Entergy Operations

Entergy Operations, Inc.

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SUBJECT: Arkansas Nuclear One - Units 1 and 2
Docket Nos. 50-313/50-368
License Nos. DPR-51 and NPF-6
Annual Environmental Radiological Report - 1990

Gentlemen:

Arkansas Nuclear One, Units 1 and 2 (ANO-1 & 2) Technical Specification 6.12.2.5 and 6.9.4, respectively, requires the submittal of an annual environmental radiological report for the previous calendar year.

Attached is the 1990 Annual Environmental Radiological Monitoring Report for ANO. The Technical Specifications require this report to be submitted by May 1 of each year. Due to additional review and resolution of comments, the submittal of this report was delayed. This delay has been discussed with the ANO-1 NRR Project Manager. This completes the reporting requirements for the referenced specifications.

Should you have any questions regarding this submittal, please contact me.

Very truly yours,

James J. Fisicaro

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Director, Licensing

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1990 ANNUAL ENVIRONMENTAL RADIOLOGICAL MONITORING REPORT

FOR ANO-1 AND ANO-2

ARKANSAS POWER AND LIGHT COMPANY

ENVIRONMENTAL SERVICES SECTION

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1.0 INTRODUCTION

This report summarizes the Environmental Radiological Monitoring Program conducted for Arkansas Nuclear One - Units 1 and 2 during the calendar year 1990. All sample analyses and data interpretation were performed by the staff of Arkansas Power and Light Company.

1.1 PLANT AND LOCATION

Arkansas Nuclear One - Units 1 and 2 are light-water cooled, pressurized water reactors located approximately 5.0 miles west of Russellville, Arkansas. ANO Unit 1 began commercial operation in December, 1974, and the second unit at the same site, ANO Unit 2, followed in March, 1980. Lake Dardanelle is the source of the circulating cooling water for ANO Unit 1, and ANO Unit 2 utilizes a cooling tower, which is dependent upon Lake Dardanelle as a source of make-up water.

1.2 ENVIRONMENTAL MONITORING PROGRAM

The Environmental Monitoring Program is based upon the Environmental Technical Specifications for ANO Unit 1, section 4.30; Unit 2, section 3/4.12, which became effective January, 1985. Table 1.2.1 details the surveillance program listing sample types, frequencies of collection and the methods of

analysis used. Table 1.2.2 lists the sample locations and types of samples collected at each location. Figure 1.2.1 depicts the environmental sampling stations within 10 miles of the plant site.

1.3 CONTROL LOCATIONS

During the calendar year 1990, the following locations were designated as control stations for the identified sample types:

a) AP&L's Substation at Danville, Arkansas (Station #7)

1) Air Particulate
2) Air Iodine
3) TLD (alternate: Station No. 5 at Knoxville, Arkansas)

b) Piney Creek Area (Station #16)

1) Lake Water
2) Bottom Sediment

c) ANO Intake Canal (Station #10)

1) Lake Water
2) Aquatic Biota (including fish collected by the Ark. Dept. of Health)
3) Bottom Sediment (collected by UALR)

d) Hudson Dairy (Station #42)

1) Milk

2.0 INTERPRETATIONS AND CONCLUSIONS

Based on data from radiological analyses of environmental samples collected in the area surrounding the ANO facility the following conclusion is made. The general public was not exposed to any environmental media containing radioactive material above the station reporting levels nor did it receive annual dose commitments above reporting levels as a result of liquid and gaseous discharges from the ANO site during 1990. In addition, no non-routine environmental radiological monitoring reports resulting from analyses of environmental samples at the ANO facility were submitted to the U.S. NRC during 1990.

The category of environmental samples collected during 1990 which contained the highest percentage of its reporting level was Cs-137 in fish collected from the discharge canal. However, the activity concentration of Cs-137 was a factor of 76.9 below the corresponding reporting level.

Maximum values of Lower Limits of Detection (LLD) are given in Table 2.0.1. Reporting levels for radioactivity concentrations in environmental samples are given in Table 2.0.2. Environmental radiological monitoring program summary data is presented in Table 2.1.1.

2.1 SAMPLES ASSOCIATED WITH AIR MONITORING

Methods of collection and analysis of environmental air samples are described in Sections 3.1.2 and 3.2. No reactor-related radioactive material was detected in any air filter samples during 1990. Gross beta activity concentration at the indicator location with the highest annual mean for 1990 was 0.029 pCi/m^3 compared to 0.029 pCi/m^3 in 1989 and a mean of 0.092 pCi/m^3 for all measurements during the preoperational period of 1973-1974.

The quarterly TLD data for 1990 indicated a total yearly average dose for the forty-two indicator locations of 106 mrem per year compared to the total yearly average dose of 83 mrem for 1989. The TLD control station at Danville, Arkansas had a damaged TLD for the third quarter; therefore, no TLD data is available for this period. The alternate control location at Knoxville, Arkansas (298° - 8.2 miles) indicated a total dose, based upon quarterly TLDs, of 116 mrem per year for 1990 compared to 89 mrem for 1989. Table 2.1.2 lists the total yearly average dose for the indicator locations for the calendar years of 1973, 1974, 1986, 1987, 1988, 1989 and 1990 compared to the total dose of background radiation (control station). Figure 2.1.1 depicts the TLD data for the maximum indicator location, the average of all indicator locations and the control station for the period 1973 through 1990.

The difference between the indicator locations and the control location for 1990 quarterly TLD results is not statistically significant. The standard deviation for the indicator locations is 4.8 mrem quarterly average dose. For a one sample t-test, (i.e., a single control compared to five indicator locations), a t-value of 0.43 is obtained. This t-value does not indicate a significant difference between the control and indicator locations at the 95% confidence level. A t-value of greater than 2.78 would be necessary to indicate a significant difference.

Factors other than statistical fluctuations that may affect the variation in recorded dose include variations of up to 15% in response of the TLD chips to the same radiation exposure, different soil types at monitoring locations, and varying heights above ground level for TLD placement.

Thermoluminescent dosimeters deployed in the environment in 1987 through 1990 were manufactured by Panasonic; whereas, prior to 1987, Harshaw Inc. dosimeters and dosimeter readers were used. Inherent differences in the construction of the dosimeters and methodology of reading TLDs probably resulted in the increased readings of both indicator and control location dose from 1987 to the present. The four quarterly TLD results for 1990 were somewhat higher at the indicator and control locations, although no particular event or occurrence in 1990 contributed to the increase in TLD readings that has been observed since 1987. This suggests that the systematic increase in dose rates resulted from

basic differences in measurement of dose between the Harshaw system and the Panasonic system.

2.2 SAMPLES ASSOCIATED WITH WATER MONITORING

2.2.1 Surface Water

Composite lake water samples were collected from two different sample sites in Lake Dardanelle on a monthly basis. In addition, the Arkansas Department of Health (ADH) and Arkansas Power and Light Company split a surface water grab sample from the ANO Discharge Canal and Piney Bay monthly. Each laboratory analyzed the grab samples for gamma-emitting isotopes and tritium.

One sample of composite water, the November, 1990, composite from the discharge canal, contained 12 pCi per liter of Co-58. This activity concentration for Co-58 is a factor of 83.3 below the level that would have to be maintained for a calendar quarter to approach the reporting level for water.

Tritium analysis values for the monthly grab sample of the discharge water collected by Arkansas Department of Health personnel varied from 240 to 2750 pCi per liter. The maximum tritium concentration in grab samples is a factor of 10.9 below the level that would have to be maintained for a full quarter to approach the reporting

level for drinking water samples. These sporadic elevated tritium concentrations are attributable to grab samples being taken during or soon after controlled releases from the plant and do not constitute a public health or environmental concern.

2.2.2 Sediments

Since 1976, bottom sediments collected from the ANO Discharge Canal (0.1 mile 180°) have contained radioisotope concentrations above the preoperational levels that are attributable to ANO operations. Figures 2.2.1 through 2.2.6 depict the levels of radionuclides found in bottom sediments from 1973 through 1990. These figures illustrate the following: the radionuclide concentration for the indicator and control stations, the LLD for that nuclide, the required LLD level (if given) in the Technical Specifications, and the nuclide concentration that would result in a 3 mrem dose to the whole body.

Since the Technical Specifications do not provide a reporting level for radioisotopes in sediments, an evaluation of potential dose to the public from this media was performed. To determine the maximum whole body dose from sediments, dose calculations were performed according to the mathematical model for

determining external dose from sediment given by U.S. Nuclear Regulatory Commission Regulatory Guide 1.109 on the sample with the highest radionuclide concentration collected in 1990. Table 2.2.1 gives the results of the calculations for sediment samples collected from the ANO Discharge Canal in February, 1990.

The maximum external dose to the skin from sediments for all measurable radionuclides was approximately 0.01 mrem per year, and the maximum whole body dose was approximately 0.01 mrem per year.

Design objectives given in 10CFR50, Appendix I, Section II.A for liquid effluents are annual doses of less than 3 mrem to the total body and less than 10 mrem to any organ. The values of 0.01 mrem per year for maximum whole body dose and 0.01 mrem per year for maximum external dose to skin of a teenager are well within the design objective criteria.

Gamma isotopic analysis of bottom sediment collected from the discharge canal February 10, 1990, indicated that silver-110m (Ag-110m) was present at a concentration of 690 ± 64 pCi per Kilogram dry weight. Presence of Ag-110m in discharge canal sediment was first detected in 1988 and its probable source was

identified as wear of the silver seal ring of the ANO-Unit II reactor vessel head. Figure 2.2.6 illustrates the sharp reduction in Ag-110m concentration in discharge canal sediment that has occurred during 1989 and 1990. This reduction is attributable to the natural radioactive decay of Ag-110m and sediment migration since installation of a new silver seal ring in 1989. Ag-110m was less than the lower limit of detection in the sediment sample collected in september, 1990 from the discharge canal.

2.2.3 Drinking Water

No reactor-produced, gamma-emitting isotopes were detected in drinking water samples collected during 1990.

2.2.4 Fish Samples

Routine fish samples collected by AP&L in 1990 included the following categories: a) catfish and b) bass and crappie. Edible portions (fillets) of these fish samples were analyzed by gamma spectrometry for reactor-related radioisotopes.

Reactor-produced radioisotopes attributed to operations at ANO were found in fish samples collected from the ANO Discharge Canal (0.1 mile 180°). Preoperational fish

samples (1974) contained no reactor-produced isotopes above the minimum detectable activity. Cs-134 was detected in two of four fish samples and Cs-137 was detected in all four fish samples collected from the ANO Discharge Canal. The average positive Cs-134 result, 4 pCi/kg, was below the minimum detectable activity range of 5 to 10 pCi/kg for the other Discharge Canal fish samples and, therefore, contains a high degree of uncertainty. This Cs-134 activity concentration is a factor of 32.5 below the maximum value of the lower limit of detection as well as a factor of 250 below the reporting level and, therefore, poses no adverse impact upon the public or environment.

The Cs-137 activity concentrations in fish taken from the Discharge Canal ranged from 10 to 26 pCi/kg. During the same time period, Cs-137 concentrations in fish taken from the control location ranged from 12 to 23 pCi/kg. The Discharge Canal fish samples, although slightly higher in Cs-137 than the control samples, are a factor of 76.9 below the reporting level and, therefore, pose no adverse impact upon the public or environment. In addition to the fish samples described above, edible portions of fish were collected by the Arkansas Department of Health in June and October, 1990. These samples contained Cs-134 and Cs-137 at levels similar to the samples discussed above.

Table 2.2.2 is a listing of concentrations of radionuclides detected in sport fish tissue samples collected by the Arkansas Department of Health during the calendar years 1986, 1987, 1988, 1989 and 1990. Figure 2.2.7 graphically depicts the Cs-134 concentrations from 1973 through 1990 and Figure 2.2.8 graphically depicts the Cs-137 concentrations from 1975 through 1990. Concentrations of Cs-134 and Cs-137 in edible portions of fish have shown a downward trend during 1988 through 1990 compared to the 1985 through 1987 time period.

2.3 SAMPLES ASSOCIATED WITH TERRESTRIAL MONITORING

2.3.1 Milk Samples

Milk samples from four sampling sites were collected by the Arkansas Department of Health and split with AP&L for the first eleven months of 1990. In November, 1990, the True-X goat dairy, an indicator location, sold all milk-producing goats and is no longer in operation. In December, 1990, milk samples from three sampling sites were collected by the Arkansas Department of Health and split with AP&L. AP&L personnel collected monthly milk samples from the L. Steuber Dairy. The milk sampling program consisted of four indicator locations and one control location for the first eleven months of 1990

and three indicator locations and one control location for December, 1990.

Positive iodine-131 results were obtained in four indicator location samples; however, the maximum I-131 concentration was less than the required lower limit of detection for this parameter. Positive results in these low concentrations contain a high percentage of counting error.

Cesium-137 was detected in the Hudson dairy milk, the control location, at a level of 2 ± 2 pCi/liter in September, 1990. This low level radioactivity concentration is attributed to international fallout based on the widespread detection of Cs-137 in soil and vegetation samples. This was reported in annual reports for previous years, including the preoperational years of 1973-1974. It is expected that migration would occur along the soil-vegetation-milk animal-milk pathway. Figure 2.3.1 depicts Cs-137 concentration in milk from 1973 through 1990.

2.3.2 Vegetation Samples

Vegetation samples were divided into two categories in 1990: a) broad leaf vegetation and b) garden products vegetation. Gamma analysis for all broad leaf vegetation samples collected in 1990 indicated less than the lower limit of detection for any gamma-emitting nuclide.

Garden vegetation samples collected in 1990 included lettuce, turnips, turnip greens, cabbage, potatoes, cucumbers, tomatoes, pepper, peaches, and radishes. All garden vegetation indicated less than the lower limit of detection for any gamma-emitting nuclide.

2.4 SAMPLES NOT COLLECTED IN 1990

Quarterly TLDs missing upon retrieval in 1990 include:

a) First Quarter 1990 - TLD Station Nos. 116, 121, 132, 136, 137, and 144 missing.

b) Second Quarter 1990 - TLD Station Nos. 121 and 133 missing.

c) Third Quarter 1990 - TLD Station No. 144 was missing, and the TLD at Station No. 7 was damaged.

d) Fourth Quarter 1990 - TLD Station Nos. 137 and 144 missing.

Missing or damaged TLDs can result from severe weather or vandalism. During 1990 TLD recovery was 94% which was the same percentage recovery as in 1989. This recovery is considered satisfactory and no changes in TLD deployment are anticipated during 1991.

At Station No. 1, the air sample pump "tripped" off-line February 20, 1990 at 1130 hours and was out-of-service until February 21, 1990 at 1400 hours.

An out-of-service air sample pump at Station No. 2 was discovered September 19, 1990. The pump head containing the filters was found on the ground resulting in a sample volume too low to allow analysis of the sample. The probable cause was excessive vibration. The sample pump head was replaced.

A weekly air sample was missed when the sample pump at Station No. 6 was found inoperative on October 30, 1990. The sample pump was changed and air sampling resumed.

During 1990 air sampling data recovery was 98%. This recovery is considered satisfactory and no changes in air sampling are anticipated during 1991.

The automatic water composite sampler at Station No. 8 was out-of-service April 23, 1990 at 1000 hours until April 25, 1990 at 1530 hours. The pump motor had failed and was repaired. Since this outage represents less than 10% of the sampling period, the April, 1990, composite sample from Station No. 8 was retained and analyzed.

2.5 COMPARISON OF RESULTS OF EPA CROSS-CHECK PROGRAM

The Environmental Services Section of Arkansas Power and Light Company participates in the U.S. Environmental Protection Agency's Environmental Radioactivity Laboratory Intercomparison Studies Program. The major objective of this program is to assist laboratories involved in environmental radiation measurements to develop and maintain both an intra-laboratory and an inter-laboratory quality control program. This is partially accomplished through a laboratory intercomparison studies program involving environmental media (milk, water and air) and a variety of radionuclides with activities at or near environmental levels.

During the calendar year 1990, the following sample types were received and analyzed:

a) Gross Alpha/Beta in Water - A one-liter sample for the analysis of gross alpha and gross beta activity.

b) Gamma in Water - A one-liter sample containing barium-133, zinc-65, cobalt-60, ruthenium-106, cesium-134 and cesium-137.

c) Tritium in Water - A twenty-five ml sample containing tritium.

d) Iodine-131 in Water - A four-liter sample containing iodine-131.

e) EPA Blind in water - A one-liter blind sample containing a mixture of radionuclides.

f) Milk - A four-liter milk sample for total potassium, strontium-89, strontium-90, iodine-131, and cesium-137 analyses.

g) Air - A two-inch diameter air filter for gross alpha, gross beta, cesium-137 and strontium-90 analyses.

A report listing the results of the analyses is mailed after each participating laboratory performs three independent determinations for each radionuclide involved in the study. This report contains the laboratory standard deviation, calculation of the normalized range, normalized deviation, sample standard deviation, and the grand average of all laboratories.

If the Environmental Services Section Laboratory results differ by more than three standard deviations from the known results given in the EPA cross-check reports, the instrument and procedure are checked for error.

Table 2.5.1 lists the date of preparation, types of EPA or Analytics, Inc. cross-check samples received and analyzed, and the number of standard deviations the AP&L lab differed from the known

value. All of the results were within three standard deviations of the known values supplied by the U.S. EPA.

3.0 PROGRAM TECHNICAL DESCRIPTION

3.1 SAMPLE HANDLING AND TREATMENT

Once a sample is received at the laboratory, the laboratory staff is responsible for properly treating and storing the sample. Environmental samples frequently require treatment prior to analysis. Treatment of the sample after it is received depends on the sample type and condition as well as the analyses to be performed on it.

3.1.1 Water Samples

One-gallon water samples are acidified with 5-ml of concentrated HCl when collected. Five milliliters of the water samples are used for tritium analysis.

3.1.2 Air Filters

Air filters are routinely beta and gamma counted as received from the sampling location. When heavy dust loadings are observed on air filters and particulate matter has rubbed off of the filter, analysis of the

envelope in which the sample arrived as well as the sample is required.

3.1.3 Milk

Milk samples are refrigerated until analyses can be performed. A preservative (formalin) is added to inhibit bacterial growth and retard spoilage. Milk samples that are to be analyzed for I-131 have 100 ml of formalin added to avoid binding of the iodine that may occur with smaller levels of formalin. Milk samples requiring gamma analysis are spiked with 10 ml of formalin.

3.1.4 Soil and Bottom Sediments

Soil and bottom sediment samples are dried and pulverized to a fine consistency before analysis. To ensure a homogeneous sample, thorough mixing is required.

3.1.5 Other Samples

Perishable samples are preserved by refrigeration or freezing. Vegetation and other samples may need to be dried, pulverized, or ashed after analysis for long-term storage.

3.2 GROSS BETA ANALYSIS OF AIR PARTICULATE SAMPLES

Air filters are counted in a low background alpha-beta counter at least 24 hours after collection in order to allow for decay of short-lived isotopes of radon and daughter products.

Calculations of the results, the two sigma error, and the lower limit of detection (LLD) are performed as indicated in the following:

$$\text{BETA RESULT (pCi/m}^3\text{)} = [(N_B/T)-(B_B/t)-(r)(N_A/T)]/(2.22*V*E)$$

$$\text{TWO SIGMA ERROR (pCi/m}^3\text{)} = 1.96\sqrt{\frac{(N_B/T)^2+(B_B/t)^2}{(2.22*V*E)}}$$

$$\text{LLD (pCi/m}^3\text{)} = 4.66\sqrt{(B_B)}/(2.22*V*E*t)$$

where:

N_A	=	gross alpha counts of sample
N_B	=	gross beta counts of sample
B_B	=	counts of blank (beta)
E	=	counting efficiency
r	=	ratio of alpha counts in beta counting (cross-talk)
T	=	number of minutes sample was counted
t	=	number of minutes blank was counted
V	=	sample aliquot size (cubic meters)
2.22	=	dpm/pCi

3.3 GROSS BETA ANALYSIS OF WATER SAMPLES

The overall beta radioactivity of water samples is performed without identifying the radioactive species present. No chemical separation techniques are involved.

Two hundred ml of the sample is evaporated in a beaker at approximately 100°C. The residue is transferred and dried in a 2-inch stainless steel planchet. The planchets are counted for 100 minutes in a low-background alpha-beta counting system. Calculation of activity includes a self-absorption correction for counter efficiency based on the weight of residue on each planchet.

Calculation of the sample activity, the two sigma error, and the lower limit of detection (LLD) are performed based on the following:

$$\text{BETA RESULT (pCi/l)} = [(N_B/T_B)-(B_B/t_B)-(r)(N_A/T_A)]/(2.22*V*E)$$

$$\text{TWO SIGMA ERROR (pCi/l)} = 1.96\sqrt{\frac{(N/T)^2+(B/t)^2}{(2.22*V*E)}}$$

$$\text{LLD (pCi/l)} = 4.66\sqrt{(B)}/(2.22*V*E*t)$$

where:

N_A	=	total alpha counts of sample
N_B	=	total beta counts of sample
T	=	counting time for sample (minutes)
B_B	=	total counts of blank (beta)
2.22	=	dpm/pCi
r	=	ratio of gross alpha counts in beta counts (cross-talk)

T_B = counting time for sample (beta)

t_B = counting time for blank

T_A = counting time for sample (alpha)

N = gross counts of sample

B = counts of blank

V = volume of sample analyzed (liters)

E = efficiency of the counter

t = counting time for blank (minutes)

If the net activity (N/T-B/t) is equal to or less than the counting error, the activity on the collection date is then below the limits of detection and, as a result, is designated less than the lower limit of detection (LLD).

3.4 TRITIUM ANALYSIS OF WATER SAMPLES

Five milliliters of distilled samples are added to 15 ml of liquid scintillation solution in a 25 ml vial, which is then counted for 300-500 minutes in a liquid scintillation spectrometer.

Calculation of the results, the two sigma error, and the lower limit of detection (LLD) are performed based on the following:

$$\text{RESULT (pCi/l)} = [(N/T)-(B/t)]/[(2.22*V*E)\exp(-\lambda\, t_2)]$$

$$\text{TWO SIGMA ERROR (pCi/l)} = 1.96\sqrt{\frac{(N/T)^2+(B/t)^2}{[(2.22*V*E)\exp(-\lambda\, t_2)]}}$$

$$\text{LLD (pCi/l)} = \frac{4.66\sqrt{B}}{2.22*E*V*t*\exp(-\lambda\, t_2)}$$

where: N = gross counts of sample

B = counts of blank

2.22	=	dpm/pCi
E	=	counting efficiency
T	=	number of minutes sample was counted
t	=	number of minutes blank was counted
V	=	sample aliquot size (l)
$\exp(-\lambda t_2)$	=	decay correction where t_2 is time elapsed between collection of sample and date of counting

3.5 IODINE-131 ANALYSIS OF SAMPLES

Up to four liters of sample are thoroughly mixed with a stable iodine carrier solution. The sample is ther passed through an anion exchange resin column to remove iodine from the sample. The iodine is then stripped from the resin with sodium hypochlorite solution, reduced with hydroxylamine hydrochloride, and extracted into carbon tetrachloride as free iodine. It is then back-extracted into sodium bisulfite solution and is precipitated as silver iodide. The precipitate is weighed to determine chemical yield and is mounted on a stainless steel planchet for low-level beta counting. The chemical yield is corrected by measuring the stable iodide content of the milk or the water with a specific ion electrode.

Calculations of the results, two sigma error, and the lower limit of detection (LLD) in pCi/l are performed based on the following:

$$\text{RESULT (pCi/l)} = [(N/T)-(B/t)]/[(2.22*E*V*Y)\exp(-\lambda\ t_2)]$$

$$\text{TWO SIGMA ERROR (pCi/l)} = 1.96\sqrt{(N/T)^2+(B/t)^2}\ /\ [(2.22*E*V*Y)\exp(-\lambda\ t_2)]$$

$$\text{LLD (pCi/l)} = 4.66\sqrt{(B/t^2)}/[(2.22*E*V*Y)\exp(-\lambda\ t_2)]$$

where:

- N = total counts of sample
- t = counting time for blank (minutes)
- T = counting time for sample (minutes)
- B = total counts of blank
- 2.22 = dpm/pCi
- V = volume of sample analyzed (liters)
- Y = chemical yield of the amount of sample counted
- $\exp(-\lambda\ t_2)$ = decay factor from the time of collection to the counting date
- E = efficiency of the counter for I-131 corrected for self absorption effects
- t_2 = elapsed time between collection of sample and counting date (days)
- $\lambda = \frac{0.693}{8.04}$ (days^{-1})

3.6 GAMMA SPECTROMETRY OF SAMPLES

3.6.1 Milk and Water

A 3.5 liter Marinelli beaker is filled with a representative aliquot of the sample. The sample is then counted for a minimum of 240 minutes in a shielded

Germanium detector coupled to a computer based data acquisition system which performs pulse height analysis.

A computer software program defines peaks by certain changes in the slope of the spectrum. The program also compares the energy of each peak with a library of peaks for isotope identification. The program then performs the radioactivity calculation using the appropriate fractional gamma ray abundance, half-life, detector efficiency, and net counts in the peak region.

3.6.2 Vegetation, Food and Garden Crops, and Fish

A maximum quantity of an undried vegetation, food, or garden crop sample is loaded into a tared 3.5 liter Marinelli beaker and weighed. The sample is then counted for a minimum of 240 minutes (or until the required LLD's are achieved) in a shielded Germanium detector as described in Section 3.6.1.

As much as possible of the edible portion of fish is loaded into a tared Marinelli beaker and weighed. The sample is diluted with deionized water to 3.5 Kg and then counted for 240 minutes (or until the required LLD's are achieved) in a shielded Germanium detector as described in Section 3.6.1.

3.6.3 Soils and Sediments

Soils and sediments are dried at low temperature (less than 100°C), loaded into a tared 1.0 liter Marinelli beaker and weighed. The sample is then counted for 240 minutes or until the required LLD's are achieved in a shielded Germanium detector as described in Section 3.6.1.

3.6.4 Charcoal Cartridges

Charcoal cartridges are counted in a Marinelli beaker with one to four cartridges positioned on the face of a Germanium detector and up to seven cartridges on the side of the Germanium detector. Each Germanium detector is calibrated for both top and side positions and a counting efficiency determined. The I-131 detection limit is determined for each charcoal cartridge by utilizing the smallest volume of air recorded for a cartridge within the Marinelli beaker. If I-131 is observed in the screening count of a set of cartridges, each charcoal cartridge is then counted separately, positioned on the face of the detector.

3.6.5 Air Particulates

The twelve to fourteen (depending on the calendar quarter) air particulate filters for a quarterly composite for each field station are stacked one on top of another and then counted for four hours (or until the required LLD's are achieved) in a shielded Germanium detector as described in Section 3.6.1.

The calculation of results, two sigma error, and the lower limit of detection (LLD) in pCi/volume or pCi/mass are performed based on the following:

$$\text{RESULT} = (S-B)/[(2.22*T*E*V*F)\exp(-\lambda t_2)]$$

$$\text{TWO SIGMA ERROR} = \frac{1.96\sqrt{(S/T)^2+(B/T)^2}}{[(2.22*E*V*F)\exp(-\lambda t_2)]}$$

$$\text{LLD} = 4.66\sqrt{B}/[(2.22*T*E*V*F)\exp(-\lambda t_2)]$$

where:

- S = Area, in counts, of sample peak and background (region of spectrum of interest)
- B = Background area, in counts, under sample peak, determined by a linear interpolation of the representative backgrounds on either side of the peak
- T = Length of time in minutes the sample was counted
- 2.22 = dpm/pCi
- E = detector efficiency for energy of interest and geometry of sample
- V = sample aliquot size (liters, cubic meters, kilograms, or grams)
- F = fractional gamma abundance (specific for each emitted gamma)

t_2 = elapsed time between collected date of sample and counting date (days)

$\lambda = \frac{0.693}{\text{half-life of isotope (days)}}$

3.7 THERMOLUMINESCENT DOSIMETRY

Each thermoluminescent dosimeter (TLD) contains two elements of lithium borate and two elements of calcium sulfate. The redundant pairs of elements provide better statistics than if only one of each type of element is used. The calcium sulfate element is the reference phosphor for the TLD reader because calcium sulfate produces approximately 25 times more light per unit exposure than lithium borate.

4.0 LAND USE CENSUS

The 1990 Land Use Census was performed on July 6, 27 and 31, 1990 in accordance with ANO Technical Specification [illegible]. The purpose of the survey was to identify the location of the [illegible] animal, the nearest resident, and the nearest garden of greater than 500 square feet producing fresh, leafy vegetables in each of the 16 meteorological sectors within a distance of 5 miles. Table 4.0.1 gives the locations of the nearest residence and garden for each of the 16 sectors surrounding ANO.

The Unit One Safety Analysis Report (SAR) wind speed/wind direction joint frequency data was used to select which gardens identified in the land use survey were to be used for sampling. Gardens were located in each of the sixteen sectors surrounding ANO during the Land Use Census.

Relative deposition rates for the nearest garden within each sector were calculated based on the garden's distance from the plant, the deposition expected (conservatively assuming a ground level release of radioactive materials), and the wind direction joint frequency occurring in the downwind sector where the garden is located. Results of the relative deposition rate calculations are given in Table 4.0.2. The gardens with the highest calculated relative deposition rates are chosen for sampling because they represent the areas which have the highest probability of being affected in the event of a routine radiological release. The Unit One SAR frequency data, Table 2-16, has been used for the relative deposition rate calculations because the data was collected over a three-year period and for that reason was considered more likely to be representative of site conditions. No changes in garden sampling locations is needed based on the results of the 1990 Land Use Census.

Milk sampling sites are chosen using the same methodology as described above for evaluating garden sampling sites. A listing of dairies was acquired from the Arkansas Department of Health and locations of animals were recorded during the Land Use Census for residences and gardens. Table 4.0.3 gives the locations of milk animals identified. Dairies located within the ANO Emergency Planning Zone were evaluated. This evaluation identified milk sampling sites in sectors with the highest probabilities of deposition. No changes in milk sampling sites are needed based upon results of the 1990 Land Use Census.

Table 4.0.4, Land Use Census, summarizes the location of the nearest resident, milk animal, and garden within a five-mile radius of the site in each of the 16 meteorological sectors.

APPENDIX A - STATISTICAL TERMINOLOGY

mean: The sum of the test results divided by the number of results taken; that is, $\bar{X} = \sum_{i=1}^{n} X_i/n$, where $\bar{X}$ = mean, X_i = individual result, and n = number of results.

precision: A measure of the reproducibility among replicate observations.

variance: The sum of the squares of deviations of the test results from the mean after division by one less than the total number of results; that is,

$$VAR = \sum_{i=1}^{n} (X - X_i)^2/(n - 1)$$

standard deviation: The square root of the variance; that is,

$$= (VAR)^{1/2} = \left[\sum_{i=1}^{n} (X - X_i)^2/(n - 1) \right]^{1/2}$$

accuracy: A measure of the agreement between observed and accepted values.

systematic error: Errors that may be traced to the personal errors

of the analyst, instrumental errors, errors that are inherent in the analytical methodology, or a combination of these. Accuracy is a measure of this type of error.

random error: The necessity for making estimations is inherent in the process of collecting data for the measurement of any quantity. For this reason, any measurement will be uncertain, in an amount that depends on the relative magnitude of the estimations involved in its evaluation. Careful experimental design can reduce this uncertainty; however, small irreducible variations will remain. Since radioactive decay is a random process, any counting measurement will have a random error associated with it. Precision measures this type of variability or error.

bias: The difference between the average of a set of test results and the accepted value. Bias usually is indicated only when a consistent difference is observed over time and can be corrected for by the application of appropriate correction factors. Bias is a measure of the systematic error.

Lower Level of Detection (LLD): The smallest concentration of radioactive material in a sample media that will be detected at the 95%

confidence level for a particular measurement system. LLD is an "a Priori" limit representing the capability of a measurement system using typical values of counting efficiency, sample volume, and elapsed time between collection and counting.

Minimum Detectable Activity (MDA): The smallest concentration of radioactive material that will be detected at a specific confidence level for a particular sample. Calculations of MDA for samples associated with the Arkansas Nuclear One radiological environmental program use the 95% confidence level; therefore, the calculation is the same as that given in Appendix B for LLD when sample specific values are substituted for system typical values.

APPENDIX B - LLD CALCULATIONS

The LLD is the smallest concentration of radioactive material in a sample media that will be detected with 95 percent confidence. For a particular measurement system (which may include radiochemical separation):

$$LLD = \frac{4.66(s_b)}{E * V * 2.22 * Y [\exp (-\lambda t)]}$$

where:

LLD is the Lower Limit of Detection as defined above (as pCi per unit mass or volume)

s_b is the standard deviation of the background counting rate or of the counting rate of a blank sample as appropriate (as counts per minute)

E is the counting efficiency (as counts per transformation)

V is the sample size (in units of mass or volume)

2.22 is the number of transformations per minute per picocurie

Y is the fractional radiochemical yield (when applicable)

λ is the radioactive decay constant for the particular radionuclide

t is the elapsed time between sample collection and analysis

The value of s_b used in the calculation of the LLD for a detection system shall be based on the actual observed variance of the background counting rate or of the counting rate of the blank samples (as appropriate) rather than on an unverified theoretically predicted variance. In calculating the LLD for a radionuclide determined by gamma-ray spectrometry, the background shall include the typical contributions of other radionuclides normally present in the sample (e.g., potassium-40 in milk samples).

FIGURE 1.2.1

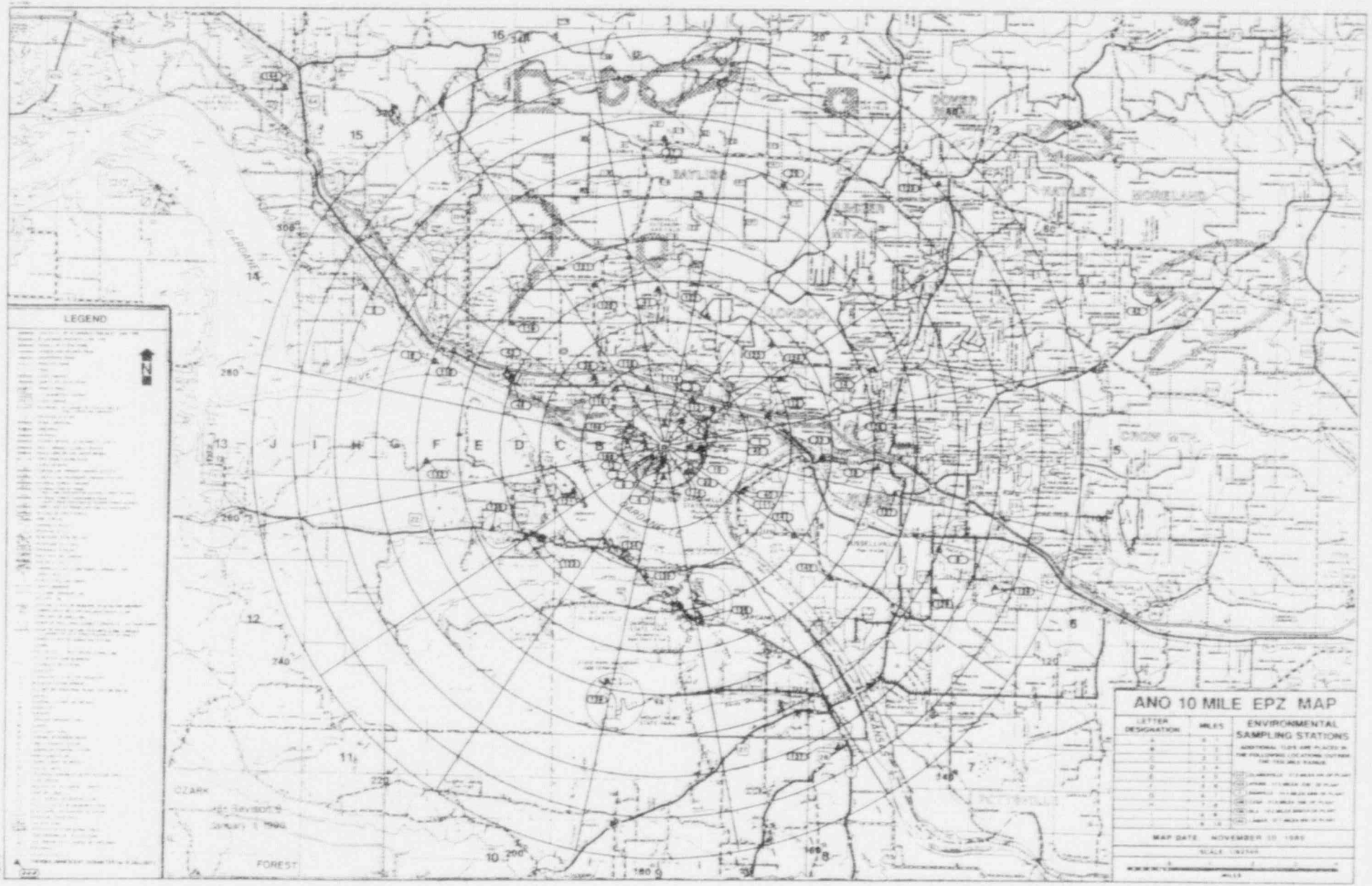
LEGEND
N
ANO 10 MILE EPZ MAP
LETTER DESIGNATION
MILES
ENVIRONMENTAL SAMPLING STATIONS
MAP DATE NOVEMBER 10 1981
SCALE 1/62500
MILES
OZARK
FOREST

FIGURE 2.1.1

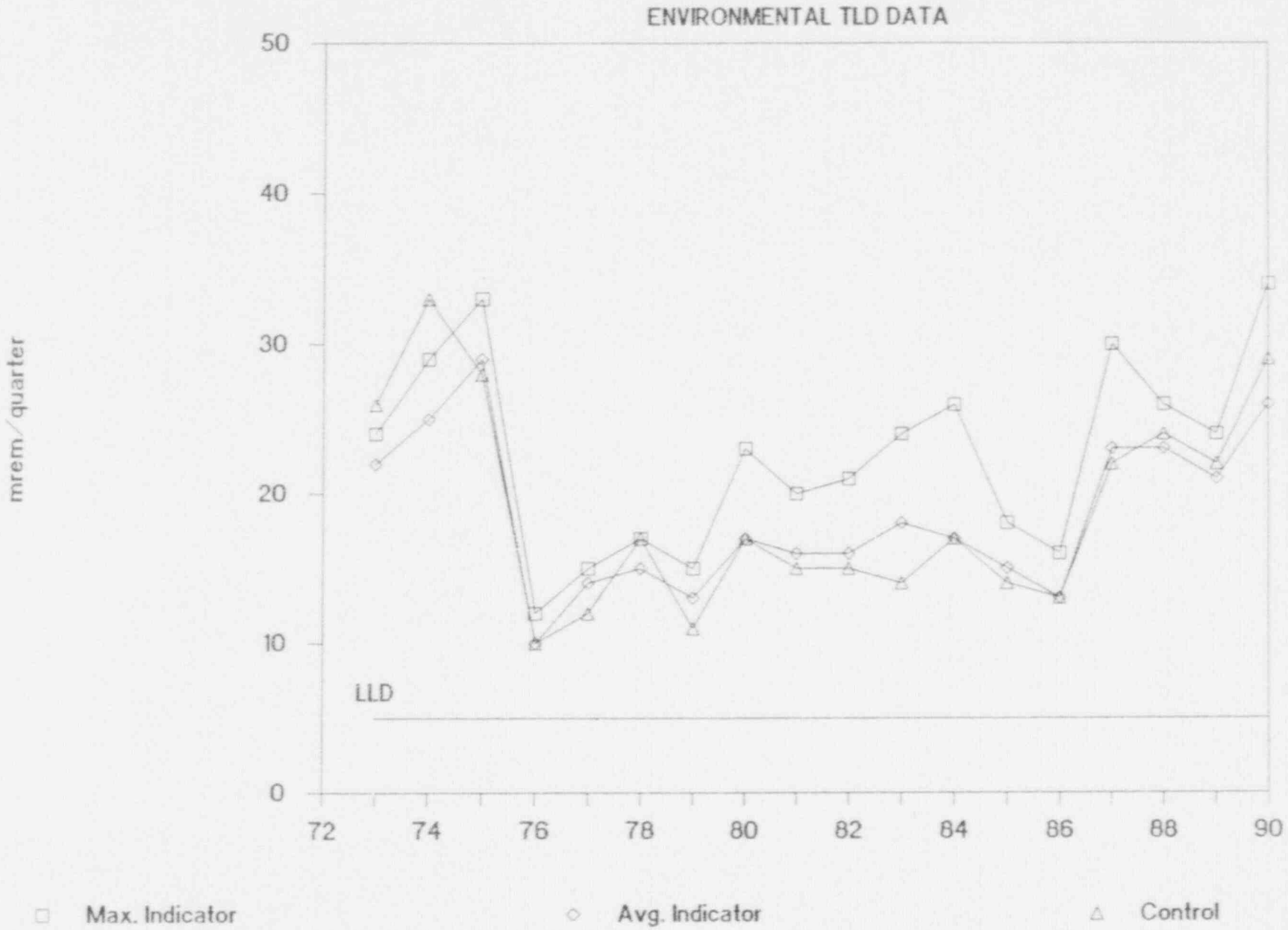
ENVIRONMENTAL TLD DATA
mrem/quarter
50
40
30
20
10
0
LLD
72
74
76
78
80
82
84
86
88
90
Max. Indicator
Avg. Indicator
Control

FIGURE 2.2.1

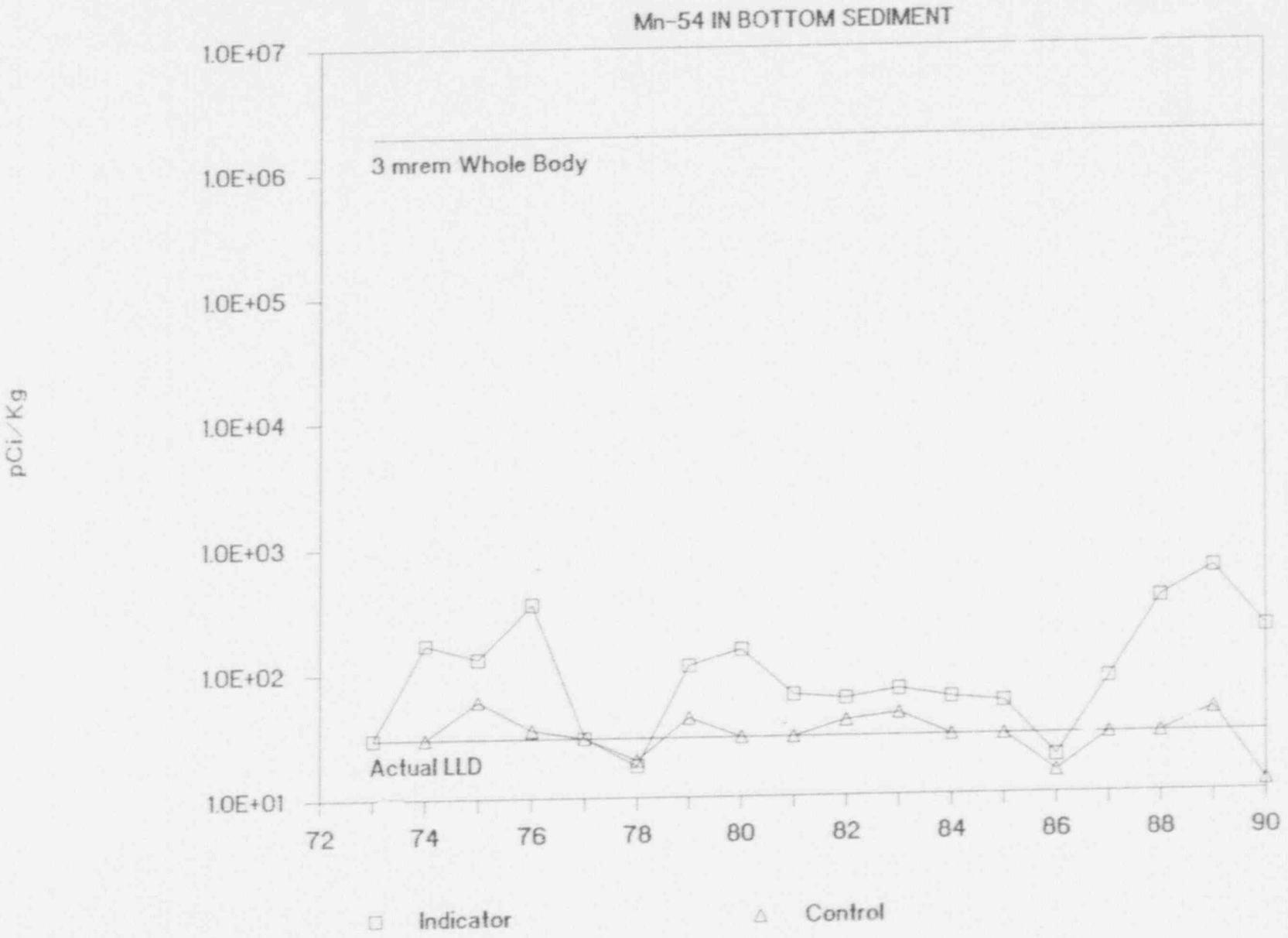
Mn-54 IN BOTTOM SEDIMENT
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
pCi/Kg
3 mrem Whole Body
Actual LLD
72
74
76
78
80
82
84
86
88
90
Indicator
Control

FIGURE 2.2.2

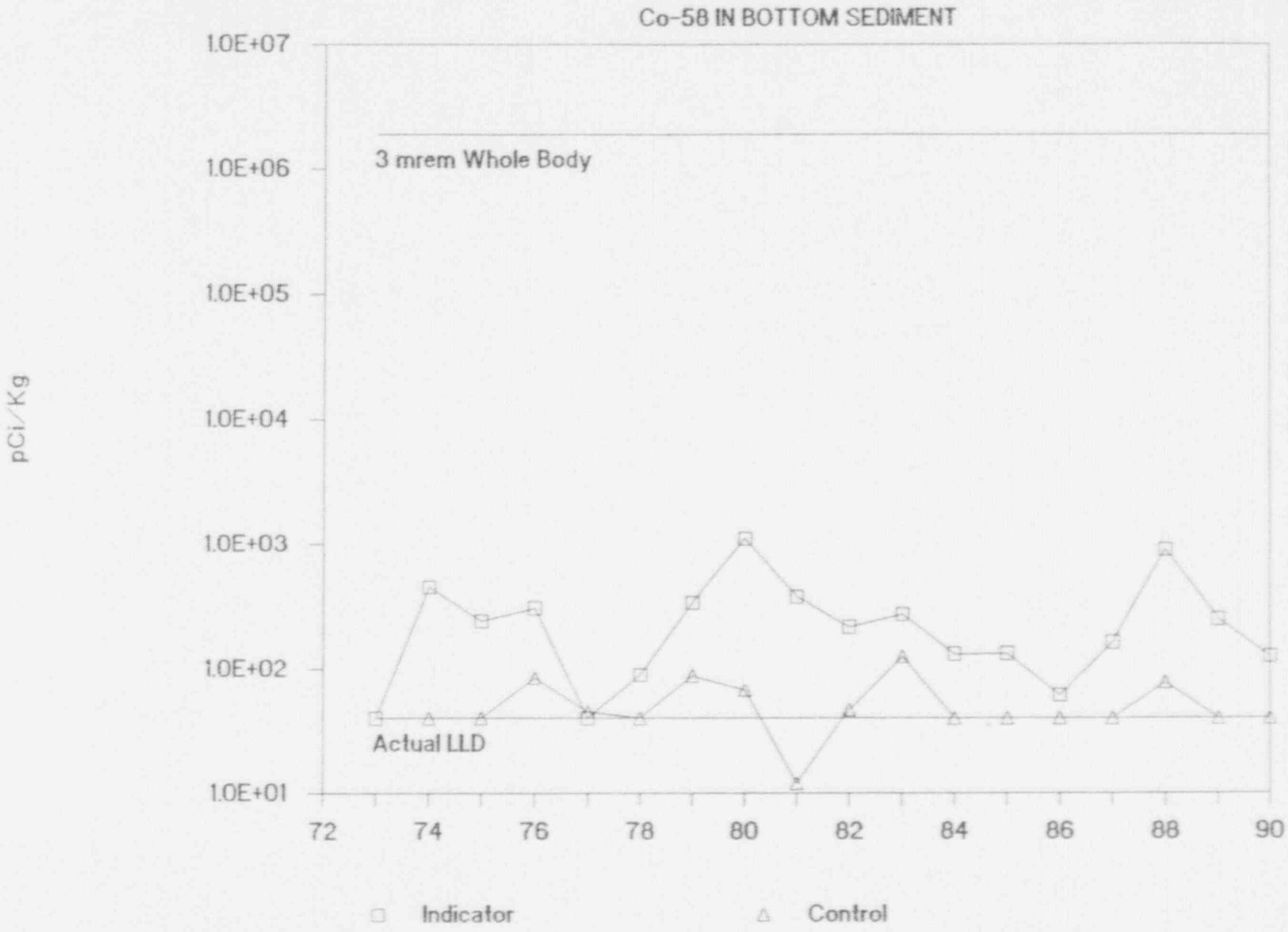
Co-58 IN BOTTOM SEDIMENT
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
pCi/Kg
3 mrem Whole Body
Actual LLD
72
74
76
78
80
82
84
86
88
90
Indicator
Control

FIGURE 2.2.3

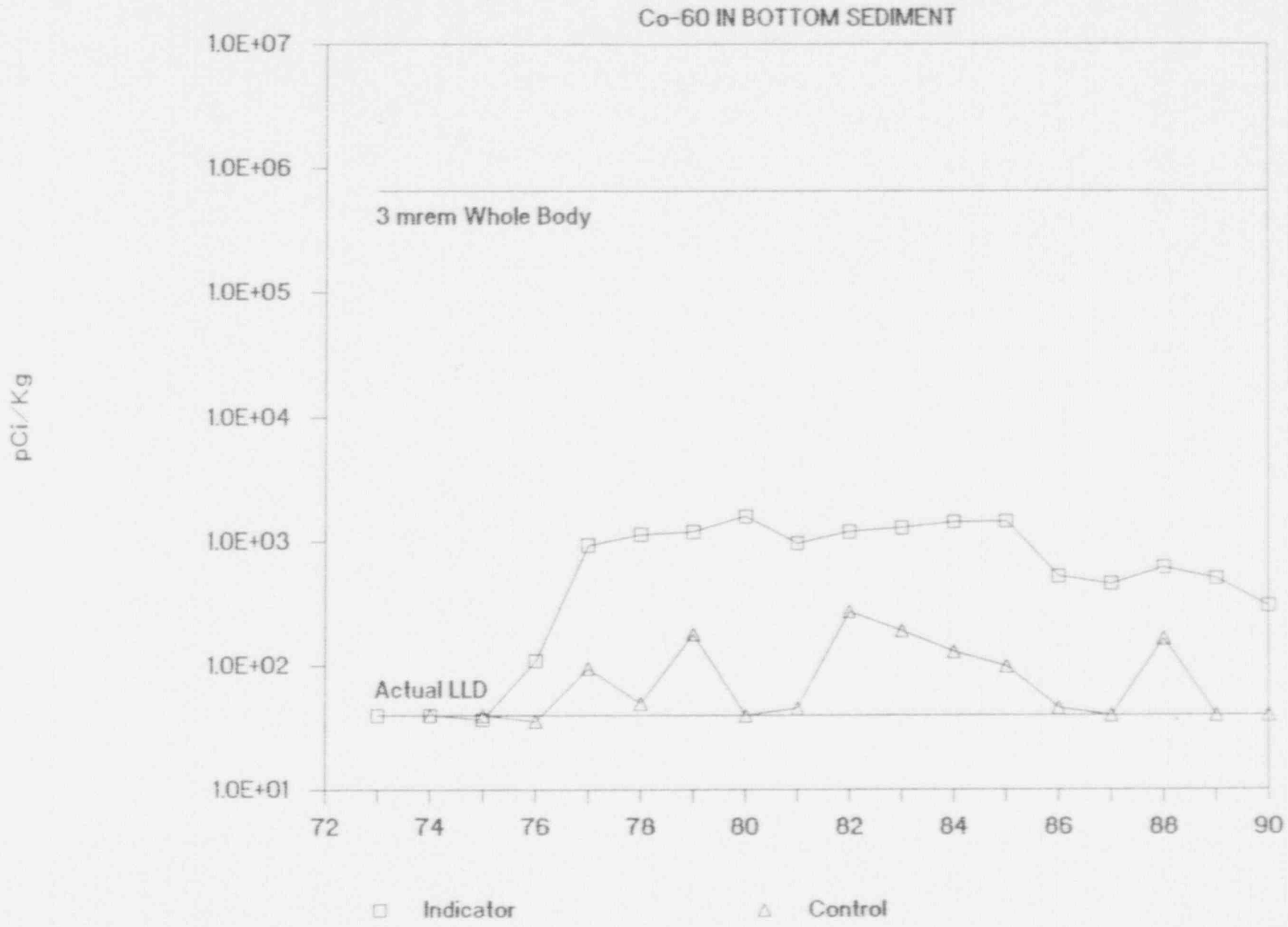
Co-60 IN BOTTOM SEDIMENT
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
pCi/Kg
3 mrem Whole Body
Actual LLD
72
74
76
78
80
82
84
86
88
90
Indicator
Control

FIGURE 2.2.4

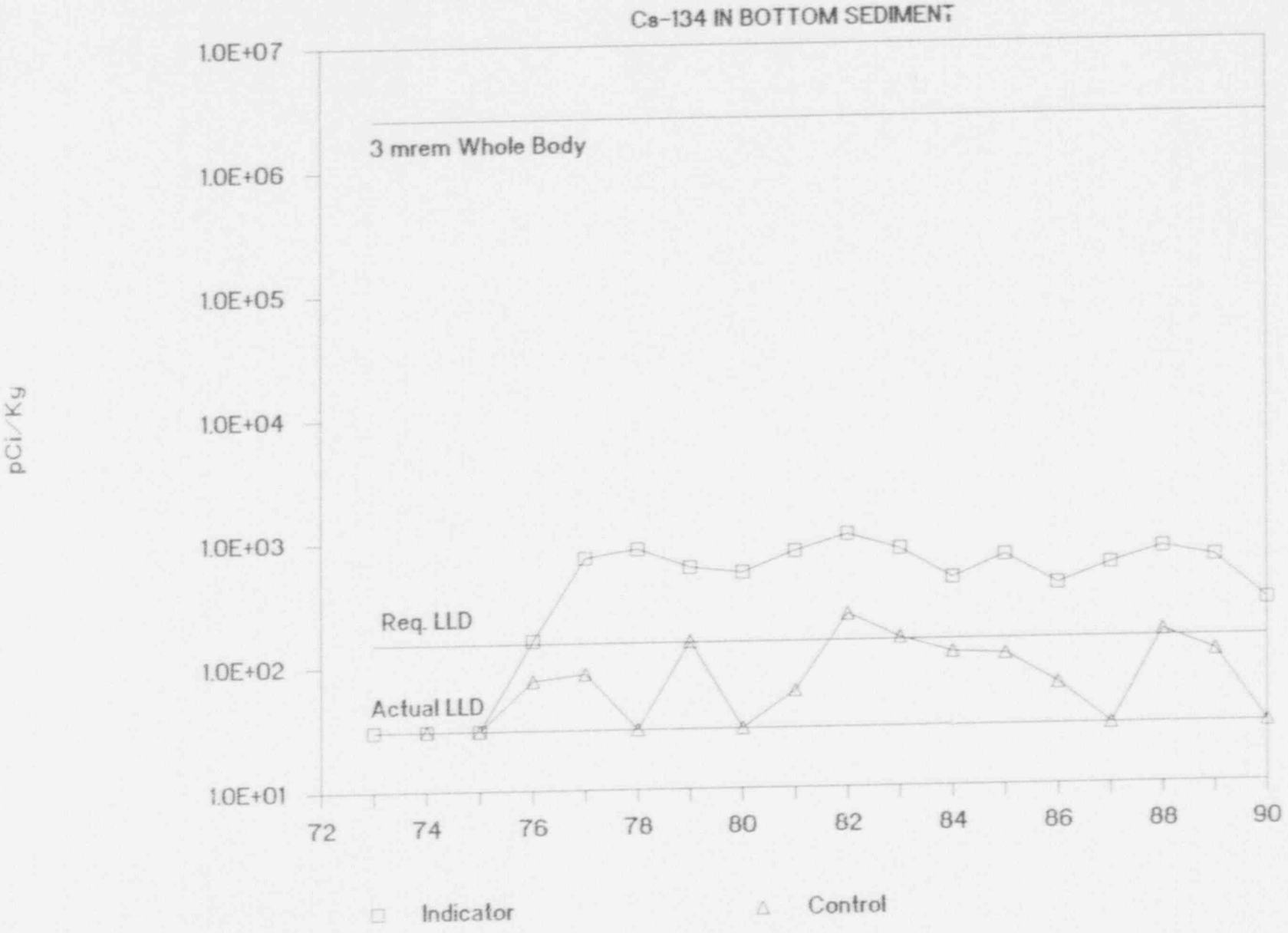
Cs-134 IN BOTTOM SEDIMENT
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
pCi/Kg
3 mrem Whole Body
Req. LLD
Actual LLD
72
74
76
78
80
82
84
86
88
90
Indicator
Control

FIGURE 2.2.5

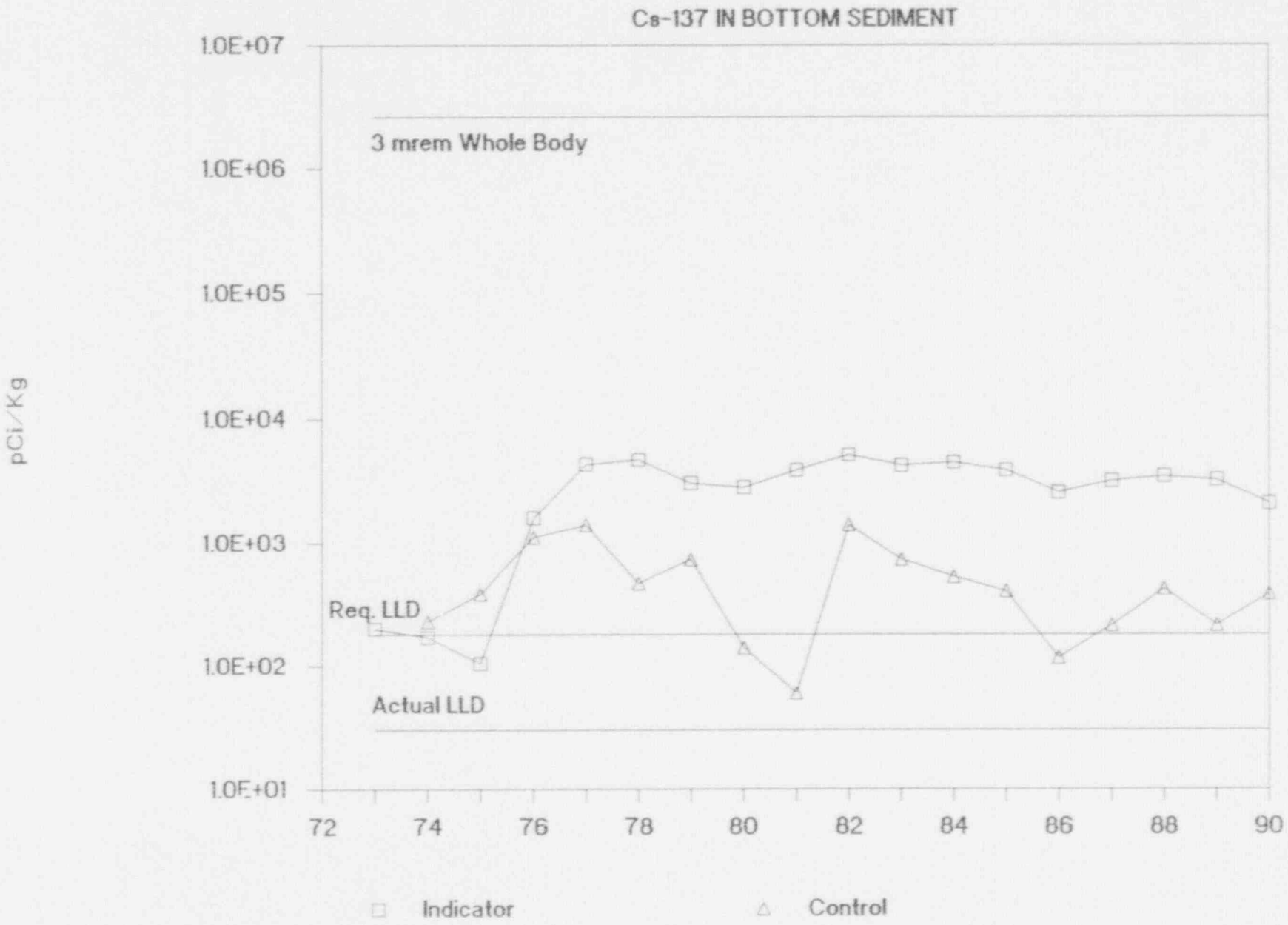
Cs-137 IN BOTTOM SEDIMENT
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
pCi/Kg
3 mrem Whole Body
Req. LLD
Actual LLD
72
74
76
78
80
82
84
86
88
90
Indicator
Control

FIGURE 2.2.6

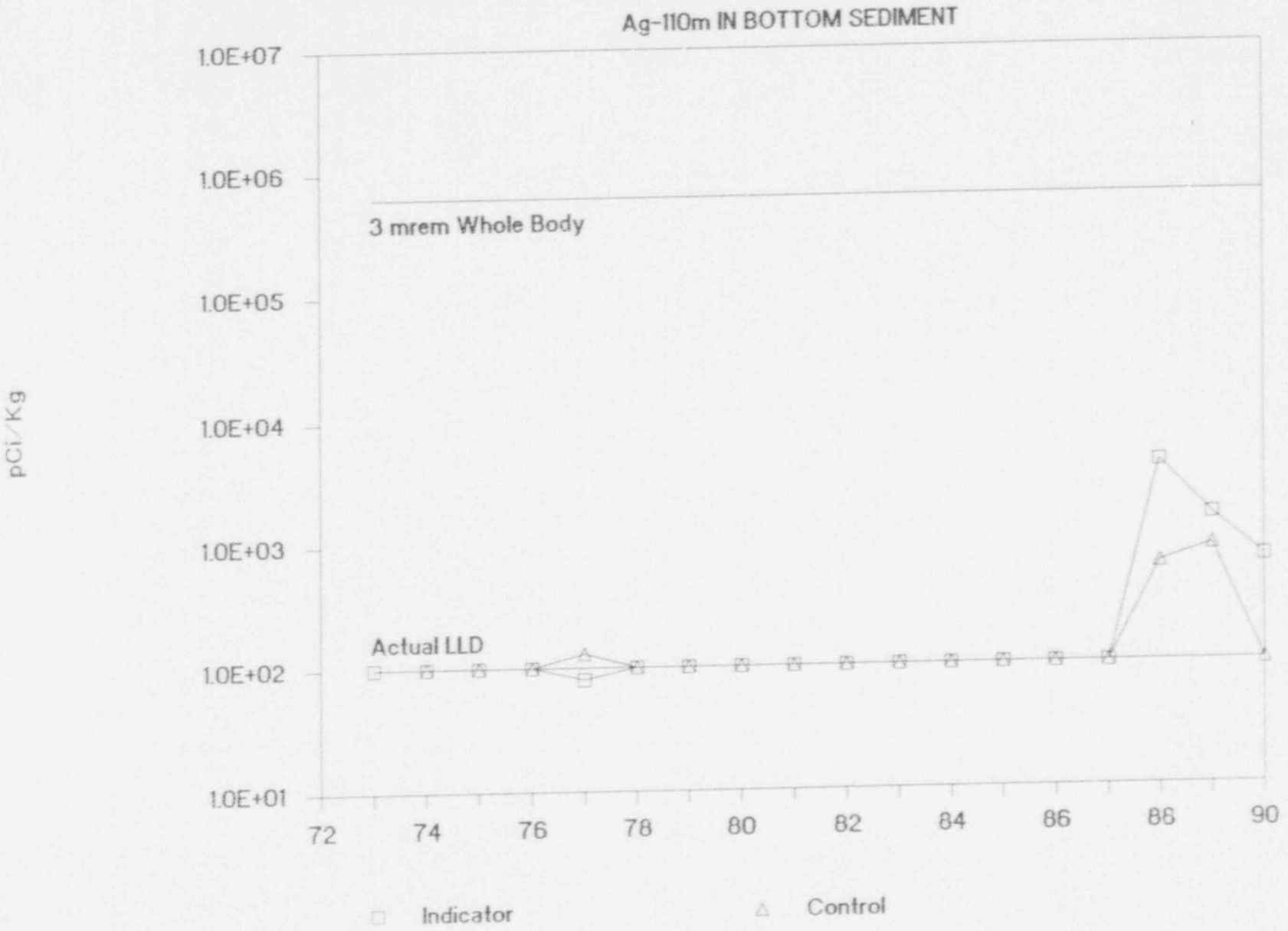
Ag-110m IN BOTTOM SEDIMENT
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1.0E+02
1.0E+01
pCi/Kg
3 mrem Whole Body
Actual LLD
72
74
76
78
80
82
84
86
88
90
Indicator
Control

FIGURE 2.2.7

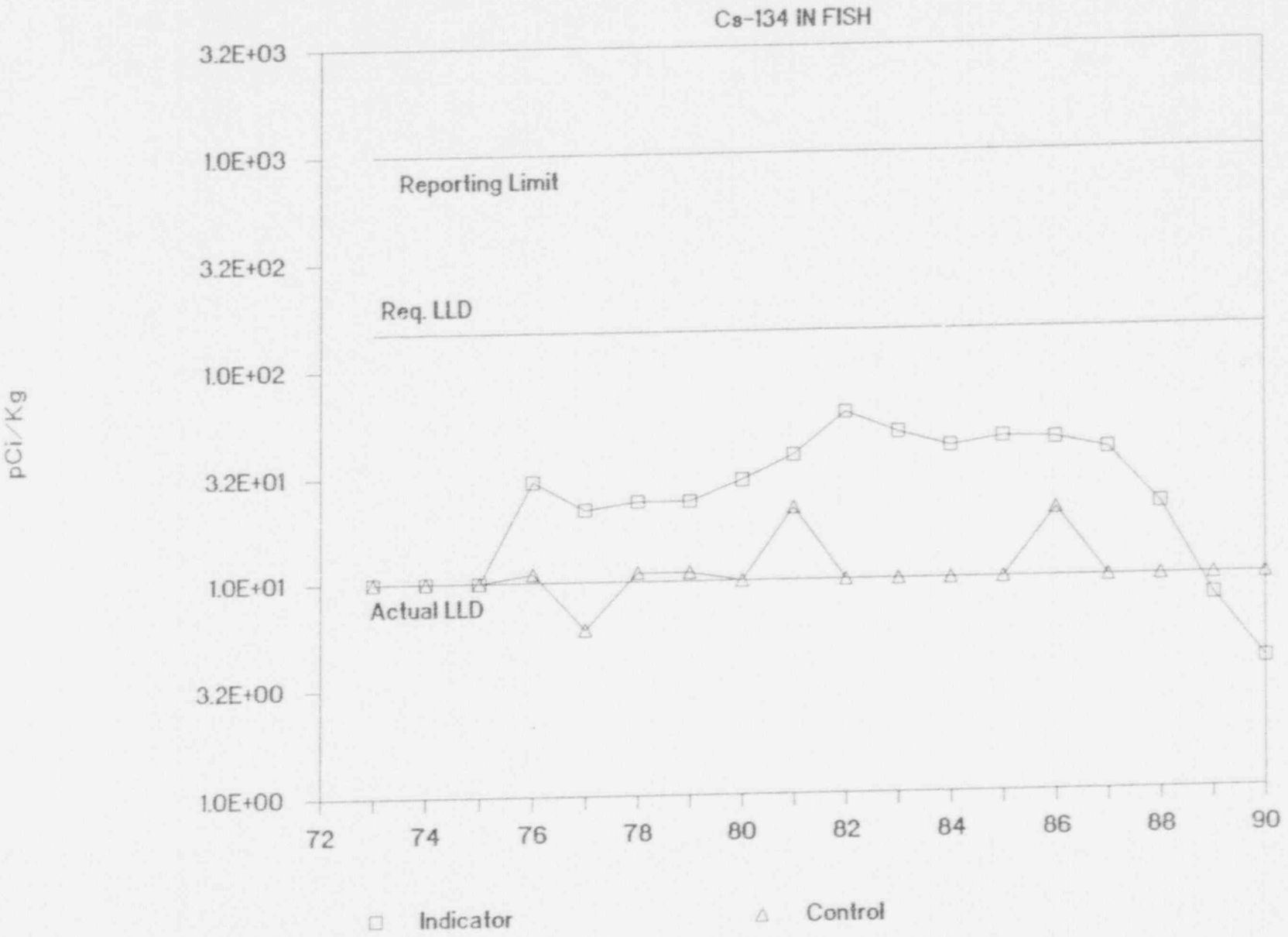
Cs-134 IN FISH
3.2E+03
1.0E+03
3.2E+02
1.0E+02
3.2E+01
1.0E+01
3.2E+00
1.0E+00
pCi/Kg
Reporting Limit
Req. LLD
Actual LLD
72
74
76
78
80
82
84
86
88
90
Indicator
Control

FIGURE 2.2.8

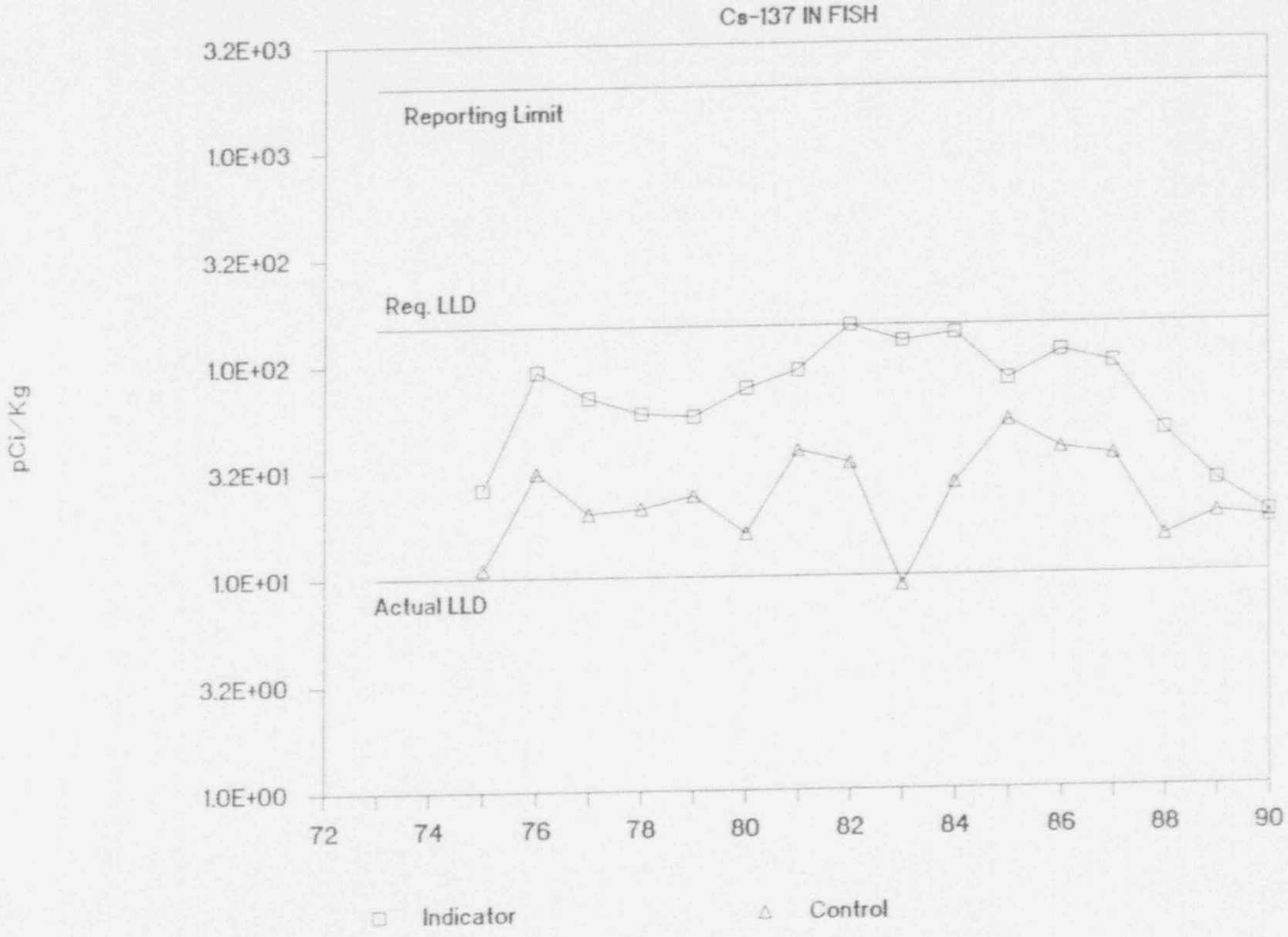
Cs-137 IN FISH
3.2E+03
1.0E+03
3.2E+02
1.0E+02
3.2E+01
1.0E+01
3.2E+00
1.0E+00
pCi/Kg
Reporting Limit
Req. LLD
Actual LLD
72
74
76
78
80
82
84
86
88
90
Indicator
Control

FIGURE 2.3.1

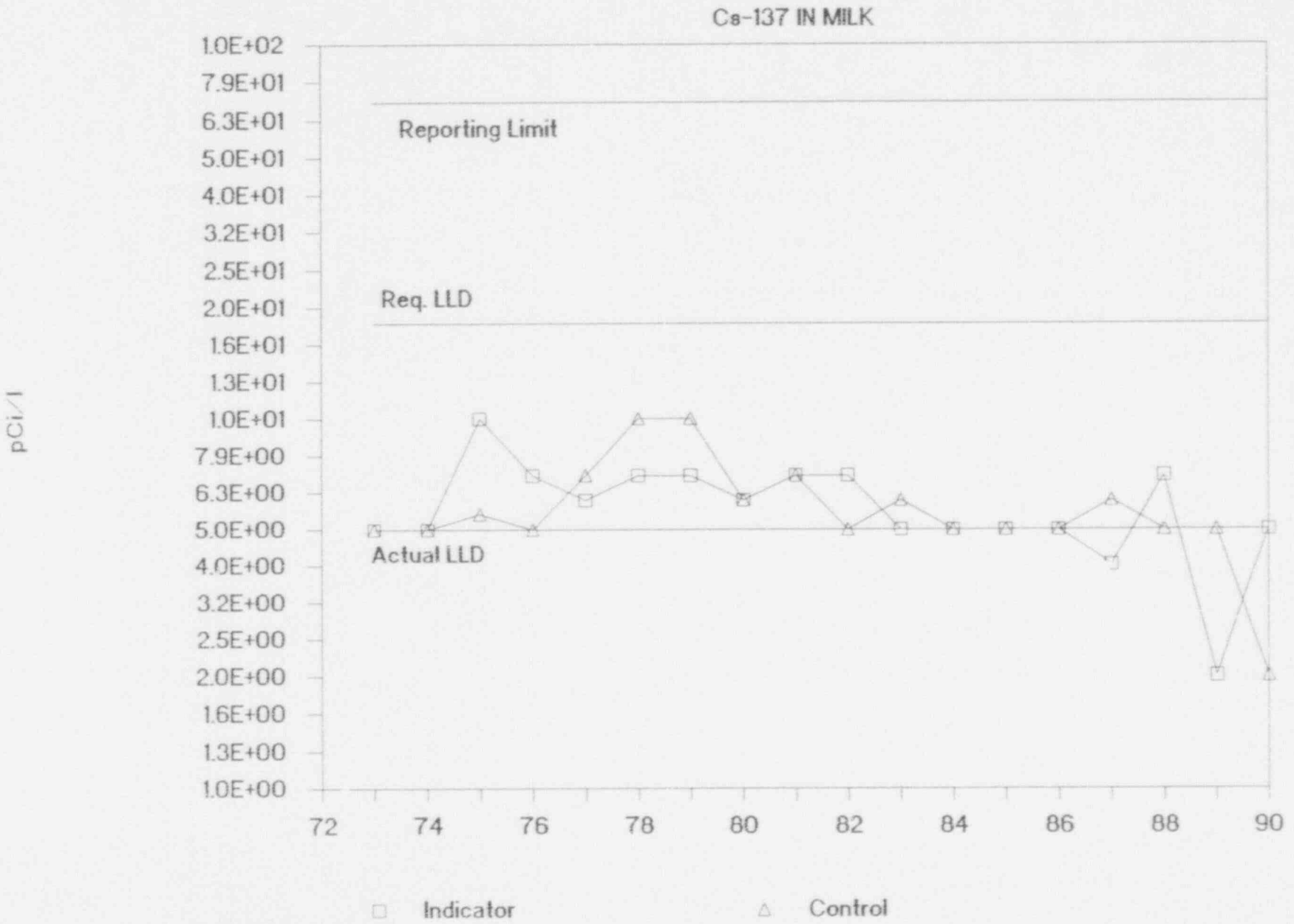
Cs-137 IN MILK
pCi/l
1.0E+02
7.9E+01
6.3E+01
5.0E+01
4.0E+01
3.2E+01
2.5E+01
2.0E+01
1.6E+01
1.3E+01
1.0E+01
7.9E+00
6.3E+00
5.0E+00
4.0E+00
3.2E+00
2.5E+00
2.0E+00
1.6E+00
1.3E+00
1.0E+00
Reporting Limit
Req. LLD
Actual LLD
72
74
76
78
80
82
84
86
88
90
Indicator
Control

TABLE 1.2.1

SAMPLE TYPES AND ANALYSES

Exposure Pathway and/or Sample	Number of Sample Locations*	Sample and Collection Frequency	Type and Frequency of Analyses
1. AIRBORNE			
a. Radioiodine and Particulates	5 locations	Continuous operation of sampler with sample collection as required by dust loading but at least once per 7 days.	Radioiodine canister. Analyze at least once per 7 days for I-131. Particulate sampler. Analyze for gross beta radioactivity $\geq$ 24 hours following filter change. Perform gamma isotopic analysis on each sample when gross beta activity is > 10 times the mean of control sample. Perform gamma isotopic analysis on composite (by location) sample at least every 92 days.
2. DIRECT RADIATION	40 locations 2 dosimeter per location	At least once per 92 days	Gamma dose. At least once per 92 days.

* Sample locations are shown in Table 1.2.2.

TABLE 1.2.1 (Continued)

SAMPLE TYPES AND ANALYSES

Exposure Pathway and/or Sample	Number of Sample Locations*	Sample and Collection Frequency	Type and Frequency of Analyses
3. WATERBORNE			
a. Surface	2 Locations	Composite** sample collected over a period ≤ 31 days.	Gamma isotopic analysis of each sample by location. Tritium analysis of composite sample at least once every 92 days.
b. Ground	2 Locations	At least once per 92 days.	Gamma isotopic and tritium analyses of each sample.
c. Drinking	cation	Monthly grab sample	I-131 analysis of each sample and Gross beta and gamma isotopic analyses of each gamma sample. Tritium analysis of composite sample at least once every 92 days.
d. Sediment from Shoreline	2 Locations	At least once per 184 days	Gamma isotopic analysis of each sample.

* Sample locations are shown in Table 1.2.2.
** Composite samples shall be collected by an aliquot at intervals not exceeding 24 hours.

TABLE 1.2.1 (Continued)

SAMPLE TYPES AND ANALYSES

Exposure Pathway and/or Sample	Number of Sample Locations*	Sample and Collection Frequency	Type and Frequency of Analyses
4. INGESTION			
a. Milk	4 Locations	At least once per 31 days when animals are on pasture.	Gamma isotopic and I-131 analyses of each sample.
b. Fish	2 Locations	One sample in season, or at least once per 184 days if not seasonal. One sample of each of the following species: 1. Catfish 2. Crappie or Bass	Gamma isotopic analysis on edible portions.
c. Food Products**	3 Locations	At time of harvest. One sample of each of the following classes of food products: 1. Fruits 2. Flowering Vegetable 3. Tubular Vegetable	Gamma isotopic analysis on edible portions.
	1 Location	At time of harvest. One sample of broad leaf vegetation.	I-131 analysis.

* Sample locations are shown in Table 1.2.2.
** If these food products are available.

TABLE 1.2.2

ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Sample Station Number: 1
Approximate Direction and Distance from Plant: 88° - 0.6 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation

Sample Station Location:

The sample station is near the meteorology tower approximately 0.6 miles east of ANO.

Sample Station Number: 2
Approximate Direction and Distance from Plant: 235° - 0.4 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation
Sample Station Location:

IF traveling from ANO,
THEN go approximately 0.2 miles west toward Gate 4. Turn left and go approximately 0.1 miles. Turn right and go approximately 0.1 miles. The sample station is on the right at the former AP&L lodge location.

IF traveling south on Flatwood Road,
THEN go approximately 0.25 miles from sample station 109. Veer left at fork in road and go approximately 0.2 miles. Turn right and go approximately 0.1 miles. Turn right and go approximately 0.1 miles. The sample station is on the right at the former AP&L lodge location.

Sample Station Number: 3
Approximate Direction and Distance from Plant: 0° - 0.6 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation
4) Ground water (alternate)

Sample Station Location:

IF traveling west on Highway 333,
THEN go approximately 0.35 miles from Gate 2 at ANO. Turn left onto gravel road and go approximately 0.05 miles. The sample station is on the left.

IF traveling east on Highway 333,
THEN go approximately 0.9 miles from junction of Highway 333 and Flatwood Road. Turn right onto gravel road and go approximately 0.05 miles. The sample station is on the left.

TABLE 1.2.2 (continued)

ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Sample Station Number: 4
Approximate Direction and Distance from Plant: 180° - 0.7 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation

Sample Station Location:

Go approximately 0.25 miles south from bridge over intake canal. Turn right onto gravel road. Proceed approximately 0.1 miles west of May Cemetery entrance. The sample station is on the left approximately 50 feet south of the road.

Sample Station Number: 5
Approximate Direction and Distance from Plant: 298° - 8.2 miles
Sample Types: 1) Direct radiation

Sample Station Location:

While traveling on Highway 64, turn onto Cherry Street in Knoxville, Arkansas and go approximately 0.7 miles. Turn left onto Highway 64 South and go approximately 0.2 miles. The sample station is on the right.

Sample Station Number: 6
Approximate Direction and Distance from Plant: 111° - 7.0 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation

Sample Station Location:

Go to the AP&L local office which is located off Highway 7T in Russellville, Arkansas (305 South Knoxville Avenue). The sample station is in the southeast corner of the back lot.

Sample Station Number: 7
Approximate Direction and Distance from Plant: 209° - 19.3 miles
Sample Types: 1) Airborne radioiodines
2) Airborne particulates
3) Direct radiation

Sample Station Location:

Turn west at junction of Highway 7 and Highway 27 in Dardanelle, Arkansas. Proceed to junction of Highway 27 and Highway 10 in Danville, Arkansas. Turn right onto Highway 10 and proceed a short distance to the AP&L supply yard, which is on the right adjacent to an AP&L substation. The sample station is in the southwest corner of the supply yard.

TABLE 1.2.2 (continued)

ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Sample Station Number: 8
Approximate Direction and Distance from Plant: 180° - 0.1 miles
Sample Types: 1) Surface water (composite)
2) Shoreline sediment
3) Fish

Sample Station Location: Plant discharge canal

Sample Station Number: 10
Approximate Direction and Distance from Plant: 95° - 0.9 miles (shoreline sediment and fish)
plant intake structure (surface water)

Sample Types: 1) Surface water (composite)
2) Shoreline sediment
3) Fish

Sample Station Location:

Surface water (composite) is collected at plant intake structure. Shoreline sediment and fish are collected at plant inlet canal.

Sample Station Number: 13
Approximate Direction and Distance from Plant: 271° - 0.5 miles
Sample Types: 1) Broad leaf vegetation
Sample Station Location:

IF traveling south on Flatwood Road,
THEN go approximately 0.2 miles from sample station 109. The sample station is on the left.

IF traveling west from ANO toward Gate 4,
THEN go approximately 0.4 miles and turn right onto Flatwood Road. Go a short distance (approximately 30 yards). The sample station is on the right.

Sample Station Number: 14
Approximate Direction and Distance from Plant: 70° - 5.3 miles
Sample Types: 1) Drinking water

Sample Station Location:

From junction of Highway 7 and Water Works Road, go approximately 0.8 miles west on Water Works Road. The sample station is on the left at the intake to the Russellville city water system from the Illinois Bayou.

Sample Station Number: 16
Approximate Direction and Distance from Plant: 290° - 5.9 miles
Sample Types: 1) Shoreline sediment

Sample Station Location:

From junction of Highway 64 and Highway 359 (Flat Rock Piney Bay Recreational Area turnoff), go approximately 0.7 miles west on Highway 64. The sample station is at the Piney Creek area on Lake Dardanelle.

Sample Station Number: 19
Approximate Direction and Distance from Plant: 95° - 5.1 miles
Sample Types: 1) Milk

Sample Station Location:

Turn from Highway 7 onto Harrell Drive in Russellville, Arkansas and go approximately 0.1 miles. Turn right and go approximately 0.25 miles. The sample station is on the left at the Arkansas Tech Dairy.

Sample Station Number: 29
Approximate Direction and Distance from Plant: 24° - 6.9 miles
Sample Types: 1) Milk (alternate)

Sample Station Location:

Turn south from Highway 333 onto County Road 141 and go approximately 0.55 miles. Turn left and go approximately 0.6 miles. Turn left and go approximately 0.05 miles. The sample station is on the right at the Harold Steuber Dairy.

Sample Station Number: 32
Approximate Direction and Distance from Plant: 132° - 0.9 miles
Sample Types: 1) Ground water
2) Food products

Sample Station Location:

From bridge over intake canal, go south approximately 0.25 miles. Turn left and go approximately 0.25 miles. Turn left on Bunker Hill Lane and go approximately 0.05 miles. The sample station is on the right at Clifton Stewart's residence.

Sample Station Number: 33
Approximate Direction and Distance from Plant: 94° - 3.8 miles
Sample Types: 1) Ground water

Sample Station Location:

From junction of Highway 64 and Highway 326 (Dike Road), go approximately 0.3 miles east on Dike Road. The sample station is on the left at the Ouita Lake Recreation Area on the Illinois Bayou.

Sample Station Number: 36
Approximate Direction and Distance from Plant: 140° - 0.05 miles
Sample Types: 1) Pond water
2) Pond sediment

Sample Station Location:

The sample station is at the Settling Pond on the ANO site east of the discharge canal.

Sample Station Number: 37
Approximate Direction and Distance from Plant: 0° - 7.5 miles
Sample Types: 1) Milk

Sample Station Location:

IF traveling north on Highway 333,
THEN go approximately 3.5 miles from junction of Highway 333 and Mill Creek Road on Highway 333. Turn left and go approximately 0.1 miles. The sample station is on the left at the Lawrence Steuber Dairy.

IF traveling from junction of Highway 7 and Highway 333,
THEN go approximately 6.0 miles west on Highway 333. Turn right and go approximately 0.1 miles. The sample station is on the left at the Lawrence Steuber Dairy.

Sample Station Number: 38
Approximate Direction and Distance from Plant: 314° - 2.4 miles
Sample Types: 1) Food products (alternate)

Sample Station Location:

From west junction of Highway 64 and Highway 333 in London, Arkansas, go approximately 0.4 miles west on Highway 64. Turn right at Hornet Estate and go approximately 0.1 miles. Turn left and go approximately 0.1 miles. The sample station is on the left at Ronnie Jones' residence.

Sample Station Number: 40
Approximate Direction and Distance from Plant: 119° - 2.2 miles
Sample Types: 1) Food products

Sample Station Location:

From junction of Highway 64 and Highway 326 (Marina Road), go approximately 2.0 miles on Marina Road. The sample station is on the left at Horace Hollis' residence just prior to curve.

Sample Station Number: 41
Approximate Direction and Distance from Plant: 358° - 3.8 miles
Sample Types: 1) Milk

Sample Station Location:

IF traveling from junction of Highway 333 and Mill Creek Road,
THEN go approximately 1.8 miles on Mill Creek Road. Turn right onto Lowe Lane and go approximately 0.1 miles. Turn right and go approximately 0.05 miles. The sample station is on the right at the James Gibson Dairy.

IF traveling from junction of Highway 64 and Mill Creek Road,
THEN go approximately 3.6 miles on Mill Creek Road. Turn left onto Lowe Lane and go approximately 0.1 miles. Turn right and go approximately 0.05 miles. The sample station is on the right at the James Gibson Dairy.

Sample Station Number: 42
Approximate Direction and Distance from Plant: 73° - 12.4 miles
Sample Types: 1) Milk

Sample Station Location:

From junction of Highway 124 and Highway 326 in Gum Log, Arkansas, go approximately 1.1 miles northeast on Highway 124. Turn left onto Gravel Hill Road and go approximately 0.6 miles. Turn right onto Hudson Loop and go approximately 0.3 miles. The sample station is on the left at the Hudson Dairy.

Sample Station Number: 43
Approximate Direction and Distance from Plant: 295° - 4.2 miles
Sample Types: 1) Goat milk

Sample Station Location:

From west junction of Highway 64 and Highway 333 in London, Arkansas, go west on Highway 64 approximately 2.5 miles. Turn right and go approximately 0.2 miles. The sample station is on the right at True-X-Farms.

Sample Station Number: 45
Approximate Direction and Distance from Plant: 90° - 0.9 miles
Sample Types: 1) Broad leaf vegetation

Sample Station Location:

The sample station is located near mouth of intake canal.

Sample Station Number: 46
Approximate Direction and Distance from Plant: 295° - 4.1 miles
Sample Types: 1) Food products

Sample Station Location:

From west junction of Highway 64 and Highway 333 in London, Arkansas, go west on Highway 64 approximately 2.4 miles. Turn right onto Scottie Lane and go approximately 0.1 miles. The sample location is on the right at Dewey Gregory's residence.

Sample Station Number: 108
Approximate Direction and Distance from Plant: 301° - 0.9 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling from Highway 333,
THEN turn south onto Flatwood Road and go approximately 0.4 miles. The sample station is on a utility pole on the right.

IF traveling north on Flatwood Road,
THEN go approximately 0.4 miles from sample station 109. The sample station is on a utility pole on the left.

Sample Station Number: 109
Approximate Direction and Distance from Plant: 285° - 0.5 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling south on Flatwood Road,
THEN go approximately 0.4 miles from sample station 108. Sample station 109 is on a utility pole on the left across from the junction of Flatwood Road and Round Mountain Road just before pavement ends.

IF traveling west from ANO toward Gate 4,
THEN go approximately 0.4 miles and turn right onto Flatwood Road. Go approximately 0.2 miles. The sample station is on a utility pole on the right across from the junction of Flatwood Road and Round Mountain Road just after pavement begins.

Sample Station Number: 110
Approximate Direction and Distance from Plant: 138° - 0.8 miles
Sample Types: 1) Direct radiation

Sample Station Location:

From bridge over intake canal, go south approximately 0.25 miles. Turn left and go approximately 0.25 miles. Turn right on Bunker Hill Lane. The sample station is on the first utility pole on the left.

Sample Station Number: 111
Approximate Direction and Distance from Plant: 121° - 2.2 miles
Sample Types: 1) Direct radiation

Sample Station Location:

From junction of Highway 64 and Highway 326 (Marina Road), go approximately 2.1 miles on Marina Road. The sample station is on a utility pole on the left just prior to curve.

Sample Station Number: 112
Approximate Direction and Distance from Plant: 74° - 2.6 miles
Sample Types: 1) Direct radiation

Sample Station Location:

Go to the junction of Highway 64 and the I-40 exit which is approximately 1.3 miles east of sample station 113. Sample station 112 is on a utility pole on the northeast corner of the junction.

Sample Station Number: 113
Approximate Direction and Distance from Plant: 52° - 1.5 miles
Sample Types: 1) Direct radiation

Sample Station Location:

Go to the east junction of Highway 333 and Highway 64. The sample station is on a utility pole on the southwest corner of the junction.

ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Sample Station Number: 114
Approximate Direction and Distance from Plant: 31° - 1.3 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling west on Highway 64,
THEN go approximately 0.6 miles west of the east junction of Highway 64 and Highway 333. The sample station is on a utility pole on the right.

IF traveling east on Highway 64,
THEN go approximately 1.1 miles from sample station 115. Sample station 114 is on a utility pole on the left.

Sample Station Number: 115
Approximate Direction and Distance from Plant: 344° - 1.4 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling west on Highway 64,
THEN go approximately 1.1 miles west of sample station 114. Sample station 115 is on a utility pole on the right.

IF traveling east on Highway 64,
THEN go approximately 0.8 miles from the west junction of Highway 64 and Highway 333 in London, Arkansas. The sample station is on a utility pole on the left.

Sample Station Number: 116
Approximate Direction and Distance from Plant: 320° - 1.8 miles
Sample Types: 1) Direct radiation

Sample Station Location:

Go one block south of the west junction of Highway 333 and Highway 64 in London, Arkansas. The sample station is on a utility pole north of the railroad tracks.

Sample Station Number: 117
Approximate Direction and Distance from Plant: 305° - 17.2 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling west on I-40,
THEN take Exit 58 at Clarksville, Arkansas. Turn right onto Rogers Street. At junction of Rogers Street and Highway 64, turn left and proceed west to first stop light. Turn left onto Cravens Street. The sample station is on a utility pole on the right between the county courthouse and the post office.

IF traveling west on Highway 64,
THEN go to first stop light past junction of Rogers Street and Highway 64. Turn left onto Cravens Street. The sample station is on a utility pole on the right between the county courthouse and the post office.

Sample Station Number: 118
Approximate Direction and Distance from Plant: 294° - 5.6 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling east on Highway 64,
THEN go approximately 0.3 miles from bridge which goes across Piney. The sample station is on a utility pole on the left.

IF traveling west on Highway 64,
THEN go approximately 0.4 miles past Flat Rock Piney Bay Recreational Area turnoff. The sample station is on a utility pole on the right.

Sample Station Number: 119
Approximate Direction and Distance from Plant: 309° - 4.8 miles
Sample Types: 1) Direct radiation

Sample Station Location:

Turn west from Highway 333 onto Will Baker Road, which intersects Highway 333 approximately 1.4 miles north of the I-40 Overpass near London, Arkansas. Go approximately 2.0 miles. The sample station is on a utility pole on the left just prior to pavement ending.

Sample Station Number: 120
Approximate Direction and Distance from Plant: 336° - 4.2 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling from I-40 Overpass in London, Arkansas,
THEN go north on Highway 333 approximately 2.4 miles. The sample station is on a utility pole on the right near Martin Chapel.

IF traveling from junction of Mill Creek Road and Highway 333,
THEN go approximately 1.0 mile south on Highway 333. The sample station is on a utility pole on the left near Martin Chapel.

Sample Station Number: 121
Approximate Direction and Distance from Plant: 349° - 4.6 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling from I-40 Overpass in London, Arkansas,
THEN go north on Highway 333 approximately 3.4 miles to Mill Creek Road. Turn right onto Mill Creek Road and go approximately 0.7 miles. The sample station is on a utility pole on the right.

IF traveling northwest on Mill Creek Road,
THEN go approximately 0.4 miles past East Point Baptist Church and Cemetery. The sample station is on a utility pole on the left.

ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Sample Station Number: 122
Approximate Direction and Distance from Plant: 18° - 3.3 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling north from junction of Highway 64 and Mill Creek Road,
THEN go approximately 2.5 miles. The sample station is on a utility pole on the right.

IF traveling southeast on Mill Creek Road,
THEN go approximately 1.9 miles from East Point Baptist Church. The sample station is on a utility pole on the left.

Sample Station Number: 123
Approximate Direction and Distance from Plant: 46° - 3.5 miles
Sample Types: 1) Direct radiation

Sample Station Location:

Turn north from Pleasant View Road onto Ball Hill Road and go approximately 0.8 miles. The sample station is on a utility pole on the left.

Sample Station Number: 124
Approximate Direction and Distance from Plant: 60° - 3.2 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling from junction of Highway 64 and Mill Creek Road,
THEN go north on Mill Creek Road approximately 0.7 miles. Turn right onto Pleasant View Road and go approximately 1.3 miles. The sample station is on the right on a utility pole which is across from a siren and below a transmission line.

IF traveling west from junction of Highway 7 and Pleasant View Road,
THEN go approximately 3.1 miles. The sample station is on the left on a utility pole which is across from a siren and below a transmission line.

Sample Station Number: 125
Approximate Direction and Distance from Plant: 46° - 9.1 miles
Sample Types: 1) Direct radiation

Sample Station Location:

While traveling north on Highway 7, turn left onto Water Street in Dover, Arkansas. Go one block and turn left onto South Elizabeth Street. Go one block and turn right onto College Street. The sample station is on a utility pole at the southeast corner of the red brick school building, which is located on top of hill.

ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Sample Station Number: 126
Approximate Direction and Distance from Plant: 81° - 5.5 miles
Sample Types: 1) Direct radiation

Sample Station Location:

The sample station is located on the west side of Highway 7 directly across from Shiloh Road, which is approximately 1.3 miles north of the junction of Highway 7 and Dike Road.

Sample Station Number: 127
Approximate Direction and Distance from Plant: 102° - 5.6 miles
Sample Types: 1) Direct radiation

Sample Station Location:

The sample station is located on the Arkansas Tech Campus on West O Street on a security light pole in front of Bryan Hall, which is the first building on the left when traveling from North Arkansas on West O Street.

Sample Station Number: 128
Approximate Direction and Distance from Plant: 113° - 8.6 miles
Sample Types: 1) Direct radiation

Sample Station Location:

The sample station is on a utility pole inside the security fence near the Russellville Airport Office. The airport is located off of East 16th Street and is well marked by airport signs.

Sample Station Number: 129
Approximate Direction and Distance from Plant: 118° - 7.3 miles
Sample Types: 1) Direct radiation

Sample Station Location:

The sample station is on a utility pole north of the Russellville High School sign, which is in front of high school on east side of Highway 7T.

Sample Station Number: 130
Approximate Direction and Distance from Plant: 245° - 4.6 miles
Sample Types: 1) Direct radiation

Sample Station Location:

At junction of Highway 7 and Highway 22 in Dardanelle, Arkansas, take Highway 22 toward Delaware, Arkansas. Go approximately 0.4 miles west of Delaware Recreation Area turnoff. The sample station is on a utility pole on the right in Delaware, Arkansas near Shirley's Beauty Salon.

TABLE 1.2.2 (continued)

ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Sample Station Number: 131
Approximate Direction and Distance from Plant: 244° - 2.4 miles
Sample Types: 1) Direct radiation

Sample Station Location:

Turn north from Highway 22 onto Highway 393 at Delaware Recreation Area turnoff and go approximately 2.9 miles. The sample station is located past the boat ramp on an oak tree near crosstie steps in northeast quadrant of circle drive.

Sample Station Number: 132
Approximate Direction and Distance from Plant: 267° - 5.8 miles
Sample Types: 1) Direct radiation

Sample Station Location:

Turn north from Highway 22 onto Highway 393 at Delaware Recreation Area turnoff and go approximately 0.9 miles. Turn left onto dirt road and go approximately 2.3 miles. The sample station is on a utility pole on the right.

Sample Station Number: 133
Approximate Direction and Distance from Plant: 233° - 3.7 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling west on Highway 22,
THEN go approximately 2.0 miles from sample station 134. Sample station 133 is on the south side of the Highway 22 causeway attached to the first NO PARKING ANY TIME sign west of the bridge.

IF traveling east on Highway 22 from Delaware, Arkansas,
THEN go approximately 0.8 miles from Delaware Recreation Area turnoff. The sample station is on the south side of the Highway 22 causeway attached to the first NO PARKING ANY TIME sign west of the bridge.

Sample Station Number: 134
Approximate Direction and Distance from Plant: 200° - 2.8 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling west on Highway 22,
THEN go approximately 0.8 miles from sample station 135. Sample station 134 is on a utility pole on the right at Mockingbird Lane.

IF traveling east on Highway 22,
THEN go approximately 2.0 miles from sample station 133. Sample station 134 is on a utility pole on the left at Mockingbird Lane.

TABLE 1.2.2 (continued)

ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Sample Station Number: 135
Approximate Direction and Distance from Plant: 188° - 3.2 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling northwest on Highway 22,
THEN go approximately 1.7 miles from sample station 136. Sample station 135 is on a utility pole on the right.

IF traveling east on Highway 22,
THEN go approximately 0.8 miles from sample station 134. Sample station 135 is on a utility pole on the left.

Sample Station Number: 136
Approximate Direction and Distance from Plant: 168° - 4.3 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling west on Highway 22,
THEN go approximately 3.7 miles from junction of Highway 22 and Highway 7. The sample station is on the right on the first utility pole west of the Little Hays Creek Bridge.

IF traveling east on Highway 22,
THEN go approximately 1.7 miles from sample station 135. Sample station 136 is on the left on the first utility pole west of the Little Hays Creek Bridge.

Sample Station Number: 137
Approximate Direction and Distance from Plant: 150° - 8.4 miles
Sample Types: 1) Direct radiation

Sample Station Location:

At junction of Highway 7 and Highway 28 in Dardanelle, Arkansas, go approximately 0.2 miles on Highway 28. The sample station is on a speed limit sign on the right in front of the Morris R. Moore Arkansas National Guard Armory.

Sample Station Number: 138
Approximate Direction and Distance from Plant: 193° - 5.8 miles
Sample Types: 1) Direct radiation

Sample Station Location:

At junction of Highway 22 and Highway 155 (Mt. Nebo Road) in Dardanelle, Arkansas, turn west and go to top of mountain. Veer right at stop sign and proceed toward Sunset Point. The sample station is down a dirt road on the right which is approximately 0.1 miles southeast of Sunset Point. The sample station is on the left side of the dirt road on a utility pole near a TV tower.

TABLE 1.2.2 (continued)

ENVIRONMENTAL SAMPLING STATIONS - RADIOLOGICAL

Sample Station Number: 139
Approximate Direction and Distance from Plant: 178° - 19.2 miles
Sample Types: 1) Direct radiation

Sample Station Location:

Take Highway 7 South through Dardanelle, Arkansas to Ola, Arkansas. Turn left at junction of Highway 7 and Highway 10 West in Ola, Arkansas and go approximately ½ block. The sample station is on a utility pole on the left in front of the U.S. Post Office.

Sample Station Number: 140
Approximate Direction and Distance from Plant: 151° - 21.8 miles
Sample Types: 1) Direct radiation

Sample Station Location:

Proceed through Ola, Arkansas and take Highway 10 East to Casa, Arkansas, which is in Perry County. Turn right at the Perry-Casa High School. The sample station is on a utility pole at the southwest corner of the school.

Sample Station Number: 141
Approximate Direction and Distance from Plant: 125° - 3.8 miles
Sample Types: 1) Direct radiation

Sample Station Location:

While traveling southwest on Highway 326 (Marina Road), go approximately 2.4 miles from sample station 111. Sample station 141 is on the right on a utility pole, which is approximately 50 yards east of a transmission line. (The sample station is approximately 0.35 miles west of the junction of Hilltop Drive and Marina Road).

Sample Station Number: 142
Approximate Direction and Distance from Plant: 129° - 5.1 miles
Sample Types: 1) Direct radiation

Sample Station Location:

The sample station is on a utility pole at the junction of Skyline Drive and Nordin Lane in Russellville, Arkansas near a peach orchard.

Sample Station Number: 143
Approximate Direction and Distance from Plant: 106° - 17.5 miles
Sample Types: 1) Direct radiation

Sample Station Location:

IF traveling east on Highway 64 to Atkins, Arkansas,
THEN turn left at junction of Highway 64 and North Church Street. Proceed north. The sample station is on a utility pole on the left in front of Atkins High School near stop sign at corner of North Church Street and Northeast 3rd Street.

IF traveling east on Interstate 40,
THEN take Exit 94 at Atkins, Arkansas. Turn left onto North Church Street and proceed south. The sample station is on a utility pole on the right in front of Atkins High School near stop sign at corner of North Church Street and Northeast 3rd Street.

Sample Station Number: 144
Approximate Direction and Distance from Plant: 313° - 12.7 miles
Sample Types: 1) Direct radiation

Sample Station Location:

While traveling on Highway 64, turn south onto Cumberland Street in Lamar, Arkansas and go approximately 0.7 miles. Veer left at stop sign. The sample station is on a utility pole across the one way fire lane in front of Lamar Elementary School.

TABLE 2.0.1

MAXIMUM VALUES OF THE LOWER LIMITS OF DETECTION (LLD)

Analyses	Water (pCi/l)	Airborne Particulate or Gas (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/l)	Food Products (pCi/kg, wet)	Sediment (pCi/kg, dry)
gross beta	4[a]	1×10^{-2}				
H-3	1000[a]					
Mn-54	15		130			
Fe-59	30		260			
Co-58, Co-60	15		130			
Zn-65	30		260			
Zr-Nb-95	15					
I-131	1*[a]	7×10^{-2}		1	60[b]	
Cs-134,Cs-137	15(10[a]),18	1×10^{-2}	130, 150	15, 18	60, 80	150, 180
Ba-La-140	15			15		

* For Monthly grab samples (a) LLD for drinking water (b) LLD for leafy vegetables

TABLE 2.0.2

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Analyses	Water (pCi/l)	Airborne Particulate or Gas (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/l)	Food Products (pCi/kg, wet)
H-3	3×10^4[a]				
Mn-54	1×10^3		3×10^4		
Fe-59	4×10^2		1×10^4		
Co-58	1×10^3		3×10^4		
Co-60	3×10^2		1×10^4		
Zn-65	3×10^2		2×10^4		
Zr-Nb-95	4×10^2[b]				
I-131	2	0.9		3	1×10^2
Cs-134	30	10	1×10^3	60	1×10^3
Cs-137	50	20	2×10^3	70	2×10^3
Ba-La-140	2×10^2[b]			3×10^2[b]	

(a) For drinking water samples.
(b) Total for parent and daughter.

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY: ANO-1 AND ANO-2 DOCKET NO.: 50-313 AND 50-368

LOCATION OF FACILITY: POPE, ARKANSAS (COUNTY, STATE) REPORTING PERIOD: JANUARY - DECEMBER 1990

TABLE 2.1.1

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL & TYPE OF ANALYSIS	LLD	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN ME DIR. (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
I. Air							
A. Particulates (pCi/m^3)	Gross β 318	0.01	0.020 (261/265) (0.006 - 0.047)	#1 0.6 mi-88°	0.022 (52/53) (0.008-0.040)	0.021 (52/53) (0.010-0.047)	0
	Gamma 24		< LLD (0/20)		< LLD	< LLD (0/4)	0
B. Air Iodine (pCi/m^3)	I-131 318	0.07	< LLD (0/265)		< LLD (0/53)	< LLD (0/53)	0
C. Direct Radiation (mrem/quarter)	TLDS 161	5	26.4 (157/157) (14 - 40)	#124 3.2 mi-60°	34 (4/4) (28-39)	29 (4/4) (25-32)	0
II. Water							
A. Lake Water (pCi/ℓ)							
	Gamma 24						
	Co-58		12(1/12)	#8 0.1 mi. 180°	12 (1/12)	< LLD (0/12)	0
	H-3 8	400	744 (4/4) (340-1050)	#8 0.1 mi. 180°	744 (4/4) (340-1050)	340 (1/4)	

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY: ANO-1 AND ANO-2 DOCKET NO.: 50-313 AND 50-368

LOCATION OF FACILITY: POPE, ARKANSAS REPORTING PERIOD: JANUARY - DECEMBER 1990
(COUNTY, STATE)

TABLE 2.1.1 (Continued)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL & TYPE OF ANALYSIS	LLD	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
B. Bottom Sediments (dry weight)	Gamma 6						
	Mn-54	30	204 (2/2) (83-325)	#8 0.1 mi. 180°	204 (2/2) (83-325)	12 (1/4)	0
(pCi/kg)	Co-58	40	126 (1/2)	#8 0.1 mi. 180°	126 (1/2)	< LLD (0/4)	0
(Split with Ark. Dept. of Health)	Co-60	40	304 (2/2) (278-329)	#8 0.1 mi. 180°	304 (2/2) (278-329)	< LLD (0/4)	0
	Cs-134	30	290 (2/2) (200-379)	#8 0.1 mi. 180°	290 (2/2) (200-379)	< LLD (0/4)	0
	Cs-137	30	2087 (2/2) (2020-2154)	#8 0.1 mi. 180°	2087 (2/2) (2020-2154)	382 (4/4) (188-850)	0
	Ag-110m	100	690 (1/2)	#8 0.1 mi. 180°	690 (1/2)	< LLD (0/4)	0
C. Ground Water (pCi/ℓ)	Gamma 8		< LLD		< LLD		0
	H-3 8	400	455 (1/8)	#33 3.8 mi. 94°	455 (1/4)		0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY: ANO-1 AND ANO-2 DOCKET NO.: 50-313 AND 50-368

LOCATION OF FACILITY: POPE, ARKANSAS (COUNTY, STATE) REPORTING PERIOD: JANUARY - DECEMBER 1990

TABLE 2.1.1 (Continued)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL & TYPE OF ANALYSIS	LLD	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
D. Russellville City Water (pCi/ℓ)	Gross β 13	4	3.8 (9/13)	#14 5.3 mi. 70°	3.8 (9/13)		0
	Gamma 13		< LLD (0/13)		< LLD		0
	H-3 4	500	580 (1/4)	#14 5.3 mi. 70°	580 (1/4)		0
	Low-Level I-131 12	1	0.5 (1/12)	#14 5.3 mi. 70°	0.5 (1/12)		0
E. Aquatic Biota							
1. Fish Flesh (wet weight) (pCi/kg)	Gamma 8 Cs-134	10	4 (2/4) (4-5)	#8 0.1 mi. 180°	4 (2/4) (4-5)	< LLD (0/4)	0
	Cs-137	10	20 (4/4) (10-26)	#8 0.1 mi. 180°	20 (4/4) (10-26)	18 (2/4) (12-23)	0
2. Edible portion of sport fish split with ADH	Gamma 3 Cs-134	10	< LLD		< LLD	< LLD (0/1)	0
	Cs-137	10	17 (2/2) (16-18)	#8 0.1 mi	17 (2/2) (16-18)	18 (1/1)	0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY: ANO-1 AND ANO-2 DOCKET NO.: 50-313 AND 50-368

LOCATION OF FACILITY: POPE, ARKANSAS (COUNTY, STATE) REPORTING PERIOD: JANUARY - DECEMBER 1990

TABLE 2.1.1 (Continued)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL & TYPE OF ANALYSIS	LLD	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
F. Lake Water Split with ADH	Gamma 24 Co-58		3 (1/12)	#8 0.1 mi. 180°	3 (1/2)	< LLD	0
(pCi/ℓ)	H-3 24	400	1511 (8/12) (310-2320)	#8 0.1 mi. 180°	1511 (8/12) (310-2320)	400 (3/12) (310-560)	0
III. Terrestrial							
A. Milk (pCi/ℓ)	Gamma 59						
	Cs-137	5	< LLD (0/47)		< LLD	2 (1/12)	0
	I-131 by Chemical Separation-60	1.0	0.2 (4/47) (0.2-0.3)	#43 4.2 mi. 295°	0.3 (1/12)	0.4 (2/12) (0.3 - 0.4)	0
B. Vegetation	Gamma 9						
1. Food Products (wet weight) (pCi/kg)	I-131	60	< LLD (0/9)				0
	Cs-134	60	< LLD (0/9)				0
	Cs-137	80	< LLD (0/9)				0

ENVIRONMENTAL RADIOLOGICAL MONITORING PROGRAM SUMMARY

NAME OF FACILITY: ANO-1 AND ANO-2 DOCKET NO.: 50-313 AND 50-368

LOCATION OF FACILITY: POPE, ARKANSAS REPORTING PERIOD: JANUARY - DECEMBER 1990
(COUNTY, STATE)

TABLE 2.1.1 (Continued)

MEDIUM OR PATHWAY (UNIT OF MEASUREMENT)	TOTAL & TYPE OF ANALYSIS	LLD	ALL INDICATOR LOCATIONS MEAN RANGE	LOCATION WITH HIGHEST ANNUAL MEAN NAME DIST. & DIR. (MI) (DEG)	MEAN RANGE	CONTROL LOCATION MEAN RANGE	NNR
2. Food Products split with ADH	Gamma 4						
	I-131	60	< LLD (0/4)				0
(Wet Weight)	Cs-134	60	< LLD (0/4)				0
(pCi/kg)	Cs-137	80	< LLD (0/4)				0
3. Broad leaf (pCi/kg)	Gamma 6						
	I-131	60	< LLD (0/6)				0
	Cs-134	60	< LLD (0/6)				0
	Cs-137	80	< LLD (0/6)				0

TABLE 2.1.2

ANNUAL DIRECT RADIATION MEASURED BY

THERMOLUMINESCENT DOSIMETERS (mrem/year)

	Indicator Locations	Control Location
Years	Quarterly Readings	Quarterly Readings
1973*	76	84
1974*	100	130
1986	54	51
1987**	93	86
1988**	92	97
1989**	83	89
1990**	106	116

* Preoperational monitoring

** Calcium sulfate dosimeters manufactured by Panasonic, Inc.

TABLE 2.2.1

CALCULATION OF MAXIMUM ANNUAL DOSE TO MAN

FROM BOTTOM SEDIMENT SAMPLE

BS08-S (900289)

(02/10/90)

ANO Discharge Canal

Isotope	Activity (pCi/Kg)	Dose to Skin (mrem/yr)	Dose to Whole Body (mrem/yr)
Ag-110m	690	0.0039	0.0033
Mn-54	325	0.0006	0.0005
Co-58	126	0.0003	0.0002
Co-60	329	0.0018	0.0015
Cs-134	379	0.0014	0.0012
Cs-137	2020	0.0026	0.0023
	TOTAL	0.0106	0.0090

NOTE: Dose calculations made according to the guidance of Nuclear Regulatory Commission Regulatory Guide 1.109, using the equation:

$R(mrem/yr) = C(pCi/Kg)\ (40\ Kg/m^2) * U(hr/yr) * D(mrem/hr\ per\ pCi/m^2) * W$

Where:
R is the annual dose to an organ or whole body
C is concentration of a particular nuclide
U is the maximum exposure time (67 hours for teen)
D is the dose factor
W is the discharge canal bank exposure ratio which is equal to 0.1

TABLE 2.2.2

COMPARISON OF GAMMA-EMITTING RADIONUCLIDES

IN SPORT FISH FROM THE ANO DISCHARGE CANAL

Date	Cs-134 (pCi/Kg)	Cs-137 (pCi/Kg)
April, 1986	36	95
October, 1986	41	93
April, 1987	26	59
October, 1987	53	161
November, 1988	12	38
April, 1989	6	31
October, 1989	10	49
June, 1990	<5	16
October, 1990	<6	18

TABLE 2.5.1

EPA CROSS-CHECK RESULTS

EPA PREP DATE	DATE EPA ISSUED RESULTS	MEDIA	NUCLIDE	EPA RESULTS	AP&L RESULTS	NORM DEV. KNOWN
10/31/89	01/23/90	Water Sample B (pCi/L)	Gross B	32.00	30.00	-0.69
			Cs-134	5.00	5.67	0.23
			Cs-137	5.00	5.67	0.23
01/26/90	03/30/90	Water (pCi/L)	Gross B	12.00	11.33	-0.23
02/09/90	03/30/90	Water (pCi/L)	Co-60	15.0	15.0	0
			Zn-65	139.0	133.67	-0.66
			Ru-106	139.0	145.33	0.78
			Cs-134	18.0	17.67	-0.12
			Cs-137	18.0	17.67	-0.12
			Ba-133	74.0	85.0	2.72
02/23/90	03/30/90	Water (pCi/L)	H-3	4976.0	5226.67	0.87
03/30/90	06/29/90	Air Filter (pCi/filter)	Gross B	31.0	34.0	1.04
			Cs-137	10.0	15.0	1.73
04/17/90	07/08/90	Water Sample B (pCi/L)	Gross B	52.0	47.0	-1.73
			Cs-134	15.0	17.33	0.81
			Cs-137	15.0	14.33	-0.23
05/11/90	07/10/90	Water (pCi/L)	Gross B	15.0	11.33	-1.27
04/27/90	07/27/90	Milk (pCi/L)	I-131	99.0	99.33	0.06
			Cs-137	24.0	22.33	-0.58
			Potassium	1550.0	1493.33	-1.26
Analytics, #CC35386-74	08/06/90	Analytics, Inc. Iodine Cartridge (µCi/cc)	I-131	3.17E-1	3.15E-1	Ratio: 0.99 Env. Lab: Analytics, Inc.
06/08/90	08/07/90	Water (pCi/L)	Co-60	24.0	26.0	0.69
			Zn-65	148.0	144.67	-0.38
			Ru-106	210.0	194.0	-0.13
			Cs-134	24.0	25.0	0.35
			Cs-137	25.0	26.0	0.35
06/22/90	08/07/90	Water (pCi/L)	H-3	2933.0	3350.0	2.02

TABLE 2.5.1 (Continued)

EPA PREP DATE	DATE EPA ISSUED RESULTS	MEDIA	NUCLIDE	EPA RESULTS	AP&L RESULTS	NORM DEV. KNOWN
08/10/90	10/03/90	Water (pCi/L)	I-131	39.0	40.0	0.29
09/21/90	10/10/90	Water (pCi/L)	Gross B	10.0	14.0	1.39
10/19/90	12/05/90	Water (pCi/L)	H-3	7203	8100	2.16
09/20/90	12/10/90	Milk (pCi/L)	I-131	58.0	56.00	-0.58
			Cs-137	20.0	20.0	0
10/05/90	12/17/90	Water (pCi/L)	Co-60	20.0	20.33	0.12
			Zn-65	115.0	118.67	0.53
			Ru-106	151.0	142.33	-1.00
			Cs-134	12.0	12.33	0.12
			Cs-137	12.0	13.00	0.35
			Ba-133	110.0	106.00	-0.63
08/31/90	12/12/90	Air Filter (pCi/Filter)	Beta	62.0	62.67	0.23
			Cs-137	20.0	28.0	2.77
Fourth Qtr. 1990 CC36036-74	01/11/91	Analytics, Inc. Iodine Cartridge (µCi/cc)	I-131	3.18E-2	3.43E-2	1.08 Ratio

TABLE 4.0.1

LAND USE CENSUS OF NEAREST RESIDENCES AND GARDENS

(Conducted July 26, 27, 31, 1990)

SECTOR	NAME	ADDRESS	LOCATION
1	a) Thomas Smith	Box 110 Hwy. 64	1° - 1.2 mi.
	b) V. Turner	Box 111 Hwy.64.	1° - 1.2 mi.
	c) Lynn (G)	Rt. 3, Box 136 Hwy. 333	5° - 0.7 mi.
	d) P. Horton	Rt. 3, Box 45 Hwy. 64	355°-1.3 mi.
	e) Duncan	Rt. 3, Box 45 Hwy. 64	355°-1.3 mi.
	f) Anderson	Rt. 3, Box 117C Hwy. 64	355°-1.3 mi.
	g) Jan Phillips	Rt. 3, Box 117C Hwy. 64	355°-1.3 mi.
	h) C. W. Gohman	Rt. 3, Box 99 Hwy. 64	0° - 1.3 mi.
	i) Kay Anderson	Rt. 3, Box 99 Hwy. 64	0° - 1.3 mi.
	j) Don Wilson	Rt. 3, Box 99 Hwy. 64	0° - 1.3 mi.
	k) Bill Hoerr	Rt. 3, Box 99 Hwy. 64	0° - 1.3 mi.
	l) Bill Minick	Rt. 3, Box 99 Hwy 64	0° - 1.3 mi.
	m) W. Bennet	Rt. 3, Box 47 Hwy. 64	355°-1.3 mi.
	n) Bocksnick	Rt. 3, Box 94A Hwy. 64	355°-1.3 mi.
	o) Caldwell	Rt. 3, Box 94B Hwy. 64	355°-1.3 mi.
	p) Langford	Rt. 3, Box 94C Hwy. 64	355°-1.3 mi.

TABLE 4.0.1 (Continued)

SECTOR	NAME	ADDRESS	LOCATION
2	a) C. H. White	Rt. 3, Box 120 Hwy. 64	24°-1.3 mi.
	b) W. W. Hale (G)	Rt. 3, Box 90 Hwy. 64	15°-1.3 mi.
	c) Huffman	Rt. 3, Box 122 Hwy. 64	20°-1.3 mi.
	d) Brafford	Rt. 3, Box 93 Hwy. 64	20°-1.3 mi.
	e) Shields (G)	Rt. 3, Box 121A Hwy. 64	20°-1.3 mi.
3	a) G. Murray (G)	44 Gum Lane off Hwy. 333	40°-0.9 mi.
	b) R. Horn	Hwy. 64	40°-0.9 mi.
	c) Dunn	Rt. 3, Box Hwy. 64	35°-1.3 mi.
	d) Bill Murray	40 Gum Lane off Hwy. 333	40°-0.9 mi.
4	a) George	Rt. 3, Box 158A off Hwy. 333	80°-0.8 mi.
	b) Russell	Russell Lane off Hwy. 333	70°-1.1 mi.
	c) Bobo	Russell Lane off Hwy. 333	70°-1.1 mi.
	d) Bailey	Russell Lane off Hwy. 333	70°-1.1 mi.
	e) Rick Carnahan	Russell Lane off Hwy. 333	70°-1.1 mi.
	f) James Husereau (G)	Gum Lane, Box 127 off Hwy. 333	65°-0.8 mi.
	g) Rigby	19 Gum Lane off Hwy. 333	60°-0.9 mi.
	h) Keith Murray	26 Gum Lane off Hwy. 333	60°-0.9 mi.
	i) Mitchell	30 Gum Lane	60°-0.9 mi.
	j) Jack McCurly	9 Gum Lane off Hwy. 333	65°-0.9 mi.

TABLE 4.0.1 (Continued)

SECTOR	NAME	ADDRESS	LOCATION
	k) R. W. Howerton	1 Gum Lane off Hwy. 333	65°-0.9 mi.
	l) Porter	3 Gum Lane off Hwy. 333	65°-0.9 mi.
	m) Muller	13 Gum Lane	65°-0.9 mi.
	n) Hebert	Gum Lane	65°-0.9 mi.
5	a) Col. Lambert (G)	Rt. 3, Box 157 off Hwy. 333	87°-0.9 mi.
	b) Odus Bibler	Bibler Lane off Hwy. 333	87°-0.9 mi.
	c) Hegeman	Hwy. 333 off Hwy. 333	80°-0.9 mi.
6	a) Wetecki	155 Scott Lane	150°-0.9 mi.
	b) Cravens (G)	155E Scott Lane	110°-0.9 mi.
	c) Gene Weldon	Scott Lane	105°-0.9 mi.
7	a) Clifton Stewart (G)	Rt. 3, Box 147 Bunker Hill Lane	140°-0.8 mi.
	b) W. R. Rabb	Rt. 3, Box 151 Bunker Hill Lane	140°-0.8 mi.
	c) M. A. Wood	Rt. 3, Box 152 Bunker Hill Lane	140°-0.8 mi.
	d) Victor Roe	Rt. 3, Box 149 Bunker Hill Lane	140°-0.8 mi.
	e) Rhodes	Rt. 3, Box 148 Bunker Hill Lane	140°-0.8 mi.
	f) McMurtrey	Rt. 3, Box 146 Bunker Hill Lane	140°-0.8 mi.
	g) Betty Horton	Rt. 3, Box 145 Bunker Hill Lane	140°-0.8 mi.
	h) W. J. Valley	Rt. 3, Box 143 Bunker Hill Lane	140°-0.8 mi.
	i) Alford	Rt. 3, Box 139 Bunker Hill Lane	140°-0.8 mi.
8	a) W. Wade	Rt. 3, Box 153 Bunker Hill Lane	150°-0.8 mi.

TABLE 4.0.1 (Continued)

SECTOR	NAME	ADDRESS	LOCATION
	b) Jennie Pfeifer (G)	Rt. 3, Box 212 off Hwy. 22	155°-4.9 mi.
	c) Wayne Mellon (G)	Box 210 Hwy. 22	155°-4.9 mi.
9	a) Grady (G)	Rt. 2, Box 1201 north of Hwy. 22	190°-2.9 mi.
	b) Van Horn	Box 1197 Hwy. 22	180°-3.6 mi.
	c) Bud Davis	Box 1196 Hwy. 22	180°-3.6 mi.
10	a) Robert McCurley (G)	Rt. 3, Box 138 off Hwy. 22	195°-0.8 mi.
	b) J. W. Cook (G)	Rt. 2, Box 182N off Hwy. 22	195°-0.8 mi.
	c) D. Wood	Box 182N Mockingbird Lane off Hwy. 22	195°-0.8 mi.
11	a) Don Johnson (G)	River Oaks Lane off Hwy. 22	230°-3.4 mi.
	b) Abernathy	Rt. 2, Box 1344 Hwy. 22	215°-3.2 mi.
	c) Wood	Rt. 2, Box 1260 Hwy. 22	215°-3.2 mi.
12	a) Bomans (G)	Box 125C Hwy. 393	255°-3.3 mi.
	b) Yockey	Box 125B Hwy. 393	255°-3.3 mi.
	c) Dennis J. Berry	Box 125A Hwy. 393	255°-3.3 mi.
	d) Ilku	Box 125AAA	255°-3.3 mi.
	e) Eugene Shelton	Box 89A off Hwy. 393	250°-0.8 mi.
13	a) Mitchell	Rt. 2, Box 342 Round Mtn. Road	280°-1.0 mi.
	b) Ben Garrison (G)	Box 117 River Mtn. Road	260°-4.2 mi.

TABLE 4.0.1 (Continued)

SECTOR	NAME	ADDRESS	LOCATION
14	a) Fetting	Box 362 Round Mtn. Lane	285°-0.8 mi. 285°-0.8 mi.
	b) Faulk (G)	Rt. 2, Box 364 Round Mtn. Lane	285°-0.8 mi.
	c) Young	Rt. 2 Box 344 Round Mtn. Lane	285°-0.8 mi.
	d) H. E. Griffin	Box 36 Round Mtn. Lane	285°-0.8 mi.
	e) C. Hudson	Box 29 Round Mtn. Lane	285°-0.8 mi.
	f) D. Bragdon	Round Mtn. Lane	285°-0.8 mi.
	g) J. R. Williams	Round Mtn. Lane	285°-0.8 mi.
	h) Warmke	Box 29A Round Mtn. Lane	285°-0.8 mi.
15	a) Lenard Price	Rt. 1, Box 77 Price Lane London, AR	305°-1.5 mi.
	b) J. T. Shivers (G)	Flatwood Drive	310°-1.0 mi.
	c) Randy Ashcraft	Rt. 1, Box 87 Flatwood Drive	310°-1.0 mi.
	d) Potts	Rt. 1, Box 85 Flatwood Drive	310°-1.0 mi.
	e) Curry	Rt. 1, Box 88A Flatwood Drive	310°-1.0 mi.
	f) Curry	Rt. 2, Box 316 Flatwood Drive	310°-1.0 mi.
	g) Thurlo Oels	Rt. 1, Box 87 Flatwood Drive	310°-1.0 mi.
	h) Stites	Rt. 1, Box 86 Flatwood Drive	310°-1.0 mi.
	i) N. Polk	Clay Street London, AR	325°-1.3 mi.
	j) Dean Anderson	Clay Street London, AR	325°-1.3 mi.
	k) Lynch	Clay Street London, AR	325°-1.3 mi.

TABLE 4.0.1 (Continued)

SECTOR	NAME	ADDRESS	LOCATION
	1) Yard	Clay Street London, AR	325°-1.3 mi.
16	a) C. W. Buchanan	Rt. 3, Box 137 off Hwy. 333	335°-1.5 mi.
	b) E. Cook (G)	Box 468 Hwy. 64 London, AR	335°-1.4 mi.
	c) Ira Cochran	Hwy. 64 London, AR	335°-1.4 mi.
	d) Heiman	Hwy. 64 London, AR	335°-1.4 mi.
	e) J. Sandus	Box 117B Hwy. 64 London, AR	330°-1.4 mi.
	f) Bryant	Box 114 Hwy. 64 London, AR	330°-1.6 mi.
	g) Andrews	Box 113 Hwy. 64 London, AR	330°-1.6 mi.
	h) Hickey	Box 113 Hwy. 64 London, AR	330°-1.6 mi.

NOTE: (G) denotes the closest gardens in each sector.

TABLE 4.0.2

TABLE OF RELATIVE DEPOSITION

Data obtained from the Land Use Census conducted July 26, 27, 31, 1990 was utilized according to Procedure ES-319, Attachment 2 to calculate the relative deposition of the nearest garden for each sector. The results are summarized below.

SECTOR	RELATIVE DEPOSITION (m^{-2})
1	3.7×10^{-9}
2	1.0×10^{-9}
3	1.7×10^{-9}
4	4.6×10^{-9}
5	1.0×10^{-8}
6	1.0×10^{-8}
7	2.6×10^{-9}
8	7.4×10^{-10}
9	2.4×10^{-10}
10	4.2×10^{-9}
11	6.0×10^{-10}
12	1.0×10^{-9}
13	8.4×10^{-10}
14	1.0×10^{-8}
15	4.2×10^{-9}
16	1.4×10^{-9}

TABLE 4.0.3

LAND USE CENSUS OF MILK-PRODUCING ANIMALS WITHIN A RADIUS OF TEN (10) MILES OF ARKANSAS NUCLEAR ONE

(July 26, 27, 31, 1990)

Milk-producing animals are divided into two categories defined as:

1. Class A Dairies - dairies in which milk is intended primarily for human consumption as Grade A milk.
2. Individual Milk Animals - family animals in which the milk is intended for home use.

CLASS A DAIRIES

	Dairy	Azimuth-Distance
1.	Ark. Tech. Univ. Dairy	95° - 5.1
2.	Harold Steuber	24° - 6.9
3.	Lawrence Steuber	0° - 7.5
4.	James Gibson	358° - 3.8
5.	Hudson Dairy	73° - 12.4
6.	J. W. Standridge	25° - 11.0
7.	Boyce Ragsdale	80° - 12.0
8.	True-X-Farms	295° - 4.2
9.	Buddy Bosnick	23° - 7.0

INDIVIDUAL MILK ANIMALS

No individual milk animals for home consumption were identified by this survey.

TABLE 4.0.4

LAND USE CENSUS
ARKANSAS NUCLEAR ONE

DISTANCE TO NEAREST MILK ANIMAL, RESIDENCE AND GARDEN (IN MILES)

(July 26, 27, 31, 1990)

Distance to nearest
(in miles)

Section	Milk Animal	Residence	Garden
N	3.8	0.7	0.7
NNE	6.9	1.3	1.3
NE		0.9	0.9
ENE	12.4	0.8	0.8
E	5.1	0.9	0.9
ESE		0.9	0.9
SE		0.8	0.8
SSE		0.8	4.9
S		2.9	2.9
SSW		0.8	0.8
SW		3.2	3.4
WSW		0.8	3.3
W		1.0	4.2
WNW	4.2	0.8	0.8
NW		1.0	1.0
NNW		1.4	1.4