes are generated from nuclear research activities, reactor operations, pilot plant operations involving radioactive materials, isotope separation processes, uranium enrichment, and uranium processing operations. Nonradioactive wastes are generated by normal industrial-type support operations that include water demineralizers, air conditioning, cooling towers, acid disposal, sewage plant operations, and steam plant operations.

Nonradioactive solid wastes are buried in a centralized sanitary landfill or designated burial areas. Radioactive solid wastes are buried in designated burial areas or placed in retrievable storage either above or below ground depending upon the type and quantity of radioactive material present and the economic value involved.

Gaseous wastes generally are treated by filtration, electrostatic precipitation, and/or chemical scrubbing techniques prior to release to the atmosphere. The major gaseous waste streams are released through stacks to provide atmospheric dilution for materials which may remain in the stream following treatment.

Liquid radioactive wastes are not released but are concentrated and contained in tanks for ultimate disposal. Process water which may contain small quantities of radioactive or chemical pollutants is discharged, after treatment, to White Oak Creek, Poplar Creek, East Fork Poplar Creek, and Bear Creek, which are small tributaries to the Clinch River.

SUMMARY

The Environmental Monitoring Program for the Oak Ridge area includes sampling and analysis of air, water from surface streams, creek sediments, biota, and soil for both radioactive and nonradioactive materials. This report presents a summary of the results of the program for calendar year 1980.

Surveillance of radioactivity in the Oak Ridge environs indicates that atmospheric concentrations of radioactivity were not significantly different from other areas in East Tennessee. Concentrations of radioactivity in the Clinch River and in fish collected from the river were less than 4 percent of the permissible concentration and intake guides for individuals in the offsite environment. While some radioactivity was released to the environment from plant operations, the concentrations in all of the media sampled were well below established standards.

The total body dose to a "hypothetical maximum exposed individual" at the site boundary was calculated to be 6.2 millirem/yr which is 1.2 percent of the DOE Manual Chapter 0524 standard. The maximum 50-year dose commitment to the critical organ of an individual from the aquatic food chain was calculated to be 53 millirem to the bone which is 3.5 percent of the allowable annual standard. The maximum dose commitment to individuals living nearest the site boundary from airborne releases, assuming continuous residence, was 1.8 millirem to the total body and 16.6 millirem to the lung. These doses are 0.4 percent and 1.1 percent, respectively, of the annual standards. The average total body dose to an Oak Ridge resident was estimated to be 0.1 millirem as compared to approximately 100 millirem/yr from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 1.2 millirem. The cumulative total body dose to the population within an 80-kilometer radius of the Oak Ridge facilities resulting from 1980 effluents was calculated to be 8.8 man-rem. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation.

Surveillance of nonradioactive materials in the Oak Ridge environs shows that established limits were not exceeded for those materials possibly present in the air as a result of plant operations.

The chemical water quality data in surface streams obtained from the water sampling program indicated that average concentrations resulting from plant effluents were in compliance with State stream guidelines with the exception of fluoride at monitoring Station E-1 which equalled the guideline.

National Pollutant Discharge Elimination System (NPDES) permit compliance information has been included in this report.

During 1980 only one spill of oil and/or hazardous materials from the Oak Ridge installations was reported to the National Response Center.

MONITORING DATA COLLECTION, ANALYSIS, AND EVALUATION

Environmental monitoring data for calendar year 1980 are summarized in Table 2 through 33. In general, the data tables show the number of samples collected at each location, the maximum concentration, the minimum concentration, the average concentration, the relevant standard, and percent of standard for the average of each parameter. Averages are usually accompanied by plus-or-minus (±) values which represent the 95 percent confidence limits. The 95 percent confidence limits which are calculated from the standard deviation of the average, assuming a normal frequency distribution, are predictions of the variability in the range of concentrations based on a limited number of measurements. They do not represent the conventional error in the average of repeated measurements on identical samples. Data which are below the minimum detectable limit are expressed as less than (<) the minimum detectable value. In computing average values, sample results below the detection limit are assigned the detection limit value with the resulting average value being expressed as less than (<) the computed value.

Average environmental concentrations are compared with applicable standards where such standards have been established, as a means of evaluating the impact of effluent releases. In some cases, for lack of an official standard, stream concentrations of nonradioactive pollutants have been compared with Tennessee State Health Department stream guidelines.

Liquid effluent monitoring data have been compared to the limits specified in the National Pollutant Discharge Elimination System (NPDES) permits issued to the Oak Ridge Facilities by the Environmental Protection Agency (EPA).

Air Monitoring

Radioactive – Atmospheric concentrations of radioactive materials occuring in the general environment of East Tennessee are monitored by two systems of monitoring stations. One system consists of nine stations (HP-31 through HP-39) which encircle the perimeter of the Oak Ridge area and provides data for evaluating releases from Oak Ridge facilities to the immediate environment, Figure 1. A second system consists of eight stations (HP-51 through HP-58) encircling the Oak Ridge area at distances of from 19 to 121 kilometers, Figure 2. This system provides background data to aid in evaluating local conditions. Sampling for radioactive particulates is carried out by passing air continuously through filter papers. Filter papers are evaluated weekly by gross beta and gross alpha counting techniques and composited by system quarterly for specific radionuclide analysis during normal operations. More frequent detailed analyses are performed if concentrations in the environment are significantly above normal. Airborne radioactive iodine is monitored in the immediate environment (HP-31 through HP-39) by passing air continuously through cartridges containing activated charcoal. Charcoal cartridges are evaluated for radioactive iodine by gamma spectrometry.

Data on the concentrations of radioactive materials in air and the quantities of radioactive materials released to the atmosphere in the Oak Ridge and surrounding areas are given in Tables 2 through 6.

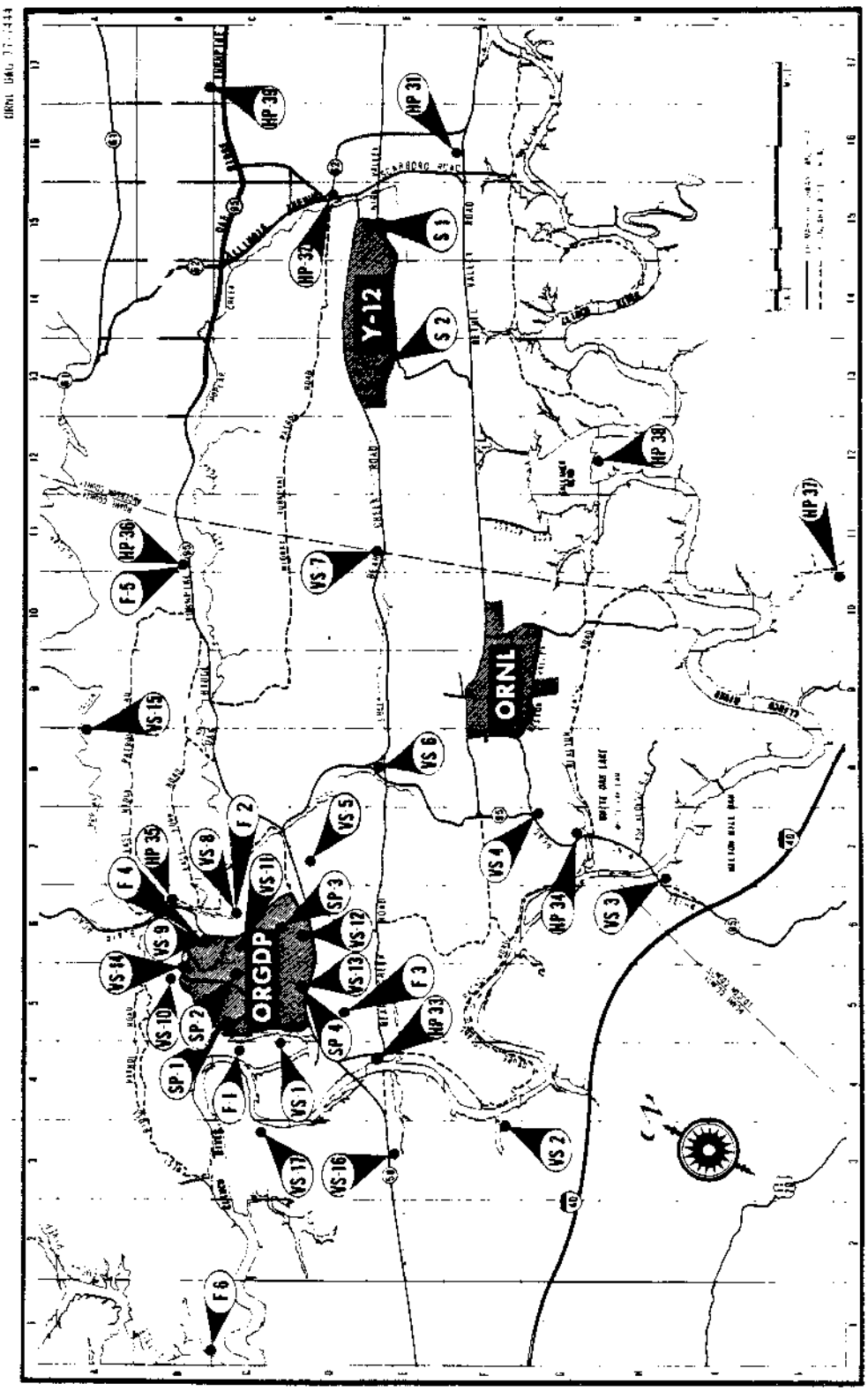

Figure 1
AIR, VEGETATION, AND SOIL SAMPLING LOCATIONS

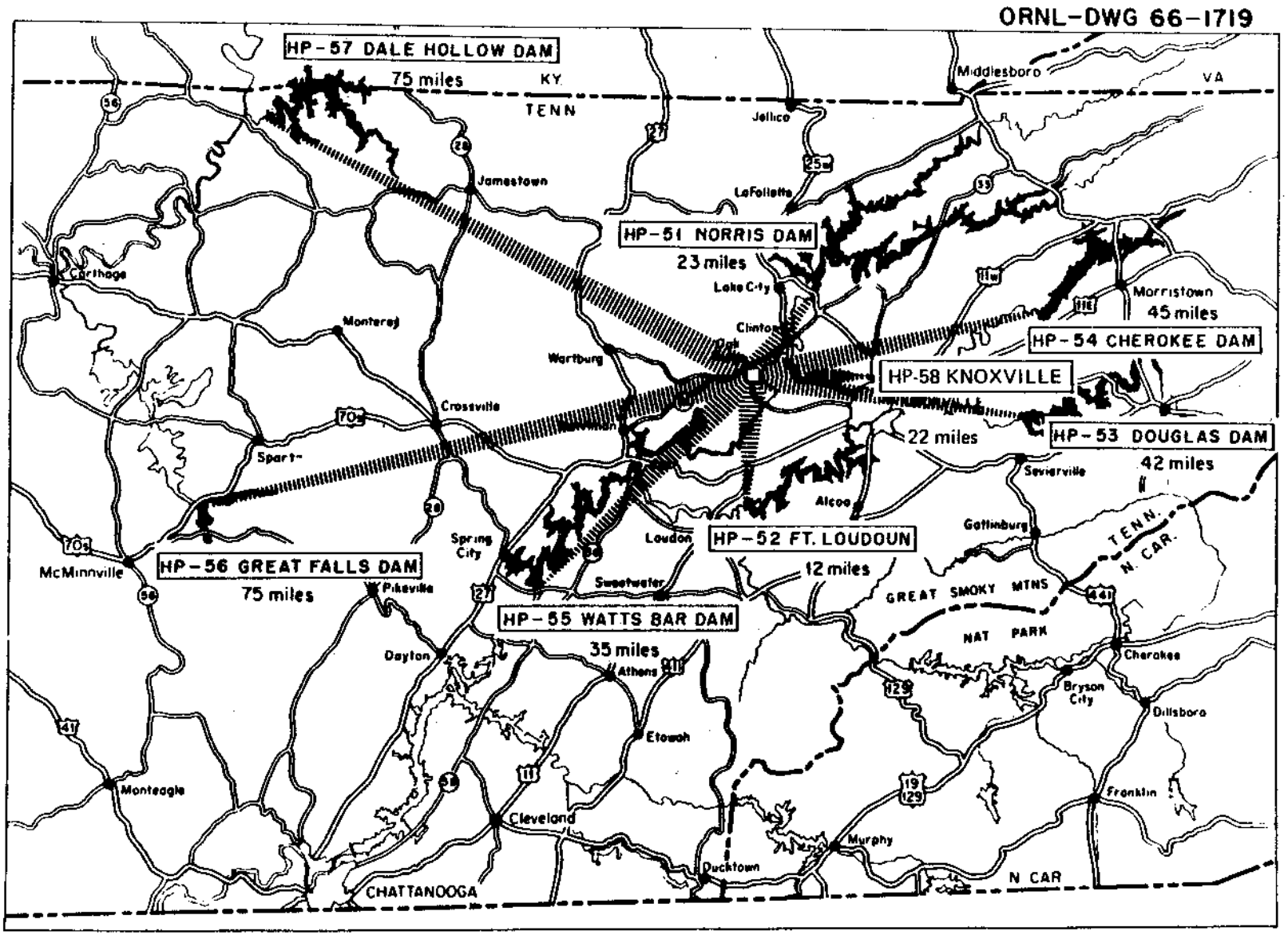

Figure 2
REMOTE AIR MONITORING LOCATIONS

The average gross beta concentrations of radioactivity from particulates in air measured by both the perimeter and remote monitoring systems were 0.03 and 0.03 percent, respectively, of the applicable concentration guide (CG) as specified in the DOE Manual, Appendix 0524[1] for individuals in uncontrolled areas (Table 2).

The average gross alpha concentrations in the perimeter and remote monitoring systems were 0.02 and 0.03 percent, respectively, of the CG for a mixture of uranium isotopes (Table 3).

The results of specific radionuclide analyses of composited filters are given in Table 4. The environmental concentrations tabulated are all at least a thousand times less than the applicable DOE concentration guides for the radionuclides detected.

The concentration of ^{131}I as measured by the perimeter air monitoring system was <0.01 percent of the inhalation concentration guide for individuals in uncontrolled areas (Table 5).

While some radioactivity was released to the atmosphere (Table 6), measurements in the Oak Ridge area show that environmental levels were well below established standards.

Nonradioactive – Environmental air samples are taken for the determination of fluorides, suspended particulates, and sulfur dioxide.

Sampling locations for fluorides are indicated by F-1 through F-6, Figure 1. The current sampling procedure is to obtain seven-day samples collected on potassium carbonate treated paper and to analyze weekly by specific ion electrode. The seven-day analyses are then averaged to obtain 30-day values.

Suspended particulates are measured at locations SP-1 through SP-4, Figure 1. The method for the determination of suspended particulates is the high volume method recommended by EPA. Particulates are collected by drawing air through weighed filter paper. The filter paper is allowed to equilibrate in a humidity controlled atmosphere and the filter is reweighed. From the weight of particulates, the sampling time, and the air flow rate, the particulate concentrating in micrograms per cubic meter is calculated. The sampling period is 24 hours.

The two continuous monitoring stations (S-1 and S-2) in the Y-12 Plant are used for measurement of ambient sulfur dioxide concentrations. Each station consists of a pulsed ultraviolet fluorescence analyzer and recorder with associated equipment located in a temperature-controlled shelter. Sulfur dioxide concentrations are interpreted on an hourly basis and averaged for 24-hour, monthly, and annual periods.

Air monitoring data for fluorides, suspended particulates, and sulfur dioxide are presented in Tables 7 through 9. The data indicate that measured environmental concentrations of fluorides, suspended particulates, and sulfur dioxide were in compliance with applicable standards.[2]

The Y-12 steam plant is being upgraded to operate more efficiently at higher steam load levels. The current electrostatic precipitator installation is not adequate to meet emission limits at higher steam load levels. Funds have been requested and preliminary design has been commenced for the installation of pollution control equipment to meet emission limits under higher operating load conditions.

External Gamma Radiation Monitoring

External gamma radiation background measurements are made routinely at the perimeter air monitoring stations and at the remote monitoring stations using calcium fluoride thermoluminescent dosimeters suspended one meter above the ground. Dosimeters at the perimeter stations are collected and analyzed monthly. Those at the remote stations are collected and analyzed semiannually.

Data on the average external gamma radiation background are given in Table 10. A considerable variation in background levels is normally experienced in East Tennessee depending upon elevation, topography, and geological character of the surrounding soil.(3)

External gamma radiation measurements were performed along the stream course of East Fork Poplar Creek to evaluate radioactivity which might be contained in the sediments as a result of effluent releases. Additionally, measurements were made along the bank of the Clinch River from the mouth of White Oak Creek several hundred yards downstream to evaluate gamma radiation levels resulting from effluent releases and "sky shine" from an experimental ^{137}Cs plot located near the river bank. Measurements were made using scintillation detectors and/or thermoluminescent dosimeters suspended one meter above the ground surface. The average background level determined at the remote stations was subtracted from the measured gamma radiation levels to determine the incremental increases resulting from plant operations.

Gamma levels long East Fork Poplar Creek ranged from 0 to 12 μR/hr above background. The external gamma radiation levels along the bank of the Clinch River ranged from 5 to 23 μR/hr above background. Potential doses to individuals in the environment from these elevated gamma radiation levels were calculated and are included, where significant, in the dose assessment section of the report.

Water Monitoring

Radioactive – Water samples are collected in the Clinch River for radioactivity analyses at Melton Hill Dam (Station C-2) 3.7 kilometers above White Oak Creek outfall, at the ORGDP sanitary water intake (Station C-3) 10 kilometers downstream from the entry of White Oak Creek, at the ORGDP recirculating water intake (Station C-4) downstream from the Poplar Creek outfall, near Brashear Island (Station C-6), and at Center's Ferry (Station C-5) near Kingston, Tennessee, Figure 3. Samples are collected continuously at all locations except for Station C-5 and Station C-6 which are collected on a daily and monthly grab-sample basis, respectively. Samples are composited for monthly or quarterly analysis depending upon location.

Water samples also are collected for radioactivity analyses at White Oak Dam (Station W-1), at the outlet of New Hope Pond on East Fork Poplar Creek (Station E-1), in Bear Creek (Station B-1), and in Poplar Creek (Stations P-1 and P-2), Figure 3. The samples collected at Stations W-1, E-1, and B-1 are continuous proportional samples. Grab samples are collected at Stations P-1 and P-2 on a weekly basis. Water samples were collected also at the juncture of White Oak Creek and the Clinch River. All samples are composited for monthly analysis.

The concentrations of fission product radionuclides present in detectably significant amounts are determined by specific radionuclide analysis and gamma spectrometry. Uranium analysis is by the fluorometric method. Transuranic alpha emitters are determined by ion exchange and alpha range analysis. The concentration of each radionuclide is compared with its respective concentration guide (CG) value as specified in the DOE Manual, Appendix 0524, and percent of concentration guide for a known mixture of radionuclides is calculated in accordance with the method given in Appendix 0524.

Data on the concentrations of radionuclides measured in the Clinch River are given in Table 11. Data on the concentrations of uranium in surface streams and the quantities of radioactivity release to surface streams are given in Tables 12 and 13.

Analysis of water samples collected at the juncture of White Oak Creek and the Clinch River indicated that the yearly average concentration of radionuclides was approximately 20 percent of the applicable concentration guide for uncontrolled areas. The calculated average concentration of radionuclides in the Clinch River, based on the analysis of water samples collected at White Oak Dam (Station W-1) and the dilution afforded by the river, was determined to be 0.2 percent of the applicable concentration guide for uncontrolled areas assuming complete mixing. The average dilution factor for 1980, based on the flow of White Oak Creek and the Clinch River, was 1130. The measured average concentrations of radionuclides in the Clinch River upstream and downstream of White Oak Creek outfall were less than 0.2 percent of the applicable concentration guide.

The calculated average concentration of transuranic alpha emitters in the Clinch River resulting from effluent releases was 4×10^{-12} μCi/ml, which is less than 0.01 percent of the concentration guide for water containing a known mixture of radionuclides.

Trends in water discharges and calculated percent concentration guide levels in the Clinch River are presented in Figures 4 and 5. Discharges of ^{90}Sr and ^{3}H are shown in Figure 4 as these nuclides contribute the majority of the radiological dose downstream.

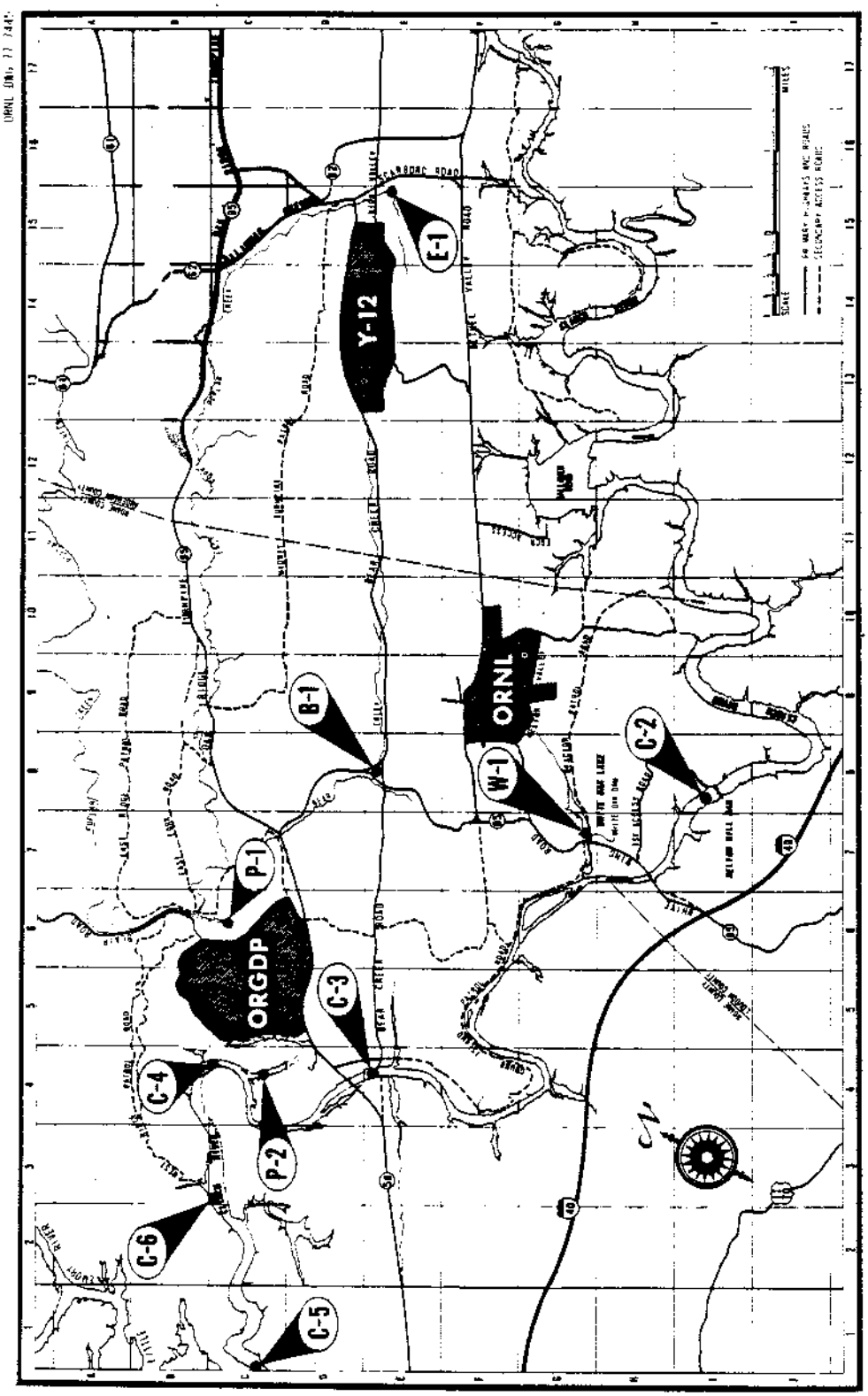

Figure 3
STREAM MONITORING LOCATIONS

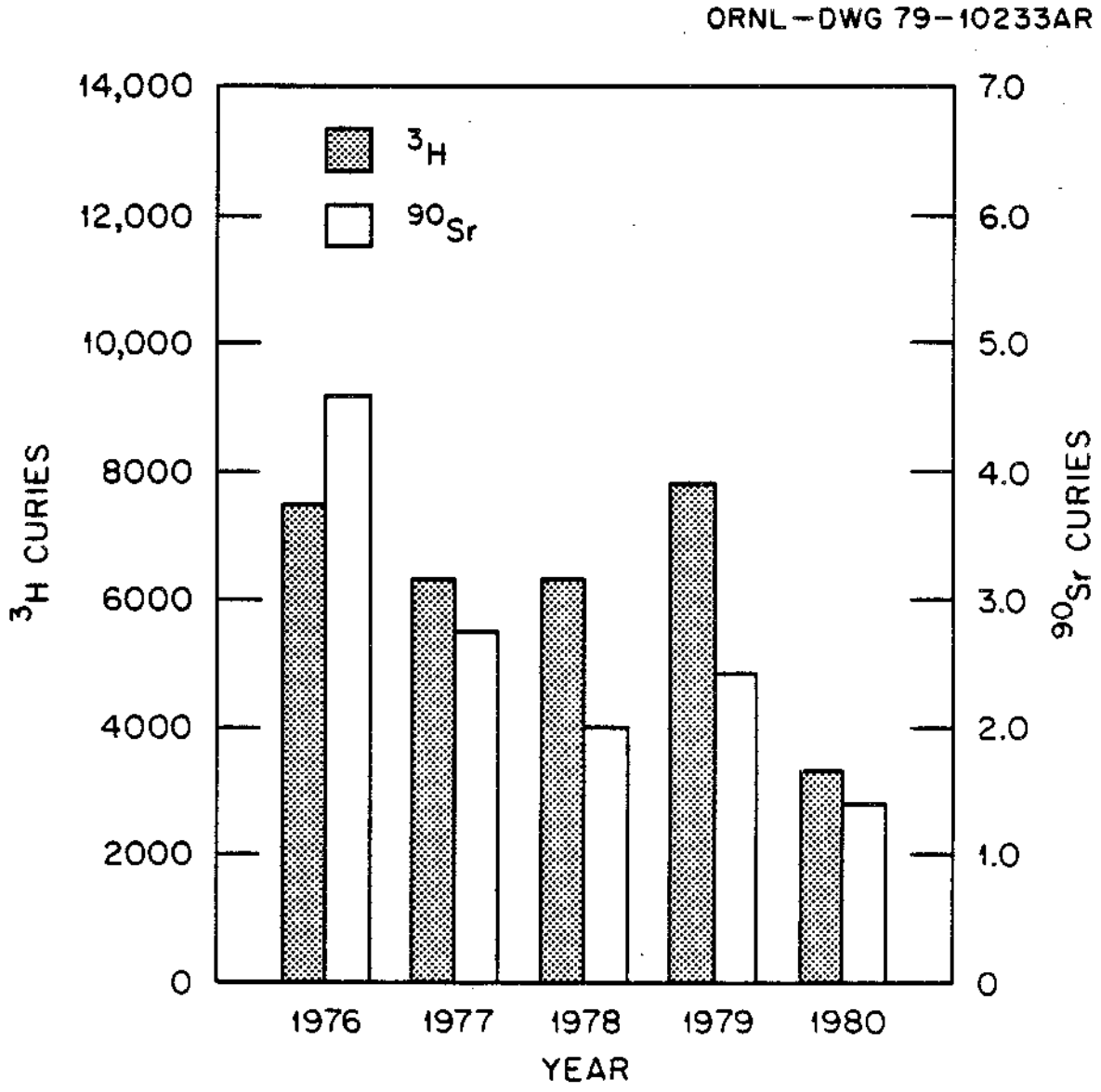

Figure 4
CURIES DISCHARGED OVER WHITE OAK DAM

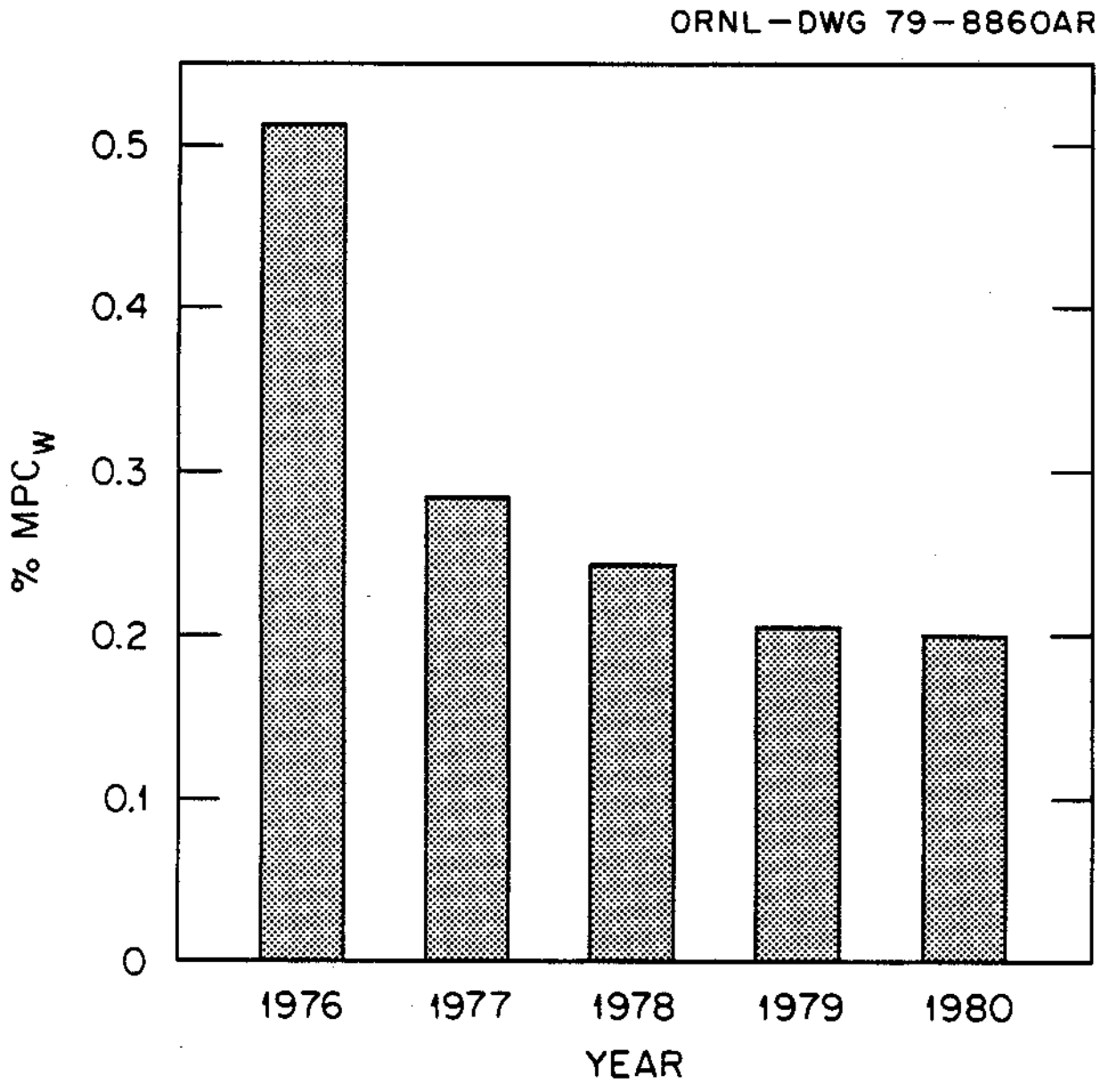

Figure 5

PERCENTAGE CONCENTRATION GUIDE LEVELS IN THE CLINCH RIVER (VALUES GIVEN ARE CALCULATED VALUES BASED ON THOSE CONCENTRATIONS MEASURED AT WHITE OAK DAM AND DILUTION AFFORDED BY THE CLINCH RIVER.)

Rainwater – The gross beta activity in rainwater was analyzed; the results are shown in Table 14. The fluctations among the stations for both the perimeter and remote networks are due to statistical random variation. It is noted that the average radioactivity is greater for the remote stations than the perimeter stations.

Nonradioactive – Water samples are collected for the analysis of nonradioactive substances at the same locations discussed previously under radioactive water sampling. All samples are composited for monthly analysis. Samples are analyzed for a variety of water quality parameters related to process release potential and background information needs by analytical procedures recommended by the Environmental Protection Agency.[4]

Data on chemical concentrations in surface streams are given in Tables 15 through 23. The average concentrations of all substances analyzed were in compliance with Tennessee stream guidelines[5, 6] except for fluoride at Station E-1 which was 100 percent of the guideline.

National Pollutant Discharge Elimination System (NPDES) permits were issued by the Environmental Protection Agency (EPA) for each of the Oak Ridge facilities operated by Union Carbide Corporation - Nuclear Division in 1975. The permits established a number of discharge locations at each installation and listed specific concentration limits and/or monitoring requirements for a number of parameters at each discharge location. Table 24 contains the discharge locations at each installation, the parameters at each location for which limits have been established, the permit limits for each parameter, and the percentage compliance experienced.

Biological Monitoring

Milk – Raw milk is monitored for ^{131}I and ^{90}Sr by the collection and analysis of samples from 12 sampling stations located within a radius of 80 kilometers of Oak Ridge. Samples are normally collected weekly at each of seven stations located near the Oak Ridge area. Five stations, located more remotely with respect to Oak Ridge operations, are sampled at a rate of one station each week. Milk sampling locations for all stations are shown in Figures 6 and 7. Samples are analyzed by ion exchange and gamma spectrometry; results are compared to intake guides specified by the Federal Radiation Council (FRC).[7]

The average concentrations of ^{131}I and ^{90}Sr in raw milk are given in Tables 25 and 26, respectively. If one assumes the average intake of milk per individual to be one liter per day, the average concentration of ^{131}I in the milk in both the immediate environs of the Oak Ridge area and in the environs remote from Oak Ridge were within FRC Range I. The average concentrations ^{90}Sr in milk from both the immediate and remote environs were within the FRC Range I.

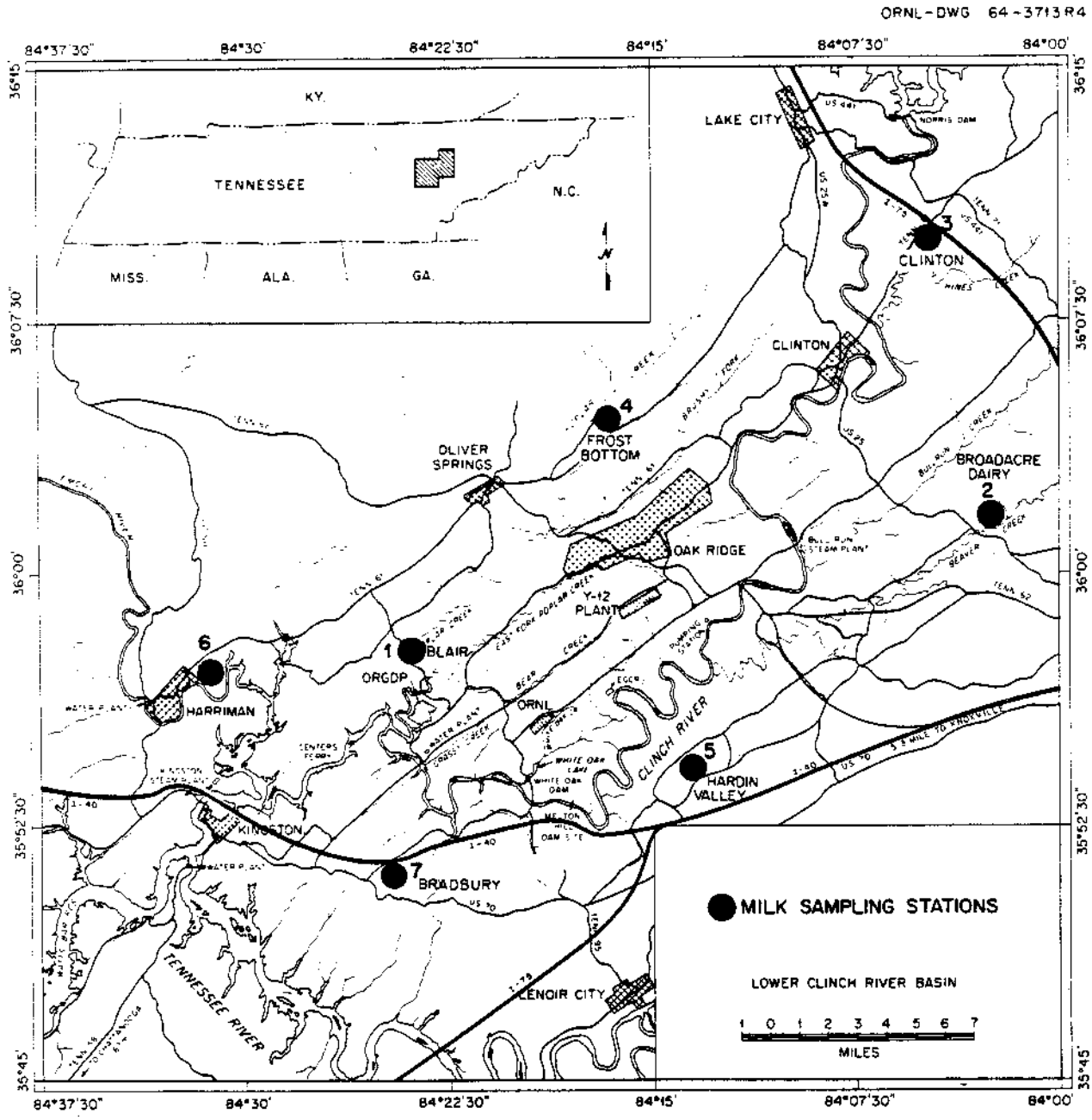

Figure 6
IMMEDIATE ENVIRONS MILK SAMPLING LOCATIONS

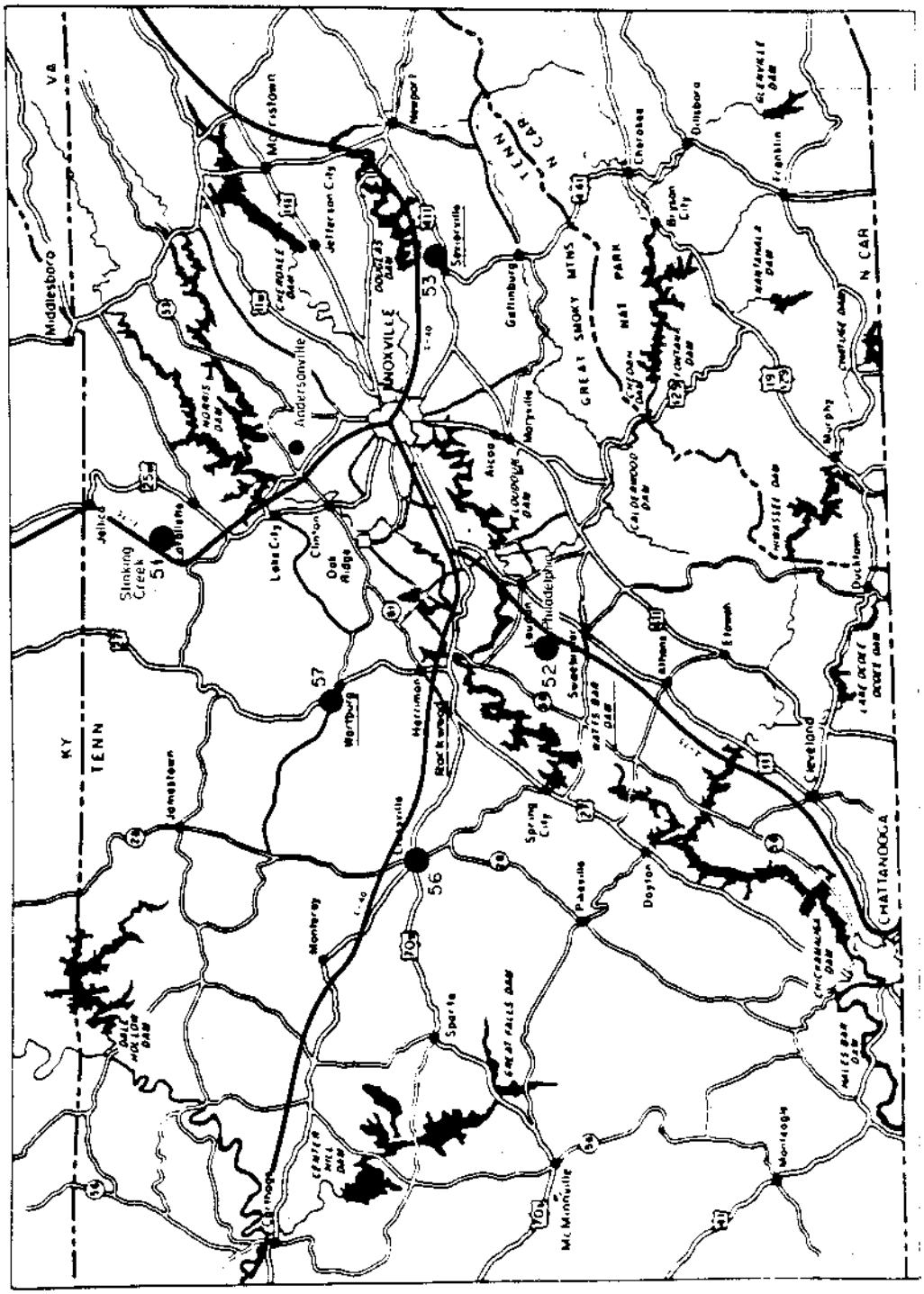

Figure 7
REMOTE ENVIRONS MILK SAMPLING LOCATIONS

Fish Sampling – Several species of fish which are commonly caught are taken from the Clinch River each year. The scales, head, and entrails are removed from the fish before ashing. Ten fish of each species are composited for each sample, and the samples are analyzed by gamma spectrometry and radiochemical techniques for the critical radionuclides which may contribute significantly to the potential radiation dose to man.

Data on the concentration of radionuclides in Clinch River fish are given in Table 27. Consumption of 16.8 kilograms of bluegill per year[8] taken from the river near White Oak Creek outfall results in approximately 3 percent of the maximum permissible intake, which represents the highest dose potential to the public from fish consumption. The maximum permissible intake is calculated to be equal to a daily intake of 2.2 liters of water, over a period of one year, containing the concentration guide of the radionuclides in question. Mercury concentrations in the fish samples collected were less than the FDA proposed action level.

Deer – Frequently, deer are killed by automobiles on the DOE Reservation. Nineteen deer samples were analyzed during 1980. Summary data of the ^{137}Cs content in deer samples are presented in Table 28. The deer with the highest concentration of ^{137}Cs would result in a dose of 0.005 millirem to the total body and 0.01 millirem to the liver (critical organ) if one assumes the consumption of 1 kilogram of meat. It should be noted that no hunting is allowed on the Reservation.

Vegetation – Samples of pine needles and grass are collected semiannually from 17 areas (Stations VS-1 through VS-17, Figure 1) and analyzed for uranium and fluoride content. Fluorometric analysis is used for the determination of uranium and colorimetric analysis is used for the determination of fluorides.

Data on the uranium and fluoride content in vegetation are presented in Table 29. The fluoride concentration in grass at all sampling points was below the 30 ppm level considered to produce no adverse effects when ingested by cattle.[9] Uranium concentrations were below levels of environmental concern.

Additionally, samples of grass were collected semiannually from the perimeter and annually from the remote air-sampling stations (see Figure 1 and 2). At each station, all the grass from five 1/5 meter-squared plots was collected. One plot was taken beside the station, and the other four were taken at 15 m from the station at 90° directions from each other. The grass from each station was then composited and analyzed by gamma spectrometry and radiochemical techniques for a variety of radionuclides. Data on the radionuclide concentrations in grass are presented in Table 30.

Soil and Sediment Monitoring

Soil – Soil samples are also collected semiannually from near the perimeter and annually from the remote stations. The same five 1/5 meter-squared plots used for grass analysis were also used for soil determinations. Two cores, 8 cm in diameter and 5 cm in depth, were taken from each plot; a composite of 10 cores was used for each station. These samples were also analyzed by gamma spectrometry and radiochemical techniques.

Data on specific radionuclide concentrations in soil are given in Table 31. The plutonium concentrations found were comparable to the value of 0.05 pCi/g considered to be a representative concentration of plutonium in U.S. surface soil.[10]

Sediment – A sediment sampling program was initiated at ORGDP in 1975 to determine the concentrations of various metallic ions in the sediment of Poplar Creek. The current sampling program consists of 14 sampling locations (Figure 8) which should be generally representative of plant effluents. Samples are collected twice during the year and analyzed by atomic absorption.

The concentrations of metals in the stream sediment samples, Table 32, generally exceed background levels for metals in remote streams, except for thorium which was below detectable limits. An examination of the effluent sources indicates that only very small quantities of any of these metals are currently being released, suggesting that present concentrations found in sediment samples are residual metals from earlier plant operations.

Calculation of Potential Radiation Dose to the Public

Potential radiation doses resulting from plant effluents were calculated for a number of dose reference points within the Oak Ridge environs. All significant sources and modes of exposure were examined, and a number of general assumptions were used in making the calculations.

The site boundary for the Oak Ridge Complex was defined as the perimeter of the DOE controlled area.

Gaseous effluents are discharged from several locations within each of the three Oak Ridge facilities. For calculational purposes, the gaseous discharges are assumed to occur from only one vent from each site. Since the release points at ORGDP and the Y-12 Plant do not physically approximate an elevated stack, their discharges are assumed to be from 10 meters above ground level; releases from ORNL are through elevated stacks. The meteorological data collected at the ORNL site were used for dispersion calculations. Concentrations of radionuclides contained in the air and deposited on the ground were estimated at distances up to 80 kilometers from the Oak Ridge facilities with the Gaussian plume model developed by Pasquill[11] and Gifford[12] incorporated in a computer program.[13] The concentration has been averaged over the crosswind direction to give the estimated ground level concentration downwind of the source of emission.[14] The deposition velocities used in the calculations were 10^{-6} cm/sec for krypton and xenon, 10^{-2} cm/sec for iodine, and 1 cm/sec for particulates.[15] Meteorological data are shown in Figure 9; the length of the bars indicates the percentage of time the wind is blowing in that direction.

Potential pathways of exposure to man from radioactive effluents released by the Oak Ridge operations that are considered in the dose estimates are presented in Figure 10. The pathways shown in the figure are not exhaustive, but they include the principal pathways of exposure based on experience.

Exposures to radionuclides that originate in the effluents released from the Oak Ridge facilities were converted to estimates of radiation dose to individuals using models and

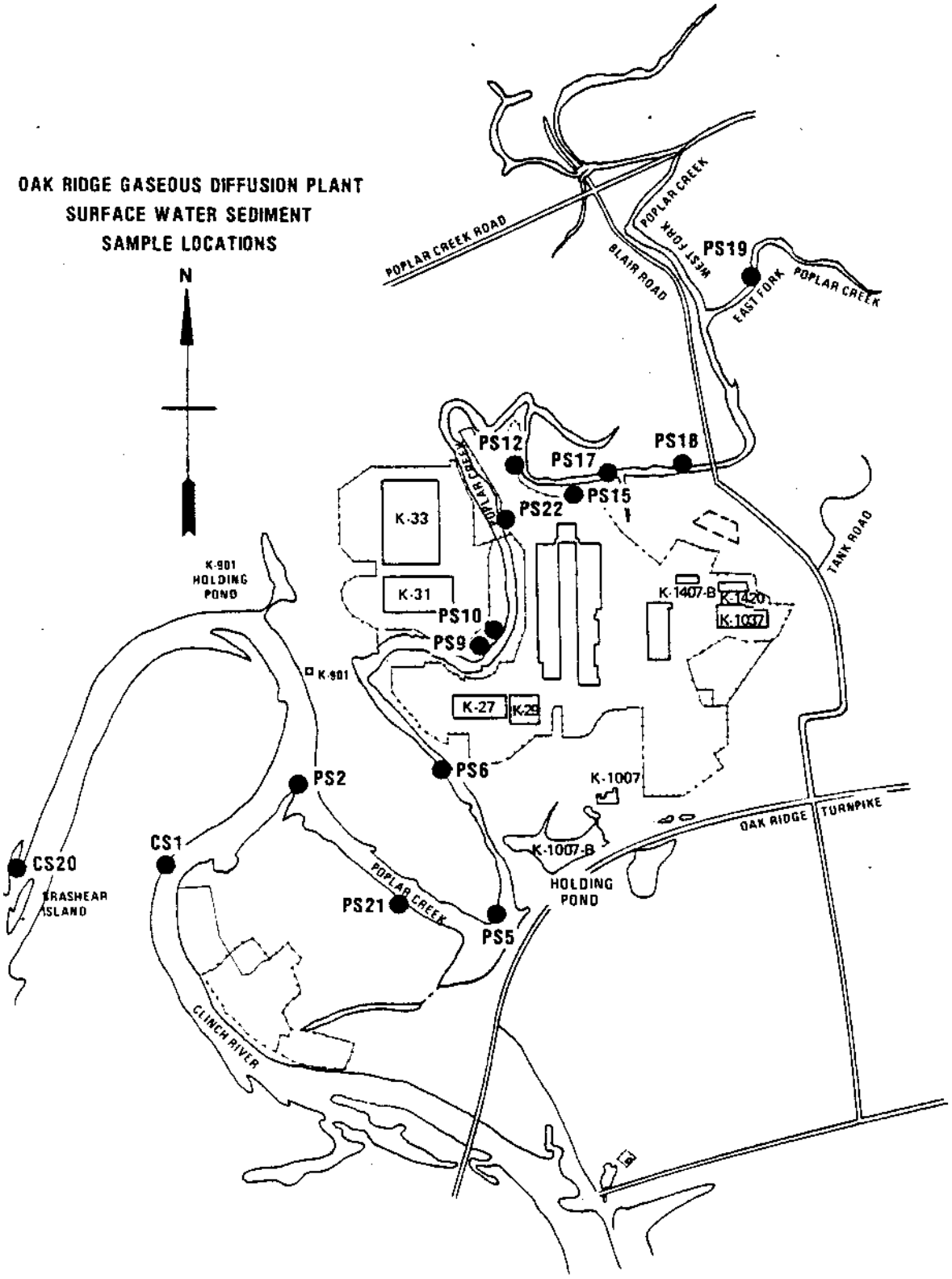

Figure 8

OAK RIDGE GASEOUS DIFFUSION PLANT SEDIMENT SAMPLING LOCATIONS

data presented in publications of the International Commission on Radiological Protection,[16-21] other recognized literature on radiation protection,[22-24] personal communication,[25] and computer programs incorporating some of these models and data.[26, 27] Radioactive material taken into the body by inhalation or ingestion will continuously irradiate the body until removed by processes of metabolism and radioactive decay; thus the estimates for internal dose are called "dose commitments;" they are obtained by integrating over the assumed remaining lifetime (50 years) of the exposed individual.

The radiation doses to the total body and to internal organs from external exposures to penetrating radiation are approximately equal, but they may vary considerably for internal exposures because some radionuclides concentrate in certain organs of the body. For this reason, estimates of radiation dose to the total body, thyroid, lungs, bone, liver, kidneys, and gastrointestinal tract were considered for various pathways of exposure. These estimates were based on parameters applicable to an average adult.[16, 21] The population dose estimate (in man-rem) is the sum of the total body doses to exposed individuals within an 80-kilometer radius of the Oak Ridge facilities.

Maximum Potential Exposure — The point of maximum potential exposure ("fence-post" dose) on the site boundary is located along the bank of the Clinch River adjacent to a cesium field experimental plot and is due primarily to "sky-shine" from the plot. A maximum potential total body exposure of 226 millirem/yr was calculated for this location assuming that an individual remained at this point for 24 hours/day for the entire year. The calculated maximum potential exposure is 45 percent of the allowable standard.[1] This is an atypical exposure location and the probability of an exposure of the magnitude calculated is considered remote since access is only by boat.

The total body dose to a "hypothetical maximum exposed individual" at the same location was calculated using a more realistic residence time of 240 hours/yr. The calculated dose under these conditions was 6.2 millirem/yr which is 1.2 percent of the allowable standard[1] and represents what is considered a probable upper limit of exposure.

A more probable exposure potential might be considered to occur at other locations beyond the site boundary as a result of airborne or liquid effluent releases.

The dose commitment to an individual continuously occupying the residence nearest the site boundary would result from inhalation and is based on an inhalation rate for the average adult of 2×10^4 liters/day. The calculated dose commitments at this location were 16.6 millrem to the lung (the critical organ) and 1.8 millirem to the total body; uranium-234 is the important radionuclide contributing to this dose. These levels are 1.1 percent and 0.4 percent, respectively, of the allowable annual standard. Due to inherent uncertainties in the meteorological data,[28] stack sampling data and calculational techniques, the calculated doses may be in error as much as 300%.

The most important contribution to dose from radioactivity within the terrestrial food-chain is by the atmosphere-pasture-cow-milk food-chain pathway. Measurements of the two principal radionuclides entering into this pathway, ^{131}I and ^{90}Sr (see Tables 25 and 26), indicate that the maximum dose to an individual in the immediate environs from ingestion of one liter of milk per day is 0.02 millirem to the thyroid and 1.5 millirem to the bone at

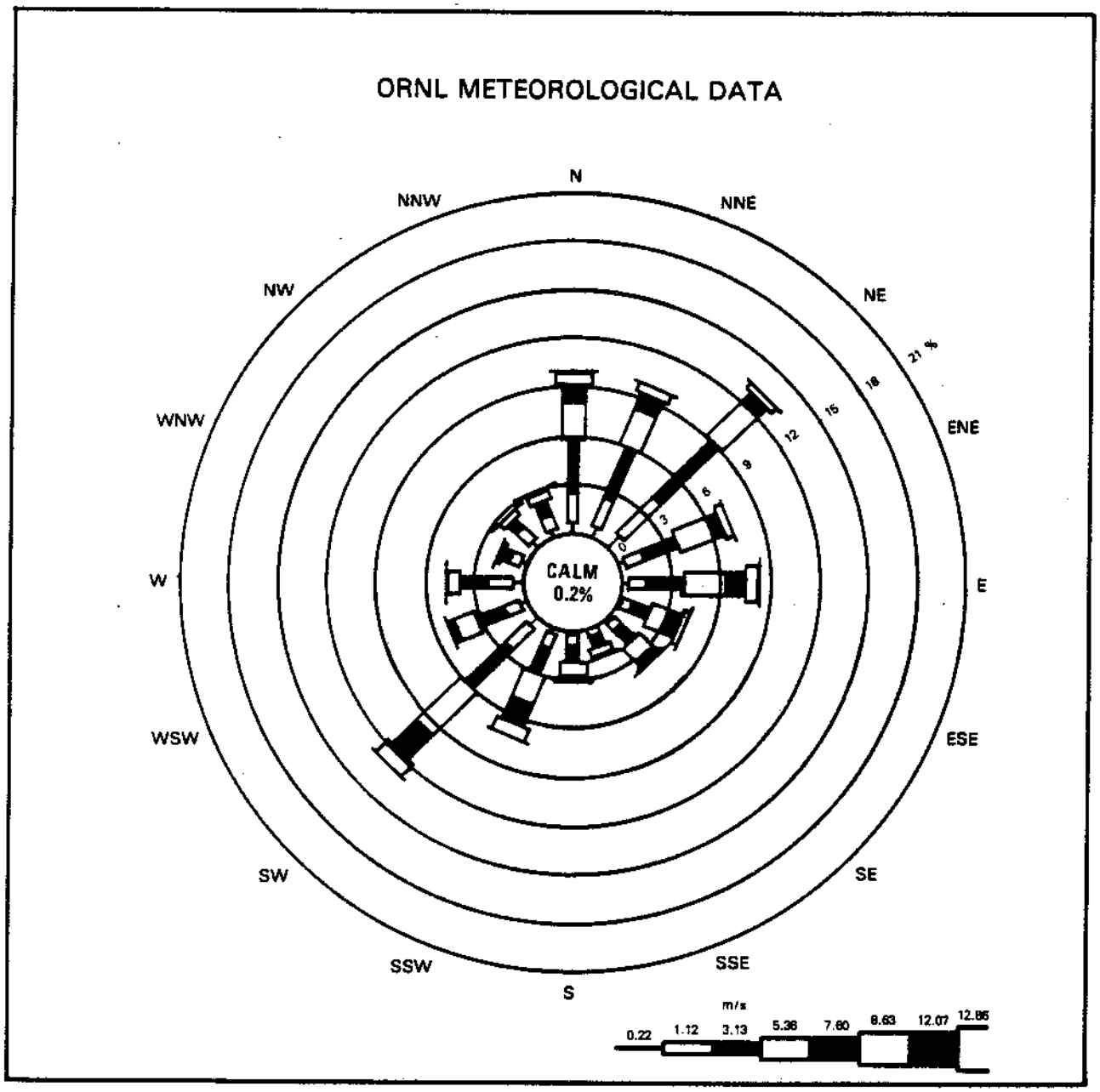

Figure 9
METEOROLOGICAL DATA FOR THE OAK RIDGE RESERVATION

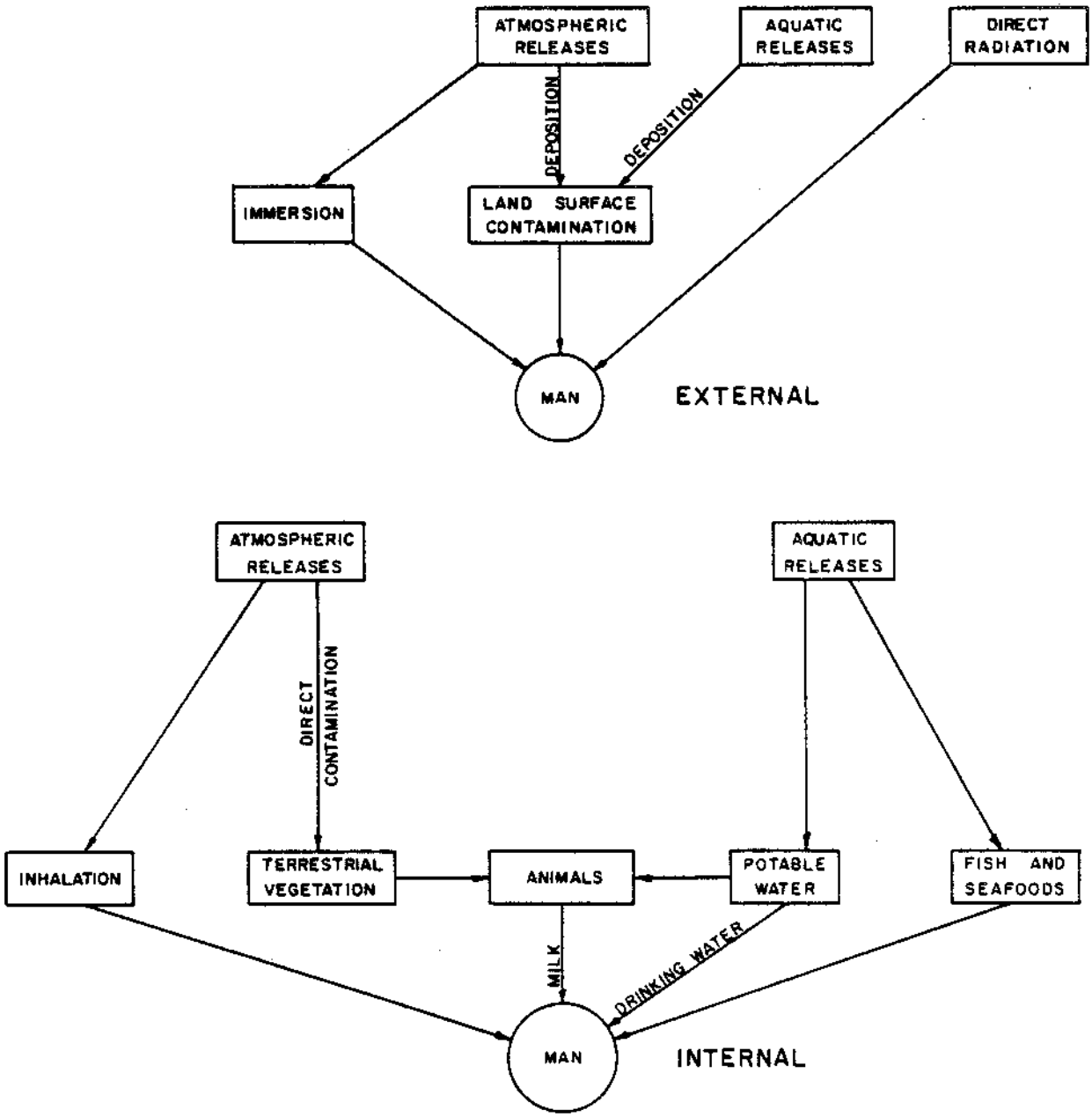

Figure 10
EXPOSURE PATHWAYS

Station 6. The average concentrations for the remote stations were assumed to be background and were subtracted from the perimeter station data in making the calculations.

The public water supply closest to the liquid discharges from the Oak Ridge facilities is located approximately 26 kilometers downstream at Kingston, Tennessee. The intake to the water filtration plant is located on the Tennessee River approximately one-half mile upstream from the confluence of the Clinch and Tennessee Rivers. Normally, Tennessee River water is used for the Kingston water supply but under certain conditions of power generation, backflow can occur. Under backflow conditions, Clinch River water may move upstream in the Tennessee River and be used as the source of water for the Kingston filtration plant. Measurements of untreated river water samples taken at the Kingston filtration plant intake indicate that the maximum dose commitment resulting from the ingestion of the daily adult requirement (about two liters per day) is 6.6 millirem to the bone and 0.15 millirem to the total body. The average concentrations in Melton Hill Dam water (background) were subtracted from the values obtained at Kingston.

Estimates of the 50-year dose commitment to an adult were calculated for consumption of 16.8 kilograms of fish per year from the Clinch River. The consumption of 16.8 kilograms[8] is about 2.5 times the national average fish consumption[29] and is used because of the popularity of fishing in East Tennessee. From the analysis of edible parts of the fish examined (see Table 27), the maximum possible organ dose commitment to an individual from the highest quarterly bluegill sample taken from CRM 20.8 is estimated to be 72 millirem to the bone from ^{90}Sr. The maximum total body dose to an individual was calculated to be 1.4 millirem.

A more probable dose commitment, based on the annual average concentration of ^{90}Sr in bluegill samples taken from CRM 20.8, was calculated to be 53 millirem to the bone and 1.1 millirem to the total body. These dose commitments are about 3.5 percent and 0.2 percent, respectively, of the allowable annual standards. Fish samples taken from Melton Hill Lake were analyzed to determine background conditions. Fish caught and consumed from other locations in the Clinch River would result in significantly less dose than the maximum calculated for CRM 20.8, see Table 27.

Summaries are given in Table 33 of the potential radiation doses to adult members of the general public at the points of highest potential exposure from gaseous and liquid effluents from the Oak Ridge facilities.

Dose to the Population – The Oak Ridge population received the largest average individual total body dose as a population group. The average total body dose to an Oak Ridge resident was estimated to be 0.11 millirem as compared to approximately 100 millirem/yr from natural background radiation; the average dose commitment to the lung of an Oak Ridge resident was 1.2 millirem. The maximum potential dose commitment to an Oak Ridge resident was calculated to be 16.6 millirem to the lung. This calculated dose is 1.1 percent of the allowable annual standard.[1]

The cumulative total body dose to the population within an 80 kilometer radius of the Oak Ridge facilities resulting from 1980 plant effluents was calculated to be 8.8 man-rem. This cumulative dose was calculated using the population distribution given in Table 1 for

ORNL atmospheric effluents; similar population distributions were used for the Y-12 and ORGDP releases. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation. About 14 percent of the collective dose from the effluents of the Oak Ridge facilities is estimated to be to the Oak Ridge population.

Table 1

INCREMENTAL POPULATION TABLE IN THE VICINITY OF ORNL[a]

DISTANCE, MILES DISTANCE, KM	0-1 0-1.6	1-2 1.6-3.2	2-3 3.2-4.8	3-4 4.8-6.4	4-5 6.4-8.0	5-10 8-16	10-20 16-32	20-30 32-48	30-40 48-64	40-50 64-80
Direction										
E	0	0	0	0	0	3,059	44,880	100,500	11,790	12,390
ENE	0	0	0	0	0	0	27,460	74,690	18,720	13,870
NE	0	0	0	0	0	9,713	12,480	7,167	4,392	7,476
NNE	0	0	0	0	1,461	13,780	4,362	11,190	12,670	6,119
N	0	0	0	0	1,490	5,578	2,177	1,441	2,223	4,508
NNW	0	0	0	0	0	1,495	0	1,152	4,559	4,676
NW	0	0	0	0	0	1,073	4,804	1,538	1,896	7,552
WNW	0	0	0	0	0	587	2,971	1,543	0	4,151
W	0	0	0	0	0	666	13,100	4,595	9,038	7,318
WSW	0	0	0	0	0	622	9,862	3,495	4,562	4,204
SW	0	0	0	0	0	733	1,840	1,909	3,962	8,578
SSW	0	0	0	0	0	721	2,055	7,897	21,580	10,530
S	0	0	0	0	0	943	8,742	7,309	6,560	1,222
SSE	0	0	0	0	1,374	7,277	1,290	4,091	469	0
SE	0	0	0	0	0	1,167	4,304	15,010	46	0
ESE	0	0	0	0	0	6,096	5,343	36,020	4,132	6,840
TOTAL	0	0	0	0	4,325	53,510	145,670	279,547	106,599	99,434
CUMULATIVE TOTAL	0	0	0	0	4,325	57,835	203,505	483,052	589,651	689,085

[a]Based on 1970 Census Data.

Table 2

CONTINUOUS AIR MONITORING DATA
Long-Lived Gross BETA Activity of Particulates in Air
1980

STATION	LOCATION	NUMBER OF SAMPLES	UNITS OF 10^{-13} μCi/ml			% CG[c]
			MAXIMUM[a]	MINIMUM[b]	AVERAGE	
			Perimeter Area[d]			
HP-31	Kerr Hollow Gate	50	0.7	0.07	0.25 ± 0.04	0.03
HP-32	Midway Gate	51	0.8	0.14	0.31 ± 0.05	0.03
HP-33	Gallaher Gate	52	2.4	0.11	0.30 ± 0.09	0.03
HP-34	White Oak Dam	52	0.9	0.12	0.32 ± 0.05	0.03
HP-35	Blair Gate	50	1.0	0.15	0.32 ± 0.05	0.03
HP-36	Turnpike Gate	52	0.6	0.06	0.25 ± 0.04	0.03
HP-37	Hickory Creek Bend	52	0.9	0.10	0.35 ± 0.05	0.04
HP-38	East of EGCR	52	0.8	0.06	0.26 ± 0.04	0.03
HP-39	Townsite	51	0.6	0.10	0.24 ± 0.03	0.02
Average					0.29 ± 0.05	0.03
			Remote Area[e]			
HP-51	Norris Dam	51	0.8	0.06	0.27 ± 0.05	0.03
HP-52	Loudoun Dam	52	1.4	0.04	0.26 ± 0.06	0.03
HP-53	Douglas Dam	52	0.9	0.10	0.27 ± 0.05	0.03
HP-54	Cherokee Dam	19	0.3	0.10	0.19 ± 0.03	0.02
HP-55	Watts Bar Dam	52	1.4	0.05	0.32 ± 0.08	0.03
HP-56	Great Falls Dam	52	0.8	0.05	0.38 ± 0.06	0.04
HP-57	Dale Hollow Dam	51	1.0	0.04	0.36 ± 0.07	0.04
HP-58	Knoxville	47	1.2	0.09	0.26 ± 0.06	0.03
Average					0.29 ± 0.06	0.03

[a]Maximum weekly average concentration.

[b]Minimum weekly average concentration-minimum detectable level is 1 x 10^{-15} μCi/ml.

[c]CG is 10^{-10} μCi/ml for unidentified radionuclides (DOE Manual, Appendix 0524, Annex A, Table II).

[d]See Figure 1.

[e]See Figure 2.

Table 3

CONTINUOUS AIR MONITORING DATA
Long-Lived Gross Alpha Activity of Particulates in Air
1980

STATION	LOCATION	NUMBER OF SAMPLES	UNITS OF 10^{-15} μCi/ml			% CG[c]
			MAXIMUM[a]	MINIMUM[b]	AVERAGE	
		Perimeter Area[d]				
HP-31	Kerr Hollow Gate	50	4.1	0.5	0.9 ± 0.2	0.02
HP-32	Midway Gate	51	2.8	0.6	1.1 ± 0.2	0.03
HP-33	Gallaher Gate	52	3.0	0.6	1.1 ± 0.2	0.03
HP-34	White Oak Dam	52	2.0	0.6	0.9 ± 0.1	0.02
HP-35	Blair Gate	50	23.3	0.5	1.5 ± 0.9	0.04
HP-36	Turnpike Gate	52	2.3	0.5	0.8 ± 0.1	0.02
HP-37	Hickory Creek Bend	52	2.7	0.6	0.9 ± 0.1	0.02
HP-38	East of EGCR	52	2.3	0.5	0.8 ± 0.1	0.02
HP-39	Townsite	51	2.3	0.6	0.9 ± 0.2	0.02
Average					1.0 ± 0.2	0.03
		Remote Area[e]				
HP-51	Norris Dam	51	3.0	0.5	1.2 ± 0.2	0.03
HP-52	Loudoun Dam	52	5.7	0.6	1.1 ± 0.2	0.03
HP-53	Douglas Dam	53	2.0	0.6	1.0 ± 0.1	0.03
HP-54	Cherokee Dam	19	2.0	0.6	1.1 ± 0.1	0.03
HP-55	Watts Bar Dam	52	4.7	0.7	1.5 ± 0.2	0.04
HP-56	Great Falls Dam	52	3.3	0.5	1.2 ± 0.2	0.03
HP-57	Dale Hollow Dam	51	5.2	0.5	1.2 ± 0.3	0.03
HP-58	Knoxville	47	3.5	0.5	1.0 ± 0.2	0.03
Average					1.2 ± 0.2	0.03

[a]Maximum weekly average concentration.

[b]Minimum weekly average concentration-minimum detectable level is 1 x 10^{-16} μCi/ml.

[c]CG is 40 x 10^{-13} μCi/ml for a mixture of uranium isotopes (DOE Manual, Appendix 0524, Annex A, Table II).

[d]See Figure 1.

[e]See Figure 2.

Table 4

CONTINUOUS AIR-MONITORING DATA
Specific Radionuclides in Air
(Composite Samples)
1980
Units of 10^{-15} μCi/ml

	PERIMETER STATIONS					REMOTE STATIONS				
RADIONUCLIDE	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Yearly Average	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Yearly Average
^{7}Be	95	109	101	78	96	89	91	82	67	82
^{90}Sr	0.01	0.18	0.02	0.12	0.08	0.07	0.14	0.05	0.17	0.11
^{106}Ru	0.33	0.72	NA	0.44	0.49	0.25	0.5	NA	0.57	0.44
^{125}Sb	0.11	NA	0.11	NA	0.11	0.13	NA	0.06	NA	0.13
^{137}Cs	0.28	0.67	0.28	0.23	0.37	0.25	0.44	0.19	0.13	0.25
^{144}Ce	0.39	0.72	NA	1.83	0.98	0.51	0.5	NA	2.01	0.87
^{228}Th	0.035	0.042	0.035	NA	0.037	0.02	0.009	0.016	NA	0.015
^{230}Th	0.03	0.038	0.033	0.017	0.03	0.01	0.01	0.015	0.007	0.011
^{232}Th	0.03	0.041	0.042	0.011	0.031	0.01	0.006	0.012	0.007	0.009
^{234}U	0.35	0.57	0.63	0.86	0.6	0.026	0.037	0.034	0.048	0.036
^{235}U	0.012	0.024	0.03	0.024	0.023	0.004	0.005	0.003	0.002	0.004
^{238}U	0.27	0.33	0.33	0.24	0.29	0.017	0.017	0.024	0.022	0.02
^{238}Pu	0.0001	0.002	0.0003	0.0008	0.0009	0.0002	0.0009	0.0003	0.0004	0.0004
^{239}Pu	0.004	0.009	0.001	0.002	0.004	0.002	0.009	0.002	0.002	0.004

NA - Not Available

Table 5

CONCENTRATION OF ^{131}I IN AIR MEASURED BY THE PERIMETER AIR MONITORING STATIONS[a]
1980

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-14} μCi/ml			% CG[d]
			MAXIMUM[b]	MINIMUM[c]	AVERAGE	
HP-31	Kerr Hollow Gate	50	0.3	0.02	0.14 ± 0.02	<0.01
HP-32	Midway Gate	51	0.3	0.02	0.14 ± 0.02	<0.01
HP-33	Gallaher Gate	52	0.3	0.02	0.14 ± 0.02	<0.01
HP-34	White Oak Dam	52	0.2	0.03	0.14 ± 0.02	<0.01
HP-35	Blair Gate	52	0.3	0.03	0.13 ± 0.02	<0.01
HP-36	Turnpike Gate	51	0.3	0.03	0.12 ± 0.02	<0.01
HP-37	Hickory Creek Bend	52	1.0	0.03	0.16 ± 0.04	<0.01
HP-38	East of EGCR	52	0.2	0.03	0.12 ± 0.02	<0.01
HP-39	Townsite	51	0.2	0.02	0.12 ± 0.01	<0.01
Average					0.13 ± 0.02	<0.01

[a]See Figure 1.

[b]Maximum weekly average concentration.

[c]Minimum weekly average concentration-minimum detectable amount of ^{131}I is 1×10^{-16} μCi/ml.

[d]CG is 1×10^{-10} μCi/ml (DOE Manual, Appendix 0524, Annex A, Table II).

Table 6
DISCHARGES OF RADIOACTIVITY TO THE ATMOSPHERE
1980

RADIONUCLIDE	CURIES DISCHARGED
Uranium[a]	0.2
^{131}I	0.2
^{3}H	14,800
^{133}Xe[b]	<42,800
^{85}Kr[b]	< 8,800
^{99}Tc	0.9
^{134}Cs	0.004
^{137}Cs	0.002
Alpha[c]	4.9×10^{-6}

[a]Uranium of varying enrichments - curie quantities calculated using the appropriate specific activity for material released.

[b]Upper limit values based on direct radiation measurements in the stack gas stream and an assumed mixture of noble gases.

[c]Unidentified alpha.

Table 7

AIR MONITORING DATA - FLUORIDES

1980

Location[a]	Number of Samples	Maximum Concentration for Averaging Interval $\mu g/m^3$		Number of Times Standard Exceeded[b]		Annual Average $\mu g/m^3$
	7 Day	7 Day	30 Day	7 Day	30 Day	
F-1	53	0.4	0.2	0	0	<0.1 ± 0.02
F-2	50	1.2	0.7	0	0	0.3 ± 0.08
F-3	53	0.5	0.3	0	0	<0.2 ± 0.04
F-4	53	0.3	0.2	0	0	<0.1 ± 0.02
F-5	51	0.2	0.1	0	0	<0.1 ± 0.01
F-6[c]	50	0.2	0.1	0	0	<0.1 ± 0.01

[a]See Figure 1.

[b]Tennessee Air Pollution Control Regulations-

3.7 $\mu g/m^3$ for 12 hour averaging interval

2.9 $\mu g/m^3$ for 24 hour averaging interval

1.6 $\mu g/m^3$ for 7 day averaging interval

1.2 $\mu g/m^3$ for 30 day averaging interval

All values are maximum-not to be exceeded more than once per year.

[c]Station F-6 approximately 8 kilometers from ORGDP upwind of the predominant prevailing wind direction, thus may be considered representative of general ambient background concentration.

NOTE: Data not amenable to comparison with 12-hour or 24-hour standard.

Table 8

AIR MONITORING DATA - SUSPENDED PARTICULATES
1980

LOCATION[a]	NUMBER OF SAMPLES	CONCENTRATION, $\mu g/m^3$			% STD.[b]
		MAXIMUM	MINIMUM	AVERAGE	
SP-1	45	90	1	30 ± 8	40
SP-2	42	93	2	31 ± 7	41
SP-3	37	108	3	33 ± 9	44
SP-4	41	99	1	26 ± 8	35

[a]See Figure 1.

[b]Tennessee Ambient Air Standards - Primary Standard.

Maximum 24 hr. Average — 260 $\mu g/m^3$

Annual Geometric Mean — 75 $\mu g/m^3$

Table 9
SULFUR DIOXIDE MONITORING DATA
1980

MONTH	MAXIMUM 24 HR. AVERAGE (PPM)		MONTHLY AVERAGE (PPM)	
	STATION S-1	STATION S-2	STATION S-1	STATION S-2
January	No Data	.033	No Data	.006
February	.042	.053	.007	.012
March	.037	.026	.009	.005
April	.004	.041	.010	.002
May	.015	.014	.006	.004
June	.002	.015	.002	.005
July	.017	.016	.007	.007
August	.020	.016	.011	.007
September	.018	.012	.011	.004
October	.027	.009	.013	.003
November	.033	.017	.010	.003
December	.023	.034	.004	.007
Annual Arithmetic Mean			.007	.005

Tennessee Ambient Standards

Maximum 24 hr. Average — 0.14 ppm

Annual Arithmetic Mean — 0.03 ppm

Minimum Detectable Limit — 0.002 ppm

Table 10
EXTERNAL GAMMA RADIATION MEASUREMENTS
1980

STATION NUMBER	LOCATION	NUMBER OF MEASUREMENTS TAKEN	BACKGROUND	
			μR/hr	mR/yr
		Perimeter Stations[a]		
HP-31	Kerr Hollow Gate	12	8.3 ± 1.6	73 ± 14
HP-32	Midway Gate	11	9.7 ± 2.6	85 ± 23
HP-33	Gallaher Gate	12	7.8 ± 1.8	68 ± 15
HP-34	White Oak Dam	12	16.0 ± 3.8	140 ± 33
HP-35	Blair Gate	11	7.6 ± 1.7	67 ± 15
HP-36	Turnpike Gate	11	7.3 ± 1.6	64 ± 14
HP-37	Hickory Creek Bend	10	8.9 ± 1.6	78 ± 13
HP-38	East of EGCR	12	8.0 ± 1.1	70 ± 10
HP-39	Townsite	12	7.3 ± 1.5	64 ± 13
Average			9.0 ± 1.3	79 ± 15
		Remote Stations[b]		
HP-51	Norris Dam	2	5.4 ± 0.33	47 ± 3
HP-52	Loudoun Dam	2	7.1 ± 0.70	62 ± 6
HP-53	Douglas Dam	2	7.3 ± 0.5	64 ± 5
HP-55	Watts Bar Dam	2	6.2 ± 0.4	54 ± 3
HP-56	Great Falls Dam	2	8.0 ± 3.2	70 ± 28
HP-57	Dale Hollow Dam	2	9.7 ± 1.6	85 ± 4
HP-58	Knoxville	2	10.2 ± 0.3	89 ± 2
Average			7.7 ± 1.7	67 ± 12

[a]See Figure 1.

[b]See Figure 2.

Table 11

RADIONUCLIDES IN THE CLINCH RIVER
1980

LOCATION	NUMBER OF SAMPLES	RANGE	CONCENTRATION OF RADIONUCLIDES OF PRIMARY CONCERN UNITS OF 10^{-9} μCi/ml					% CG[a]
			^{90}Sr	^{137}Cs	^{106}Ru	^{60}Co	^{3}H	
C-2CRM 23.1	4	Max.	0.23	0.18	0.27	0.23	850	
		Min.	0.05	<0.01	0.05	0.05	700	
		Avg.	0.11 ± 0.08	<0.07 ± 0.07	0.17 ± 0.09	0.11 ± 0.08	760 ± 80	<0.07
C-3 CRM 14.5	4	Max.	1.82	0.18	0.27	0.41	3,233	
		Min.	0.18	<0.01	0.05	0.09	745	
		Avg.	0.75 ± 0.7	<0.08 ± 0.08	0.17 ± 0.09	0.21 ± 0.15	1,510 ± 1,190	<0.16
C-5 CRM 4.5	4	Max.	3.55	1.8	1.36	0.18	1,860	
		Min.	0.09	<0.01	0.09	0.05	600	
		Avg.	1.2 ± 1.6	<0.07 ± 0.07	0.64 ± 0.5	0.08 ± 0.07	960 ± 600	<0.11

[a]Most restrictive concentration guide for each isotope used for calculating percent concentration guide. The method for calculating percent of concentration guide for a known mixture of radionuclides is given in DOE Manual, Appendix 0524, Annex A.(1)

Table 12

URANIUM CONCENTRATION IN SURFACE STREAMS
1980

STATION NUMBER[a]	LOCATION	NUMBER OF SAMPLES	UNITS OF 10^{-8} μCi/ml			% CG[b]
			MAXIMUM	MINIMUM	AVERAGE	
P-1	Poplar Creek	12	0.7	<0.07	<0.2 ± 0.1	<0.1
P-2	Poplar Creek	12	1.0	<0.07	<0.4 ± 0.2	<0.1
C-3	Clinch River	12	0.1	<0.07	<0.09 ± 0.02	<0.1
C-4	Clinch River	12	0.5	<0.07	<0.2 ± 0.1	<0.1
C-6	Clinch River	12	0.2	<0.07	<0.1 ± 0.03	<0.1
E-1	East Fork Poplar Creek	11	6.9	3.1	5.2 ± 1.3	0.2
B-1	Bear Creek	11	3.7	0.8	1.8 ± 0.9	0.1

[a]See Figure 3.

[b]CG is 3×10^{-5} μCi/ml for a mixture of uranium isotopes (DOE Manual, Appendix 0524, Annex A, Table II).

Table 13
DISCHARGES OF RADIOACTIVITY TO SURFACE STREAMS
1980

RADIONUCLIDE	CURIES DISCHARGED
^{137}Cs	0.6
^{60}Co	1.37
^{3}H	3,370
^{131}I	0.09
^{106}Ru	<0.01
^{90}Sr	1.35
^{99}Tc	5.1
Uranium[a]	0.6
^{232}Th	0.008
Transuranics[b]	0.04

[a]Uranium of varying enrichments – curie quantities calculated using the appropriate specific activity for material released.

[b]Value based on gross transuranic alpha emitter analysis.

Table 14
LONG-LIVED GROSS BETA ACTIVITY IN RAINWATER
1980

STATION NUMBER	LOCATION	NUMBER SAMPLES TAKEN	UNITS OF 10^{-8} μCi/ml[a]
		Perimeter Area[b]	
HP-31	Kerr Hollow Gate	38	1.0 ± 0.2
HP-32	Midway Gate	36	0.8 ± 0.2
HP-33	Gallaher Gate	41	1.2 ± 0.3
HP-34	White Oak Dam	40	1.0 ± 0.3
HP-35	Blair Gate	38	0.9 ± 0.2
HP-36	Turnpike Gate	36	0.8 ± 0.3
HP-37	Hickory Creek Bend	36	0.8 ± 0.2
HP-38	East of EGCR	40	1.3 ± 0.2
HP-39	Townsite	36	1.0 ± 0.3
Average			1.0 ± 0.2
		Remote Area[c]	
HP-51	Norris Dam	43	3.1 ± 0.3
HP-52	Loudoun Dam	27	4.7 ± 0.3
HP-53	Douglas Dam	26	2.4 ± 0.4
HP-54	Cherokee Dam	27	2.0 ± 0.5
HP-55	Watts Bar Dam	28	2.6 ± 0.4
HP-56	Great Falls Dam	30	2.7 ± 0.4
HP-57	Dale Hollow Dam	27	3.1 ± 0.3
HP-58	Knoxville	37	2.4 ± 0.5
Average			2.9 ± 0.2

[a]Weekly average concentration.

[b]See Figure 1.

[c]See Figure 2.

Table 15

CHEMICAL WATER QUALITY DATA – WHITE OAK DAM
(Location W-1, Figure 3)
1980

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cr	10	<0.01	<0.01	<0.01	0.05	<20
Zn	10	<0.02	<0.02	<0.02	0.1	<20
NO_3(N)	10	9.8	0.01	4.6 ± 2.2	10	46
Hg	12	<0.001	<0.001	<0.001	0.005	<20

[a]Tennessee Stream Guidelines.

Table 16

CHEMICAL WATER QUALITY DATA – MELTON HILL DAM
(Location C-2, Figure 3)
1980

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cr	10	<0.01	<0.01	<0.01	0.05	<20
Zn	10	<0.02	<0.02	<0.02	0.1	<20
NO_3(N)	10	2.2	0.1	<0.55 ± 0.5	10	< 6
Hg	11	<0.001	<0.001	<0.001	0.005	<20

[a]Tennessee Stream Guidelines.

Table 17

CHEMICAL WATER QUALITY DATA – ORGDP SANITARY WATER PUMPING STATION
(Location C-3, Figure 3)
1980

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.003	< 0.002	< 0.002 ± 0.0002	0.01	<20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	<20
CN	12	< 0.002	< 0.002	< 0.002	0.01	<20
NO_3(N)	12	1.3	0.2	0.5 ± 0.2	10	5
Pb	12	< 0.01	< 0.01	< 0.01	0.05	<20
$SO_4^=$	12	32	14	23 ± 4	250	9
T.D.S.	12	172	86	141 ± 17	500	28
Zn	12	0.2	< 0.02	< 0.06 ± 0.3	0.1	<60
F^-	12	0.1	< 0.1	< 0.1	1	<10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.2	< 0.01	< 0.02 ± 0.03	0.1	<20

[a]Tennessee Stream Guidelines.

Table 18

CHEMICAL WATER QUALITY DATA – ORGDP RECIRCULATING WATER PUMPING STATION
(Location C-4, Figure 3)
1980

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.004	< 0.002	< 0.002 ± 0.0004	0.01	<20
Cr	12	0.03	< 0.01	< 0.01 ± 0.003	0.05	<20
CN	12	< 0.002	< 0.002	< 0.002	0.01	<20
NO_3(N)	12	2.8	0.2	0.6 ± 0.4	10	6
Pb	12	< 0.01	< 0.01	< 0.01	0.05	<20
$SO_4^=$	12	35	17	23 ± 4	250	9
T.D.S.	12	283	64	183 ± 36	500	37
Zn	12	0.1	< 0.02	< 0.06 ± 0.01	0.1	<60
F^-	12	0.1	< 0.1	< 0.1	1	<10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.2	< 0.01	< 0.03 ± 0.04	0.1	<30

[a]Tennessee Stream Guidelines.

Table 19

CHEMICAL WATER QUALITY DATA – CLINCH RIVER DOWNSTREAM OF ORGDP
(Location C-6, Figure 3)
1980

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.003	< 0.002	< 0.002 ± 0.0002	0.01	<20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	<20
CN	12	< 0.002	< 0.002	< 0.002	0.01	<20
NO_3(N)	12	2.7	0.1	0.6 ± 0.4	10	6
Pb	12	< 0.01	< 0.01	< 0.01	0.05	<20
$SO_4^=$	12	30	4	19 ± 4	250	8
T.D.S.	12	219	110	162 ± 19	500	32
Zn	12	0.06	0.01	0.03 ± 0.01	0.1	30
F^-	12	0.2	< 0.1	< 0.1 ± 0.01	1	<10
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.1	< 0.01	< 0.02 ± 0.02	0.1	<20

[a]Tennessee Stream Guidelines.

Table 20

CHEMICAL WATER QUALITY DATA – EAST FORK POPLAR CREEK
(Location E-1, Figure 3)
1980

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.002	< 0.002	< 0.002	0.01	< 20
Cl^-	12	21	< 2	< 7 ± 6	250	< 3
Cr	12	< 0.01	< 0.01	< 0.01	0.05	< 20
F^-	12	1.3	0.7	1.0 ± 0.2	1	100
Hg	12	0.003	< 0.001	< 0.002 ± 0.001	0.005	< 40
NO_3(N)	12	5.2	0.7	2.7 ± 1.2	10	27
Pb	12	0.03	< 0.01	< 0.02 ± 0.01	0.05	< 40
$SO_4^=$	12	63	18	39 ± 11	250	16
T.D.S.	12	241	177	201 ± 20	500	40
Zn	12	0.05	< 0.02	< 0.03 ± 0.01	0.1	< 30

[a]Tennessee Stream Guidelines.

Table 21

CHEMICAL WATER QUALITY DATA – BEAR CREEK
(Location B-1, Figure 3)
1980

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.002	< 0.002	< 0.002	0.01	<20
Cl^-	12	13	< 2	< 4 ± 3	250	< 2
F^-	12	0.4	< 0.1	< 0.2 ± 0.1	1	<20
NO_3(N)	12	25	< 0.1	< 8 ± 7	10	<80
$SO_4^=$	12	24	<10	<11 ± 5	250	< 5
Zn	12	0.02	< 0.02	< 0.02	0.1	<20

[a]Tennessee Stream Guidelines.

Table 22

CHEMICAL WATER QUALITY DATA – POPLAR CREEK ABOVE BLAIR BRIDGE
(Location P-1, Figure 3)

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.004	< 0.002	< 0.002 ± 0.0004	0.01	<20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	<20
CN	12	< 0.002	< 0.002	< 0.002	0.01	<20
NO_3(N)	12	4	0.2	1 ± 0.6	10	10
Pb	12	0.01	< 0.01	< 0.01	0.05	<20
$SO_4^{=}$	12	70	31	41 ± 7	250	16
T.D.S.	12	317	126	220 ± 40	500	44
Zn	12	0.3	< 0.02	< 0.06 ± 0.04	0.1	<60
F^-	12	0.4	0.1	0.2 ± 0.06	1	20
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.2	< 0.01	< 0.03 ± 0.03	0.1	<30

[a]Tennessee Stream Guidelines.

Table 23

CHEMICAL WATER QUALITY DATA – POPLAR CREEK NEAR CLINCH RIVER
(Location P-2, Figure 3)
1980

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD.
		MAXIMUM	MINIMUM	AVERAGE	STD.[a]	
Cd	12	0.004	< 0.002	< 0.002 ± 0.0004	0.01	<20
Cr	12	< 0.01	< 0.01	< 0.01	0.05	<20
CN	12	< 0.002	< 0.002	< 0.002	0.01	<20
NO_3(N)	12	3.2	0.1	0.9 ± 0.5	10	9
Pb	12	0.01	< 0.01	< 0.01	0.05	<20
$SO_4^{=}$	12	86	23	34 ± 11	250	14
T.D.S.	12	270	127	186 ± 27	500	37
Zn	12	0.09	< 0.02	< 0.04 ± 0.02	0.1	<40
F^{-}	12	0.3	< 0.1	< 0.2 ± 0.04	1	<20
Hg	12	< 0.001	< 0.001	< 0.001	0.005	<20
Ni	12	0.07	< 0.01	< 0.02 ± 0.01	0.1	<20

[a]Tennessee Stream Guidelines.

Table 24

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) EXPERIENCE 1980

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/l	EFFLUENT LIMITS DAILY MAXIMUM mg/l	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
ORNL				
001				
(White Oak Creek)	Dissolved Oxygen (min.)	5	--	95
	Dissolved Solids	--	2000	97
	Oil and Grease	10	15	100
	Chromium (Total)	--	0.05	96
	pH (pH units)	--	6.0 – 9.0	98
002				
(Melton Branch)	Chromium (total)	--	0.05	98
	Dissolved Solids	--	2000	92
	Oil and Grease	10	15	100
	pH (pH units)	--	6.0 – 9.0	100
003				
(Main Sanitary Treatment Facility)	Ammonia (N)	--	5	29
	BOD	--	20	83
	Chlorine Residual	--	0.5 – 2.0	93
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	100
	pH (pH units)	--	6.0 – 9.0	100
	Suspended Solids	--	30	89
	Settleable Solids (ml/l)	--	0.5	98
004				
(7900 Area Sanitary Treatment Facility)	BOD	--	30	No Discharges From This Facility
	Chlorine Residual	--	0.5 – 2.0	
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	
	pH (pH units)	--	6.0 – 9.0	
	Suspended Solids	--	30	
	Settleable Solids (ml/l)	--	0.5	
Y-12 PLANT				
001				
(Kerr Hollow Quarry)	Dissolved Solids	--	2000	100
	Lithium	--	5	100
	pH (pH units)	--	6.0 – 9.0	100
	Suspended Solids	--	50	100
	Zirconium	--	3	No Disposals
002				
(Rogers Quarry)	pH (pH units)	--	6.0 – 9.0	89
	Suspended Solids[a]	30	50	100
	Setteable Solids (ml/l)[(a)]	--	0.5	100

Table 24
(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/l	EFFLUENT LIMITS DAILY MAXIMUM mg/l	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
003				
(New Hope Pond)	Ammonia (N)	– –	1.6	100
	Chromium	0.05	0.08	100
	Dissolved oxygen (Min.)	5	– –	96
	Dissolved Solids	– –	2000	100
	Fluoride	1.5	2.0	92
	Lithium	– –	5	100
	Oil and Grease	10	15	92
	ph (pH units)	– –	6.0 – 9.0	99
	Phosphate (as MBAS)	5	8	100
	Suspended Solids[a]	– –	20	94
	Settleable Solids (ml/l)[a]	– –	0.5	96
	Total Nitrogen (N)	– –	20	100
	Zinc	0.1	0.2	94
004				
(Bear Creek)	Oil and Grease	10	15	100
	pH (pH units)	– –	6.0 – 8.5	100
ORGDP				
001				
(K-1700 Discharge)	Aluminum	– –	1.0	100
	Chromium (Total)	0.05	0.08	100
	Nitrate	– –	20	100
	Suspended Solids	30	50	100
	Oil and Grease	10	15	100
	pH (pH units)	– –	6.0 – 9.0	93
002				
(K-1410 Metal Plating Facility)	Cyanide	– –	None Detectable	100
	Oil and Grease	10	15	100
	pH (pH units)	– –	6.0 – 9.0	100
004				
(K-1131 Steam Condensate Discharge)	pH (pH units)	– –	6.0 – 9.0	100
	Flow (MGD)	0.005	0.008	100
005				
(K-1203 Sanitary Treatment Facility)	Ammonia (N)	5[b]	7[c]	100
	BOD	15[b]	20[c]	86
	Chlorine Residual	– –	0.5 – 2.0	95
	Dissolved Oxygen (Min.)	5	– –	100
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	100
	pH (pH units)	– –	6.0 – 9.0	100
	Suspended Solids	30[b]	45[c]	94
	Settleable Solids (ml/l)	– –	0.5	89

Table 24

(CONTINUED)

DISCHARGE POINT	EFFLUENT PARAMETERS	EFFLUENT LIMITS DAILY AVERAGE mg/l	EFFLUENT LIMITS DAILY MAXIMUM mg/l	PERCENTAGE OF MEASUREMENTS IN COMPLIANCE
006				
(K-1007B Holding Pond)	COD	20	25	100
	Chromium	– –	0.05	100
	Dissolved Oxygen (Min.)	5	– –	100
	Fluoride	1.0	1.5	100
	Oil and Grease	10	15	100
	pH (pH units)	– –	6.0 – 9.0	100
	Suspended Solids[a]	30	50	100
007				
(K-901A Holding Pond)	Chromium (total)	– –	0.05	98
	Fluoride	1.0	1.5	92
	Oil and Grease	10	15	100
	pH (pH units)	– –	6.0 – 10	100
	Suspended Solids	30	50	100
008[d]				
(K-710 Sanitary Treatment Facility)	BOD	30[b]	45[c]	No Discharges
	Suspended Solids	30[b]	45[c]	From This
	Fecal Coliform Bact. (No/100 ml)	200[b]	400[c]	Facility
	pH (pH units)	– –	6.0 – 9.0	
	Chlorine Residual	– –	0.5 – 2.0	
	Settleable Solids (ml/l)	– –	0.1	
009				
(Sanitary Water Plant)	Suspended Solids[a]	30	50	100
	Aluminum	– –	250	100
	Sulphate	– –	1400	100
	pH (pH units)	– –	6.0 – 9.0	100

[a]Limit applicable only during normal operations. Not applicable during periods of increased discharge due to surface run-off resulting from precipitation.

[b]Monthly Average.

[c]Weekly Average.

[d]Due to the small flow rates at the K-710 Sanitary Treatment Facility, a rapid sand filter was installed May 1, 1978 eliminating the surface discharge and monitoring requirements.

Table 25
CONCENTRATION OF ^{131}I IN MILK[a]
1980

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF 10^{-9} μci/ml			COMPARISON WITH STANDARDS[c]
		MAXIMUM	MINIMUM[b]	AVERAGE	
		Immediate Environs[d]			
1	46	0.46	<0.45	<0.45	Range I
2	49	0.45	<0.45	<0.45	Range I
3	46	0.45	<0.45	<0.45	Range I
4	45	0.62	<0.45	<0.45 ± 0.06	Range I
5	48	0.62	<0.45	<0.45 ± 0.06	Range I
6	46	1.30	<0.45	<0.48 ± 0.3	Range I
7	46	0.62	<0.45	<0.45 ± 0.1	Range I
Average				<0.45 ± 0.05	
		Remote Environs[e]			
51	7	<0.45	<0.45	<0.45	Range I
52	4	<0.45	<0.45	<0.45	Range I
53	9	<0.45	<0.45	<0.45	Range I
56	8	<0.45	<0.45	<0.45	Range I
57	6	<0.45	<0.45	<0.45	Range I
Average				<0.45	

[a]Raw milk samples, except for Station 2 which is a dairy.

[b]Minimum detectable concentration of ^{131}I is 0.45×10^{-9} μCi/ml.

[c]Applicable FRC standard, assuming 1 liter per day intake:

Range I	0 to 1×10^{-8} μCi/ml	- Adequate surveillance required to confirm calculated intakes.
Range II	1×10^{-8} μCi/ml to 1×10^{-7} μCi/ml	- Active surveillance required.
Range III	1×10^{-7} μCi/ml to 1×10^{-6} μCi/ml	- Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[d]See Figure 6.

[e]See Figure 7.

Table 26
CONCENTRATION OF ^{90}Sr IN MILK[a]
1980

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF 10^{-9} μCi/ml			COMPARISON WITH STANDARDS[c]
		MAXIMUM	MINIMUM[b]	AVERAGE	
		Immediate Environs[d]			
1	46	4.7	0.4	1.7 ± 0.2	Range I
2	48	2.7	0.7	1.5 ± 0.1	Range I
3	46	2.6	0.8	1.6 ± 0.1	Range I
4	45	7.0	0.9	2.0 ± 0.3	Range I
5	32	2.8	0.8	1.6 ± 0.1	Range I
6	49	2.8	0.4	2.1 ± 0.2	Range I
7	48	2.7	0.8	1.6 ± 0.1	Range I
Average				1.7 ± 0.2	
		Remote Environs[e]			
51	7	2.7	0.8	2.0 ± 0.5	Range I
52	4	1.9	0.8	1.2 ± 0.5	Range I
53	9	2.7	0.7	1.0 ± 0.4	Range I
56	8	1.8	0.8	1.3 ± 0.2	Range I
57	6	3.5	2.0	2.4 ± 0.8	Range I
Average				1.6 ± 0.5	

[a]Raw milk samples, except for Station 2 which is a dairy.

[b]Minimum detectable concentration of ^{90}Sr in milk is 0.5×10^{-9} μCi/ml.

[c]Applicable FRC standard, assuming 1 liter per day intake:

Range I	0 to 2×10^{-8} μCi/ml	- Adequate surveillance required to confirm calculated intakes.
Range II	2×10^{-8} μCi/ml to 2×10^{-7} μCi/ml	- Active surveillance required.
Range III	2×10^{-7} μCi/ml to 2×10^{-6} μCi/ml	- Positive control action required.

Note: Upper limit of Range II can be considered the concentration guide.

[d]See Figure 6.

[e]See Figure 7.

Table 27

RADIONUCLIDE CONTENT IN CLINCH RIVER FISH

1980

pCi/kg Wet Weight

LOCATION	Species[a]	^{90}Sr	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U	^{137}Cs	^{60}Co	^{40}K	% MPI[b]	Hg (ng/g)	% of A.L.[c]
CRM 5.0	Bass	5.2	0.01	0.01	0.1	0.02	0.3	122	1.5	3573	0.03	157	31%
	Blue Gill	5.2	0.01	0.05	0.26	0.06	0.42	66	1.4	3900	0.04	220	44
	Carp	19.2	0.13	0.06	0.72	0.18	1.4	67	2.4	4277	0.14	199	40
	Shad	17.6	0.03	0.03	4.8	0.48	6.6	97	4	3917	0.08	25	5
	Crappie	13.9	0.01	0.01	6.3	0.21	0.94	77	5.6	3831	0.11	65	13
CRM 12.0	Bass	9	0.13	0.01	0.72	0.11	1.1	334	7.9	3475	0.10	430	86
	Blue Gill	14.4	0.09	0.12	1.4	0.11	2.4	34.6	5.3	4771	0.10	470	94
	Carp	4.2	0.01	0.01	0.38	0.05	0.52	27.5	2.7	3480	0.03	102	20
	Shad	53	0.17	0.04	11.9	0.75	16.3	66	4.4	2948	0.38	18.2	4
	Crappie	10.8	0.03	0.08	0.32	0.06	0.50	79	3.2	3338	0.09	122	24
CRM 20.8[d]	Bass	14.4	0.07	0.04	0.16	0.04	0.3	136	6.8	3278	0.11	99	20
	Blue Gill	391	0.28	0.26	1.4	0.44	1.4	1289	59	4406	2.86	219	44
	Carp	49	0.05	0.01	0.32	0.06	0.49	233	15.3	3584	0.37	193	39
	Shad	18.7	0.53	0.07	2.4	0.28	3.7	345	34	3163	0.17	24	5
	Crappie	12.9	0.25	0.01	1.1	0.16	1.3	47	5.1	3625	0.10	45	9
CRM 25.0	Bass	5.4	0.03	0.03	0.68	0.57		4.7	2.5	4057	0.04	11	2
	Blue Gill	7.7	0.1	0.16	1.7	0.52	(NO	14	4.8	4608	0.06	59	12
	Carp	3.2	0.02	0.03	0.5	0.08	DATA)	8.4	1.7	2854	0.02	109	4
	Shad	6.6	0.43	0.08	0.48	0.07		9	2.2	4136	0.05	7.4	1
	Crappie	0.72	0.03	0.16	1.3	0.75		3.4	2.9	3949	0.01	21	22

[a]Composite of 10 fish in each species.

[b]Maximum Permissible Intake - Intake of radionuclide from eating fish is calculated to be equal to a daily intake of 2.2 liters of water over a period of one year, containing the concentration guide of radionuclides in question. Consumption of fish is assumed to be 16.8 kg/yr of the species in question. Only man-made radionuclides were used in the calculation.

[c]Percent of proposed FDA Mercury in fish action level of 500 ng/g; Mercury data included in this table as a matter of convenience.

[d]Average of quarterly samples.

Table 28
^{137}Cs CONCENTRATION IN DEER SAMPLES
1980
pCi/kg Wet Weight

SAMPLE NUMBER	MUSCLE	LIVER
1	10	43
2	30	<10
3	< 10	<10*
4	27	15
5	10	<10
6	< 10	<10
7	< 10	<10
8	< 10	<10
9	27	<10
10	41	<10
11	27	17
12	68	38
13	60	30
14	< 10	<10
15	< 10	<10
16	78	15
17	103	70
18	24	<10
19	38	<10

*This liver sample contained 18 pCi/kg ^{60}Co.

Table 29
VEGETATION SAMPLING DATA
1980

STATION NUMBER[a]	F^- CONCENTRATION[b] µg/g (ppm)		U (TOTAL) CONCENTRATION[b] µg/g (ppm)	
	GRASS	PINE NEEDLES	GRASS	PINE NEEDLES
1	12	–	0.6	–
2	8	< 7	1.6	0.2
3	9	5	1.2	0.3
4	6	7	0.7	0.2
5	8	15	0.7	0.5
6	6	6	0.6	0.3
7	7	6	0.5	0.2
8	14	9	0.6	0.4
9	7	6	0.7	0.2
10	11	< 7	0.5	0.1
11	15	13	1.7	1.1
12	8	4	0.4	0.4
13	13	–	1.1	–
14	9	–	0.5	–
15	24	–	0.6	–
16	14	–	1.2	–
17	8	–	0.8	–

[a]See Figure 1.

[b]Average concentration of two sample collections, January and July. Analytical results are on a dry weight basis.

NOTE: Applicable guides for flora have not been established. However, for comparison the *American Industrial Hygiene Association Journal* for January-February 1969 (pp. 98-101) states that dairy cattle is the species of livestock most sensitive to fluorides in grasses. For comparative purposes the following fluoride concentrations and their effect on dairy cattle are given.

30 ppm	-	no adverse effects
30 to 40 ppm	-	borderline chronic
40 to 60 ppm	-	moderate chronic
60 to 110 ppm	-	severe chronic
above 250 ppm	-	acute

Table 30

RADIOACTIVITY IN GRASS SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS
1980
(Units of pCi/g-Dry Weight)

SAMPLING LOCATION[a]	^{7}Be	^{90}Sr	^{137}Cs	^{239}Pu	^{238}Pu	^{238}U	^{235}U	^{234}U
				Perimeter[b]				
HP-31	17	0.7	0.1	0.002	0.001	0.05	0.016	0.11
HP-32	12	0.6	ND	0.002	0.001	0.10	0.013	0.33
HP-33	5	1.2	0.1	0.001	0.001	0.03	0.005	0.04
HP-34	8	1.1	0.2	0.002	0.001	0.02	0.006	0.03
HP-35	18	0.8	0.1	0.001	0.001	0.03	0.007	0.07
HP-36	3	0.8	ND	0.001	0.001	0.03	0.033	0.04
HP-37	10	0.4	0.1	0.001	0.001	0.02	0.003	0.03
HP-38	7	0.5	ND	0.001	0.001	0.01	0.003	0.03
HP-39	15	0.7	0.1	0.001	0.001	0.04	0.005	0.07
Average	11	0.8	0.1	0.001	0.001	0.04	0.01	0.08
				Remote[c]				
HP-51		0.2	ND	<0.001	<0.0003	0.02	0.003	0.02
HP-52		0.5	0.06	0.001	<0.0002	0.01	0.004	0.01
HP-53	(NO	0.3	0.11	0.001	0.0002	0.04	0.005	0.04
HP-55		0.3	0.06	0.002	<0.0011	0.02	0.013	0.03
HP-56	DATA)	0.7	0.11	0.001	<0.0002	0.02	0.011	0.02
HP-57		0.6	ND	0.001	<0.0002	0.01	0.014	0.04
HP-58		0.2	ND	0.001	<0.0006	0.01	0.008	0.01
Average		0.4	0.09	<0.001	<0.0004	0.02	0.008	0.02

[a]See Figures 1 and 2.

[b]Average of two samples.

[c]One sample

ND - Not detectable.

Table 31

RADIOACTIVITY IN SOIL SAMPLES FROM PERIMETER AND REMOTE MONITORING STATIONS
1980
(Units of pCi/g - Dry Weight)

SAMPLING LOCATION[a]	^{90}Sr	^{137}Cs	^{234}U	^{235}U	^{238}U	^{238}Pu	^{239}Pu
			Perimeter[b]				
HP-31	0.2	1.5	0.7	0.43	0.18	0.002	0.02
HP-32	0.6	1.7	1.2	0.06	0.66	0.002	0.02
HP-33	0.3	2.4	0.4	0.02	0.29	0.003	0.03
HP-34	0.2	0.9	0.3	0.02	0.23	0.002	0.01
HP-35	0.2	1.3	0.5	0.02	0.35	0.001	0.01
HP-36	0.2	1.4	0.3	0.03	0.24	0.001	0.02
HP-37	0.2	0.6	0.6	0.08	0.33	0.003	0.01
HP-38	0.2	1.1	0.3	0.01	0.24	0.001	0.01
HP-39	0.3	2.2	0.7	0.04	0.41	0.001	0.03
Average	0.3	1.5	0.6	0.08	0.33	0.002	0.02
			Remote[c]				
HP-51	0.32	1.0	0.51	0.03	0.41	0.001	0.03
HP-52	0.23	1.9	0.32	0.02	0.30	0.001	0.02
HP-53	0.30	1.1	0.49	0.07	0.41	0.001	0.01
HP-55	0.84	1.5	0.38	0.02	0.32	0.002	0.03
HP-56	0.49	1.6	0.43	0.02	0.38	0.001	0.02
HP-57	0.51	3.5	0.65	0.04	0.54	0.003	0.04
HP-58	0.14	1.5	0.41	0.03	0.32	0.001	0.02
Average	0.40	1.7	0.46	0.02	0.38	0.001	0.02

[a]See Figures 1 and 2.

[b]Average of two samples.

[c]One sample.

Table 32

STREAM SEDIMENT SAMPLES
July/November 1980
Average Concentration (μg/g dry weight basis)

STATION	U	Hg	Pb[a]	Ni	Cu	Zn	Cr	Mn	Cd	Al	Th
CS1	1	4	38	37	34	83	35	2409	2	43,000	<20
PS2	8	4	57	99	95	135	130	653	3	79,000	<20
PS5	6	5	33	47	33	88	41	515	1	53,500	<20
PS6	18	12	40	100	62	168	175	958	4	66,000	<20
PS9	4	5	21	42	26	80	42	935	2	38,500	<20
PS10	17	19	36	144	112	131	152	540	3	39,000	<20
PS12	4	6	27	42	25	65	26	522	2	34,000	<20
PS15	31	4	38	198	77	118	73	784	2	48,000	<20
PS17	13	11	35	66	41	101	38	508	2	39,500	<20
PS18	4	10	23	36	23	69	25	432	2	28,500	<20
PS19	9	14	36	37	120	92	50	847	1	58,500	<20
PS21	7	4	62	94	113	146	83	701	4	93,500	<20
PS22	8	13	37	59	37	114	50	572	2	37,000	<20
CS20	1	1	<12	14	11	32	14	391	1	15,000	<20

[a]Average of two samples, some results were below detectable limit.

Table 33

SUMMARY OF THE ESTIMATED RADIATION DOSE
TO AN ADULT INDIVIDUAL DURING 1980 AT LOCATIONS OF MAXIMUM EXPOSURE

PATHWAY	LOCATION	DOSE (MILLIREM) TOTAL BODY	DOSE (MILLIREM) CRITICAL ORGAN
Gaseous Effluents			
All pathways	Nearest resident	1.8[a]	16.6 (lung)[a]
Terrestrial food chains to milk	Milk sampling station number 6 (^{90}Sr)	0.02	1.5 (bone)
Liquid Effluents			
Aquatic food chains to fish	Clinch River (^{90}Sr)	1.1	53 (bone)
Drinking water[b]	Kingston, Tennessee (^{90}Sr)	0.15	6.6 (bone)
Direct radiation along water, shores, and mud flats.[c]	In Clinch River, downstream from White Oak Creek near experimental Cs field plots	6.2	6.2 (total body)

[a]Uncertainties in these calculated doses may be as much as 300% (see text).

[b]Based on the analysis of raw (unprocessed) water; see text.

[c]Assuming a residence time of 240 hr/yr.

NOTE: Average background total body dose in the U.S., [30] is 106 mrem/yr.

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APPENDIX A
QUALITY ASSURANCE

Radiological

The Environmental Surveillance and Evaluation Section at Oak Ridge National Laboratory has initiated a quality assurance program to ensure that a high degree of accuracy and reliability is maintained in its surveillance activities. The program in effect at ORNL consists of quality control of techniques and procedures, and includes the establishment of a detailed written description of all activities pertaining to the Environmental Surveillance and Evaluation Section. This includes:

1. Operating procedures for each activity.
2. Inspection lists of operating and maintenance activities.
3. Check-off frequency lists for all quality assurance steps, such as schedules for equipment inspection and test control.
4. Documentation of compliance of quality assurance procedures.
5. Participation in intralaboratory and interlaboratory sample-exchange programs.
6. Evaluation of the adequacy of sample preparation work and data analysis.
7. Identification of the role, responsibilities, and authority of each staff member as related to quality assurance.

A schematic diagram showing a flow chart of this quality assurance program is given in Figure A1. A more detailed discussion of the ORNL QA program is given in Ref. (A1) and (A2).

Chemical

A Nuclear Division Committee on Environmental Analysis established an interlaboratory quality control program in 1977. The purpose of this program is to provide quality control data for environmental analysis within the Nuclear Division. A unified Environmental and Effluent Analysis Manual was issued in March of 1977 which currently contains 96 analytical procedures; EPA-certified analytical methods are used wherever possible.

All Nuclear Division analytical laboratories maintain internal measurement control programs that are part of planned and systematic actions taken to prevent incorrect results. Standard samples containing all parameters measured are purchased and submitted to the laboratories for analysis. Standard samples of known values are processed along with routine samples and the results are recorded and examined to determine if they fall within prescribed limits. Analytical results are transmitted to the Y-12 Plant Quality Division for statistical review and a semi-annual report is provided to the analytical laboratories.

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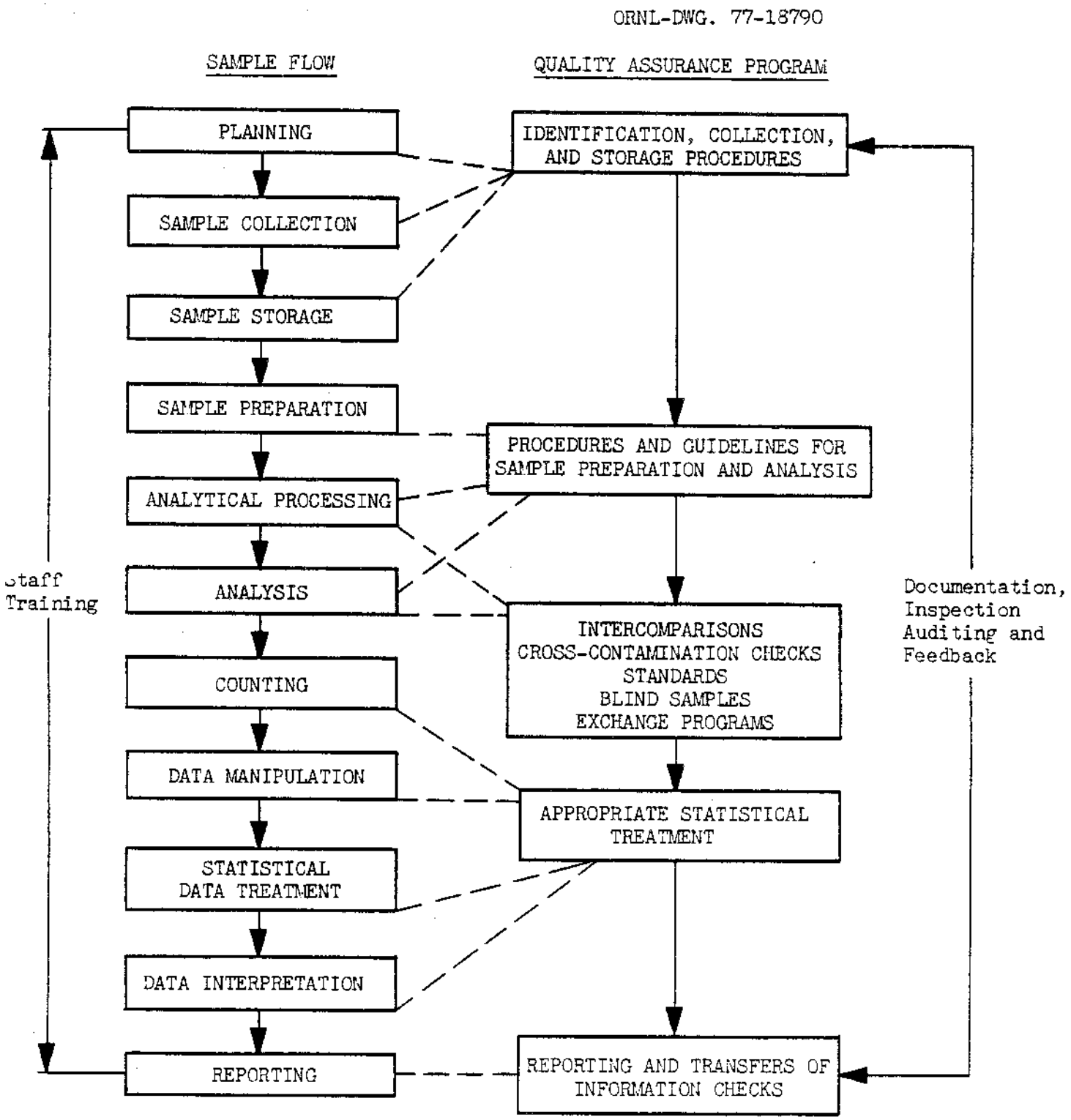

Figure A1
FLOW CHART OF QA PROGRAM

EXTERNAL DISTRIBUTION

Director, Division of Industrial and Radiological Health,
Tennessee State Health Department
Director, Tennessee State Health Department
Federal Activities Coordinator, EPA Region IV
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