DOE/NV/10327-39

#44

18022

ONSITE ENVIRONMENTAL REPORT FOR THE NEVADA TEST SITE

(JANUARY 1987 THROUGH DECEMBER 1987)

By
Daniel A. Gonzalez

Contributors
Orin L. Haworth; Frank R. Markwell; Robert J. Straight

Submitted August 1988

Work Performed Under Contract No. DE-AC08-84NV10327

Reynolds Electrical & Engineering Co., Inc.
Environmental Sciences Department
Post Office Box 98521
Las Vegas, Nevada 89193-8521

Prepared for the
United States Department of Energy
Nevada Operations Office

DOE/NV/10327-39

ONSITE ENVIRONMENTAL REPORT FOR THE NEVADA TEST SITE

(JANUARY 1987 THROUGH DECEMBER 1987)

By
Daniel A. Gonzalez

Contributors
Orin L. Haworth; Frank R. Markwell; Robert J. Straight

Submitted August 1988

Work Performed Under Contract No. DE-AC08-84NV10327

Reynolds Electrical & Engineering Co., Inc.
Environmental Sciences Department
Post Office Box 98521
Las Vegas, Nevada 89193-8521

ABSTRACT

This report documents environmental monitoring at the Nevada Test Site (NTS) as conducted by the Department of Energy (DOE) onsite radiological safety contractor from January 1987 through December 1987. It presents results and evaluations of radiological and non-radiological measurements in air and water, and of direct gamma radiation exposure rates. Moreover, it establishes relevant correlations between the data recorded and DOE concentration guides (CG's).

This report was formerly entitled *Radiological Effluent and Onsite Area Monitoring Report for the Nevada Test Site*.

The radiological monitoring results for CY-1987 reveal that the concentrations of radionuclides in air and water on the Nevada Test Site were low compared to DOE guidelines.

The highest average gross beta concentration in air was 0.006 percent of the DOE concentration guide (CG). This concentration is considered close to background for the NTS. The highest average ^{239}Pu concentration in air was 28.5 percent of the CG. The highest average tritium concentration was 0.22 percent of the CG. ^{85}Kr concentrations compared favorably to the offsite average and to worldwide concentrations. All ^{133}Xe positive results were associated with specific events.

The highest average gross beta concentration in potable water was well within the allowed CG. Tritium and ^{239}Pu levels were below detection levels and consequently below CG's.

Contaminated waters contained measurable amounts of tritium and some ^{239}Pu. Effluent measurements were maintained and reported to the DOE. The reported estimates of total curies released into the environment are listed in Chapter VIII.

External gamma rates increased consistently for all stations as a result of the implementation of a new dosimeter processing system. The levels measured compared favorably with levels measured in years past, therefore the increase is not attributed to a change in the environment.

Drinking water and air pollution permits were obtained and maintained during CY-1987 as part of the continual monitoring of non-radiological substances. All measurements were within DOE and state regulations. Community drinking water systems were checked for various chemicals and found to be within regulatory levels.

Dose results to workers performing light activity work at stations possessing maximum concentration averages were calculated and the data indicated that minimum doses were obtained as the result of NTS activities.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

Credit must be given to R. W. Wilson and J. Hooper for their excellent work on the program. I would also like to thank O. L. Haworth, R. J. Straight, and F. R. Markwell for their contributions. As always, thanks go to J. L. Morrison and the reviewers of this report for their cooperation and assistance.

D. A. Gonzalez

INTRODUCTION

This report documents environmental monitoring on the Nevada Test Site (NTS) as performed by Reynolds Electrical & Engineering Co., Inc. (REECo) during the calendar year of 1987. As part of its contract, DE-AC08-84NV10327, REECo is responsible for providing radiological safety services within the confines of the Test Site. REECo is also responsible for the non-radiological services within the Test Site. This task is accomplished by the Industrial Hygiene Section. For a number of years, the Environmental Surveillance Program and the Industrial Hygiene Program have been part of a Department of Energy (DOE) program designed to control, minimize and document exposures of radioactive and chemically toxic substances to the NTS working population.

HISTORY OF THE NTS

The NTS (Figure 1), since 1951, has been the primary location for testing the nation's nuclear devices. The first test was held in January 1951 and subsequent tests included surface shots, tower shots, balloon suspensions, and air drops. Underground testing began in 1957, and, since 1963, all events have been buried in large-diameter holes or tunnels.

GEOLOGY

The following geological descriptions of the Nevada Test Site were taken from *The Nevada Test Site Field Trip Guidebook* published by the Los Alamos National Laboratory:

> The rock sequence at the NTS is composed of upper Precambrian and Paleozoic rocks which were complexly deformed by Mesozoic compressional tectonism. Tertiary and Quaternary volcanic and clastic rocks overlie the older rocks and were deposited concurrent with Cenozoic extensional faulting. The upper Miocene ash-flow tuffs and lavas found in this area emanated primarily from the Timber Mountain-Oasis Valley caldera complex located in the western part of the NTS.
>
> Studies performed in conjunction with nuclear testing and radioactive waste isolation have addressed many aspects of the geologic history of the NTS, which have in turn greatly enhanced our understanding of the geology of the Great Southern Basin.
>
> A good geologic understanding of stratigraphy, structure, geochemistry, and physical properties of the rocks is essential for adequate containment of underground nuclear tests. Many of the recent geologic studies at NTS, particularly in Yucca Flat, Pahute Mesa, and Mid-Valley, are aimed at understanding subsurface geology to help ensure complete containment of radionuclides produced as a result of underground testing.

CLIMATE

The NTS covers an area of 3,711 square kilometers (1,433 square miles), with terrain and climate conditions typical of the high southwest desert region and mountainous areas (Figure 1). Temperatures vary from -20°C to 50°C (-4°F to 122°F)The area is subject to high winds, dust-laden atmosphere, and low humidity. Elevations range from dry lake beds to rugged mountains as high as 2,300 meters (7546 feet).

The NTS lies in the most arid part of Nevada which is the driest state in the union. Precipitation ranges from 7.6 to 15.2 cm (3 to 6 inches) in the flats and up to 28 cm (11 inches) in the upland areas. Much of this precipitation falls as snow during the winter months. In fact, most of the precipitation falls during winter and summer. During winter, the precipitation originates in low pressure cells from the west. In summer, the precipitation comes from southern and southeastern convective storms. As a result of this variation, the climate varies from arid to sub-humid in the upper elevations.

RADIOLOGICAL MONITORING

The radiological monitoring program examines the environment for radioactivity. This program supports documentation of the radiation exposure of NTS workers. The monitoring program provides data concerning onsite releases and the detection of worldwide fallout originat-

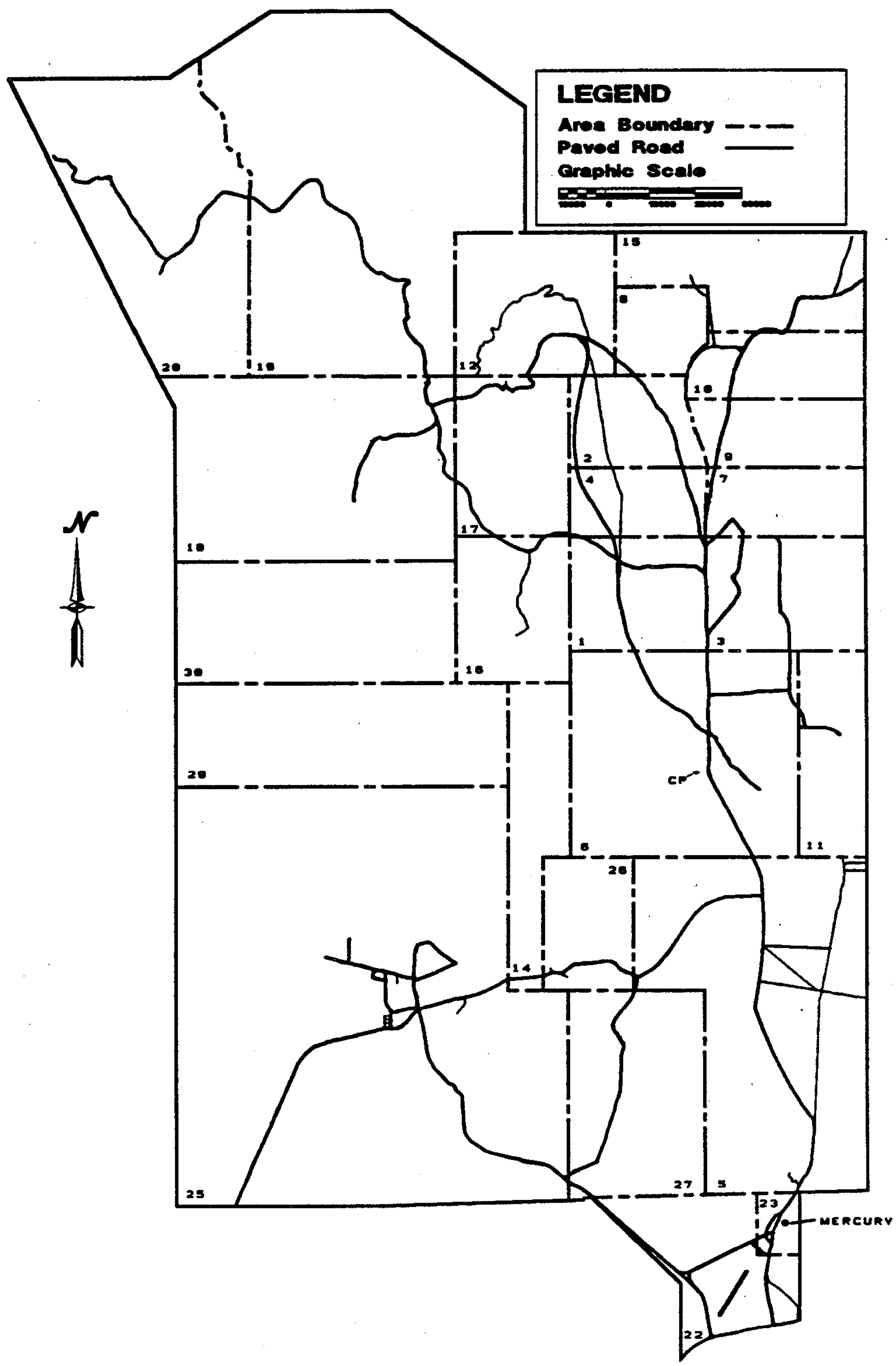


Figure 1 - Nevada Test Site

ing from foreign sources. The program follows the standards presented in *A Guide For Environmental Radiological Surveillance at U.S. Department of Energy Installations*, DOE/EP-0023 (Reference 2). These standards dictate the following objectives for the protection of the public and the environment:

- Evaluate the containment of radioactivity onsite.
- Detect rapid changes in radioactivity and evaluate long-term trends.
- Assess doses-to-man from radioactive releases as a result of DOE operations.
- Evaluate pathways of exposure by collecting data on contaminants released to the environment.
- Maintain a data base.
- Detect and evaluate radioactivity from offsite sources.
- Demonstrate compliance with applicable regulations and legal requirements concerning releases to the environment.

The Environmental Monitoring Program achieves these objectives through a comprehensive program which samples radioactivity in air and water, in addition to measuring external gamma levels.

Air and potable water samples are collected at specific areas where personnel spend significant amounts of time. Additional air sampling stations are located at sites throughout the NTS in support of the testing program and the Radiological Waste Management Project. The frequency of sampling for each of these surveillance networks is determined by the potential for human exposure. Weekly potable water samples, for example, are taken at each cafeteria.

Water samples are taken at supply wells, open reservoirs, natural springs, contaminated ponds, and sewage ponds to evaluate the possibility of any movement of radioactive contaminants into the NTS water system.

Thermoluminescent dosimeters (TLDs) measure the ambient NTS external gamma levels and are collected quarterly. The "Summary of the Environmental Program" is shown in Table 1.

Sampling was continuous during this reporting period except when stations were discontinued, inaccessible, a loss of data occurred, or during the absence of sampling media. A review of all analytical results from this sampling program relative to the DOE applicable standards was performed daily to insure that potential problems were noted in a timely fashion. Table 2 lists the applicable standards for the NTS used in the evaluations of the results of this program (References 3, 22 and 28).

Laboratory operations employed several analytical procedures to evaluate samples. These procedures included gross beta, gamma spectroscopy, noble gas sampling, plutonium, tritium and thermoluminescent dosimeter analyses.

The gross beta analysis was the most informative of the Test Site samples. This analysis allowed for rapid determinations of trends in gross radioactivity, and because of counting system characteristics, had a low detection limit. This meant that positive measurements were obtained down to the lowest limits of ambient radioactivity.

The tritium analysis provided data bearing on the radionuclide movement within the groundwater matrix. This mobile radionuclide would be among the first to be detectable if a movement of radionuclides from underground test events were occurring.

The remaining analyses demonstrated their worth in several instances. Noble gas sampling, for example, indicated whether radioactivity increases in air originated within the NTS or from other offsite sources. Plutonium analysis measured small amounts of ^{239}Pu in the air near safety shot areas. TLD analysis of direct gamma radiation onsite showed:

- Elevated exposure rates at the coordinates of the NTS atmospheric tests.
- Consistent exposure rates when the TLDs were used over a three-month period.

All laboratory analyses procedures appropriate to the environmental surveillance program are shown in Table 3.

NON-RADIOLOGICAL MONITORING

Environmental compliance for non-radiological substances is the responsibility of the Industrial Hygiene Section. Among state and federal regulations of concern are:

- Clean Water Act
- Safe Drinking Water Act (SDWA)
- Clean Air Act
- Resource Conservation and Recovery Act
- Comprehensive Environmental Response, Cpmensation and Liability Act (CERCLA)
- Toxic Substances Control Act (TSCA)
- The Solid Waste Disposal Act (SWDA)

TABLE 1 - Summary of Environmental Program

Sample Type	Description	Collection Frequency	of Samples	Analysis
Air	Continuous sampling through Whatman GF/A glass filter and a charcoal cartridge	Weekly	44	Gamma Spectroscopy, gross beta, ^{239}Pu (monthly composite)
	Low-volume sampling through silica gel	Biweekly	16	HTO (tritium)
	Continuous low volume sampling	Weekly	7	^{85}Kr and ^{133}Xe
Potable Water	1-liter grab sample	Weekly	7	Gamma Spectroscopy, gross beta, tritium ^{239}Pu (quarterly)
Supply Wells	1-liter grab sample	Monthly	16	Gamma Spectroscopy, gross beta, tritium, ^{239}Pu (quarterly)
Open Reservoirs	1-liter grab sample	Monthly	17*	Gamma Spectroscopy gross beta, tritium, ^{239}Pu (quarterly)
Natural Springs	1-liter grab sample	Monthly	9*	Gamma Spectroscopy gross beta, tritium, ^{239}Pu (quarterly)
Contaminated Ponds	1-liter grab sample	Monthly	8*	Gamma Spectroscopy gross beta, tritium, ^{239}Pu (quarterly)
Effluent Ponds	3-liter grab sample	Quarterly	5	Gamma Spectroscopy, gross beta, tritium, ^{239}Pu
External Gamma Radiation Levels	UD-814AS Thermoluminescent Dosimeters	Semi-annually	153	Total integrated exposure over field cycle

* Not all of these locations were sampled due to inaccessibility or lack of water.

INTRODUCTION

The Industrial Hygiene Section submits permit applications and maintains information on existing septic tank and leach field systems and manages air pollution and drinking water system permits.

Drinking water systems are analyzed for chemical constituents and the results are compared to the applicable regulations.

TABLE 2 - Applicable Standards for the NTS

(μCi/ml)

Nuclide	DCG for Air*	CG for NTS Waters**	MCL for Drinking Water***
^{3}H	1×10^{-7}	1×10^{-1}	2×10^{-5}
^{85}Kr	3×10^{-6}	--	--
^{133}Xe	5×10^{-7}	--	--
^{239}Pu	2×10^{-14}	1×10^{-4}	5×10^{-6}
Beta****	1×10^{-9}	1×10^{-5}	1.5×10^{-8}

* This column contains the derived concentration guides (DCG) for the predominant nuclides detected at the NTS, as listed in DOE Draft Order 5480.XX, Attachment 1 (Reference 28).

** These concentrations were applicable to the discharge of liquid effluents to sanitary sewage systems. This column also lists the concentration guides (CG) for NTS waters as listed in 5480.1B, Chapter XI, Table 1.

*** Drinking water maximum contaminant levels (MCL) are as required by the National Interim Primary Drinking Water Regulation (Reference 22).

**** Concentration guides for gross beta are derived according to DOE Order 5480.1B, Attachment XI-1.3, page 14 (Reference 3).

TABLE 3 - Laboratory Analytical Procedures

Type of Analysis	Type of Sample	Analytical Equipment	Counting Period (Min.)	Analytical Procedures	Sample Size	Detection Limit
Gross Beta	Air	Gas-flow Proportional Counter	20	Place filter on a 12.7 cm stainless steel planchet.	10^9 ml	2×10^{-16} µCi/ml
	Water	Gas-flow Proportional Counter	100	Evaporate, transfer residue to a 12.7 cm stainless steel planchet.	1000 ml	1×10^{-9} µCi/ml
Gamma Spectroscopy	Air (particulate)	Germanium Semiconductor	20	Same as for gross beta.	10^9 ml	5×10^{-15} µCi/ml
	Air (gaseous)	Germanium Semiconductor	20	Place charcoal cartridge in plastic bag.	10^9 ml	5×10^{-15} µCi/ml
	Water	Germanium Semiconductor	20	Aliquot sample into Nalgene bottle.	500 ml	1×10^{-8} µCi/ml
^{85}Kr	Air	Liquid Scintillation Counter	200	Cryogenic-gas chromatographic techniques used to collect krypton into liquid scintillation solution.	3×10^5 ml	4×10^{-12} µCi/ml
^{239}Pu	Air	Silicon Semiconductor	333	Filter is ashed and put in solution. Pu is purified by anion exchange resin column, then electrodeposited on a stainless steel disc.	4×10^9 ml	1×10^{-17} µCi/ml
	Water	Silicon Semiconductor	1000	Pu is concentrated with $Fe(OH)_3$ and purified with anion resin column. Electrodeposited on a stainless steel disc.	1000 ml	4×10^{-11} µCi/ml
Tritium	Air	Liquid Scintillation Counter	100	Distill the H_2O and aliquot 5 ml into a scintillation solution.	6×10^6 ml	3×10^{-13} µCi/ml
	Water	Liquid Scintillation Counter	100	Distill 20 ml of sample and aliquot 4 ml into a scintillation solution.	4 ml	4×10^{-7} µCi/ml
^{133}Xe	Air	Liquid Scintillation Counter	200	Cryogenic-gas chromatographic techniques used to collect xenon into liquid scintillation solution.	3×10^5 ml	10×10^{-12} µCi/ml
Direct Gamma Radiation	TLD	Panasonic UD-710A TLD Reader		Automated		10 mR/quarter

SUMMARY OF RESULTS

The results obtained from the Environmental Monitoring Program for the reporting period of CY-1987 show that the radioactivity in air and water, and external gamma exposure levels in the NTS environments were low compared to DOE guidelines. The resulting dose calculations portray minimal doses resulting from ingestion of radionuclides even at locations of maximum average concentration.

RADIOACTIVITY IN AIR

The highest CY-1987 average gross beta concentration in air was 5.7×10^{-14} µCi/ml at the Area 3 Compound. This average represents 0.006 percent of the applicable derived concentration guide of 1×10^{-9} µCi/ml as listed in Table 2. The site average for the forty-seven stations was 2.4×10^{-14} µCi/ml. This gross beta concentration is consistent with average background for the Nevada Test Site.

All particulate air filters and charcoal cartridges were analyzed using gamma spectroscopy. Except for detection of background levels of ^{7}Be and ^{40}K (on the order of $\times 10^{-14}$ µCi/ml), gamma results were consistently below detection limits.

The ^{239}Pu concentrations in air were primarily on the order of 10^{-17} µCi/ml as compared with the derived concentration guide of 2×10^{-14} µCi/ml [DOE Draft Order 5480.XX, Chapter XI, Attachment 1, Table 1] (Reference 28). The highest average ^{239}Pu concentration occurred in Area 3 at U3ax/bl North. This ^{239}Pu concentration of 5.7×10^{-15} µCi/ml represents 28.5 percent of the derived concentration guide. The majority of NTS air sampling stations measured plutonium concentrations similar to those found in the base camp (Mercury), and all were negligible in terms of exposure to NTS personnel.

The highest average tritium concentration in air occurred at the Area 5 Radioactive Waste Management Site (RWMS) NE sampler. This concentration, 2.2×10^{-10} µCi/ml, represents 0.22 percent of the derived concentration guide.

The average concentration of ^{85}Kr for CY-1987 was 28×10^{-12} µCi/ml, which was lower than the CY-1986 average of 35×10^{-12} µCi/ml. This decrease in ^{85}Kr concentration in ambient air was expected. Both the onsite and offsite programs (conducted by the Environmental Protection Agency) experienced a slight reduction in the yearly average. This was the direct result of a change in the krypton standard used for calibrating the liquid scintillation counters. Both monitoring programs shared the ^{85}Kr standard. A comparison of the annual average onsite and offsite reveals comparable results.

All else remaining equal, a slight increase is anticipated for CY-1988 since nuclear technologies, predominantly nuclear power generation, continue to generate and release small quantities of ^{85}Kr (Reference 25).

^{133}Xe concentrations continued to be nondetectable except for instances related to specific events.

RADIOACTIVITY IN WATER

Measurements of radioactivity in the principal NTS water system showed that no release or movement of radionuclides occurred during the reporting period. The highest average gross beta concentration in potable waters and supply wells was 8.7×10^{-9} µCi/ml from the Area 6 Cafeteria and 16.0×10^{-9} uCi/ml from Area 15 Well UE15d. Water from several of the open reservoirs showed gross beta activities believed to be associated with the occasional influx of radionuclides from surface contamination in the surrounding areas. There was no human consumption of this water, and the activity was still within the applicable standards.

The highest average ^{239}Pu concentration from contaminated waters was 2.6×10^{-9} µCi/ml at the E Tunnel Effluent point. This value represents 0.003 percent of the concentration guide for ^{239}Pu. For all other waters sampled, the highest average ^{239}Pu concentration was 5.8×10^{-10} µCi/ml at Well 16D. This value represents 0.01 percent of the maximum contaminant level (MCL) for ^{239}Pu. All of the positive plutonium results, however, have a high percentage error associated with them. The error is likely to be caused by statistical fluctuations inherent to the counting system.

The highest average concentration of tritium for all noncontaminated waters occurred at Area 3 Cafeteria. This concentration of < 1.2×10^{-6} μCi/ml represents < 6 percent of the limit allowed by drinking water standards.

Measurable amounts of tritium were present in the contaminated waste ponds. The amounts of effluent released to the environment for the year were calculated and reported to DOE Headquarters in accordance with DOE Order 5484.1, Chapter IV. The highest tritium concentration for contaminated waters was 2.3×10^{-1} μCi/ml at T Tunnel Pond No. 1.

AMBIENT EXPOSURE

TLD measurements of the NTS gamma radiation rates at the 153 locations showed some variation during CY-1987. A nine-station control network displayed slightly higher results than previous years. This has been attributed to a change in the TLD processing system. The remaining 144 stations recorded changes related to known effects. The maximum dose rate of 2046 mrem/year occurred at the Stake 2n-8 station but the majority of NTS locations measured in the range of approximately 140-200 mrem/year. Stake 2n-8 station was surrounded by four above-ground event sites and close by to a Contamination Control Area. Similarly, a portion of the 153 TLD stations on NTS were at or near known Radiation Areas and Contamination Control Areas.

WASTE MANAGEMENT

Sampling conducted at the Area 5 and Area 3 Waste Management facilities indicated that there were no appreciable releases of nuclides to the environment. At both facilities air samples, water samples, and TLD measurements were taken. The maximum average gross beta in air concentration was 0.002 percent of the CG. Tritium in air concentrations ranged on the order of 1×10^{-11} μCi/ml of air with the highest average concentration being 0.22 percent of the CG. ^{239}Pu concentrations were at background levels in area 5. The Area 3 Bulk Waste Management Facility displayed the highest concentration of ^{239}Pu of the Test Site samplers. Nevertheless, this concentration was still within concentration guides set for the general public.

DOSE ASSESSMENT

The maximum dose to an individual working at the NTS in CY-1987 was calculated to be 13 mrem at Area 3 U3ax/bl North based on a 50-year whole body committed dose equivalent (H_{50}) and the averaged concentrations over the current year. The recommendations of the International Commission on Radiation Protection, publication 30, *Limits for Intakes of Radionuclides by Workers* (ICRP 30) (Reference 4) were used to obtain H_{50} to an individual performing light activity work within the NTS. The greatest average concentrations from a site along with contributions from other present radionuclides were used to determine dose.

RADIOLOGICAL SAMPLING AND ANALYSIS

Over 4,500 samples are collected and analyzed annually for the radiological measurement and characterization of the Nevada Test Site. All sample collection, preparation, analysis and review are performed by the staff of the Laboratory Operations Section of REECo's Environmental Sciences Department.

AIR MONITORING

Particulate Air Monitoring

Air sampling units were located at 44 stations on the NTS to measure the radionuclides in the form of particulates and halogens. All placements were chosen primarily to provide monitoring of radioactivity at sites with high population density. Geographical coverage, access, and availability of commercial power were also considered.

An air sampling unit consists of a positive displacement pump drawing air through a nine-centimeter diameter Whatman GF/A filter for particulates, followed by a charcoal cartridge collecting radioiodines. The filter and cartridge are mounted in a plastic, cone-shaped sample holder. The unit draws approximately 100 liters per minute. A dry-gas meter measures the volume of air displaced over the sampling period (typically seven days). The unit samples a total volume of approximately 1000 cubic meters.

The samples are held for no less than five and no more than seven days prior to analysis to allow naturally-occurring radon and its daughter products to decay. Gross beta counting is performed with a gas flow proportional counter for 20 minutes. The lower limit of detection for typical parameters involved is 2×10^{-16} μCi/ml. Gamma spectroscopy is accomplished using germanium detectors with an input to 2000 channels, calibrated at 1 kiloelectronvolt (keV) per channel from 0 to 2 megaelectronvolt (MeV).

The weekly air samples for a given sampling station are batched on a monthly basis and radiochemically analyzed for ^{239}Pu. The procedure incorporated an acid dissolution and an ion exchange recovery on a resin bed. Plutonium was deposited by plating on a stainless steel disc. The chemical yield of the plutonium was determined with an internal ^{236}Pu tracer. Alpha spectroscopy was performed utilizing a solid state silicon surface barrier detector. The lower limit of detection for the parameters involved was approximately 1×10^{-17} μCi/ml.

Tritium Air Monitoring

A separate sampler is designed for the collection of airborne tritiated water vapor (HTO). The portable sampler is capable of unattended operation for up to two weeks in desert areas. A small electronic pump draws air into the apparatus at approximately 0.5 liters per minute, and the HTO is removed from the air stream by two silica gel drying columns. Appropriate aliquots of condensed moisture are obtained by heating the silica gel. Liquid scintillation counting determined the HTO activity. The lower limit of detection for tritiated water vapor analysis is 3×10^{-13} μCi/ml.

Noble Gas Monitoring

Noble gas sampling units are housed in a metal tool box. Three metal air bottles are attached to the sampling units with short hoses. A vacuum is maintained on the first bottle which causes a steady flow of air to be collected in the other two bottles. The flow rate is approximately 0.5 milliliters per minute. The two collection bottles are exchanged weekly which yield a sample volume of about 3×10^{5} milliliters.

The noble gases are separated and collected from the atmospheric sample by a series of cryogenic-gas chromatographic techniques. Water and carbon dioxide are removed at room temperature and the krypton and xenon are collected on charcoal at liquid nitrogen temperatures. These gases are transferred to a molecular sieve where they are separated from any remaining gases and each other. The krypton and xenon are transferred to separate scintillation vials and counted on a liquid scintillation counter. The lower limits of detection for krypton and xenon are 4×10^{-12} and 10×10^{-12} μCi/ml respectively.

WATER MONITORING

Water samples are collected at various frequencies from selected potable water consumption points, supply wells, natural springs, open reservoirs, final effluent ponds and contaminated ponds. The frequency of collection is determined on the basis of a preliminary radiological pathways analysis. Potable water is collected weekly; supply wells, monthly. Samples are collected in 1-liter glass containers. All samples are analyzed for gross beta, tritium, and gamma emitting isotopes. Plutonium analyses are performed on a quarterly basis.

A 500-ml aliquot is taken from the water sample and counted in a Nalgene bottle for gamma activity with a germanium detector. A 5-ml aliquot is used for tritium analysis via liquid scintillation counting. The remainder of the original sample is evaporated to 15-ml, transferred to a stainless steel counting planchet and evaporated to dryness after the addition of a wetting agent. Beta counting is accomplished as described above ("Air Monitoring") except that the water samples are counted for 100 minutes.

Lower limits of detection are:

- Gamma spectroscopy, $\approx 1 \times 10^{-8}$ µCi/ml.
- Tritium, 9×10^{-7} µCi/ml.
- Gross beta, 1×10^{-9} µCi/ml.

For the quarterly plutonium analysis, an additional 1-liter sample is collected. The radiochemical procedure is similar to that described in Chapter I. As mentioned, alpha spectroscopy is used to measure any ^{239}Pu. The lower limit of detection for this procedure is 4×10^{-11} µCi/ml.

AMBIENT GAMMA MONITORING (TLD)

TLDs were located at 153 stations on the NTS to measure the external gamma radiation from the environment. These locations are chosen to:

- Provide a background control network.
- Measure the residual activity from the atmospheric testing program.
- Document the radiological conditions at the Radioactive Waste Management Site (RWMS).

The dosimeters used are UD-814AS environmental dosimeters manufactured by Panasonic. One TLD badge consists of four elements housed in an air-tight, water-tight, ultraviolet-light protected case. The first element, Lithium borate, is only slightly shielded in order to capture low energy radiations. The last three elements, Calcium Sulfate, are shielded by 1000 mg/cm^2 of lead to screen out low energy radiations.

Each TLD holder is placed about one meter above the ground at each monitoring location. The known systematic errors of the dosimeter in this application are the minimized detection of lower energy photons and fade of the phosphor's stored energy with time. Previous research has indicated that only about 5-10% of the total exposure from natural background is from gamma emitters below 150 keV (Reference 5).

DATA TREATMENT

Each set of data obtained from this program underwent a thorough inspection for accuracy. Not only was the data analyzed automatically by computer, it was also verified by REECo Environmental Sciences Department (ESD) personnel prior to acceptance. If serious differences from the expected value were found, a review of the field handling, sample preparation, and processing was done. On the occasions when the problem could not be resolved by an environmental analyst, a recount or second sample was secured whenever possible.

All data are inspected on a daily basis and listed in tabular form. This treatment facilitated the data review process and revealed trends or periodicity. Each station's data are plotted against a logarithmic axis because of the possible magnitudes of variation in environmental data. The averaging plots in each section show arithmetic means and the range of data at each point. Arithmetic mean values, although severely affected by outliers (suspicious data), are compared to the applicable standards and listed in all tables.

RADIOACTIVITY IN AIR

Forty-four particulate air sampling stations were sampled continuously for radioactivity in air (Figures 2 and 3). At each of the 44 locations, samples were collected weekly and analyzed for particulates (glass fibre filter) and halogens (charcoal cartridge). The sample filters were combined on a monthly basis and chemically analyzed for ^{239}Pu. Air monitoring was also performed at seven locations for the noble gases ^{85}Kr and ^{133}Xe. These noble gas samples were collected on a weekly basis. Tritiated water vapor was monitored at fifteen locations on a semi-weekly basis.

GROSS BETA

The network average for the whole year for gross beta activity, excluding Gate 200, was 2.4×10^{-14} μCi/ml or 0.002 percent of the derived concentration guide of 1×10^{-9} μCi/ml (DOE Order 5480.1B, Chapter XI). Figure 2 displays the network arithmetic averages for CY-1987. This plot graphically displays changes in airborne radioactivity over the surveillance period. The data ranges were included for each of these points.

Samples collected at Gate 200 were counted for gross beta without allowing seven days for the decay of natural radioactivity, as were the other air samples. Although the $^{222}Rn/^{220}Rn$ results from these samples were higher and more variable due to the natural radioactivity, they served as rapid indicators of unusual events, such as fallout from foreign sources.

The computer plotted displays of the gross beta and ^{239}Pu activities for the entire air surveillance network are presented in Appendix A. Figure 3 summarizes the 1987 gross beta averages by location. Table 4 lists these yearly and half-year averages. The remaining plots in Appendix A depict the actual measurements at each station.

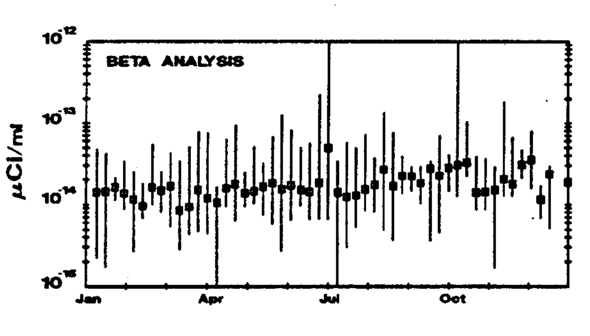


Figure 2 - 1987 Air Network Averages

PLUTONIUM-239

All stations averaged below 10^{-15} μCi/ml of ^{239}Pu for CY-1987, with the majority being on the order of 10^{-17} μCi/ml. The maximum average concentration was found at U3ax/bl North which was 5.7×10^{-15} μCi/ml, or 28.5 percent of the derived concentration guides (DCG) for members of the public. Table 5 lists the ^{239}Pu concentrations for the year. Figure 4 shows the ^{239}Pu yearly results at their respective locations.

The presence of this radionuclide is primarily due to tests conducted before 1960 in which nuclear devices were detonated with high explosives (safety shots). These tests spread low-fired plutonium throughout the eastern and northeastern areas of the NTS. Two decades later, increased plutonium concentrations in the air are still detected in Areas 1, 2, 3, 7, 8, 9, 10 and 15. During the waste clean up efforts of these old atmospheric safety shot sites, some of the ^{239}Pu becomes airborne. The U3ax/bl site is part of this consolidation effort. It is there that contaminated earth is buried. During CY-1988 the U3ax/bl site was closed and a new site called U3ah/at was opened.

TRITIUM (HTO)

The highest average concentration of tritium was 2.2×10^{-10} μCi/ml at the Area 5 RWMS-NE sampler. This amount represents 0.22 percent of the derived concentration guide for tritium in air.

The locations of all of the tritium samplers along with their yearly averages are shown in Figure 5. All of these stations were sampled for two-week periods. Table 6 lists the maximums, minimums, and averages for each sampling location. Appendix B plots actual measurements for each location.

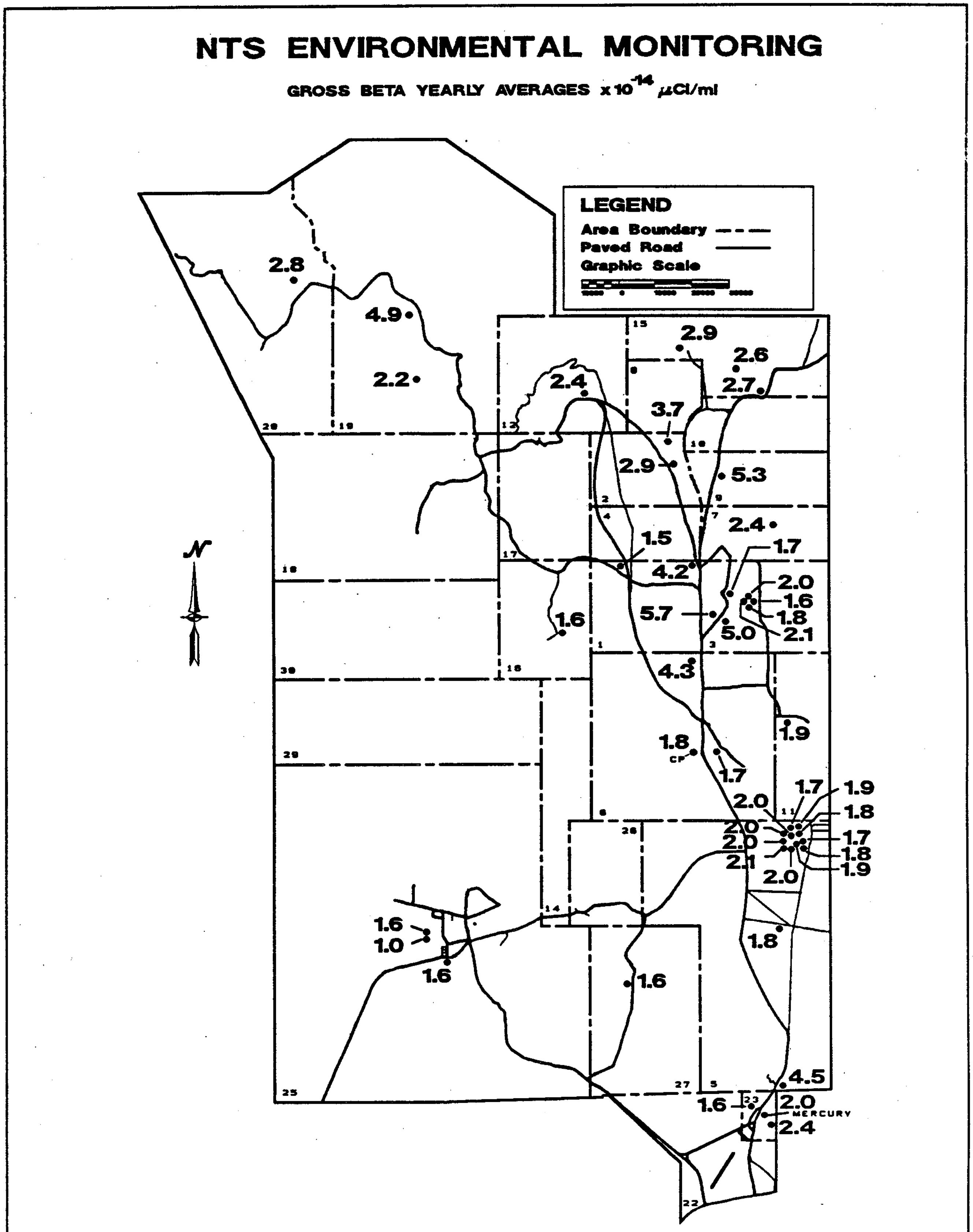


Figure 3 - Air Sampling Stations (Beta)

TABLE 4 - Air Surveillance Data for Gross Beta

Station	Concentration (x 10^{-14} μCi/ml) 01/87-06/87	07/87-12/87	01/87-12/87*
Area 1 BJY	6.1	2.3	4.2
Area 1 Gravel Pit	1.3	1.7	1.5
Area 2 Hydraulic Lift Yard	5.0	1.9	3.7
Area 2 Compound	3.8	2.0	2.9
Area 3 Compound	1.4	9.6	5.7
Area 3 Complex No. 2	1.5	8.2	5.0
Area 3 U3ax South	1.4	2.1	1.8
Area 3 U3ax East	1.3	1.9	1.6
Area 3 U3ax North	1.7	2.3	2.0
Area 3 U3ax West	1.5	2.5	2.1
Area 3 3-300 Bunker	1.4	2.1	1.7
Area 5 DOD Yard	1.3	2.0	1.7
Area 5 Gate 200	5.0	4.2	4.5
Area 5 Pit No. 3	1.6	2.0	1.9
Area 5 RWMS No. 1	1.6	2.1	1.9
Area 5 RWMS No. 2	1.4	2.1	1.8
Area 5 RWMS No. 3	1.4	2.0	1.7
Area 5 RWMS No. 4	1.5	2.0	1.8
Area 5 RWMS No. 5	1.5	2.5	2.0
Area 5 RWMS No. 6	1.6	2.4	2.0
Area 5 RWMS No. 7	1.5	2.4	2.0
Area 5 RWMS No. 8	1.8	2.4	2.1
Area 5 RWMS No. 9	1.5	2.6	2.0
Area 5 Well 5B	1.5	2.1	1.8
Area 6 CP Complex	1.4	2.1	1.8
Area 6 Well 3	6.5	1.9	4.3
Area 6 Yucca Complex	1.5	1.8	1.7

* Calendar year averages do not necessarily reflect the numerical average of the first and second half of the year.

TABLE 4 - Air Surveillance Data for Gross Beta concluded

Station	Concentration (x 10^{-14} $\mu Ci/ml$) 01/87-06/87	07/87-12/87	01/87-12/87
Area 7 UE7ns	1.4	3.3	2.4
Area 9 9-300 Bunker	7.8	1.9	5.3
Area 11 Gate 293	1.6	2.2	1.9
Area 12 Compound	3.2	1.7	2.4
Area 15 EPA Farm	2.9	2.3	2.6
Area 15 Gate 700 South	3.5	1.9	2.7
Area 15 PILEDRIVER	3.3	2.3	2.9
Area 16 Substation	1.3	1.8	1.6
Area 19 Echo Peak	1.1	3.3	2.2
Area 19 Substation	1.3	8.2	4.9
Area 20 Dispensary	1.4	4.1	2.8
Area 23 Bldg 790	1.3	1.9	1.6
Area 23 H & S Roof	1.7	2.2	2.0
Area 23 East Boundary	-	2.4	2.4
Area 25 EMAD South	1.0	-	1.0
Area 25 EMAD North	1.3	1.9	1.6
Area 25 NRDS	1.3	1.9	1.6
Area 27 Cafeteria	1.3	1.9	1.6

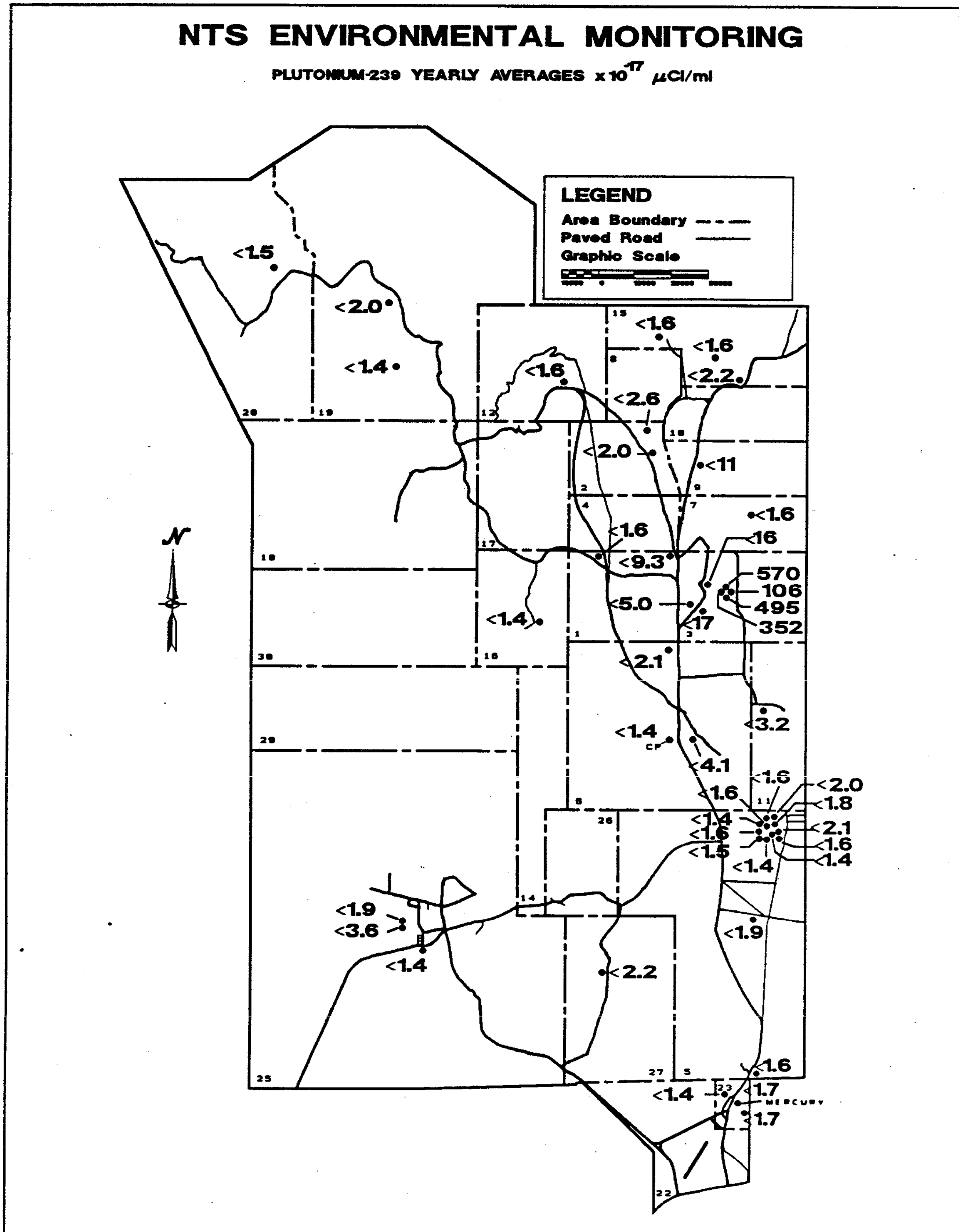


Figure 4 - Air Sampling Stations (Plutonium)

TABLE 5 - Air Surveillance Data for Plutonium

Concentration

(x 10^{-17} μCi/ml)

Station	01/87-06/87	07/87-12/87	01/87-12/87*
Area 1 BJY	< 13	< 5.7	< 9.3
Area 1 Gravel Pit	< 1.6	< 1.5	< 1.6
Area 2 Hydraulic Lift Yard	< 3.0	< 2.1	< 2.6
Area 2 Compound	< 2.5	< 1.4	< 2.0
Area 3 Compound	< 5.6	< 4.4	< 5.0
Area 3 Complex No. 2	< 25	< 9.4	< 17
Area 3 U3ax South	427	550	495
Area 3 U3ax East	180	33	106
Area 3 U3ax North	470	671	570
Area 3 U3ax West	545	159	352
Area 3 3-300 Bunker	< 18	< 14	< 16
Area 5 DOD Yard	< 1.8	< 1.5	< 1.6
Area 5 Gate 200	< 1.8	< 1.4	< 1.6
Area 5 Pit No. 3	< 4.0	< 1.4	< 2.0
Area 5 RWMS No. 1	< 1.3	< 1.5	< 1.4
Area 5 RWMS No. 2	< 1.8	< 1.4	< 1.6
Area 5 RWMS No. 3	< 2.9	< 1.3	< 2.1
Area 5 RWMS No. 4	< 2.1	< 1.5	< 1.8
Area 5 RWMS No. 5	< 1.9	< 1.3	< 1.6
Area 5 RWMS No. 6	< 1.4	< 1.5	< 1.4
Area 5 RWMS No. 7	< 1.7	< 1.6	< 1.6
Area 5 RWMS No. 8	< 1.6	< 1.4	< 1.5
Area 5 RWMS No. 9	< 1.4	< 1.3	< 1.4
Area 5 Well 5B	< 1.3	< 2.4	< 1.9
Area 6 CP Complex	< 1.4	< 1.4	< 1.4
Area 6 Well 3	< 2.0	< 2.1	< 2.1
Area 6 Yucca Complex	< 5.6	< 2.6	< 4.1
Area 7 UE7ns	< 1.4	< 1.8	< 1.6

* Calendar year averages do not necessarily reflect the numerical average of the first and second half of the year.

TABLE 5 - Air Surveillance Data for Plutonium concluded

Station	Concentration (x 10^{-17} µCi/ml) 01/87-06/87	07/87-12/87	01/87-12/87
Area 9 9-300 Bunker	< 8.9	< 15	< 11
Area 11 Gate 293	< 3.3	< 3.0	< 3.2
Area 12 Compound	< 1.8	< 1.4	< 1.6
Area 15 EPA Farm	< 1.4	< 1.7	< 1.6
Area 15 Gate 700s	< 1.4	< 3.1	< 2.2
Area 15 Piledriver	< 1.4	< 1.9	< 1.6
Area 16 Substation	< 1.5	< 1.4	< 1.4
Area 19 Echo Peak	< 1.4	< 1.5	< 1.4
Area 19 Substation	< 2.2	< 1.7	< 2.0
Area 20 Dispensary	< 1.3	< 1.7	< 1.5
Area 23 Bldg 790	< 1.5	< 1.4	< 1.4
Area 23 H & S Roof	< 1.7	< 1.6	< 1.7
Area 23 East Boundary	-	< 1.7	< 1.7
Area 25 EMAD South	< 3.6	-	< 3.6
Area 25 EMAD North	< 1.6	< 2.2	< 1.9
Area 25 NRDS	< 1.0	< 1.7	< 1.4
Area 27 Cafeteria	< 1.7	< 2.7	< 2.2

NTS ENVIRONMENTAL MONITORING

HTO YEARLY AVERAGES x 10^{-11} μCi/ml

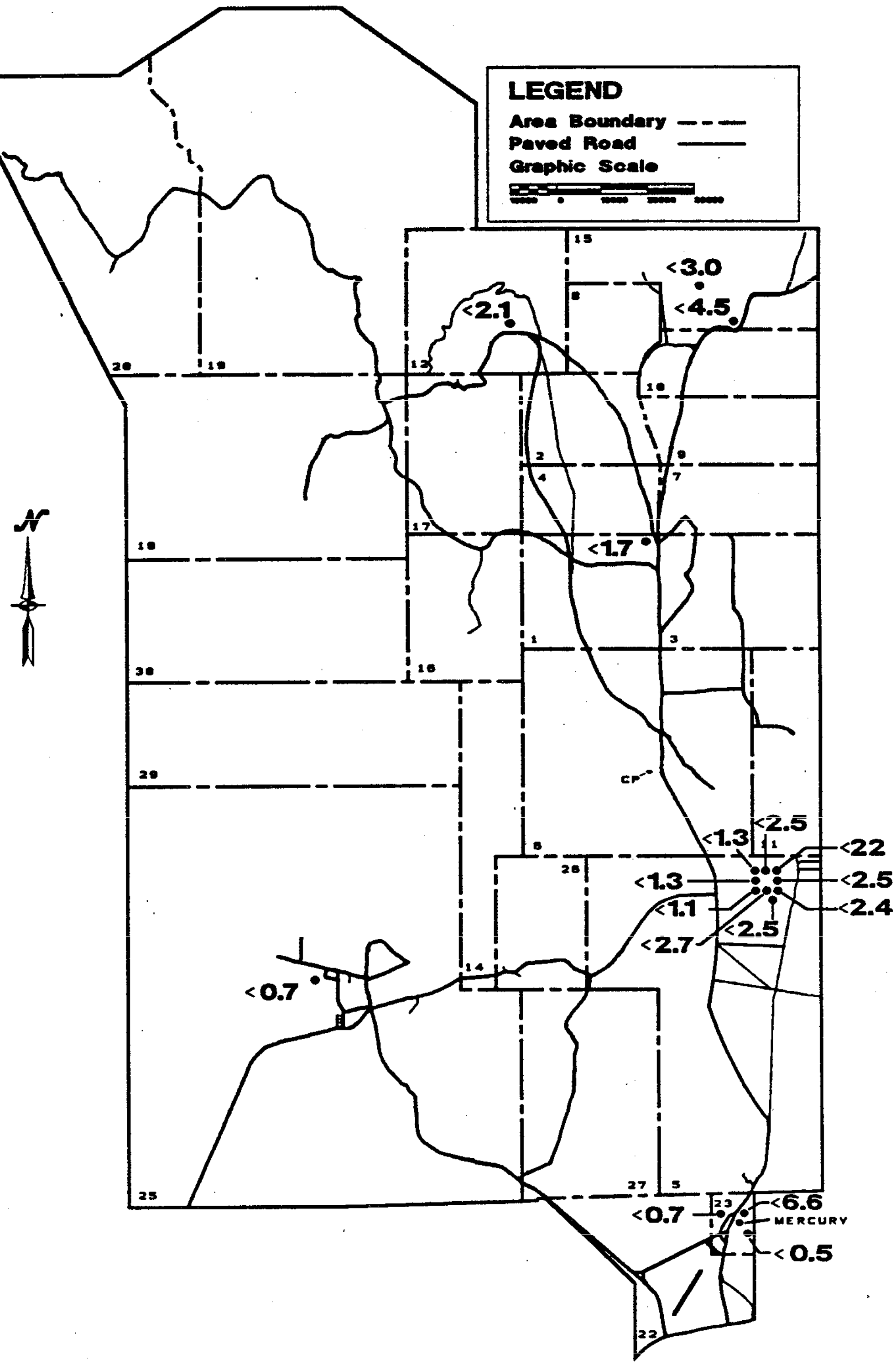


Figure 5 - Tritium in Air Sampling Stations

TABLE 6 - Tritium in Air

Stations	Concentrations (μCi/ml) Maximum	Minimum	Average
Area 1 BJY	4.5×10^{-11}	2.5×10^{-12}	$< 1.7 \times 10^{-11}$
Area 5 RWMS-1	1.1×10^{-10}	3.7×10^{-12}	$< 2.5 \times 10^{-11}$
Area 5 RWMS-SE	8.5×10^{-11}	6.8×10^{-13}	$< 2.4 \times 10^{-11}$
Area 5 RWMS-(SE-NE)	8.1×10^{-11}	2.2×10^{-12}	$< 2.5 \times 10^{-11}$
Area 5 RWMS-NE	6.0×10^{-10}	2.8×10^{-11}	$< 2.2 \times 10^{-10}$
Area 5 RWMS-(NE-NW)	6.2×10^{-11}	4.6×10^{-12}	$< 2.5 \times 10^{-11}$
Area 5 RWMS-NW	5.1×10^{-11}	2.2×10^{-12}	$< 1.3 \times 10^{-11}$
Area 5 RWMS-(NW-SW)	3.2×10^{-11}	1.0×10^{-12}	$< 1.3 \times 10^{-11}$
Area 5 RWMS-SW	2.6×10^{-11}	1.4×10^{-12}	$< 1.1 \times 10^{-11}$
Area 5 RWMS-(SW-SE)	8.3×10^{-11}	2.1×10^{-12}	$< 2.7 \times 10^{-11}$
Area 12 Base Camp	6.3×10^{-11}	3.4×10^{-12}	$< 2.1 \times 10^{-11}$
Area 15 EPA Farm	1.0×10^{-10}	2.7×10^{-12}	$< 3.0 \times 10^{-11}$
Area 15 Gate 700 South	8.1×10^{-10}	1.9×10^{-12}	$< 4.5 \times 10^{-11}$
Area 23 Bldg 650	7.3×10^{-10}	1.8×10^{-12}	$< 6.6 \times 10^{-11}$
Area 23 Site Boundary	1.2×10^{-11}	$< 3.8 \times 10^{-13}$	$< 4.6 \times 10^{-12}$
Area 23 Bldg 790	2.3×10^{-11}	$< 1.3 \times 10^{-12}$	$< 6.6 \times 10^{-12}$
Area 25 EMAD	3.0×10^{-11}	$< 8.1 \times 10^{-13}$	$< 6.7 \times 10^{-12}$

KRYPTON-85

The average concentration of ^{85}Kr for the entire network was lower in CY-1987, decreasing from an average of 35 $\times 10^{-12}$ µCi/ml in CY-1986 to an average of 28 $\times 10^{-12}$ µCi/ml in CY-1987. This decrease was anticipated since a new calibration source was introduced. Both the onsite and offsite program (managed by the EPA) use the same calibration source. In June of 1986 the EPA suspected a failing source. In January of 1987 a new sorce was obtained and the intruments were recalibrated. The net result was a network wide reduction of the calculated concentrations.

The EPA's annual average of 25.5 $\times 10^{-12}$ µCi/ml compared well with the onsite average of 28 $\times 10^{-12}$ µCi/ml. The onsite average, not counting the Area 20 results, was 26 $\times 10^{-12}$ µCi/ml. We expect the annual average for CY-1988 to follow the increasing trend established by sources worldwide (predominantly nuclear power generating facilities) which generate and release small quantities of ^{85}Kr (Reference 25). The network average of 28 $\times 10^{-12}$ µCi/ml included elevated measurements taken at the Area 20 camp. These ^{85}Kr concentrations during CY-1987 ranged from 11 $\times 10^{-12}$ mCi/ml to 73 $\times 10^{-12}$ µCi/ml. The location and yearly average for each noble gas sampling station is shown in Figure 6. Table 7 lists the average ^{85}Kr concentrations at each location along with the minimum and maximum values detected.

XENON-133

The maximum average ^{133}Xe concentration occurred at Gate 200. This concentration was 0.004 percent of the derived concentration guide. All positive ^{133}Xe results were directly related to slight seepage from Pahute Mesa and Rainier Mesa events. Table 7 lists the average ^{133}Xe concentrations at each location along with the lowest and highest values detected.

Figure 6 presents ^{133}Xe sampling locations and yearly concentration averages.

TABLE 7 - Noble Gases in Air

Concentrations ($\times 10^{-12}$ µCi/ml)

Stations	Kr-85 Max	Kr-85 Min	Kr-85 Avg	Xe-133 Max	Xe-133 Min	Xe-133 Avg
Area 1 BJY	48.5	14.4	25.3	55.7	< 0.8	< 17.7
Area 1 Gravel Pit	43.1	20.4	26.2	< 87.3	< 5.0	< 20.3
Area 5 Gate 200	61.5	13.3	27.3	< 49.7	< 8.3	< 19.0
Area 12 Complex	51.5	10.5	25.7	51.4	< 4.7	< 15.3
Area 15 PILEDRIVER	49.9	11.0	26.2	< 45.9	< 4.9	< 16.0
Area 20 Camp	73.4	18.4	39.3	123.0	< 3.8	< 19.6
Area 25 EMAD Site	59.9	11.0	26.4	< 51.0	< 4.9	< 19.5

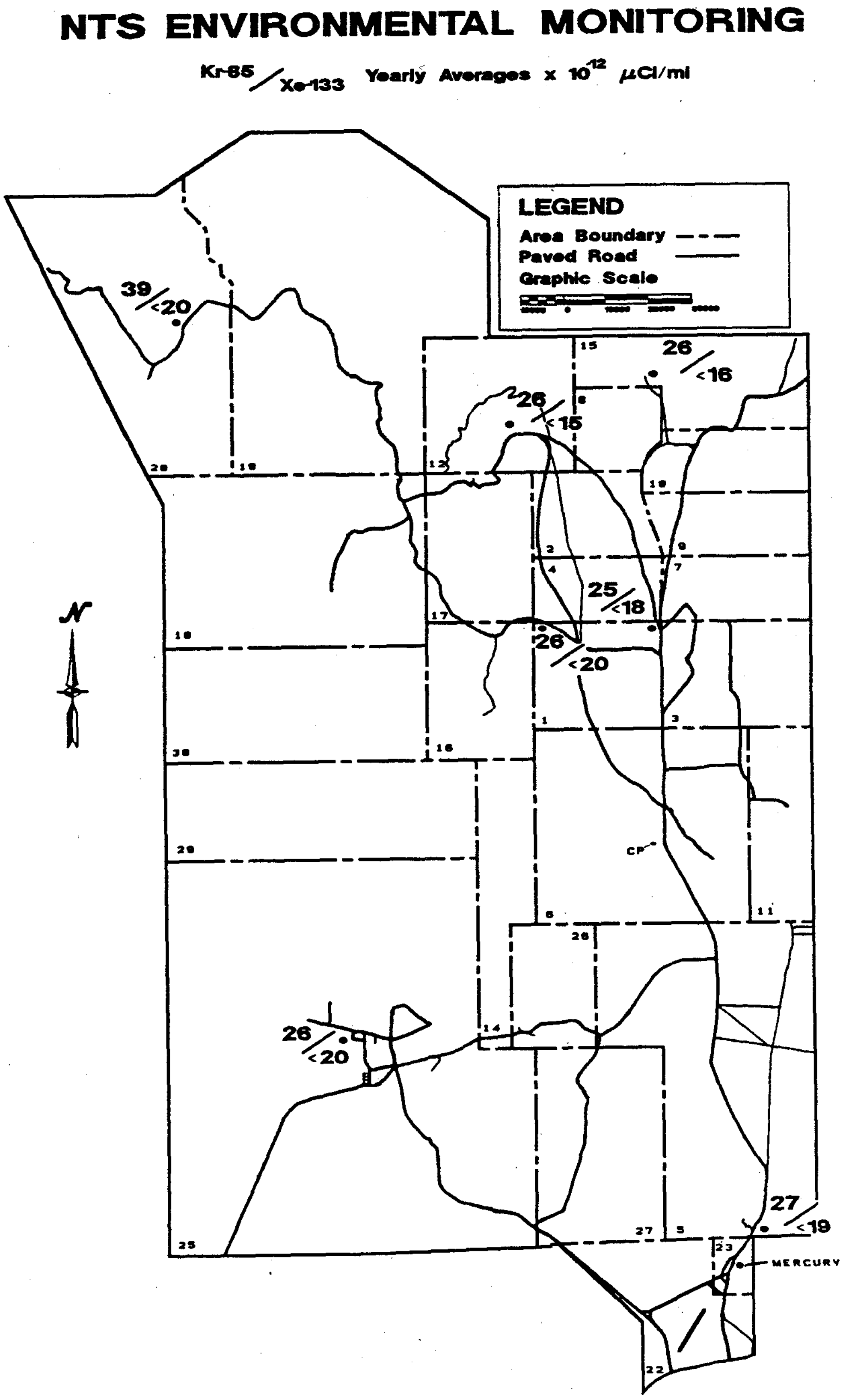


Figure 6 - Noble Gas Stations

RADIOACTIVITY IN SURFACE AND GROUNDWATER

The principal water distribution system on the NTS can be the critical pathway for the ingestion of waterborne radionuclides. Consequently, the system is sampled and evaluated on a frequent routine. The NTS water system consists of 16 supply wells, 7 potable water stations, and 15 open reservoirs. The wells feed directly to many of the reservoirs, and the drinking water is pumped from the wells to the points of consumption. The supply wells and open reservoirs are sampled on a monthly basis. All drinking water is collected weekly to provide a constant check of the end use activity and to allow frequent comparisons to the radioactivity of the water in the wells. The identification of any radionuclides above natural background in the supply well system initiated a closer review of the drinking water. The surface and groundwater monitoring network creates a large data base to evaluate long-term trends or intermittent changes in activity. Natural springs, contaminated ponds, and effluent ponds are also monitored. The springs and contaminated ponds are collected monthly when water is available for sampling. The effluent ponds are sampled quarterly.

SUPPLY WELLS

Water from sixteen supply wells was used for a variety of sanitary and industrial purposes. The criteria for collection was primarily based on potential for human consumption. This data assists in documenting the radiological characteristics of the NTS groundwater system. The sample results are maintained in a data base so that long-term trends and changes may be studied.

Gross Beta

The highest average concentration of gross beta recorded was 1.6×10^{-8} µCi/ml at the UE15d Well. The lowest average gross beta activity for the onsite supply wells was $<1 \times 10^{-9}$ µCi/ml at Well U19c.

The activities of each well and the entire network average appeared consistent over this reporting period. In previous reports (References 8 and 23) it was shown that the majority of gross beta activity was attributable to naturally occurring ^{40}K. The average of the entire network, as compared to previous years is shown in Figure 7.

The yearly gross beta averages are shown at their respective locations in Figure 8. Appendix C consists of the plots of each station for measured gross beta activity with 2 sigma error bars. Table 8 lists the 1987 averages for each location.

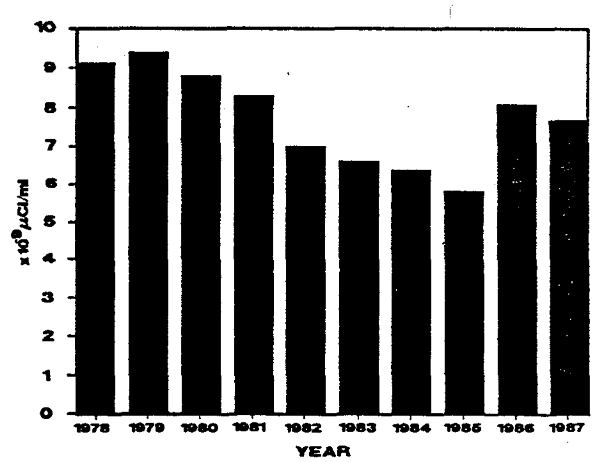


Figure 7 - Supply Well Gross Beta Yearly Comparisons

Tritium and Plutonium

There were no tritium results above detection limits for any of the supply wells. The tritium results above detection limits for all noncontaminated NTS waters are given in Table 9. There were also no positive plutonium results for any supply well during CY-1987. Appendix C includes plots of the network monthly results for gross beta. Figure 9 displays the arithmetic means and ranges of gross beta for supply wells. The tritium and plutonium results were less than detectable and, as such, need not be plotted.

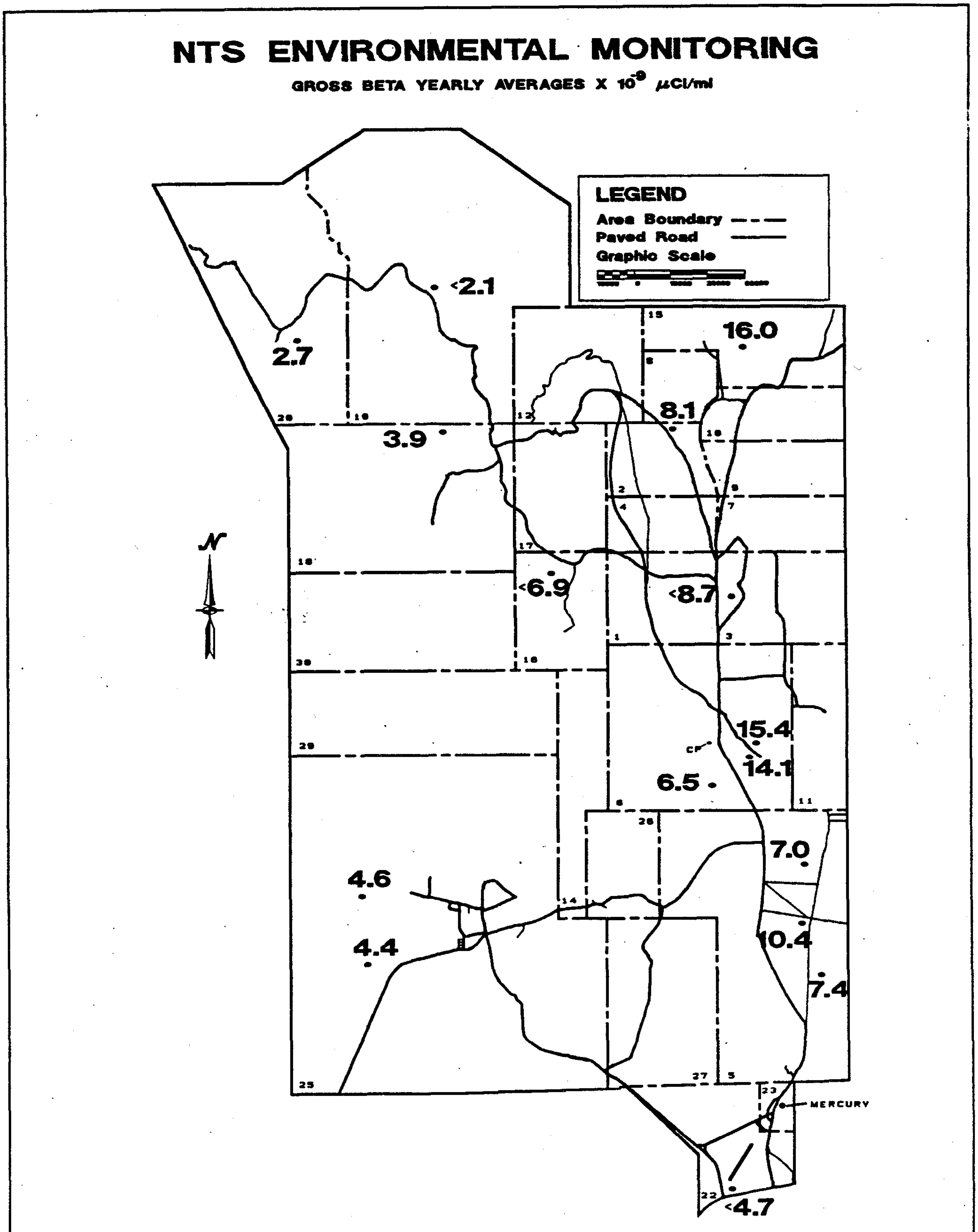


Figure 8 - Supply Well Sampling Stations

TABLE 8 - Supply Well Data for Gross Beta

Station	Gross Beta Yearly Average ($\times 10^{-9}$ μCi/ml)
Area 2 Well 2	8.1
Area 3 Well A	<8.7
Area 5 Well 5B	10.4
Area 5 Well 5C	7.4
Area 5 Well UE5c	7.0
Area 6 Well C	15.4
Area 6 Well C1	14.1
Area 6 Well 4	6.5
Area 15 Well UE15d	16.0
Area 16 Well 16D	<6.9
Area 18 Well 8	3.9
Area 19 Well U19c	<2.1
Area 20 Water Well	2.7
Area 22 Army Well No. 1	<4.7
Area 25 Well J12	4.4
Area 25 Well J13	4.6

TABLE 9 - Tritium Values Above Detection Limits from Noncontaminated Waters

WATER TYPE	STATION	DATE	μCi/ml $\pm 2\sigma$% error
Potable water	Area 3 Cafeteria	01/26/87	$1.9 \times 10^{-6} \pm 30.0$
Potable water	Area 3 Cafeteria	07/09/87	$1.9 \times 10^{-6} \pm 24.6$
Potable water	Area 3 Cafeteria	07/20/87	$1.1 \times 10^{-6} \pm 42.8$
Potable water	Area 3 Cafeteria	08/10/87	$2.4 \times 10^{-6} \pm 17.9$
Potable water	Area 3 Cafeteria	08/17/87	$3.0 \times 10^{-6} \pm 14.7$
Potable water	Area 3 Cafeteria	08/24/87	$4.7 \times 10^{-6} \pm 10.9$
Potable water	Area 2 Rest Room	03/23/87	$2.3 \times 10^{-6} \pm 20.4$
Potable water	Area 2 Rest Room	06/30/87	$1.5 \times 10^{-6} \pm 33.2$
Potable water	Area 2 Rest Room	07/27/87	$1.5 \times 10^{-6} \pm 27.6$
Potable water	Area 2 Rest Room	08/03/87	$1.3 \times 10^{-6} \pm 31.0$
Potable water	Area 2 Rest Room	08/10/87	$2.9 \times 10^{-6} \pm 15.3$
Potable water	Area 2 Rest Room	08/24/87	$1.3 \times 10^{-6} \pm 33.8$
Potable water	Area 12 Cafeteria	02/03/87	$1.4 \times 10^{-6} \pm 38.9$
Potable water	Area 12 Cafeteria	08/10/87	$1.1 \times 10^{-6} \pm 36.3$
Potable water	Area 23 Cafeteria	01/26/87	$7.1 \times 10^{-6} \pm 10.0$
Natural Springs	Topopah Springs	07/23/87	$1.7 \times 10^{-6} \pm 27.3$
Reservoir	Well A Reservoir	01/09/87	$1.3 \times 10^{-6} \pm 41.2$
Reservoir	Camp 17 Reservoir	07/10/87	$1.1 \times 10^{-6} \pm 41.3$

POTABLE WATER

As a check of any effect the water distribution system might have on end use activity, eight consumption points were sampled during the reporting period.

Gross Beta

The highest average recorded was 8.7×10^{-9} µCi/ml at the Area 6 Cafeteria. This was 58 percent of the screening level for drinking water as required by the National Interim Primary Drinking Water Regulations. Appendix D contains the computer plots of the measured gross beta activity with the 2 sigma error bars included. An average plot is provided in Figure 10 which shows the network mean trend throughout the reporting period along with the range at each point for gross beta. Table 10 contains a list of the average gross beta activity measured at each potable sample location for CY-1987. The locations of all stations are shown in Figure 11 with their gross beta yearly averages.

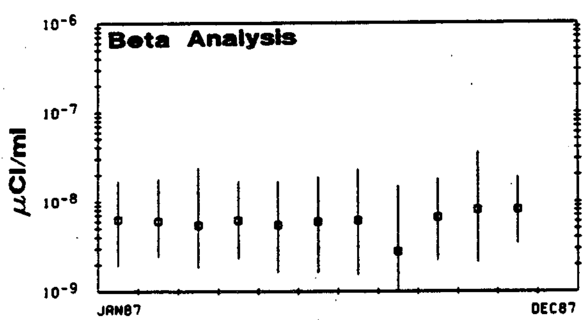


Figure 9 - 1987 Supply Well Network Averages

The lowest average gross beta activity, excluding Cascade brand bottled water, was 3.0×10^{-9} µCi/ml at the Area 12 Cafeteria. The Cascade water was demineralized water brought in from offsite and was used as a check of the laboratory system.

Gross beta measurements at these potable water stations indicated that no release or movement of radionuclides occurred in the NTS water system throughout CY-1987.

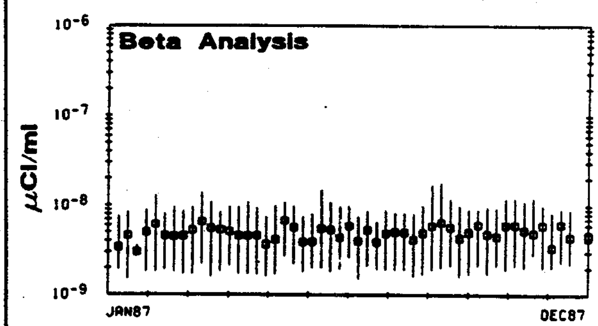


Figure 10 - 1987 Potable Water Network Averages

The average of the entire network, as compared to averages reported in previous environmental reports, is shown in Figure 12.

All potable water, except Cascade bottled water, was obtained from supply wells. A comparison of these waters and their suppliers appears in Table 11. As previously stated, some supply wells were used strickly for industrial purposes and will not be listed in Table 11. In previous reports (References 8 and 23) it was shown that the majority of the radioactivity in supply well and potable water was from naturally occurring ^{40}K.

TABLE 10 - Averages of Potable Water Data for Gross Beta

Station	Gross Beta Yearly Average ($\times 10^{-9}$ µCi/ml)
Area 2 Rest Room	3.3
Area 3 Cafeteria	8.3
Area 6 Cafeteria	8.7
Area 6 Cascade	<2.0
Area 12 Cafeteria	3.2
Area 23 Cafeteria	7.2
Area 27 Cafeteria	8.1

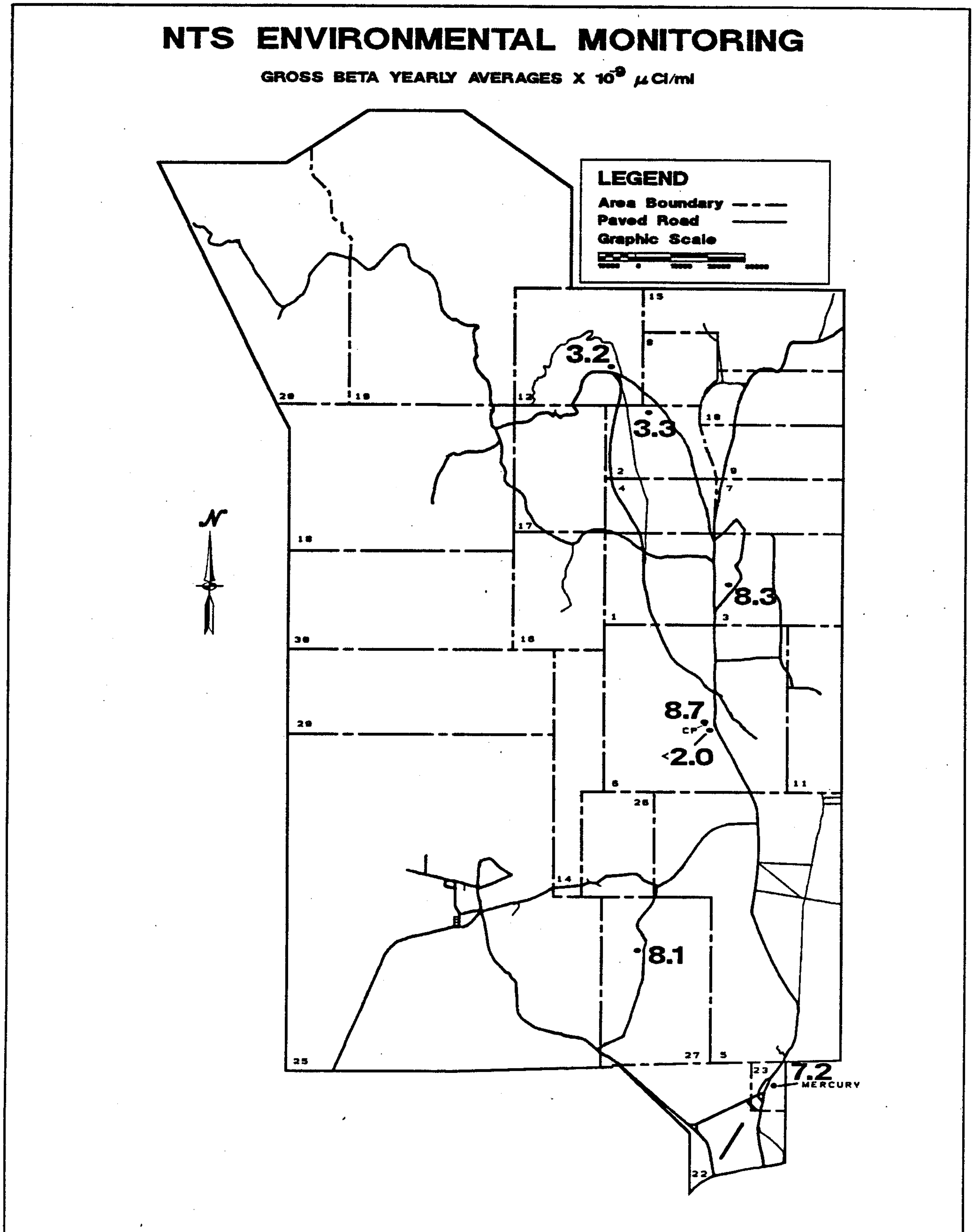


Figure 11 - Potable Water Sampling Stations

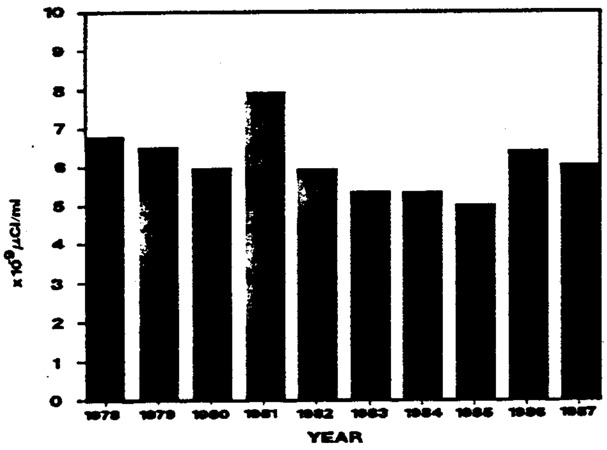


Figure 12 - Potable Water Gross Beta Yearly Comparisons

Tritium

The highest average of tritium was 1.2 × 10^{-6} µCi/ml at the Area 3 Cafeteria. This is 6.0 percent of the standard for tritium in drinking water. The majority of the positive measurements are near the detection limit of the system and are believed to be caused by the statistical fluctuation inherent in counting. Furthermore, a new scintillation cocktail was being tested and was found to provide a high background count under certain circumstances. This cocktail was discontinued after some use, and for the remainder of the year, there were no more positive tritium results. All positive tritium results were given in Table 9.

Plutonium

There was one positive plutonium result for the Area 12 cafeteria. This value of 1.4 × 10^{-10} µCi/ml ± 35.7% represents 0.003 percent of the standard for drinking water. Further sampling at Area 12 cafeteria showed no more positive plutonium results leading the author to conclude that the positive result was a false positive, possibly caused by statistical fluctuations inherent in counting. Appendix D includes the plots of the network results for tritium and plutonium.

Table 12, NTS Drinking Water Results, displays results from sampling conducted at the potable water stations. Listed in this table are maximum and minimum results for each station during CY-1987. The yearly average and gross alpha results from sampling conducted quarterly at each station is also presented.

OPEN RESERVOIRS

Open reservoirs have been established at various locations on the NTS for industrial purposes. Fifteen locations were sampled during the report period. The locations are shown in Figure 13 along with their gross beta yearly averages. Comparisons were made to controlled area standards rather than drinking water standards because there is no known consumption of these waters.

Gross Beta

The highest average beta concentration was 12 × 10^{-9} µCi/ml at Well UE5c Reservoir. The lowest gross beta average was 1.9 × 10^{-9} µCi/ml at Well U19c Reservoir. Table 13 includes a list of the CY-1987 gross beta averages at each location.

The values for the reservoirs supplied by wells were in most cases slightly higher than other reservoirs. This is most likely caused by resuspended contaminated material settling into the open reservoirs and/or run-off into the reservoirs from contaminated areas. Table 14 shows the gross beta activities of the open reservoirs that were supplied by wells, along with the activities of the associated wells. Figure 14 shows the average gross beta

TABLE 11 - Comparison of Potable and Supply Water for Gross Beta Averages

(× 10^{-9} µCi/ml)

Station (end use/supply)	CY-1987
Area 2 Rest Room	3.3
Area 18 Well 8	3.9
Area 3 Cafeteria	8.3
Area 3 Well A	<8.7
Area 6 Cafeteria	8.7
Area 6 Well C/C1	15.4/14.1
Area 6 Cascade Water	<2.0
Area 12 Cafeteria	3.2
Area 18 Well 8	3.9
Area 23 Cafeteria	7.2
Area 5 Well 5B/5C	10.4/7.4
Area 22 Army Well No. 1	<4.7
Area 27 Cafeteria	8.1
Area 5 Well 5B/5C	10.4/7.4
Area 22 Army Well No. 1	<4.7

TABLE 12 - NTS Safe Drinking Water Act Results

	Location			
Analysis	Area 3 Cafeteria	Area 2 Rest Room	Area 12 Cafeteria	Area 23 Cafeteria
Gross Alpha ($\times 10^{-9}$ μCi/ml)				
Maximum	8.6	<4.3	<4.4	19
Minimum	<3.0	<1.3	<1.0	<2.4
Average	<5.4	<3.2	<2.5	<9.6
Gross Beta ($\times 10^{-9}$ μCi/ml)				
Maximum	10	9.1	7.4	18
Minimum	5.4	<1.6	1.9	2.6
Average	8.3	<3.3	3.2	7.2
Tritium ($\times 10^{-6}$ μCi/ml)				
Maximum	4.7	2.9	1.4	7.1
Minimum	<0.7	<0.7	<0.7	<0.7
Average	<1.2	<1.1	<1.0	<1.1

TABLE 12 - NTS Safe Drinking Water Act Results concluded

Analysis	Area 27 Cafeteria	Cascade Water	Area 6 Cafeteria
	Location		
Gross Alpha ($\times 10^{-9}$ μCi/ml)			
Maximum	21	< 1.1	< 17
Minimum	< 2.7	< 1.0	4.9
Average	< 10	< 1.0	< 12
Gross Beta ($\times 10^{-9}$ μCi/ml)			
Maximum	15	7.0	14
Minimum	< 1.9	< 1.5	4.1
Average	< 8.1	< 2.0	8.7
Tritium ($\times 10^{-6}$ μCi/ml)			
Maximum	< 1.4	< 1.5	< 1.5
Minimum	< 0.7	< 0.7	< 0.7
Average	< 1.0	< 1.0	< 1.0

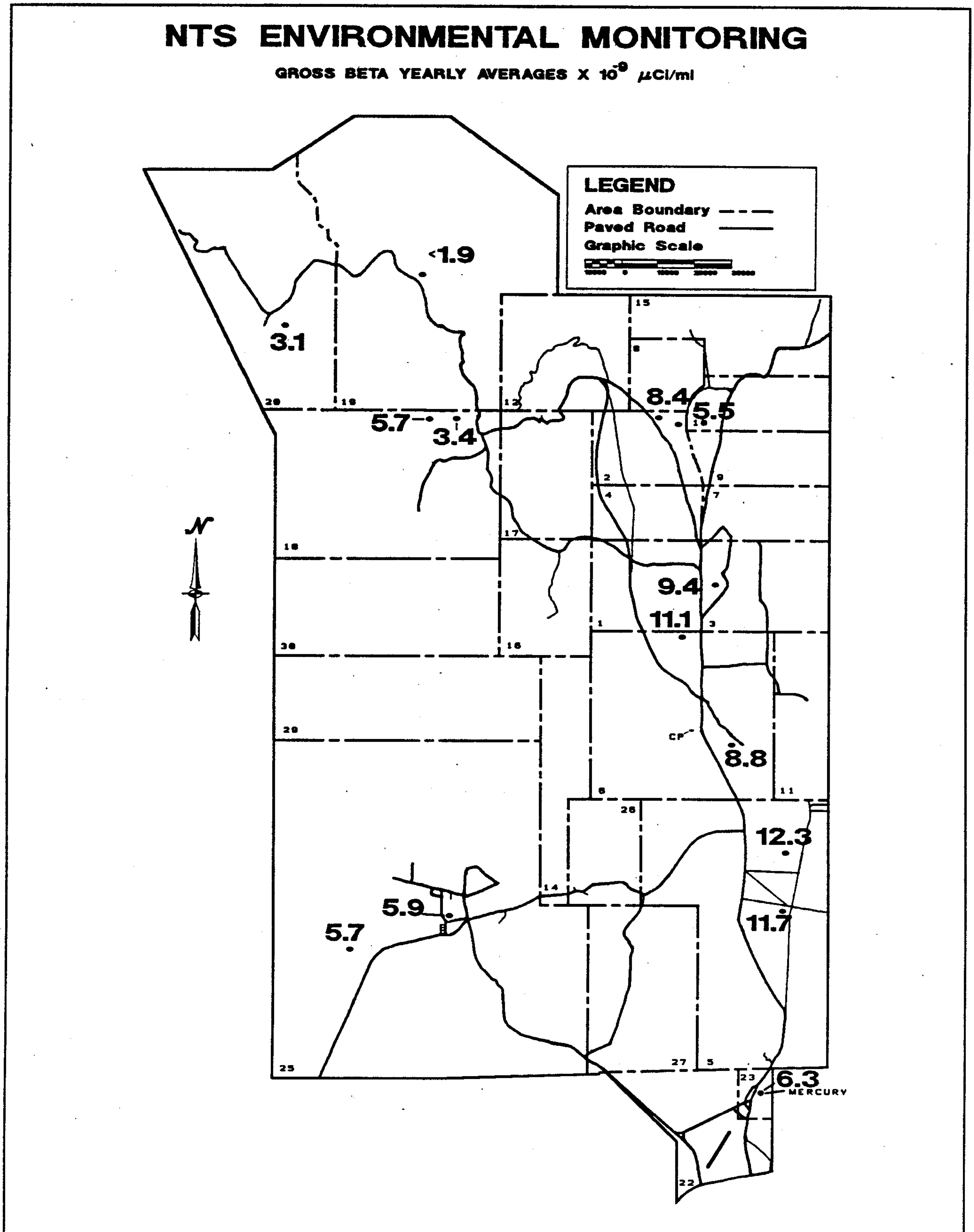


Figure 13 - Open Reservoir Sampling Stations

TABLE 13 - Averages of Open Reservoir Data for Gross Beta

Station	Gross Beta Yearly Average ($\times 10^{-9}$ μCi/ml)
Area 2 Well 2 Reservoir	8.4
Area 2 Mud Plant Reservoir	5.5
Area 3 Well A Reservoir	9.4
Area 3 Mud Plant Reservoir	11.2
Area 5 Well 5B Reservoir	11.7
Area 5 Well Ue5c Reservoir	12.3
Area 6 Well 3 Reservoir	11.1
Area 6 Well C1 Reservoir	8.8
Area 18 Camp 17 Reservoir	3.4
Area 18 Well 8 Reservoir	5.7
Area 19 Well U19c Reservoir	<1.9
Area 20 Well 20A Reservoir	3.1
Area 23 Swimming Pool	6.3
Area 25 Well J-11 Reservoir	5.9
Area 25 Well J-12 Reservoir	5.7

results for the entire network, as compared to previous years.

Appendix E consists of the plots of each station of the measured gross beta activity with 2 sigma error bars. An averaging plot, Figure 15, displays the entire network mean trend and range throughout the reporting period for gross beta. These plots demonstrate consistent concentrations of gross beta activity at all locations throughout CY-1987.

Tritium and Plutonium

There were two positive tritium values for all open reservoirs during CY-1987. Both results were close to detection limits and consequently many orders of magnitude below concentration guides. One of the two positive results is attributed to the test scintillation cocktail. The positive tritium results for all noncontaminated waters can be seen in Table 9.

There were no positive plutonium results.

NATURAL SPRINGS

The term *natural springs* was a label given to the spring supplied pools located within the NTS. There is no known human consumption from these springs. Many of the springs are watering holes for wild animals.

TABLE 14 - Comparison of Open Reservoir and Supply Water for Gross Beta

Station (Reservoir/Supply)	Gross Beta Yearly Average ($\times 10^{-9}$ μCi/ml)
Area 2 Well 2 Reservoir	8.4
Area 2 Well 2	8.1
Area 3 Well A Reservoir	9.4
Area 3 Well A	<8.7
Area 5 Well 5B Reservoir	11.7
Area 5 Well 5B	10.4
Area 5 Well Ue5c Reservoir	12.3
Area 5 Well Ue5c	7.0
Area 6 Well C1 Reservoir	8.8
Area 6 Well C1	14.1
Area 19 Well U19c Reservoir	<1.9
Area 19 Well U19c	<2.1
Area 25 Well J-12 Reservoir	5.7
Area 25 Well J-12	4.4

Gross Beta

The highest gross beta average recorded was 29.8 $\times 10^{-9}$ μCi/ml at Reitmann Seep, which represented 0.15 percent of the CG. The network average, as compared to those presented in previous reports, is shown in Figure 16.

Appendix F contains the plots of all the natural spring sampling stations. Averages of the measured gross beta activity are presented with 2 sigma error bars. An averaging plot, Figure 17, displays the trend of the network mean throughout the reporting period as well as the range for gross beta. Table 15 presents a list of the gross beta averages at each location. Nine locations sampled on a monthly basis (when accessible) are shown in Figure 18 along with their gross beta yearly averages.

Tritium and Plutonium

There was one positive tritium result at Topopah Springs of 1.3 $\times 10^{-6}$ μCi/ml which represented 6.5 percent of the drinking water regulations. This positive value is also con-

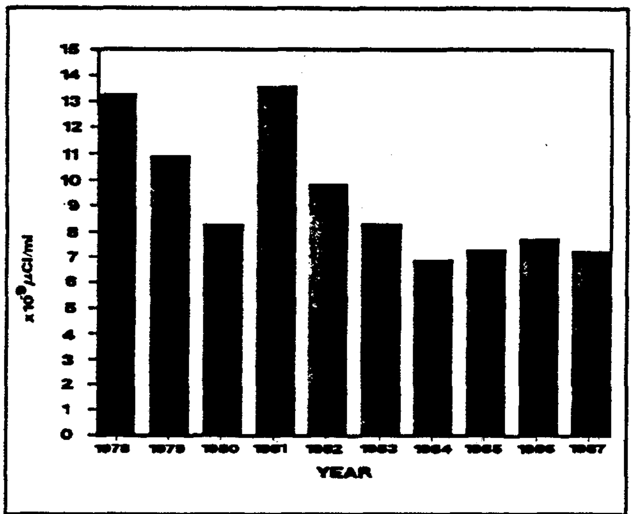


Figure 14 - Open Reservoir Gross Beta Yearly Comparisons

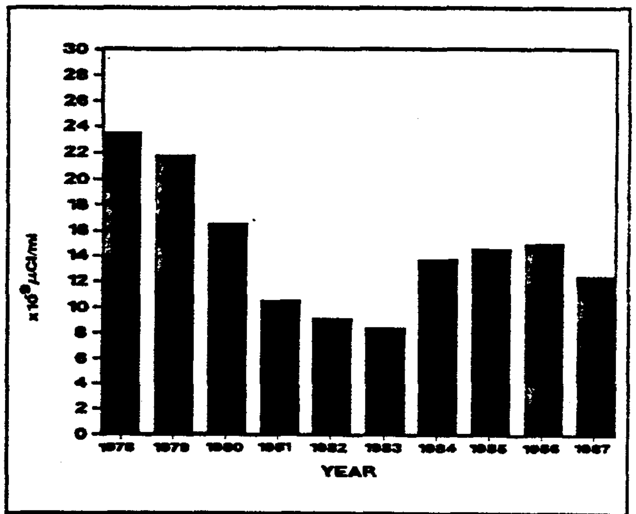


Figure 16 - Natural Spring Gross Beta Yearly Comparisons

sidered to be a result of the experimental tritium cocktail solution. As was previously stated, there is no known human consumption of these waters. The positive results for tritium for all noncontaminated waters are listed in Table 9.

There was one positive plutonium result at Reitmann Seep during CY-1987. This result of 1.5×10^{-10} µCi/ml ±42.7% is 0.003 percent of the limit for drinking water. The result is, however, very close to detection levels with a high error term. Further sampling at this site produced no other positive results. This suggests that the one positive result was false and due to the statistical fluctuations of background counts inherent in radiation measurements.

Appendix F includes plots of the results for tritium and plutonium at the natural spring sampling stations.

CONTAMINATED PONDS

Nine contaminated stations were sampled on a special study basis. These ponds were impound waters from tunnel test areas and a contaminated laundry release point. They are monitored in accordance with DOE Order

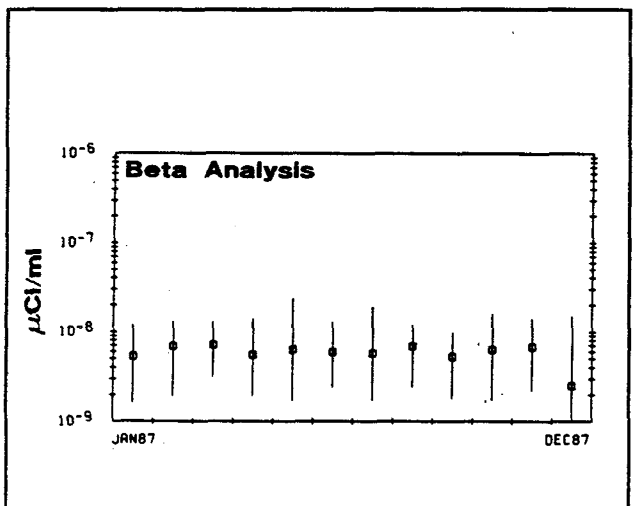


Figure 15 - 1987 Open Reservoir Network Averages

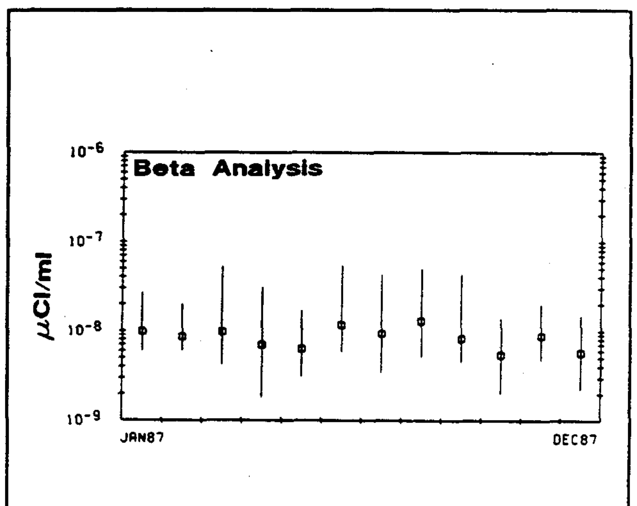


Figure 17 - 1987 Natural Springs Network Averages

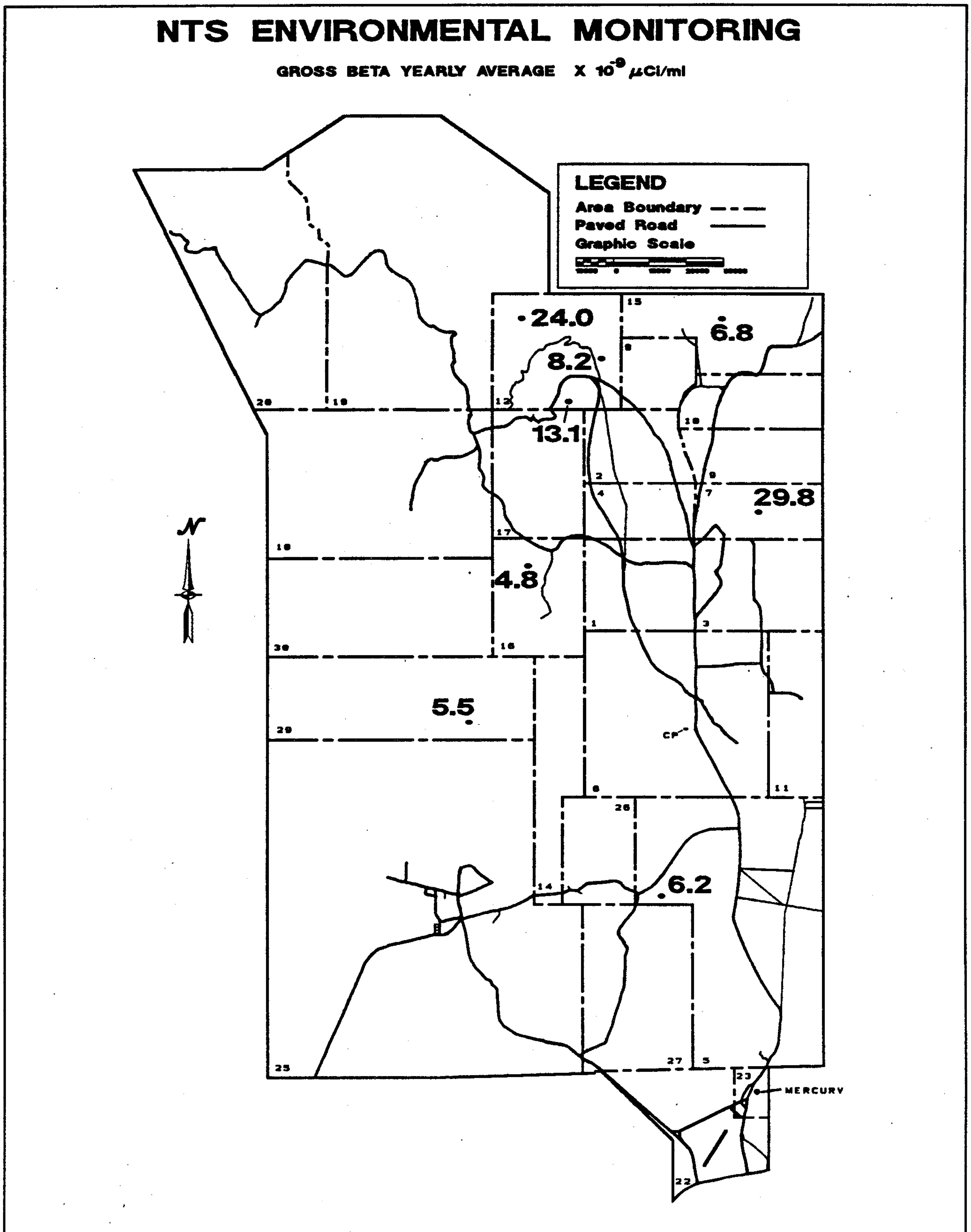


Figure 18 - Natural Springs Sampling Stations

TABLE 15 - Averages of Natural Springs Data for Gross Beta

Station	Gross Beta Yearly Average ($\times 10^{-9}$ μCi/ml)
Area 5 Cane Spring	6.2
Area 7 Reitmann Seep	29.8
Area 12 White Rock Spring	8.2
Area 12 Captain Jack Spring	13.1
Area 12 Gold Meadows Pond	24.0
Area 15 Tub Spring	6.8
Area 16 Tippipah Spring	4.8
Area 29 Topopah Spring	5.5

5484.1, Chapter IV to provide a data base for calculations of any offsite releases. Tritium results from these sites are reported to DOE Headquarters on an annual basis. These results are listed in Chapter VIII, "Effluent Monitoring," along with results from other effluent discharge sites. The network averages and associated range are shown in Figure 19. The gross beta concentration for each location is shown in Figure 20.

Table 16 is a list of the gross beta, tritium, and ^{239}Pu averages at the seven active stations. The first two pages of Appendix G contain the contaminated pond network averages. The remaining plots show the gross beta, ^{239}Pu, and tritium concentrations at each station. The differences between CY-1986 and CY-1987 can be attributed to the decrease or increase in use of the ponds.

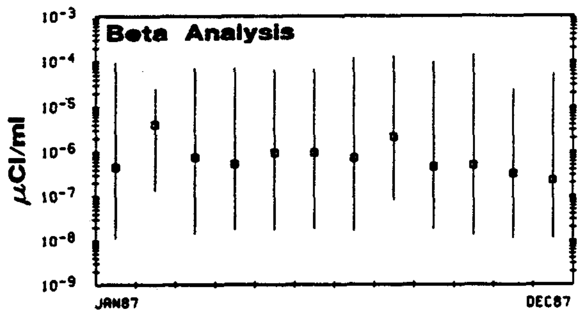


Figure 19 - 1987 Contaminated Pond Network Averages

EFFLUENT PONDS

Samples from five effluent pond locations were collected during CY-1987. These ponds are closed systems which contain both sanitary and radioactive waste for evaporative treatment. They are located in Areas 6 (3 stations), 12, and 23. Contact with the working population was minimal. The highest average gross beta value was 2.6×10^{-8} μCi/ml. Plutonium and tritium concentrations were less than detectable at all locations.

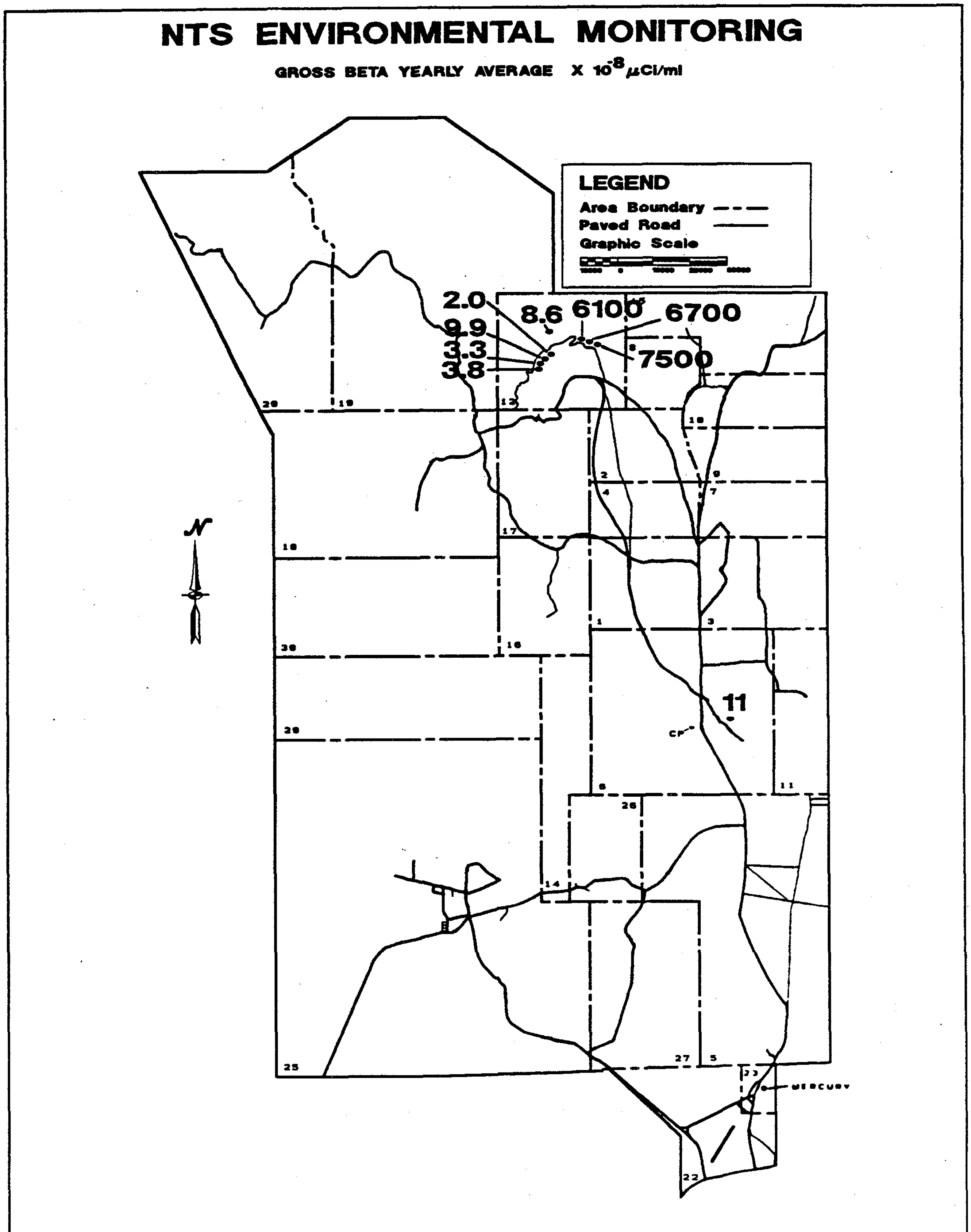


Figure 20 - Contaminated Ponds Sampling Stations

TABLE 16 - Contaminated Pond Yearly Concentration Averages

(μCi/ml)

Station	Tritium Yearly Avg	Gross Beta Yearly Avg	Pu-239 Yearly Avg
Area 6 Yucca Decontamination Pond	3.9×10^{-6}	1.1×10^{-7}	$< 3.9 \times 10^{-10}$
Area 12 E Tunnel Effluent	2.6×10^{-3}	8.6×10^{-8}	2.6×10^{-9}
Area 12 N Tunnel Effluent	2.7×10^{-4}	2.0×10^{-8}	$< 7.7 \times 10^{-11}$
Area 12 N Tunnel Pond No. 1	1.1×10^{-2}	1.8×10^{-6}	$< 6.8 \times 10^{-11}$
Area 12 N Tunnel Pond No. 2	3.6×10^{-4}	3.3×10^{-8}	$< 5.3 \times 10^{-11}$
Area 12 N Tunnel Pond No. 3	3.9×10^{-4}	3.8×10^{-8}	$< 4.2 \times 10^{-11}$
Area 12 T Tunnel Effluent	2.0×10^{-1}	6.1×10^{-5}	1.4×10^{-10}
Area 12 T Tunnel Pond No. 1	2.3×10^{-1}	6.7×10^{-5}	$< 9.6 \times 10^{-11}$
Area 12 T Tunnel Pond No. 2	2.2×10^{-1}	7.5×10^{-5}	$< 2.4 \times 10^{-10}$

AMBIENT GAMMA MONITORING

A program to measure the ambient gamma exposure rates on the NTS was established in 1977 with 21 stations. The program was expanded to 86 locations in CY-1978, 139 stations in CY-1979, 152 in CY-1980, and 163 in CY-1981. Three stations were discontinued during the latter part of CY-1985. One station was discontinued in CY-1986, reducing the total to 159 stations. During CY-1987 a few roads were restaked and the number of stations was changed to 153.

A new dosimetry monitoring system was implemented at the NTS in 1987 using a thermoluminescent processing system. The new system consists of the Panasonic UD-710A Thermoluminescent Dosimeter (TLD) readers and the UD-814AS environmental dosimeters. Each ambient gamma station was monitored with TLDs which were replaced on a half-year cycle. Some TLDs were lost and still others were inaccessible due to environmental conditions.

RESULTS

The CY-1987 results are consistently higher than the CY-1986 results. The cause originates in the new monitoring system rather than from actual exposure level increases.

The author believes that the new TLD system delivers values that are closer to true rates than those from the system previously in use. An inspection of the data reveals that the CY-1987 results closely follow the CY-1981 through CY-1983 results.

In March 1984 the Environmental Protection Agency began processing NTS TLDs and continued to do so through CY-1986. Beginning with January 1987 REECo once again processed its own TLDs.

For the first half of CY-1987 the UD-814AS dosimeters were unavailable. UD-802 TLDs were used instead of UD-814s. Although the statistics were not as desirable, the 802 TLD was still a valid temporary replacement. The fourth element of the UD-802 dosimeter is identical to the second through fourth elements of the UD-814AS.

The overall network range of the control stations was 0.14 mrem/day to 0.39 mrem/day, with an average natural background on NTS of approximately 0.28 mrem/day (102 mrem/year). The control station values measured in CY-1987 correspond favorably with rates measured at surrounding offsite Nevada locations by the Environmental Protection Agency in CY-1986 (Reference 24) The control network average also compares favorably with the average annual per capita dose to the whole U.S. population of 103 mrem/year.

The remaining 151 stations of the network yielded dose rates which ranged from 0.13 mrem/day to 5.59 mrem/day.

"Gamma Monitoring Results - Summary 1987" (Table 17) lists the individual station data for the first half and second half of CY-1987. In addition, this table shows associated average daily dose rates and the adjusted annual dose for each monitoring station.

Table 17, page 44, displays the boundary TLD results. These stations are located essentially on the NTS boundary and are accessible only by helicopter.

"TLD Control Station Comparison" (Table 18) lists the results for the nine locations that comprised the original control network. This table compares past results from 1981 through the present.

TABLE 17 - Gamma Monitoring Results - Summary of 1987

REPORTING PERIOD: JANUARY 1987 TO MARCH 1988

AREA	NAME	DOSE RATE mrem/day 1st	2nd	AVG	1986 ANNUAL DOSE mrem/yr	1987 ANNUAL DOSE mrem/yr
1	BJY	0.42	0.37	0.39	89	144
1	SANDBAG HUT	0.41	--	0.41	96	149
1	STAKE TH-38	0.46	0.34	0.40	99	146
2	STAKE M-140	0.47	0.40	0.43	99	159
2	STAKE M-150	0.55	0.42	0.48	102	176
2	STAKE 2N-8	5.99	5.19	5.59	1610	2046
2	STAKE 2L-9	1.02	0.76	0.89	217	324
2	STAKE TH-58	0.34	0.29	0.32	79	116
2	STAKE 2L-17	0.51	0.43	0.47	107	172
3	STAKE 3B-20	0.30	0.29	0.30	80	108
3	ANGLE ROAD	0.49	0.54	0.52	140	183
3	U3AX/BL, NE	1.13	1.11	1.12	254	408
3	U3AX/BL, NW	0.57	--	0.57	156	209
3	U3AX/BL, S	0.52	0.53	0.53	135	193
3	U3AX/BL, SE	0.55	0.67	0.61	152	223
3	U3BY, N	1.30	--	1.30	253	623
3	U3BY, S	0.49	0.52	0.51	139	186
3	U3BZ, N	0.59	0.69	0.64	181	234
3	U3BZ, S	0.46	--	0.46	123	170
3	U3CJ, N	0.32	0.46	0.39	117	143
3	U3CO, S	1.86	2.28	2.07	629	758
3	U3CO, N	3.10	--	3.10	1003	1134
3	U3EY, S	0.42	0.44	0.43	119	158
3	U3DU, N	0.58	0.54	0.56	138	206
3	U3DU, S	0.47	0.59	0.53	159	195
4	STAKE M-130	0.43	0.35	0.39	87	183
4	STAKE 4A-9	4.62	4.34	4.48	1325	1641
4	STAKE TH-48	--	0.39	0.39	96	144
5	RWMS CORNER, NW	0.48	0.40	0.44	95	162
5	RWMS-E, 500	0.97	0.94	0.96	92	349
5	RWMS-E, 1000	0.44	0.37	0.41	89	149
5	RWMS-E, 1500	0.46	0.34	0.40	88	146
5	RWMS-EAST GATE	0.56	0.37	0.47	85	170
5	RWMS-N, 500	0.40	0.40	0.40	98	146
5	RWMS-N, 1000	0.43	0.39	0.41	57	150
5	RWMS-N, 1500	0.47	0.45	0.46	91	168
5	RWMS-NE CORNER	0.47	0.45	0.46	89	168
5	RWMS OFFICES	0.28	0.28	0.28	80	101
5	RWMS-S, 500	0.38	0.24	0.31	92	113
5	RWMS SOUTH GATE	0.58	0.94	0.76	110	278

TABLE 17 - Gamma Monitoring results - Summary of 1987

REPORTING PERIOD: JANUARY 1987 TO MARCH 1988

AREA	NAME	DOSE RATE mrem/day 1st	2nd	AVG	1986 ANNUAL DOSE mrem/yr	1987 ANNUAL DOSE mrem/yr
5	RWMS-SW CORNER	0.39	0.35	0.37	88	135
5	RWMS-W 500	0.44	0.39	0.42	92	152
5	RWMS-W 1000	0.47	0.33	0.41	98	148
5	RWMS-W 1500	0.39	0.40	0.40	94	145
5	WELL 5B	0.35	0.29	0.32	79	119
6	6-09 & O.B. ROAD	0.32	0.40	0.36	106	183
6	CP-6	0.19	0.23	0.21	49	76
6	CP-2 ROOM 4	0.22	0.23	0.22	58	81
6	CP-50 CALIBRATION BENCH	0.36	0.33	0.35	82	127
6	CP-50 INSTRUMENT CALIBRATION DRAWER	0.37	0.37	0.37	122	136
6	DECONTAMINATION PAD BACK OFFICE	0.28	0.30	0.29	87	105
6	DECONTAMINATION PAD FRONT OFFICE	0.24	0.27	0.25	52	92
6	STAKE TH-1	0.30	--	0.30	62	110
6	STAKE TH-9	0.40	--	0.40	89	146
6	STAKE TH-18	0.36	--	0.36	80	131
6	YUCCA OIL STORAGE	0.30	--	0.30	79	112
7	7-300 BUNKER	1.26	--	1.26	318	461
8	STAKE 8K-25	--	0.33	0.33	94	120
9	9-300 BUNKER	0.41	0.41	0.41	96	149
10	GATE 700 SOUTH	0.40	--	0.40	--	147
10	STAKE 10A-24	0.67	0.64	0.66	170	240
10	STAKE CA-14	0.51	0.44	0.48	99	174
10	CIRCLE AND L ROADS	0.48	0.36	0.42	95	155
10	SEDAN VISITORS BOX	0.56	0.47	0.51	116	188
10	SEDAN ENTRY ROAD	1.65	1.69	1.67	496	611
11	GATE 293	0.30	0.42	0.36	107	133
12	STAKE M-168	0.45	0.35	0.40	112	146
12	STAKE M-170	0.46	--	0.46	99	168
12	STAKE M-175	0.39	0.38	0.39	109	141
12	BUILDING 12-10	0.34	0.38	0.36	111	132
12	T TUNNEL No. 2 (LOWER MINT)	0.95	--	0.95	694	349
12	STAKE TH-68.5	0.37	0.31	0.34	84	123
12	UPPER HAINES LAKE	0.43	0.33	0.38	108	138
12	N TUNNEL No. 1	0.47	0.34	0.40	112	148

TABLE 17 - Gamma Monitoring results - Summary of 1987

REPORTING PERIOD: JANUARY 1987 TO MARCH 1988

AREA	NAME	DOSE RATE mrem/day 1st	2nd	AVG	1986 ANNUAL DOSE mrem/yr	1987 ANNUAL DOSE mrem/yr
15	EPA FARM	--	0.37	0.37	81	134
15	LAMP SHACK	0.42	0.37	0.39	94	144
15	U15E LLNL TRAILER	0.40	--	0.40	99	148
15	U15E TRAILER No. 621	0.32	0.30	0.31	67	114
15	U15E STORAGE SHED	0.44	0.38	0.41	92	151
15	U15E SUBSTATION	0.39	0.31	0.35	67	129
17	STAKE M-190	--	0.42	0.42	126	153
17	STAKE M-185	0.43	0.39	0.41	116	149
18	STAKE 18P-35	0.51	0.44	0.48	124	175
18	STAKE M-196	0.47	0.43	0.45	124	163
18	STAKE 18P-39	0.52	0.44	0.48	124	175
18	GATE 18-1C	0.50	--	0.50	122	183
19	STAKE 19P-41	0.53	0.48	0.51	132	185
19	STAKE 19P-46	0.44	0.39	0.41	119	152
19	STAKE 19P-54	0.46	0.40	0.43	115	158
19	STAKE 19P-59	0.52	0.50	0.51	132	185
19	STAKE 19P-66	0.53	0.43	0.48	135	176
19	STAKE 19P-71	0.56	0.45	0.51	129	185
19	STAKE 19P-77	0.44	0.50	0.47	151	173
19	STAKE 19P-87	--	0.51	0.51	139	186
19	STAKE 19P-88	0.63	0.51	0.57	132	207
19	STAKE 19P-91	0.49	0.48	0.49	130	178
19	STAKE C-16	0.45	0.44	0.45	131	163
19	STAKE C-25	0.42	0.41	0.41	131	151
19	STAKE C-27	0.53	0.46	0.50	135	182
19	STAKE C-31	--	1.88	1.88	137	689
19	STAKE R-20	--	0.46	0.46	136	168
19	STAKE R-27	--	0.53	0.53	139	185
19	STAKE R-3	--	0.52	0.52	154	191
19	STAKE R-31	--	0.47	0.47	158	172
19	STAKE R-9	--	0.46	0.46	132	167
19	WELL U19C	--	2.90	2.90	132	1062
20	STAKE 20P-120.5	0.41	0.65	0.53	147	193
20	STAKE 20P-116.5	0.51	0.43	0.46	140	172
20	AREA 20 CAMP	0.48	0.42	0.45	136	165
20	STAKE 20P-134	0.48	0.45	0.47	114	172
20	STAKE 20P-124	0.51	0.43	0.47	134	175
20	STAKE 20P-129	0.51	0.48	0.49	138	180
20	STAKE J-16	0.53	0.46	0.50	133	181
20	STAKE J-24	0.45	0.46	0.46	134	167

TABLE 17 - Gamma Monitoring Results - Summary of 1987

REPORTING PERIOD: JANUARY 1987 TO MARCH 1988

AREA	NAME	DOSE RATE mrem/day 1st	2nd	AVG	1986 ANNUAL DOSE mrem/yr	1987 ANNUAL DOSE mrem/yr
20	STAKE J-31	1.15	1.21	1.18	374	432
22	DESERT ROCK CONTROL TOWER	0.19	0.19	0.19	55	68
22	BLDG. 190	0.60	0.46	0.53	72	195
23	BLDG. 610 GATE	0.23	0.18	0.20	49	75
23	BLDG. 610 WORK AREA	2.93	2.27	2.60	536	952
23	BLDG. 650 DOSIMETRY ROOM	0.14	--	0.14	112	51
23	BLDG. 650 ROOF	0.15	0.19	0.17	47	62
23	BLDG. 650 SAMPLE STORAGE	0.60	0.17	0.38	107	140
23	GATE 100	0.14	0.20	0.17	53	62
23	POST OFFICE	0.25	0.23	0.24	57	89
23	BUILDING 180, SCALER	0.25	0.27	0.26	93	95
25	GATE 25-4P	--	0.37	0.37	106	134
25	GATE 25-7P	0.35	0.36	0.35	99	130
25	EMAD-E	0.38	0.35	0.36	97	134
25	EMAD-N	--	0.30	0.30	147	109
25	EMAD-S	0.37	0.35	0.36	99	133
25	EMAD-W	0.36	0.32	0.34	98	124
25	HENRE SITE	0.37	0.31	0.34	99	123
25	NRDS WAREHOUSE	0.45	0.34	0.39	100	144
27	AREA 27 CAFE	--	0.38	0.38	89	139

TABLE 17 - Gamma Monitoring Results - Summary of 1987

REPORTING PERIOD: JANUARY 1987 TO MARCH 1988

AREA	NAME	DOSE RATE mrem/day 1-5/87	5-9/87	9-3/88	AVG	1986 ANNUAL DOSE mrem/year	1987 ANNUAL DOSE mrem/year
3	N844,200 E704,900	--	--	0.16	0.16	64	60
5	N710,800 E720,000	--	--	0.08	0.08	62	30
9	N874,600 E691,500	--	0.25	0.20	0.22	69	82
11	N788,800 E709,500	--	0.33	0.30	0.32	127	116
12	N903,800 E635,500	--	0.34	0.26	0.31	99	115
15	N907,600 E686,200	--	0.40	0.39	0.39	376	144
18	N849,500 E545,000	0.68	0.60	0.37	0.55	131	201
19	N935,500 E639,750	--	0.44	0.36	0.40	113	146
19	N955,500 E614,200	0.67	0.50	--	0.58	180	214
20	N887,000 E558,000	--	0.50	0.44	0.47	155	172
20	N948,800 E527,800	0.74	0.52	0.40	0.55	139	202
20	N944,700 E563,300	0.57	0.30	0.23	0.37	84	134
22	N670,600 E667,300	0.43	--	--	0.43	53	158
25	N731,300 E638,700	0.54	--	0.25	0.40	98	145

TABLE 18 - TLD Control Station Comparison

	Dose Rate (mrem/day)						
Station	1981	1982	1983	1984	1985	1986	1987
Bldg. 650 Dosimetry	0.21	0.19	0.21	0.15	0.13	0.31	0.14
Bldg. 650 Roof	0.18	0.18	0.18	0.14	0.12	0.13	0.17
Area 27 Cafeteria	0.41	0.37	0.39	0.32	0.29	0.27	0.38
CP-6	0.25	0.20	0.25	0.18	0.17	0.13	0.21
HENRE Site	0.39	0.37	0.36	0.30	0.28	0.27	0.34
NRDS Warehouse	0.40	0.38	0.36	0.32	0.28	0.28	0.39
Post Office	0.20	0.18	0.18	0.14	0.13	0.16	0.24
Well 5B	0.38	0.33	0.33	0.27	0.26	0.22	0.32
Yucca Oil Storage	0.30	0.28	0.28	0.23	0.21	0.22	0.30
Network Average	0.30	0.28	0.28	0.23	0.21	0.22	0.28

RADIOACTIVE WASTE MANAGEMENT PROJECT

Robert J. Straight

The Radioactive Waste Management Project (RWMP) safely disposes of dry, solid low-level waste generated primarily within the Department of Energy. This task is accomplished by shallow land disposal. RWMP facilities also temporarily and securely store some classified items and transuranic (TRU) wastes pending final and permanent disposal.

In addition, the RWMP governs the disposition and monitoring of radioactive wastes generated at the Nevada Test Site. No material is accepted from commercial sources.

SITES

The RWMP uses two locations for disposal and storage of radioactive wastes.

The first of these sites is Area 5, 14 miles from Mercury, which receives shipments from 16 offsite generators. The facility comprises centralized pits, trenches and large-diameter bore holes. The TRU storage area and the classified materials disposal area are also located there.

The Greater Confinement Disposal Test (GCDT) operates in Area 5 as a complement to shallow land disposal. This experiment provides information about the diffusion behavior of simulated contaminants and soil moisture under the influence of decay heat of highly radioactive waste materials.

The second RWMP site, the Bulk Waste Management Facility (BWMF), is located in Area 3, 30 miles from Mercury. A wide variety of bulk materials contaminated by onsite operations are isolated and buried in subsidence craters here.

These locations appear on the map in Figure 21.

OVERVIEW OF OPERATIONS

All vehicles transporting radioactive waste are inspected before being allowed to enter the Nevada Test Site. Before off-loading at the disposal site, the shipment is monitored and inspected for damage or load shifting. After unloading, each vehicle is monitored again and decontaminated as necessary.

Low-level wastes constitute the greatest volume of materials received. Wastes of high-specific activity, however, can be handled safely. These materials are placed in bore holes using equipment controlled remotely from a location behind a large earth berm.

AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE (RWMS)

Site Description

Area 5 covers an area of approximately 700 acres, bounded on the south and west by typical desert, on the north by the Massachusetts Mountains and on the east by the playa of Frenchman Flat. Elevation is 3150 feet and distance to groundwater is estimated to be 800 feet.

The climate of the site is typical of the northern Mojave Desert, generally hot and dry. The approximate average temperature at lower elevations is 75 degrees Fahrenheit, ranging from a typical maximum of 100 degrees to a typical minimum of 50 degrees. Average precipitation is less than ten inches per year.

Prevailing winds are northerly in the winter months and southerly in the summer.

There are no deep wells or permanent natural sources of surface water in the immediate area.

Prevalent plants include the creosote bush (Larrea tridentata), white burrage (Ambrosia dumosa) and goldenhead (Acamptopappus shockleyi). Various types of cacti and other grasses are also found there.

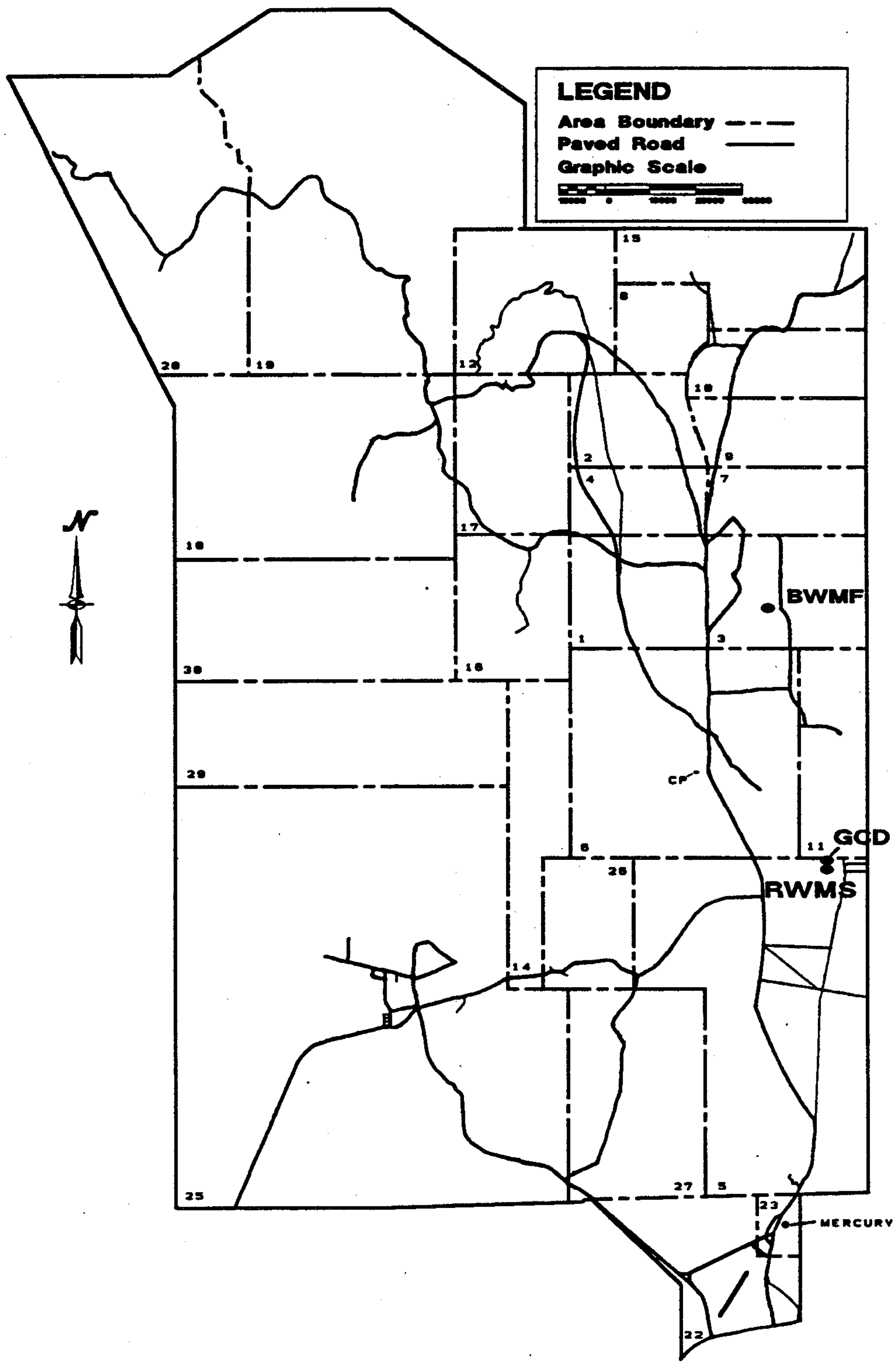


Figure 21 - Radioactive Waste Management Project

Coyotes, rabbits, ground squirrels and other small mammals are frequently seen in the area. A permanent family of kit foxes is seen in the spring and early summer months as the pups are raised.

Desert reptiles of various types and species are also common.

Raptors include hawks and falcons. Ravens, golden eagles and the occasional vulture can be seen on or near the disposal site.

There are no known threatened or endangered species, plant or animal, at any of the RWMP disposal sites though the desert tortoise is found in parts of Area 5.

General Operations

Shipments for disposal in Area 5 are packaged in appropriate containers according to Department of Transportation (DOT) regulations. These may be steel drums, heavy cardboard boxes (Tri-Walls), or steel or wooden boxes and are off-loaded by trained personnel. Monitors are present during off-loading to ensure that radiological problems are resolved quickly.

All containers are stacked in orderly fashion and the location of each package noted by alpha-numeric Nevada Grid Coordinates and depth. The containers are covered with a minimum of four feet of soil as the pit or trench is filled. Any package can be retrieved at a later date should it be necessary.

A large number of soil samples have been collected within the site as part of ongoing site characterization studies. Ten percent of these samples are sent to the Radiological Measurements Laboratory in Mercury for gamma analysis. Ten percent of those are analyzed further for ^{239}Pu and ^{90}Sr. At least 500 grams of all such samples are archived for future use.

The soil studies show a very diffuse pattern of ^{137}Cs surface deposition in a general northwest-southeast direction through the site. The concentrations are typically less than one picocurie per gram and are of no radiological significance. Much of the contamination is found in areas still untouched by operations at the site. The source is fallout from discontinued atmospheric tests.

All other radionuclides found are naturally occurring.

Samples of standing water, resulting from precipitation, are collected whenever possible and analyzed for gamma and gross beta activity.

Routine Site Monitoring

A network of air samplers is maintained around the perimeter of RWMS as part of the routine effluent monitoring program. In addition, TLDs are used to obtain long-term gamma dose measurements. Figure 3 shows the arrangement and gross beta in air results for monitoring stations around the site.

The air sampling program, as it applies to the RWMP, is primarily for the collection of airborne particulate matter. Air is drawn at approximately five cubic feet/minute through a Whatman GF/A glass fiber filter.

Radioactive gases are collected at the same time using an activated charcoal cartridge downstream of the particulate filter.

Tritium is collected as tritium oxide with another sampler.

Air samples are collected on a weekly basis. Each sample is separated into its component parts (filter and charcoal cartridge) and counted for beta and/or gamma activity as appropriate. All filter samples collected from each location are saved and analyzed for plutonium on a monthly basis.

The tritium sampler is housed in the same shelter and consists of two serial desiccant columns, a rotameter and a small aquarium pump. Typical air flow is 0.5 liter per minute.

Samples are collected biweekly. The desiccant (indicating silica gel) is heated to drive off the collected water vapor. A portion of the condensed moisture is analyzed by liquid scintillation spectrometry.

Gross Beta

The maximum average gross beta in air concentration was 2.1×10^{-14} µCi/ml. This concentration is 0.002 percent of the derived concentration guide. Results of the gross beta stations were grouped closely together and all were within two standard deviations from the overall site average.

Gross Beta results for the RWMS appear on Table 4.

Figure 22 displays the locations and results for gross beta and plutonium in air concentrations during CY-1987.

Tritium and Plutonium

The maximum concentration of tritium in air for the RWMS during CY-1987 was $< 2.2 \times 10^{-10}$ μCi/ml. This value represents < 0.22 percent of the derived concentration guide. Table 6 displays the tritium in air results for RWMS while Figure 23 displays the sampling locations and results.

The average concentration of ^{239}Pu in air at RWMS was $< 2.1 \times 10^{-17}$ μCi/ml. This concentration is < 0.11 percent of the derived concentration guide for ^{239}Pu. Plutonium results for the RWMS appear on Table 5.

Gamma Monitoring

The average annual dose rate for the NTS control network was 102 mrem per year or approximately 9 μrem per hour. The average dose rate at the RWMS site was 168 mrem per year or approximately 19 μrem per hour. This value compares favorably with the literature value of 11-to-20 μR per hour (Reference 13).

Well 5B, a station two miles to the south, had an annual dose rate of 119 mrem per year or 14 μrem per hour. A summary of gamma monitoring results can be seen on Table 17.

In certain instances, soil samples are taken from the bottom of monitoring wells for gamma and tritium analyses.

Figure 24 displays the gamma monitoring locations and results for CY-1987.

The results from the surveillance network around the RWMS indicate that there were no detectable releases of radioactive materials as a result of operations during CY-1987.

AREA 5 GREATER CONFINEMENT DISPOSAL TEST

Test Objective

As a complement to shallow land disposal, the concept of greater confinement was proposed. Primarily, the experiment was designed to provide information about the diffusion behavior of simulated contaminants and soil moisture under the influence of decay heat of highly radioactive waste materials.

Shafts

Large augered shafts were chosen in Area 5 for study and a formal test of the idea was conducted during 1982-1987. A shaft ten feet in diameter and 120-feet deep was dug and back-filled to 100-feet.

Instrumentation

This shaft required extensive instrumentation as well as satellite holes needed to follow tracers as they were forced outside the main shaft. Sensors of various types were placed at carefully determined locations in three dimensions around the centerline of the shaft. These include moisture and temperature probes and soil gas samplers arranged in three long strings at 120-degree spacing and anchored at the bottom.

Provisions were made for release of gaseous tracers near each gas sampler to be collected and analyzed by gas chromatography. A recirculation system was part of the original design which would permit the removal of gas samples without severe disturbance of the soil gas balance.

Test Material

Approximately 400,000 curies of radioactive materials were used to fill the shaft from the 100-foot depth to the 60-foot depth. The remainder was back-filled with original soil. A heavy steel lid was placed over the shaft and small covers on the satellite holes.

Sampling and Modeling Results

The sampling phase of the test has been completed. Modeling studies are now in progress to help predict the long-term migratory behavior of the tracers. From these studies it will be possible to make predictions regarding similar behavior of certain broad classes of compounds which might be received as mixed wastes.

The GCDT sampling system is used by personnel from the University of California at Berkeley for tritium migration studies. It has become especially important to monitor the area for fugitive tritium emissions.

The tracer sampling lines are now connected to apparatus which will allow soil moisture to be collected. The collection system is housed in an isolated cargo container for protection and mitigation of temperature extremes.

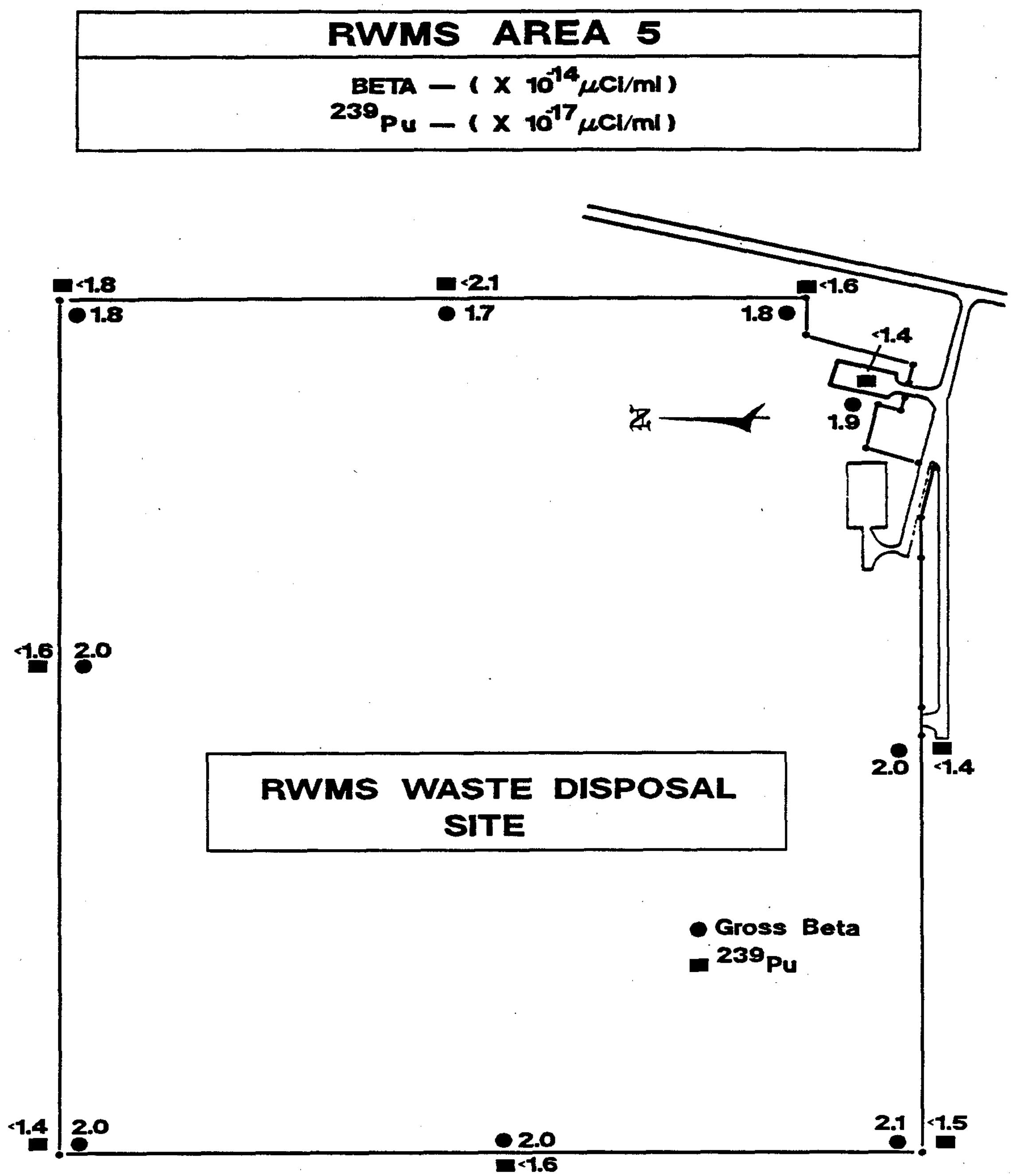


Figure 22 - RWMS Air Monitoring Stations

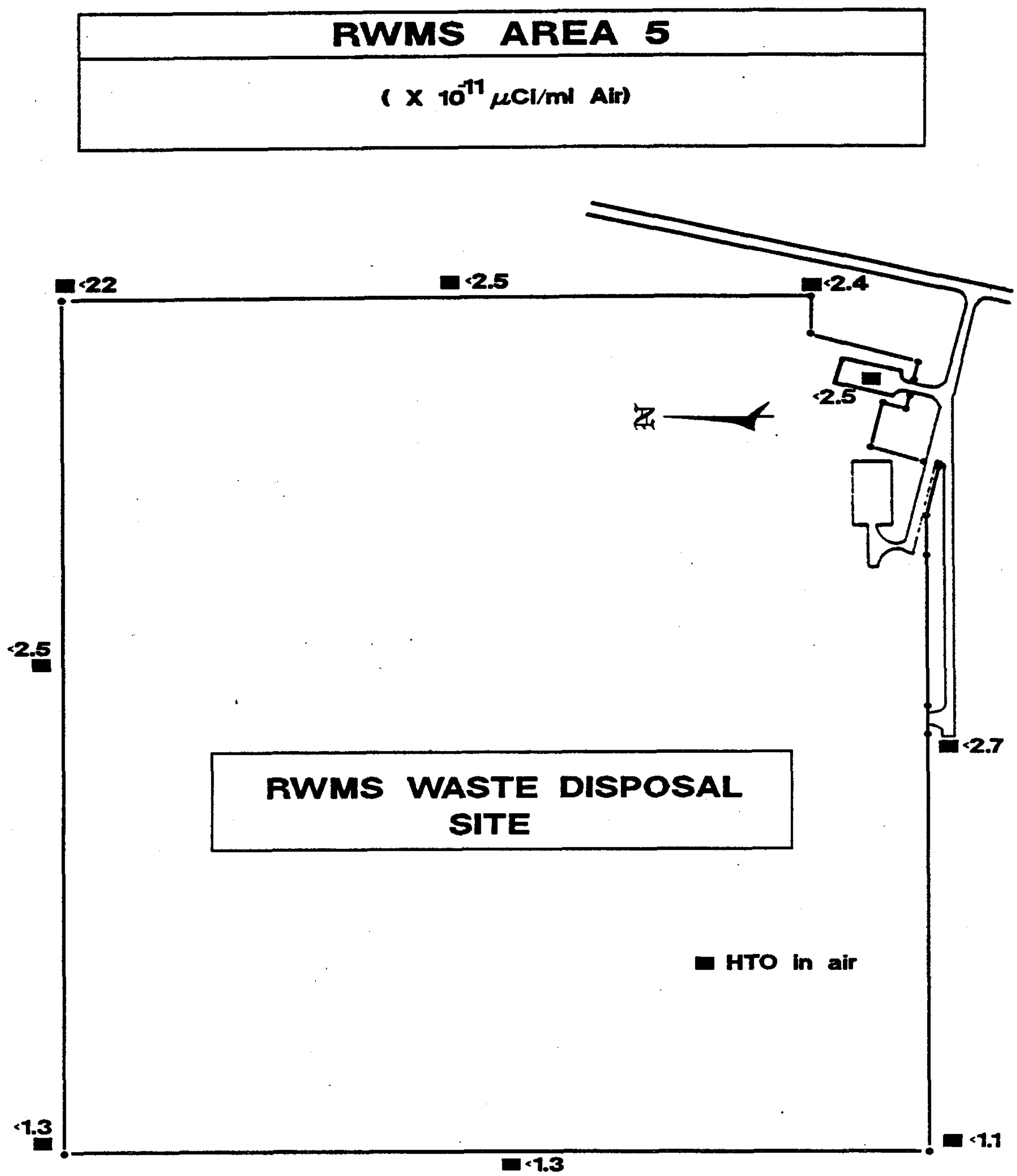


Figure 23 - RWMS Tritium Monitoring Stations

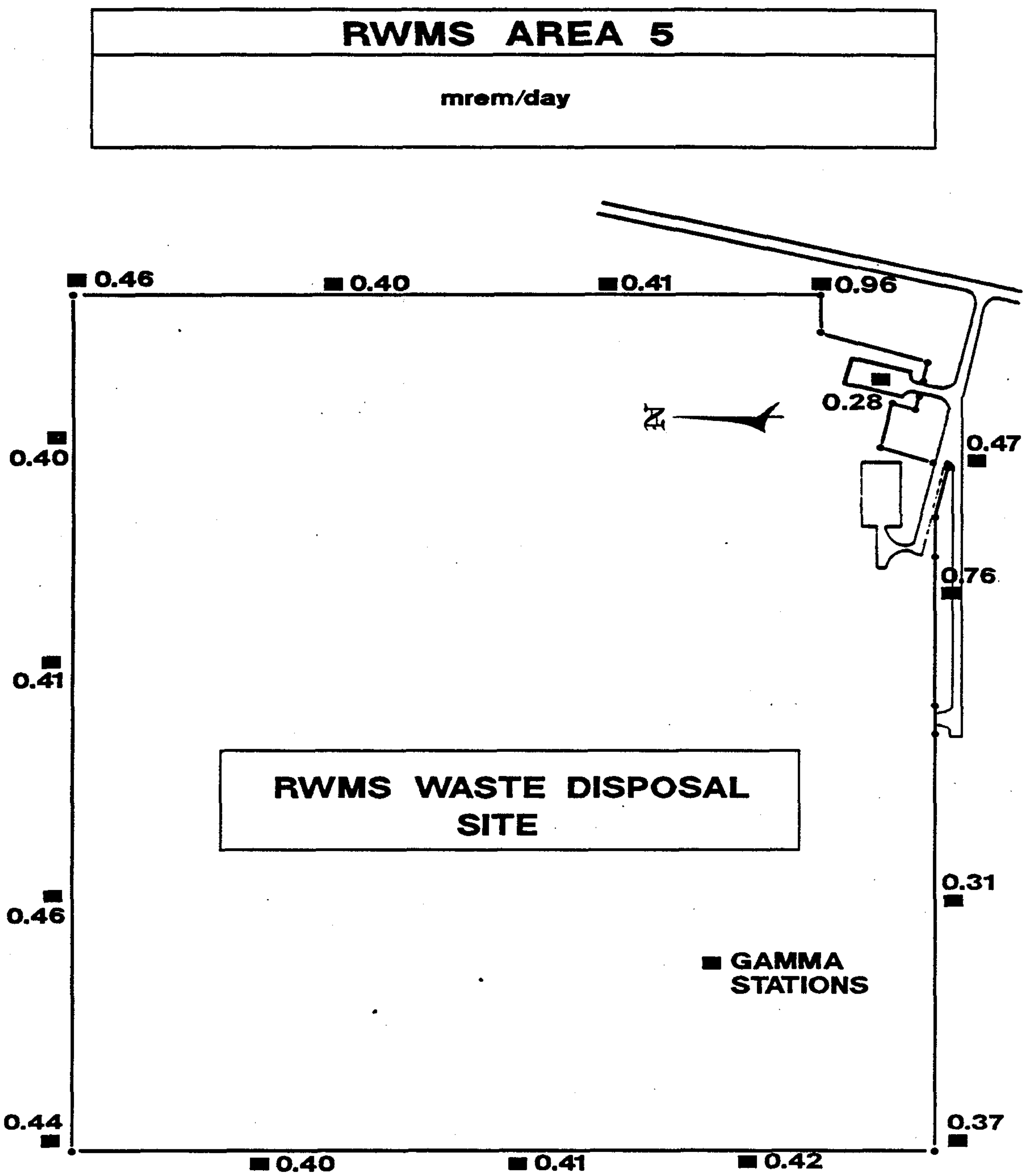


Figure 24 - RWMS Gamma Monitoring Stations

On occasion a monitoring system for airborne tritium in the cargo container has revealed higher than normal tritium levels. This has been followed by urinalysis of personnel working with the collection system. Elevated tritium concentrations have been detected but have not approached action levels. The building now has positive ventilation and access is restricted.

The collected samples consist of small amounts of condensed water vapor which are transported to Mercury where further work is performed. The laboratory area is monitored. No tritium above background levels has been detected.

The head-space under the lid of the main shaft has been sampled and both tritium oxide and tritium gas have been detected.

AREA 3 BULK WASTE MANAGEMENT FACILITY

Responsibility

The Waste Consolidation Project is responsible for the removal of bulk debris and soil resulting from discontinued atmospheric tests. The bulk waste is located in an area where numerous atmospheric tests were conducted. The material to be disposed of is known to be contaminated.

Site Description

The BWMF is located north of Mercury on Yucca Flat, at an elevation of 4050 feet, and covers an area of approximately 50 acres. It is located on the floor of the Yucca Flat valley, bounded by the Eleana Range on the west, the Belted Range on the north and the Halfpint Range and the Nellis Bombing and Gunnery Range on the east.

General site characteristics are similar to those of Area 5. The most prevalent vegetation here is, however, Fremont thornbush (Lycium andersonii) and hopsage (Grayia spinosa).

Site Operations

Shipments are brought to the site in large trucks, unloaded in subsidence craters and covered with soil. The craters in U3ax and U3bl have been filled with materials of this type. The nearby craters of U3ah and U3at are now operational.

In CY-1987 40,000 cubic yards of material from three different sites were collected and buried.

Area 3 Sampling

Soil samples are collected on rectangular grids after each site has been excavated. The samples are analyzed according to protocols similar to those used in Area 5. After analysis of the data, each site is released to DOE for further use.

Air samplers are used to monitor disposal operations around the craters when waste materials are being transported to them and unloaded. The procedure is similar to that used in Area 5. Since tritium is not handled, however, it is not monitored. The results of these air samplers may be found in Chapter IV.

There have been no radiological incidents associated with this project.

EFFLUENT MONITORING

Various effluents are released into the NTS environment as part of routine operations. These effluents are monitored by the three major weapons testing national laboratories and REECo. The results are submitted to the DOE on a yearly basis by each appropriate organization. This section contains all of the results submitted to the DOE by Reynolds Electrical & Engineering Company, Inc. (REECo), Lawrence Livermore National Laboratory (LLNL), Sandia National Laboratories (SNL), and Los Alamos National Laboratory (LANL).

INTRODUCTION

Radioactivity released to onsite waste treatment or disposal systems shall be monitored to assess the efficacy of treatment and control, and to provide a quantitative and qualitative annual summary of the radioactivity released onsite. In order to meet this DOE requirement the various organizations listed monitor effluent points for nuclides released as effluents.

REECo

Five effluent discharge points were monitored during CY-1987. All five locations were monitored as part of the continuing surface and groundwater monitoring program. Sampling was a one-time grab sample per month. Sampling methods and analysis are identical to those previously described for water analysis. Plots showing the individual results of these stations can be found in Appendix G. Table 19 displays the results submitted to the DOE. Foreseeing the possibility of confusion, note that the "REECo Effluent Monitoring Results," Table 19, lists almost in its entirety the contaminated pond sampling stations. It does not list the stations referred to as *Effluent Ponds*.

LLNL

Eight effluent discharge points were monitored during CY-1987. All locations monitored were as a result of post-shot drilling operations where the effluent release point was the post-shot drilling vent-line stack. The waste treatment system used was a mudtrap cyclone absolute filter and charcoal filter bed. The monitoring system used was a sealed ion chamber, Jordan Nuclear Co., model AS1150SR monitoring a 20-inch diameter vent line. Sampling was continuous. The results can be found in Table 20.

SNL

Two effluent release points, T Tunnel and G Tunnel, were monitored during CY-1987. In both cases the ventilation system was monitored during controlled releases. At T Tunnel the effluent was passed through two inches of activated charcoal bed prior to its release. The monitoring system used was a Victoreen Ramp-4 ionization chamber. The detector was placed on the vent line and the monitoring was continuous during the ventilation. At G Tunnel the effluent was tritiated water vapor. Drierite was used to capture tritiated water vapor. The sampling was not continuous. A total of 53 grab samples were taken. The results are listed in Table 21.

LANL

Three effluent release points were monitored during CY-1987. Two were direct measurements of drill-back operations. These sites were continuously monitored using air samplers equipped with charcoal canisters and paper

TABLE 19 - REECo Effluent Monitoring Results

Station	Nuclide	Release (Ci)
Area 5 U5eRNM-2S	^{3}H	8.9×10^{2}
Area 6 Yucca Pond	^{3}H	1.5×10^{-2}
Area 12 E-Tunnel	^{3}H	5.1
Area 12 N-Tunnel	^{3}H	1.3×10^{1}
Area 12 T-Tunnel	^{3}H	8.0×10^{3}
Area 12 T-Tunnel	^{137}Cs	6.9×10^{-2}
Area 12 T-Tunnel	^{103}Ru	7.4×10^{-2}
Area 12 T-Tunnel	^{106}Rh	1.6

pre-filters. The last was a post-shot yard drain which has been active since CY-1973. This site was monitored for mixed fission products (MFP) and as such the result does not reflect any specific radionuclide. Sampling frequency consists of a one-time water grab sample per year. The results are presented in Table 22.

TABLE 21 - SNL Effluent Monitoring Results

Station	Nuclide	Release (Ci)
Area 12 G-Tunnel	^{85}Kr	3.0
Area 12 T-Tunnel	^{3}H	$1.26 \times 10^{+2}$

TABLE 20 - LLNL Effluent Monitoring Results

Station	Nuclide	Release (Ci)
U10bh	HT	2.3×10^{-3}
	^{85}Kr	1.0×10^{-4}
	^{137}Cs	8.0×10^{-6}
U20as	HT	4.8×10^{-2}
	^{85}Kr	1.6×10^{-2}
U20ap	^{37}Ar	1.0
	^{85}Kr	2.0
	^{133}Xe	4.4
	^{131m}Xe	1.0
	^{133m}Xe	2.0
U2ge	^{133}Xe	1.9×10^{-2}
	^{133m}Xe	8.0×10^{-4}
	^{135}Xe	5.0×10^{-3}
U2gas	HT	9.9×10^{-3}
	^{85}Kr	6.6×10^{-4}
U4t	HT	6.7×10^{-3}
	^{85}Kr	6.0×10^{-4}
	^{127}Xe	3.0×10^{-5}
U2gb	HT	1.5×10^{-1}
	^{85}Kr	2.5×10^{-4}
U20av	HT	1.9×10^{-1}
	^{85}Kr	2.4×10^{-2}
	^{137}Cs	9.0×10^{-6}

TABLE 22 - LANL Effluent Monitoring Results

Station	Nuclide	Release (Ci)
U3mg Drill Rig	^{133}Xe	$2.5 \times 10^{+1}$
U3mg Drill Rig	^{131}I	1.0×10^{-1}
U19aq Drill Rig	^{133}Xe	4.0
U19aq Drill Rig	^{131}I	1.0×10^{-3}
Area 3 Post Shot Drain, Bohneville	MFP	0.0

DOSE ASSESSMENT

The maximum postulated dose from NTS operations was calculated for individuals at work within the Test Site during the entire CY-1987. This was performed by identifying the maximum radionuclide concentration at any specific location and comparing that concentration to the derived air concentration (DAC), or to the annual limit of intake (ALI) listed in ICRP 30 (Reference 4). Furthermore, all other monitored radionuclide concentrations at that site were also used to calculate any additional dose to the individual as if that person would have spent the work year at that site performing "light activity" work (as referenced in ICRP 30). This process was repeated for each site where a maximum radionuclide concentration of tritium, ^{85}Kr, ^{133}Xe, ^{239}Pu, or ^{90}Sr was detected (the gross beta in air concentration was assumed to consist of ^{90}Sr). The parameters used to make all calculations are provided so that the reader may perform this calculation for any location on the NTS. These values are listed in Table 23.

The dose from air immersion was calculated for a one-year occupational exposure to a semi-infinite cloud. The ICRP 30 states that for the purpose of estimating dose from a semi-infinite cloud of noble gas, the external dose far outweighs the internal dose and, as such, only the external dose is calculated.

INGESTION DOSE

The dose from the ingestion pathways was calculated for an individual at work within the NTS boundary during CY-1986. The only pathway considered was the ingestion of water. Ingestion of foodstuffs was not considered because of the lack of locally grown food adjacent to the site boundary. The water was assumed to be similar to the potable water sampled onsite.

The radionuclides considered for the calculation were ^{239}Pu and tritium. The gross beta concentration was not used in the calculation because it was shown earlier (Reference 23) that the gross beta concentration was primarily due to the naturally occurring ^{40}K content.

The Cascade bottled water brought onsite was assumed to have natural background levels of tritium. This amount was subtracted from the potable water stations used to obtain the net concentrations used in the dose calculations. There was no background subtraction for ^{239}Pu in water. These values used for dose calculations are listed in Table 24.

The assumed fluid intake for the individual was 1.6 liters per work day (400 liters per work year) and was derived from ICRP Publications 23 (Reference 15).

INHALATION DOSE

The doses from the inhalation of tritium, ^{90}Sr (gross beta) activity, and ^{239}Pu were calculated for the individual at work within the NTS boundary. As previously stated, the dose has been calculated for each of the locations where a maximum radionuclide concentration occurred. The additional doses from concentrations of other nuclides at that station are also calculated. Thus, a total dose to an individual performing *light activity* at that site is obtained. Background quantities are subtracted from the concentrations used for tritium calculations.

The concentrations used for calculating the inhalation dose are listed in Table 24. The individual was assumed to breathe 2.4×10^3 cubic meters of air in one *light activity* work year (Reference 4). The results of the H_{50} doses to an individual working continuously at each maximum concentration site are listed in Table 25.

The units used for dose calculations are Becquerel (Bq) per unit volume. This unit, the Bq, is used by ICRP 30 and a conversion to µCi would introduce unnecessary error.

IMMERSION DOSE

The dose received by an individual at the NTS for a full working year from either of the noble gases was each substantially less than one mrem. The DAC for ^{85}Kr, as listed in ICRP 30, is 5×10^6 Bqm^{-3}. When compared to an onsite average concentration of 1.5 Bqm^{-3}, it is evident that the resulting dose is meaningless. Therefore this calculation was not included.

CONCLUSIONS

The dose to an individual working within the Nevada Test Site, even in areas of maximum yearly concentrations was low compared to standards. A total 50-year committed dose of 13 mrem was the highest calculated dose. This dose was derived from the average concentrations from air and water at the Area 3 U3ax/bl N sampling station. Other stations for which dose results were calcualted are listed in Table 25, "ICRP 30 Calculated Dose Results."

TABLE 23 - ICRP 30 Values Used for Calculating Dose

Radionuclide	ALI (Bq)	DAC (Bqm^{-3})
^{3}H	3×10^{9}	8×10^{5}
^{90}Sr	1×10^{6}	6×10^{1}
^{239}Pu	2×10^{5}	8×10^{-2}
^{85}Kr	-	5×10^{6}
^{133}Xe	-	4×10^{6}

TABLE 24 - Concentrations Used for Dose Calculations

INHALATION (µCi/ml)

Station	^{3}H	^{90}Sr	^{239}Pu
Area 3 Compound	1.7×10^{-11}*	5.0×10^{-14}	5.0×10^{-17}
U3ax/bl North	1.7×10^{-11}*	2.0×10^{-14}	5.7×10^{-15}
Area 5 RWMS No. 2	2.0×10^{-10}	1.8×10^{-14}	1.6×10^{-17}
Background	4.6×10^{-12}	0.0	0.0

INGESTION (µCi/ml)

Station	^{3}H	^{90}Sr	^{239}Pu
Area 3 Cafeteria	1.2×10^{-6}	-	4.9×10^{-11}
Area 5 RWMS No. 4	1.0×10^{-6}	-	0.0
Area 12 Cafeteria	1.0×10^{-6}	-	8.1×10^{-11}
Background	1.0×10^{-6}	-	0.0

* Concentration used is from the closest tritium monitoring station available - Area 1 BJY

TABLE 25 - ICRP 30 Calculated Dose Results

Station	H_{50}(mrem)
Area 3 Compound	0.30
U3ax/bl N	13
Area 3 Cafeteria	0.30
RWMS North East	0.14
Area 12 Cafeteria	0.19

NON-RADIOLOGICAL MONITORING REPORT

Orin L. Haworth

During 1987, the Nevada Test Site was inspected by the state and federal authorities for compliance with the Clean Air Act and Resource Conservation and Recovery Act (RCRA). No violations were issued by the state as a result of their air pollution inspection, but four deficiencies were noted during the EPA RCRA inspection.

Fourteen sewage lagoon permit applications were submitted to the state, along with information on 41 existing septic tank and leach field systems. Six new air pollution permits were obtained to bring REECo's total to 25. The six drinking water systems were permitted for another year and a current Part A Permit application for mixed waste disposal was amended.

INTRODUCTION

Non-radiological environmental compliance is primarily the responsibility of the Industrial Hygiene Section of the REECo Environmental Sciences Department. Among state and federal regulations of concern are the:

- Clean Water Act
- Safe Drinking Water Act (SDWA)
- Clean Air Act
- Resource Conservation and Recovery Act (RCRA)
- Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)
- Toxic Substances Control Act (TSCA)
- The Solid Waste Disposal Act (SWDA)

Many of the activities regulated by these laws require a permit or notification to operate. The permits or notification to operate are processed by the Industrial Hygiene Section.

This section provides CY-1987 information on the status of environmental permits, environmental sampling performed, and the results of state and federal inspections. At the end of the section is a short discussion of the DOE Headquarters Environmental Survey Team preliminary findings, and corrective actions taken by REECo in CY-1987.

LABORATORY CERTIFICATION

Collecting and analyzing environmental samples is an important Industrial Hygiene Section function. Many different types of samples were collected during CY-1987, most of which were analyzed by the Industrial Hygiene Laboratory.

Some hazardous waste and drinking water samples, however, were sent offsite because analyses needed to be performed by an Environmental Protection Agency (EPA), or state-approved laboratory.

Sampling was performed to support the RCRA, CERCLA and TSCA programs, and CY reports were submitted to the state for Air Pollution Permits, Hazardous Waste Generation, and polychlorinated biphenyl (PCB) activity.

CLEAN WATER ACT

Sewage Lagoons

Applications for Sewage Lagoon Permits were prepared and submitted to the state of Nevada for the following sewage lagoon systems:

- Area 2
- Area 6, CP Compound
- Area 6, Yucca Lake
- Area 6, DAF
- Area 6, CP-72
- Area 11, Technical Support Facility
- Area 12, Sewage Plant
- Area 12, Fleet Operations
- Area 23, Gate 100
- Area 23, Mercury
- Area 25, Central Support
- Area 25, Engine Test Stand
- Area 25, Test Cell C

- Area 25, Reactor Control Point

Water samples were collected from the Area 11 and Area 12 Fleet Operations systems and analyzed for lead, silver and pH.

The hazardous waste threshold for lead and silver is 5 milligrams per liter (mg/l) or greater. The pH is hazardous if less than 2 or greater than 12.5.

The pH for both samples was 7.5. The concentrations (in mg/l) for lead and silver were 2.7 and 2.0 at Area 11, and 0.02 and 0.01 for Area 12.

Septic Tank and Leach Field Information

Septic tank and leach field information was provided to the state on 41 existing septic tanks and leach field systems. The state will now advise REECo, through DOE/NV, what, if any, systems require permit applications.

An application for a permit must be made for all new systems to be constructed. Most existing systems, however, will be permitted by *grandfather action* without a specific application for permit. No applications for new septic tank systems were submitted.

Permit Status

No permits were issued by the state for either the sewage lagoons or the septic tank systems, and there are no previously permitted systems.

DRINKING WATER

Drinking Water Systems Overview

There are currently six drinking water systems which utilize eleven wells. The Area 2, 12, and 23 systems are community systems. The systems for Areas 1, 3, 6, and 25 are non-community systems. Community systems supply residential populations, while non-community systems supply non-residential work place areas. REECo Site Maintenance Department operates these water systems.

These systems are all chlorinated by automatic equipment. New or repaired water lines are super-chlorinated before being put into service in accordance with American Water Works Association Standards and the Uniform Plumbing Code. Each system is tested monthly for pH, residual chlorine, and bacteria content by Industrial Hygiene Section personnel.

Daily chlorine levels are logged by Site Maintenance personnel.

A water sample for chemical analysis is collected from each well by the Nevada State Health Division at approximately three-year intervals. These chemical analyses were last performed August 1984, and are scheduled again for March 1988.

Permit Status

Each of the six systems has a permit from the state of Nevada which is renewed annually. There were no new permits issued this year, and no amendments were made to any of the existing permits. Sample Results and Standards Comparison

All systems are sampled monthly for pH, chlorine residual, and bacteria. In all cases the samples results were within the limits prescribed by the SDWA and state of Nevada regulations which are:

• Residual Chlorine	at least 0.02 ppm
• pH	between 6.5 and 8.5
• Coliform Bacteria	< 2.2 colonies/100 ml

Table 26 gives the results of the August 1984 analysis of the community systems wells, and compares the results to the SDWA standards where one exists.

The results show that no analyte exceeded the SDWA maximum allowed levels when the community systems were last sampled by the state inspector.

Non-community systems need only meet the nitrate levels of no more than 10 mg/l. All of the NTS systems were below that level when last tested in 1984.

Quality Assurance

The monthly samples are collected in containers supplied by the state and are delivered to a state-approved laboratory for analysis. Both the collection and transportation of the samples are performed by a registration-eligible Sanitarian.

The three-year chemical samples were collected by a state Environmental Health Specialist and taken to a state-approved laboratory. These laboratories have approved

Quality Assurance (QA) programs as part of their state certification.

If any of the analytes are found to be outside the acceptable range, prompt remedial action is taken to correct the problem. These remedial actions and their results are then reported back to the state.

AIR POLLUTION

Permit Status

During CY-1987 two operating permits and four registration certificates were obtained from the state of Nevada. One operating permit was a renewal of a one-year open-burning permit for fire training exercises, and the other was for the Area 1 Aggregate Plant, which was moved from Area 5.

Three of the registration certificates were for cafeteria boilers added to Area 12 (1) and Area 23 (2). The fourth registration certification was for a NTS site-wide surface disturbance permit. The surface disturbance permit requires an annual report of all disturbances of five acres or greater. Notification prior to starting the disturbance is not required.

Table 27 lists all air pollution permits which were active at the end of CY-1987 for which REECo has responsibility for compliance with the permit restrictions.

A report was sent to the state of Nevada on April 15, 1987 which gave the CY-1986 operating hours and cubic yards produced under those permits which have that reporting requirement (permits number 919, 922, 923, 928, 1082, 1217 and 1287). None of the operating restrictions were exceeded.

The CY-1987 report will be sent in 1988, and will again indicate that no restrictions were exceeded.

Inspection Results

The state of Nevada conducted an inspection of the NTS facilities on January 14 and 15, 1987. No violations were observed, and no *Notice of Violation* was issued as a result of their inspection. The issue of not using water to control the dust from down-hole stemming material, however, was raised regarding the Shaker Plant and Area 3 Portable Stemming Facility. The question will be resolved by the state during their next inspection in CY-1988.

RCRA ACTIVITIES

Permit Status and Inspection

REECo has been assigned EPA Generator Identification Number NV3890090001, and is responsible for the offsite disposal of all hazardous waste generated at the NTS. One offsite shipment of hazardous waste was made on June 16, 1987.

The required Hazardous Waste Generator Annual Report was sent to the state of Nevada on February 27, 1987.

On February 11 the EPA conducted a RCRA compliance inspection of the NTS and found four deficiencies:

- Hazardous waste being temporarily stored greater than 90 days.
- Insufficient separation between incompatible materials in storage.
- Stored waste needs protection from the sun.
- The Closure Plan for the Area 23 Hazardous Waste Disposal Site had not been completed.

Item 1 was corrected by obtaining a continuous use contract with a disposal firm to ensure prompt offsite shipment. A proper facility for temporary storage while awaiting offsite shipment is scheduled for construction in 1988 to correct items 2 and 3. The Closure Plan in item 4 is scheduled for submittal to the state of Nevada in January 1988.

Tunnel Pond Sampling

On August 7 water samples were collected from the effluent lines at E, G, P, N, and T Tunnels and from two holding ponds at both N and T Tunnels. Samples were also collected from the bottom of the holding ponds which contained both soil and sediment. The samples were analyzed by an offsite laboratory for metals, volatile organics and semi-volatile organics.

No volatile or semi-volatile organic primary pollutants were found that are detectable by the EPA approved methods. The metal content of the liquid and soil was normal. There were no metals near the hazardous threshold level. The results indicate that there were no hazardous chemicals in the tunnel effluents or in the tunnel ponds at the time the samples were taken.

TABLE 26 - Chemical Analysis of Community Systems, 1984

Chemical Analysis Performed	Maximum Level Allowed	Area 23 System Army Well	Area 23 System 5B	Area 23 System 5C	Area 2&12 8
Calcium	-	45.4	7.4	0.7	7.8
Magnesium	-	21.4	2.2	0.2	1.2
pH	-	7.6	8.5	8.9	7.3
Alkalinity	-	222	152	262	67
Sulfate	250 mg/l	23.6	28	13.5	8.3
Chloride	250 mg/l	16	23	9	6
Nitrate	10 mg/l	0.2	2.8	1.6	1.3
Fluoride	1.6 mg/l	1.1	0.9	1.0	0.8
Iron	0.3 mg/l	.030	.048	.030	.043
Manganese	0.05 mg/l	.024	.012	.012	.019
Total Dissolved Solids	500 units	310	325	374	152
Arsenic	0.05 mg/l	.006	.006	.01	.001
Lead	0.05 mg/l	.002	.002	.002	.002
Selenium	0.01 mg/l	.001	.001	.001	.002
Barium	1 mg/l	.08	.012	.012	.012
Zinc	5 mg/l	.007	.007	.007	.012
Copper	1 mg/l	.007	.007	.007	.007
Mercury	0.002 mg/l	.0003	.0007	.0003	.0003
Chromium	0.05 mg/l	.029	.029	.029	.029
Cadmium	0.01 mg/l	.007	.003	.003	.005
Silver	0.05 mg/l	.005	.009	.005	.010
Turbidity	-	.15	.35	.25	0.2
Color	15 units	<3	<3	3	<3

TABLE 27 - Active NTS Air Pollution Permits

Permit No.	Facility or Operation	Exp. Date
OP919	Area 3 Portec Aggregate Hopper	12-03-89
OP922	Area 1 Shaker Plant	12-03-89
OP923	Area 1 Rotary Dryer	12-03-89
OP925	Area 23, Bldg. 753 Boiler	12-03-89
OP928	Area 12 Concrete Batch Plant	12-03-89
OP957	Area 2 Portable Stemming	12-03-89
OP958	Area 2 Portable Stemming System	12-03-89
OP1035	Portable Boiler	10-20-90
OP1036	Area 6 Decontamination Boiler	10-20-90
OP1082	Area 1 Concrete Batch Plant	01-30-91
OP1084	Area 1 Shaker Surface	01-30-91
OP1085	Area 6 Diesel Tanks	02-25-91
OP1086	Mercury Gasoline Tank	02-25-91
OP1087	Mercury Diesel Tank	02-25-91
OP1089	Area 3 Portable Stemming System	02-25-91
OP1090	Area 6 Gasoline Tank	02-25-91
OP1217	Area 1 Portable Crusher	12-03-89
OP1287	Area 1 Aggregate Plant	02-12-92
OP88-3	Open Burning for Training Exercises	09-30-88
RC 974	Area 6 DAF Surface Disturbance	-
RC 1122	Area 14 Surface Disturbance	-
RC 1367	NTS Surface Disturbance	-
RC 1524	Mercury Cafeteria Boiler	-
RC 1525	Mercury Cafeteria Boiler	-
RC 1526	Area 12 Cafeteria Boiler	-

Mixed Waste Disposal Permit Application

During 1987 the Part A application for mixed waste disposal at the NTS was amended to include:

- Solid waste disposal at the Area 3 Radioactive Waste Management Site (Bulk Waste Management Facility).
- Liquid disposal in the Area 6 Decontamination Facility Evaporative Pond.
- The Area 23 Building 650 leach field.

Interim status was granted by the state of Nevada for mixed waste disposal on September 17, 1987. No mixed waste was disposed of during the remainder of the year.

CERCLA ACTIVITIES

The only environmental sampling that was undertaken to comply with CERCLA regulations was soil and swipe samples collected at Sugar Bunker in Area 25. The samples were analyzed by the Industrial Hygiene Environmental Laboratory for beryllium contamination. Swipe samples were taken inside the bunker and on the exterior walls. The soil samples were collected outside around the bunker. All the results were below the detectable limits of 0.2 ppm for the soil samples and 0.01 grams for the swipes.

TSCA ACTIVITIES

REECo has a PCB Identification Number, NVG-PCB-006, issued by the state of Nevada, and is responsible for the offsite disposal of PCB oils and PCB transformers at the NTS. On June 24 an annual report for CY-1986 was submitted to the state, as required by state Regulations. There was no state or federal inspection of the NTS for TSCA Compliance during 1987.

During 1987, 141 oil samples were collected at the NTS and analyzed by the Industrial Hygiene Environmental Laboratory for PCB concentration. These oil samples were collected from transformers or barrels of oil awaiting disposal. An additional 56 standard samples were run for quality control.

DOE ENVIRONMENTAL SURVEY

A DOE Environmental Survey Team conducted a three-week inspection/audit of the NTS from June 22 to July 10, 1987. The purpose of the inspection was to identify possible environmental problems and determine where samples needed to be collected to verify those assessments. Environmental problems identified in this manner were to be consolidated for all DOE sites and then ranked in order of importance to allocate funds for corrective actions.

The non-radiological findings of the survey mainly dealt with the present and past operations that may have generated wastes which were improperly disposed of at the locations where they were generated. All such current activities which were deemed contrary to current regulations were halted immediately. The inspection also revealed that three boilers and the sewage lagoon systems were operating without state of Nevada operating permits. Applications for all such facilities were submitted to the state. There were a few operations that required updating of their procedures and/or letters to be written instructing personnel to more closely observe existing procedures.

No Category I findings were identified by the survey team. Category I items are situations that would pose an immediate threat to human life and require an immediate response. Most of the survey findings had been corrected by the end of 1987, with the majority of the remaining findings awaiting sampling results of determine if a problem exists. A final report of the NTS survey findings will not be released until late 1988 or early 1989.

QUALITY ASSURANCE

Frank R. Markwell

Comprehensive quality assurance programs were maintained to ensure that the data collected were representative of actual concentrations in the environment. These programs covered surface and groundwater monitoring for radioactive materials. First, extensive environmental data were obtained to eliminate an unrealistic reliance on only a few results. Second, newly collected data were compared with both recent results and historical data for each location and each environmental medium to ensure that deviations from previous conditions were identified and promptly evaluated. Third, samples at all locations were collected using well-established and documented procedures to ensure consistency in sample collection. Fourth, samples were analyzed by documented standard analytical procedures. Fifth, the quality of the data was verified by a continuing program of analytical laboratory quality control, participation in interlaboratory cross-checks, and replicate sampling and analysis. These programs help ensure that the monitoring data can be used to evaluate accurately the environmental impacts from NTS operations.

ANALYTICAL LABORATORY QUALITY ASSURANCE

The radiochemical analyses for the environmental monitoring program were performed by the REECo Laboratory located in Mercury. This laboratory maintains both an internal and external quality assurance program.

Internal

The internal quality assurance program included routine calibration of counting instruments, daily source and background counts, routine yield determinations of radiochemical procedures, replicate analyses to check precision, and analyses of reagents to ensure purity of chemicals. Calibration standards traceable to the National Bureau of Standards were used for radiochemical calibrations when available.

The laboratory analyzed the environmental samples according to the procedures listed in the Environmental Sciences Department Radioanalytical Procedures Manual. The manual also lists the instrument and analytical control procedures used by the laboratory.

Instrument Control

Each day the gamma spectrometers are set to count sources of known activity and a calibration check is performed if necessary. Data are recorded in a sample logbook, compared to previous known values, and plotted on a chart. Once a week, data are accumulated and presented to the Quality Control Coordinator (QCC) and the Instrument Control Supervisor, then permanently filed.

The alpha spectrometers are set to count sources of known activity on a weekly basis and the data are recorded in the instrument logbook. The data includes the start channel, peak channel, full width at half maximum (FWHM), integral, count rate, and stop channel for each peak. Peak, FWHM, integral, and count rate information are also recorded on floppy disks using the dBASE III program. On a weekly basis, the data are accumulated and presented to the Quality Control Coordinator and the Instrument Control Supervisor, then permanently filed.

The proportional counters are set to count sources of known activity on a daily basis, and the data are recorded in the instrument logbook for comparison to previously acquired values. On a weekly basis the data are accumulated, presented to QCC, and permanently filed.

The liquid scintillation counters are set to count standards of known activity prior to the analysis of a group of samples. Data are recorded in the instrument logbook and compared to previously acquired values. On a weekly basis, the data are accumulated, presented to QCC, and permanently filed.

Radioanalytical Control

The Internal Radiochemistry QC program is intended to control and document the precision (and to some degree the accuracy) of radiochemical analyses performed routinely in the ESD Laboratory. Control is achieved through the analysis of spiked samples and blanks. For analysis of tritium in air, duplicate samples are used to monitor precision since there is no convenient way to spike a representative sample. The results of QC sample analyses are documented in control charts, logbooks, and on a computerized database.

QC samples are submitted on a batch basis. (A batch is a group of field samples which will be processed together, the number of which is limited by Laboratory equipment constraints.) Quality control samples are included in each batch. If a problem is detected with a QC sample, it can be directly correlated with the specific field samples that comprised the batch in question. The total number of QC samples submitted is a minimum of 10% of the field samples analyzed.

Interlaboratory

The laboratory continued participation in the DOE Quality Assessment Program (QAP) and the Environmental Protection Agency's (EPA) Laboratory Intercomparison Studies Program. These programs provide standard samples of various environmental media (water, milk, air filters, soil, foodstuffs, and tissue ash) containing one or more radionuclides in known amounts. After the samples were analyzed, the results were forwarded to DOE and EPA for comparison with known values and with the results from other laboratories. Both EPA and DOE have established criteria for evaluating the accuracy of results (References 29 and 30). These programs provided a regular means of evaluating the accuracy of the results and indications where corrective actions were needed. Summaries of the 1987 results in these two programs are provided in Tables 28 and 29.

TABLE 28 - Laboratory Performance on DOE Quality Assessment Program

Sample Media	Radionuclides	Number Analyzed	Number of Analyses Within Control Limits
Air Filters	^{7}Be, ^{54}Mn, ^{60}Co, ^{90}Sr, ^{125}Sb, ^{25}Zn, ^{137}Cs, ^{239}Pu, ^{241}Am, ^{106}Ru	16	15
Soil	^{40}K, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{239}Pu	9	6
Vegetation	^{40}K, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{239}Pu, ^{241}Am	6	2
Tissue	^{90}Sr	1	0
Water	^{3}H, ^{54}Mn, ^{60}Co, ^{90}Sr, ^{137}Cs, ^{239}Pu, ^{241}Am	14	13

TABLE 29 - Laboratory Performance on EPA Laboratory Intercomparison Program

Sample Media	Radionuclides	Number Analyzed	Number of Analyses Within Control Limits
Water	Gross Alpha, Gross Beta	12	11
	^{51}Cr, ^{65}Zn, ^{60}Co, ^{106}Ru, ^{134}Cs, ^{137}Cs	18	13
Water	^{239}Pu, U	3	2
Water	^{89}Sr, ^{90}Sr	4	4
Water	^{3}H	3	1
Air Filters	Gross Alpha, Gross Beta, ^{90}Sr, ^{137}Cs	4	3
Urine	^{3}H	1	1

REFERENCES

1. ERDA, "Final Environmental Impact Statement, Nye County Nevada" (ERDA-1551), Nevada Operations Office, U.S. Energy Research and Development Administration, Las Vegas, Nevada. Available from U.S. Dept. of Commerce, NTIS, Springfield, VA, 22161, September 1977.

2. "A Guide for Environmental Radiological Surveillance at U.S. Department of Energy Installations" (DOE/EP-0023), Pacific Northwest Laboratories, Richland, Washington, 1981.

3. "Standards for Radiation Protection" (DOE ORDER, 5480.1B, Chapter XI), Department of Energy, Washington, DC, 1986.

4. "Limits for Intakes of Radionuclides by Workers" (ICRP Publication 30), Pergamon Press, Oxford, July 1978.

5. Harold L. Beck, "Environmental Radiation Fields," Health and Safety Laboratory, U.S. Atomic Energy Commission, New York, New York, 1972.

6. Gail De Planque Burke and Thomas F. Gesell, "Error Analysis of Environmental Radiation Measurements Made with Integrating Detector," NBS Special Publication 456, pp. 187-198, 1976.

7. "American National Standard; Performance Testing and Procedural Specifications for Thermoluminescent Dosimetry (Environmental Applications)" (ANSI N545-1975), American National Standards Institute, Inc., New York, New York, 1975.

8. Wayne A. Scoggins, "Environmental Surveillance Report for the Nevada Test Site, January 1982 through December 1982" (DOE/NV0-410-76), Reynolds Electrical & Engineering Co., Inc., Las Vegas, Nevada, 1983.

9. Michael W. Lantz, "Environmental Surveillance Report for the Nevada Test Site January 1979 through December 1979" (NVO/0410-60), Reynolds Electrical & Engineering, Co., Inc., Las Vegas, Nevada 1980.

10. Bureau of Radiological Health, "Radiological Health Handbook," U.S. Department of Health, Education and Welfare, Rockville, Maryland, 1970.

11. "Offsite Environmental Monitoring Report for the Nevada Test Site and Other Test Areas Used for Underground Detonations" (EPA-600/4-82-061), January through December 1982, Environmental Protection Agency, Las Vegas, Nevada, 1982.

12. D. H. Slade, ed., "Meteorology and Atomic Energy," U.S. Atomic Energy Commission, 1968.

13. "Radiological Survey of the Nevada Test Site (Survey Period: 1970-1971)" (EG&G-1183-1552), EG&G, Las Vegas, Nevada, 1972.

14. G. R. Hoenes and J. K. Soldat, "Age-Specific Radiation Dose Commitment Factors for a One-Year Chronic Intake" (NUREG-0172), Battelle Pacific Northwest Laboratories, Richland, Washington, 1977.

15. "Report of the Task Group on Reference Manual - A Report Prepared by a Task Group of Committee 2 of ICRP" (ICRP Publication 23), Pergamon Press, Oxford 1977.

16. "Recommendation of the International Commission on Radiological Protection - Report of Committee 2 on Permissible Dose of Internal Radiation (1959)" (ICRP Publication 2), Pergamon Press, Oxford, 1960.

17. "Radiation Protection - Recommendation of the International Commission on Radiological Protection" (ICRP Publication 26), Pergamon Press, Oxford, 1977.

18. "National Background Radiation in the United States - Recommendation of the National Council on Radiation Protection and Measurements, (NCRP Report No. 45), Washington, DC, 1975.

19. J. H. Harley ed., "EML Procedures Manual," (HASL-300), Environmental Measurements Laboratory, New York, New York, 1972.

20. P. E. Bramson, H. M. Parker and J. K. Soldat, "Dosimetry for Radioactive Gases," Battelle Pacific Northwest Laboratories, Richland, Washington, 1973.

21. P. C. Nyberg, et al, "An Automated TLD System for Gamma Radiation Monitoring," IEEE Transaction on Nuclear Science, Vol. N3-27, No. 1, February 1980, pp. 713-717.

22. "National Interim Primary Drinking Water Regulations" (EPA-570/9-76-003), Environmental Protection Agency, June 24, 1977.

23. Wayne A. Scoggins, "Environmental Surveillance Report for the Nevada Test Site January 1973 through December 1983" (DOE/NV/10327-4), Reynolds Electrical & Engineering, Co., Inc., Las Vegas, Nevada, 1984.

24. "Offsite Environmental Monitoring Report - Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1983" (EPA-600/4-84-040), Environmental Protection Agency, Las Vegas, Nevada 1984.

25. "Krypton-85 in the Atmosphere - Accumulation, Biological Significance, and Control Technology - Recommendation of the National Council on Radiation Protection and Measurements" (NCRP Report No. 44), Washington, D.C., 1975.

26. "Safety Assessment for Area 5 Radioactive Waste Management Site" (DOE/NV/10253-1), Reynolds Electrical & Engineering Co., Inc., Las Vegas, Nevada, 1982.

27. "Site Characterization in Connection with the Low Level Defense Waste Management Site in Area 5 of the Nevada Test Site, Nye County, Nevada--Final Report" (DOE/NV/10162-13), Desert Research Institute, Las Vegas, Nevada, 1984.

28. "Radiation Protection of the Public and the Environment" (DOE Draft ORDER, 5480.XX), Department of Energy, Washington, D.C., March 31, 1987.

29. A. N. Jarvis, and L. Sui, "Environmental Radioactivity Laboratory Intercomparisons Studies Program" (EPA-600/4-81-004), U.S. Environmental Protection Agency, Las Vegas, Nevada, 1981.

30. C. G. Sanderson, "Environmental Measurements Laboratory Semi-Annual" Department of Energy Quality Assessment Program Data Evaluation Report" (DOE EML-478), U.S. Department of Energy, New York, New York, 1987.

APPENDICES

APPENDIX A

NTS Environmental Monitoring

Air Sampling Stations and Plots

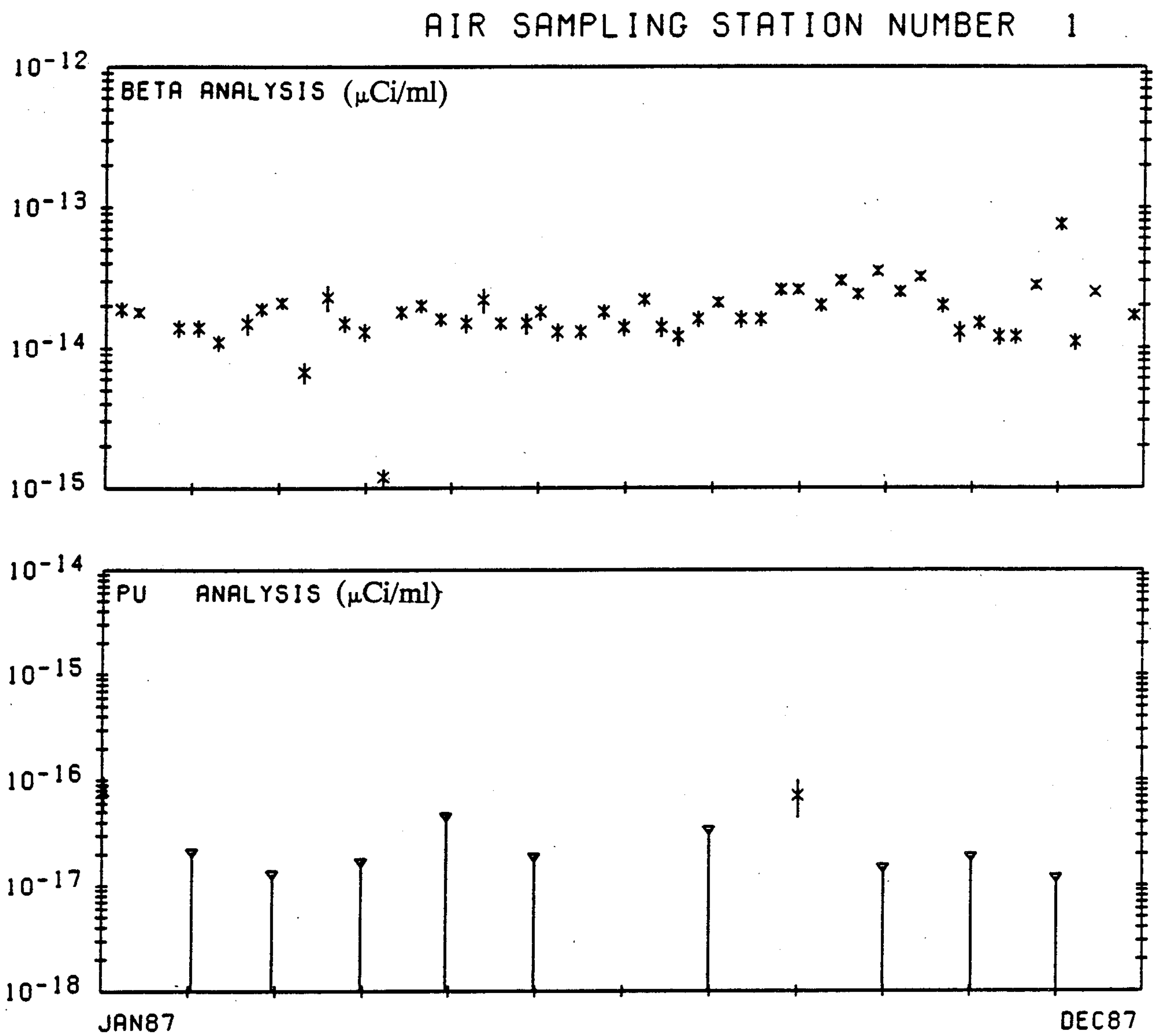
SYMBOLS

Several symbols are used in Appendix A to denote the data points. The plots of Appendix A show the gross beta and plutonium data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with the line to the bottom of the plot signifies a result below detection limits.

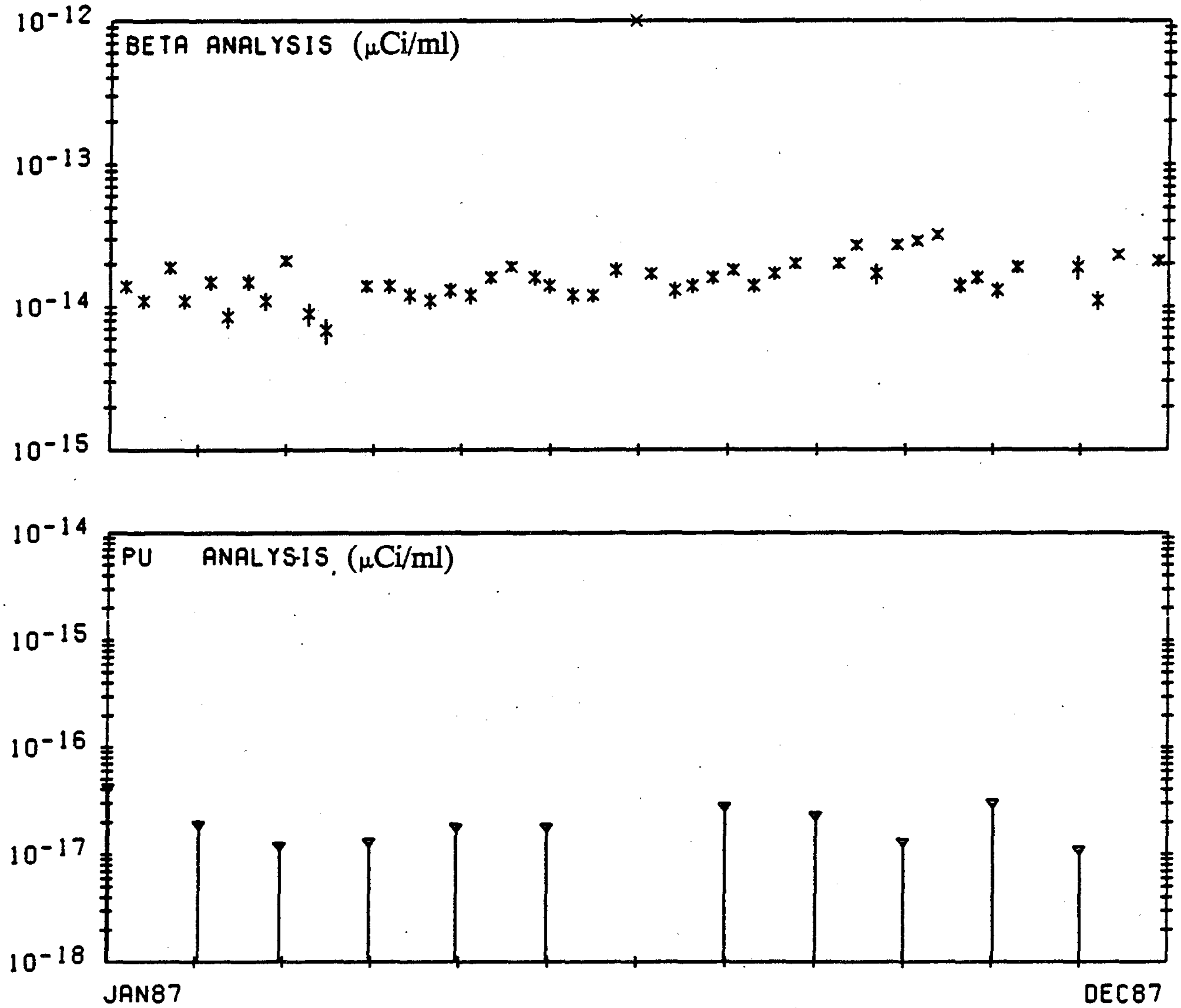
NTS Environmental Monitoring

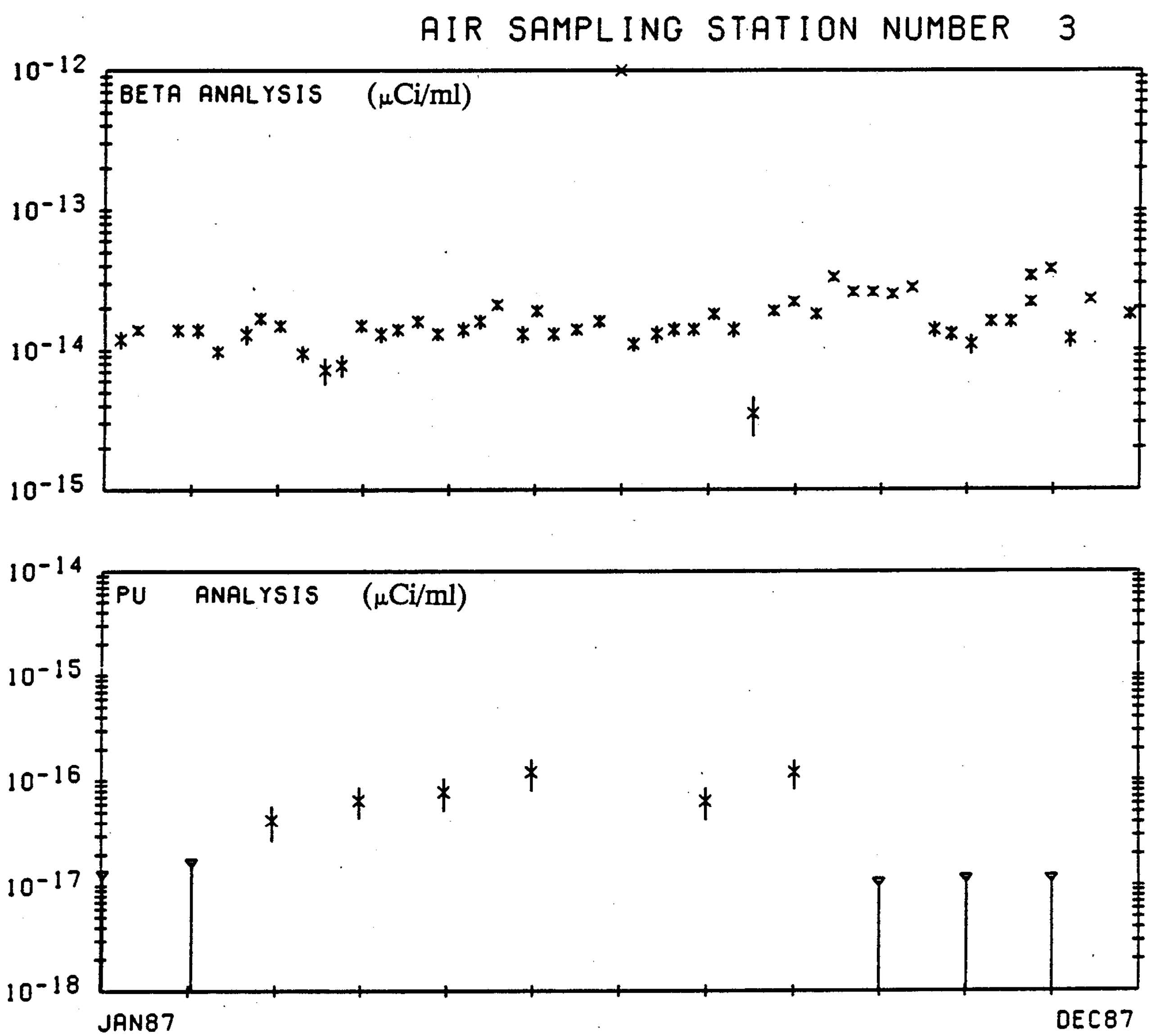
Air Sampling Locations

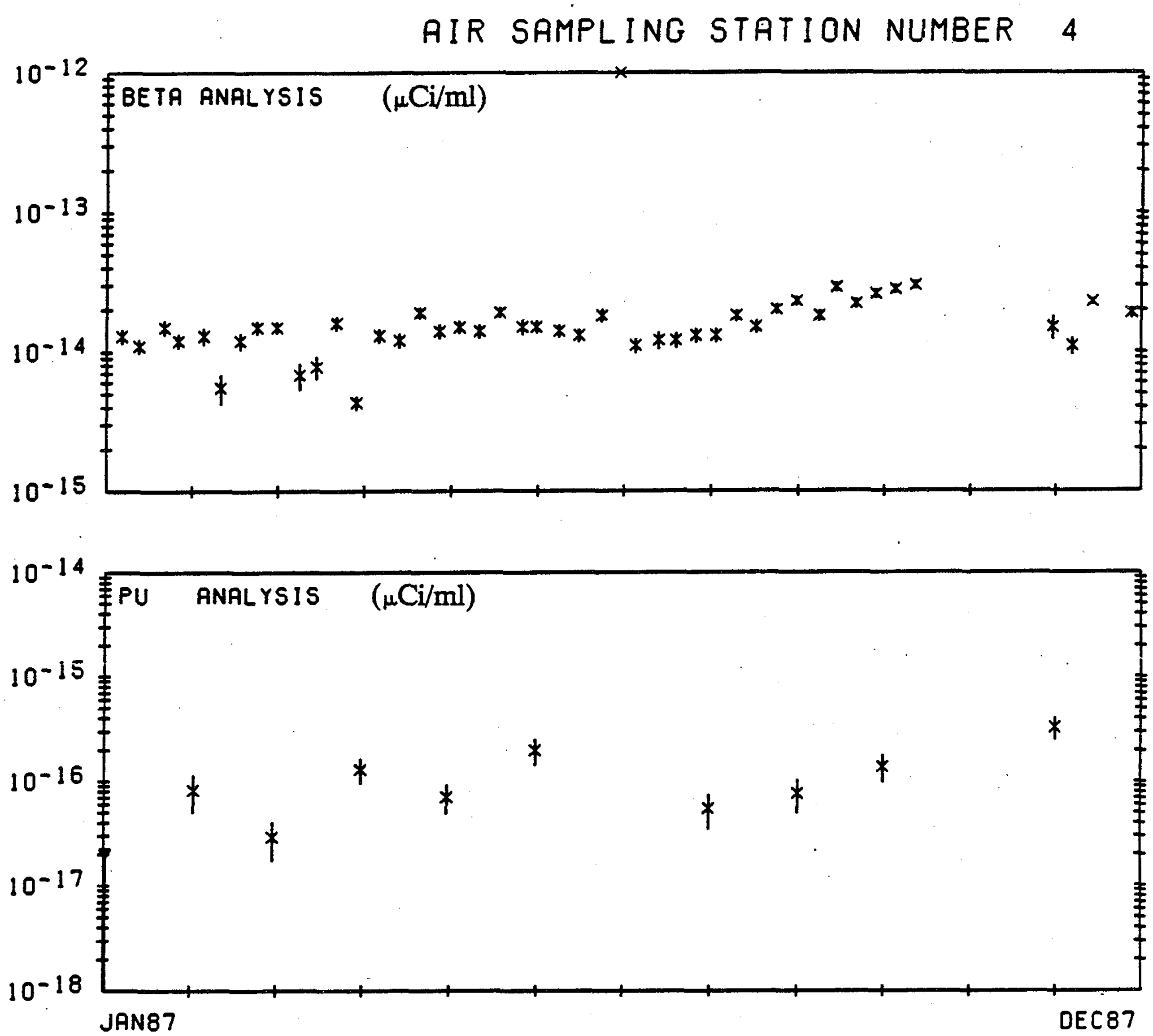
Station Number	Location
1	Area 11 Gate 293
2	Area 6 Well 3
3	Area 3 Complex No. 2
4	Area 9 9-300 Bunker
5	Area 15 Gate 700 South
6	Area 2 Hydraulic Lift Yard
7	Area 2 Compound
8	Area 12 Compound
9	Area 19 Echo Peak
10	Area 19 Substation
11	Area 16 Substation
13	Area 23 H & S Roof
14	Area 23 Building 790
15	Area 23 Building 790 No. 2
16	Area 27 Cafeteria
17	Area 25 NRDS
19	Area 5 Well 5B
20	Area 5 RWMS No. 1
21	Area 5 DOD Yard
22	Area 6 Yucca Complex
23	Area 6 CP Complex
24	Area 5 Pit No. 3
25	Area 1 Gravel Pit
26	Area 1 BJY
27	Area 3 3-300 Bunker
28	Area 5 RWMS No. 2
29	Area 5 RWMS No. 3
30	Area 25 E-MAD North
31	Area 25 E-MAD South
32	Area 5 RWMS No. 4
33	Area 3 U3ax/bl South
34	Area 3 U3ax/bl East
35	Area 3 U3ax/bl North
36	Area 3 U3ax/bl West
37	Area 7 UE7ns
38	Area 15 EPA Farm
39	Area 5 RWMS No. 5
40	Area 5 RWMS No. 6
41	Area 5 RWMS No. 7
42	Area 5 RWMS No. 8
43	Area 5 RWMS No. 9
44	Area 15 PILEDRIVER
45	Area 23 East Boundary
46	Area 20 Dispensary
47	Area 3 Complex No. 2
48	Area 5 Gate 200


AIR SAMPLING STATION NUMBER 1
BETA ANALYSIS (μCi/ml)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
PU ANALYSIS (μCi/ml)
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
JAN87
DEC87

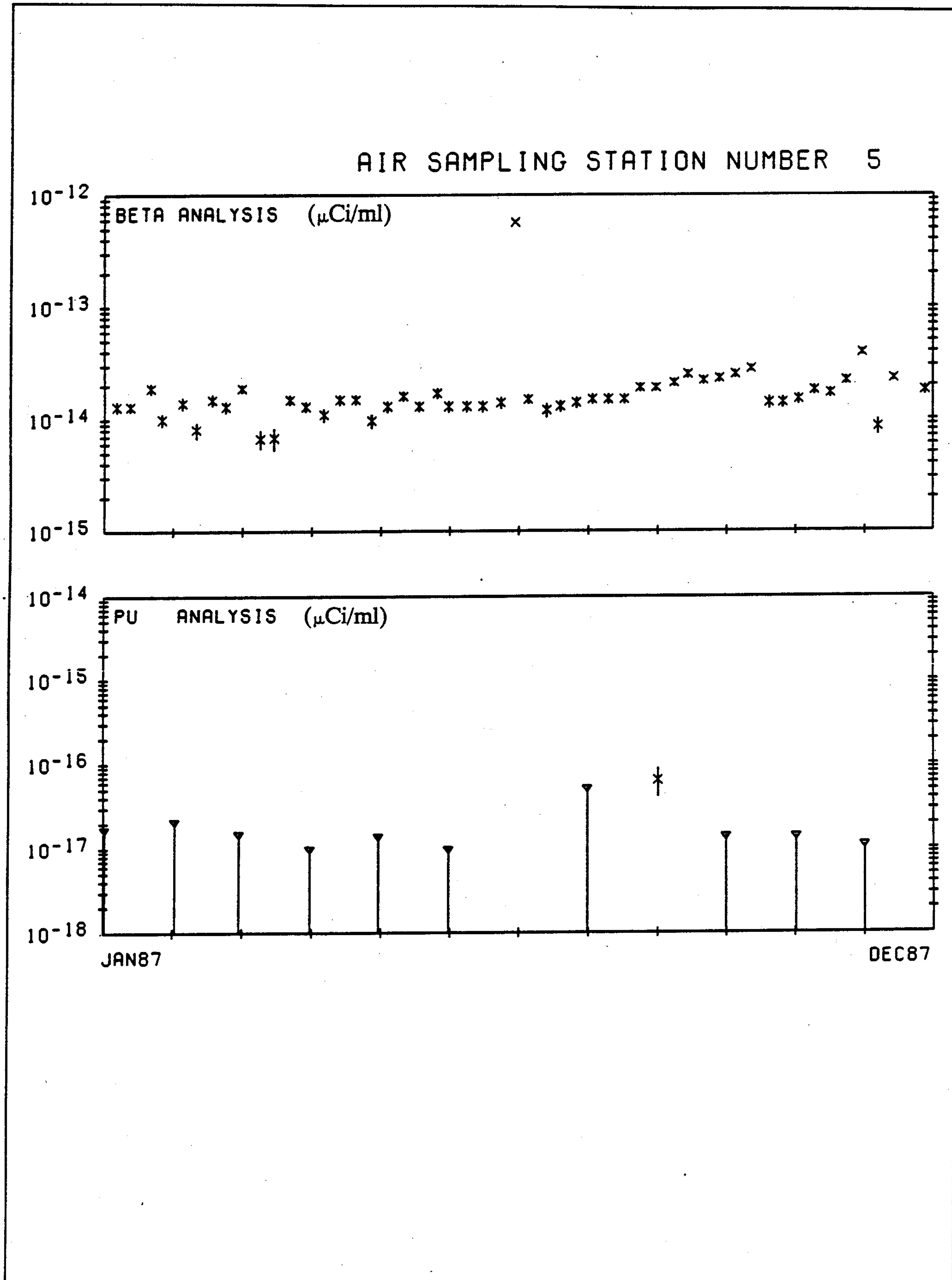
AIR SAMPLING STATION NUMBER 2

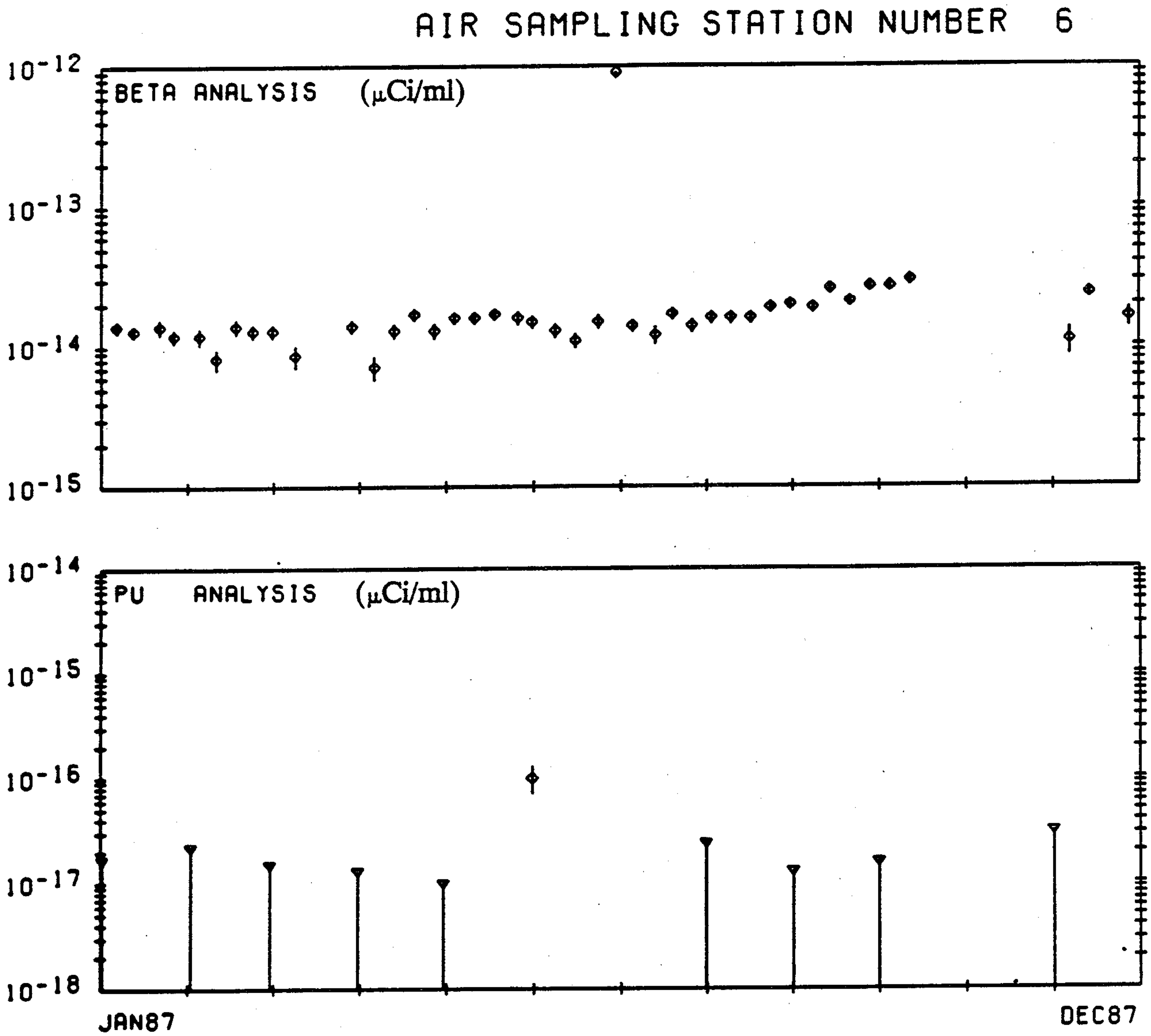



AIR SAMPLING STATION NUMBER 3
BETA ANALYSIS (μCi/ml)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
PU ANALYSIS (μCi/ml)
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
JAN87
DEC87

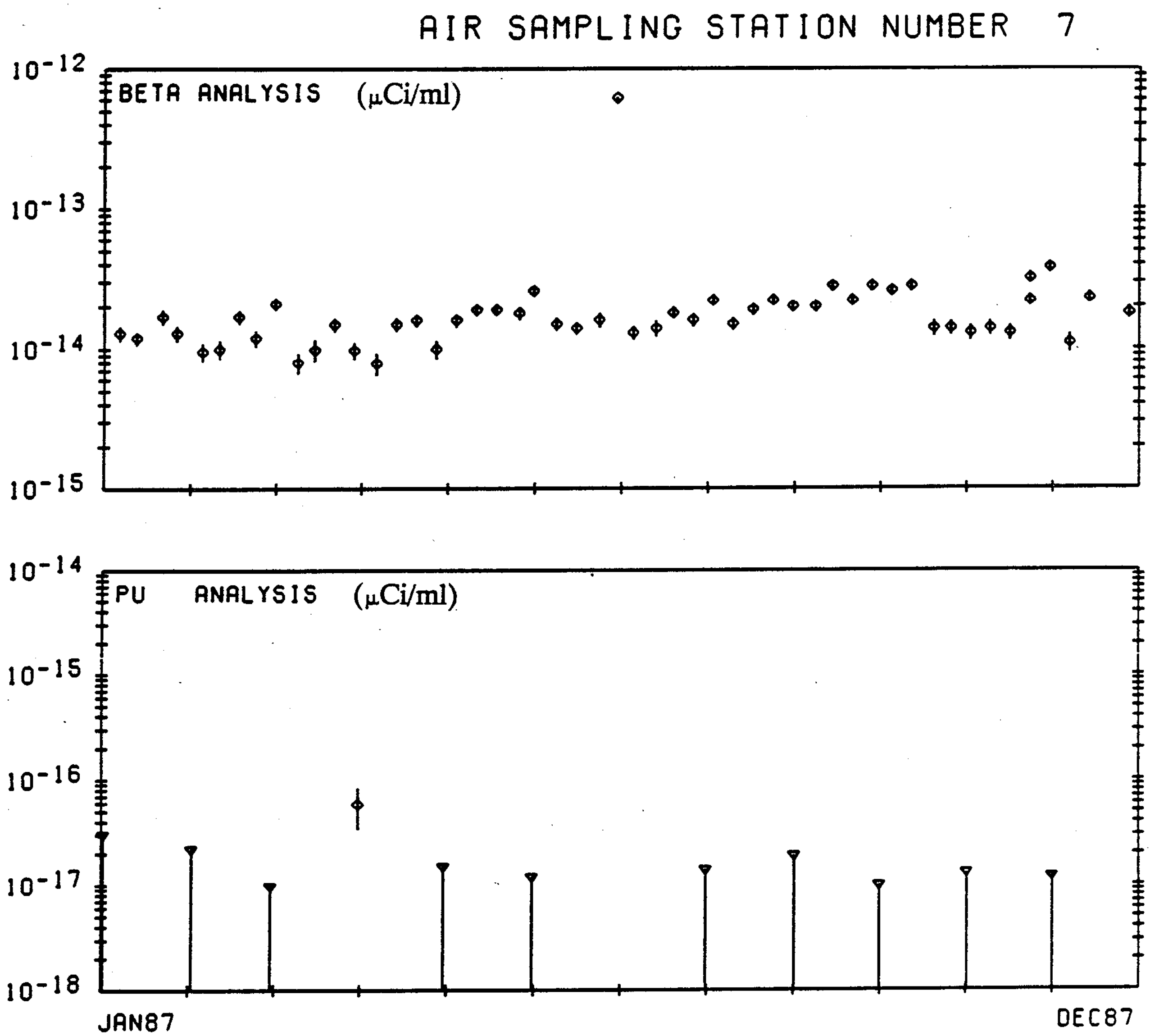


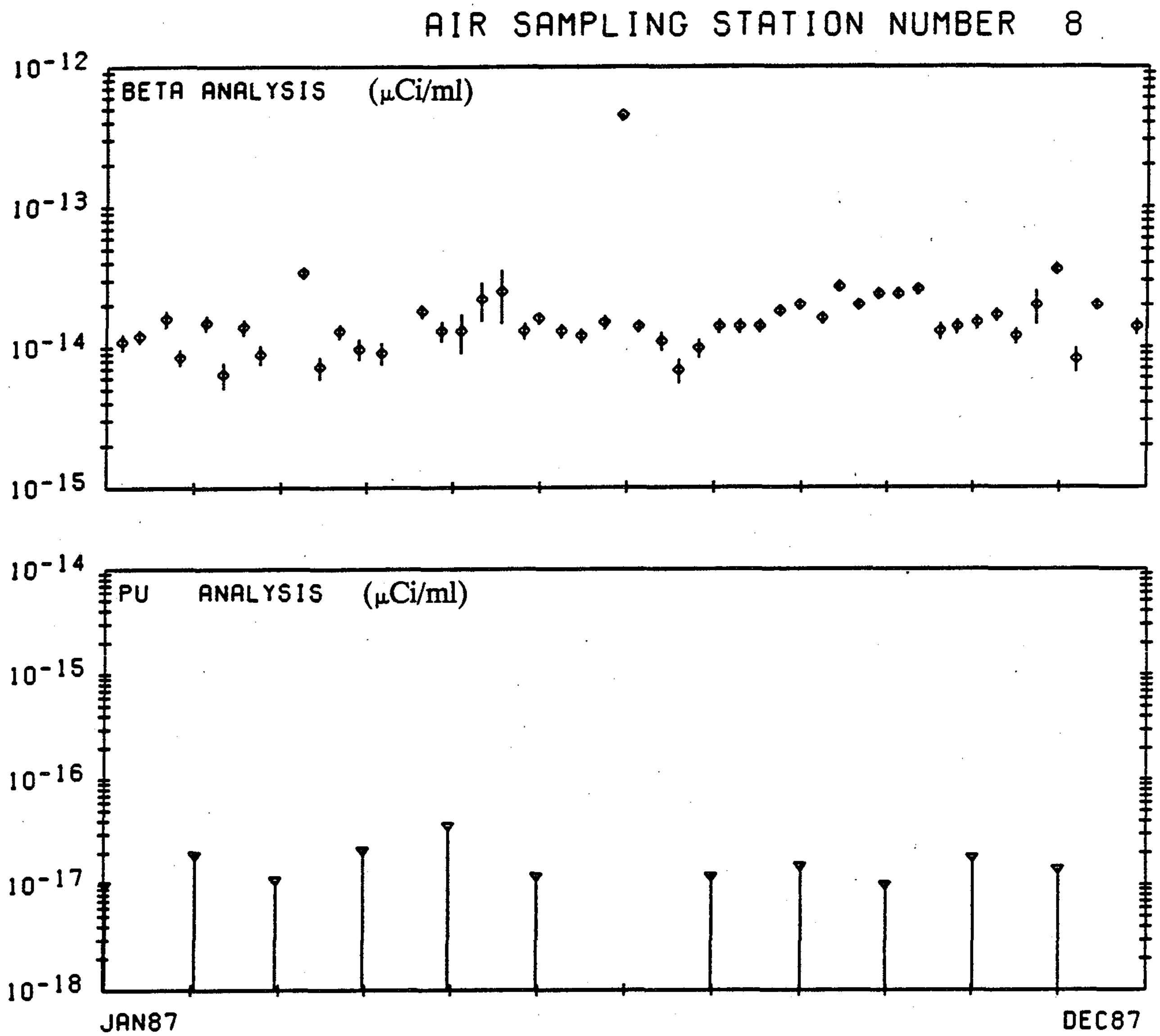
AIR SAMPLING STATION NUMBER 4
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

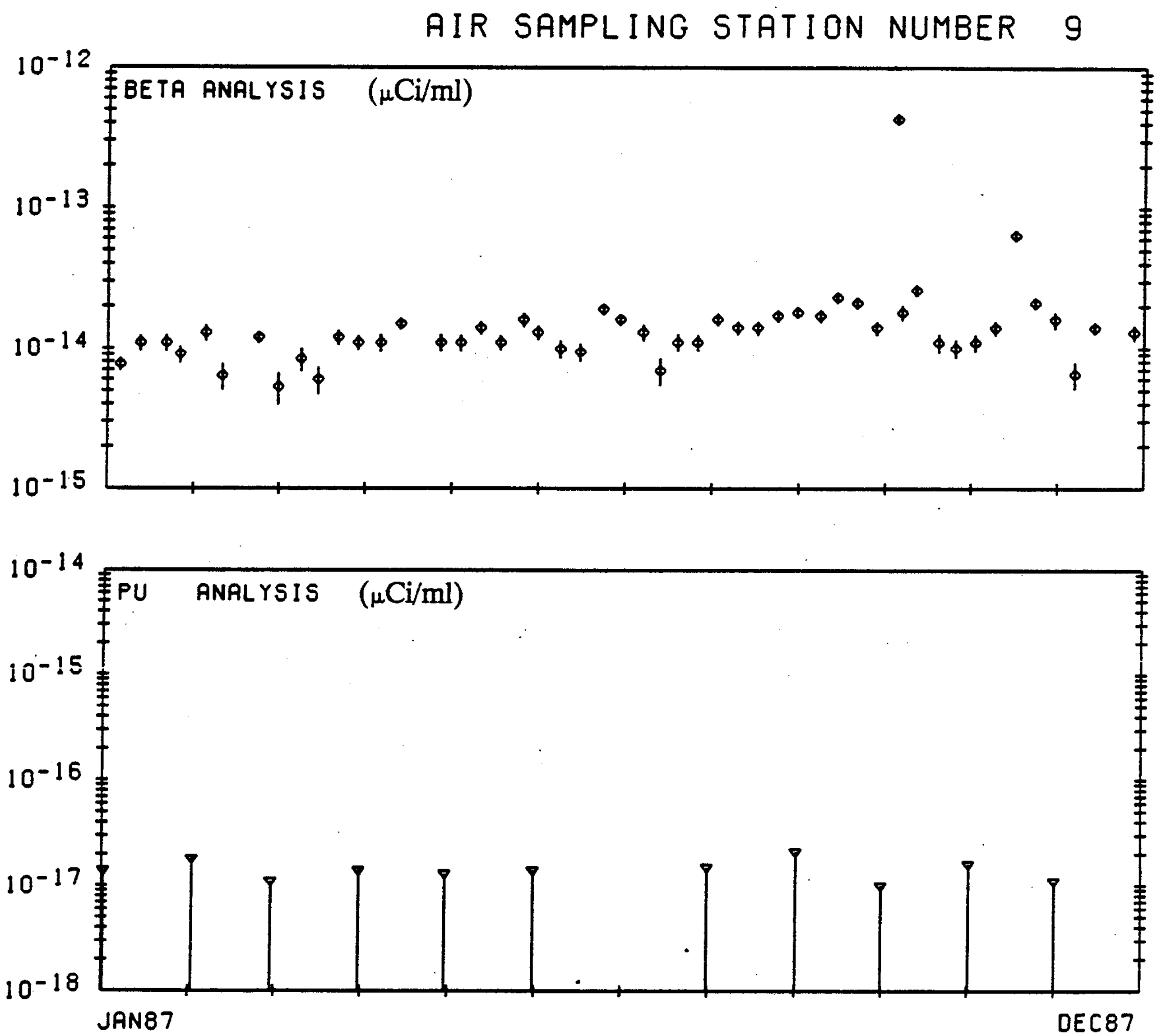

AIR SAMPLING STATION NUMBER 5
BETA ANALYSIS (μCi/ml)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
PU ANALYSIS (μCi/ml)
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
JAN87
DEC87

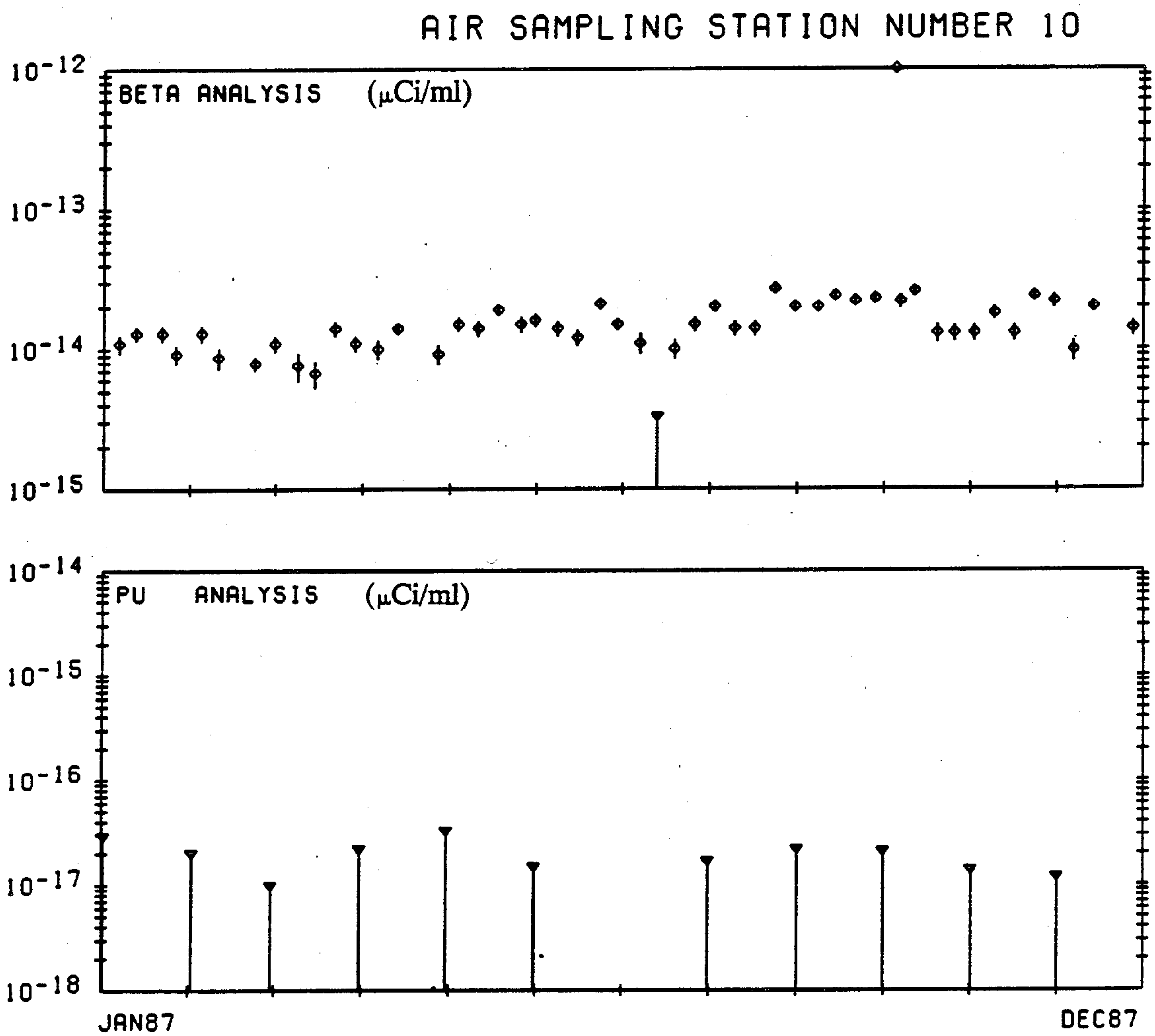


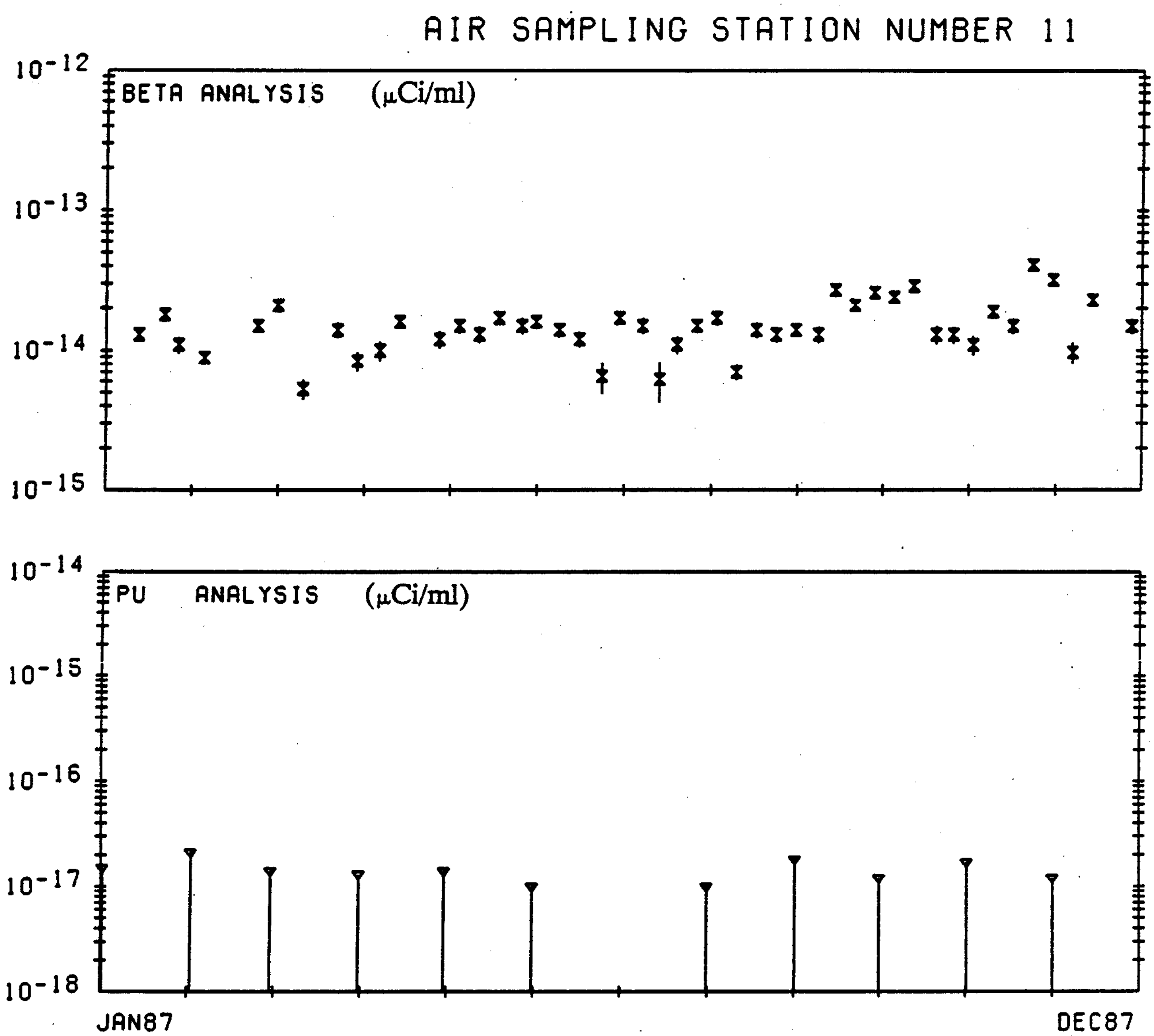
AIR SAMPLING STATION NUMBER 6
BETA ANALYSIS (µCi/ml)
10^-12
10^-13
10^-14
10^-15
PU ANALYSIS (µCi/ml)
10^-14
10^-15
10^-16
10^-17
10^-18
JAN87
DEC87

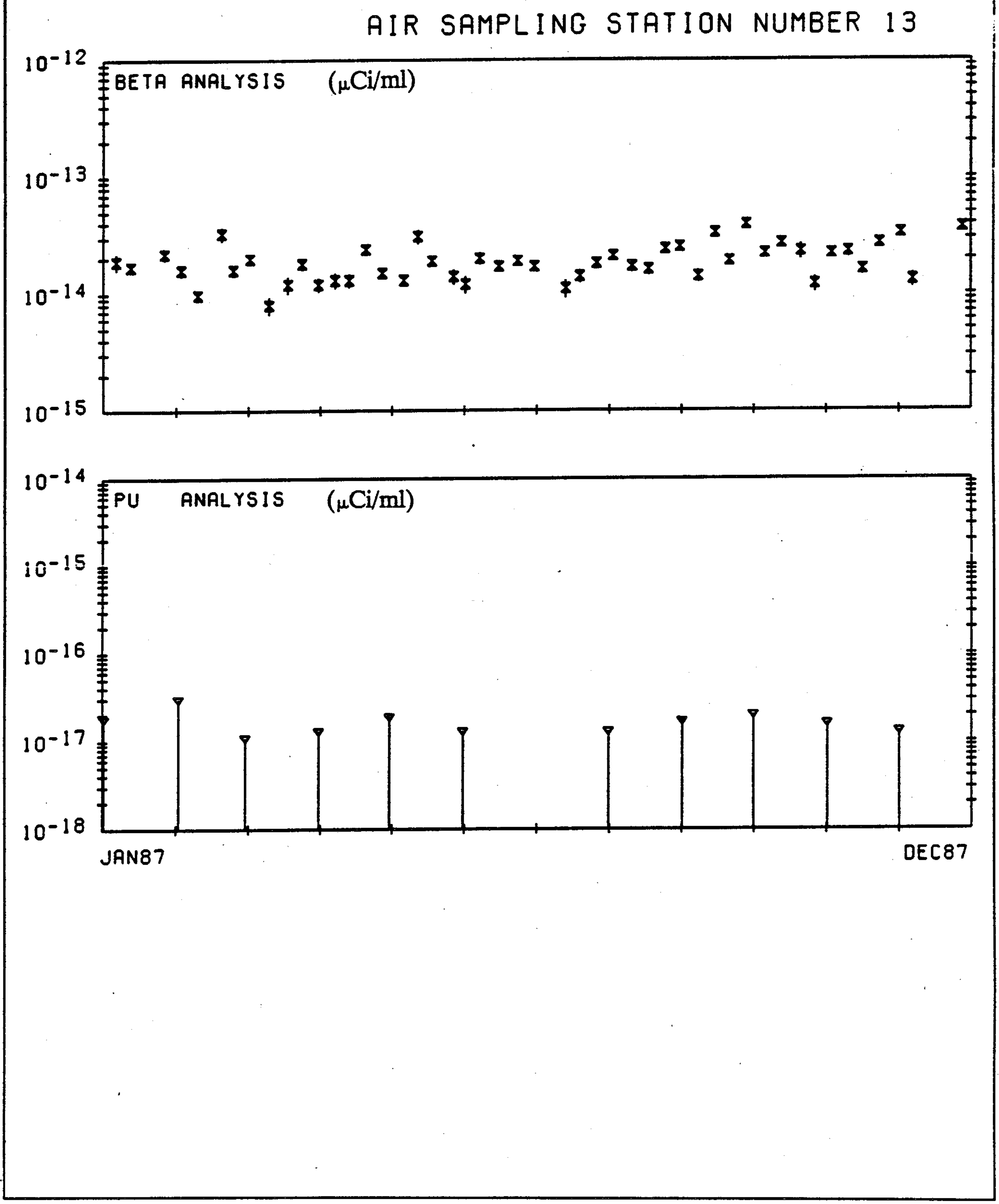

AIR SAMPLING STATION NUMBER 7
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

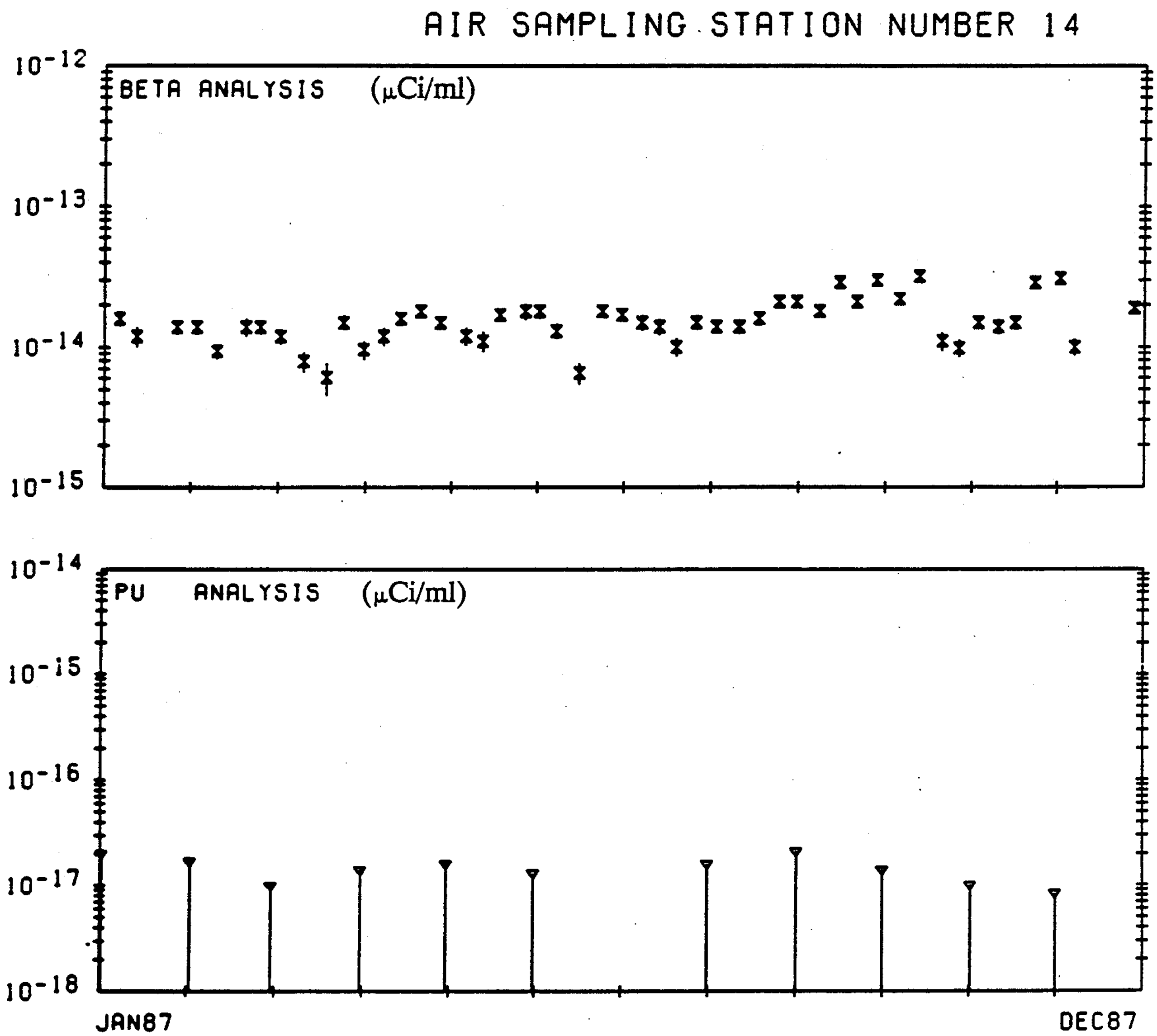

AIR SAMPLING STATION NUMBER 8
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

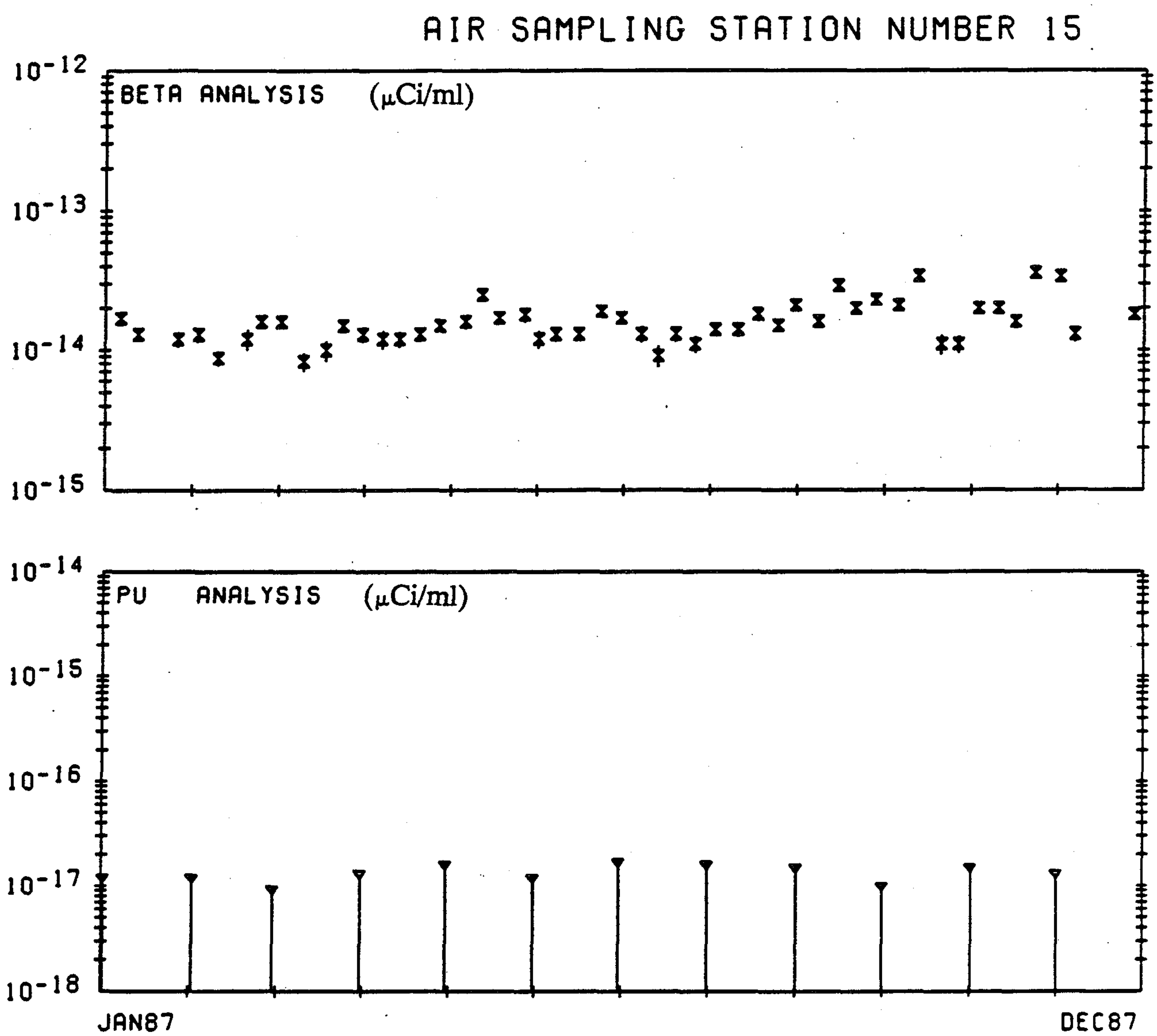

AIR SAMPLING STATION NUMBER 9
BETA ANALYSIS (µCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (µCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87


AIR SAMPLING STATION NUMBER 10
BETA ANALYSIS (μCi/ml)
PU ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

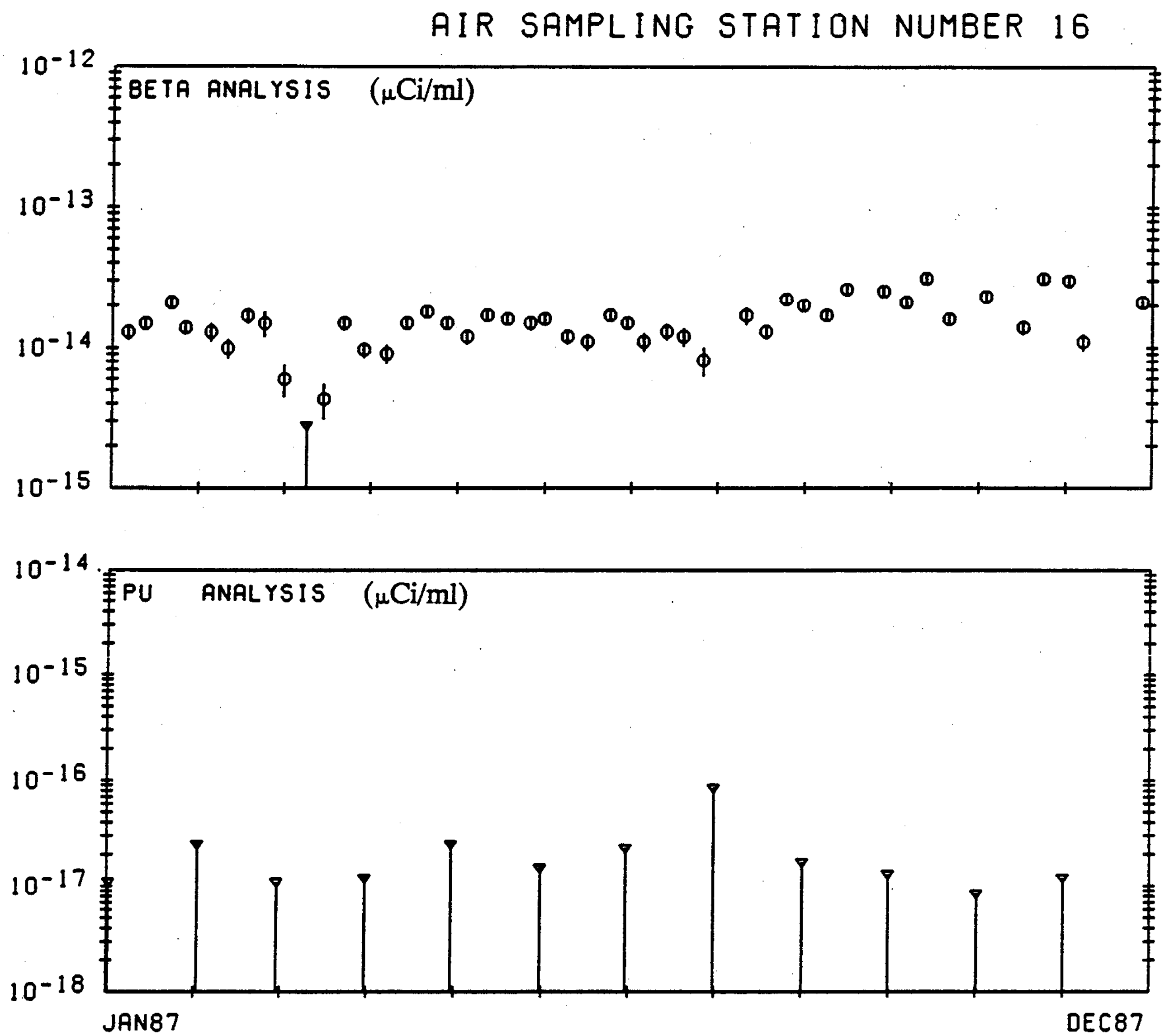

AIR SAMPLING STATION NUMBER 11
BETA ANALYSIS (μCi/ml)
10^{-12}
10^{-13}
10^{-14}
10^{-15}
PU ANALYSIS (μCi/ml)
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
JAN87
DEC87

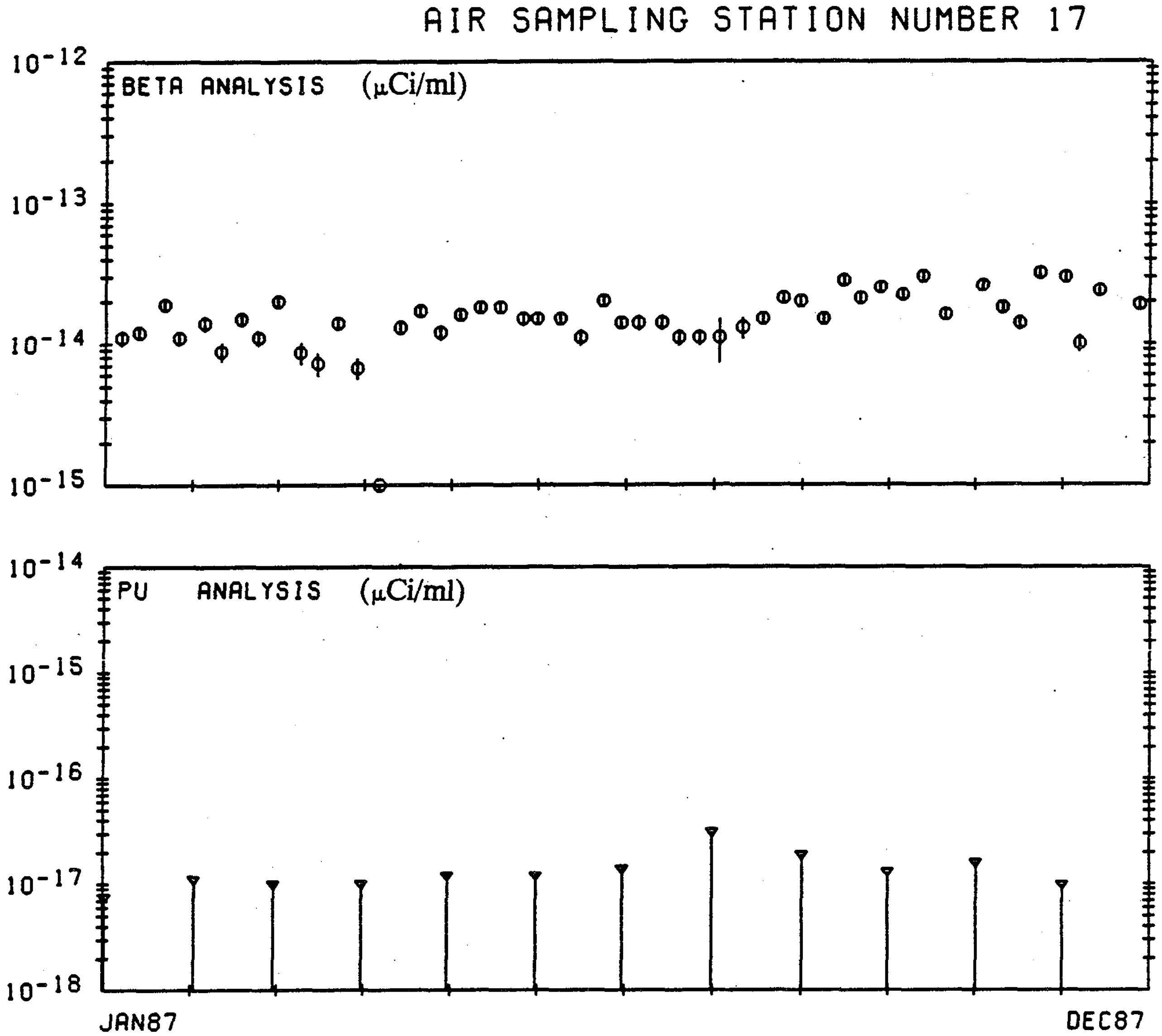

AIR SAMPLING STATION NUMBER 13
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

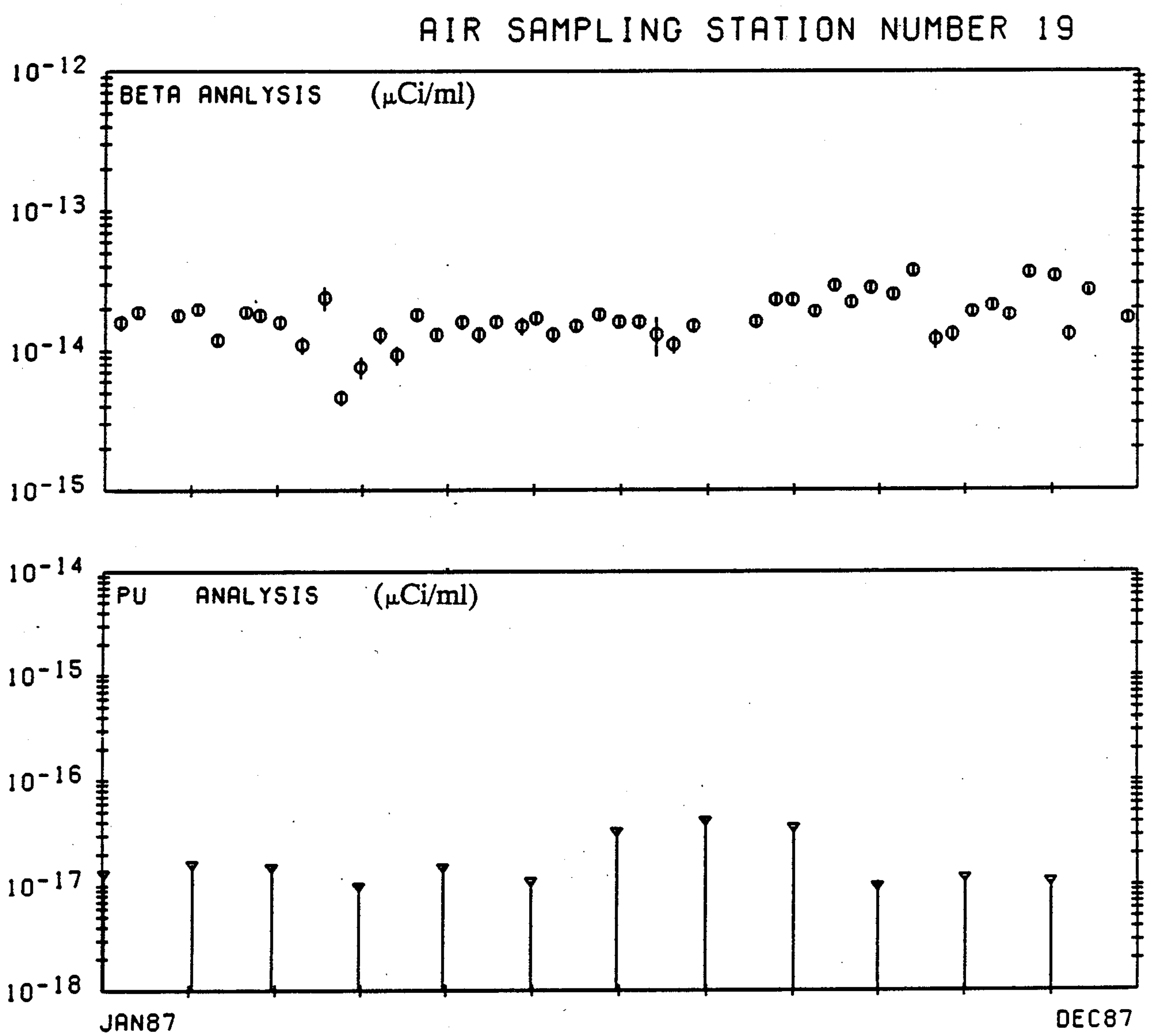

AIR SAMPLING STATION NUMBER 14
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

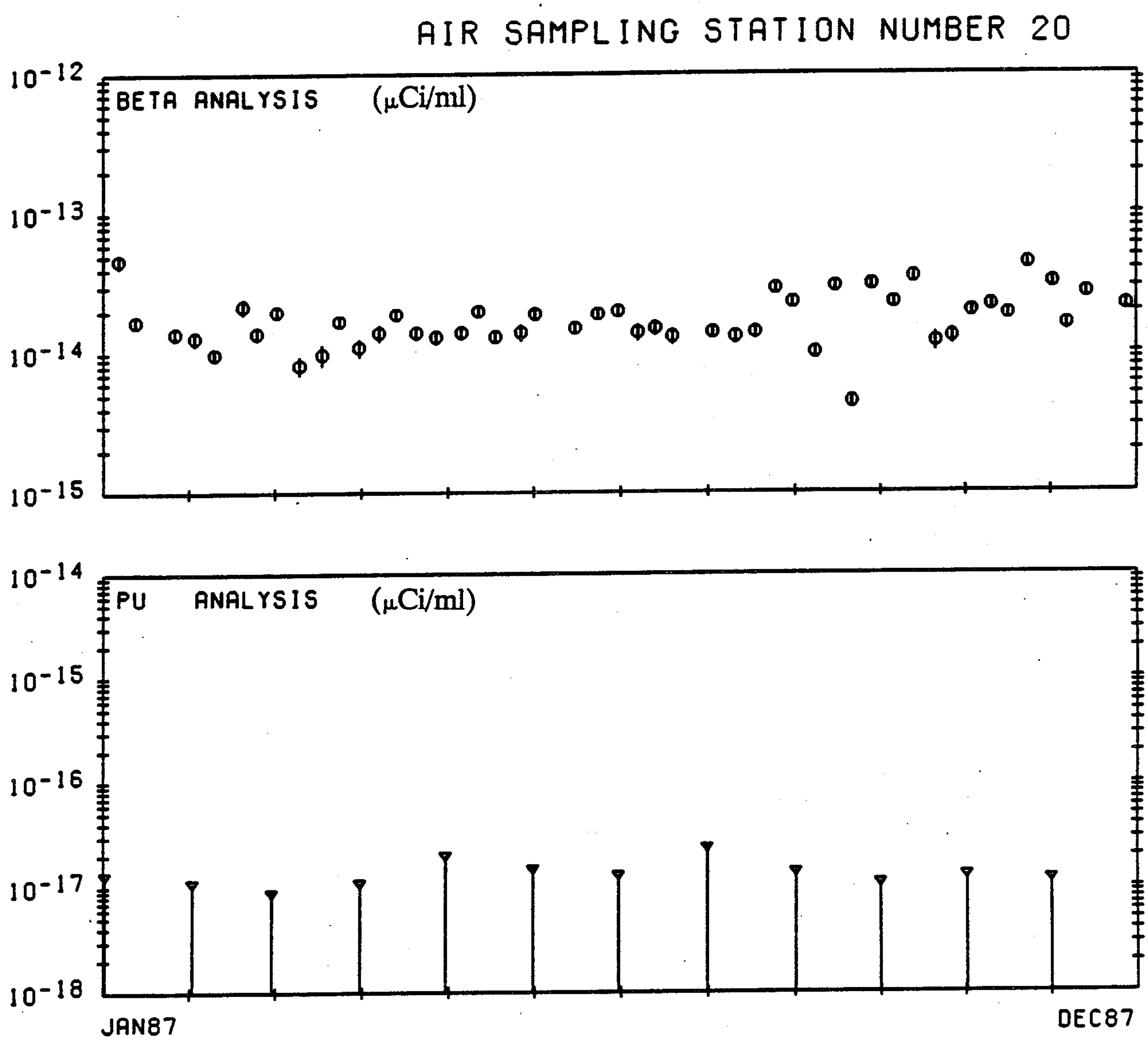


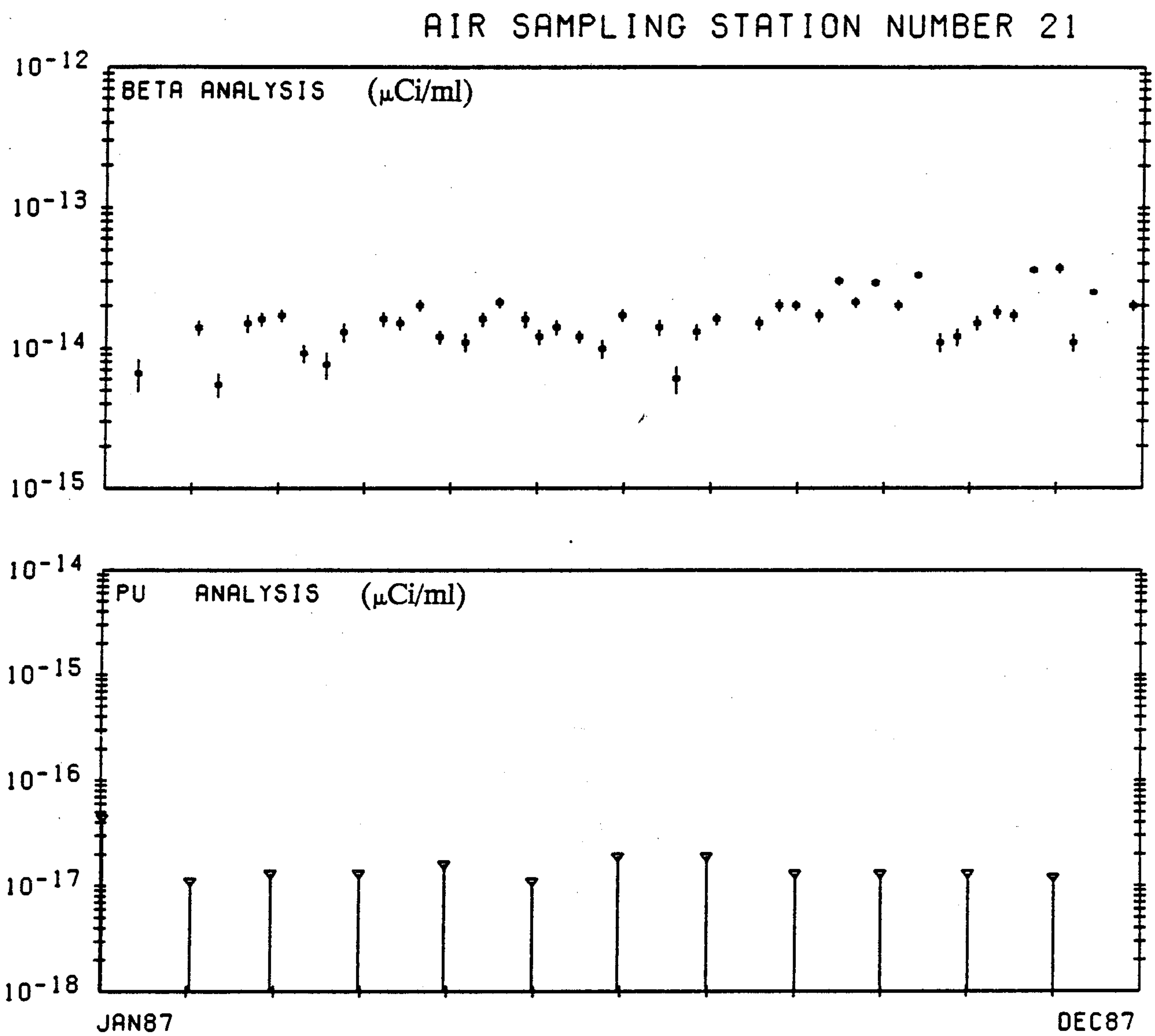
AIR SAMPLING STATION NUMBER 15
BETA ANALYSIS (μCi/ml)
10^{-12}
10^{-13}
10^{-14}
10^{-15}
PU ANALYSIS (μCi/ml)
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
JAN87
DEC87


AIR SAMPLING STATION NUMBER 16
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

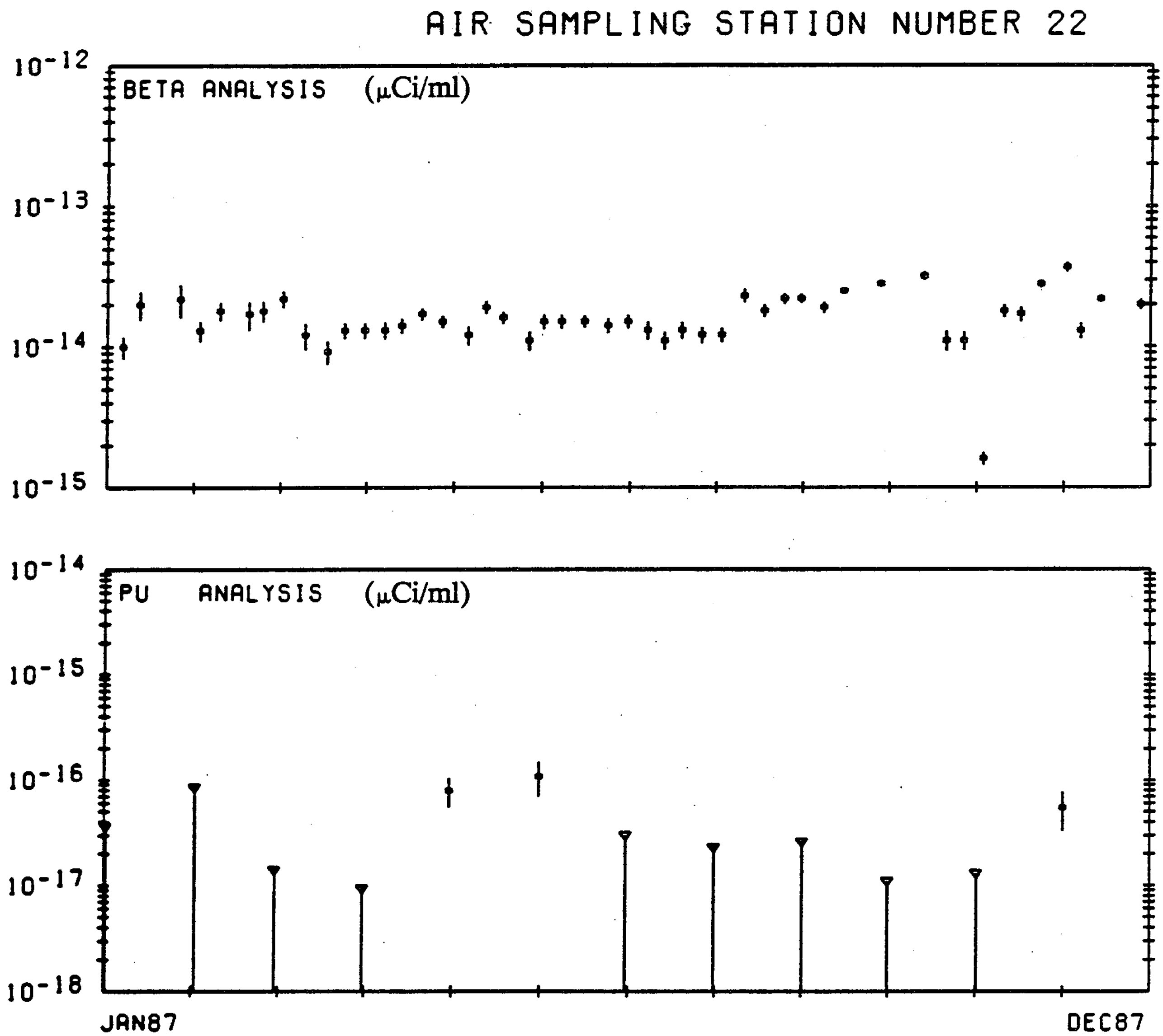

AIR SAMPLING STATION NUMBER 17
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87


AIR SAMPLING STATION NUMBER 19
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

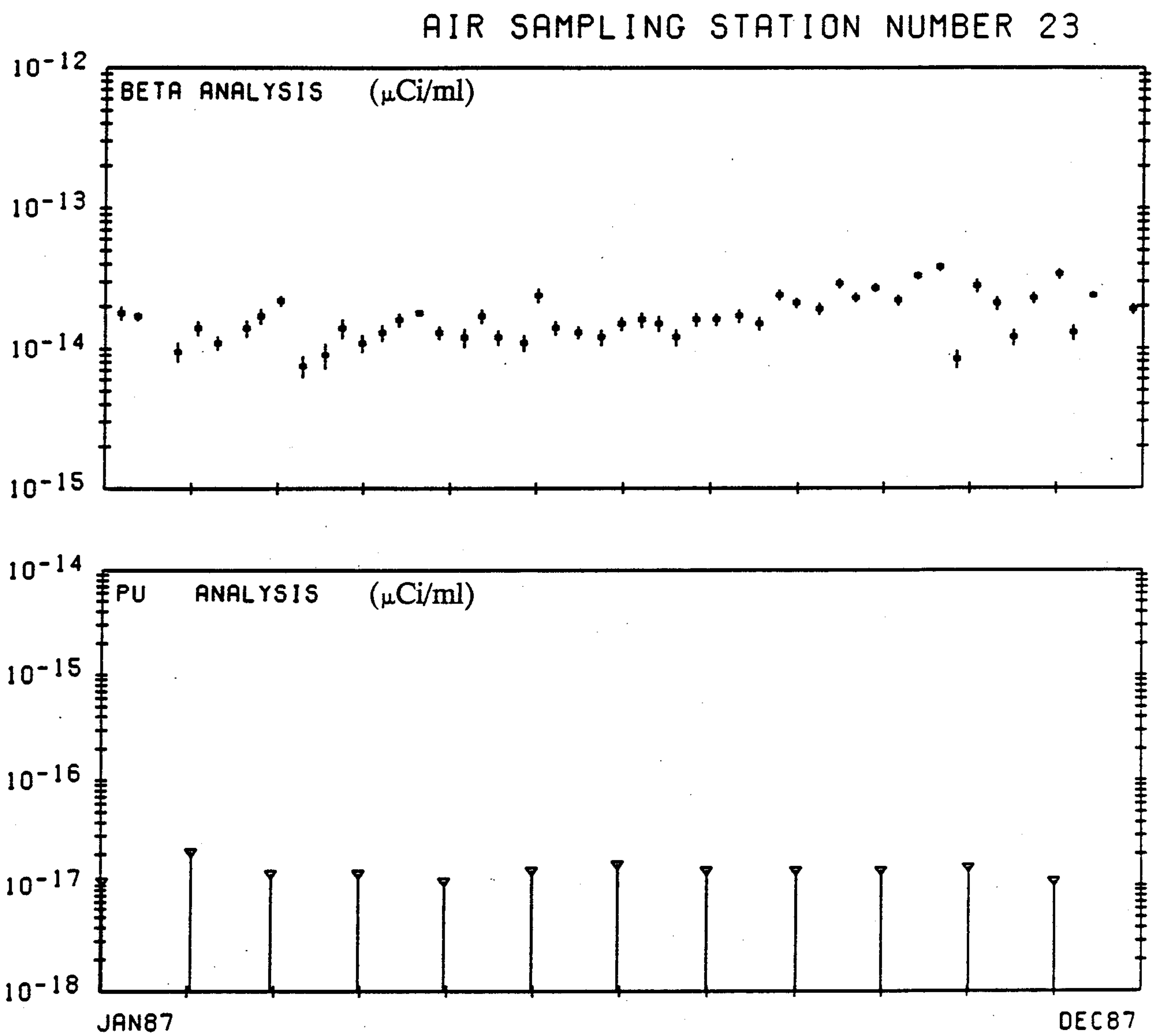

AIR SAMPLING STATION NUMBER 20
BETA ANALYSIS (μCi/ml)
PU ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87



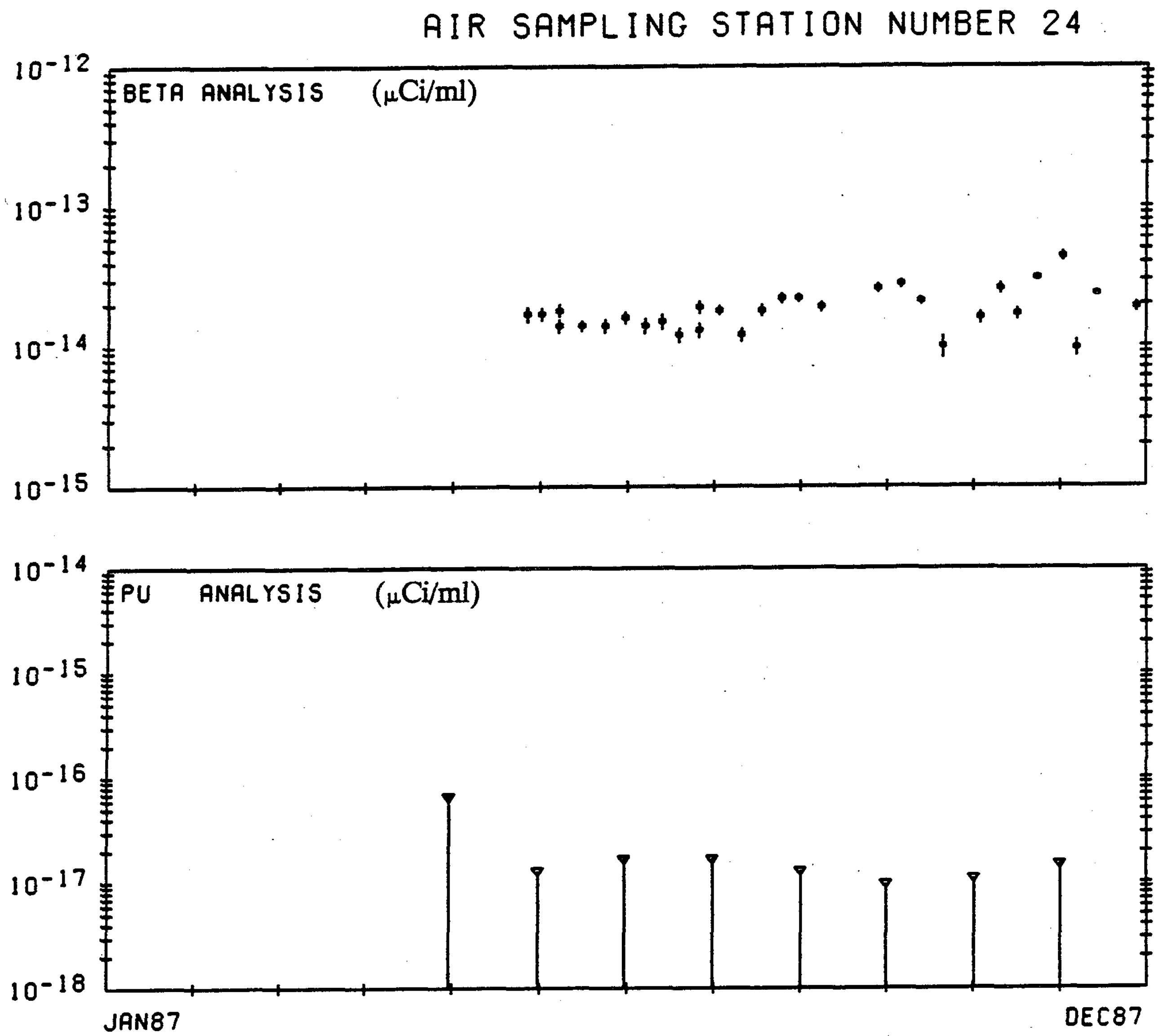
AIR SAMPLING STATION NUMBER 21
BETA ANALYSIS (µCi/ml)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
PU ANALYSIS (µCi/ml)
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
JAN87
DEC87

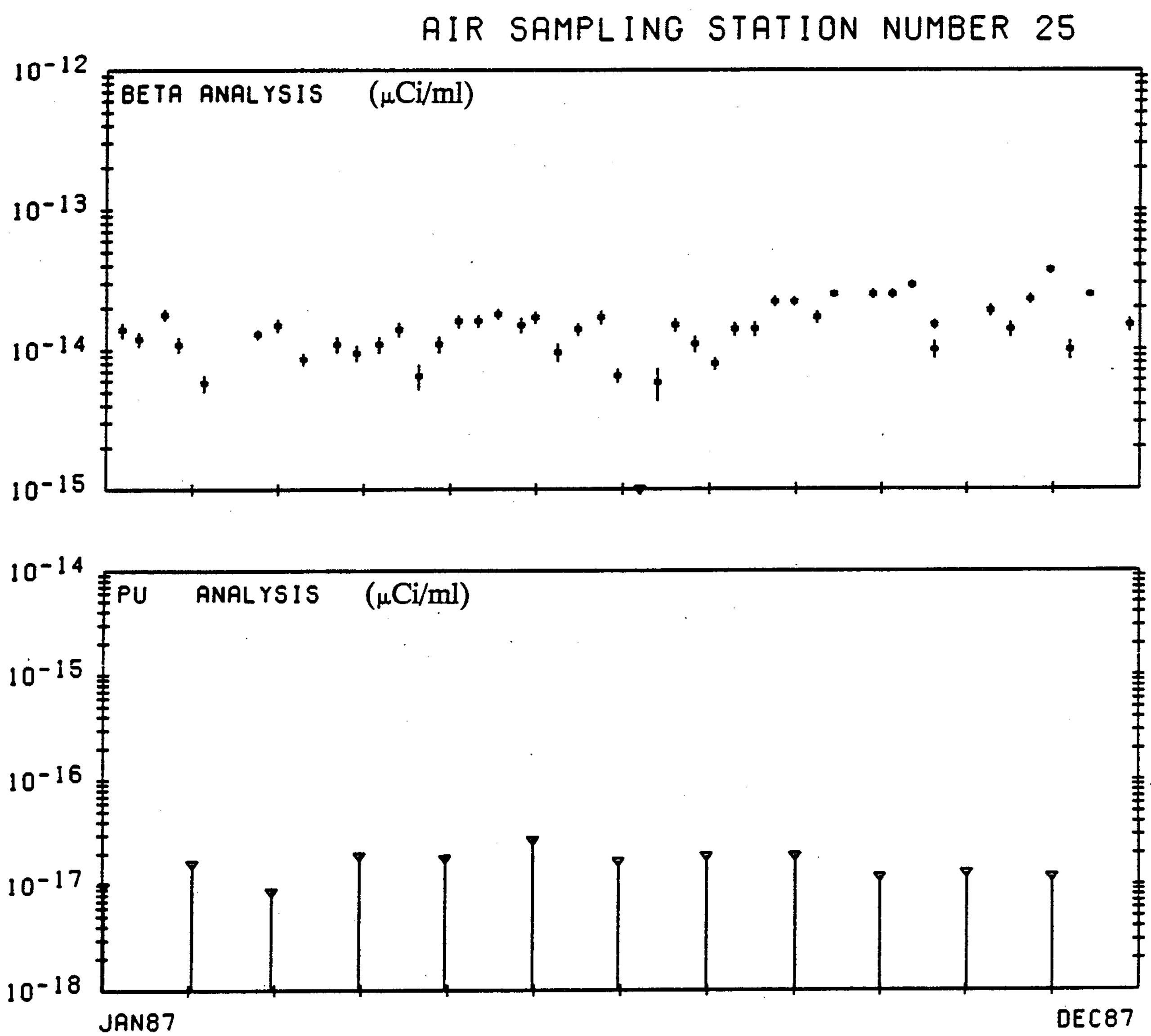


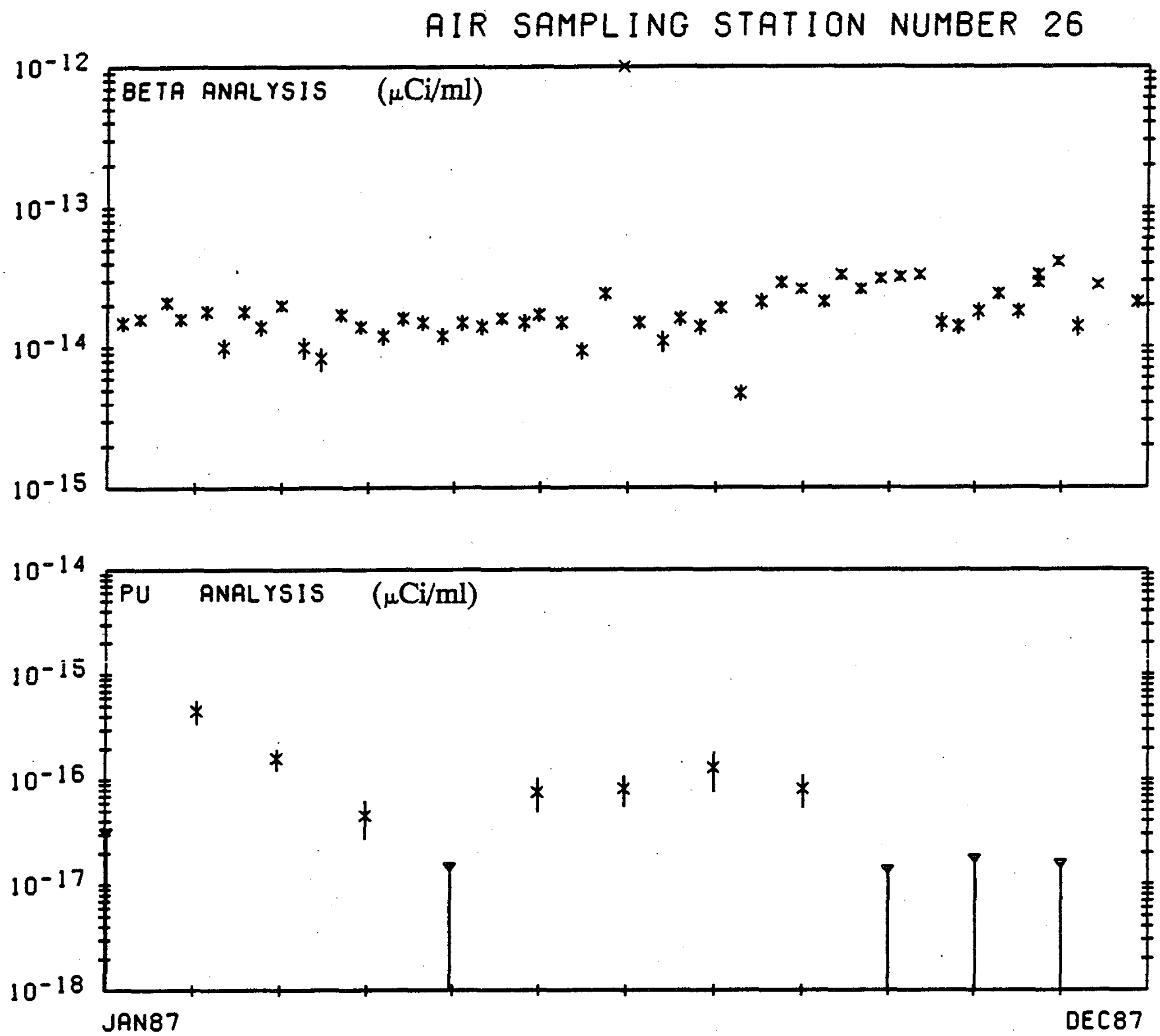
AIR SAMPLING STATION NUMBER 22
BETA ANALYSIS (μCi/ml)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
PU ANALYSIS (μCi/ml)
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
JAN87
DEC87



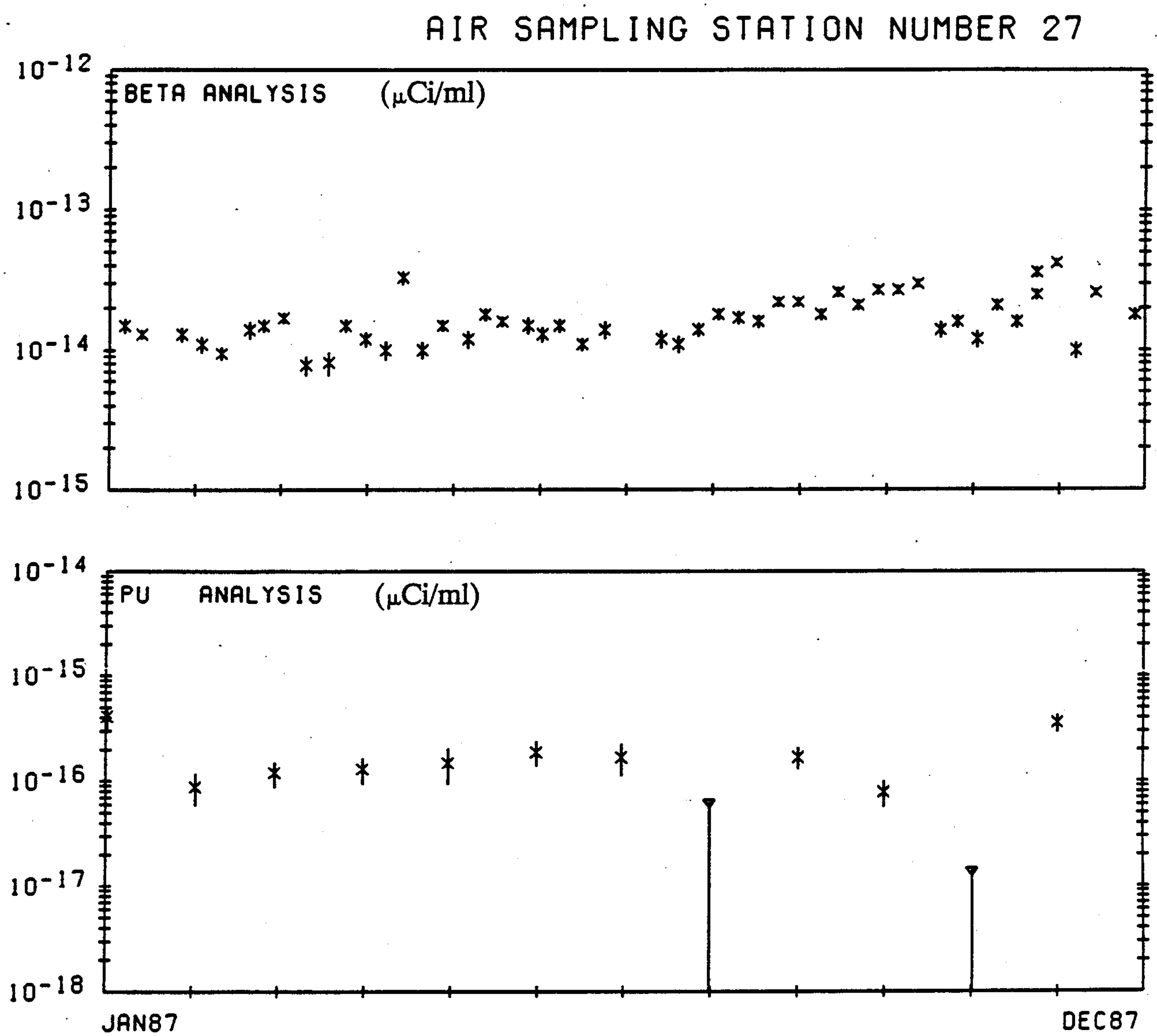
AIR SAMPLING STATION NUMBER 23
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

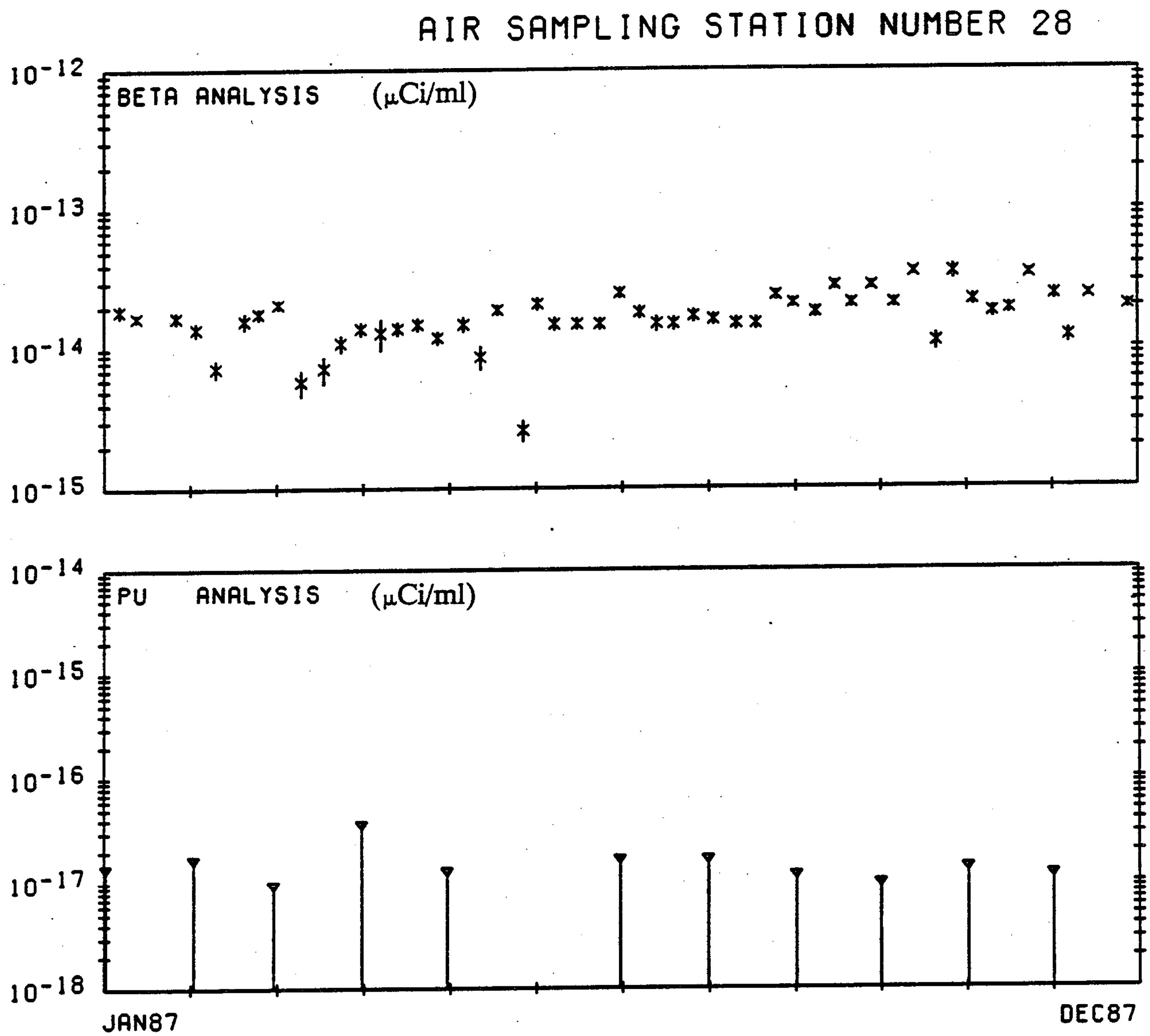

AIR SAMPLING STATION NUMBER 24
BETA ANALYSIS (μCi/ml)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
PU ANALYSIS (μCi/ml)
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
JAN87
DEC87

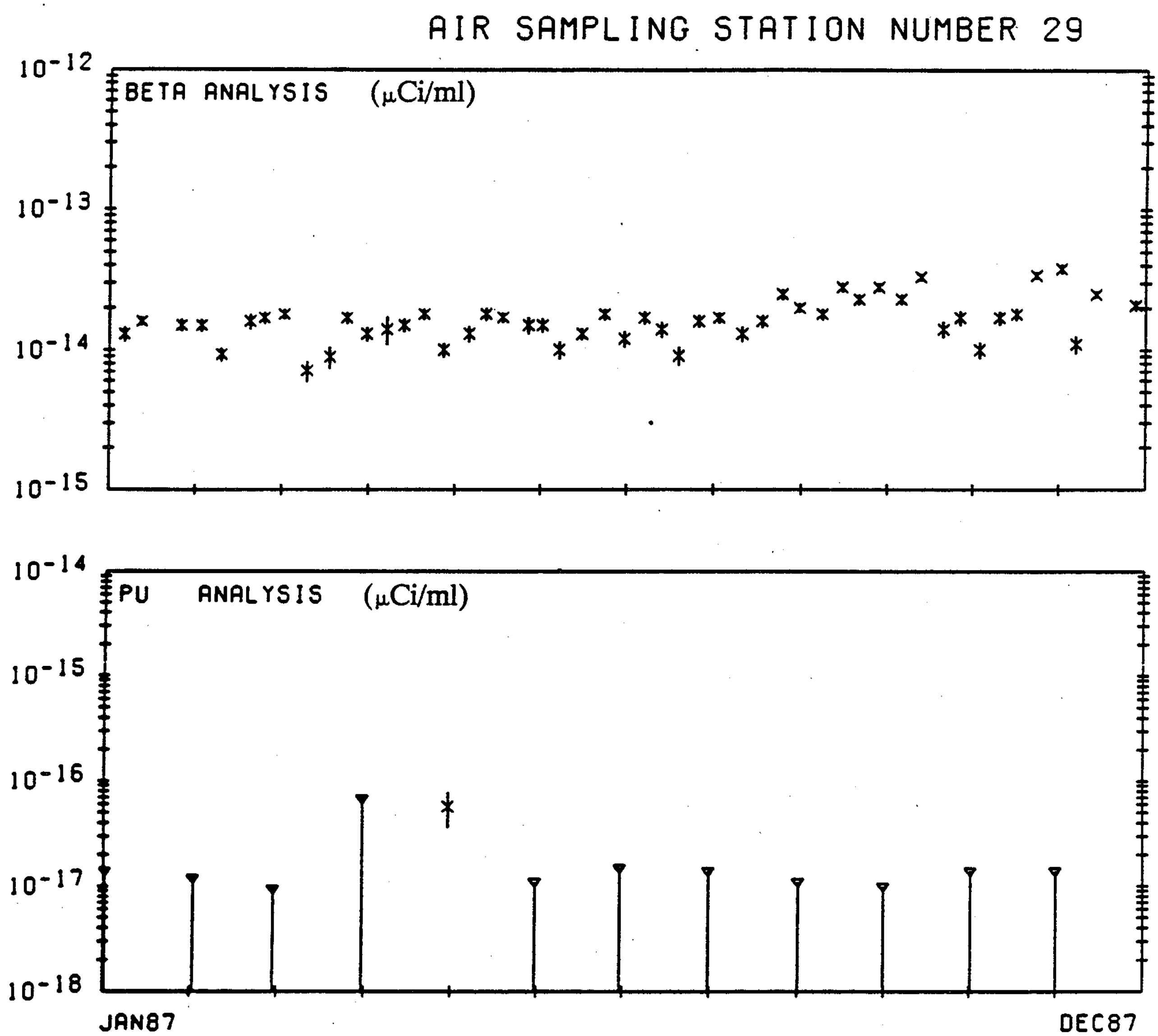

AIR SAMPLING STATION NUMBER 25
BETA ANALYSIS (μCi/ml)
10^{-12}
10^{-13}
10^{-14}
10^{-15}
PU ANALYSIS (μCi/ml)
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
JAN87
DEC87



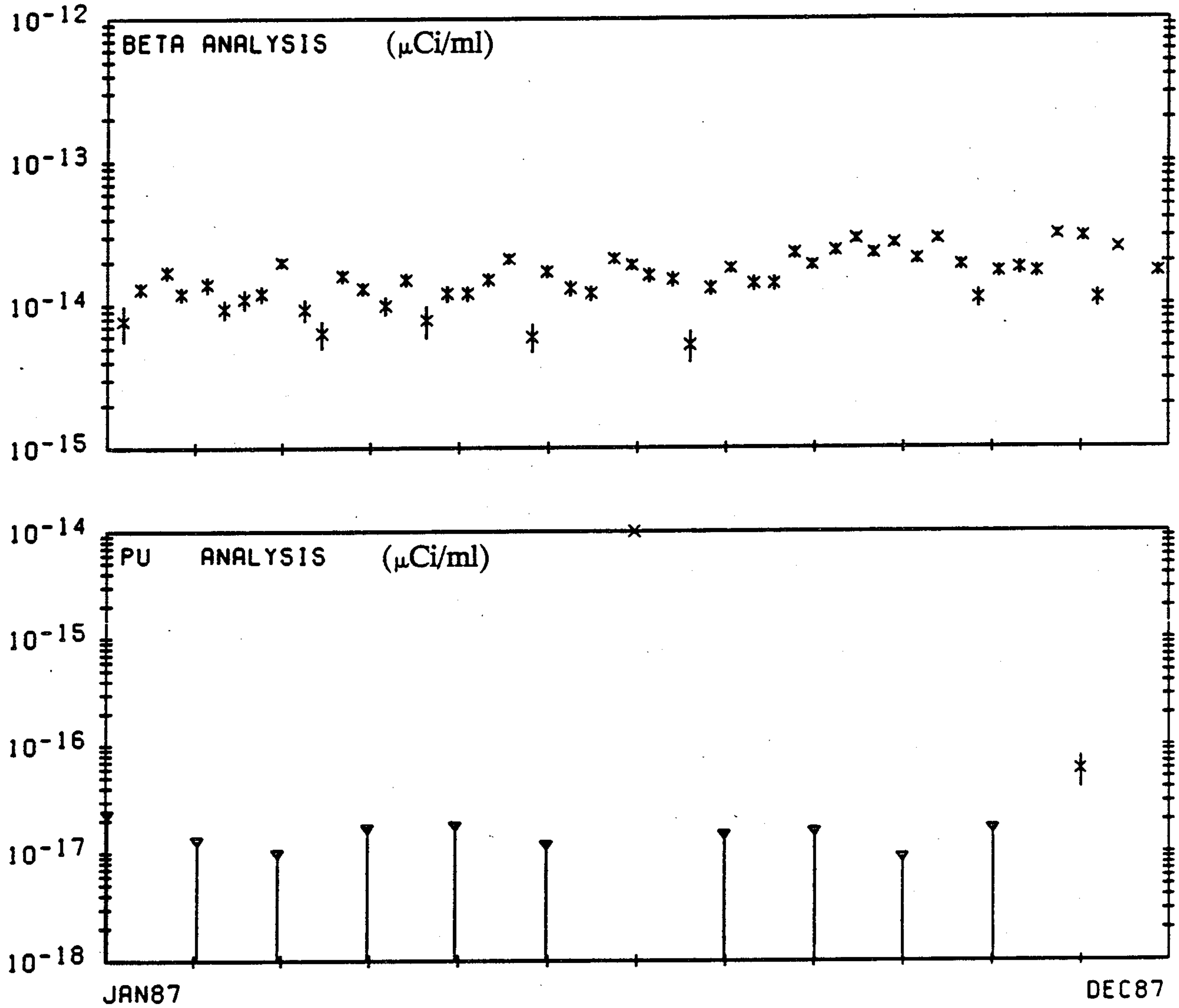
AIR SAMPLING STATION NUMBER 26
BETA ANALYSIS (μCi/ml)
PU ANALYSIS (μCi/ml)
10^-12
10^-13
10^-14
10^-15
10^-14
10^-15
10^-16
10^-17
10^-18
JAN87
DEC87

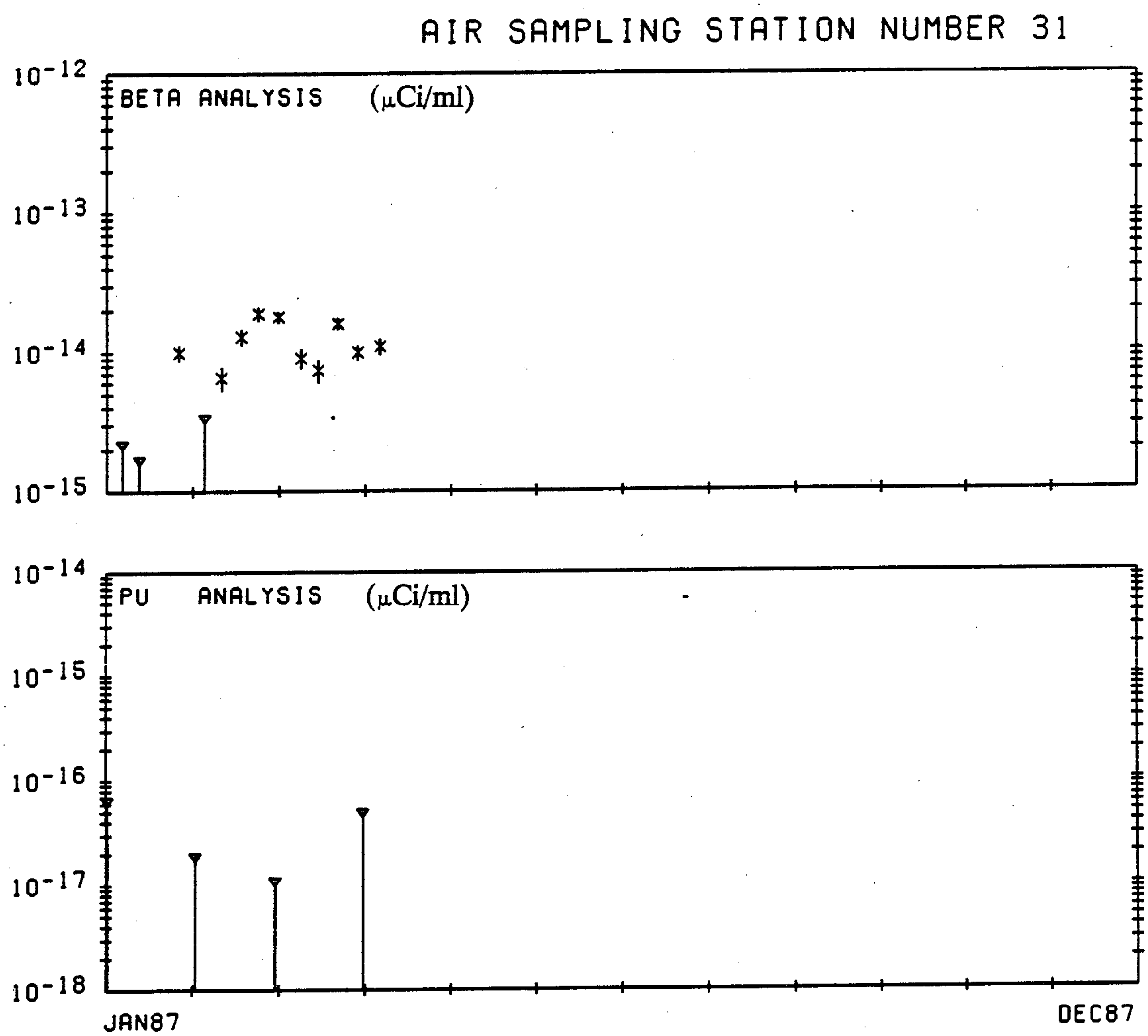

AIR SAMPLING STATION NUMBER 27
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87


AIR SAMPLING STATION NUMBER 28
BETA ANALYSIS (µCi/ml)
PU ANALYSIS (µCi/ml)
10-12
10-13
10-14
10-15
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

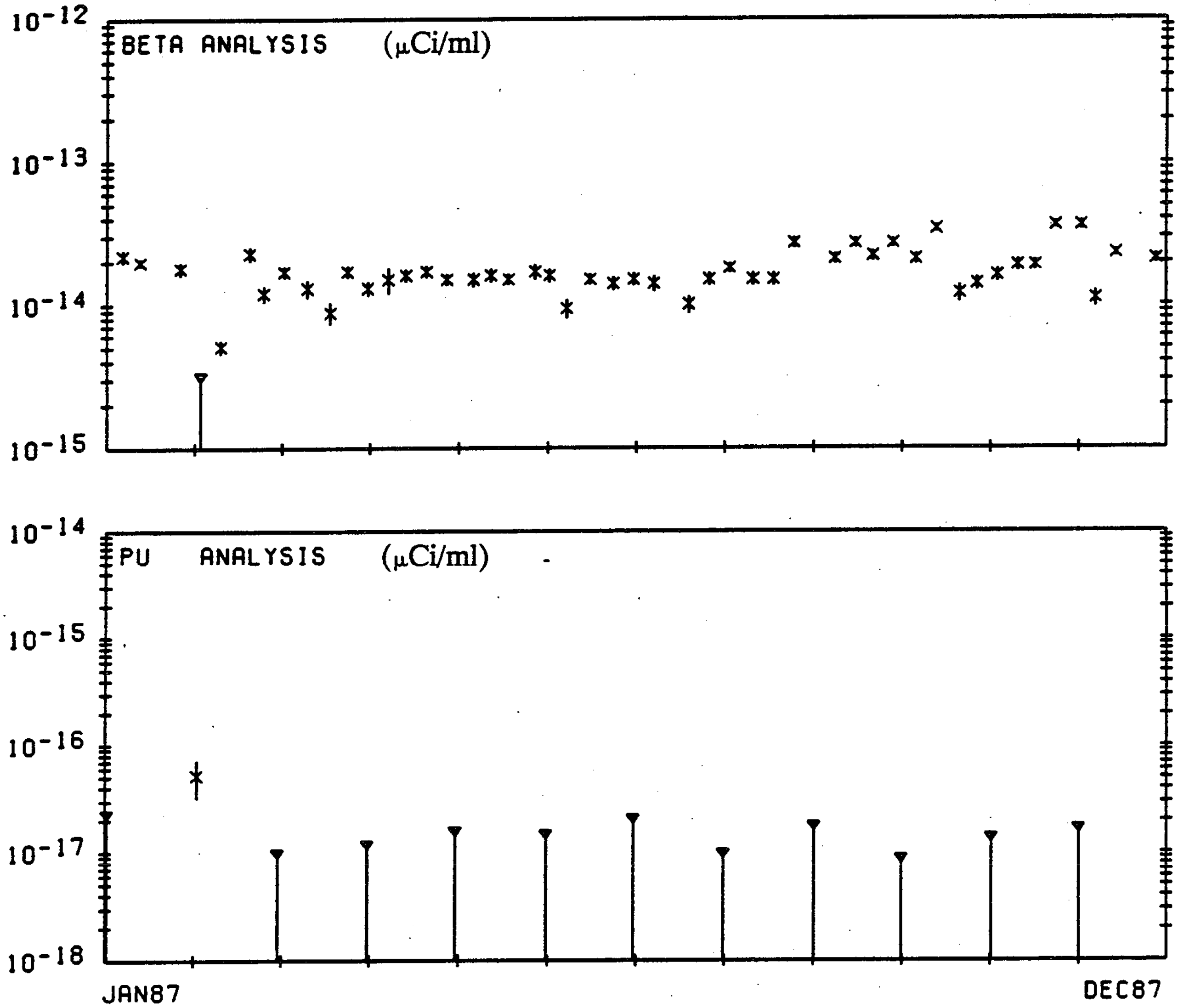

AIR SAMPLING STATION NUMBER 29
BETA ANALYSIS (µCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (µCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

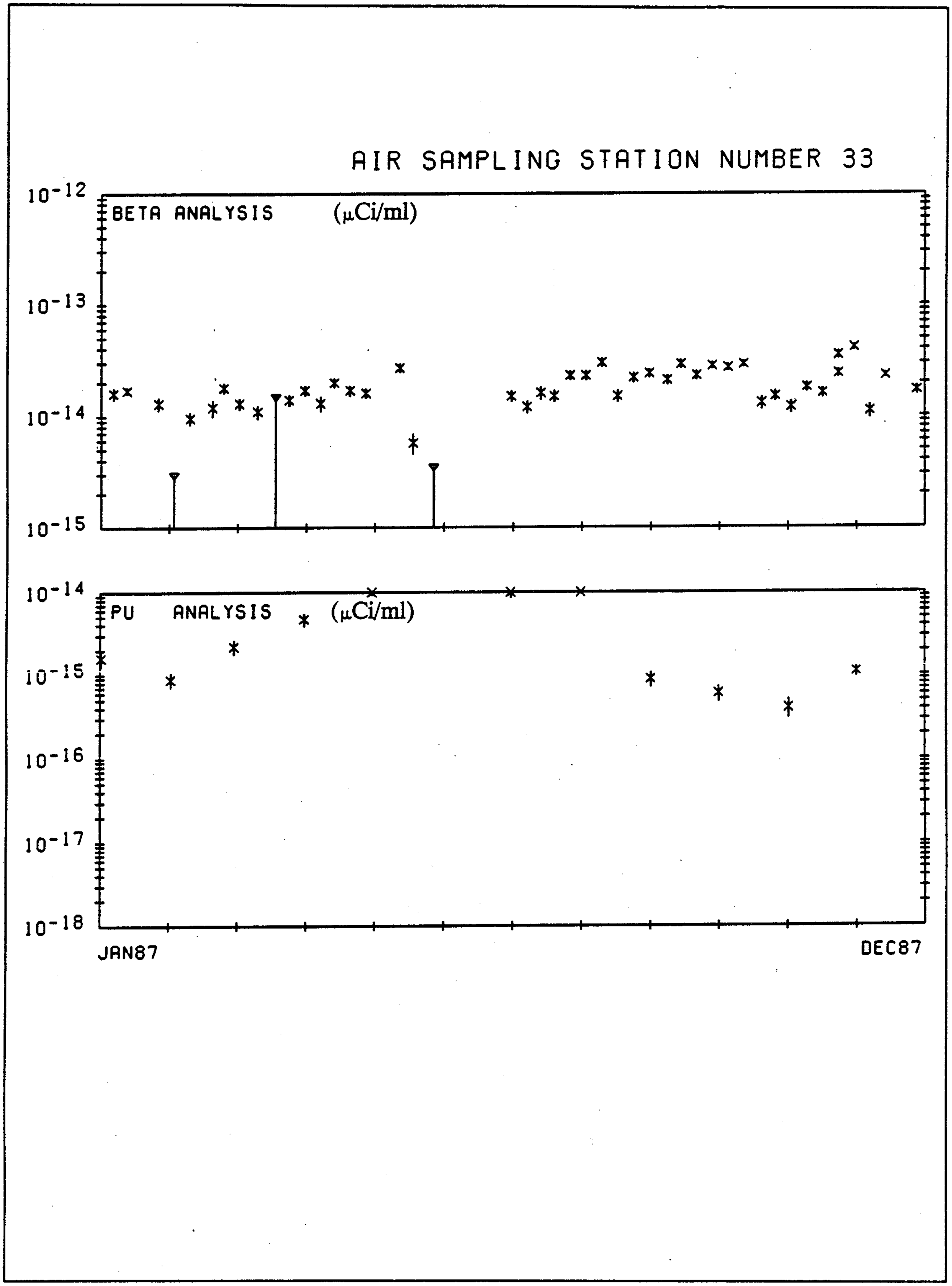
AIR SAMPLING STATION NUMBER 30

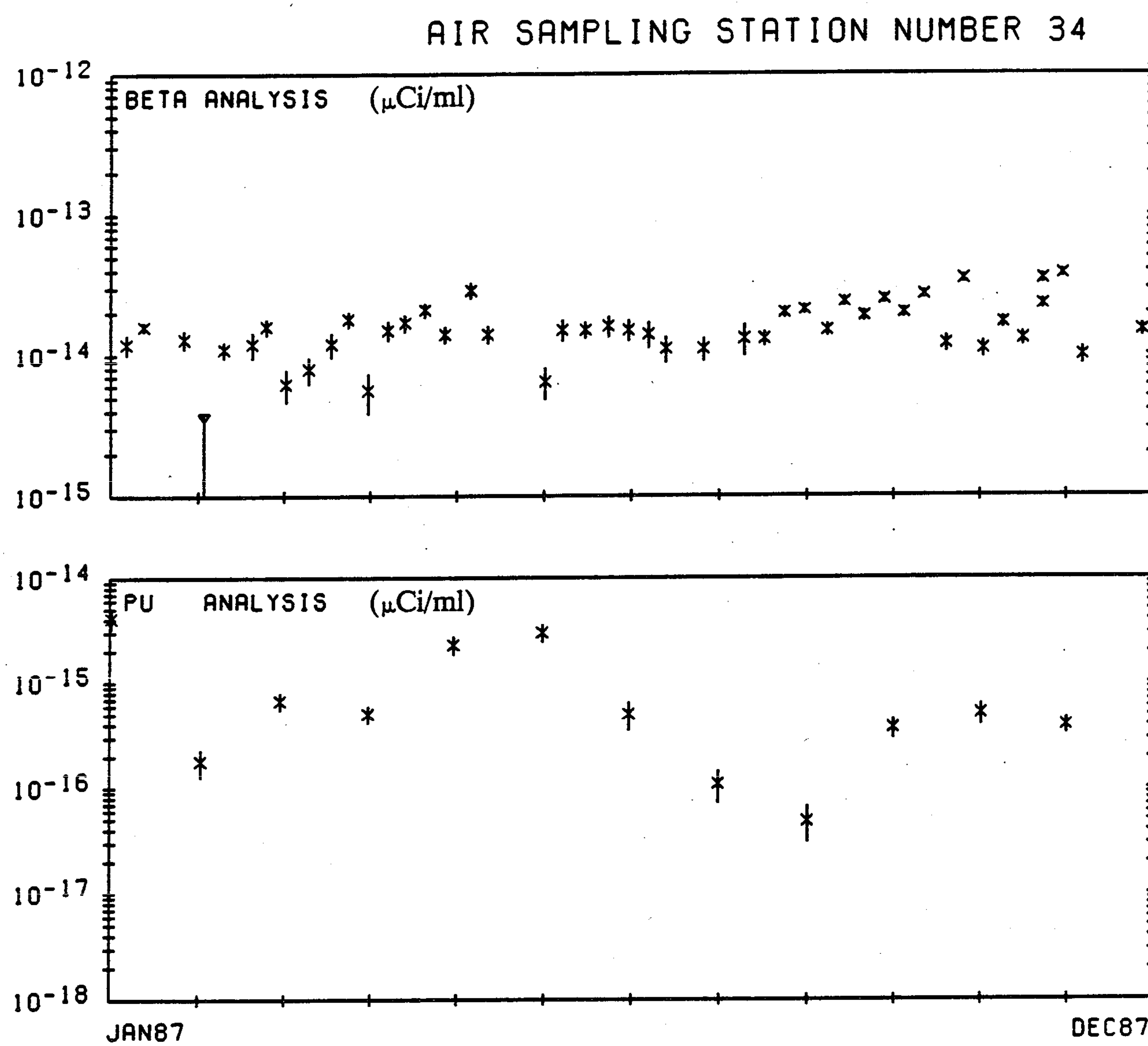


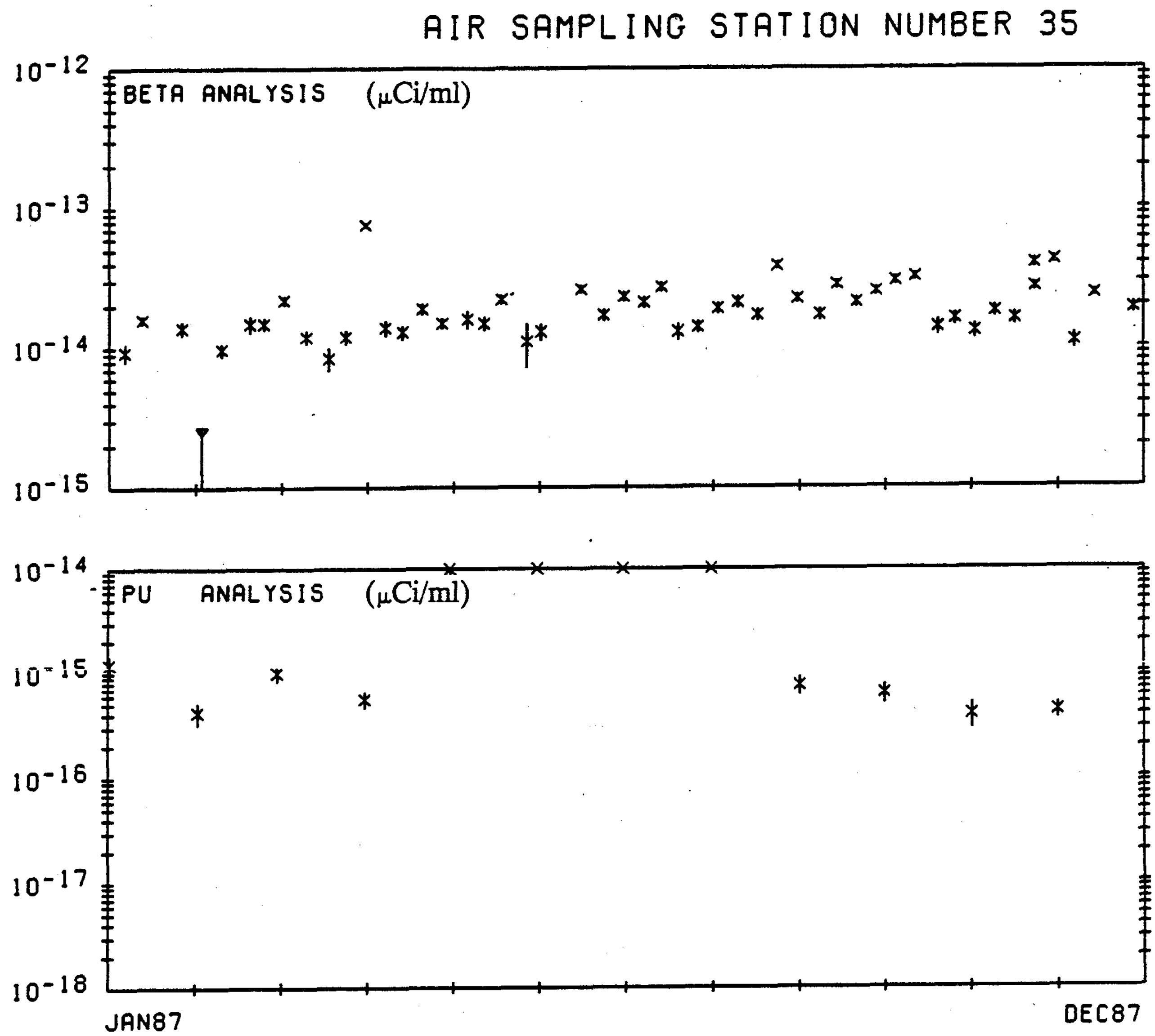

AIR SAMPLING STATION NUMBER 31
10-12
10-13
10-14
10-15
BETA ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
PU ANALYSIS (μCi/ml)
JAN87
DEC87

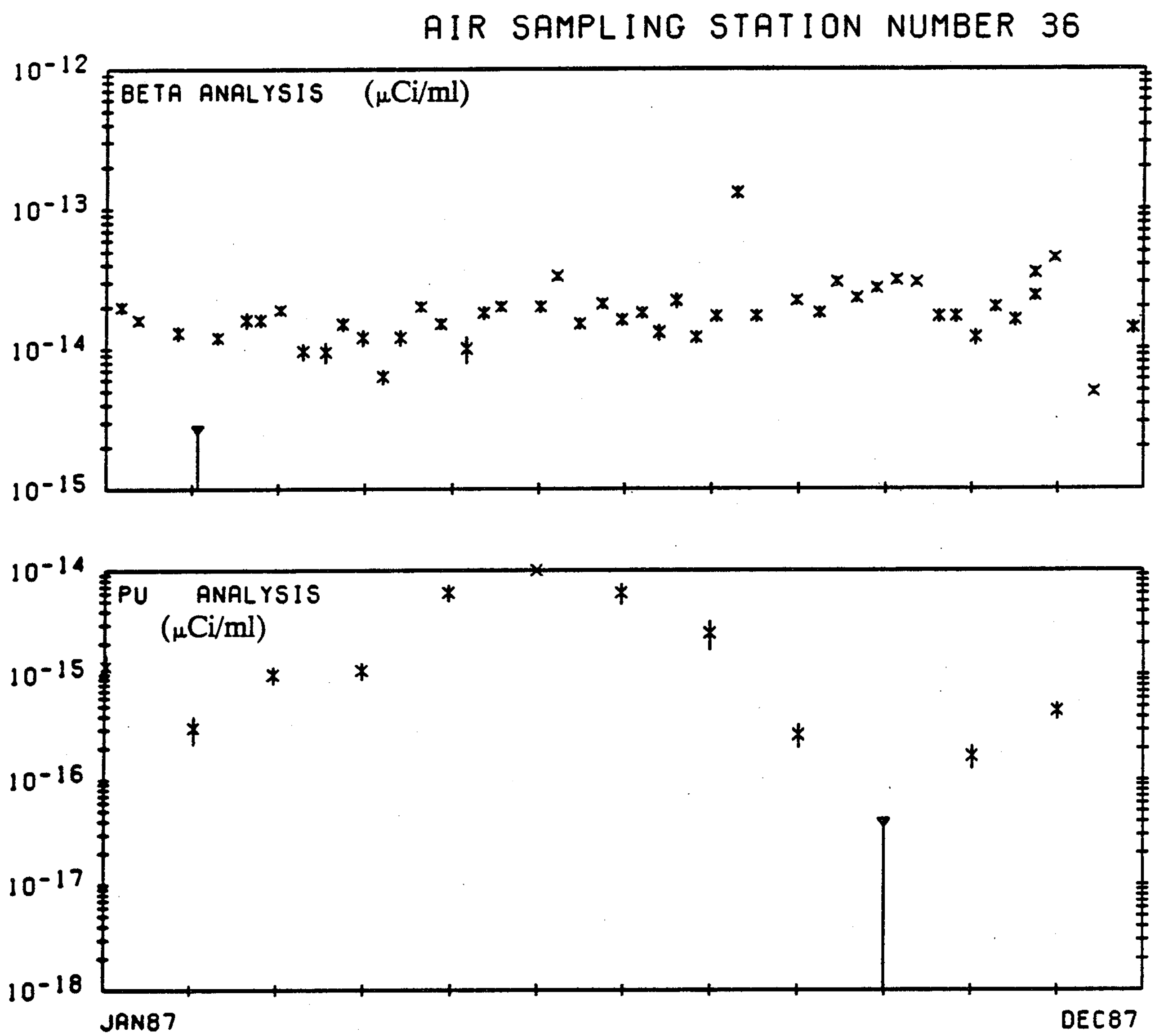
AIR SAMPLING STATION NUMBER 32

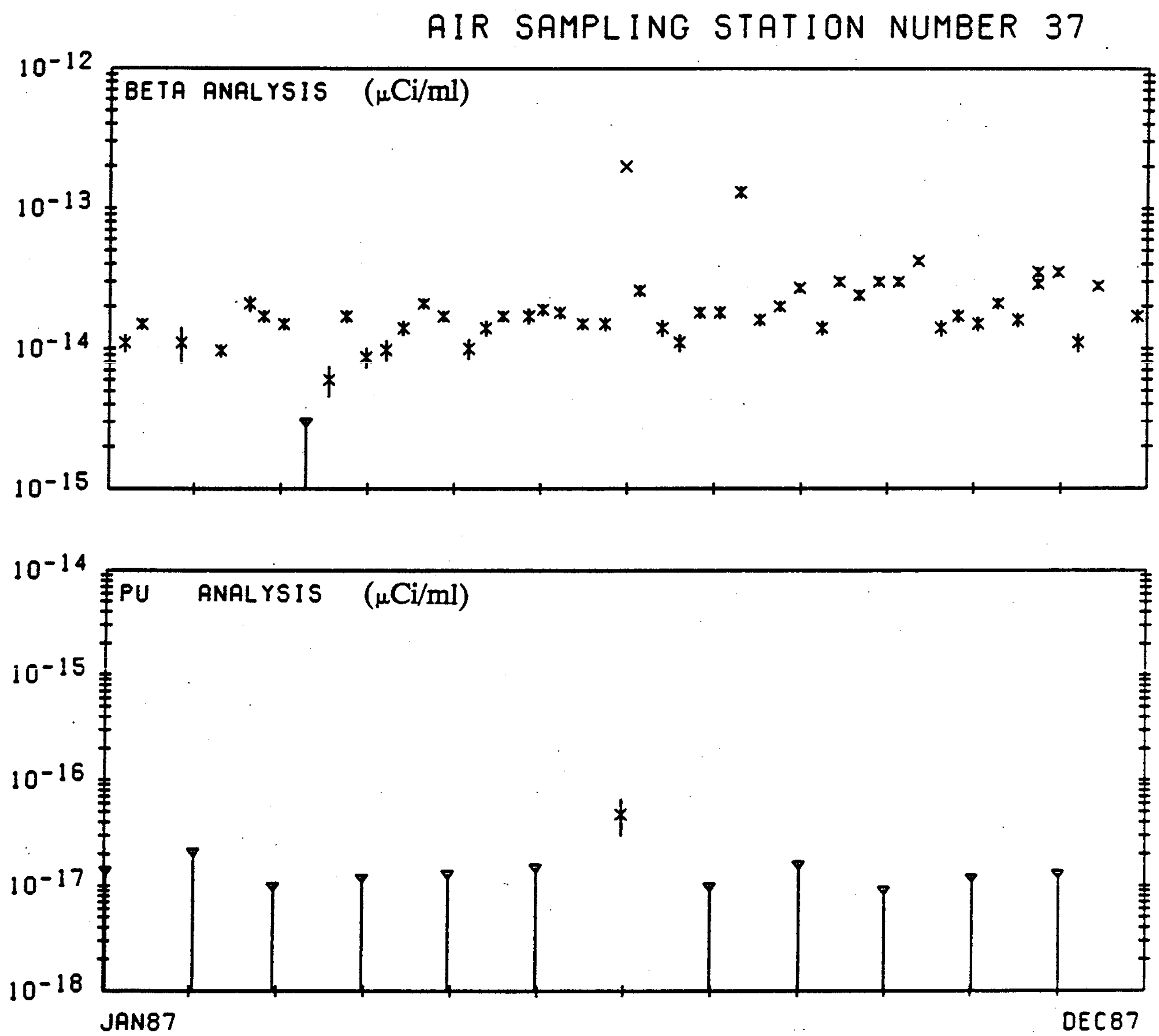


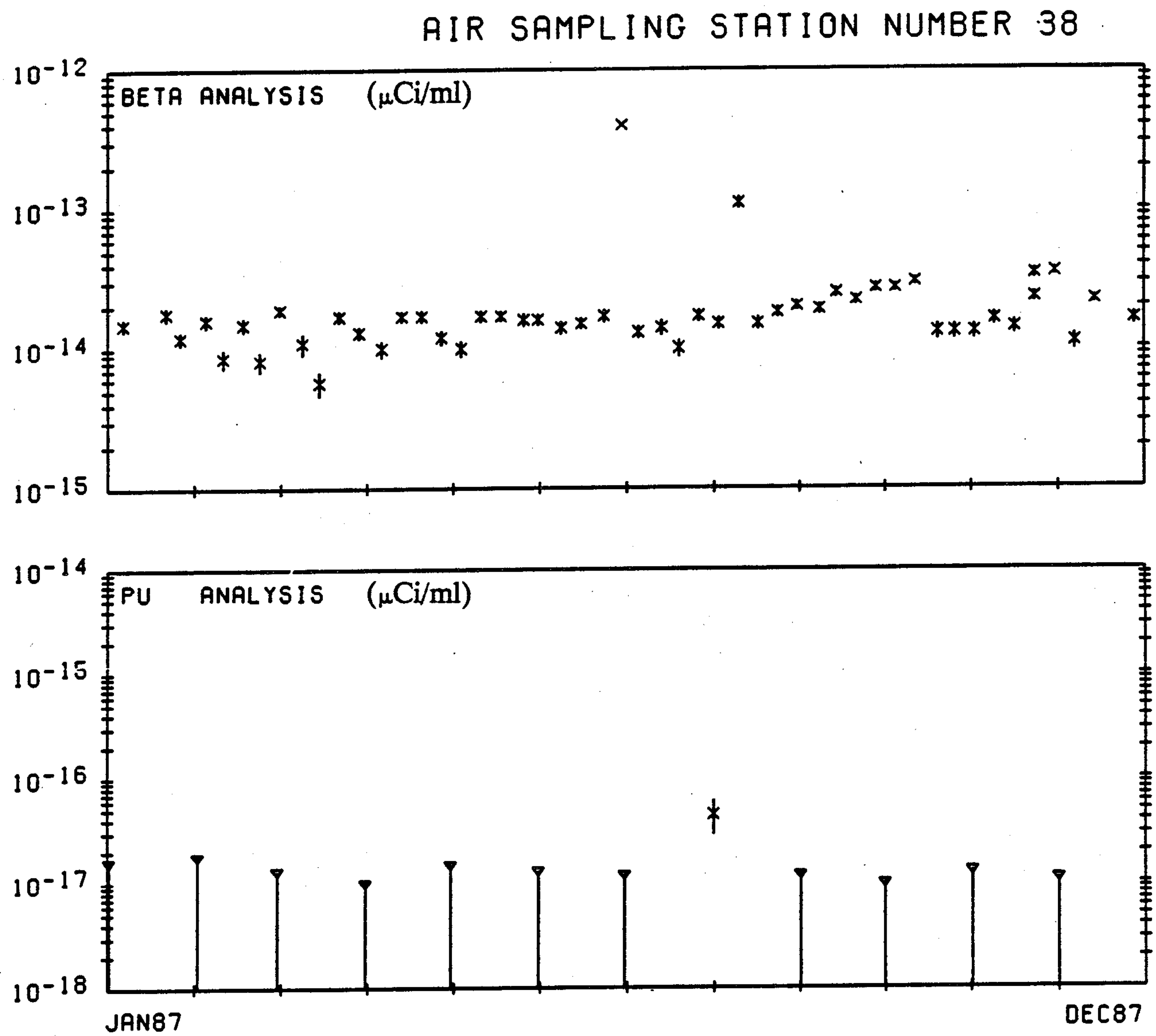

AIR SAMPLING STATION NUMBER 33
BETA ANALYSIS (μCi/ml)
PU ANALYSIS (μCi/ml)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
JAN87
DEC87

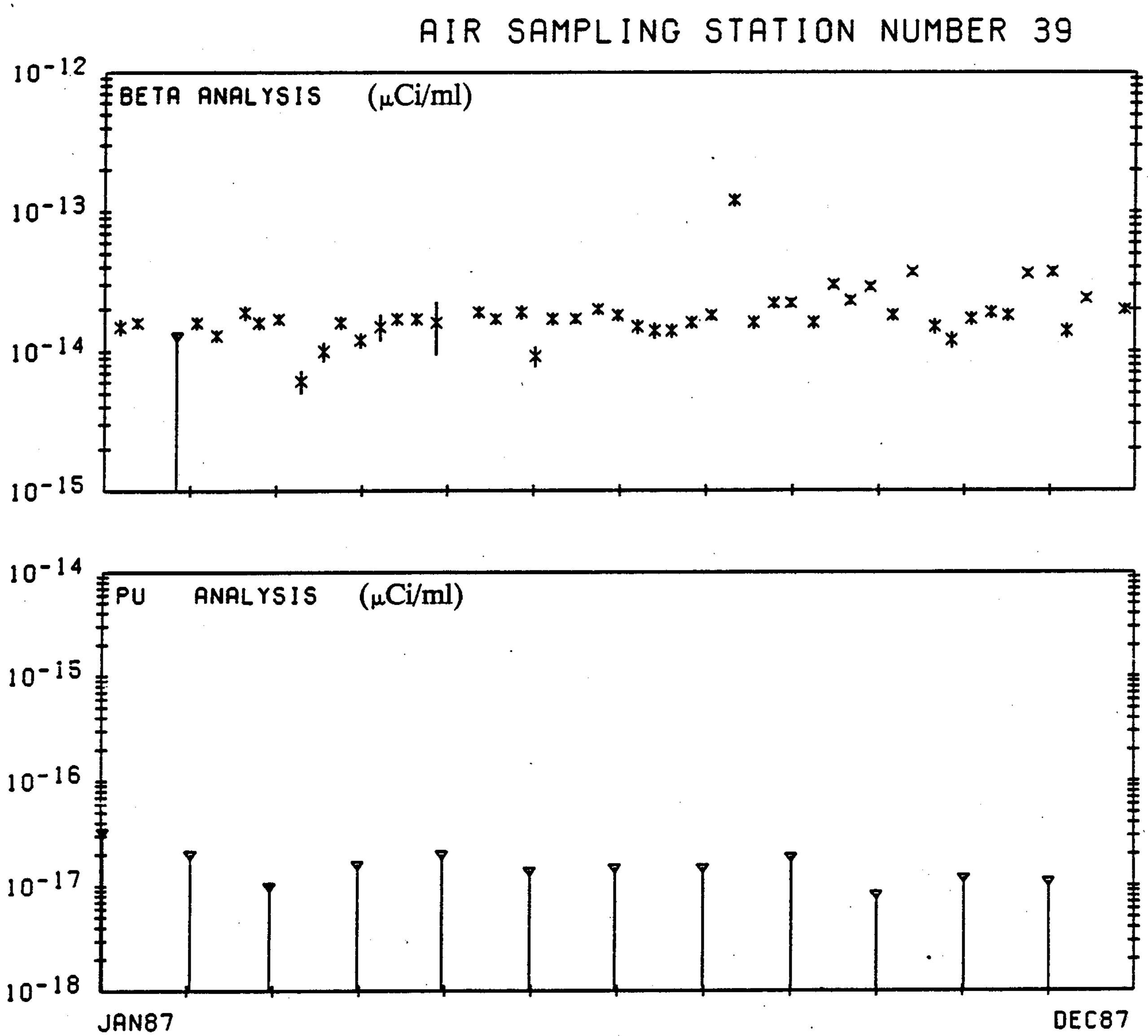

AIR SAMPLING STATION NUMBER 34
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

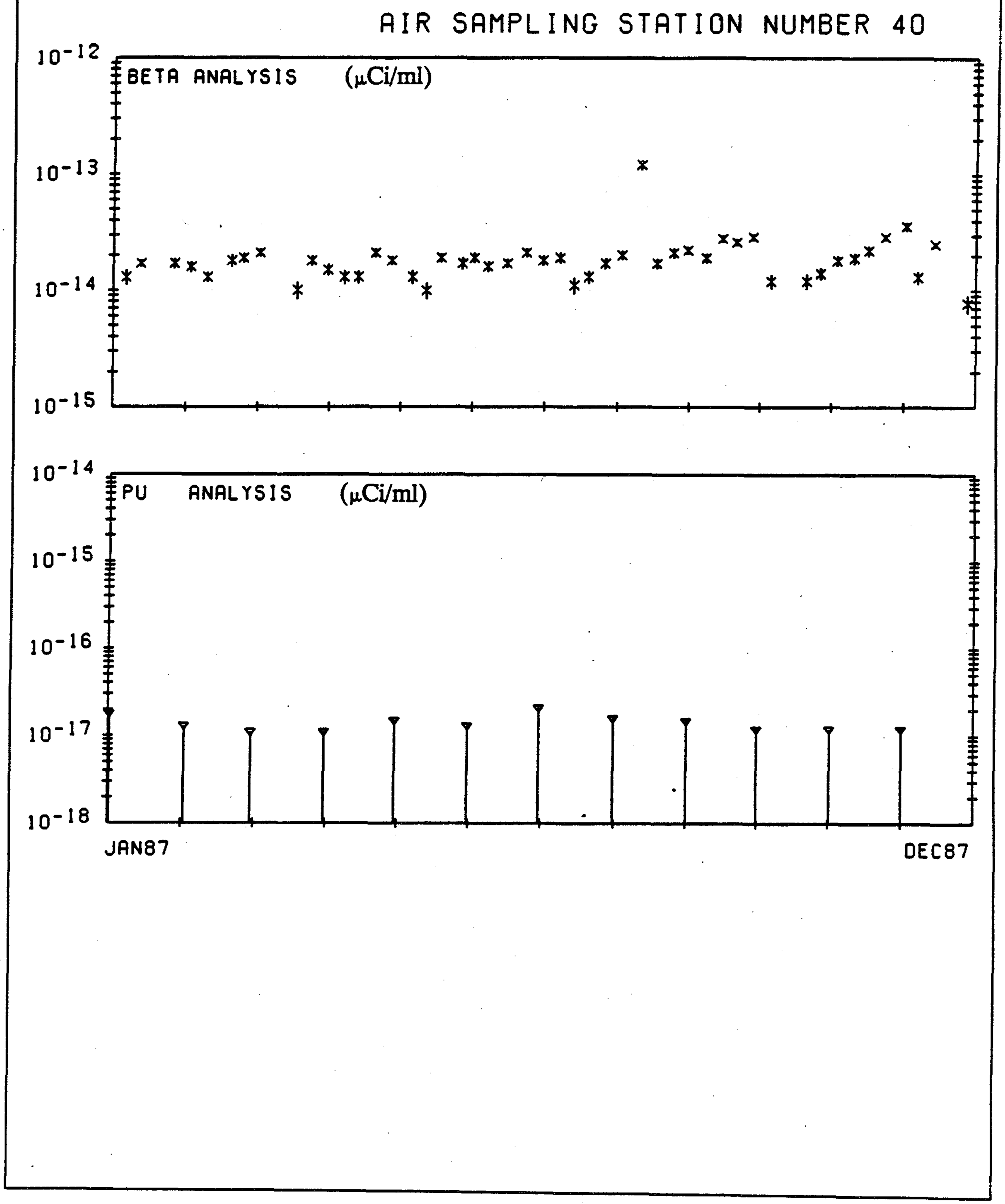

AIR SAMPLING STATION NUMBER 35
BETA ANALYSIS (µCi/ml)
PU ANALYSIS (µCi/ml)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
JAN87
DEC87

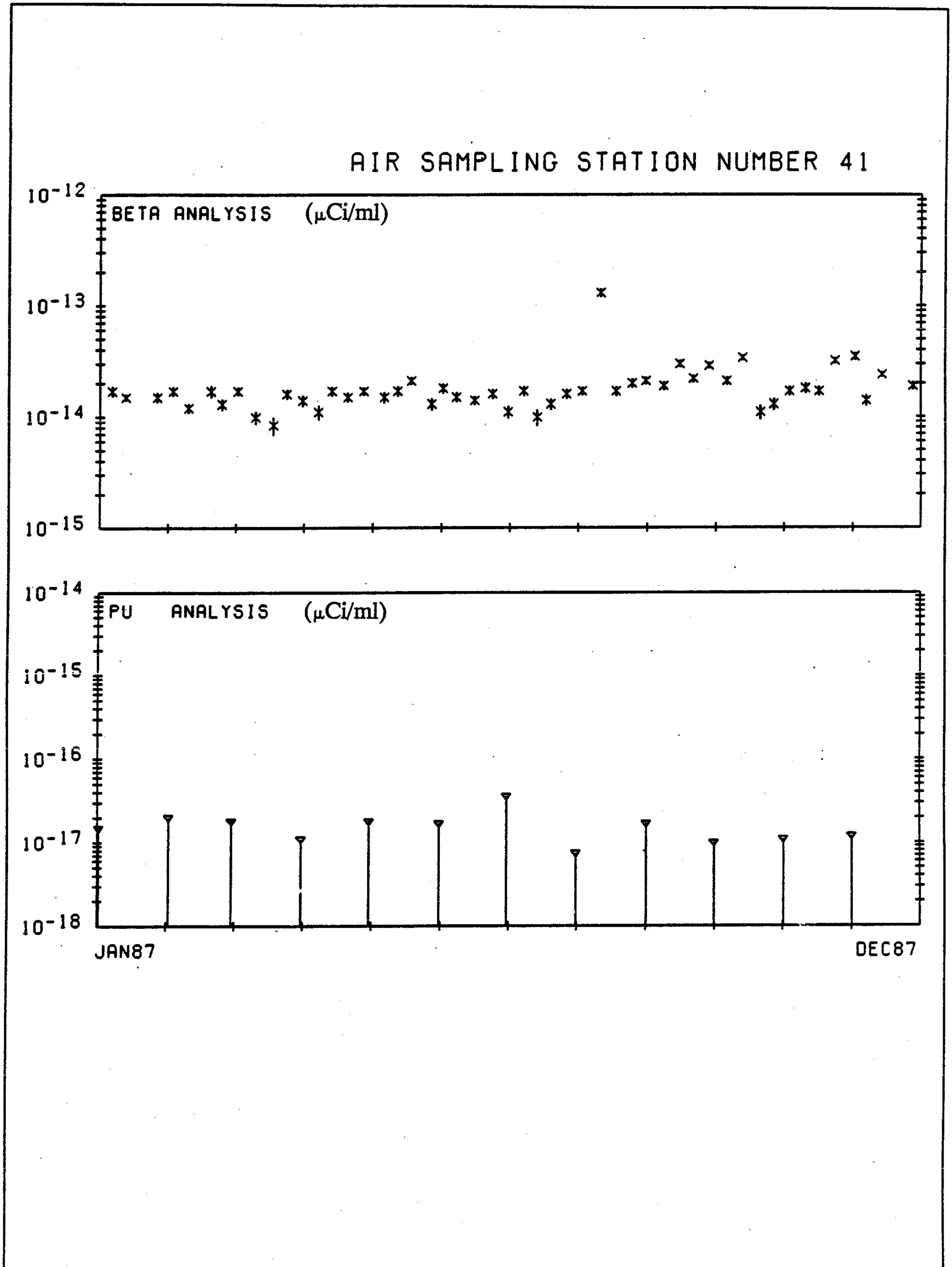

AIR SAMPLING STATION NUMBER 36
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
BETA ANALYSIS (μCi/ml)
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
PU ANALYSIS
(μCi/ml)
JAN87
DEC87

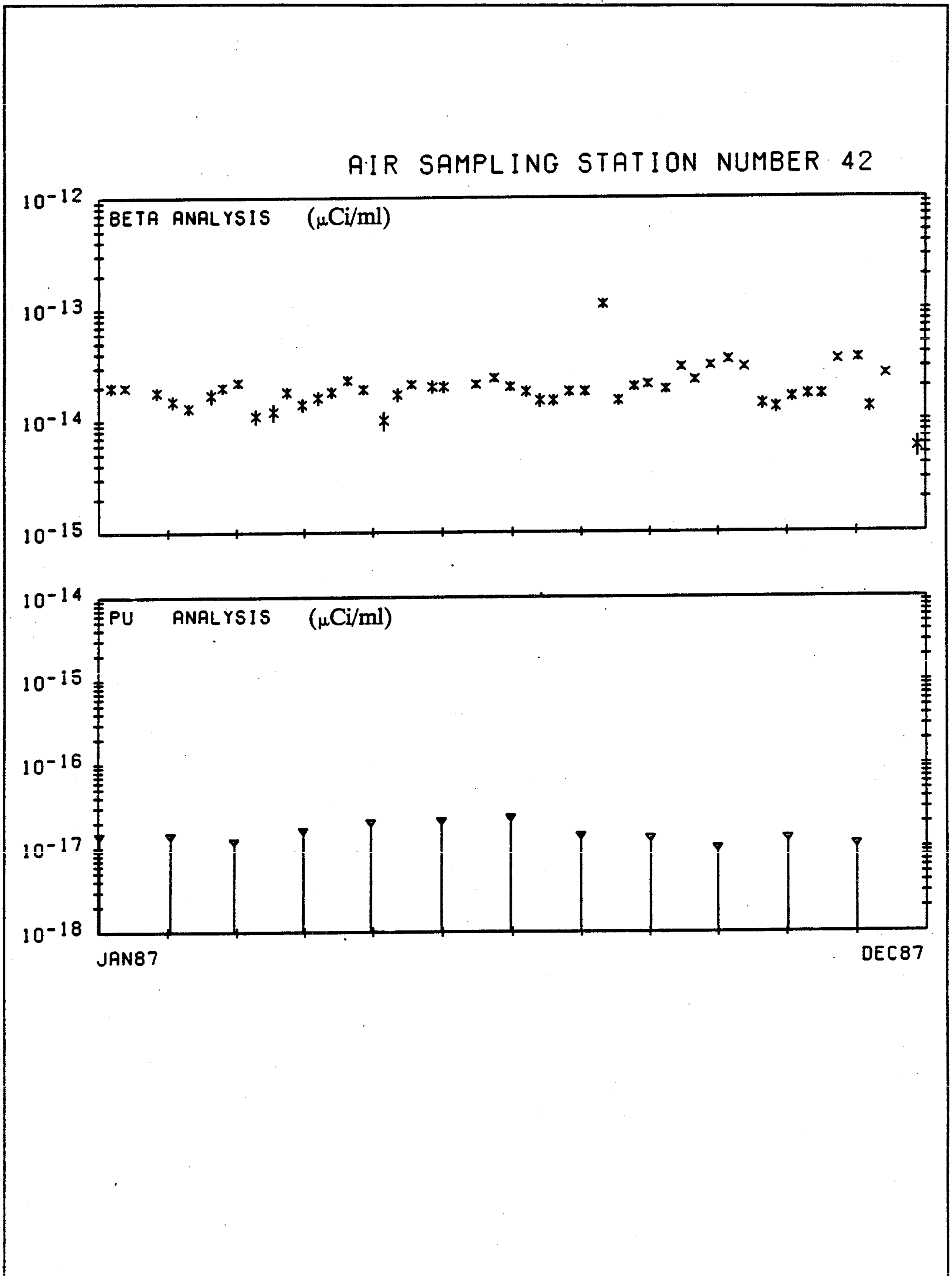

AIR SAMPLING STATION NUMBER 37
BETA ANALYSIS (µCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (µCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87


AIR SAMPLING STATION NUMBER 38
BETA ANALYSIS (μCi/ml)
PU ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

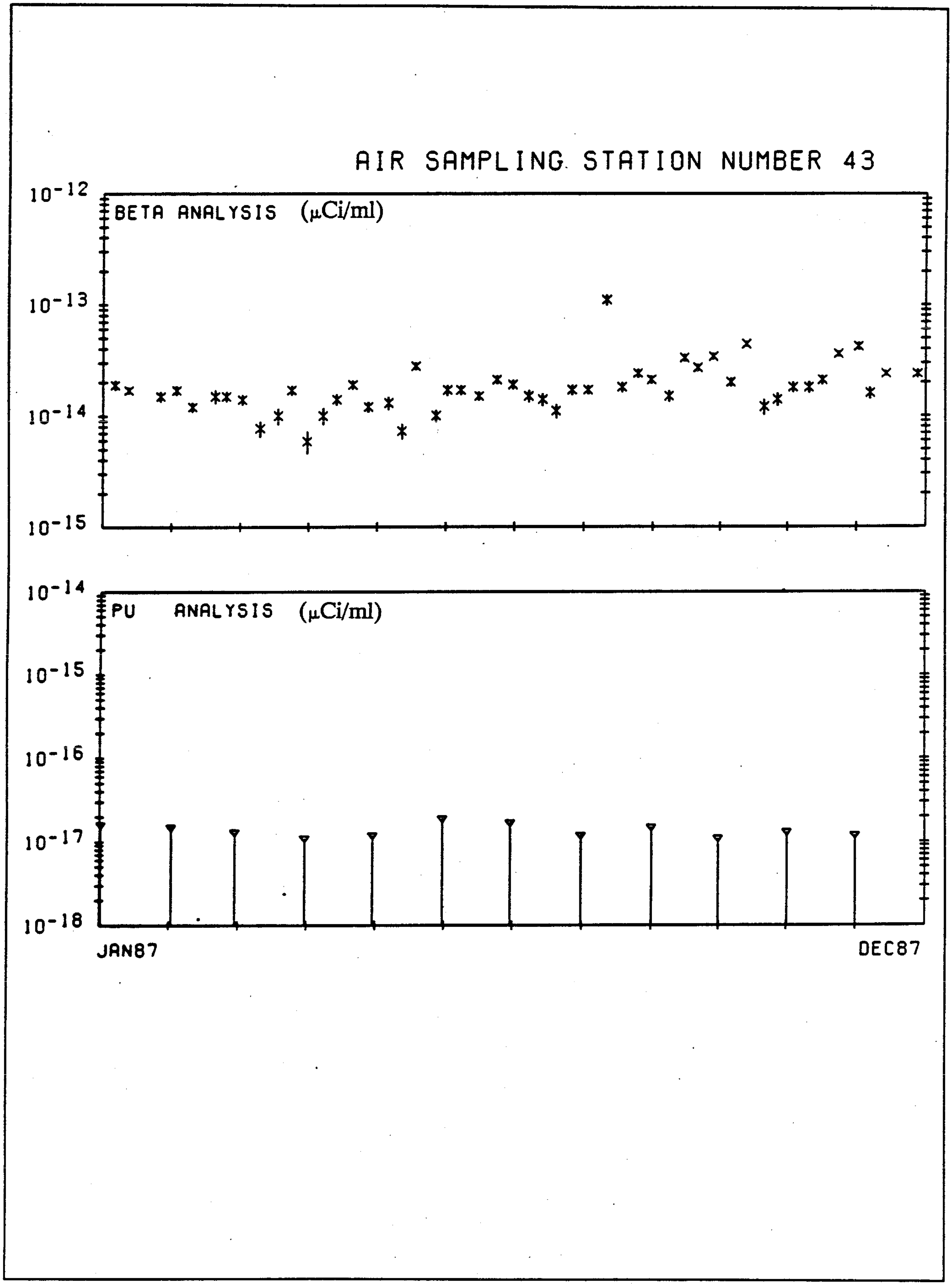

AIR SAMPLING STATION NUMBER 39
BETA ANALYSIS (µCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (µCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

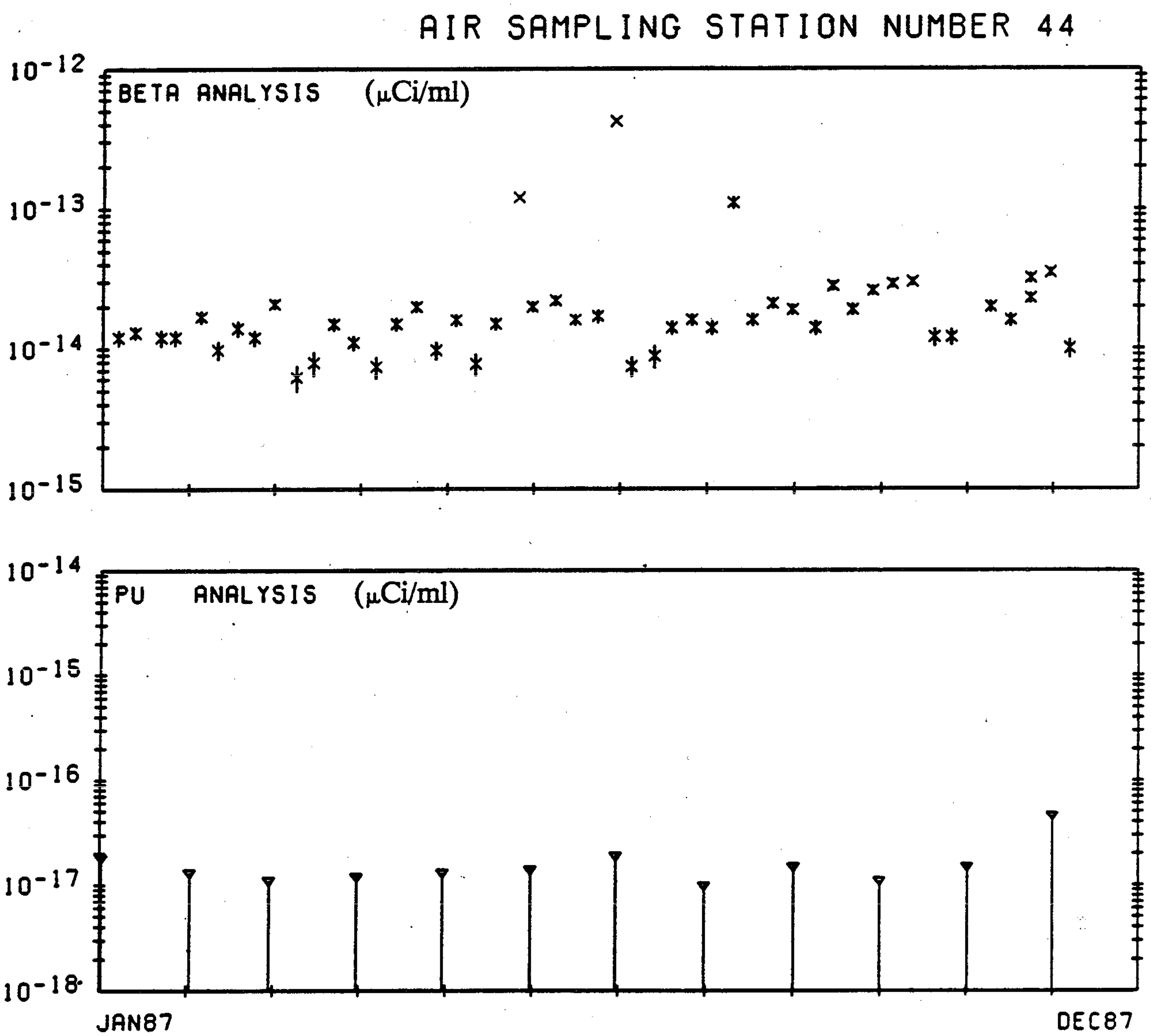

AIR SAMPLING STATION NUMBER 40
BETA ANALYSIS (µCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (µCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

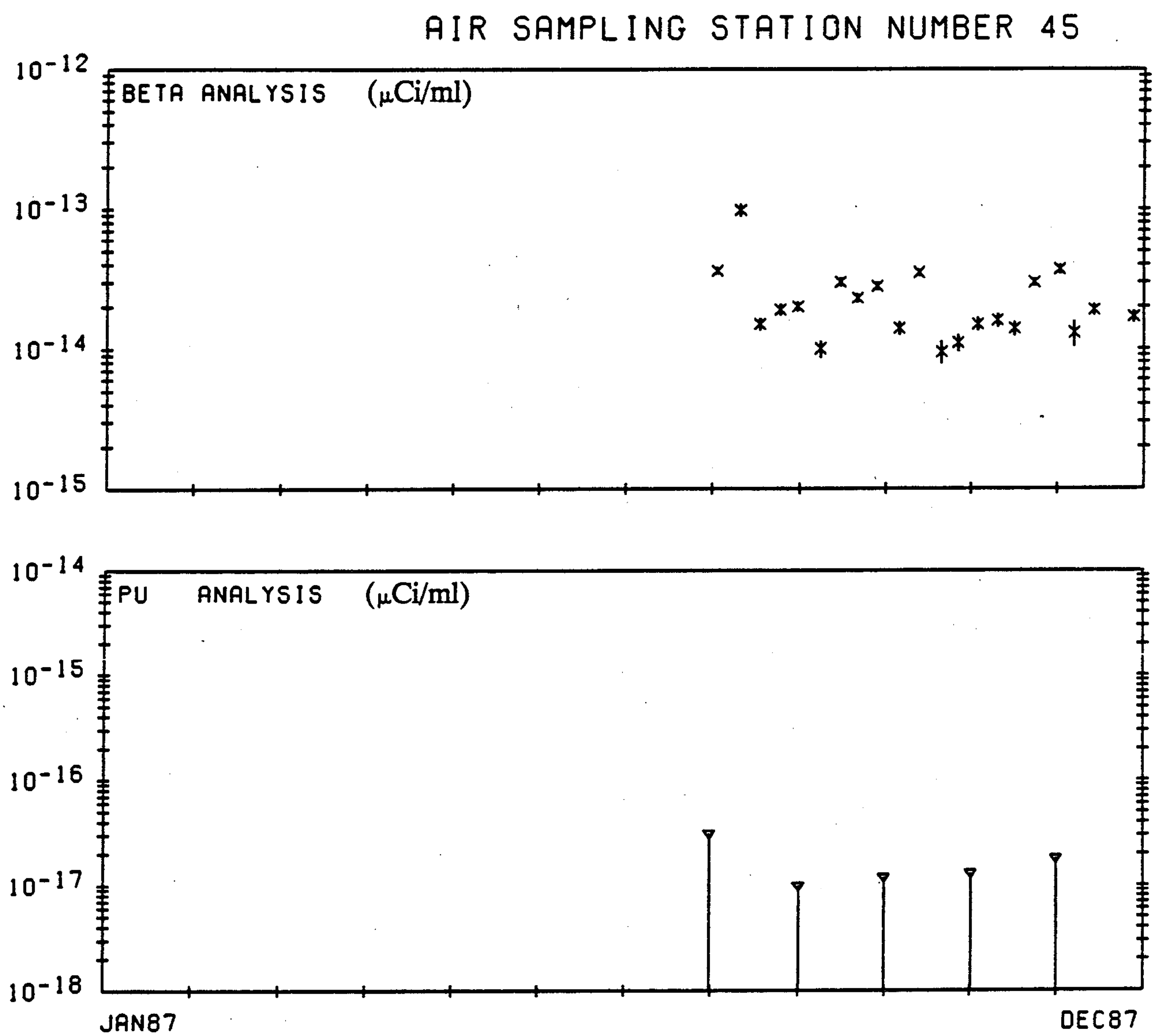

AIR SAMPLING STATION NUMBER 41
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87



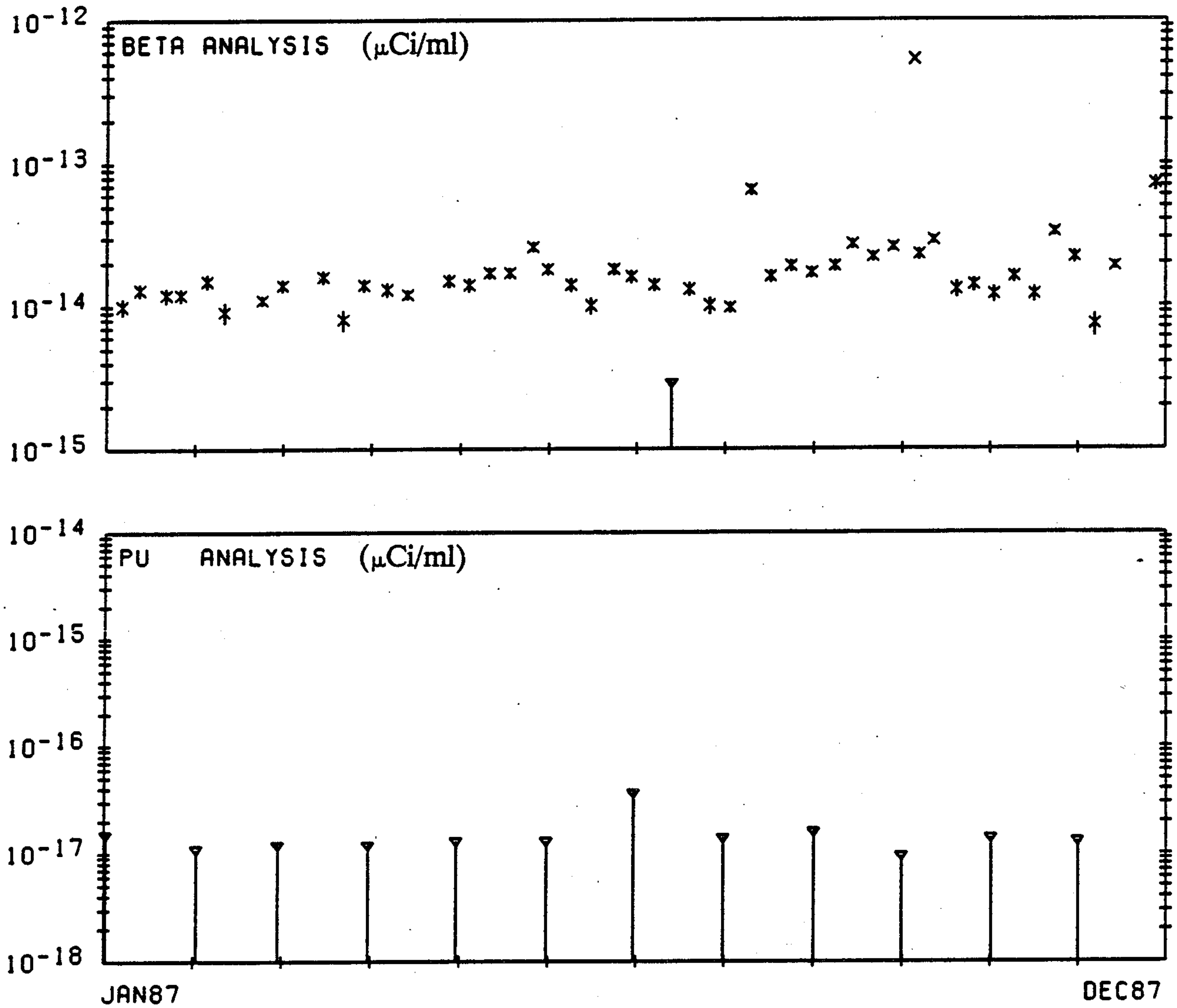
AIR SAMPLING STATION NUMBER 42
BETA ANALYSIS (μCi/ml)
PU ANALYSIS (μCi/ml)
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{-14}
10^{-15}
10^{-16}
10^{-17}
10^{-18}
JAN87
DEC87

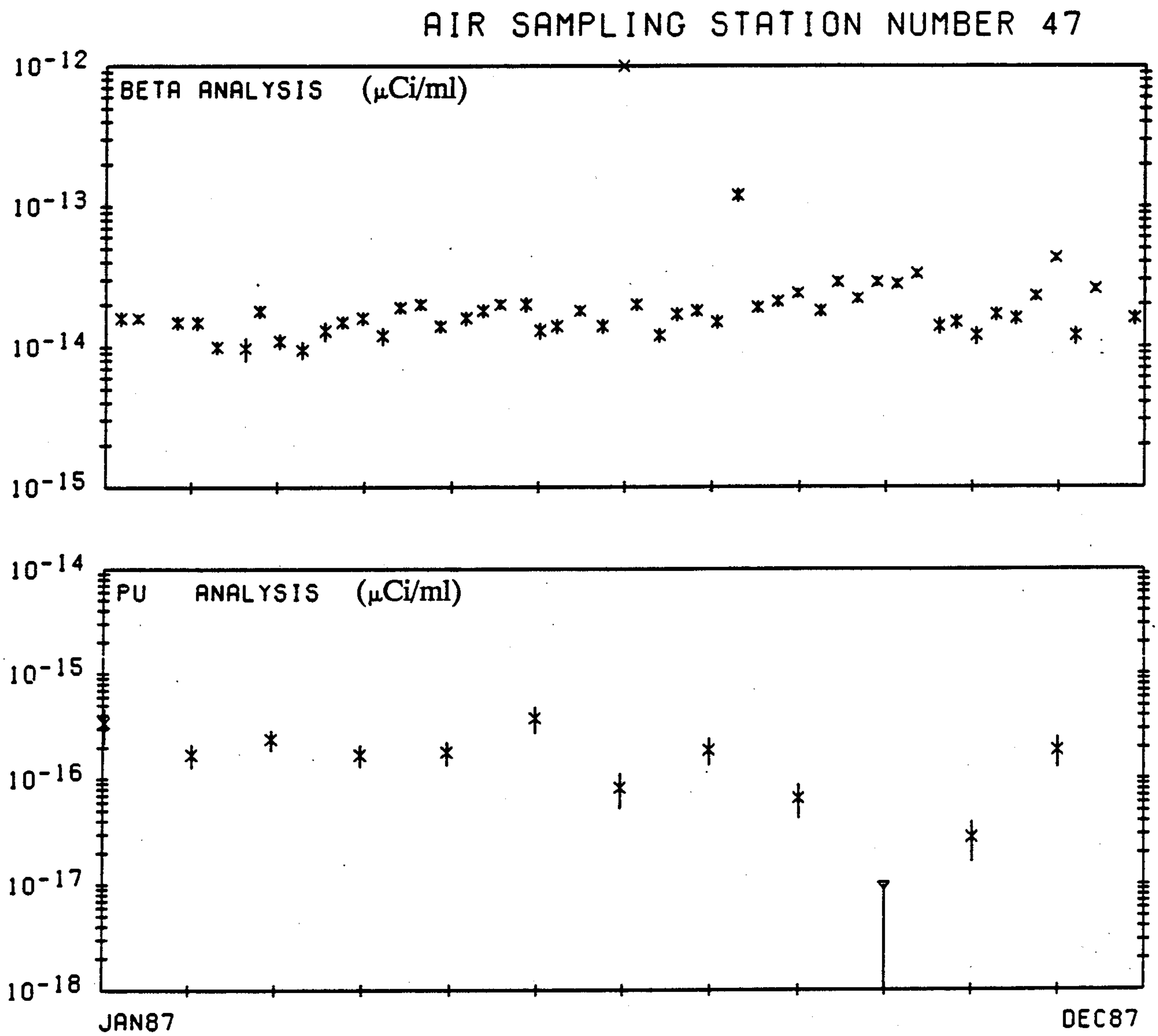

AIR SAMPLING STATION NUMBER 43
BETA ANALYSIS (µCi/ml)
10⁻¹²
10⁻¹³
10⁻¹⁴
10⁻¹⁵
PU ANALYSIS (µCi/ml)
10⁻¹⁴
10⁻¹⁵
10⁻¹⁶
10⁻¹⁷
10⁻¹⁸
JAN87
DEC87

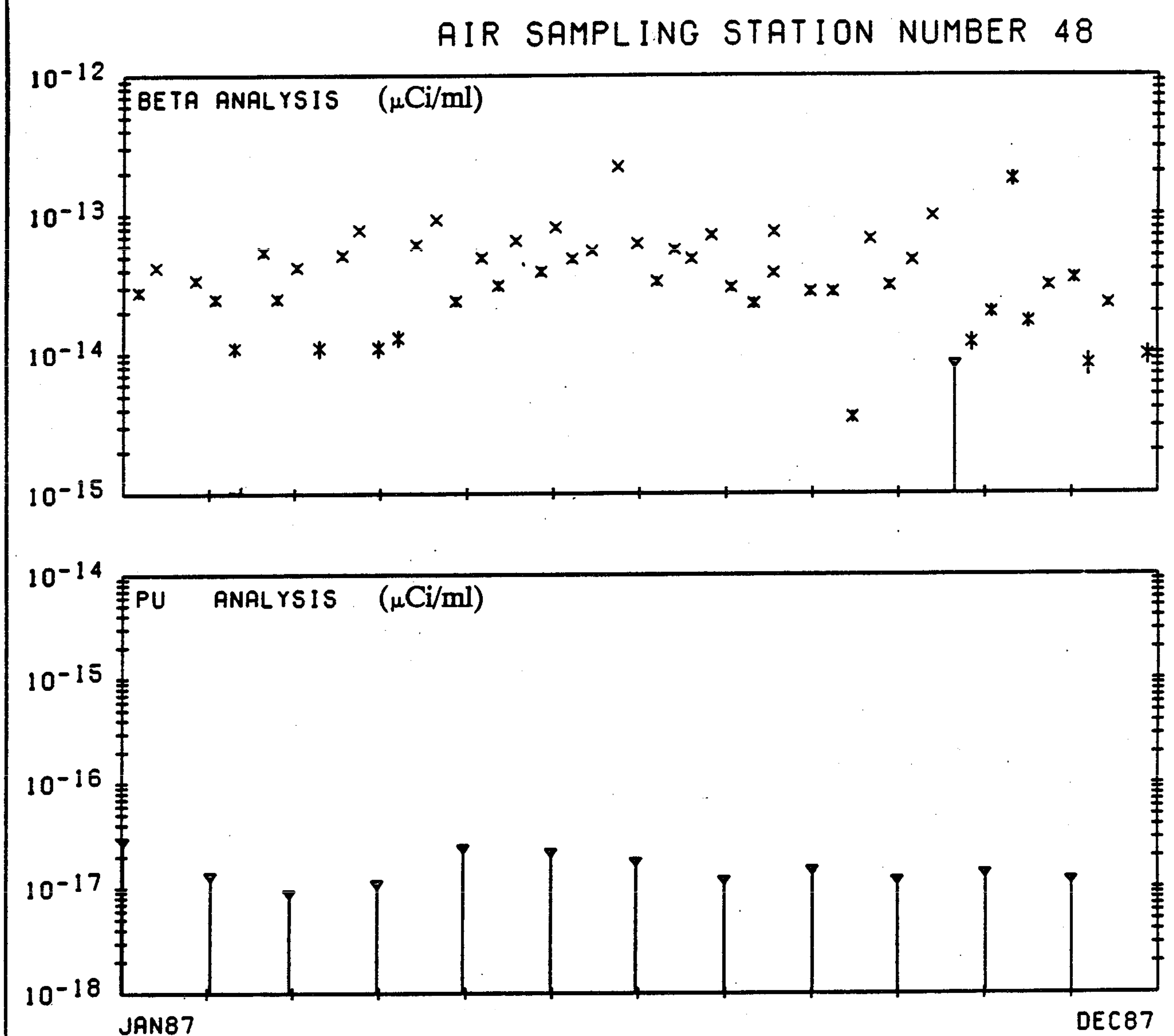

AIR SAMPLING STATION NUMBER 44
BETA ANALYSIS (µCi/ml)
PU ANALYSIS (µCi/ml)
10^-12
10^-13
10^-14
10^-15
10^-14
10^-15
10^-16
10^-17
10^-18
JAN87
DEC87


AIR SAMPLING STATION NUMBER 45
BETA ANALYSIS (µCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (µCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

AIR SAMPLING STATION NUMBER 46




AIR SAMPLING STATION NUMBER 47
BETA ANALYSIS (μCi/ml)
10^-12
10^-13
10^-14
10^-15
PU ANALYSIS (μCi/ml)
10^-14
10^-15
10^-16
10^-17
10^-18
JAN87
DEC87


AIR SAMPLING STATION NUMBER 48
BETA ANALYSIS (μCi/ml)
10-12
10-13
10-14
10-15
PU ANALYSIS (μCi/ml)
10-14
10-15
10-16
10-17
10-18
JAN87
DEC87

APPENDIX B

NTS Environmental Monitoring

Tritium in Air Sampling Stations and Plots

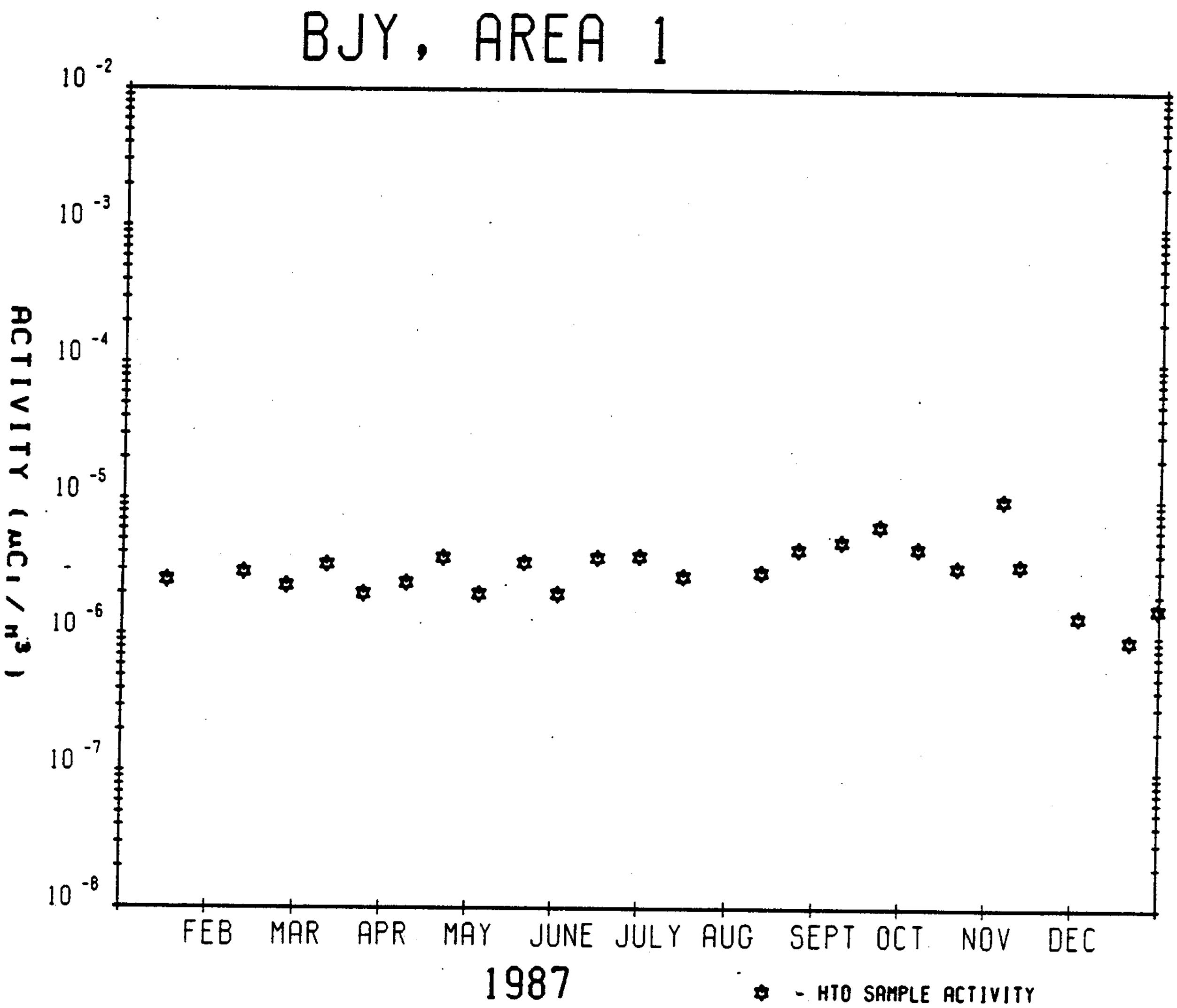
SYMBOLS

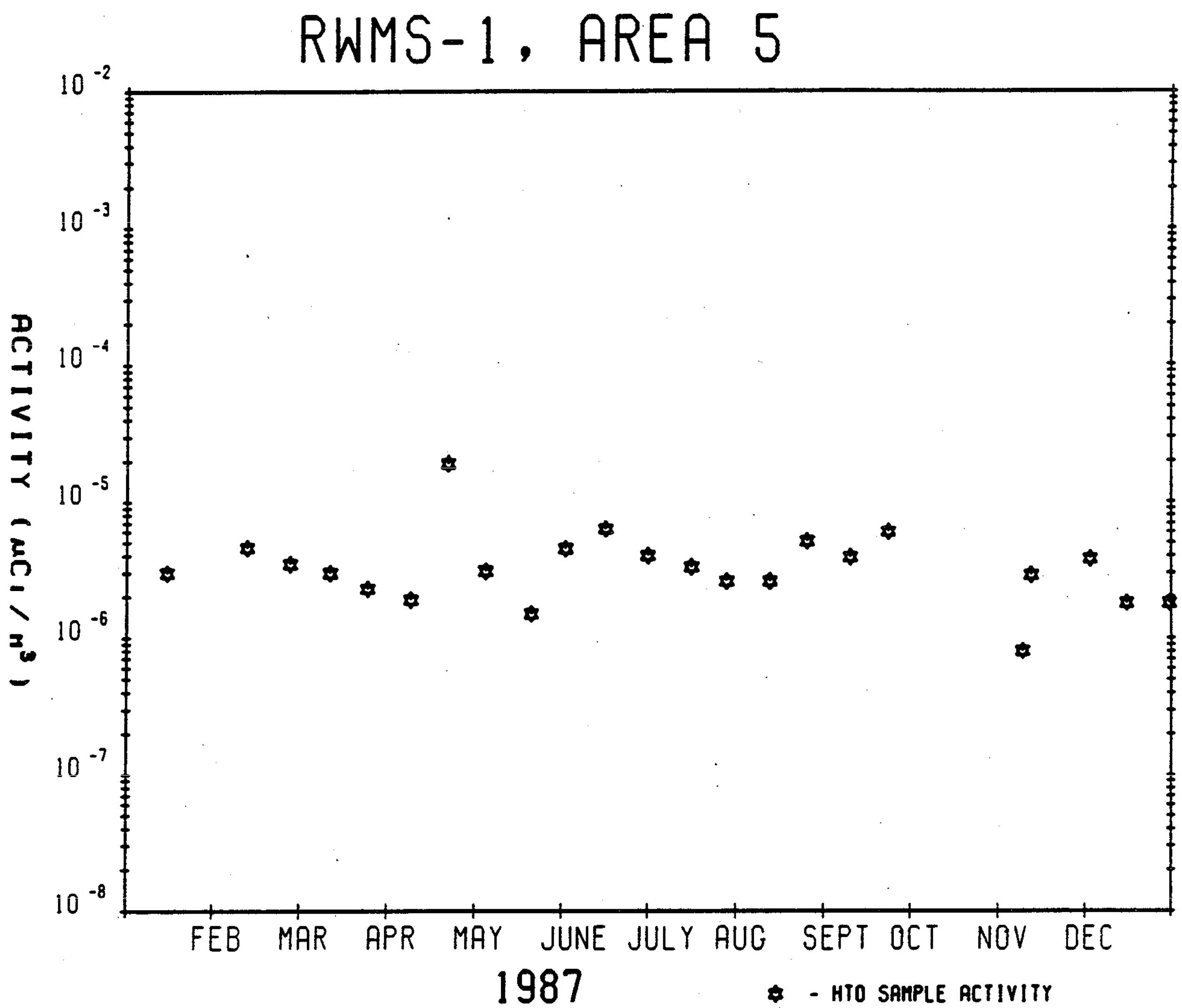
The tritium in air data for each station is plotted in Appendix B for the entire year.

NTS Environmental Monitoring

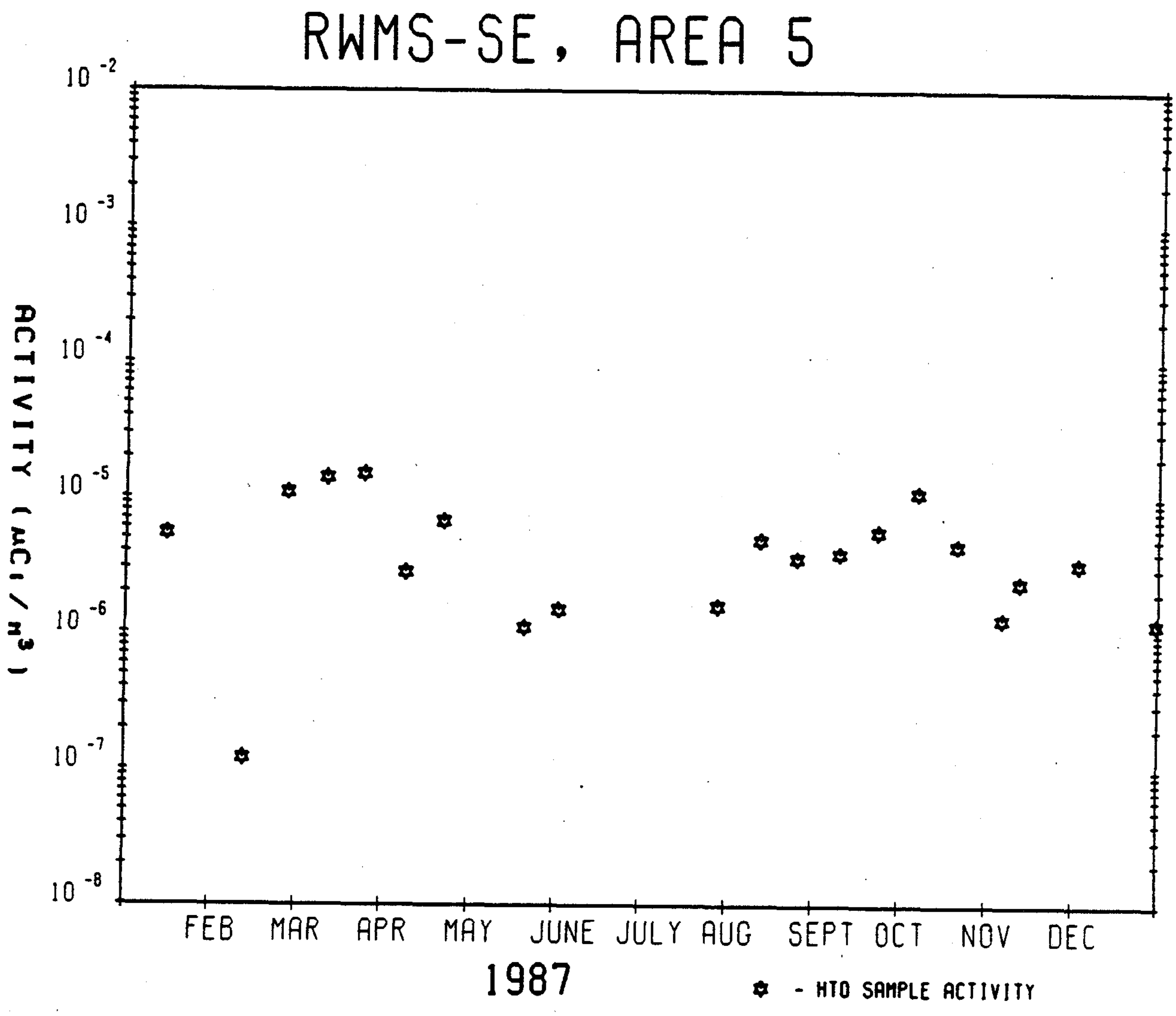
Tritium in Air Sampling Locations

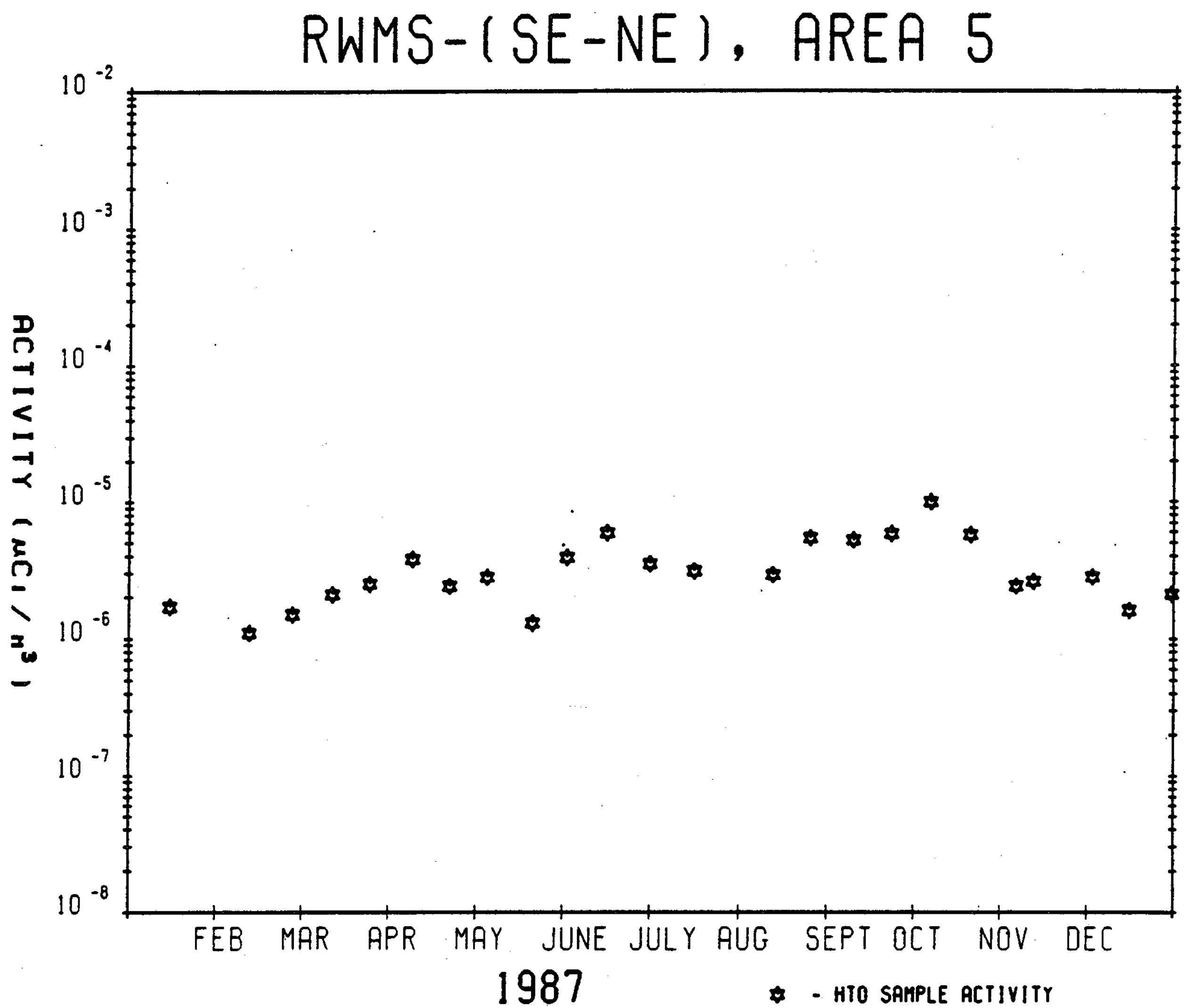
Area	Location
1	BJY
5	RWMS - 1
5	RWMS - SE
5	RWMS - (SE-NE)
5	RWMS - NE
5	RWMS - (NE-NW)
5	RWMS - NW
5	RWMS - (NW-SW)
5	RWMS - SW
5	RWMS - (SW-SE)
12	Base Camp
15	EPA Farm
15	Gate 700 South
23	Building 790
23	Building 650
23	Boundary
25	E-MAD


BJY, AREA 1
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
ACTIVITY (μCi / m3)
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

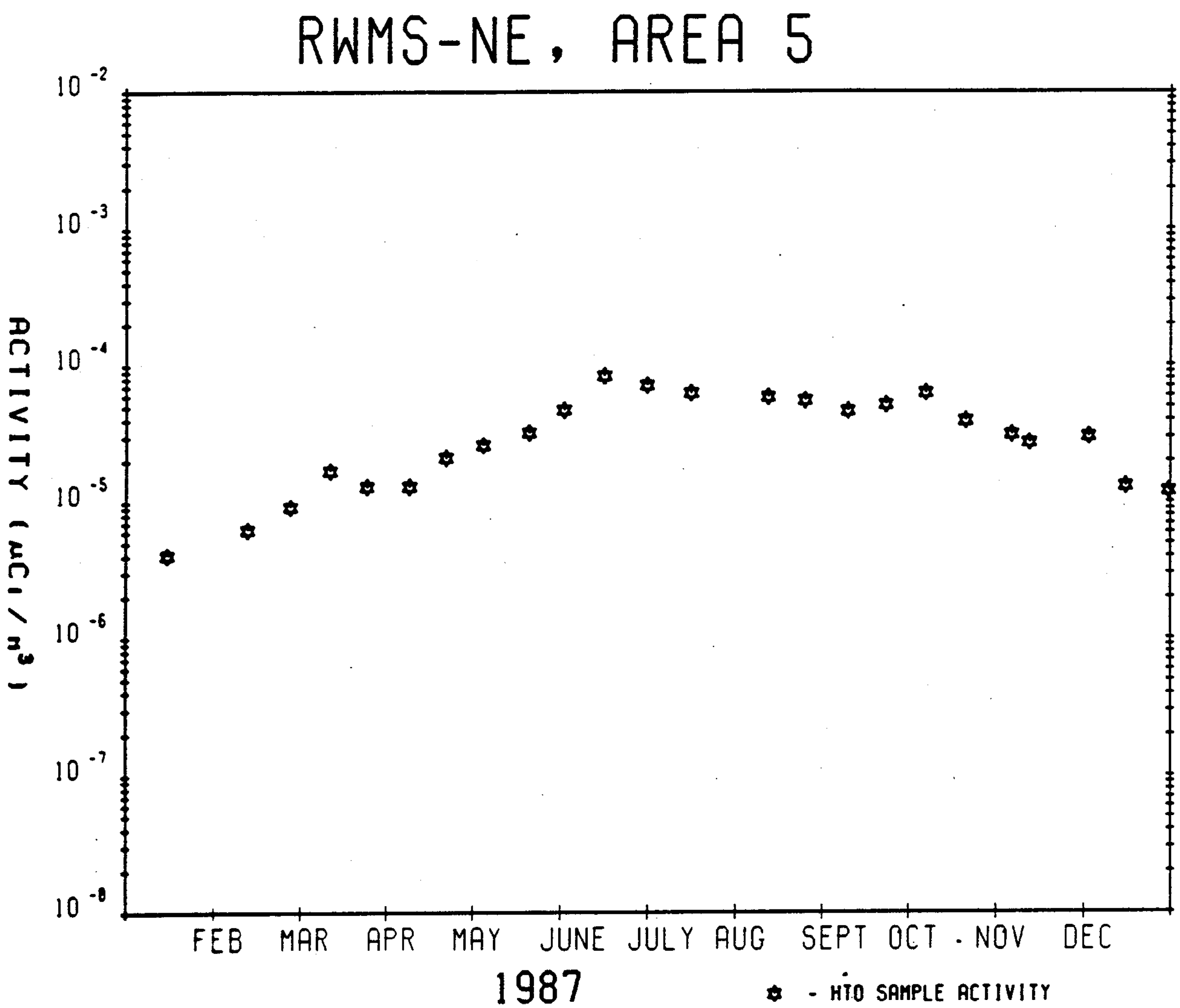


RWMS-1, AREA 5
ACTIVITY (µCi/m³)
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

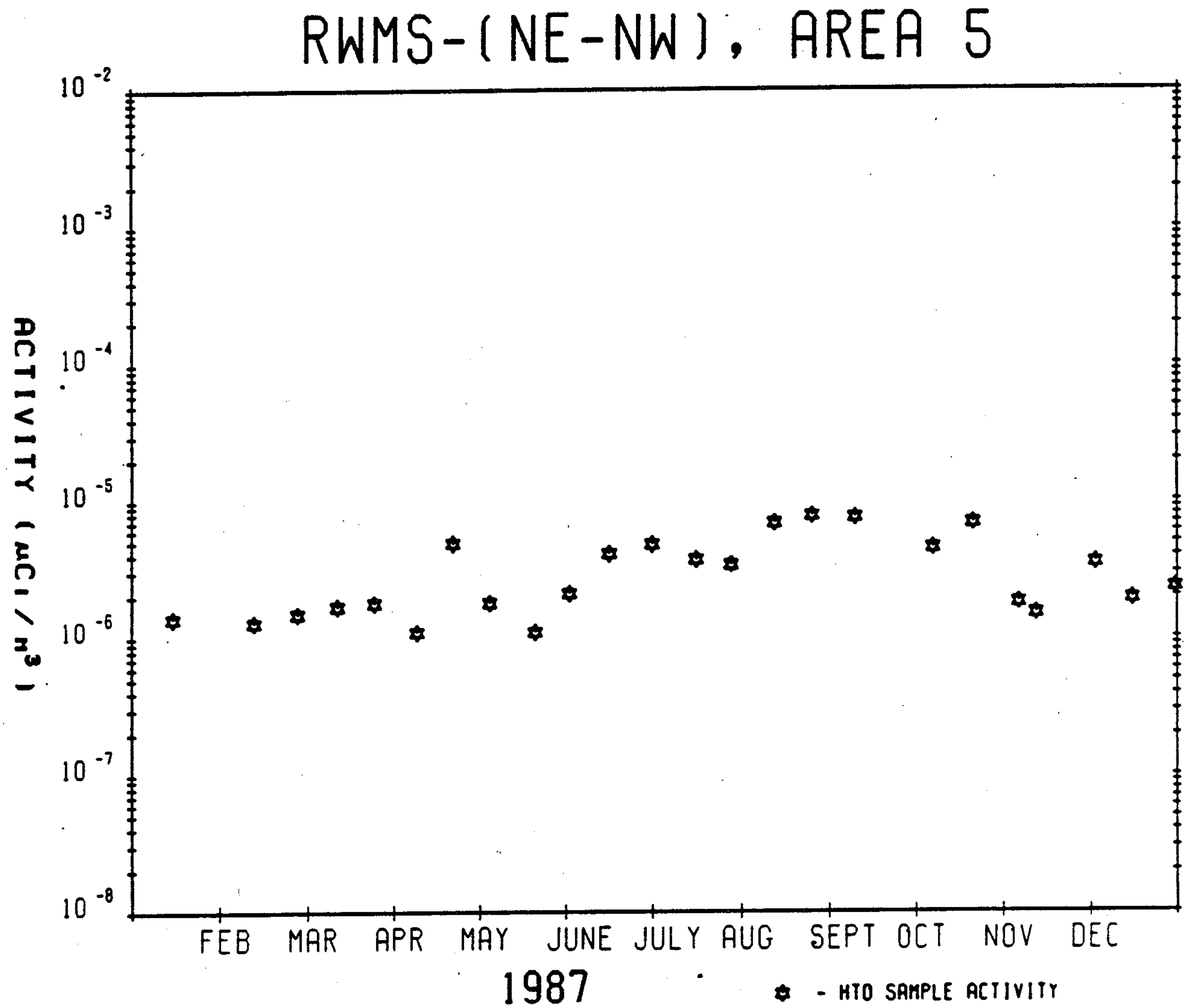

RWMS-SE, AREA 5
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
ACTIVITY (μCi / m3)
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY



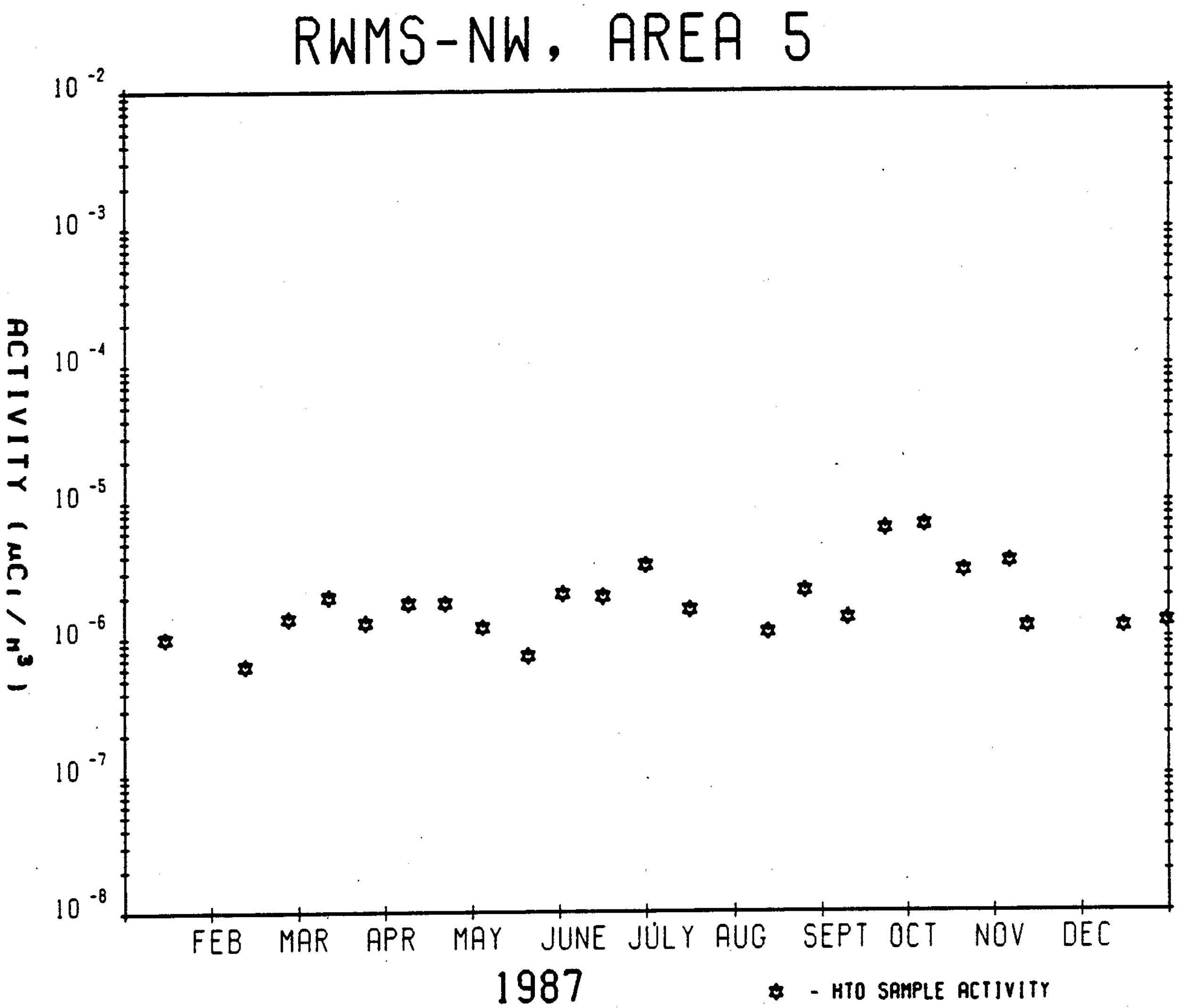
RWMS-(SE-NE), AREA 5
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
ACTIVITY (µCi / m3)
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

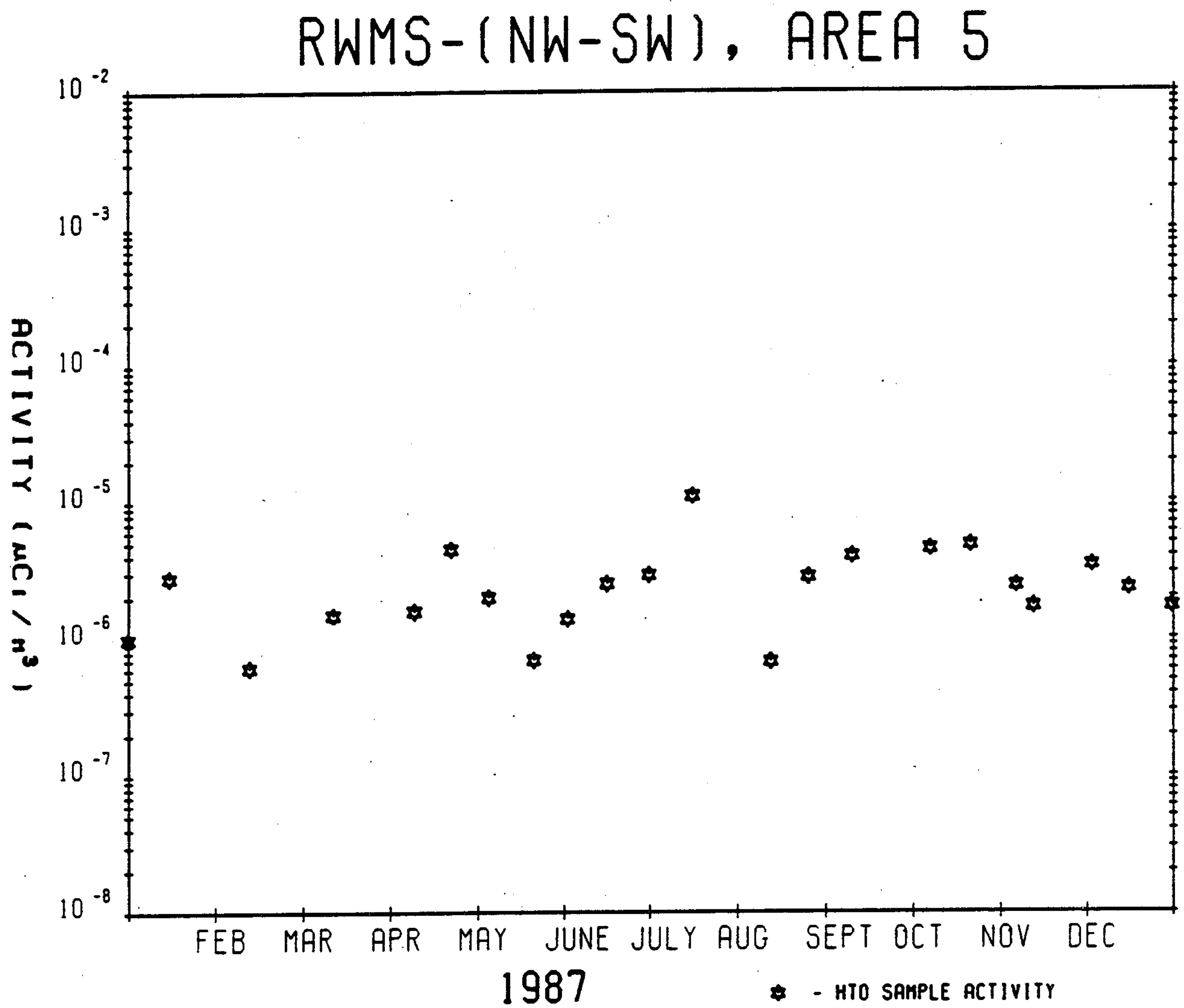


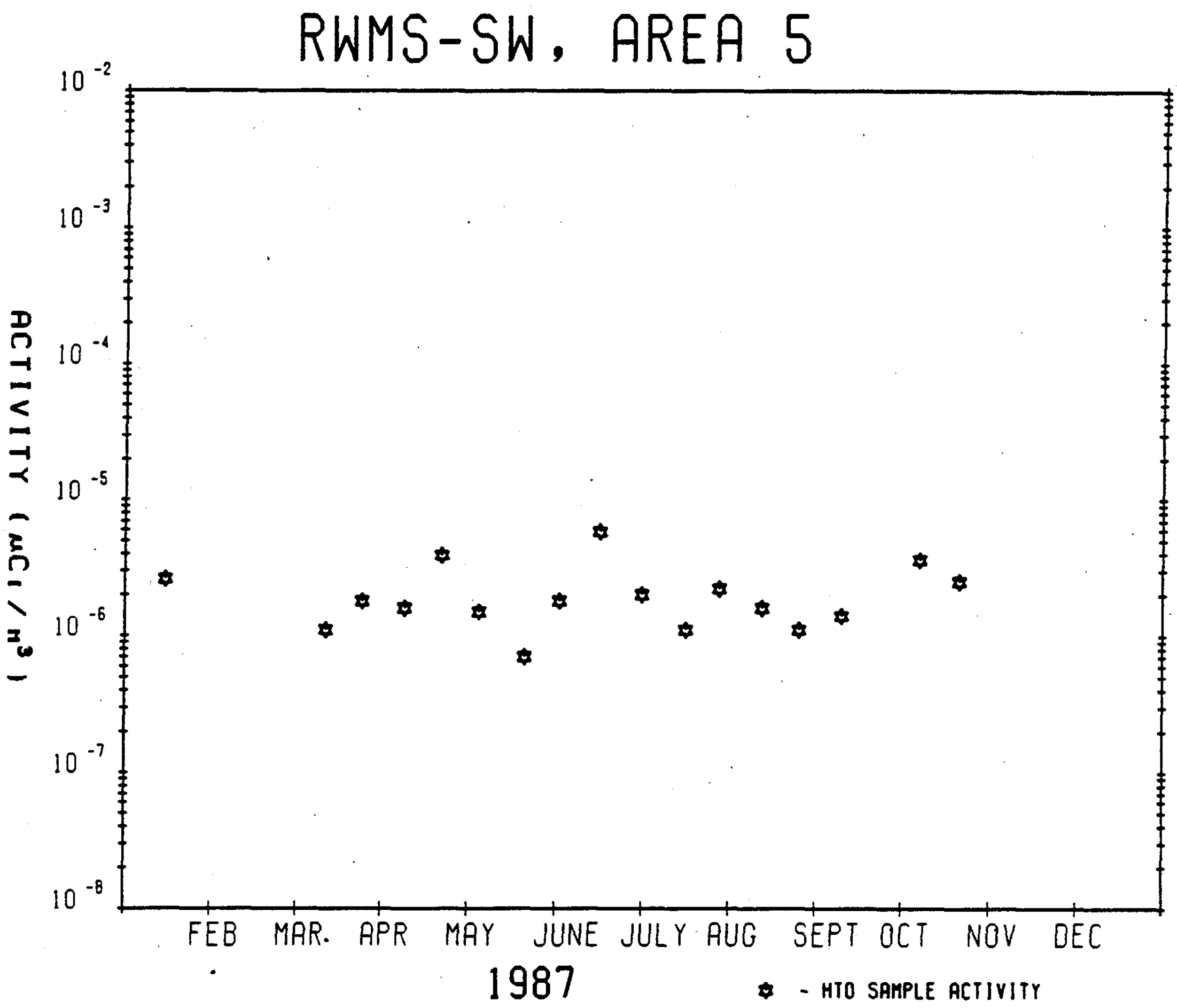
RWMS-NE, AREA 5
ACTIVITY (µCi/m³)
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

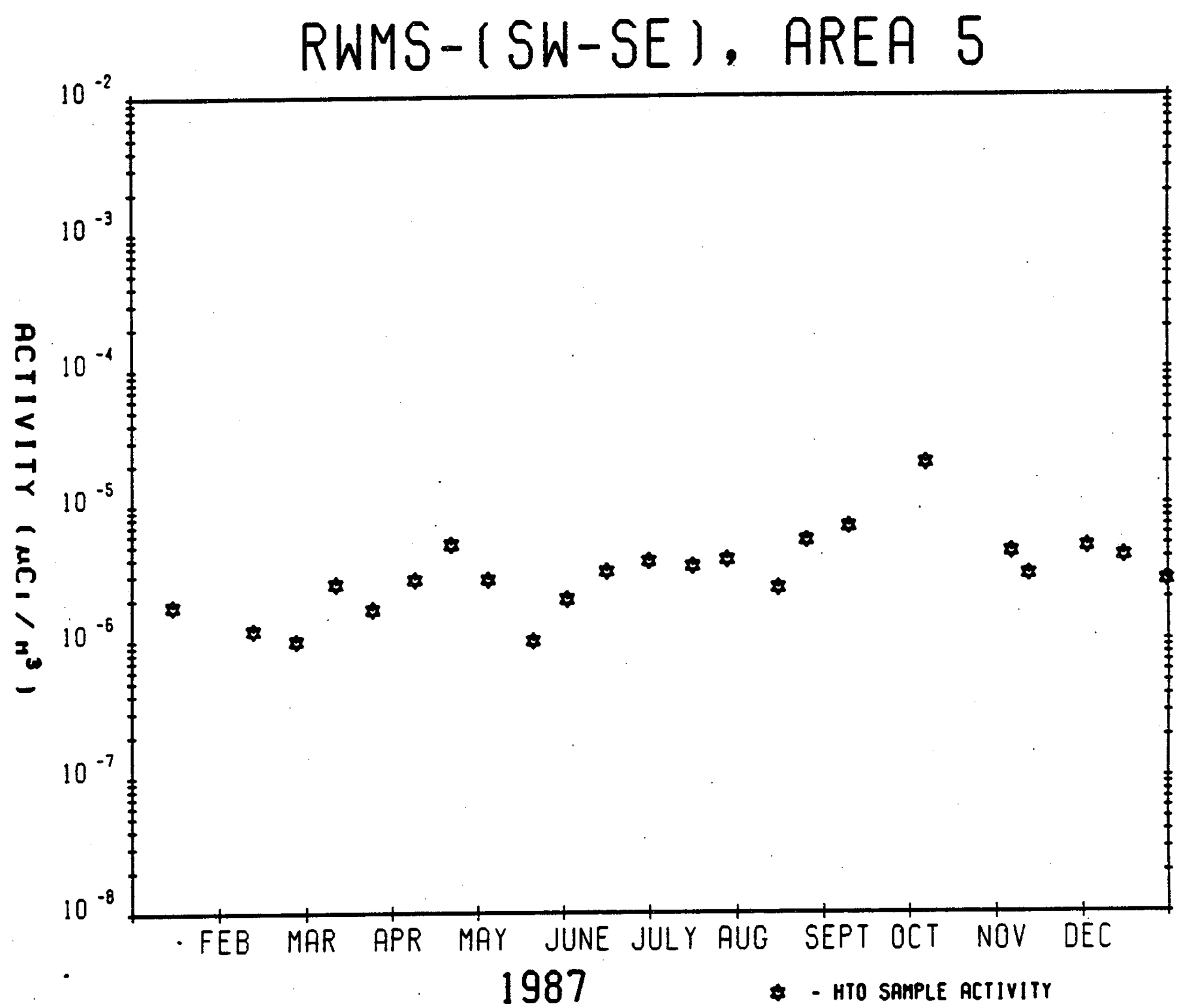


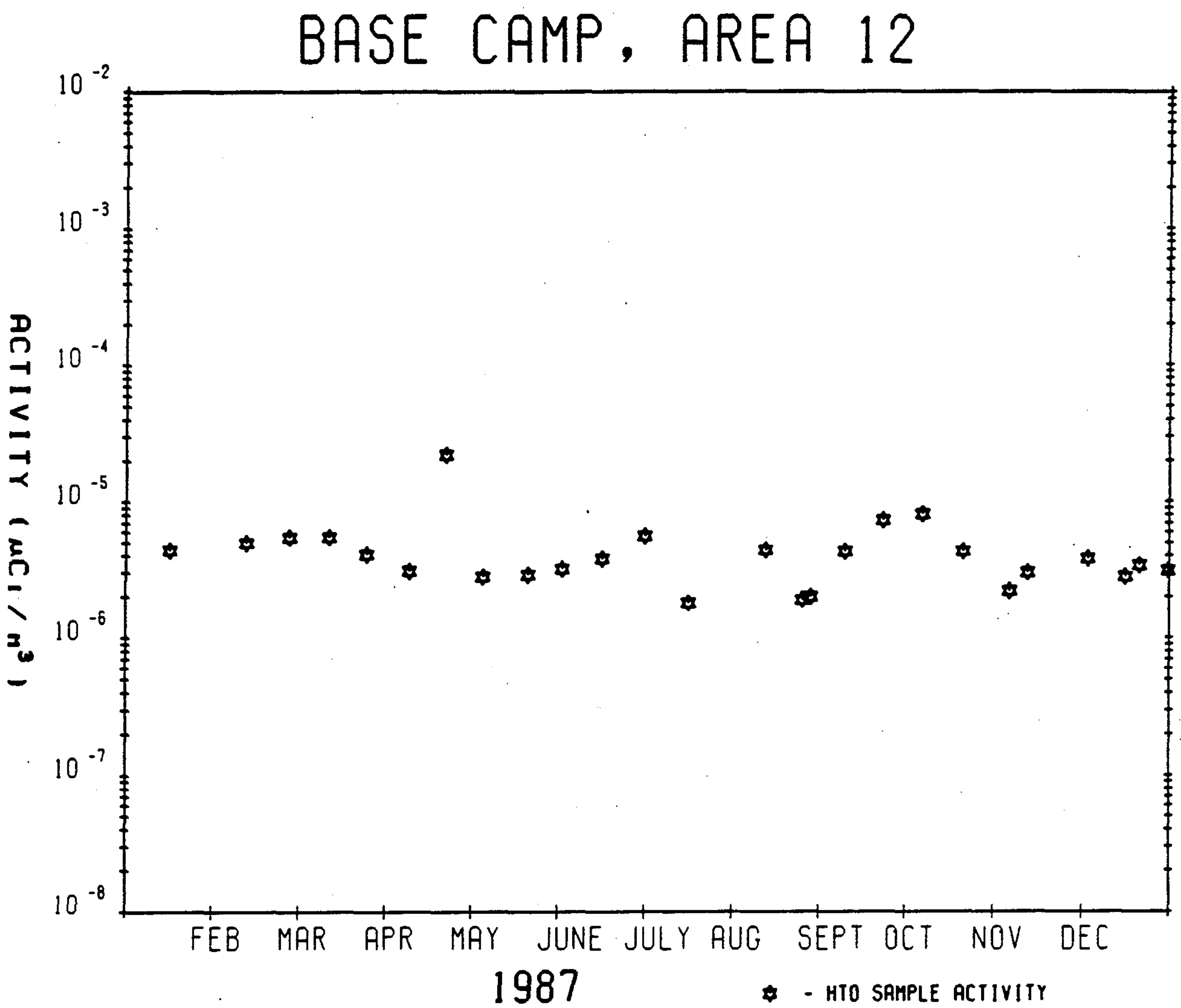
RWMS-(NE-NW), AREA 5
ACTIVITY (μCi / m³)
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
1987
- HTO SAMPLE ACTIVITY

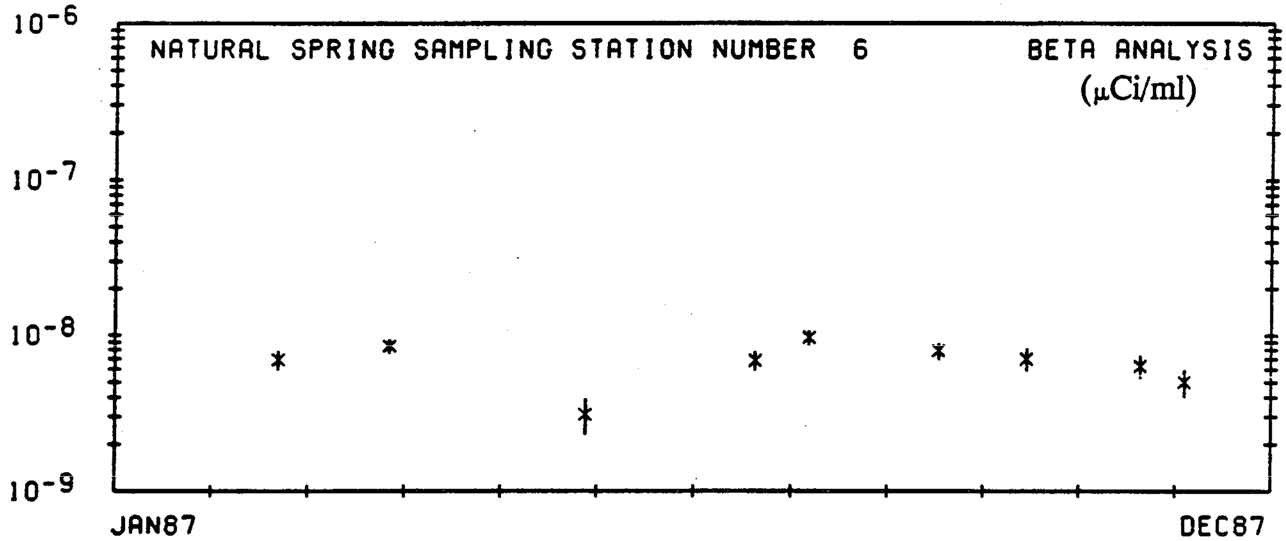

RWMS-NW, AREA 5
ACTIVITY (µCi / m³)
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

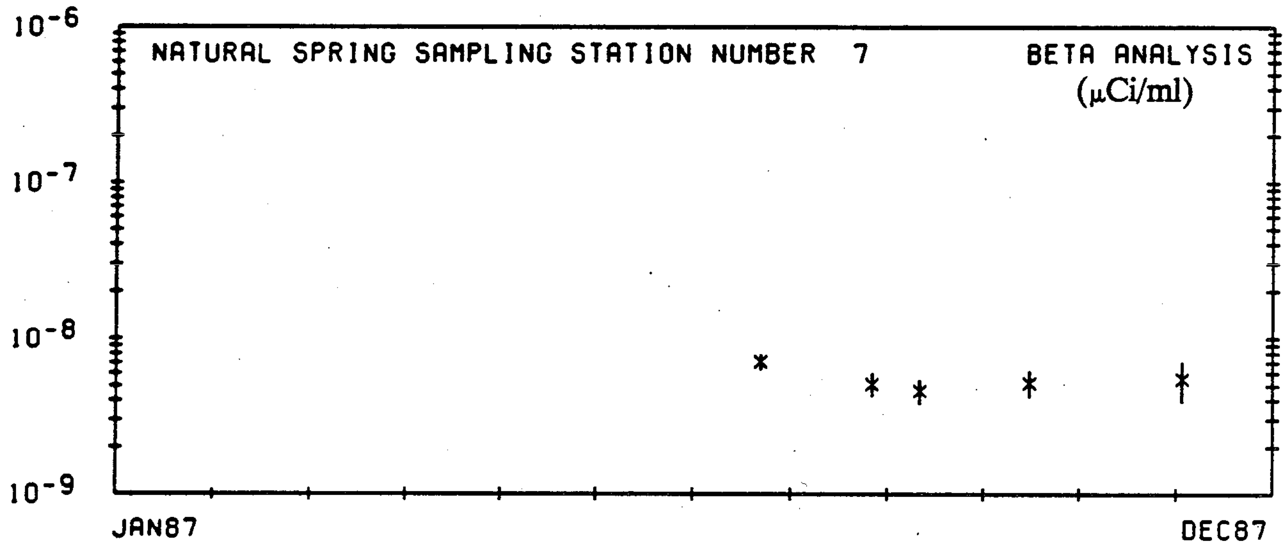

RWMS-(NW-SW), AREA 5
ACTIVITY (µCi/m³)
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

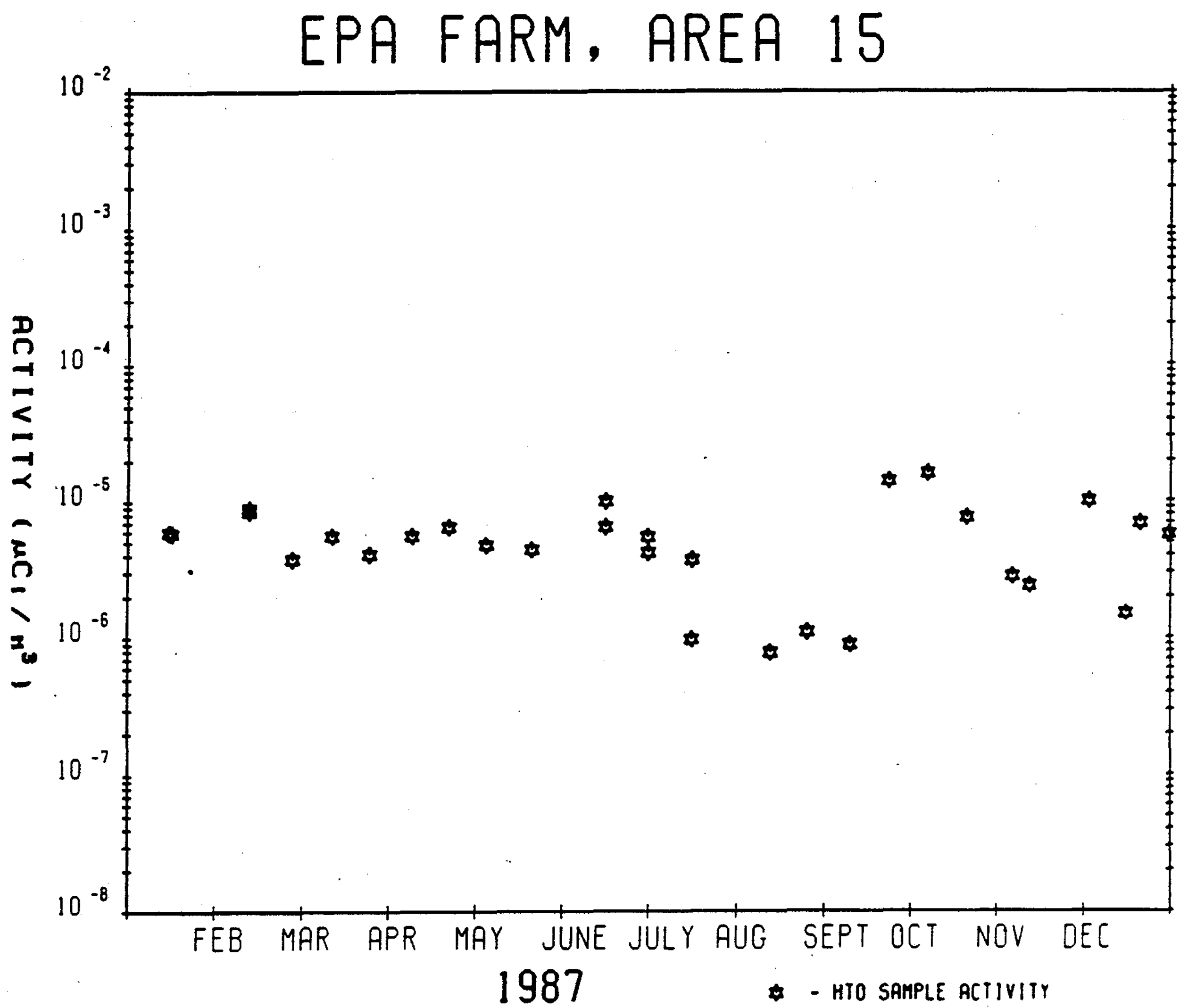

RWMS-SW, AREA 5
ACTIVITY (µCi / m³)
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
FEB MAR. APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

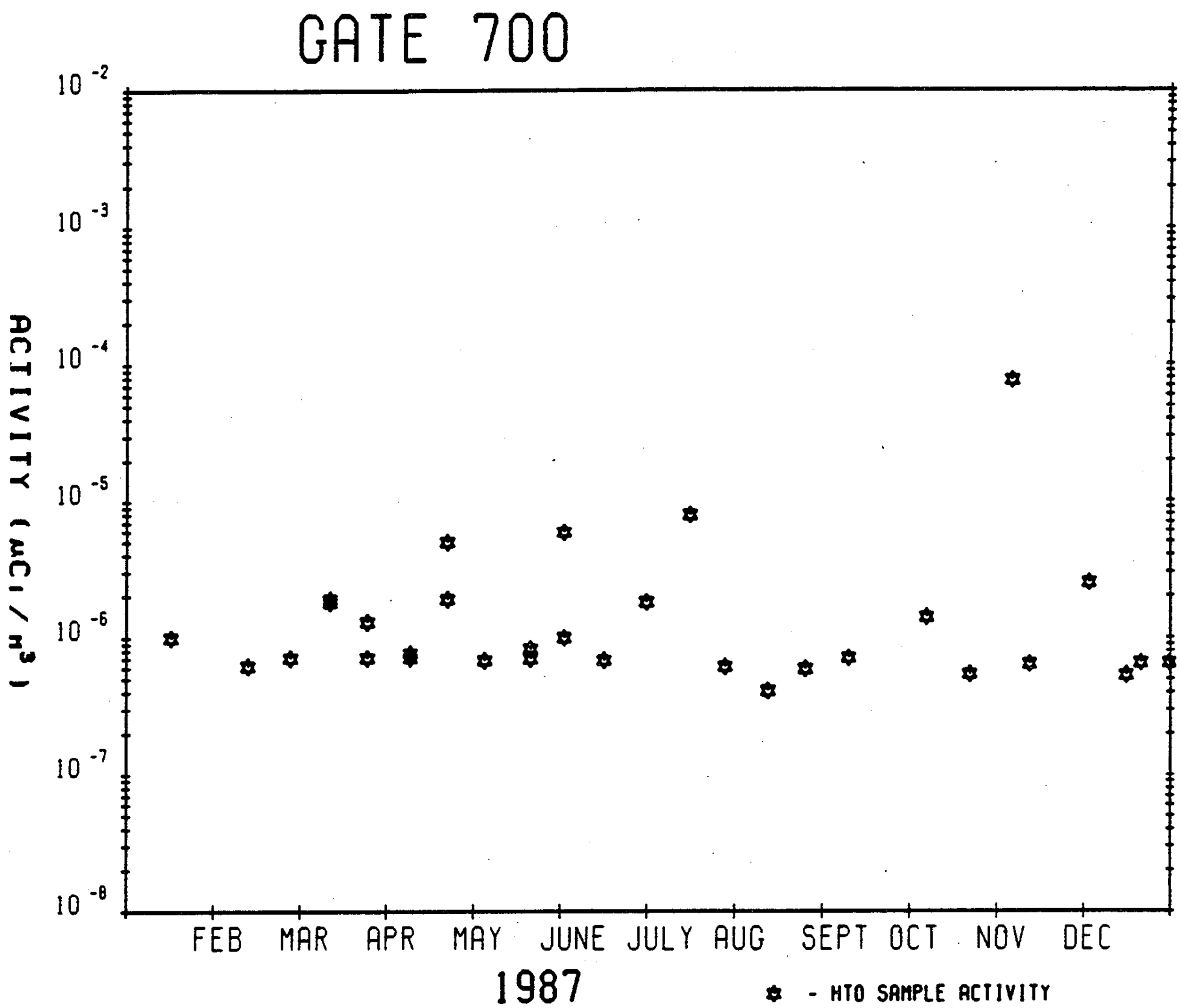

RWMS-(SW-SE), AREA 5
ACTIVITY (μCi/m³)
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

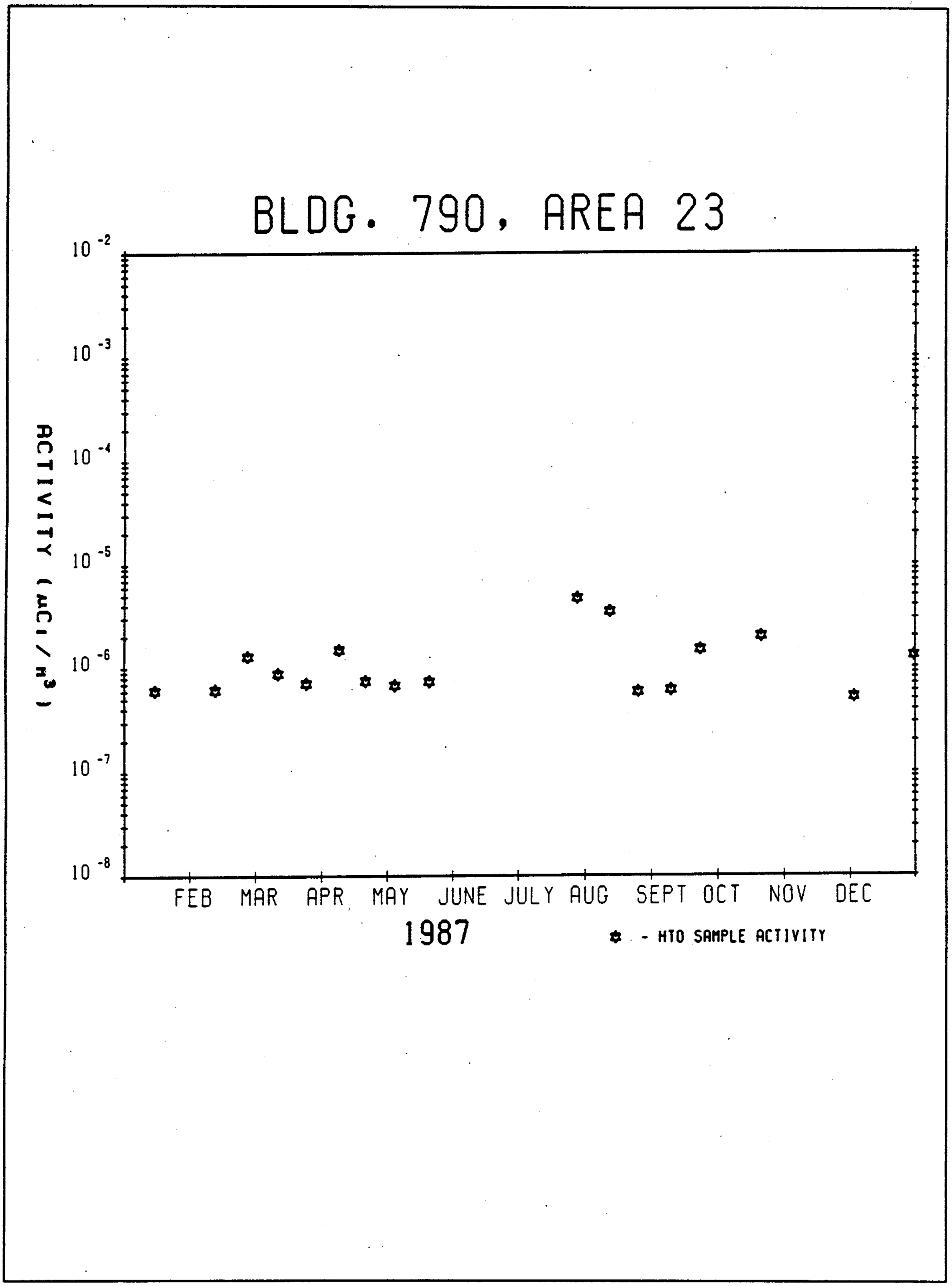

BASE CAMP, AREA 12
ACTIVITY (μCi / m³)
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

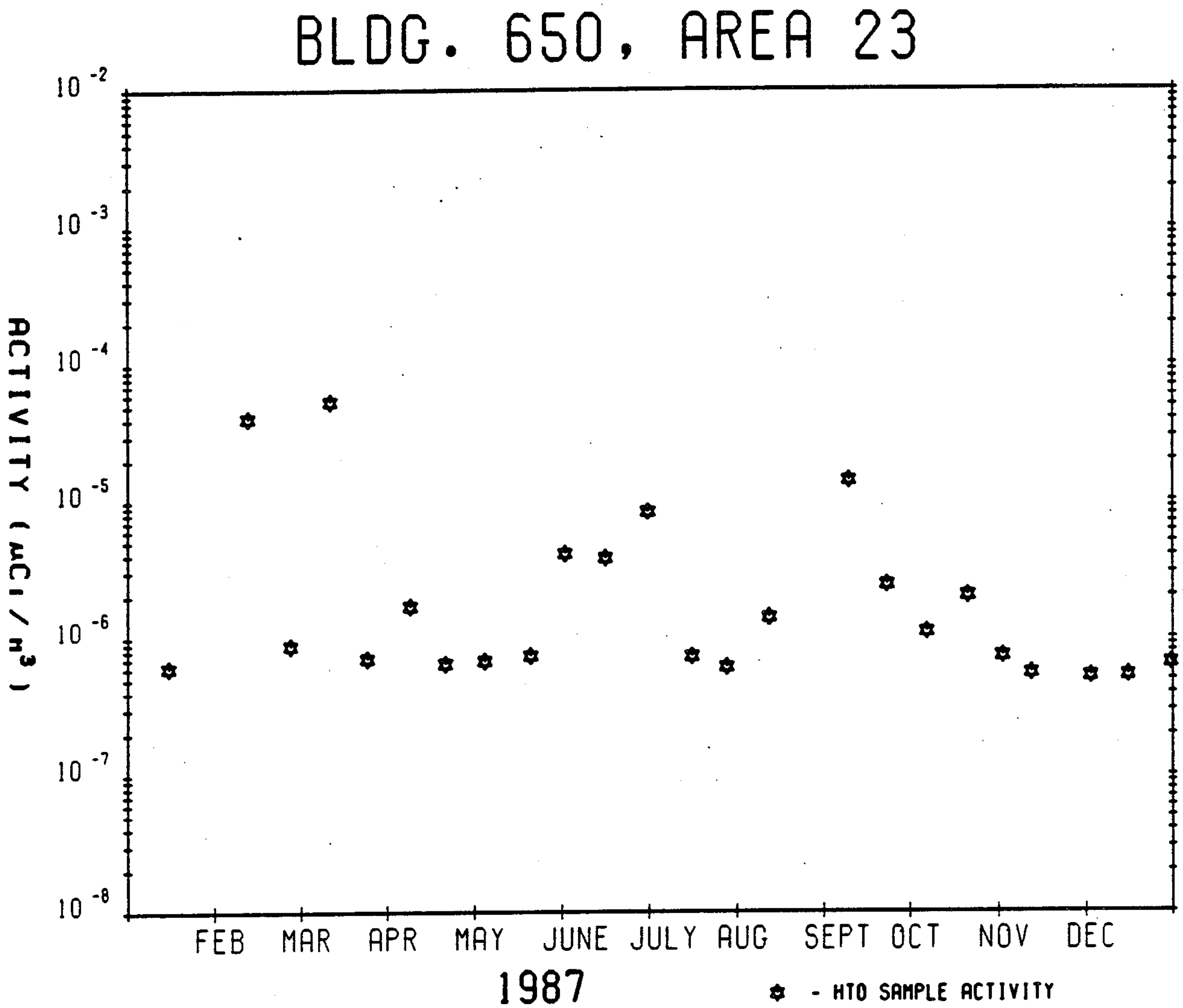

NATURAL SPRING SAMPLING STATION NUMBER 6
BETA ANALYSIS
(μCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87


NATURAL SPRING SAMPLING STATION NUMBER 7
BETA ANALYSIS
(μCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87

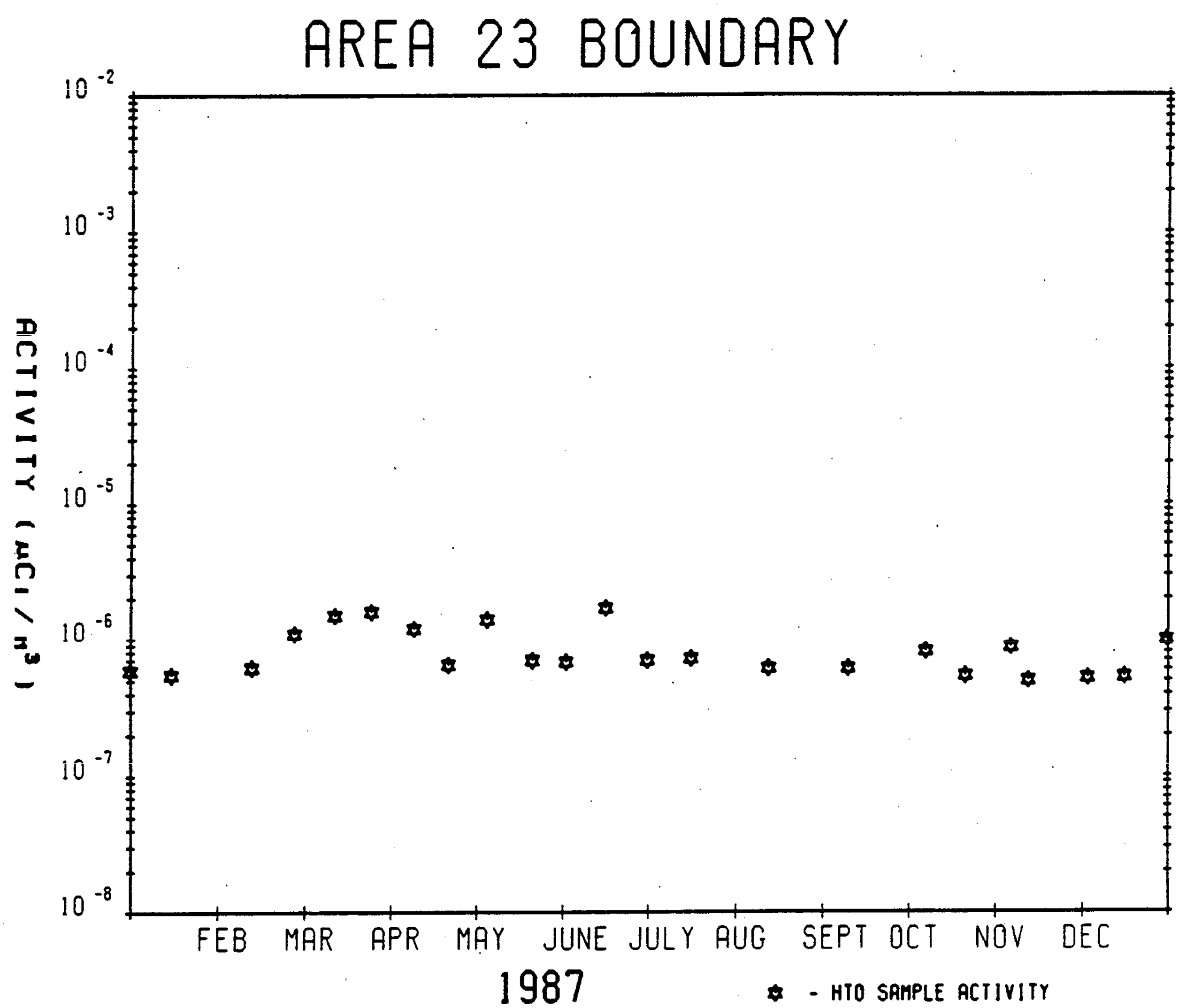

EPA FARM, AREA 15
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
ACTIVITY (μCi / m3)
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY


GATE 700
ACTIVITY (μCi / m³)
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
FEB
MAR
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
1987
- HTO SAMPLE ACTIVITY


BLDG. 790, AREA 23
ACTIVITY (µCi / m³)
10⁻²
10⁻³
10⁻⁴
10⁻⁵
10⁻⁶
10⁻⁷
10⁻⁸
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

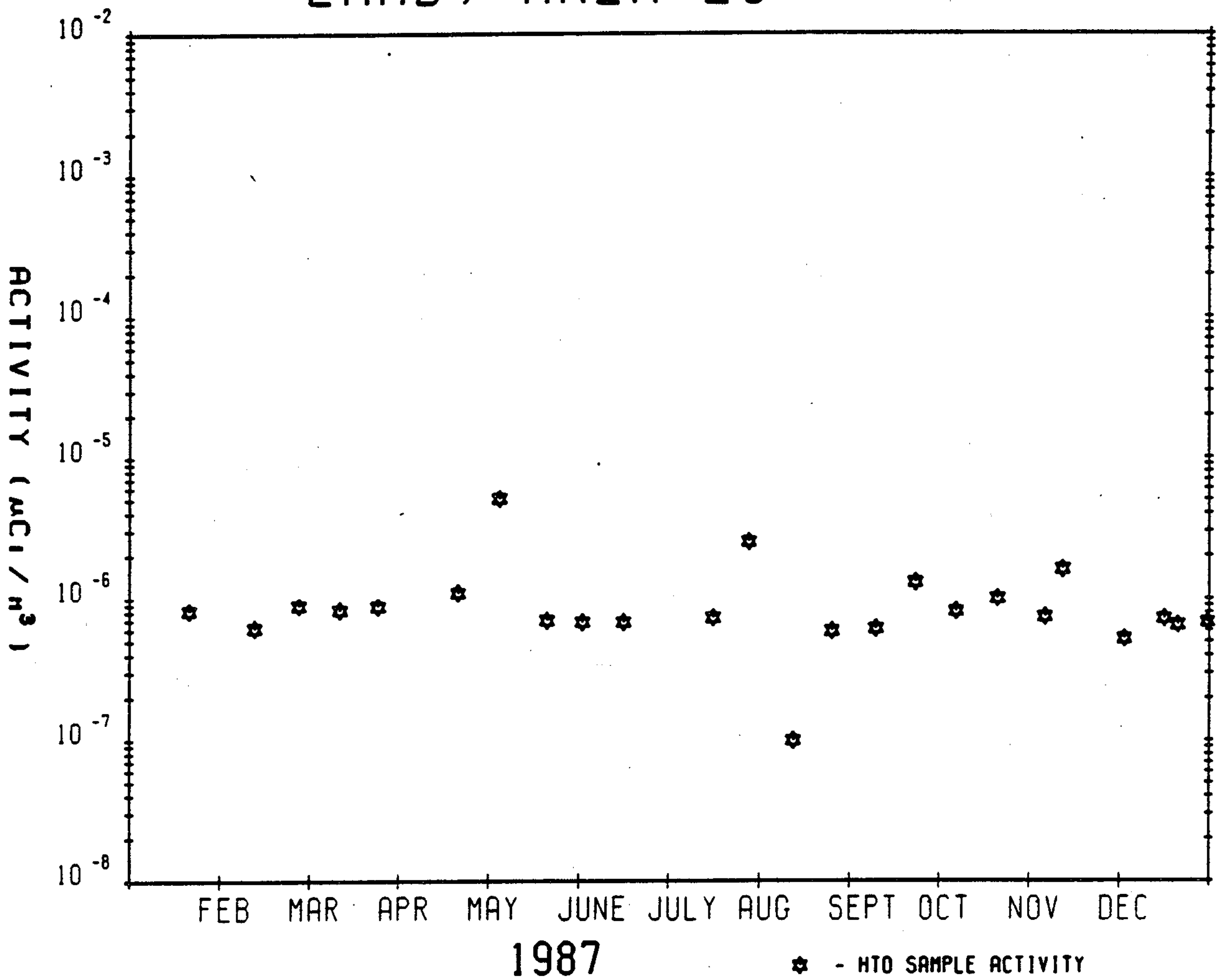


BLDG. 650, AREA 23
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
ACTIVITY (µCi / m³)
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY



AREA 23 BOUNDARY
ACTIVITY (µCi/m³)
10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

EMAD, AREA 25



10 -2
10 -3
10 -4
10 -5
10 -6
10 -7
10 -8
ACTIVITY (μCi / m³)
FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC
1987
- HTO SAMPLE ACTIVITY

APPENDIX C

NTS Environmental Monitoring

Supply Well Stations and Plots

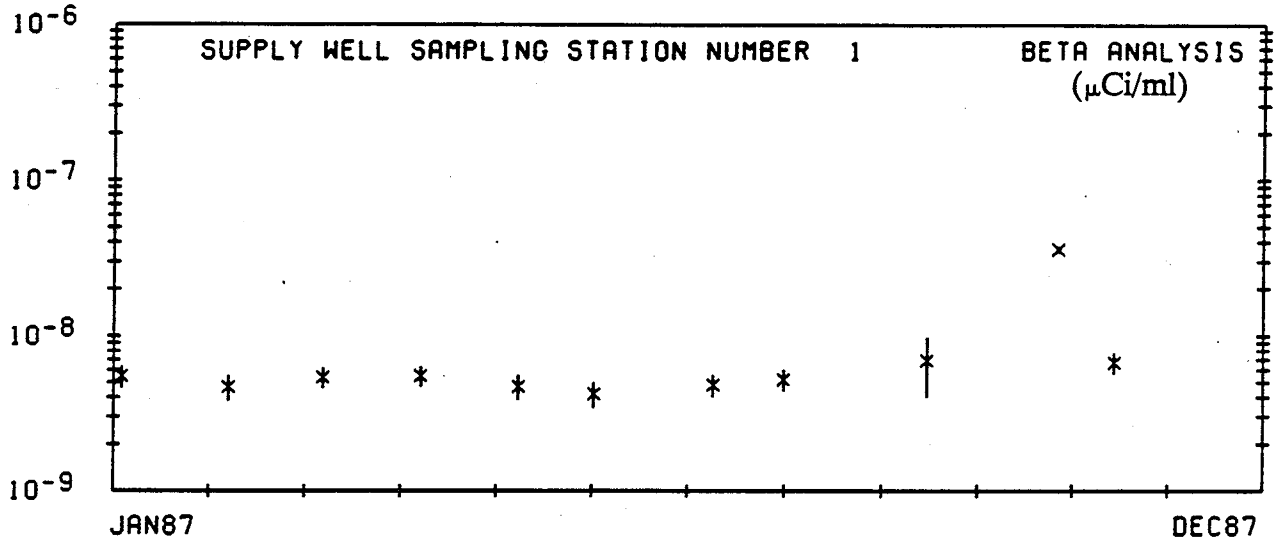
SYMBOLS

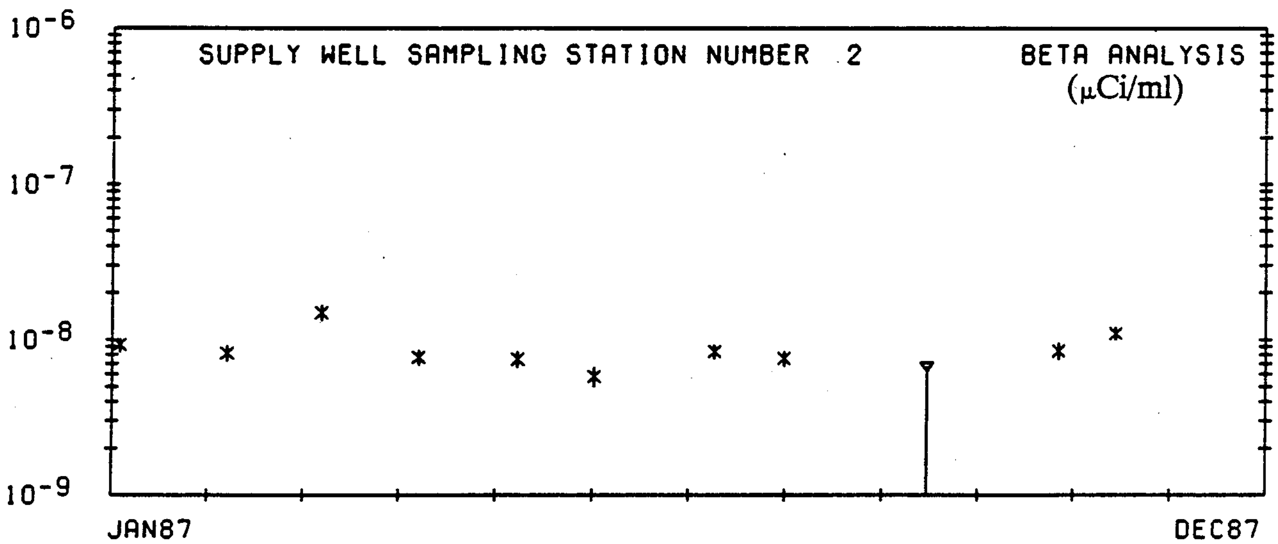
Several symbols are used in Appendix C to denote the data points. The plots display the gross beta data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits.

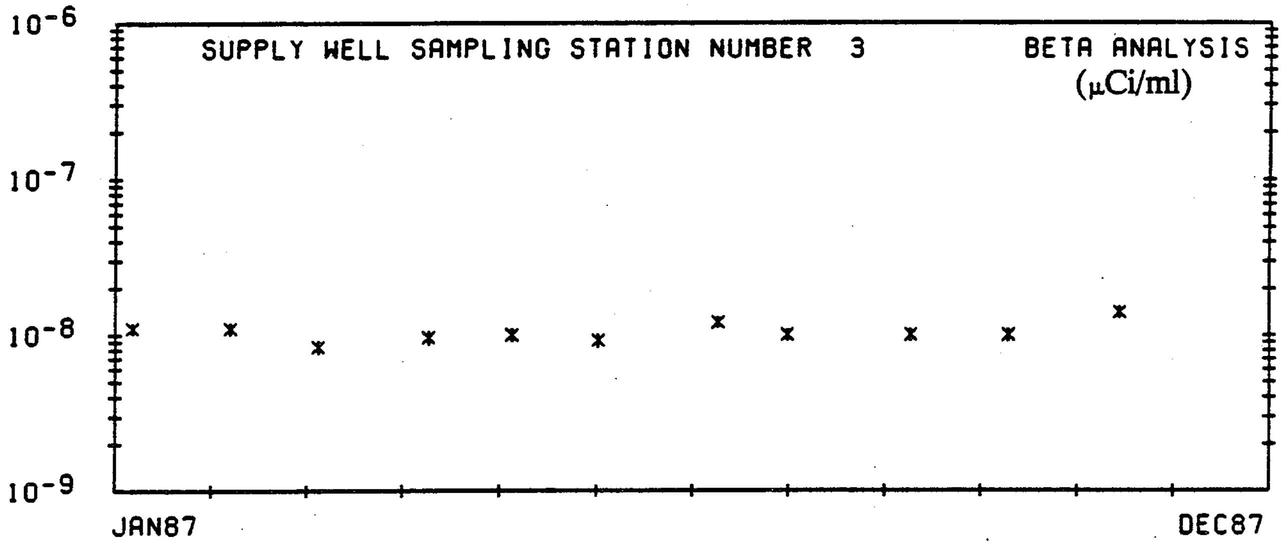
NTS Environmental Monitoring

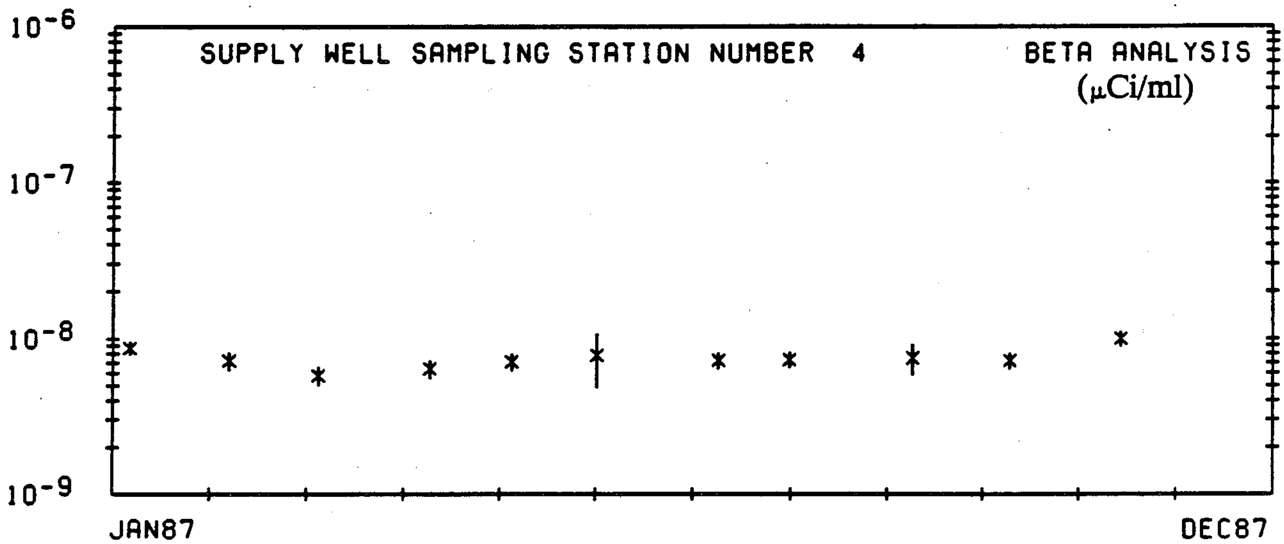
Supply Well Sampling Locations

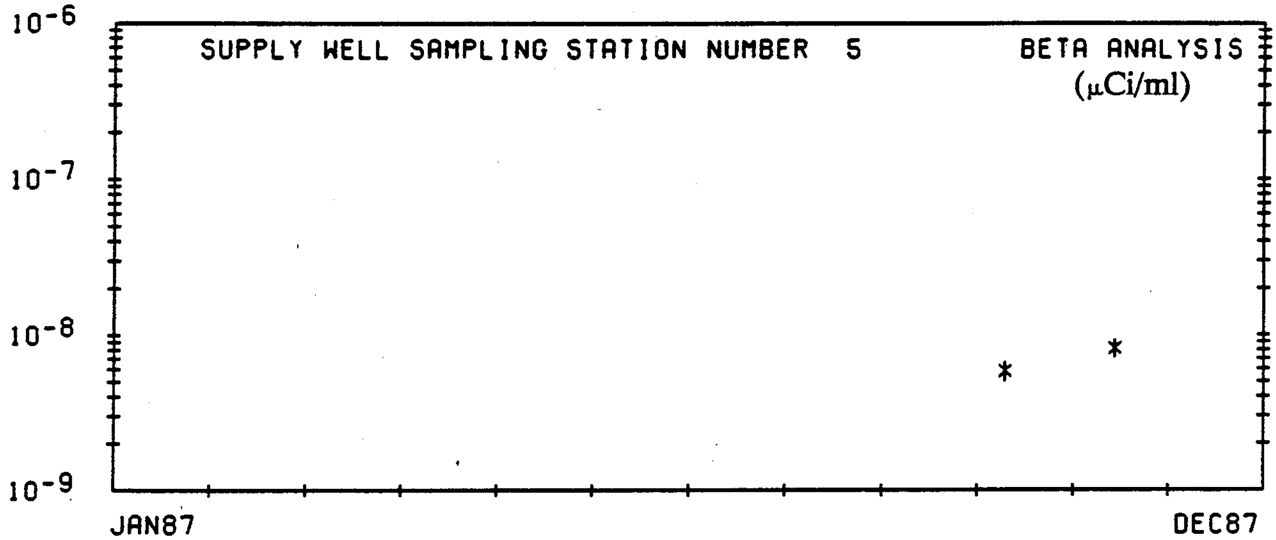
Station	Location
1	Area 2 Well 2
2	Area 3 Well A
3	Area 5 Well 5B
4	Area 5 Well 5C
5	Area 5 Well UE5c
6	Area 6 Well C
7	Area 6 Well C1
8	Area 15 Well UE15d
9	Area 18 Well 8
13	Area 22 Army Well No. 1
14	Area 25 Well J 12
15	Area 25 Well J 13
18	Area 19 Well U19c
19	Area 6 Well 4
20	Area 20 Water Well
21	Area 16 Well 16D

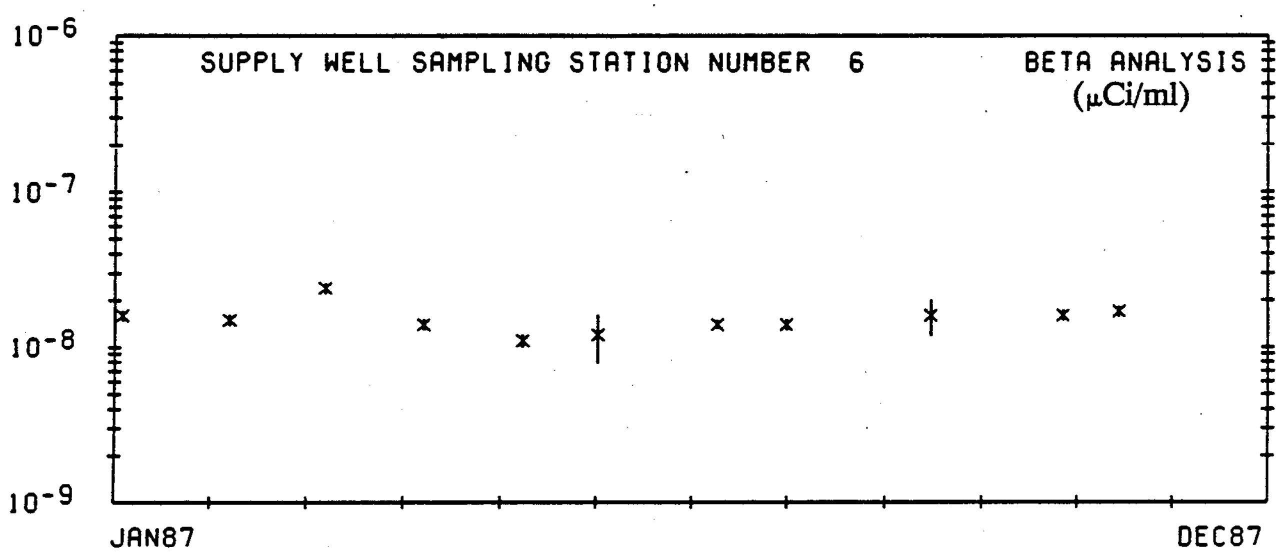

SUPPLY WELL SAMPLING STATION NUMBER 1
BETA ANALYSIS
(µCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87

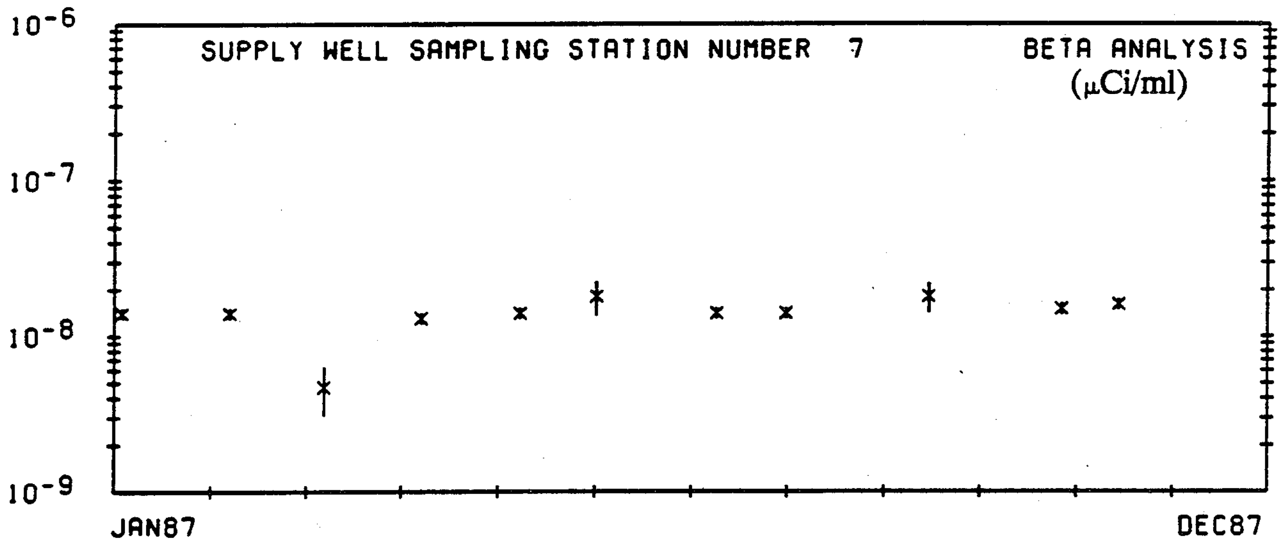

SUPPLY WELL SAMPLING STATION NUMBER 2
BETA ANALYSIS
(µCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87


SUPPLY WELL SAMPLING STATION NUMBER 3
BETA ANALYSIS (μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87

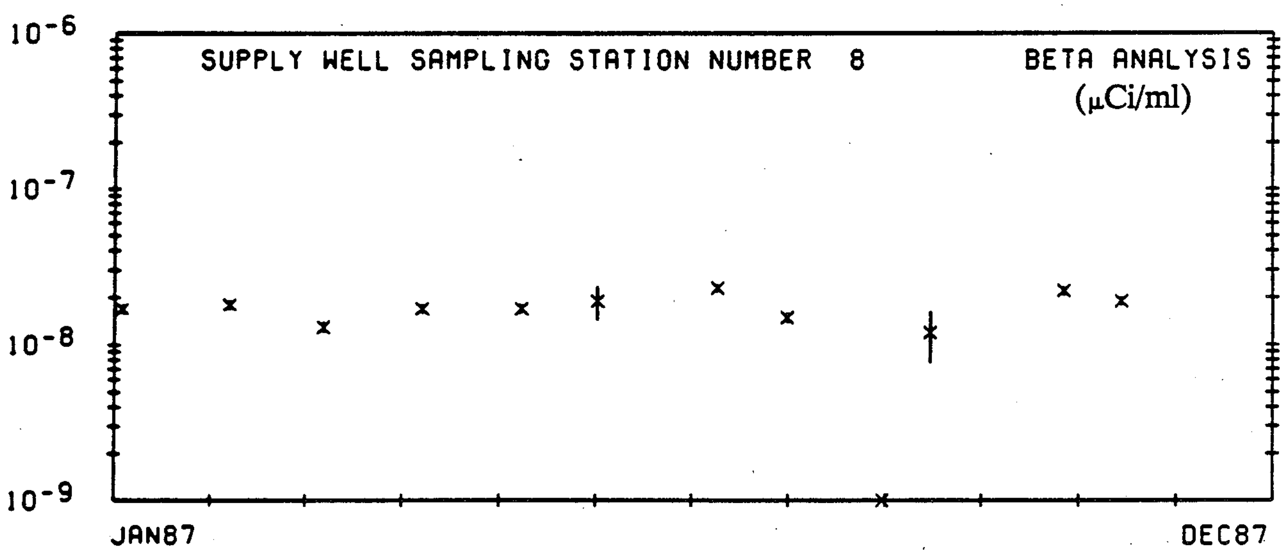

SUPPLY WELL SAMPLING STATION NUMBER 4
BETA ANALYSIS (μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87


SUPPLY WELL SAMPLING STATION NUMBER 5
BETA ANALYSIS
(μCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87

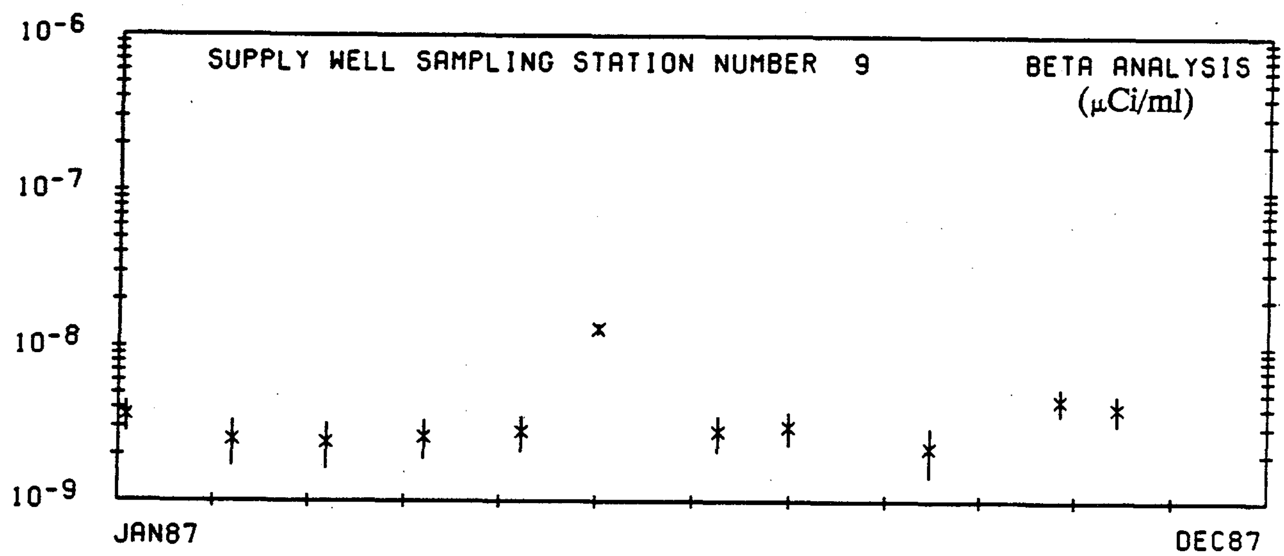

SUPPLY WELL SAMPLING STATION NUMBER 6
BETA ANALYSIS
(μCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87

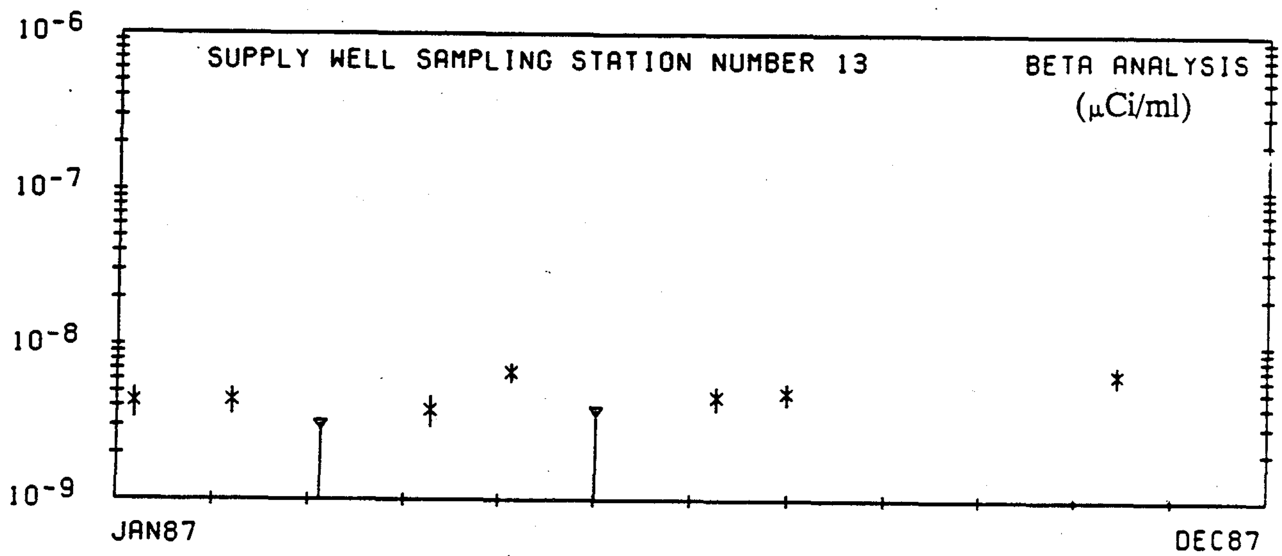


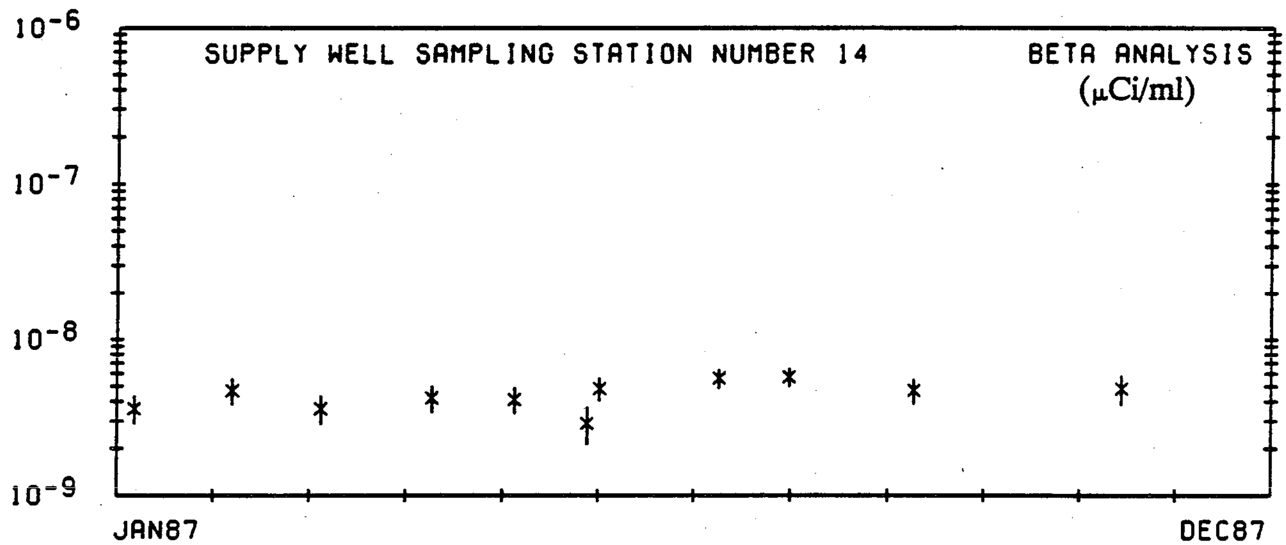
SUPPLY WELL SAMPLING STATION NUMBER 7
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87



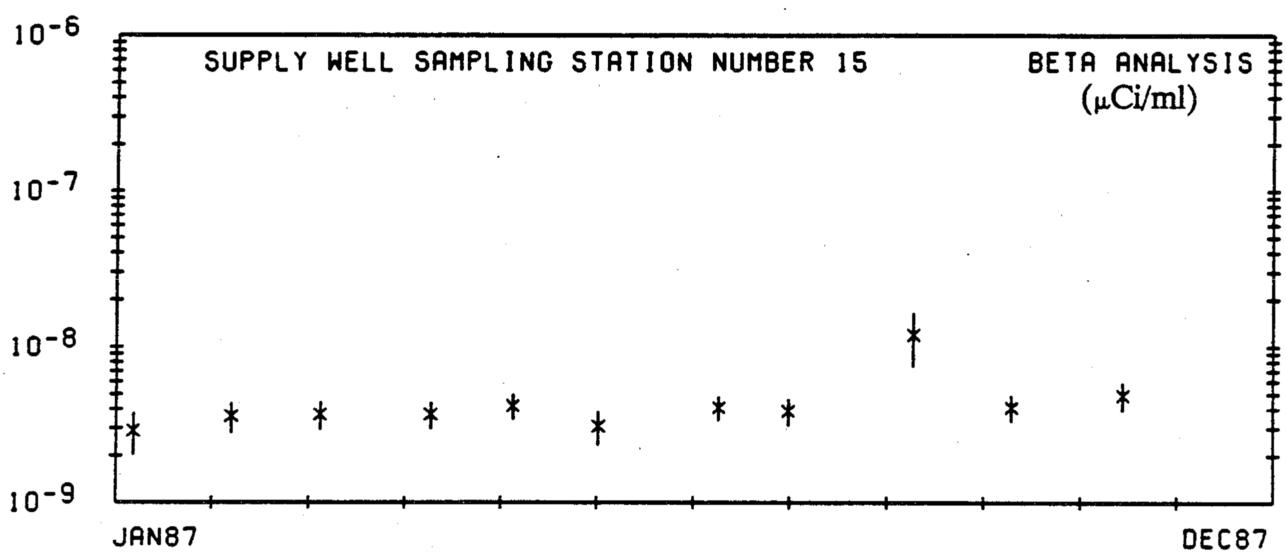
SUPPLY WELL SAMPLING STATION NUMBER 8
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87


SUPPLY WELL SAMPLING STATION NUMBER 9
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87

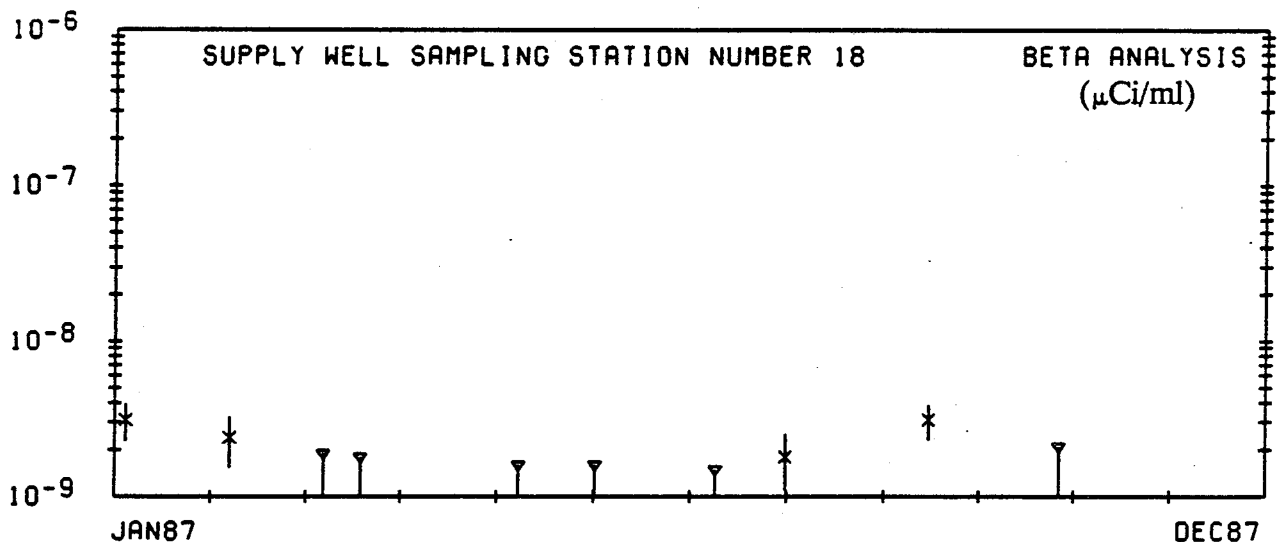

SUPPLY WELL SAMPLING STATION NUMBER 13
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87



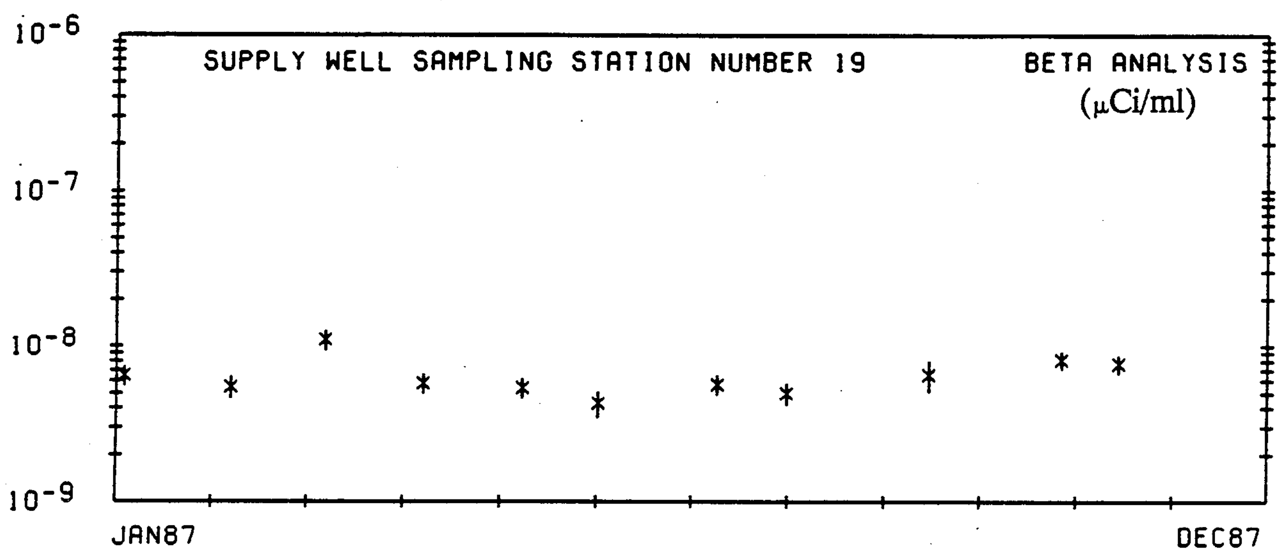
SUPPLY WELL SAMPLING STATION NUMBER 14
BETA ANALYSIS (μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87



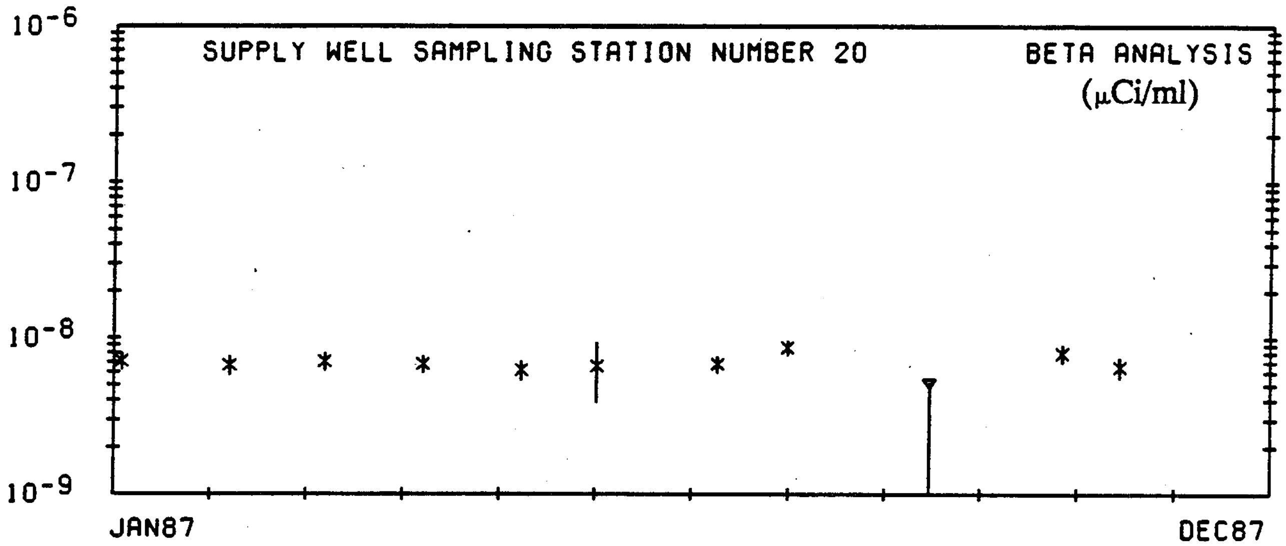
SUPPLY WELL SAMPLING STATION NUMBER 15
BETA ANALYSIS (μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87



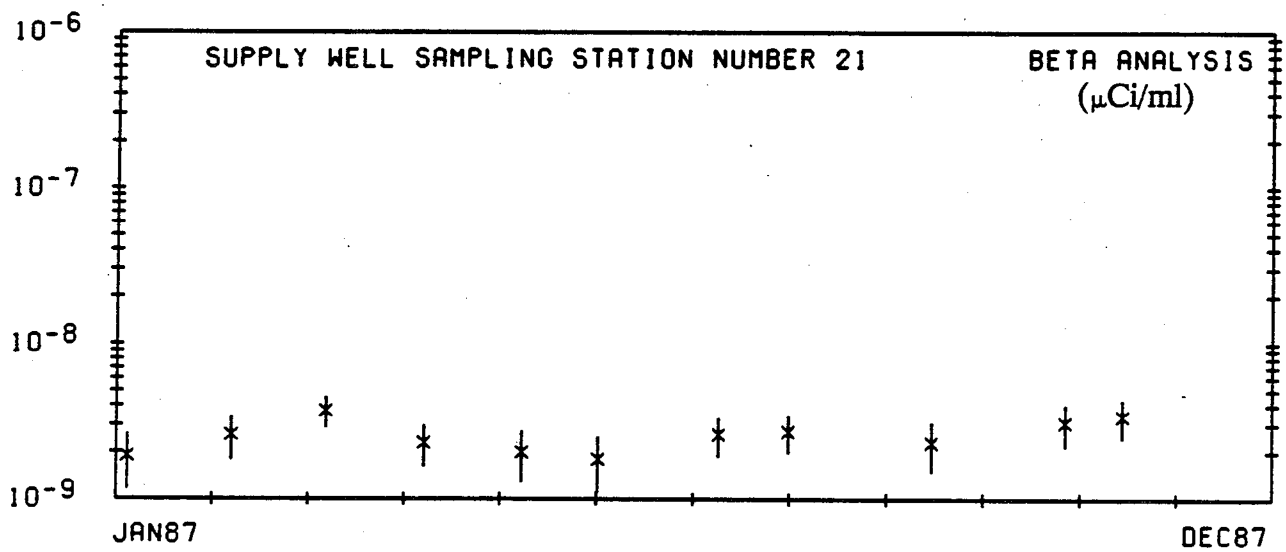
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
SUPPLY WELL SAMPLING STATION NUMBER 18
BETA ANALYSIS
(μCi/ml)
JAN87
DEC87



10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
SUPPLY WELL SAMPLING STATION NUMBER 19
BETA ANALYSIS
(μCi/ml)
JAN87
DEC87



SUPPLY WELL SAMPLING STATION NUMBER 20
BETA ANALYSIS
(μCi/ml)
10^{-6}
10^{-7}
10^{-8}
10^{-9}
JAN87
DEC87



SUPPLY WELL SAMPLING STATION NUMBER 21
BETA ANALYSIS
(μCi/ml)
10^{-6}
10^{-7}
10^{-8}
10^{-9}
JAN87
DEC87

APPENDIX D

NTS Environmental Monitoring

Potable Water Stations and Plots

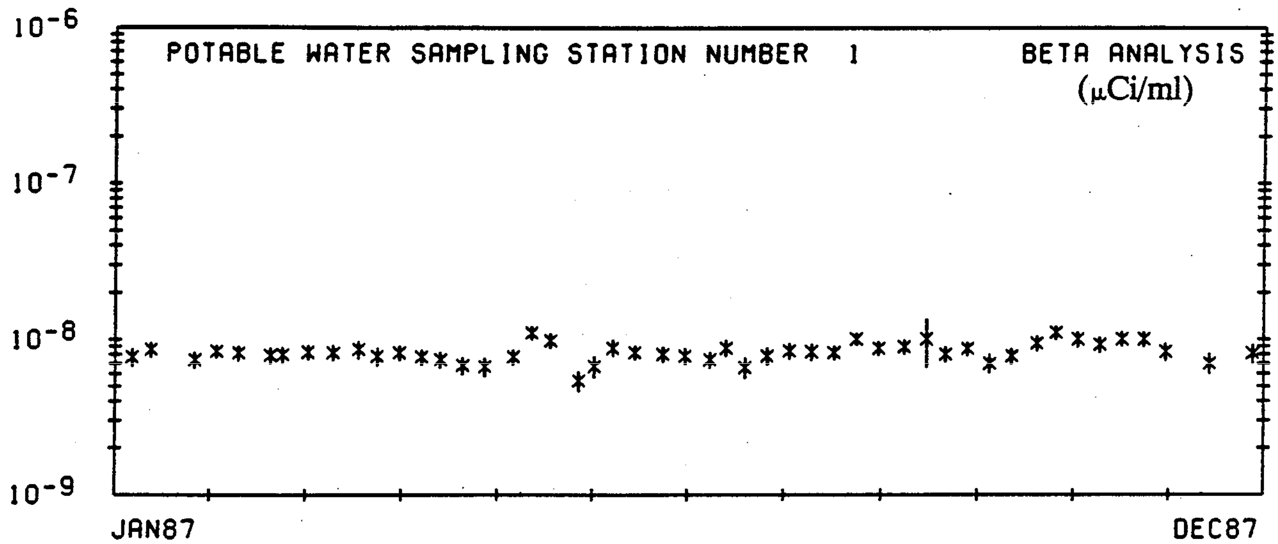
SYMBOLS

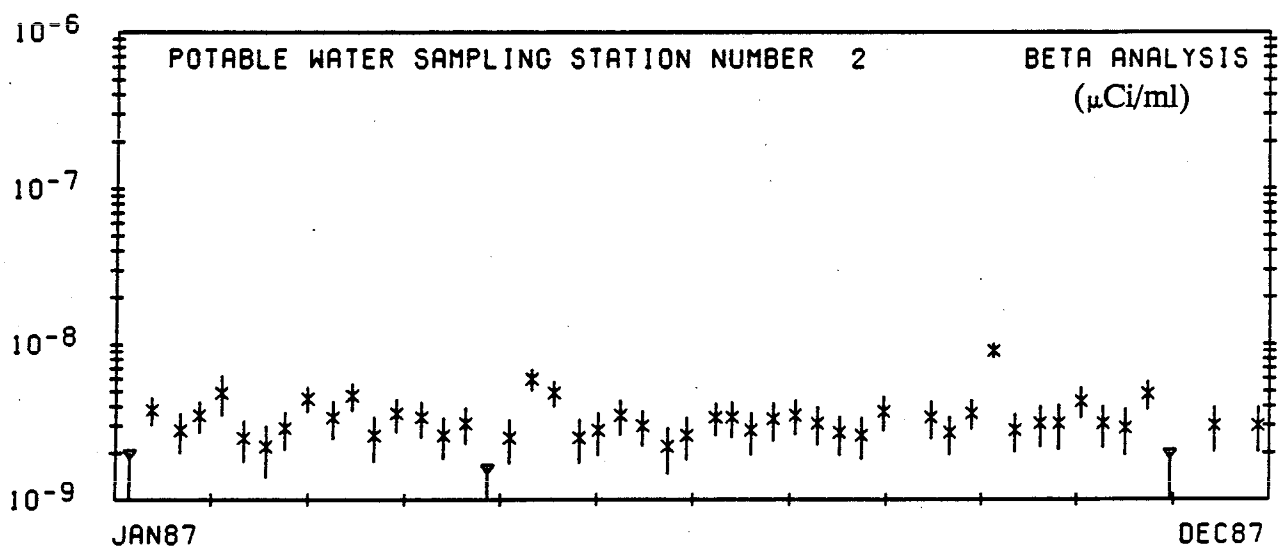
Several symbols are used in Appendix D to denote the data points. The plots display the gross beta data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits.

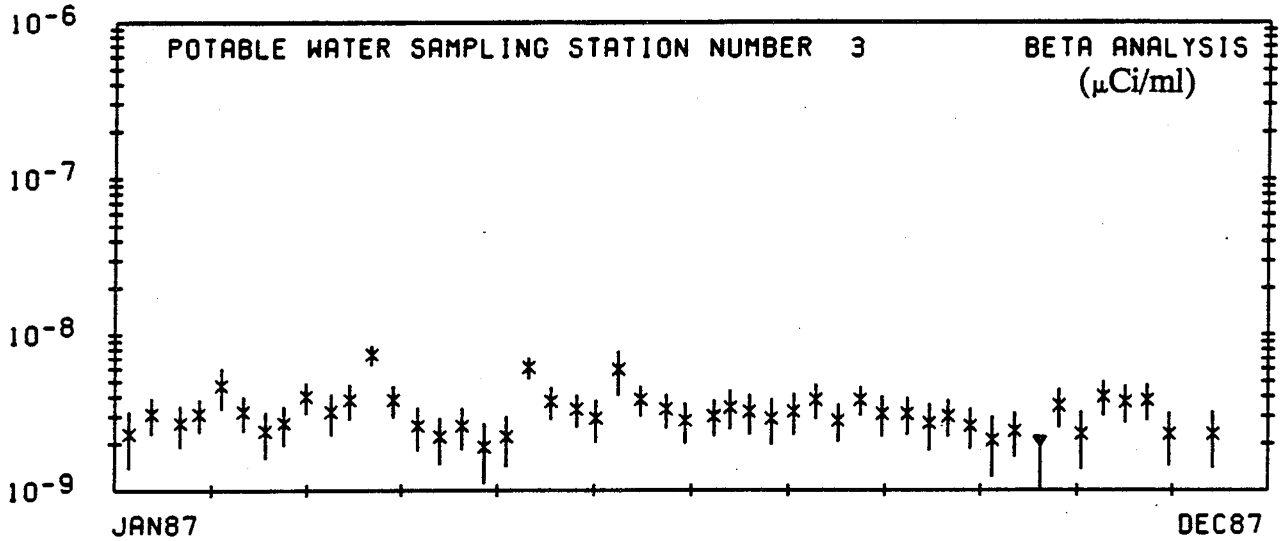
NTS Environmental Monitoring

Potable Water Sampling Locations

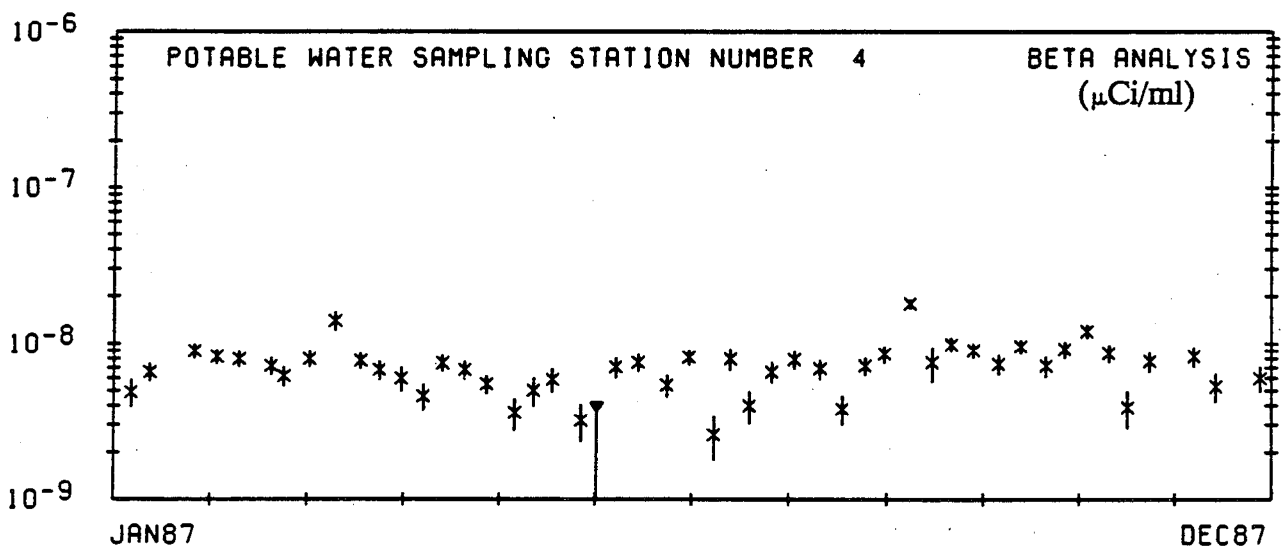
Station	Location
1	Area 3 Cafeteria
2	Area 2 Restroom
3	Area 12 Cafeteria
4	Area 23 Cafeteria
5	Area 27 Cafeteria
6	Area 6 Cascade Water
7	Area 6 Cafeteria


POTABLE WATER SAMPLING STATION NUMBER 1
BETA ANALYSIS
(µCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87

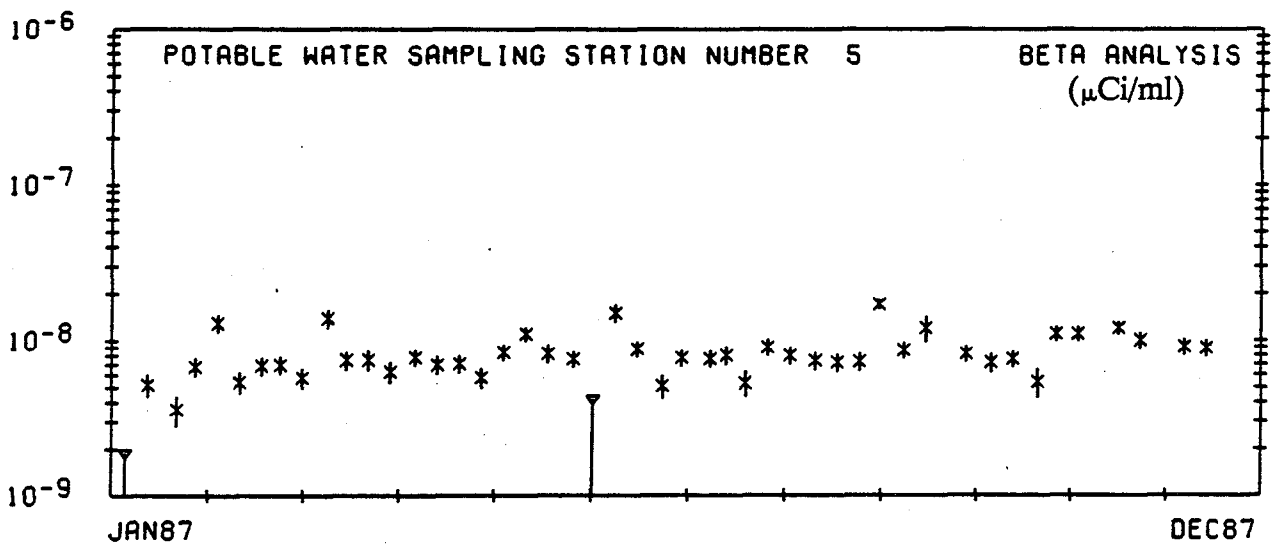

POTABLE WATER SAMPLING STATION NUMBER 2
BETA ANALYSIS
(µCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87



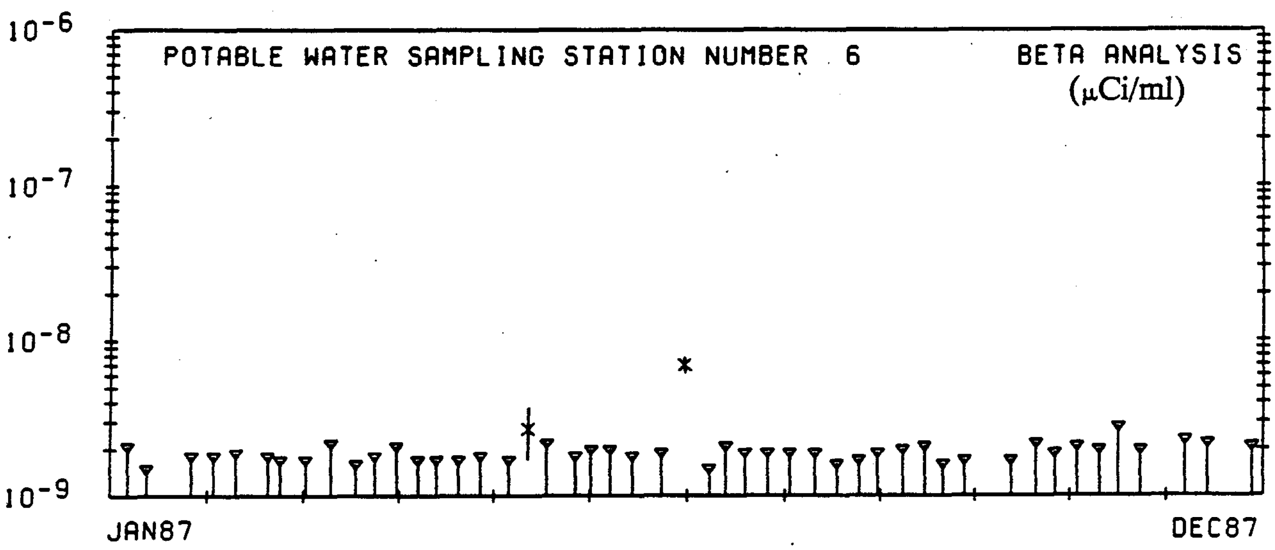
POTABLE WATER SAMPLING STATION NUMBER 3
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87



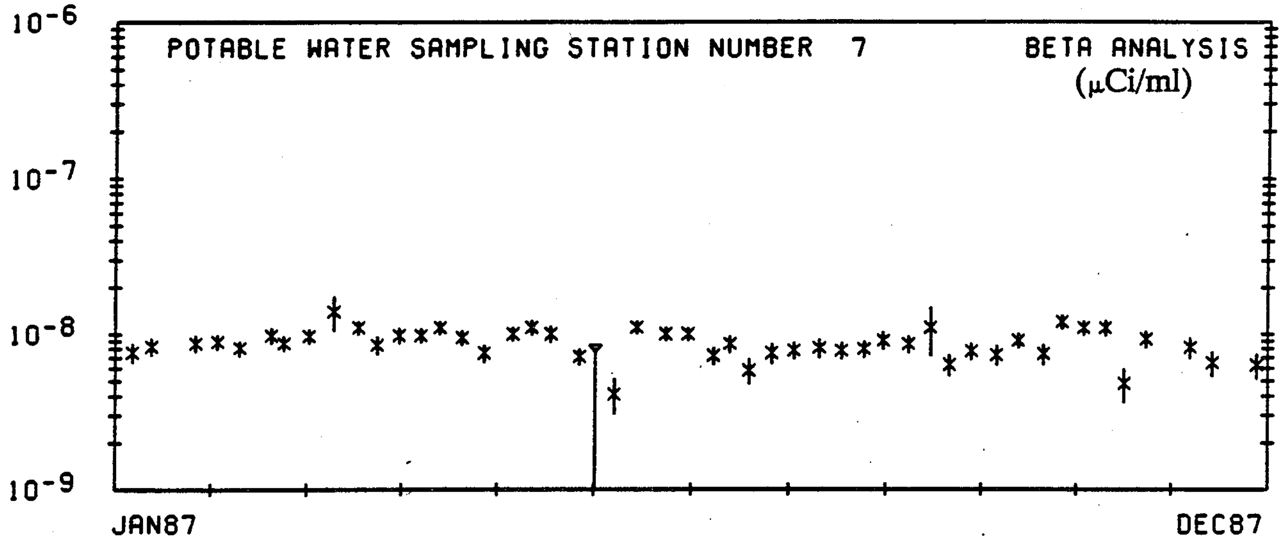
POTABLE WATER SAMPLING STATION NUMBER 4
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87



10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
POTABLE WATER SAMPLING STATION NUMBER 5
BETA ANALYSIS
(μCi/ml)
JAN87
DEC87



10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
POTABLE WATER SAMPLING STATION NUMBER 6
BETA ANALYSIS
(μCi/ml)
JAN87
DEC87



POTABLE WATER SAMPLING STATION NUMBER 7
BETA ANALYSIS (μCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87

APPENDIX E

NTS Environmental Monitoring

Open Reservoir Stations and Plots

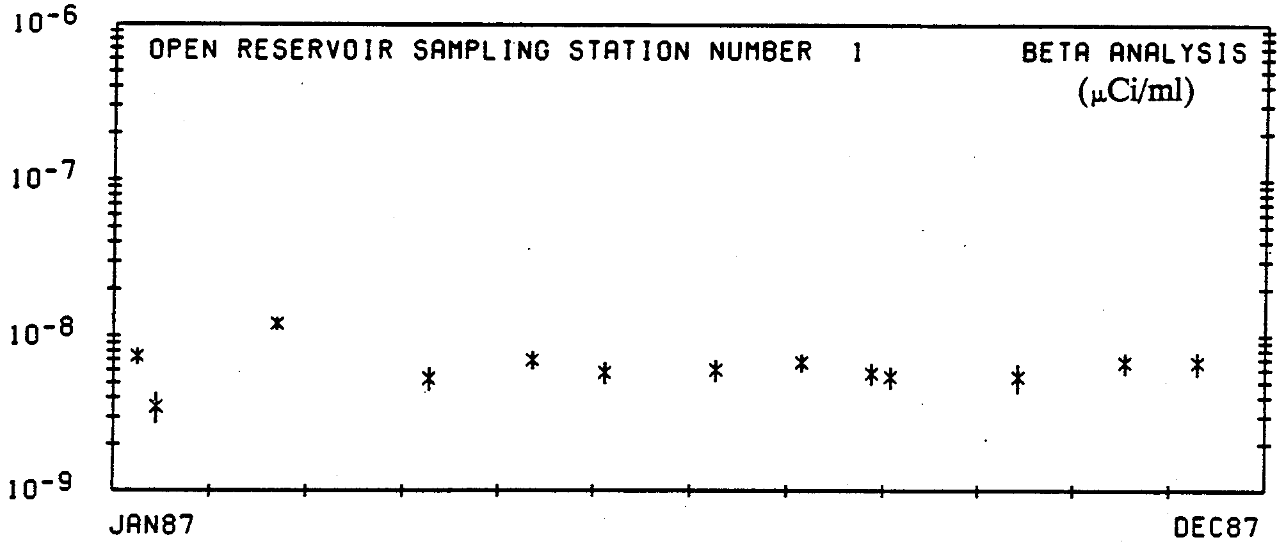
SYMBOLS

Several symbols are used in Appendix E to denote the data points. The plots display the gross beta data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits.

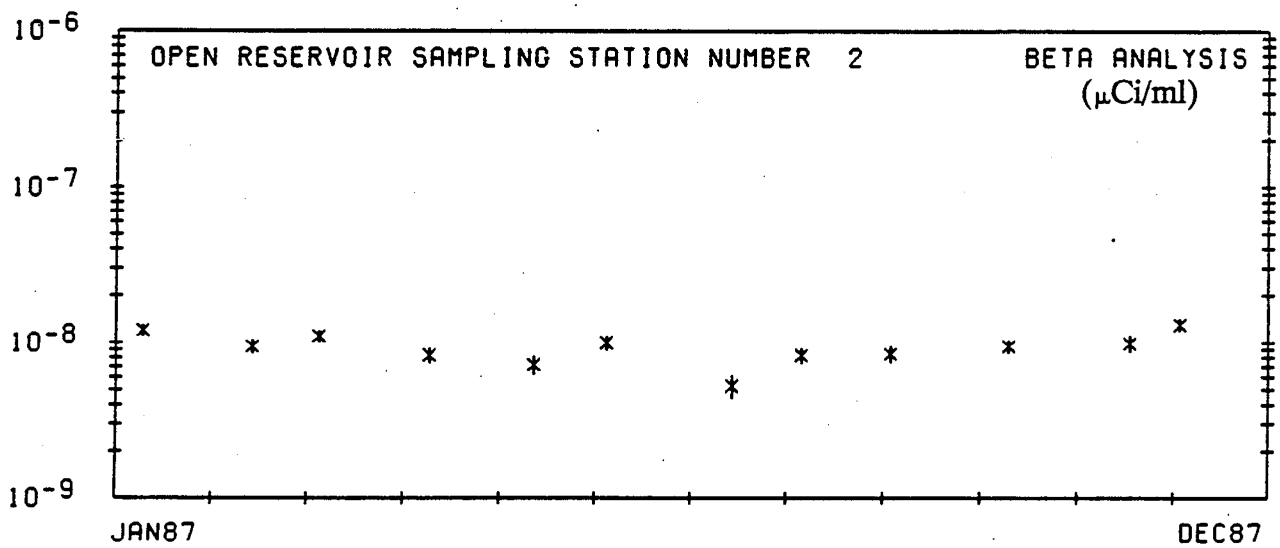
NTS Environmental Monitoring

Open Reservoir Sampling Locations

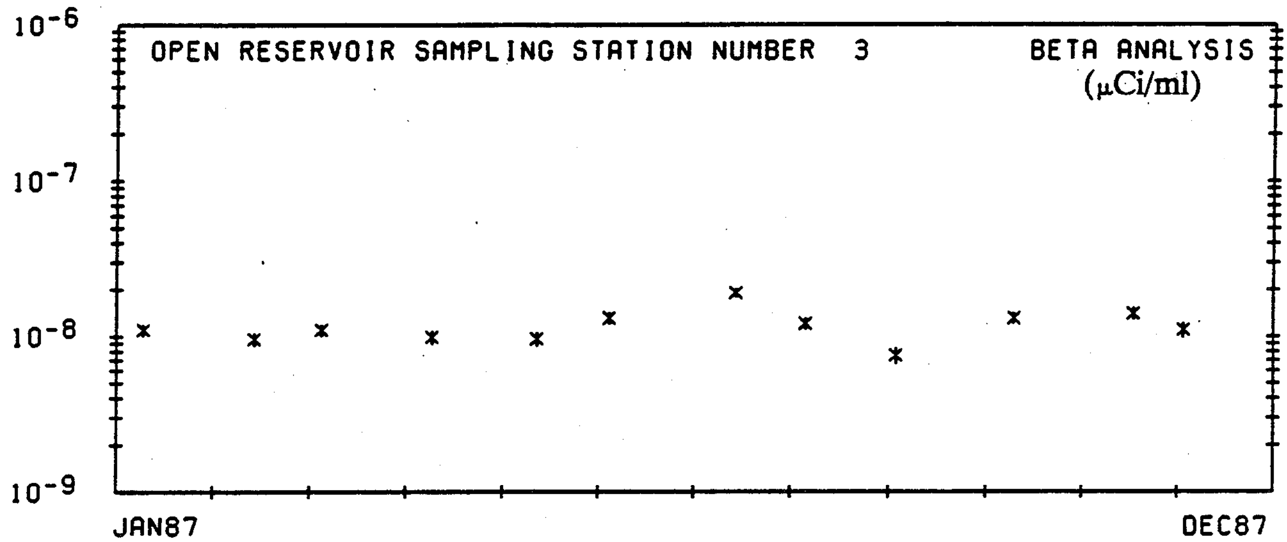
Station	Location
1	Area 2 Well 2 Reservoir
2	Area 3 Well A Reservoir
3	Area 5 Well 5B Reservoir
4	Area 5 Well UE5c Reservoir
5	Area 6 Well 3 Reservoir
6	Area 6 Well C1 Reservoir
8	Area 18 Camp 17 Reservoir
11	Area 20 Well 20A Reservoir
12	Area 23 Swimming Pool
16	Area 19 Well U19c Reservoir
17	Area 25 Well J 12 Reservoir
18	Area 3 Mud Plant Reservoir
19	Area 2 Mud Plant Reservoir
20	Area 25 Well J 11
21	Area 18 Well 8 Reservoir

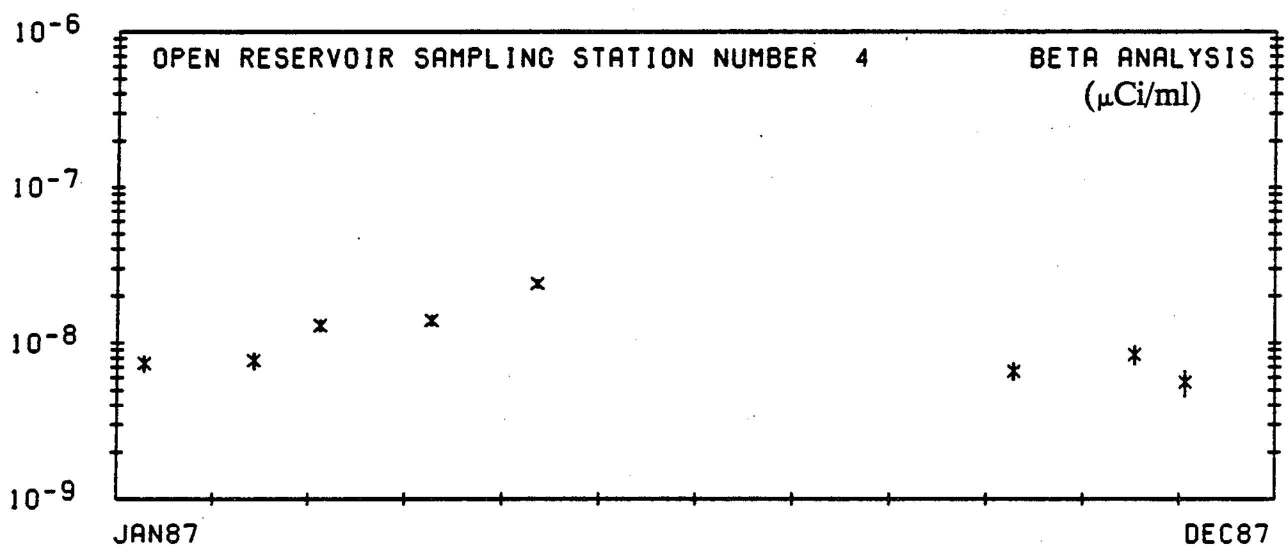


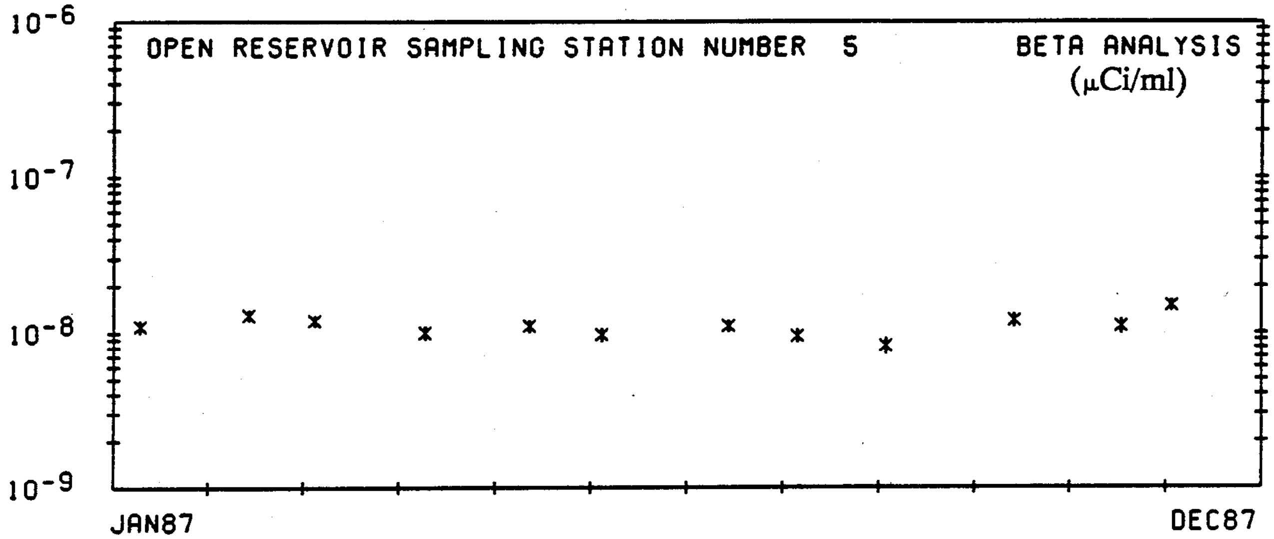
OPEN RESERVOIR SAMPLING STATION NUMBER 1
BETA ANALYSIS
(µCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87

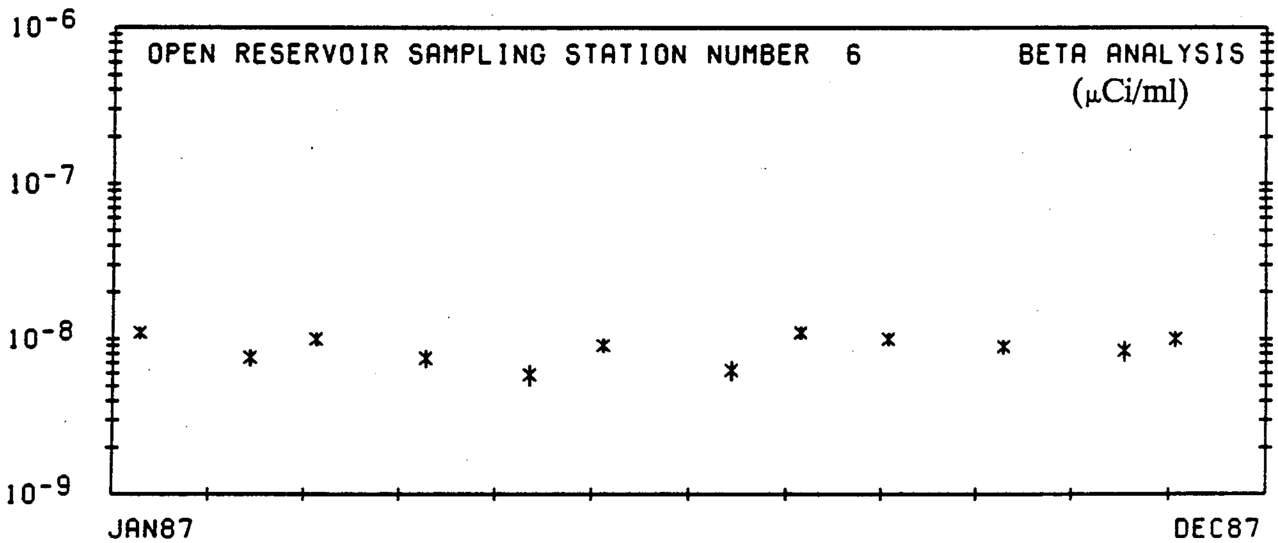


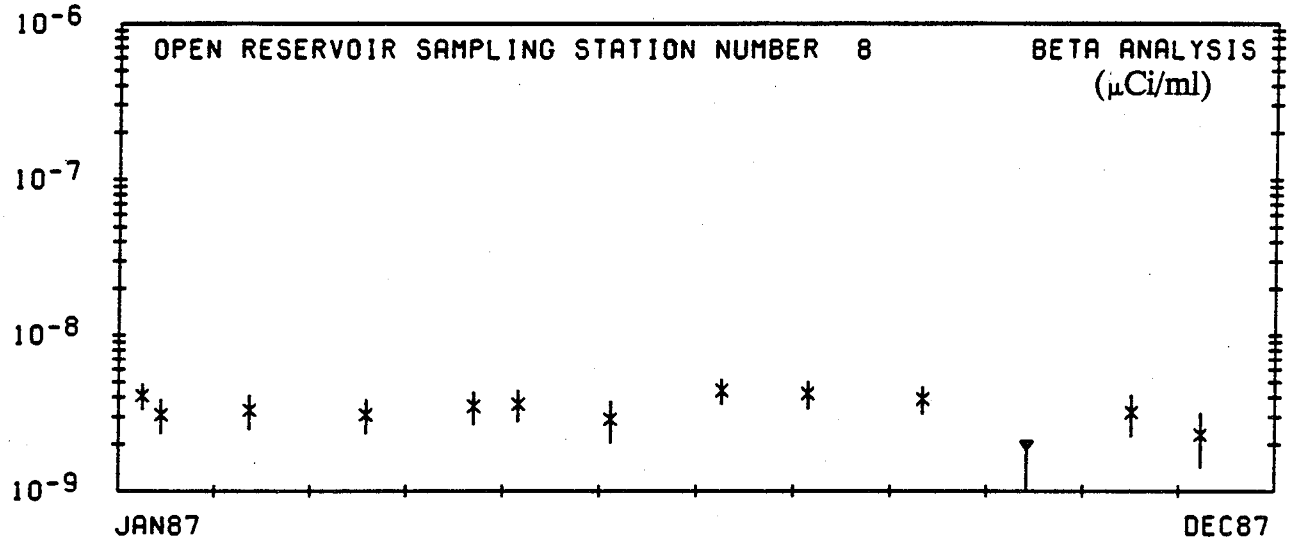
OPEN RESERVOIR SAMPLING STATION NUMBER 2
BETA ANALYSIS
(µCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87


OPEN RESERVOIR SAMPLING STATION NUMBER 3
BETA ANALYSIS
(μCi/ml)
10^{-6}
10^{-7}
10^{-8}
10^{-9}
JAN87
DEC87

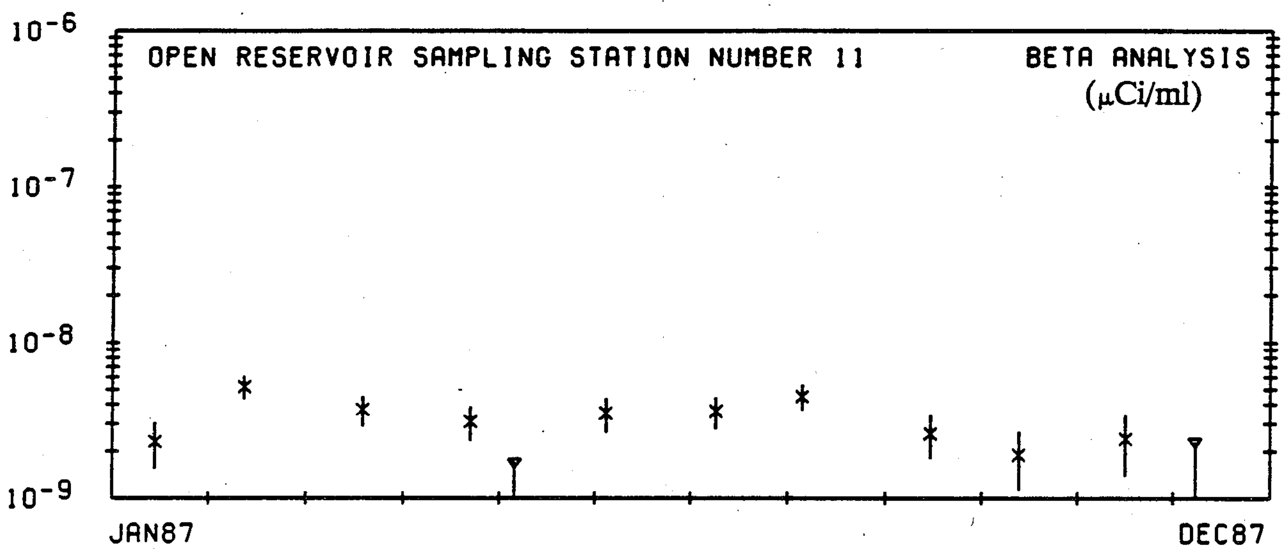

OPEN RESERVOIR SAMPLING STATION NUMBER 4
BETA ANALYSIS
(μCi/ml)
10^{-6}
10^{-7}
10^{-8}
10^{-9}
JAN87
DEC87


10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
OPEN RESERVOIR SAMPLING STATION NUMBER 5
BETA ANALYSIS
(μCi/ml)
JAN87
DEC87

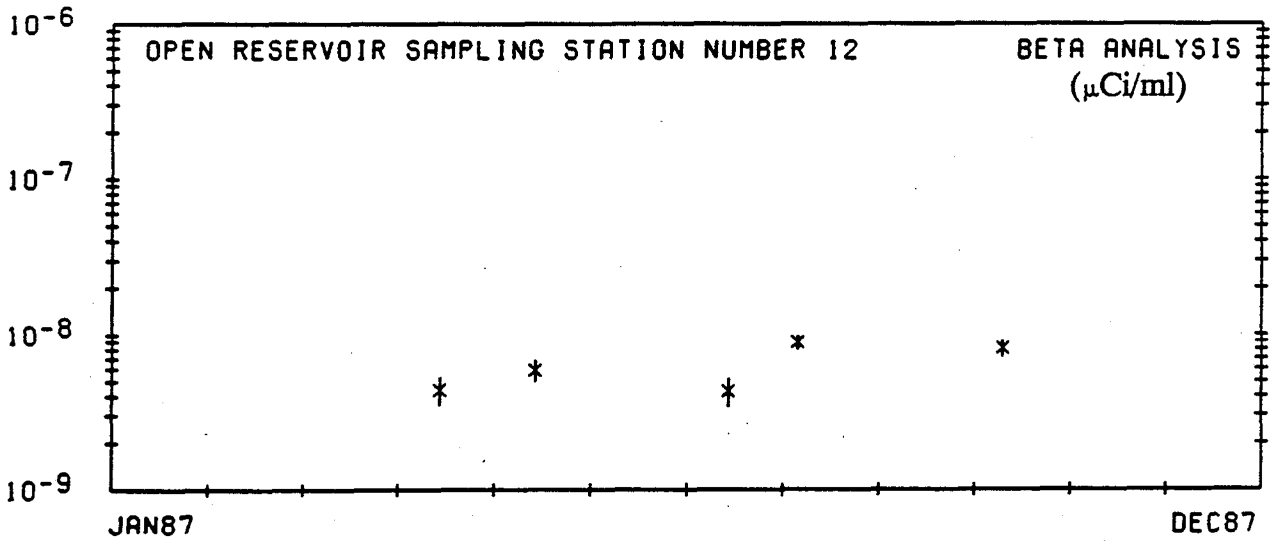

10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
OPEN RESERVOIR SAMPLING STATION NUMBER 6
BETA ANALYSIS
(μCi/ml)
JAN87
DEC87

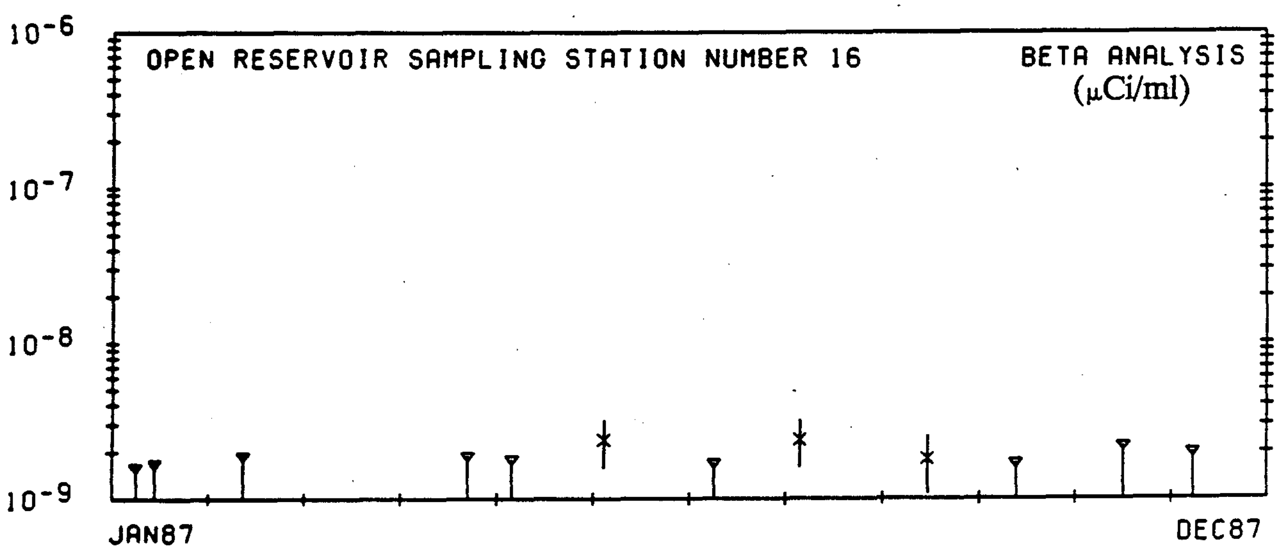


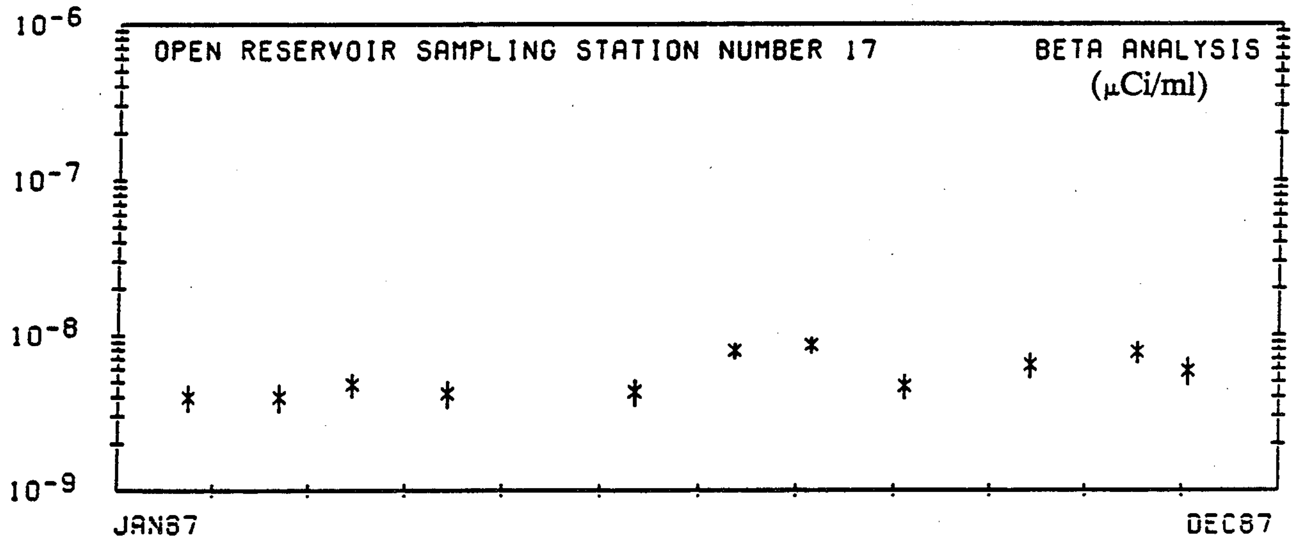
OPEN RESERVOIR SAMPLING STATION NUMBER 8
BETA ANALYSIS
(µCi/ml)
10^-6
10^-7
10^-8
10^-9
JAN87
DEC87

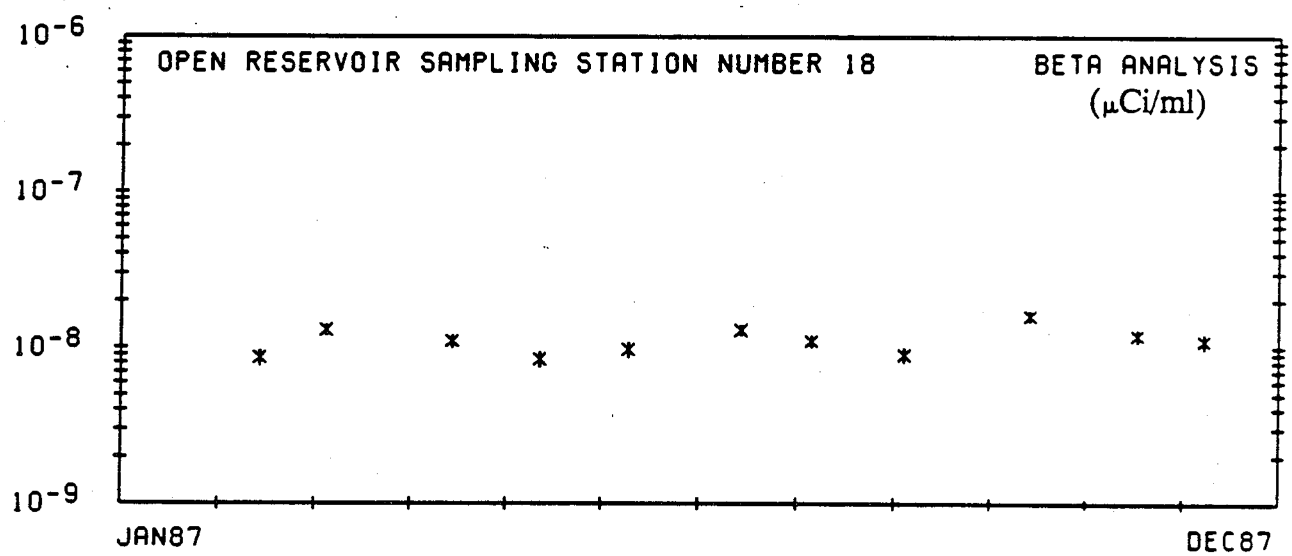


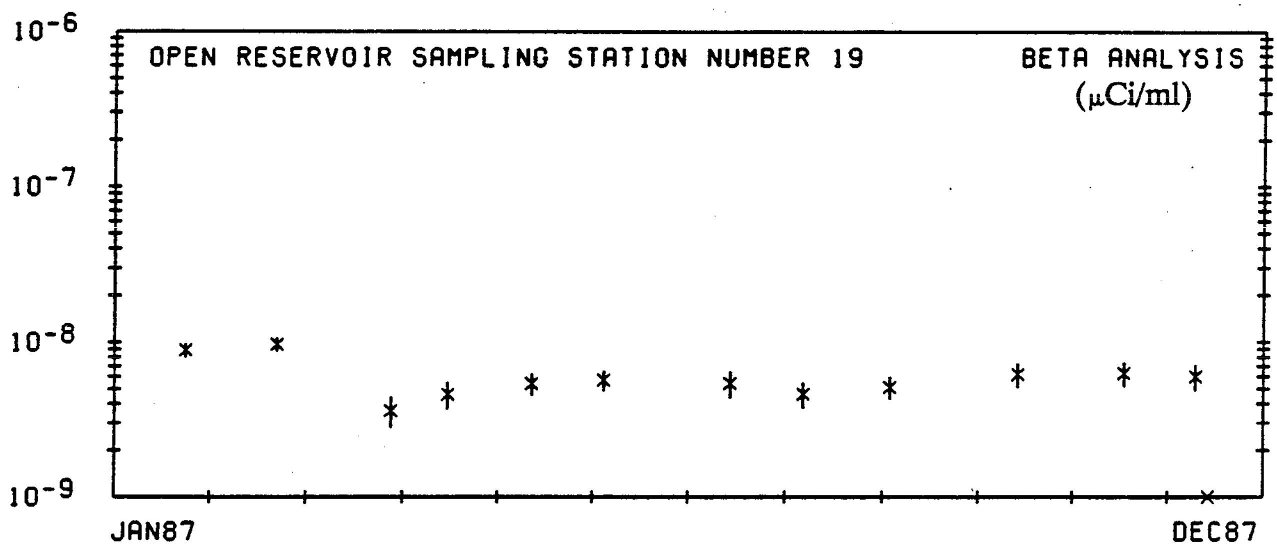
OPEN RESERVOIR SAMPLING STATION NUMBER 11
BETA ANALYSIS
(µCi/ml)
10^-6
10^-7
10^-8
10^-9
JAN87
DEC87

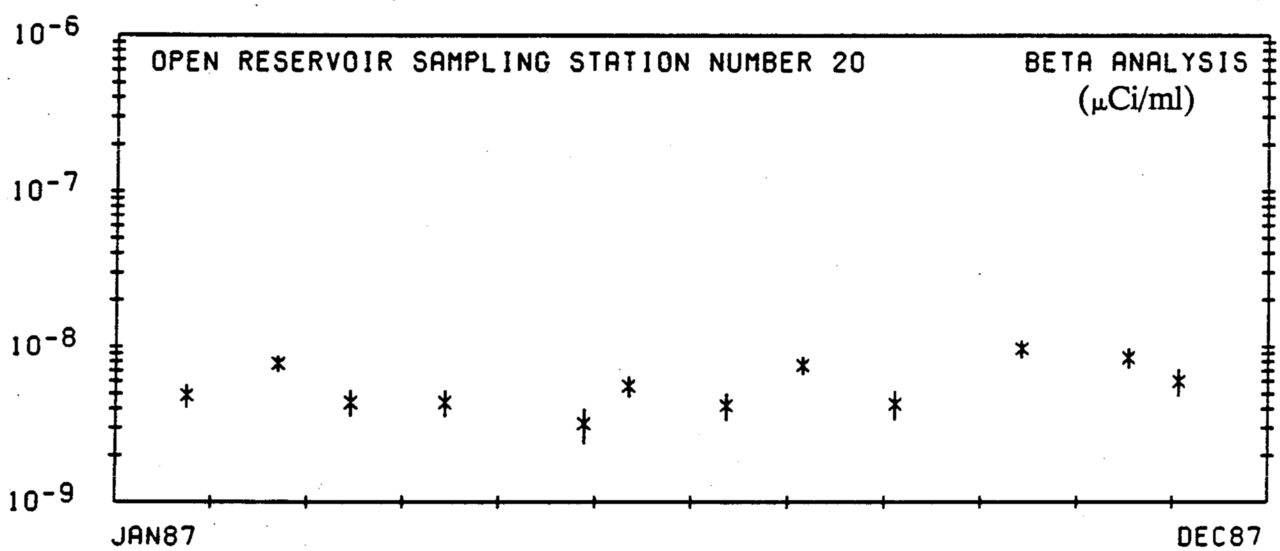

OPEN RESERVOIR SAMPLING STATION NUMBER 12
BETA ANALYSIS
(µCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87

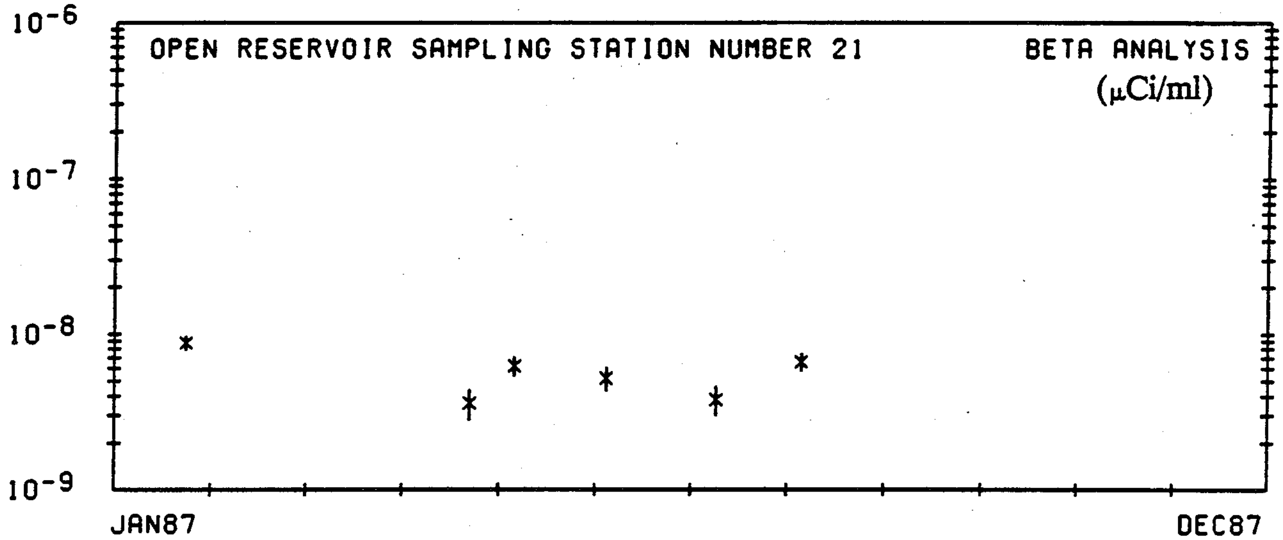

OPEN RESERVOIR SAMPLING STATION NUMBER 16
BETA ANALYSIS
(µCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87


OPEN RESERVOIR SAMPLING STATION NUMBER 17
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87


OPEN RESERVOIR SAMPLING STATION NUMBER 18
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87


10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
OPEN RESERVOIR SAMPLING STATION NUMBER 19
BETA ANALYSIS
(µCi/ml)
JAN87
DEC87


10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
OPEN RESERVOIR SAMPLING STATION NUMBER 20
BETA ANALYSIS
(µCi/ml)
JAN87
DEC87


OPEN RESERVOIR SAMPLING STATION NUMBER 21
BETA ANALYSIS
(µCi/ml)
10-6
10-7
10-8
10-9
JAN87
DEC87

APPENDIX F

NTS Environmental Monitoring

Natural Spring Stations and Plots

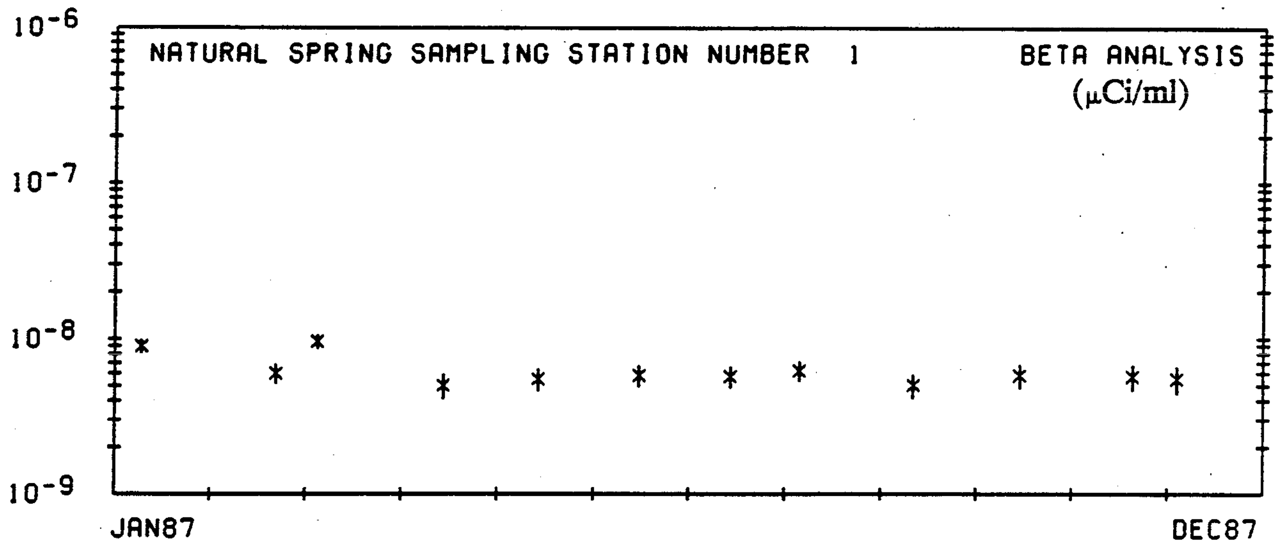
SYMBOLS

Several symbols are used in Appendix F to denote the data points. The plots display the gross beta data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits.

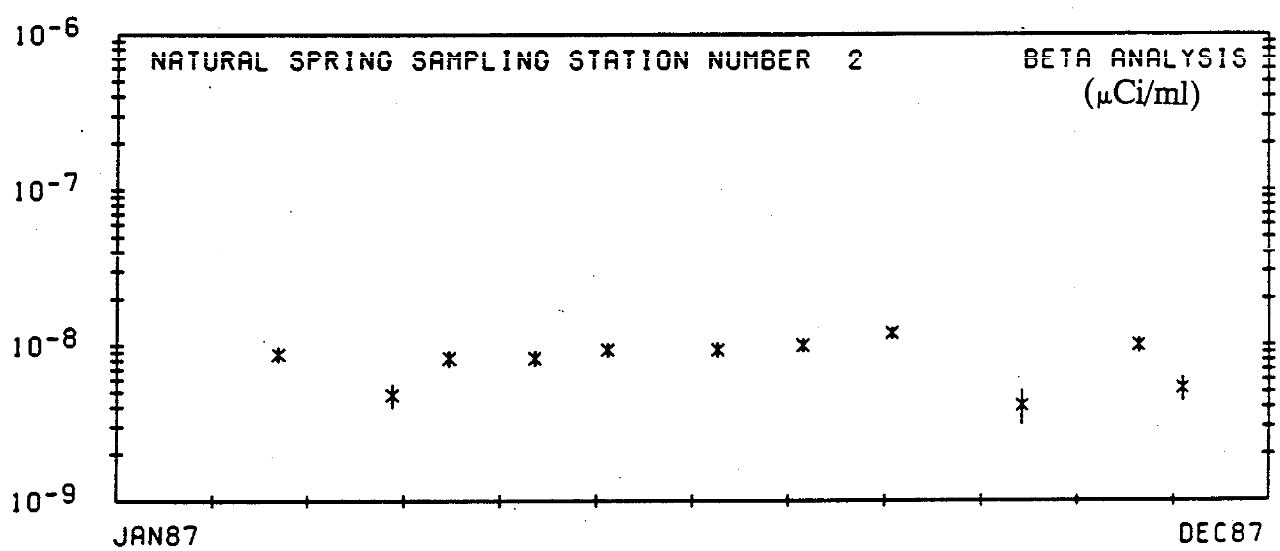
NTS Environmental Monitoring

Natural Spring Sampling Locations

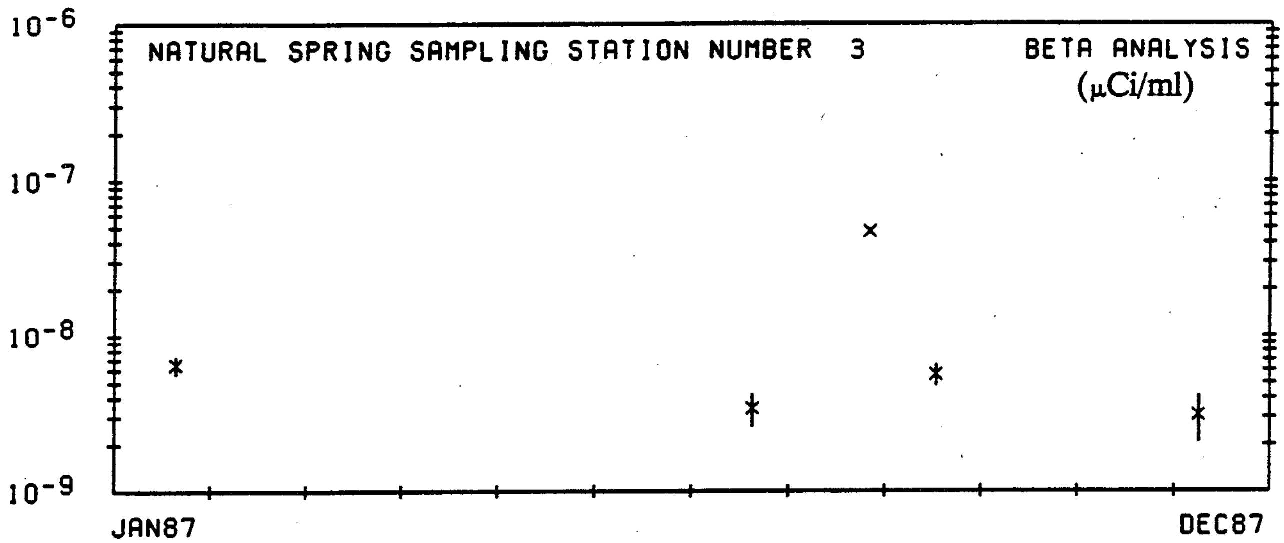
Station	Location
1	Area 5 Cane Spring
2	Area 12 White Rock Spring
3	Area 12 Captain Jack Spring
4	Area 12 Gold Meadows Pond
6	Area 15 Tub Spring
7	Area 29 Topopah Spring
8	Area 7 Reitmann Seep
9	Area 16 Tippipah Spring

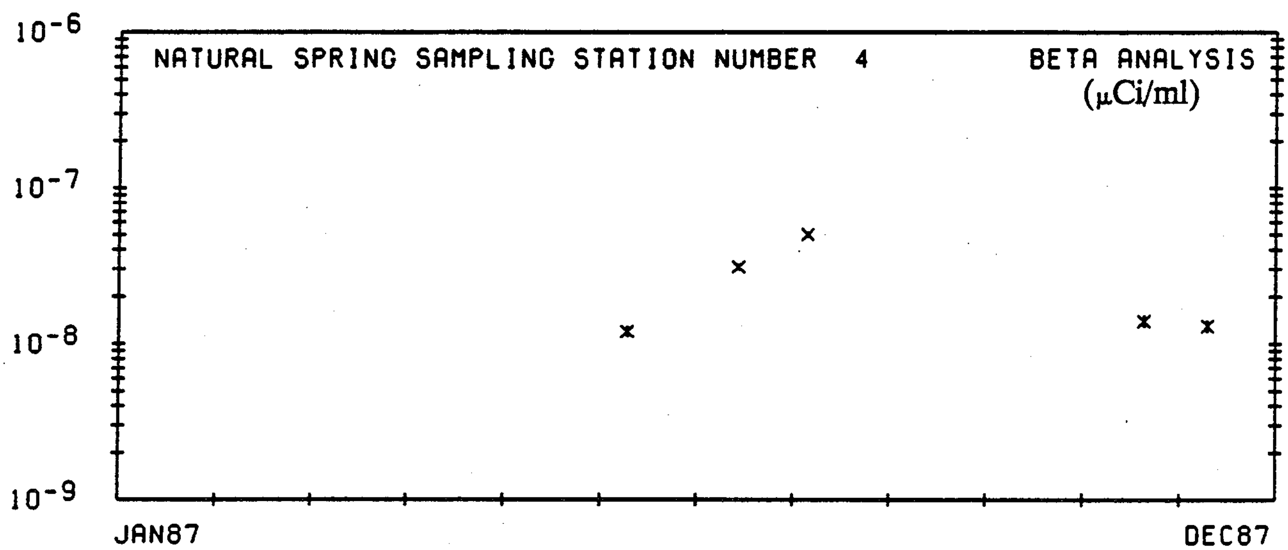


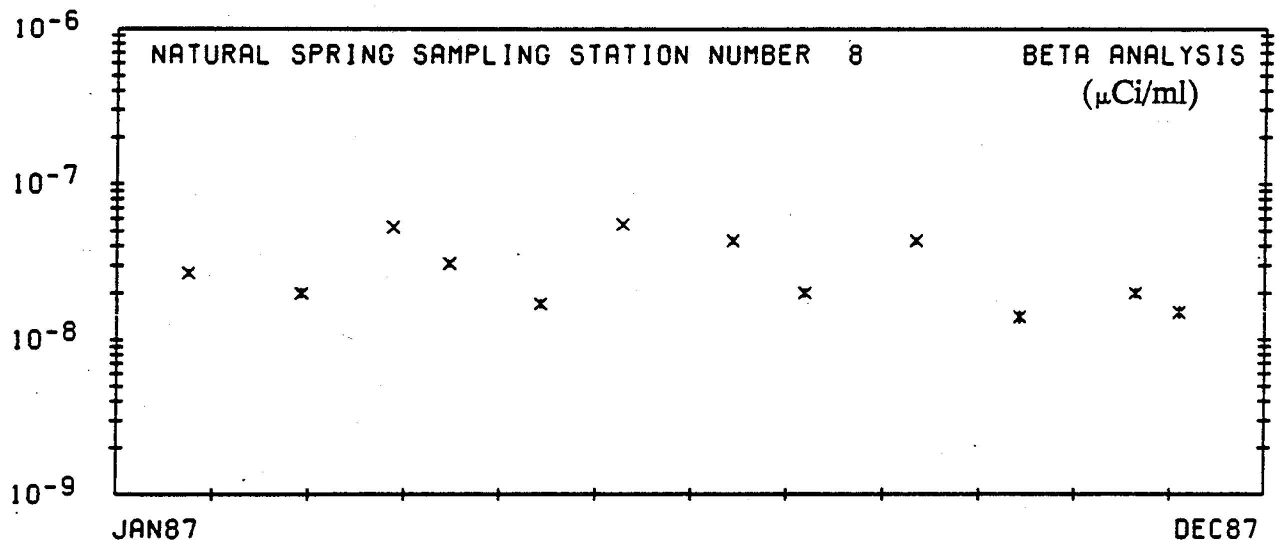
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
NATURAL SPRING SAMPLING STATION NUMBER 1
BETA ANALYSIS (μCi/ml)
JAN87
DEC87

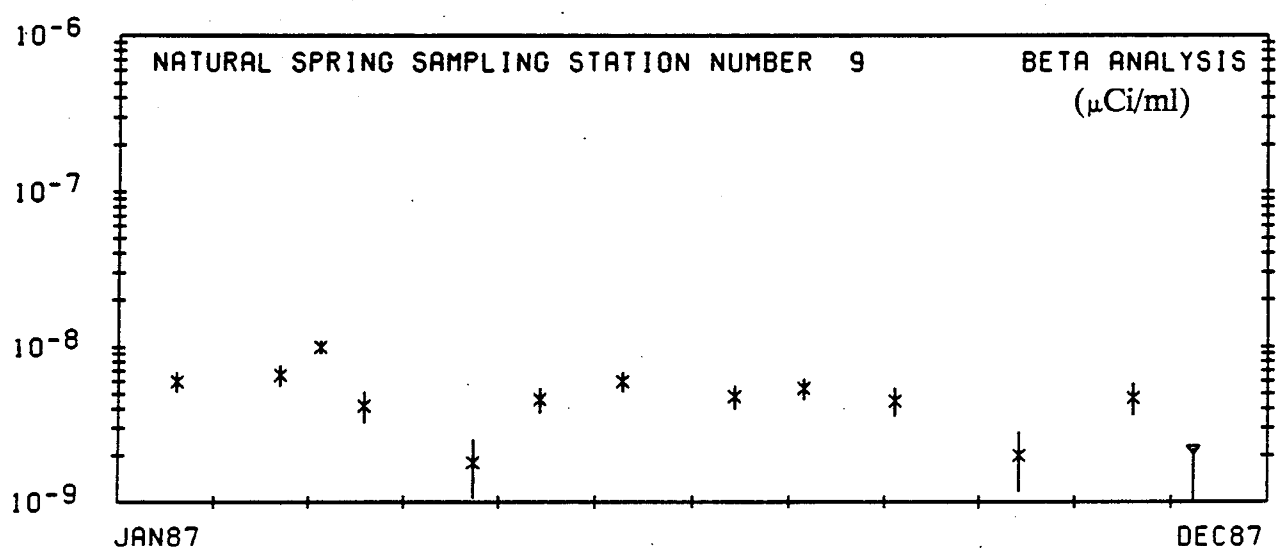


10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
NATURAL SPRING SAMPLING STATION NUMBER 2
BETA ANALYSIS (μCi/ml)
JAN87
DEC87


NATURAL SPRING SAMPLING STATION NUMBER 3
BETA ANALYSIS (μCi/ml)
10^-6
10^-7
10^-8
10^-9
JAN87
DEC87


NATURAL SPRING SAMPLING STATION NUMBER 4
BETA ANALYSIS (μCi/ml)
10^-6
10^-7
10^-8
10^-9
JAN87
DEC87


NATURAL SPRING SAMPLING STATION NUMBER 8
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87


NATURAL SPRING SAMPLING STATION NUMBER 9
BETA ANALYSIS
(μCi/ml)
10⁻⁶
10⁻⁷
10⁻⁸
10⁻⁹
JAN87
DEC87

APPENDIX G

NTS Environmental Monitoring

Contaminated Pond Stations and Plots

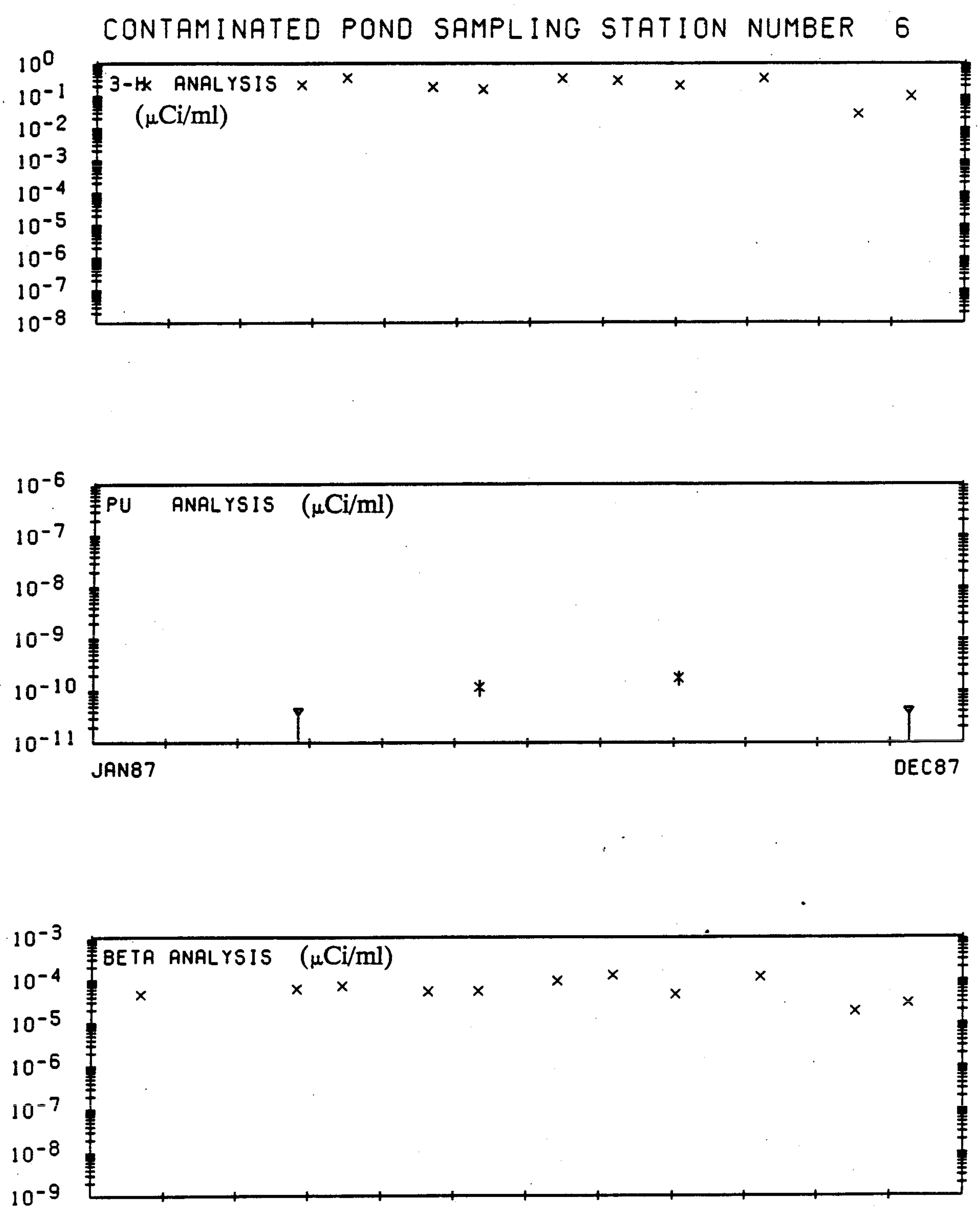
SYMBOLS

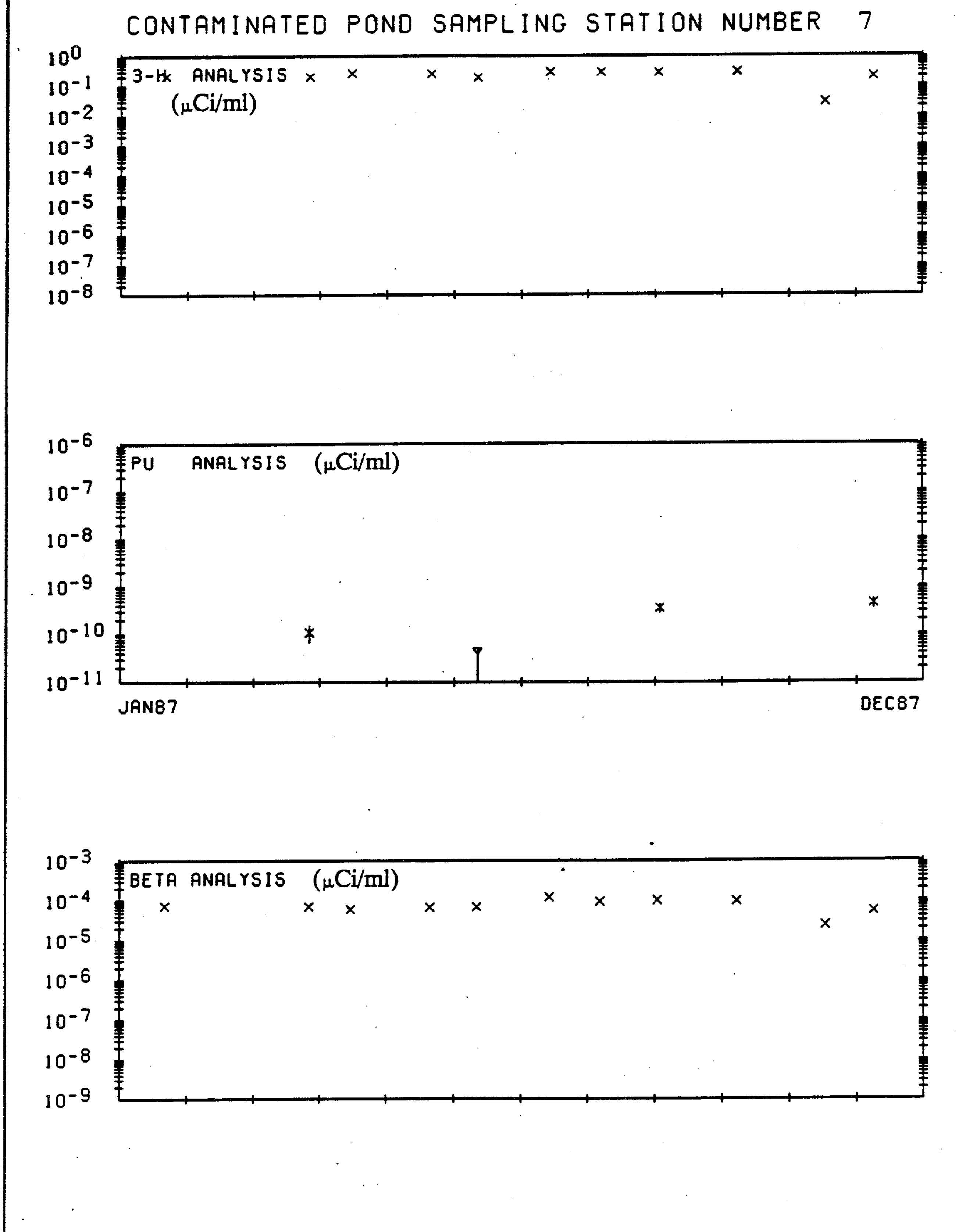
Several symbols are used in Appendix G to denote the data points. The plots display the gross beta data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits. For each station, gross beta, plutonium 239 and tritium is plotted.

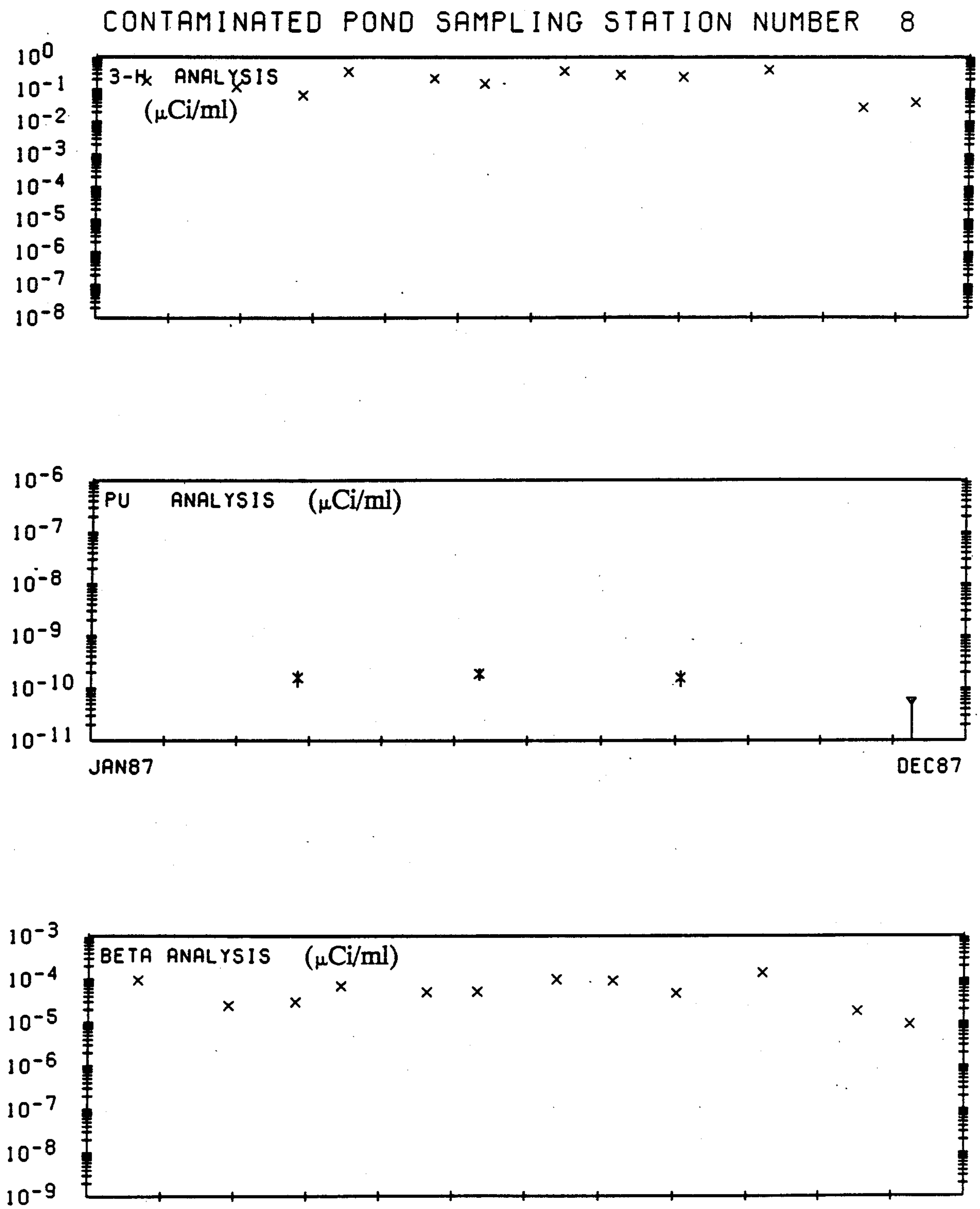
NTS Environmental Monitoring

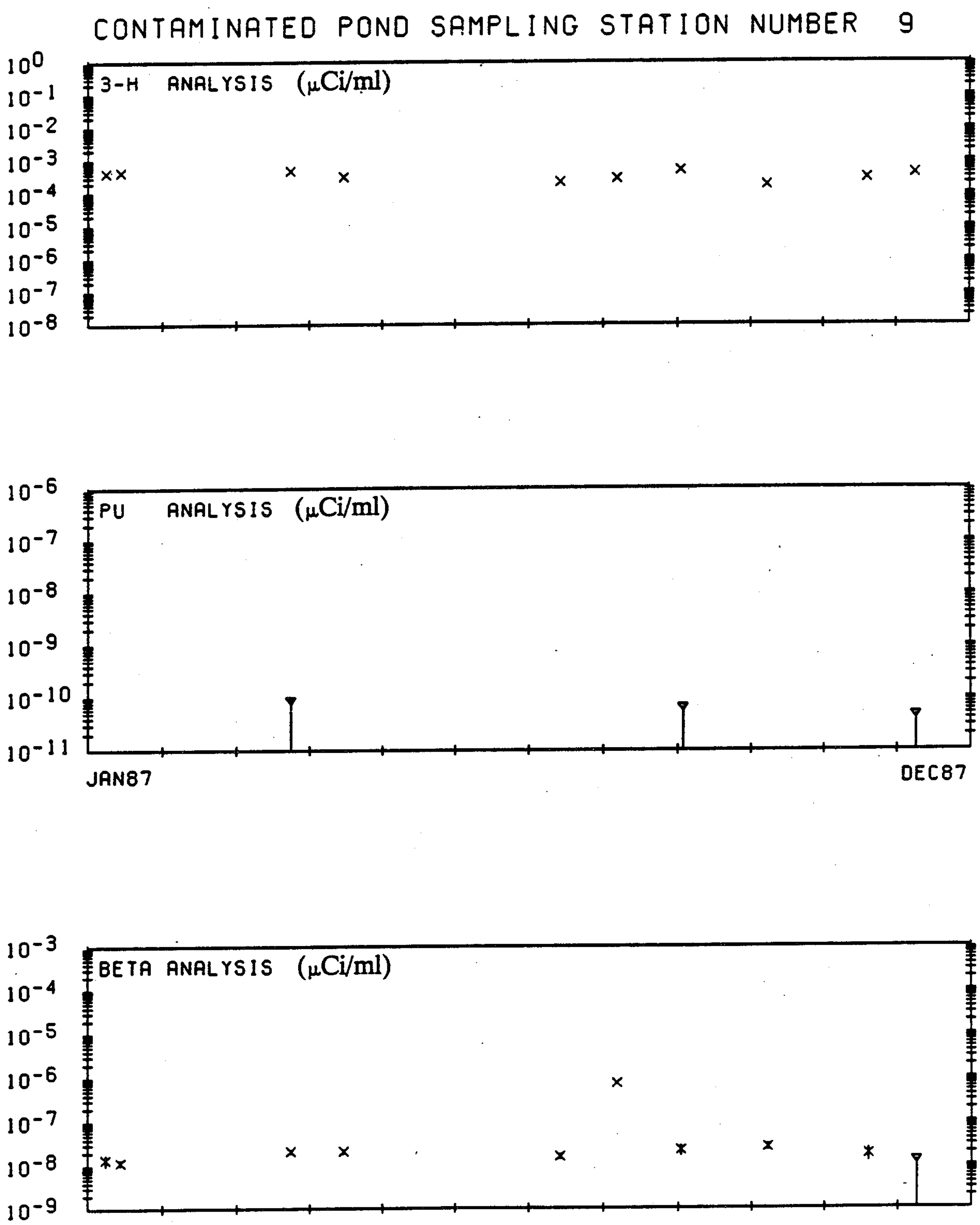
Contaminated Pond Sampling Locations

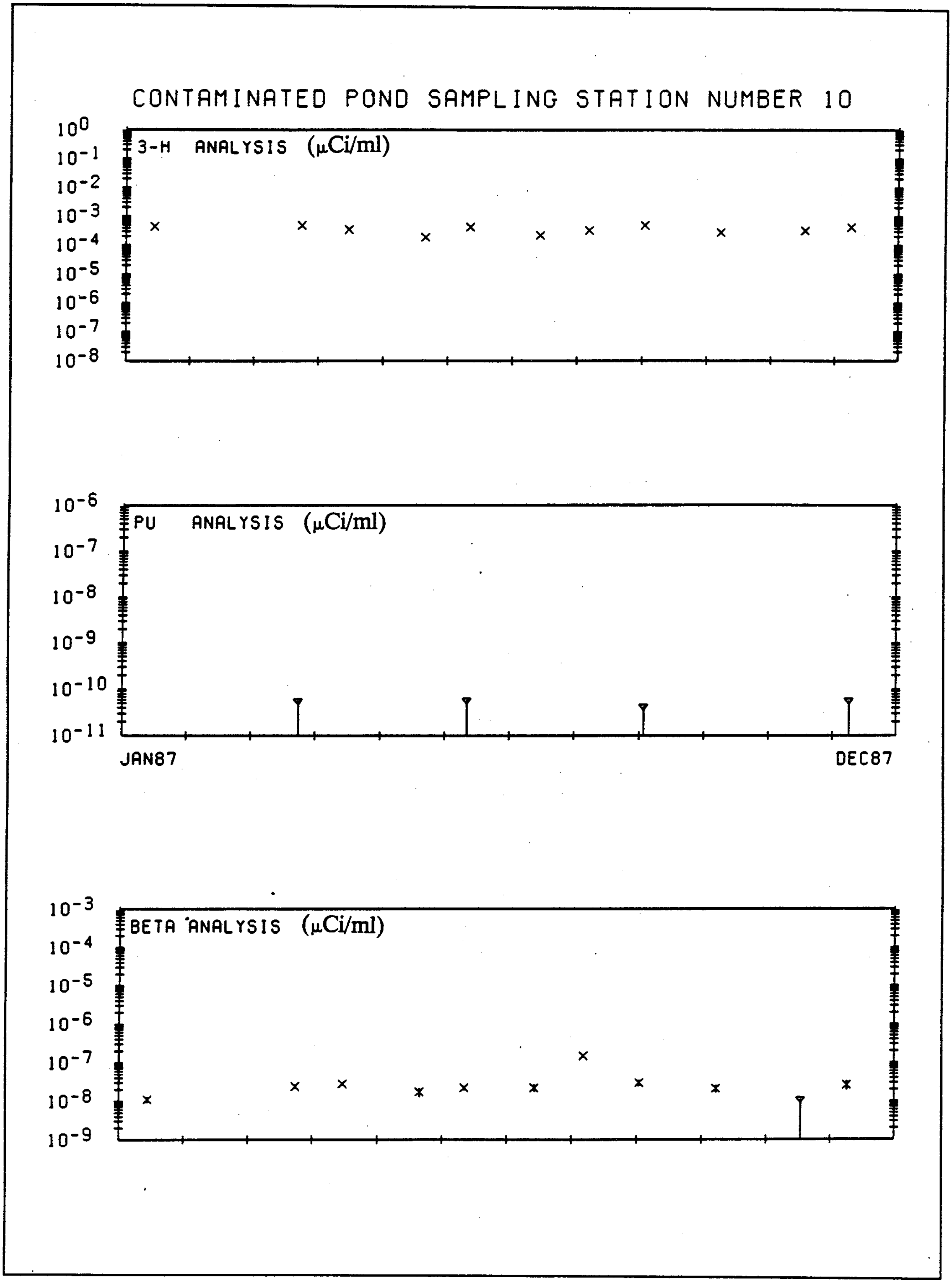
Station	Location
6	T Tunnel Pond No. 1
7	T Tunnel Pond No. 2
8	T Tunnel Effluent
9	N Tunnel Pond No. 1
10	N Tunnel Pond No. 2
11	N Tunnel Pond No. 3
12	N Tunnel Effluent
13	Yucca Waste Pond
14	E Tunnel Effluent

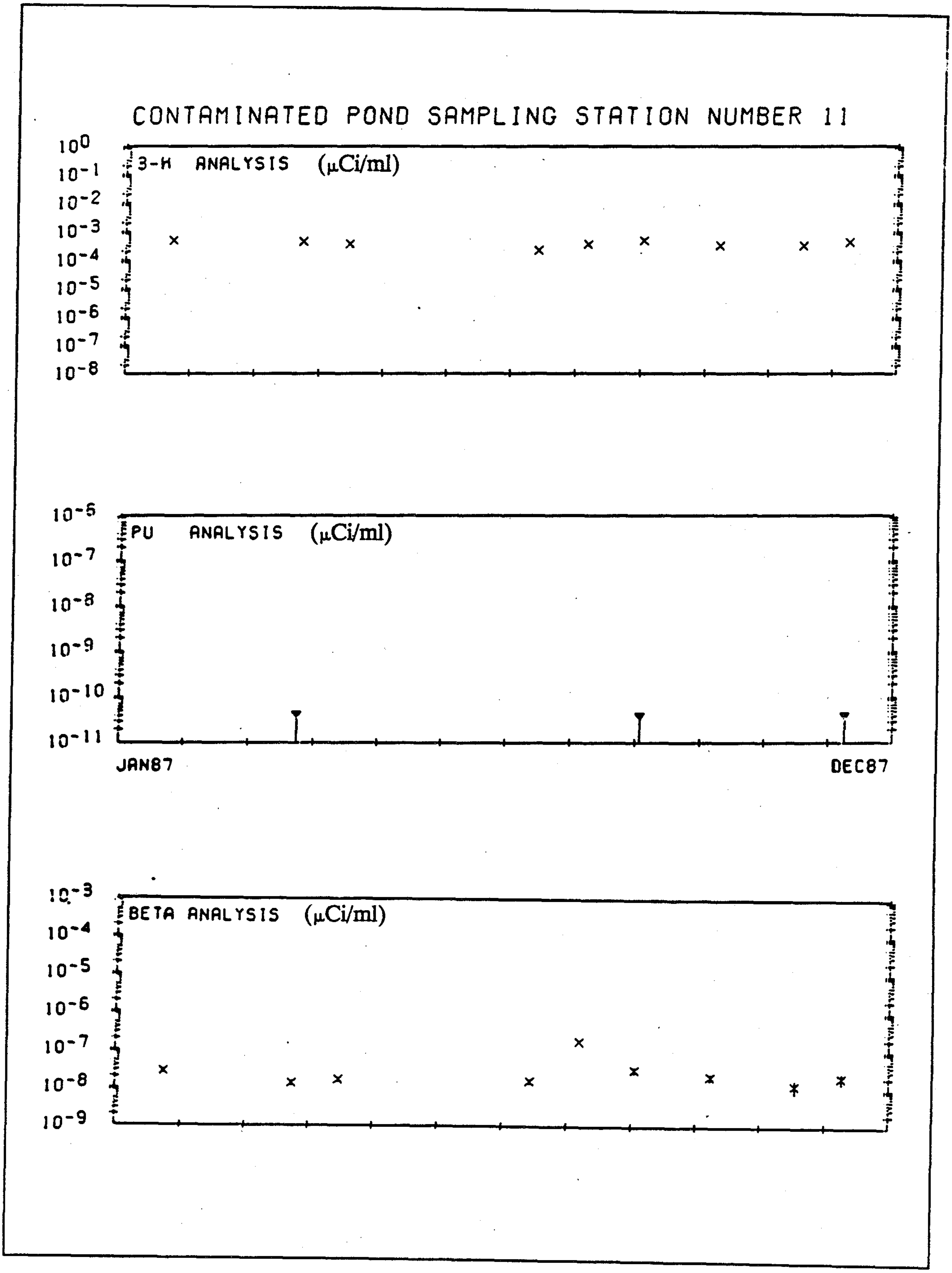

CONTAMINATED POND SAMPLING STATION NUMBER 6
3-H ANALYSIS
(µCi/ml)
PU ANALYSIS (µCi/ml)
BETA ANALYSIS (µCi/ml)
JAN87
DEC87
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}

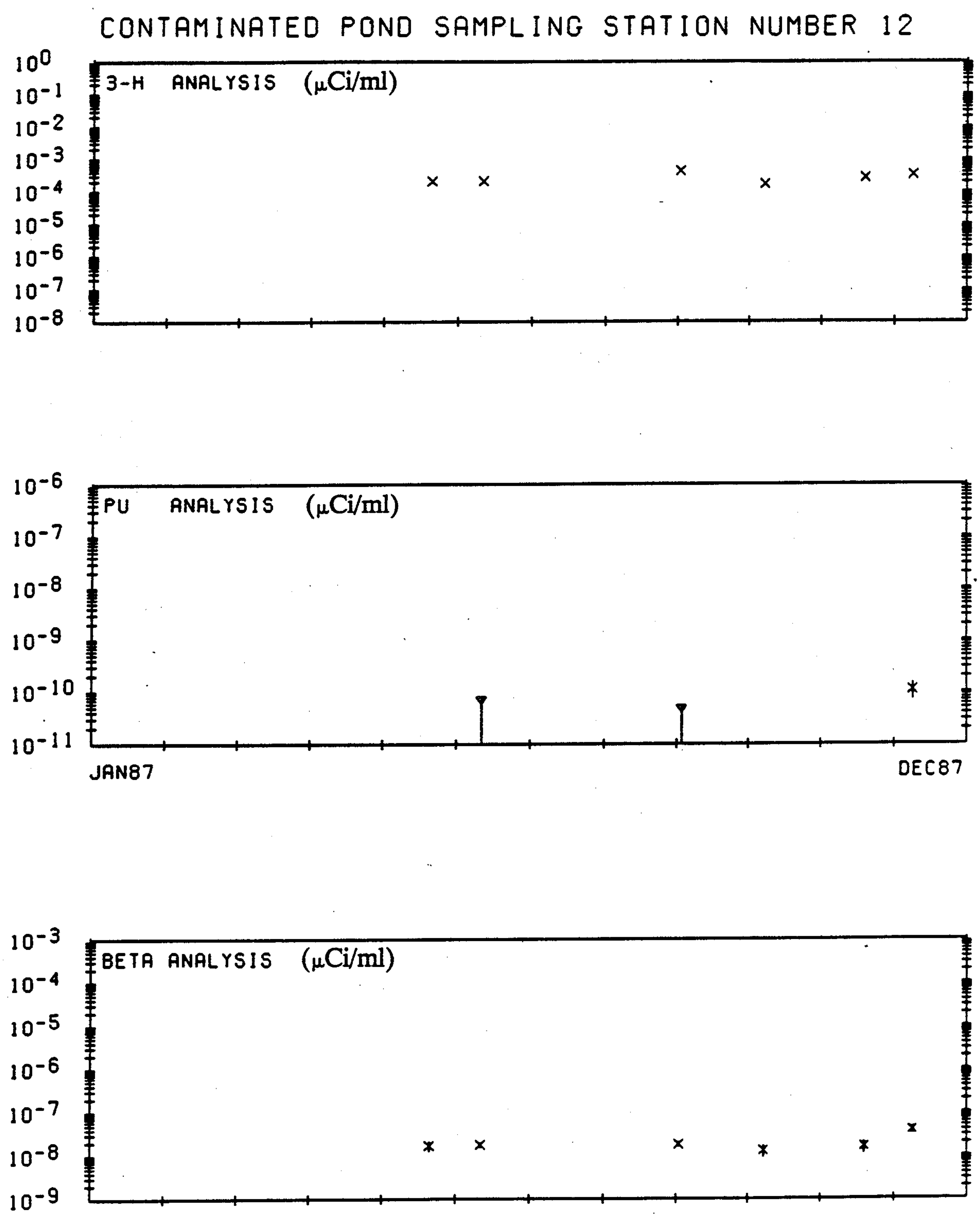

CONTAMINATED POND SAMPLING STATION NUMBER 7
3-H ANALYSIS (μCi/ml)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS (μCi/ml)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN87
DEC87
BETA ANALYSIS (μCi/ml)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9

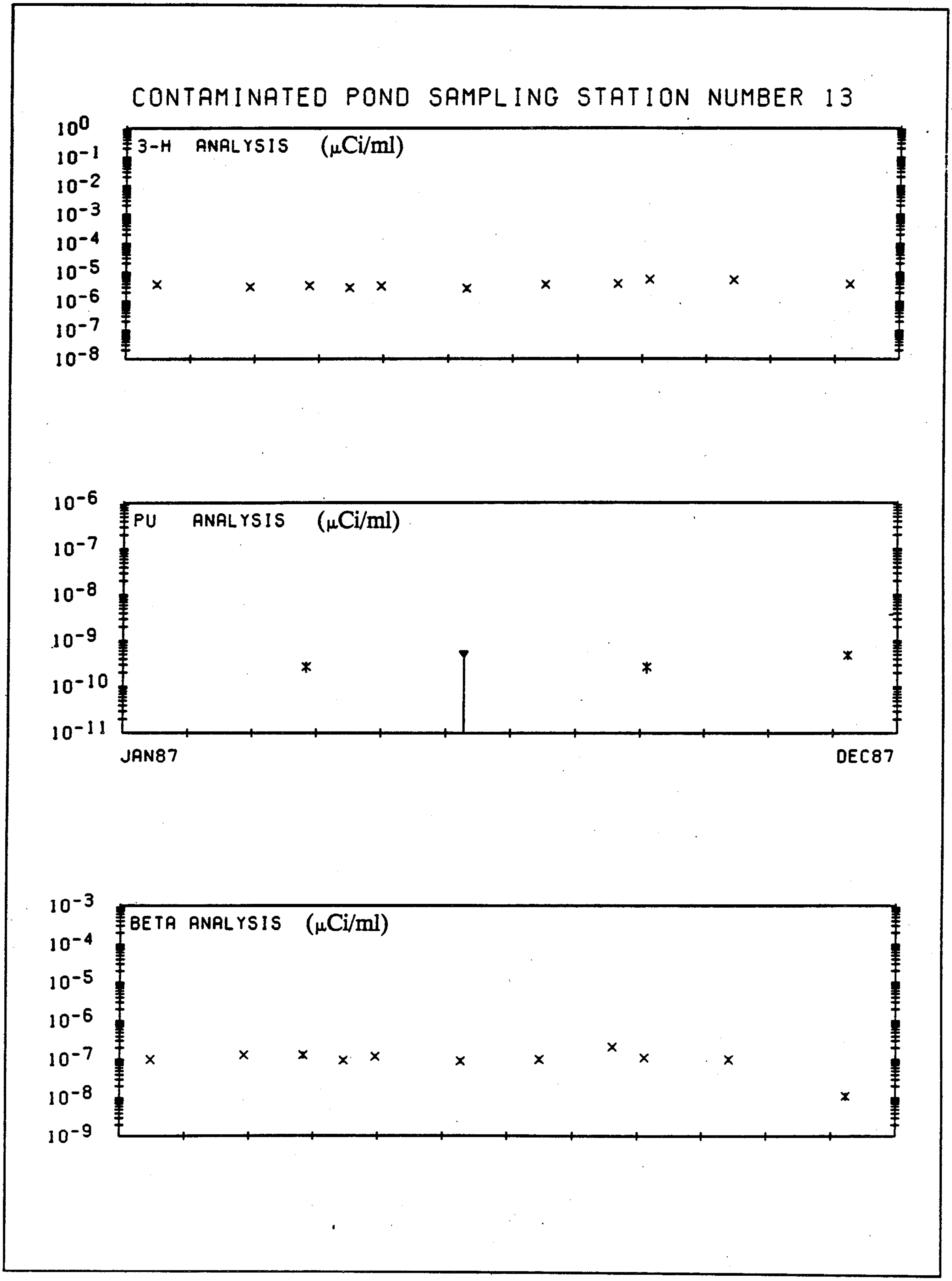

CONTAMINATED POND SAMPLING STATION NUMBER 8
3-H ANALYSIS
(µCi/ml)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS (µCi/ml)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN87
DEC87
BETA ANALYSIS (µCi/ml)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9

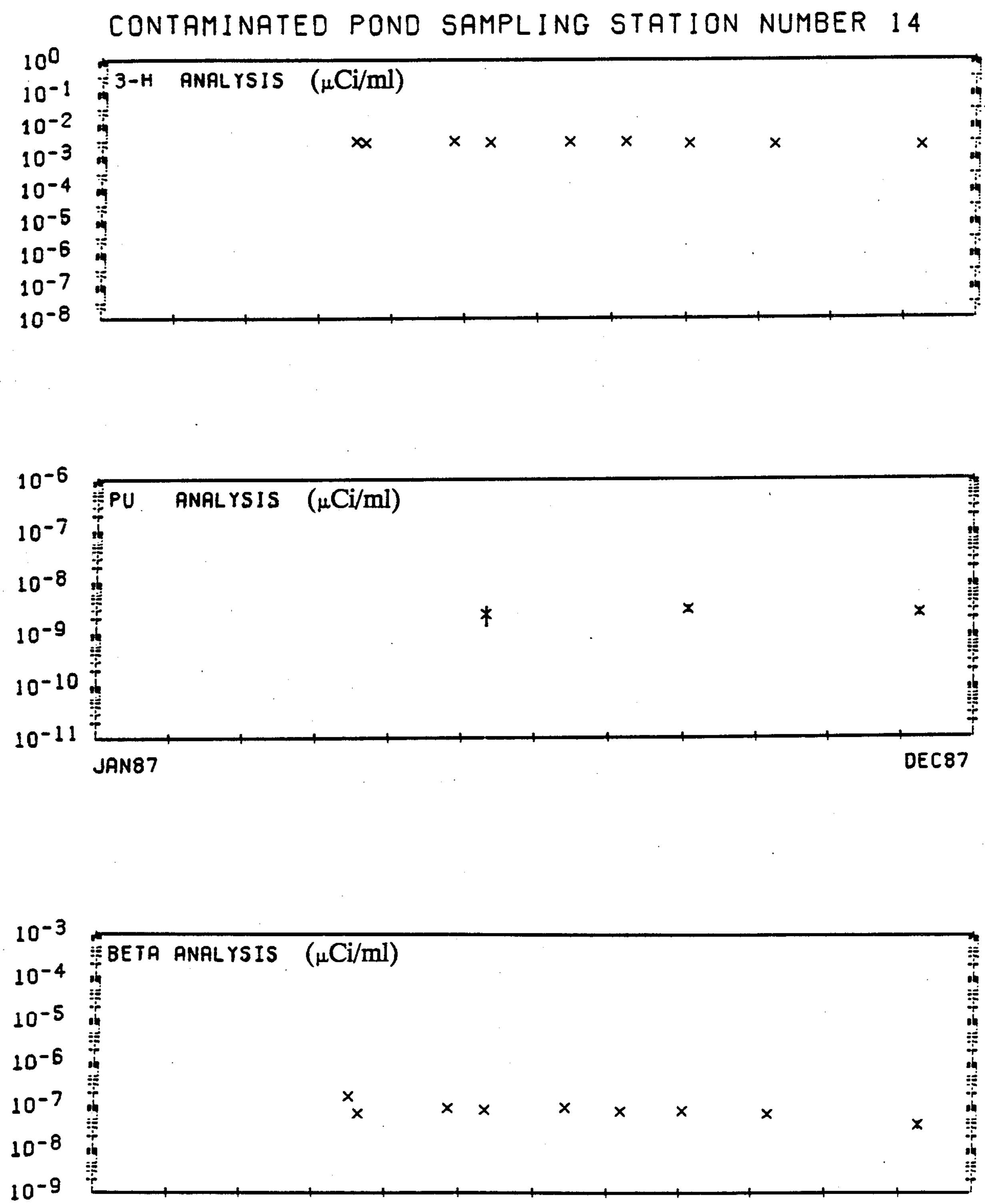

CONTAMINATED POND SAMPLING STATION NUMBER 9
3-H ANALYSIS (μCi/ml)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS (μCi/ml)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN87
DEC87
BETA ANALYSIS (μCi/ml)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9


CONTAMINATED POND SAMPLING STATION NUMBER 10
3-H ANALYSIS (μCi/ml)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS (μCi/ml)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN87
DEC87
BETA ANALYSIS (μCi/ml)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9


CONTAMINATED POND SAMPLING STATION NUMBER 11
3-H ANALYSIS (µCi/ml)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS (µCi/ml)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN87
DEC87
BETA ANALYSIS (µCi/ml)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9


CONTAMINATED POND SAMPLING STATION NUMBER 12
3-H ANALYSIS (μCi/ml)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS (μCi/ml)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN87
DEC87
BETA ANALYSIS (μCi/ml)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9


CONTAMINATED POND SAMPLING STATION NUMBER 13
3-H ANALYSIS (μCi/ml)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS (μCi/ml)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN87
DEC87
BETA ANALYSIS (μCi/ml)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9


CONTAMINATED POND SAMPLING STATION NUMBER 14
3-H ANALYSIS (µCi/ml)
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS (µCi/ml)
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN87
DEC87
BETA ANALYSIS (µCi/ml)
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9