ORNL-3665
UC-41 – Health and Safety
TID-4500 (31st ed.)

APPLIED HEALTH PHYSICS ANNUAL REPORT FOR 1963

OAK RIDGE NATIONAL LABORATORY

operated by

UNION CARBIDE CORPORATION

for the

U.S. ATOMIC ENERGY COMMISSION

Printed in USA. Price: $1.75 Available from the
Office of Technical Services
U. S. Department of Commerce
Washington 25, D. C.

ORNL-3665

CONTRACT NO. W-7405-ENG-26

HEALTH PHYSICS DIVISION

APPLIED HEALTH PHYSICS ANNUAL REPORT FOR 1963

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AUGUST 1964

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
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1.0 SUMMARY

The waste releases from the Laboratory, atmospheric and liquid, were such that the concentration of radioactive materials in the environs were well below the maximum levels recommended by the NCRP and FRC. There was a reduction in the number of beta curies released via White Oak Creek to Clinch River, 469 curies in 1963 compared with 1436 curies in 1962. Also, there was a reduction in the average concentration of ^{131}I in milk samples processed, 13 pc/liter in 1963 compared with 96 pc/liter in 1962. The concentration of radioactive materials in the air and the background readings for 1963 did not show a significant change as compared with 1962.

There was one significant personnel exposure recorded during the year. One employee received an exposure to tritium which resulted in an estimated body deposition of approximately 87 mc. The indicated dose to the whole body was estimated to result in a total dose of about 14 rem (computed over the entire period during which the tritium will be retained by the body).

The Laboratory experienced 43 unusual occurrences during 1963. All but one of which were classified as minor events. The one radiation event was the tritium exposure noted above. The frequency rate for unusual occurrences continued to drop during 1963. Forty-three unusual occurrences were recorded during 1963 as compared with 55 for 1962.

2.0 ENVIRONS MONITORING

2.1 Introduction

The Health Physics Division monitors for air-borne radioactivity in the East Tennessee area by the use of three separate monitoring networks. The local air monitoring (LAM) network consists of twenty-two stations which are positioned in relation to ORNL operational activities (Figs. 1 and 2); the perimeter air monitoring (PAM) network consists of seven stations which are located on the perimeter of the AEC controlled area (Fig. 3); and the remote air monitoring (RAM) network consists of seven stations which are located outside the AEC controlled area at distances of from 12 to 75 miles from ORNL (Fig. 4). The monitoring networks provide for the collection of (1) air-borne radioactivity by air filtration techniques, (2) radioparticulate fall-out material by impingement on gummed paper trays, and (3) rain water for measurement of fall-out occurring as rain-out. The filter data are representative of radioparticulate matter which might be considered respirable; the gummed paper data are representative of radioparticulate fall-out; and the rain water data provide information on the soluble and insoluble fractions of the radioactive content of fall-out material.[1]

Low level radioactive liquid wastes originating from ORNL operations are discharged, after preliminary treatment, to the White Oak Creek which is a small tributary of the Clinch River. Liquid waste releases are controlled so that the resulting average radioactive concentrations in the Clinch River comply with maximum permissible concentrations established for populations in the neighborhood of an atomic energy installation as recommended by the National Committee on Radiation Protection (NCRP) and the Federal Radiation Council (FRC).

The radioactive content of the White Oak Creek discharge is determined at White Oak Dam (Fig. 5) which is the last control point along the stream prior to entry of White Oak Creek waters into Clinch River waters. Water samples are collected at a number of locations along the Clinch River, beginning at a point above the entry of wastes into the river via White Oak Creek and ending at Center's Ferry (near Kingston, Tennessee) about 16 miles downstream from the confluence of White Oak Creek and the Clinch River. Water samples are analyzed for gross radioactivity and for certain specified long-lived radionuclides. Using the maximum permissible concentration values for drinking water, $(MPC)_W$, for each isotope as recommended by NCRP, a weighted average $(MPC)_W$ for the mixture of radionuclides is calculated on the basis of the isotopic distribution in the water. The average concentrations of gross activity are used for control purposes.

Raw milk samples are collected at ten sampling stations located within a radius of 50 miles from ORNL. Samples are taken on a weekly basis from

[1] A detailed discussion concerning techniques used in processing air and water samples for environmental monitoring purposes is given in ORNL-2601.

six stations which are located outside the AEC controlled area within a 12-mile radius of ORNL. Samples are collected every five weeks from the four remaining stations, all of which are located outside the 12-mile radius up to distances of about 50 miles. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of ORNL provide data by which one may evaluate the possible effect of waste releases originating from ORNL operations; second, samples collected remote to the immediate vicinity of the ORNL area provide background data which are essential in establishing a proper index from which the intentional or accidental release of radioactive materials originating from Oak Ridge operations may be evaluated.

Experiments have shown that cattle thyroid analysis provides a practical method for the detection of radioiodine in the environment. Although this particular technique does not present a means of evaluating the hazard to man from ^{131}I in the environment, it does provide a much more sensitive indicator for detecting the presence of radioiodine in the environment than is available by milk analysis.[2] Near the close of the third quarter arrangements were made to obtain cattle thyroid tissue each week through a cooperative program with the UT-AEC research staff. The thyroid tissues provided are taken from cattle (slaughtered for other purposes) that have been pastured within a 100-mile radius of ORNL. Radioiodine analysis is accomplished by gamma scintillation counting techniques using a 4" x 4" crystal and a single channel gamma spectrometer.

Aerial background surveys are made at least once each calendar quarter over the ORNL area and for several miles distant from ORNL in the general direction of low altitude prevailing winds. Using light aircraft and flying at speeds of approximately 120 miles per hour, experiments have shown that, at an altitude of approximately 300 feet, it is possible to detect ^{131}I contamination upon grasslands with reasonable accuracy by scintillation detectors down to levels of about 0.5 $\mu c/m^2$. Thus, light aircraft, equipped with portable scintillation detectors and used in the manner described above, provide a practical means of detecting extensive high-level deposits of ^{131}I on ground surfaces.

Background gamma radiation measurements are made monthly at a number of locations within the Oak Ridge geographical area and less frequently at locations throughout other portions of the East Tennessee area. These measurements are taken with calibrated GM and scintillation type detectors at a distance of three feet above the surface of the ground.

River bottom sediments in the Clinch and Tennessee Rivers have been surveyed and analyzed annually since the year 1951 for the purpose of providing data relative to the dispersion of radioactive wastes released from Oak Ridge operations to the Clinch River.

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[2] ORNL-3492, Applied Health Physics Annual Report for 1962, p. 72.

2.2 Atmospheric Monitoring

Twelve new air monitoring stations were added to the LAM network during the year bringing the total number of stations to twenty-two. (The twelve new stations were operated only a few weeks during 1963 and the data generated by the twelve new stations are not included in the statistical summary which follows.)

2.2.1 Air Concentrations - The average concentrations of radioactive materials in the atmosphere, as measured by filtration methods provided by the LAM, PAM, and RAM networks during 1963, were as follows:

Network	Concentration (μc/cc)
LAM	4.9×10^{-12}
PAM	4.0×10^{-12}
RAM	4.3×10^{-12}

The LAM network value of 4.9×10^{-12} μc/cc is about 0.49 per cent of the $(MPCU)_a$[3] based on occupational exposure. When evalulated in terms of the maximum permissible concentration for persons residing in the neighborhood of an atomic energy installation, the PAM and RAM network values represent 4.0 and 4.3 per cent of the $(MPCU)_a$ respectively. Table 1 gives a tabulation of data for each station within each network. The weekly values for each network are graphically illustrated in Fig. 6.

2.2.2 Fall-Out (Gummed Paper Technique) - Radioparticulate fall-out decreased in 1963 by a factor of about 3 from the values obtained during 1962. In general, fall-out activity was highest during the early part of 1963 with a uniform decrease occurring throughout all networks until about the middle of the third quarter. Beginning in the third quarter, the LAM network averages were several times greater than those recorded by the other two networks (Fig. 7). It has been noted that LAM network measurements are affected by fall-out originating from local operations as well as weapons testing operations and normally show higher values than those recorded by the PAM and RAM networks when world-wide fall-out is low. The average number of particles per square foot collected each week by gummed paper fall-out collector techniques is shown for each monitoring station in each network in Table 2.

The abundance of radioactive particles collected on the air monitor filters in 1963 decreased by a factor of about 1.5 when compared to 1962. The radioparticulate count per 1000 cubic feet of air sampled by filtration techniques at each air monitoring station in each network is shown in Table 1.

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[3] The $(MPCU)_a$ is defined as the maximum permissible concentration for an unknown mixture of radioisotopes in air. NBS Handbook 69, Table 4, p. 94, gives exposure values applicable to various mixtures of radionuclides and establishes guide lines for deriving the $(MPCU)_a$.

2.2.3 Atmospheric Radioiodine (Charcoal Collector Techniques) - Atmospheric radioiodine averaged about 0.015 pc/m^3, 0.005 per cent $(MPC)_a$ for ^{131}I during 1963. The maximum levels were observed at the Gallaher, White Oak Dam and Blair stations. The highest level was observed at the Gallaher station where the calculated concentration was 0.79 pc/m^3, 0.25 per cent $(MPC)_a$ for ^{131}I, when corrected for decay and averaged over the collection period of one week. The observation at the above three stations correlated with a release of approximately 3191 millicuries of radioiodine from ORNL[4] at a time when atmospheric conditions were favorable for the released radioiodine to be carried to these stations.

2.3 Water Analysis

2.3.1 Rain Water - The average concentrations of radioactivity in rain water collected from the three networks during 1963 were as follows:

Network	Concentration (μc/cc)
LAM	8.4×10^{-7}
PAM	8.9×10^{-7}
RAM	13×10^{-7}

The lack of a significant difference between network averages indicates that the radioactivity in the collected rain water was not of local origin. The higher average value measured by the RAM network during 1963 may be attributed to the samples collected during weeks 15 and 19 (Fig. 8). During weeks 15 and 19, no rain was collected by the LAM and PAM networks, while 0.01 inches of rainfall were collected at one or more stations of the RAM network. A collection of a small total amount of rainfall, or of a sample taken during the first part of a rain, results in a higher than normal concentration of radioactivity in rain water collected. (This phenomenon tends to explain the higher average value obtained by the RAM network for 1963.) Average values derived for each station are shown in Table 3.

2.3.2 Clinch River Water - A total of 469 beta curies of radioactivity was released via White Oak Creek to the Clinch River during 1963 (Table 4). Radiochemical analyses of the effluent passing through White Oak Dam indicated that about 92 per cent of the radioactivity consisted of ^{106}Ru which is essentially the same as that recorded during 1962. The percentage of ^{90}Sr in the effluent leaving White Oak Dam was 1.7 per cent in 1963 as compared to 1.3 per cent in 1962.

The calculated average concentration of radioactive materials in the Clinch River at Clinch River Mile (CRM)20.8 (the point of entry of White Oak Creek into the river) was 1.6×10^{-7} μc/ml which represents 4.7 per cent of the weighted average $(MPC)_w$ recommended for persons who reside in the neighborhood of an atomic energy installation (Table 5). The average

[4] "Summary of Waste Discharges, Week Ending 10-27-63," L. C. Lasher.

concentration of radioactive materials in the Clinch River did not exceed 17 per cent of the $(MPC)_w$ during any given week during 1963 (Fig. 9).

The measured average concentration of radioactivity in the water taken from the Clinch River at CRM 41.5 (above the entry of White Oak Creek) was 1.3 per cent of the weighted average $(MPC)_w$ (Table 5). The concentration of ^{90}Sr in the river above the entry of White Oak Creek is about the same as the contribution calculated for White Oak Creek effluent at CRM 20.8 assuming uniform mixing of the two streams. The radioactive materials in the river upstream presumably are the result of fall-out from world-wide weapons testing and natural causes.

The measured average concentration of radioactive materials in the Clinch River at CRM 4.5 (near Kingston, Tennessee) was 1.0×10^{-7} μc/ml. This value represents 3.7 per cent of the $(MPC)_w$ as applied to persons residing in the neighborhood of an atomic energy installation.

2.4 Milk Analyses

The average concentration of ^{90}Sr in raw milk samples collected from within a radius of 50 miles of the Laboratory during the first nine months of 1963 was 43 pc/liter. The average concentration of ^{131}I for the entire year (1963) was 13 pc/liter. Both the average ^{90}Sr and ^{131}I values derived from samples processed at ORNL fall within FRC Range II limits if one assumes the average daily intake per individual to be one liter per day.

The average ^{131}I concentration in raw milk samples during 1963 (13 pc/liter) was lower than the values recorded during 1962 by a factor of about 7 and approached the lower limit of detection (10 pc/liter) of the method used for the analysis of ^{131}I in milk. The average concentration of ^{90}Sr in milk during 1963 increased by a factor of 1.3 from the average value measured during 1962. This increase of a factor of 1.3 measured in the Oak Ridge area compares with a predicted[5] increase of a factor of 2 for the United States as a whole.

2.5 Cattle Thyroid Analysis

Thyroid tissues taken from cattle pastured within a radius of 100 miles of Oak Ridge were analyzed for radioiodine at the rate of five thyroid specimens per week from September through December. Of the 71 thyroid specimens assayed for radioiodine, 14 specimens showed quantities of ^{131}I that were significantly different from zero; the remaining 57 were below the limit of detection ($\sim$ 1.0 pc/g) of the method used. Radioiodine content averaged 6.4 pc/g of tissue in those cases where radioactivity was detectable. The maximum value observed on any one thyroid was 17 pc/g. The iodine concentrations measured in cattle thyroid tissue during this period were on the order of 1/100 of the levels measured in mid 1962 during nuclear weapons testing operations. The 1963 data indicate that the concentration of radioiodine in the East Tennessee environment is relatively insignificant when compared with maximum permissible intake levels.

[5] Federal Radiation Council Report No. 4, May 1963.

2.6 Background Measurements

Background measurements were taken at a number of locations (established in 1961) in the East Tennessee area during routine servicing visits to the remote air monitoring stations. Measurements were made at each location on a frequency of once each five weeks. Average background readings and the location of each station are presented in Fig. 10. The average background level during 1963 as measured at these stations was 0.018 mR/hr, which is essentially the same as the value recorded in 1962.

Background measurements made monthly with a calibrated GM tube monitor at five selected locations adjacent to the ORNL area yielded an average background reading of approximately 0.026 mR/hr during 1963. The 1963 value is about 2 times the average background level measured in the Oak Ridge area in 1943 prior to the start-up of the Oak Ridge Graphite Reactor. A comparison of average background values taken both on and off the X-10 site for the years 1950-1963 is presented in Fig. 11.

2.7 Annual Survey of the Clinch and Tennessee Rivers

The annual survey of the Clinch and Tennessee Rivers, carried out during the summer of 1963, was extended 20 miles upstream from the mouth of White Oak Creek to Clinch River Mile (CRM) 42.8. Previous surveys ended at CRM 22.8. The expanse of the Tennessee River covered by the survey extended from Fort Loudoun Reservoir (TRM 615.8) through Guntersville Reservoir (TRM 354.4). (The techniques and procedures used are described in ORNL-2847.)

Figures 12 and 13 show the gamma count rate observed at the surface of the Clinch and Tennessee River bottom silt for the years 1961, 1962, and 1963. The longitudinal dispersion of radioactive materials in the silt of the Clinch River (Fig. 12) is essentially the same as was observed in 1961 and 1962 except for the stretch of river immediately downstream from the mouth of White Oak Creek (CRM 20.8) and immediately upstream from the point of entry of the Emory River (CRM 4.4). The average of all gamma measurements taken in the Clinch River, downstream from CRM 21.5, was about the same in 1963 (47 c/m) as was observed in 1962 (49 c/m). The total number of curies discharged to the Clinch River, however, decreased from 1700 curies during the 12-month period just prior to the 1962 survey to 794 curies during the corresponding period in 1963.

The average gamma count rate on bottom silt located in the Tennessee River (Fig. 13) showed a decrease in Watts Bar and Hales Bar reservoirs; there was essentially no change in Chicamauga and Guntersville reservoirs. The average gamma count rate observed in both Clinch and Tennessee River bottom silt for the years 1951 through 1963 is given in Fig. 14. A slight decrease was noted in the gamma radiation emanating from bottom silt in both rivers in 1963 when compared to the 1962 data.

Radiochemical analyses data obtained from Clinch and Tennessee River silt collected in the 1962 and 1963 surveys are given in Tables 6 and 7.

No significant increases or decreases are noted in the average concentrations of the major radionuclides in Clinch River silt, Table 6.

Increases recorded in the concentrations of ^{144}Ce, ^{90}Sr, $^{95}Zr + ^{95}Nb$, and the rare earths in Tennessee River silt (Table 7) may be attributed to fall-out from world-wide nuclear weapons testing. This conclusion is supported by increases in concentrations of the same radionuclides in Fort Loudoun silt ("Fort Loudoun Background Data," Table 7).

3.0 PERSONNEL MONITORING

The Dosimetry Section of Applied Health Physics has the major responsibility for the personnel monitoring program at ORNL. Dose analysis is accomplished mainly through the use of personal meters, bio-assays, and in vivo counting (whole body counter) techniques.

3.1 Dose Analysis Summary, 1963

3.1.1 External Exposures - No employee received an external radiation dose which exceeded the maximum permissible levels recommended by the Federal Radiation Council (FRC). The highest whole body radiation dose received by an employee was about 5.1 rem or 42 per cent of the maximum permissible annual dose. The range of doses for persons using ORNL badge-meters is shown in Table 8.

As of December 31, 1963, only one employee had a cumulative whole body dose which exceeded the recommended maximum permissible dose as based on the age proration formula 5(N-18) (see Table 9). Nearly all of the dose recorded for this individual (67.6 rem) resulted from an accidental exposure which occurred during 1957, and at the end of 1963 represented about 113 per cent of the dose permitted by the age proration formula; his average dose per year of employment at ORNL was 8.5 rem. Only one other employee had an average annual exposure rate that exceeded 5 rem per year of employment (Table 10); in this latter case the average annual dose was 5.2 rem and the cumulative dose was accrued over a period of about 12 years.

As of December 31, 1963, the highest cumulative dose of whole body radiation received by an employee was approximately 83 rem. The 83 rem dose was accrued over an employment period of about 19 years and represented an annual exposure of about 4.3 rem.

The highest cumulative hand exposure recorded during 1963 was about 18.2 rem or 24 per cent of the recommended maximum permissible annual dose to the extremities.

No employee received a dose to the skin of the whole body that exceeded 30 per cent of the maximum permissible annual skin dose of 30 rem.

3.1.2 Internal Exposures - During 1963, one employee received an exposure to tritium oxide which resulted in an estimated body deposition of approximately 87 mc. The integrated dose to the whole body was estimated to result in a total dose of about 14 rem (computed over the entire period during which the tritium will be retained by the body). The employee was restricted to work with non-radioactive materials until the quantity of tritium deposition in the body is reduced to permissible levels. There were no other cases of internal exposure where the deposition of radioactive materials within the body was estimated to have averaged greater than half a maximum permissible body burden.[1]

Three employees continued to have estimated body burdens of transuranic alpha emitters (mainly ^{239}Pu) of 35 to 40 per cent of the recommended maximum permissible value.[2] Health Physics procedures require that individuals who exceed 30 per cent of a maximum permissible body burden be placed on a work assignment where the potential for internal exposure is reduced.

3.2 External Dose Techniques

3.2.1 Film Meters - Film meters are issued to all persons who have access to ORNL facilities in which there is a potential for radiation exposures in excess of RPG levels. Either an ORNL badge-meter (Fig. 15) or a temporary pass-meter (Fig. 16) may be used. Badge-meters are assigned to all ORNL employees, and to certain other persons who are authorized to enter ORNL facilities frequently. Temporary pass-meters are issued in lieu of badge-meters for short-term use.

Beginning in August, 1963, visitors to ORNL facilities who did not require access to the radiation zones were issued temporary pass-meters labeled "Entry to Radiation Zone Prohibited." Routine record keeping of dose data generated by films taken from such meters was discontinued after experience showed that none of the 15,000 or more meters issued on this basis was exposed to a detectably significant dose (2 mR, 60 KeV or 20 mR, 1 MeV). These meters, however, provide for dosimetry in the event of a radiation accident.

NTA (nuclear track) film packets are included in all badge-meters issued to ORNL employees and assignees. The NTA films are processed routinely if the badge-meter is assigned to an individual who normally works where there may be exposure to neutrons. Spot checks are made on ten per cent of the NTA films used by other individuals.

Beta-gamma sensitive films from badge-meters issued to all employees and assignees are processed routinely each calendar quarter (or more frequently if necessary). Films used in other meters are processed as conditions of use may require. High-level radiation dosimetry components of the badge-meters (sulfur, gold, indium, and phosphate glass) are for use in the event that doses exceed the capability of the monitoring films.

3.2.2 Pocket Meters - Pocket meters (indirect reading, ionization chambers), Fig. 17, are made available at all principal points of entry to ORNL premises. A pair of pocket meters is carried for the duration of a

[1] AEC Manual Chapter 0502 requires an evaluation of the radiation exposure status of an employee when monitoring techniques indicate that a body burden equals or exceeds 50 per cent of a maximum permissible limit.

[2] Handbook 69 values are the basis for these determinations.

work shift by persons who work in an area where the potential for a dose of 20 mR or more exists during the work shift. Pocket meter pairs are processed at the end of each work shift by health physics technicians and the readings of 20 mR or more are reported daily to supervision.

Pocket meters provide for a day-to-day record of integrated exposures and warn if excessive exposures should occur.

3.2.3 Hand Exposure Meters - Hand exposure meters (Fig. 18) are film-loaded finger rings used to measure hand exposure. Hand exposure meters are issued on a weekly basis to persons for use during operations where it is likely that the hand dose is such as to exceed 1 rem during the week. Hand exposure meters are issued and collected by Radiation Survey Unit personnel who determine the need for this type of monitoring and arrange for a processing schedule.

3.2.4 Metering Resume - Shown in Table 11 are the quantities of personnel metering devices used and processed during 1963. The number of films processed was less than in 1962, and should be even less in 1964, because of the reduction in monitoring requirements for visitors to the Laboratory.

3.3 Internal Dose Techniques

3.3.1 Bio-Assays - Urine and fecal samples are analyzed for the purpose of making internal dose determinations. The frequency of sampling and the type of radiochemical analysis performed is based upon each specific radioisotope and the exposure potential. Because of the small quantities of radioactive material in most samples, qualitative analyses are not feasible, and only quantitative analyses of predetermined isotopes are performed routinely.

In most cases bio-assay data require interpretation to determine the dose of the person; computer programs are used for evaluation of extensive data on urinary excretion of ^{239}Pu and ^{90}Sr. An estimate of dose is made for all cases in which it appears that one-third of a body burden, averaged over a calendar year, may be exceeded.

3.3.2 Whole Body Counter - The whole body counter (In Vivo Gamma Spectrometer) may be used for determining internally deposited quantities of most of the gamma ray-emitting substances, and many of the more energetic beta-emitting substances. Thus, it provides a direct method of determining body burdens of those substances.

3.4 Records and Reports

Most records and reports are prepared by electro-data processing (EDP) techniques through the use of high-speed digital computer systems. The IBM 7090, located at the Central Data Processing Facility (CDPF), turns out routine weekly, quarterly, and annual reports involving external dose data. (A typical weekly report is shown in Fig. 19; a typical quarterly report is shown in Fig. 20. An IBM 1401, located at the Y-12 Plant, is used to provide the weekly pocket meter report (see Fig. 21). Quarterly bio-assay listings are prepared by the IBM 7090 at CDPF; a weekly Bio-Assay Sample Status Report (Fig. 22) is processed by the ORNL Math Panel utilizing a CDC 1604.

Reports involving AEC-ORO and TVA-EGCR film services are generated by the IBM 7090 at CDPF. Data generated from films used in the temporary tag-pass meter are used in an annual report prepared by use of the IBM 1401 located at the Y-12 Plant.

Plutonium-239 body burden estimates are prepared in report form (usually quarterly) by use of the IBM 7090 at CDPF.

All other reports are prepared by hand. Permanent files are maintained at Applied Health Physics Headquarters for each individual who is assigned an ORNL badge-meter. An IBM card cross-indexing system is maintained at the principal monitoring stations for the purpose of expediting meter assignments. These IBM cards are compatible with the various computer programs and provide for the internal audit of all personnel monitoring record data.

Copies of the EDP reports, both temporary and final, are maintained for both the internal and external dose programs. Data used in the EDP program are stored on computer quality magnetic tapes. Data pertinent to the work of the dosimetry groups and information used in the non-EDP reports are maintained in record form by Dose Data personnel.

3.5 Program Developments

A weekly report based on pocket meter readings was programmed for the computer during 1963. The daily pocket meter readings are used as input information; the finished weekly report lists pocket meter readings for each individual for each day in which pocket meters were used, totals the readings for the week, and shows the cumulative total for the quarter to date.

During 1963 a computer program was adopted for the purpose of providing a weekly report relative to the status of the bio-assay program. The report lists employees who are currently participating in the bio-assay sampling program. Individuals are cataloged by work area and division. The report gives information relative to (1) samples on request but not received, (2) samples received during the week of the report, (3) samples in process, and (4) results of samples completed during the week of the report. A statistical summary of the status of all samples by type of analysis and sample priority in addition to the above information is also provided.

Modifications were made in the EDP program for external exposure dose data during the year. (This program provides a quarterly summary of data for each individual and shows the current radiation exposure status.)

Each ORNL division is provided with a dose summary for each individual associated with the division. An annual individual summary is prepared which tabulates the exposure history within the current calendar decade.

4.0 LABORATORY OPERATIONS MONITORING

The Applied Health Physics Annual Report for 1959 (ORNL-3073) described a system for classifying radiation accidents, or near accidents, and the term "unusual occurrence" was adopted to describe these events. During the years 1961-1962, unusual occurrences were classified into minor and major events (ORNL-3284, p. 10). However, this two-part classification proved to be too broad in that the major event, by definition, covered a wide range of circumstances which included simple technical oversights that were not distinguished from events which took on more serious proportions. Consequently, during the summer of 1962, a joint study was undertaken by Applied Health Physics and Radiation Safety and Control[1] which resulted in the establishment of guidelines for classifying unusual occurrences according to a severity index system.

4.1 Unusual Occurrence Severity Index System

4.1.1 Minor Occurrence - An unusual occurrence which does not qualify as a "radiation event" (see 4.1.2 infra) is classified as a "minor occurrence" if the occurrence includes one or more of the following:

1. An event involving a violation of a health physics regulatory policy.

2. An event which might have had an adverse effect on public relations or would have resulted in a radiation accident under less fortunate circumstances.

3. An event involving an unplanned personnel exposure where (a) the external exposure in any one work week is in the range (i) 0.1 to 0.3 rem for exposure to the total body, head and trunk, lens of the eye, gonads, or blood forming organs, (ii) 0.6 to 1.0 rem for exposure to the skin of the body, (iii) 1.5 to 2.5 rem for exposures to the extremities, and/or (b) an individual is exposed to radiocontaminants at levels which require decontamination under medical supervision of a nature that (i) the external exposure resulting from such contamination does not equal or exceed the above prescribed upper limits, and (ii) the internal exposure is such that analysis of body fluids indicates an elimination rate that is less than 25 per cent of the excretion index.[2] (The limits established above are based on provisions set forth in Procedure No. 20, Reg. No. 2, p. 3, of the Health Physics Manual.)

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[1]Radiation Safety and Control Quarterly Report—July, August, and September, 1962, ORNL CF-62-11-19, November 5, 1962.

[2]The excretion index (EI) is that quantity of an internally deposited radioisotope which is estimated to be eliminated in the urine during a 24-hour period if the person has a maximum permissible body burden of the radioisotope as defined in NCRP Handbook 69 (published by NBS) for the occupational worker.

4. An event involving the uncontrolled release of radioactivity which results in a significant interruption of the normal operating routine under conditions where the maximum permissible concentration (MPC) values are not exceeded when averaged over a 24-hour period and/or the combined costs of evaluation and recovery are less than $500.

4.1.2 Radiation Event - The radiation event is defined as an unusual occurrence which involves one or more of the following:

1. An event which results in (a) a radiation dose to personnel that equals or exceeds (i) 0.3 rem to the total body, (ii) 1.0 rem to the skin of the body, (iii) 2.5 rem to the extremities, and/or (b) an event involving one or more internal exposures such that analysis of body fluids indicates an elimination rate equal to or exceeding 25 per cent of the excretion index.

2. An event involving an unplanned release of radioactive materials to the environment such that the resulting levels, averaged over a period of 24 hours, exceeds the appropriate MPC.

3. An event resulting in recovery and/or evaluation costs equal to or exceeding the sum of $500.

The radiation event has been assigned a severity index class number according to personnel exposure ranges, contamination levels, and/or cost analyses. The classification numbers assigned to each range are shown in Table 12.

4.2 Unusual Occurrences Summarized, 1960-63

The Laboratory experienced 43 unusual occurrences during 1963 (see Table 13, Part I). This represents a reduction in unusual occurrences of about (a) 22 per cent under 1962, (b) 42 per cent under 1961, and (c) 50 per cent under 1960.

4.3 Significant Occurrences, 1960-63

An unusual occurrence is designated as a "significant" occurrence for purposes of this report when the event is such as to (1) exceed a recommended maximum permissible limit and/or (2) require a work stoppage in an operation while clean-up measures are instituted following a radioactive contaminant release. Thirty-two of the 43 unusual occurrences reported during 1963 were classified as significant. There were 30 significant occurrences during 1962, 41 during 1961, and 60 during 1960. The four-year experience indicates that the unusual occurrence does not take on significant proportions more than 75 per cent of the time.

4.4 Personnel Exposures, 1960-63

Only four unusual occurrences during 1963 involved personnel exposures in excess of planned operational limits (Table 13, Part II). Ten such occurrences were reported in 1960 and seven such occurrences were reported in 1961 and 1962. One of the four personnel exposures reported in 1963 involved an occurrence that was classified as a Class III Radiation Event. The remaining three exposures were not significant. No radiation events were reported in 1962. One occurrence each was reported in 1961 and 1960.

4.5 Contamination Incidents

Thirty-two of the unusual occurrences which occurred during 1963 involved radioactivity releases (Table 13, Part III). Although some work restrictions and/or clean-up measures were required in all these cases, only two of the incidents were listed as significant.

During four years, which ended with 1963, it was evident that contamination incidents governed the unusual occurrence frequency rate (Fig. 23). The contamination incident frequency rate for 1961 and 1962 showed significant decreases from the 1960 rate while the rate for 1963 remained substantially the same as that recorded for the year 1962.

4.6 Unusual Occurrence Frequency Rate

As a general rule the frequency rate will be somewhat related to (1) the quantity of radioactivity handled (2) the number of radiation workers involved, and (3) the radiation hazard potential associated with a particular operation and/or facility. In the tabulations shown below, no attempt was made to evaluate the frequency rate in terms of the above three factors. Consequently the data do not necessarily reflect on the quality of performance with respect to health physics procedures within a particular division.

4.6.1 <u>Frequency Rate Among Laboratory Divisions</u> - During 1963 there were 43 unusual occurrences recorded among ten Laboratory divisions (Table 14). Four of the ten divisions recorded 34 events (or approximately 80 per cent of all unusual occurrences for 1963) as follows:

1. Chemical Technology - 11 events,
2. Analytical Chemistry - 9 events,
3. Operations - 9 events,
4. Isotopes - 5 events.

There were 260 unusual occurrences (Table 14) recorded among 19 Laboratory divisions during the four-year period ending with 1963. During this four-year period about 89 per cent of all the unusual occurrences were recorded among nine of the 19 operating groups as follows:

1. Chemical Technology - 60 events,
2. Isotopes - 46 events,

3. Operations - 41 events,
4. Analytical Chemistry - 21 events,
5. Reactor - 18 events,
6. Plant and Equipment (E and M) - 13 events,
7. Electronuclear Research - 12 events,
8. Metals and Ceramics - 11 events,
9. Neutron Physics - 10 events.

From Table 14 it will be observed that the Electronuclear Research Division and the Reactor Division recorded no events during 1963. The Plant and Equipment Division (formerly designated Engineering and Mechanical Division) and the Metals and Ceramics Division recorded only one event each during 1963.

4.6.2 <u>Frequency Rate Among Operating Facilities</u> - Unusual occurrences took place in 17 operating facilities (Table 15) during 1963. (Two events occurred out-of-doors in areas designated as "miscellaneous.") Two or more events occurred in seven of the 17 facilities. Three or more events occurred in only three facilities, and only one of the 17 operating facilities experienced more than three events. There were 17 events experienced in Building 3019. The number of events recorded for Building 3517 showed a drop from eight events in 1962 to three events during 1963.

Over the four-year period ending with 1963 (Table 15) there were 238 unusual occurrences recorded in 44 operating facilities. (There were 22 events, shown under the heading miscellaneous in Table 15, which occurred out-of-doors in areas that could not be classified generally as operating facilities.) Approximately 46 per cent of the 238 events occurred in only five of the 44 operating facilities as follows:

1. Bldg. 3019 - 53 events,
2. Bldg. 3517 - 20 events,
3. Bldg. 3042 - 14 events,
4. Bldg. 9201-2 - 12 events,
5. Bldg. 7500 - 12 events.

Nine facilities recorded between six and nine events representing about 26 per cent of the four-year total as follows:

6. Bldg. 3025 - 9 events,
7. Bldg. 4501 - 8 events,
8. Bldg. 3001 - 7 events,
9. Bldg. 3005 - 7 events,
10. Bldg. 9204-1 - 7 events,
11. Bldg. 9207 - 6 events,
12. Bldg. 4507 - 6 events,
13. Bldg. 4500N - 6 events,
14. Bldg. 3028 - 6 events.

The remaining events (about 28 per cent) were spread over 30 of the 44 operating facilities, with 16 facilities recording only one event each during the four-year period.

Four of the 14 operating facilities (3042, 7500, 3001 and 3005) which recorded six or more events during the four-year period ending with 1963 involved the operation of nuclear reactors. The 40 events that occurred in these four facilities represent about 23 per cent of the 173 events recorded in the 14 facilities. Operations performed in the ten remaining facilities noted above and the remaining facilities with five or less events shown in Table 15 reveal that chemical type operations continue to be the principal source of unusual occurrences.

5.0 LABORATORY ASSAYS

Laboratory Assays Units provide laboratory support to the Applied Health Physics Monitoring Sections. These services include (1) the analysis of body fluids and excreta (bio-assay) for the monitoring of personnel for internal radiation exposure, (2) the radiochemical analysis of environs samples, (3) counting services for the environs monitoring and radiation survey programs, (4) autoradiography, (5) laundry monitoring, and (6) whole body counting (in vivo gamma spectrometry).

5.1 Bio-Assay Analysis

The number and type of analyses performed by the Bio-Assay Unit during 1963 are given in Table 17. A total of 8932 analyses were performed which included 7904 analyses on samples taken from donors; 1028 standard samples were processed for control purposes. Approximately 83 per cent of the samples were analyzed for strontium and gross alpha activity. The total number of analyses on samples submitted during 1963 increased by about seven per cent over the number processed during 1962.

5.2 Counting Facility

A total of 332,569 samples were processed during 1963. A breakdown showing the number and type of samples counted is presented in Table 18. There was a drop of approximately 25 per cent in the number of samples processed during 1963 as compared with the previous year.

In August of 1963, a single channel gamma spectrometer was equipped and standardized for counting ^{131}I in animal thyroid tissue. Beginning in September 1963, the counting facility assumed responsibility for routine cattle thyroid analysis as a support to the Environs Monitoring program. (The Health Physics Technology Section had conducted a similar program on an experimental basis for a number of months.)

5.3 Environs Monitoring Sample Analysis

Extensive analysis by a number of techniques is required for the evaluation of samples collected from the environment by the Environs Monitoring Group. Table 19 presents the number and type of environs samples analyzed during 1963 and the type of analysis performed on each type of sample. A total of 13,614 environs monitoring samples were analyzed during 1963 as compared to a total of 13,753 samples analyzed in 1962. Analysis of environs monitoring samples may range from a single determination to as many as ten determinations per sample depending upon the radionuclides present. The methods of analysis used by the various analytical groups are described in the ORNL Master Analytical Manual.

5.4 Autoradiography

A total of 2,000 films were processed during 1963 in support of radio-particulate studies conducted by the Environs Monitoring Units.[1]

5.5 Laundry Monitoring

Approximately 618,800 articles of wearing apparel passed through the Laundry Monitoring Unit during 1963. About one per cent of the items checked were found, following laundering, to be above maximum permissible contamination limits for contamination zone clothing.

5.6 Whole Body Counter[2]

During the calendar year 1963 the whole body counting program included 1,054 human counts; 789 of the counts, or approximately 75 per cent, showed a normal human spectrum. By way of comparison, the totals for 1961 and 1962 were 329 and 395 human counts, respectively. Table 20 lists the number of cases and quantity of isotopes detected in the counts which showed measurable activity other than normal ^{137}Cs and ^{40}K.

Near the close of calendar year 1963, the normal counting load was 40 human counts per week; one day per week was utilized for calibrations, research and development, and/or routine maintenance. The maximum number of counts in any one week during 1963 was 62. (During this period the work was extended over two 8-hour shifts each day in order to accommodate persons normally assigned to the 4-12 shift.)

Practically all of the 1963 counts were made using the rolling bed scan geometry. When a whole body scan is to be made, the subject lies prone on a power-driven, rolling bed; the subject is scanned from head to toe as he lies prone on the bed which moves over tracks and under the stationary 8" x 4" NaI(Tl) crystal. Normal distance of scanning is approximately 60 inches in a 20-minute counting time interval. This particular counting method has superseded the tilted chair as the standard technique for routine counts.

Improvements made in equipment and operating techniques resulted in an increase in the number of subjects counted during 1963 of about 2.6 times the number counted during 1962. Modifications in the system are described

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[1] Methods described in ORNL-2601, "Radioactive Waste Management at Oak Ridge National Laboratory."

[2] Data submitted by the Health Physics Technology Section, B. R. Fish-Chief, P. E. Brown, G. R. Patterson, W. H. Wilkie.

elsewhere.[3,4,5] Listed roughly in order of the favorable impact they have had, the improvements include the installation of (1) a second 512 channel analyzer, (2) a paper tape to typewriter data convertor, (3) the rolling scan bed, (4) a new procedure for scheduling persons to be counted, and (5) a computer program for data analysis.

The second 512 channel analyzer, which became operational in August 1963, and the tape to typewriter data convertor have contributed the most toward the extension and expansion of the whole body counting program to its present capabilities. One 512 channel analyzer makes available computer-memory features for the examination of spectra which evidence gamma ray photopeaks other than the cesium and potassium isotopes normally present in humans; the second 512 channel analyzer is used for routine counting. Counting time losses have been minimized due to the fact that one analyzer can be used as a standby if the other should be inoperative due to equipment failure or need of maintenance.

The paper tape to typewriter data convertor has cut in half the time required for reading data out of the analyzer memory unit. Formerly, typing and tape punching were derived from the analyzer memory unit. Under the present system, data can be typed from the tape while the memory unit is being cleared for the next count.

The rolling scan bed has reduced the time required to change from the routine whole body count (scan) to a chest count. The bed is used for both types of counts and needs only to be elevated slightly in order to bring the chest of the subject within range of the crystal; the old method required a replacement of the chair with a cot and a lowering of the crystal. A change in the position of the crystal necessitated time-consuming re-calibrations and a re-alignment of the crystal and analyzer.

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[3] Applied Health Physics Progress Report, ORNL-CF-62-2-74 (1961).

[4] Applied Health Physics Progress Report, ORNL-3490 (1962).

[5] Health Physics Division Annual Progress Report for Period Ending June 30, 1963, ORNL-3492, pp. 194, 202-205.

6.0 HEALTH PHYSICS INSTRUMENTATION

The Health Physics Division shares with the Instrumentation and Controls Division the responsibility for the development of electronic radiation monitoring instruments used in the Laboratory health physics program. Normally Health Physics is responsible for determining the need for new instrument types and modifications to existing types, specifies the health physics requirements for design criteria, originates work orders, tests and evaluates the preliminary design, and approves the final design. Health Physics is also responsible for calibrating all instruments used in the health physics program and is allocated the funds for maintenance of these instruments. Maintenance is performed or cross-ordered by the Instrumentation and Controls Division.

Non-electronic personnel monitoring devices are designed, tested, calibrated, and maintained by Health Physics.

6.1 Instrument Inventory

The electronic instruments used in the health physics program are divided, for convenience in servicing and calibrating, into two classes: the first class includes battery-powered portable instruments, the second class includes the stationary instruments that are a.c. powered. Portable instruments are assigned and issued to the Radiation Survey Units. Stationary instruments are the property of the Laboratory division which has the monitoring responsibility in the area in which the instrument is located. Table 21 lists portable instruments on hand at the close of FY 1963; Table 22 lists stationary instruments on hand at the end of 1963. There were net increases in 1963 of 72 portable instruments and 112 stationary instruments.

During 1963, 601 new pocket meters and 264 new fiber dosimeters (200 mR range) were issued by ORNL Stores. Most of the meters issued were replacements for instruments which had been lost or damaged.

A Health Physics Portable Instrument Service Summary (Fig. 24) is prepared on an IBM 7090. This computer programmed report enables the Instruments Group to maintain a current inventory on most health physics instrument requirements.

6.2 Calibrations Facility

Health Physics maintains a calibration facility for the calibration and maintenance of portable radiation instruments and personnel metering devices. The facility is equipped with calibration sources, remote control devices, and shop space for the use of Instrumentation and Controls Division maintenance personnel. Health Physics personnel assign, arrange for maintenance of, calibrate, provide delivery services for, and maintain inventory and servicing data of all portable health physics survey instruments.

Portable instruments are serviced (1) whenever repairs are needed, (2) at least once each two months for those which have replacement-type batteries, and (3) at least once each three months for those instruments which have "permanent" (rechargeable) batteries. The calibration services performed during FY 1963 on portable instruments (see Table 23) were about 15 per cent greater than were performed during the prior year due to the increase in inventory.

Stationary instruments are calibrated by Calibrations Group personnel or by Radiation Survey personnel who use sources which are designed, standardized, and provided by the Calibrations Group.

6.3 Instrumentation Development

During 1963 new designs were made and/or tested as follows:

1. Semi-Automatic Film Reader - A re-design of the light source and detector for the Semi-Automatic Film Reader (reported in ORNL-3490) was undertaken because it was found that photodiodes of the types proposed had excessive recovery times and drift. A photomultiplier is used as a detector in the re-design.

2. Monitoring Instruments for Health Center - Engineering and design have been completed for improved instrumentation to be used by the Health Division for treatment of cases in which radioactive contamination is involved. The new design is better adapted (improved sensitivity and less bulk) for medical purposes than is the equipment presently available.

3. Large-Area Alpha Scintillation Detector - A work order was issued to the Radiation Detection Section of the Instrumentation and Controls Division for the engineering and design of a large area alpha scintillation detector. A scintillation type detector is considered superior to a gas proportional detector for this particular instrument for the following reasons: (1) the scintillation detector does not require a counter gas with associated tubing and attendant hazards, and (2) it will operate at lower voltages which in turn allows for simpler electronics. Scintillation detectors currently in use present a sensitive area of about 100 cm^2 (4 in. x 4 in.). The proposed scintillation detector will have a sensitive area of 460 cm^2 (6 in. x 12 in.). The new device will greatly improve hand, foot, clothing, and laboratory area monitoring.

4. Calibration of Pocket Meters - A method for checking the calibration and operational quality of pocket meters by means of an electronic calibrating device has been tested and implemented. Malfunctioning pocket meters are readily detected with this method. (All pocket meters are checked by the above method at least once each quarter.)

5. Fogged Monitoring Films - About ten per cent of the monitoring films taken from badge-meters assigned to ORNL employees for the

third quarter (July - September) 1963 were found to be heat-fogged over a range that extended from moderate to severe. A questionnaire was circulated to the employees who used films that were fogged and it was found that in practically every case the badge-meter user had left the device in a closed automobile on certain days when outside temperatures were high.

6. Fast Neutron Survey Meter - Work was completed and a report (TM-653) was issued on the energy response of the Model Q-2047, Fast Neutron Survey Meter.

7. Hand Exposure Meter - The ORNL Hand Exposure Meter was fitted with a plastic filter in order that beta exposures could be more accurately determined (see Fig. 18).

8. New Cutie Pie - A prototype of a transistorized version of the ORNL Cutie Pie has been completed, tested, and evaluated by the Health Physics Instruments Group personnel. It is being field-tested by the Health Physics Radiation Survey Section personnel. The new design will reduce high resistance leakage problems encountered in earlier models, simplify range switching, and is more sensitive to gamma radiation; however, the time-constant in the new design has been increased slightly over the time-constant of the current models.

9. New Background Monitor - A dose integrating, background monitor, which was designed to Health Physics specifications by the Instrumentation and Controls Division, has been field-tested by the Environs Monitoring Group personnel. The instrument will permit continuous, long term (30 days or more) accumulation of radiation background data. Additional instruments have been ordered.

10. Neutron Dosimeter - A neutron dosimeter, Texas Nuclear Corporation, Model 9120, was purchased and tested; it was found to perform essentially as specified by the manufacturer. The instrument will be used in monitoring for intermediate energy neutrons.

11. A computer program was devised and tested which provides inventory, in-service data, and approximate servicing costs for the more than 1000 portable health physics instruments. The data generated assists in projecting replacement needs, in determining the reliability in instruments by type and age, and in providing for cost analysis.

7.0 PUBLICATIONS AND REPORTS

7.1 Publications

R. L. Clark, "Model Mask to be Used in Welding Operations," ORNL CF 63-9-41, September 20, 1963.

H. M. Butler and A. D. Warden, "Protective Apparel for Use in Contamination Zones," ORNL CF 63-9-45, September 20, 1963.

A. D. Warden, "Comparison of Hand Exposure Data with Film Badge Meter Results," ORNL CF 63-1-4, January 5, 1963.

H. M. Butler, "Clothing for Use in Contamination Zones," Nuclear Safety, Vol. 5, No. 1, October, 1963.

D. M. Davis and E. D. Gupton, "Health Physics Instrument Manual," ORNL-332 (Third Edition), May 20, 1963.

E. D. Gupton and S. Fukushi, "Energy Response, Gamma Discrimination and Stability of the ORNL Model Q-2047, Fast Neutron Survey Meter," ORNL TM-653, June 12, 1963.

7.2 Interdepartmental Reports

Applied Health Physics Quarterly Report - January, February, and March of 1963, ORNL CF 63-9-8.

Applied Health Physics Quarterly Report - April, May, and June of 1963, ORNL CF 63-10-14.

Applied Health Physics Quarterly Report - July, August, and September of 1963, ORNL CF 63-12-39.

Applied Health Physics Quarterly Report - October, November, and December of 1963, ORNL CF 64-3-3.

8.0 TABLES

Table 1 CONCENTRATION OF RADIOACTIVE MATERIALS IN AIR - 1963
(Filter Paper Data—Weekly Average)

Station Number	Location	Long-Lived Activity 10^{-13} μc/cc	No. of Particles by Activity Ranges $< 10^5$ d/24 hr	10^5-10^6 d/24 hr	10^6-10^7 d/24 hr	$> 10^7$ d/24 hr	Total	Particles Per 1000 ft^3
				Laboratory Area				
HP-1	S 3587	52	82	0.31	0.0	0.0	83	2.1
HP-2	NE 3025	58	67	0.33	0.0	0.0	67	1.9
HP-3	SW 1000	49	82	0.31	0.02	0.0	83	1.4
HP-4	W Settling Basin	29	56	0.33	0.0	0.0	56	1.0
HP-5	E 2506	60	71	0.37	0.0	0.0	71	2.5
HP-6	SW 3027	40	77	0.12	0.0	0.0	77	1.4
HP-7	W 7001	53	75	0.17	0.0	0.0	76	1.5
HP-8	Rock Quarry	52	77	0.31	0.02	0.02	76	1.5
HP-9	N Bethel Valley Rd.	45	104	0.37	0.0	0.0	105	1.7
HP-10	W 2075	52	83	0.44	0.02	0.0	83	2.0
Average		49	78	0.30	0.01	0.00	78	1.7
				Perimeter Area				
HP-31	Kerr Hollow Gate	40	78	0.37	0.00	0.00	79	1.6
HP-32	Midway Gate	42	81	0.38	0.00	0.00	81	1.6
HP-33	Gallaher Gate	36	81	0.29	0.00	0.00	81	1.6
HP-34	White Wing Gate	37	95	0.27	0.00	0.00	96	1.9
HP-35	Blair Gate	45	99	0.37	0.00	0.00	99	2.0
HP-36	Turnpike Gate	43	100	0.73	0.00	0.00	101	2.0
HP-37	Hickory Creek Bend	38	76	0.40	0.00	0.00	76	1.5
Average		40	87	0.40	0.00	0.00	88	1.8
				Remote Area				
HP-51	Norris Dam	40	76	0.56	0.00	0.00	77	1.4
HP-52	Loudoun Dam	47	80	0.62	0.00	0.00	80	1.5
HP-53	Douglas Dam	46	83	0.55	0.00	0.00	83	1.5
HP-54	Cherokee Dam	47	116	0.56	0.00	0.00	117	2.1
HP-55	Watts Bar Dam	42	118	0.44	0.00	0.00	118	2.1
HP-56	Great Falls Dam	44	93	0.73	0.02	0.00	94	1.7
HP-57	Dale Hollow Dam	41	103	0.38	0.02	0.00	103	1.9
Average		43	95	0.55	0.01	0.00	96	1.7

Table 2 RADIOPARTICULATE FALL-OUT - 1963

(Gummed Paper Data—Weekly Average)

Station Number	Location	Long-Lived Activity 10^{-4} μc/ft^2	No. of Particles by Activity Ranges $< 10^5$ d/24 hr	10^5-10^6 d/24 hr	10^6-10^7 d/24 hr	$> 10^7$ d/24 hr	Total Particles Per Sq. Ft.
Laboratory Area							
HP-1	S 3587	10	16	0.19	0.00	0.00	16
HP-2	NE 3025	10	20	0.21	0.00	0.00	20
HP-3	SW 1000	10	14	0.21	0.00	0.00	14
HP-4	W Settling Basin	11	14	0.21	0.02	0.00	15
HP-5	E 2506	11	18	0.23	0.00	0.00	18
HP-6	SW 3027	11	18	0.21	0.02	0.00	18
HP-7	W 7001	10	18	0.12	0.00	0.00	18
HP-8	Rock Quarry	9	15	0.13	0.00	0.00	15
HP-9	N Bethel Valley Rd.	9	15	0.17	0.02	0.00	15
HP-10	W 2075	10	20	0.29	0.00	0.02	20
Average		10	17	0.20	0.01	0.00	17
Perimeter Area							
HP-31	Kerr Hollow Gate	10	13	0.29	0.00	0.00	14
HP-32	Midway Gate	11	13	0.23	0.00	0.00	13
HP-33	Gallaher Gate	10	19	0.10	0.02	0.00	19
HP-34	White Wing Gate	10	15	0.23	0.02	0.00	15
HP-35	Blair Gate	10	17	0.31	0.00	0.04	18
HP-36	Turnpike Gate	11	19	0.10	0.00	0.00	19
HP-37	Hickory Creek Bend	10	18	0.27	0.00	0.00	18
Average		10	16	0.22	0.01	0.01	16
Remote Area							
HP-51	Norris Dam	9	12	0.23	0.00	0.00	13
HP-52	Loudoun Dam	9	10	0.25	0.00	0.00	10
HP-53	Douglas Dam	9	11	0.23	0.00	0.00	11
HP-54	Cherokee Dam	9	11	0.21	0.00	0.00	11
HP-55	Watts Bar Dam	9	9	0.13	0.00	0.00	9
HP-56	Great Falls Dam	8	9	0.17	0.00	0.02	10
HP-57	Dale Hollow Dam	10	9	0.23	0.02	0.00	9
Average		9	10	0.21	0.00	0.00	10

Table 3 CONCENTRATION OF RADIOACTIVE MATERIALS IN RAIN WATER - 1963
(Weekly Average by Stations)

Station Number	Location	Activity in Collected Rain Water, μc/cc
	Laboratory Area	
HP-7	West 7001	8.4×10^{-7}
	Perimeter Area	
HP-31	Kerr Hollow Gate	9.6×10^{-7}
HP-32	Midway Gate	8.3
HP-33	Gallaher Gate	7.5
HP-34	White Wing Gate	9.3
HP-35	Blair Gate	8.6
HP-36	Turnpike Gate	9.8
HP-37	Hickory Creek Bend	8.9
Average		8.9×10^{-7}
	Remote Area	
HP-51	Norris Dam	13.9×10^{-7}
HP-52	Loudoun Dam	8.4
HP-53	Douglas Dam	12.7
HP-54	Cherokee Dam	13.7
HP-55	Watts Bar Dam	9.9
HP-56	Great Falls Dam	18.2
HP-57	Dale Hollow Dam	10.4
Average		12.5×10^{-7}

Table 4 LIQUID WASTES DISCHARGED FROM WHITE OAK CREEK, 1963

	Curies		% Deviation from 1962 Weekly Average
	Total for Year	Weekly Average	
Beta Activity	469	9.0	- 67
Transuranic Alpha Emitters	0.166	.0032	+167

Table 5 RADIOACTIVITY IN CLINCH RIVER - 1963

Location	Sr^{90}	Ce^{144}	Cs^{137}	$Ru^{103-106}$	Co^{60}	Zr^{95}-Nb^{95}	Average Concentration of Total Radioactivity 10^{-8} μc/cc	$(MPC)_w$[a] 10^{-6} μc/cc	% of $(MPC)_w$
	Concentration of Nuclides of Primary Concern in Units of 10^{-8} μc/cc								
CRM 41.5[b]	0.13	0.20	0.02	0.92	0.01	0.26	1.5	1.13	1.3
CRM 20.8[c]	0.14	0.02	0.09	4.8	0.25	0.02	16	3.30	4.7
CRM 4.5[b]	0.29	0.27	0.23	8.3	0.47	0.40	10	2.67	3.7

[a]Weighted average $(MPC)_w$ calculated for the mixture, using $(MPC)_w$ values for specific radionuclides recommended in NBS Handbook 69.

[b]Measured values.

[c]Calculated values based on the levels of waste released and the dilution afforded by the river.

Table 6 RADIONUCLIDES IN CLINCH RIVER SILT - 1962-1963
(Units of 10^{-6} μc/g of Dried Mud)

Location	Cs^{137}		Ce^{144}		Sr^{90}		Co^{60}		$Ru^{103-106}$		$Zr^{95}+Nb^{95}$		$TRE^{a}+Y^{90}$ (as Y^{90})	
	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963
CRM 42.8		2.6		17		0.29		*		14		14		15
39.1		1.3		7.7		0.49		*		6.4		6.3		6.3
34.7		2.6		19		0.34		*		14		16		16
31.1		2.7		16		0.36		*		13		12		9
29.0		2.7		16		0.52		*		12		13		9
27.0		3.0		22		0.50		*		16		19		15
24.9		3.0		20		0.52		*		15		17		14
23.4		0.90		3.8		0.43		*		2.8		3.4		3.3
Average		2.4		14		0.43				12		13		11
CRM 21.5	3.2	2.7	11	0.43	0.36	0.63	*	*	11	0.45	16	0.14	10	0.89
19.1	5.2	2.9	3.8	0.90	0.41	0.74	0.72	1.9	6.1	4.4	6.2	0.90	3.5	5.2
16.3	58	218	5.2	4.2	0.72	3.1	8.1	16	50	17	3.9	2.2	14	34
15.2	55	16	5.2	3.5	0.90	0.81	7.3	2.8	46	13	4.2	3.8	13	5.6
14.0	237	150	6.2	5.0	1.8	1.7	20	12	43	29	3.6	3.4	31	23
11.0	63	75	6.9	8.8	1.0	1.2	8.6	8.0	68	35	5.4	7.4	16	22
8.0	59	62	8.5	8.8	1.0	0.90	8.6	8.9	70	48	5.4	6.9	18	16
5.8	94	67	8.4	12	1.6	1.3	12	9.5	68	49	6.5	10	22	19
4.7	86	53	9.5	11	1.2	1.4	14	8.5	86	44	6.0	9.7	22	17
2.6	73	63	7.7	6.7	0.72	0.81	10	7.7	77	26	5.6	5.4	16	17
1.1	56	68	13	17	0.72	1.4	9.0	8.5	76	50	11	17	16	23
Average	72	71	7.7	7.1	0.95	1.3	9.8	8.4	55	55	6.7	6.1	17	17

[a]Total Rare Earths minus cerium
*None detected

Table 7 RADIONUCLIDES IN TENNESSE RIVER SILT - 1962-1963

(Units of 10^{-6} μc/g of Dried Mud)

Location	Cs^{137}		Ce^{144}		Sr^{90}		Co^{60}		$Ru^{103-106}$		Zr^{95} + Nb^{95}		TRE^{a} + Y^{90} (as Y^{90})	
	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963	1962	1963
TRM 570.8	1.4	1.8	3.9	7.2	0.45	0.61	*	0.45	2.1	7.5	1.2	6.3	3.0	4.1
562.7	23	18	4.3	12	0.45	0.77	3.0	2.7	18	21	2.1	9.8	5.0	9.2
552.7	29	26	5.1	14	0.77	0.65	3.8	3.4	18	26	2.2	12	6.0	13
543.8	33	14	6.4	11	0.32	0.52	5.3	2.3	27	14	2.8	11	6.7	11
532.0	29	13	5.9	10	0.45	0.56	4.2	2.3	24	13	2.9	9.5	4.6	8.8
491.9	13	10	3.6	10	0.36	0.52	2.0	1.8	14	10	2.3	8.1	3.5	9.8
475.1	9.9	9.9	2.7	11	0.36	0.74	1.7	1.8	9.9	9.9	1.8	9.0	1.7	8.9
434.1	9.5	8.1	4.2	20	0.32	0.23	1.6	0.90	15	8.1	2.4	22	3.1	19
381.2	5.3	5.9	1.8	9.1	0.18	0.61	0.90	0.90	6.4	5.9	0.60	9.0	0.80	8.4
354.4	4.9	5.0	2.7	13	0.27	1.1	0.95	0.90	11	5.0	1.4	11	2.6	12
Average	16	10	4.1	12	0.39	0.63	2.3	1.7	14	12	2.0	11	3.7	10
Fort Loudoun Background Data														
TRM 604.4	1.8	2.2	4.8	10	*	0.61	*	*	5.1	9.4	3.0	6.8	2.7	5.9
615.8	--	2.1	--	9.5	--	0.54	--	*	--	8.5	--	5.5	--	9.5
Average	1.8	2.2	4.8	9.8		0.58			5.1	9.0	3.0	6.2	2.7	7.2

[a]TRE - total rare earths minus cerium

*None detected

--No samples taken in 1962

Table 8 Dose Data Summary for Laboratory Population Involving Exposure to Whole Body Radiation—1963

Group	Number of Rem Doses in Each Range							
	0-1	1-2	2-3	3-4	4-5	5-6	6 up	Total
ORNL Employees	4961	178	22	9	5	1	0	5176
ORNL-Badged Non-Employees	935	1	0	0	0	0	0	936
TOTAL	5896	179	22	9	5	1	0	6112

Table 9 Average Rem per Year Since Age 18

	Number of Doses in Each Range				
	0-2.5	2.5-5.0	5.0-7.5	7.5 up	Total
ORNL Employees	5167	8	1	0	5176

Table 10 Average Rem per Year of Employment at ORNL

	Number of Doses in Each Range					
	0-2.5	2.5-5.0	5.0-7.5	7.5-10.0	10.0 up	Total
ORNL Employees	5142	32	1	1	0	5176

Table 11 PERSONNEL METER SERVICES

		Total
A.	Pocket Meter Usage	
	1. Number of Pairs Used	11630
	2. Average Number of Users per Quarter	1671
B.	Badge-Meter Usage	
	1. Film Badge-Meters Serviced	21579
	2. Film Meters (Temporary Passes)	30316
	Total Number of Meters Issued	51895
C.	Films Processed for Monitoring Data	
	1. Beta-Gamma	44598
	2. NTA	7194
	3. Hand Meter	2594
	Total	54386

Table 12 RADIATION EVENT SEVERITY INDEX

Class	External Exposure (rem) Total Body	Skin	Extremities	Internal Exposure	Unplanned Radiocontaminant Release Averaged over a Twenty-four Hour Period	Cost Ranges
I	0.3 to 1.0	1 to 3	2.5 to 8	(Body Fluids) 0.25 x EI to 1.0 x EI	Exceeds the MPC Value	$500 to $1,000
II	1 to 3	3 to 10	8 to 25	(Body Fluids) 1.0 x EI or more	Exceeds 1000 x MPC	$1,000 to $5,000
III	3* to 25	10 to 150	25 to 375	(Body Burden) Exceeds the RPG	------------------	$5,000 to $100,000
IV	25* or more	150* or more	375* or more	---------------	Exceeds 5000 x MPC	$100,000 or more

Terms: (a) EI is the excretion index; (b) RPG is the radiation protection guide limits established by the Federal Radiation Council; (c) MPC is the maximum permissible concentration value recommended in NCRP Handbook 69 (published by NBS).

*These levels are taken from the reporting instructions given in AEC 0502-057, "Reporting and Investigating Accidents and Radiation Exposures."

Table 13 UNUSUAL OCCURRENCES SUMMARIZED FOR THE 4-YEAR PERIOD ENDING WITH 1963

	Yearly Totals			
	1960	1961	1962	1963
Part I. Overall Summary				
1. Recordable events involving personnel exposure below MPE limits and/or requiring little or no clean-up measures following a radioactive contaminant release	27	34	25	11
2. Significant events involving personnel exposure above MPE limits and/or requiring special clean-up measures following a release of radioactive contaminants	60	41	30	32
TOTALS	87	75	55	43
Part II. Personnel Exposure Breakdown				
3. Minor events constituting exposures in excess of planned operational exposure limits	9	6	7	3
4. Radiation events constituting exposures in excess of FRC limits with work restrictions imposed	1	1	0	1
TOTALS	10	7	7	4
Part III. Area Contamination Breakdown				
5. Minor events requiring special clean-up measures handled by the regular work staff with no appreciable program loss	56	37	28	30
6. Significant events involving special clean-up measures that required interdepartmental assistance with minor departmental program loss	2	3	2	2
7. Major events resulting in the temporary suspension of parts of the Laboratory program	1	0	0	0
TOTALS	59	40	30	32

Table 14 UNUSUAL OCCURRENCE FREQUENCY RATE WITHIN THE DIVISIONS FOR THE 4-YEAR PERIOD ENDING WITH 1963

Division	No. of Unusual Occurrences 1960	1961	1962	1963	4-Year Total	Per Cent Lab. Total (4-Year Period)
Analytical Chemistry	4	3	5	9	21	8.0
Biology	2	1	1	2	6	2.3
Chemical Technology	17	19	13	11	60	23.1
Chemistry	3	2			5	1.9
Plant and Equipment	5	4	3	1	13	5.0
Inspection Engineering			1		1	0.4
Electronuclear Research	5	7			12	4.6
Health Physics	1			1*	2	0.8
Instrumentation and Controls	1				1	0.4
Isotopes	14	9	18	5	46	17.7
Metals and Ceramics	3	5	2	1	11	4.2
Neutron Physics	2	3	3	2	10	3.8
Operations	14	12	6	9*	41	15.7
Physics		1	2	3	6	2.3
Reactor	11	7			18	6.9
Reactor Chemistry	1	1			2	0.7
Solid State	3		1		4	1.5
Thermonuclear		1			1	0.3
Construction	1				1	0.4
Totals	87	75	55	43	260	100.0

*Shared responsibility with another division for one unusual occurrence.

Table 15 UNUSUAL OCCURRENCES CLASSIFIED ACCORDING TO THE OPERATING FACILITIES IN WHICH THEY OCCUR FOR THE 4-YEAR PERIOD ENDING WITH 1963

Building or Facility	Number Recorded 1960	1961	1962	1963	4-year Total
2000	2	1	1		4
2001	1				1
2005		1			1
2007	1				1
2024		1			1
2523				1	1
2528	1				1
3001	3	2	2		7
3005	4	1		2	7
3010			1	1	2
3012	1				1
3019	11	16	9	17	53
3025	3	2	2	2	9
3026-C	2	1			3
3026-D		2			2
3028	2	2	2		6
3029	2	1	1		4
3031		1			1
3032			2		2
3033	1		2		3
3038			3	1	4
3042	3	5	3	3	14
3044	1				1
3047				1	1
3500	1				1
3505		1			1
3508	2	1	1		4
3517	6	3	8	3	20
3550	1		2	2	5
4500-N	2	2	1	1	6
4500-S				1	1
4501	3	5			8
4507		2	3	1	6
4508				1	1
5500			2	1	3
7500	5	7			12
7700			2	1	3
9201-2	4	8			12
9204-1	6	1			7
9204-3	4		1		5
9207	2	1	1	2	6
9213	2	2	1		5
9733-3	1				1
9766			1		1
Misc.	10	6	4		20
Burial Ground #5				1	1
South Tank Farm				1	1
GRAND TOTALS	87	75	55	43	260

Table 16 BIO-ASSAYS ANALYSES - 1963

Analytical Procedure	Number of Analyses	
Urine:		
Gross Alpha	3483	
Sr	3007	
U	932	
TRE (total rare earths)	53	
Cs^{137}	42	
H^3	121	
Pu^{239}	21	
Ru^{106}	8	
P^{32}	4	
Other	88	
Total		7759
Fecal:		
Gross Alpha	91	
Sr	6	
TRE (total rare earths)	1	
Pu^{239}	1	
U	11	
Other	15	
Total		125
Miscellaneous:		
Blood, sputum, breath		20
Standards and Blanks		1028
GRAND TOTAL		8932

Table 17 COUNTING FACILITY RESUME, 1963

Type of Sample	Number of Samples Alpha	Beta	Gamma	Unit Total	Weekly Average
Smear Tabs	133,376	147,014		280,390	5,392.1
Air Filters	24,773	23,548		48,321	929.3
Environs Monitoring	221	3,566		3,787	72.8
Animal Thyroids			71	71	5.0
GRAND TOTAL	158,370	174,128	71	332,569	6,399.2

Table 18 ENVIRONMENTAL MONITORING SAMPLES, 1963

	Sample Type	Type of Analysis	Number Samples
1.	Monitoring network filters	Gross beta, autoradiogram	2605
2.	Gummed paper fall-out trays	Gross beta, autoradiogram	1248
3.	CAM filters	Gross beta, autoradiogram	7280
4.	Rain water	Gross beta	661
5.	White Oak Dam Effluent	Gross beta, radiochemical, gamma spectrometry	1324
6.	Clinch River water	Gross beta, radiochemical, gamma spectrometry	26
7.	Raw milk	Radiochemical	272
8.	Pasture grass	Radiochemical, gamma spectrometry	44
9.	Potable water	Radiochemical, gamma spectrometry	52
10.	Silt composites	Radiochemical, gamma spectrometry	31
11.	Animal Thyroids	Gamma spectrometry	71
		Total	13614

Table 19 MEASURABLE RADIOACTIVITY FOUND IN ROUTINE WHOLE BODY MONITORING PROGRAM - CALENDAR YEAR 1963

Isotope	Maximum Amount Detected (μc)	MPBB (μc)	Number of Cases
Ra^{226}	< 0.005	0.1	1*
Ce^{144}-Pr^{144}	0.007	5	12
Cs^{137}	0.190	30	169**
I^{131}	0.150	0.7	32
Sb^{125}	0.010	40	17
Ru^{106}-Rh^{106}	0.047	3	19
Zr^{95}-Nb^{95}	0.070	20	43
Sr^{90}-Y^{90}	$\leq$ 0.035	2	2
Se^{95}	0.250	90	6
Zn^{65}	0.016	60	20
Cu^{64}	< 0.005	10	1
Co^{60}	0.220	10	20
Fe^{59}	0.015	20	6***
Co^{58}	0.038	30	5
Cr^{51}	0.042	800	4

*In addition to the one case reported here for an ORNL employee, a Laboratory consultant who was known to have a radium burden of long standing, not at all connected with his work at ORNL, was counted. The amount of deposit was estimated to be 2.4 μc Ra^{226} plus one-third of the daughters expected at equilibrium.

**The amount of fallout Cs^{137} appearing in "unexposed" persons via the diet has been increasing ever since atmospheric testing of nuclear weapons was resumed in 1961. During the year 1962, 6-10 nc Cs^{137} was considered "normal" or from a dietary intake only; during the first quarter of 1963, 10-12 nc Cs^{137} was considered "normal"; during the second quarter, $\leq$ 15 nc Cs^{137} was considered "normal"; for the last two quarters of the year, indications $\leq$ 20 nc Cs^{137} were considered "normal".

***In addition to ORNL employee cases reported here, one AEC Fellowship student was counted who, as part of a medical examination procedure, had received an I.V. injection of 10 μc Fe^{59} at Vanderbilt University, March 14, 1963. As of July 2, 1963, his in vivo count indicated a burden of $\sim$ 1.48 μc Fe^{59}.

Table 20 PORTABLE INSTRUMENT INVENTORY, 1963

Instrument Type	Working Inventory July 1962	Instruments Acquired FY 1963	Instruments Retired FY 1963	Working Inventory July 1963
GM Survey Meter	325	21	5	341
Cutie Pie	292	96	39	349
Juno	37	0	1	36
Alpha Survey Meter	124	1	0	125
Neutron Survey Meter	41	3	4	40
Miscellaneous	17	0	0	17
TOTAL INVENTORY	836	121	49	908

Table 21 INVENTORY OF STATIONARY, RADIATION MONITORING INSTRUMENTS FOR THE YEAR 1963

Instrument Type	Installed During 1963	Total Dec. 31, 1963
Air Monitor, Alpha	18	48
Air Monitor, Beta	20	148
Air Monitor, Environmental	12	36
Hand-Foot Monitor	3	22
Lab Monitor, Alpha	12	61
Lab Monitor, Beta	38	106
Monitron	9	192
Other	0	26
TOTAL	112	639

Table 22 CALIBRATIONS RESUME, 1963

A. Portable Instruments Calibrated

1.	Beta-Gamma	3,679
2.	Neutron	119
3.	Alpha	740
4.	Pocket chambers and dosimeters	1,661

B. Films Calibrated

1.	Beta-Gamma	5,984
2.	Neutron	31

9.0 FIGURES

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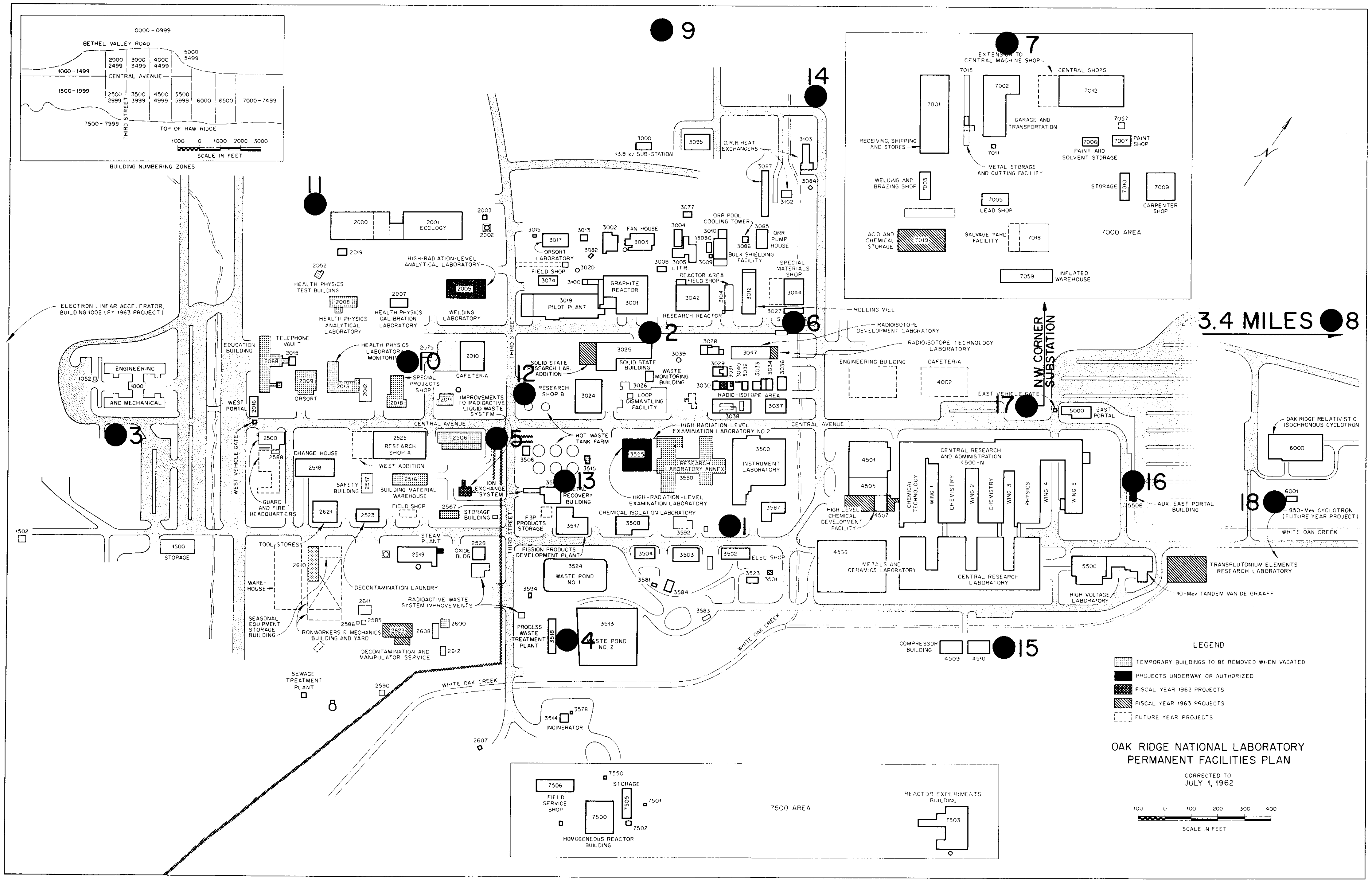

Fig. 1. (Map of) Laboratory Area Showing the Approximate Location of the Local Monitoring Stations Constituting the LAM Network.

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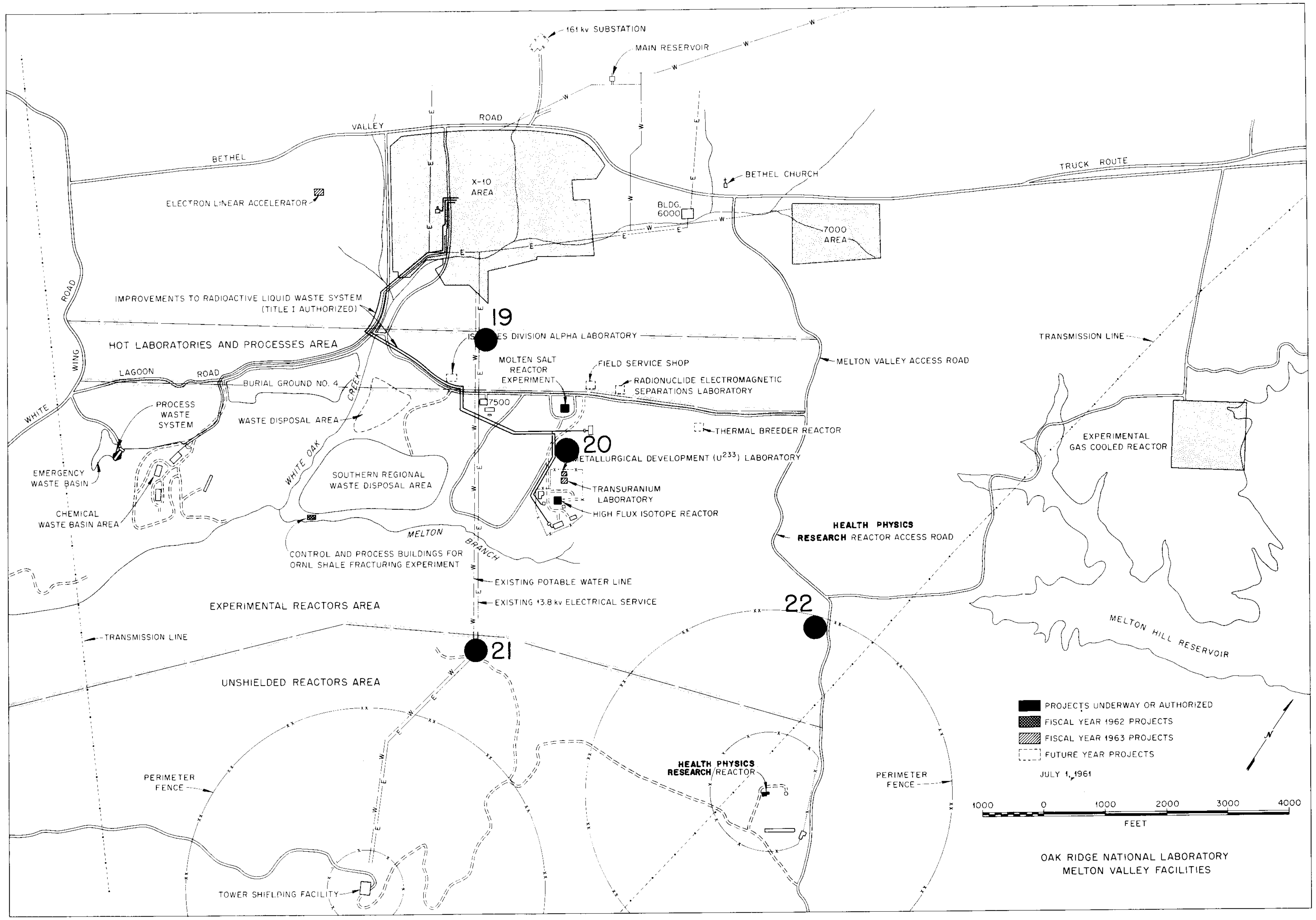

Fig. 2. (Map of) Laboratory Area Showing the Approximate Location of the Local Monitoring Stations Constituting the LAM Network.

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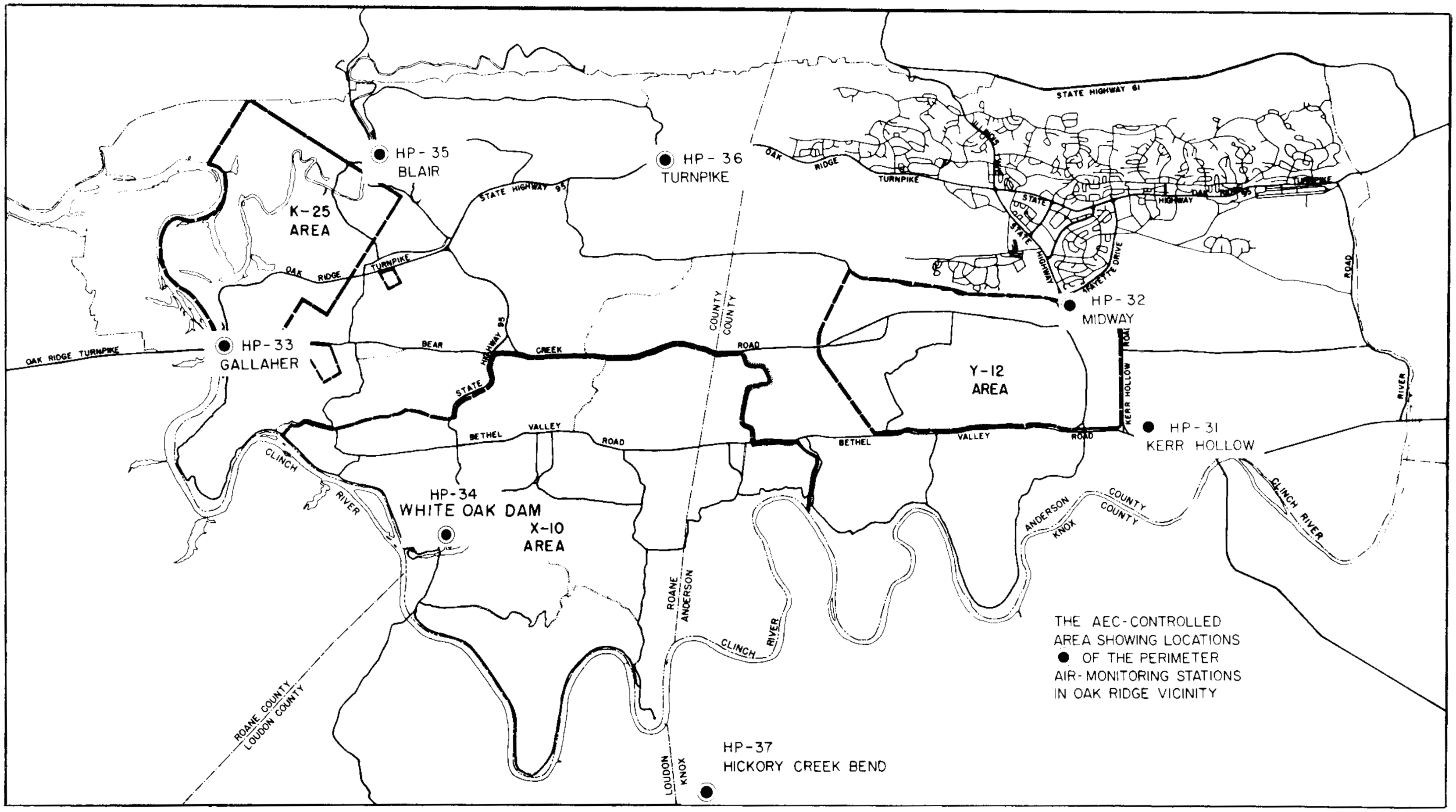

Fig. 3. (Map of) AEC Controlled Area and Vicinity Showing the Approximate Location of the Perimeter Air Monitoring Stations Constituting the PAM Network.

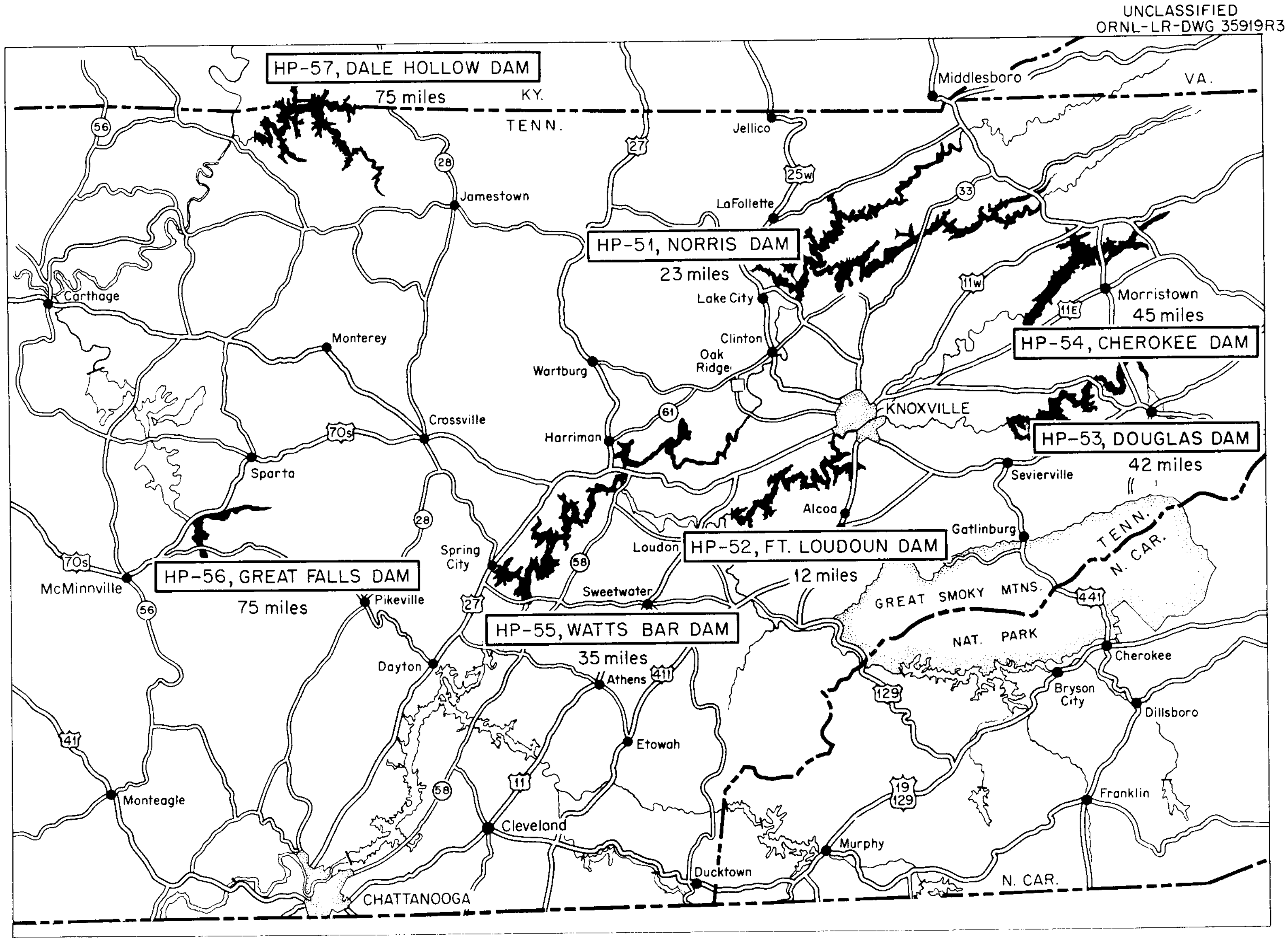

Fig. 4. (Map of) East Tennessee Area Showing TVA and U.S. Corps of Eng. Dam Sites at Which are Located the Remote Air Monitoring Stations Constituting the RAM Network.

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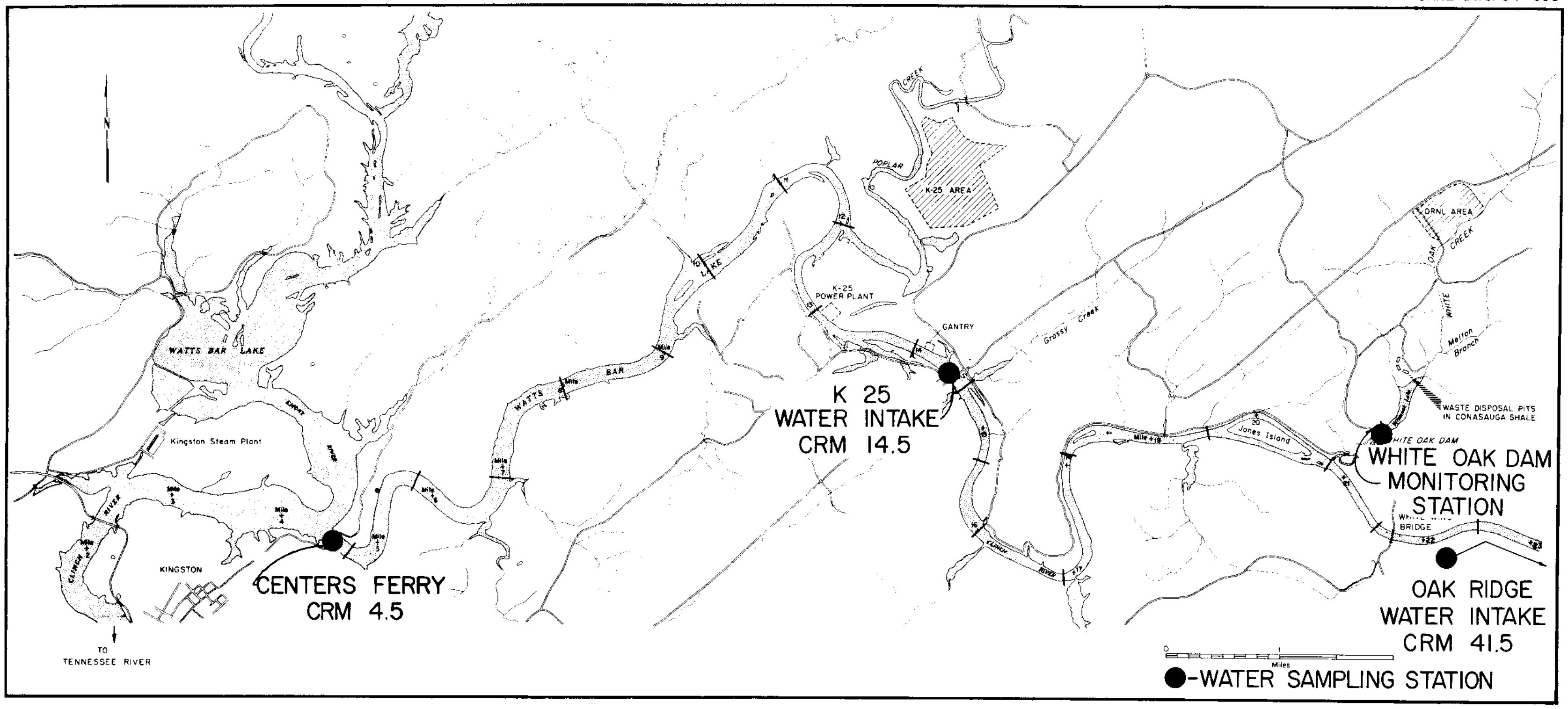

Fig. 5. (Map of) Water Sampling Locations.

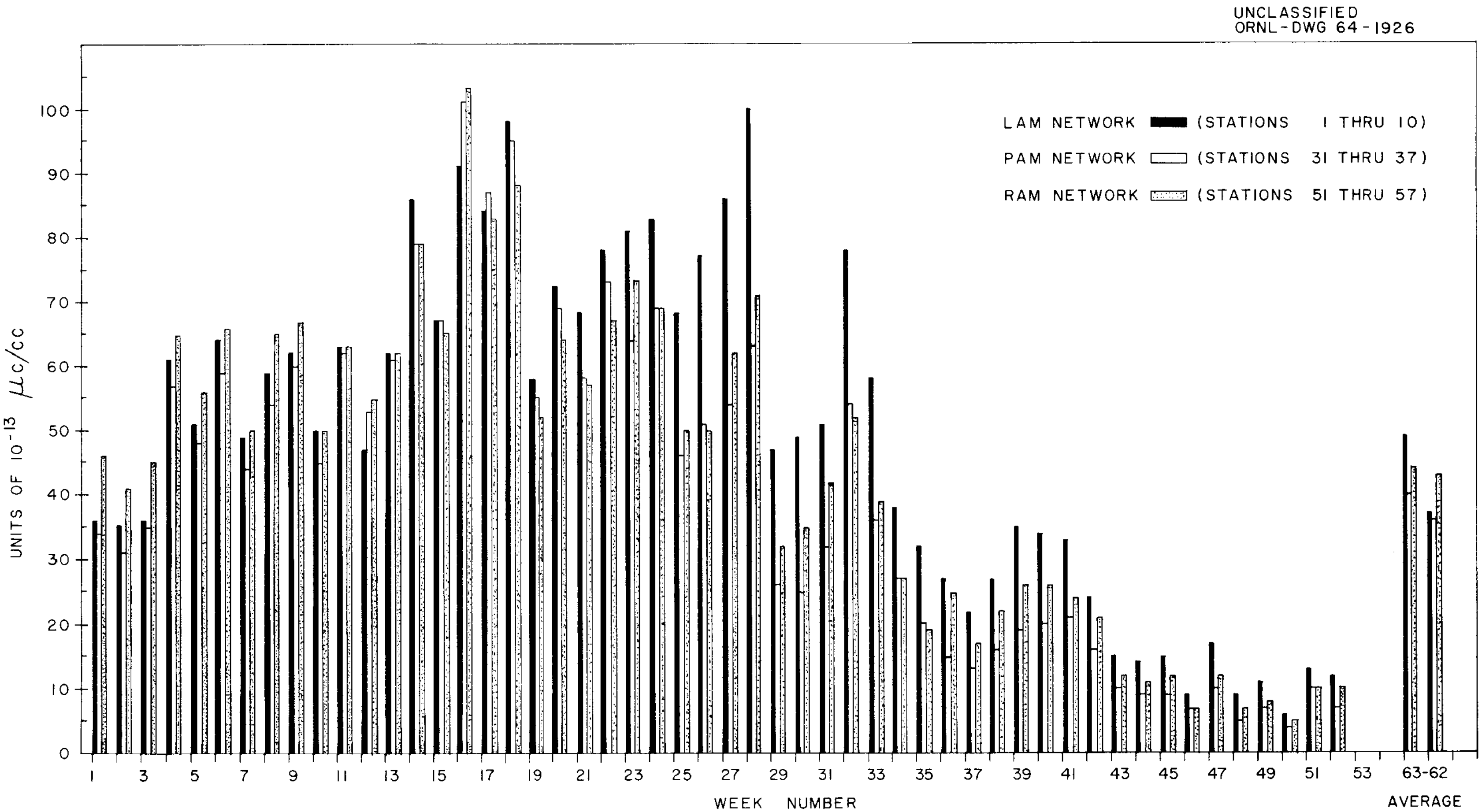

Fig. 6. Concentration of Radioactive Materials in Air as Determined from Filter Paper Data, 1963.

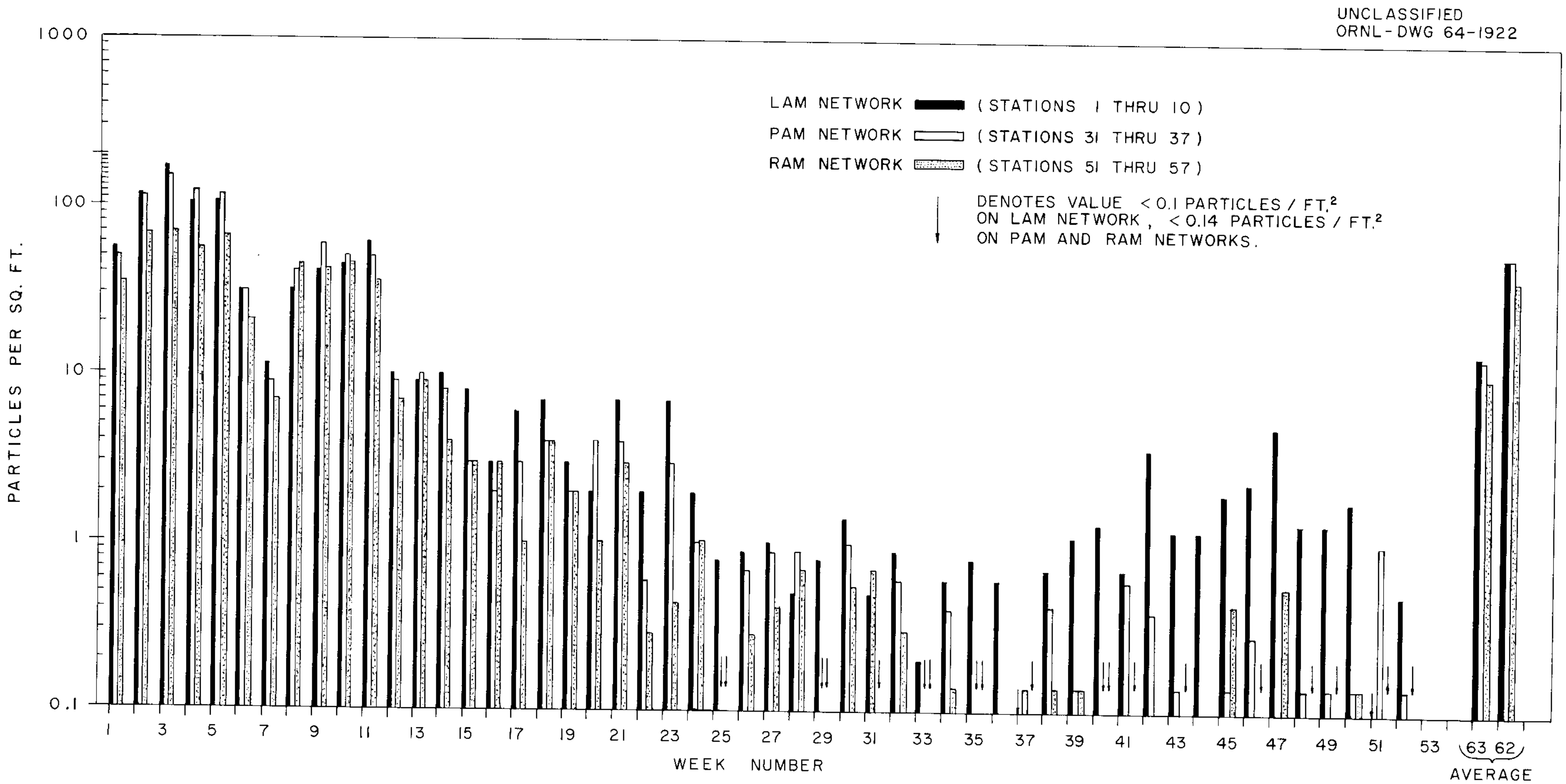

Fig. 7. Radioparticulate Fall-Out Measurements as Determined by Autoradiographic Techniques Using Gummed Paper Collectors, 1963.

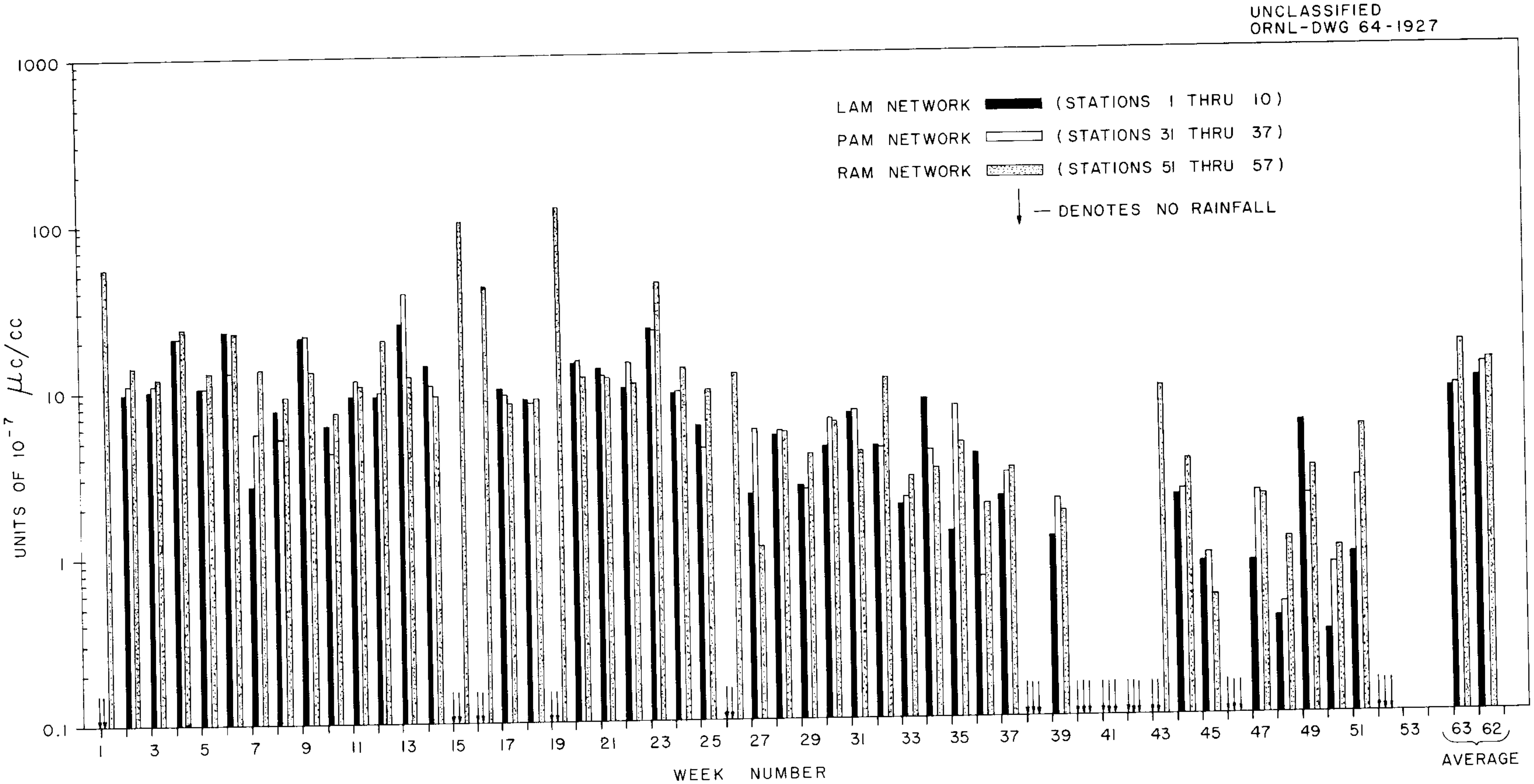

Fig. 8. Concentration of Radioactive Materials in Rainwater, 1963.

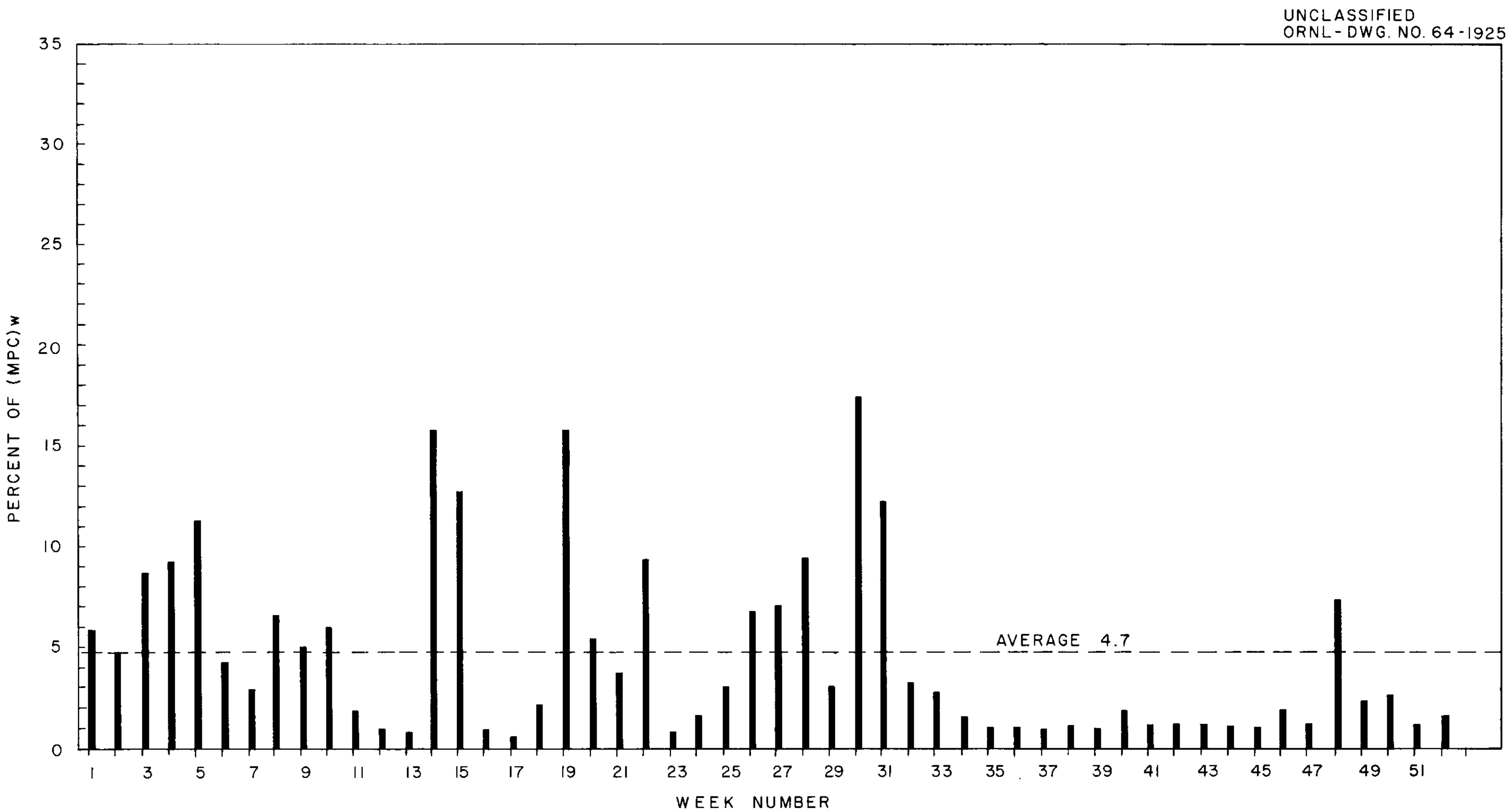

Fig. 9. Estimated Per Cent (MPC)w of Radioactivity in Clinch River Water Below the Mouth of White Oak Creek, 1963.

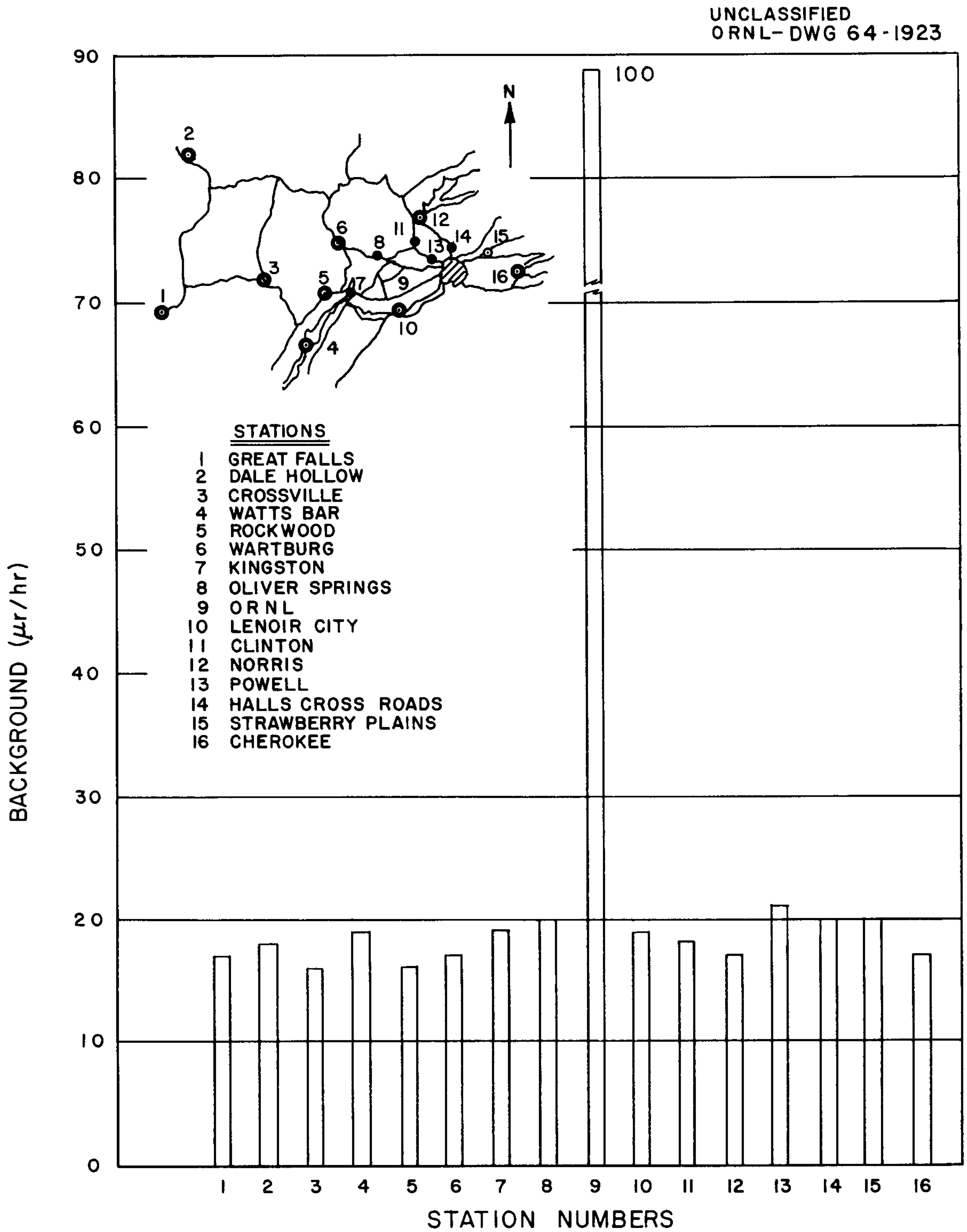

Fig. 10. Radiation Measurements Taken During 1963, 3 ft. Above the Ground Surface Out to Distances of 75 Miles from ORNL.

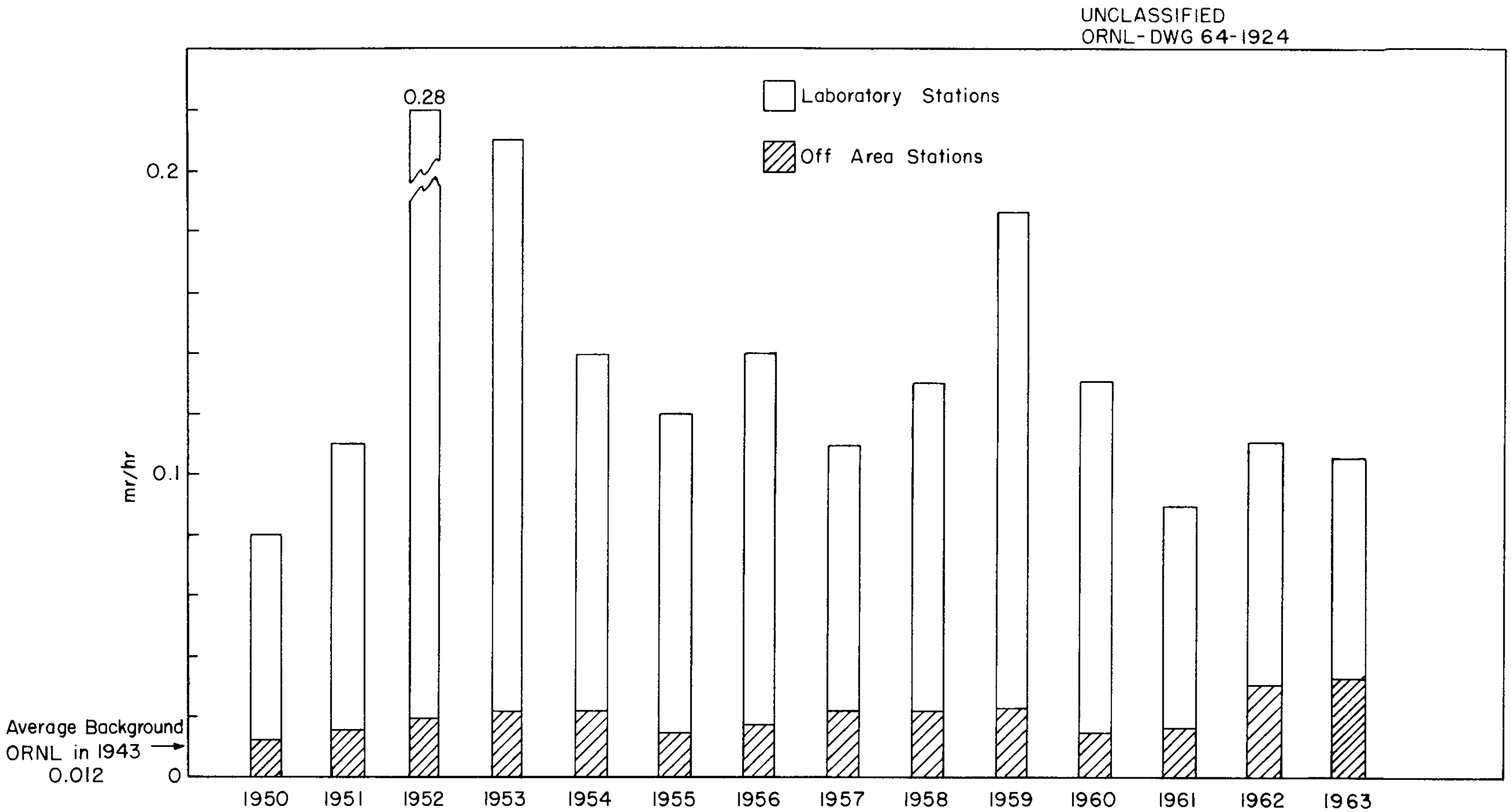

Fig. 11. Radiation Measurements Taken 3 ft. Above the Ground Surfaces at ORNL Compared with Like Measurements Taken Elsewhere within the AEC Controlled Area for the Years 1950-1963.

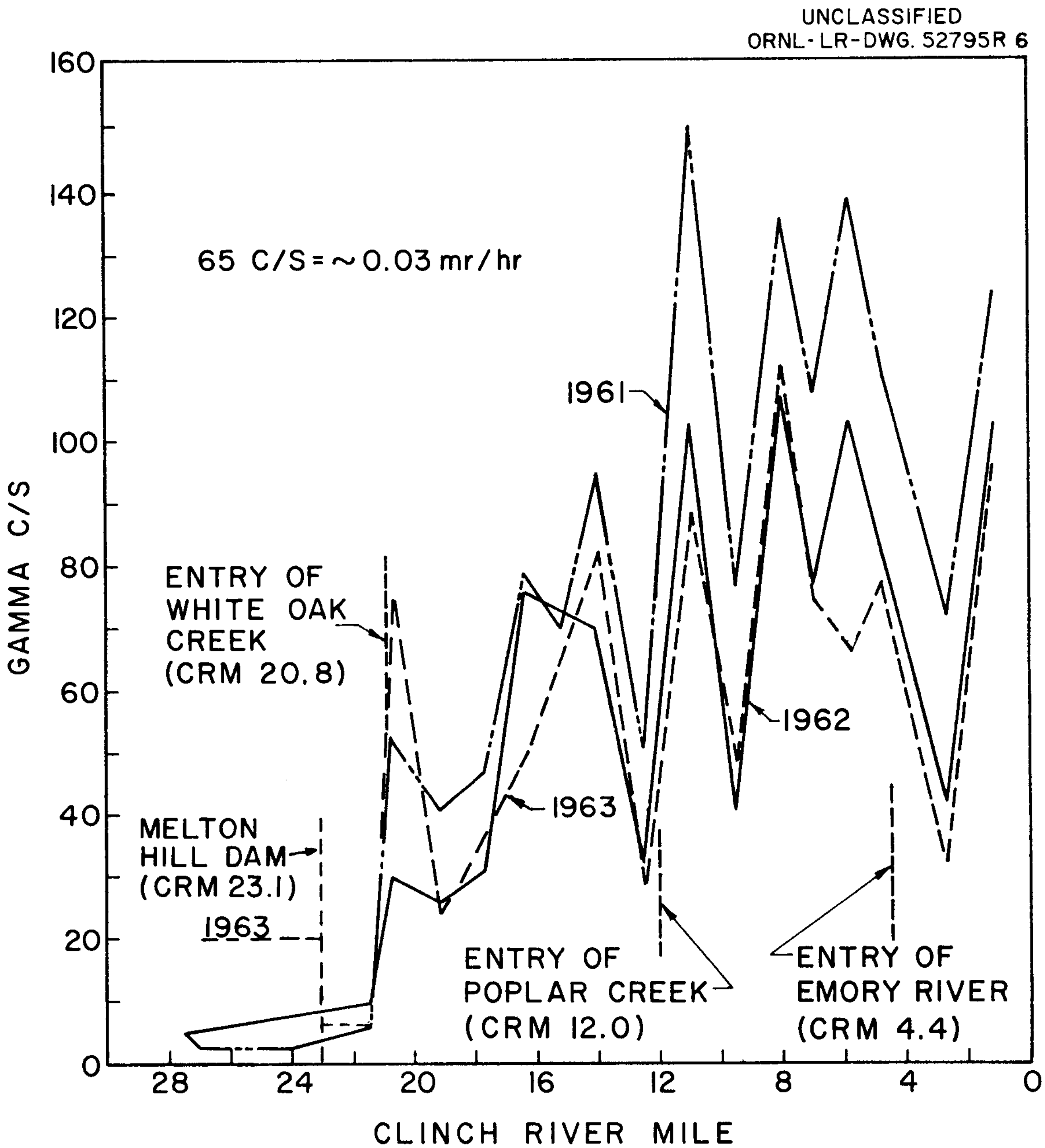

Fig. 12. Gamma Count at Surface of Clinch River Silt.

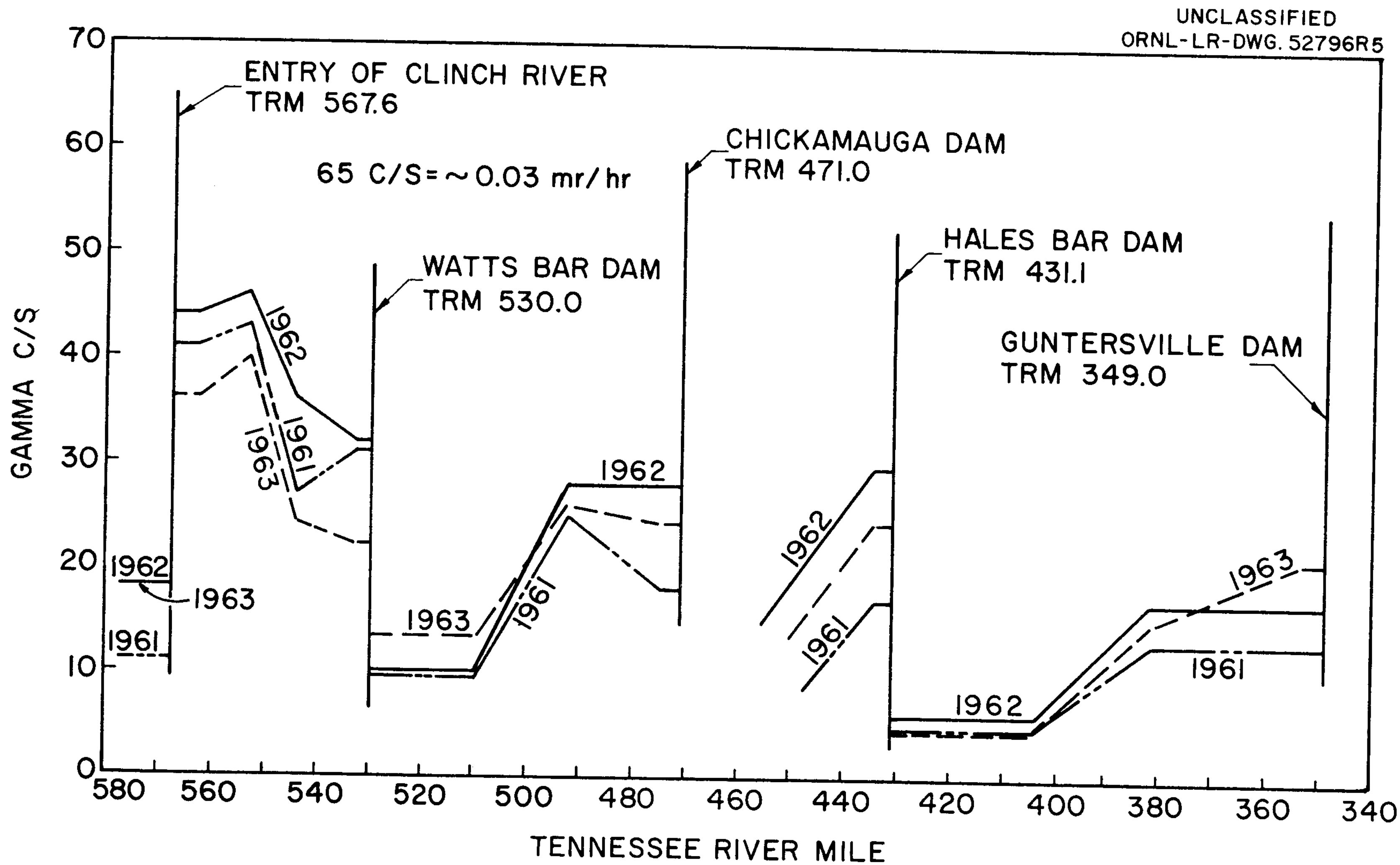

Fig. 13. Gamma Count at Surface of Tennessee River Silt.

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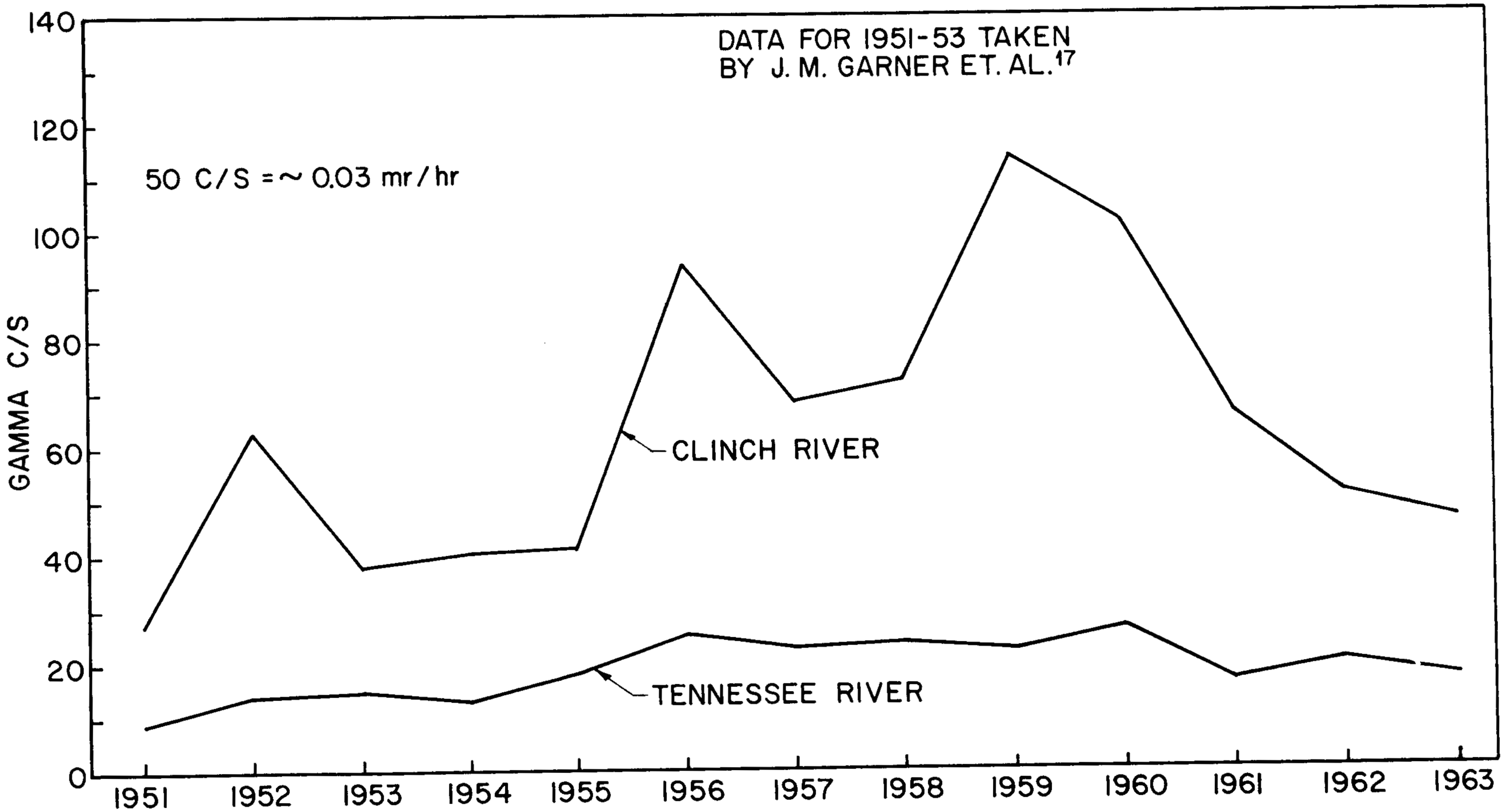

Fig. 14. Average Gamma Count at Surface of Silt Clinch and Tennessee Rivers, 1951-63.

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ORNL-LR-DWG 50112

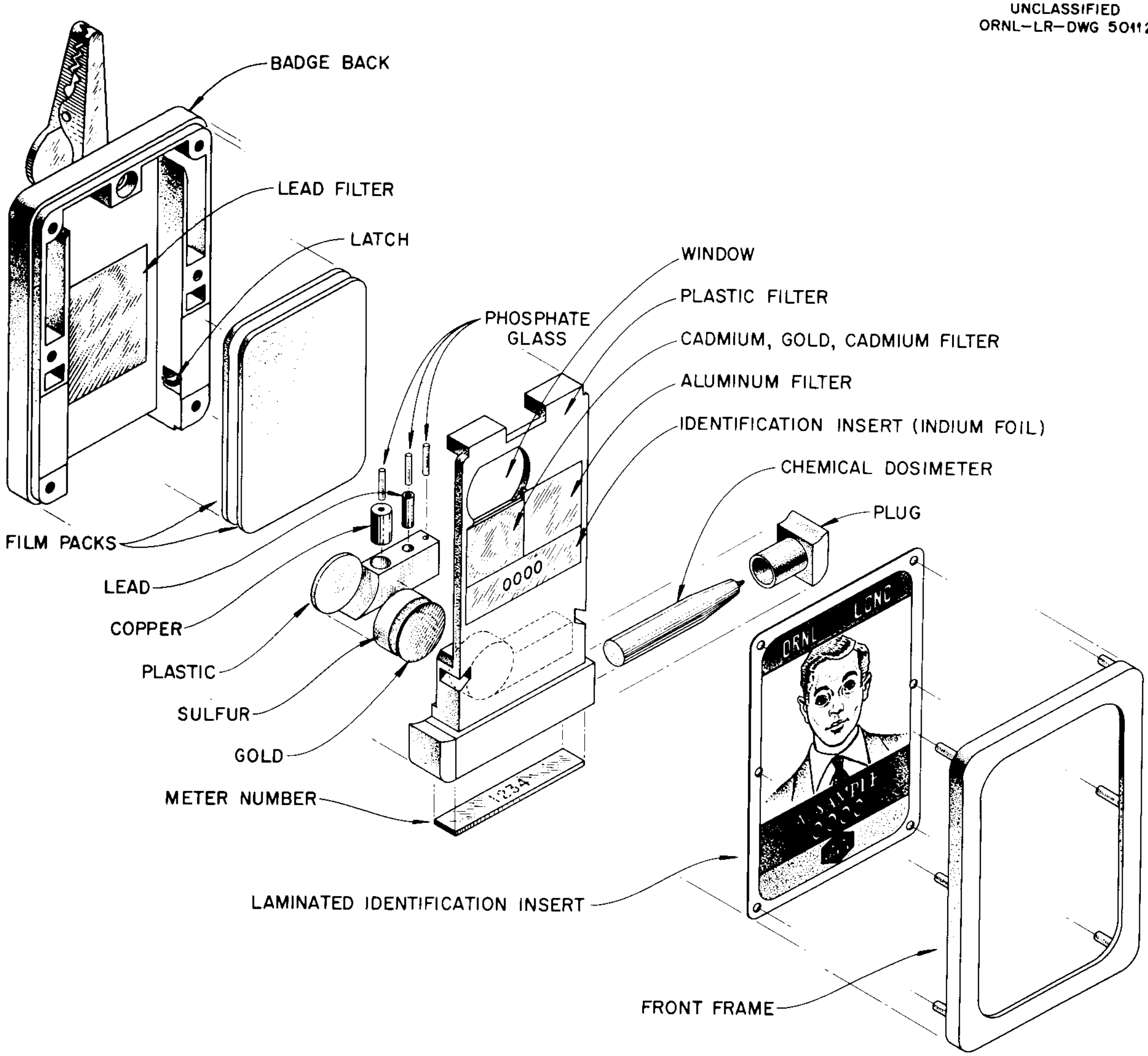

Fig. 15. ORNL Badge-Meter, Model II.

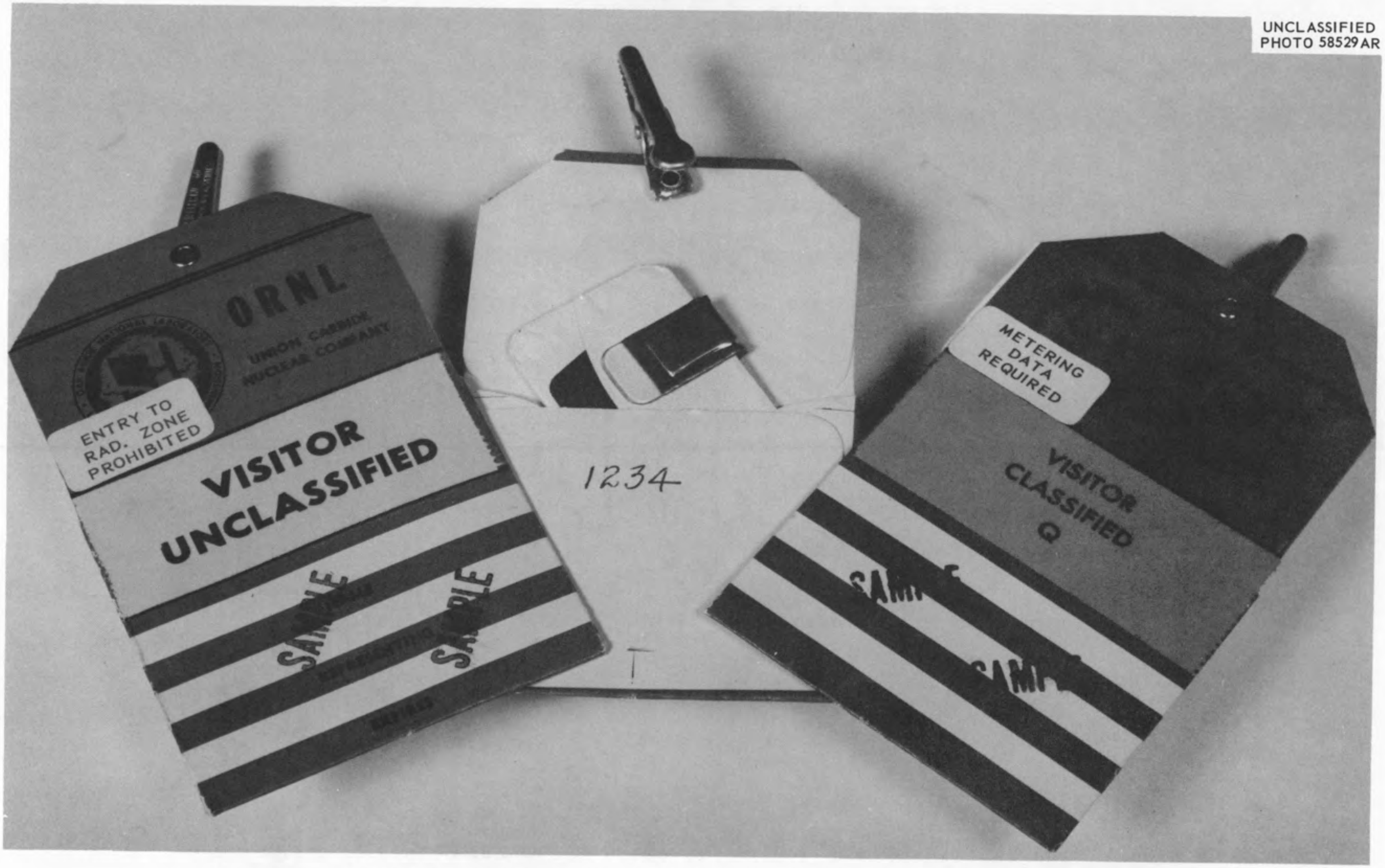

Fig. 16. Typical Temporary Security Passes Equipped with Monitoring Film.

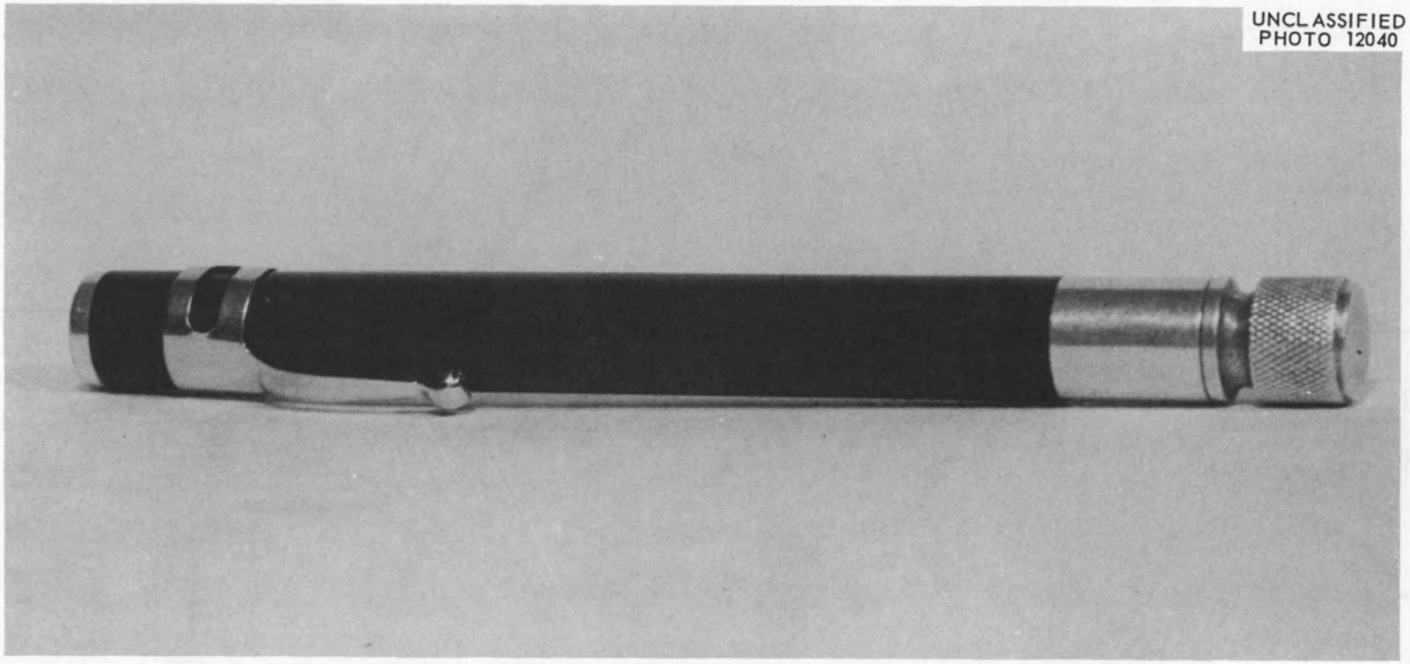

Fig. 17. Pocket Ionization Chamber.

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ORNL-DWG 63-699

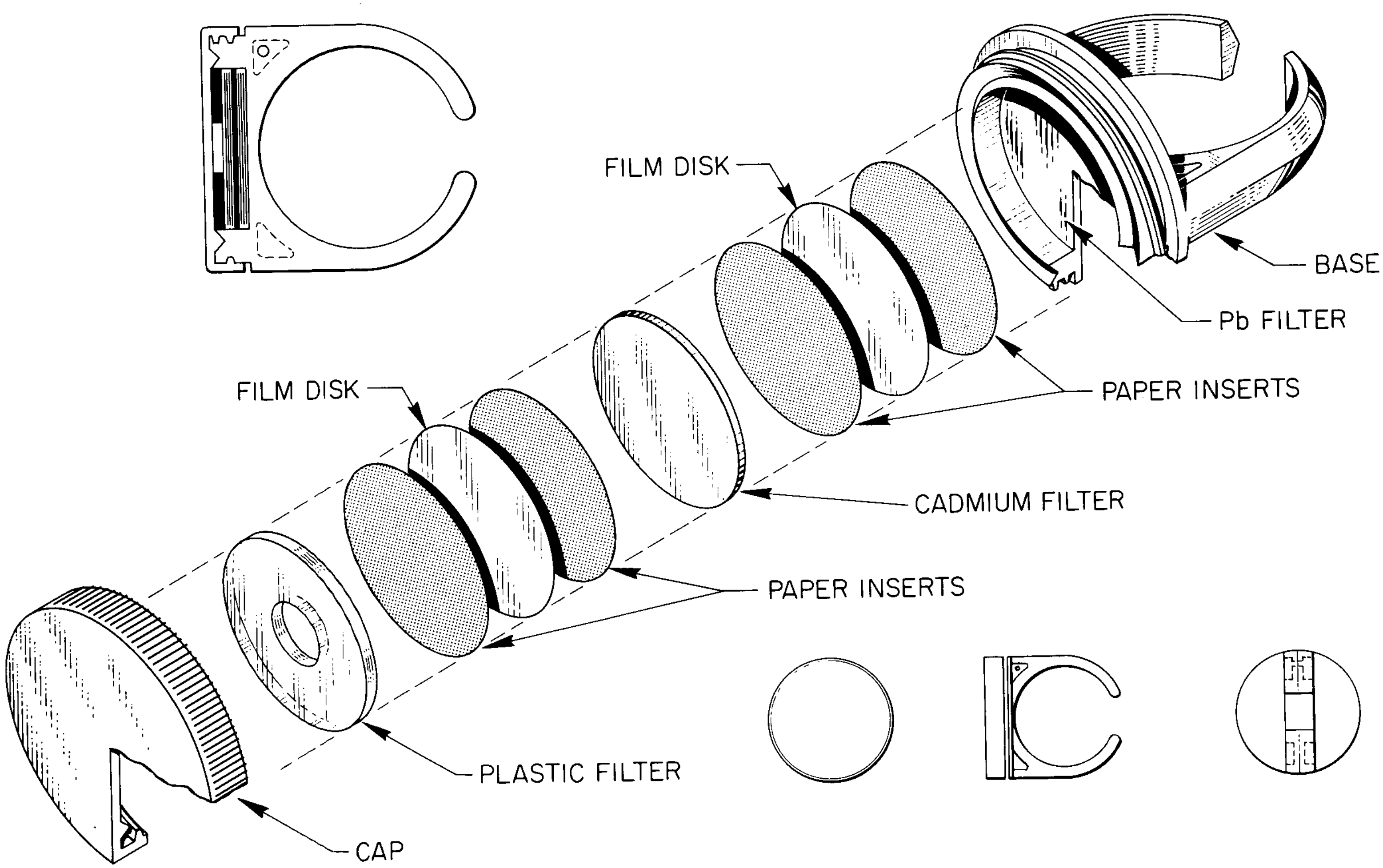

Fig. 18. Details of the ORNL Hand Exposure Meter.

Name	ID Number	Symbol	Dosimetry Dates Wk-Yr	Dosimetry Dates Qtr-Yr	Meter Dose DS	Meter Dose DC
Last Name, Initials	PR. No.	PF	35-63	3-63	0.000	0.000
Last Name, Initials	PR. No.	PF	31-63	3-63	0.120	0.090
Last Name, Initials	PR. No.	PF	30-63	3-63	0.030	0.000
Last Name, Initials	PR. No.	PF	36-63	3-63	0.070	0.020
Last Name, Initials	PR. No.	PF	34-63	3-63	0.000	0.000
Last Name, Initials	PR. No.	PF	36-63	3-36	0.370	0.310
Last Name, Initials	PR. No.	PF	32-63	3-63	0.000	0.000
Last Name, Initials	PR. No.	PF	33-63	3-63	0.040	0.020
Last Name, Initials	PR. No.	PF	34-63	3-63	0.260	0.130
Last Name, Initials	PR. No.	PF	35-63	3-63	0.040	0.010

Fig. 19. ORNL Film Monitoring Data - HP Week 36.

HEALTH PHYSICS DIVISION
DEPARTMENT 3193
RADIATION SURVEY

Name	ID Number	Symbol	Date Wk-Yr	REM DS	REM DC	REM This Qtr DS	REM This Qtr DC	REM This Yr DS	REM This Yr DC	Total REM DC	A	DC/A
----	-----	PF	39-63	0.860	0.630	0.860	0.630	1.68	1.32	35.59	18	2.02
		PN	39-63	0.000	0.000							
----	-----	PF	39-63	0.340	0.240	0.340	0.240	0.34	0.24	0.24	1	0.80
----	-----	PF	39-63	0.020	0.010	0.020	0.010	0.02	0.01	5.21	14	0.38
----	-----	PF	39-63	0.070	0.040	0.070	0.040	0.30	0.19	18.38	16	1.19
----	-----	PF	39-63	0.390	0.310	0.390	0.310	1.40	1.14	2.74	20	0.14
----	-----	PF	39-63	0.350	0.150	0.350	0.150	0.77	0.49	9.60	17	0.56
----	-----	PEL	27-63	0.010	0.010	0.150	0.120	0.27	0.24	5.55	6	1.09
		PF	39-63	0.140	0.110							
		PN	39-63	0.000	0.000							
----	-----	PF	39-63	0.400	0.200	0.400	0.200	0.73	0.45	7.43	12	0.64
----	-----	PF	39-63	0.180	0.150	0.180	0.150	0.60	0.49	8.43	7	1.34
----	-----	PF	39-63	0.330	0.110	0.360	0.140	0.81	0.34	3.00	13	0.24
		PN	39-63	0.030	0.030							
----	-----	PF	39-63	0.180	0.080	0.180	0.080	0.51	0.33	29.82	18	1.68
		PN	39-63	0.000	0.000							
----	-----	PF	39-63	0.320	0.270	0.320	0.270	1.14	0.98	22.76	13	1.76
		PN	39-63	0.000	0.000							
----	-----	PF	39-63	0.420	0.290	0.420	0.290	1.85	1.11	15.86	16	1.04
----	-----	PF	39-63	0.320	0.140	0.320	0.140	0.67	0.46	8.96	11	0.84
----	-----	PF	39-63	0.390	0.210	0.390	0.210	1.21	0.72	33.62	18	1.87

Fig. 20. ORNL Personnel Radiation Exposure Record for 1963, Third Quarter.

Dept. 3193 HP Wk. 39

Name	Pr. No.	DC	M	T	W	T	F	S	S	Wk.	Qtr.	Symbol
----	-----		0	0	20	10	0			30	295	D
----	-----		10	5	5	0	0			20	350	
----	-----			0	0	0	0				155	
----	-----		0	0	0						65	
----	-----		15	10	10	10	10			55	385	
----	-----		0	0	0	0	0				70	
----	-----		10	0	10	10	0			30	175	
----	-----		0	0			0	0			185	
----	-----		10	0	0	0				10	40	
----	-----											
----	-----		0	0							40	
----	-----		10	0	5	0	0			15	220	
----	-----		10	0	10	0	0			20	225	
----	-----		10	5	0	0	0			15	110	
----	-----				0	0	0	0			115	
----	-----		40	90	0	0	0			130	260	DW
----	-----		0	10	0	10	0			20	270	
----	-----		15		0	0	0			15	225	
----	-----		10	5	0	10	0			25	275	
----	-----				0	0					140	
----	-----		10	10			0	0		20	250	
----	-----		0	0	0	0	5			5	170	
----	-----			5	0	0	0			5	770	
----	-----		0	0	0	20				20	135	D
----	-----		0		0	0	0				145	
----	-----		5	5		0	0			10	395	
----	-----		0	10	10	0	10			30	260	
----	-----		0	10	10	10				30	400	
----	-----										35	
----	-----		0	5	0	0	0			5	140	

Fig. 21. Pocket Meter Weekly Report.

RESULTS THIS REPORT 12-20-63

Div. Code	Name	Payroll Number	HP Area Number	Type Analysis	Receipt Date	Type Sample	Sample Priority	d/m/Sample	d/m/24 hrs.
HP	----	-----	3550	GUO	12-16-63	U	3		0
HP	----	-----	3019	GUO	12-12-63	U	3		0
HP	----	-----	3019	GUO	12-16-63	U	3		0
HP	----	-----	3019	GUO	12-12-63	U	3		0
Div. Total 4									

Fig. 22. Weekly Bio-Assay Sample Status Report.

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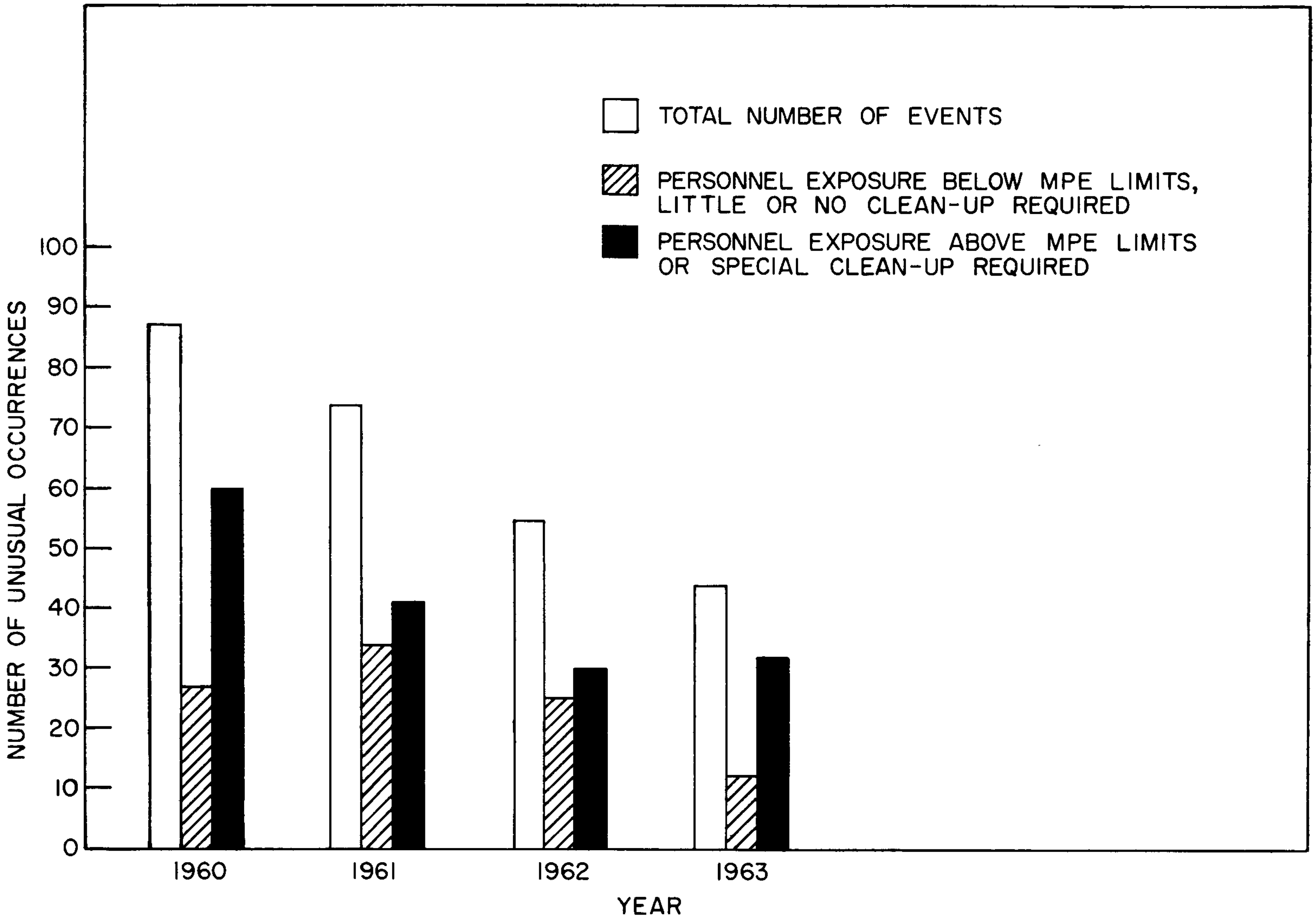

Fig. 23. Number of Unusual Occurrences by Year, 1960-63.

ANNUAL REPORT
SUMMARY

TYPE	NO. INSTS.	COST TOTAL	COST AVG.	YEARS IN SERVICE TOTAL	YEARS IN SERVICE AVG.	DAYS IN SERVICE THIS YR. TOTAL	DAYS IN SERVICE THIS YR. AVG.	SERVICE FREQUENCY TOTAL	SERVICE FREQUENCY AVG.	LABOR INDEX TOTAL	LABOR INDEX AVG.	PARTS INDEX TOTAL	PARTS INDEX AVG.
A1	19	7710.	406.	164	9	2405	127	40	2	18.5	1.0	17.5	0.9
C1	35	6278.	179.	454	13	4445	127	84	2	29.9	0.9	29.2	0.8
C2	321	78012.	243.	1461	5	91230	284	1424	4	331.7	1.0	333.8	1.0
C3	16	3482.	218.	118	7	3695	231	51	3	18.0	1.1	16.0	1.0
C4	16	4380.	274.	32	2	5552	347	83	5	16.7	1.0	16.7	1.0
GROUP TOTAL	388	92152.	238.	2065	5	104922	270	1642	4	396.4	1.0	395.7	1.0
E1	1	90.	90.	16	16	0	0	0	0	0.	0.	0.	0.
F1	11	2750.	250.	121	11	3325	302	38	3	11.8	1.1	11.4	1.0
G1	103	15689.	152.	1234	12	35336	343	503	5	102.7	1.0	110.3	1.1
G2	103	22103.	215.	648	6	33467	325	608	6	107.6	1.0	130.6	1.3
G3	73	2117.	29.	170	2	22479	308	280	4	74.3	1.0	73.0	1.0
G4	8	4278.	535.	17	2	2989	374	52	7	8.0	1.0	8.0	1.0
G5	59	18176.	308.	45	1	15553	264	162	3	61.8	1.0	60.0	1.0
GROUP TOTAL	346	62363.	180.	2114	6	109824	317	1605	5	354.4	1.0	382.0	1.1
GA1	63	37885.	601.	154	2	20458	325	394	6	71.4	1.1	65.3	1.0
J1	37	4792.	130.	481	13	11693	316	113	3	39.7	1.1	37.2	1.0
M1	4	2420.	605.	38	10	1137	284	8	2	4.7	1.2	4.2	1.1
NF1	9	3240.	360.	72	8	1839	204	15	2	7.2	0.8	7.0	0.8
NF2	18	11158.	620.	15	1	4131	230	32	2	18.0	1.0	19.0	1.1
GROUP TOTAL	27	14398.	533.	87	3	5970	221	47	2	25.2	0.9	26.0	1.0
NT1	17	11526.	678.	24	1	5505	324	47	3	17.2	1.0	17.5	1.0
SA1	4	3647.	912.	11	3	991	248	9	2	3.7	0.9	3.3	0.8
SA2	43	19111.	444.	56	1	11727	273	117	3	45.4	1.1	44.4	1.0
GROUP TOTAL	47	22758.	484.	67	1	12718	271	126	3	49.1	1.0	47.8	1.0
SG2	1	1032.	1032.	10	10	393	393	5	5	1.0	1.0	1.0	1.0
GRAND TOTAL	961	259876.	270.	5341	6	278350	290	4065	4	989.4	1.0	1005.7	1.0

Fig. 24. Health Physics Portable Instrument Service Data, Fiscal Year 1963.

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