

Frank O'Donnell
Y/UB-4

ENVIRONMENTAL MONITORING REPORT
UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT
ADMINISTRATION
OAK RIDGE FACILITIES

Calendar Year 1975

**UNION
CARBIDE**

NUCLEAR DIVISION
OAK RIDGE, TENNESSEE

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UNION CARBIDE CORPORATION - NUCLEAR DIVISION
Oak Ridge Gaseous Diffusion Plant
Oak Ridge National Laboratory
Oak Ridge Y-12 Plant

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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 Energy Research and Development Administration (ERDA) 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 740 feet to 1360 feet above mean sea level with a maximum relief of 620 feet. 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 100°F or higher and 0°F 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 54 inches.

The topography of the Oak Ridge Area is such that all drainage from the ERDA 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 5 miles of the ERDA 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 ERDA Reservation are: Oliver Springs (pop. 3400) 7 miles to the northwest; Clinton (pop. 4800) 10 miles to the northeast; Lenoir City (pop. 5300) 7 miles to the southeast; Kingston (pop. 4100) 7 miles to the southwest; and Harriman (pop. 8700) 8 miles to the west. Knoxville, the major metropolitan area nearest Oak Ridge, is located about 25 miles to the east and has a population of approximately 175,000.

The ERDA 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 ERDA facilities are in the area: the Comparative Animal Research Laboratory, and 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 Energy Research and Development Administration-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 four major responsibilities: (1) production of nuclear weapon components, (2) fabrication support for weapon design agencies, (3) support for the Oak Ridge National Laboratory, and (4) support and assistance 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 ERDA 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, several food products, vegetation, and soil for both radioactive and nonradioactive materials. This report presents a summary of the results of the program for calendar year 1975.

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 8.4 mrem/yr which is 1.7 percent of the ERDA Manual Chapter 0524 standard. The maximum dose to the critical organ of an individual from the aquatic food chain was calculated to be 3.4 millirem to the bone which is 0.7 percent of the allowable standard. The maximum dose to individuals living nearest the site boundary from airborne releases, assuming continuous residence, was 0.4 mrem/yr to the total body and 6.9 millirem to the lung. These doses are 0.08 percent and 0.5 percent, respectively, of the standards. The average dose to an Oak Ridge resident (the critical population group) was calculated to be 0.06 mrem/yr to the total body and 0.3 millirem to the lung as compared to approximately 100 mrem/yr from natural background radiation. The cumulative total body dose to the population within a 50-mile radius of the Oak Ridge facilities resulting from 1975 effluents was calculated to be 7.4 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 with the exception of fluorides which exceeded the limits on several occasions. Pollution control projects are in progress to reduce fluoride emissions. The ORGDP steam plant was out of compliance with State emission limits for particulates and visible emissions during the winter months when coal was used as a supplemental fuel. A project has been approved to provide for the installation of electrostatic precipitators for particulate removal. It is planned to meet SO₂ emission standards through the purchase of suitable quality coal.

The chemical water quality data obtained from the water sampling program indicated compliance with standards with the exception of chromium, nitrates, pH, and dissolved oxygen. Environmental protection projects are in progress or under consideration to bring these parameters into compliance. Sewage treatment plants at ORNL and ORGDP currently do not meet Federal secondary treatment requirements. Projects to provide secondary treatment at these facilities are expected to be completed during 1976.

MONITORING DATA COLLECTION, ANALYSIS, AND EVALUATION

Environmental monitoring data for calendar year 1975 are summarized in Tables 1 through 27. 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 average value.

Average concentrations are compared with environmental 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.

Air Monitoring

Radioactive – Atmospheric concentrations of radioactive materials occurring 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 12 to 75 miles, 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 quarterly by system 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 1 through 5.

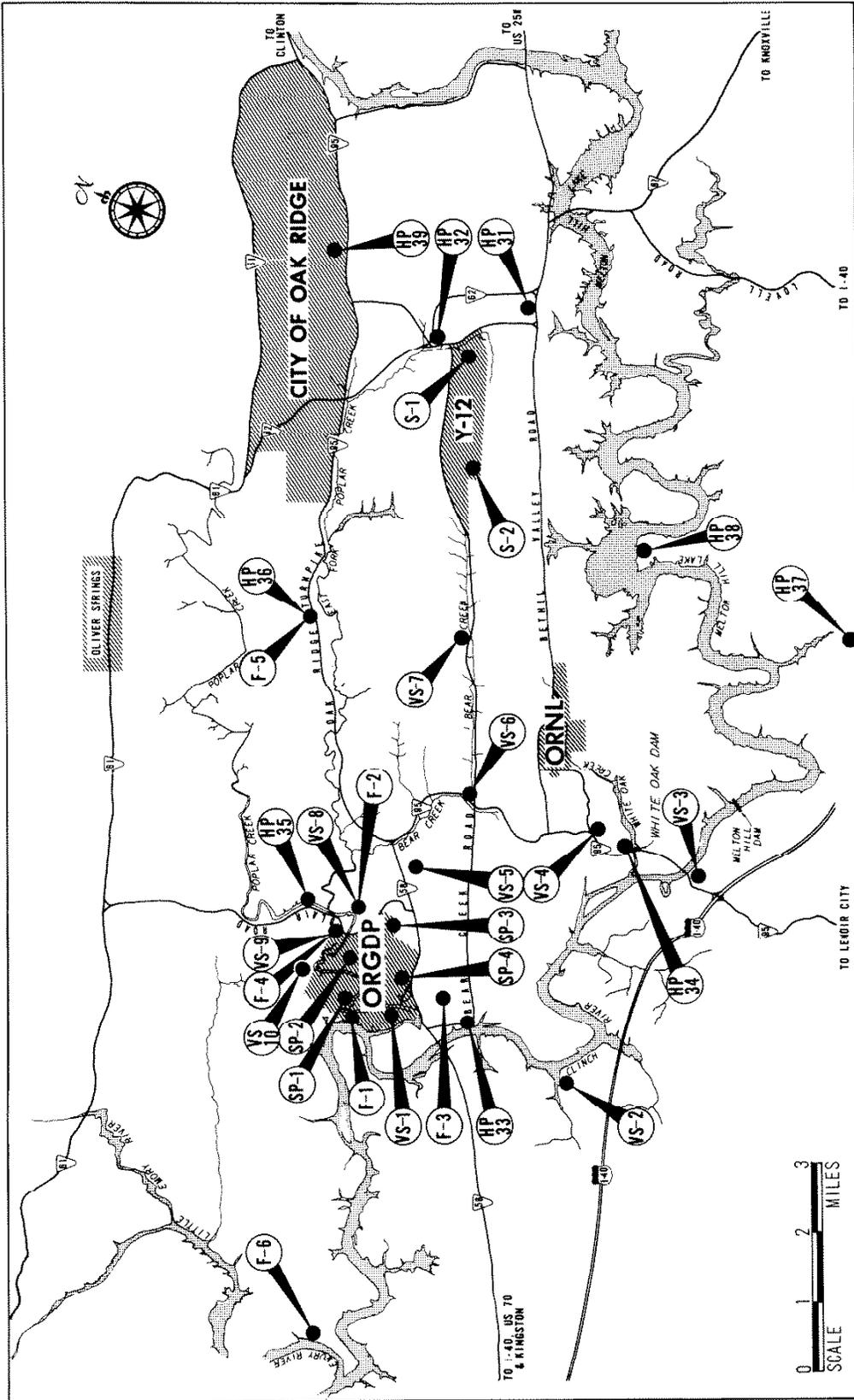


Figure 1
AIR, VEGETATION, AND SOIL SAMPLING LOCATIONS

ORNL-DWG 66-1719

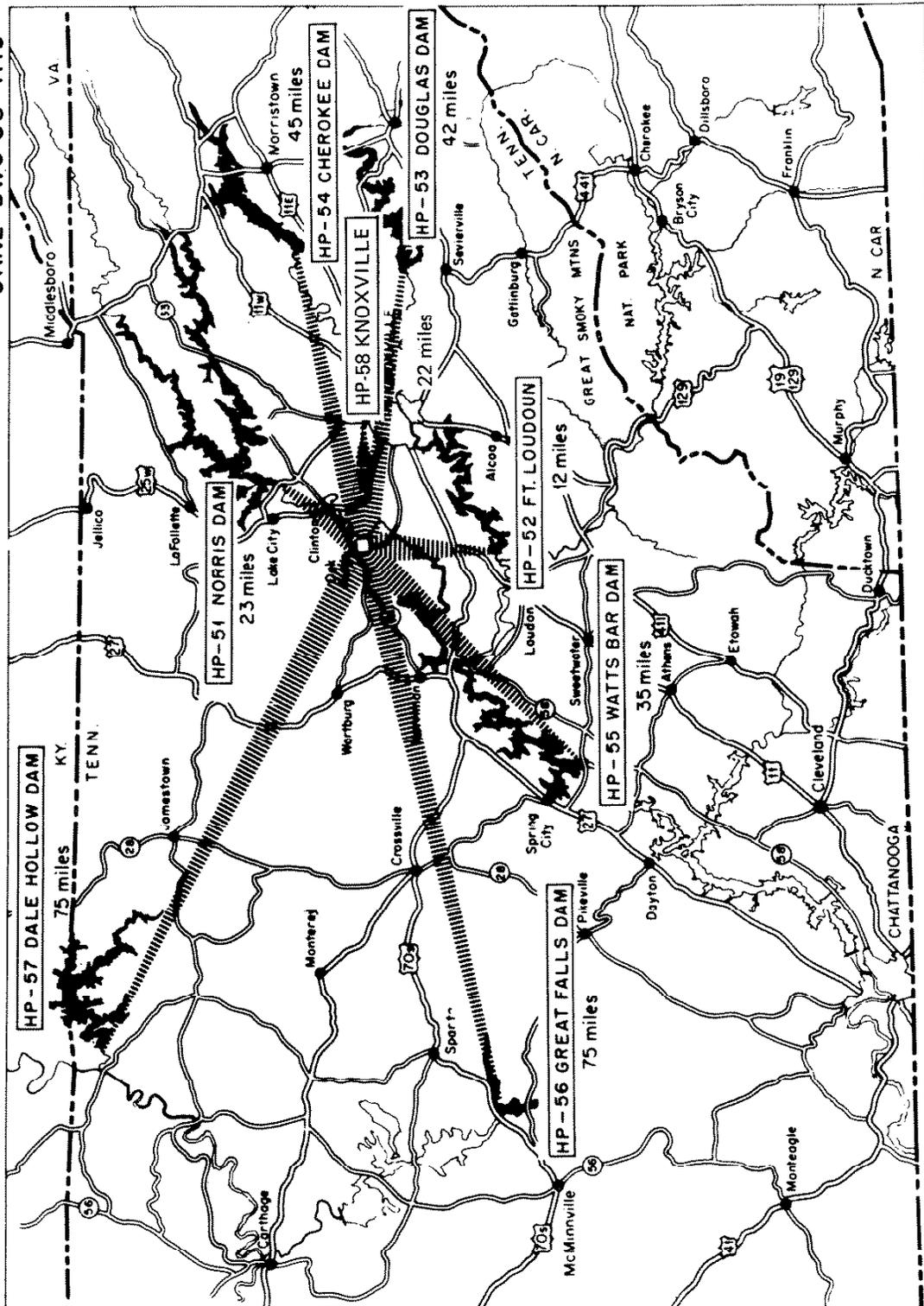


Figure 2
REMOTE AIR MONITORING LOCATIONS

The average gross beta concentrations of radioactivity from particulates in air measured by both the perimeter and remote monitoring systems were 0.04 percent of the applicable concentration guide (CG) as specified in the ERDA Manual, Appendix 0524⁽¹⁾ for individuals in uncontrolled areas (Table 1). These average values measured for 1975 are lower than those for 1974 by a factor of approximately two.

The average gross alpha concentrations in both the perimeter and remote monitoring systems were 0.03 percent of the CG for a mixture of uranium isotopes (Table 2).

The results of specific radionuclide analyses of composited filters are given in Table 3. The higher levels noted for uranium in the perimeter system are attributed to airborne releases from uranium enrichment and processing operations at ORGDP and the Y-12 Plant. The environmental concentrations tabulated are all at least a thousand times less than the applicable ERDA 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 4).

While some radioactivity was released to the atmosphere (Table 5), 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. Concentrations in the ppb range are determined by collecting 24-hour samples in caustic solution in a Boyce-Thompson type sampler on an eight day frequency and analyzing the resulting solution by specific ion electrode.

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 re-weighed. 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.

Two continuous monitoring stations (S-1 and S-2) were installed in the Y-12 Plant area for the measurement of ambient concentrations of sulfur dioxide. Each station consists of a flame photometric continuous 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 6 through 8. These data indicate that average environmental concentrations of particulates and sulfur dioxide were in compliance with applicable standards⁽²⁾ during calendar year 1975. Fluoride concentrations exceeded the standards on several occasions. High fluoride concentrations during the past few years, which again occurred during 1975, have resulted in the initiation of several projects to reduce fluoride emissions. The majority of these abatement projects are due to be completed by the end of FY-1976.

Steam plant operations were in compliance with State emission limits except for the steam plant at ORGDP. The particulate emissions for the ORGDP steam plant do not comply with Tennessee standards when coal is burned. The particulate standard states that no more than 0.2 pound of particulates may be discharged for each one million Btu's of heat input. The latest measurement of the ORGDP steam plant effluent indicates that 0.8 to 1.0 pound of particulates is released for each one million Btu's input when coal is burned. Electrostatic precipitators for removal of particulate matter are expected to be installed and operable by October 1, 1977.

The ash resulting from the combustion of coal is the only solid waste generated by the steam plant. During the peak of the coal burning season (January and February), this ash is generated at a rate of about 10 tons per day. Presently, this waste is deposited in local landfill areas.

External Gamma Radiation Monitoring

External gamma radiation background measurements are made routinely at seven of the perimeter air monitoring stations, at one station located near Melton Hill Dam, and at the remote monitoring stations using calcium fluoride thermoluminescent dosimeters suspended one meter above the ground. Dosimeters at the perimeter stations and Melton Hill Dam are collected and analyzed monthly. Those at the remote stations are collected and analyzed semi-annually.

Data on the average external gamma radiation background are given in Table 9. The slight difference between the average levels in the perimeter and remote environs is considered to be within the variation in background levels normally experienced in East Tennessee which is dependent 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 ¹³⁷Cs 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 perimeter stations was subtracted from the measured gamma radiation levels to determine the incremental increases resulting from plant operations.

Gamma levels along East Fork Poplar Creek ranged from 0 to 14 $\mu\text{R/hr}$ above background. The external gamma radiation levels along the bank of the Clinch River ranged from 6 to 35 $\mu\text{R/hr}$ above background. Potential doses to individuals in the environment from these elevated gamma radiation levels were evaluated 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 (Section C-2) 2.3 miles above White Oak Creek outfall, at the ORGDP sanitary water intake (Section C-3) 6.3 miles downstream from the entry of White Oak Creek, at the ORGDP recirculating water intake (Station C-4) downstream from the Poplar Creek outfall, 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 which are collected on a grab-sample basis daily. Grab samples at Station C-5 are deemed adequate since day-to-day variations in concentration should be minimal due to the hydrology of the reservoir system and the distance downstream from Oak Ridge operations. 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. Samples collected at Stations P-1 and P-2 are weekly grab samples. Continuous samplers have been installed at Stations P-1 and P-2 and will be operational in 1976. 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 ERDA 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 fission product radionuclides, uranium in surface streams, and the quantities of radioactivity released to surface streams are given in Tables 10 through 12. The average concentrations of specific radionuclides in offsite surface streams at all points of measurement were less than 1 percent of the applicable concentration guides for uncontrolled areas.

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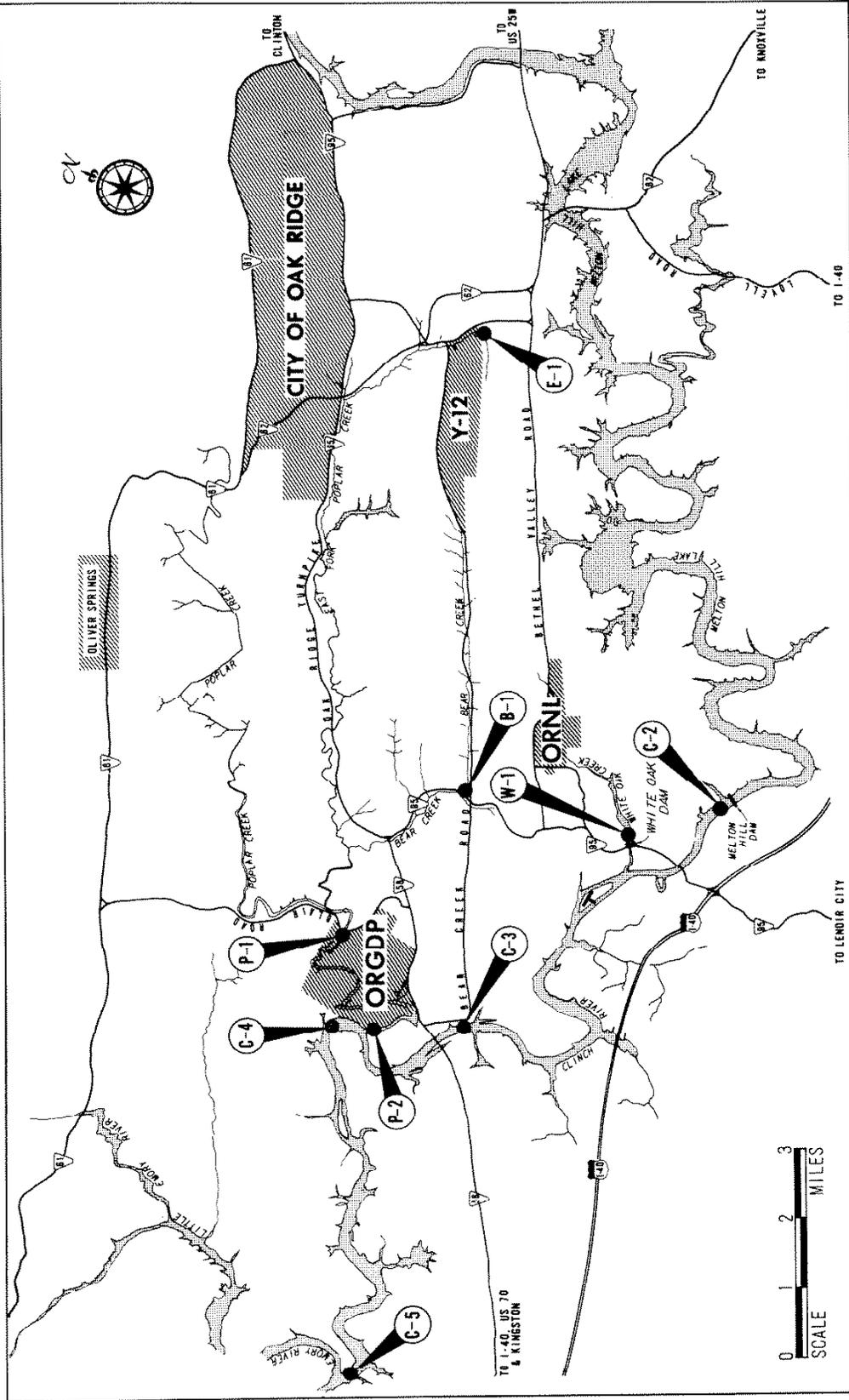


Figure 3
STREAM MONITORING LOCATIONS

The average concentration of transuranic alpha emitters in the Clinch River at Clinch River Mile (CRM) 20.8 resulting from effluent releases was 2.6×10^{-12} $\mu\text{Ci}/\text{ml}$, which is less than 0.01 percent of the concentration guide for water containing a known mixture of radionuclides.*

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 13 through 20. The average concentrations of all substances analyzed were in compliance with Tennessee stream guidelines⁽⁵⁾ except for chromium at Station W-1 and nitrates at Station B-1. Pollution control projects are underway to reduce concentrations of these substances to levels below the standards.

Dissolved oxygen (DO) and pH measurements are made continuously at White Oak Dam (Station W-1) and continuous pH measurements are made at the outfall of New Hope Pond (Station E-1). Dissolved oxygen measurements are made weekly at Station E-1 with a direct reading instrument.

Measurements of dissolved oxygen and pH at White Oak Dam indicated DO values ranging from 4 to > 15 mg/l and pH values from 6.7 to 9.2. The dissolved oxygen was out of compliance with the State standard⁽⁶⁾ on 24 occasions and the pH was out of compliance with the State standard on 16 separate occasions. Noncompliance of DO and pH at White Oak Dam was attributed to natural causes.

Measurements of dissolved oxygen and pH at the outfall of New Hope Pond indicated DO values ranging from 2.9 to 9.5 mg/l and pH values ranging from 6.2 to 8.8. The dissolved oxygen was out of compliance with the State standard on 22 occasions; however, since the addition of an aerator near the outfall of New Hope Pond, DO measurements have been in compliance. The pH measurements at the outfall of New Hope Pond were out of compliance on 22 occasions. This high incidence of pH noncompliance was attributed to natural causes.

Sewage treatment plants at ORNL and ORGDP currently do not meet the new Federal secondary treatment requirements. Projects to provide secondary treatment at these facilities are expected to be completed and operable during 1976.

Food Sources

Milk Monitoring — Raw milk is monitored for ^{131}I and ^{90}Sr by the collection and analysis of samples from 11 sampling stations located within a radius of 50 miles of Oak Ridge.

*CG determined by method given in ERDA Manual, Appendix 0524 for determining the concentration guide for a known mixture of radionuclides.

Samples are normally collected weekly at each of seven 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 4 and 5. 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 21 and 22, 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 is within FRC Range I. The average concentrations of ^{90}Sr in milk from both the immediate and remote environs were within the FRC Range I. The concentration of ^{90}Sr in milk is different at different locations; part of the variation has been found to result from differences in farming methods used at different farms. Pastureland that is not fertilized and is overgrazed (a not too uncommon practice in this area) apparently results in a higher than normal concentration of ^{90}Sr in milk from cows pastured on this land.

Fish Sampling — Two species of fish which are commonly caught and eaten—white crappie and carp—are taken from the Clinch River and Melton Hill Lake during the spring and summer of each year. The fish are prepared for radiochemical analysis in a manner analogous to human utilization. The scales, head, and entrails are removed from the fish before cooking. The crappie are pan fried, and the bones are removed before the flesh is assayed. The carp are cooked in a pressure cooker, the bones and skin are removed, and both the flesh and juices are assayed for radioactivity. 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 concentrations of radionuclides in Clinch River and Melton Hill Lake fish are given in Table 23. The data contain some anomalies which may be due to the limited number of samples collected and the sensitivities of the methods of analyses used. Some of the values measured in Melton Hill Lake, above Oak Ridge operations, are higher than those measured in the Clinch River below plant operations. Additional sampling and analyses will be conducted to verify these values. Consumption of 37 pounds of fish per year⁽⁸⁾ results in less than 2 percent of the maximum permissible intake (MPI). 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.

Vegetation and Soil

Vegetation — Samples of pine needles and grass are collected semi-annually from 10 areas (Stations VS-1 through VS-10, 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 24. The

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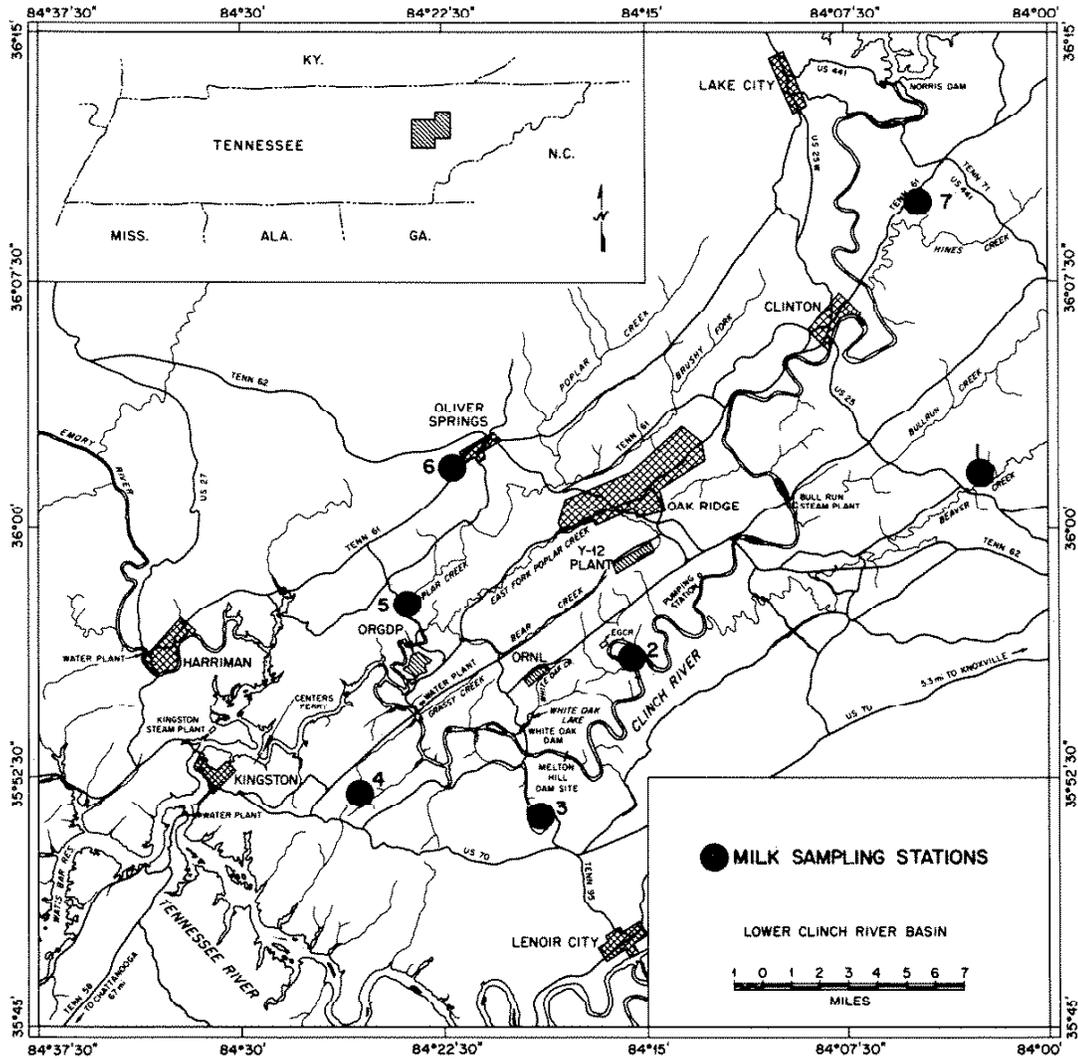


Figure 4
IMMEDIATE ENVIRONS MILK SAMPLING LOCATIONS

fluoride concentration in grass at five of the sampling points was above the 30 ppm level considered to produce no adverse effects when ingested by cattle.⁽⁹⁾ This apparent increase, relative to data collected in 1974, may be attributed to increased activities at ORGDP. Realizing that such increases could occur, plans were instigated in 1973 to provide abatement of two major gaseous fluoride emissions. Both of these abatement projects, which consist of KOH scrubbers, have recently been completed and should be operational by July 1976.

The reason for the high average uranium content in pine needles at sampling location VS-10 is not apparent. This concentration is inconsistent with other sampling station data and resulted from one sample being an order of magnitude higher than another sample collected at the same location. The high value is considered an anomaly which may have been due to sampling and/or analytical error. Follow-up sampling will be conducted for verification.

Soil – Soil samples are collected annually from near the Perimeter Air Monitoring Stations, Figure 1. Nine samples, approximately three inches in diameter and one centimeter thick, are collected in a one-square-meter area at each location, composited, and analyzed radio-chemically for uranium and plutonium content to determine background information for future comparison in event of an accidental release.

Data on uranium and plutonium concentrations in soil are given in Table 25. 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⁾

Sediments

A sediment sampling program was initiated in 1975 to determine concentrations of various metallic ions in the sediment in Poplar Creek. Eight sampling locations were established at various intervals along the creek, beginning above plant discharge points and extending to the mouth of the creek. Samples were collected twice during the year and were analyzed for uranium, mercury, lead, cadmium, copper, nickel, chromium, zinc, manganese, aluminum, and thorium. Insufficient comparative data precludes any qualitative analysis of this current sediment sample data. Future plans include collection of additional samples from the upper west fork of Poplar Creek to determine background levels. Sediment data are presented in Table 26.

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 ERDA-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 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 50 miles 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^{-3} cm/sec for tritium, and 1 cm/sec for particulates and iodine.⁽¹⁵⁾

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 6. 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⁾ and computer programs incorporating some of these models and data.^(25, 26) 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 pathways of exposure 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 a 50-mile radius of the Oak Ridge facilities.

Maximum Potential Exposure at the Site Boundary – 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 310 mrem/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 62 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.

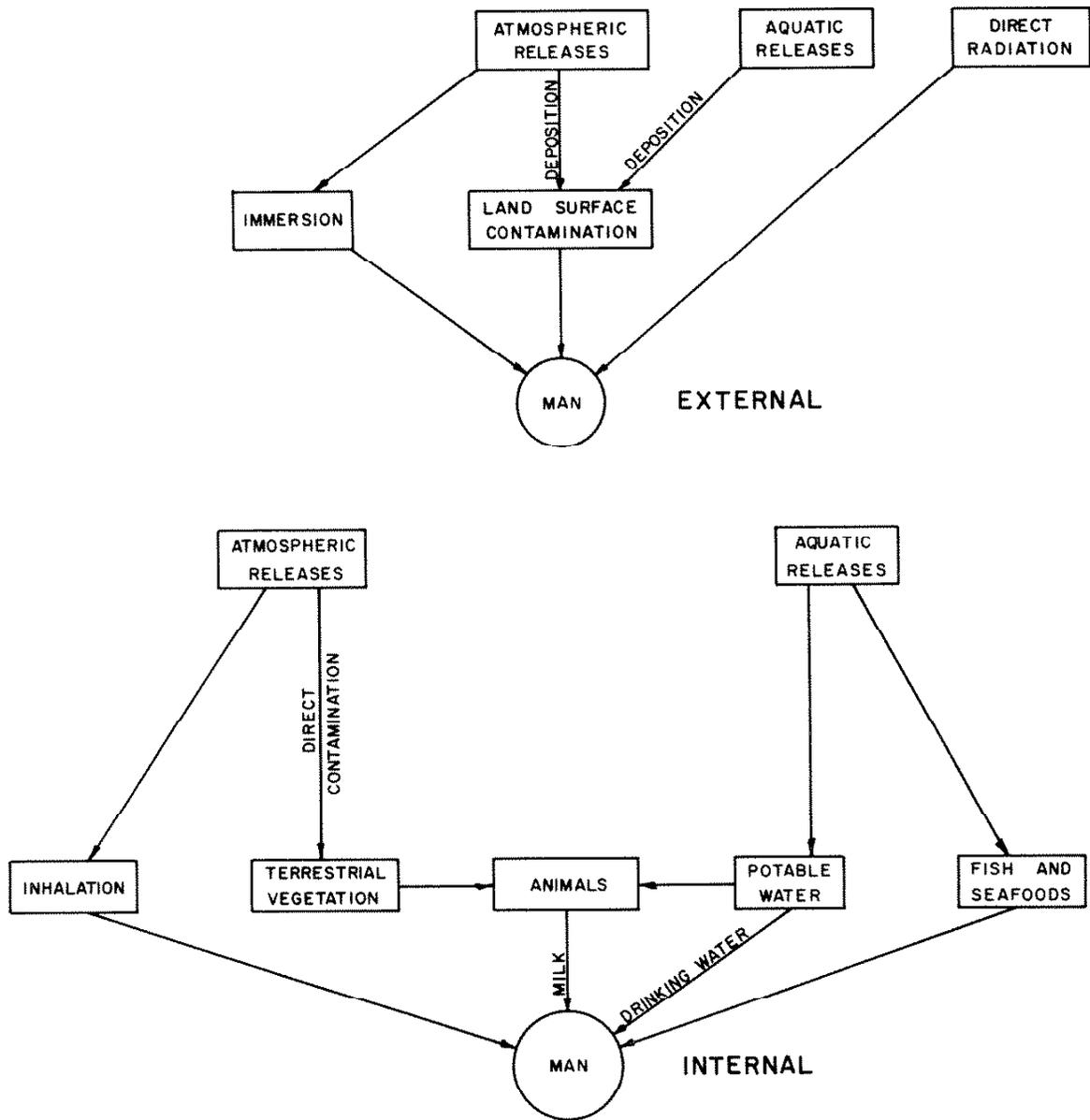


Figure 6
EXPOSURE PATHWAYS

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 8.4 mrem/yr which is 1.7 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.

An estimated annual radiation dose of 0.4 millirem to the total body of an individual continuously occupying the residence nearest the site boundary is based on an inhalation rate⁽²³⁾ for an average adult of 2×10^4 liters/day. The lung is the critical organ for this pathway and would receive 6.9 millirem; uranium-234 is the important radionuclide contributing to this dose. These levels are 0.08 percent and 0.5 percent, respectively, of the allowable standard.

The most important contribution to dose for contamination within the terrestrial food-chain pathway 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 21 and 22), indicate that the maximum dose to an individual in the immediate environs resulting from ingestion of one liter of milk per day is 0.5 millirem to the thyroid at Station Number 1, and 18.5 millirem to the bone at Station Number 6. Data collected at remote stations indicate that background radiation (i.e., weapons fallout) is responsible for about 69 percent of the dose from ^{131}I and at least 52 percent (9.6 millirem) of the dose from ^{90}Sr .

The public water supply closest to the liquid discharges from the Oak Ridge facilities is located approximately 16 miles 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. It is estimated that these conditions would prevail a maximum of 20 percent of the time. Measurements of untreated river water samples at Kingston (see Table 10) indicate that the maximum dose resulting from the ingestion of 20 percent of the daily adult requirement (about two liters per day) is 0.4 millirem to the bone; ^{90}Sr present in the waters upstream of the Oak Ridge facilities accounts for 29 percent (0.1 millirem) of this dose. The resulting 0.3 millirem is about 0.01 percent of the standard.

Estimates of radiation dose to an adult were calculated for consumption of 18.5 pounds of white crappie and 18.5 pounds of carp per year from the Clinch River. This total consumption of 37 pounds⁽⁸⁾ is about 2.5 times the national average fish consumption⁽²⁷⁾ and is used because of the popularity of fishing in East Tennessee. From the analysis of edible parts of the fish examined (see Table 23), the maximum organ dose to an individual attributed to facility effluents is estimated to be 3.4 millirem to the bone from ^{90}Sr . The

total body dose was calculated to be 0.07 millirem. These doses are 0.7 percent and 0.01 percent, respectively, of the allowable standard. Fish samples taken from Melton Hill Lake were analyzed to determine background conditions.

Summaries are given in Table 27 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 maximum potential dose to an Oak Ridge resident was calculated to be 6.9 millirem to the lung. This calculated dose is 0.5 percent of the allowable standard.⁽¹⁾ The average total body dose to an Oak Ridge resident was estimated to be 0.06 mrem/yr as compared to approximately 100 mrem/yr from natural background radiation; the average dose to the lung of an Oak Ridge resident was 0.3 millirem.

The cumulative total body dose to the population within a 50-mile radius of the Oak Ridge facilities resulting from 1975 plant effluents was calculated to be 7.4 man-rem. This dose may be compared to an estimated 74,000 man-rem to the same population resulting from natural background radiation. About 24 percent of the collective dose from the effluents of the Oak Ridge facilities is estimated to be to the Oak Ridge population.

Table 1
 CONTINUOUS AIR MONITORING DATA
 Long-Lived Gross Beta Activity of Particulates in Air
 1975

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-13} $\mu\text{Ci/ml}$			% CG ^c
			MAXIMUM ^a	MINIMUM ^b	AVERAGE	
Perimeter Area ^d						
HP-31	Kerr Hollow Gate	52	1.4	0.08	0.38 ± 0.04	0.04
HP-32	Midway Gate	52	1.1	0.09	0.39 ± 0.03	0.04
HP-33	Gallaher Gate	52	1.4	0.05	0.42 ± 0.04	0.04
HP-34	White Oak Dam	52	1.3	0.08	0.40 ± 0.04	0.04
HP-35	Blair Gate	52	1.2	0.10	0.44 ± 0.04	0.04
HP-36	Turnpike Gate	52	1.4	0.11	0.44 ± 0.04	0.04
HP-37	Hickory Creek Bend	52	1.2	0.09	0.36 ± 0.03	0.04
HP-38	East of EGCR	52	1.1	0.10	0.40 ± 0.04	0.04
HP-39	Townsite	52	1.1	0.10	0.39 ± 0.03	0.04
Average					0.40 ± 0.01	0.04
Remote Area ^e						
HP-51	Norris Dam	51	1.8	0.10	0.39 ± 0.04	0.04
HP-52	Loudoun Dam	50	1.0	0.06	0.42 ± 0.04	0.04
HP-53	Douglas Dam	52	1.3	0.04	0.45 ± 0.04	0.05
HP-54	Cherokee Dam	45	1.2	0.09	0.54 ± 0.04	0.05
HP-55	Watts Bar Dam	49	1.5	0.04	0.34 ± 0.04	0.03
HP-56	Great Falls Dam	47	0.9	0.09	0.38 ± 0.03	0.04
HP-57	Dale Hollow Dam	52	1.4	0.06	0.39 ± 0.04	0.04
HP-58	Knoxville	49	3.4	0.06	0.40 ± 0.07	0.04
Average					0.41 ± 0.02	0.04

^a Maximum weekly average concentration.

^b Minimum weekly average concentration – minimum detectable level is 5×10^{-6} μCi per sample.

^c CG is 10^{-10} $\mu\text{Ci/ml}$ for unidentified radionuclides (ERDA Manual, Appendix 0524, Annex A, Table II).

^d See Figure 1.

^e See Figure 2.

Table 2
 CONTINUOUS AIR MONITORING DATA
 Long-Lived Gross Alpha Activity of Particulates in Air
 1975

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF $10^{-15} \mu\text{Ci/ml}$			% CG ^c
			MAXIMUM ^a	MINIMUM ^b	AVERAGE	
Perimeter Area ^d						
HP-31	Kerr Hollow Gate	52	2.9	0.6	1.0 ± 0.9	0.03
HP-32	Midway Gate	52	3.7	0.6	1.4 ± 0.13	0.04
HP-33	Gallaher Gate	52	6.5	0.6	1.4 ± 0.16	0.04
HP-34	White Oak Dam	52	3.0	0.6	1.0 ± 0.09	0.03
HP-35	Blair Gate	52	11.7	0.6	1.6 ± 0.26	0.04
HP-36	Turnpike Gate	52	5.3	0.6	1.4 ± 0.14	0.04
HP-37	Hickory Creek Bend	52	2.9	0.6	1.0 ± 0.09	0.03
HP-38	East of EGCR	52	2.4	0.6	0.9 ± 0.07	0.02
HP-39	Townsite	52	5.1	0.6	1.2 ± 0.12	0.03
Average					1.2 ± 0.05	0.03
Remote Area ^e						
HP-51	Norris Dam	51	2.9	0.5	1.0 ± 0.09	0.03
HP-52	Loudoun Dam	50	3.5	0.6	1.0 ± 0.10	0.03
HP-53	Douglas Dam	52	2.8	0.6	1.0 ± 0.09	0.03
HP-54	Cherokee Dam	45	5.0	0.5	1.3 ± 0.15	0.03
HP-55	Watts Bar Dam	49	3.2	0.6	1.1 ± 0.10	0.03
HP-56	Great Falls Dam	47	3.2	0.6	1.0 ± 0.09	0.03
HP-57	Dale Hollow Dam	52	2.2	0.5	0.8 ± 0.06	0.02
HP-58	Knoxville	49	2.3	0.5	$0.8 \pm .07$	0.02
Average					1.0 ± 0.09	0.03

^a Maximum weekly average concentration.

^b Minimum weekly average concentration - minimum detectable level is $2 \times 10^{-6} \mu\text{Ci}$ per sample.

^c CG is $40 \times 10^{-13} \mu\text{Ci/ml}$ for a mixture of Uranium Isotopes. (ERDA Manual, Appendix 0524, Annex A, Table II).

^d See Figure 1.

^e See Figure 2.

Table 3
 CONTINUOUS AIR MONITORING DATA
 SPECIFIC RADIONUCLIDES IN AIR
 (Composite Samples)
 1975

RADIONUCLIDE	UNITS OF $10^{-15} \mu\text{Ci/ml}$	
	PERIMETER STATIONS	REMOTE STATIONS
Be-7	110 ± 20	120 ± 24
Mn-54	0.13 ± 0.03	0.13 ± 0.03
Sr-90	0.78 ± 0.04	0.44 ± 0.03
Zr-95 — Nb-95	12 ± 2	< 0.1
Ru-106	< 6.7	< 8.7
Sb-125	< 1.0	0.93 ± 0.2
Cs-137	< 1.4	1.6 ± 0.3
Ce-144	11 ± 2	0.14 ± 0.03
Th-228	0.014 ± 0.0002	0.010 ± 0.0001
Th-230	0.026 ± 0.0002	0.012 ± 0.0001
Th-232	0.014 ± 0.002	0.0088 ± 0.0001
U-234-235	1.1 ± 0.05	0.072 ± 0.008
U-238	0.41 ± 0.007	0.033 ± 0.007
Pu-238	< 0.001	< 0.001
Pu-239	0.014 ± 0.001	0.013 ± 0.001

Table 4
 CONCENTRATION OF ^{131}I IN AIR
 AS MEASURED BY THE PERIMETER AIR MONITORING STATIONS^a
 1975

STATION NUMBER	LOCATION	NUMBER OF SAMPLES TAKEN	UNITS OF 10^{-14} $\mu\text{Ci}/\text{ml}$			% CG ^d
			MAXIMUM ^b	MINIMUM ^c	AVERAGE	
HP-31	Kerr Hollow Gate	52	2.7	0.3	0.7	< 0.01
HP-32	Midway Gate	52	2.0	0.3	0.8	< 0.01
HP-33	Gallaher Gate	52	2.0	0.3	0.6	< 0.01
HP-34	White Oak Dam	52	2.2	0.3	0.8	< 0.01
HP-35	Blair Gate	52	1.5	< 0.2	< 0.7	< 0.01
HP-36	Turnpike Gate	52	1.7	0.3	0.6	< 0.01
HP-37	Hickory Creek Bend	52	1.5	0.3	0.6	< 0.01
HP-38	East of EGCR	52	1.9	0.3	0.6	< 0.01
HP-39	Townsite	52	1.6	0.3	0.6	< 0.01
Average					< 0.8	< 0.01

^a See Figure 1.

^b Maximum weekly average concentration.

^c Minimum weekly average concentration—minimum detectable amount of ^{131}I is 3×10^{-6} μCi per sample.

^d CG is 1×10^{-10} $\mu\text{Ci}/\text{ml}$ (ERDA Manual, Appendix 0524, Annex A, Table II).

Table 5
DISCHARGES OF RADIOACTIVITY TO THE ATMOSPHERE
1975

RADIONUCLIDE	CURIES DISCHARGED
Uranium ^a	0.16
¹³¹ I	2
³ H	550
¹³³ Xe ^b	<88,000
⁸⁵ Kr ^b	<18,000
⁹⁹ Tc ^c	0.3
Pu ^c	4 x 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 instrument measurements in the stack gas stream and an assumed mixture of noble gases.

c Mixture of all isotopes.

Table 6
AIR MONITORING DATA — FLUORIDES
1975

LOCATION ^a	NUMBER OF SAMPLES ^b	MAXIMUM 24-HOUR SAMPLE (ppb)	TIMES 24-HOUR STANDARD ^c EXCEEDED	MAXIMUM 30-DAY AVERAGE (ppb)	TIMES 30-DAY STANDARD ^c EXCEEDED	ANNUAL AVERAGE (ppb)
F-1	46	7.0	3	2.6	2	1.1 ± 0.4
F-2	50	26.3	4	8.0	3	1.7 ± 1.1
F-3	46	3.9	1	1.9	3	1.2 ± 0.2
F-4	50	2.8	0	1.5	0	1.0 ± 0.2
F-5	49	14.0	2	3.8	2	1.1 ± 0.6
F-6 ^d	45	3.3	0	1.3	0	1.0 ± 0.2

^a See Figure 1.

^b Sample duration — 24 hours.

^c Tennessee Air Pollution Control Regulations —
4.5 ppb for 12 hour averaging interval
3.5 ppb for 24 hour averaging interval
2.0 ppb for 7 day averaging interval
1.5 ppb for 30 day averaging interval

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

^d Station F-6 is approximately 5 miles from ORGDP in upwind direction of the prevailing winds, thus may be considered representative of general ambient background concentration.

NOTE: Data not amenable to comparison with 12 hour and 7 day standards.

Table 7
 AIR MONITORING DATA – SUSPENDED PARTICULATES
 1975

LOCATION ^a	NUMBER OF SAMPLES	CONCENTRATION, $\mu\text{g}/\text{m}^3$			% STD. ^b
		MAXIMUM	MINIMUM	AVERAGE	
SP-1	14	69.8	16.9	35.0 ± 10.6	47
SP-2	14	69.1	8.7	34.1 ± 9.5	46
SP-3	14	101.0	6.4	41.0 ± 15.5	55
SP-4	12	73.8	14.7	37.3 ± 11.2	50

^a See Figure 1.

^b Tennessee Air Pollution Control Regulations – Primary standard based on annual geometric mean is $75.0 \mu\text{g}/\text{m}^3$.

Table 8
SULFUR DIOXIDE MONITORING DATA
1975

MONTH	MAXIMUM 24 HR. AVERAGE (PPM)		MONTHLY AVERAGE (PPM)	
	STATION S-1	STATION S-2	STATION S-1	STATION S-2
January	0.065	0.047	0.017	0.007
February	0.032	0.016	0.012	0.005
March	0.027	0.009	0.006	< 0.005
April	0.042	0.021	0.010	0.005
May	0.037	0.023	0.009	0.006
June	0.006	0.020	< 0.005	0.005
July	0.011	0.016	0.005	0.007
August	0.010	0.014	< 0.005	0.006
September	0.067	0.016	0.008	0.005
October	(Instruments inoperable)			
November	"	"		
December	"	"		
Annual Arithmetic Mean			0.008	0.006

Tennessee Ambient Standards.

- Maximum 24 hr. Average — 0.14 ppm.
- Annual Arithmetic Mean — 0.03 ppm.
- Minimum Detectable Limit — 0.005 ppm.

Table 9
EXTERNAL GAMMA RADIATION MEASUREMENTS
1975

STATION NUMBER	LOCATION	BACKGROUND	
		$\mu\text{R/hr}$	mR/yr
Perimeter Stations ^a			
HP-31	Kerr Hollow Gate	9.1	80
HP-32	Midway Gate	10	88
HP-33	Gallaher Gate	8.9	78
HP-35	Blair Gate	7.6	67
HP-36	Turnpike Gate	7.4	65
HP-37	Hickory Creek Bend	7.6	67
HP-38	East of EGCR	7.6	67
HP-40	Melton Hill	5.7	50
Average		8	70
Remote Stations ^b			
HP-51	Norris Dam	5.8	51
HP-52	Loudoun Dam	6.9	60
HP-53	Douglas Dam	7.0	61
HP-54	Cherokee Dam	6.7	59
HP-55	Watts Bar Dam	6.5	57
HP-56	Great Falls Dam	6.3	55
HP-57	Dale Hollow Dam	8.1	71
HP-58	Knoxville	11	96
Average		7.3	64

^a See Figure 1.

^b See Figure 2.

Table 10
 RADIONUCLIDES IN THE CLINCH RIVER
 1975

LOCATION	NUMBER OF SAMPLES	RANGE	CONCENTRATION OF RADIONUCLIDES OF PRIMARY CONCERN UNITS OF 10^{-9} $\mu\text{Ci}/\text{ml}$				% CG ^c
			⁹⁰ Sr	¹³⁷ Cs	¹⁰⁶ Ru	³ H	
C-2 CRM 23.1 ^a	4	Max.	0.14	0.05	0.09	820	
		Min.	0.05	< 0.01	0.09	630	
		Avg.	0.07 ± 0.02	< 0.02 ± 0.01	0.09	730 ± 52	< 0.05
CRM 20.8 ^b	12	Max.	2.42	0.17	0.09	6000	
		Min.	0.40	0.03	0.01	170	
		Avg.	1.20 ± 0.19	0.09 ± 0.01	0.05 ± 0.01	1800 ± 450	0.49
C-3 CRM 14.5 ^a	4	Max.	1.32	0.14	0.18	4100	
		Min.	0.09	0.05	0.09	2000	
		Avg.	0.42 ± 0.30	0.07 ± 0.02	0.13 ± 0.02	2500 ± 530	0.23
C-5 CRM 4.5 ^a	4	Max.	0.82	0.05	0.27	1400	
		Min.	0.05	0.05	0.09	600	
		Avg.	0.31 ± 0.18	0.05	0.19 ± 0.05	1100 ± 190	0.15

^a Measured values in the Clinch River.

^b Values given for this location are calculated values based on the concentrations measured at White Oak Dam (Station W-1) and the dilution afforded by the Clinch River. They do not include radioactive materials (e.g., fallout) that may enter the river upstream of White Oak Creek outfall (CRM 20.8).

^c 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 ERDA Manual, Appendix 0524, Annex A.⁽¹⁾

Table 11
 URANIUM CONCENTRATION IN SURFACE STREAMS
 1975

STATION NUMBER ^a	LOCATION	NUMBER OF SAMPLES	UNITS OF 10^{-8} $\mu\text{Ci}/\text{ml}$			% CG ^b
			MAXIMUM	MINIMUM	AVERAGE	
P-1	Poplar Creek	12	5.0	0.1	1.6 ± 0.8	<0.1
P-2	Poplar Creek	12	2.1	0.2	1.0 ± 0.4	<0.1
C-3	Clinch River	12	0.7	0.1	0.3 ± 0.2	<0.1
C-4	Clinch River	12	1.4	0.1	0.4 ± 0.2	<0.1
E-1	East Fork Poplar Creek	12	10.3	4.0	6.3 ± 1.3	0.2
B-1	Bear Creek	11	8.7	2.6	5.0 ± 1.6	0.2

^a See Figure 3.

^b CG is 3×10^{-5} $\mu\text{Ci}/\text{ml}$ for a mixture of uranium isotopes (ERDA Manual, Appendix 0524, Annex A, Table II).

Table 12
DISCHARGES OF RADIOACTIVITY TO SURFACE STREAMS
1975

RADIONUCLIDE	CURIES DISCHARGED
^{137}Cs	0.6
^{60}Co	0.5
^3H	11,000
^{131}I	0.3
^{106}Ru	0.3
^{90}Sr	7.2
^{99}Tc	9
Uranium ^a	1.6
^{232}Th	0.03
Transuranics ^b	0.02

^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 13
 CHEMICAL WATER QUALITY DATA -- WHITE OAK DAM
 (Location W-1, Figure 3)
 1975

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l			% STD.
		MAXIMUM	MINIMUM	AVERAGE	
Cr	12	0.2	< 0.005	< 0.06 ± 0.05	< 120
Zn	12	0.03	< 0.005	< 0.02 ± 0.03	< 20
NO ₃ (N)	12	1	0.4	0.7 ± 0.2	7
Hg	12	0.0003	0.0001	0.0002 ± 0.0001	4

^a Tennessee Stream Guidelines.

Table 14
 CHEMICAL WATER QUALITY DATA – MELTON HILL DAM
 (Location C-2, Figure 3)
 1975

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l			% STD.
		MAXIMUM	MINIMUM	AVERAGE	
Cr	12	0.02	< 0.005	< 0.01 ± 0.007	0.05 < 20
Zn	12	0.02	< 0.005	< 0.01 ± 0.03	0.1 < 10
NO ₃ (N)	12	0.5	0.07	0.3 ± 0.1	10 3
Hg	12	< 0.0001	< 0.0001	< 0.0001	0.005 < 2

^a Tennessee Stream Guidelines.

Table 15
 CHEMICAL WATER QUALITY DATA – ORGDP SANITARY WATER
 PUMPING STATION
 (Location C-3, Figure 3)
 1975

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD. ^a
		MAXIMUM	MINIMUM	AVERAGE	STD. ^a	
Cd	12	< 0.005	< 0.005	< 0.005	0.01	< 50
Cl ⁻	2	3.8	2	2	250	< 1
Cr	12	0.008	< 0.005	< 0.006 ± 0.001	0.05	< 12
CN	2	0.002	< 0.001	< 0.001	0.01	< 10
NO ₃ (N)	2	1.6	0.8	1.2	10	12
Pb	12	0.02	< 0.01	< 0.01 ± 0.003	0.05	< 20
SO ₄ ⁻	2	15	5	10	250	4
T.D.S.	2	128	120	124	500	25
Zn	12	0.2	< 0.005	< 0.04 ± 0.03	0.1	< 40
F ⁻	2	0.8	< 0.1	< 0.5	1.0	< 50
Hg	12	< 0.001	< 0.001	< 0.001	0.005	< 20
Ni	12	0.3	0.01	0.07 ± 0.06	0.1	70

^a Tennessee Stream Guidelines.

NOTE: Deviations were not reported for substances having only two samples, as the statistical methods used are not meaningful for a population this small.

Table 16
 CHEMICAL WATER QUALITY DATA – ORGDP RECIRCULATING
 WATER PUMPING STATION
 (Location C-4, Figure 3)
 1975

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l			% STD. ^a
		MAXIMUM	MINIMUM	AVERAGE	
Cd	12	< 0.005	< 0.005	< 0.005	0.01
Cl ⁻	2	4	4	4	250
Cr	12	0.2	< 0.005	< 0.03 ± 0.04	0.05
CN	2	0.002	< 0.001	< 0.002	0.01
NO ₃ (N)	2	4.2	2.5	3.4	10
Pb	12	0.25	< 0.01	< 0.03 ± 0.04	0.05
SO ₄ ⁻	2	17	6	12	250
T.D.S.	2	144	113	129	500
Zn	12	0.06	< 0.005	< 0.02 ± 0.01	0.1
F ⁻	2	0.2	0.1	0.15	1.0
Hg	12	0.01	< 0.001	< 0.002 ± 0.002	0.005
Ni	12	0.1	< 0.01	< 0.04 ± 0.03	0.1

^a Tennessee Stream Guidelines.

NOTE: Deviations were not reported for substances having only two samples, as the statistical methods used are not meaningful for a population this small.

Table 17
 CHEMICAL WATER QUALITY DATA – EAST FORK POPLAR CREEK
 (Location E-1, Figure 3)
 1975

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l				% STD. ^a
		MAXIMUM	MINIMUM	AVERAGE	STD. ^a	
Cd	12	0.004	< 0.002	< 0.002 ± 0.0004	0.01	< 20
Cl ⁻	12	12	6	10 ± 1	250	4
Cr	12	0.01	< 0.01	< 0.01	0.05	< 20
F ⁻	12	1.3	< 0.1	< 0.9 ± 0.2	1.0	< 90
Hg	12	0.0009	< 0.0005	< 0.0006 ± 0.00006	0.005	< 12
NO ₃ (N)	12	8	3	4 ± 1	10	40
Pb	12	0.03	< 0.01	< 0.02 ± 0.006	0.05	< 40
SO ₄ ⁻²	12	65	25	43 ± 7	250	17
T.D.S.	12	253	149	185 ± 19	500	37
Zn	12	0.1	< 0.02	< 0.07 ± 0.02	0.1	< 70

^a Tennessee Stream Guidelines.

Table 18
 CHEMICAL WATER QUALITY DATA — BEAR CREEK
 (Location B-1, Figure 3)
 1975

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l			% STD.
		MAXIMUM	MINIMUM	AVERAGE	
Cd	11	0.006	< 0.002	< 0.003 ± 0.0008	0.01 < 30
Cl ⁻	11	17	2	7 ± 4	250 3
F ⁻	11	0.4	0.3	0.3 ± 0.03	1.0 30
NO ₃ (N)	11	25	6	15 ± 4	10 150
SO ₄ ⁻	11	31	< 15	< 19 ± 3	250 < 8
Zn	11	0.09	< 0.02	< 0.05 ± 0.02	0.1 < 50

a Tennessee Stream Guidelines.

Table 19
 CHEMICAL WATER QUALITY DATA – POPLAR CREEK ABOVE BLAIR BRIDGE
 (Location P-1, Figure 3)
 1975

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION mg/l			% STD. ^a
		MAXIMUM	MINIMUM	AVERAGE	
Cd	12	< 0.005	< 0.005	< 0.005	0.01 < 50
Cl ⁻	2	8	4	6	250 2
Cr	12	0.04	< 0.005	< 0.01 ± 0.008	0.05 < 20
CN	2	0.003	< 0.001	< 0.002	0.01 < 20
NO ₃ (N)	2	6	2.6	4.3	10 43
Pb	12	0.02	< 0.01	< 0.01 ± 0.003	0.05 < 20
SO ₄ ²⁻	2	23	11	17	250 7
T.D.S.	2	177	104	141	500 28
Zn	12	0.07	< 0.005	< 0.03 ± 0.01	0.1 < 30
F ⁻	2	0.3	< 0.1	< 0.2	1.0 < 20
Hg	12	0.01	< 0.001	< 0.002 ± 0.002	0.005 < 40
Ni	12	0.07	< 0.01	< 0.03 ± 0.02	0.1 < 30

^a Tennessee Stream Guidelines.

NOTE: Deviations were not reported for substances having only two samples, as the statistical methods used are not meaningful for a population this small.

Table 20
 CHEMICAL WATER QUALITY DATA – POPLAR CREEK NEAR CLINCH RIVER
 (Location P-2, Figure 3)
 1975

SUBSTANCE	NUMBER OF SAMPLES	CONCENTRATION, mg/l			% STD. ^a
		MAXIMUM	MINIMUM	AVERAGE	
Cd	12	< 0.005	< 0.005	< 0.005	0.01
Cl ⁻	2	6	4.1	5.1	250
Cr	12	0.05	0.005	0.01 ± 0.008	0.05
CN	2	0.004	< 0.001	< 0.002	0.01
NO ₃ (N)	2	2.6	1.7	2.1	10
Pb	12	0.02	< 0.01	< 0.01 ± 0.003	0.05
SO ₄ ⁻	2	10	8	9	250
T.D.S.	2	149	142	146	500
Zn	12	0.12	0.007	0.03 ± 0.02	0.1
F ⁻	2	0.3	0.1	0.2	1.0
Hg	12	0.01	< 0.001	< 0.002 ± 0.002	0.005
Ni	12	0.18	0.01	0.03 ± 0.03	0.1

^a Tennessee Stream Guidelines.

NOTE: Deviations were not reported for substances having only two samples, as the statistical methods used are not meaningful for a population this small.

Table 21
 CONCENTRATION OF ^{131}I IN RAW MILK
 1975

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF $10^{-9} \mu\text{Ci/ml}$			COMPARISON WITH STANDARD ^b
		MAXIMUM	MINIMUM ^a	AVERAGE	
Immediate Environs ^c					
1	46	5.4	< 0.45	< 0.68	FRC Range I
2	47	5.0	< 0.45	< 0.59	FRC Range I
3	47	2.7	< 0.45	< 0.56	FRC Range I
4	33	1.3	< 0.45	< 0.49	FRC Range I
5	47	2.5	< 0.45	< 0.53	FRC Range I
6	47	1.6	< 0.45	< 0.50	FRC Range I
7	47	1.2	< 0.45	< 0.51	FRC Range I
Average				< 0.56 ± 0.03	FRC Range I
Remote Environs ^d					
51	9	0.45	< 0.45	< 0.45	FRC Range I
52	10	1.0	< 0.45	< 0.52	FRC Range I
53	7	0.45	< 0.45	< 0.45	FRC Range I
54	10	0.45	< 0.45	< 0.45	FRC Range I
Average				< 0.47 ± 0.05	FRC Range I

^a Minimum detectable concentration of ^{131}I is $0.45 \times 10^{-9} \mu\text{Ci/ml}$.

^b Applicable FRC standard, assuming 1 liter per day intake:

Range I	0 to $1 \times 10^{-8} \mu\text{Ci/ml}$	— Adequate surveillance required to confirm calculated intakes.
Range II	$1 \times 10^{-8} \mu\text{Ci/ml}$ to $1 \times 10^{-7} \mu\text{Ci/ml}$	— Active surveillance required.
Range III	$1 \times 10^{-7} \mu\text{Ci/ml}$ to $1 \times 10^{-6} \mu\text{Ci/ml}$	— Positive control action required.

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

^c See Figure 4.

^d See Figure 5.

Table 22
 CONCENTRATION OF ^{90}Sr IN RAW MILK
 1975

STATION NUMBER	NUMBER OF SAMPLES	UNITS OF $10^{-9} \mu\text{Ci/ml}$			COMPARISON WITH STANDARD ^b
		MAXIMUM	MINIMUM ^a	AVERAGE	
Immediate Environs ^c					
1	48	4.6	1.7	3.2	FRC Range I
2	48	3.9	1.0	2.5	FRC Range I
3	48	5.1	1.3	3.3	FRC Range I
4	35	4.0	1.0	2.2	FRC Range I
5	48	7.3	3.0	5.0	FRC Range I
6	48	10	3.1	6.1	FRC Range I
7	34	3.9	1.2	2.7	FRC Range I
Average				3.7 ± 0.10	FRC Range I
Remote Environs ^d					
51	9	3.9	2.4	3.1	FRC Range I
52	10	7.2	0.7	2.2	FRC Range I
53	7	4.6	2.8	3.5	FRC Range I
54	9	4.7	3.1	4.1	FRC Range I
Average				3.2 ± 0.37	FRC Range I

^a Minimum detectable concentration of ^{90}Sr in milk is $0.5 \times 10^{-9} \mu\text{Ci/ml}$.

^b Applicable FRC standard, assuming 1 liter per day intake:

Range I	0 to $2 \times 10^{-8} \mu\text{Ci/ml}$	—	Adequate surveillance required to confirm calculated intakes.
Range II	$2 \times 10^{-8} \mu\text{Ci/ml}$ to $2 \times 10^{-7} \mu\text{Ci/ml}$	—	Active surveillance required.
Range III	$2 \times 10^{-7} \mu\text{Ci/ml}$ to $2 \times 10^{-6} \mu\text{Ci/ml}$	—	Positive control action required.

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

^c See Figure 4.

^d See Figure 5.

Table 23
 RADIONUCLIDE CONTENT OF CLINCH RIVER AND MELTON HILL LAKE FISH
 1975

SPECIES	NUMBER OF SAMPLES ^a	pCi/kg Wet Weight						ESTIMATED % MPI ^b
		⁹⁰ Sr	⁶⁰ Co	¹⁰⁶ Ru	¹³⁷ Cs	^{110m} Ag	¹²⁵ Sb	
White Crappie	1	140	41	130	490	72	28	1.0
Carp	1	46	5.9	25	29	20	10	0.3
White Crappie	1	220	45	230	30	90	39	1.6
Carp	1	13	14	26	17			0.1

Clinch River Mile 41.0 (Melton Hill Lake)

Clinch River Mile 14.5 (Below ORNL)

a Composite of ten fish in each species.

b Maximum Permissible Intake – Intake of radionuclides 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 the radionuclides in question. Consumption of fish is assumed to be 37 lb/yr of the species in question.

Table 24
VEGETATION SAMPLING DATA
1975

STATION NUMBER ^a	F ⁻ CONCENTRATION ^b μg/g (ppm)		U (TOTAL) CONCENTRATION ^b μg/g (ppm)	
	GRASS	PINE NEEDLES	GRASS	PINE NEEDLES
VS 1	8	—	0.3	—
VS 2	8 ^c	8	0.1	< 0.1
VS 3	40	5	0.1	< 0.1
VS 4	17	9	0.3	< 0.1
VS 5	24 ^c	9	0.1	0.2
VS 6	5	4	0.3	< 0.1
VS 7	44	8	0.2	< 0.1
VS 8	97	28	0.4	0.3
VS 9	46	12	0.3	0.3
VS 10	32	18	< 0.1	2.4

^a See Figure 1.

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

^c Only one sample collected.

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 25
 SOIL SAMPLES FROM NEAR
 PERIMETER AIR MONITORING STATIONS
 1975

SAMPLING ^a LOCATION	NUMBER OF SAMPLES ^b	DRY SOIL ^c UNITS OF 10^{-8} $\mu\text{Ci/g}$	
		PLUTONIUM (a)	URANIUM (a)
HP-31	1	3.3	180
HP-32	1	5.4	170
HP-33	1	3.7	29
HP-34	1	5.0	33
HP-35	1	5.0	29
HP-36	1	3.6	35
HP-37	1	2.1	26
HP-38	1	2.5	35
HP-39	1	4.3	59
Average		3.9	66

^a See Figure 1.

^b Nine samples, approximately three inches in diameter and one centimeter thick, collected in a one-square-meter area at each location and composited for analysis.

^c Applicable guides for soil contamination have not been established.

NOTE: Representative concentration of Plutonium in U. S. surface soil is 5×10^{-8} $\mu\text{Ci/g}$ (10).

Table 26
 POPLAR CREEK SEDIMENT SAMPLES
 July/November 1975

Average Concentration ($\mu\text{g/g}$ dry weight basis)

STATION	U	Hg	Pb	Ni	Cu	Zn	Cr	Mn	Cd	Al	Th
SD-1	4.48	11	112.5	105	100	120	105	690	3	50,000	< 20
SD-2	8.25	< 2.55	110	90	145	160	130	585	< 2.55	63,500	< 20*
SD-3	10.21	5	175	130	205	200	210	660	< 2.55	62,000	< 20*
SD-4	4.31	3.5	225	85	120	130	130	430	< 0.55	64,500	< 20*
SD-5	5.39	3.5	30	95	80	115	95	390	< 0.55	44,500	< 20*
SD-6	2.71	5.25	87.5	75	195	115	80	835	3.5	59,000	< 20*
SD-7	90.51	5.5	47.5	580	290	245	390	565	3	55,500	< 20*
SD-8	4.46	3	30	70	120	110	60	560	< 0.1	51,500	< 20

*Only one sample analyzed.

NOTE: Station SD-8 is above ORGDP and Station SD-1 is at the mouth of Poplar Creek.

Table 27
 SUMMARY OF THE ESTIMATED RADIATION DOSE
 TO AN ADULT INDIVIDUAL DURING 1975 AT LOCATIONS OF MAXIMUM EXPOSURE
 FROM GASEOUS AND LIQUID EFFLUENTS OF THE OAK RIDGE FACILITIES

PATHWAY	LOCATION	DOSE (MILLIREM)	
		TOTAL BODY	CRITICAL ORGAN
Gaseous effluents			
Inhalation plus direct radiation from air and ground	Nearest resident to side boundary	0.4	6.9 (lung)
Terrestrial food chains	Milk sampling Station #6	0.2	8.8 (bone)
Liquid effluents			
Aquatic food chains	Clinch-Tennessee River system	0.07	3.4 (bone)
Drinking water ^a	Kingston, Tennessee	0.02	0.3 (bone)
Direct radiation along water, shores and mud flats	Downstream from White Oak Creek near Cs field plots	8.4	8.4 (total body)

^a Based on the analysis of raw (unprocessed) water; see text.

NOTE: Average background dose in the U. S. (28) 106 mrem/yr.

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