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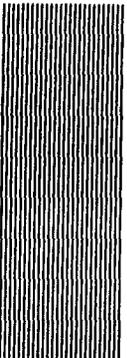
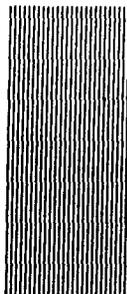
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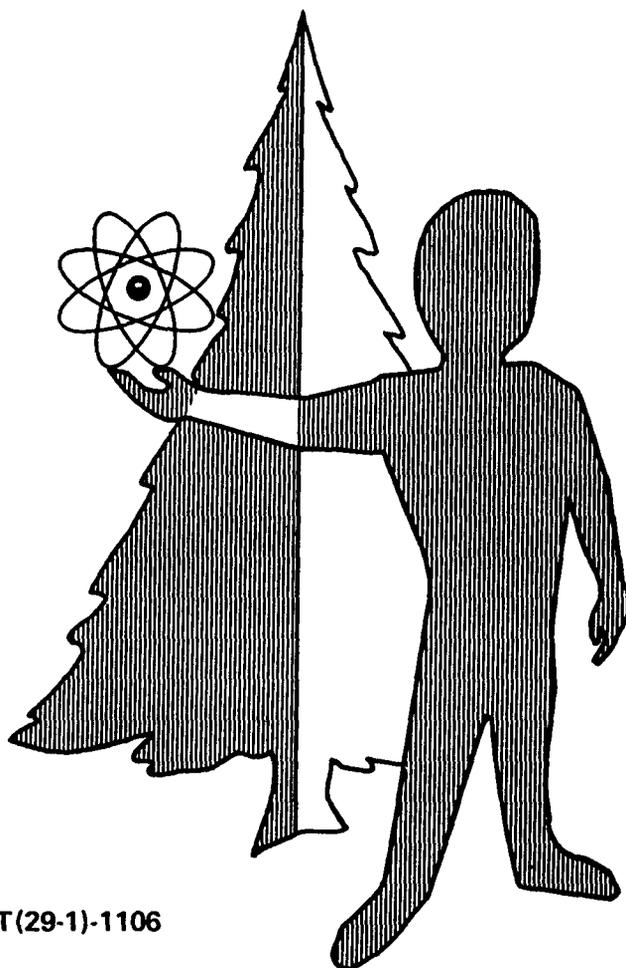
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ANNUAL ENVIRONMENTAL MONITORING REPORT Rocky Flats Plant

JANUARY - DECEMBER 1973

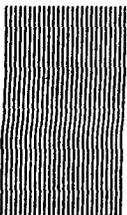


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Environmental Sciences & Waste Control

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**ANNUAL ENVIRONMENTAL MONITORING REPORT
ROCKY FLATS PLANT
A USAEC-Owned Facility**

January through December 1973

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ANNUAL ENVIRONMENTAL MONITORING REPORT
 ROCKY FLATS PLANT
 A USAEC-Owned Facility

January through December 1973

George J Werkema and Milton A Thompson

INTRODUCTION

The Rocky Flats Plant is owned by the U S Government and operated by Dow Chemical U S A under contract with the U S Atomic Energy Commission The plant is located in Jefferson County, Colorado, about 16 air miles northwest of Denver (Figure 1)

The site consists of about 2,520 acres of fenced property At the approximate center of the site is a 384-acre, controlled area that contains all of the Plant's major structures

The Rocky Flats Plant is primarily a radioactive metal fabrication and chemical processing plant It s mission involves foundry, fabrication, plutonium recovery and purification operations, and associated support functions

Annual precipitation recorded at the site during 1973 was 21 55 inches For the 21-year period, 1952 through 1973, the average annual rainfall was 15 84 inches The extreme temperatures recorded during 1973 were -7 to 97 °F, with an annual mean temperature of 47 °F The mean wind velocity was 8 6 miles per hour, with a peak gust of 92 miles per hour on January 12, 1973 Peak gusts in excess of 50 miles per hour occurred monthly, except during late summer and early fall Hourly observations showed the predominant wind direction during 1973 was from the west This direction accounted for 22% of wind-direction data

Assorted low-growing prairie grasses, prickly pear, and spanish bayonet cactus constitute the main

ground cover Cottonwood trees grow adjacent to the watercourses

Surface water runoff from the Rocky Flats Plant is from west to east Runoff is carried from Plant property by two major drainage basins, the North and South forks of Walnut Creek on the north, and Woman Creek to the south South Walnut Creek is the main effluent watercourse The confluence of North and South Walnut Creek is one-half mile east of the Plant's eastern boundary (Figure 2) One mile east of the confluence is Great Western Reservoir, the water supply for the city of Broomfield Woman Creek flows east from Rocky Flats into Standley Lake or it can be diverted into Mower Reservoir, a source of irrigation water Standley Lake is the water supply for the city of Westminster and portions of the Thornton-Northglenn area North Walnut Creek, South Walnut Creek, and Woman Creek are effluent release routes and have been designated A, B, and C, respectively

The environmental monitoring program at the Rocky Flats Plant is the responsibility of the Environmental Sciences and Waste Control Department's Environmental Control group Most of the information and data contained in this report were released monthly to the Rocky Flats Area Office of the U S Atomic Energy Commission, the Division of Occupational and Radiological Health of the Colorado Department of Health, and the Regional Office of the Environmental Protection Agency Concentrations of plutonium in Rocky Flats and community ambient air and airborne plutonium releases are presented for the first time in this report

The Colorado Department of Health also maintains air, soil, and water sampling programs around the Rocky Flats site as a portion of its statewide surveillance. The Jefferson County Health Department performs monthly sewage plant effluent sampling and analysis and has a continuous particulate air sampler on the plant site that is operated by the Colorado Department of Health. The Health and Safety Laboratory of the U S Atomic Energy Commission maintains three particulate air sampling stations in the vicinity of the Rocky Flats Plant and periodically performs soil sampling and analysis. Additional monitoring is performed by the U S Environmental Protection Agency through its studies of accumulations of plant effluent materials in various environmental media.

SUMMARY

Results of the environmental monitoring program in the Rocky Flats vicinity indicate the average environmental concentrations of plutonium-239 in air and water during 1973 were less than two percent of applicable U S Atomic Energy Commission Radioactivity Concentration Guides. Average concentrations of americium-241 and hydrogen-3 (tritium) in water samples were less than one percent of applicable U S Atomic Energy Commission Radioactivity Concentration Guides. The annual average concentrations of residual chlorine, settleable solids, and turbidity in Rocky Flats sewage plant effluent did not meet the new wastewater discharge standards promulgated by the Colorado Department of Health in 1973.

MONITORING DATA COLLECTION, ANALYSIS, AND EVALUATION

Applicable Standards

The U S Atomic Energy Commission has published radioactivity concentration guides (RCG's)¹ governing concentrations of radionuclides in air (RCG_a) and water (RCG_w) accessible for intake by occupationally exposed individuals, incidentally exposed individuals, and the population at large.

Although the standards for radioactivity relate to concentrations above background, all measurements reported herein include background radioactivity. Numerical values of the standards are cited as appropriate in the tables presented elsewhere in this report.

All radionuclides in plant effluents and environmental samples are assumed to be soluble for purposes of comparison with appropriate concentration standards. This assumption is an additional safeguard since the radioactivity concentration guides for soluble radionuclides are more restrictive than those for insoluble radioactive materials.

During 1973, concentrations of total long-lived alpha activity in airborne effluents from plutonium areas were maintained below 60×10^{-15} microcuries per milliliter ($\mu Ci/ml$), the soluble plutonium concentration guide value for an individual in an uncontrolled area. All references to plutonium standards in this report pertain to plutonium-239 unless otherwise noted.

Airborne effluents from uranium areas were maintained below 3×10^{-12} $\mu Ci/ml$ during 1973. The concentration of uranium plus plutonium in effluent water at the plant boundary was maintained below 1600×10^{-9} $\mu Ci/ml$, the soluble plutonium concentration guide value for a suitable sample of an exposed population. The comparable standard for americium-241 is 1300×10^{-9} $\mu Ci/ml$. The Environmental Protection Agency's discharge limitation for beryllium is 10 grams in a 24-hour period.²

Chemical and bacteriological parameters of effluent water from plant operations are compared with waste water discharge standards promulgated by the Colorado Department of Health,³ or by the U S Environmental Protection Agency,⁴ whichever are more restrictive.

Airborne Effluent Monitoring

Exhaust air from Rocky Flats production and research facilities was sampled continuously. In the plutonium facilities, there were at least two sampling points located in each exhaust air duct.

downstream from the final stage of filters. The filterable particulate component of the sample stream was collected on Gelman Type E glass fiber filter media. Particulate samples were collected weekly in uranium and beryllium facilities and three times each week in plutonium facilities. Each sample was analyzed for total long-lived alpha-emitting radionuclides and beryllium, as appropriate. Beginning in July 1973, samples from plutonium facilities were composited weekly and analyzed specifically for plutonium. All references to plutonium concentrations in this report pertain to plutonium-238, 239, and 240 unless otherwise noted.

Plutonium was determined in effluent and environmental samples by a radiochemical technique in which plutonium was separated from other radionuclides by ion exchange chromatography,⁵ electroplated on a stainless steel disk, and analyzed by alpha pulse height spectrometry. The chemical recovery of that analytical procedure for plutonium was determined by adding a standard aliquot of a plutonium-236 tracer. Effluent beryllium concentrations were determined using the atomic absorption method.⁶

The Minimum Detectable concentration (MDC) for effluent samples from plutonium facilities was $0.002 \times 10^{-12} \mu\text{Ci/ml}$ by direct counting. The effluent MDC from uranium facilities was $0.001 \times 10^{-12} \mu\text{Ci/ml}$ by direct counting, and the MDC for a beryllium effluent sample was $0.0002 \mu\text{g/m}^3$.

Table 1 shows the quantities of radionuclides and beryllium released from plant facilities during 1973. The releases of total long-lived alpha-emitting radionuclides shown in Table 1 include long-lived alpha activity due to natural background.

Data Reduction

Throughout the data presented, samples that had concentrations below the MDC were considered as having the MDC for averaging purposes. When one or more MDC values are included in a set of values, the computed mean value of that set is indicated by a "less than" sign (<). The error term ($\pm\%$) associated with maximum concentrations (C_{max}) of total long lived alpha represents the counting error at the 95 percent confidence level. The

average concentrations (C_{avg}) are represented by pairs of numbers that define the 95% confidence interval for C_{avg} . This interval is centered at \bar{c} and is bounded by the percentage deviations from \bar{c} . The probability that C_{avg} lies within the stated interval is 95%, or

$$P \left[\left(\bar{c} - t_{0.975} \sqrt{\frac{\sum_{i=1}^n c_i^2 - n\bar{c}^2}{n(n-1)}} \right) \leq C_{\text{avg}} \leq \left(\bar{c} + t_{0.975} \sqrt{\frac{\sum_{i=1}^n c_i^2 - n\bar{c}^2}{n(n-1)}} \right) \right] = 0.95,$$

where

\bar{c} — is the arithmetic mean of observed concentrations and is volume weighted whenever the volume is measured,

$t_{0.975}$ — is taken from a standard t-test table,

n — is the number of samples, and

c_i — is an individual observed concentration

Ambient Air Monitoring

Ambient air was sampled continuously at 13 locations within and on the perimeter of the Rocky Flats Plant exclusion area (Figure 3). Gast, Model 0465-V4A-025 sampling pumps were used to draw air through Gelman Type E glass fiber filter media at a sampling rate of two cubic foot per minute (cfm). The filters were collected five days each week and analyzed for total long-lived alpha-emitting radionuclides. The sample collected on Thursday of each week was further analyzed for total long-lived beta-emitting radionuclides. Beginning in July 1973, the daily samples were composited monthly and analyzed for plutonium. Sample MDCs for long-lived alpha activity in the Plant's exclusion area ranged between $0.0055 \times 10^{-12} \mu\text{Ci/ml}$ for a daily sample to $0.0018 \times 10^{-12} \mu\text{Ci/ml}$ for a sample collected over the weekend. The MDC for long-lived beta activity in these samples was typically $0.0629 \times 10^{-12} \mu\text{Ci/ml}$.

Table 2 shows the volume-weighted, monthly, arithmetic, average concentrations of total long-lived alpha-emitting radionuclides in airborne particulates at sample stations within the Plant's exclusion area during the first half of 1973. The average concentration of total long-lived alpha-emitters in ambient air at all exclusion area stations during the first half of 1973 was $<6.0 \pm 17\% \times 10^{-15} \mu\text{Ci/ml}$. This concentration was less than 10% of the RCG_a for soluble plutonium in ambient air accessible to incidentally exposed individuals. Plutonium concentrations in ambient air within the exclusion area during the last half of 1973 were obtained by radiochemical analysis of monthly composite samples. The results are shown in Table 3. The average concentration of plutonium in ambient air at all exclusion area stations during the last half of 1973 was $<1.21 \pm 99\% \times 10^{-15} \mu\text{Ci/ml}$. This concentration was less than 2% of the RCG_a for soluble plutonium in ambient air accessible to incidentally exposed individuals.

The volume-weighted, monthly, arithmetic, average concentrations of long-lived beta-emitting radionuclides in airborne particulates of sample stations within the exclusion area during 1973 are given in Table 4. The annual, average concentration of long-lived beta emitters at all exclusion area stations during 1973 was $<0.119 \times 10^{-12} \mu\text{Ci/ml}$. This concentration was less than 0.12% of the RCG_a for total long-lived beta activity in ambient air accessible to incidentally exposed individuals.

Airborne particulate samples were collected at 12 locations surrounding the Rocky Flats Plant between two and four miles distance from the plant center (Figure 4). Air was drawn continuously through Delbag Microsorban filter media at a 27 cfm sampling rate. Beginning in April 1973, samples were collected three days each week, composited monthly, and radiochemically analyzed specifically for plutonium. The MDC for plutonium in those samples was $0.002 \times 10^{-15} \mu\text{Ci/ml}$ for a 30,000 m^3 sample volume.

Table 5 shows the volume-weighted, monthly, arithmetic, average concentrations of plutonium in filterable airborne particulates at the two- to four-mile sample stations. The annual, average concentration of plutonium in ambient air at those

stations during 1973 was $<0.053 \pm 53\% \times 10^{-15} \mu\text{Ci/ml}$. That concentration was less than 0.26% of the RCG_a for soluble plutonium in public areas. The monthly average concentrations of plutonium at those stations are graphed in Figure 5.

Airborne particulate samples were collected at 9 locations in or near population centers in the vicinity of the Rocky Flats Plant. Those locations, shown in Figure 4, included Boulder, Broomfield, Denver, Golden, Lafayette, Marshall, Westminster, northwest Arvada (S-18), and Coal Creek Canyon (S-11). Beginning in March 1973, air was drawn continuously through Gelman Type E glass fiber filter media at a sampling rate of 2 cfm. Prior to March 1973, community ambient air was sampled for 10 minutes each hour. Samples were collected weekly and analyzed for total long-lived alpha- and beta-emitting radionuclides. Beginning in July 1973, weekly samples were composited monthly and analyzed for plutonium. The MDC for long-lived alpha activity in community samples was typically $0.0008 \times 10^{-12} \mu\text{Ci/ml}$, whereas the total long-lived beta activity MDC's were about $0.0094 \times 10^{-12} \mu\text{Ci/ml}$. The MDC for plutonium in ambient community samples was $0.015 \times 10^{-15} \mu\text{Ci/ml}$ for a 3,000 m^3 sample.

The monthly, volume-weighted, arithmetic, average concentrations of long-lived alpha-emitting radionuclides in ambient air at community samplers during the first half of 1973 are shown in Table 6. The average concentration of long-lived alpha emitters during that period at all community samplers was $<2.6 \pm 20\% \times 10^{-15} \mu\text{Ci/ml}$. That concentration was less than 13% of the RCG_a for soluble plutonium in public areas.

Monthly concentrations of plutonium at community air sample stations during the last half of 1973 are shown in Table 7. During that period, the average concentration of plutonium in population centers near the Rocky Flats Plant was $<0.264 \pm 163\% \times 10^{-15} \mu\text{Ci/ml}$. That concentration was less than 1.3% of the RCG_a for soluble plutonium in public areas. A single anomalous result from a sample collected at Golden during July 1973 was responsible for elevating the six-month average above typical background concentrations for the area.

The other six-month station averages shown in Table 7 are typical of background from global fallout

Table 8 presents the monthly average concentrations of long-lived beta-emitting radionuclides in ambient air at community samplers during 1973. The annual, average concentration of long-lived beta emitters at all community samplers was $<0.038 \pm 14\% \times 10^{-12} \mu\text{Ci/ml}$. That concentration was less than 0.1% of the RCG_a for total long-lived beta activity in public areas.

Waterborne Effluent Monitoring

Waste water discharged from the Rocky Flats Plant consisted of treated sanitary and process waste, cooling tower blowdown, steam condensate, and filter backwash from the water treatment plant. Sanitary wastes were treated in an activated sludge, secondary treatment facility, then discharged to the "B" branch (southernmost) of Walnut Creek (Figure 2). Four holding ponds, B-1, B-2, B-3, and B-4 on the "B" branch of Walnut Creek provided additional treatment of water discharged from the sanitary waste treatment facility. Ponds B-1 and B-2 were equipped to impound accidental spills.

The "A" branch of Walnut Creek received cooling water blowdown and steam condensate from process and laboratory facilities on the north side of the plant reservation. Three holding ponds, A-1, A-2, and A-3 were located on the "A" branch of Walnut Creek, with A-1 and A-2 being equipped to impound accidental spills.

Water treatment plant filter backwash and cooling tower blowdown from process facilities on the south side of the plant reservation were discharged to Woman Creek. One holding pond, C-1, was located on Woman Creek and was usable for impounding accidental spills.

Water was sampled continuously and collected daily from the outfalls of Ponds A-3, B-4, and C-1 (Figure 2). The daily samples were composited into weekly samples for analysis of uranium plus plutonium (gross alpha) and specifically for plutonium. Uranium and plutonium were isolated

from other long-lived alpha emitters by ion exchange chromatography,⁵ and their concentrations determined by alpha pulse height spectrometry. Weekly samples from Pond B-4 were also radiochemically analyzed for americium. The chemical recovery of the analytical procedure for plutonium was determined by adding a plutonium-236 tracer. Americium recovery was determined by a curium-244 tracer. The MDCs for uranium, plutonium, and americium in water samples were identical and equal to $0.01 \times 10^{-9} \mu\text{Ci/ml}$.

During 1973, sanitary waste was combined with treated and low-level process waste for final treatment at the sewage treatment plant. Annual, average concentrations of chemical and biological parameters of routine sewage plant effluent samples are shown in Table 9 and compared with applicable discharge water quality standards. The annual average concentrations of residual chlorine, settleable solids, and turbidity in the Rocky Flats sewage plant effluent did not meet the new wastewater discharge standards promulgated by the Colorado Department of Health in 1973. A tertiary treatment facility, which will be completed in 1974, will remove solids and turbidity and permit more efficient operation of the chlorine contact basin.

Concentrations of uranium plus plutonium, and plutonium in water sampled at the outfalls of Ponds A-3, B-4, and C-1 are shown in Tables 10, 11, and 12, respectively. The annual, average concentrations of plutonium in the outfalls of Ponds A-3, B-4, and C-1 during 1973 were $<0.29 \pm 37\% \times 10^{-9} \mu\text{Ci/ml}$ ($<0.02\%$ of RCG_w), $7.37 \pm 47\% \times 10^{-9} \mu\text{Ci/ml}$ (0.46% of RCG_w), and $<0.18 \pm 42\% \times 10^{-9} \mu\text{Ci/ml}$ ($<0.01\%$ of RCG_w), respectively. The monthly, average plutonium concentrations in Pond B-4 are graphed in Figure 6. The annual, average americium-241 concentration in Pond B-4 effluent during 1973 was $<1.79 \pm 122\% \times 10^{-9} \mu\text{Ci/ml}$, as shown in Table 13. That concentration was less than 0.14% of the RCG_w for soluble americium-241 in public areas.

Walnut Creek was sampled continuously during 1973 at Indiana Street, which is downstream from the confluence of the stream's five tributaries and approximately one mile east of the Plant's east boundary. A sample was collected daily, the

samples were composited weekly and analyzed for uranium plus plutonium, plutonium, and americium. Results of the analyses for uranium plus plutonium and plutonium are shown in Table 14. The annual, average concentrations of uranium plus plutonium and plutonium at the Indiana Street location were $11.43 \pm 60\% \times 10^{-9} \mu\text{Ci/ml}$ (0.27% of RCG_w) and $3.11 \pm 43\% \times 10^{-9} \mu\text{Ci/ml}$ (0.19% of RCG_w), respectively. The annual, average concentration of americium-241 in Walnut Creek at Indiana Street was $<1.31 \pm 81\% \times 10^{-9} \mu\text{Ci/ml}$ as shown in Table 13. That concentration was less than 0.10% of the RCG_w for soluble americium-241 in public water supplies.

Regional Water Monitoring

Water samples were collected weekly from two reservoirs and nine tap water locations around the Rocky Flats and greater Denver areas. The reservoirs included Great Western Reservoir, which is the Broomfield water supply, and Standley Lake, which served Westminster and portions of the Thornton-Northglenn area (Figure 4). Tap or treated water was collected from the surrounding communities of Arvada, Boulder, Broomfield, Denver, Golden, Lafayette, Louisville, Thornton, and Westminster. The weekly samples were composited monthly and analyzed for uranium plus plutonium and plutonium. These data are summarized in Table 15. The annual, average plutonium concentration was $<0.06 \pm 45\% \times 10^{-9} \mu\text{Ci/ml}$ in reservoir water samples and $<0.07 \pm 34\% \times 10^{-9} \mu\text{Ci/ml}$ in community water samples. These concentrations were less than 0.004% of the RCG_w for soluble plutonium in public water supplies. The concentration of americium-241 was also determined in water samples from Great Western Reservoir and Standley Lake. Table 13 presents the results of those analyses. The annual, average americium-241 concentrations in Great Western Reservoir and Standley Lake were $<0.16 \pm 148\% \times 10^{-9} \mu\text{Ci/ml}$ (0.01% of RCG_w) and $<0.20 \pm 185\% \times 10^{-9} \mu\text{Ci/ml}$ (<0.02% of RCG_w), respectively.

In September 1973, water samples were collected from additional area reservoirs, lakes, and streams. Samples were collected to a distance of about 20 miles from the Plant and were analyzed for uranium plus plutonium and specifically for plutonium. The MDCs for uranium plus plutonium and plutonium in those samples were identical and equal to $0.01 \times 10^{-9} \mu\text{Ci/ml}$. The data presented in Table 16 show the annual, average plutonium concentration in those samples was $<0.31 \pm 0.76\% \times 10^{-9} \mu\text{Ci/ml}$. That concentration was less than 0.02% of the RCG_w for soluble plutonium in public areas.

Soil Sampling

The geometry of all soil samples is carefully controlled by driving a 10-cm by 10-cm cutting tool 5 cm into undisturbed soil and excavating the soil contained within the tool cavity. The samples are oven dried at 120 °C, then weighed, homogenized, and sieved to remove the coarser rubble. Ten grams of pulverized soil are prepared for plutonium analysis using the method reported by Talvitt⁷. The chemical recovery of the analytical procedure for plutonium is determined by adding a plutonium-236 tracer. The MDC for plutonium in these samples is $<0.03 \times 10^{-6} \mu\text{Ci/g}$ (dry weight). There are no Federal standards for the concentration of plutonium in soil.

Two land areas within the Rocky Flats Plant site were studied extensively during 1973. An aerial radiological survey of the site in 1973 indicated maximum radiation levels about 5 times natural background within a 1-hectare area southeast of a former oil storage area, which is now covered with asphalt. Soil samples collected by Dow Health Physics personnel in 1970 and subsequent years indicated the presence of plutonium in the soil in the same area. The maximum concentration observed in 1970 was $26 \mu\text{Ci/m}^2$. The 1970 soil analysis data were published in a report by Michels⁸.

Subsequent to the aerial survey, ground surveys of the 1-hectare area, using sensitive field instruments for detecting low-energy radiation (FIDLER), were made by the USAEC Health and Safety Laboratory and by Dow Environmental Control. An isorad map from data provided by the Dow survey is shown in Figure 7. Agreement between results of the Health and Safety Laboratory and Dow surveys was good. Recent radiochemical analyses of a limited number of soil samples from the area have yielded plutonium concentrations up to $99.0 \mu\text{Ci}/\text{m}^2$. Those samples were taken from locations indicated by the FIDLER survey and were not intended to correspond to previously sampled locations.

In a second study, 200 soil samples were collected at 50-foot intervals along five north-south traverses between the Plant's security and boundary fences to the east. The range of plutonium concentrations in the soil from that area was 0.003 to $9.72 \mu\text{Ci}/\text{m}^2$. The samples were collected to determine the sensitivity and calibration factor for an aerial radiological survey by personnel from EG&G, Incorporated.

Sixty routine soil samples were collected during 1973 in the plant environs. Samples were collected each 18 degrees of arc on circles of 1-, 2-, and 5-mile radius, concentric with the center of the plant, and analyzed for plutonium. Compared to previous years' data, the 1973 values for plutonium in soil appeared significantly lower. This apparent decrease was attributed to improved sensitivity and reliability of the radiochemical method of analysis.

The 1973 data are displayed on an azimuthal map in Figure 8. This map indicates the majority of anomalous values were found in samples collected in the eastern sector between $\text{N}54^\circ\text{E}$ and $\text{E}54^\circ\text{S}$. The distribution of plutonium in this sector is related to the westerly, prevailing winds at Rocky Flats.

Tritium

Tritium was released in plant effluent water during 1973 as the result of processing a shipment of plutonium that, unknown to Rocky Flats Plant personnel, had been contaminated with tritium by

another USAEC facility. To prevent a recurrence of such an incident, procedures have been established to detect tritium and other radionuclides in all incoming shipments and in plant effluents. This incident has been investigated by the USAEC⁹ and by the USEPA¹⁰.

Beginning in October 1973, water sampled continuously at the outfalls of Ponds A-3, B-4, C-1, and in Walnut Creek at Indiana Street was analyzed daily for tritium by liquid scintillation spectrometry. The water sample collected weekly at Great Western Reservoir was also analyzed for tritium. The average concentrations of tritium in those samples are summarized in Table 17.

Sanitary Landfill

The Rocky Flats Plant sanitary landfill is located at the west end of an arroyo that collects surface runoff water tributary to Walnut Creek. Except during infrequent periods of high rainfall, the "Landfill" branch of Walnut Creek is dry along most of its length. Two earthen dams were constructed in the "Landfill" branch in September 1973 to retain landfill seepage water in which concentrations of tritium above background were detected. As the ponds filled, the water was transferred to low-level, process-waste storage ponds.

Landfill seepage water has been analyzed daily since October 1973 for tritium and other radionuclides. The decrease in tritium concentration is shown graphically in Figure 9.

ASSESSMENT OF THE ROCKY FLATS PLANT'S CONTRIBUTION TO PUBLIC RADIATION DOSE

Throughout this report, it has been assumed that plutonium discharged in Rocky Flats Plant effluents is in a soluble chemical form. This assumption is conservative because the RCGs for insoluble plutonium in air and water are larger than those for soluble plutonium.¹ Radioactivity Concentration Guides (formerly Maximum Permissible Concentrations) were originally recommended by the International Commission on Radiological Protection (ICRP).¹¹

The ICRP selected bone as the critical organ for uptake of soluble plutonium. The assumption was made that the residence time in any intermediate organs, such as lung, the lymphatic system, or the circulatory system, was relatively short for purposes of long-term dose assessment. The ICRP derived RCGs for radionuclides that localize in the bone on the basis of a direct comparison with radium-226, taking into account such individual differences among radionuclides as radioactive decay, daughter products, nonuniform distribution of radionuclides in the bone, essentialness of exposed tissue, and radiosensitivity of exposed tissue.

The Radioactivity Concentration Guides for soluble plutonium are those concentrations in air and water that, after fifty years continuous exposure, will result in a specific accumulation in the bone of an exposed individual. That accumulation is the amount of plutonium biologically equivalent to 0.003 μCi of radium-226 in exposure of the population at large. The amount of plutonium taken to be biologically equivalent to 0.003 μCi of radium-226 in the bone is 0.001 μCi . The 50-year bone accumulations presented in the subsequent discussion were calculated by multiplying 0.001 μCi by the ratio of the observed concentration to the RCG, that is,

$$\text{Accumulation} = 0.001 \mu\text{Ci} \times \frac{C_{\text{avg}}}{\text{RCG}}$$

There is no direct means to compute radiation dose commitments resulting from accumulation of nonuniformly distributed alpha-emitting radionuclides in bone. For purposes of uniformity in reporting, population dose commitments in this report have been estimated by multiplying the appropriate Radiation Protection Standard by the ratio of the observed radionuclide concentration to the RCG, that is,

$$\text{Dose} = \text{Standard} \times \frac{C_{\text{avg}}}{\text{RCG}}$$

The Radiation Protection Standard for dose to the bone for the population at large is 1 rem per year.

Air samplers are located on those public highways nearest the Rocky Flats Plant boundary. The plutonium concentrations in air samples collected at those locations during 1973 are shown in Table 5. The volume-weighted, annual, average concentration of plutonium in air at those stations during 1973 was less than $0.053 \times 10^{-15} \mu\text{Ci/ml}$. That concentration was less than 0.26% of the RCG_a for soluble plutonium in air accessible to the population at large, and was indistinguishable from normal fluctuations in plutonium concentration in air from world-wide fallout. After 50 years of continuous exposure to air containing $0.053 \times 10^{-15} \mu\text{Ci/ml}$ plutonium, an exposed individual would have a bone accumulation of $2.6 \times 10^{-6} \mu\text{Ci}$ of plutonium and an annual dose commitment to the bone of less than 2.6×10^{-3} rem.

Air samplers are located in population centers near the Rocky Flats Plant. The plutonium concentrations in air samples collected at those locations during July-December 1973 are shown in Table 7. The volume-weighted, six-month average concentration of plutonium in air at those stations, including one suspect result from the sample collected at Golden in July, was less than $0.264 \times 10^{-15} \mu\text{Ci/ml}$. This concentration was less than 1.3% of the RCG_a for soluble plutonium in air accessible to the population at large. After 50 years of continuous exposure to air containing $0.264 \times 10^{-15} \mu\text{Ci/ml}$ plutonium, an exposed individual would have a bone accumulation of $1.3 \times 10^{-6} \text{ Ci}$ of plutonium and an annual dose commitment to the bone of less than 1.3×10^{-2} rem.

Samples of tap water from population centers near the Rocky Flats Plant are collected weekly, composited monthly, and analyzed for plutonium. Results of analyses are shown in Table 15. The sample-weighted, annual, average concentration of plutonium in community water during 1973 was less than $0.07 \times 10^{-9} \mu\text{Ci/ml}$. This concentration was less than 0.004% of the RCG_w for soluble

plutonium in water accessible to the public at large. After 50 years of drinking only water containing 0.07×10^{-9} $\mu\text{Ci/ml}$ plutonium, an exposed individual would have a bone accumulation of 4×10^{-8} μCi of plutonium, and an annual dose commitment to the bone of less than 4×10^{-5} rem.

The critical organ for tritiated water exposure is taken to be body tissue.¹¹ Tritium equilibrates rapidly with protium (hydrogen-1) atoms in body tissue and fluids. An evaluation of dose can be made by multiplying the radiation protection standard, 0.17 rem, by the ratio of the observed average concentration in drinking water to the applicable RCG.

Tritiated water was discharged to Great Western Reservoir, the water supply for the city of Broomfield, as the result of an accidental release from the Rocky Flats Plant during May 1973.⁹ Beginning in October, water samples were collected weekly from Great Western Reservoir and analyzed for tritium. The average concentration of tritium in Great Western Reservoir water during October-December 1973, shown in Table 17, was 8.221×10^{-6} $\mu\text{Ci/ml}$. This concentration is 0.82% of the RCG_w for tritium in water accessible to the population at large. The dose commitment to an individual drinking only water containing 8.221×10^{-6} $\mu\text{Ci/ml}$ tritium for seven months is 8×10^{-4} rem.

For purposes of comparison, the annual natural background dose commitment for a person living in Colorado is about 0.2 rem, including external radiation from radionuclides in soil, cosmic sources, and internal radiation from natural radionuclides such as potassium-40, which are incorporated in biological material.

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- 3 Standards for the Discharge of Wastes, Water Pollution Control Commission, Colorado Department of Health, 1972
- 4 Secondary Treatment Information, 40 CFR, Part 133, U S Environmental Protection Agency, August 14, 1973
- 5 "Standard Laboratory Procedures for the Determination of Radioactivity and Chemical Concentrations in Environmental and Bioassay Samples," D L Bokowski, (Ed), USAEC RFP-2039 Rocky Flats Division, Dow Chemical U S A , to be published
- 6 D L Bokowski, "Rapid Determination of Beryllium by a Direct-Reading Atomic Absorption Spectrometer," *Am Ind Hyg Assoc* , 29, pp 474-481 (1968)
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- 8 D E Michels, "Diagnosis of Plutonium Re-entrained in Air," USAEC RFP-1927, Rocky Flats Divison, Dow Chemical U S A , April 27, 1973
- 9 "Investigation of the Tritium Release Occurrence at the Rocky Flats Plant," U S Atomic Energy Commission, November 26, 1973
- 10 "Investigative Report of the 1973 Tritium Release at the Rocky Flats Plant in Golden, Colorado," U S Environmental Protection Agency, Region VIII, to be published, (1974)
- 11 Report of ICRP Committee II on Permissible Dose for Internal Radiation (1959) *Health Physics* 3, 1960

TABLES 1 through 17

Table 1 Airborne Radionuclides Released to Atmosphere

Month	Plutonium Facilities μCi^*	Enriched Uranium Facilities μCi^{**}	Depleted Uranium and Research Facilities μCi^{**}	Beryllium Facilities grams ***
January	<11 36	< 0 69	< 3 19	<0 23
February	< 3 49	< 0 31	< 2 14	<0 28
March	< 2 44	< 1 54	< 1 10	<0 13
April	< 3 79	< 5 49	< 1 58	<0 22
May	< 2 88	< 0 54	< 1 96	<0 09
June	< 2 16	< 0 26	< 8 09	<0.14
July	< 2 83	< 0 44	<31 75	<0 33
August	< 1 78	< 0 28	< 4 08	<0 34
September	< 2 14	< 0 42	< 1 04	<0 55
October	< 5 39	< 0 55	< 1 45	<3 32
November	<30 68	< 0 04	< 2 4	<0 75
December	< 8 45	< 0 10	< 4 66	<0 70
Total	<77 39	< 10 66	<63 44	<7 1

*Radiometrically determined as total long-lived alpha activity during January-June Radiochemically determined as plutonium-239 during July-December

**Radiometrically determined as total long-lived alpha activity

***The USEPA discharge limitation for beryllium is 3,650 grams/year

Table 2 Total Long-Lived Alpha Activity in Rocky Flats Ambient Air
 Volume-Weighted Station Averages Concentrations ($\times 10^{-15} \mu\text{Ci}/\text{ml}$)

Station	January	February	March	April	May	June
S-1	<4 2 ± 34%	<5 0 ± 28%	<8 7 ± 123%	<4 8 ± 29%	< 4 8 ± 35%	< 4 9 ± 37%
S 2	<4 6 ± 22%	<4 9 ± 32%	<6 4 ± 62%	<5 3 ± 40%	< 5 1 ± 29%	< 4 9 ± 38%
S 3	<4 9 ± 51%	<5 0 ± 28%	<6 2 ± 40%	<5 0 ± 33%	< 5 6 ± 36%	< 5 7 ± 41%
S-4	<4 5 ± 37%	<4 1 ± 30%	<4 5 ± 38%	<5 2 ± 28%	< 5 3 ± 34%	< 5 4 ± 31%
S-5	<4 1 ± 28%	<4 2 ± 35%	<4 4 ± 37%	<7 3 ± 43%	*	*
S-6	<3 8 ± 30%	<4 2 ± 34%	<4 8 ± 38%	<5 3 ± 28%	< 4 9 ± 32%	< 5 2 ± 31%
S-7	<4 5 ± 25%	<4 1 ± 66%	<5 0 ± 38%	<5 8 ± 33%	<17 0 ± 42%	< 5 7 ± 35%
S-8	<5 1 ± 31%	<6 2 ± 24%	<7 9 ± 45%	<6 6 ± 34%	< 6 4 ± 33%	< 9 0 ± 47%
S-9	<4 4 ± 33%	<4 0 ± 31%	<8 9 ± 49%	<7 5 ± 50%	< 4 7 ± 40%	< 5 3 ± 42%
S-10	<4 2 ± 33%	<4 5 ± 39%	<5 6 ± 60%	<5 8 ± 34%	< 5 7 ± 54%	< 5 4 ± 31%
S-50	<5 5 ± 54%	<5 7 ± 28%	<4 6 ± 36%	<6 8 ± 50%	<10 0 ± 31%	<34 2 ± 223%
S-51	<5 1 ± 35%	<5 4 ± 42%	<5 9 ± 40%	<6 2 ± 32%	< 5 8 ± 47%	< 6 4 ± 38%
S 52	<4 4 ± 34%	<3 9 ± 34%	<5 5 ± 41%	<4 9 ± 58%	< 7 4 ± 92%	< 4 4 ± 34%
Volume weighted average	<4 5 ± 10%	<4 7 ± 9%	<6 1 ± 18%	<6 0 ± 11%	< 6 9 ± 14%	< 8 2 ± 75%

January-June 1973 Summary

Station	n	Vol (m ³)	Concentration ($\times 10^{-15} \mu\text{Ci}/\text{ml}$)			% of RCG _a **
			C _{min}	C _{max}	C _{avg}	
S-1	122	14181 0	<1 8	118 9 ± 17%	< 5 5 ± 36%	< 9 2
S-2	120	13773 5	<1 8	45 4 ± 27%	< 5 2 ± 17%	< 8 7
S-3	115	13284 5	<1 8	26 3 ± 36%	< 5 4 ± 16%	< 9 0
S-4	118	13529 0	<1 8	15 8 ± 46%	< 4 8 ± 13%	< 8 0
S-5	81	9291 0	<1 8	27 0 ± 35%	< 4 9 ± 19%	< 8 2
S-6	122	14181 0	<1 8	18 4 ± 43%	< 4 7 ± 13%	< 7 8
S-7	114	13366 0	<1 8	79 9 ± 10%	< 7 1 ± 20%	<11 8
S-8	117	13366 0	<1 8	39 4 ± 29%	< 6 9 ± 16%	<11 5
S-9	121	14099 5	<1 8	44 0 ± 16%	< 5 8 ± 19%	< 9 7
S-10	111	12795 5	<1 8	20 2 ± 41%	< 5 1 ± 16%	< 8 5
S-50	121	14099 5	<1 8	727 3 ± 7%	<10 9 ± 109%	<18 2
S-51	96	11002 5	<1 8	23 6 ± 38%	< 5 7 ± 16%	< 9 5
S-52	103	11736 0	<1 8	47 3 ± 27%	< 5 1 ± 22%	< 8 5
Summary	1461	168705 0	<1 8	727 3 ± 7%	-	-
Volume-weighted average	-	-	-	-	< 6 0 ± 17%	<10 0

*Sampler S-5 out of service

**The RCG_a for soluble plutonium-239 in ambient air accessible to incidentally exposed individuals is $60 \times 10^{-15} \mu\text{Ci}/\text{ml}$

Table 3 Plutonium in Rocky Flats Ambient Air

Monthly Composite Station Concentrations ($\times 10^{-15}$ $\mu\text{Ci/ml}$)

Station	July	August	September	October	November	December
S-1	4 795	0 124	0 105	0 276	0 085	0 032
S 2	0 067	0 312	0 160	0 326	0 164	0 120
S-3	0 229	0 649	0 061	0 195	0 188	0 180
S-4	0 188	0 522	0 148	0 217	0 223	0 239
S-5	0 129	0 097	0 095	0 005	0 072	0 062
S-6	0 177	0 495	0 134	0 219	0 370	0 168
S-7	1 273	0 030	0 604	0 906	0 306	0 462
S-8	1 687	4 109	1 017	2 864	2 478	1 457
S-9	0 120	0 258	0 304	0 519	0 117	0 195
S-10	0 582	0 103	0 233	0 338	0 613	0 403
S 50	0 383	1 934	0 691	1 520	0 456	0 438
S 51	0 094	*	*	*	0 832	45 531
S 52	0 928	0 317	0 182	0 861	0 308	0 486
Volume weighted average	0 539 \pm 156%	0 369 \pm 224%	0 211 \pm 106%	0 370 \pm 161%	0 497 \pm 77%	5 375 \pm 138%

July-December 1973 Summary

Station	n	Vol (m^3)	Concentration ($\times 10^{-15}$ $\mu\text{Ci/ml}$)			% of RCG _a ***
			C _{min}	C _{max}	C _{avg} **	
S-1	6	11994 0	0 032	4 795	1 114 \pm 174%	1 8
S-2	6	14765 0	0 067	0 326	0 190 \pm 58%	0 3
S-3	6	14680 0	0 610	0 649	0 254 \pm 83%	0 4
S-4	6	14765 0	0 148	0 522	0 258 \pm 54%	0 4
S-5	6	177750 0	0 005	0 129	0 077 \pm 57%	0 1
S-6	6	14684 0	0 134	0 495	0 266 \pm 53%	0 4
S-7	6	14765 0	<0 030	1 273	<0 588 \pm 80%	<1 0
S-8	6	14765 0	1 017	4 109	2 297 \pm 50%	3 8
S-9	6	14435 0	0 117	0 519	0 248 \pm 66%	0 4
S-10	6	14033 0	0 103	0 613	0 378 \pm 55%	0 6
S-50	6	11909 5	0 383	1 934	0 699 \pm 122%	1 1
S-51	3	55932 0	0 094	45 531	6 509 \pm 1136%	10 8
S-52	6	14680 0	0 182	0 928	0 507 \pm 66%	0 8
Summary	75	389157 5	0 005	45 531	—	—
Volume-weighted average	—	—	—	—	<1 214 \pm 99%	<2 0

*Sampler out of service

**Volume-weighted average

***RCG_a for soluble plutonium-239 in ambient air accessible to incidentally exposed individuals is 60×10^{-15} $\mu\text{Ci/ml}$

Table 4 Total Long-Lived Beta Activity in Rocky Flats Ambient Air
Volume Weighted Station Averages Concentrations ($\times 10^{-12}$ $\mu\text{Ci}/\text{ml}$)

Station	January	February	March	April	May	June
S-1	<0 102 \pm 100%	<0 112 \pm 188%	<0 160 \pm 51%	<0 105 \pm 103%	<0 081 \pm 27%	<0 095 \pm 66%
S 2	<0 080 \pm 60%	0 178 \pm 111%	<0 114 \pm 81%	<0 161 \pm 102%	<0 112 \pm 75%	<0 103 \pm 72%
S-3	<0 087 \pm 32%	<0 073 \pm 61%	0 309 \pm 79%	<0 187 \pm 154%	<0 079 \pm 65%	<0 063 \pm 0%
S-4	0 196 \pm 56%	<0 122 \pm 193%	<0 159 \pm 82%	<0 204 \pm 85%	<0 082 \pm 71%	<0 084 \pm 69%
S 5	<0 106 \pm 94%	<0 139 \pm 696%	<0 154 \pm 124%	<0 234 \pm 107%	*	*
S-6	<0 089 \pm 78%	<0 156 \pm 257%	<0 120 \pm 70%	<0 134 \pm 60%	<0 104 \pm 85%	<0 082 \pm 73%
S 7	<0 112 \pm 69%	<0 063 \pm 0%	0 225 \pm 89%	<0 171 \pm 152%	<0 139 \pm 105%	<0 128 \pm 63%
S 8	<0 064 \pm 4%	<0 138 \pm 234%	<0 238 \pm 76%	<0 128 \pm 101%	<0 099 \pm 69%	0 170 \pm 47%
S 9	<0 084 \pm 68%	<0 063 \pm 0%	<0 158 \pm 101%	0 130 \pm 80%	<0 072 \pm 40%	<0 103 \pm 72%
S 10	<0 103 \pm 109%	<0 155 \pm 201%	<0 177 \pm 223%	<0 084 \pm 81%	<0 097 \pm 112%	<0 071 \pm 35%
S-50	<0 102 \pm 66%	<0 141 \pm 216%	<0 238 \pm 84%	<0 198 \pm 121%	<0 093 \pm 89%	<0 064 \pm 4%
S-51	<0 150 \pm 131%	<0 093 \pm 131%	<0 178 \pm 119%	<0 063 \pm 0%	<0 106 \pm 49%	<0 106 \pm 50%
S-52	<0 063 \pm 0%	<0 176 \pm 277%	<0 211 \pm 84%	0 102 \pm 240%	<0 121 \pm 99%	<0 093 \pm 102%
Volume-weighted average	<0 103 \pm 17%	<0 127 \pm 26%	<0 188 \pm 18%	<0 153 \pm 20%	<0 099 \pm 15%	<0 097 \pm 14%
Station	July	August	September	October	November	December
S-1	<0 123 \pm 52%	<0 108 \pm 285%	<0 155 \pm 146%	<0 122 \pm 56%	0 041 \pm 13%	0 062 \pm 55%
S-2	<0 137 \pm 57%	<0 197 \pm 77%	<0 095 \pm 33%	<0 141 \pm 75%	<0 084 \pm 0%	0 118 \pm 13%
S-3	<0 123 \pm 78%	<0 104 \pm 36%	<0 092 \pm 29%	<0 141 \pm 79%	<0 084 \pm 0%	<0 140 \pm 53%
S-4	<0 185 \pm 61%	<0 166 \pm 59%	<0 169 \pm 116%	<0 151 \pm 71%	<0 132 \pm 75%	<0 107 \pm 73%
S-6	<0 136 \pm 45%	<0 148 \pm 50%	<0 151 \pm 133%	<0 096 \pm 40%	<0 084 \pm 0%	<0 101 \pm 52%
S-7	<0 167 \pm 71%	<0 148 \pm 86%	<0 143 \pm 76%	<0 151 \pm 83%	<0 103 \pm 60%	<0 187 \pm 105%
S-8	<0 136 \pm 76%	<0 147 \pm 57%	<0 138 \pm 56%	<0 161 \pm 75%	<0 092 \pm 29%	<0 095 \pm 138%
S-9	<0 148 \pm 47%	<0 129 \pm 50%	<0 097 \pm 27%	<0 138 \pm 75%	<0 129 \pm 108%	<0 122 \pm 15%
S-10	<0 092 \pm 77%	<0 157 \pm 71%	<0 142 \pm 176%	<0 120 \pm 47%	<0 105 \pm 65%	<0 110 \pm 9%
S-50	<0 113 \pm 60%	*	<0 084 \pm 0%	<0 111 \pm 43%	<0 138 \pm 87%	<0 151 \pm 2%
S-51	<0 127 \pm 43%	*	*	*	*	*
S-52	<0 108 \pm 63%	<0 111 \pm 49%	<0 216 \pm 118%	<0 124 \pm 52%	<0 028 \pm 72%	0 046 \pm 108%
Volume-weighted average	<0 135 \pm 16%	<0 144 \pm 15%	<0 135 \pm 20%	<0 132 \pm 12%	<0 062 \pm 37%	<0 086 \pm 28%

*Sampler out of service

Table 4 Total Long-Lived Beta Activity in Rocky Flats Ambient Air (Continued)

Volume Weighted Station Averages Concentrations ($\times 10^{-12}$ $\mu\text{Ci}/\text{ml}$)						
January-June 1973 Summary						
Station	n	Vol (m^3)	Concentration ($\times 10^{-12}$ $\mu\text{Ci}/\text{ml}$)			% of RCG _a **
			C _{min}	C _{max}	C _{avg}	
S-1	25	2037 5	<0 0629	0 248 \pm 29%	<0 110 \pm 23%	<0 11
S-2	25	2037 5	<0 0629	0 298 \pm 27%	<0 120 \pm 24%	<0 12
S-3	23	1874 5	<0 0629	0 563 \pm 19%	<0 142 \pm 41%	<0 14
S-4	25	2037 5	<0 0629	0 315 \pm 26%	<0 145 \pm 26%	<0 14
S-5	16	1304 0	<0 0629	0 420 \pm 22%	<0 157 \pm 43%	<0 16
S-6	25	2037 5	<0 0629	0 342 \pm 25%	<0 112 \pm 26%	<0 11
S-7	23	1874 5	<0 0629	0.508 \pm 20%	<0 152 \pm 32%	<0 15
S-8	24	1956 0	<0 0629	0 425 \pm 22%	<0 144 \pm 30%	<0 14
S-9	25	2037 5	<0.0629	0 376 \pm 24%	<0 105 \pm 28%	<0 10
S-10	23	1874 5	<0 0629	0 359 \pm 24%	<0 110 \pm 34%	<0 11
S-50	25	2037 5	<0 0629	0 464 \pm 21%	<0 142 \pm 34%	<0 14
S-51	20	1630 0	<0 0629	0 331 \pm 25%	<0 125 \pm 31%	<0 12
S-52	22	1793 0	<0 0629	0 403 \pm 23%	<0 132 \pm 37%	<0 13
Summary	301	24531 5	<0 0629	0 563 \pm 19%	-	-
Volume-weighted average	-	-	-	-	<0 130 \pm 8%	<0 13
July-December 1973 Summary						
S-1	29	6601 5	0 0273	0 368 \pm 28%	<0 075 \pm 56%	<0 08
S-2	34	3097 0	<0 0839	0 434 \pm 26%	<0 133 \pm 25%	<0 13
S-3	31	2852 5	<0 0839	0 478 \pm 24%	<0 117 \pm 25%	<0 12
S-4	34	3097 0	<0 0839	0 604 \pm 22%	<0 161 \pm 28%	<0 16
S-6	34	3097 0	<0 0839	0 339 \pm 29%	<0 125 \pm 22%	<0 12
S-7	34	3097 0	<0 0839	0 714 \pm 20%	<0 156 \pm 30%	<0 16
S-8	34	3097 0	<0 0420	0 640 \pm 21%	<0 130 \pm 31%	<0 13
S-9	33	3015 5	<0 0839	0 398 \pm 27%	<0 134 \pm 21%	<0 13
S-10	28	2608 0	<0 0839	0 309 \pm 30%	<0 115 \pm 24%	<0 12
S-50	26	2445 0	<0 0839	0 294 \pm 31%	<0 118 \pm 22%	<0 12
S-51	11	1141 0	<0 0839	0 250 \pm 34%	<0 127 \pm 43%	<0 13
S-52	31	6764.5	<0 0120	0 449 \pm 25%	<0 066 \pm 66%	<0 07
Summary	359	40913 0	<0 0120	0 714 \pm 20%	-	-
Volume-weighted average	-	-	-	-	<0 112 \pm 10%	<0 11
January-December 1973 Summary						
S-1	54	8639 0	0 0273	0 368 \pm 28%	<0 083 \pm 31%	<0 08
S-2	59	5134 5	<0 0629	0 434 \pm 26%	<0 128 \pm 17%	<0 13
S-3	54	4727 0	<0 0629	0 563 \pm 19%	<0 127 \pm 23%	<0 13
S-4	59	5134 5	<0 0629	0 604 \pm 22%	<0 155 \pm 19%	<0 16
S-5	16	1304 0	<0 0629	0 420 \pm 22%	<0 157 \pm 43%	<0 16
S-6	59	5134 5	<0 0629	0 342 \pm 25%	<0 120 \pm 16%	<0 12
S-7	57	4971 5	<0 0629	0 714 \pm 20%	<0 155 \pm 21%	<0 16
S-8	58	5053 0	<0 0420	0 640 \pm 21%	<0 135 \pm 21%	<0 14
S-9	58	5053 0	<0 0629	0 398 \pm 27%	<0 122 \pm 16%	<0 12
S-10	51	4482 5	<0 0629	0 359 \pm 24%	<0 113 \pm 19%	<0 11
S-50	51	4482.5	<0 0629	0 464 \pm 21%	<0 129 \pm 20%	<0 13
S-51	31	2771 0	<0 0629	0 331 \pm 25%	<0 126 \pm 24%	<0 13
S-52	53	8557 5	<0 0120	0 449 \pm 25%	<0 080 \pm 42%	<0 08
Summary	660	65444 5	<0 0120	0 714 \pm 20%	-	-
Volume-weighted average	-	-	-	-	<0 119 \pm 7%	<0 12

*Sampler out of service

**The Radioactivity Concentration Guide (RCG_a) value for total long-lived beta activity in ambient air accessible to incidentally exposed individuals is 100×10^{-12} $\mu\text{Ci}/\text{ml}$

Table 5 Plutonium in Two-to-Four-Mile-Distant Ambient Air
Monthly Composite Station Concentrations ($\times 10^{-15}$ $\mu\text{Ci}/\text{m}^3$)

Station	January	February	March	April	May	June
S-26	0 161	0 094	0 045	0 038	0 015	0 151
S-27	<0 029	0 266	0 134	0 020	0 045	0 064
S-28	<0 018	0 190	<0 079	0 035	0 014	0 057
S-29	<0 031	0 777	0 127	*	*	*
S-30	<0 013	<0 156	*	*	*	*
S-31	<0 045	0 087	<0 111	0 059	0 021	0 043
S-32	<0 049	0 196	0 340	<0 002	0 027	0 044
S-33	<0 022	0 184	0 051	0 025	<0 002	0 174
S-34	<0 329	0 202	0 046	0 029	0 021	0 015
S 35	0 090	<0 251	<0 236	0 020	<0 005	0 053
S 36	0 238	<0 150	0 065	0 039	0 024	0 050
S-37	<0 177	<0 359	0 211	0 018	0 013	0 141
Volume-weighted average	<0 104 \pm 87%	<0 195 \pm 99%	<0 128 \pm 72%	<0 029 \pm 54%	<0 019 \pm 65%	0 078 \pm 72%
Station	July	August	September	October	November	December
S-26	0 007	0 003	0 013	0 020	0 014	<0 003
S-27	0 010	0 003	0 004	0 010	0 012	0 007
S-28	0 017	<0 002	0 005	0 265	0 005	0 011
S-29	*	*	*	*	*	*
S-30	*	*	*	*	*	*
S-31	0 020	0 002	0 006	0 005	0 023	<0 002
S-32	0 032	*	0 005	0 007	<0 003	0 009
S-33	0 008	0 003	0 010	*	*	*
S-34	0 012	<0 002	0 007	0 219	<0 003	0 008
S-35	0 007	0 006	0 005	0 014	0 022	0 009
S-36	0 017	0 003	0 006	0 012	<0 003	<0 003
S-37	0 008	0 018	0 105	0 008	<0 003	0 007
Volume-weighted average	0 014 \pm 58%	<0 005 \pm 118%	0 017 \pm 187%	0 061 \pm 183%	<0 010 \pm 95%	<0 007 \pm 53%

*Sampler out of service

Table 5 Plutonium in Two to Four-Mile Distant Ambient Air (Continued)

Monthly Composite Station Concentrations ($\times 10^{-15}$ $\mu\text{Ci}/\text{ml}$)

January-June 1973 Summary

Station	n	Vol (m^3)	Pu (Concentrations $\times 10^{-15}$ $\mu\text{Ci}/\text{ml}$)			% of RCG _a ***
			C _{min}	C _{max}	C _{avg} **	
S-26	16	153965 5	0 015	0 161	0 073 \pm 142%	0 36
S-27	16	151273 4	0 020	0 266	<0 089 \pm 159%	<0 44
S-28	16	165765 2	0 014	0 190	<0 058 \pm 181%	<0 29
S-29	7	21025 0	<0 031	0 777	<0 145 \pm 1194%	<0 72
S-30	5	30119 0	<0 013	<0 156	<0 108 \pm 938%	<0 54
S-31	16	164043 4	0 021	<0 111	<0 061 \pm 80%	<0 30
S-32	12	156857 5	<0 002	0 340	<0 116 \pm 164%	<0 58
S-33	16	165041 4	<0 002	0 184	<0 068 \pm 188%	<0 34
S-34	16	162015 8	0 015	<0 329	<0 088 \pm 234%	<0 44
S-35	16	156249 8	<0 005	<0 251	<0 103 \pm 160%	<0 52
S-36	15	160923 7	0 024	0 238	<0 080 \pm 171%	<0 40
S-37	16	125736 8	0 013	<0 359	<0 115 \pm 200%	<0 58
Summary	167	1613021 5	<0 002	0 777	-	-
Volume-weighted average	-	-	-	-	<0 085 \pm 54%	<0 42

July-December 1973 Summary

S-26	6	152010 0	0 003	0 020	0 009 \pm 128%	0 04
S-27	6	146090 0	0 003	0 012	0 008 \pm 65%	0 04
S-28	6	170610 0	<0 002	0 265	0 042 \pm 375%	0 21
S-29	*	*	*	*	*	*
S-30	*	*	*	*	*	*
S-31	6	157830 0	<0 002	0 023	0 010 \pm 129%	0 05
S-32	5	148940 0	<0 003	0 032	0 011 \pm 200%	0 06
S-33	3	67265 0	0 003	0 010	0 007 \pm 235%	0 04
S-34	6	145070 0	<0 002	0 219	0 034 \pm 390%	0 17
S-35	6	157460 0	0 005	0 022	0 011 \pm 72%	0 06
S-36	6	165195 0	<0 003	0 017	0 007 \pm 138%	0 04
S-37	6	158550 0	<0 003	0 105	0 021 \pm 286%	0 10
Summary	56	1469020 0	<0 002	0 265	-	-
Volume-weighted average	-	-	-	-	0 017 \pm 104%	0 08

January-December 1973 Summary

S-26	22	305975 5	0 003	0 161	0 041 \pm 129%	0 20
S-27	22	297368 4	0 003	0 266	0 049 \pm 142%	0 24
S-28	22	336375 2	<0 002	0 265	<0 050 \pm 156%	0 25
S-29	7	21025 0	<0 031	0 777	<0 145 \pm 1194%	0 72
S-30	5	30119 0	<0 013	<0 156	<0 108 \pm 938%	0 54
S-31	22	321873 4	<0 002	<0 111	<0 036 \pm 87%	0 18
S-32	17	305797 5	<0 002	0 340	<0 065 \pm 157%	0 32
S-33	19	227306 4	<0 002	0 184	<0 051 \pm 158%	0 26
S-34	22	307085 8	<0 002	0 329	<0 063 \pm 165%	0 31
S-35	22	313709 8	<0 005	0 251	<0 057 \pm 142%	0 28
S-36	21	326118 7	<0 003	0 238	<0 043 \pm 157%	0 22
S 37	22	284286 8	<0 003	<0 359	<0 063 \pm 178%	0 32
Summary	223	3077041 4	<0 002	0 777	-	-
Volume-weighted average	-	-	-	-	<0 053 \pm 53%	0 26

*Sampler out of service

**Volume-weighted average

***RCG_a for soluble plutonium-239 in ambient air accessible to the population at large is 20×10^{-15} $\mu\text{Ci}/\text{ml}$

Table 6 Total Long Lived Alpha Activity in Ambient Community Air
Volume Weighted Station Averages Concentrations ($\times 10^{-15}$ $\mu\text{Ci}/\text{ml}$)

Community	January	February	March	April	May	June
Boulder	<6.1 \pm 96%	<4.8 \pm 71%	<3.5 \pm 206%	<2.4 \pm 104%	2.6 \pm 50%	2.5 \pm 110%
Broomfield	*	*	<3.0 \pm 145%	<1.8 \pm 83%	1.9 \pm 72%	2.1 \pm 52%
Coal Creek	<1.3 \pm 59%	<1.2 \pm 48%	3.1 \pm 150%	1.9 \pm 31%	2.1 \pm 44%	<1.9 \pm 163%
Denver	6.8 \pm 76%	8.9 \pm 133%	5.1 \pm 168%	2.7 \pm 55%	3.3 \pm 63%	2.7 \pm 23%
Golden	<5.4 \pm 7%	<6.8 \pm 53%	4.1 \pm 206%	<2.5 \pm 92%	2.1 \pm 28%	3.6 \pm 42%
Lafayette	<7.8 \pm 103%	<5.0 \pm 8%	3.8 \pm 251%	2.1 \pm 63%	1.7 \pm 47%	<1.5 \pm 80%
Marshall	<5.7 \pm 2%	<5.6 \pm 3%	<3.7 \pm 162%	1.9 \pm 44%	1.9 \pm 40%	2.2 \pm 87%
Wagner	<4.5 \pm 233%	<3.7 \pm 0%	3.8 \pm 532%	1.5 \pm 60%	2.1 \pm 62%	2.2 \pm 15%
Westminster	<8.9 \pm 47%	<10.2 \pm 38%	3.8 \pm 213%	3.0 \pm 66%	2.2 \pm 62%	1.7 \pm 108%
Volume weighted average	<3.9 \pm 45%	<3.6 \pm 53%	<3.7 \pm 49%	<2.2 \pm 17%	2.2 \pm 12%	<2.3 \pm 17%

January-June 1973 Summary

Community	n	Vol (m^3)	Concentration ($\times 10^{-15}$ $\mu\text{Ci}/\text{ml}$)			% of RCG _a **
			C _{min}	C _{max}	C _{avg}	
Boulder	26	9990.7	<0.7	14.5 \pm 39%	<3.0 \pm 48%	<15.0
Broomfield	16	9193.9	<1.0	6.5 \pm 75%	<2.1 \pm 41%	<10.5
Coal Creek	26	13415.2	<0.8	6.6 \pm 37%	<1.8 \pm 33%	<9.0
Denver	23	10083.5	<1.6	14.0 \pm 49%	3.5 \pm 52%	17.5
Golden	26	9833.5	<0.7	11.3 \pm 34%	<3.1 \pm 43%	<15.5
Lafayette	26	9605.5	<0.7	19.4 \pm 39%	<2.5 \pm 77%	<12.5
Marshall	26	7339.5	<1.3	7.3 \pm 42%	<2.6 \pm 46%	<13.0
Wagner	20	8045.1	<0.8	22.6 \pm 34%	<2.3 \pm 107%	<11.5
Westminster	25	8441.3	<0.9	13.3 \pm 65%	<2.8 \pm 77%	<14.0
Summary	214	85948.2	<0.7	22.6 \pm 34%	-	-
Volume-weighted average	-	-	-	-	<2.6 \pm 20%	<13.0

*Sampler out of service

**The RCG_a for soluble plutonium-239 in ambient air accessible to the population at large is 20×10^{-15} $\mu\text{Ci}/\text{ml}$

Table 7 Plutonium in Ambient Community Air
 Monthly Composite Station Concentrations ($\times 10^{-15}$ $\mu\text{Ci/ml}$)

Community	July	August	September	October	November	December
Boulder	<0 020	0 018	0 064	<0 015	<0 015	0 035
Broomfield	<0 015	<0 015	<0 015	<0 020	0 017	0 033
Coal Creek	<0 020	<0 015	0 028	0 116	0 044	0 067
Denver	<0 020	*	<0 015	<0 020	<0 015	0 037
Golden	10 782	<0 015	0 017	<0 015	<0 020	<0 015
Lafayette	<0 020	<0 015	0 487	0 026	0 055	0 026
Marshall	<0 050	0 035	0 033	0 029	<0 030	0 068
Wagner	<0 030	0 033	0 055	<0 030	<0 020	<0 015
Westminster	<0 020	0 146	*	*	*	<0 030
Volume weighted average	<1 328 \pm 206%	<0 023 \pm 181%	<0 093 \pm 144%	<0 032 \pm 89%	<0 027 \pm 46%	<0 035 \pm 45%

July December 1973 Summary

Community	n	Vol (m^3)	Concentration ($\times 10^{-15}$ $\mu\text{Ci/ml}$)			% of RCG _a ***
			C _{min}	C _{max}	C _{avg} **	
Boulder	6	18095 0	<0 015	0 064	<0 028 \pm 73%	<0 14
Broomfield	6	17919 0	<0 015	0 033	<0 019 \pm 42%	<0 10
Coal Creek	6	15453 0	<0 015	0 116	<0 045 \pm 93%	<0 22
Denver	5	13207 0	<0 015	0 037	<0 021 \pm 53%	<0 10
Golden	6	16647 0	<0 015	10 782	<1 717 \pm 270%	<8 6
Lafayette	6	16611 0	<0 015	0 487	<0 103 \pm 192%	<0 52
Marshall	6	10660 0	<0 029	0 068	<0 040 \pm 42%	<0 20
Wagner	6	12303 0	<0 015	0 055	<0 030 \pm 51%	<0 20
Westminster	3	4625 0	<0 020	0 146	<0 040 \pm 527%	<0 20
Summary	50	125520 0	<0 015	10 782	—	—
Volume-weighted average	—	—	—	—	<0 264 \pm 163%	<1 3

*Sampler out of service

**Volume-weighted average

***The RCG_a for soluble plutonium-239 in ambient air accessible to the population at large is 20×10^{-15} $\mu\text{Ci/ml}$

Table 8 Total Long-Lived Beta Activity in Ambient Community Air
 Volume Weighted Station Averages Concentrations ($\times 10^{-12}$ $\mu\text{Ci}/\text{ml}$)

Community	January	February	March	April	May	June
Boulder	<0 061 \pm 57%	<0 109 \pm 118%	<0 032 \pm 139%	<0 025 \pm 69%	0 028 \pm 93%	<0 027 \pm 145%
Broomfield	*	*	0 043 \pm 165%	<0 021 \pm 121%	0 023 \pm 120%	<0 021 \pm 87%
Coal Creek	<0 024 \pm 91%	<0 017 \pm 148%	<0 028 \pm 141%	<0 037 \pm 88%	0 030 \pm 79%	<0 020 \pm 73%
Denver	<0 046 \pm 113%	<0 051 \pm 114%	<0 049 \pm 577%	0 023 \pm 57%	0 032 \pm 26%	0 026 \pm 54%
Golden	<0 094 \pm 64%	<0 154 \pm 170%	<0 053 \pm 193%	<0 019 \pm 120%	0 027 \pm 40%	<0 030 \pm 111%
Lafayette	<0 073 \pm 40%	<0 128 \pm 119%	<0 030 \pm 145%	<0 033 \pm 52%	0 029 \pm 114%	<0 012 \pm 36%
Marshall	<0 118 \pm 83%	0 114 \pm 72%	<0 044 \pm 194%	<0 029 \pm 94%	<0 022 \pm 66%	<0 024 \pm 221%
Wagner	<0 042 \pm 15%	<0 042 \pm 0%	0 034 \pm 263%	<0 025 \pm 174%	<0 028 \pm 174%	0 033 \pm 42%
Westminster	<0 110 \pm 79%	<0 293 \pm 179%	<0 035 \pm 151%	0 029 \pm 87%	0 026 \pm 52%	<0 028 \pm 148%
Volume weighted average	<0 051 \pm 47%	<0 067 \pm 86%	<0 038 \pm 58%	<0 026 \pm 22%	<0 027 \pm 18%	<0 024 \pm 25%

Community	July	August	September	October	November	December
Boulder	0 086 \pm 224%	0 051 \pm 56%	0 035 \pm 91%	<0 028 \pm 101%	0 036 \pm 55%	0 025 \pm 90%
Broomfield	0 059 \pm 42%	0 041 \pm 63%	0 048 \pm 83%	0 040 \pm 38%	0 034 \pm 61%	<0 026 \pm 101%
Coal Creek	0 081 \pm 100%	0 049 \pm 68%	<0 017 \pm 117%	0 056 \pm 31%	0 026 \pm 53%	<0 030 \pm 136%
Denver	0 054 \pm 147%	0 056 \pm 68%	<0 038 \pm 167%	<0 042 \pm 95%	<0 028 \pm 70%	<0 018 \pm 87%
Golden	0 037 \pm 64%	0 046 \pm 20%	0 060 \pm 118%	0 048 \pm 56%	0 024 \pm 62%	0 043 \pm 53%
Lafayette	<0 045 \pm 142%	0 048 \pm 52%	<0 029 \pm 201%	<0 041 \pm 93%	<0 022 \pm 53%	<0 026 \pm 132%
Marshall	0 126 \pm 194%	0 064 \pm 50%	<0 036 \pm 71%	<0 049 \pm 181%	<0 030 \pm 76%	<0 021 \pm 46%
Wagner	0 084 \pm 50%	<0 048 \pm 60%	<0 048 \pm 92%	<0 062 \pm 92%	<0 032 \pm 57%	<0 032 \pm 104%
Westminster	0 065 \pm 34%	0 022 \pm 0%	*	*	*	<0 023 \pm 212%
Volume-weighted average	<0 066 \pm 37%	<0 049 \pm 15%	<0 039 \pm 26%	<0 044 \pm 23%	<0 029 \pm 16%	<0 027 \pm 19%

*Sampler out of service

Table 8 Total Long Lived Beta Activity in Ambient Community Air (Continued)

Volume Weighted Station Averages Concentrations ($\times 10^{-12}$ $\mu\text{Ci}/\text{ml}$)

Community	n	Vol (m^3)	Concentration ($\times 10^{-12}$ $\mu\text{Ci}/\text{ml}$)			% of RCG_a^*
			C_{min}	C_{max}	C_{avg}	
January-June 1973 Summary						
Boulder	26	9990 7	<0 0095	0 211 \pm 26%	<0 033 \pm 63%	<0 1
Broomfield	16	9193 9	<0 0079	0 089 \pm 51%	<0 025 \pm 57%	<0 1
Coal Creek	26	13415 2	<0 0090	0 075 \pm 24%	<0 026 \pm 30%	<0 1
Denver	23	10083 5	<0 0111	0 324 \pm 26%	<0 031 \pm 98%	<0 1
Golden	26	9833 5	<0 0079	0 399 \pm 22%	<0 036 \pm 101%	<0 1
Lafayette	26	9605 5	<0 0094	0 259 \pm 27%	<0 032 \pm 80%	<0 1
Marshall	26	7339 5	<0 0094	0 244 \pm 30%	<0 037 \pm 77%	<0 1
Wagner	20	8045 1	<0 0064	0 114 \pm 38%	<0 030 \pm 50%	<0 1
Westminster	25	8441 3	<0 0068	0 523 \pm 26%	<0 036 \pm 146%	<0 1
Summary	214	85948 2	<0 0064	0 523 \pm 26%	—	—
Volume weighted average	—	—	—	—	<0 031 \pm 30%	<0 1
July-December 1973 Summary						
Boulder	26	18843 4	<0 0089	0 265 \pm 16%	<0 042 \pm 49%	<0 1
Broomfield	26	18639 4	<0 0106	0 074 \pm 20%	<0 042 \pm 18%	<0 1
Coal Creek	25	15496 5	<0 0106	0 154 \pm 17%	<0 042 \pm 32%	<0 1
Denver	26	17140 2	<0 0091	0 125 \pm 19%	<0 039 \pm 32%	<0 1
Golden	26	17290 0	<0 0096	0 123 \pm 16%	0 042 \pm 21%	<0 1
Lafayette	26	17208 6	<0 0091	0 103 \pm 19%	<0 035 \pm 31%	<0 1
Marshall	26	10973 2	<0 0091	0 330 \pm 19%	<0 050 \pm 59%	<0 2
Wagner	26	12854 4	<0 0125	0 123 \pm 21%	<0 049 \pm 25%	<0 1
Westminster	7	4421 6	<0 0146	0 079 \pm 20%	<0 047 \pm 48%	<0 1
Summary	214	132867 3	<0 0089	0 330 \pm 19%	—	—
Volume-weighted average	—	—	—	—	<0 042 \pm 12%	<0 1
January-December 1973 Summary						
Boulder	52	28834 1	<0 0089	0 265 \pm 16%	<0 039 \pm 36%	<0 1
Broomfield	42	27833 3	<0 0079	0 089 \pm 51%	<0 036 \pm 19%	<0 1
Coal Creek	51	28911 7	<0 0090	0 154 \pm 17%	<0 035 \pm 22%	<0 1
Denver	49	27223 7	<0 0091	0 324 \pm 26%	<0 036 \pm 41%	<0 1
Golden	52	27123 5	<0 0079	0 399 \pm 22%	<0 040 \pm 45%	<0 1
Lafayette	52	26814 1	<0 0091	0 259 \pm 27%	<0 034 \pm 39%	<0 1
Marshall	52	18312 7	<0 0091	0 330 \pm 19%	<0 045 \pm 44%	<0 1
Wagner	46	20899 5	<0 0064	0 123 \pm 21%	<0 041 \pm 22%	<0 1
Westminster	32	12862 9	<0 0068	0 523 \pm 26%	<0 040 \pm 100%	<0 1
Summary	428	218815 5	<0 0064	0 523 \pm 26%	—	—
Volume-weighted average	—	—	—	—	<0 038 \pm 14%	<0 1

*The RCG_a for total long-lived beta activity in ambient air accessible to the population at large is 33×10^{-12} $\mu\text{Ci}/\text{ml}$

Table 9 Annual Average Concentrations of Nonradioactive Constituents of Sewage Plant Effluent

Parameter	Average	Most Restrictive Standard	Agency*	% of Standard
pH	7.5	6.0 to 9.0	CDH	In range
Fecal Coliform Count	168/100 ml	200/100 ml**	USEPA	84
Dissolved Oxygen	7.7 mg/l	>2.0 mg/l	CDH	In range
Residual Chlorine	1.4 mg/l	0.1 <(C1) <0.5 mg/l**	CDH	280
Suspended Solids	20.4 mg/l	30 mg/l	CDH	68
Settleable Solids	1.2 ml/l	0.5 ml/l	CDH	240
BOD ₅	26.8 mg/l	30 mg/l	CDH	89
Turbidity	32 JTU	30 JTU	CDH	106
Color	24 Units	30 Units	CDH	80

*CDH - Colorado Department of Health, Water Pollution Control Commission,

USEPA - U.S. Environmental Protection Agency

**The USEPA and CDH standards for fecal coliform count and residual chlorine concentration are in conflict because 0.5 mg/l residual chlorine has been determined as inadequate to reduce the fecal coliform count in Rocky Flats sewage plant effluent to the USEPA limitation value

Table 10 Uranium + Plutonium and Plutonium in Pond A-3 Water Samples

Sample Period	n	U + Pu (Concentration × 10 ⁻⁹ μCi/ml)			Pu (Concentration × 10 ⁻⁹ μCi/ml)		
		C _{min}	C _{max}	C _{avg} *	C _{min}	C _{max}	C _{avg} *
January	4	7.08	17.17	11.68 ± 51%	<0.01	1.34	<0.38 ± 238%
February	4	4.71	13.63	9.41 ± 64%	0.06	0.24	0.14 ± 89%
March	5	3.61	5.58	4.84 ± 18%	0.08	0.16	0.11 ± 31%
April	4	0.90	11.14	4.58 ± 140%	0.10	0.51	0.23 ± 115%
May	3	0.42	18.36	7.71 ± 225%	0.12	0.32	0.25 ± 81%
June	5	1.84	13.66	5.52 ± 102%	0.03	0.51	0.37 ± 62%
6-mo Summary	25	0.42	18.36	-	<0.01	1.34	-
6-mo Average*	-	-	-	7.10 ± 29%	-	-	<0.24 ± 48%
July	4	1.41	10.70	3.86 ± 164%	0.10	0.32	0.21 ± 73%
August	5	2.39	12.99	5.96 ± 80%	0.03	0.64	0.31 ± 111%
September	4	1.61	2.70	2.22 ± 29%	0.15	0.61	0.36 ± 89%
October	4	0.85	1.67	1.21 ± 43%	0.06	0.32	0.15 ± 111%
November	5	1.66	4.83	2.63 ± 56%	0.05	2.35	0.70 ± 156%
December	4	0.44	2.55	1.46 ± 99%	0.02	0.45	0.22 ± 120%
6-mo Summary	26	0.44	12.99	-	0.02	2.35	-
6-mo Average*	-	-	-	3.00 ± 39%	-	-	0.34 ± 55%
Annual Summary	51	0.42	18.36	-	<0.01	2.35	-
Annual Average*	-	-	-	5.01 ± 26%	-	-	<0.29 ± 37%
% of RCG _w **	-	-	-	0.31%	-	-	<0.15%

*Sample-weighted average

**RCG_w for soluble U + Pu is given by $\frac{C_U}{RCG_w} + \frac{C_{Pu}}{RCG_{Pu}} < 1$ where RCG_U = 10,000 × 10⁻⁹ μCi/ml and RCG_{Pu} = 1600 × 10⁻⁹ μCi/ml

RCG_w for soluble plutonium-239 is 1600 × 10⁻⁹ μCi/ml

Table 11 Uranium + Plutonium and Plutonium in Pond B-4 Water Samples

Sample Period	n	Vol (X 10 ⁶ liters)	U + Pu (Concentration × 10 ⁻⁹ μCi/ml)			Release (mCi)	Pu (Concentration × 10 ⁻⁹ μCi/ml)			Release (mCi)
			C _{min}	C _{max}	C _{avg} *		C _{min}	C _{max}	C _{avg} *	
January	4	27.3	23.05	53.27	38.68 ± 57%	1.06	12.96	45.27	25.67 ± 84%	0.70
February	4	22.2	32.94	81.48	65.42 ± 47%	1.45	7.75	57.67	35.98 ± 84%	0.80
March	5	29.6	14.26	45.61	24.91 ± 56%	0.74	6.83	26.18	12.19 ± 80%	0.36
April	4	69.7	4.90	20.37	12.15 ± 73%	0.85	1.24	12.39	4.56 ± 161%	0.32
May	3	243.0	0.93	16.87	10.88 ± 146%	2.64	0.18	3.59	1.86 ± 169%	0.45
June	5	36.7	15.06	90.19	35.24 ± 101%	1.29	5.61	24.17	16.09 ± 54%	0.59
6-mo Summary	25	428.5	0.93	90.19	—	8.03	0.18	57.67	—	3.22
6-mo Average*	—	—	—	—	18.74 ± 55%	—	—	—	7.52 ± 86%	—
July	4	22.0	9.72	24.03	16.56 ± 49%	0.36	7.83	22.37	15.31 ± 54%	0.34
August	5	10.6	9.64	13.76	11.22 ± 16%	0.12	6.79	11.62	9.27 ± 27%	0.10
September	4	23.0	4.35	9.48	6.39 ± 52%	0.15	3.56	6.53	5.06 ± 40%	0.12
October	4	20.0	4.23	7.89	5.37 ± 44%	0.11	2.08	6.93	3.88 ± 76%	0.08
November	5	12.0	3.40	7.04	5.62 ± 30%	0.07	2.57	4.66	3.35 ± 29%	0.04
December	4	26.0	3.84	8.31	5.92 ± 44%	0.15	2.98	6.35	4.05 ± 53%	0.10
6-mo Summary	26	113.6	3.40	24.03	—	0.96	2.08	22.37	—	0.78
6-mo Average*	—	—	—	—	8.43 ± 23%	—	—	—	6.81 ± 29%	—
Annual Summary	51	542.1	3.40	90.19	—	8.99	0.18	57.67	—	4.00
Annual Average*	—	—	—	—	16.58 ± 36%	—	—	—	7.37 ± 47%	—
% of RCG _w **	—	—	—	—	0.55%	—	—	—	0.46%	—

*Volume-weighted average

**RCG_w for soluble U + Pu is given by $\frac{C_U}{RCG_U} + \frac{C_{Pu}}{RCG_{Pu}} < 1$ where RCG_U = 10,000 × 10⁻⁹ μCi/ml and RCG_{Pu} = 1600 × 10⁻⁹ μCi/ml

RCG_w for soluble plutonium-239 is 1600 × 10⁻⁹ μCi/ml

Table 12 Uranium + Plutonium and Plutonium in Pond C-1 Water Samples

Sample Period	n	U + Pu (Concentration $\times 10^{-9}$ $\mu\text{Ci/ml}$)			Pu (Concentration $\times 10^{-9}$ $\mu\text{Ci/ml}$)		
		C _{min}	C _{max}	C _{avg} *	C _{min}	C _{max}	C _{avg} *
January	4	1.26	11.90	5.16 \pm 128%	<0.01	1.67	<0.56 \pm 194%
February	4	1.78	11.57	5.69 \pm 108%	<0.01	0.12	<0.05 \pm 139%
March	5	1.09	3.21	2.16 \pm 49%	0.02	0.06	0.04 \pm 57%
April	4	0.87	1.99	1.50 \pm 52%	0.04	0.20	0.11 \pm 88%
May	4	<0.01	7.30	<2.39 \pm 193%	<0.01	0.09	<0.05 \pm 111%
June	5	0.32	2.45	0.93 \pm 109%	0.02	0.54	0.23 \pm 100%
6-mo Summary	26	<0.01	11.90	-	<0.01	1.67	-
6 mo Average*	-	-	-	<2.86 \pm 45%	-	-	<0.17 \pm 81%
July	4	0.25	0.92	0.59 \pm 64%	0.05	0.07	0.06 \pm 23%
August	5	0.52	3.83	1.49 \pm 103%	0.04	0.41	0.23 \pm 109%
September	4	0.69	2.02	1.15 \pm 74%	0.09	0.13	0.11 \pm 25%
October	4	0.41	2.81	1.23 \pm 122%	0.06	0.22	0.11 \pm 101%
November	5	0.62	1.21	0.87 \pm 32%	0.04	0.52	0.30 \pm 80%
December	4	0.67	1.57	0.96 \pm 61%	0.03	0.61	0.31 \pm 148%
6-mo Summary	26	0.25	3.83	-	0.03	0.61	-
6-mo Average*	-	-	-	1.06 \pm 29%	-	-	0.19 \pm 40%
Annual Summary	52	<0.01	11.90	-	<0.01	1.67	-
Annual Average*	-	-	-	1.96 \pm 35%	-	-	<0.18 \pm 42%
% of RCG _w **	-	-	-	0.03%	-	-	<0.01%

*Sample-weighted average

**RCG_w for soluble U + Pu is given by $\frac{C_U}{RCG_U} + \frac{C_{Pu}}{RCG_{Pu}} < 1$ where RCG_U = 10,000 $\times 10^{-9}$ $\mu\text{Ci/ml}$ and RCG_{Pu} = 1600 $\times 10^{-9}$ $\mu\text{Ci/ml}$
 RCG_w for soluble plutonium-239 is 1600 $\times 10^{-9}$ $\mu\text{Ci/ml}$

Table 13 Americium-241 in Water Samples.*

Location	n	Concentration $\times 10^{-9}$ $\mu\text{Ci/ml}$			% of RCG _w ***
		C _{min}	C _{max}	C _{avg} **	
Pond B-4	19	<0.01	16.86	<1.79 \pm 122%	<0.14
Walnut Creek at Indiana Street	20	<0.01	8.96	<1.31 \pm 81%	<0.10
Great Western Reservoir	5	<0.01	0.45	<0.16 \pm 148%	<0.01
Standley Lake	5	<0.01	0.78	<0.20 \pm 185%	<0.02

*Analysis of water samples for americium-241 was discontinued in July 1973 because of poor americium recovery in the analytical procedure. An improved procedure was developed and put into use in January 1974.

**The average for Pond B-4 is volume-weighted, all others are sample-weighted.

***RCG_w for americium-241 is 1300 $\times 10^{-9}$ $\mu\text{Ci/ml}$

Table 14 Uranium + Plutonium and Plutonium in Walnut Creek

Sample Period	n	U + Pu (Concentration $\times 10^{-9}$ $\mu\text{Ci/ml}$)			Pu (Concentration $\times 10^{-9}$ $\mu\text{Ci/ml}$)		
		C_{\min}	C_{\max}	C_{avg}^*	C_{\min}	C_{\max}	C_{avg}^*
January	4	9.98	36.02	22.00 \pm 74%	3.34	21.18	11.79 \pm 102%
February	4	15.74	33.71	25.38 \pm 41%	5.08	14.69	10.57 \pm 53%
March	5	6.30	17.05	10.96 \pm 54%	1.56	8.21	3.35 \pm 95%
April	4	3.21	7.69	5.21 \pm 56%	0.30	5.44	1.85 \pm 183%
May	4	3.23	166.36**	51.55 \pm 209%	0.09	1.01	0.63 \pm 97%
June	5	2.20	16.92	7.93 \pm 99%	0.78	10.21**	3.03 \pm 153%
6-mo Summary	26	2.20	166.36**	—	0.09	21.18	—
6-mo Average*	—	—	—	19.65 \pm 65%	—	—	5.05 \pm 46%
July	4	1.34	3.60	2.84 \pm 50%	1.09	2.30	1.56 \pm 49%
August	5	0.73	2.62	1.65 \pm 48%	0.30	0.84	0.52 \pm 51%
September	3	0.98	4.28	2.34 \pm 136%	0.46	3.62	1.64 \pm 194%
October	4	1.68	6.41	3.01 \pm 105%	0.26	0.88	0.60 \pm 60%
November	5	1.54	3.26	2.19 \pm 35%	0.59	1.39	0.78 \pm 61%
December	3	2.78	4.21	3.56 \pm 37%	0.39	3.01	1.39 \pm 188%
6-mo Summary	24	0.73	6.41	—	0.26	3.62	—
6-mo Average*	—	—	—	2.51 \pm 22%	—	—	1.01 \pm 35%
Annual Summary	50	0.73	166.36**	—	0.09	21.18	—
Annual Average*	—	—	—	11.43 \pm 60%	—	—	3.11 \pm 43%
% of RCG_w ***	—	—	—	0.27%	—	—	0.19%

*Sample-weighted average

**Suspect data The values as shown are included in the computation of averages

*** RCG_w for soluble U + Pu is given by $\frac{C_U}{\text{RCG}_U} + \frac{C_{\text{Pu}}}{\text{RCG}_{\text{Pu}}} < 1$ where $\text{RCG}_U = 10,000 \times 10^{-9} \mu\text{Ci/ml}$ and $\text{RCG}_{\text{Pu}} = 1600 \times 10^{-9} \mu\text{Ci/ml}$ RCG_w for soluble plutonium-239 is $1600 \times 10^{-9} \mu\text{Ci/ml}$

Table 15 Uranium + Plutonium and Plutonium in Public Water Supplies Annual Average* Concentrations ($\times 10^{-9}$ $\mu\text{Ci/ml}$)

Reservoirs	n	U + Pu				Pu			
		C_{\min}	C_{\max}	C_{avg}^*	% of RCG _w **	C_{\min}	C_{\max}	C_{avg}^*	% of RCG _w **
Great Western	15	0.26	9.38	3.00 \pm 49%	0.03	<0.01	0.31	<0.08 \pm 59%	<0.005
Standley Lake	14	0.13	9.33	3.63 \pm 48%	0.04	<0.01	0.17	<0.04 \pm 69%	<0.002
Finished Water									
Arvada	15	0.04	23.60	3.64 \pm 93%	0.04	<0.01	0.20	<0.03 \pm 93%	<0.002
Boulder	15	<0.01	2.55	< 0.68 \pm 70%	<0.01	<0.01	0.57	<0.09 \pm 98%	<0.006
Broomfield	14	0.09	13.23	2.73 \pm 84%	0.03	<0.01	0.49	<0.11 \pm 74%	<0.007
Denver	15	0.09	9.75	2.88 \pm 57%	0.03	<0.01	0.55	<0.08 \pm 114%	<0.005
Golden	15	0.11	14.06	3.01 \pm 70%	0.03	<0.01	0.12	<0.02 \pm 79%	<0.001
Lafayette	15	0.02	3.85	0.95 \pm 69%	0.02	<0.01	0.85	<0.11 \pm 105%	<0.007
Louisville	15	<0.01	2.14	< 0.44 \pm 75%	<0.01	<0.01	0.29	<0.05 \pm 90%	<0.003
Thornton	13	0.11	113.12	21.74 \pm 91%	0.22	<0.01	0.70	<0.12 \pm 105%	<0.008
Westminster	15	0.08	5.35	1.02 \pm 76%	0.01	<0.01	0.32	<0.04 \pm 108%	<0.002
Reservoir Summary	29	0.13	9.38	-	-	<0.01	0.31	-	-
Reservoir Average*	-	-	-	< 3.31 \pm 32%	<0.03	-	-	<0.06 \pm 45%	<0.004
Finished Water Summary	132	<0.01	113.12	-	-	<0.01	0.85	-	-
Finished Water Average*	-	-	-	< 3.87 \pm 54%	<0.04	-	-	<0.07 \pm 34%	<0.004

*Sample weighted average

**RCG_w for soluble U + Pu is given by $\frac{C_U}{RCG_U} + \frac{C_{Pu}}{RCG_{Pu}} < 1$ where RCG_U = 10,000 $\times 10^{-9}$ $\mu\text{Ci/ml}$ and RCG_{Pu} = 1600 $\times 10^{-9}$ $\mu\text{Ci/ml}$

RCG_w for soluble plutonium-239 is 1600 $\times 10^{-9}$ $\mu\text{Ci/ml}$ Table 16 Uranium + Plutonium and Plutonium in Regional Lakes, Reservoirs, and Streams September 1973 Average* Concentrations ($\times 10^{-9}$ $\mu\text{Ci/ml}$)

Distance From Rocky Flats Plant	n	U + Pu				Pu			
		C_{\min}	C_{\max}	C_{avg}^*	% of RCG _w **	C_{\min}	C_{\max}	C_{avg}^*	% of RCG _w **
Less than 5 miles	14	0.03	2.50	0.71 \pm 68%	0.03	<0.01	2.08	<0.38 \pm 96 %	<0.02
Greater than 5 miles	16	0.04	10.04	2.81 \pm 57%	0.04	<0.01	2.40	<0.25 \pm 137 %	<0.02
Summary of all samples	30	0.03	10.04	-	-	<0.01	2.40	-	-
Average of all samples*	-	-	-	1.82 \pm 51%	0.03	-	-	<0.31 \pm 0.76%	<0.02

*Sample weighted average

**RCG_w for soluble U + Pu is given by $\frac{C_U}{RCG_U} + \frac{C_{Pu}}{RCG_{Pu}} < 1$ where RCG_U = 10,000 $\times 10^{-9}$ $\mu\text{Ci/ml}$ and RCG_{Pu} = 1600 $\times 10^{-9}$ $\mu\text{Ci/ml}$

RCG_w for soluble plutonium 239 is 1600 $\times 10^{-9}$ $\mu\text{Ci/ml}$

Table 17 Tritium in Water Samples *

Station	n	Tritium (Concentrations $\times 10^{-6}$ $\mu\text{Ci/ml}$)			% of RCG _w ***
		C_{\min}	C_{\max}	C_{avg}^{**}	
Pond A-3	65	0.913	6.709	2.885 \pm 9%	0.29
Pond B-4	58	<0.500	5.733	<2.664 \pm 10%	<0.27
Pond C 1	72	<0.500	5.994	<1.409 \pm 19%	<0.14
Walnut Creek at Indiana Street	57	1.020	17.280	6.698 \pm 12%	0.67
Great Western Reservoir	10	6.713	9.888	8.221 \pm 9%	0.82

*Samples collected during October-December 1973

**Sample-weighted average

***RCG_w for tritium in water released to uncontrolled areas is 1000 $\times 10^{-6}$ $\mu\text{Ci/ml}$

FIGURES 1 through 9

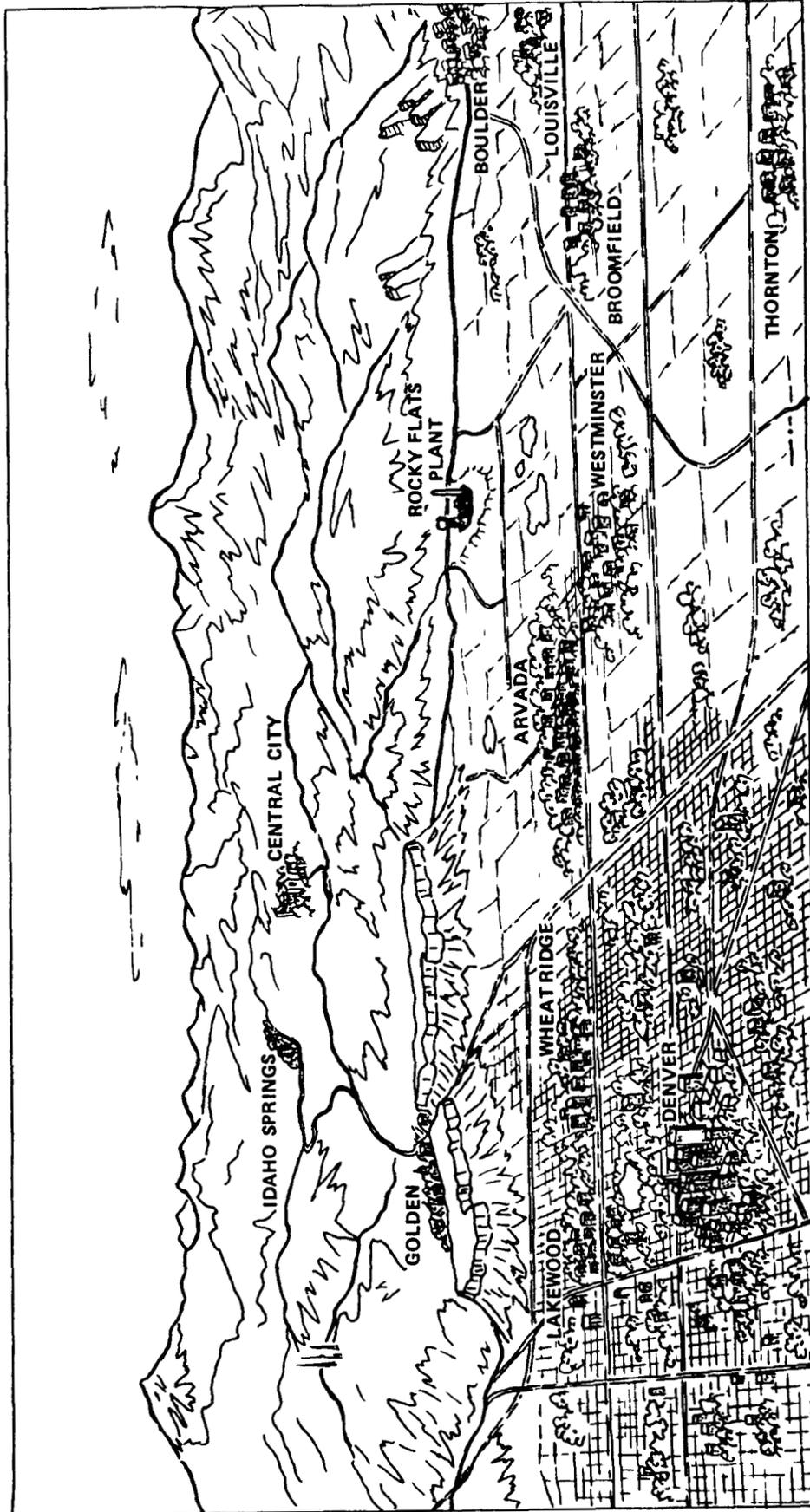


Figure 1 Location of the Rocky Flats Plant and Surrounding Communities

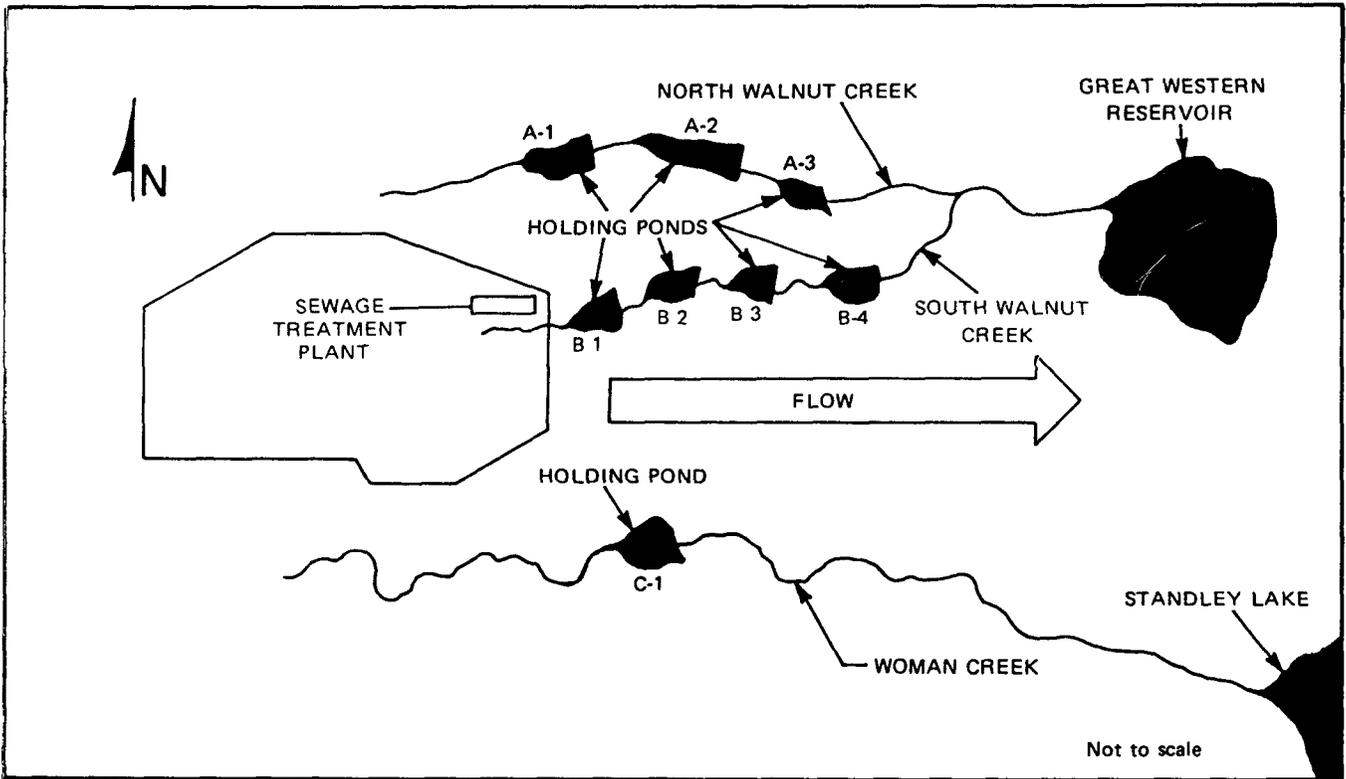


Figure 2 Liquid Effluent Water Courses

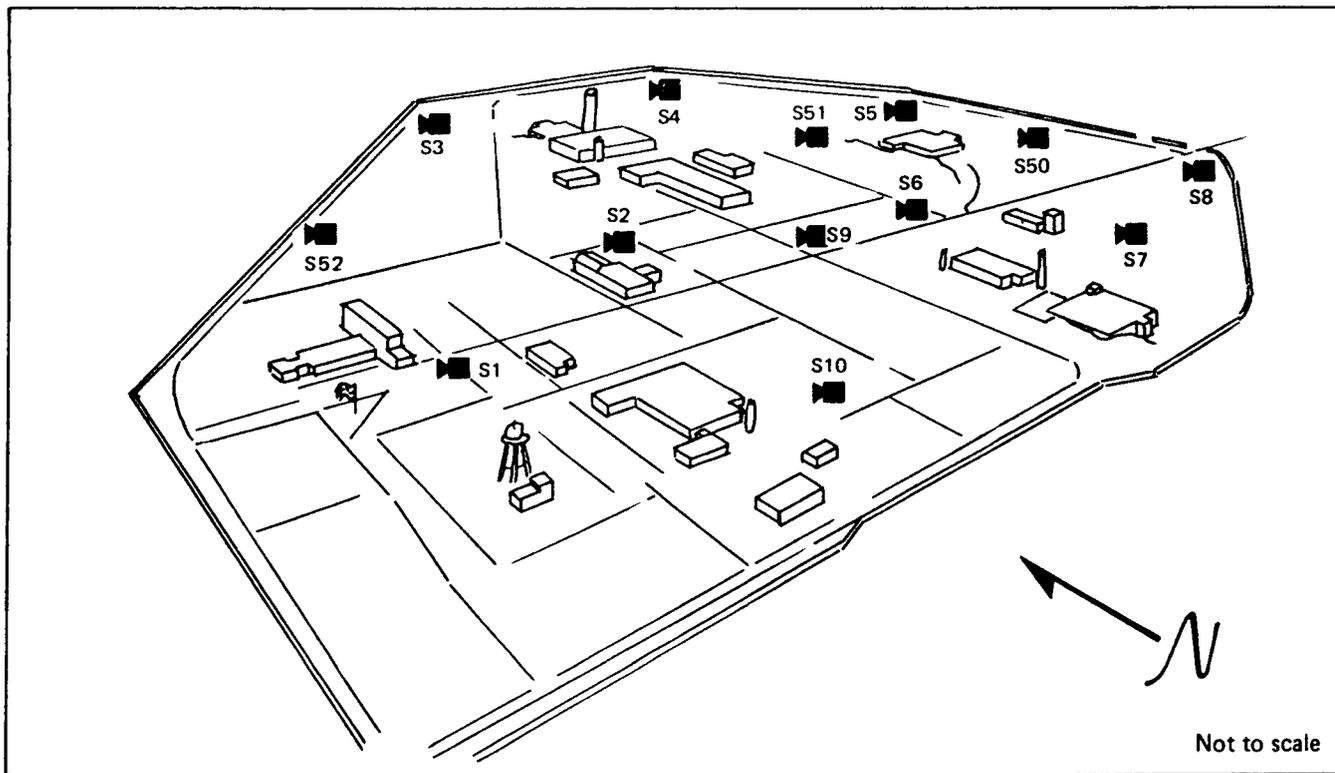
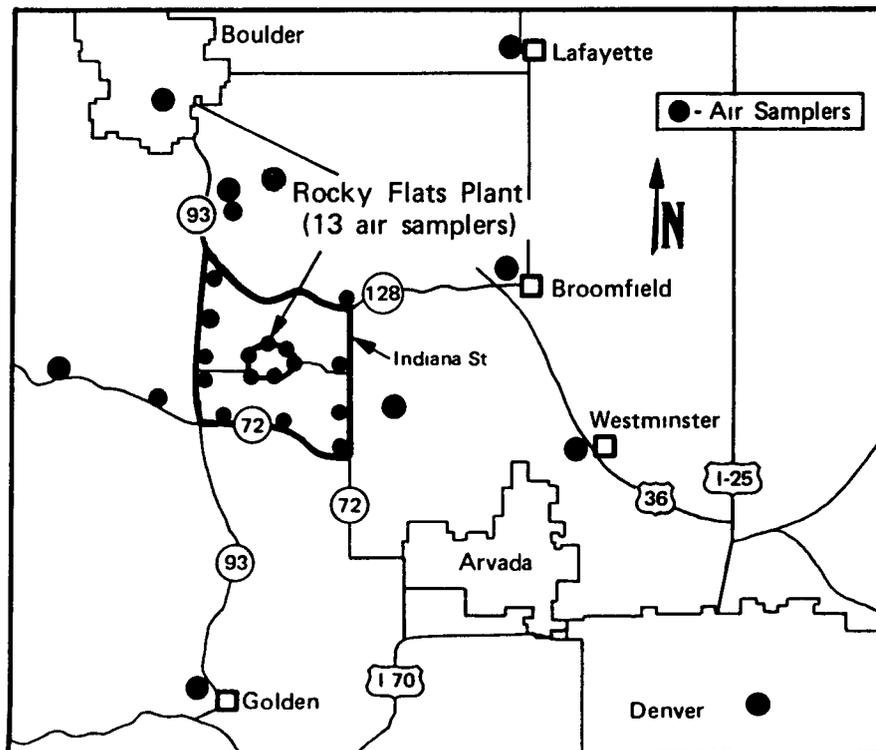


Figure 3 On-Site Air Sampling Stations

Figure 4 Off-Site Air Sampling Stations The larger dots represent community samplers



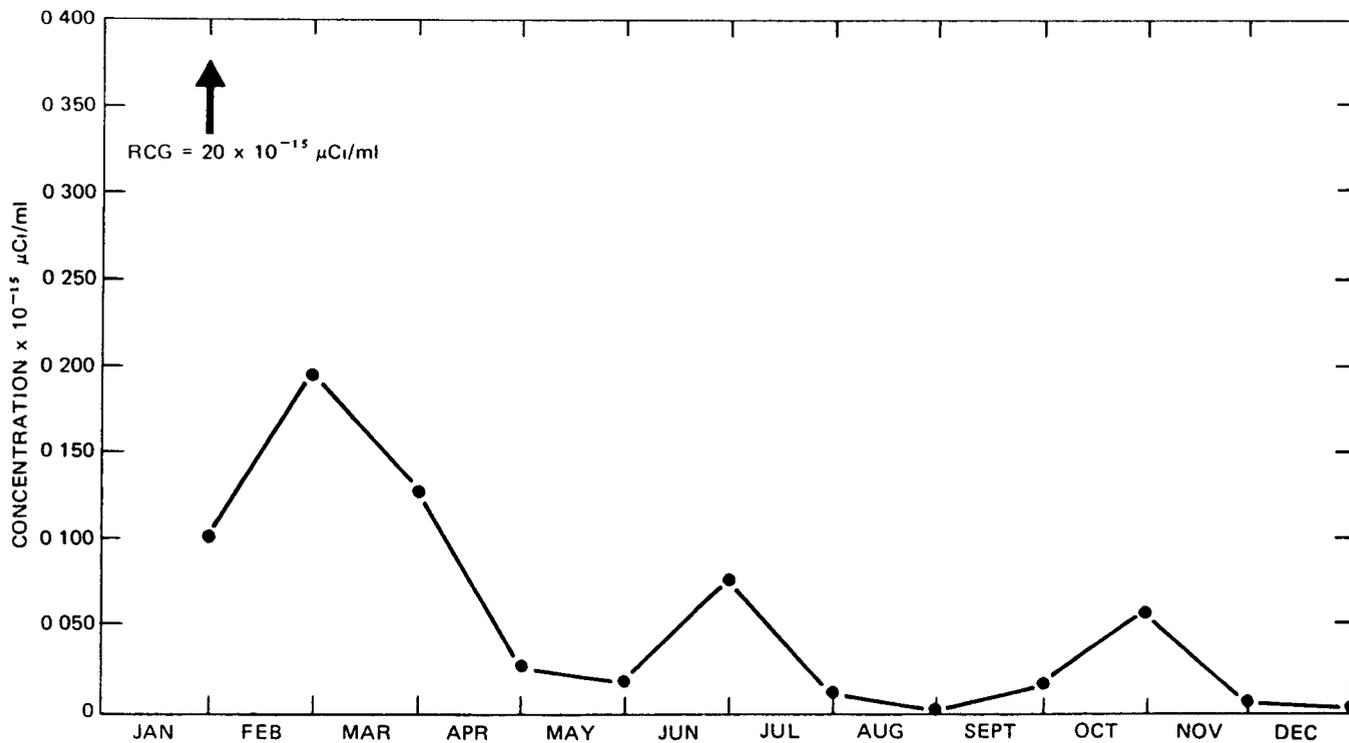
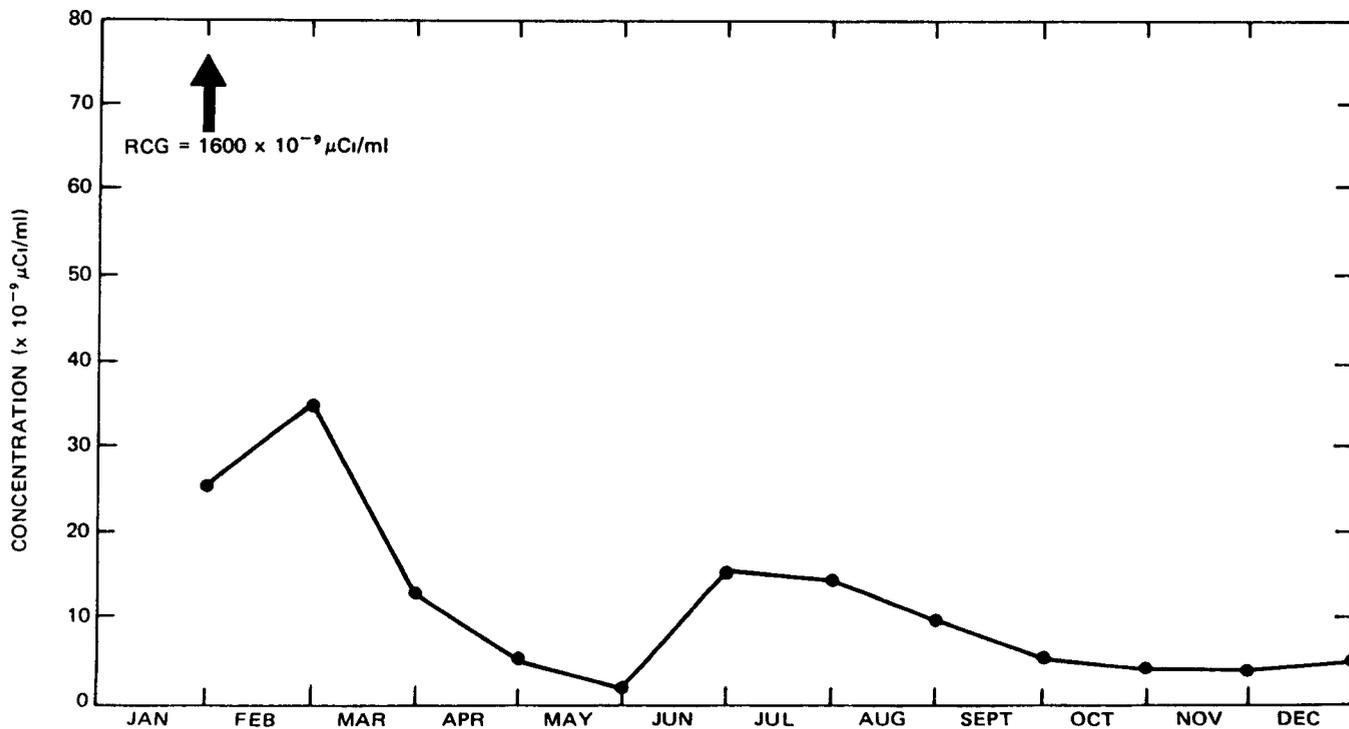


Figure 5 Plutonium 239 in 2 to 4-Mile Distant Ambient Air
(Volume Weighted Monthly Average Concentrations)

Figure 6 Plutonium-239 in Pond B-4 Water Samples
(Volume Weighted Monthly Average Concentrations)



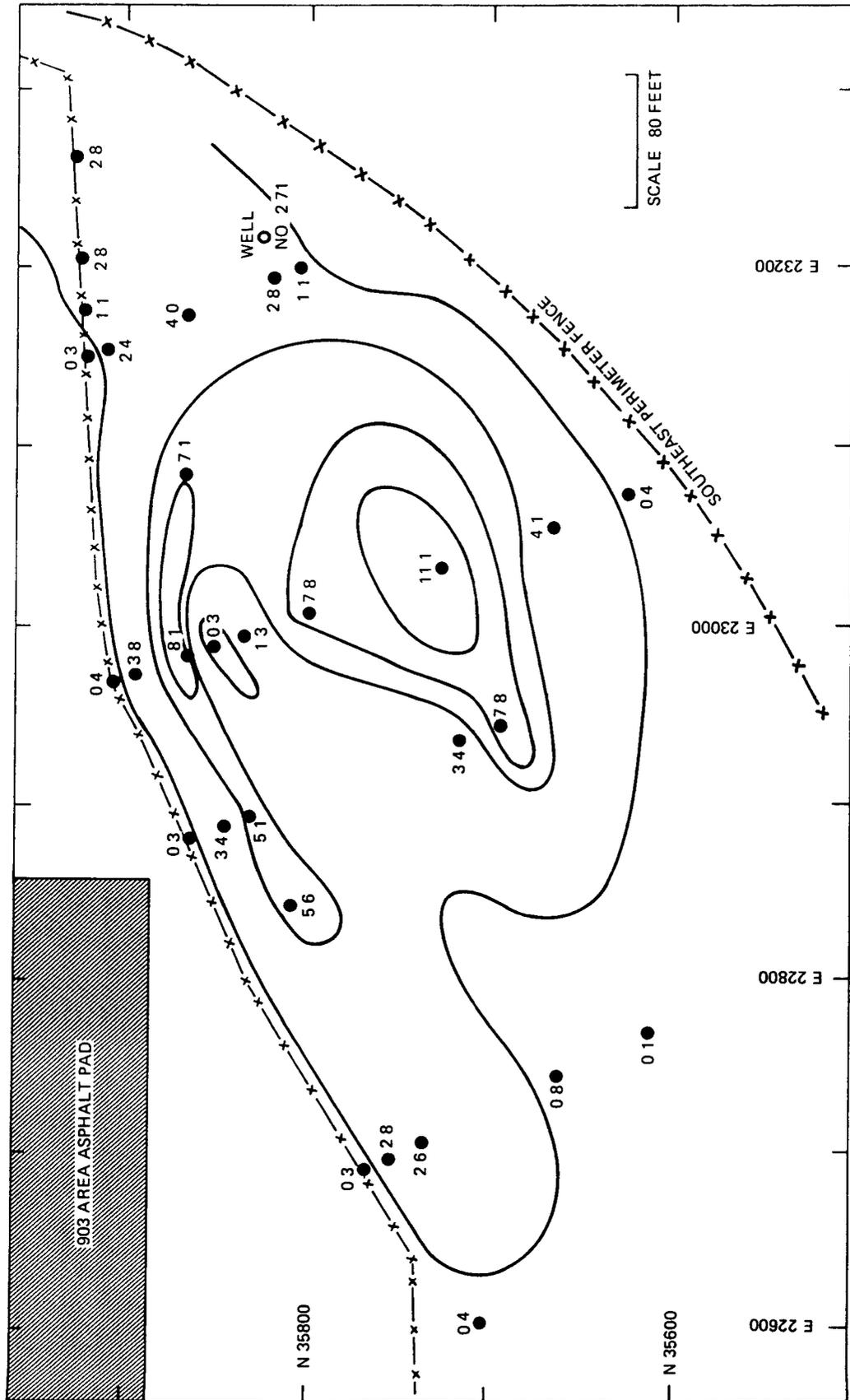


Figure 7 Americium Concentrations ($\mu\text{Ci}/\text{m}^2$) Detected by FIDLER Survey Multiply concentrations by 10 to obtain approximate plutonium concentrations in $\mu\text{Ci}/\text{m}^2$

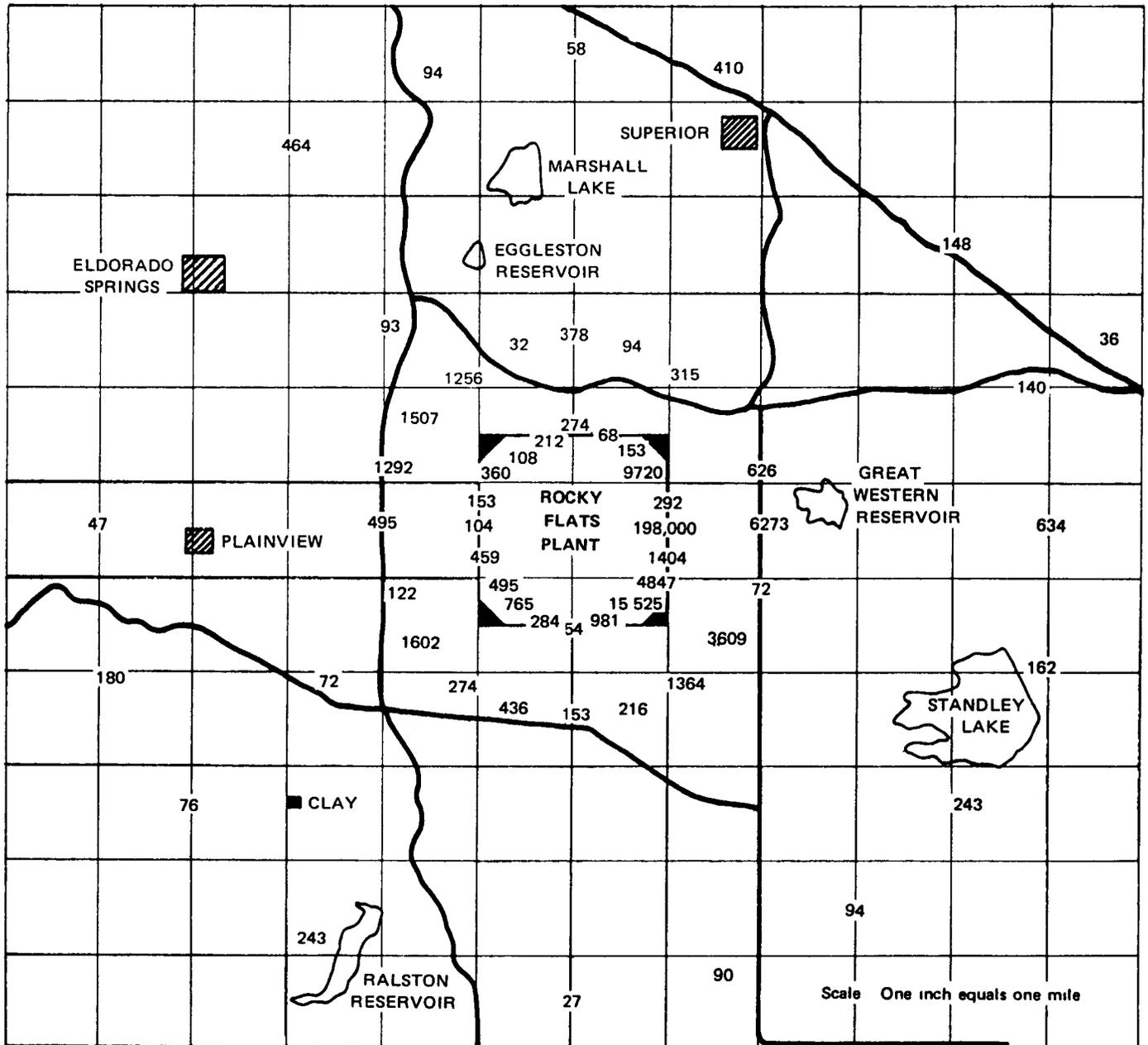


Figure 8 Plutonium Concentrations in Soil Concentrations $\times 10^{-6} \mu\text{Ci}/\text{m}^2 = \text{d}/\text{m}/\text{g} \times 4.5 \times 10^{-3}$ The average worldwide background from fallout is $225 \times 10^{-6} \mu\text{Ci}/\text{m}^2$

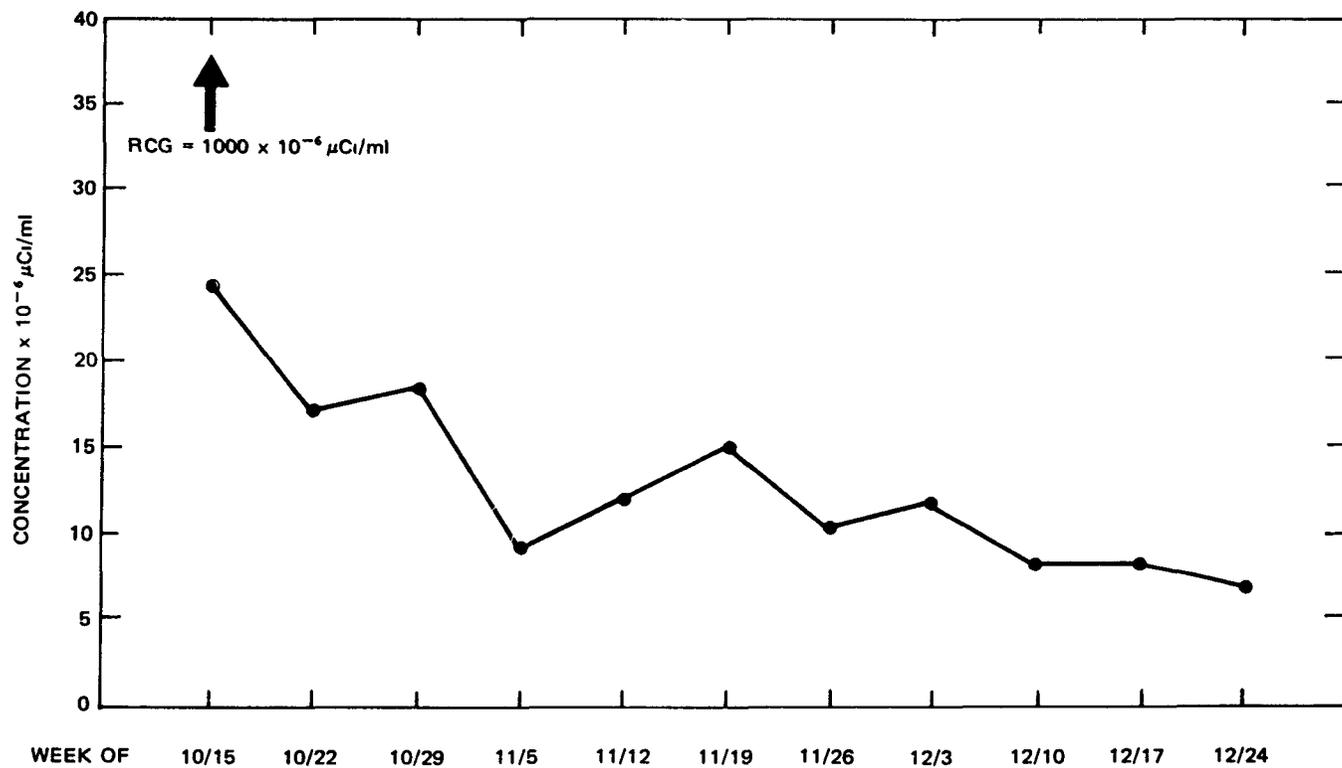


Figure 9 Tritium in Landfill Seepage (Weekly Average Concentrations)