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#43

ONSITE ENVIRONMENTAL REPORT FOR THE NEVADA TEST SITE

(JANUARY 1988 THROUGH DECEMBER 1988)

By
Daniel A. Gonzalez

Contributors

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Submitted December 1989
Work Performed Under Contract No. DE-AC08-89NV10630

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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 1988 through December 1988. It presents results and evaluations of radiological and non-radiological measurements in air and water, and of direct gamma radiation exposure rates. Moreover, it presents relevant comparisons between the data recorded, DOE concentration guides (CG's) and applicable standards.

The radiological monitoring results for CY-1988 reveal that the concentrations of radionuclides in air and water on the Nevada Test Site were far below the allowable limits set forth in the DOE guidelines.

The highest average gross beta concentration in air was 0.002 percent of the DOE derived concentration guide (DCG). This concentration is considered close to background for the NTS. The highest average ^{239}Pu concentration in air was 2.3 percent of the DCG. The highest average tritium concentration in air was 0.04 percent of the DCG. ^{85}Kr concentrations compared favorably to the offsite average and to worldwide concentrations. All ^{133}Xe positive results were associated with specific events. Both ^{85}Kr and ^{133}Xe concentrations were far below the allowable limits.

The highest average gross beta concentration in potable water was well within the allowed CG. Tritium and ^{239}Pu levels were, for the majority, below detection levels and in all cases, 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 the chapter titled Effluent Monitoring.

External gamma rates were consistent with data obtained from years past.

Drinking water and air pollution permits were obtained and maintained during CY-1988 as part of the continual monitoring of non-radiological substances.

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.

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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 C. S. Soong, B. F. Eubank, Y. K. Lee, PhD., S. E. Patton and R. J. Straight for their contributions. A special thanks go to 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 1988. As part of its contract, DE-AC08-84NV10327, REECo is responsible for providing radiological safety within the confines of the Test Site. REECo is also responsible for the non-radiological industrial hygiene and environmental monitoring within the Test Site. The U.S. Environmental Protection Agency (Environmental Monitoring Systems Laboratory, Las Vegas) conducts the offsite radiological monitoring program.

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 NTS is located in the Great Basin physiographic province, characterized by basin-and-range topography of linear, fault-bounded ranges separated by valleys filled with alluvial sediment. Surface drainage is internal within the Great Basin, with no through-flowing rivers. The highest range on the NTS is the Belted Range, varying in elevation from 5000 to 7400 ft. The elevations of the valley floors range from 3000 to 4500 ft. Some valleys contain playas at their lowest point. Slopes on the range edges are steep and dissected, while slopes closer to the basins are gentler because alluvium has been deposited from adjacent highlands.

The geologic units at the NTS can be divided into three main groups (Figures 2 and 3). The oldest is a thick sequence (up to 37,000 ft) of Precambrian to Paleozoic-age marine sediments that accumulated in the miogeosynclinal belt of the Cordilleran geosyncline. Though these sedimentary rocks are only exposed along valley edges, they occur extensively in the subsurface across the eastern and southern portions of the NTS. The next large group of rocks includes pyroclastic and lava-flow type volcanics deposited during Tertiary volcanism. These rocks dominate in the western part of the NTS where there are several large caldera centers, and locally can be more than 13,000 ft thick.

The youngest units are Quaternary-age alluvial deposits and minor basalt flows that occur in the valleys and along drainages. These deposits are generally less than 2000 ft thick. Though limited in occurrence, there are a few intrusive granitic stocks of Mesozoic age along the northern edge of Yucca Flat.

Two major periods of deformation have disturbed the stratigraphic sequence. During the late Mesozoic, folding and thrust faulting occurred in the area. This activity redistributed some of the Proterozoic and Paleozoic rocks into patterns that control the present flow paths in deep groundwater systems. The second major period of deformation occurred during the late Cenozoic due to extensional tectonism and basin-and-range faulting. Resultant block faulting has a profound effect on NTS hydrology by causing the juxtaposition of hydrogeologic units of differing transmissivities and creation of the characteristic basin-and-range topography with alluvium-filled valleys. Strike-slip faults in the area, such as the Las Vegas Shear Zone, are also believed to control regional groundwater flow.

Hydrogeology

The NTS has three primary water-bearing units (corresponding to the major geologic units described above): the Lower Carbonate Aquifer, the Volcanic Aquifer and the Valley-Fill Aquifer. In addition, an Upper Carbonate Aquifer occurs in a limited area west of Yucca Flat. The water table occurs variously in each of these units, depending on the local structure. Confined groundwater conditions also occur in the Lower Carbonate Aquifer. The depth to the saturated zone is highly variable, but is generally at least 500 ft below land surface and often more than 1000 ft. Interbasin (topographic basin) groundwater flow occurs through the high transmissivity Lower Carbonate Aquifer. In many areas, the carbonates are separated from overlying units by aquitards of low permeability clastics or volcanics. Stratigraphically above the aquitards are permeable volcanics that transmit water primarily through fractures and joints. The volcanics in

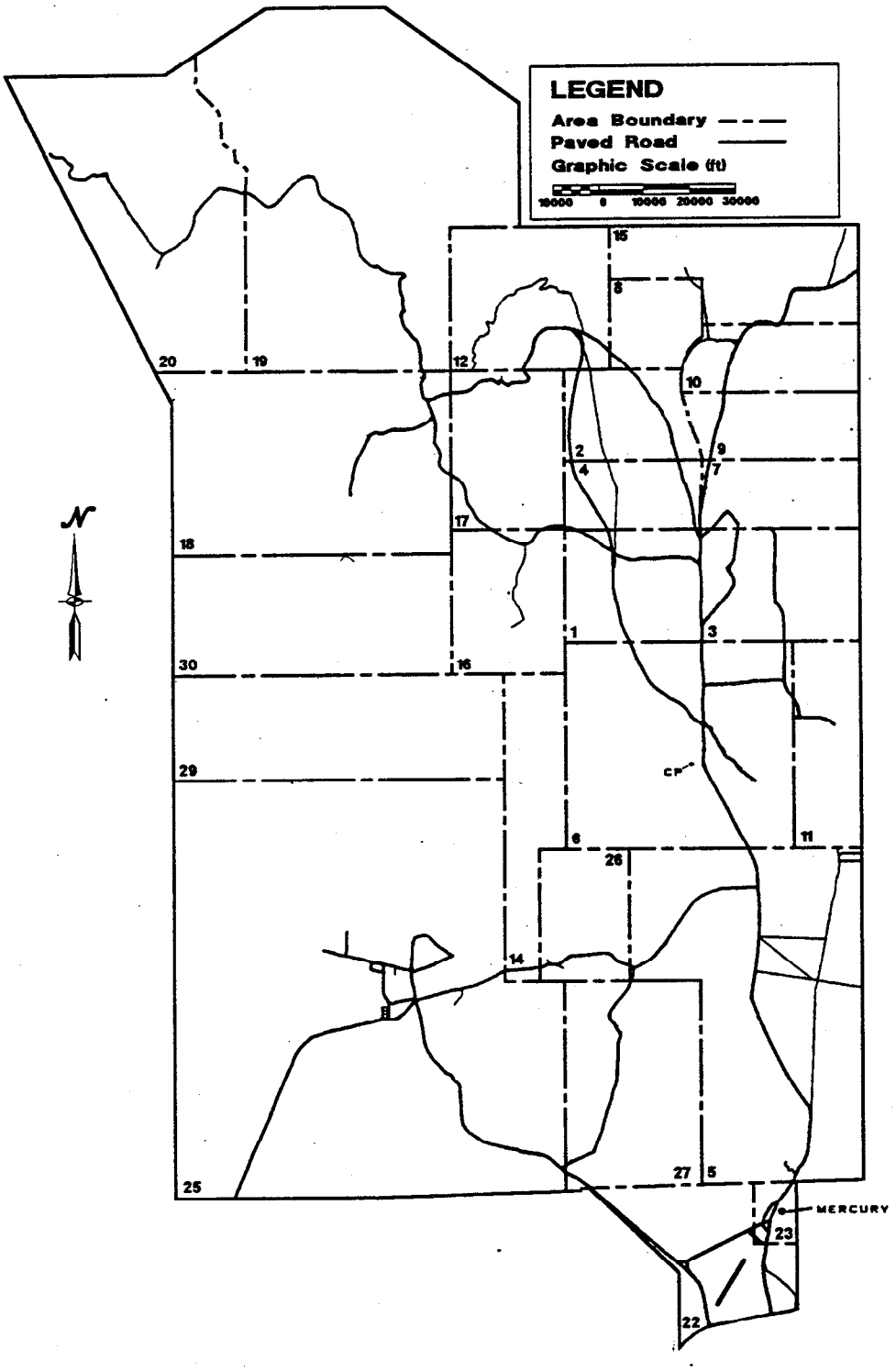


Figure 1 - Nevada Test Site

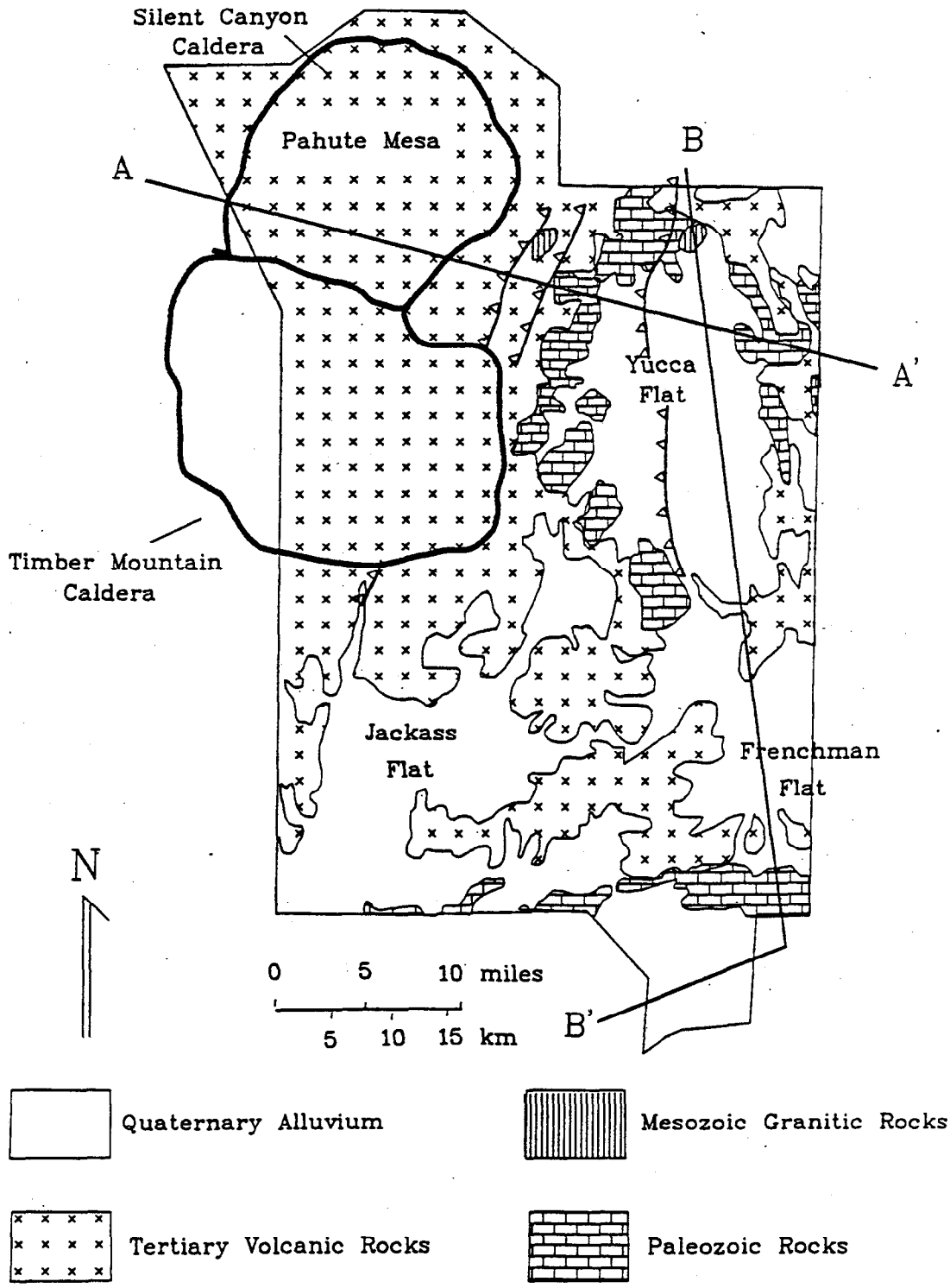
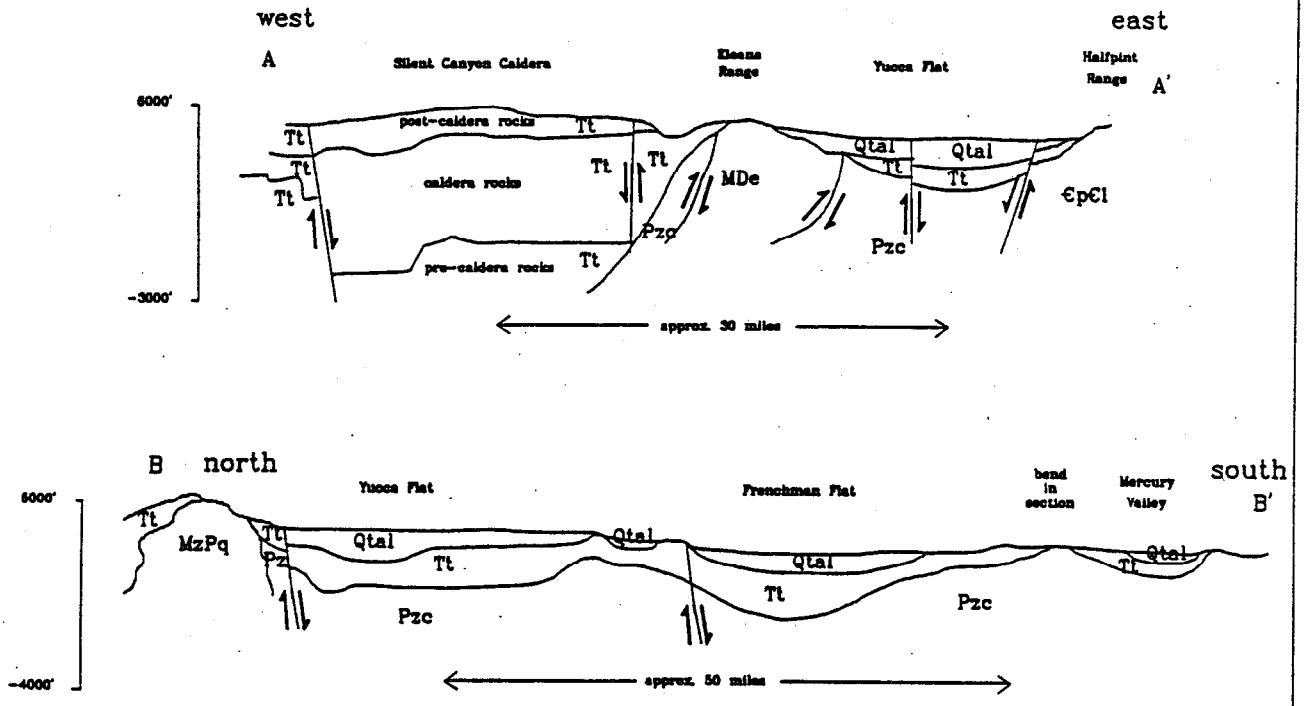


Figure 2 - Geologic Map of the NTS



Symbol	Geologic Unit	Hydrogeologic Unit
Qtal	Quaternary and Tertiary valley fill	Valley-fill aquifer
Tt	Tertiary tuff, lakebeds, lava flows	Volcanic Aquifers and Aquitards
MzPq	Mesozoic quartz monzonite stock	minor aquitard
MDe	Eleana Formation	Upper Clastic Aquitard
Pzc	Paleozoic carbonate rocks	Lower Carbonate Aquifer
€pCl	Early Cambrian and Precambrian clastics	Lower Clastic Aquitard

Figure 3 - Geologic Cross-Section of the NTS

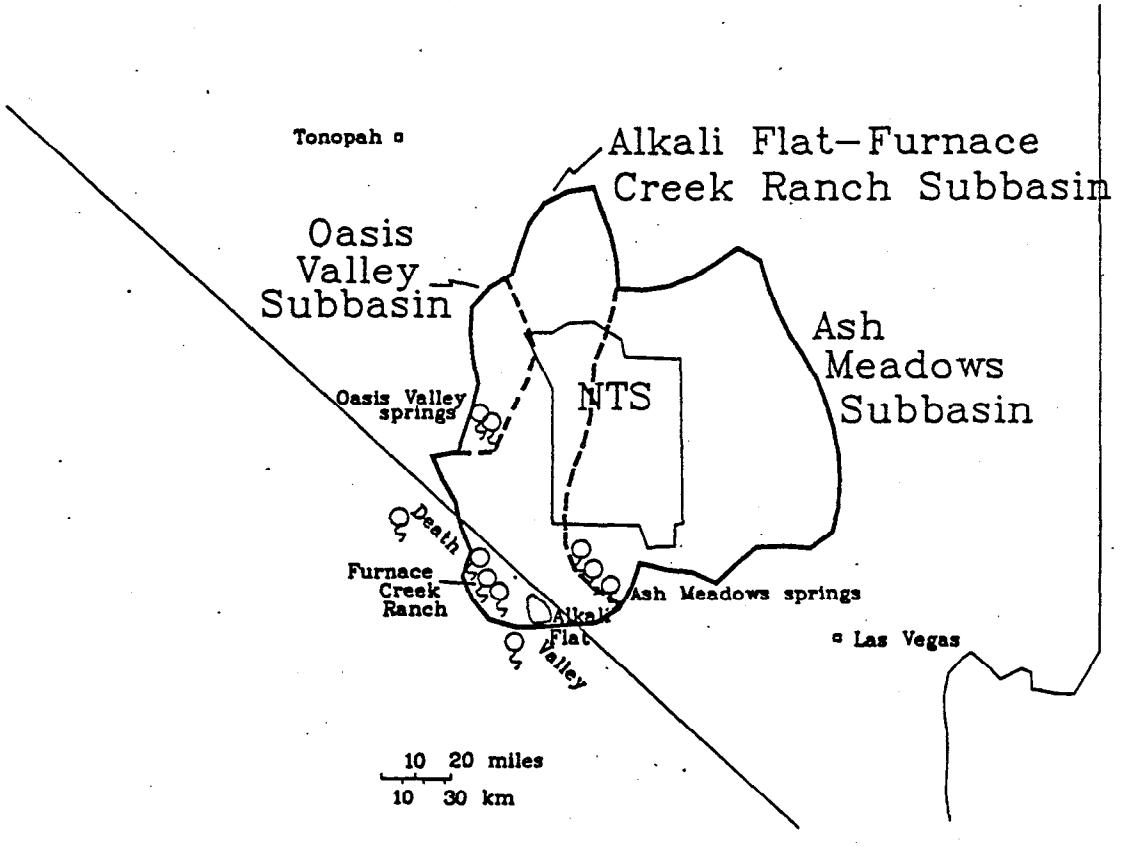


Figure 4 - Groundwater Basins at the NTS

the eastern part of the NTS are generally saturated only in the deeper parts of intermontane basins. Across Pahute Mesa and the western part of the NTS, however, the volcanics are widely saturated and contain the water table. The Valley-Fill material is an important aquifer only in the larger valleys at the NTS. Discharge from both the Volcanic and Valley-Fill Aquifers may occur by leakage to the underlying Lower Carbonate Aquifer.

The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley Groundwater Basin (Figure 4). The actual subbasin boundaries are poorly defined, but the basin hydrology can be summarized as follows. Groundwater beneath the eastern part of the NTS is in the Ash Meadows Subbasin, defined by discharge through evapotranspiration along a spring line in Ash Meadows (south of the NTS). Most of the western NTS is in the Alkali Flat-Furnace Creek Ranch Subbasin that discharges by evapotranspiration at Alkali Flat and by spring discharge near Furnace Creek Ranch. Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley Subbasin, discharging by evapotranspiration at Oasis Valley. Some underflow past all of the subbasin discharge areas probably travels to springs in Death Valley. Recharge for all of the subbasins probably occurs by precipitation at higher elevations and infiltration along streamcourses and in playas. Regional groundwater flow is from the upland recharge areas in the north and east, toward discharge areas at Ash Meadows and Death Valley, southwest of the site. Due to the large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions can be radically different from the regional trend. Groundwater is the only local source of drinking water in the NTS area. Drinking and industrial water-supply wells for the NTS produce from the Lower and Upper Carbonate Aquifers, the Volcanic Aquifer and the Valley-Fill Aquifer. Though a few springs emerge from perched groundwater lenses at the NTS, discharge rates are low and the spring water is not currently used for DOE activities. South of the NTS, private and public supply wells are completed in the Valley-Fill Aquifer. It is estimated that between 45 and 65 people drink groundwater pumped from wells within 5 miles of the NTS boundary.

CLIMATE

The climate of the Nevada Test Site (NTS) is influenced greatly by the orographic effect of terrain. To describe the climate it is necessary to discuss three distinct zones that exist in the orographically complex area of the NTS. The zones are: the mesas at elevations of 6500 to 7500 feet above mean sea level (MSL); the dry lake beds at 4000 ft MSL; and lower terrain, 2500-3500 ft MSL.

Annual precipitation in Southern Nevada depends largely upon elevation. A characteristic of desert climates is the temporal and spatial variability of precipitation. Topography contributes to this variability. For example, on the NTS, the mesas accumulate an average annual precipitation of 9 inches whereas, the lower elevations receive approximately 6 inches. More specifically, in Area 20, the annual average precipitation is 8.65 inches; however, in the driest year, 1973, only 2.38 inches were measured and in the wettest year, 1965, a total of 11.91 inches occurred. By contrast, in Yucca Flat (in Area 6), the average annual precipitation is 6.31 inches. In the driest year, 1964, only 2.47 inches were measured, but 13.56 inches fell in the wettest year, 1969. Precipitation at Mercury averages 6.23 inches annually. However, as little as 2.95 inches fell in 1975 and as much as 11.17 inches fell in 1984.

Large-scale atmospheric circulations drive the annual precipitation cycle in Southern Nevada. Winter storms bring in moisture from the Pacific Ocean and produce widespread areas of precipitation which occur from November through April. In summer, the moisture is transported northward from the tropical Pacific Ocean, off the west coast of Mexico. This moist tropical air flows northward through the Gulf of California and into the desert southwest. During summer, intense heating of the ground below this moist air mass provides the necessary trigger for thunderstorm development. Precipitation usually falls in isolated showers, with large variations in precipitation amounts within a shower area. Summer precipitation occurs mainly in July and August. On occasion, a tropical storm will move northeastward from the west coast of Mexico, bringing widespread heavy precipitation to Southern Nevada during September or October.

Elevation also influences temperature. At the time of maximum temperature in mid-afternoon, elevation exerts the major control, with the temperatures decreasing 3 to 4 degrees Fahrenheit per 1000 feet increase in elevation on the NTS. The lower limit applies in winter and the higher limit in summer. At the time of minimum temperature, near sunrise, topography exerts the major control in association with air drainage, and the change in temperature with elevation is no longer systematic. Large differences in the average daily minimum temperatures at stations with same elevation are common due to the pooling of cold air in the basins at night and early morning.

At an elevation of 6565 ft MSL in Area 20 on Pahute Mesa, the average daily maximum/minimum temperatures are 40/28 F in January and 80/62 F in July. The

extreme temperatures are 67/-1 F in January and 95/41 F in July. However, in Area 6 (Yucca Flat, 3924 ft MSL) the average daily maximum/minimum temperatures are 51/21 F in January and 96/57 F in July. The extreme temperatures are 73/-10 F in January and 108/40 F in July. Mercury experiences an average daily maximum/minimum temperature range of 51/38 F in January and 92/75 F in July. The extreme temperatures at Mercury are 69/12 F in January and 109/59 F in July.

Several atmospheric phenomena may interact to produce the surface wind regime observed at the NTS. The movements of large-scale pressure systems control the seasonal changes in the wind direction frequencies; southerly winds predominate during summer and northerly winds during winter. The general downward slope in the terrain from north to south results in an intermediate-scale scenario that is reflected in the characteristic diurnal wind reversal from southerly winds during the day to northerly winds at night. This north/south reversal is strongest in the summer and, on occasion, becomes intense enough to override the wind regime associated with large-scale pressure systems. This phenomenon is, of course, very sensitive to the orientation of the mountain slopes and valleys.

At the higher elevations in Area 20, the average annual wind speed is 10.5 miles per hour (MPH). The prevailing wind direction during winter months is from north-northeast and during summer months is from the south. In Yucca Flat the average annual wind speed is 7 MPH. The prevailing wind direction during winter months is north-northwest and during summer months is south-southwest. At Mercury the average annual wind speed is 8 MPH in which the prevailing wind direction is northwest during the winter months and southwest during the summer months.

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 originating 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 that a program for the protection of the public and the environment should:

- 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; and
- 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.

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 assure 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).

Analytical Process

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.

Gross beta 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.

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.

Noble gas sampling 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 locations of the earlier atmospheric tests.

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

Detection Limit

Each time the laboratory calculates a result from an air or water sample, a 'detection limit' is also calculated for that result. The detection limit for any instrument is the minimum quantity of radioactivity which that instrument is able to detect. The detection limit is influenced by the quantity of sample, the counting time, the efficiency of the instrument to detect the radioactivity and the amount of radiation present even when no sample is being counted (the instrument background).

If the sample result is numerically less than the detection limit, then we can say that the quantity of radioactivity in that sample is less than the detection limit. This happens, for example, when there is no difference between the counts acquired from a sample and a background count. When the result is below the detection limit, the detection limit is used as the sample result. In this manner, the detection limit is presented as a 'less than' number. A typical ^{239}Pu in air result that was below the detection limit might be $< 2.4 \times 10^{-17}$ μCi/ml.

When averages or doses involve detection limit results, we must signify that at least one detection limit was used by displaying the data as 'less than.' To demonstrate, the average of 4.2 Ci and <2.2 Ci is <3.2 Ci. In previous years, the laboratory also determined the result to be below the detection limit when the two sigma error term associated with the sample result was greater than 43%. However, that practice was discontinued for CY-1988. Because of this change, many results that previously would have been regarded as below the detection limit are now shown as the result calculated.

NON-RADIOLOGICAL MONITORING

Insuring compliance with environmental regulations concerned with non-radiological substances is the responsibility of the Industrial Hygiene Section. Some of the state and federal regulations of concern are:

- Clean Water Act (CWA)
- Safe Drinking Water Act (SDWA)
- Clean Air Act (CAA)
- 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)

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 1 - Summary of Onsite Environmental Sampling Program

Sample Type	Description	Collection Frequency	Number of Sampling Locations	Type of Analysis
Air	Continuous sampling through Whatman GF/A glass filter and a charcoal cartridge	Weekly	46	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	9	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, 239Pu (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	150	Total integrated exposure over field cycle

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

TABLE 2 - Applicable Standards for the NTS

(μCi/ml)

Nuclide	DCG for Air[1]	DCG for Water[2]	CG for Water	MCL for Drinking Water[3]
^{3}H	1×10^{-7}	2×10^{-3}	1×10^{-1}	2×10^{-5}
^{85}Kr	3×10^{-6}	--	--	--
^{133}Xe	5×10^{-7}	--	--	--
$^{226}Ra/^{228}Ra$[5]	--	--	--	5×10^{-9}
^{239}Pu	2×10^{-14}	3×10^{-8}	1×10^{-4}	--
Beta[4]	1×10^{-9}	1×10^{-7}	1×10^{-5}	1.5×10^{-8}
Alpha[6]	--	--	--	1.5×10^{-8}

[1]This column contains the derived concentration guides (DCG) for the predominant nuclides detected at the NTS, as listed in DOE Draft Order 5400.xx, Attachment 1 (Reference 28).

[2]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 DOE Order 5480.1B, Chapter XI, Table 1 (Reference 3).

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

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

[5]This MCL is for the *combined* concentration.

[6]Including ^{226}Ra but excluding radon and uranium.

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-1988 show that the radioactivity in air and water, and external gamma exposure levels in the NTS environs 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-1988 average gross beta concentration in air, excluding Area 5 Gate 200, was 2.2×10^{-14} μCi/ml at Area 23 H & S Roof. This average represents 0.002 percent of the applicable derived concentration guide of 1×10^{-9} μCi/ml as listed in Table 2. The site average for the forty-six stations was 1.9×10^{-14} μCi/ml. This gross beta concentration is consistent with average background for the Nevada Test Site. The samples taken at the Area 5 Gate 200 location were not included in the overall average because these samples were not held for a week (as are all other samples) prior to counting. The results from this location included the activity from naturally occuring radionuclides. Area 5 Gate 200 sample results were useful for obtaining a rapid indication of any dramatic change in the beta activity.

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 1×10^{-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 5400.xx, Chapter XI, Attachment 1, Table 1] (Reference 28). The highest average ^{239}Pu concentration occurred in Area 3 at U3ah/at West. This ^{239}Pu concentration of 4.6×10^{-16} μCi/ml represents 2.3 percent of the derived concentration guide for members of the general public. It should be noted that the nearest member of the general public is quite a distance away from the U3ah/at site and typical dispersion would reduce this concentration several orders of magnitude below this amount. 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 or members of the general public.

The highest average tritium concentration in air occurred at the Area 15 Gate 700 South sampler. This concentration, 4.2×10^{-11} μCi/ml, represents 0.04 percent of the derived concentration guide.

The average concentration of ^{85}Kr for CY-1988 was 24.5×10^{-12} μCi/ml (or 24.5 pCi/m^3), which was lower than the CY-1987 average of 28×10^{-12} μCi/ml. This decrease in ^{85}Kr concentration in ambient air is inconsistent with the general trend towards an increase in the environmental levels of ^{85}Kr (Reference 25), however, the annual average of 24.5×10^{-12} μCi/ml compared very well with the EPAs average from samplers located outside the NTS. Both the onsite and offsite programs (conducted by the Environmental Protection Agency) experienced a slight reduction in the yearly average.

^{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 8.0×10^{-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 1.1×10^{-8} μCi/ml at the E Tunnel Effluent point. This value represents 0.01 percent of the controlled area concentration guide for ^{239}Pu. For all other waters sampled, the highest average ^{239}Pu concentration was $< 1.1 \times 10^{-10}$ μCi/ml at Gold Meadows. This value represents 0.01 percent of the concentration

guide for ^{239}Pu. All of the positive ^{239}Pu results, however, have an associated high percentage error. The error was likely caused by statistical fluctuations inherent to the counting system.

The highest average concentration of ^{3}H for all noncontaminated waters occurred at Gold Meadows. This concentration of $< 8.2 \times 10^{-7}$ μCi/ml represents < 4 percent of the MCL. This average represents an average detection limit rather than an average ^{3}H concentrations since the large majority of the results were below the detection limit.

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 1.5×10^{-1} μCi/ml at T Tunnel Pond No. 2.

AMBIENT EXPOSURE

TLD measurements of the NTS gamma radiation rates at the 150 locations showed some variation during CY-1988. 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 141 stations recorded changes related to known effects. The maximum dose rate of 1905 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 150 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. ^{3}H in air concentrations ranged on the order of 1×10^{-11} μCi/ml of air with the highest average concentration being 0.04 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 MONITORING METHODS

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 Health Physics Department.

AIR MONITORING

Particulate Air Monitoring

Air sampling units were located at 46 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 l/min of air. 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 incorporates an acid dissolution and an ion exchange recovery on a resin bed. Plutonium is deposited by plating on a stainless steel disc. The chemical yield of the plutonium is determined with an internal ^{239}Pu tracer. Alpha spectroscopy is performed utilizing a solid state silicon surface barrier detector. The lower limit of detection for the parameters involved is 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 l/min, 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 determines 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 ml/min. The two collection bottles are exchanged weekly and yield a sample volume of about 3×10^{5} ml.

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 (sewage lagoons) 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 are sampled 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 1. 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, made of lithium borate, is only slightly shielded in order to capture low energy radiation. The last three elements, made of calcium sulfate, are shielded by 1000 mg/cm^2 of lead to screen out low energy radiation.

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 an inspection for accuracy. The data were analyzed automatically by computer, they were also verified by REECo Health Physics Department (HPD) personnel prior to acceptance. If serious differences from an expected value were found, the sample field handling, preparation and processing were reviewed. 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-six particulate air sampling stations were sampled continuously for radioactivity in air (Figures 6 and 7). At each of the 46 locations, samples were collected weekly and analyzed for particulates (glass fiber filter) and halogens (charcoal cartridge). The sample filters were combined on a monthly basis and radiochemically 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 weekly. Tritiated water vapor was monitored continuously and collected every two weeks at 17 locations.

GROSS BETA

The network average for the whole year for gross beta activity, excluding Gate 200, was 1.9 x 10^{-14} μCi/ml or 0.002 percent of the derived concentration guide of 1 x 10^{-9} μCi/ml (DOE Order 5480.1B, Chapter XI). Figure 5 displays the network arithmetic averages for CY-1988. This plot graphically displays changes in airborne radioactivity over the surveillance period. The data ranges are included for each of these points.

Air samples were held for seven days prior to counting to allow for the decay of radon and radon daughters. However, samples collected at Gate 200 were counted for gross beta without allowing seven days for this decay. Although the ^{222}Rn/^{220}Rn results from the Gate 200 samples were higher and more variable, 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 6 summarizes the 1988 gross beta averages by location. Table 4 lists yearly and half-year averages. The remaining plots in Appendix A depict the actual measurements at each station.

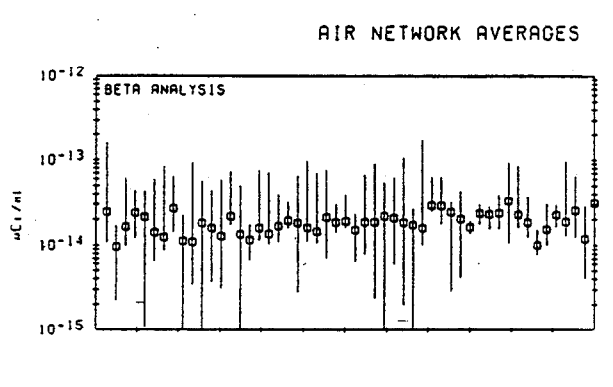


Figure 5 - 1988 Air Network Averages

PLUTONIUM-239

All stations averaged below 10^{-15} μCi/ml of ^{239}Pu for CY-1988, with the majority being on the order of 10^{-17} μCi/ml. The maximum annual average concentration was found at U3ah/ax West which was 4.6 x 10^{-16} μCi/ml, or 2.3 percent of the derived concentration guides (DCG) for members of the public. Table 5 lists the average ^{239}Pu concentrations for the year. Figure 7 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, elevated levels of plutonium 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 U3ah/at site is part of this consolidation effort. It is there that contaminated earth is buried.

TRITIUM (HTO)

The highest annual average concentration of tritium was 4.2 x 10^{-11} μCi/ml at the Gate 700 South sampler. This amount represents 0.04 percent of the derived concentration guide for tritium in air.

The locations of the seventeen tritium samplers along with their yearly averages are shown in Figure 8. Each of these stations was sampled continuously for a two-week period. Table 6 lists the maximum, minimum, and average concentration for each sampling location. Appendix B plots actual measurements for each location. Inspection of Table 6 reveals some negative results. In past reports,

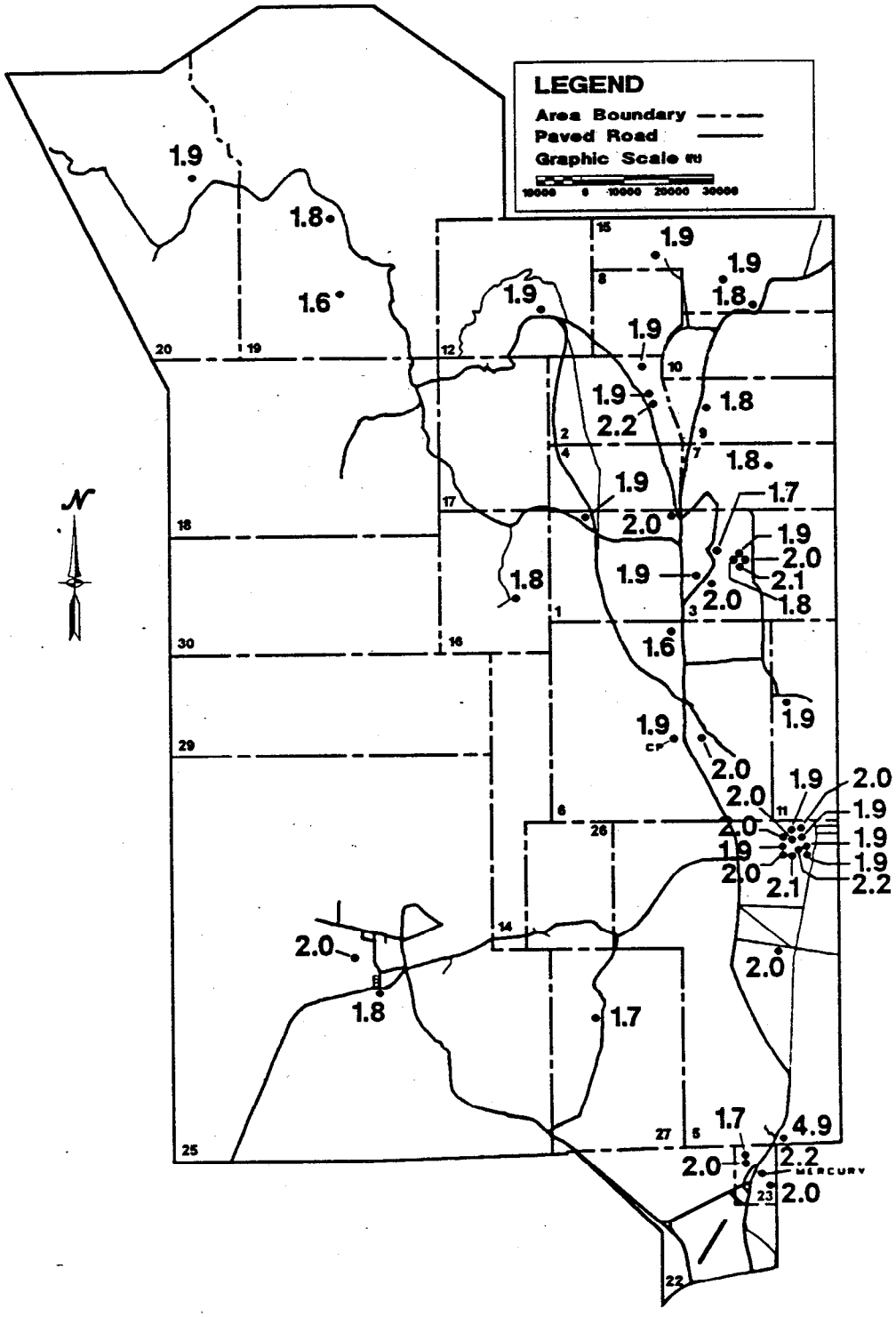


Figure 6 - Air Sampling Stations (Beta)

TABLE 4 - Air Surveillance Data for Gross Beta

Station	Concentration (x 10^{-14} μCi/ml) 01/88-06/88	07/88-12/88	01/88-12/88*
Area 1 BJY	1.8	2.3	2.0
Area 1 Gravel Pit	1.7	2.1	1.9
Area 2 Hydraulic Lift Yard	1.7	2.0	1.9
Area 2 Compound	1.7	2.1	1.9
Area 2 Substation 2-1	-	2.2	2.2
Area 3 Compound	1.7	2.1	1.9
Area 3 Complex No. 2	1.9	2.2	2.0
Area 3 U3ah/at South	2.1	2.1	2.1
Area 3 U3ah/at East	1.7	2.3	2.0
Area 3 U3ah/at North	1.6	2.1	1.9
Area 3 U3ah/at West	1.6	2.1	1.8
Area 3 3-300 Bunker	1.6	1.9	1.7
Area 5 DOD Yard	1.7	2.2	1.9
Area 5 Gate 200	4.5	5.2	4.9
Area 5 Pit No. 3	1.8	2.2	2.0
Area 5 RWMS No. 1	1.9	2.4	2.2
Area 5 RWMS No. 2	1.7	2.1	1.9
Area 5 RWMS No. 3	1.7	2.1	1.9
Area 5 RWMS No. 4	1.7	2.0	1.9
Area 5 RWMS No. 5	1.8	2.2	2.0
Area 5 RWMS No. 6	1.9	2.2	2.0
Area 5 RWMS No. 7	1.7	2.0	1.9
Area 5 RWMS No. 8	1.9	2.1	2.0
Area 5 RWMS No. 9	1.9	2.3	2.1
Area 5 Well 5B	1.7	2.2	2.0
Area 6 CP Complex	1.7	2.1	1.9
Area 6 Well 3	1.6	1.6	1.6

* 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} μCi/ml) 01/88-06/88	07/88-12/88	01/88-12/88
Area 6 Yucca Complex	1.7	2.3	2.0
Area 7 UE7ns	1.6	1.9	1.8
Area 9 9-300 Bunker	1.6	2.1	1.8
Area 11 Gate 293	1.7	2.1	1.9
Area 12 Compound	1.6	2.2	1.9
Area 15 EPA Farm	1.9	1.9	1.9
Area 15 Gate 700	1.6	1.9	1.8
Area 15 PILEDRIVER	1.8	2.0	1.9
Area 16 Substation	1.6	2.0	1.8
Area 19 Echo Peak	1.4	1.7	1.6
Area 19 Substation	1.6	2.1	1.8
Area 20 Dispensary	2.0	1.9	1.9
Area 23 Bldg 790	1.7	2.3	2.0
Area 23 Bldg 790 #2	1.6	1.9	1.7
Area 23 H & S Roof	2.0	2.4	2.2
Area 23 East Boundary	2.0	2.0	2.0
Area 25 EMAD North	1.6	2.3	2.0
Area 25 NRDS	1.6	2.0	1.8
Area 27 Cafeteria	1.6	1.9	1.7

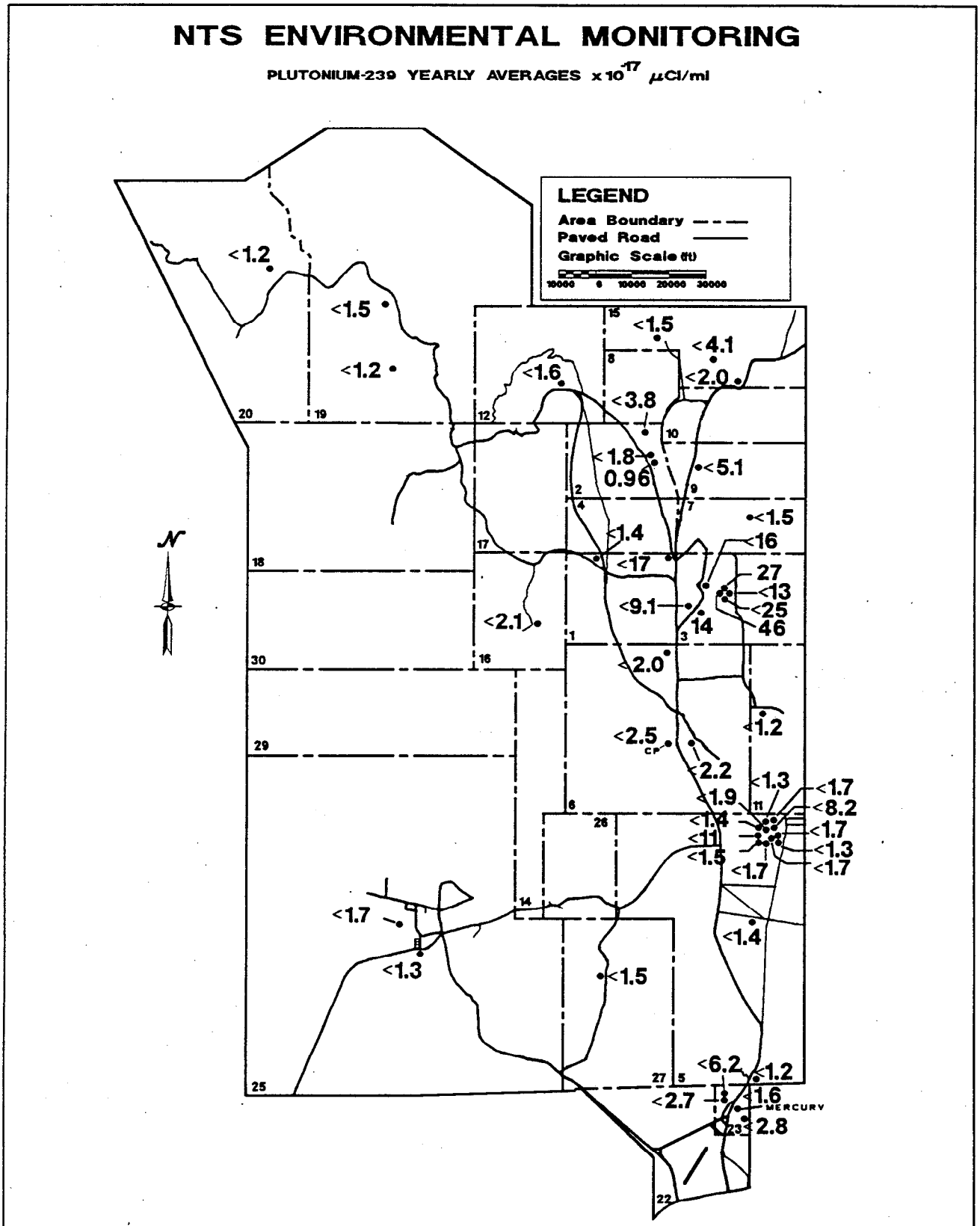


Figure 7 - Air Sampling Stations (Plutonium)

TABLE 5 - Air Surveillance Data for Plutonium

Station	Concentration (x 10^{-17} μCi/ml) 01/88-06/88	07/88-12/88	01/88-12/88*
Area 1 BJY	<22	<9.1	<17
Area 1 Gravel Pit	<1.3	<1.5	<1.4
Area 2 Hydraulic Lift Yard	<2.1	<6.7	<3.8
Area 2 Compound	<2.1	<1.4	<1.8
Area 2 Substation 2-1	-	0.96	0.96
Area 3 Compound	<8.4	10	<9.1
Area 3 Complex No. 2	13	16	14
Area 3 U3ah/at South	<21	32	<25
Area 3 U3ah/at East	<11	<17	<13
Area 3 U3ax North	24	30	27
Area 3 U3ax West	31	68	46
Area 3 3-300 Bunker	<9.9	<26	<16
Area 5 DOD Yard	<1.6	<1.0	<1.3
Area 5 Gate 200	<1.3	<1.1	<1.2
Area 5 Pit No. 3	<1.5	<1.9	<1.7
Area 5 RWMS No. 1	<2.0	<1.3	<1.7
Area 5 RWMS No. 2	<1.5	<0.90	<1.3
Area 5 RWMS No. 3	<2.2	<1.0	<1.7
Area 5 RWMS No. 4	<13	<0.80	<8.2
Area 5 RWMS No. 5	<1.5	<2.3	<1.9
Area 5 RWMS No. 6	<1.3	<1.4	<1.4
Area 5 RWMS No. 7	<18	<1.5	<11
Area 5 RWMS No. 8	<1.5	<1.4	<1.5
Area 5 RWMS No. 9	<1.4	<2.2	<1.7
Area 5 Well 5B	<1.8	<0.94	<1.4
Area 6 CP Complex	<1.5	<3.8	<2.5
Area 6 Well 3	<2.0	<2.0	<2.0
Area 6 Yucca Complex	<2.6	<1.7	<2.2

* 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) 01/88-06/88	07/88-12/88	01/88-12/88
Area 7 UE7ns	< 1.8	< 1.2	< 1.5
Area 9 9-300 Bunker	< 2.0	10	< 5.1
Area 11 Gate 293	< 1.2	< 1.3	< 1.2
Area 12 Compound	< 1.5	< 1.6	< 1.6
Area 15 EPA Farm	< 3.1	< 5.7	< 4.1
Area 15 Gate 700	< 1.5	< 2.6	< 2.0
Area 15 PILEDRIVER	< 1.3	< 1.9	< 1.5
Area 16 Substation	< 2.1	< 2.1	< 2.1
Area 19 Echo Peak	< 1.6	< 0.64	< 1.2
Area 19 Substation	< 1.9	< 0.97	< 1.5
Area 20 Dispensary	< 1.4	< 0.95	< 1.2
Area 23 Bldg 790	< 3.7	< 1.3	< 2.7
Area 23 Bldg 790 #2	< 1.2	< 12	< 6.2
Area 23 H & S Roof	< 2.1	< 0.97	< 1.6
Area 23 East Boundary	< 3.7	< 1.6	< 2.8
Area 25 EMAD North	< 2.1	< 1.1	< 1.7
Area 25 NRDS	< 1.7	< 0.79	< 1.3
Area 27 Cafeteria	< 1.9	< 0.99	< 1.5

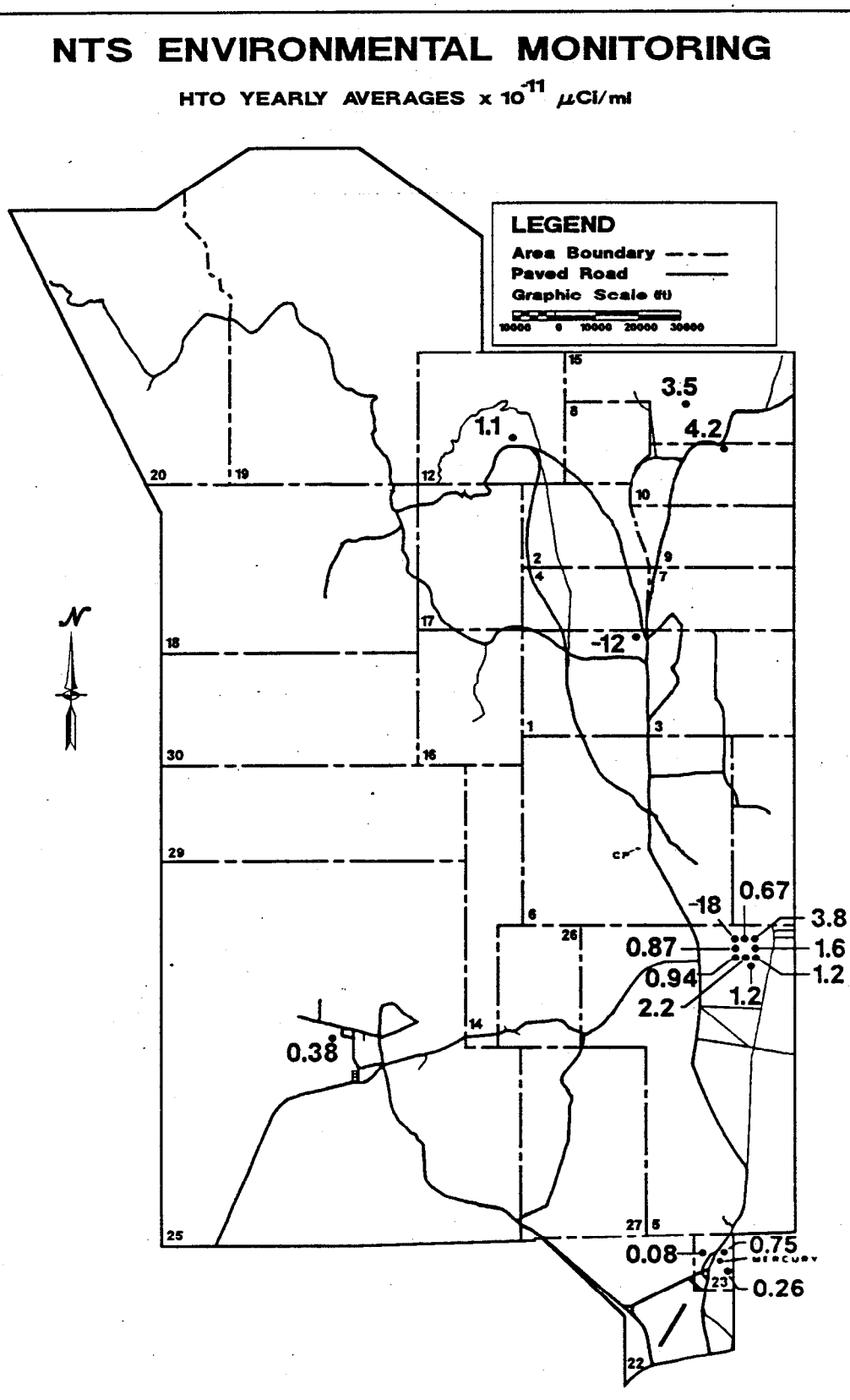


Figure 8 - Tritium in Air Sampling Stations

TABLE 6 - Tritium in Air

	Concentrations (μCi/ml)		
Stations	**Maximum**	**Minimum**	**Average**
Area 1 BJY	4.4×10^{-11}	-2.9×10^{-09}	-1.2×10^{-10}
Area 5 RWMS-1	2.6×10^{-11}	1.5×10^{-12}	1.2×10^{-11}
Area 5 RWMS-SE	2.5×10^{-11}	1.9×10^{-12}	1.2×10^{-11}
Area 5 RWMS-(SE-NE)	3.2×10^{-11}	2.7×10^{-12}	1.6×10^{-11}
Area 5 RWMS-NE	1.0×10^{-10}	7.2×10^{-12}	3.8×10^{-11}
Area 5 RWMS-(NE-NW)	1.8×10^{-11}	1.3×10^{-12}	6.7×10^{-12}
Area 5 RWMS-NW	2.2×10^{-11}	-4.6×10^{-09}	-1.8×10^{-10}
Area 5 RWMS-(NW-SW)	2.1×10^{-11}	-4.1×10^{-12}	8.7×10^{-12}
Area 5 RWMS-SW	2.0×10^{-11}	4.8×10^{-12}	9.4×10^{-12}
Area 5 RWMS-(SW-SE)	5.5×10^{-11}	-2.4×10^{-11}	2.2×10^{-11}
Area 12 Base Camp	2.0×10^{-11}	3.0×10^{-13}	1.1×10^{-11}
Area 15 EPA Farm	6.8×10^{-11}	2.1×10^{-11}	3.5×10^{-11}
Area 15 Gate 700 South	9.7×10^{-10}	-2.7×10^{-11}	4.2×10^{-11}
Area 23 Bldg 650	7.2×10^{-11}	1.1×10^{-12}	7.5×10^{-12}
Area 23 Site Boundary	7.0×10^{-12}	-2.3×10^{-12}	2.6×10^{-12}
Area 23 Bldg 790	1.2×10^{-11}	-8.2×10^{-11}	8.0×10^{-13}
Area 25 EMAD	1.8×10^{-11}	-3.1×10^{-12}	3.8×10^{-12}

only the detection limits were reported when the sample results were lower than the detection limit. However, DOE draft orders soon to be issued will require all results, regardless of their magnitude, to be reported. For the CY-1988 report, only the tritium in air results are being presented as required in the draft orders. Next year's report will incorporate the issued orders.

KRYPTON-85

The average concentration of ^{85}Kr for the entire network was slightly lower in CY-1988, decreasing from an average of 28 x 10^{-12} μCi/ml (or 28 pCi/m^3) in CY-1987 to an average of 24.5 x 10^{-12} μCi/ml in CY-1988.

The annual average of 25 x 10^{-12} μCi/ml observed by EPA in its offsite network compared very well with the onsite average of 24.5 x 10^{-12} μCi/ml. The onsite average, not counting the Area 20 Camp (on the Pahute Mesa) results, was still 23.8 x 10^{-12} μCi/ml indicating that during CY-1988, Pahute Mesa shots did not contribute significant ^{85}Kr seepage to the environment. The ^{85}Kr concentrations during CY-1988 ranged from 11.7 x 10^{-12} μCi/ml to 86.9 x 10^{-12} μCi/ml. The location and yearly average for each noble gas sampling station is shown in Figure 9. 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 the Area 1 Gravel Pit. This concentration was 0.003 percent of the derived concentration guide. There were very few ^{133}Xe results above the detection limit from the permanent stations during CY-1988. The maximum weekly result occurred at the Area 25 EMAD Site. This concentration of 15.6 x 10^{-12} μCi/ml was 0.003 percent of the DCG for members of the general public. Table 7 lists the average ^{133}Xe concentrations at each location along with the lowest and highest values detected. Figure 9 presents ^{133}Xe sampling locations and yearly concentration averages.

TABLE 7 - Noble Gases in Air

Concentrations

(x 10^{-12} μCi/ml)

Stations	Kr-85			Xe-133		
	Max	Min	Avg	Max	Min	Avg
Area 1 BJY	43.8	15.0	23.7	<67.0	<3.6	<12.1
Area 1 Gravel Pit	30.6	15.9	22.8	<71.1	<3.8	<13.4
Area 5 Gate 200	33.4	13.3	23.4	<86.0	<3.8	<13.0
Area 12 Complex	86.9	16.3	26.0	<32.6	<3.1	<9.9
Area 15 PILEDRIVER	37.8	14.5	24.4	<42.8	<3.6	<12.2
Area 20 Camp	47.8	15.7	28.8	<19.1	<3.3	<8.2
Area 25 EMAD Site	32.5	11.7	22.5	<64.1	<2.5	<13.0

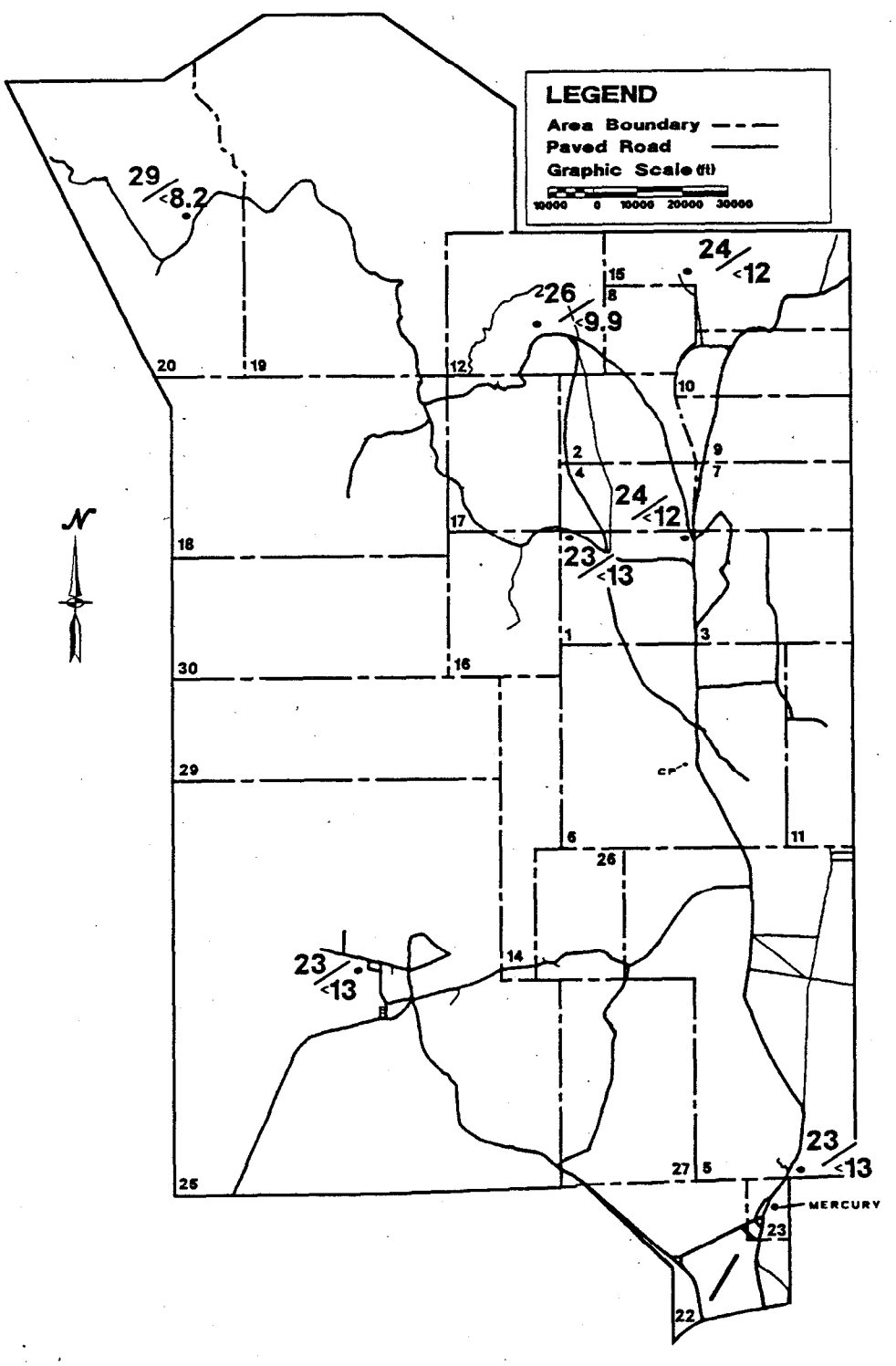


Figure 9 - Noble Gas Stations

RADIOACTIVITY IN SURFACE AND GROUNDWATER

The principal water distribution system on the NTS is the potential critical pathway for the ingestion of waterborne radionuclides. Consequently, the system is sampled and evaluated frequently. The NTS water system consists of 16 supply wells, 9 potable water stations and 14 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 supply wells. The identification of any radionuclides above the detection limit from the supply well system initiates closer reviews 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. Samples from 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 is used for a variety of sanitary and industrial purposes. Samples are collected from those wells which could potentially provide water for human consumption. These data assist 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.

In October of 1988, use of Area 3 Well A as a water supply well was discontinued. An explanation for the motives behind this act are discussed in the chapter titled Compliance Summary. From October throughout the remainder of the year (and during 1989), areas previously served by Area 3 Well A received water transported from the Area 6 water system (Wells C, C1 and 4).

Gross Beta

The highest average concentration of gross beta recorded was 15.9×10^{-8} μCi/ml at the UE15d Well.

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 10.

The gross beta annual averages are shown at their respective locations in Figure 11. Appendix C consists of the plots of data for each station for measured gross beta activity with 2 sigma error bars. Table 8 lists the 1988 averages for each location.

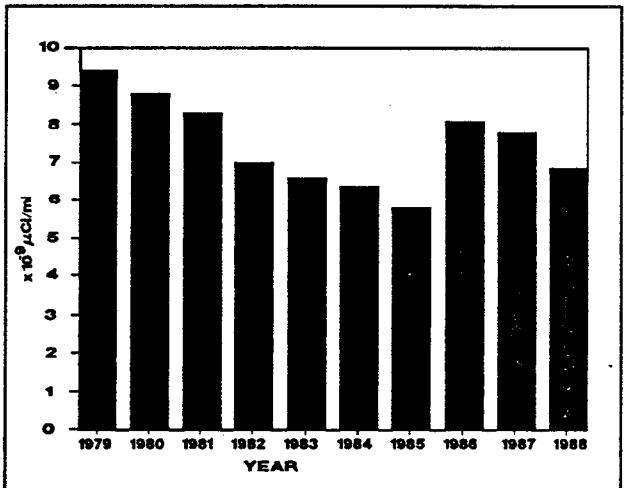


Figure 10 - Supply Well Gross Beta Yearly Comparisons

Tritium and Plutonium

There were two supply well tritium results above the detection limit during CY-1988. The positive results occurred once each at Wells 5B and J-13. Both results were only slightly above the detection limit with a high error term and neither well displayed further positive results for the remainder of the year. The tritium results above detection limits for all non-contaminated NTS waters are given in Table 9. The number of entries in Table 9 increased in CY-1988 compared to CY-1987. However, the reason is attributed to a change in the reporting system within the laboratory rather than to an increase in the level of groundwater radioactivity. In previous years, the

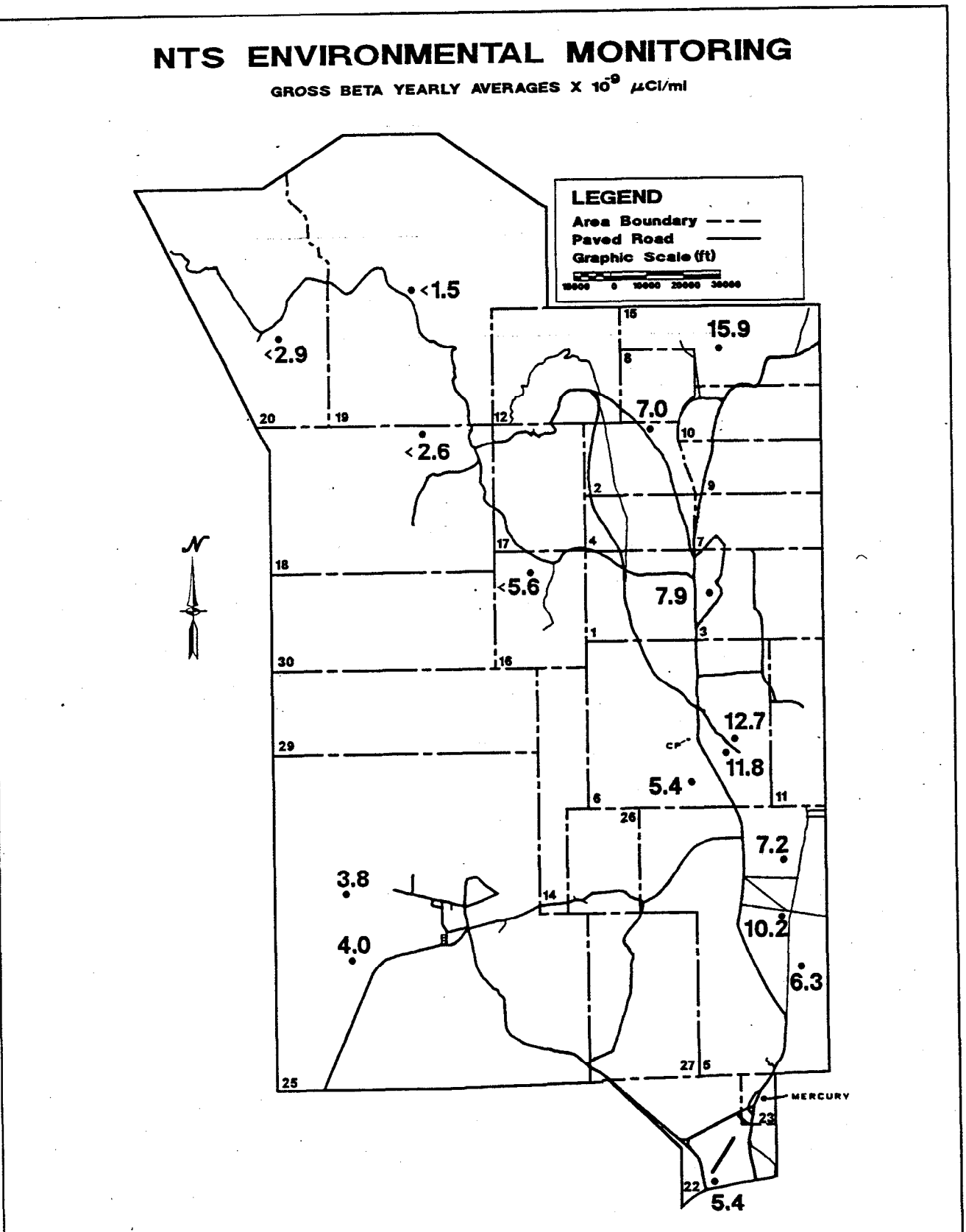


Figure 11 - Supply Well Sampling Stations

TABLE 8 - Supply Well Data for Gross Beta

Station	Gross Beta Annual Average (x 10^{-9} μCi/ml)
Area 2 Well 2	7.0
Area 3 Well A	7.9
Area 5 Well 5B	10.2
Area 5 Well 5C	6.3
Area 5 Well UE5c	7.2
Area 6 Well C	12.7
Area 6 Well C1	11.8
Area 6 Well 4	5.4
Area 15 Well UE15d	15.9
Area 16 Well 16D	<5.6
Area 18 Well 8	<2.6
Area 19 Well U19c	<1.5
Area 20 Water Well	<2.9
Area 22 Army Well No. 1	5.4
Area 25 Well J12	4.0
Area 25 Well J13	3.8

TABLE 9 - Tritium Values Above Detection Limits

WATER TYPE	STATION	DATE	μCi/ml +/-2σ% error
Potable	Area 3 Cafeteria	08/08/88	5.1×10^{-7} +/- 72.2
Potable	Area 3 Cafeteria	08/15/88	6.3×10^{-7} +/- 73.6
Potable	Area 3 Cafeteria	12/05/88	4.3×10^{-7} +/- 69.2
Potable	Area 2 Restroom	08/08/88	3.9×10^{-7} +/- 94.0
Potable	Area 2 Restroom	11/21/88	4.0×10^{-7} +/- 86.6
Potable	Area 12 Cafeteria	08/15/88	5.9×10^{-7} +/- 79.5
Potable	Area 12 Cafeteria	09/06/88	4.7×10^{-7} +/- 80.4
Potable	Area 23 Cafeteria	10/31/88	6.3×10^{-7} +/- 75.7
Potable	Area 27 Cafeteria	10/31/88	6.2×10^{-7} +/- 77.9
Potable	Area 6 Bottled Water	07/11/88	8.7×10^{-7} +/- 58.0
Potable	Area 6 Cafeteria	08/10/88	6.3×10^{-7} +/- 77.2
Potable	Area 6 Cafeteria	09/26/88	3.5×10^{-7} +/- 99.6
Potable	Area 6 Cafeteria	10/19/88	4.2×10^{-7} +/- 83.9
Potable	Area 25 Service Station	11/21/88	4.0×10^{-7} +/- 86.6
Natural Spring	Area 5 Cane	09/07/88	5.9×10^{-7} +/- 82.5
Natural Spring	Area 12 Captain Jack	07/13/88	4.4×10^{-7} +/- 82.1
Natural Spring	Area 12 Captain Jack	08/18/88	5.8×10^{-7} +/- 79.8
Natural Spring	Area 12 Gold Meadows	07/12/88	4.5×10^{-7} +/- 83.8
Natural Spring	Area 29 Topopah	06/28/88	6.1×10^{-7} +/- 79.0
Natural Spring	Area 29 Topopah	10/11/88	3.5×10^{-7} +/- 98.8
Natural Spring	Area 7 Reitmann Seep	07/13/88	4.2×10^{-7} +/- 84.9
Reservoir	Area 2 Well 2	08/12/88	5.5×10^{-7} +/- 83.4
Reservoir	Area 5 Well 5B	09/07/88	5.8×10^{-7} +/- 84.4
Reservoir	Area 5 Well Ue5c	09/07/88	6.4×10^{-7} +/- 76.6
Reservoir	Area 6 Well 3	09/07/88	5.2×10^{-7} +/- 94.1
Reservoir	Area 18 Camp 17	09/07/88	4.9×10^{-7} +/- 98.4
Reservoir	Area 20 Well 20A	07/12/88	1.7×10^{-6} +/- 23.7
Reservoir	Area 19 Well U19c	10/05/88	3.8×10^{-7} +/- 93.4
Supply Well	Area 5 Well 5B	08/11/88	6.0×10^{-7} +/- 81.3
Supply Well	Area 25 Well J-13	10/07/88	5.8×10^{-7} +/- 65.4

laboratory regarded a result to be below the detection limit when the 2 sigma error associated with the analysis was above 43%. That meant that even though the sample result was above the detection limit, it would not be reported as such if the 2 sigma error was above 43%. For the CY-1988 report, all results above the detection limit are presented regardless of the associated error term. This holds true not only for tritium results, but also for many other results presented in this report.

There were no positive plutonium results for any supply well during CY-1988. Appendix C includes plots of the network monthly results for gross beta. Figure 12 displays the arithmetic means and ranges of gross beta for supply wells. The tritium and plutonium results were, for the most part, less than detectable and as such, are not be plotted.

POTABLE WATER

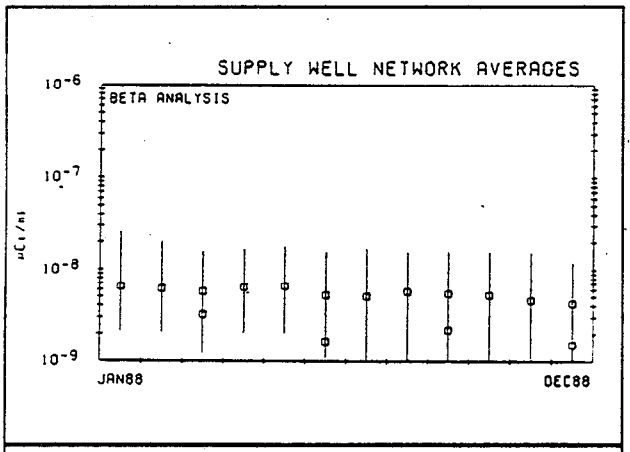


Figure 12 - 1988 Supply Well Network Averages

As a check of any effect the water distribution system might have on end use activity, nine consumption points were sampled during the reporting period. In order to be certain that all of the water available for consumption was being considered, each drinking water system has in previous years been identified and sampled. The NTS contained a total of six drinking water systems each fed by a series of supply wells during most of CY-1988. As previously mentioned, the potable water supply well Area 3 Well A was shut down in October of 1988, which in turn eliminated the need for an Area 3 sampling station. The water now consumed in Area 3 is transported from the Area 6 supply well system.

The station Area 6 Cascade Water has been renamed starting with this report. The name 'Cascade' was the brand name of the bottled water used for many years on the NTS. The NTS is currently using another bottled water distributor. This source of drinking water will be referred to as Area 6 Bottled Water for this and future reports.

Gross Beta

The highest average recorded was 8.0×10^{-9} μCi/ml at the Area 6 Cafeteria. This was 53 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 13 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 water sample location for CY-1988. The locations of all stations are shown in Figure 14 with their gross beta yearly averages.

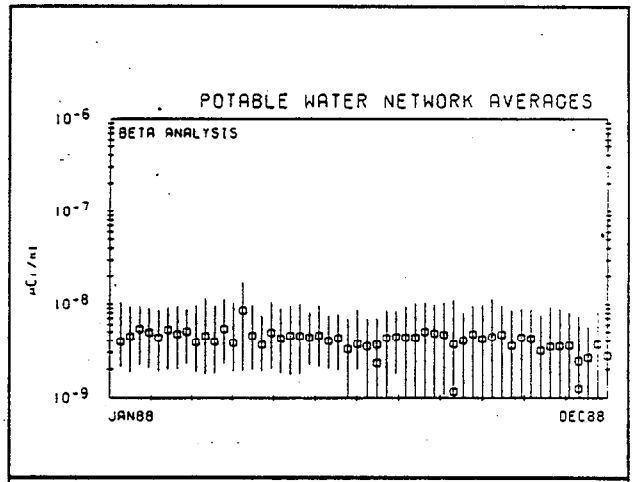


Figure 13 - 1988 Potable Water Network Averages

The demineralized bottled water was brought in from offsite and was used as a check of the laboratory system.

Gross beta measurements at these potable water sampling stations indicated that no release or movement of radionuclides occurred in the NTS water system throughout CY-1988.

The average of the entire network, as compared to averages reported in previous environmental reports, is shown in Figure 15.

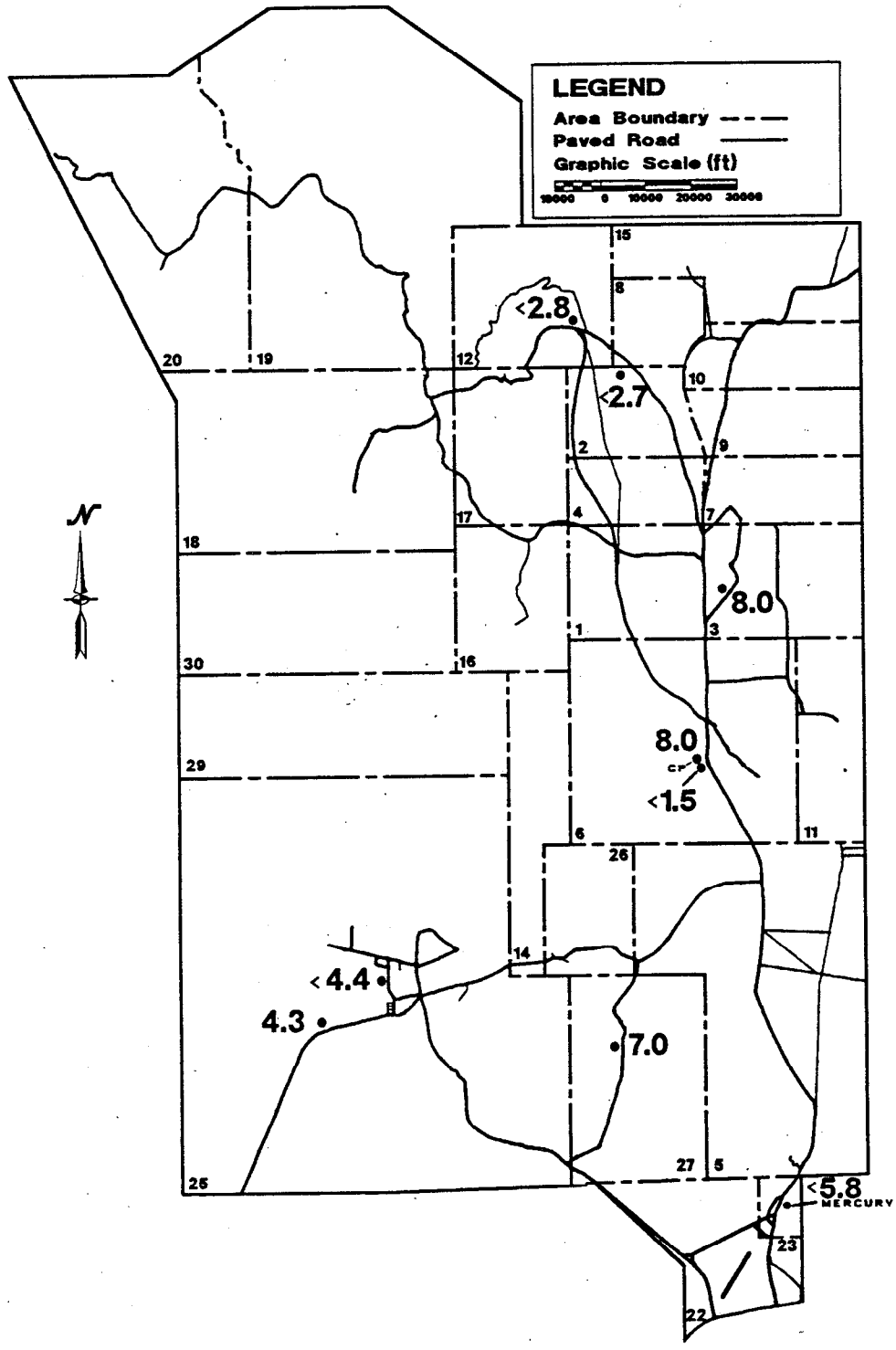


Figure 14 - Potable Water Sampling Stations

All potable water, except the bottled water, was obtained from supply wells. A comparison of these waters and their supply source appears in Table 11. As previously stated, some supply wells were used strictly for industrial purposes and are 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.

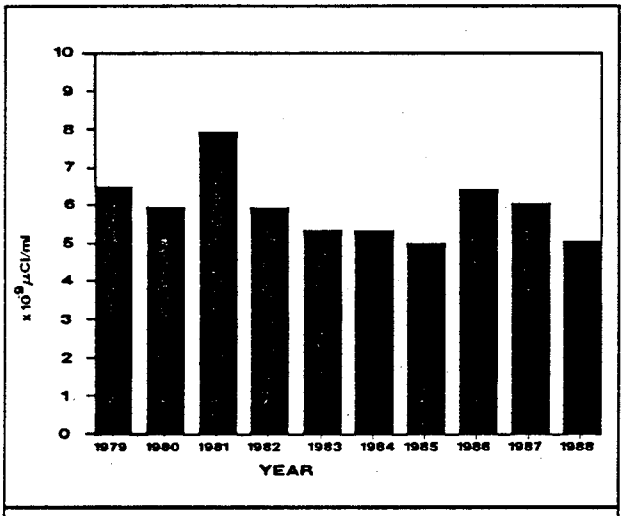


Figure 15 - Potable Water Gross Beta Yearly Comparisons

Tritium

The maximum average tritium concentration occured at the Area 25 Building 4221 sampling station. This average is 3.6 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. All positive tritium results were given in Table 9.

Plutonium

There was one ^{239}Pu result above the detection limit from the Area 25 Building 4221 sampling station. The result was many orders of magnitude below the concentration guides and contained a high error term. In previous reports this result would have been considered to fall below the detection limit. No plots are provided in Appendix D since the results were, for the most part, below the detection limit.

TABLE 10 - Potable and Supply Water Gross Beta Averages

Station	Gross Beta Annual Average (x 10^{-9} µCi/ml)
Area 2 Rest Room	< 2.7
Area 3 Cafeteria	8.0
Area 6 Cafeteria	8.0
Area 6 Bottled Water	< 1.5
Area 12 Cafeteria	< 2.8
Area 23 Cafeteria	< 5.8
Area 25 Service Station	< 4.4
Area 25 Building 4221	4.3
Area 27 Cafeteria	7.0

Alpha

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

TABLE 11 - Averages of Potable Water Data for Gross Beta

(x 10^{-9} µCi/ml)

Station (end use/supply)	CY-1988
Area 2 Rest Room	**< 2.7**
Area 12 Cafeteria	**< 2.8**
Area 18 Well 8	< 2.6
Area 3 Cafeteria	**8.0**
Area 3 Well A	7.9
Area 6 Cafeteria	**8.0**
Area 6 Well C	12.7
Area 6 Well C1	11.8
Area 6 Well 4	5.4
Area 6 Bottled Water	< 1.5
Area 23 Cafeteria	**< 5.8**
Area 27 Cafeteria	**7.0**
Area 5 Well 5B	10.2
Area 5 Well 5C	6.3
Area 22 Army Well No. 1	5.4
Area 25 Building 4221	**4.3**
Area 25 Service Station	**< 4.4**
Area 25 Well J12	4.0
Area 25 Well J13	3.8

TABLE 12 - Summary of NTS Safe Drinking Water Act Results For CY 1988

Analysis	Sample Location: Area 3 Cafeteria	Area 2 Rest Room	Area 12 Cafeteria	Area 23 Cafeteria
Gross Alpha (x 10^{-9} μCi/ml)				
Maximum	7.5	0.94	1.2	9.7
Minimum	< 0.46	< 0.42	< 0.42	1.7
Average	< 4.3	< 0.48	< 0.77	4.6
Gross Beta (x 10^{-9} μCi/ml)				
Maximum	17	16	9.0	11
Minimum	2.5	< 0.81	1.6	1.9
Average	8.0	< 2.7	< 2.8	< 5.8
Tritium (x 10^{-6} μCi/ml)				
Maximum	< 1.4	< 1.4	< 1.4	< 1.4
Minimum	< 0.29	< 0.29	< 0.29	< 0.29
Average	< 0.66	< 0.65	< 0.65	< 0.66

TABLE 12 - Summary of NTS Safe Drinking Water Act Results For CY 1988

Analysis	Sample Location: Area 27 Cafeteria	Area 6 Bottled Water	Area 6 Cafeteria	Area 25 Serv. Sta.	Area 25 Bldg. 4221
Gross Alpha (x 10^{-9} μCi/ml)					
Maximum	5.7	0.83	10.7	1.4	N/A
Minimum	1.7	< 0.33	3.4	< 0.66	N/A
Average	3.5	< 0.58	7.6	< 0.77	N/A
Gross Beta (x 10^{-9} μCi/ml)					
Maximum	9.8	4.2	14	11	5.6
Minimum	2.5	< 0.78	3.6	1.8	3.4
Average	7.0	< 1.5	8.0	< 4.4	4.3
Tritium (x 10^{-6} μCi/ml)					
Maximum	< 1.4	< 1.4	< 1.4	< 1.4	< 0.76
Minimum	< 0.29	< 0.29	< 0.29	< 0.29	< 0.68
Average	< 0.65	< 0.66	< 0.66	< 0.63	< 0.72

each station during CY-1988. The annual average and gross alpha results from sampling conducted quarterly at each station is also presented. In accordance with the EPA Interim Drinking Water Act gross alpha measurements were conducted on the drinking water systems. Gross alpha measurement results are given in Table 12. Two drinking water supply wells and one drinking water consumption point averaged over 5 x 10^{-9} μCi/ml (5 pCi/L) which is the screening level for ^{226}Ra analysis.

A sampling team from the state of Nevada Division of Environmental Protection also sampled various supply wells during CY-1988. Based on their analysis results, several wells were later re-sampled and submitted to an offsite laboratory for ^{226}Ra analysis. The results are presented in Table 13, Radium-226 Results from Potable Water Wells. The results reveal that the concentrations of ^{226}Ra are well below the levels listed in the Drinking Water Act.

TABLE 13 - Radium-226 Results from Potable Water Wells

	^{226}Ra Concenfration (x 10^{-9} μCi/ml +/- 2σ%)
Area 3 Well A	< 0.1
Area 6 Well 4	< 0.1
Area 6 Well C	0.7 +/- 14
Area 6 Well C1	0.5 +/- 20
Area 16 Well 16D	1.1 +/- 9

OPEN RESERVOIRS

Open reservoirs have been established at various locations on the NTS for industrial purposes. Fourteen locations were sampled during the report period. The locations are shown in Figure 16 along with their gross beta annual 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 13.3 x 10^{-9} μCi/ml at Well 5B Reservoir. This value is 0.13 percent of the Concentration Guide for non-potable NTS waters. Table 14 includes a list of the CY-1988 gross beta averages at each location.

TABLE 14 - Averages of Open Reservoir Data for Gross Beta

Station	Gross Beta Annual Average (x 10^{-9} μCi/ml)
Area 2 Well 2 Reservoir	5.9
Area 2 Mud Plant Reservoir	6.1
Area 3 Well A Reservoir	7.6
Area 3 Mud Plant Reservoir	9.0
Area 5 Well 5B Reservoir	13.3
Area 5 Well Ue5c Reservoir	6.5
Area 6 Well 3 Reservoir	10.9
Area 6 Well C1 Reservoir	8.7
Area 18 Camp 17 Reservoir	3.3
Area 19 Well U19c Reservoir	< 1.6
Area 20 Well 20A Reservoir	< 1.9
Area 23 Swimming Pool	< 3.7
Area 25 Well J-11 Reservoir	5.2
Area 25 Well J-12 Reservoir	< 5.4

Table 15 shows the gross beta activities of the open reservoirs that were supplied by wells, along with the activities of the associated wells. Figure 17 shows the average gross beta results for the entire network, as compared to previous years.

TABLE 15 - Comparisons of Open Reservoir and Supply Water

Station (Reservoir/Supply)	Gross Beta Annual Average (x 10^{-9} μCi/ml)
Area 2 Well 2 Reservoir	5.9
Area 2 Well 2	7.0
Area 3 Well A Reservoir	7.6
Area 3 Well A	7.9
Area 5 Well 5B Reservoir	13.3
Area 5 Well 5B	10.2
Area 5 Well Ue5c Reservoir	6.5
Area 5 Well Ue5c	7.2
Area 6 Well C1 Reservoir	8.7
Area 6 Well C1	11.8
Area 19 Well U19c Reservoir	< 1.6
Area 19 Well U19c	< 1.5
Area 25 Well J-12 Reservoir	< 5.4
Area 25 Well J-12	4.0

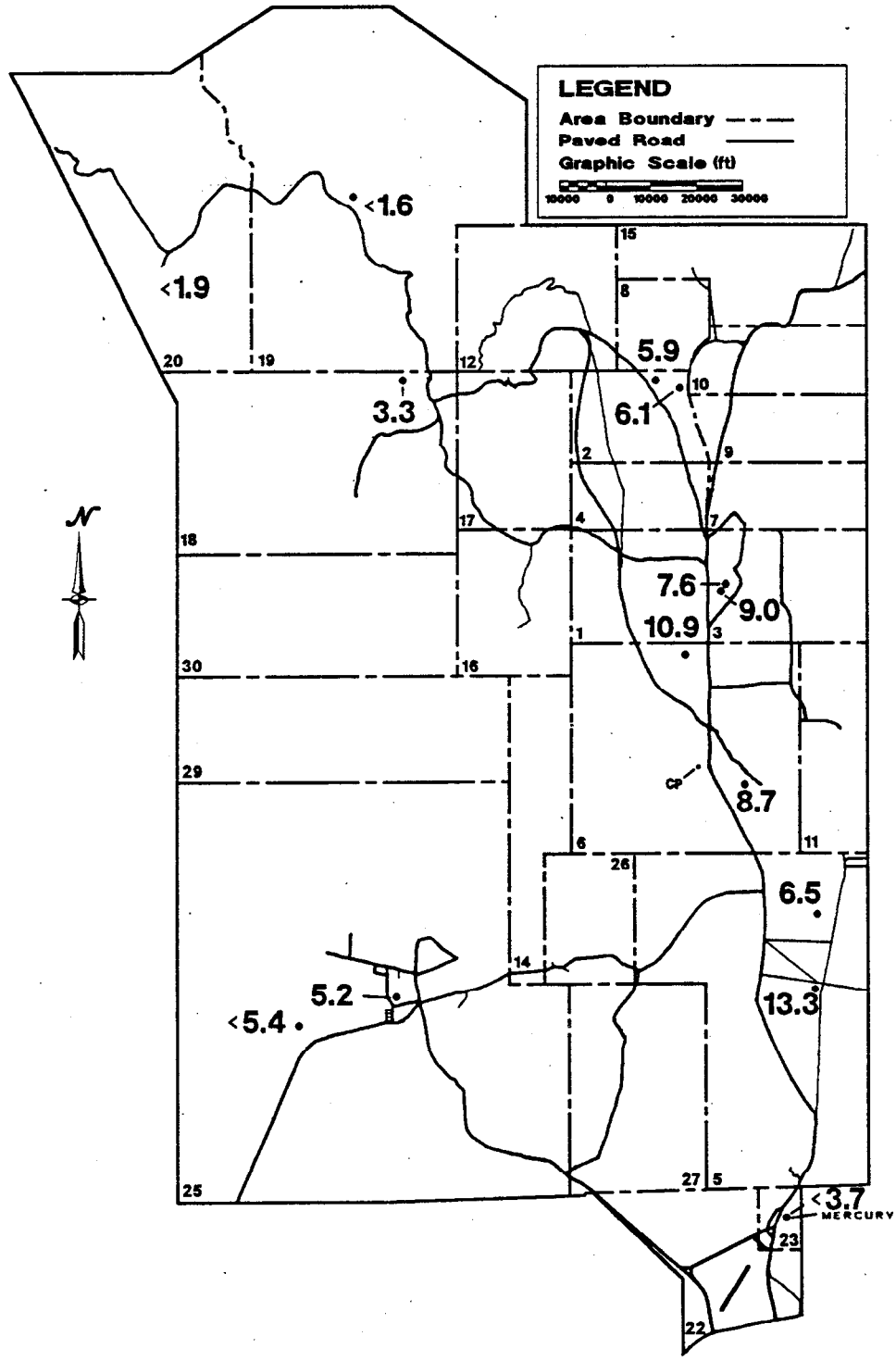


Figure 16 - Open Reservoir Sampling Stations

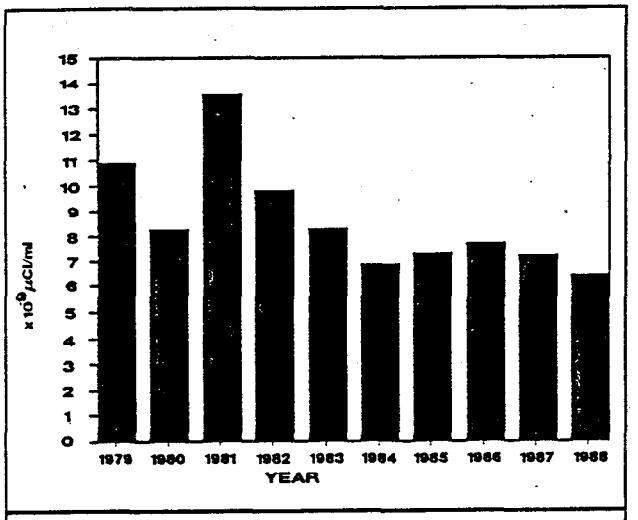


Figure 17 - Open Reservoirs Gross Beta Yearly Comparisons

Appendix E consists of the plots of each station of the measured gross beta activity with standard deviation error bars. An averaging plot, Figure 18, 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-1988.

Tritium and Plutonium

Table 9 displays the positive tritium results for all non-contaminated waters. As was previously stated, the increase in the number of positive results over the previous year is attributed to a change in the reporting procedure rather than to an increase in the level of groundwater radioactivity. The average concentrations of tritium and plutonium in open reservoirs during CY-1988 are not significantly different from the CY-1987 averages. Since the majority of results are below the detection limit, the averages from CY-1987 and CY-1988 simply reflect the average detection limits.

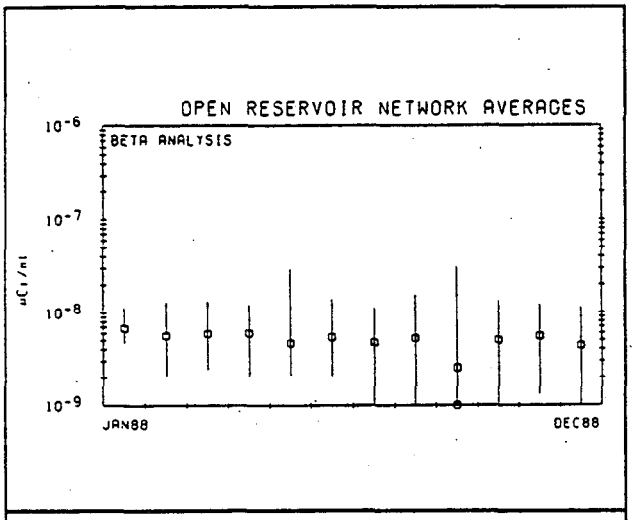


Figure 18 - 1988 Open Reservoir Network Averages

Four water samples taken at three open reservoirs (Area 25 Well J-11, Area 3 Mud Plant (2) and Well U19c) contained ^{239}Pu above the detection limit. In previous years, these results would have been considered below detection due to their large standard deviations All results above the detection limit had coefficients of variation of between 70% and 94%.

NATURAL SPRINGS

The term *natural springs* is a label given to the spring-supplied pools located within the NTS. Although there is no known human consumption from these springs, the measured concentrations are compared here to the concentration guides for drinking water. Many of the springs are known watering holes for wild animals.

Gross Beta

The highest gross beta average recorded was 23.9×10^{-9} μCi/ml at Reitmann Seep, which represented 0.24 percent of the CG. The network average, as compared to those presented in previous reports, is shown in Figure 19.

Appendix F contains the plots for all the natural spring sampling stations. Averages of the measured gross beta activity are presented with standard deviation error bars. An averaging plot, Figure 20, displays the trend of the network mean throughout the reporting period as well as the range for gross beta. Table 16 presents a list of the gross beta averages at each location. Eight locations sampled on a monthly basis (when accessible) are shown in Figure 21 along with their gross beta annual averages.

Tritium and Plutonium

There were seven tritium results above the detection limit from various springs. These results are shown in Table 9. However, of the seven results, the highest was 3.1 percent of the drinking water regulation. These values above the detection limit are also considered to be a result of the change in the reporting process within the laboratory rather than an increase in the level of environmental

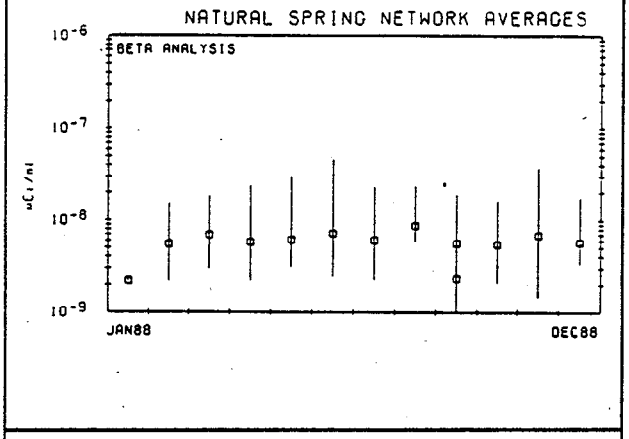


Figure 19 - 1988 Natural Springs Network Averages

radioactivity. The coefficients of variation associated with these seven results were all above 79%.

There were three ^{239}Pu results above the detection limit from Captain Jack, Tub and Toppopah Springs. The result from Tub Springs of 2.1 x 10^{-10} μCi/ml %32.8% was 0.004 percent of the limit for drinking water. Further sampling at this site produced no other results above the detection limit. The other 239Pu results above the detection limits each contained error terms in excess of 70%.

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

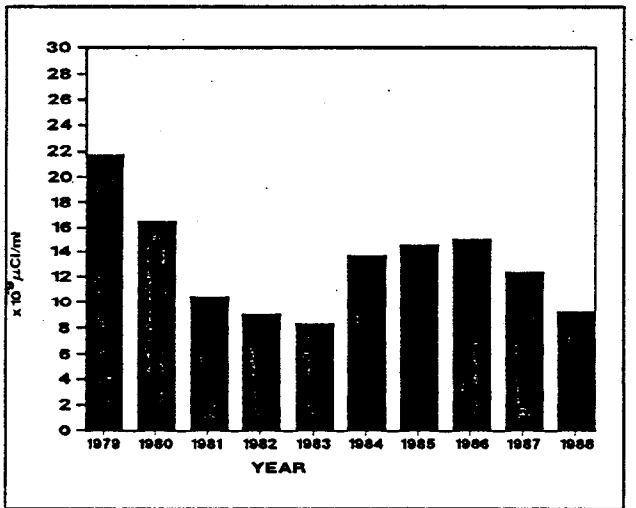


Figure 20 - Natural Springs Gross Beta Yearly Comparisons

TABLE 16 - Averages of Natural Spring Data for Gross Beta

Station	Gross Beta Yearly Average (x 10^{-9} μCi/ml)
Area 5 Cane Spring	6.3
Area 7 Reitmann Seep	23.9
Area 12 White Rock Spring	6.7
Area 12 Captain Jack Spring	4.1
Area 12 Gold Meadows Pond	21.0
Area 15 Tub Spring	5.6
Area 16 Tippipah Spring	<3.0
Area 29 Topopah Spring	4.5

CONTAMINATED PONDS

Ten contaminated stations were sampled on a special study basis. These ponds were impounded waters from tunnel test areas and a contaminated laundry release point. The H & S sump behind the radiological laboratory was sampled during CY-1988. However, this sump ran dry for a long period of time and was no longer sampled. Sampling has resumed in CY-1989.

The contaminated ponds are monitored in accordance with DOE Order 5484.1, Chapter IV to provide a data base for calculations of any offsite releases. Tritium and significant gamma results from these sites are reported to DOE Headquarters on an annual basis. These results are listed in the Effluent Monitoring chapter along with results from other effluent discharge sites. The network averages and associated ranges are shown in Figure 22. The average gross beta concentration for each location is shown in Figure 23.

Table 17 is a list of the gross beta, tritium and ^{239}Pu annual 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.

EFFLUENT PONDS

Samples from four effluent pond locations were collected during CY-1988. The Yucca Steam #2 sampling station was discontinued the latter part of 1987. These ponds are closed systems which contain both sanitary and radioactive waste for evaporative treatment. They are located in

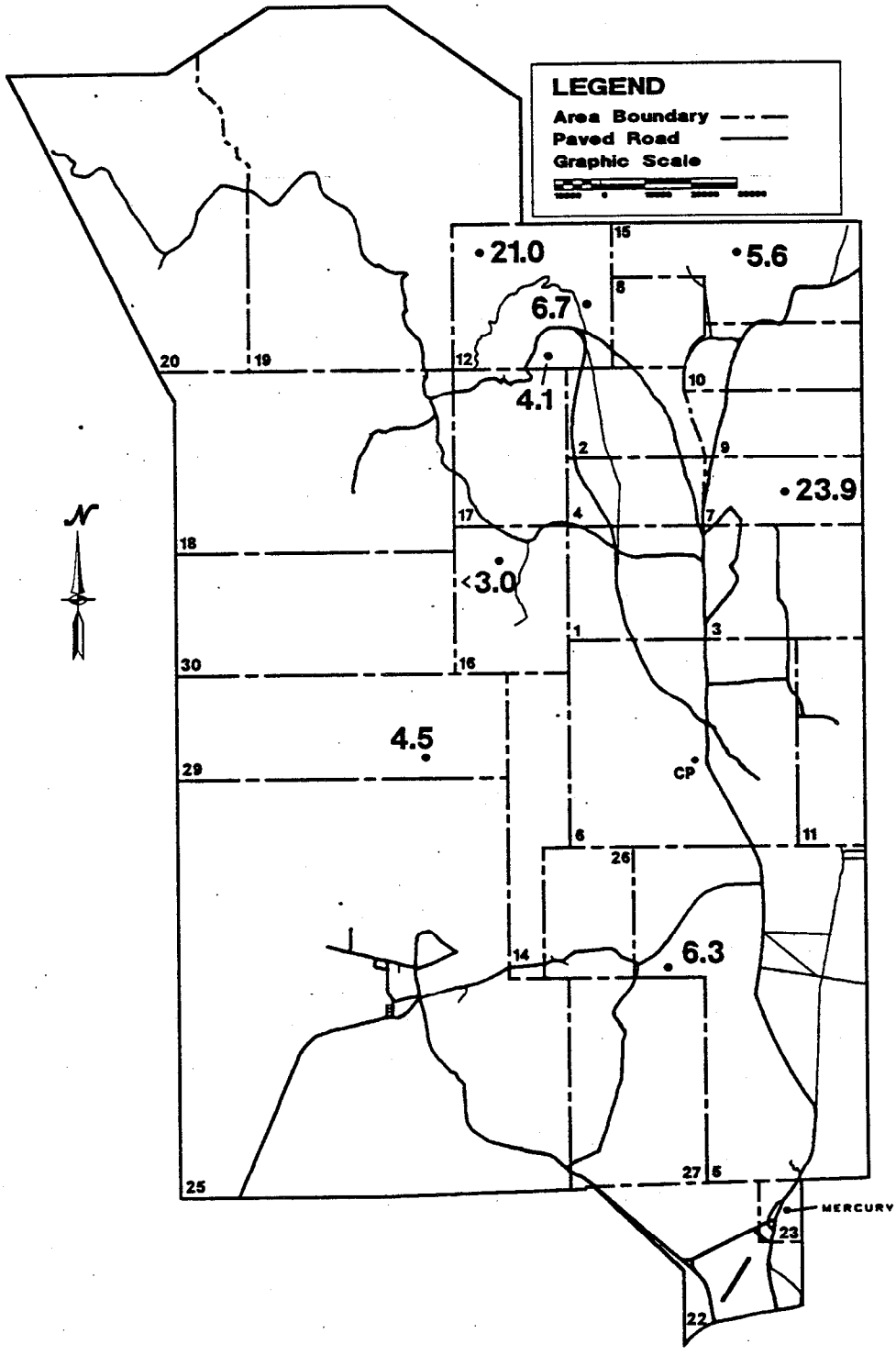


Figure 21 - Natural Spring Sampling Stations

Areas 6 (2 stations), 12 and 23. The highest average gross beta value was 1.7×10^{-8} μCi/ml. Plutonium and tritium concentrations were less than detectable at all locations.

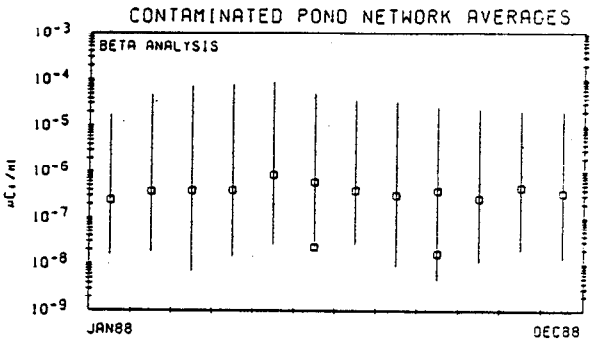


Figure 22 - 1988 Contaminated Pond Network Averages

TABLE 17 - Contaminated Pond Yearly Concentration Averages

(μCi/ml)

Station	Tritium Annual Avg	Gross Beta Annual Avg	Pu-239 Annual Avg
Area 6 Yucca Decontamination Pond	3.5×10^{-6}	8.8×10^{-8}	1.7×10^{-10}
Area 12 E Tunnel Effluent	2.6×10^{-3}	1.9×10^{-7}	1.1×10^{-8}
Area 12 N Tunnel Effluent	2.6×10^{-4}	$< 3.5 \times 10^{-8}$	$< 2.2 \times 10^{-9}$
Area 12 N Tunnel Pond No. 1	2.3×10^{-4}	$< 4.3 \times 10^{-8}$	$< 3.3 \times 10^{-11}$
Area 12 N Tunnel Pond No. 2	2.6×10^{-4}	$< 2.6 \times 10^{-8}$	$< 3.2 \times 10^{-11}$
Area 12 N Tunnel Pond No. 3	2.9×10^{-4}	$< 2.3 \times 10^{-8}$	$< 2.9 \times 10^{-11}$
Area 12 T Tunnel Effluent	1.2×10^{-1}	3.2×10^{-5}	8.9×10^{-9}
Area 12 T Tunnel Pond No. 1	1.5×10^{-1}	4.0×10^{-5}	9.3×10^{-9}
Area 12 T Tunnel Pond No. 2	1.5×10^{-1}	4.5×10^{-5}	8.2×10^{-9}
Area 23 H & S Sump	$< 8.6 \times 10^{-7}$	7.5×10^{-6}	2.6×10^{-9}

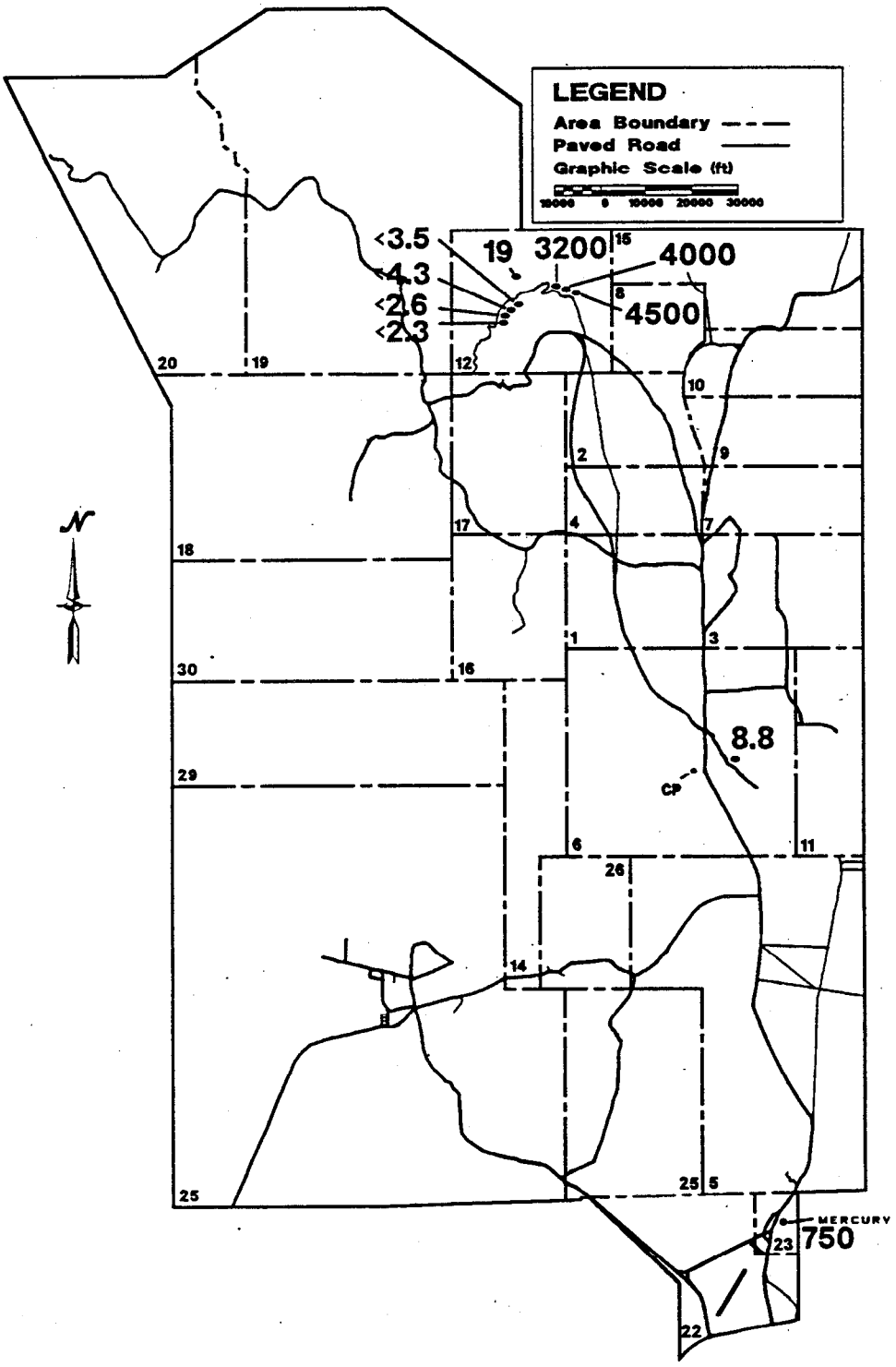


Figure 23 - Contaminated Pond Sampling Stations

AMBIENT GAMMA MONITORING

The program used 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. In CY-1988 three more locations were discontinued, reducing the total to 150 stations.

A new dosimetry monitoring system was implemented at the NTS in 1987 using a thermoluminescent dosimeter 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. The majority of the TLDs were recovered, but some were lost and still others were inaccessible due to environmental conditions.

RESULTS

The external gamma exposures recorded during CY-1987 and CY-1988 are consistantly higher than the corresponding exposures during CY-1986. The differences are attributable to the new dosimetry system and do not reflect real exposure rate increases.

The overall network range of the control stations was 0.24 mR per day to 0.49 mR/day, with an average natural background on NTS of approximately 0.36 mR per day (131 mR per year). The control station values measured in CY-1987 were comparable with rates measured at surrounding off-site 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 per year.

The remaining 141 stations of the network yielded exposure rates which ranged from 0.18 mR/day to 5.22 mR per day with an average exposure rate of 0.56 mR/day (203 mR/yr). These CY-1988 exposure rates are similar to the CY-1987 rates. The average net exposure rate (average station TLD minus average control TLD) for CY-1988 is 0.20 mR per day (73 mR per yr).

"Gamma Monitoring Results - Summary 1988" (Table 18) lists the individual station data for the first half and second half of CY-1988. In addition, this table shows associated average daily exposure rates and the annual exposure for each monitoring station.

Table 18, page 46, 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 19) lists the results for the nine locations that comprise the original control network. This table compares past results from 1982 through the present.

TABLE 18 - Gamma Monitoring Results - Summary of 1988

REPORTING PERIOD: MARCH 1988 TO MARCH 1989

AREA	NAME	EXPOSURE RATE mR/day 1st	2nd	AVG	1987 ANNUAL EXPOSURE (mR/yr)	1988 ANNUAL EXPOSURE (mR/yr)
1	BJY	0.52	0.42	0.47	144	172
1	SANDBAG HUT	0.41	0.33	0.37	149	135
1	STAKE TH-28	–	0.30	0.30	110	–
1	STAKE TH-38	0.50	0.35	0.43	146	157
2	STAKE M-140	0.51	0.41	0.46	159	168
2	STAKE M-150	0.56	0.43	0.50	176	181
2	STAKE 2N-8	5.22	–	–	2046	1905
2	STAKE 2L-6	1.05	0.81	0.93	324	339
2	STAKE TH-58	0.43	0.40	0.50	116	151
3	STAKE D & B RD JCT	–	0.28	0.28	–	102
3	ANGLE ROAD	0.63	–	0.63	183	230
3	U3AX/BL, NE	1.12	0.93	1.03	408	374
3	U3AX/BL, NW	–	–	–	209	–
3	U3AX/BL, S	0.59	0.47	0.53	193	193
3	U3AX/BL, SE	0.65	0.54	0.60	223	217
3	U3BY, N	1.22	0.91	1.07	623	388
3	U3BY, S	0.62	0.51	0.57	186	206
3	U3BZ, N	0.88	0.66	0.77	234	281
3	U3BZ, S	0.55	0.45	0.50	170	183
3	U3CJ, N	0.45	–	0.45	143	164
3	U3CO, S	–	2.11	2.11	758	770
3	U3CO, N	2.73	3.35	3.04	1134	1110
3	U3EY, S	0.53	0.42	0.48	158	347
3	U3DU, N	–	0.51	0.51	206	186
3	U3DU, S	0.73	0.59	0.66	195	241
3	LANL TRLS	–	0.38	0.38	–	139
4	STAKE M-130	0.49	0.39	0.44	183	161
4	STAKE 4A-9	–	4.41	4.41	1641	1484
4	STAKE TH-48	0.55	0.36	0.46	144	166
5	RWMS CORNER, NW	0.57	0.45	0.51	162	186
5	RWMS-E, 500	0.55	0.42	0.49	349	177
5	RWMS-E, 1000	0.58	0.43	0.51	149	184
5	RWMS-E, 1500	0.56	0.40	0.48	146	175
5	RWMS-EAST GATE	0.48	0.41	0.45	170	162
5	RWMS-N, 500	0.80	0.45	0.63	146	228
5	RWMS-N, 1000	0.54	0.42	0.48	150	175
5	RWMS-N, 1500	0.53	0.42	0.48	168	174
5	RWMS-NE CORNER	0.58	0.42	0.50	168	183
5	RWMS OFFICES	–	0.35	0.35	101	128
5	RWMS-S, 500	0.58	0.42	0.50	113	183
5	RWMS SOUTH GATE	1.01	0.52	0.77	278	558

TABLE 18 - Gamma Monitoring results - Summary of 1988

REPORTING PERIOD: MARCH 1988 TO MARCH 1989

AREA	NAME	EXPOSURE RATE mR/day 1st	2nd	AVG	1987 ANNUAL EXPOSURE (mR/yr)	1988 ANNUAL EXPOSURE (mR/yr)
5	RWMS-SW CORNER	0.52	0.40	0.46	135	168
5	RWMS-W 500	0.550	0.43	0.49	152	179
5	RWMS-W 1000	0.58	0.46	0.52	148	190
5	RWMS-W 1500	0.56	–	0.56	145	204
5	WELL 5B	0.48	0.24	0.36	119	157
6	WELL 3	–	0.37	0.37	–	135
6	2-04 RD.	–	5.22	5.22	–	191
6	6-09 & O.B. ROAD	–	–	–	183	–
6	CP-6	0.48	0.24	0.36	76	131
6	CP-2 ROOM 4	–	0.22	0.22	81	80
6	CP-50 CALIBRATION BENCH	0.39	0.27	0.33	127	120
6	CP-50 INSTRUMENT CALIBRATION DRAWER	0.35	0.34	0.35	136	126
6	DECONTAMINATION PAD BACK OFFICE	0.29	0.35	0.32	105	117
6	DECONTAMINATION PAD FRONT OFFICE	–	0.22	0.22	92	80
6	STAKE TH-1	0.34	0.21	0.28	110	100
6	STAKE TH-9	0.50	0.30	0.40	146	146
6	STAKE TH-18	0.44	0.26	0.35	131	128
6	YUCCA OIL STORAGE	–	0.29	0.29	112	106
7	7-300 BUNKER	1.50	1.16	1.33	461	485
8	STAKE 8K-25	0.48	0.34	0.41	120	150
9	9-300 BUNKER	0.57	0.41	0.49	149	179
10	CABLE YARD	–	0.45	0.45	–	164
10	STAKE 10A-24	0.79	0.65	0.72	240	263
10	STAKE CA-14	0.56	–	0.56	174	204
10	CIRCLE AND L ROADS	0.56	0.40	0.48	155	175
10	SEDAN VISITORS BOX	0.64	0.51	0.58	188	210
10	SEDAN ENTRY ROAD	1.84	1.59	1.72	611	626
11	GATE 293	0.48	0.39	0.43	133	158
12	STAKE M-168	–	0.34	0.34	146	124
12	STAKE M-170	1.38	0.37	0.88	168	319
12	STAKE M-175	–	0.36	0.36	141	131
12	BUILDING 12-10	–	0.38	0.38	132	139
12	T TUNNEL No. 2 (LOWER MINT)	–	0.98	0.98	349	358
12	STAKE TH-68.5	0.44	0.28	0.36	123	131

TABLE 18 - Gamma Monitoring Results - Summary of 1988

REPORTING PERIOD: MARCH 1988 TO MARCH 1989

AREA	LOCATION	EXPOSURE RATE mR/day 1st	2nd	AVG	1987 ANNUAL EXPOSURE (mR/yr)	1988 ANNUAL EXPOSURE (mR/yr)
12	UPPER HAINES LAKE	0.53	0.33	0.43	138	157
12	N TUNNEL No. 1	0.68	0.39	0.36	148	195
15	EPA FARM	0.49	0.36	0.43	134	155
15	LAMP SHACK	0.52	0.41	0.47	144	170
15	U15E STORAGE SHED	0.54	0.41	0.48	151	173
15	U15E SUBSTATION	0.44	0.31	0.38	129	137
17	STAKE M-190	0.68	0.42	0.55	153	201
17	STAKE M-185	–	0.39	0.39	149	142
18	STAKE 18P-35	0.67	0.45	0.56	175	204
18	STAKE M-196	0.79	0.41	0.60	163	219
18	STAKE 18P-39	–	0.36	0.36	175	131
18	GATE 18A 134.5	–	0.80	0.80	183	292
19	STAKE 19P-41	0.71	0.44	0.58	185	214
19	STAKE 19P-46	0.60	0.38	0.49	152	179
19	STAKE 19P-54	0.60	0.39	0.50	158	181
19	STAKE 19P-59	0.76	0.41	0.59	185	214
19	STAKE 19P-66	0.74	–	0.74	176	270
19	STAKE 19P-71	0.66	0.43	0.55	185	199
19	STAKE 19P-77	0.61	0.48	0.55	173	199
19	STAKE 19P-87	1.81	0.90	1.36	186	495
19	STAKE 19P-88	–	0.84	0.84	207	307
19	STAKE 19P-91	0.58	0.45	0.52	178	188
19	STAKE C-16	0.71	0.40	0.56	163	203
19	STAKE C-25	0.69	0.40	0.55	151	199
19	STAKE C-27	0.65	0.40	0.53	182	192
19	STAKE C-31	0.72	–	0.72	689	262
19	STAKE R-20	0.58	0.43	0.51	168	184
19	STAKE R-27	0.57	0.45	0.51	185	186
19	STAKE R-3	0.66	0.48	0.57	191	208
19	STAKE R-31	0.55	0.43	0.49	172	179
19	STAKE R-7	0.65	0.50	0.58	167	210
19	WELL U19C	0.66	0.39	0.53	1062	192
20	STAKE 20P-120.5	0.55	0.41	0.48	193	175
20	STAKE 20P-116.5	0.59	0.43	0.51	172	186
20	P & K RD JCT	0.57	0.44	0.50	165	184
20	STAKE 20P-134	0.59	0.43	0.51	172	186
20	STAKE 20P-124	0.61	0.47	0.54	175	197
20	STAKE 20P-129	0.58	0.44	0.51	180	186
20	STAKE J-6	–	0.48	0.48	–	175
20	STAKE J-16	0.59	0.44	0.52	181	188
20	STAKE J-24	0.60	0.44	0.52	167	190

TABLE 18 - Gamma Monitoring Results - Summary of 1988

REPORTING PERIOD: MARCH 1988 TO MARCH 1989

AREA	LOCATION	EXPOSURE RATE mR/day 1st	2nd	AVG	1987 ANNUAL EXPOSURE (mR/yr)	1988 ANNUAL EXPOSURE (mR/yr)
20	STAKE J-31	1.39	1.04	1.22	432	443
22	DESERT ROCK CONTROL TOWER	–	0.23	0.23	68	84
22	BLDG. 190	0.84	0.64	0.74	195	270
23	BLDG. 610 GATE	0.29	0.19	0.24	75	88
23	BLDG. 610 WORK AREA	2.55	1.83	2.19	952	80
23	BLDG. 650 DOSIMETRY ROOM	0.30	0.22	0.26	51	95
23	BLDG. 650 ROOF	0.29	0.18	0.24	62	86
23	BLDG. 650 SAMPLE STORAGE	0.50	0.19	0.35	140	126
23	GATE 100	0.30	0.20	0.25	62	91
23	POSTOFFICE	0.34	0.24	0.29	89	106
23	BUILDING 180, SCALER	0.44	0.32	0.38	95	139
25	GATE 25-4P	0.53	0.42	0.48	134	173
25	GATE 25-7P	0.58	0.40	0.49	130	179
25	EMAD-E	0.51	0.38	0.45	134	173
25	EMAD-N	0.47	0.34	0.41	109	148
25	EMAD-S	0.49	0.39	0.44	133	161
25	EMAD-W	0.48	0.36	0.42	124	153
25	HENRE SITE	0.53	0.40	0.47	123	170
25	NRDS WAREHOUSE	0.51	0.40	0.46	144	166
27	AREA 27 CAFE	0.56	0.42	0.49	139	179

TABLE 18 - Gamma Monitoring Results - Summary of 1988

REPORTING PERIOD: MARCH 1988 TO MARCH 1989

AREA	UTM COORDINATE LOCATION	EXPOSURE RATE mR/day 1st	2nd	AVG	1987 ANNUAL EXPOSURE (mR/yr)	1988 ANNUAL EXPOSURE (mR/yr)
3	N844,200 E704,900	0.27	0.19	0.23	60	84
5	N710,800 E720,000	0.26	0.19	0.23	30	82
9	N874,600 E691,500	0.29	0.22	0.26	82	93
11	N788,800 E709,500	0.54	0.42	0.48	116	175
12	N903,800 E635,500	0.43	0.31	0.37	115	135
15	N907,600 E686,200	0.54	0.44	0.49	144	178
18	N849,500 E545,000	0.58	0.43	0.51	201	184
19	N935,500 E639,750	0.98	0.40	0.69	146	252
19	N955,500 E614,200	0.57	0.42	0.50	214	181
20	N887,000 E558,000	0.60	0.50	0.55	172	201
20	N948,800 E527,800	0.62	0.44	0.53	202	193
20	N944,700 E563,300	0.07	0.26	0.17	134	60
22	N670,600 E667,300	0.26	0.20	0.23	158	84
25	N731,300 E638,700	0.37	0.27	0.32	145	117
25	N754,400 E557,800	–	0.40	0.40	–	146

TABLE 19 - TLD Control Station Comparison

	Exposure Rate (mR/day)						
Station	1982	1983	1984	1985	1986	1987	1988
Bldg. 650 Dosimetry	0.19	0.21	0.15	0.13	0.31	0.14	0.26
Bldg. 650 Roof	0.18	0.18	0.14	0.12	0.13	0.17	0.24
Area 27 Cafeteria	0.37	0.39	0.32	0.29	0.27	0.38	0.49
CP-6	0.20	0.25	0.18	0.17	0.13	0.21	0.36
HENRE Site	0.37	0.36	0.30	0.28	0.27	0.34	0.47
NRDS Warehouse	0.38	0.36	0.32	0.28	0.28	0.39	0.46
Post Office	0.18	0.18	0.14	0.13	0.16	0.24	0.29
Well 5B	0.33	0.33	0.27	0.26	0.22	0.32	0.43
Yucca Oil Storage	0.28	0.28	0.23	0.21	0.22	0.30	0.29
Network Average	0.28	0.28	0.23	0.21	0.22	0.28	0.37

RADIOACTIVE WASTE MANAGEMENT

Robert J. Straight, Daniel A. Gonzalez

The Radioactive Waste Management Project (RWMP), was established at the Nevada Test Site in January, 1961. On that date the first of six trenches was opened for the disposal of radioactive waste materials from the NTS. In 1978 operations expanded to include the disposal of low level waste (LLW) generated at other DOE facilities.

Approximately 5000 people live within a 50-mile radius of the RWMS, both on and off the NTS. The nearest off-site population center is Indian Springs, formerly a U.S. Air Force base, 19 miles east-southeast from the RWMS. The nearest major population center is the greater Las Vegas area.

Disposal managed by the Defense Waste Management Department (DWMD), successor to the RWMP. Burial in shallow pits, trenches, augured shafts and subsidence craters is handled at two different sites 13 miles apart, one of which is in Area 5, the Radioactive Waste Management Site (RWMS) and one in Area 3, the Bulk Waste Management Facility (BWMF). Radioactive Waste Management sites are displayed in Figure 24.

THE RADIOACTIVE WASTE MANAGEMENT SITE

The RWMS occupies approximately 700 acres of the Frenchman basin in the southeastern part of the NTS. It lies 14 miles north of the main gate, in Area 5. Area 5 includes much of the Frenchman Flat playa where nuclear tests were conducted in the 1950's to determine civilian effects of nuclear weapons.

The Frenchman basin is bounded by the Massachusetts Mountains to the north, Black Ridge and Mt. Salyer to the west, the Buried Hills and Ranger Mountains to the east, and Mercury Ridge to the south. The general surface rock type in the area consists of alluvial sediment. The basin is filled with up to 1000 feet of these sediments which have collected there from the surrounding mountains.

The disposal site is located on the relatively flat alluvial fan extending southward from the Massachusetts Mountains which lie approximately two miles away. In the vicinity of the disposal site the slope of the terrain is two percent in this direction. Towards the west, in the direction of the Mercury Highway, the slope is approximately three percent. Two intermittent washes cut through the site from the northwest; an earthen dike has been constructed along the northern border of the RWMS to prevent water flow into the disposal area from this direction.

Elevation at the main RWMS office, Building 5-7, is 3185 feet. The highest elevation within the disposal site boundary is 3335 feet at the extreme northwest corner. The lowest elevation is 3180 feet at the extreme southeast corner.

There are no permanent sources of surface water or water wells at the RWMS, domestic water supplies for the site are obtained from storage tanks. Depth to the water table is approximately 800 feet. Preliminary modeling studies have shown the travel time from the surface to the water table to be thousands of years.

The RWMS contains the low-level waste management unit (LLWMU) which is comprised of the low-level waste (LLW) disposal unit, the Transuranic (TRU) Waste Storage Cell (WSC) and the greater confinement disposal (GCD) unit. Of the 732 acres of the RWMS, 92 acres are fully fenced and posted with warning signs and are in current use for low level waste disposal operations. Of the 92 acres, approximately 17 acres have been or are being used for actual disposal.

The mixed waste management unit (MWMU) is located just north of the RWMS and will be part of routine disposal operations. This area, covering approximately 190 acres, will contain 96 landfill cells to be used for mixed waste disposal. The MWMU is currently operated under interim status authorization from the state of Nevada pending approval of the permit application.

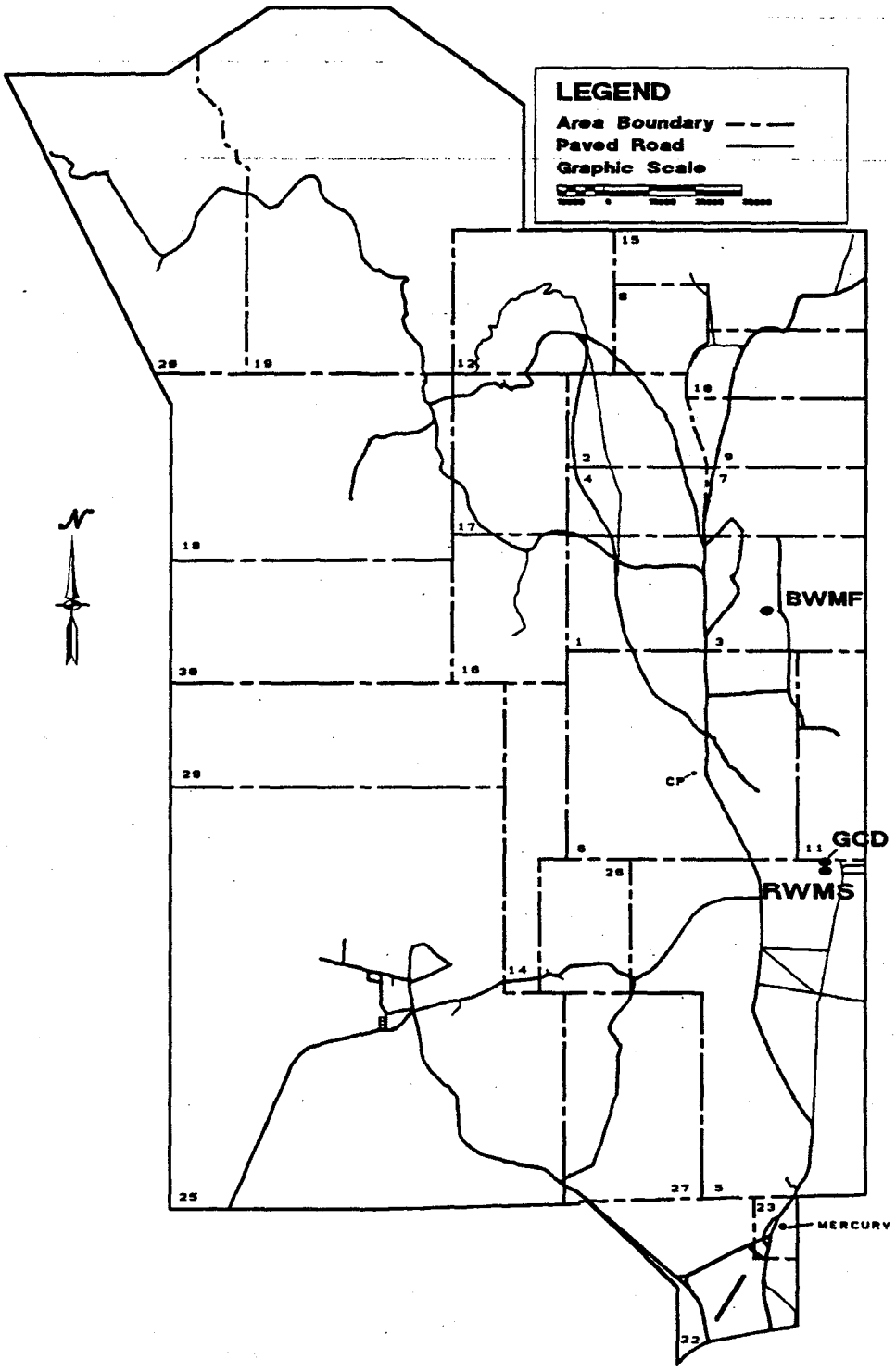


Figure 24 - Radioactive Waste Management Sites

TABLE 20 - Radioactive Waste Management Site, Area 5
During CY-1988

GENERATOR	SHIPMENTS	CURIES/ISOTOPE	VOLUME (m^3)	WEIGHT (kg)
Decon Pad, NTS	1	0.0005/MFP*	36	1,134
EG&G, Mound	344	875,000/^{3}H	7,646	6,186,250
EG&G Santa Barbara	2	35.7/^{60}Co	2	3,870
HPD Laboratory, NTS	3	0.007/MFP	6	5,766
HPD Soils Laboratory, NTS	1	0.0017/MFP	9	925
LLNL-Livermore	10	940/D38**	663	186,660
Lovelace Foundation	1	0.0463/^{144}Ce	41	17,050
Rockwell, Canoga Park	7	1.64/^{137}Cs	133	46,850
Rocky Flats Plant	93	5.19/^{238}Pu	5,097	1,529,100
Sandia-Livermore	1	49,200/^{3}H	1	165
U.S. Army, Aberdeen	6	12.7/^{238}U	81	10,600
Westinghouse, Ohio	278	72.0/^{238}U	7,388	4,343,890
TOTAL	**749**	**925,000 Ci**	**21,106**	**12,427,594**

*MFP = Mixed Fission Products

**D38 = Depleted Uranium (Contains Less Than 0.71 Atom-% ^{235}U)

Mixed waste is received only from the DOE Rocky Flats Plant and is presently buried in Pit 3. The first shipment was received in December, 1988.

OPERATIONS AT THE RWMS

The RWMS (as well as the BWMF) accepts only waste materials which are defense-related. All waste must comply with DOE Order 5820.2A, today 18 waste generators are authorized to send material to the NTS for disposal: U.S. Army/Aberdeen, U.S. Navy, Rockwell/Rocketdyne, EG&G/Energy Measurements, Westinghouse Materials Company of Ohio, General Atomics, Lockheed, EPA/Las Vegas, Lawrence Livermore National Laboratory, Lovelace Foundation, EG&G Mound Technologies, New Brunswick Laboratory, Pantex, Rockwell/Rocky Flats Plant, Sandia Laboratories/Livermore, Defense Nuclear Agency, EG&G/Santa Barbara and Bendix/Kansas City. The site itself is operated in full compliance with applicable Environmental Protection Agency (EPA) and Nevada regulations, and DOE Orders.

Wastes are usually received in DOT Type A containers, e.g., heavy plywood boxes or 55-gallon steel drums. These containers are neatly stacked and the location of each

TABLE 21 - Bulk Waste Management Facility, Area 3

GENERATOR	SHIPMENTS	CURIES/ISOTOPE	VOLUME (m3)	WEIGHT (kg)
Area 12, Tunnels, NTS	51	0.0374/MFP*	752	541,224
Decon Pad, NTS	5	0.0355/MFP	68	6,622
EG&G, Mound	5	86/^{3}H	131	78,750
HPD Laboratory, NTS	6	0.011/MFP	22	18,738
HPD Soils Laboratory,NTS	1	0.0017/MFP	9	925
LANL-NTS	10	2.86/MFP	15	2,894
LLNL-NTS	10	2.47/MFP	1	98
On-Site Cleanup	930	**	16,740	
*Westinghouse, Ohio	119	3.01/^{238}U	4,815	1,874,250
TOTAL	**1,131**	**> 93.4 Ci**	**22,553**	**> 2,444,751**

* Mixed Fission Products

**Unknown

package within the stack is noted in case retrieval is necessary. An eight-foot cap of clean soil, which extends four feet above grade is eventually placed over the waste materials to effectively isolate them from the biosphere and the environment in general.

Most of the shipments received are tritium and plutonium-contaminated materials; however, special equipment and facilities are available for handling high specific activity (HSA) gamma emitters. Reusable Type B transportation containers are used to ship the HSA wastes which are received on occasion. Wastes shipped in this fashion are packaged in smaller containers which are removed from the outer container and placed in greater confinement disposal (GCD) shafts.

GREATER CONFINEMENT DISPOSAL

Greater confinement disposal was suggested as a supplemental disposal method to augment shallow land burial (SLB). This latter method is not suitable for the disposal of certain materials which might constitute special hazards to the public or the environment. As a result the concept of deeper burial in augured shafts was proposed. Details of the concept and the test which was devised to help characterize the method are given in DOE/NV/10327-39.

Work at the GCDT shaft is being continued by personnel from the University of California, Berkeley, in an effort to determine the tritium source term. Air samples taken by the DWMD from the headspace over the satellite holes around the main shaft have shown tritium oxide (HTO) concentrations to vary from 3.1×10^{-8} μCi/ml of air to 7.8×10^{-10} μCi/ml of air depending upon location. Tritium gas (HT) concentrations are typically lower than the respec-

tive HTO concentrations. The maximum permissible concentrations of HTO and HT in air for non-occupational exposures are 5.0×10^{-6} μCi/ml of air and 4.0×10^{-4} μCi/ml of air respectively.

The GCD unit at the RWMS is surrounded by an earth berm in an isolated part of the site. Preliminary results show an airborne HTO concentration of 3.3×10^{-7} μCi/ml of air and HT concentration of 1.5×10^{-6} μCi/ml of air in the headspace inside a covered shaft containing HSA tritium waste.

TRANSURANIC WASTE STORAGE

The TRU pad is used for interim storage of TRU waste materials from Lawrence Livermore National Laboratory (LLNL), pending shipment to the Waste Isolation Pilot Plant in New Mexico. During CY-1988 a RCRA storage pad was constructed specifically for the storage of these materials.

THE BULK WASTE MANAGEMENT FACILITY

The second site is known as the Bulk Waste Management Facility (BWMF). It lies at an elevation of 4050 feet and covers approximately 50 acres. It is located in a large valley bounded by mountains and the Nellis Bombing and Gunnery Range. Its climate and topography is similar to that of the site in Area 5. Further details regarding the BWMF are available in DOE/NV/10327-39.

Waste materials which cannot be packaged are disposed of at the BWMF, only LLW can be accepted. Much of the waste material buried there is contaminated soil and metal remaining from the atmospheric testing of nuclear weapons at the NTS. These materials are collected by DWMD personnel from individual test or disposal areas, transported to Area 3 by truck and unloaded in subsidence craters (which result due to surface ground collapse after underground nuclear detonations). As layers of waste material are added, they are covered with uncontaminated soil until the crater is filled.

Two craters, U3ax and U3bl, were filled in this manner, and between 1974 and 1988, 208,000 cubic meters of contaminated material were consolidated at this location. An eight-foot cap of clean soil extending four feet above grade was placed over the craters to isolate them and the waste they contain. In compliance with the Resource Conservation and Recovery Act of 1976 (RCRA), a closure plan for this location has been submitted for which approval is pending.

Onsite cleanup operations continue with waste materials being placed in the U3ah and U3at craters. Three contaminated areas were cleaned during CY-1988 and work was begun on four more. 16,565 cubic meters of waste were moved as part of these operations, representing 95% of the total onsite cleanup effort for CY-1988.

Table 21 summarizes the DWMD disposal operations for CY-1988.

ROUTINE ENVIRONMENTAL AND EFFLUENT MONITORING

The Environmental Surveillance Branch (ESB) of the REECo Health Physics Department is responsible for collection of most of the samples taken for effluent and environmental monitoring on the NTS, including the RWMS and the BWMF. At the RWMS airborne particulate material is collected at nine sites around the perimeter fence and from six sites within the fence. At the BWMF four samplers are deployed around the perimeter fence of that site. Descriptions of the air sampling equipment used at both the RWMS and the BWMF can be found in the chapter entitled Radioactivity in Air.

Naturally occuring radionuclides like ^{238}U, ^{232}Th decay daughters and ^{40}K are sometimes detected. The sampling locations and the average annual concentrations for gross beta activity and ^{239}Pu are shown in Figure 25.

Thermoluminescent dosimeters (TLD's) are deployed and collected quarterly to obtain long-term gamma exposure rate readings. There are 16 TLD locations around the RWMS and four similar stations around the BWMF. The TLD stations and the average daily dose for CY-1988 are shown in Figure 26 & 27.

AIRBORNE TRITIUM MONITORING AT THE RWMS

The primary non-natural airborne contaminant at the RWMS is tritium (^{3}H). Due to its tendency to migrate with (or as) soil moisture, it represents the greatest potential for human exposure over the long term. Large quantities have been buried at the RWMS and special monitoring is performed at locations of high risk.

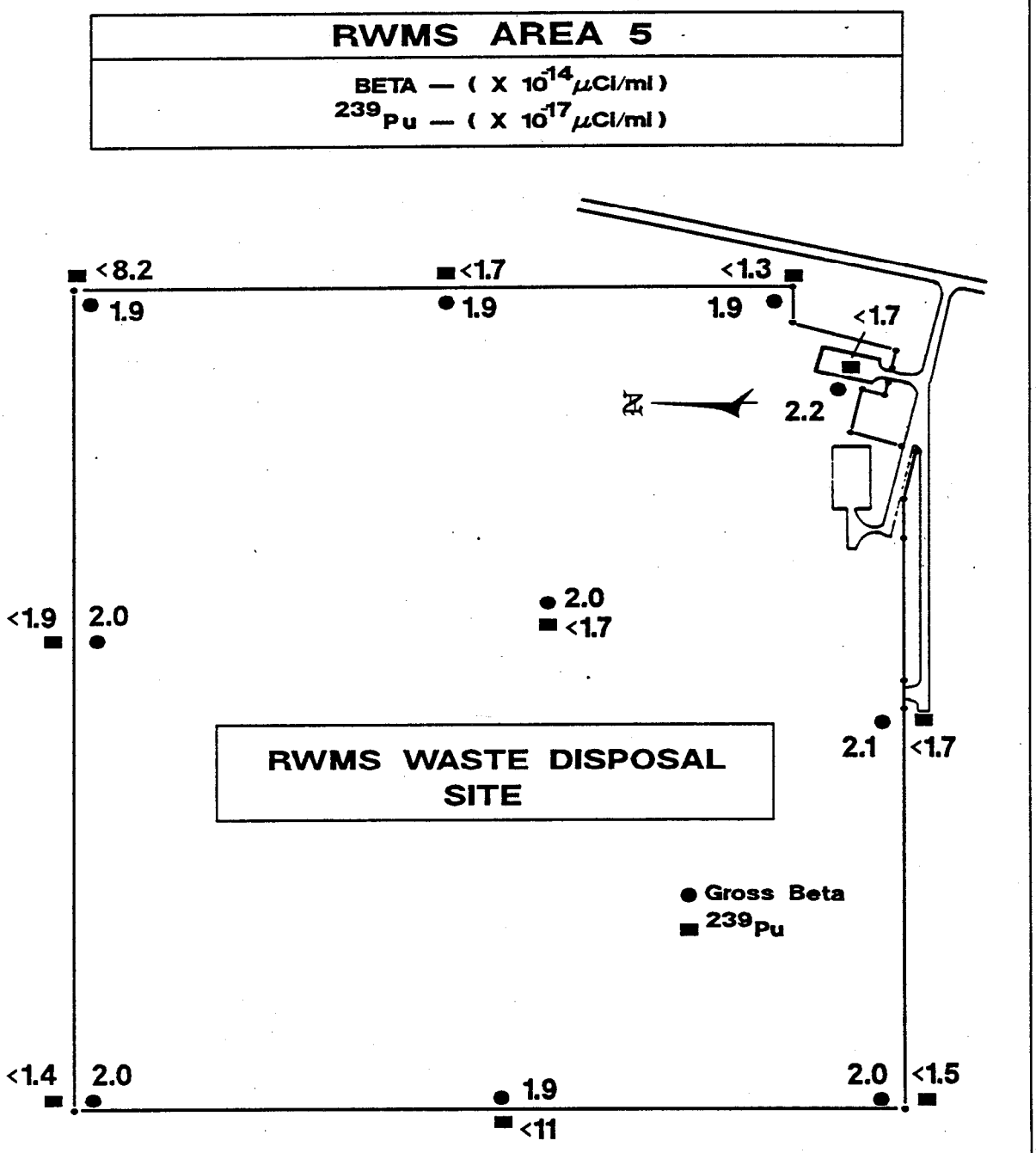


Figure 25 - RWMS Air Monitoring Stations

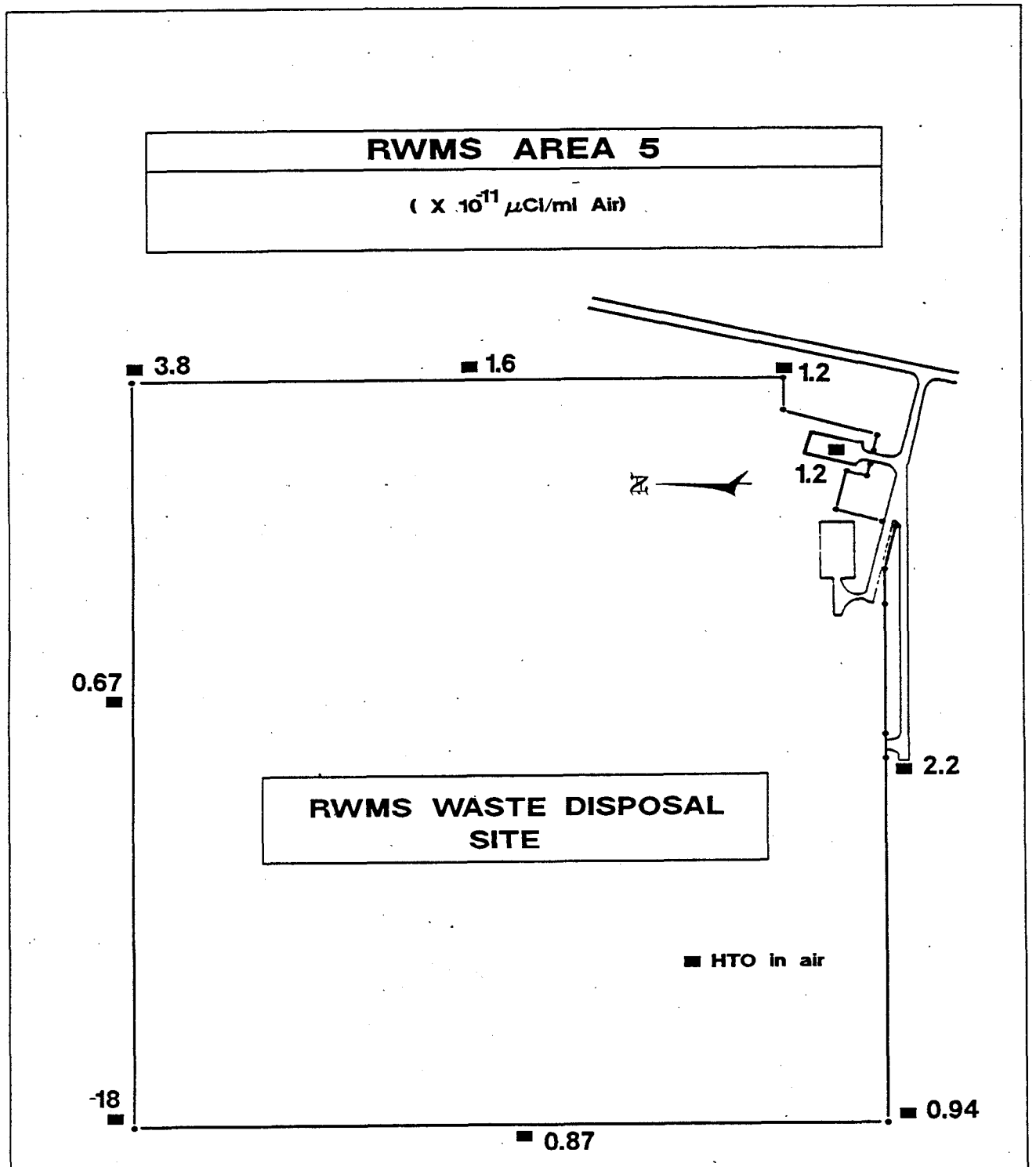


Figure 26 - RWMS Tritium Monitoring Stations

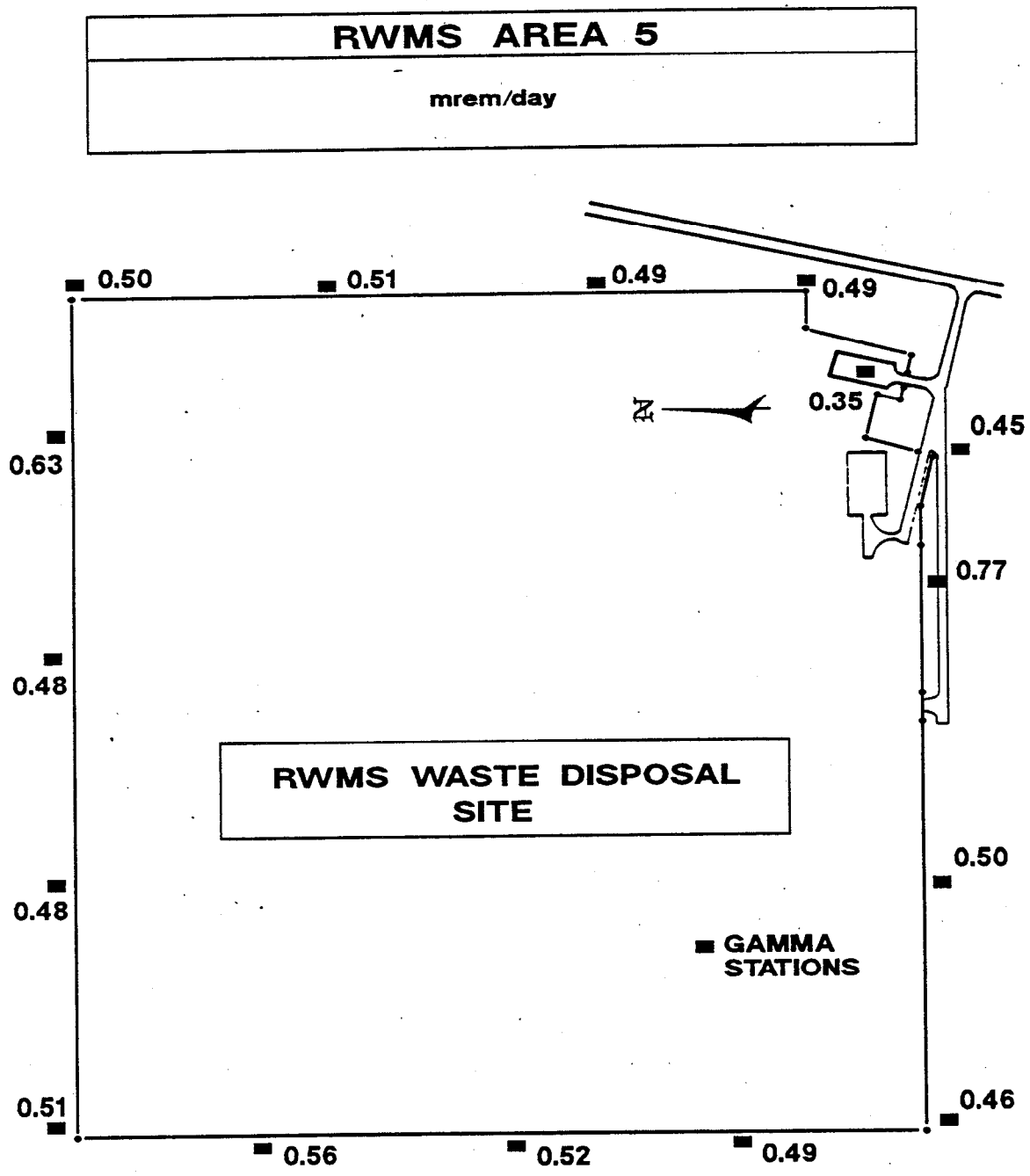


Figure 27 - RWMS Gamma Monitoring Stations

At the RWMS, samplers for tritium oxide are located together with the particulate samplers. These consist of a column of silica gel, a pump for drawing air through the desiccant and a rotameter to measure the sampling rate. They are collected routinely every two weeks, during which 0.3-0.5 liter of air per minute is sampled continuously. No samples of this type are taken at the BWMF since the amount of tritium buried there is negligible.

Three monitoring stations have been established where the potential for exposure is high. The results of the samples collected at these locations are summarized in Table 22, Airborne Tritium Concentrations.

Due to the nature of the operations at the RWMS very little contamination is detected other than naturally occurring radioactive materials. Stringent packaging requirements, unloading protocols, monitoring and limited access work together to keep what little contamination is detected from spreading. The air sample network in and around the site shows this to be true. Water samples are taken as available (precipitation and runoff) whereas soil samples are most often taken for baseline measurements when new properties are added to the site.

TABLE 22 - Airborne Tritium Concentrations

($\times 10^{-11}$ μCi/ml HTO of air)

Station No.	Maximum	Minimum	Average
1	9.32	2.68	5.40
2	1.50	0.782	1.20
3	68.9	0.810	11.5

SOIL SAMPLING

In 1987 an additional 450 acres of land were added to the RWMS. Baseline soil samples were taken on a 100 units grid during the latter part of 1987 and the summer months of 1988. A total of 1996 samples were taken, 1528 of which were collected in CY-1988. Of these a total of 128 samples were sent to the laboratory for various analyses. The primary gamma emitters found were naturally occurring. Small amounts of ^{137}Cs were found in some samples which represents residual fallout from nuclear tests in Area 5.

WATER SAMPLING

There are few opportunities to collect surface water samples of any kind at either disposal site. When they can be collected they are taken from areas of high traffic and analyzed for gamma emitters. No activity above background levels was found in any of the samples taken during CY-1988.

SWIPE SAMPLES

Surface contamination samples (swipe samples) are taken weekly as checks on the radiological integrity of the various facilities in Areas 5 and 3 and analyzed in those areas. The swipes are taken at office areas, lunchrooms, work surfaces, laboratories, vehicles, etc. No gross alpha or gross beta activity above background levels was found on any of the samples from either site during CY-1988.

MISCELLANEOUS

Portal Monitor

During CY-1988 a new portal monitor was purchased to replace the one in use at Area 5. All personnel entering the fenced area must pass through this instrument before departing the site at the end of shift. The new instrument is known to be much more sensitive than the previous one but so far, only naturally occuring radinuclides have been detected.

Radon Sampling

A large quantity of waste material containing uranium and thorium is in temporary storage in an isolated location at the RWMS pending final disposal there. The materials are packaged in wooden boxes which in turn are stored in 28 steel cargo containers. These containers are passively ventilated through holes in the container walls and samples of the atmosphere inside are taken as needed from these vent holes. The containers are located inside a fenced area which is posted with warning signs and the containers are not opened for any reason due to the airborne contamination known to be present in them.

Results of the sampling of these containers show widely varying amounts of radon (^{222}Rn) in the interiors. The radon is obviously seeping through the walls of the containers or around the lids since it is seen that the radon daughters (^{218}Po, ^{214}Pb, ^{214}Bi) are not in equilibrium with the parent. This implies that the radon is not remaining in the containers long enough for equilibrium to be established (4 hours).

Instrumentation was bought to aid in development of a sampling procedure for the atmosphere in these containers. Further sampling showed radon concentrations to be quite variable from one container to the next but, generally, less so from one sampling period to the next for the same location. In CY-1988 these concentrations varied from 2.3 x 10^{-6} μCi/ml (2300 pCi/L) of air to 6 x 10^{-9} μCi/ml of air.

In addition to the airborne alpha emitters present collection of ^{214}Bi inside these containers would constitute an additional gamma hazard besides that from the parent material. Ventilation reduces the hazards from penetrating radiations and is in keeping with the philosophy of keeping doses as low as reasonably achievable (ALARA).

Vadose Zone Monitoring

As part of the mixed waste disposal project a method for monitoring a waste stack is needed to give an indication of leakage of hazardous materials into the floor of the disposal pit. Work has been proceeding on this monitoring system.

Because of the very low levels of hazardous materials which must be detected (parts per billion) in order to give early warning of a leak, many natural interferences have been found. This has greatly complicated the process of characterization of the background soil, which must be done in order to detect slight changes in serial samples from a given location. Inserting soil gas samplers can easily contaminate clean soil to the extent that small amounts of foreign materials may go undetected but which might be indicative of migration of hazardous materials.

It has been found that collection of materials of interest on small charcoal tubes from soil gas samples and thermal desorption of the collected materials into a gas chromatograph provides excellent analytical sensitivity. This appears to be the most promising method for accomplishing the needed work.

EFFLUENT MONITORING

Bernard F. Eubank, Daniel A. Gonzalez

Various radiological effluents are released into the NTS environment as part of routine operations. These effluents are monitored by the three major nuclear testing organizations and REECo. The results are submitted to the DOE on a yearly basis by each organization.

Contained in this section is a summary of the specific event (nuclear testing) monitoring and general environmental surveillance conducted prior to and after each event. Listed in this section are the various events by name and the results of measurements taken at each event site.

INTRODUCTION

Radioactivity released to onsite waste treatment or disposal systems is 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 below monitor effluent points for radionuclides released as effluents. It is important to note that the liquid releases presented in this chapter were not released into the offsite environment. They were released into onsite containment ponds.

The Reynolds Electrical & Engineering Co., Inc. (REECo) Health Physics Department (HPD) provided onsite radiological safety support including monitoring for effluents during 11 announced nuclear tests in CY-1988. These tests were conducted by the NTS Users: Los Alamos National Laboratory (LANL); Lawrence Livermore National Laboratory (LLNL); and the Defense Nuclear Agency (DNA). The U.S. Department of Energy (DOE) had the final responsibility for these nuclear tests.

The test-associated services provided by REECo included detecting, recording, evaluating, and reporting radiological and industrial hygiene conditions prior to, during, and after each test. Selected personnel, equipped with specialized collection and measurement instruments, were ready to respond rapidly should an accidental release of radioactive materials occur.

Complete radiological safety and industrial hygiene coverage was also provided during post-event drillback and mining operations. Methods of data accumulation included recording telemetered radiation measurements from surveys of the test area, monitoring of post-event drill sites and mining operations, aerial monitoring, air sampling, bioassays whole-body counting and environmental sampling of soil and water.

There were no whole-body external or internal exposures which exceeded the radiation protection guides in DOE Order 5480.11, during CY-1988.

REECo collected grab samples from several effluent sources. The samples were analyzed for radioactive contaminants and from an estimation of the flow of contaminated water entering the containment ponds, a total quantity of contamination was calculated.

In addition to the monitoring efforts conducted by REECo, Sandia National Laboratory (SNL) also conducts routine effluent sampling at the U12g tunnel complex. Using a weekly grab sample, the SNL scientists can measure the tritiated water vapor emitted from the tunnel. REECo and SNL monitoring results are discussed later in the chapter.

TEST SUPPORT ACTIVITIES

Telemetered data from the surface ground zero array was the first information recorded by REECo personnel following detonation of a nuclear device. Each gamma-sensitive ion chamber detector was linked by microwave and hard wire communications to a readout console in Control Point Building No. 1, 2 or the Control and Data Acquisition Center. The console also contained a readout for each of the permanent telemetered remote area monitoring stations. Readings on each readout and the time of the readings in minutes after zero time (detonation) were recorded and displayed.

When released by the Test Controller, REECo personnel accompanied the Test Group Director's inspection party entering the potential radiological exclusion area to perform an initial survey. Radiation measurements, obtained using portable detection instruments, plus measurement time and location were recorded on survey forms and the information reported via radio. Locations were determined from roadside numbered reference stakes. Maps showing the locations of these reference stakes in relation to roads and landmarks were provided to participating test groups. Radiation exposure rates obtained with portable instruments usually were made at waist-high level (approximately one meter from the surface).

POST-EVENT SUPPORT ACTIVITIES

During the post-event drillback and mining activities, REECo personnel maintained continuous environmental surveillance in the work area. For drillback coverage, radiation detector probes were placed in strategic locations in the work areas and connected to recorders and alarms to warn of increases in radiation levels. Routinely, monitors using portable instruments periodically checked radiation levels and gas concentrations in the work area, and issued protective equipment or evacuated the area of personnel when necessary.

For drillback containment, the LANL utilized a pressurized recirculation radioactive effluent containment system. The LLNL used a ventline filter system designed to trap radioactive particulates released from the drill casing. In the ventline system, trapped radioactive material was allowed to decay under controlled conditions.

When requested by the user conducting the experiment, portable air sampling units were placed at predetermined locations. The sampler drew air at a calibrated rate through a prefilter and charcoal cartridge. Gaseous radionuclides present (radioiodine in particular) were trapped in the cartridges. The filters and cartridges were changed at specific times and analyzed by the REECo laboratory.

Environmental surveillance was maintained through continuous sampling and analysis of air and water at numerous locations on the NTS. The collected samples were analyzed by the REECo laboratory.

TEST EVENT SUMMARIES

Kernville

The KERNVILLE event was conducted by LLNL at site U20ar at 1010 hours on February 15, 1988. Telemetry measurements began at 1011 hours on February 15, 1988, and ended at 1010 hours on February 16, 1988. The maximum exposure rate detected was 0.05 mR/h (background). There was no detectable release of fission products within the first 60 minutes after detonation and there was no detectable release of radioactivity during post-event operations.

The initial radiation survey into the test area began at 1101 hours on February 15, 1988, and the maximum gamma exposure rate detected by portable radiation detector was 0.05 mR/h. The initial survey was completed at 1153 hours on February 15, 1988. No post-event drilling was scheduled or conducted.

Abilene

The ABILENE event was conducted by LANL at site U3mn at 1015 hours on April 7, 1988. Telemetry measurements began at 1015 hours on April 7, 1988, and ended at 1008 hours on April 8, 1988. The maximum radiation exposure rate detected was background.

The initial radiation survey into the test area began at 1045 hours on April 7, 1988, the maximum gamma exposure rate detected was 0.05 mR/h (background). The initial survey was completed at 1057 hours on April 7, 1988. There was no detectable release of fission products within the first 60 minutes after detonation and during post-event drilling operations.

Schellbourne

The SCHELLBOURNE event was conducted by LLNL at site U2gf at 0835 hours on May 13, 1988. Telemetry measurements began at 0836 hours on May 13, 1988 and ended at 0835 hours on May 14, 1988. The maximum exposure rate detected was 0.05 mR/h (background). There was no detectable release of fission products within the first 60 minutes after detonation. Radioactivity released during post-event operations through the ventline filters and reported to the DOE included 13.97 curies of ^{133}Xe, 0.18 Curies of ^{133m}Xe, 7.3 Curies of ^{135}Xe, 3.2×10^{-5} Curies of ^{131}I and 1.1×10^{-4} Curies of ^{133}I.

The initial radiation survey into the test area began at 0902 hours on May 13, 1988, and the maximum gamma exposure rate detected was 0.05 mR/h. The initial survey

was completed at 0924 hours on May 13, 1988. Post-event drilling began at 1730 hours on May 14, 1988, and in accordance with LLNL requirements, the post-event drill hole had gas sampling tubing cemented to the surface at 1230 hours on May 20, 1988. The maximum gamma radiation exposure rate detected in a work area during post-event drilling operations was 1.0 R/h at PS# 1AB at 1543 hours on May 17, 1988. This exposure rate was caused by the coring operation which exposed the core sample for a period of 5 seconds.

Laredo

The LAREDO event was conducted by LANL at site U3mh at 1530 hours on May 21, 1988. Telemetry measurements began at 1530 hours on May 21, 1988, and ended at 0800 hours on May 23, 1988. The maximum exposure rate detected was background.

The initial radiation survey into the test area began at 1635 hours on May 21, 1988, and the maximum gamma exposure rate detected was 0.05 mR/h (background). The initial survey was completed at 1706 hours on May 21, 1988.

Post-event drilling began at 0150 hours on May 24, 1988. In accordance with LANL requirements, a gas sampling tube was cemented in the post-event drill hole and capped at 1226 hours on June 21, 1988. The gas sampling hole was cemented on February 27, 1989.

The maximum gamma radiation exposure rate detected in a work area during post-event drilling operations was 80 mR/h at PS#1A at 1125 hours on May 25, 1988. This exposure rate was caused by the coring operation. The core sample was exposed for approximately two minutes on the rig floor.

Comstock

The COMSTOCK event was conducted by LLNL at site U20ay at 0600 hours on June 2, 1988. Telemetry measurements began at 0601 hours on June 2, 1988 and ended at 0800 hours on June 3, 1988. The maximum exposure rate detected was 0.5 mR/h (background). There was no detectable release of fission products within the first 60 minutes after detonation. A detectable release of radioactivity occurred while laying down a joint of pipe during the coring operation at 0246 hours on June 6, 1988. The drill rig platform detector/recorder measured 35 mR/h for a 15-second duration.

The initial radiation survey into the test area began at 0645 hours on June 2, 1988, and the maximum gamma exposure rate detected was 0.05 mR/h. The initial survey was completed at 0747 hours on June 2, 1988. Post-event drilling began at 1840 hours on June 3, 1988.

The maximum gamma radiation exposure rate detected in a work area during post-event drilling (coring) operations was 40 mR/h on PS#1A at 0325 hours on June 6, 1988. The core sample was exposed for approximately two minutes. There were no whole-body external or internal exposures which exceeded the radiation protection guides in DOE Order 5480.1 Chapter XI.

Rhyolite/Nightingale

The RHYOLITE/NIGHTINGALE event was conducted by LLNL at site U2ey at 0700 hours on June 22, 1988. Telemetry measurements began at 0701 hours on June 22, 1988, and ended at 0800 hours on June 23, 1988. The maximum exposure rate detected was 0.05 mR/h (background). There was no detectable release of fission products within the first 60 minutes after detonation and during post-event operations.

The initial radiation survey into the test area began at 0731 hours on June 22, 1988, and the maximum gamma exposure rate detected was 0.05 mR/h. The initial survey was completed at 0755 hours on June 22, 1988. No post-event drilling was scheduled or conducted.

Alamo

The ALAMO event was conducted by LANL at site U19au at 0805 hours on July 7, 1988. Telemetry measurements began at 0805 hours on July 7, 1988, and ended at 0809 hours on July 8, 1988. The maximum exposure rate detected was background. There was no detectable release of fission products within the first 60 minutes after detonation.

The initial radiation survey into the test area began at 0825 hours on July 7, 1988, and the maximum gamma exposure rate detected was background. The initial survey was completed at 0858 hours on July 7, 1988.

Post-event drilling began at 2235 hours on July 11, 1988. In accordance with LANL requirements, the post-event drill hole was cemented to the surface and capped at 2130 hours on August 9, 1988.

The maximum gamma radiation exposure rate detected in a work area during post-event drilling operations was 50 mR/h on PS# 1AS at 0125 hours on July 16, 1988 , a result of the Dresser Atlas Source check.

Kearsarge

The KEARSARGE event was conducted by LLNL at site U19ax at 1000 hours on August 17, 1988. Telemetry measurements began at 1001 hours on August 17, 1988, and ended at 1000 hours on August 18, 1988. The maximum exposure rate detected was 0.05 mR/h (background). There was no detectable release of fission products within the first 60 minutes after detonation.

The initial radiation survey into the test area began at 1120 hours on August 17, 1988, and the maximum gamma exposure rate detected was 0.05 mR/h. The initial survey was completed at 1148 hours on August 17, 1988.

Post-event drilling began at 0315 hours on September 7, 1988. In accordance with LANL requirements, the post-event drill hole was cemented to the surface and capped at 1605 hours on October 3, 1988.

The maximum gamma radiation exposure rate detected in a work area during post-event drilling operations was 60 mR/h on PS#1AS at 0425 hours on September 10, 1988, which was due to the sampling operation.

Bullfrog

The BULLFROG event was conducted by LLNL at site U4au at 1100 hours on August 30, 1988. Telemetry measurements began at 1101 hours on August 30, 1988, and ended at 1100 hours on August 31, 1988. The maximum exposure rate detected was 0.05 mR/h (background). There was no detectable release of fission products within the first 60 minutes after detonation. There were releases of radioactivity during post-event operations. Less than five curies of xenon was released through the ventline filters.

The initial radiation survey into the test area began at 1204 hours on August 30, 1988, and the maximum gamma exposure rate detected was 0.05 mR/h. The initial survey was completed at 1222 hours on August 30, 1988.

Post-event drilling began at 1540 hours on August 31, 1988. In accordance with LLNL requirements, the post-event drill hole had gas sampling tubing cemented to the surface at 2305 hours on September 4, 1988.

The maximum gamma radiation exposure rate detected in a work area during post-event drilling operations was 80 mR/h on PS#1A at 1405 hours on September 2, 1988. This was caused by coring operation and had a duration of five minutes.

LLNL also conducted its own effluent monitoring during the post-shot operations. The total xenon isotope effluents were measured, calculated, and reported to the DOE as 4.1 Curies of ^{133}Xe, 0.26 Curies of ^{133m}Xe, and 0.07 Curies of ^{135}Xe.

Dalhart

The DALHART event was conducted by LANL at site U4u at 0700 hours on October 13, 1988. Telemetry measurements began at 0700 hours on October 13, 1988 and ended at 0700 hours on October 14, 1988. The maximum exposure rate detected was 0.05 (background). There was no detectable release of fission products within the first 60 minutes after detonation.

The initial radiation survey into the test area began at 0855 hours on October 13, 1988, and the maximum gamma exposure rate detected was 0.05 mR/h. The initial survey was completed at 0946 hours on October 13, 1988.

Post-shot drilling began at 1735 hours on October 14, 1988. The maximum gamma exposure rate detected in a work area during post-event drilling operations was 120 mR/h on PS#1A at 0725 hours on October 20, 1988. This was during the packaging of samples.

Misty Echo

The MISTY ECHO event was conducted by DNA at U12n.23 at 1230 hours on December 10, 1988. Telemetry measurements began at 1230 hours on December 10, 1988, and ended at 1230 hours on December 13, 1988. The maximum exposure rate detected was background. There was no detectable release of fission products within the first 60 minutes after detonation. Event radioactivity was contained within the cavity until ventilation was established , at which time controlled effluent releases were conducted.

The initial surface radiation survey into the test area began at 1324 hours on December 10, 1988. The maximum gamma exposure rate detected between Gate 300 and the portal yard was 0.04 mR/h (background). Survey teams stood by at the U12n tunnel portal during gas sampling of the tunnel atmosphere. Gas sampling was completed at 1610 hours and by 1615 hours all personnel had departed the U12n portal. No radiation levels above background were detected. The initial reentry team departed the portal for the underground tunnel survey at 1033 hours on December 11, 1988. REECo Health Physics Department monitoring personnel accompanied work teams and User agency reentry teams during entries into the tunnel complex. The mesa ventilation hole was

opened, the mesa ventilation fan was started, at 1222 hours and air samplers were started at the mesa ventilation pad. All radiation readings were background. All reentry teams were surveyed and released by 2000 hours. The maximum radiation level detected during initial reentry operations was background.

On December 11, 1988, at 2200 hours the Mining Department started mining the U12n extension gas seal plug and the main draft gas seal plug. Mining was completed on the gas seal plug at 0130 hours on December 13, 1988.

ROUTINE MONITORING

REECo

Five liquid effluent discharge points were monitored during CY-1988. All sites emitted liquid discharges into evaporating ponds and were therefore controlled within the NTS. All five locations were monitored as part of the continuing surface and groundwater monitoring program.

Sampling consisted of collecting a single grab sample from each pond once a month. Sampling methods and analysis are identical to those previously described for water analysis. The total release quantity was calculated using an estimated total volume of water released for the calendar year at each location. Plots showing the individual results of these stations can be found in Appendix G.

Table 23 displays the REECo liquid discharge monitoring results. Note that Table 23 lists almost all of the contaminated pond sampling stations. Table 23 does not list the stations referred to in the Radioactivity in Surface and Groundwater chapter as *Effluent Ponds*.

SNL

The U12g tunnel complex ventillation system was routinely monitored during CY-1988 for ^{3}H in water vapor. Sampling was conducted weekly for four hours. The sampling material used was drierite which simply extracted the tritiated water vapor from air. SNL calculated a total release of 68.2 Curies of ^{3}H from the U12g tunnel complex for CY-1988.

CONCLUSION

Radioactive effluents released to the environment as part of test operations at the NTS were measured and quantified by several organizations. The total number of curies released as air emissions for CY-1988 is presented in Table 24. Considering all radionuclides measured, approximately 90 Curies were released as airborne effluents. Radioactive liquid effluents measured by REECo totaled approximately 4100 Curies.

TABLE 23 - Radioactive Liquid Discharge Monitoring Results

Station	Nuclide	Release (Ci)
Area 5 U5eRNM-2S	^{3}H	6.3×10^{2}
Area 6 Yucca Pond	^{3}H	1.4×10^{-2}
Area 12 E-Tunnel	^{3}H	1.2×10^{2}
Area 12 N-Tunnel	^{3}H	1.1
Area 12 T-Tunnel	^{3}H	4.0×10^{3}

TABLE 24 - Air Monitoring Results

Airborne Releases

Isotope	Curie
^{133}Xe	18.07
^{133m}Xe	0.44
^{135}Xe	7.37
^{131}I	3.2×10^{-5}
^{133}I	1.1×10^{-4}
^{3}H	68.2

DOSE ASSESSMENT

The maximum postulated effective dose equivalent from NTS operations was calculated for hypothetical individuals at work within the test site during CY-1988 considering all possible exposure pathways, (i.e. ingestion, inhalation and immersion). This calculation was performed by identifying the locations where the maximum radionuclide concentration occurred 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 those locations 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 ^{3}H, ^{85}Kr, ^{133}Xe, ^{239}Pu, or ^{90}Sr was detected (the concentration of gross beta in air was assumed to consist of ^{90}Sr and the quoted limit for gross beta is actually the limit for ^{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 25.

The dose from air immersion in ^{85}Kr 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 ^{85}Kr, the external dose far outweighs the internal dose. Therefore, only the external dose is calculated.

DOSE TERMINOLOGY

Throughout this chapter, several acronyms and terms are used to describe dose to a member of the population. Whether the dose is internal or external, or whether it comes from air or water, we measure or calculate dose in units called rems. A rem is a measure of the radiation that is absorbed within our tissues.

The ICRP 30 publication defines the term Annual Limits on Intake (ALI). An ALI is the amount of a radionuclide which, when taken into the body, leads to a 50-year dose commitment not exceeding 5 rem. A 50-year dose commitment (H_{50}) is the dose which we are committed to for 50 years following some internal deposition of radionuclide(s). This quantity does not consider any external exposures received.

Consequently, one can derive the concentrations in air that would lead to this ALI by the use of assumptions concerning breathing rate, metabolic rates, etc. The actual assumptions compiled form a hypothetical individual called reference man who, in theory, is supposed to represent the average man. This modified ALI is called the Derived Air Concentration (DAC).

The DOE has also used the term effective dose equivalent. This term is the sum of the 50-year dose commitment from internal deposition of radionuclides and that received penetrating external radiation.

INGESTION DOSE

The dose from the ingestion pathway was calculated for an individual at work within the NTS boundary during CY-1988. 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 ingestion dose calculation were ^{239}Pu and ^{3}H. 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 bottled water brought onsite was assumed to have natural background levels of ^{3}H. 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 26.

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 ^{3}H, ^{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 radionuclides 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 25. 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 26.

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 about 1 Bqm^{-3}, it is evident that the resulting dose is meaningless. Therefore, this calculation was not included.

CALCULATION

The mathematical method to calculate the 50-year committed dose is based on a comparison of the measured concentration of a particular radionuclide to the ALI. A worker exposed to one ALI during a calendar year will receive a 50-year committed dose of 5000 mrem with the exception of a few radionuclides. So, in general, any percentage of the ALI will deliver that same percentage of the 5000 mrem 50-year committed dose.

The ALIs are given in units of activity. Therefore when a comparison to the ALI is based on a concentration (activity per unit volume), an assumption on the amount of intake per year is made so that the concentration can be multiplied by a volume. For example, it is assumed that a worker will consume 400 liters of water at work during the calendar year. The product of the concentration and the volume will be in units of activity.

The DAC values are used to calculate 50-year committed dose from those radionuclide concentrations measured in air. The assumption of breathing rate is already included in the DAC so a straight comparison of the measured concentration can be made. Again, a worker exposed to one DAC during the calendar year will generally receive a 50-year committed dose of 5000 mrem. As stated, there are exceptions to this rule. One exception is the case of ^{85}Kr. By the time a worker immersed in ^{85}Kr would receive a 50-year committed dose of 5000 mrem he would have exceeded the allowable dose to the skin. So therefore, the ALI for ^{85}Kr is not based on 5000 mrem but on the limit to the skin.

To make the actual calculation, compare the inhalation values listed in Table 26 to the DACs listed in Table 25. The ratio of the measured concentration to the DAC will produce the fraction of 5000 mrem 50-year committed dose. The value produced in this calculation is the inhalation portion of the 50-year committed dose. Next calculate the ingestion portion of the 50-year committed dose

TABLE 25 - 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 26 - Concentrations Used for Dose Calculations

INHALATION (μCi/ml)

Station	^{3}H	^{90}Sr	^{239}Pu
Gate 700s	4.2×10^{-11}	1.9×10^{-14}	$< 2.0 \times 10^{-17}$
H & S Roof	7.5×10^{-12}	2.2×10^{-14}	$< 1.6 \times 10^{-17}$
U3ah/at West	-1.2×10^{-10}	2.0×10^{-14}	4.6×10^{-16}
Background	8.0×10^{-13}	0.0	0.0

INGESTION (μCi/ml)

Station	^{3}H	^{90}Sr	^{239}Pu
Area 2 Restroom	$< 6.6 \times 10^{-7}$	-	$< 5.0 \times 10^{-11}$
Area 23 Cafeteria	$< 6.6 \times 10^{-7}$	-	$< 4.3 \times 10^{-11}$
Area 3 Cafeteria	$< 6.6 \times 10^{-7}$	-	$< 4.0 \times 10^{-11}$
Background	$< 6.6 \times 10^{-7}$	-	0.0

TABLE 27 - ICRP 30 Calculated Dose Results

Station	H_{50}(mrem)
Gate 700s	0.16
H & S Roof	0.15
U3ah/at West	1.14

by comparing, in similar fashion, the ingestion measured concentration, multiplied by 400 liters, to the ALI value for that radionuclide listed in Table 25. If there was any immersion dose to be calculated, the same method would be used to arrive at the immersion 50-year committed dose. Lastly, sum the ingestion and inhalation (and any immersion) 50-year committed doses to arrive at the total 50-year committed dose. The results of this summation are listed in Table 27.

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 1.1 mrem was the highest calculated dose. This dose was derived from the average concentrations from air and water at the Area 3 U3ah/at West sampling station. Other stations for which dose results were calculated are listed in Table 27, ICRP 30 Calculated Dose Results.

NON-RADIOLOGICAL MONITORING

Carlton S. Soong

The primary function of the Industrial Hygiene Department (IHD) is to conduct sampling and analysis services for occupational health concerns within the NTS. IHD also provides some support for non-radiological environmental monitoring. Within IHD, the Environmental Health Section has environmental sampling responsibilities in the areas of the Safe Drinking Water Act and Clean Water Act. IHD conducts sampling and analysis activities in conjunction with the National Emissions Standards for Hazardous Air Pollutants (NESHAPS) and the Toxic Substances Control Act (TSCA). Laboratory support is also provided to the Environmental Health Section.

Future departmental responsibilities will include increased sampling and analytical activities to support the Defense Waste Management Department and Resource Conservation and Recovery Act (RCRA) compliance activities.

SAFE DRINKING WATER ACT CY-1988 SAMPLING

All onsite water distribution systems for potable water were sampled monthly. Sample containers were provided by the State of Nevada laboratory and samples are collected and transported by a sanitarian. Common sampling points include restrooms, drinking fountains and cafeterias. Samples are analyzed for coliform bacteria by the State of Nevada Department of Human Resources Bureau of Regulatory Services laboratory located at 620 Belrose, Las Vegas, NV 89158.

The sampling technician performed field determinations for residual chlorine and pH. Residual chlorine (RC) and pH levels are determined by state-approved colorimetric methods using a Lamotte Test Kit. The residual chlorine (RC) level is recorded on the request for sample analysis form submitted to the laboratory. If the RC is less than the state limit of 0.02 ppm, and the coliform bacteria exceeds 2.2 colonies/100ml, the system is declared unsafe and closed. In order to reopen the system, samples collected on three consecutive days must show negative coliform results. An RC level of less than 0.02 ppm is not of regulatory importance if the coliform results are negative. Sample results for CY-1988 are listed in Table 28.

Annual water samples for chemical analysis were collected by the state of Nevada in Febuary and March of 1988. The samples were collected by a state environmental health specialist and analyzed in a state-approved laboratory. These laboratories have approved quality assurance (QA) programs as part of their state certification. Table 29 lists the results and maximum allowable concentrations for each chemical constituent. Levels exceeding the regulatory limits are shown in bold text.

Drinking water samples from various distribution systems on the NTS were analyzed for lead. Thirty-four samples were collected from systems less than 5 years old and twenty-four samples from systems over 5 years old. No lead was detected in any of the samples.

CLEAN WATER ACT-1988 SAMPLING

In compliance with the state of Nevada Operating Permit requirements for the Area 25 sewage lagoon systems, quarterly sampling was initiated during the second quarter of 1988. Sampling results are listed in Table 30. Note that for the second quarter reporting only average flow rates were required. Biological oxygen demand (BOD), total suspended solids (TSS), pH and average flow rate were reported for the third and fourth quarters. Due to flow meter breakdown, no flow rates were reported for the fourth quarter. BOD and TSS analysis was done by the City of Henderson Laboratory, 243 Water Street, Henderson, NV 89105. All pH determinations were performed by REECo.

TOXIC SUBSTANCES CONTROL ACT-1988 SAMPLING

During CY-1988 the REECo laboratory analyzed 146 transformer oil samples to determine PCB concentra-

Table 28 - Monthly Monitoring Results for Potable Water

Permit No. NY-5084-12NC 1988

Area 1 Office Bldg.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RC (ppm)	0.4	0.0	0.3	0.3	0.0	0.2	0.2	0.3	0.3	0.3	0.0	0.1
pH	7.4	7.5	7.4	7.4	7.4	7.6	7.4	7.6	7.4	7.4	7.4	7.4
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	0

Permit No. NY-4097-12NC 1988

Area 3 Cafeteria	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RC (ppm)	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.4	0.3	0.0	0.5	X
pH	7.4	7.9	7.9	7.6	7.8	7.6	7.6	7.4	7.6	7.8	7.8	X
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	X

Permit No. NY-5000-12NC 1988

Area 6 Ice House	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RC (ppm)	0.6	0.6	0.5	0.5	0.5	0.3	0.3	0.3	0.4	-	-T-	
pH	7.2	7.6	7.4	7.2	7.4	7.2	7.2	7.2	7.4	-	-T-	
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	-	-	-
Well 3 Yrd. Housing												
RC (ppm)	0.2	0.6	0.3	0.3	0.2	0.2	0.2	0.3	0.2	0.1	0.3	-
pH	7.2	7.6	7.4	7.2	7.4	7.2	7.2	7.2	7.4	7.4	7.6	-
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	-
CP Cafeteria												
RC (ppm)	0.6	0.6	0.5	0.5	0.2	0.3	0.3	0.4	0.1	0.2	-	-
pH	7.2	7.6	7.4	7.2	7.4	7.2	7.2	7.2	7.4	7.4	7.6	-
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	-
WSI Training Bldg.												
RC	-	-	0.3									
pH	-	-	7.4									
Coliform	-	-	<2.2									

RC = Residual Chlorine (ppm)
X = Well A Closed
Coliform = #/100ml = colonies/100ml

TABLE 28 - Monthly Monitoring Results for Potable Water

Permit No. NY-5000-12NC 1988

Area 6 Bldg. 625	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RC (ppm)	-	-	-	-	-	-	-	-	-	0.1	0.2	-
pH	-	-	-	-	-	-	-	-	-	7.4	7.7	-
Coliform (#/100ml)	-	-	-	-	-	-	-	-	-	0	0	-
Well 3 Special												
RC (ppm)	-	-	-	-	-	-	-	-	-	-	0.1	-
pH	-	-	-	-	-	-	-	-	-	-	7.6	-
Coliform (#/100ml)	-	-	-	-	-	-	-	-	-	-	0	-
Bldg. 213												
RC (ppm)	-	-	-	-	-	-	-	-	-	-	-	0.1
pH	-	-	-	-	-	-	-	-	-	-	-	7.6
Coliform (#/100ml)	-	-	-	-	-	-	-	-	-	-	-	0
Bldg. 214												
RC (ppm)	-	-	-	-	-	-	-	-	-	-	-	0.1
pH	-	-	-	-	-	-	-	-	-	-	-	7.4
Coliform (#/100ml)	-	-	-	-	-	-	-	-	-	-	-	0

Permit No. NY-4099-12NC 1988

Area 2 Latrine	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RC (ppm)	0.6	0.6	0.3	0.5	0.6	0.5	0.5	0.4	0.5	0.6	0.2	H
pH	7.8	7.4	7.8	7.4	7.4	7.4	7.4	7.4	7.6	7.6	7.5	H
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	H
Area 12 Cafeteria												
RC (ppm)	0.6	0.8	0.4	0.6	0.5	0.5	0.5	0.6	0.6	0.6	0.2	H
pH	7.8	7.4	7.8	7.4	7.4	7.4	7.4	7.4	7.6	7.6	7.6	H
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	H
Area 12 Medical												
RC (ppm)	0.6	0.8	0.4	0.6	0.6	0.5	0.2	0.6	0.6	0.6	0.1	H
pH	7.8	7.4	7.8	7.4	7.4	7.4	7.4	7.4	7.6	7.6	7.6	H
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	H

H = Area closed for holidays.
RC = Residual Chlorine (ppm)
Coliform = #/100 ml = colonies/100ml

TABLE 28 - Monthly Monitoring Results for Potable Water

Permit No. NY-360-12NC 1988

Area 22 Desert Rock	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RC (ppm)	0.1	0.2	0.2	0.2	0.5	0.3	0.3	0.5	0.3	0.3	0.3	-
pH	7.8	8.0	8.0	8.2	8.0	8.0	8.0	7.8	8.3	8.0	8.0	-
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	-
Area 23 Cafeteria												
RC (ppm)	0.3	0.2	0.5	1.0	0.1	0.6	0.6	0.4	0.5	0.7	0.4	-
pH	7.8	7.9	8.0	8.2	8.2	8.0	8.0	8.0	8.3	7.9	8.0	-
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	-
Area 23 Bowling Alley												
RC (ppm)	0.2	0.1	0.5	0.6	0.4	0.6	0.6	0.5	0.3	0.6	0.4	-
pH	7.8	7.9	8.0	8.2	8.2	8.2	8.2	7.8	8.3	7.8	8.0	-
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	-

Permit No. NY-360-12NC 1988

Area 23 Bldg. 652	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RC (ppm)	0.2	0.5	0.6	0.5	0.6	0.6	0.6	0.6	0.4	0.6	0.4	-
pH	7.8	8.0	8.2	7.8	7.8	7.8	7.8	7.8	8.3	7.7	8.0	-
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	-

Permit No. NY-4098-12NC 1988

Area 25 Site Maint.	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
RC (ppm)	0.2	0.5	0.4	0.5	0.8	0.8	0.6	0.8	0.3	0.8	1.0	-
pH	8.0	8.2	8.2	8.1	8.2	8.2	7.8	7.8	8.0	8.1	8.0	-
Coliform (#/100ml)	0	0	0	0	0	0	0	0	0	0	0	-

RC = Residual Chlorine
Coliform = #/100ml = colonies/100ml

TABLE 29 - Chemical Analysis Results for NTS Drinking Water

Constituent	ARMY WELL	WELL 5B	WELL A	Regulatory Limit
Total Dissolved Solids	346	367	287	500 ppm
Hardness	32	17	84	N/A
Calcium	8	5	22	250 ppm
Magnesium	3	1	7	125 ppm
Sodium	116	116	52	N/A
Potassium	2	8	8	N/A
Sulfate	5	41	21	250 ppm
Chloride	18	14	6	250 ppm
Nitrate	1.8	10.1	9.1	45 ppm
Alkalinity	222	210	174	400 ppm
Bicarbonate	271	217	212	N/A
Carbonate	0	19	0	N/A
Fluoride	1.01	0.91	0.64	1.7 ppm
Arsenic	0.016	0.020	0.006	0.05 ppm
Iron	**0.36**	0.00	0.02	0.3 ppm
Manganese	0.01	0.00	0.00	0.05 ppm
Copper	0.01	0.00	0.01	1.0 ppm
Zinc	0.02	0.00	0.00	5.0 ppm
Barium	0.02	0.00	0.01	1.0 ppm
Boron	0.2	0.4	0.2	N/A
Silica	18	56	73	N/A
Color	5	3	3	15 Units
Turbidity	2	0.1	0.3	10 ppm
pH	7.91	**8.65**	7.88	6.5-8.5
EC	586	550	405	N/A
MBA	<0.1	<0.1	<0.1	0.5 ppm
Barium*	0.01	0.00	0.00	1.0 ppm
Cadmium*	<0.001	<0.001	<0.001	0.01 ppm
Chromium*	<0.005	<0.005	<0.005	0.05 ppm
Lead*	<0.005	<0.005	<0.005	0.05 ppm
Mercury*	<0.0001	<0.0005	<0.0005	0.002 ppm
Selenium*	<0.001	0.001	0.002	0.01 ppm
Silver*	<0.005	<0.005	<0.005	0.05 ppm

MBA - Detergent (foaming agent)
EC - Electrical Conductivity
* - Analysis by AA Furnace

TABLE 29 - Chemical Analysis Results for NTS Drinking Water

Constituent	WELL C	WELL C-1	WELL 8	Regulatory Limits
Total Dissolved Solids	631	636	143	500 ppm
Hardness	294	296	22	N/A
Calcium	73	74	7	250 ppm
Magnesium	27	27	1	125 ppm
Sodium	123	124	31	N/A
Potassium	14	14	3	N/A
Sulfate	67	64	15	250 ppm
Chloride	34	36	6	250 ppm
Nitrate	0.3	0.4	5.4	45 ppm
Alkalinity	480	488	68	400 ppm
Bicarbonate	586	595	83	N/A
Carbonate	0	0	0	N/A
Fluoride	1.13	1.13	0.82	1.7 ppm
Arsenic	0.004	0.005	<0.003	0.05 ppm
Iron	0.01	0.08	0.05	0.3 ppm
Manganese	0.00	0.00	0.00	0.05 ppm
Copper	0.00	0.00	0.01	1.0 ppm
Zinc	0.01	0.00	0.01	5.0 ppm
Barium	0.11	0.11	0.00	1.0 ppm
Boron	0.6	0.6	0.0	N/A
Silica	36	36	50	N/A
Color	3	3	3	15 Units
Turbidity	0.2	0.2	0.3	10 ppm
pH	7.07	7.38	7.50	6.5-8.5
EC	1071	1071	202	N/A
MBA	<0.1	<0.1	<0.1	0.5 ppm
Barium*	0.10	0.11	0.00	1.0 ppm
Cadmium*	0.001	0.001	<0.001	0.01 ppm
Chromium*	<0.005	<0.005	<0.005	0.05 ppm
Lead*	<0.005	<0.005	<0.005	0.05 ppm
Mercury*	<0.0005	<0.0005	<0.005	0.002 ppm
Selenium*	<0.001	<0.001	<0.001	0.01 ppm
Silver*	<0.005	<0.005	<0.005	0.05 ppm

MBA - Detergent (foaming agent)
EC - Electrical Conductivity
* - Analysis by AA Furnace

TABLE 29 - Chemical Analysis Results for NTS Drinking Water

Constituent	WELL 8	WELL 16D	WELL J-11	Regulatory Limits
Total Dissolved Solids	144	405	229	500 ppm
Hardness	24	287	59	NA
Calcium	8	77	22	250 ppm
Magnesium	1	23	1	125 ppm
Sodium	31	32	43	N/A
Potassium	3	6	4	N/A
Sulfate	15	58	21	250 ppm
Chloride	6	9	6	250 ppm
Nitrate	5.3	0.0	8.7	45 ppm
Alkalinity	68	302	122	400 ppm
Bicarbonate	83	368	110	N/A
Carbonate	0	0	19	N/A
Fluoride	0.82	0.54	**2.12**	1.7 ppm
Arsenic	<0.003	<0.003	0.010	0.05 ppm
Iron	0.02	0.01	0.10	0.3 ppm
Manganese	0.00	0.00	0.00	0.05 ppm
Copper	0.01	0.00	0.01	1.0 ppm
Zinc	0.04	0.01	0.00	5.0 ppm
Barium	0.00	0.13	0.01	1.0 ppm
Boron	0.0	0.2	0.1	N/A
Silica	50	37	59	N/A
Color	3	3	3	15 units
Turbidity	0.2	0.2	0.5	10 ppm
pH	7.61	7.50	**8.70**	6.5-8.5
EC	201	677	318	N/A
MBAS	<0.1	<0.1	<0.1	0.5 ppm
Barium*	0.00	0.12	0.00	1.0 ppm
Cadmium*	<0.001	<0.001	<0.001	0.01 ppm
Chromium*	<0.005	<0.005	<0.005	0.05 ppm
Lead*	<0.005	<0.005	<0.005	0.05 ppm
Mercury*	<0.0005	<0.0005	<0.0005	0.002 ppm
Selenium*	<0.001	0.002	<0.001	0.01 ppm
Silver*	<0.005	<0.005	<0.001	0.05 ppm

MBAS - Detergent (foaming agent)
EC - Electrical Conductivity
* - Analysis by AA Furnace
Levels exceeding the limits are shown as bold

TABLE 30 - Area 25 Quarterly Sewage Lagoon Sampling Result

System	BOD mg/L	TSS mg/L	pH	Average Flowrate (MGD)
2nd Qtr., April-June				
Engine Test Stand	---Not in use---			0
Central Support Area				0.000558
Test Cell "C"				0.000498
Reactor Control Pt.				0.000578
3rd Qtr., July-Sept.				
Engine Test Stand	---Not in use---			0
Central Support Area			9.5	0.000630
Test Cell "C"			9.0	0.000105
Reactor Control Pt.	<75	4	10.1	0.000615
4th Qtr., Oct.-Dec.				
Engine Test Stand	---Not in use---			0
Central Support Area			6.2	Flow meter break-
Test Cell "C"			8.2	down, no data.
Reactor Control Pt.	<75	32	7.6	

tions. PCB analyses were also done on 16 soil samples, 14 waste oil samples and 74 swipe samples.

Transformer oil results are as follows; 118 samples were less than 5 ppm (limit of detection), 14 samples were between 5 and 500 ppm and 14 samples had concentrations in excess of 500 ppm. Of the 16 soil samples analyzed, only 5 exceeded the 5 ppm limit of detection and no sample exceeded 10ppm. Six waste oil samples exceeded 500 ppm, four exceeded 30 ppm and four were less than 5 ppm PCB concentration. Seventy-four swipe samples were analyzed in conjunction with a cleanup project involving the release of PCBs in a capacitor room. The sample results ranged from less than 1 ppm to 400 ppm.

NATIONAL EMISSIONS STANDARDS FOR HAZARDOUS AIR POLLUTANTS

During CY-1988, REECo collected and analyzed 219 bulk and air samples in conjunction with asbestos removal and renovation projects at the NTS. Of the 156 bulk samples collected, 57 were positive for asbestos and 99 were negative. Sixty-three air samples were collected and analyzed, and 108 QA samples were analyzed.

ENVIRONMENTAL COMPLIANCE

Carlton S. Soong

On June 1, 1988, the REECo Environmental Compliance Office (ECO) was established. Before this date environmental compliance functions were handled by the Industrial Hygiene Section of the Health Physics Department. The ECO's primary mission is to serve as oversight review to assure compliance with all environmental laws and regulations and act as a point of contact with the DOE, state and federal agencies. on environmental compliance

ECO FUNCTIONS

The newly established REECo Environmental Compliance Office prepares enviromental permit applications, and required reports to DOE/NV for submittal to state/federal agencies. These reports are:

- Quarterly - Hazardous Waste Volume Report
- Sewage Lagoon Discharge Monitoring Report
- Annually - (PCB) Report
- (RCRA) Hazardous Waste Generator Report
- Fuel Analysis Report (for boilers) Open Burning Report
- Air Quality Annual Report
- Environmental Monitoring Report (public document)

The ECO performs appraisals and facility inspections of REECo departments. Bi-annual inspections are conducted at all permitted facilities. Other field operations departments are inspected annually and administrative departments are reviewed semi-annually.

Reviews for environmental compliance of equipment requisitions, project plans, building/construction drawings and subcontract proposals are the responsibility of the ECO. Reviews target compliance with DOE, state and federal environmental regulations and generation/disposal of hazardous wastes.

Appropriate documents and professional publications are reviewed by the ECO to keep management informed of changes in environmental regulations. Update services are employed in key regulatory areas such as 40CFR, 20CFR, 49CFR, and the Federal Register.

The ECO makes required notifications to DOE/NV involving accidental spills or leaks of hazardous material/wastes, modifications to permitted processes, and emergency repairs of permitted processes.

Drinking Water Systems Overview

During 1988 there were five drinking water systems utilizing a total of ten wells at the Nevada Test Site (NTS). The systems serving Area 2, 12 and 23 are community systems. The systems for Areas 1, 6 and 25 are non-community systems (at the NTS, all non-community systems are treated with the same requirements applicable to community systems). Community systems are defined in Appendix A of the Nevada Administrative Code (NAC) Chapter 445 as a public water system which serves at least 15 service connections used by year-round residents or regularly serve at least 25 year-round residents. Area 12 serves approximately 300 year-round residents and Area 23 serves approximately 600 year-round residents. Non-community systems supply non-residential work areas. 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 coliform bacteria content by Industrial Hygiene Department personnel, per the requirements of the NAC 445.141.21. Daily chlorine levels are logged by Site Maintenance Department personnel. Monitoring results were within state compliance limits.

A water sample for chemical analysis is collected from each well by the State Health Division at approximately three-year intervals in accordance with NAC 445.247. Sampling was conducted during February and March of 1988. Sample results and maximum allowable levels are listed in Table 29 in the chapter titled Non-Radiological Monitoring.

Permit Status

Each of the five drinking water systems has a Permit to Operate issued by the state of Nevada, as required in NAC 445.371, and these permits are renewed annually. No new permit applications were submitted in CY-1988 and no amendments were made to any of the existing permits. Well A (Permit #NY-4097-12NC), in Area 3, was closed by DOE/NV in October 1988. This closure was not due to water quality problems but to circumstances involving the CERCLA-NPL rating scheme.

National Primary Drinking Water Regulation

In response to the National Primary Drinking Water Regulations and the state of Nevada concerning public education to reduce exposure to lead, REECo employees at the NTS were provided with the brochure Lead, Drinking Water and You, published by the American Water Works Association. The brochures were issued with payroll checks on December 8 and 9, 1988. All other DOE contractors using the water distribution systems at the NTS were provided with this information to distribute to their employees.

CLEAN AIR ACT

Permit Activities

In accordance with NAC 445.704, Air Quality Permits are required for new and existing sources of air pollution operating in the state of Nevada. Air pollution sources common to the NTS include aggregate production, emplacement hole stemming activities, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities.

During CY-1988, two operating permits (OP), two permits to construct (PTC), and two open burning permits (PTOB) were obtained from the state of Nevada. One OP was issued for surface disturbances covering the entire NTS. This permit requires notifying the state by April 15, annually for all surfaces disturbances greater than five acres which occurred during the previous calendar year. An OP was also received for the boiler servicing the Area 12 cafeteria. PTCs were issued for the slant screens located at the Area 5 (DWMS). Two PTOBs were issued; one, a renewal for fire department training exercises and one for Area 27 Lawrence Livermore National Laboratory (LLNL) operations.

Table 31, NTS Air Pollution Permits, lists all air pollution permits which were active at the end of CY-1988. In September 1988, all permits were amended to reflect U.S. DOE as the permit holder. REECo will continue to provide necessary report information for transmittal to the state. Annual production and operating hours for the NTS OPs for CY-1987 was reported to the state on April 7, 1988. No operating restrictions were exceeded.

Air Quality Inspections

The state of Nevada conducted an Air Quality Inspection on July 13, 1988. Facilities inspected included the Area 5 DWMS (slant screens for screening fill material), surface disturbance sites visited were U6g, h and i, U7ca, U4u, U2gi and U2gh; and batching operations Fenix & Scission of Nevada (FSN) at Well 3. Well 3 operations were not observed due to equipment breakdown. No deficiencies were noted.

CLEAN WATER ACT

Sewage Lagoons

The state of Nevada issued Permit Number NEV 87060 on April 1, 1988, giving the U.S. DOE Authorization to Discharge to the following sewage lagoon systems:

Area 25: Reactor Control Point
Latitude: 3647'41.24"
Longitude: 11616'11.28"

Area 25: Central Support Area
Latitude: 3646'35.25"
Longitude: 11617'35.46"

Area 25: Engine Test Stand No. 1
Latitude: 3649'40.87"
Longitude: 11616'32.15"

Area 25: Device Assembly Facility
Latitude: 3653'44.57"
Longitude: 11622'46.42"

Although permit information was provided for other sewage systems the state did not issue any other permits in 1988. The state reserves the right to take as much as 180 days for review of permit information. It is expected that permits for other sewage systems will be issued in the first quarter of 1989.

DOE approved construction drawings were submitted to the state for new sewage lagoon systems in Area 6 and Area 12. Permits to construct for these projects are expected to be issued in early 1989.

Samples were collected in the Reactor Control Point System and analyzed for total suspended solids (TSS), pH biological oxygen demand (BOD) and average flow rate

as required by the operating permit. Other Area 25 sewage lagoons require that only pH and flowrate measurements be reported. Monitoring results were reported to the state for the second, third, and fourth quarters of 1988 and are listed in Table 30, Area 25 Quarterly Sewage Lagoon Sampling Results in the chapter titled Non-Radiological Monitoring Results.

TOXIC SUBSTANCES CONTROL ACT (TSCA)

REECo has a PCB Identification Number, NVG-PCB-006, issued by the state of Nevada and is responsible for the off-site disposal of PCB oils and PCB transformers at the NTS. On June 30, 1988 an annual report for CY-1987 was submitted to the state. This report reflects the quantity and status of PCB-contaminated transformers and other PCB equipment at the NTS. Also reported is the number of shipments of PCBs and PCB contaminated items from the NTS to an EPA approved disposal facility. Any transformers which have not yet been tested for PCBs are reported as PCB-contaminated. There was no state or federal inspection of the NTS for TSCA compliance during 1988.

TABLE 31 - NTS Air Pollution Permits

PERMIT NO.	FACILITY OR OPERATION	EXP. DATE
0P919	AREA 3 PORTEC AGGREGATE HOPPER	12-03-89
0P922	AREA 1 SHAKER PLANT	12-03-89
0P923	AREA 1 ROTARY DRYER	12-03-89
0P925	AREA 23, BLDG. 753 BOILER	12-03-89
0P928	AREA 12 CONCRETE BATCH PLANT	12-03-89
0P957	AREA 2 PORTABLE STEMMING	12-03-89
0P958	AREA 2 PORTABLE STEMMING SYSTEM	12-03-89
0P1035	PORTABLE BOILER	10-20-90
0P1036	AREA 6 DECONTAMINATION BOILER	10-20-90
0P1082	AREA 1 CONCRETE BATCH PLANT	01-30-91
0P1085	AREA 6 DIESEL TANKS	02-25-91
0P1086	MERCURY GASOLINE TANK	02-25-91
0P1087	MERCURY DIESEL TANK	02-25-91
0P1089	AREA 3 PORTABLE STEMMING SYSTEM	02-25-91
0P1090	AREA 6 GASOLINE TANK	02-25-91
0P1217	AREA 1 PORTABLE CRUSHER	12-03-89
0P1287	AREA 1 AGGREGATE PLANT	02-12-92
0P88-3	OPEN BURNING FOR TRAINING EXERCISES	09-30-89
0P1591	NTS SURFACE DISTURBANCE	--
0P1583	MERCURY CAFETERIA BOILER	03-23-93
0P1584	MERCURY CAFETERIA BOILER	03-23-93
0P1585	AREA 12 CAFETERIA BOILER	03-23-93
0P8818	BURN PERMIT AREA 27	01-31-89

RESOURCE CONSERVATION RECOVERY ACT (RCRA)

Hazardous Waste Activity

Four off-site shipments of hazardous waste were made in CY-1988. These occurred on March 16, April 25, July 25 and November 9. The required Hazardous Waste Generator Annual Report was sent to the state of Nevada on March 30, 1989. The report identifies wastes, amounts disposed and the facilities that receive the waste. Copies of the EPA Uniform Hazardous Waste Manifests which accompanied the shipments were also included with the report.

Inspections

On April 28, 1988 the EPA and the state of Nevada conducted a RCRA compliance inspection of the NTS. RCRA regulations are set forth in 40CFR 260-280 and generally refer to all elements of hazardous waste handling and disposal. NTS facilities inspected included: satellite accumulation areas, the Area 23 hazardous waste accumulation point, the Area 5 DWMS, and various units associated with the NTS RCRA Part A and Part B Permit Application. Documentation inspected included: personnel training records, EPA Uniform Hazardous Waste Manifests, Land Disposal Restriction Notifications, Part A and B Permit Applications, previous Hazardous Waste Generator Reports and various written procedures associated with the management of RCRA programs. Deficiencies noted were as follows:

- Part A Permit Application was required for the Area 11 Explosive Ordnance Disposal (EOD) Unit.
- A dented barrel of hazardous waste was noted at the Area 23 accumulation facility.
- Necessary notification for land-banned solvents was not provided for one off-site shipment.

Corrective actions taken to achieve compliance included:

- The existing Part A Permit Application for the NTS was modified to include the Area 11 EOD Unit and transmitted to EPA through DOE/NV, on August 9, 1988.
- Contents of the dented barrel were transferred to an undamaged container.
- REECo implemented operating procedures to assure that Land Disposal Restrictions Notifications are included with appropriate off-site shipments.

During the period August 15-17, 1988 the state of Nevada conducted a RCRA inspection on the NTS. No deficiencies were noted during this inspection.

RCRA Part B Permit Application

On November 7, 1988 the RCRA Part B Permit Application was submitted to EPA for the Area 11 EOD Unit. The permit application was necessary to satisfy the requirements of 40CFR 264.600 and to ensure interim status for this disposal unit.

(RCRA) Closure Plans

In October 1988, RCRA closure plans were initiated for the Area 6 Decontamination Facility Evaporation Pond and the Building 650 Leachfield. These disposal units have received mixed waste during past operations. To prevent the spread of hazardous constituents from these disposal units, closure plans will be developed as required 40CFR 265.110. These closure plans will address: the closure process, closure performance standards, unit description, operational history, geology, hydrology, site characterization, health and safety, QA/QC, closure design (engineering, schedules, cost estimate, post closure plan, financial assurance), and a health-based risk assessment outline. These closure plans are scheduled for completion in CY-1989 and will be submitted to the state of, Nevada and the EPA. Subsequent to state approval, the closure plan will be carried out.

DOE ENVIRONMENTAL SURVEY

In 1987 U.S. DOE Headquarters sent an environmental survey team to the NTS to conduct a review of the environmental status. Pursuant to the environmental problems identified, an Environmental Survey Action Plan (ESAP) was developed in 1988. The ESAP was designed to list and describe specific environmental problems to provide scheduling and financial estimates for corrections, and to be used as a living document to track the corrective action process. This document will be updated on regular basis as corrective measures are implemented.

Presently, 25 of a total 105 action items were certified as completed/closed. This information is presented in Table 32, Action Plan Items. A copy of this document has been transmitted to the state of Nevada and the U.S. EPA, Region IX.

NATIONAL EMISSIONS STANDARD FOR HAZARDOUS AIR POLLUTANTS (NESHAP)

On June 20, 1988 a NESHAP notification for asbestos removal at renovated facilities was made to U.S. EPA per the requirements of 40CFR 61.145(d). The notification involved removal of approximately 260 linear feet of transit pipe (contains asbestos) and 260 square feet of asbestos-containing floor tile from Building 4215 in Area 25.

TABLE 32 - Action Plan Items

RADIATION DISPOSAL ISSUES	15 (6 Closed) (consolidation sites, craters, core holes)
WASTE WATER DISPOSAL	42 (3 Closed) (sewage, ponds, sumps, leachfields, steam cleaning)
AIR POLLUTION PERMITTING	6 (4 Closed) (fume hoods, open burning, stemming, fugitive dust)
RCRA PERMITTING ACTIONS	3 (1 Closed) (EOD, 650 leachfield, Decontamination Pad)
STORAGE	7 (3 Closed) (tanks, hazardous materials/waste)
SOLID WASTE DISPOSAL	19 (5 Closed) (landfills, spills, muckpiles)
QUALITY ASSURANCE	7 (3 Closed) (monitoring, lab procedures)
TOTAL	105 (25 Closed)

BECAMP

Scott E. Patton

BECAMP, an acronym for the Basic Environmental Compliance and Monitoring Program, was established in 1986 by the Department of Energy, Nevada Operations Office (DOE/NVO), to assess changes over time in the radiological and ecological conditions at the Nevada Test Site (NTS) and to provide information necessary for NTS compliance with applicable environmental regulations. Five objectives were developed to meet the primary goals of BECAMP. Within the five objectives, specific tasks and yearly milestones are established to direct the efforts of BECAMP participants. BECAMP efforts are directed to (1) maintain and enhance the knowledge of the radionuclide inventory and study the movement of surface contaminants on and around the NTS (2) maintain and update human dose-assessment models for the NTS and its environs and periodically conduct field studies to test the predictions of the models (3) provide a major yearly thematic, peer-reviewed publication to address an important issue related to the potential environmental impacts of past, present, and future activities at the NTS (4) maintain an understanding of the spacial distribution and changes over time of the flora and fauna on the NTS (5) comply with applicable environmental regulations. In FY-1988 the BECAMP continued to make significant strides in establishing itself as an environmental monitoring program on the NTS. The second year of operation for the program focused on initiating, developing and implementing field-monitoring protocols.

INTRODUCTION

The BECAMP FY-1988 Year-End Summary Report (Reference 31) provides a summary of the progress made and work completed on BECAMP milestones for fiscal year 1988. This document was prepared from the year-end summary reports submitted by the principal investigators participating in BECAMP. Included in this document is a brief description of BECAMP, a summary of BECAMP accomplishments for FY-1988, summary reports of work completed toward FY-1988 milestones, a list of BECAMP participants for FY-1988, and a list of publications from BECAMP participants in FY-1988 that relate to BECAMP efforts.

Specific work tasks and milestones are developed annualy to meet the objectives of BECAMP. These work tasks and milestones were originally divided among the five BECAMP objectives. The five BECAMP objectives were revised for managerial purposes into ten work tasks in FY-1988. The ten BECAMP Tasks are as follows:

- **TASK 1** - Movement of Radionuclides On and Around the NTS.
- **TASK 2** - Human Dose-Assessment Models.
- **TASK 3** - Monitoring of the Flora and Fauna on the NTS.
- **TASK 4** - Annual Peer-Reviewed Publications.
- **TASK 5** - NTS Compliance with Environmental Regulations.
- **TASK 6** - Specific Environmental Evaluations.
- **TASK 7** - Data Base.
- **TASK 8** - Quality Assurance.
- **TASK 9** - Monitoring Design and Statistical Analysis.
- **TASK 10** - Project Management.

FY-1988 ACCOMPLISHMENTS

Radionuclides in Soil

Work continued on investigating the movement of radionuclides in soil with the evaluation of computer-model codes for vertical, horizontal and water-driven erosional transport of radionuclides. Site-specific parameters that could be measured in the field were identified and field studies were initiated to investigate these parameters. Measurements of hydraulic conductivity were completed in Mercury and Area 11. In addition to model development, BECAMP investigators also

continued to document the actual movement of radionuclides at NTS. A calibration and monitoring protocol was developed for in situ measurements of ^{241}Am in soils of Areas 13 and 11. Area 13 in situ measurements were completed.

BECAMP investigators are also involved in completing the Radionuclide Inventory and Distribution Program (RIDP). This effort is almost complete and will provide an inventory of radionuclides in surface soil of the entire NTS. Such a detailed study of so large an area is unque, and a major synthesis paper will be completed in the future.

Dose-Assessment Model

The Nevada Applied Ecology Group (NAEG) dose assessment model was expanded and updated to include the external gamma-exposure pathway and the addition of several radionuclides. A sensitivity and uncertainty analysis of the basic NAEG/NTS dose-assessment model was also completed. The work was documented in two papers, one of which was submitted for publication in a peer-reviewed journal. The current version of the model will be known as the BECAMP/NTS model.

Flora and Fauna

In the first full year of monitoring, considerable progress was made toward determining the status of the flora and fauna of the NTS. Monitoring sites surveyed included three previously monitored and two new base-line study plots in undisturbed areas and eight new sites in disturbed areas. Investigations included the sampling of annual and perennial plants, lizards and animals for the observation of trends and patterns in species densities, survivorship and reproduction. Twenty-three natural springs and man-made water sources were surveyed for large mammals and game birds. In addition, several previously unrecorded species were found and the populations of three rare species were determined. In addition, surveys were conducted to determine the presence of threatened or endangered species and the existence of archeological sites on the NTS.

BECAMP Data Base

Additional accomplishments for FY-1988 included developing the basic structure of the BECAMP Data Base and establishing and implementing the BECAMP Quality-Assurance program.

Publications

A notable accomplishment was the publication of a paper synthesizing the accumulated data on the ecosystem dynamics of aged plutonium in a desert environment. This study was unique in its breadth of coverage and analysis. An additional summary paper on plutonium dynamics was published as well.

QUALITY ASSURANCE

Yun Ko Lee, PhD.

This chapter reviews the 1988 quality assurance program for the NTS Radiological Environmental Monitoring Program. This program covered air, air effluents, noble gases, surface and ground water monitoring for radioactive materials. Radiological monitoring and radiochemical analyses of the NTS samples were performed by the Laboratory Operations Section (LOS) of the Health Physics Department of Reynolds Electrical & Engineering Co. The LOS maintained both internal and external quality assurance programs to ensure that the data and analytical results collected were representative of the actual concentrations in the environment.

INTRODUCTION

Numerous environmental samples were collected at various locations in the NTS on a routine basis in support of the testing programs and the Radiological Waste Management Project. Samples from all locations were collected using well established standard operating procedures. Current data were compared to 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.

The quality of analytical data was controlled with a continuous program involving calibration of counting instruments with National Institute of Standards Technology (NIST) traceable standards; standard procedures for counting and radiochemistry; personnel training and qualification; and samples analyzed along with quality control samples.

Review of analytical results relative to the applicable standards of the Department of Energy was performed on a daily basis to ensure that potential problems were noted in a a timely fashion. During 1988, the Laboratory Operations Section continued to participate in laboratory intercomparison studies conducted by the Department of Energy and the Environmental Protection Agency. These quality assurance programs help ensure that the monitoring data can be used to evaluate accurately the environmental impacts from NTS operations.

An internal quality assurance/quality control program of radiological monitoring is maintained to focus on the routine checks listed below:

- personnel training and work assignment qualification.
- calibration of sampling and counting instruments.
- source and background count checks for counting systems.
- yield determination of radiochemistry procedures.
- spikes, blanks and replicates as quality control samples to verify the maintenance of procedural controls.
- QC charts review to assure control of methods and processes.
- analytical data reviewed before being reported.
- NIST-traceable standards and reference materials used for instrument calibration and quality control samples.

An external QA/QC program of the LOS analytical laboratory is maintained with participation in the DOE Quality Assessment Program (QAP) and the EPA Laboratory Intercomparison Study Program.

SAMPLE CONTROL

Environmental monitoring samples are collected throughout the NTS and analyzed by the REECo Laboratory Operations Section (LOS) according to documented standard operating procedures. All samples submitted for analysis are received and examined by the sample receiving personnel. Information furnished on the sample label is checked against that given in the accompanying Laboratory Services Request. The Sample Preparation Technician prepares sample materials for analysis. All samples are logged-in through the Laboratory Data Analysis System. Samples requiring chemical processing are signed out by appropriate chemistry laboratory personnel. Samples ready to be

counted are signed out by personnel of the counting laboratory.

INSTRUMENT CONTROL

The efficiencies of counting instruments are established using standards prepared from reference materials issued by the NIST or certified reference materials traceable to the NIST.

The gamma spectrometers are set to count check sources of known activity on a daily basis. The peaks' centroid energies are compared against the expected energy. A calibration check is performed if necessary. Data are recorded in the instrument logbook. The count rate is compared to previous count rate statistics and plotted on a chart.

The sample holders of the alpha spectrometers are cleaned at least once a week prior to performing the instrument check. The alpha spectrometers are set to count check sources of known activity on a weekly basis. The peak channel, the full width at half maximum (FWHM), and the count rate for each peak are recorded in the instrument logbook. A background check is also performed and documented.

The proportional counters are set to count background and check sources of known activity on a daily basis. Data are recorded in the instrument logbook for comparison to previously acquired values.

The liquid scintillation counters are set to count background and the standards of known activity along with each lot of ten or less samples to be analyzed. Data are recorded in the instrument logbook. The instruments are under service and maintenance contract with the instrument manufacturer.

For all counting instruments, instrument control data are accumulated and presented to the Section Quality Assurance Coordinator (SQC) and the Instrument Control Supervisor to be permanently filed on a weekly basis. If data obtained from background and/or check source counts are considered to be outside the instrument control limits, or show any inconsistencies, the cause of the problem is investigated and corrective action initiated. If the problem originates from the counting instrument, the instrument is removed from service. Any nonconforming instrument should be repaired and recertified before allowed to be back in service. Performance histories of the counting instruments are maintained in logbooks and/or computer files.

RADIOANALYSIS CONTROL

Personnel handling sample collection, preparation and analysis are to be trained and/or qualified for their work assignments by their supervisors. An internal QA/QC program has been implemented to control and document the accuracy and precision of data generated in the analytical laboratory. Spiked samples are prepared from NIST-traceable materials for various analyses. Whenever it is practicable, spikes, blanks and replicates are submitted as quality control samples to be analyzed with every lot of field samples. The ratio of the number of quality control samples to that of the field samples varies depending on the type of analysis, and sometimes is limited by laboratory equipment constraints. Specific quality control procedures are established and documented for each analysis. The quality control program mandates that at least ten percent of the samples in each sample lot analyzed shall be quality control samples. However, in real practice, the number of quality control samples analyzed is usually greater than ten percent of the total. The analyses quality control samples are frequently checked against the known values and examined with standard statistical methods. Control charts are plotted. If any result is found to be outside the control limits, the cause of the problem is investigated and corrected, and the entire sample lot is reanalyzed.

In some of the radiochemistry procedures, NIST-traceable standard solutions are used whenever feasible as tracers to determine the chemical yield of the process. The yield is compared to previously determined acceptable control limits to provide an immediate evaluation of the procedure.

DATA CONTROL

Sample data and analysis data are entered into or acquired for the Laboratory Data Analysis System of the Laboratory Operations Section Computer. Adequate safeguards are provided over the computer facilities as outlined in DOE Order 1360.2 to assure quality through the protection of data and results. Analytical results produced by the Laboratory Operations Section are subjected to review by the Analysis Supervisor before being distributed or reported.

INTERLABORATORY QUALITY ASSURANCE PROGRAMS

In addition to the internal QA/QC program, the Laboratory Operations Section continued to participate in interlaboratory quality assurance programs in 1988.

One program is the laboratory intercomparison study conducted by the Environmental Monitoring Systems Laboratory (EMSL-LV) of the Environmental Protection Agency (EPA). The second is the Quality Assessment Program conducted by the Environmental Measurements Laboratory (EML) of the Department of Energy (DOE). Under both programs, a variety of standardized samples are sent to the participating laboratories at intervals throughout the year. The standard samples consist of various environmental media (water, air filters, soil, milk, foodstuffs, vegetation and tissue ash) containing one or more radionuclides in known amounts. After the samples are analyzed, the results are forwarded to the sponsor laboratory for comparison with known values and with the results from other participating laboratories. Both EMSL-LV and EML-DOE have established criteria for evaluating the accuracy and precision of results (References 29 and 30). These programs serve as a regular means of evaluating performance of the radioanalytical laboratory and provide indications where corrective actions are needed.

Summaries of the 1988 results in the laboratory quality assurance programs conducted by the EMSL-LV and EML-DOE are provided in Tables 33 and 34. The 20% indicator shown in these tables is just a convenient measure of overall relative performance of the participating laboratories. It cannot be used as a sole determinant for accuracy. As shown in Tables 33 and 34, the REECo results were generally within the control limits determined by the program sponsors. The few results outside the control limits were investigated, and corrective actions were taken to correct the problems if deemed necessary.

RECENT DEVELOPMENT OF THE QA/QC PROGRAM

The Laboratory Operations Quality Assurance Plan was written in April 1988 with particular emphases to address the 18 criteria of ANSI/ASME NQA-1 and 10CFR50 Appendix B. During the second half of 1988, the Laboratory Operations Section was proceeding to revise, update and rewrite all of its standard operating procedures. A new procedure was being developed to enforce the control of sample chain-of-custody. Implementation of such restructured operating procedures is expected in the first half of 1989.

Quality assurance activities continue to be influenced by programmatic changes. In November, 1988 development of the overall REECo Company Quality Assurance Program has modified some of the QA procedures. As a result, some of the Laboratory Operations QA procedures needed to be revised to incorporate the required changes. In the second half of 1988 a part-time staff was appointed to the Quality Assurance Section to oversee the QA functions and activities of the Laboratory Operations Section.

TABLE 33 - EMSL-LV Interlaboratory Comparison

Analysis And Date	Water Samples, pCi/l REECo[a]	EMSL-LV[b]	Control Limits[c]	Ratio REECo/EMSL-LV	No. of Labs[d]	% of Labs within ±20%[e]
Gross Alpha						
01/22/88	0.67 +/- 0.58	4.00 +/- 5.00	0-12.7	0.17	156	54
03/18/88	5.0 +/- 1.0	6.00 +/- 5.00	0-14.7	0.83	124	60
04/24/88	36.7 +/- 1.5	46.0 +/- 11.0	27.0-65.1	0.80	116	55
05/20/88	8.7 +/- 0.6	11.0 +/- 5.00	2.3-19.7	0.79	129	50
07/22/88	10.3 +/- 1.2	15.0 +/- 5.00	6.3-23.7	0.69	115	54
11/25/88	9.7 +/- 0.6	9.00 +/- 5.00	0.4-17.7	1.08	117	67
Gross Beta						
01/22/88	6.0 +/- 1.0	8.00 +/- 5.00	0-16.7	0.75	154	60
03/18/88	11.7 +/- 1.2	13.00 +/- 5.00	4.3-21.7	0.90	125	75
04/24/88	44.0 +/- 5.3	57.0 +/- 5.00	48.3-65.7	0.77	114	87
07/22/88	5.0 +/- 0.0	4.00 +/- 5.00	0-12.7	1.25	113	19
10/18/88	39.7 +/- 2.3	54.0 +/- 5.00	45.3-62.7	0.74	117	84
11/25/88	9.7 +/- 0.6	9.00 +/- 5.00	0.3-17.7	1.07	119	62
H-3						
02/12/88	3366.7 +/- 23.1	3327.0 +/- 362.0	2700.0-3954.0	1.01	116	89
06/10/88	5282.3 +/- 41.7	5565.0 +/- 557.0	4600.3-6529.8	0.95	115	89
10/14/88	2110.0 +/- 132.3	2316.0 +/- 350.0	1709.8-2922.2	0.91	110	92
Cr-51						
06/03/88	296.0 +/- 9.9	302.0 +/- 30.0	250.0-354.0	0.98	115	86
10/07/88	246.0 +/- 12.5	251.0 +/- 25.0	207.7-294.3	0.98	116	86
Co-60						
02/05/88	68.3 +/- 3.1	69.0 +/- 5.0	60.3-77.7	0.99	122	93
04/24/88	50.7 +/- 3.2	50.0 +/- 5.0	41.3-58.7	1.01	92	91
06/03/88	16.0 +/- 1.0	15.0 +/- 5.0	6.3-23.7	1.07	117	75
10/07/88	27.0 +/- 1.0	25.0 +/- 5.0	16.3-33.7	1.08	117	91
Zn-65						
02/05/88	97.7 +/- 6.7	94.0 +/- 9.4	77.7-110.3	1.03	122	93
06/03/88	106.0 +/- 5.6	101.0 +/- 10.0	83.7-118.3	1.05	119	91
10/07/88	157.3 +/- 7.2	151.0 +/- 15.0	125.0-177.0	1.04	118	95
Sr-89						
04/24/88	5.3 +/- 2.1	5.0 +/- 5.0	0-13.7	1.06	58	53
05/06/88	19.3 +/- 0.6	20.0 +/- 5.0	11.3-28.7	0.97	66	65
05/20/88	11.3 +/- 2.5	11.0 +/- 5.0	2.3-19.7	1.03	127	71
10/18/88	10.7 +/- 1.2	11.0 +/- 5.0	2.3-19.7	0.97	60	63

a Average value reported by REECo.

b The known value or value assigned by EMSL-LV.

c The Control limits determined by EMSL-LV.

d The number of participating laboratories that reported analysis results for the analysis.

e The percentage of participating laboratories reporting an average value that is within ± 20% of the EMSL-LV value.

TABLE 33 - EMSL-LV Interlaboratory Comparison

Analysis And Date	REECo[a]	EMSL-LV[b]	Control Limits[c]	Ratio REECo/EMSL-LV	No. of Labs[d]	% of Labs within ±20%[e]
Water Samples, pCi/l						
Sr-90						
04/24/88	5.0 +/- 1.0	5.0 +/- 1.5	2.4-7.6	1.00	67	76
05/06/88	20.3 +/- 0.6	20.0 +/- 1.5	17.4-22.6	1.02	71	79
10/18/88	9.0 +/- 0.0	10.0 +/- 1.5	7.4-12.6	0.90	63	84
Ru-106						
02/06/88	97.7 +/- 11.9	105.0 +/- 10.5	86.8-123.2	0.93	118	86
06/03/88	207.7 +/- 5.5	195.0 +/- 20.0	160.4-229.6	1.07	119	88
10/07/88	165.7 +/- 5.0	152.0 +/- 15.0	126.0-178.0	1.09	116	84
Cs-134						
02/05/88	58.7 +/- 4.0	64.0 +/- 5.0	55.3-72.7	0.92	122	93
04/24/88	6.7 +/- 0.6	7.0 +/- 5.0	0-15.7	0.96	83	75
06/03/88	19.7 +/- 2.1	20.0 +/- 5.0	11.3-28.7	0.98	117	91
10/07/88	24.0 +/- 1.0	25.0 +/- 5.0	16.3-33.7	0.96	118	94
10/18/88	14.0 +/- 1.0	15.0 +/- 5.0	6.3-23.7	0.93	89	84
Cr-137						
02/05/88	93.7 +/- 3.8	94.0 +/- 5.0	85.3-102.7	1.00	122	93
04/24/88	7.0 +/- 1.0	7.0 +/- 5.0	0-15.7	1.00	86	63
06/03/88	23.7 +/- 3.1	25.0 +/- 5.0	16.3-33.7	0.95	119	85
10/07/88	16.7 +/- 0.6	15.0 +/- 5.0	6.3-23.7	1.11	117	85
10/18/88	15.0 +/- 0.0	15.0 +/- 5.0	6.3-23.7	1.00	91	86
Ra-225						
04/24/88	4.7 +/- 0.6	6.4 +/- 1.0	4.7-8.1	0.73	84	79
Air Filters, pCi/Filter						
Gross Alpha						
08/25/88	8.0 +/- 0.0	8.0 +/- 5.0	0-16.7	1.00	111	68
Gross Beta						
08/26/88	36.0 +/- 1.0	29.0 +/- 5.0	20.3-37.7	1.24	112	84
Sr-90						
08/26/88	7.7 +/- 0.6	8.0 +/- 1.5	5.4-10.6	0.96	54	76
Cs-137						
08/26/88	22.0 +/- 4.4	12.0 +/- 5.0	3.3-20.7	1.83	105	73
Urine Samples, pCi/l						
H-3						
04/29/88	6093 +/- 70.2	6202.0 +/- 620.0	5128.1-7275.9	0.98	38	82
11/11/88	2946.7 +/- 55.1	3025.0 +/- 359.0	2403.2-3646.8	0.97	36	78

a Average value reported by REECo.
b The known value or value assigned by EMSL-LV.
c The Control limits determined by EMSL-LV.
d The number of participating laboratories that reported analysis results for the analysis.
e The percentage of participating laboratories reporting an average value that is within ±20%of the EMSL-LV value.

TABLE 34 - EML-DOE Interlaboratory Comparison*

Air Filter Samples, pCi/Filter

Analysis And Date	REECo[a]	EML-DOE[b]	Mean[c]	Ratio REECo/EML	No. of Labs[d]	% of Labs within ±20%[e]
Be-7						
03/88	4.86×10^{-3}	4.7×10^{-3}	4.52×10^{-3}	1.03	37	86
09/88	1.91×10^{-3}	2.16×10^{-3}	2.29×10^{-3}	0.88	37	81
Mn-54						
03/88	3.88×10^{-2}	3.63×10^{-2}	3.69×10^{-2}	1.07	38	84
09/88	1.84×10^{-2}	1.85×10^{-2}	1.98×10^{-2}	0.99	38	84
Co-57						
03/88	1.58×10^{-2}	1.62×10^{-2}	1.56×10^{-2}	0.98	38	84
09/88	3.48×10^{-2}	3.94×10^{-2}	3.94×10^{-2}	0.84	38	84
Co-60						
03/88	2.96×10^{-2}	2.82×10^{-2}	2.77×10^{-2}	1.05	38	78
09/88	3.14×10^{-2}	3.74×10^{-2}	3.40×10^{-2}	0.84	38	84
Sr-90						
03/88	7.25	4.91	5.04	1.48	20	70
09/88	10.1	9.50	9.27	1.06	20	70
Cs-134						
03/88	3.41×10^{-2}	3.81×10^{-2}	3.36×10^{-2}	0.90	38	65
09/88	1.40×10^{-2}	1.91×10^{-2}	1.75×10^{-2}	0.73	38	81
Cs-137						
03/88	2.43×10^{-2}	2.11×10^{-2}	2.26×10^{-2}	1.15	38	83
09/88	2.41×10^{-2}	2.45×10^{-2}	2.57×10^{-2}	0.98	38	86
Pu-239						
03/88	2.34	2.52	2.49	0.93	27	77
09/88	1.33	1.09	1.21	1.22	25	76
Am-241						
03/88	2.39	3.02	2.89	0.79	16	75

*Semi-annual Department of Energy QAP Report, #EML-513 and #EML-518, Environmental Measurements Laboratory, D.O.E., New York, N.Y., 10014-3621.

a Average value reported by REECo.

b The known value or value assigned by EML-DOE.

c Mean value of submitted results of all participating laboratories in the range of 0.5 to 2.0 times EML value.

d The number of participating laboratories that reported analysis results for the analysis.

e The percentage of participating laboratories reporting an average value that is within ±20%of the EMSL-EPA value.

TABLE 34 - EML-DOE Interlaboratory Comparison*

Analysis And Date	REECo[a]	EML-DOE[b]	Mean[c]	Ratio REECo/EML	No. of Labs[d]	% of Labs within ±20%[e]
Soil Samples, pCi/gm						
K-40						
03/88	1.33	0.600	0.743	2.22	24	33
09/88	5.96	7.48	7.81	0.80	24	75
Sr-90						
09/88	1.09	1.39	1.27	0.78	20	40
Cs-137						
03/88	0.569	0.400	0.400	1.42	34	79
09/88	0.730	0.910	0.970	0.80	33	66
Pu-239						
03/88	5.20×10^{-2}	4.10×10^{-2}	5.28×10^{-2}	1.27	25	32
09/88	0.450	0.380	0.392	1.18	25	92
Vegetation Samples, pCi/gm						
K-40						
03/88	2.92×10^{-1}	3.60×10^{-1}	384×10^{-1}	0.81	23	56
09/88	8.73	10.5	9.96	0.83	22	59
Sr-90						
03/88	1.08×10^{-1}	1.09×10^{-1}	1.09×10^{-1}	0.99	20	80
09/88	3.76	3.80	3.91	0.99	16	87
Cs-137						
03/88	3.41	4.62	5.01	0.74	29	65
09/88	1.90	1.52	1.60	0.85	28	71
Pu-239						
03/88	7.00×10^{-2}	4.50×10^{-2}	5.85×10^{-2}	1.56	22	18
09/88	2.00×10^{-2}	2.10×10^{-2}	2.16×10^{-2}	0.95	19	73

*Semi-annual Department of Energy QAP Report, #EML-513 and #EML-518, Environmental Measurements Laboratory, D.O.E., New York, N.Y., 10014-3621.

a Average value reported by REECo.

b The known value or value assigned by EML-DOE.

c Mean value of submitted results of all participating laboratories in the range of 0.5 to 2.0 times EML value.

d The number of participating laboratories that reported analysis results for the analysis

e The percentage of participating laboratories reporting an average value that is within ±20% of the EMSL-EPA value.

TABLE 34 - EML-DOE Interlaboratory Comparison*

Analysis And Date	Water Samples, pCi/l REECo[a]	EML-DOE[b]	Mean[c]	Ratio REECo/EML	No. of Labs[d]	% of Labs within ±20%[e]
H-3						
03/88	1.94×10^{-1}	2.07×10^{-1}	2.04×10^{-1}	0.94	34	85
09/88	1.21×10^{-1}	1.06×10^{-1}	1.12×10^{-1}	1.14	32	84
Mn-54						
03/88	7.17	6.80	7.07	1.05	35	94
09/88	1.63	1.52	1.61	1.07	36	97
Co-57						
03/88	1.89	2.05	1.92	0.92	35	97
09/88	3.45	3.36	3.74	1.03	37	91
Co-60						
03/88	1.92	2.03	1.87	0.95	35	97
09/88	3.94	3.68	3.87	1.07	37	100
Sr-90						
03/88	0.623	0.530	0.539	1.18	23	86
09/88	0.920	0.930	0.831	0.99	20	80
Cs-134						
03/88	2.92	3.56	3.00	0.82	35	77
09/88	1.07	0.970	1.09	1.10	36	77
Cs-137						
03/88	1.78	1.84	1.78	0.97	36	100
09/88	2.14	1.95	2.13	1.10	37	97
Pu-239						
03/88	1.84×10^{-2}	2.43×10^{-2}	1.94×10^{-2}	0.76	26	46
09/88	6.00×10^{-3}	5.40×10^{-3}	4.88×10^{-3}	1.11	25	84
Am-241						
03/88	3.56×10^{-3}	4.10×10^{-3}	4.14×10^{-3}	0.87	18	72

*Semi-annual Department of Energy QAP Report, #EML-513 and #EML-518, Environmental Measurements Laboratory, D.O.E., New York, N.Y., 10014-3621.

a Average value reported by REECo.

b The known value or value assigned by EML-DOE.

c Mean value of submitted results of all participating laboratories in the range of 0.5 to 2.0 times EML value.

d The number of participating laboratories that reported analysis results for the analysis

e The percentage of participating laboratories reporting an average value that is within ±20%of the EMSL-EPA value.

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APPENDIX A

NTS Environmental Monitoring

Air Sampling Stations and Plots

SYMBOLS

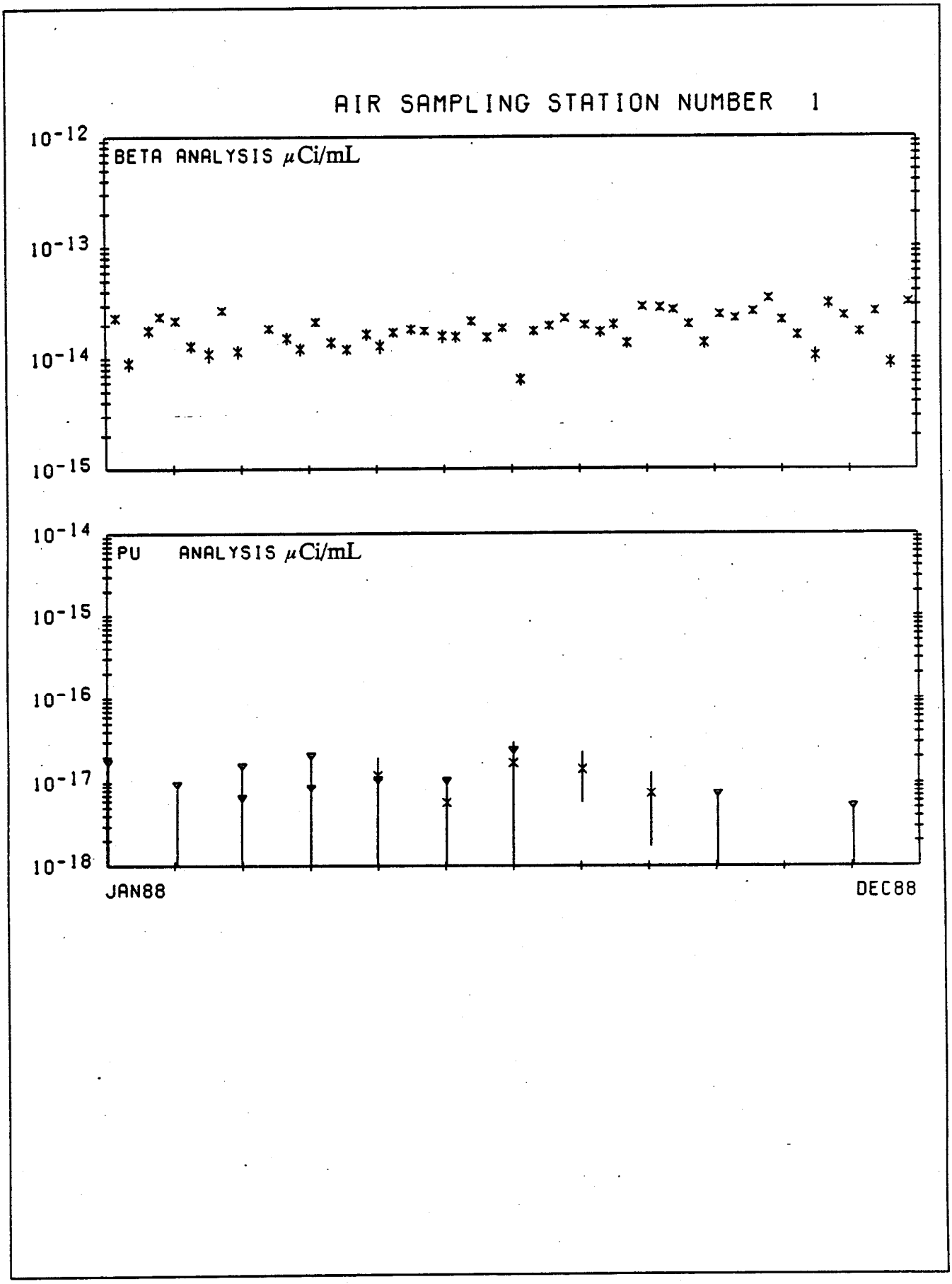
Several symbols are used in Appendix A to denote the data points. The plots of Appendix A show the gross beta and plutonium data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with the line to the bottom of the plot signifies a result below detection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

APPENDIX A

NTS Environmental Monitoring

Air Sampling Locations

Station Number	Location
1	Area 11 Gate 293
2	Area 6 Well 3
3	Area 3 Complex
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
18	Area 2 Substation 2-1
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
31	Area 25 E-MAD
32	Area 5 RWMS No. 4
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
61	Area 3 U3ah/at South
62	Area 3 U3ah/at East
63	Area 3 U3ah/at North
64	Area 3 U3ah/at West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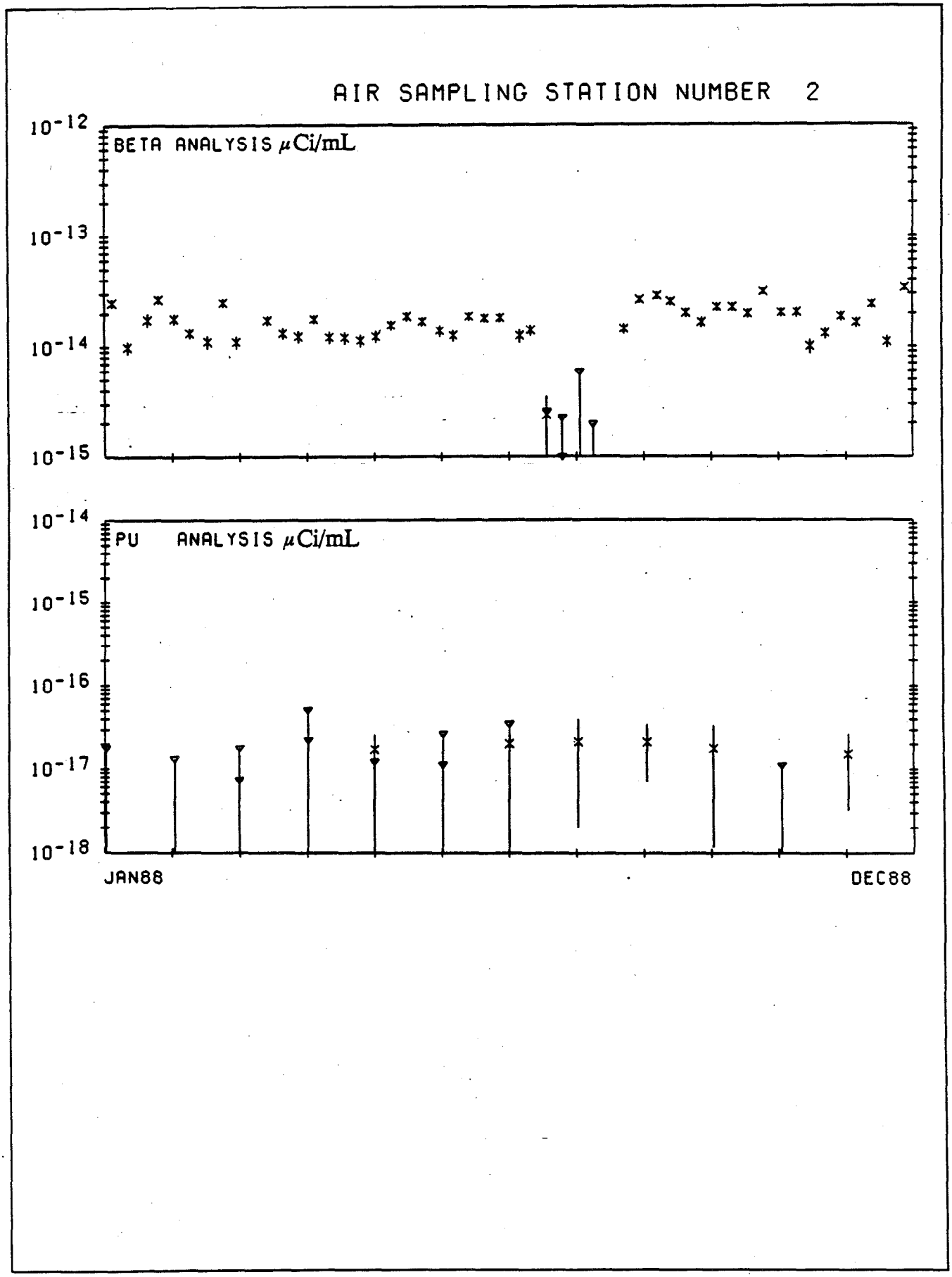
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88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PU ANALYSIS μCi/mL
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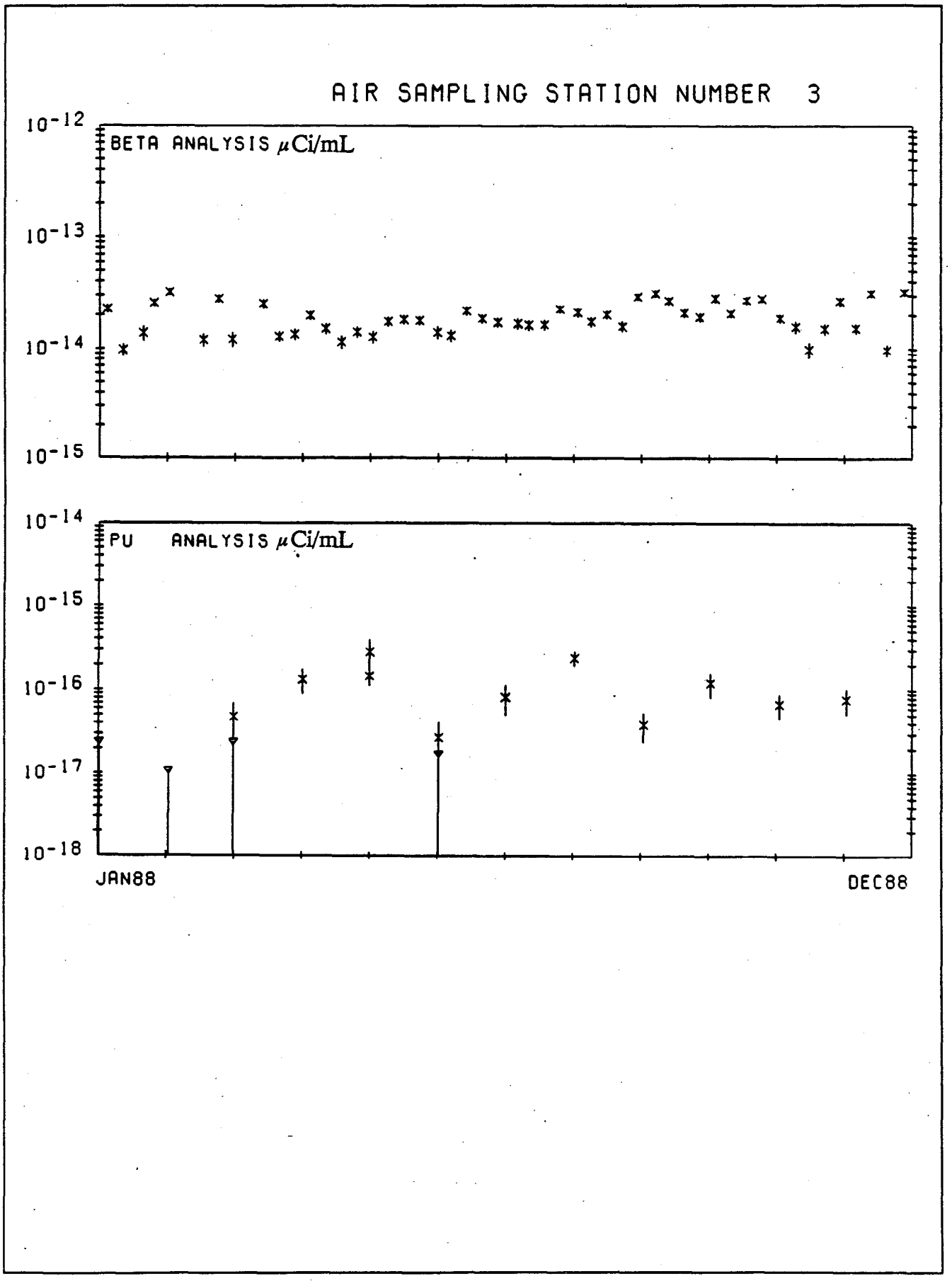
10-15
10-16
10-17
10-18
JAN88
DEC88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10-15
PU ANALYSIS μCi/mL
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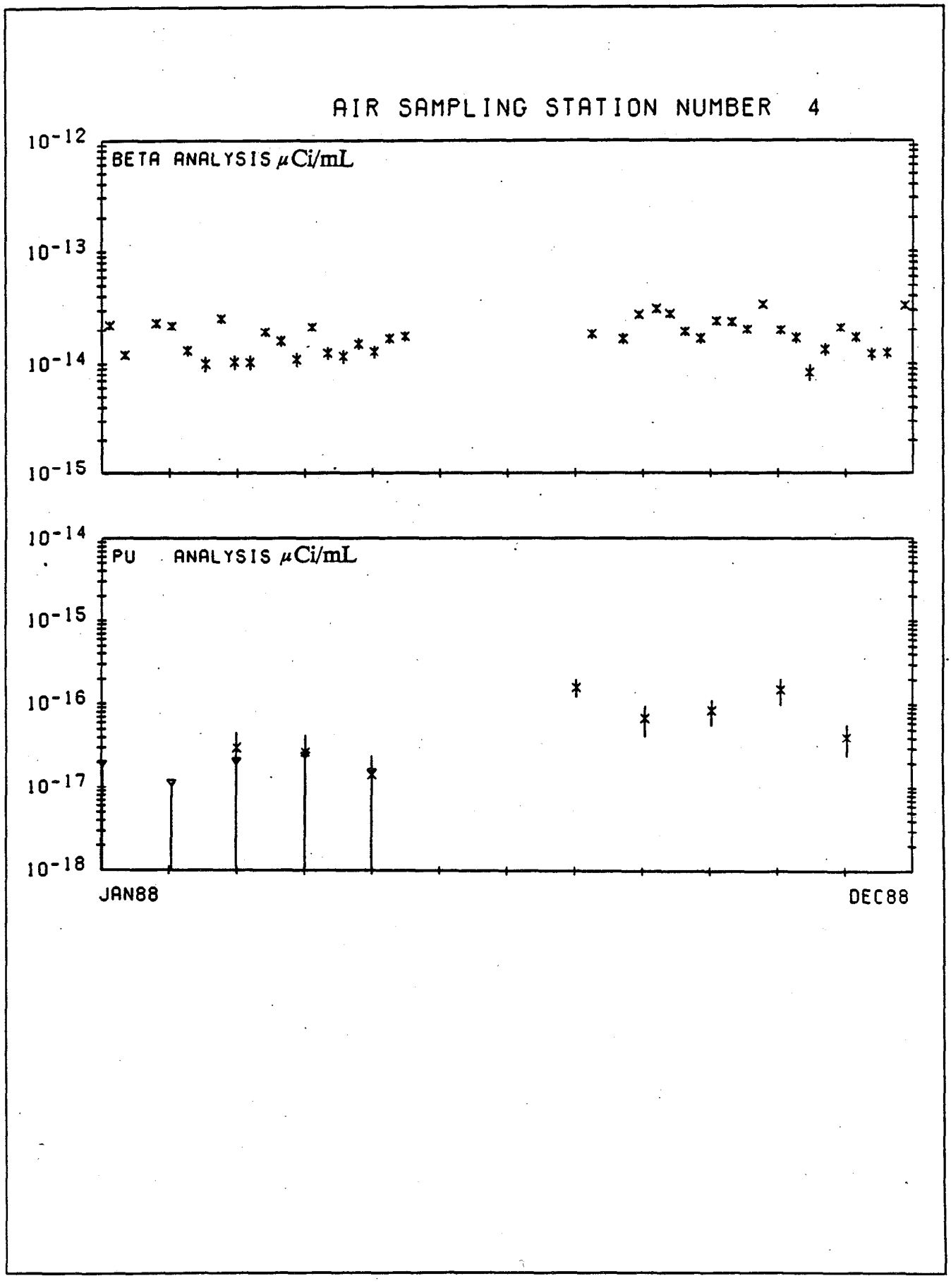
10-17
10-18
JAN88
DEC88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PU ANALYSIS μCi/mL
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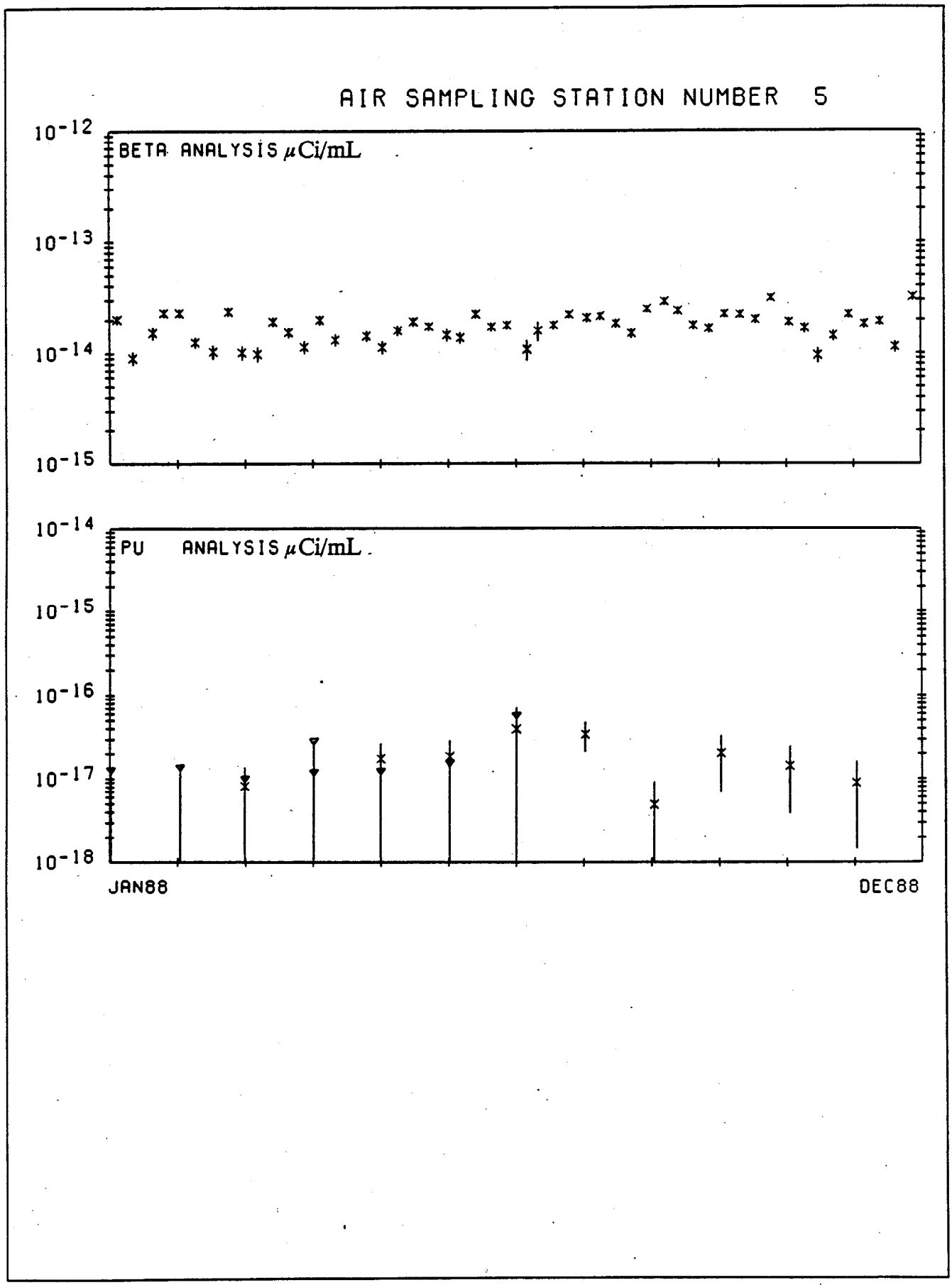
10-15
10-16
10-17
10-18
JAN88
DEC88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PU ANALYSIS μCi/mL
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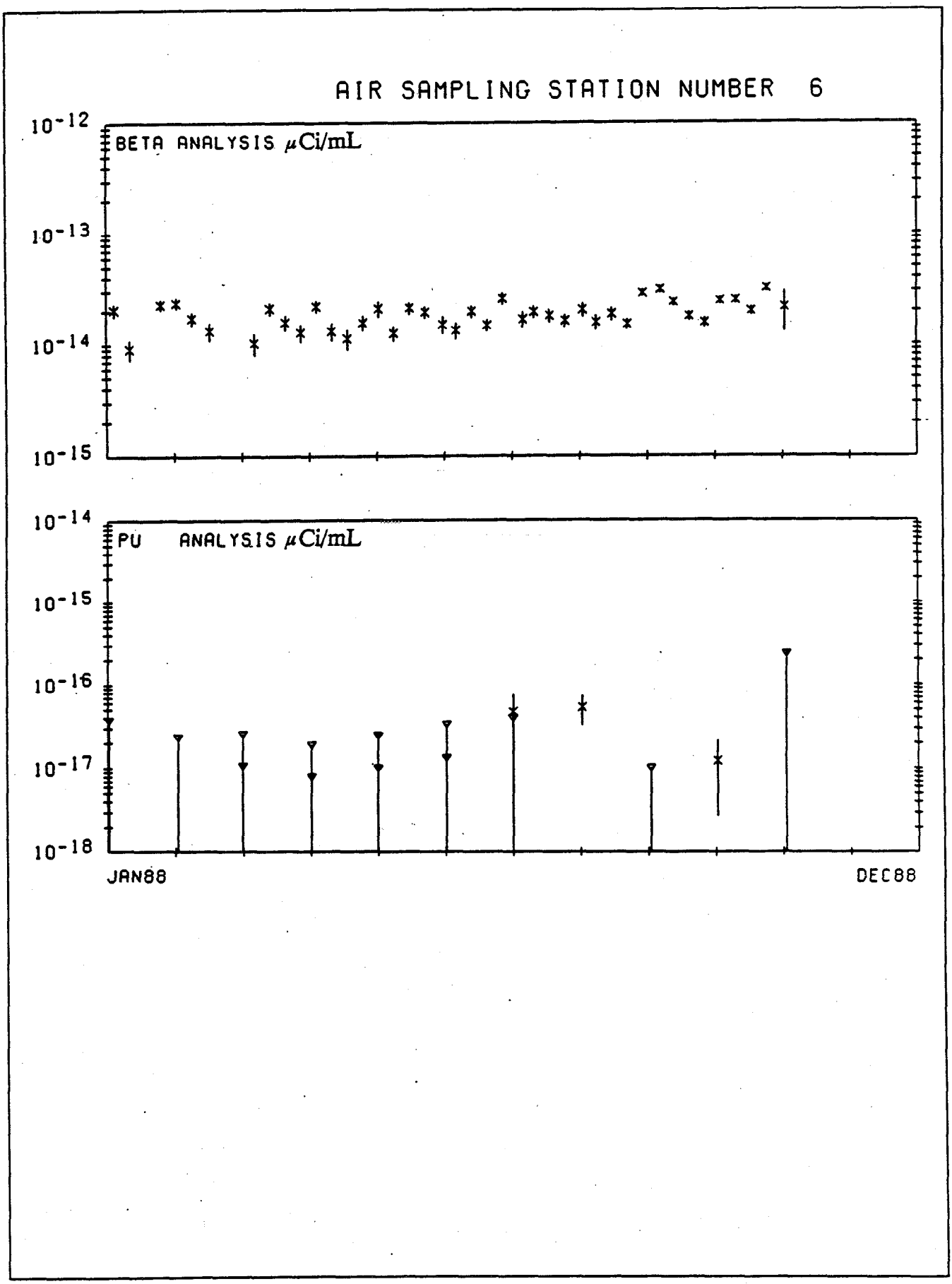
10-15
10-16
10-17
10-18
JAN88
DEC88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10-15
PU ANALYSIS μCi/mL
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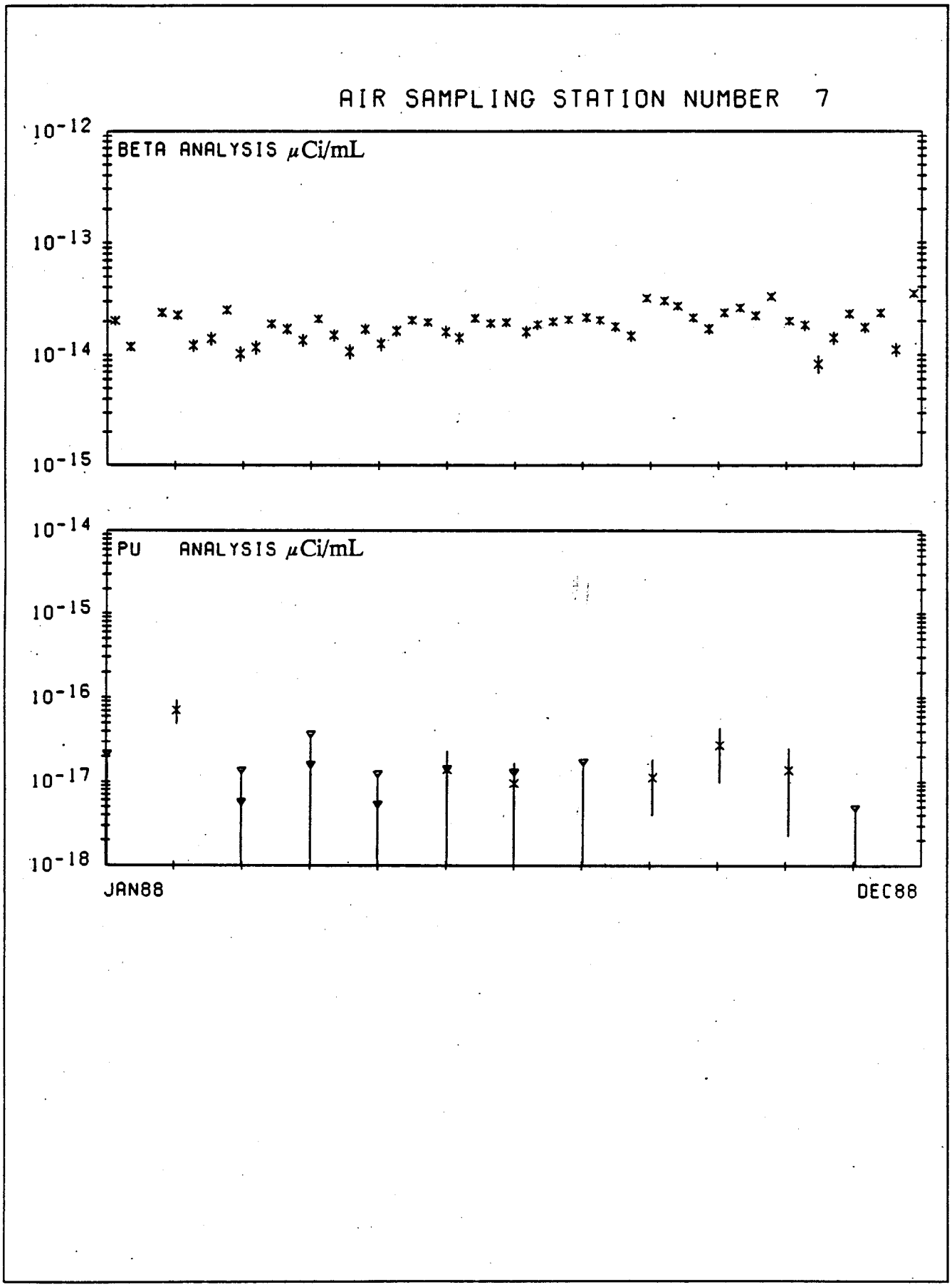
10-15
10-16
10-17
10-18
JAN88
DEC88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10-13
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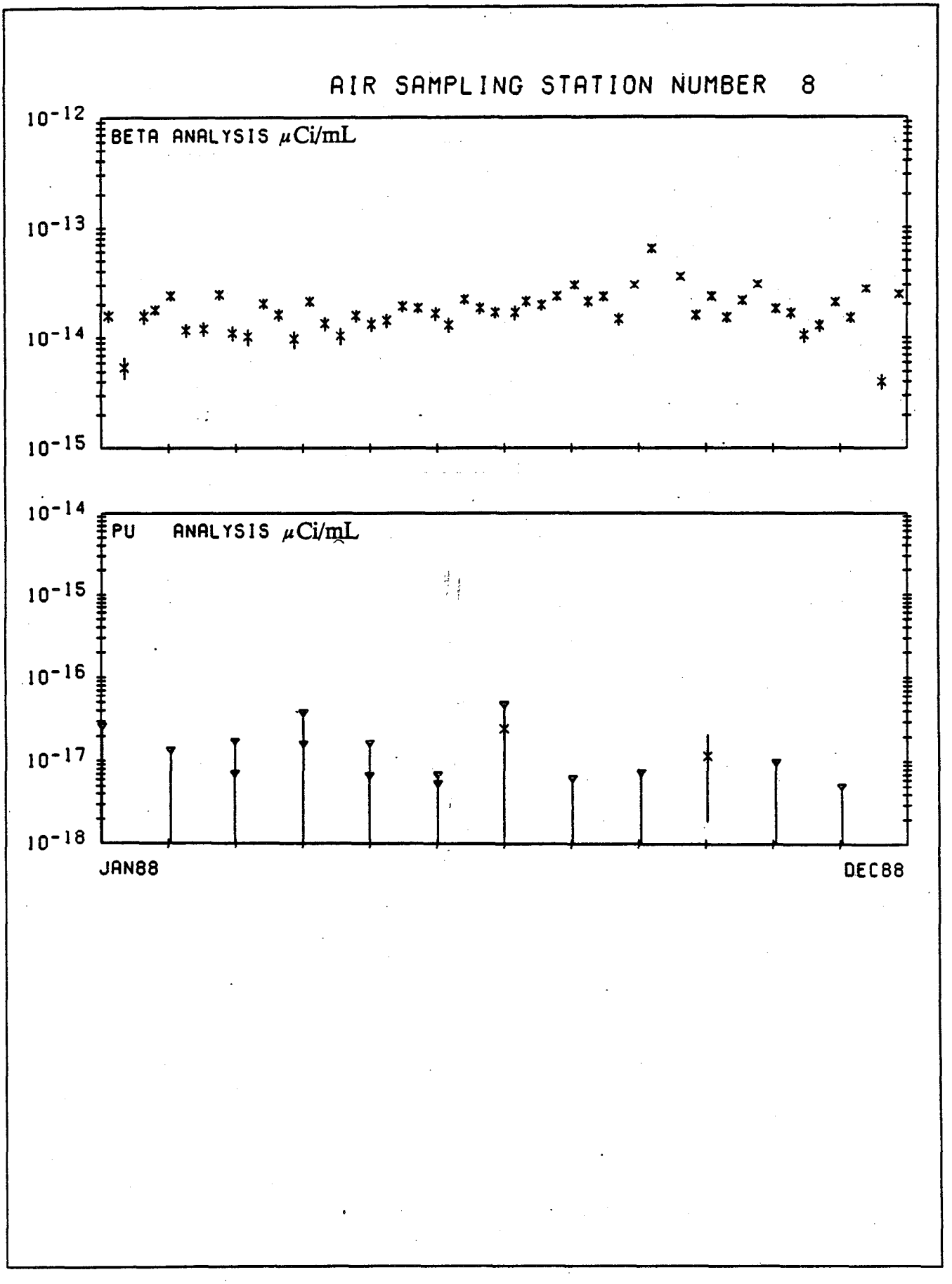
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88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PU ANALYSIS μCi/mL
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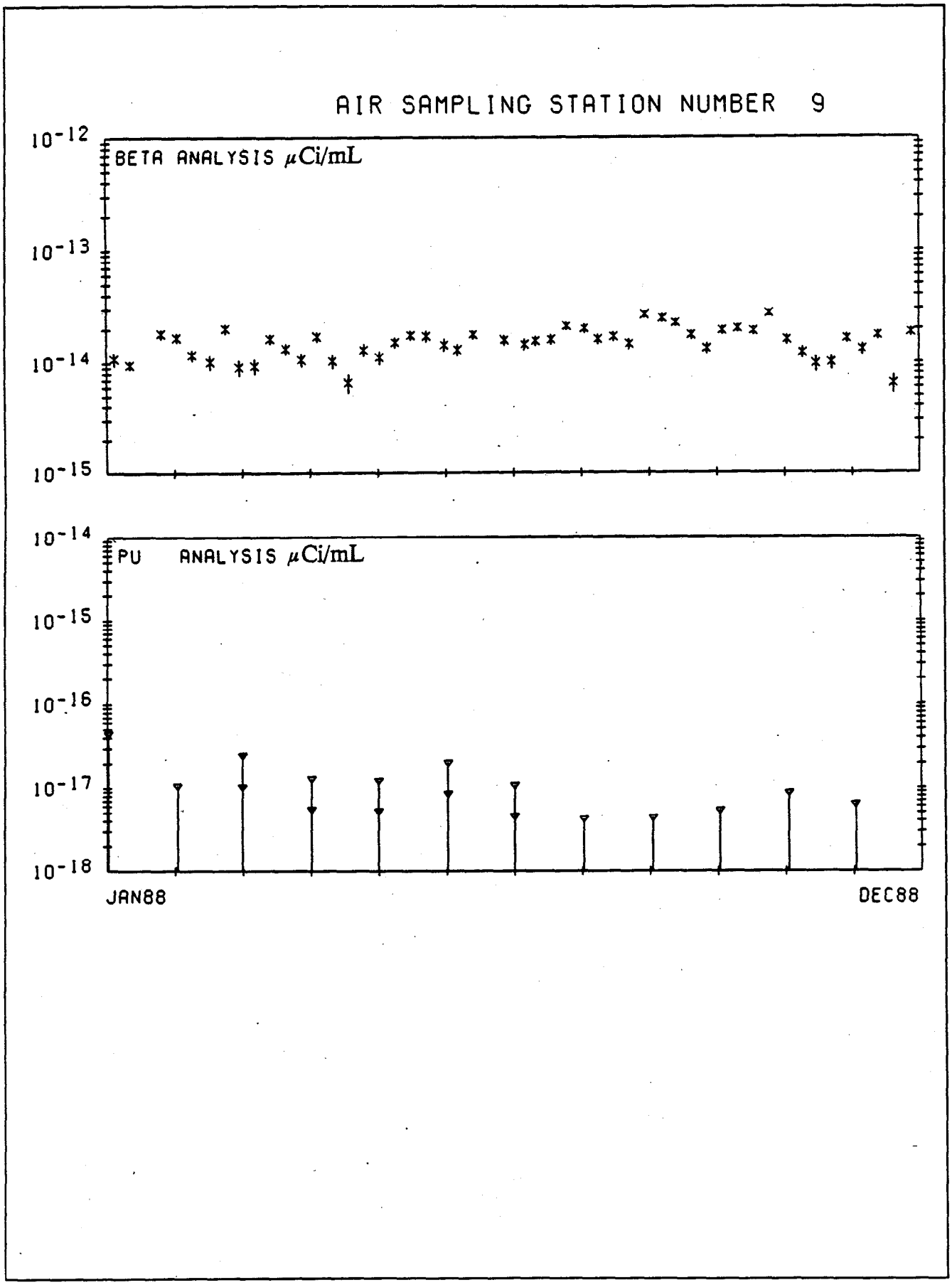
10-15
10-16
10-17
10-18
JAN88
DEC88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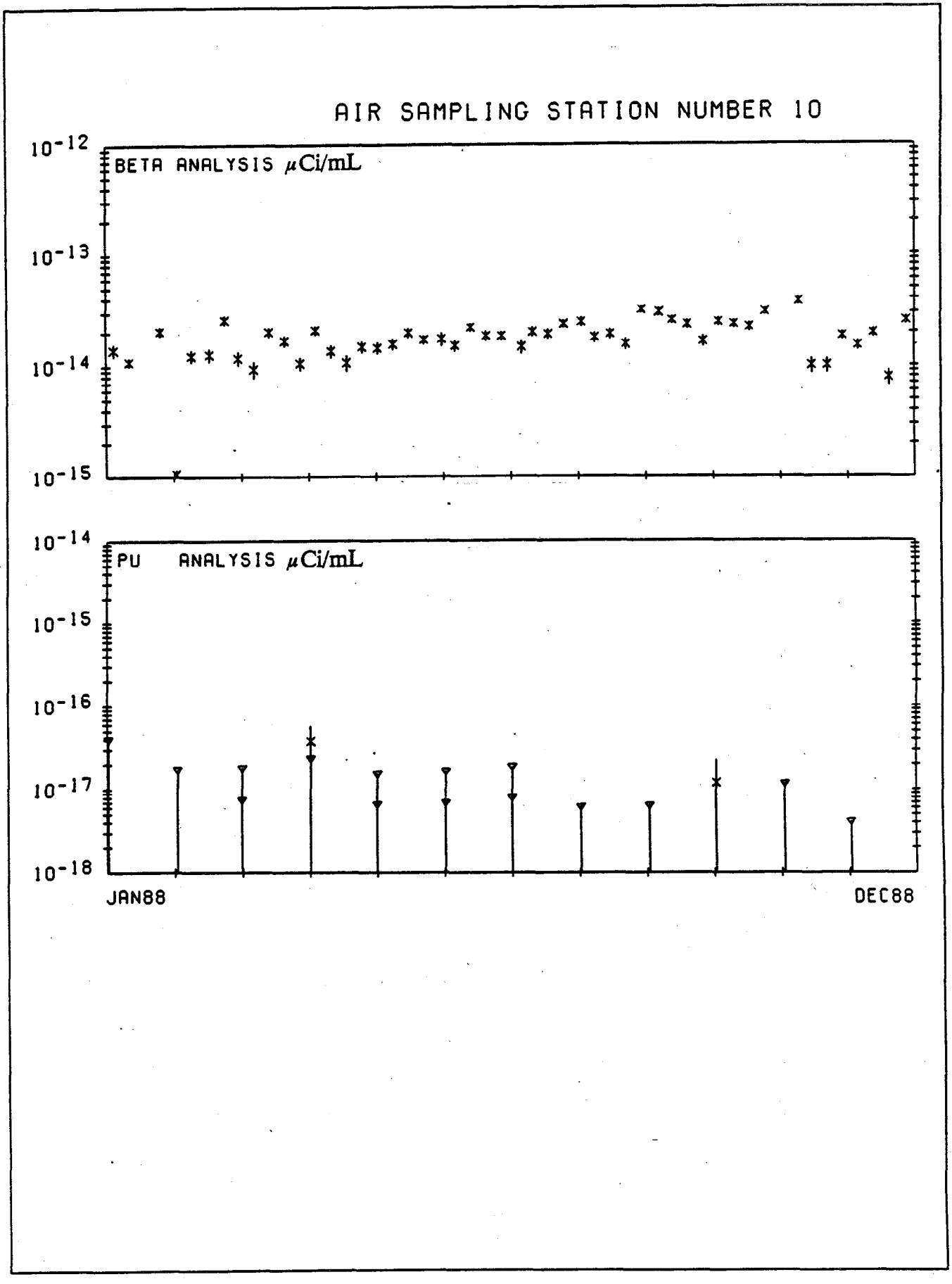
10-16
10-17
10-18
JAN88
DEC88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PU ANALYSIS μCi/mL
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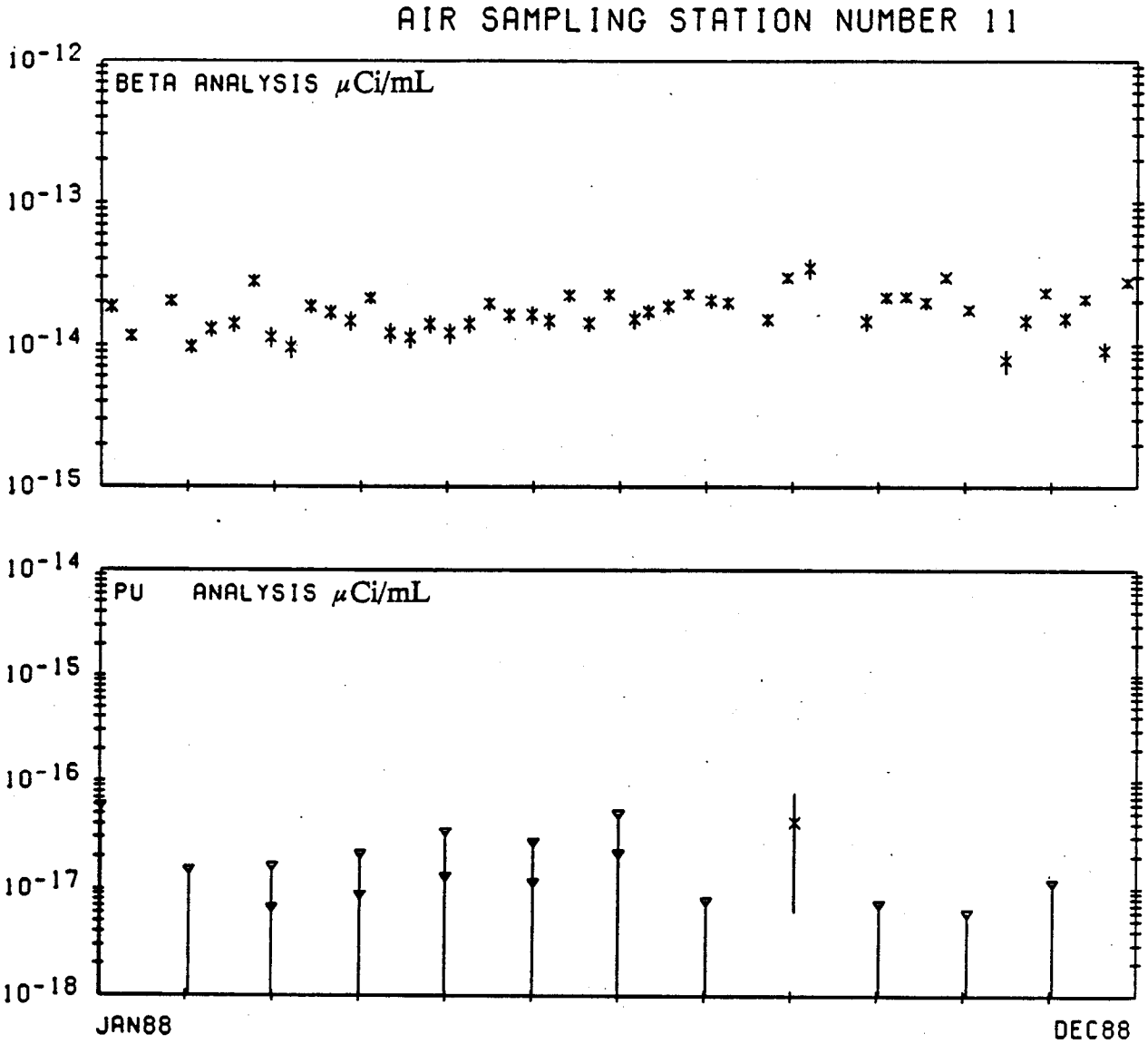
10-16
10-17
10-18
JAN88
DEC88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PU ANALYSIS μCi/mL
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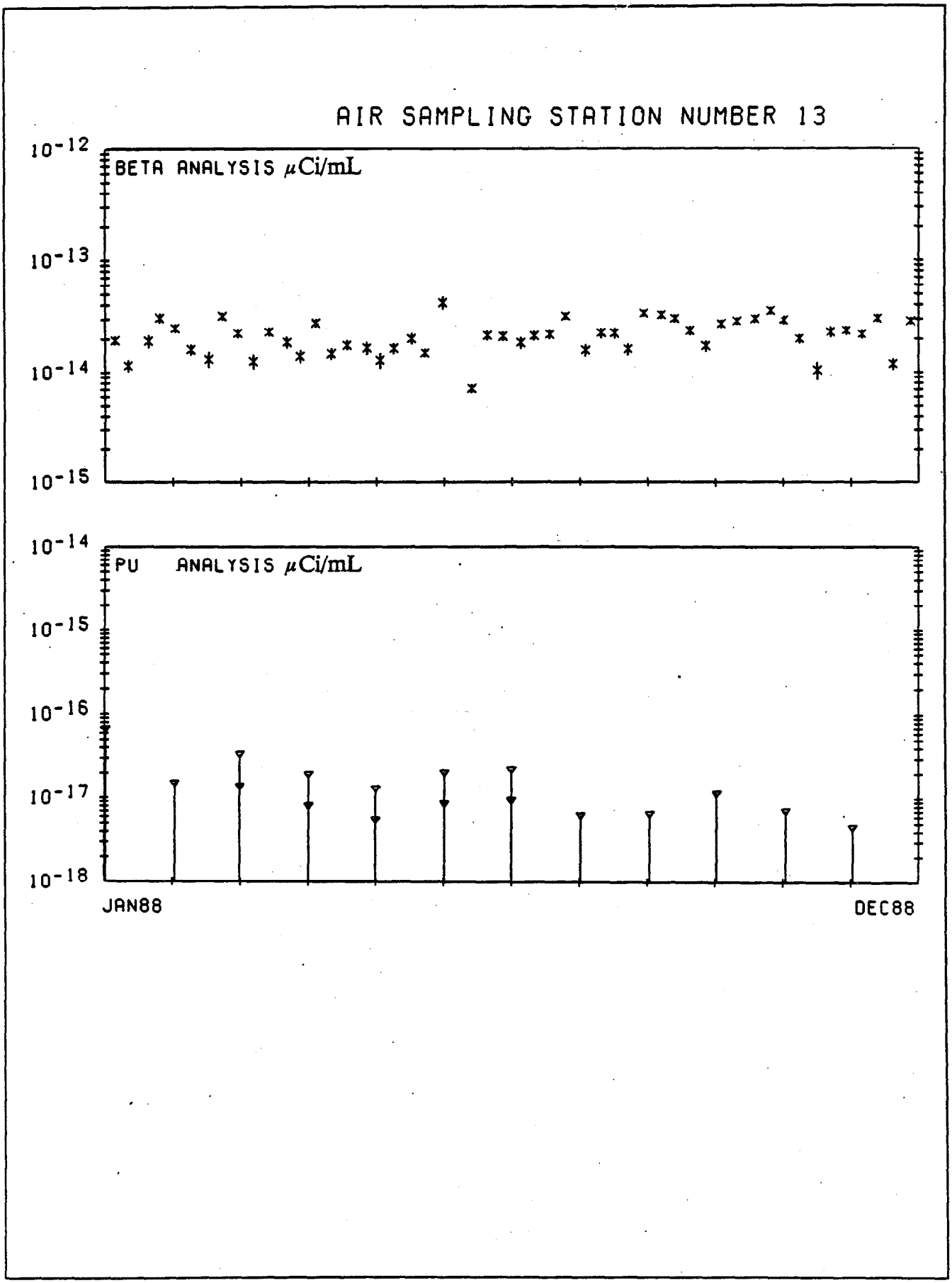
10-16
10-17
10-18
JAN88
DEC88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10-17
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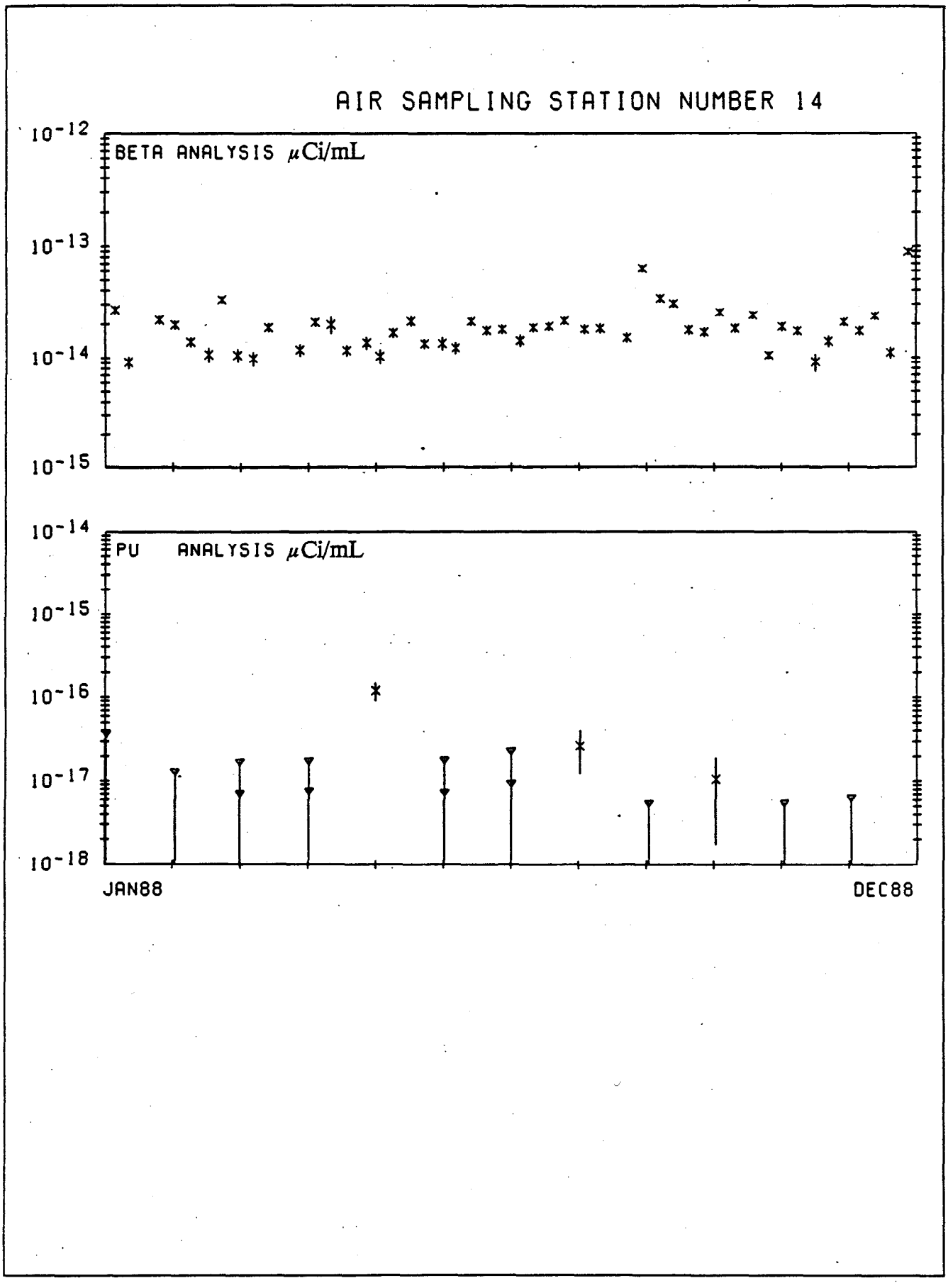
JAN88
DEC88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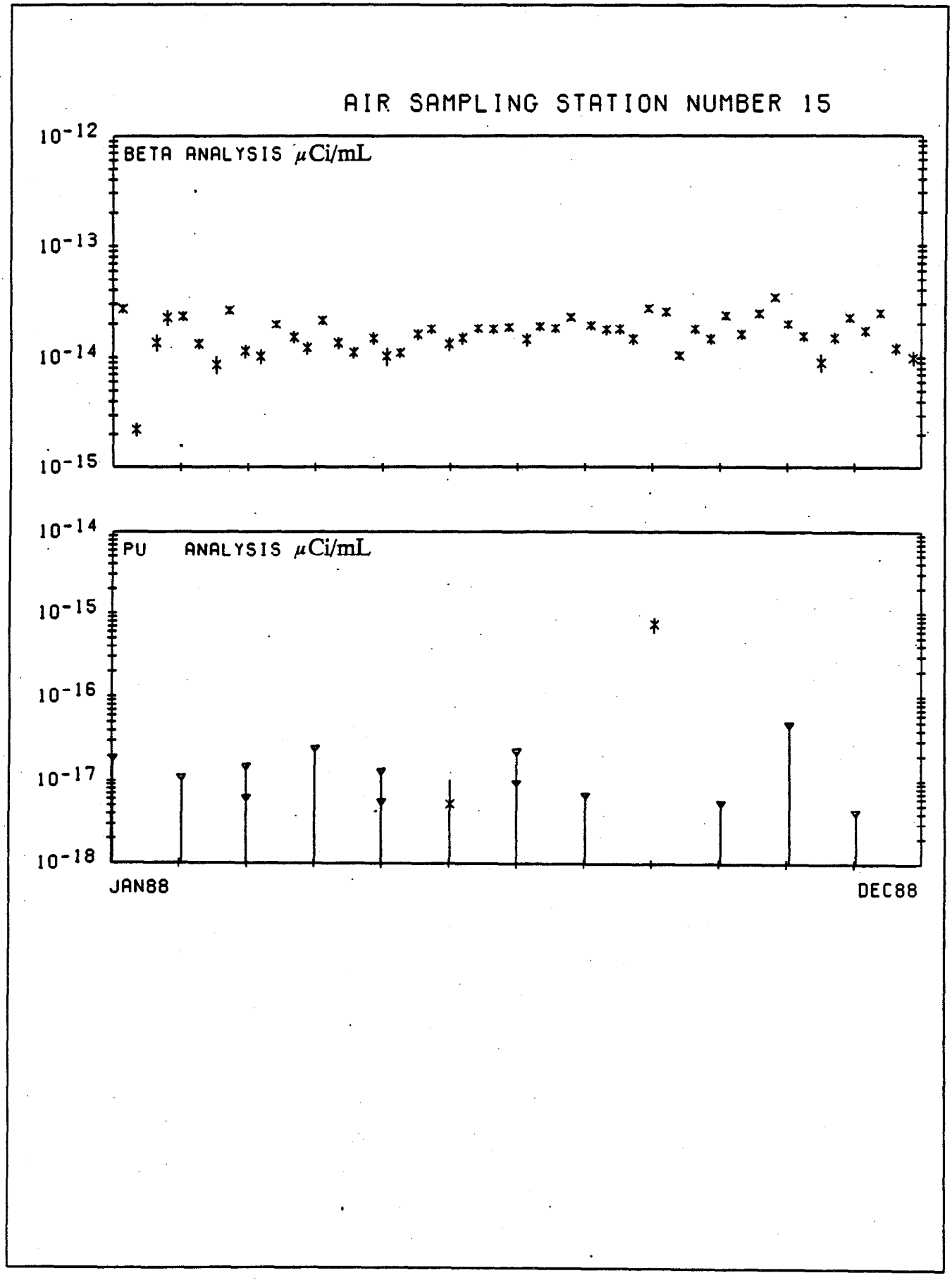
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10-16
10-17
10-18
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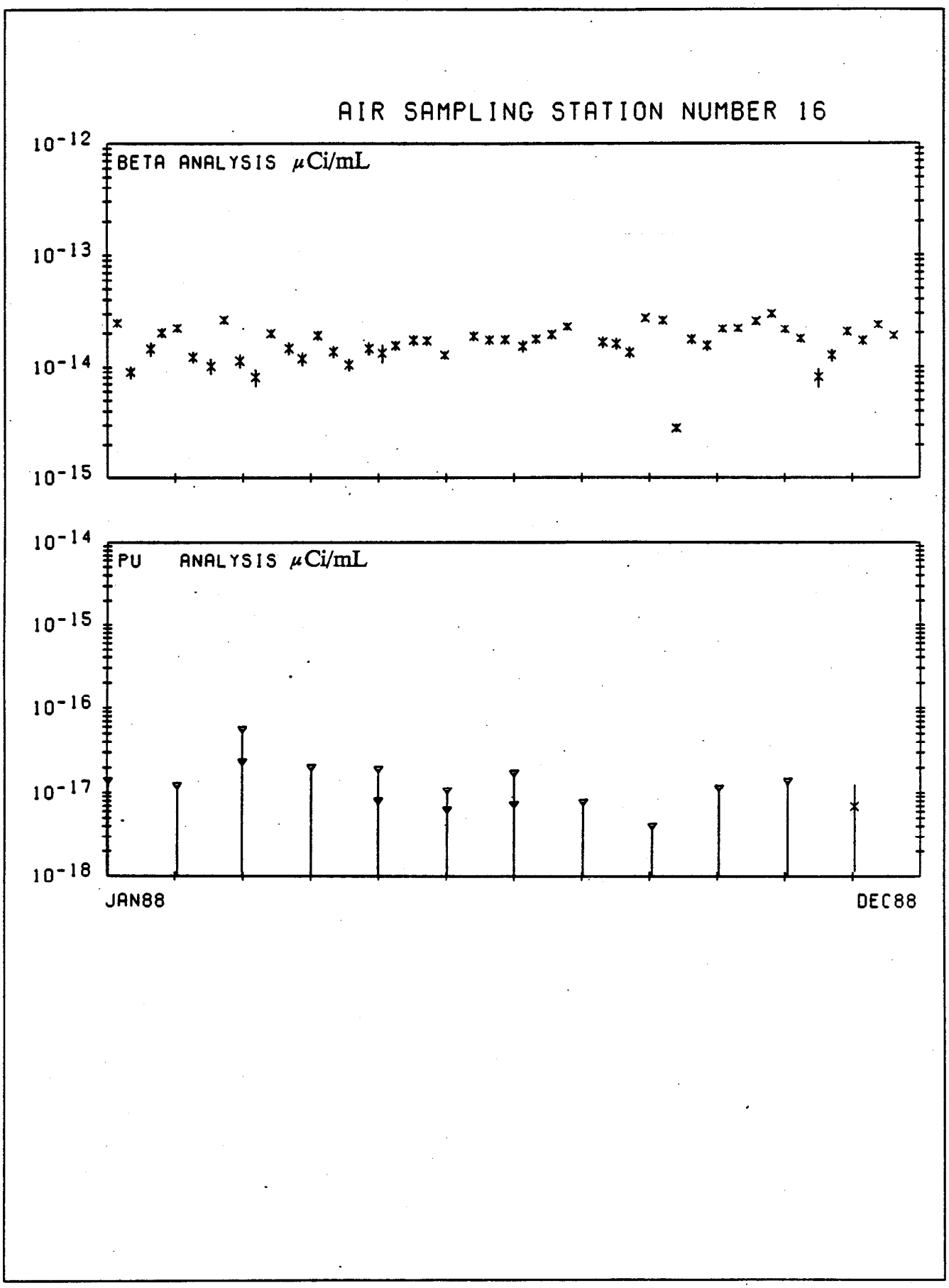
DEC88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10-14
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PU ANALYSIS μCi/mL
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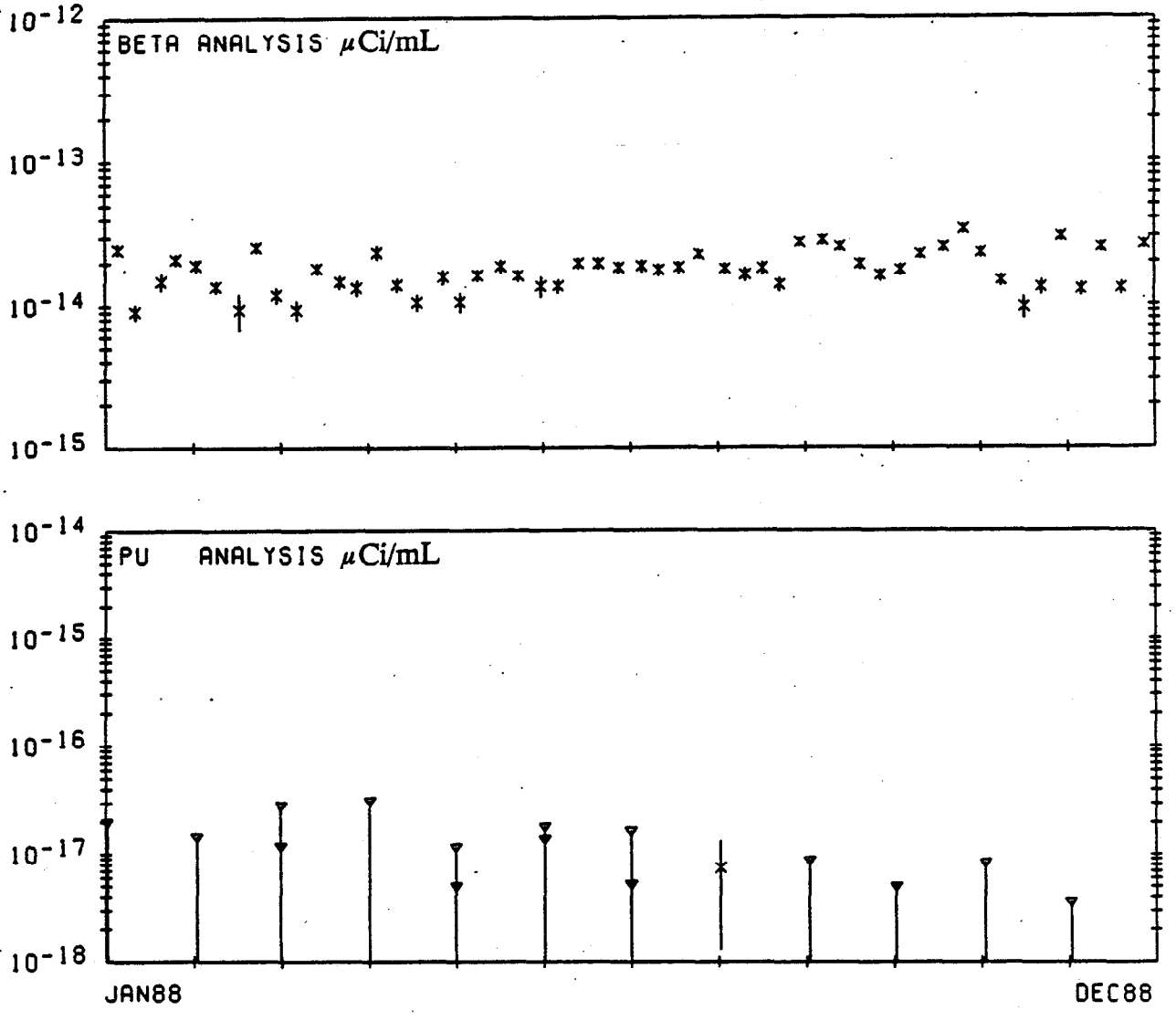
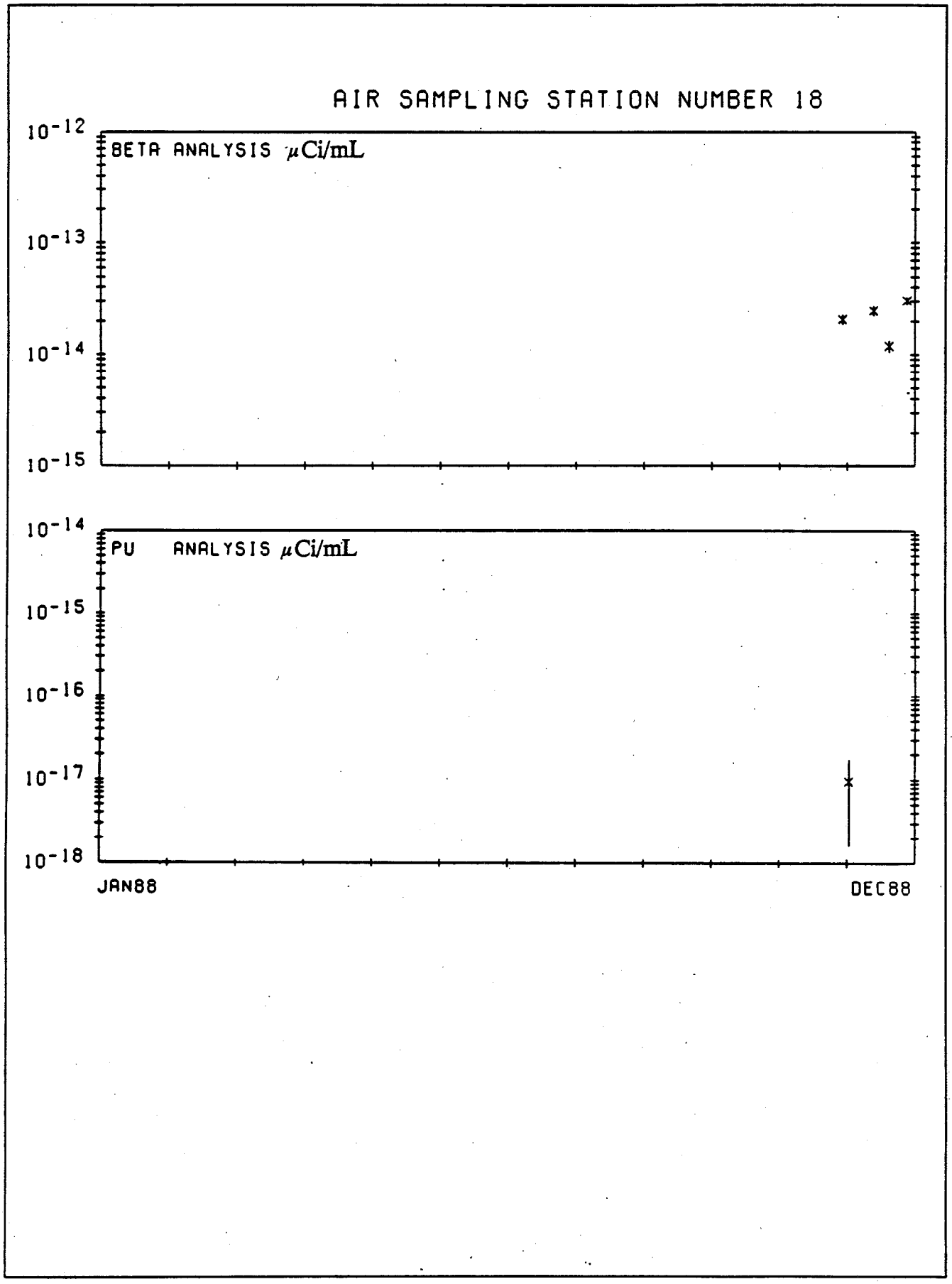
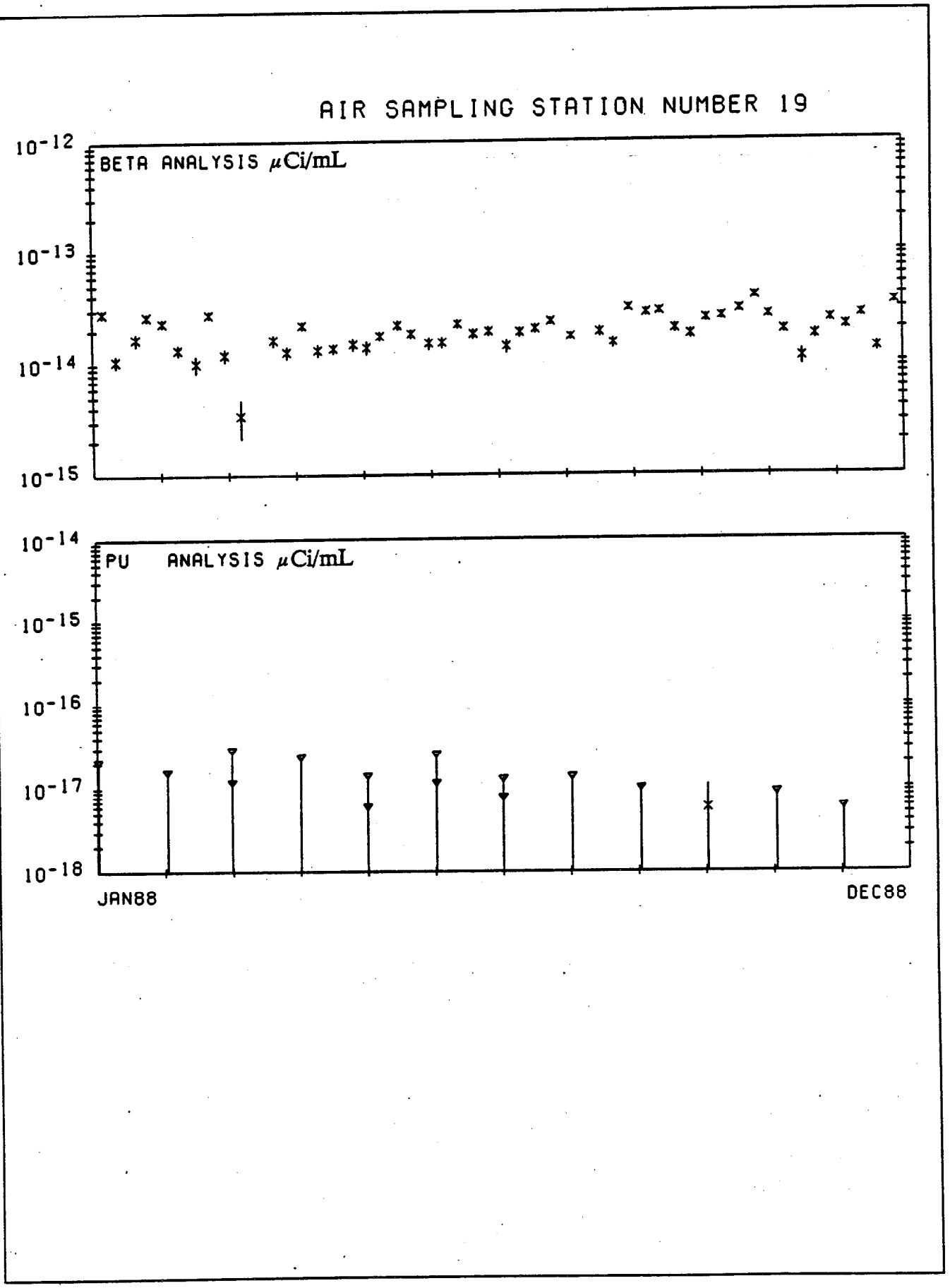
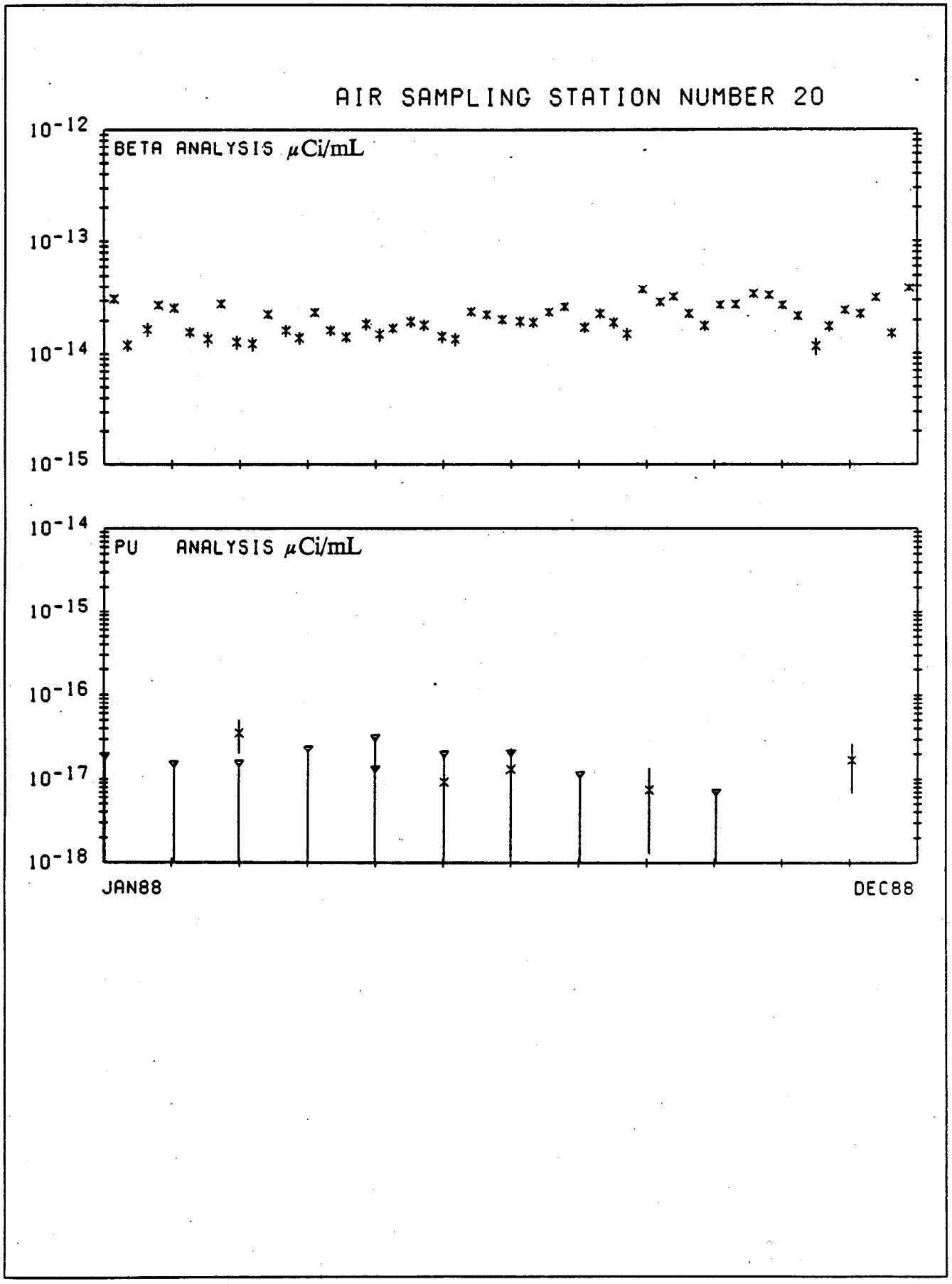
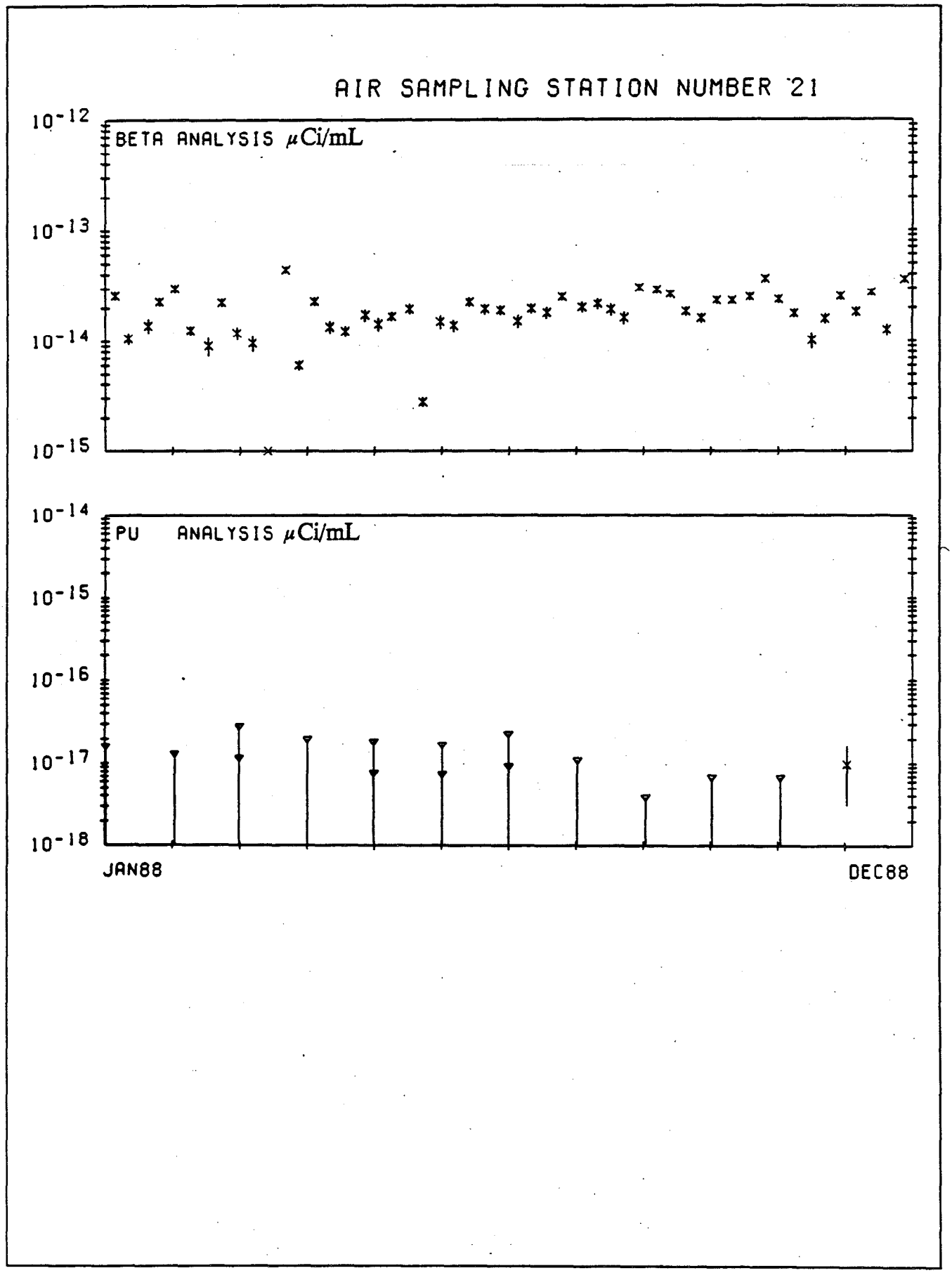
10-15
10-16
10-17
10-18
JAN88
DEC88

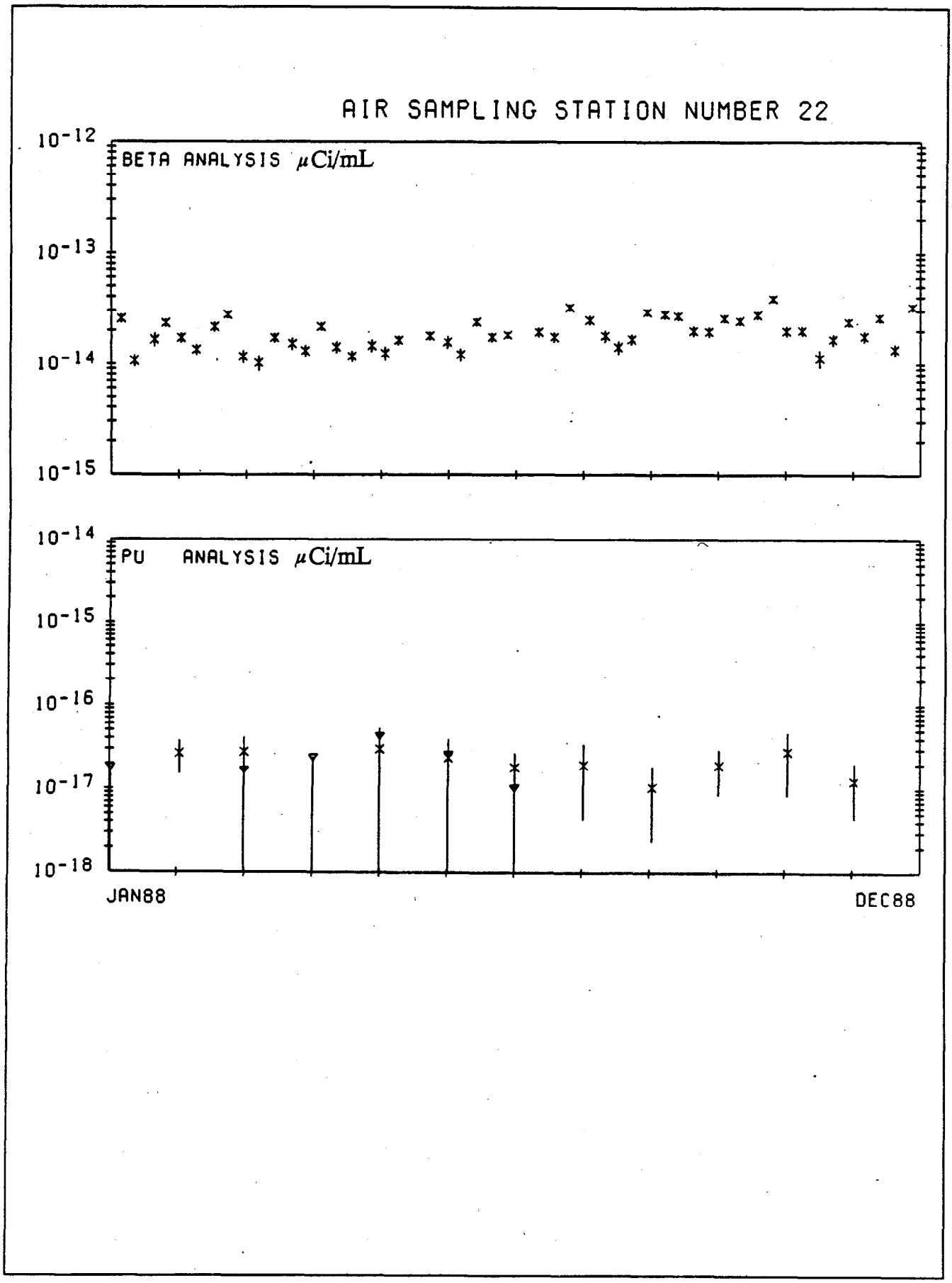

AIR SAMPLING STATION NUMBER 17
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

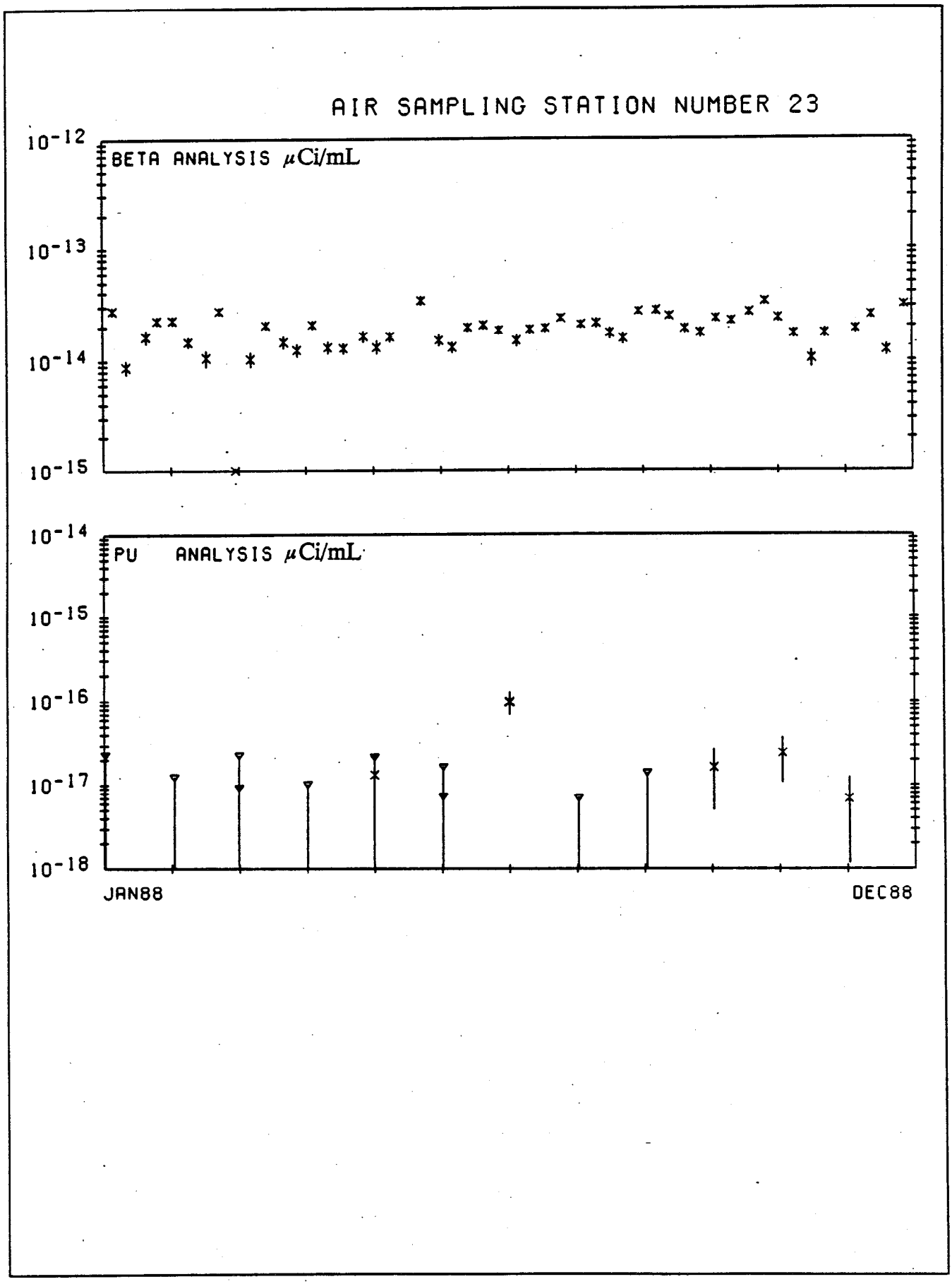

AIR SAMPLING STATION NUMBER 18
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

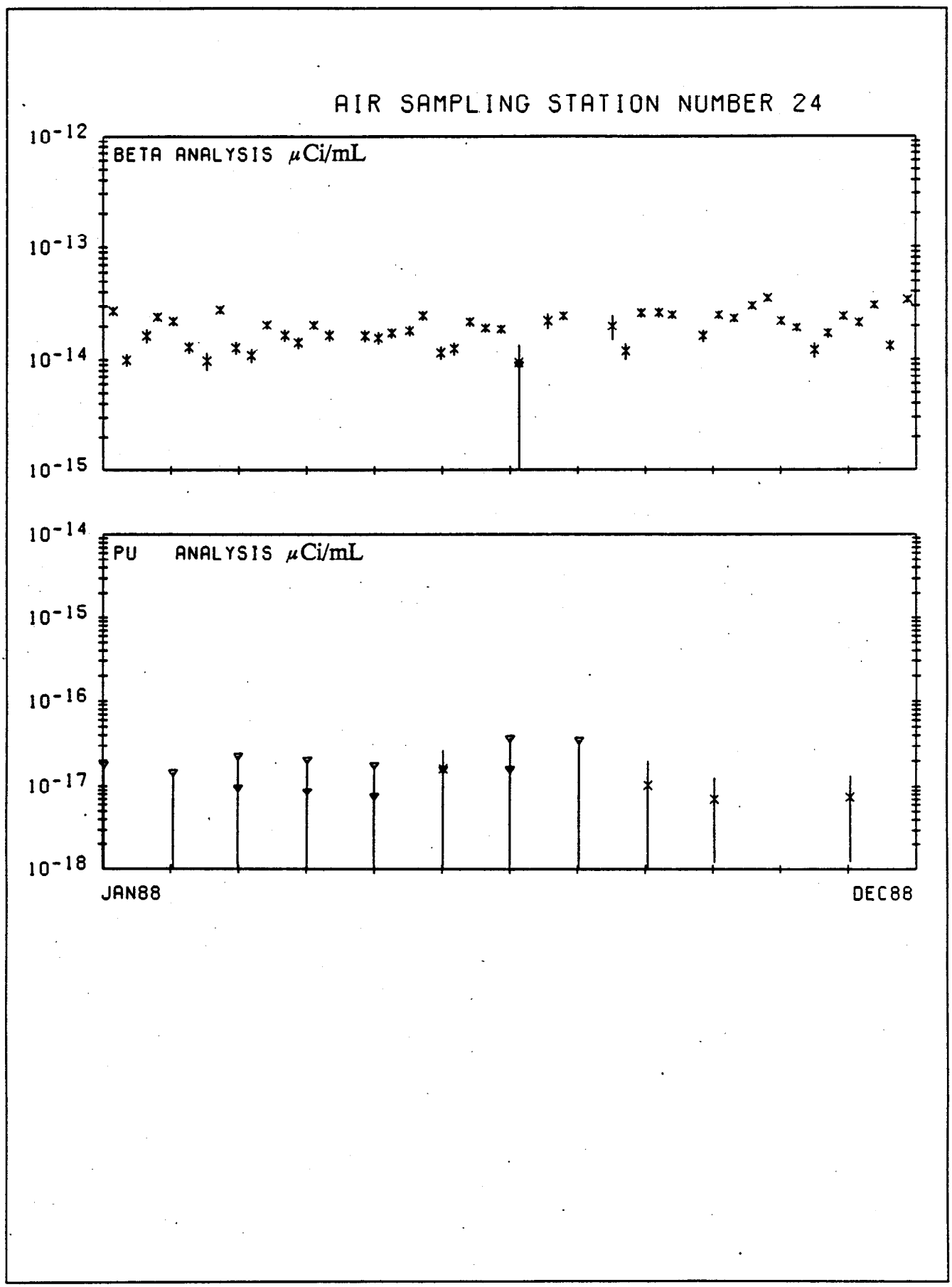

AIR SAMPLING STATION NUMBER 19
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

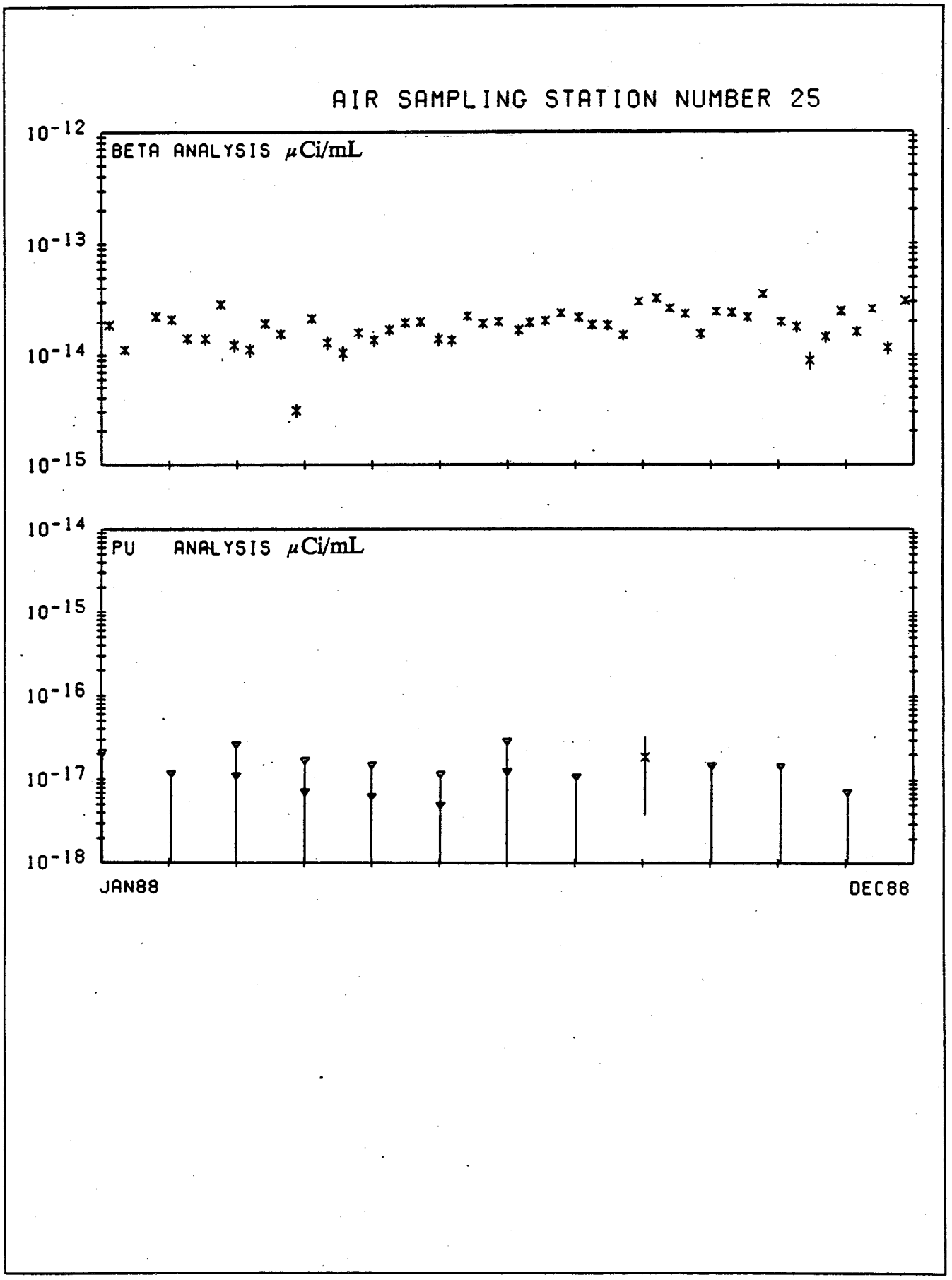

AIR SAMPLING STATION NUMBER 20
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

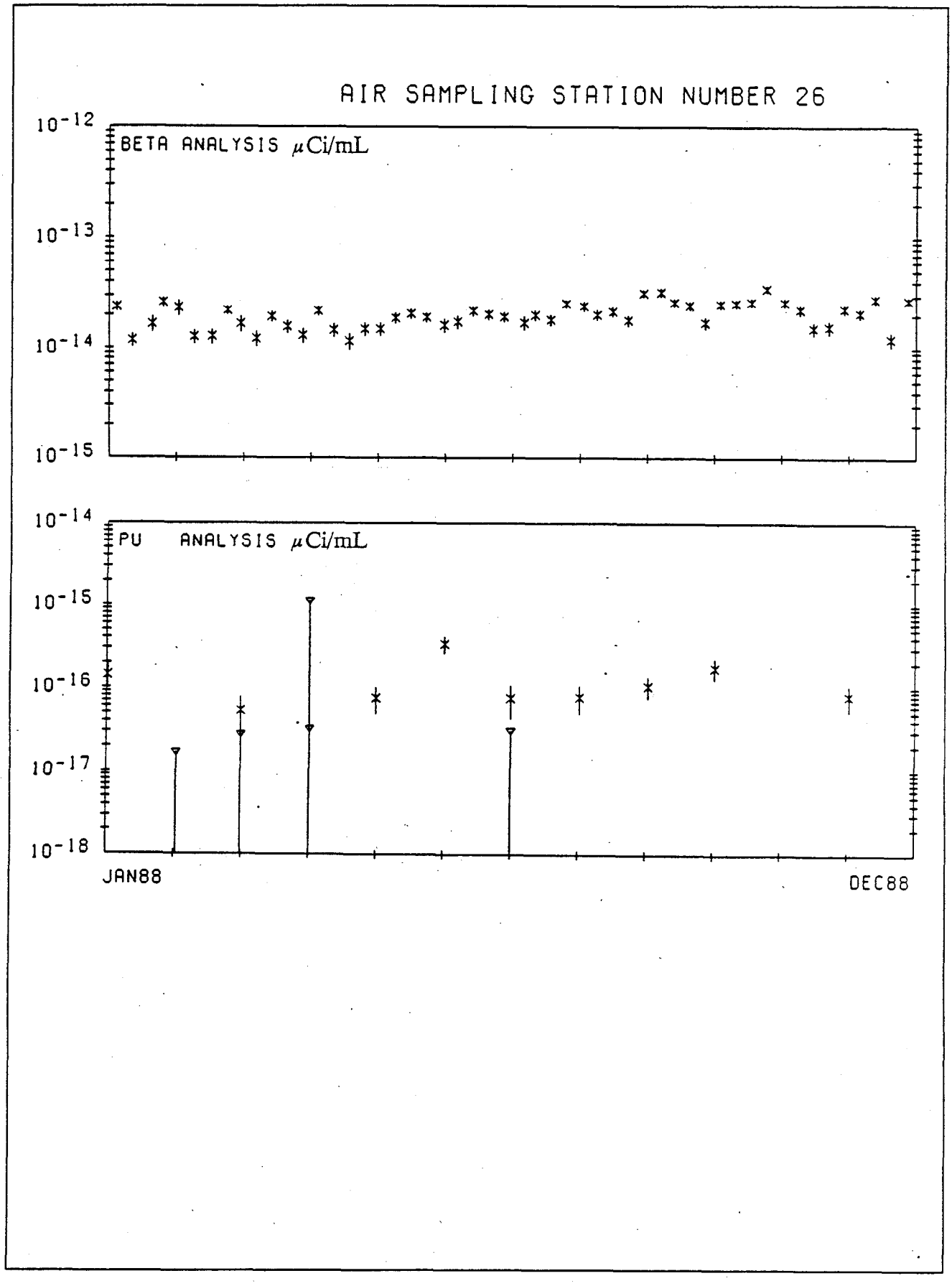

AIR SAMPLING STATION NUMBER 21
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

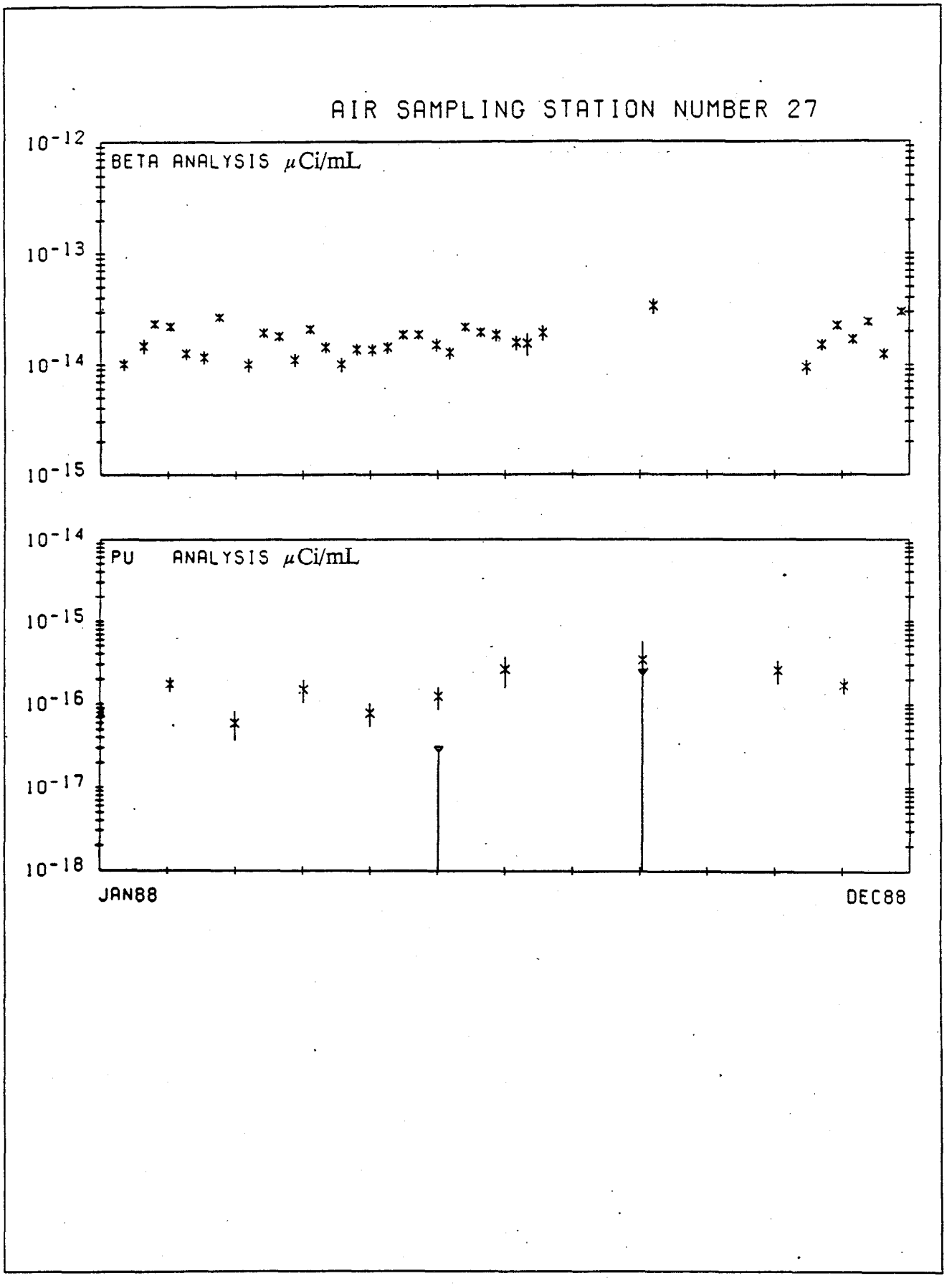

AIR SAMPLING STATION NUMBER 22
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

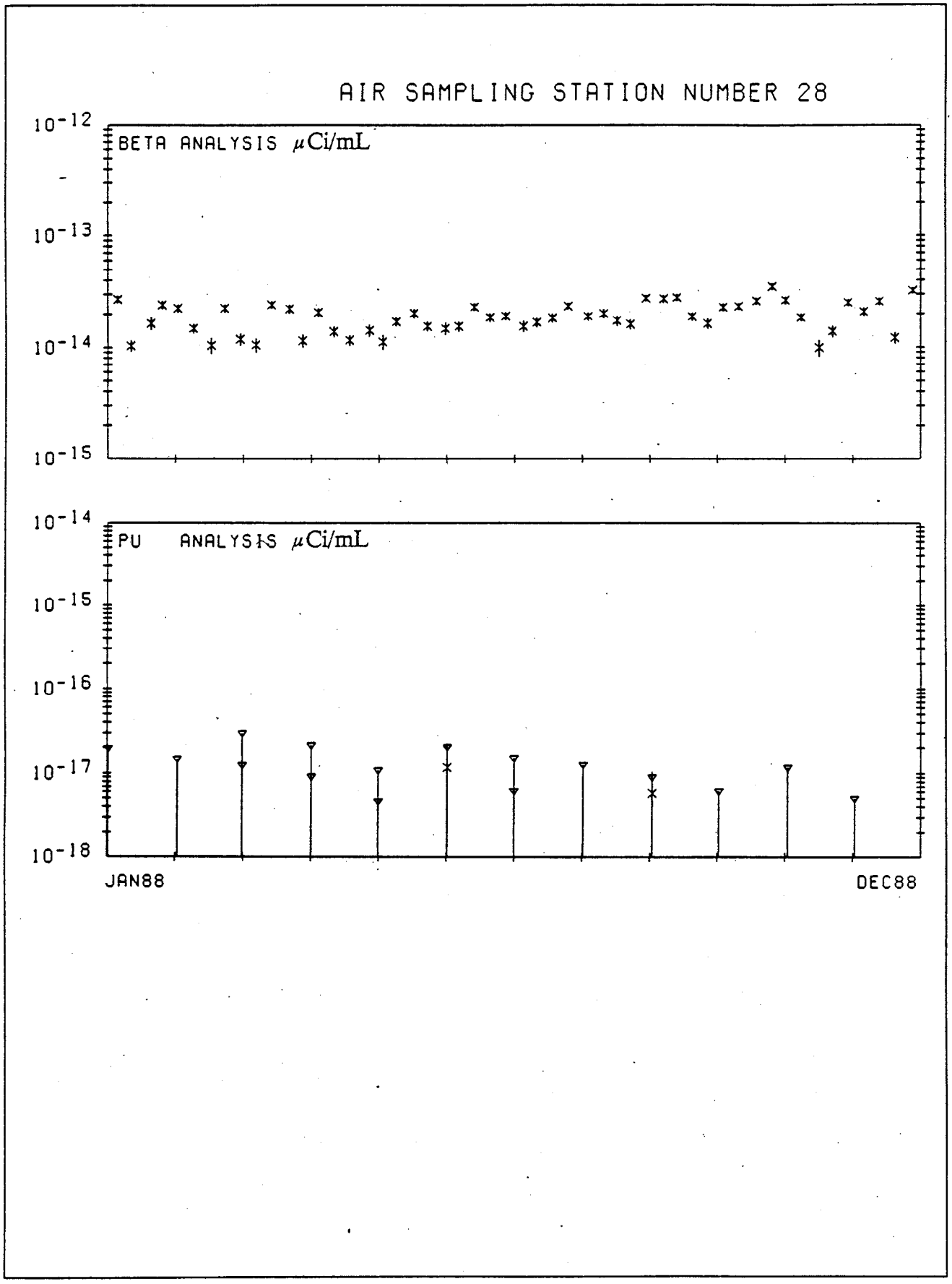

AIR SAMPLING STATION NUMBER 23
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

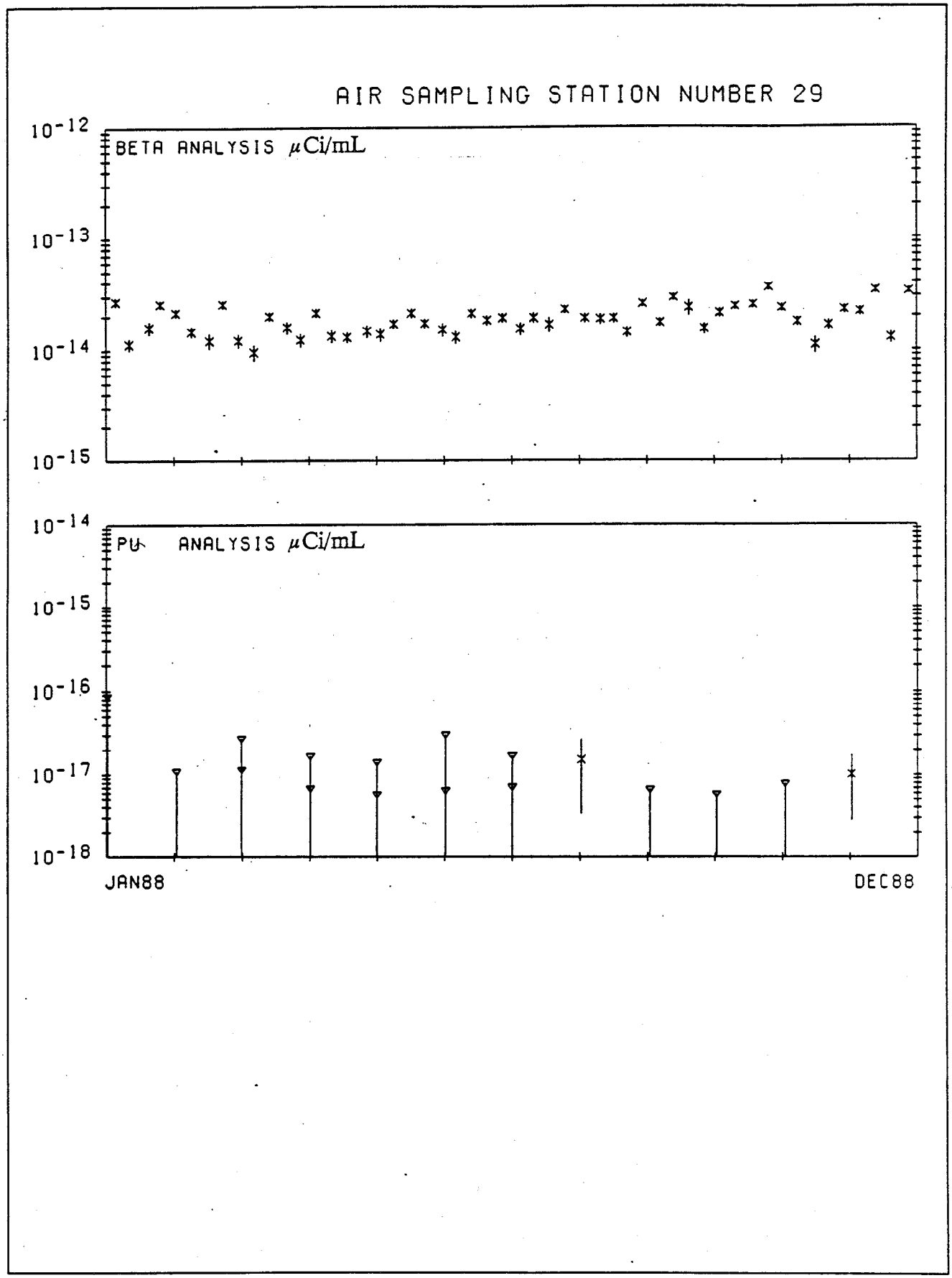

AIR SAMPLING STATION NUMBER 24
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

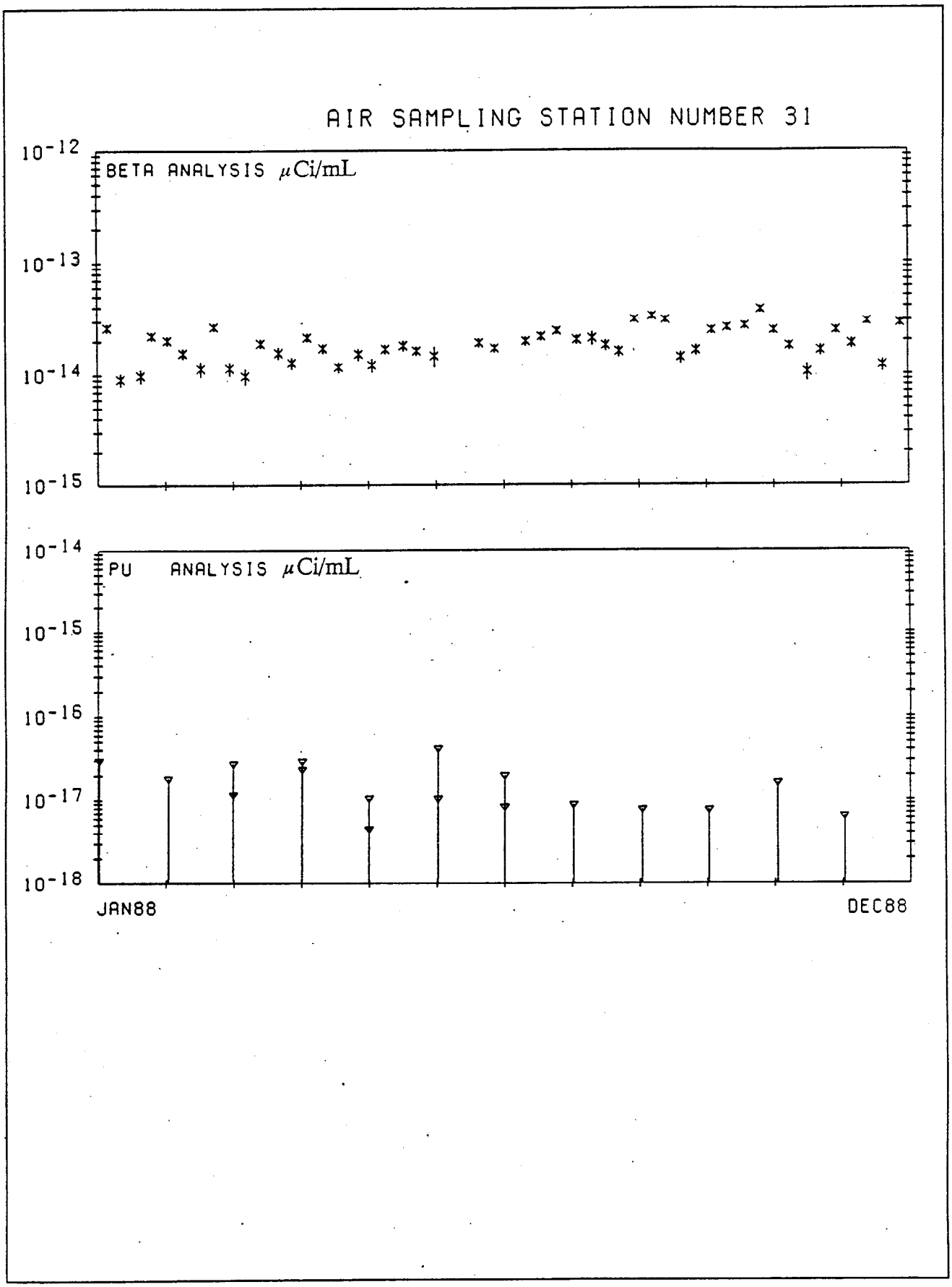

AIR SAMPLING STATION NUMBER 25
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

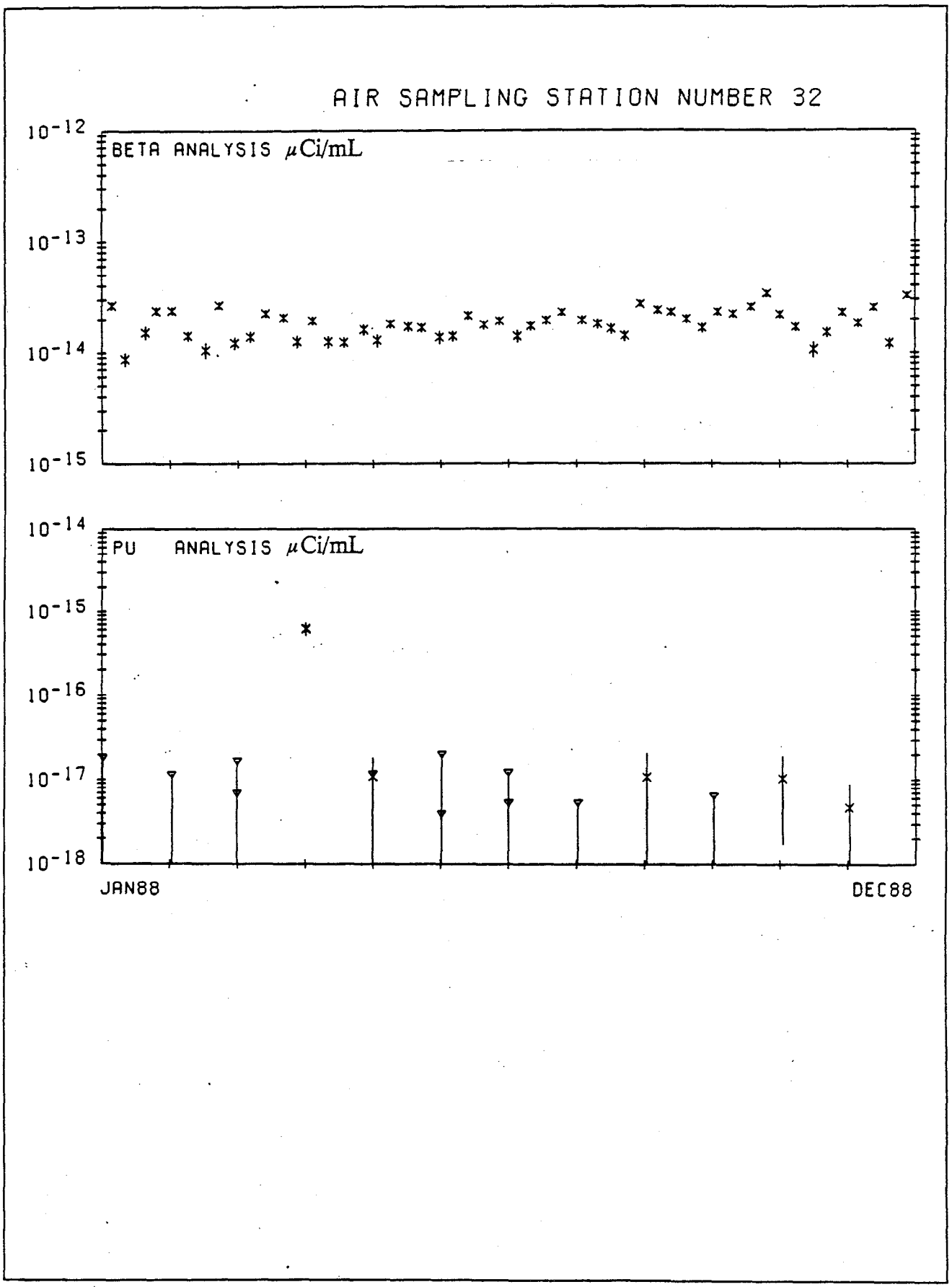

AIR SAMPLING STATION NUMBER 26
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

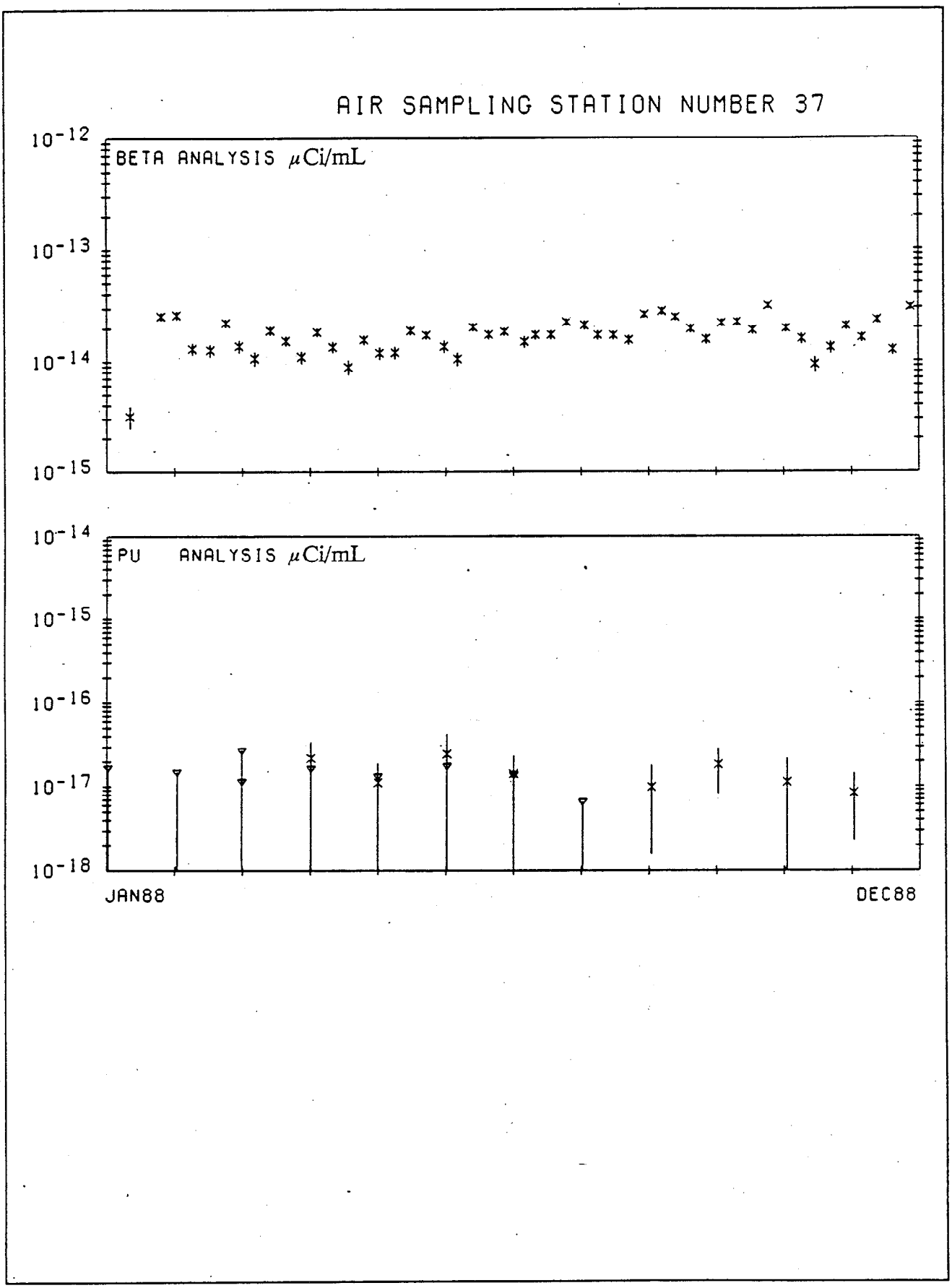

AIR SAMPLING STATION NUMBER 27
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

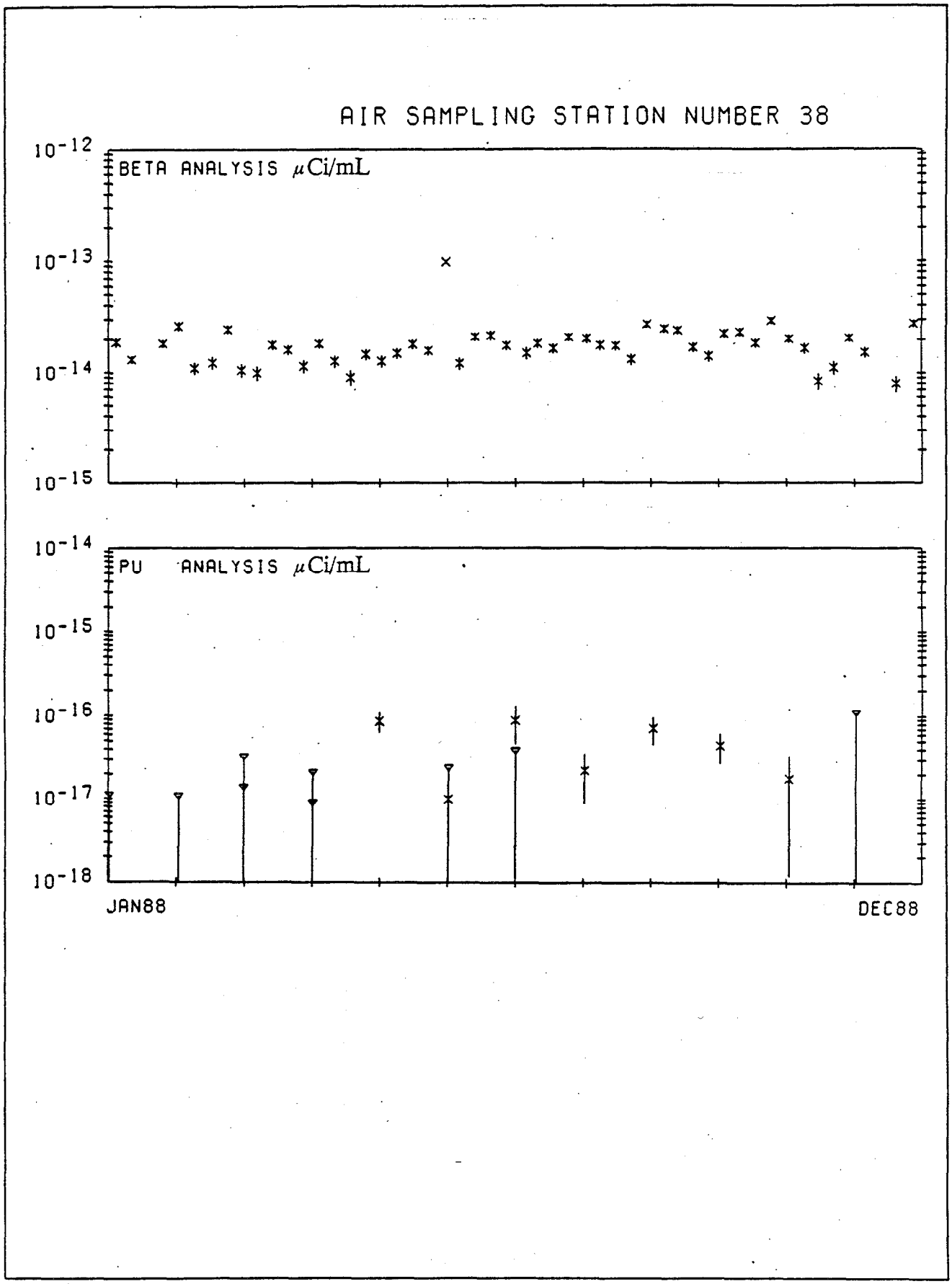

AIR SAMPLING STATION NUMBER 28
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

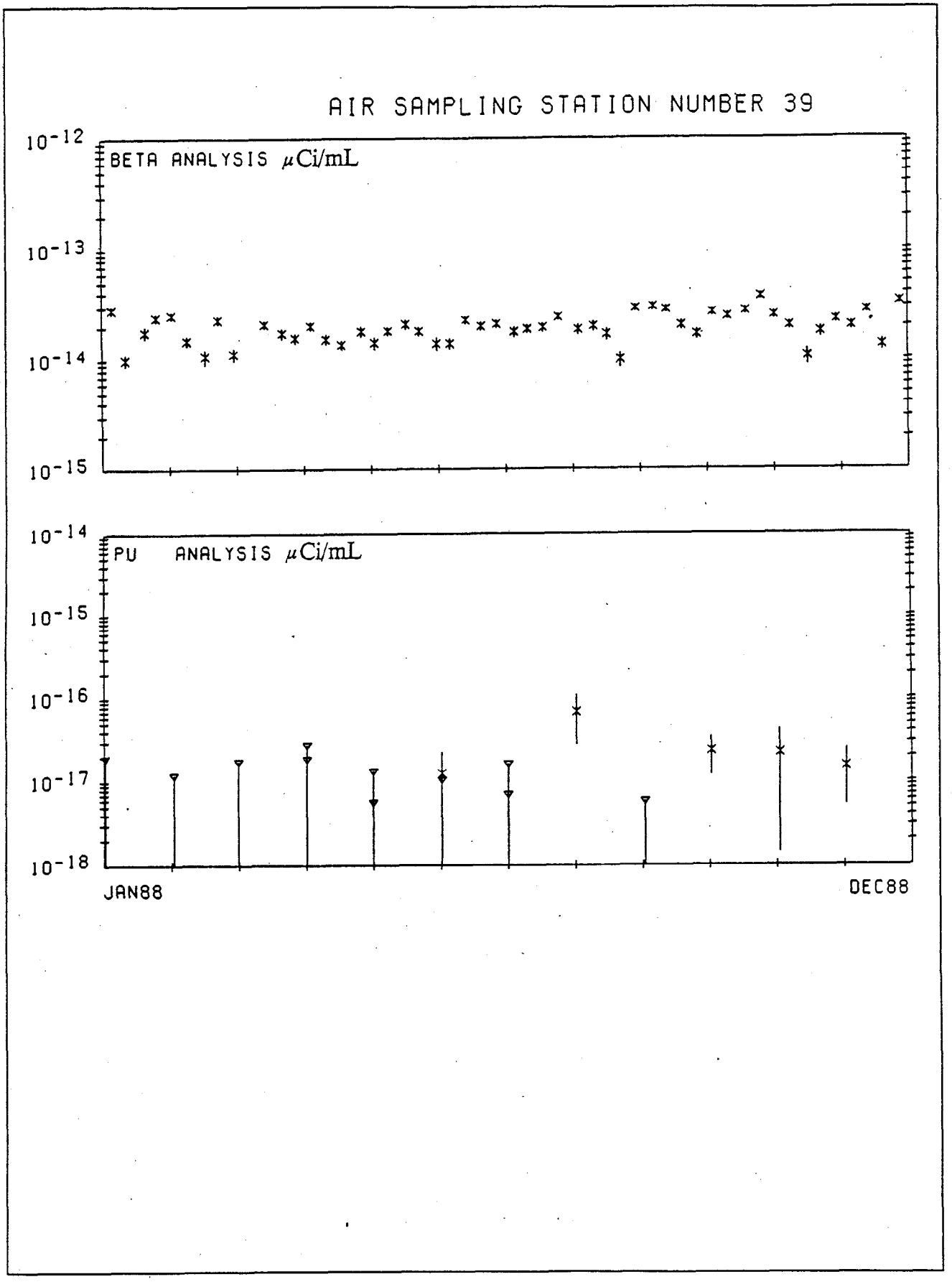

AIR SAMPLING STATION NUMBER 29
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

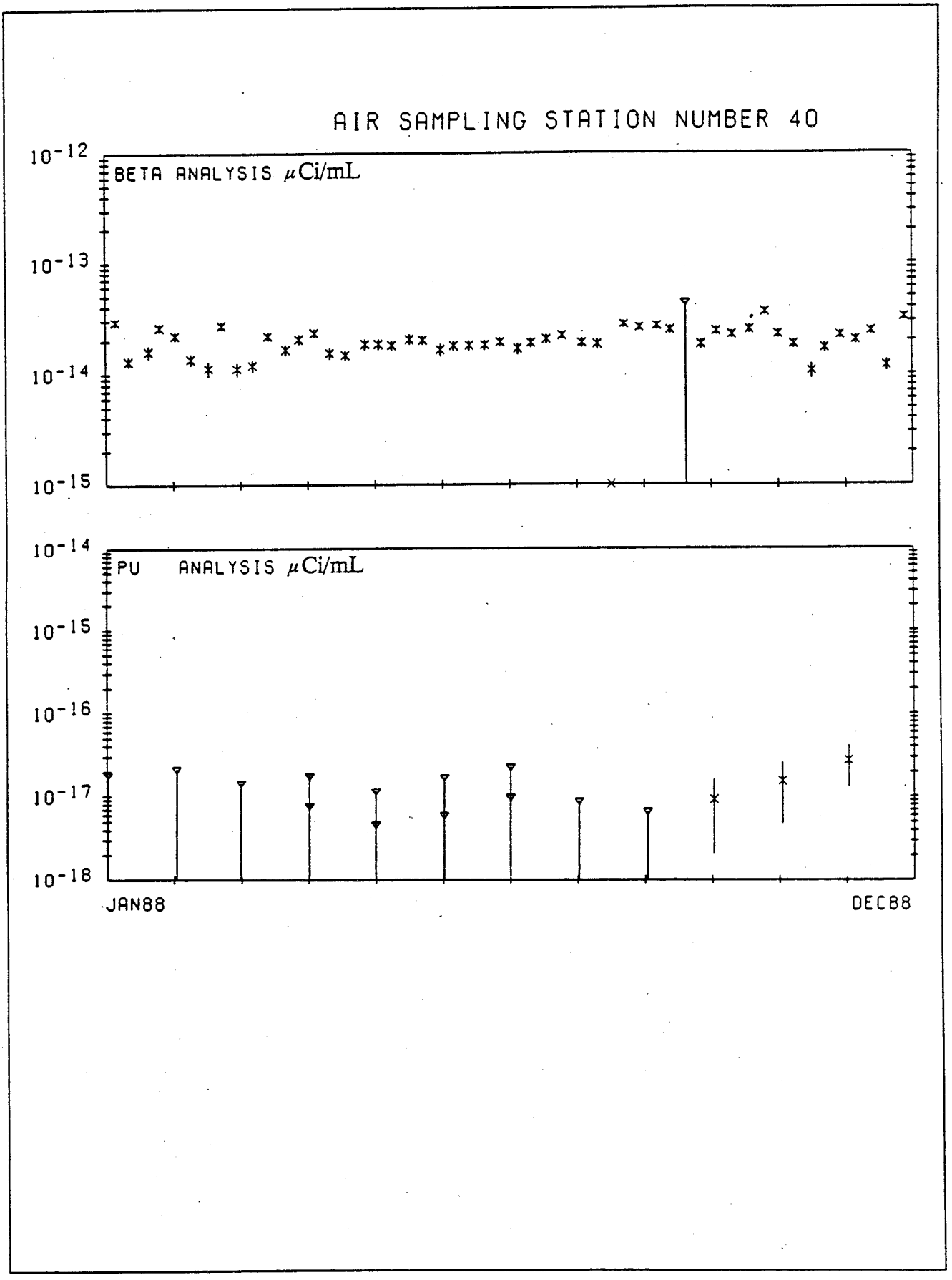

AIR SAMPLING STATION NUMBER 31
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

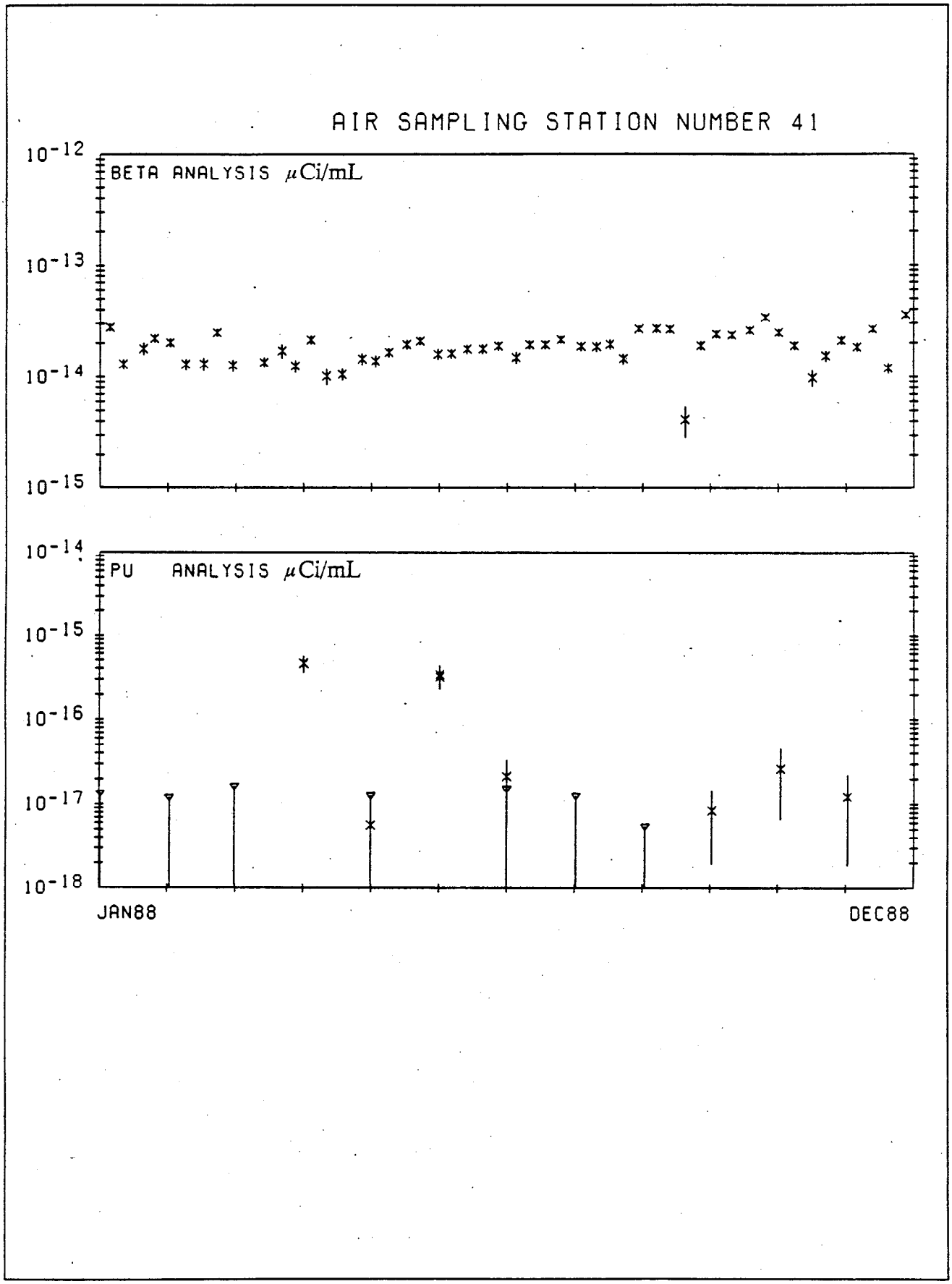

AIR SAMPLING STATION NUMBER 32
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

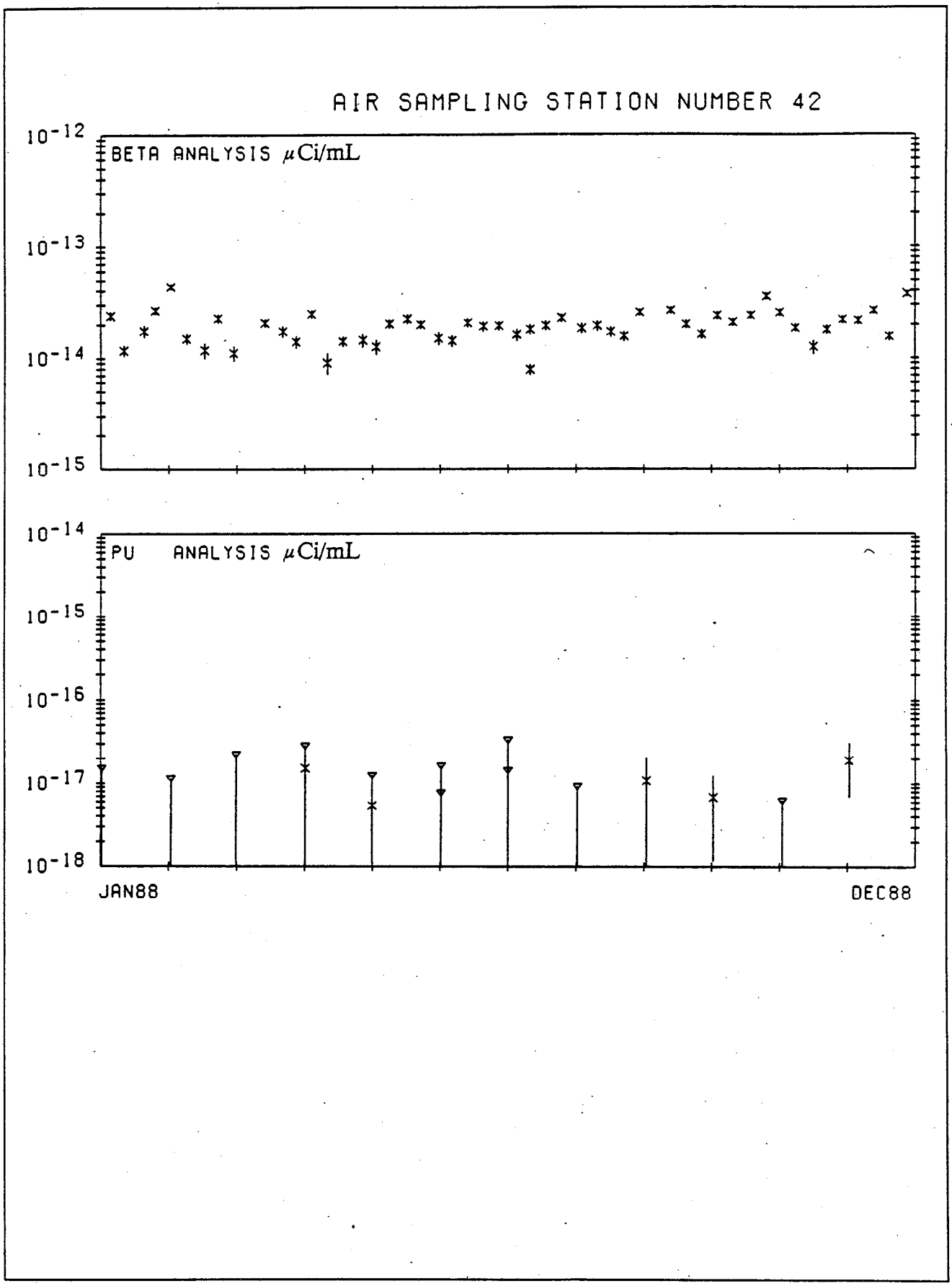

AIR SAMPLING STATION NUMBER 37
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

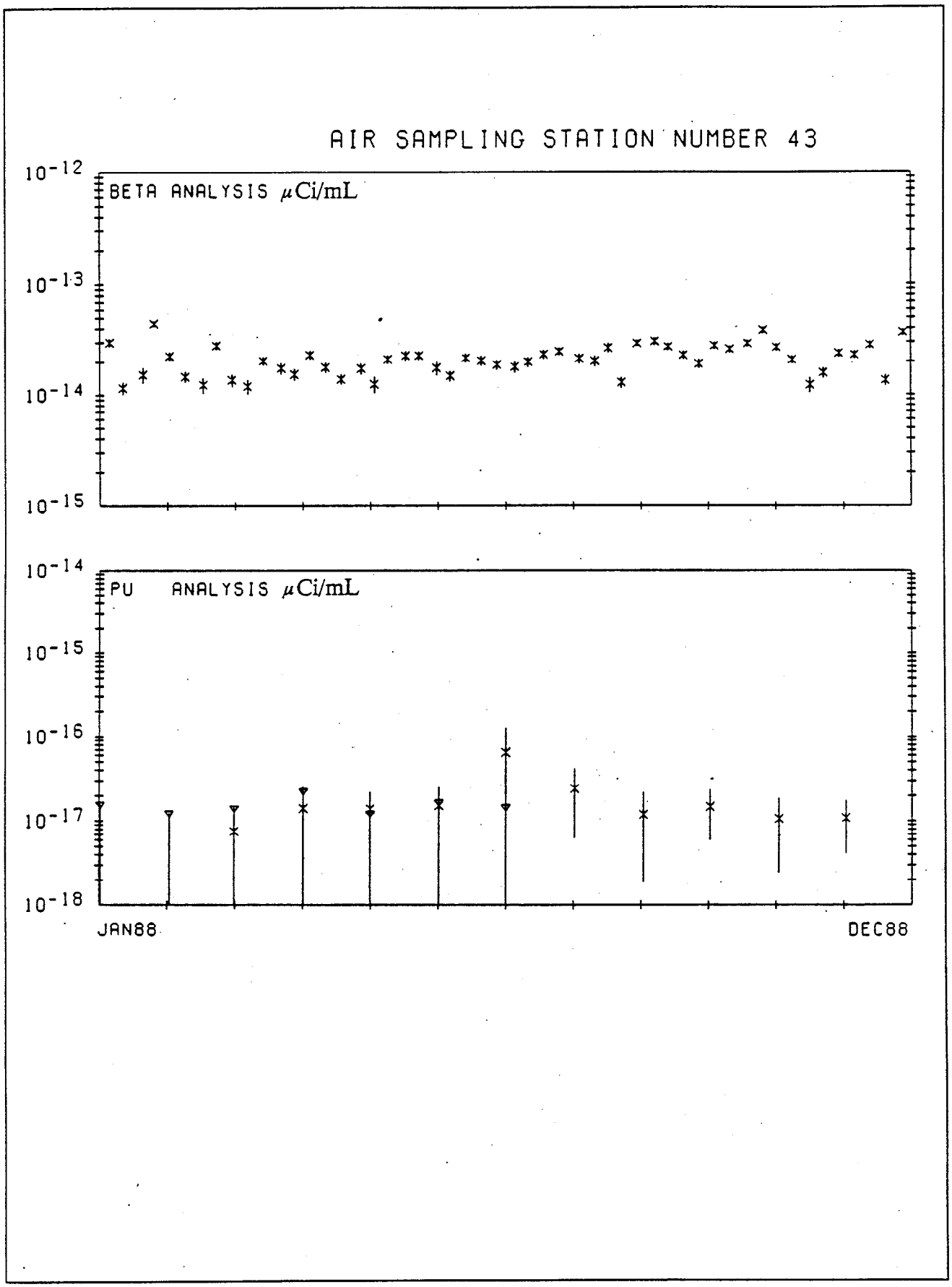

AIR SAMPLING STATION NUMBER 38
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

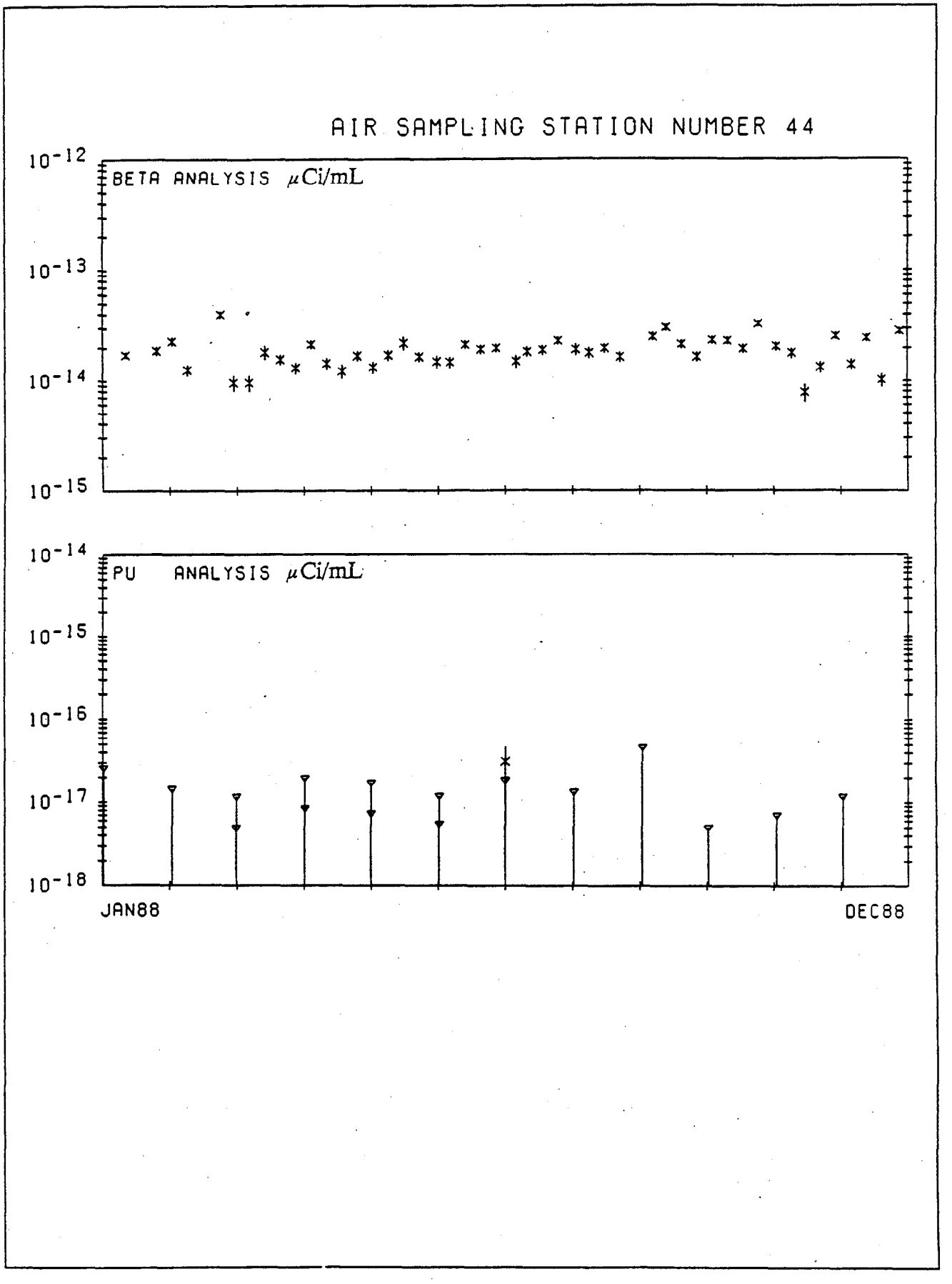

AIR SAMPLING STATION NUMBER 39
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

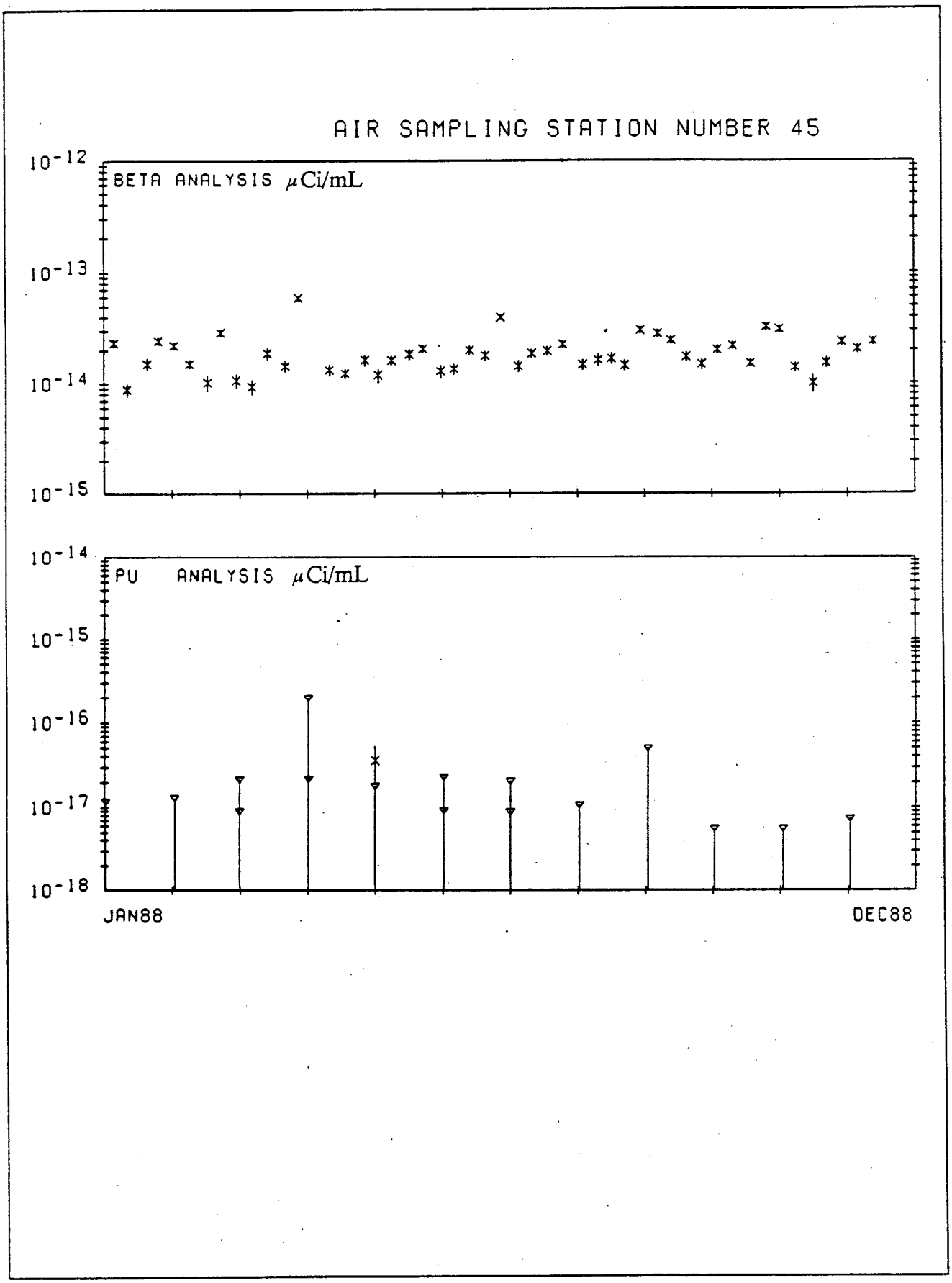

AIR SAMPLING STATION NUMBER 40
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

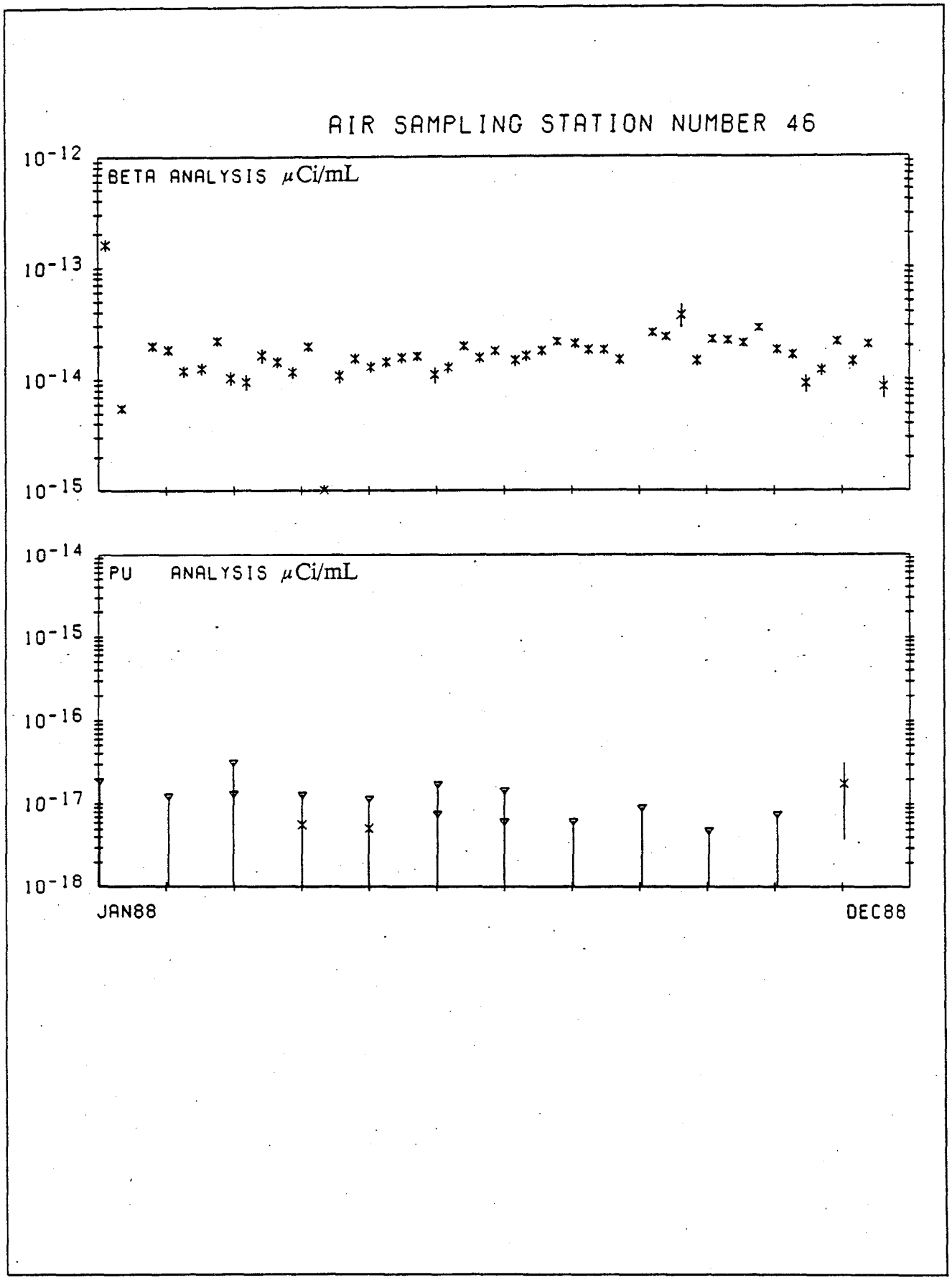

AIR SAMPLING STATION NUMBER 41
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

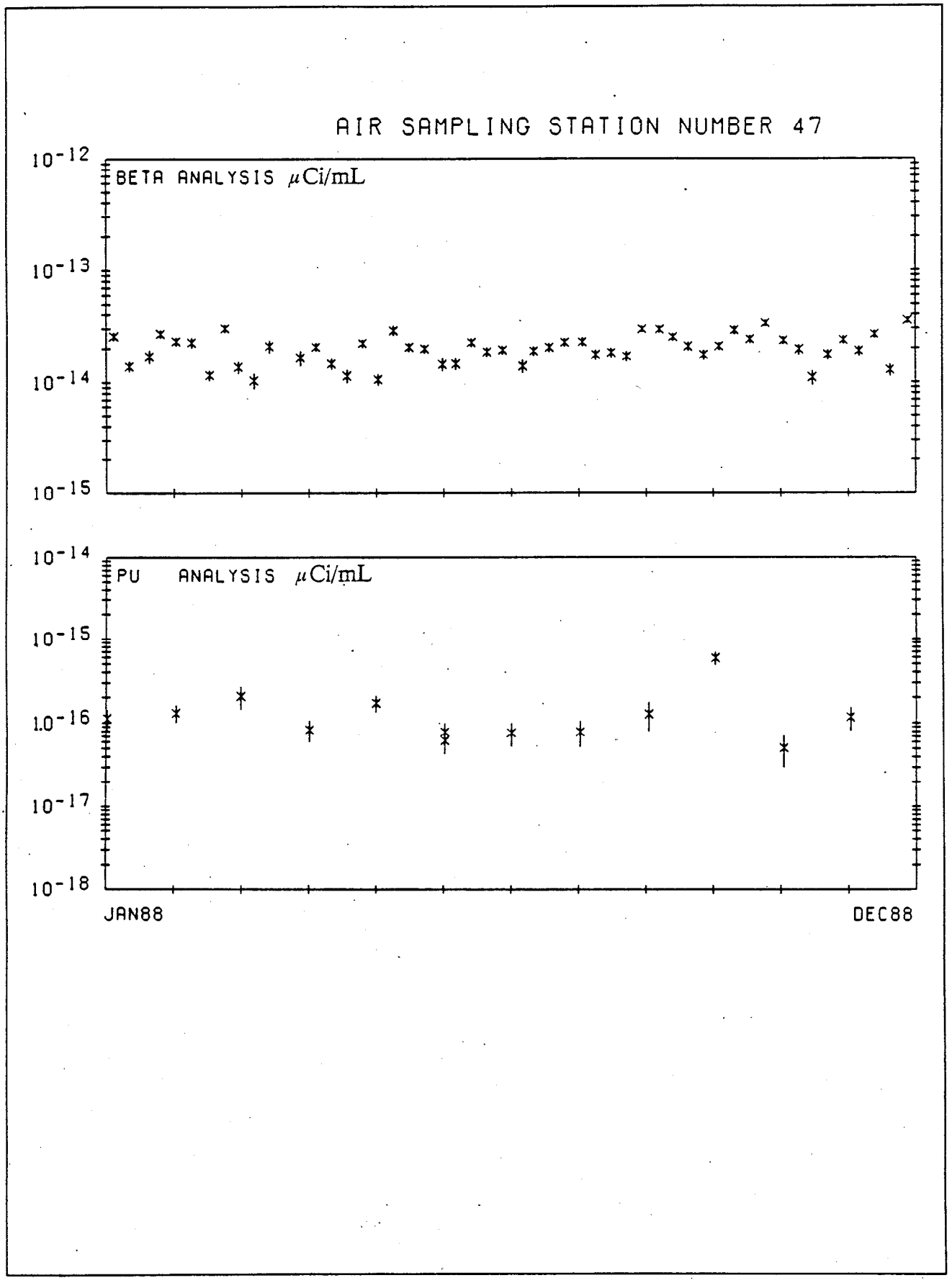

AIR SAMPLING STATION NUMBER 42
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

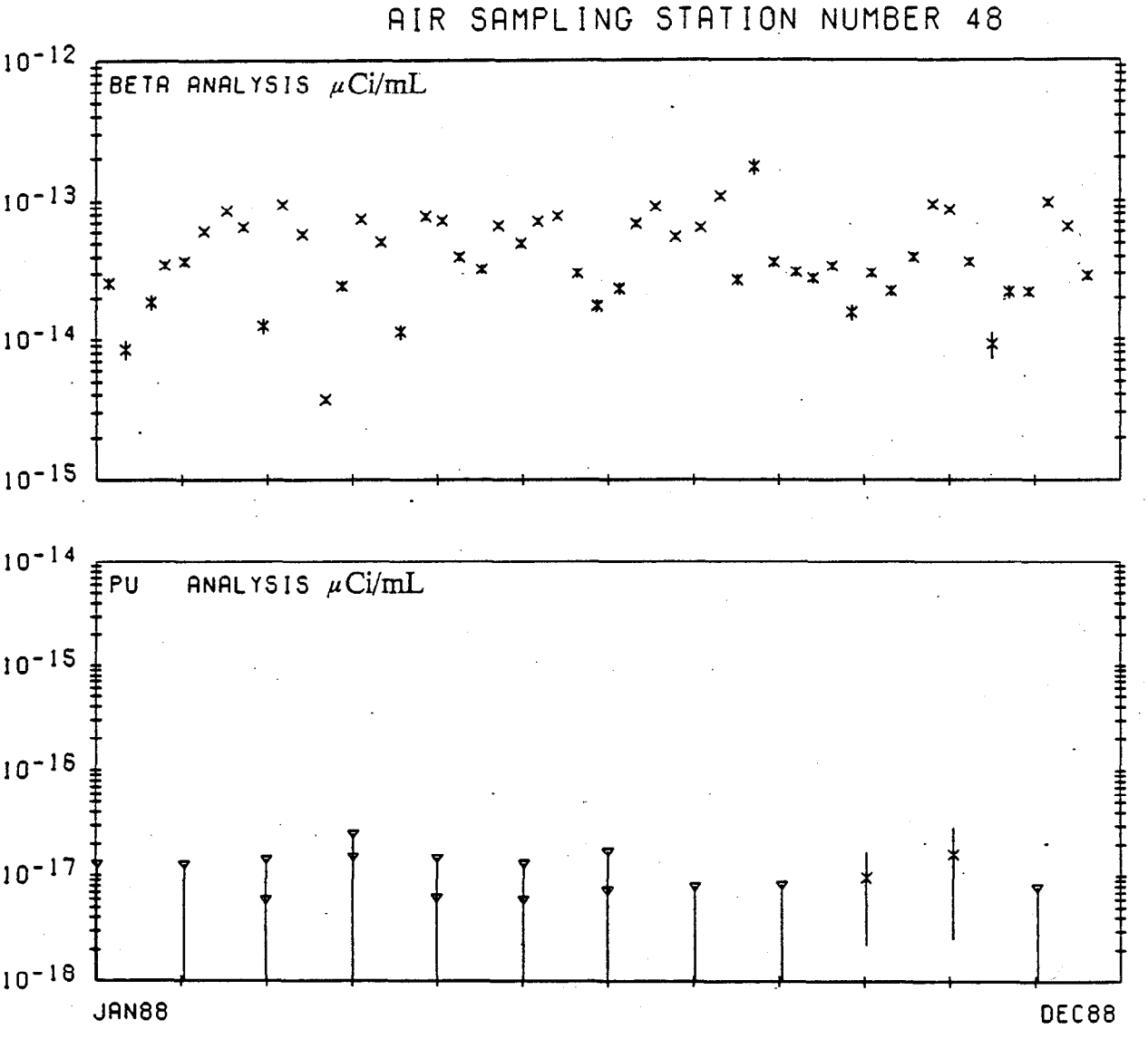

AIR SAMPLING STATION NUMBER 43
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

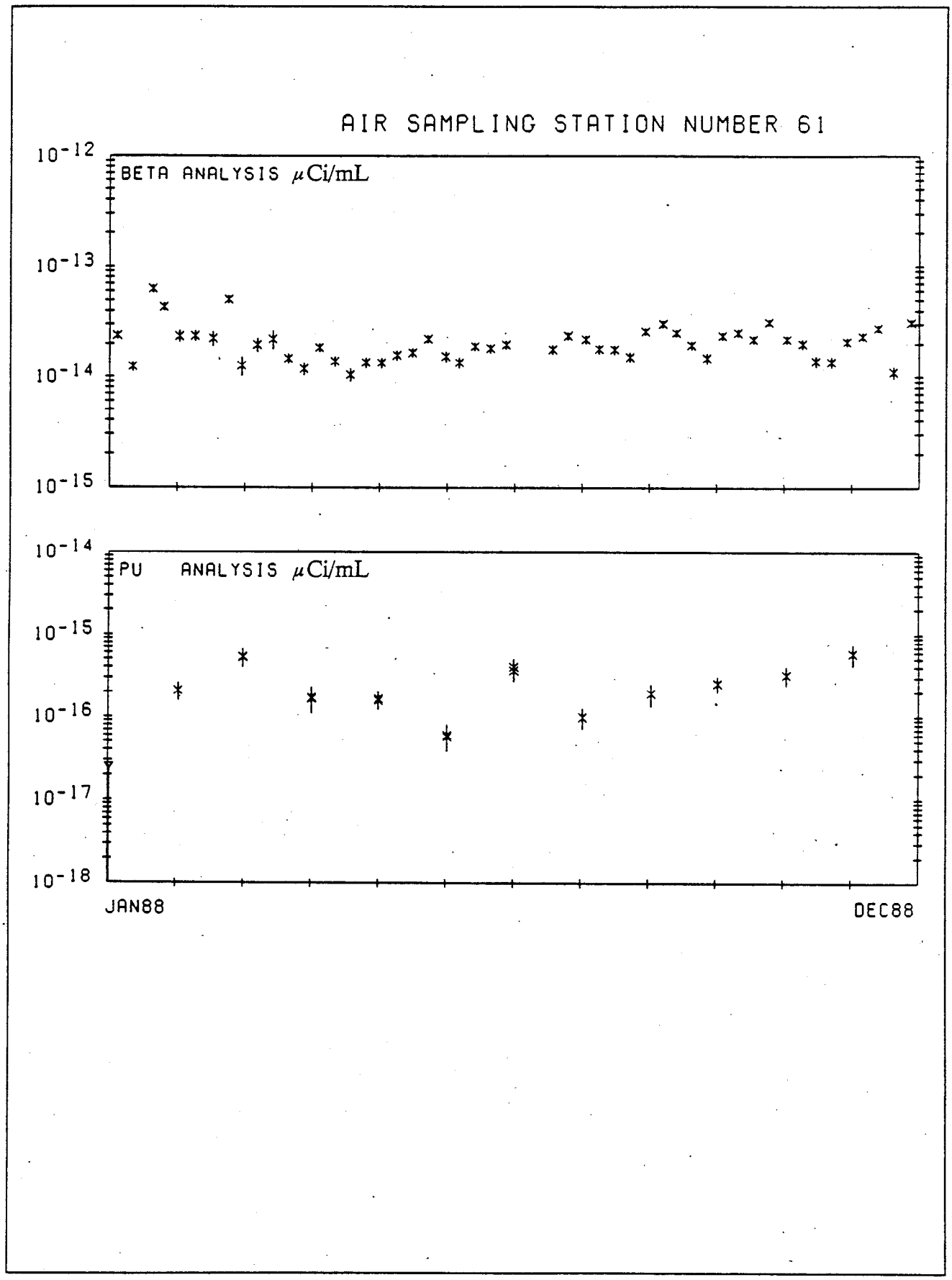

AIR SAMPLING STATION NUMBER 44
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

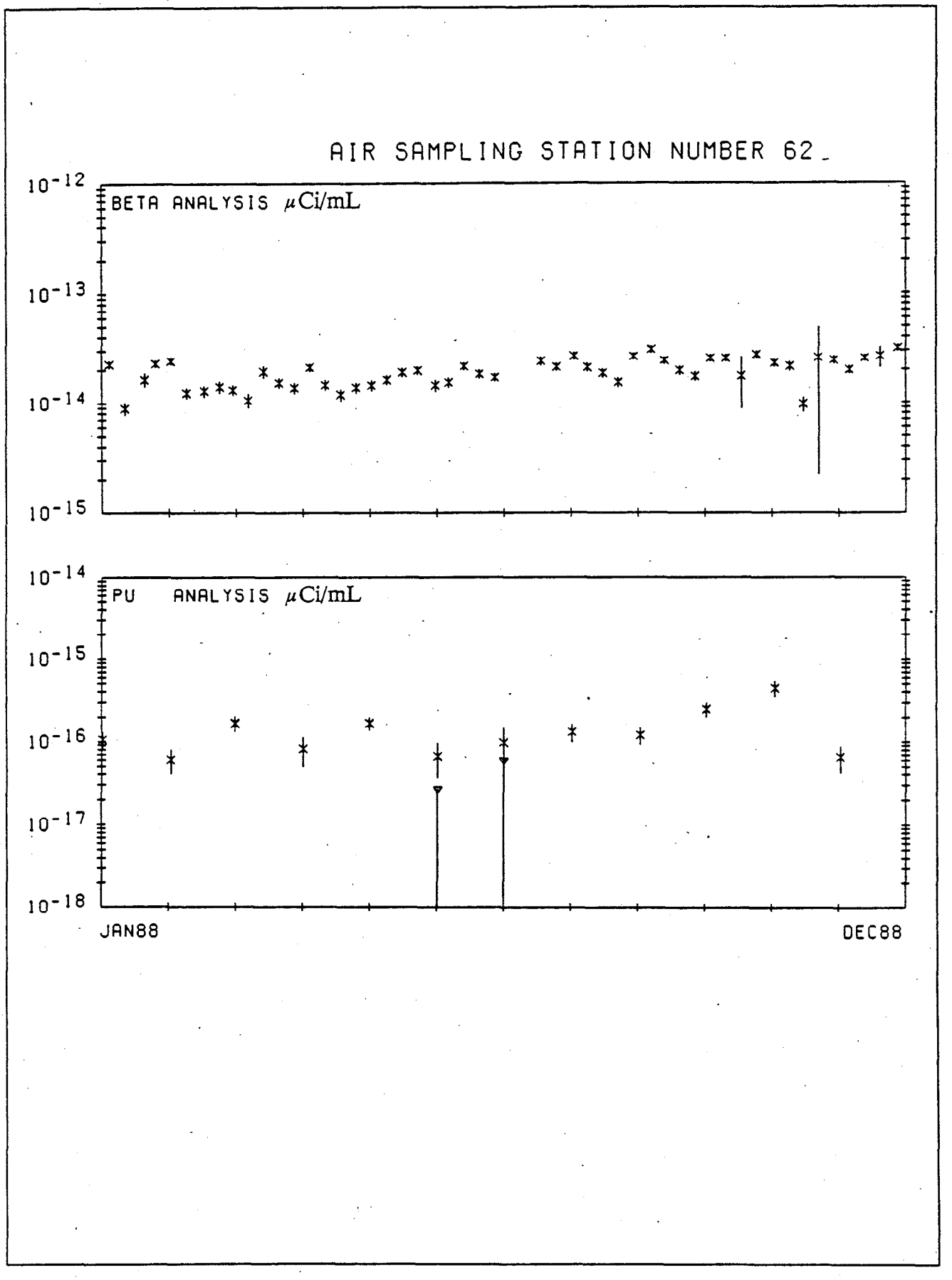

AIR SAMPLING STATION NUMBER 45
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

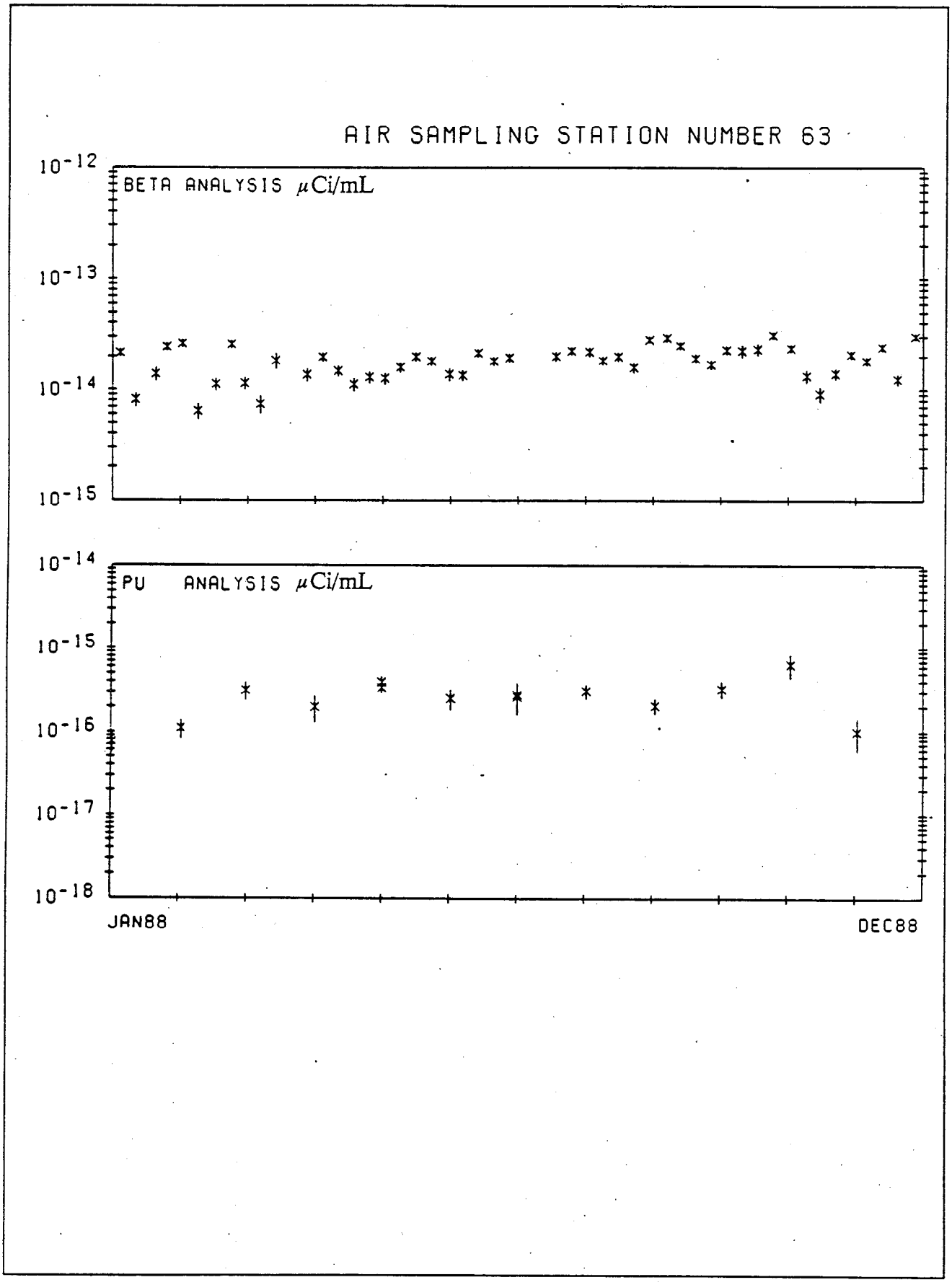

AIR SAMPLING STATION NUMBER 46
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
10-16
10-17
10-18
JAN88
DEC88

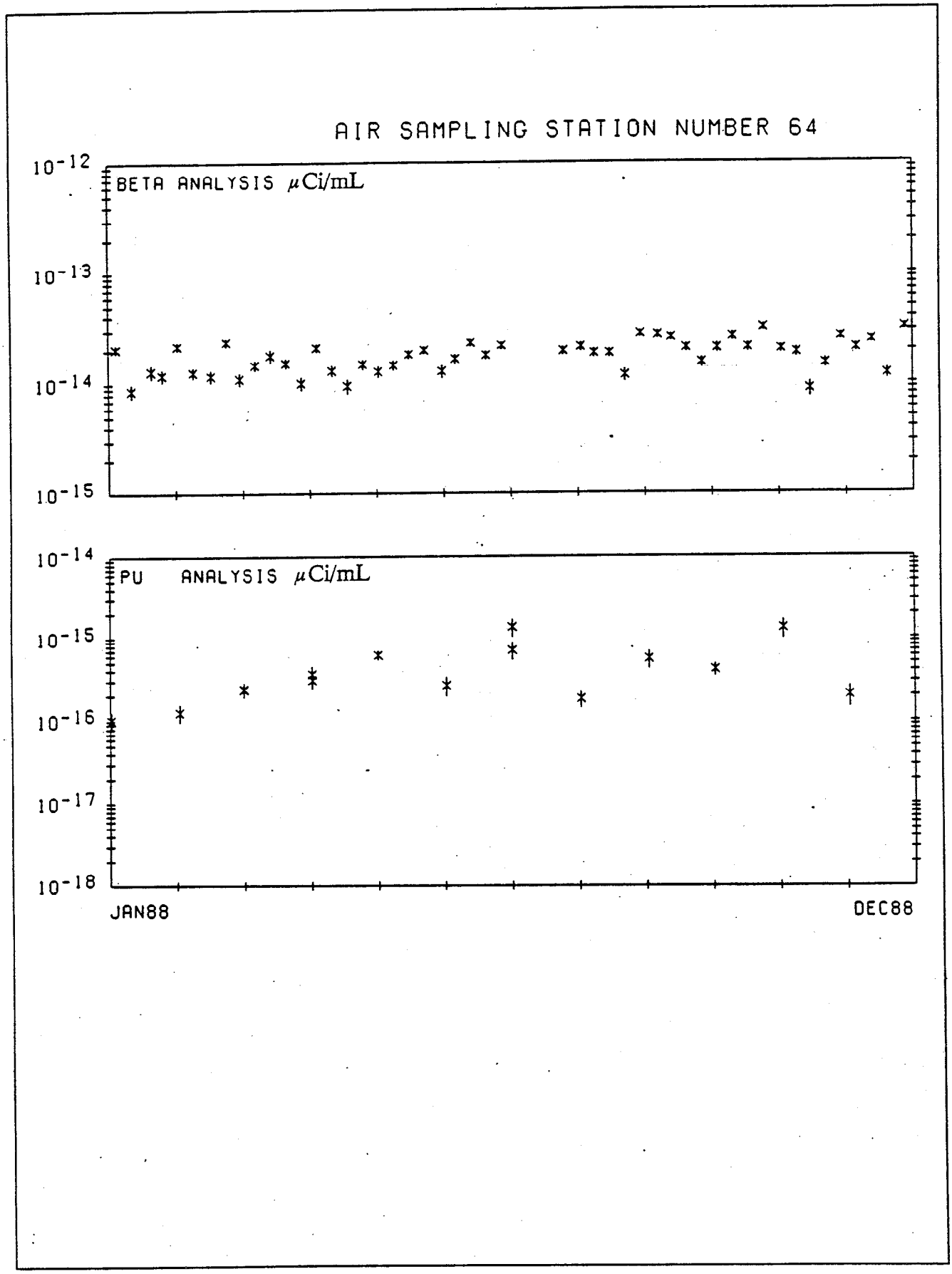

AIR SAMPLING STATION NUMBER 47
BETA ANALYSIS μCi/mL
10-12
10-13
10-14
10-15
PU ANALYSIS μCi/mL
10-14
10-15
1.0-16
10-17
10-18
JAN88
DEC88


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
JAN88
DEC88


AIR SAMPLING STATION NUMBER 61
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
JAN88
DEC88


AIR SAMPLING STATION NUMBER 62
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
JAN88
DEC88


AIR SAMPLING STATION NUMBER 63
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
JAN88
DEC88


AIR SAMPLING STATION NUMBER 64
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
JAN88
DEC88

APPENDIX B

NTS Environmental Monitoring

Supply Well Stations and Plots

SYMBOLS

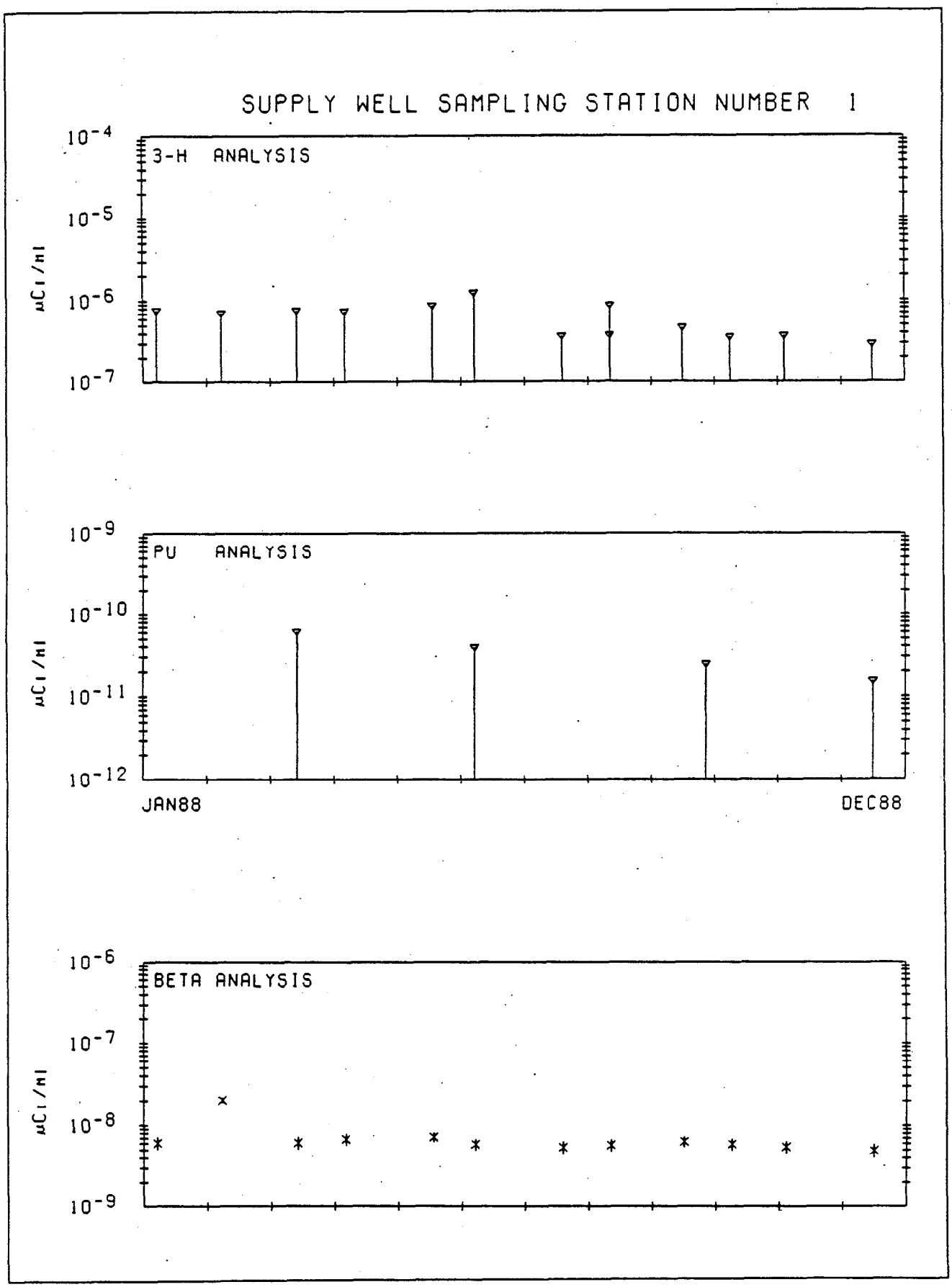
Several symbols are used in Appendix B to denote the data points. The plots display the gross beta, ^{239}Pu and ^{3}H data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits.

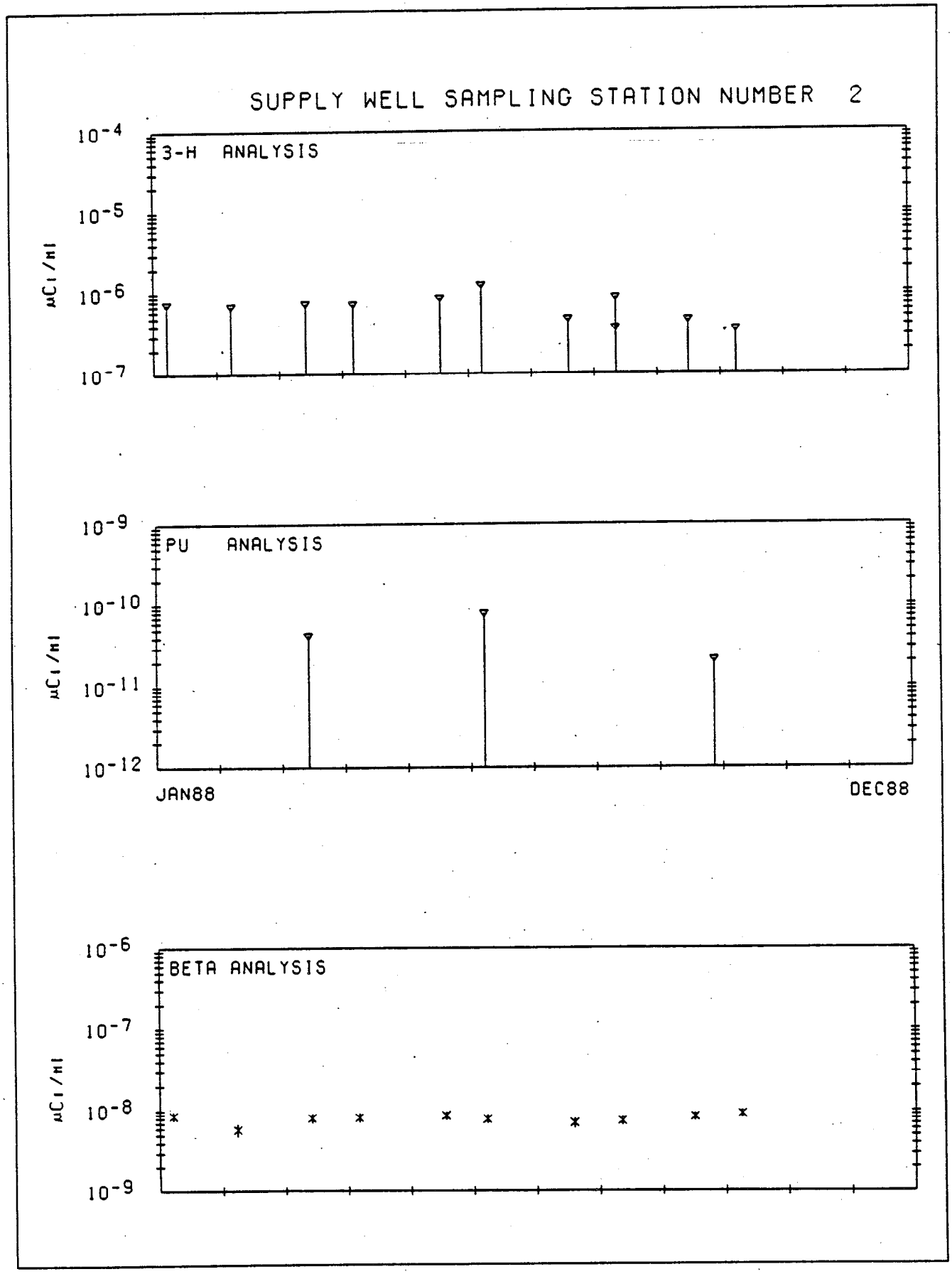
APPENDIX B

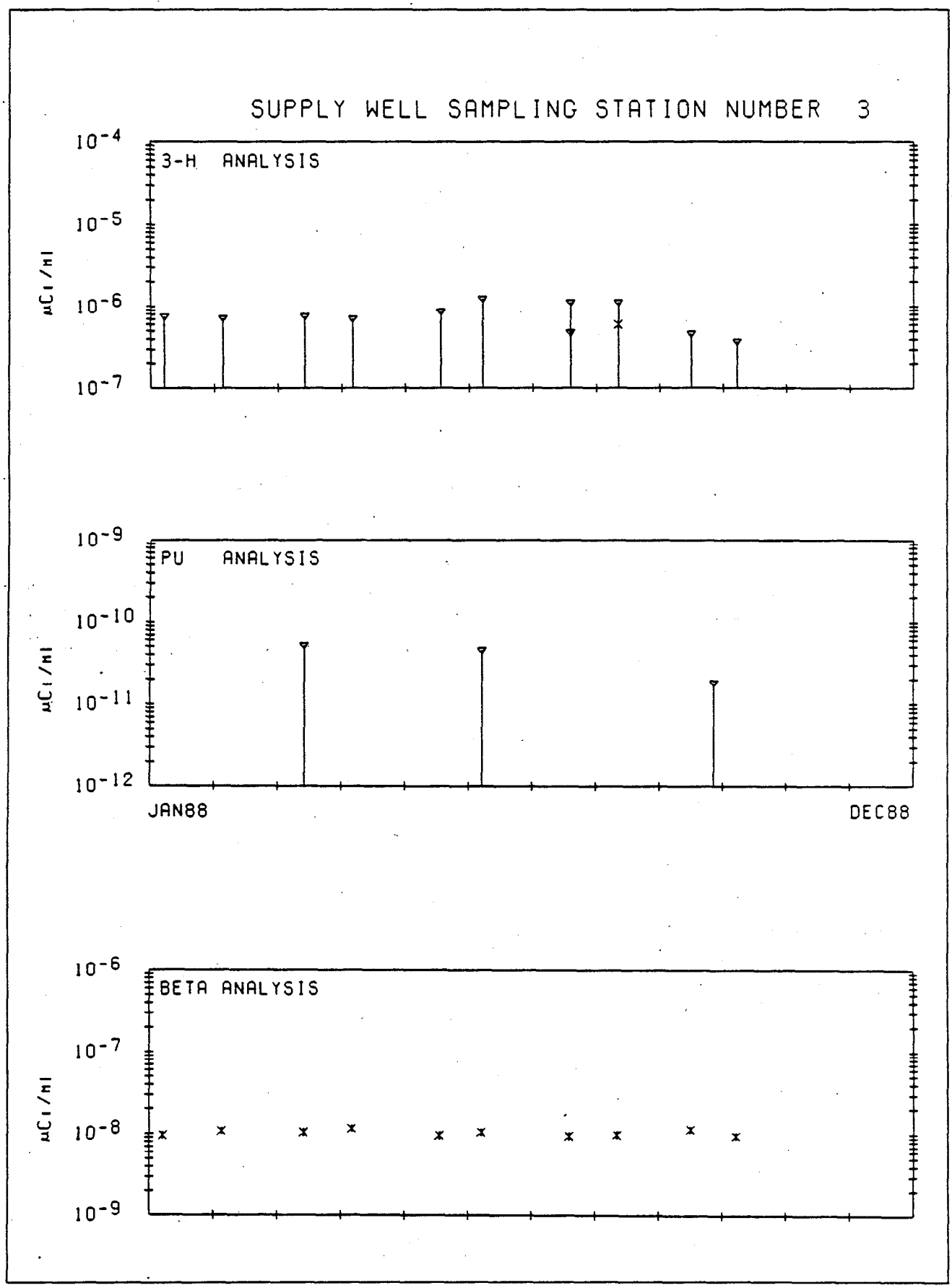
NTS Environmental Monitoring

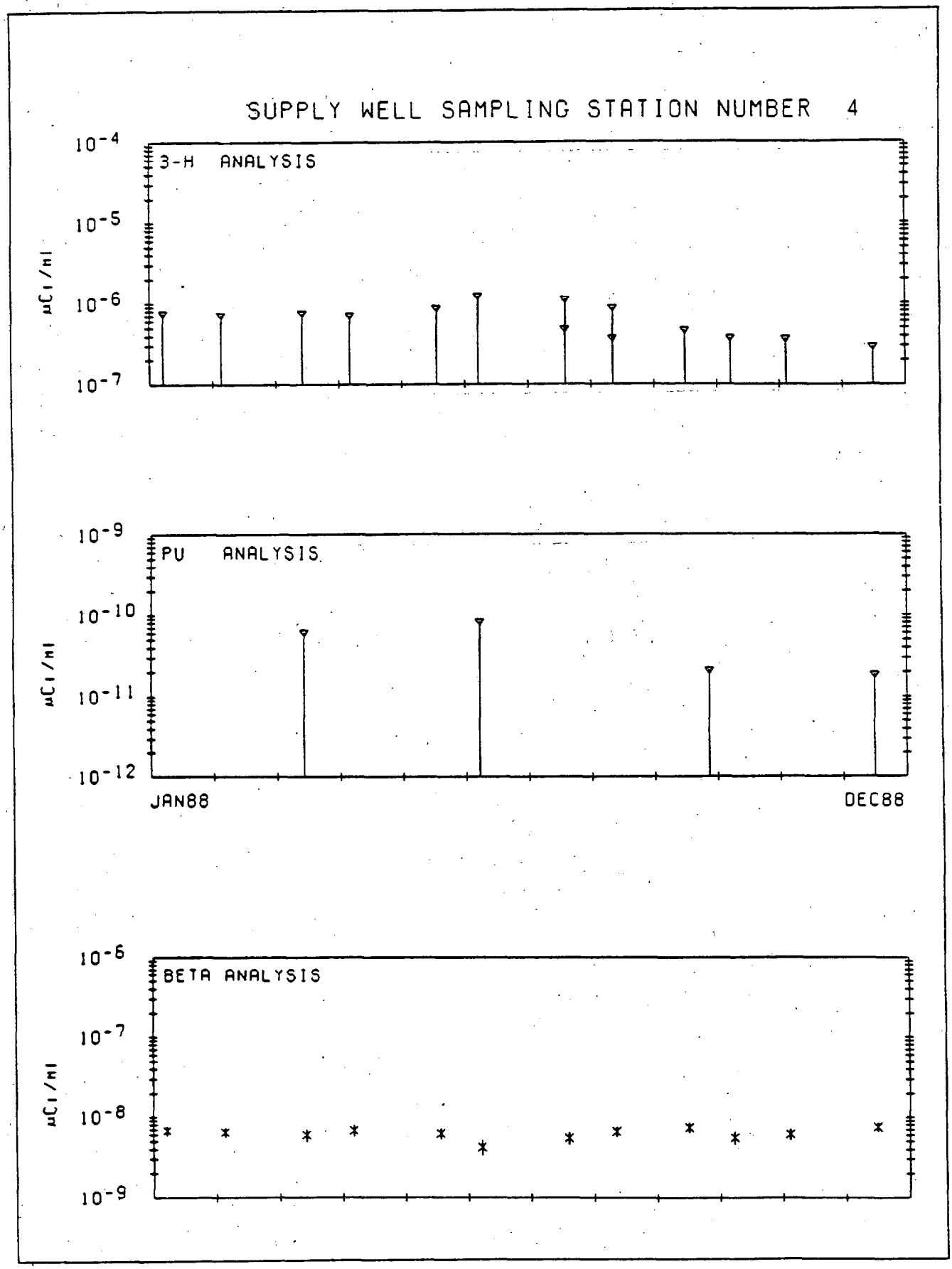
Supply Well Sampling Locations

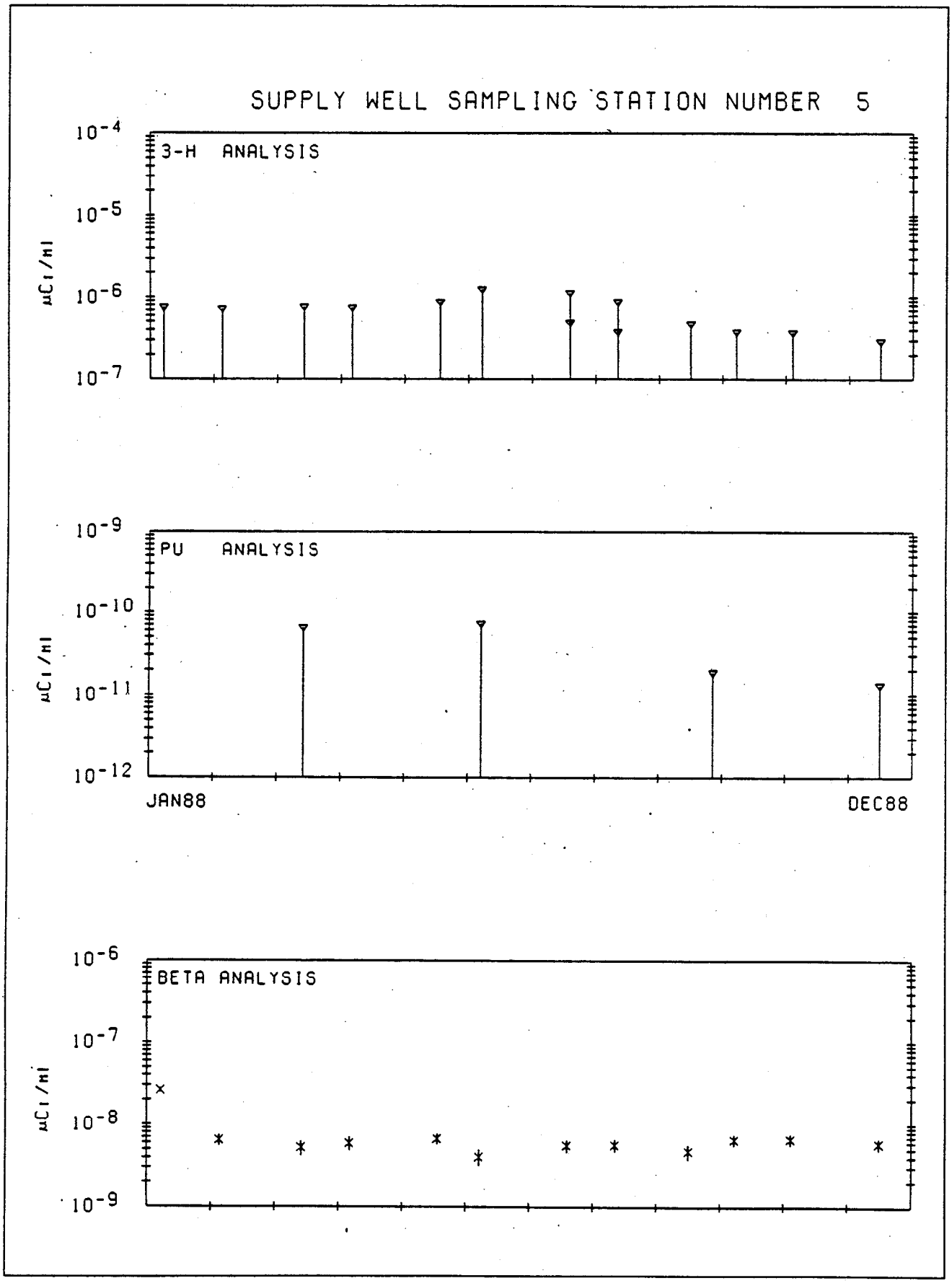
Station	Location
1	Area 2 Well 2
2	Area 3 Well A
3	Area 5 Well 5B
4	Area 5 Well 5C
5	Area 5 Well UE5c
6	Area 6 Well C
7	Area 6 Well C1
8	Area 15 Well UE15d
9	Area 18 Well 8
13	Area 22 Army Well No. 1
14	Area 25 Well J 12
15	Area 25 Well J 13
18	Area 19 Well U19c
19	Area 6 Well 4
20	Area 16 Well 16D
21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

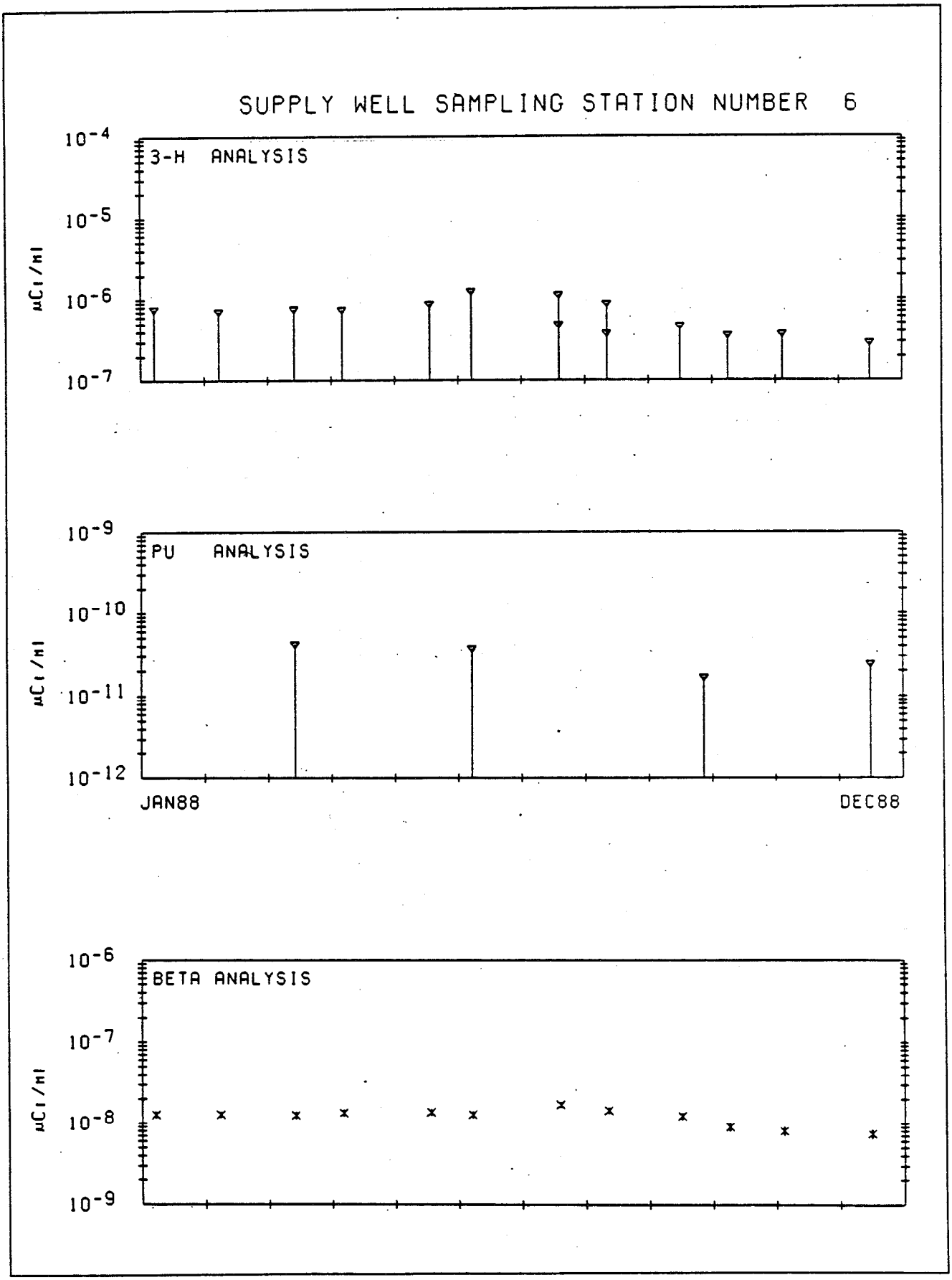

SUPPLY WELL SAMPLING STATION NUMBER 1
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

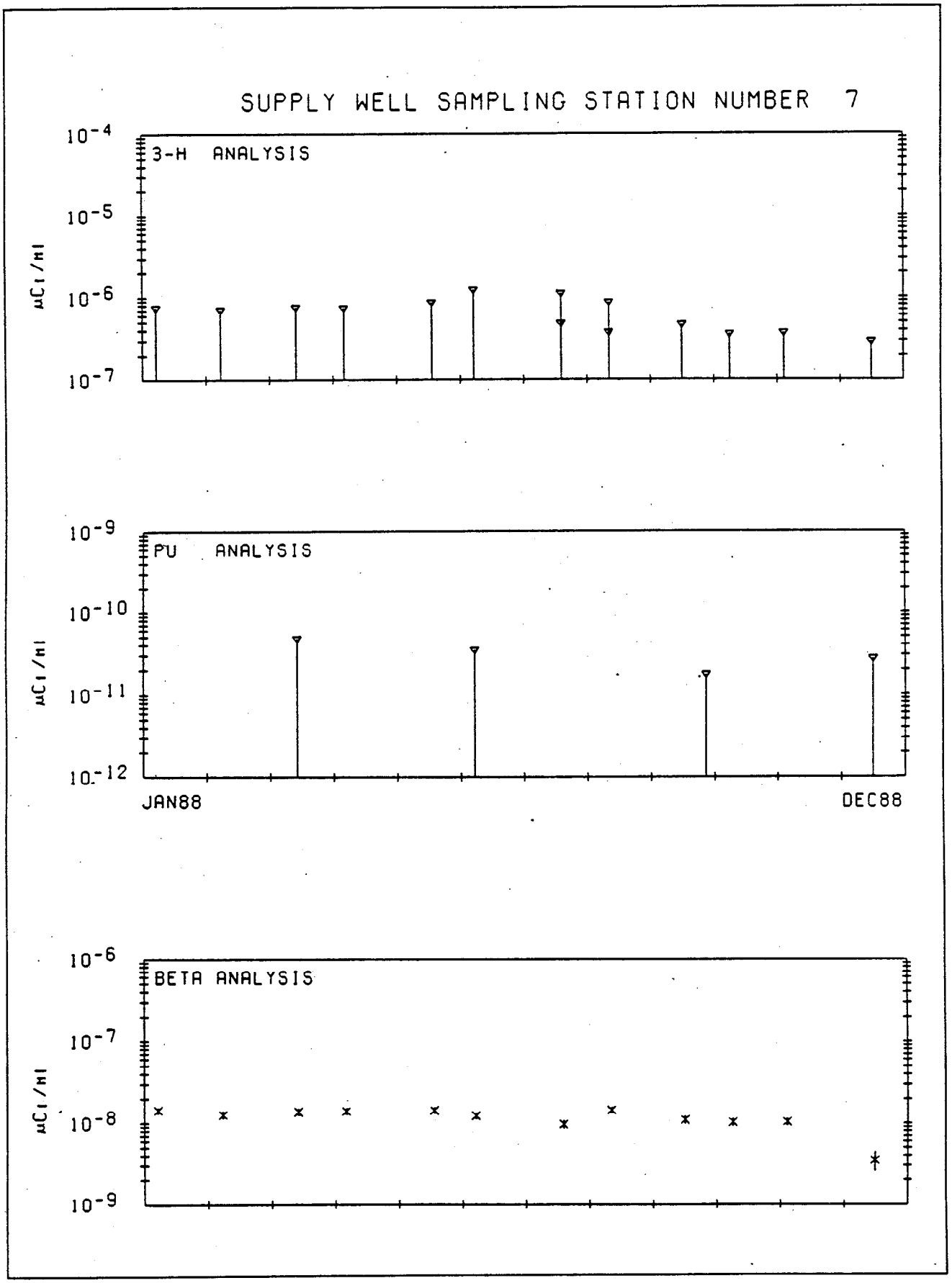

SUPPLY WELL SAMPLING STATION NUMBER 2
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

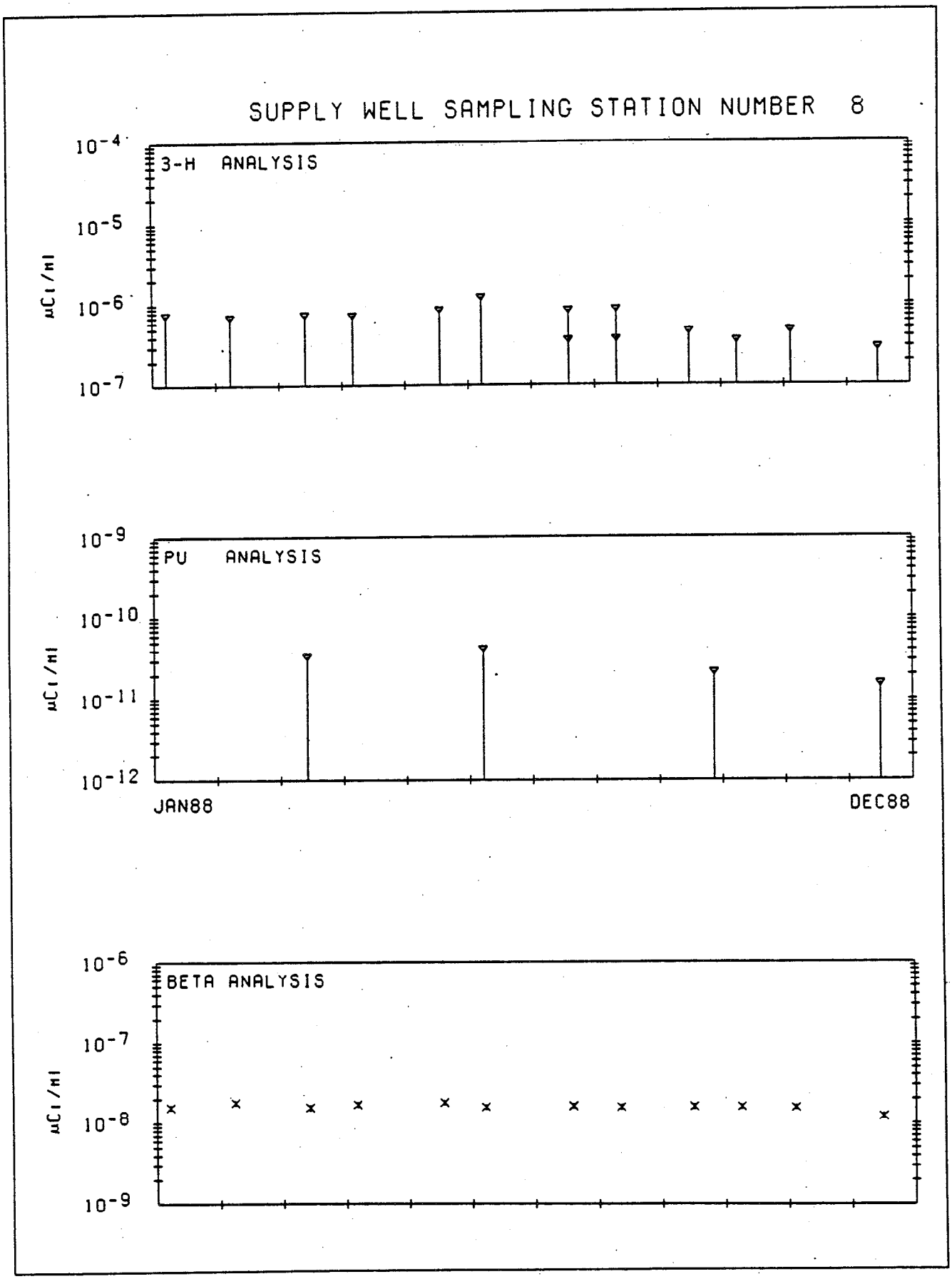

SUPPLY WELL SAMPLING STATION NUMBER 3
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

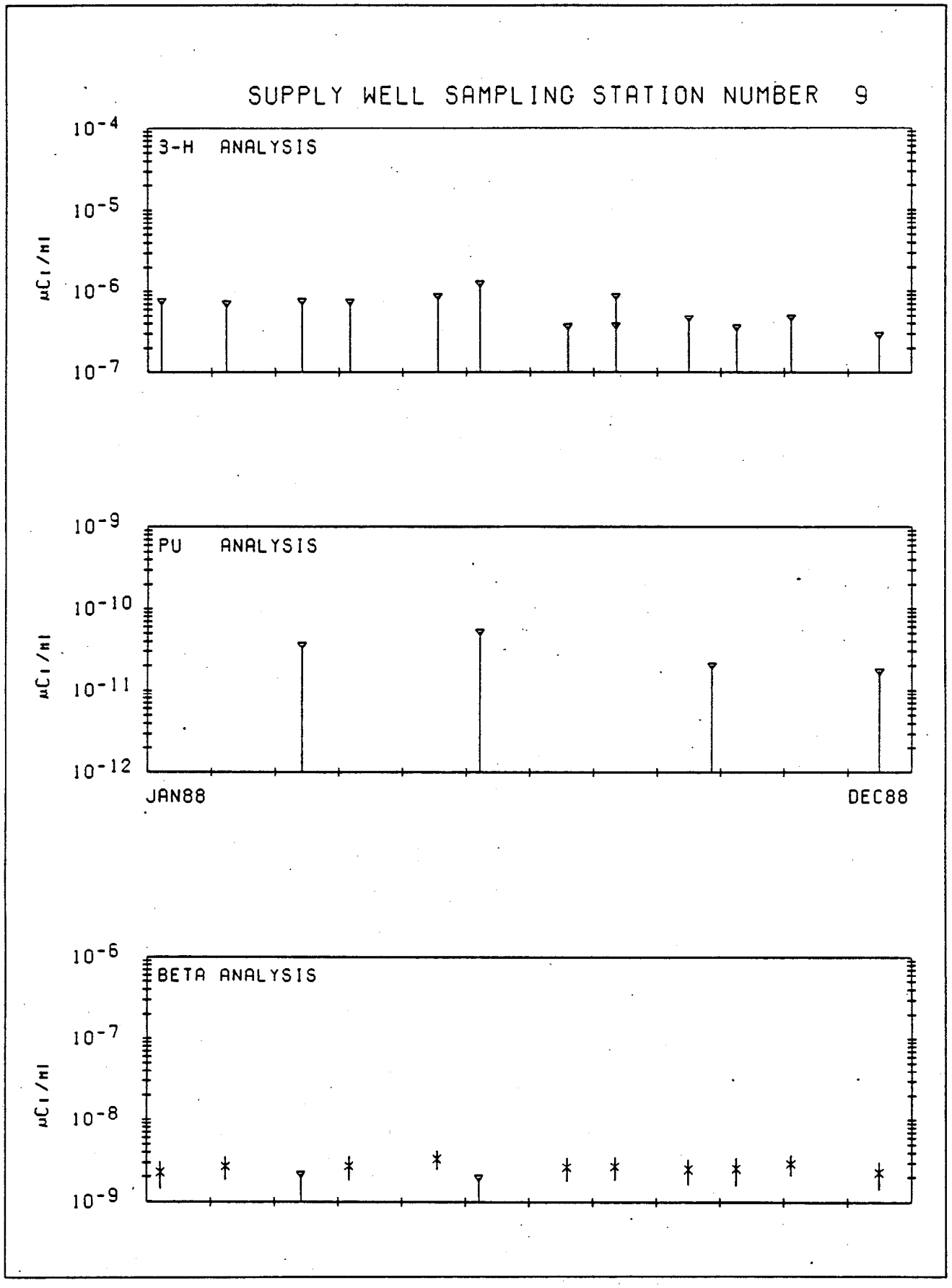

SUPPLY WELL SAMPLING STATION NUMBER 4
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

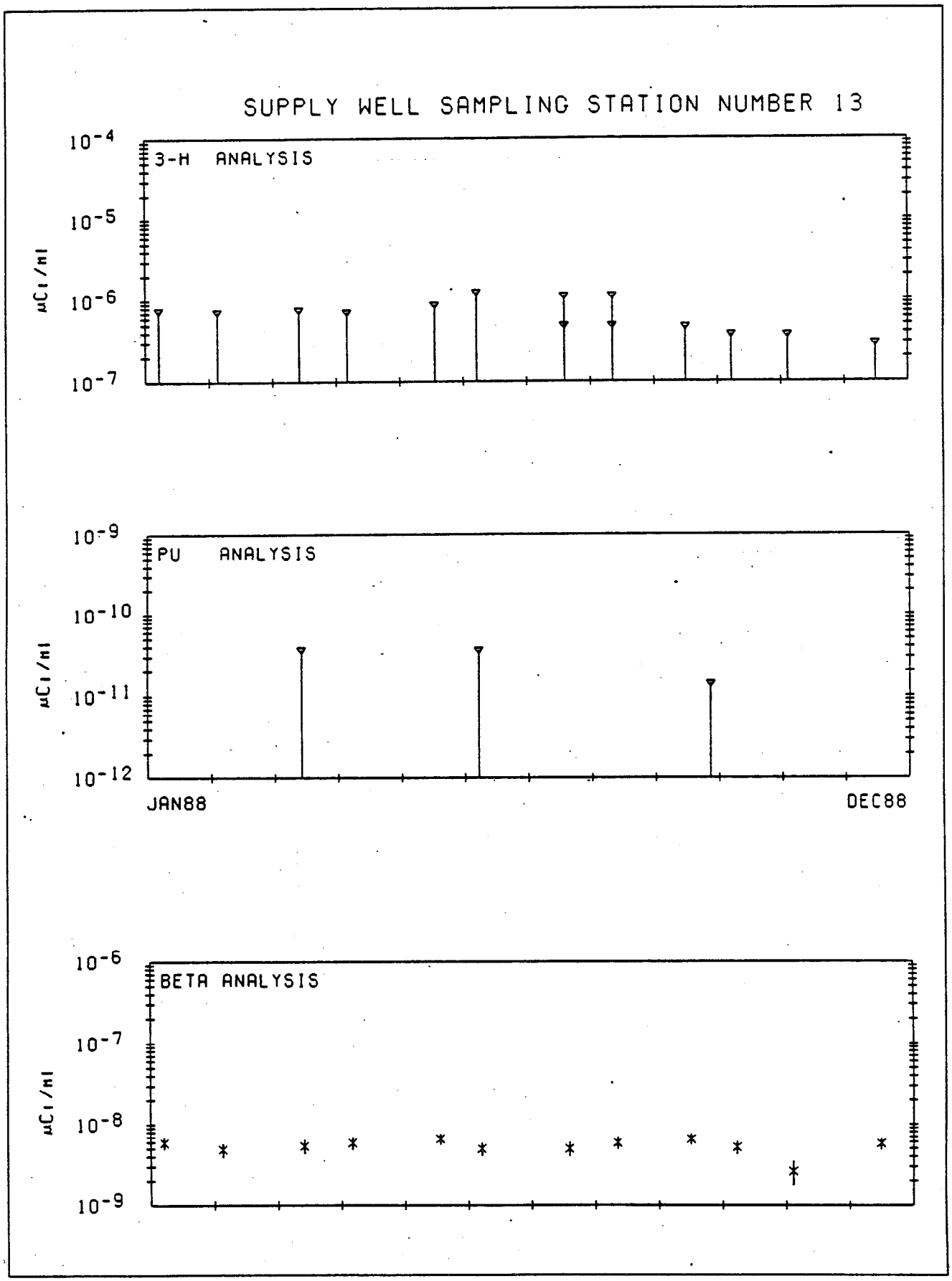

SUPPLY WELL SAMPLING STATION NUMBER 5
3-H ANALYSIS
µCi/ml
10-4
10-5
10-6
10-7
PU ANALYSIS
µCi/ml
10-9
10-10
10-11
10-12
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10-6
10-7
10-8
10-9

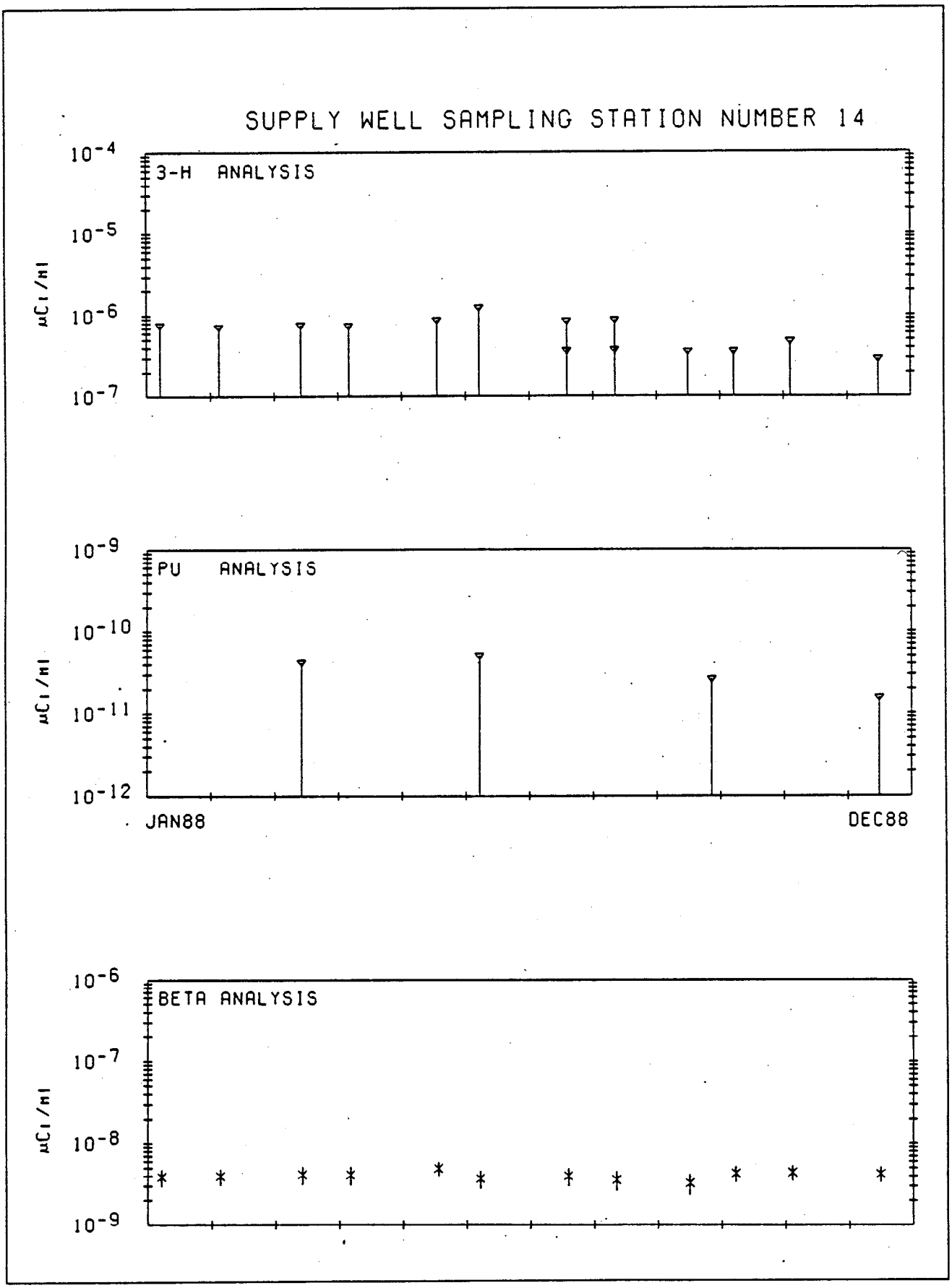

SUPPLY WELL SAMPLING STATION NUMBER 6
3-H ANALYSIS
10-4
10-5
10-6
10-7
µCi/ml
PU ANALYSIS
10-9
10-10
10-11
10-12
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10-6
10-7
10-8
10-9
µCi/ml

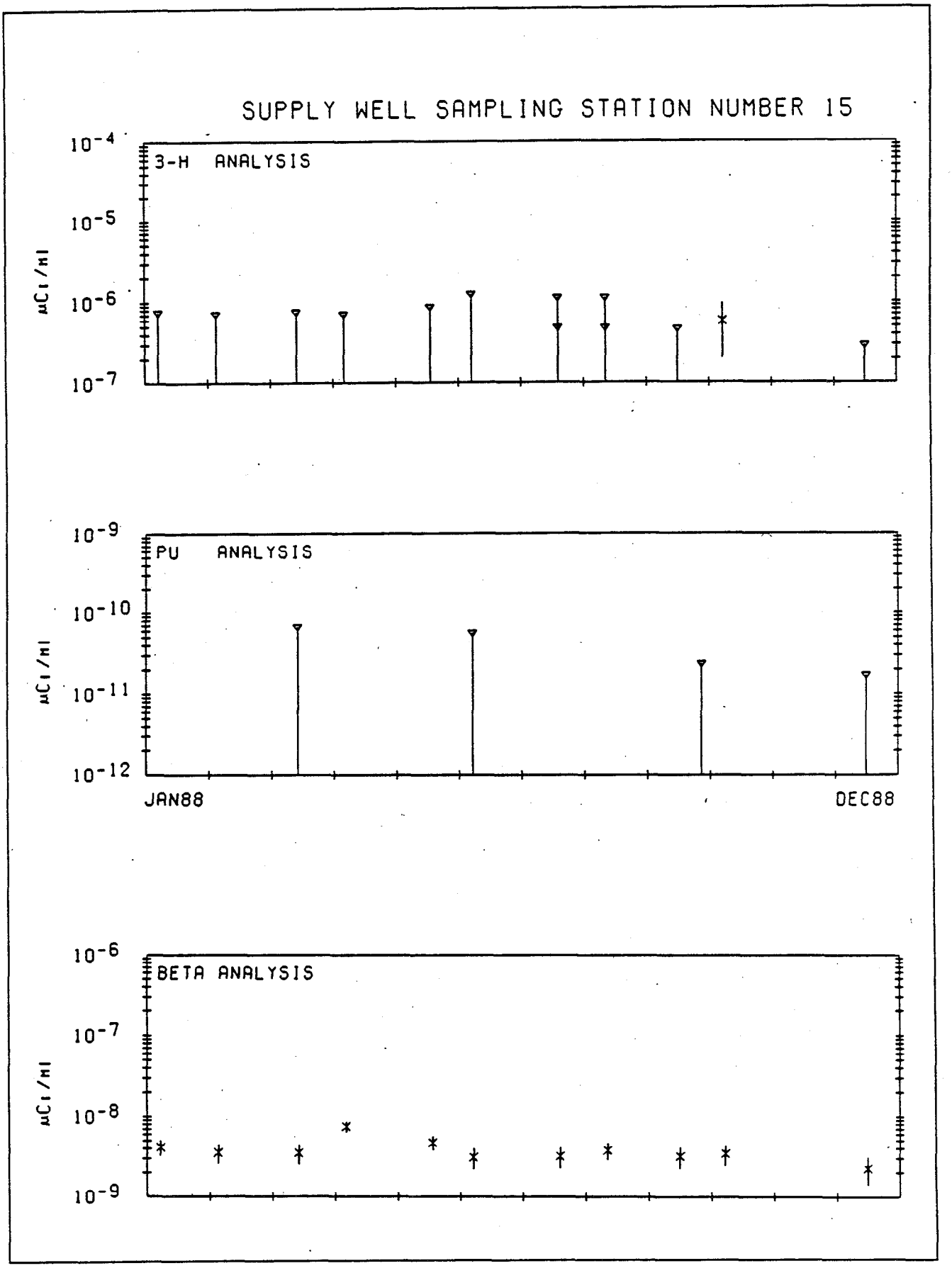

SUPPLY WELL SAMPLING STATION NUMBER 7
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

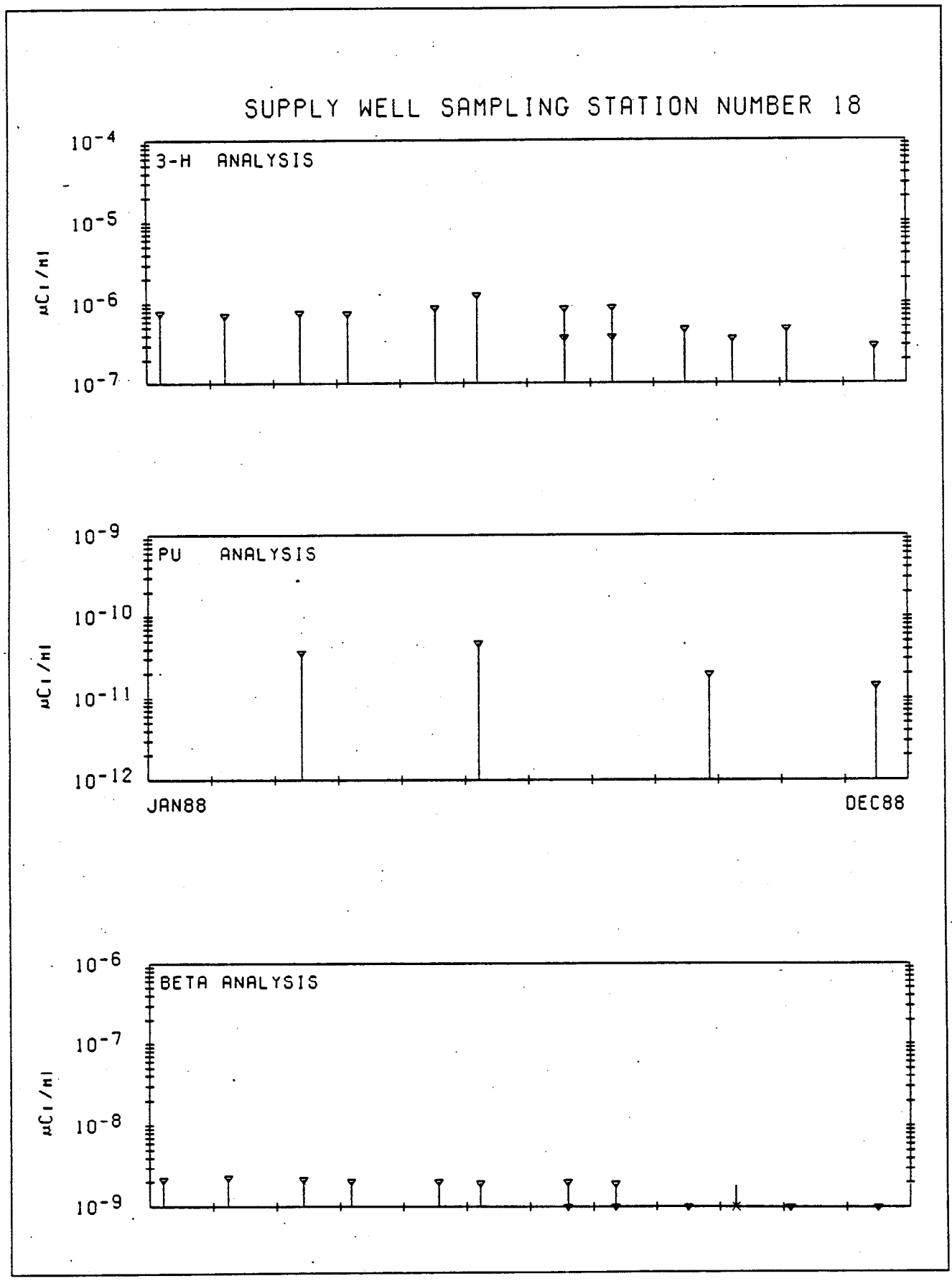

SUPPLY WELL SAMPLING STATION NUMBER 8
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

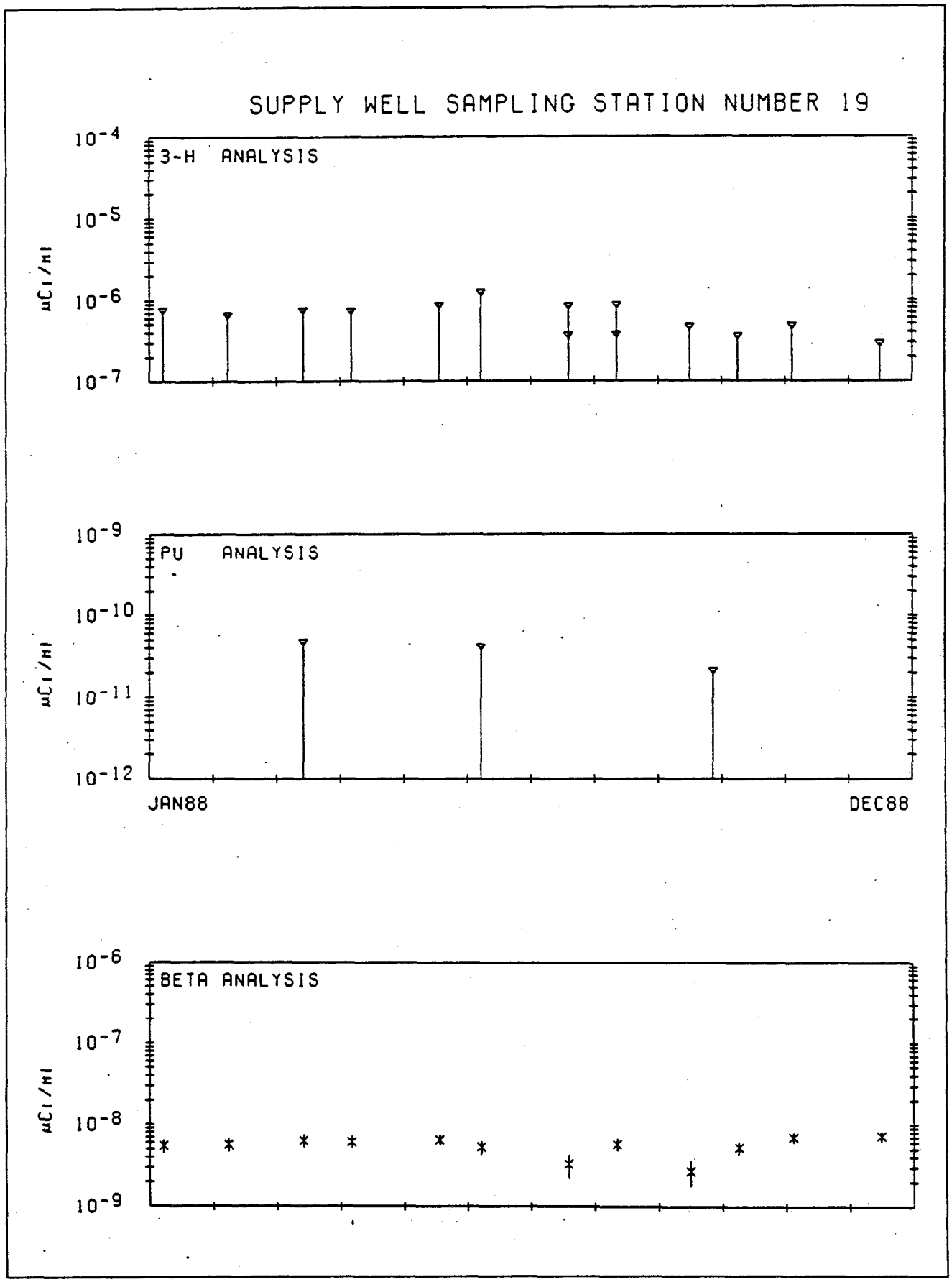

SUPPLY WELL SAMPLING STATION NUMBER 9
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

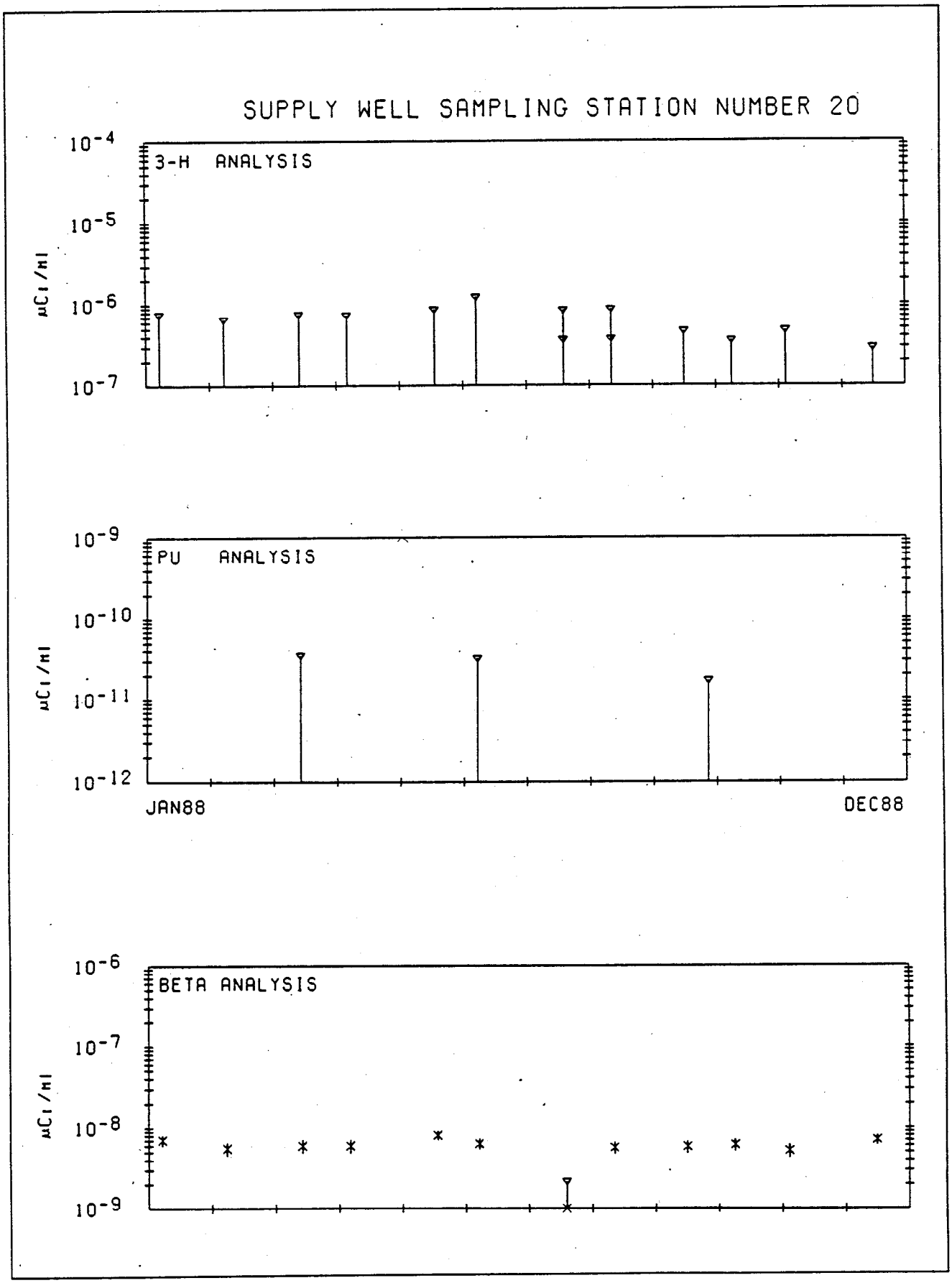

SUPPLY WELL SAMPLING STATION NUMBER 13
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

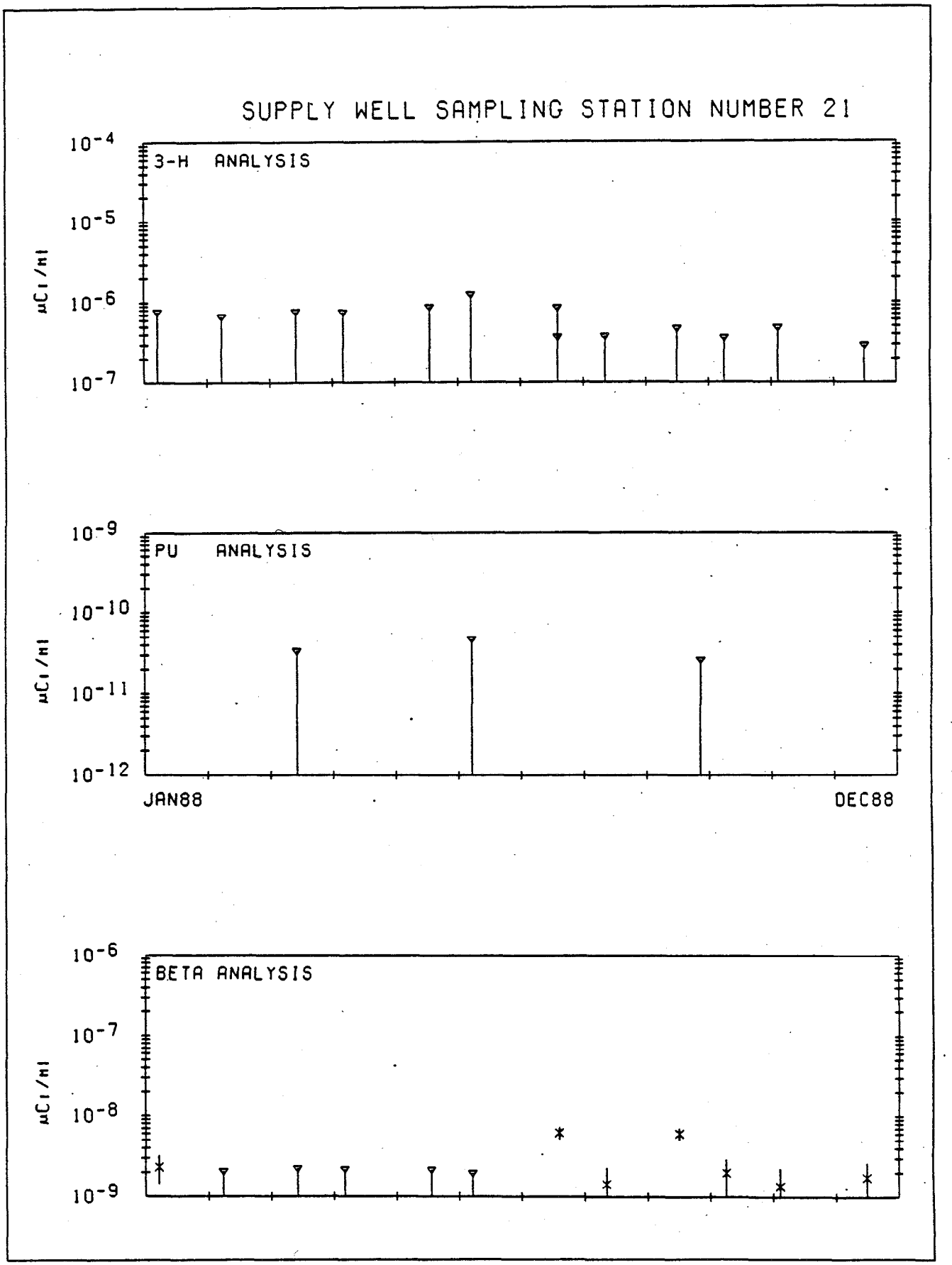

SUPPLY WELL SAMPLING STATION NUMBER 14
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


SUPPLY WELL SAMPLING STATION NUMBER 15
3-H ANALYSIS
10-4
10-5
10-6
10-7
µCi/ml
PU ANALYSIS
10-9
10-10
10-11
10-12
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10-6
10-7
10-8
10-9
µCi/ml


SUPPLY WELL SAMPLING STATION NUMBER 18
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


SUPPLY WELL SAMPLING STATION NUMBER 19
3-H ANALYSIS
μCi/ml
10-4
10-5
10-6
10-7
PU ANALYSIS
μCi/ml
10-9
10-10
10-11
10-12
JAN88
DEC88
BETA ANALYSIS
μCi/ml
10-6
10-7
10-8
10-9


SUPPLY WELL SAMPLING STATION NUMBER 20
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


SUPPLY WELL SAMPLING STATION NUMBER 21
3-H ANALYSIS
10-4
10-5
10-6
10-7
µCi/ml
PU ANALYSIS
10-9
10-10
10-11
10-12
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10-6
10-7
10-8
10-9
µCi/ml

APPENDIX C

NTS Environmental Monitoring

Potable Water Stations and Plots

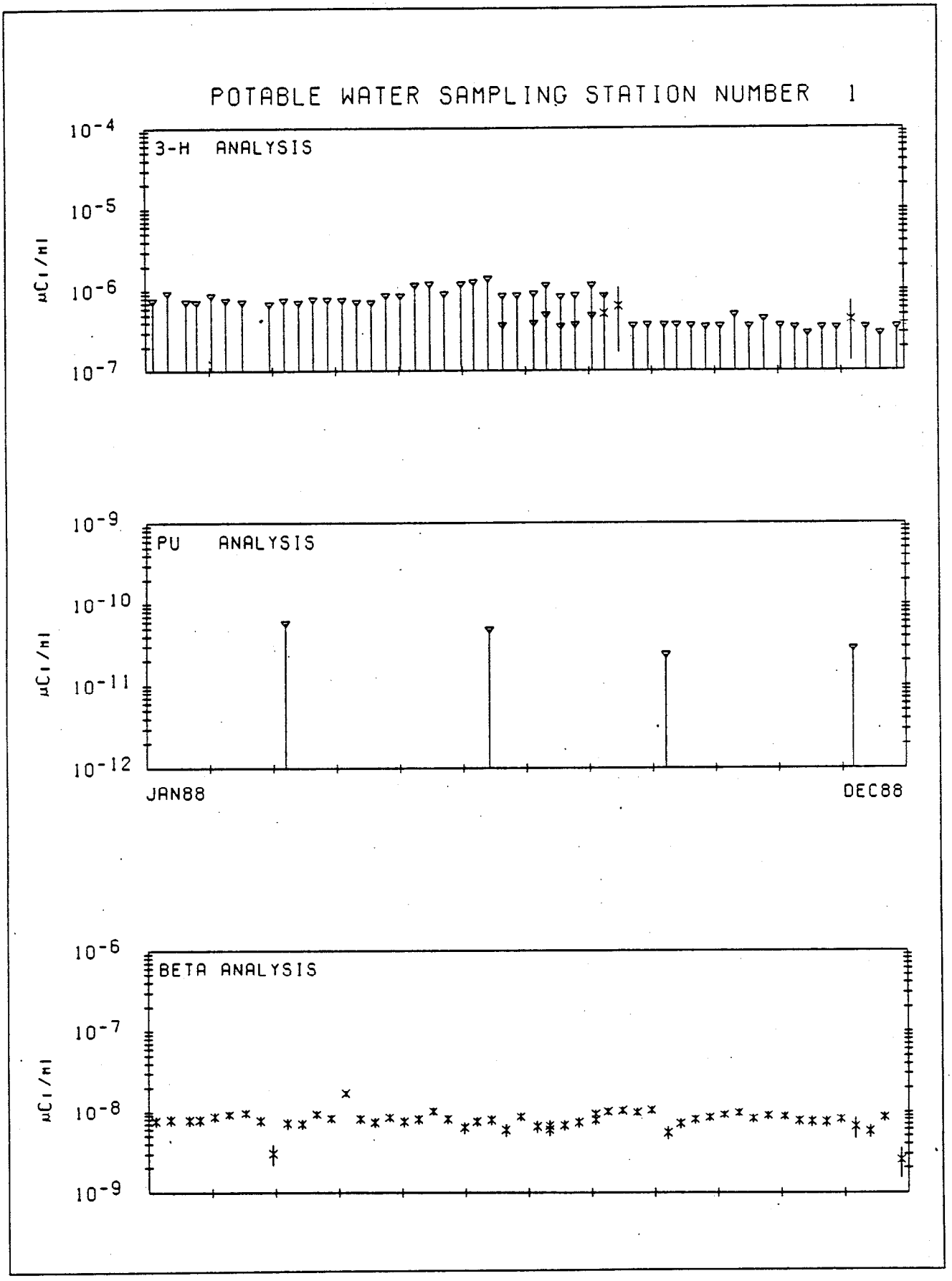
SYMBOLS

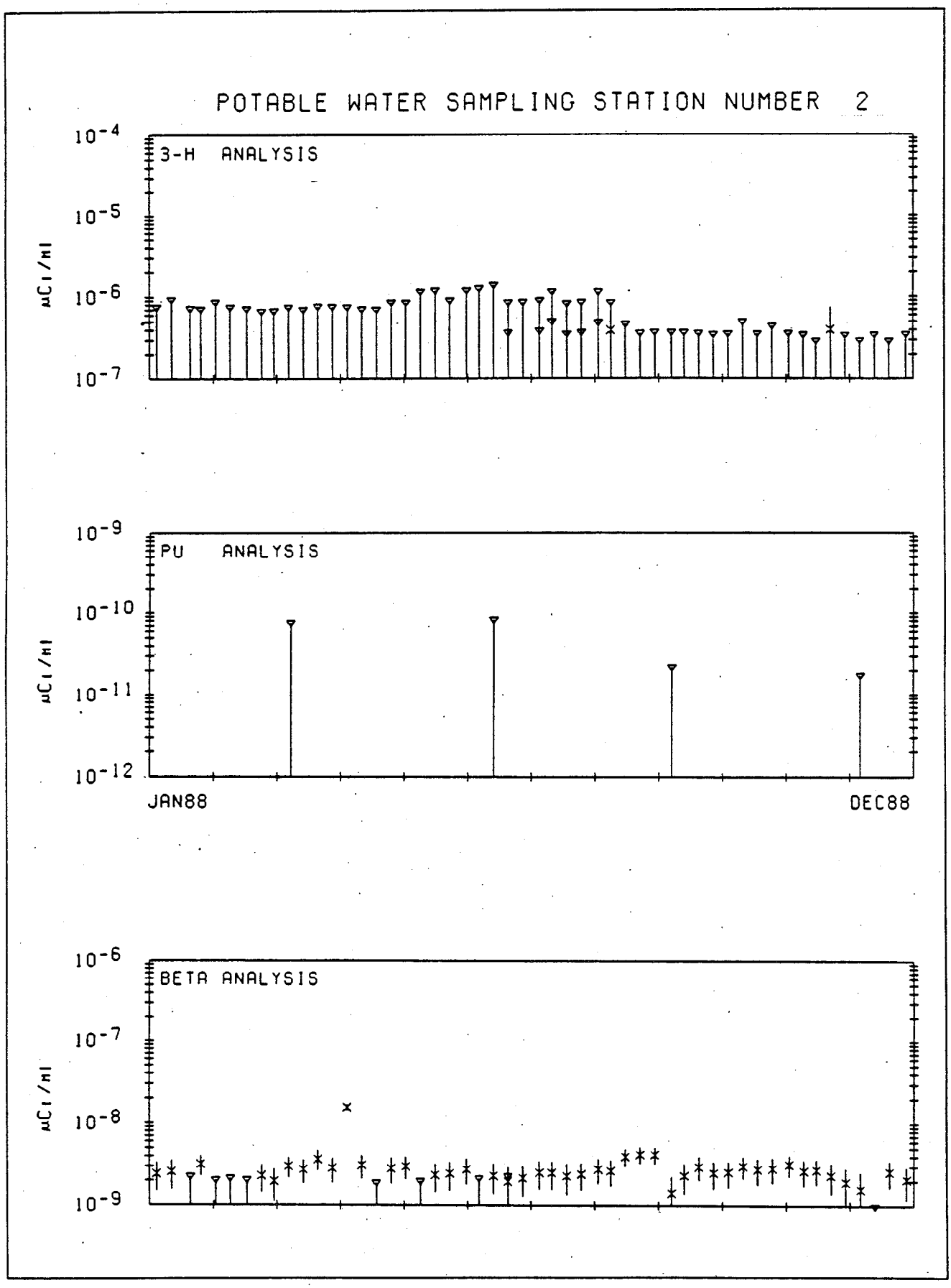
Several symbols are used in Appendix C to denote the data points. The plots display the gross beta, ^{239}Pu and ^{3}H data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits.

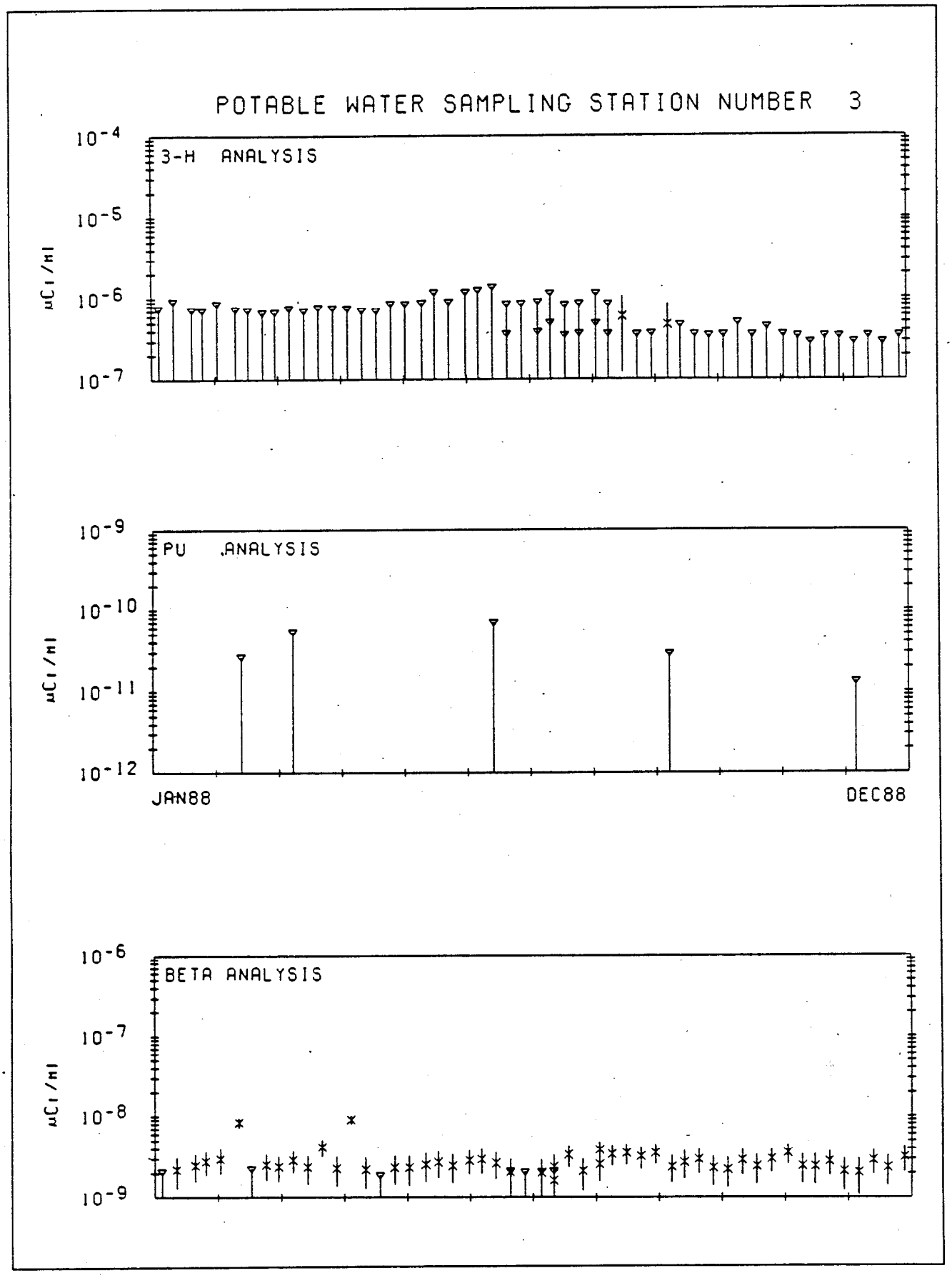
NTS Environmental Monitoring

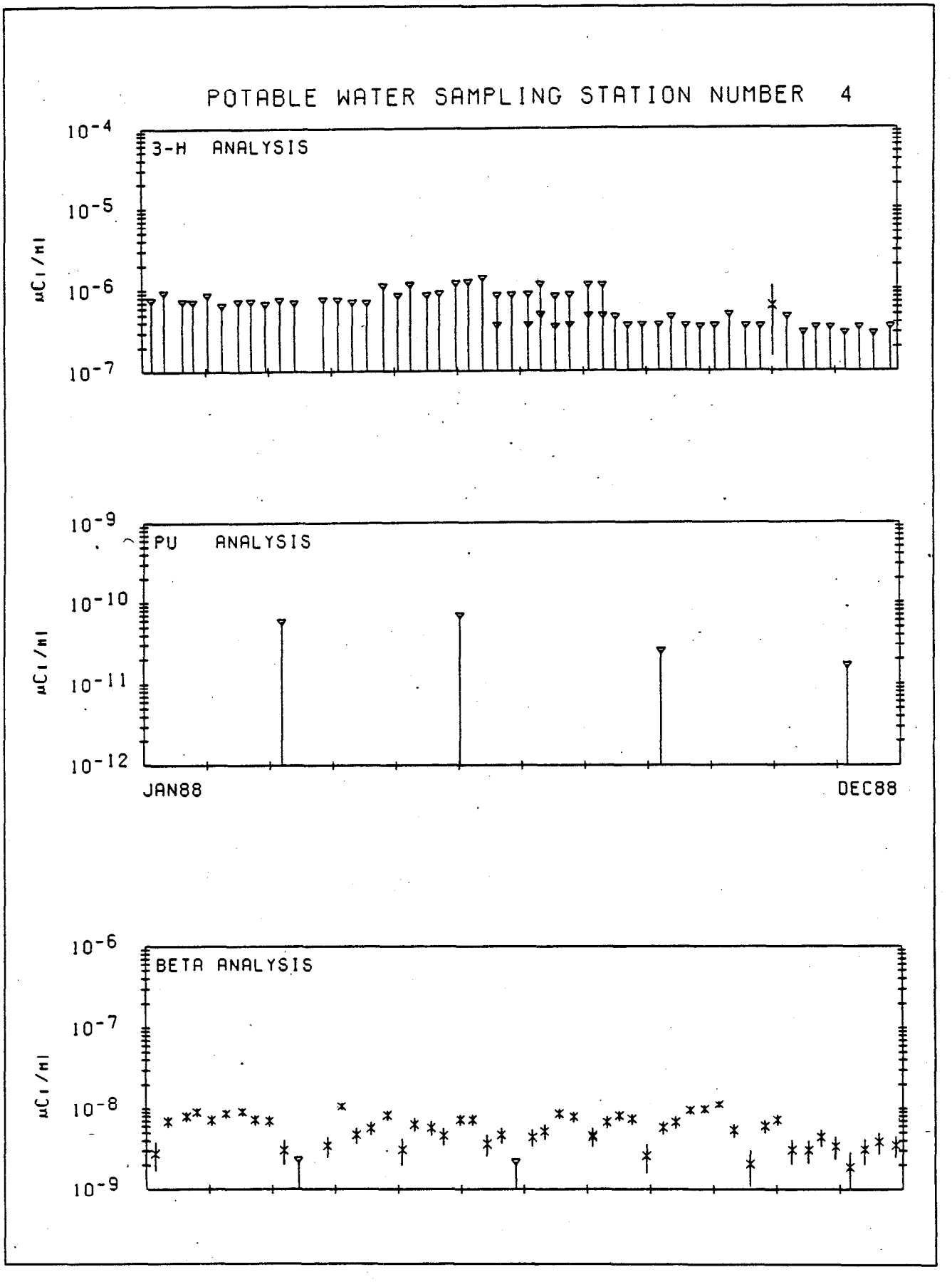
Potable Water Sampling Locations

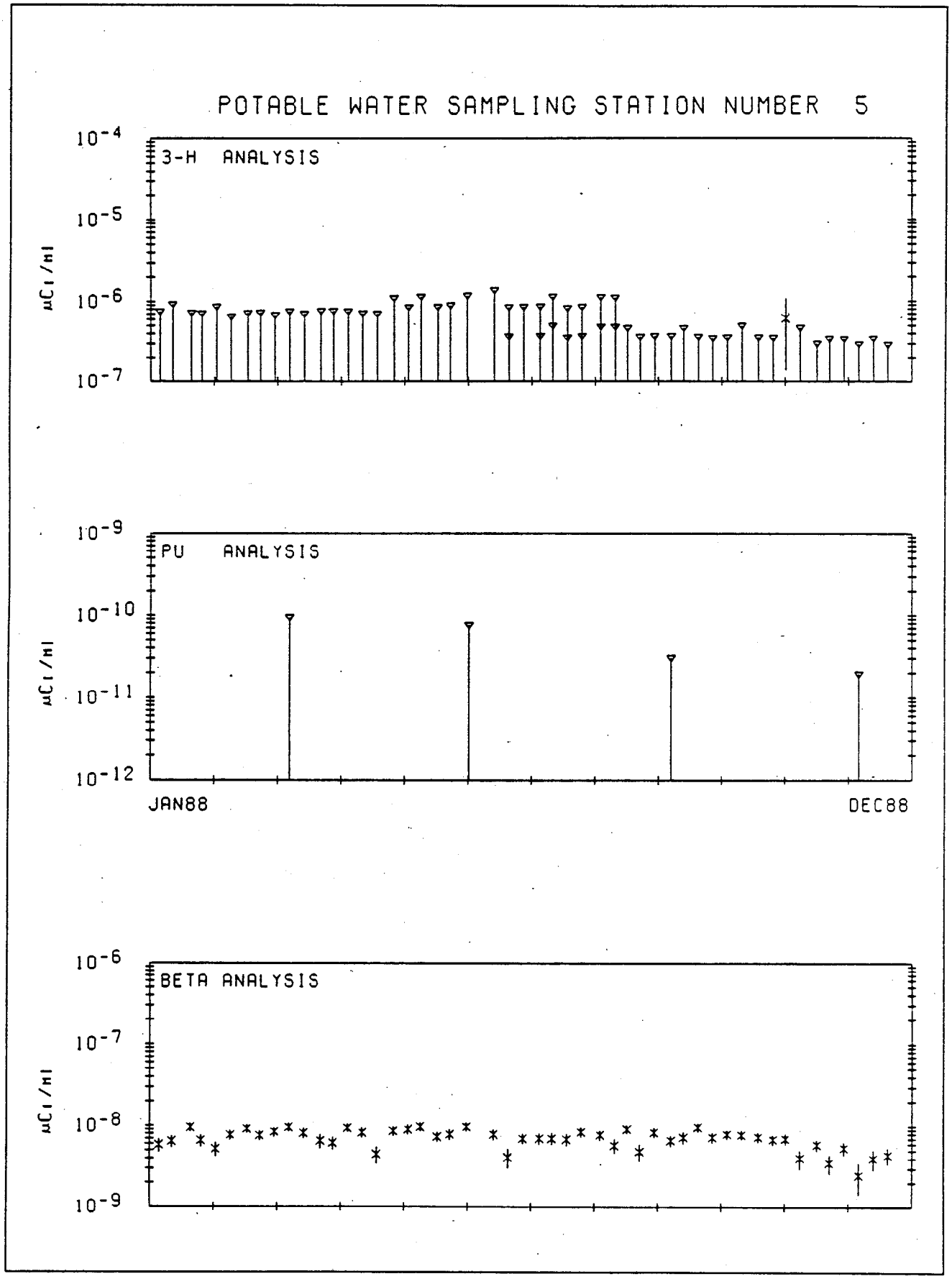
Station	Location
1	Area 3 Cafeteria
2	Area 2 Restroom
3	Area 12 Cafeteria
4	Area 23 Cafeteria
5	Area 27 Cafeteria
6	Area 6 Cascade Water
7	Area 6 Cafeteria
66	Area 25 Service Station
77	Area 25 Building 4221

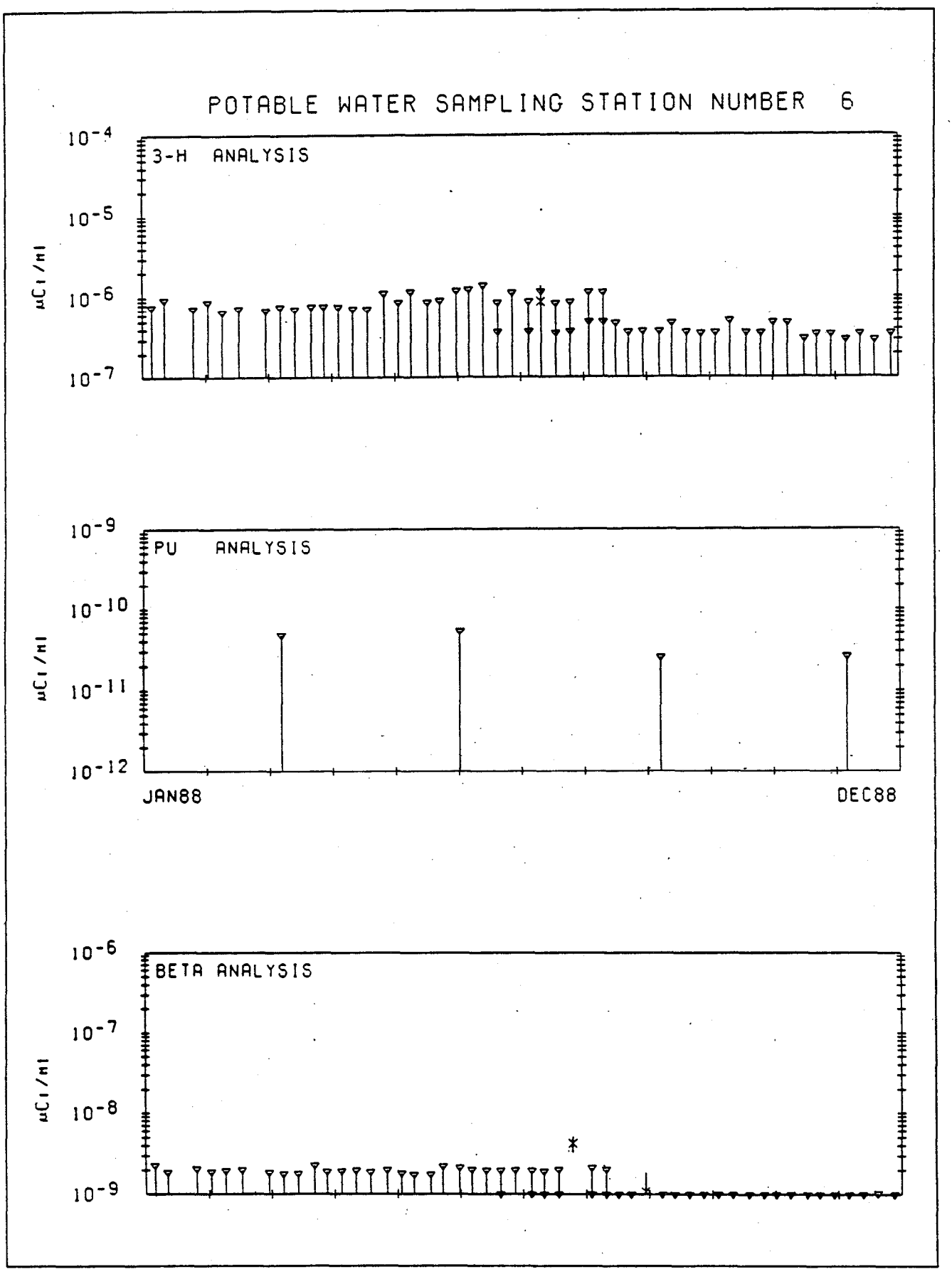

POTABLE WATER SAMPLING STATION NUMBER 1
3-H ANALYSIS
µCi/ml
10-4
10-5
10-6
10-7
PU ANALYSIS
µCi/ml
10-9
10-10
10-11
10-12
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10-6
10-7
10-8
10-9

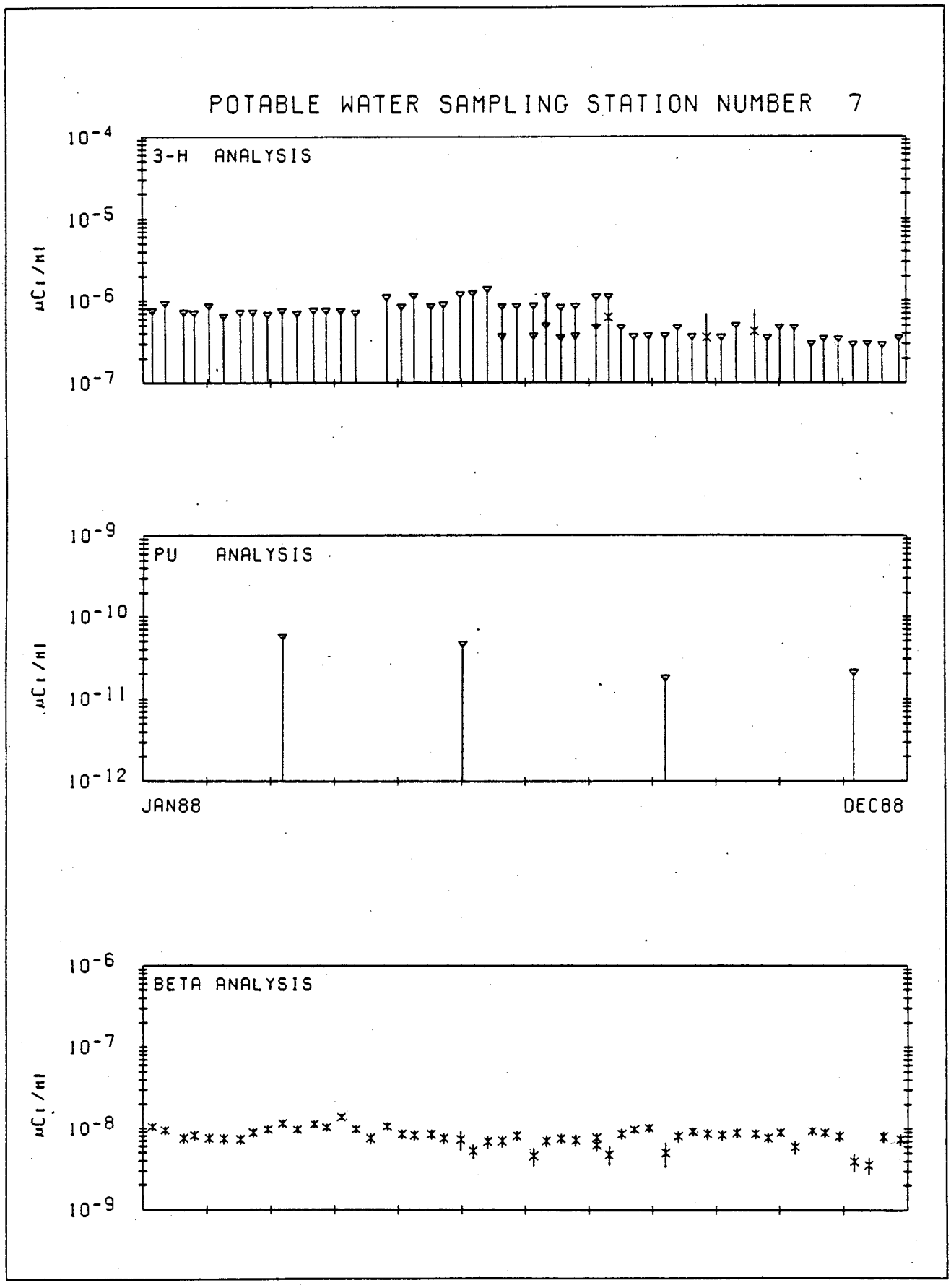

POTABLE WATER SAMPLING STATION NUMBER 2
3-H ANALYSIS
µCi/ml
10-4
10-5
10-6
10-7
PU ANALYSIS
µCi/ml
10-9
10-10
10-11
10-12
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10-6
10-7
10-8
10-9

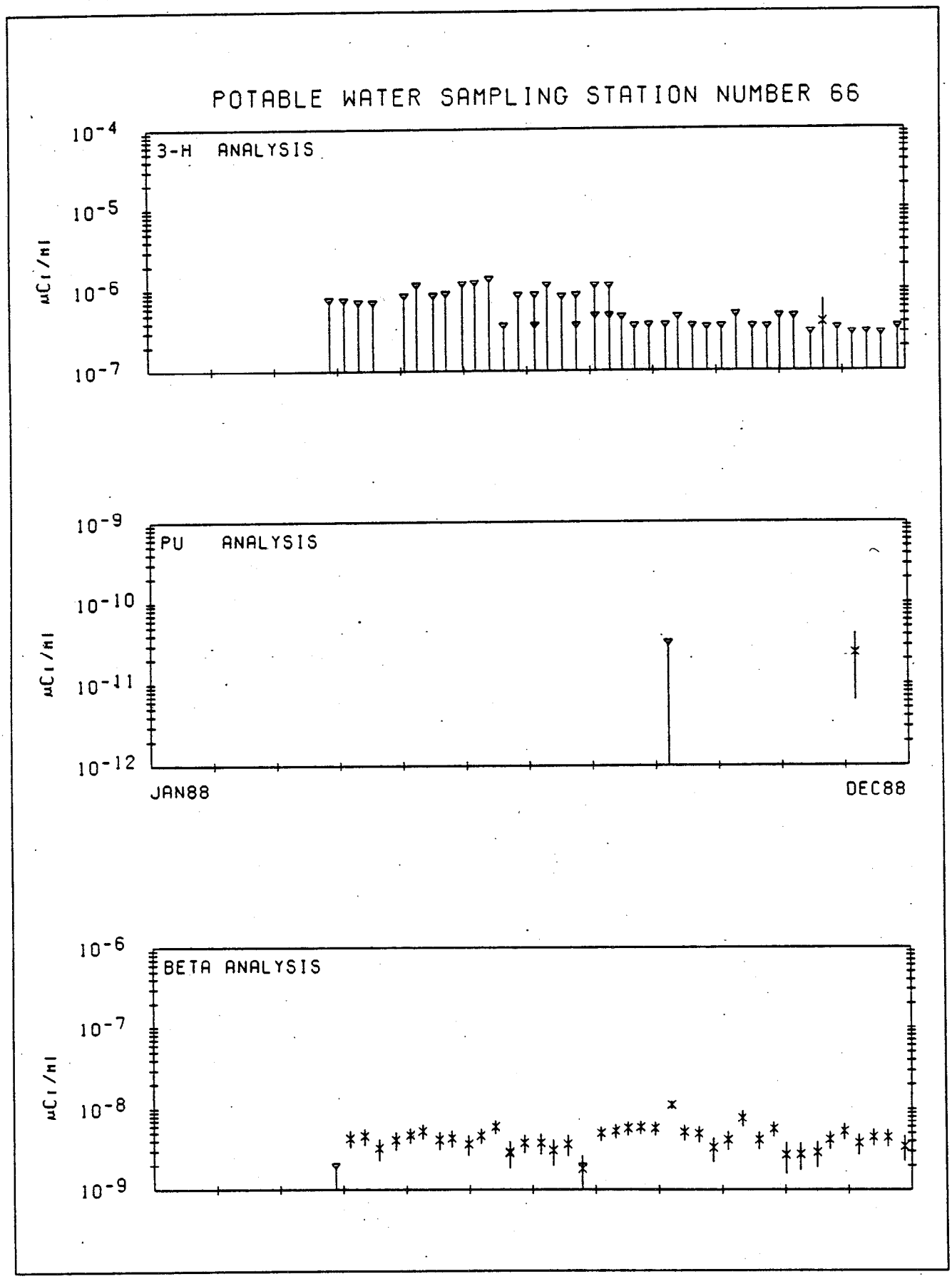

POTABLE WATER SAMPLING STATION NUMBER 3
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


POTABLE WATER SAMPLING STATION NUMBER 4
3-H ANALYSIS
10-4
10-5
10-6
10-7
µCi/ml
PU ANALYSIS
10-9
10-10
10-11
10-12
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10-6
10-7
10-8
10-9
µCi/ml


POTABLE WATER SAMPLING STATION NUMBER 5
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

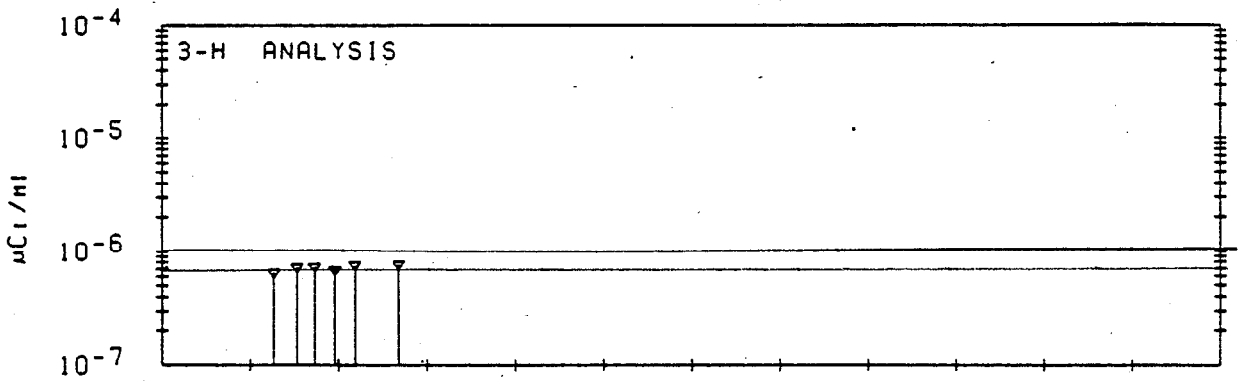

POTABLE WATER SAMPLING STATION NUMBER 6
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


POTABLE WATER SAMPLING STATION NUMBER 7
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


POTABLE WATER SAMPLING STATION NUMBER 66
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

Area 25 Bldg. 4221

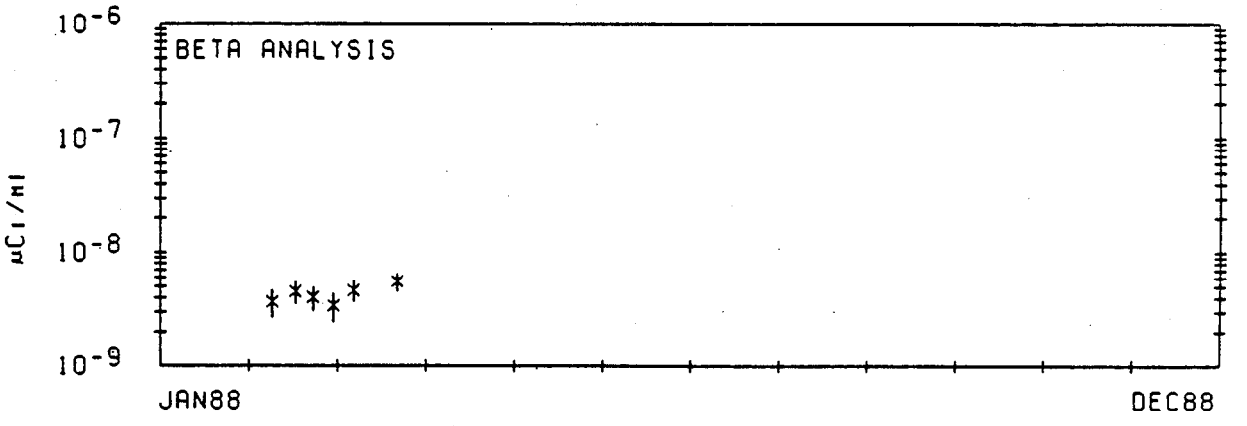
POTABLE WATER SAMPLING STATION NUMBER 77



$(^3H) = 8 \times 10^{-6}\ (\mu Ci/ml) = 8 \times 10^{-12}\ Ci/ml = 8 \times 10^{-9}\ Ci/l$

$= 8{,}000\ pCi/l$!!

^{239}Pu data missing.



APPENDIX D

NTS Environmental Monitoring

Open Reservoir Stations and Plots

SYMBOLS

Several symbols are used in Appendix D to denote the data points. The plots display the gross beta, ^{239}Pu and ^{3}H 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.

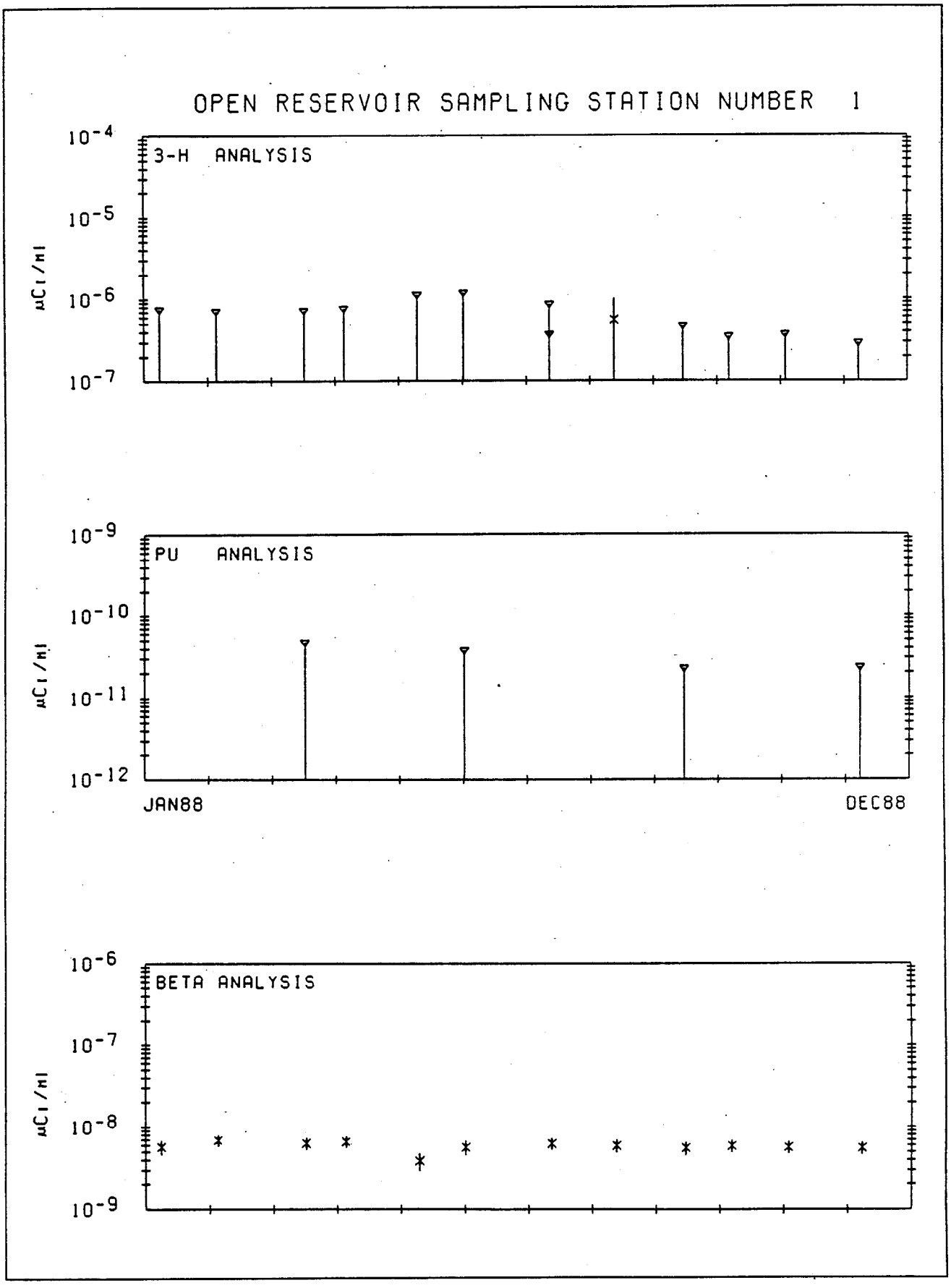
APPENDIX D

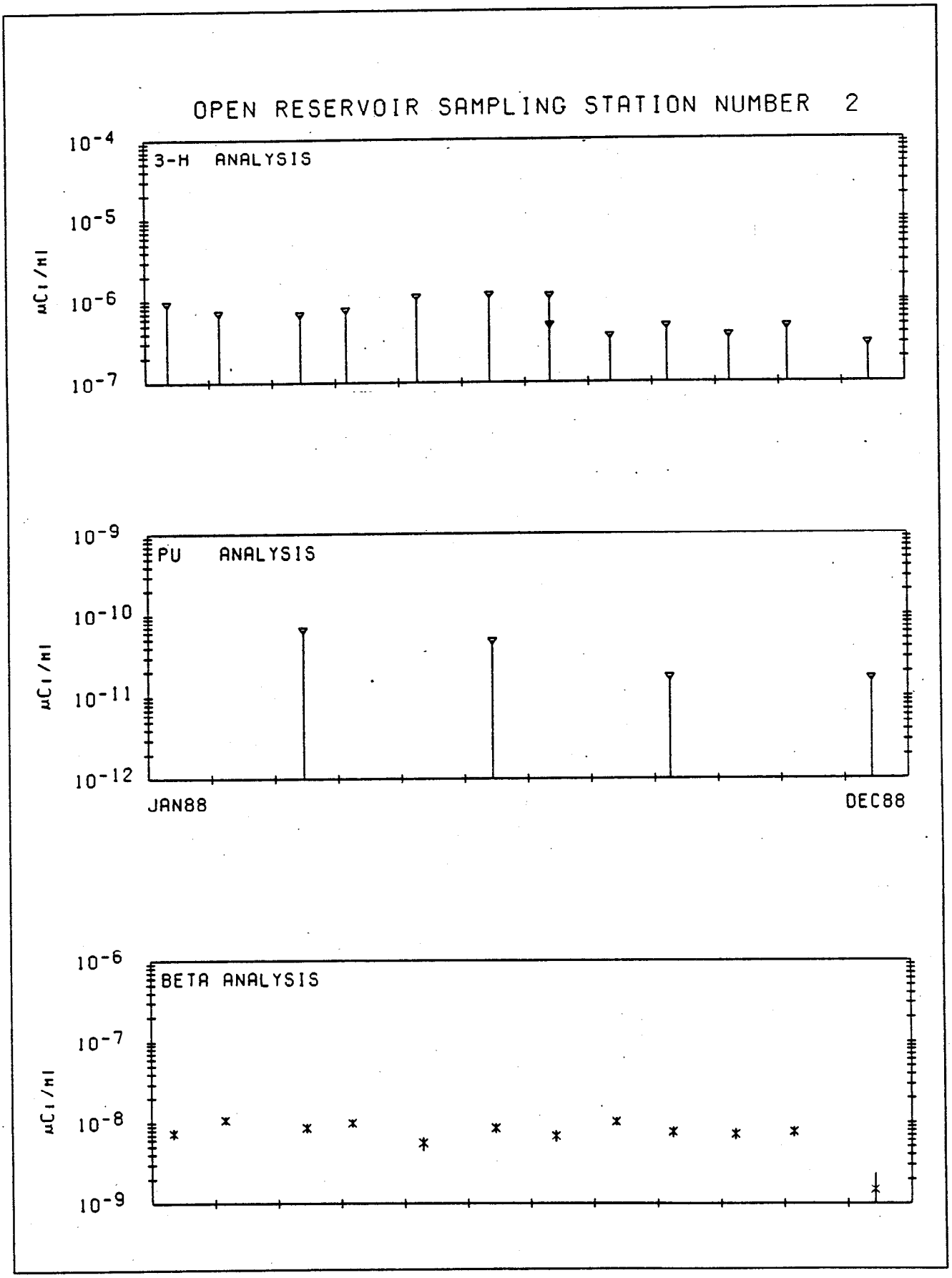
NTS Environmental Monitoring

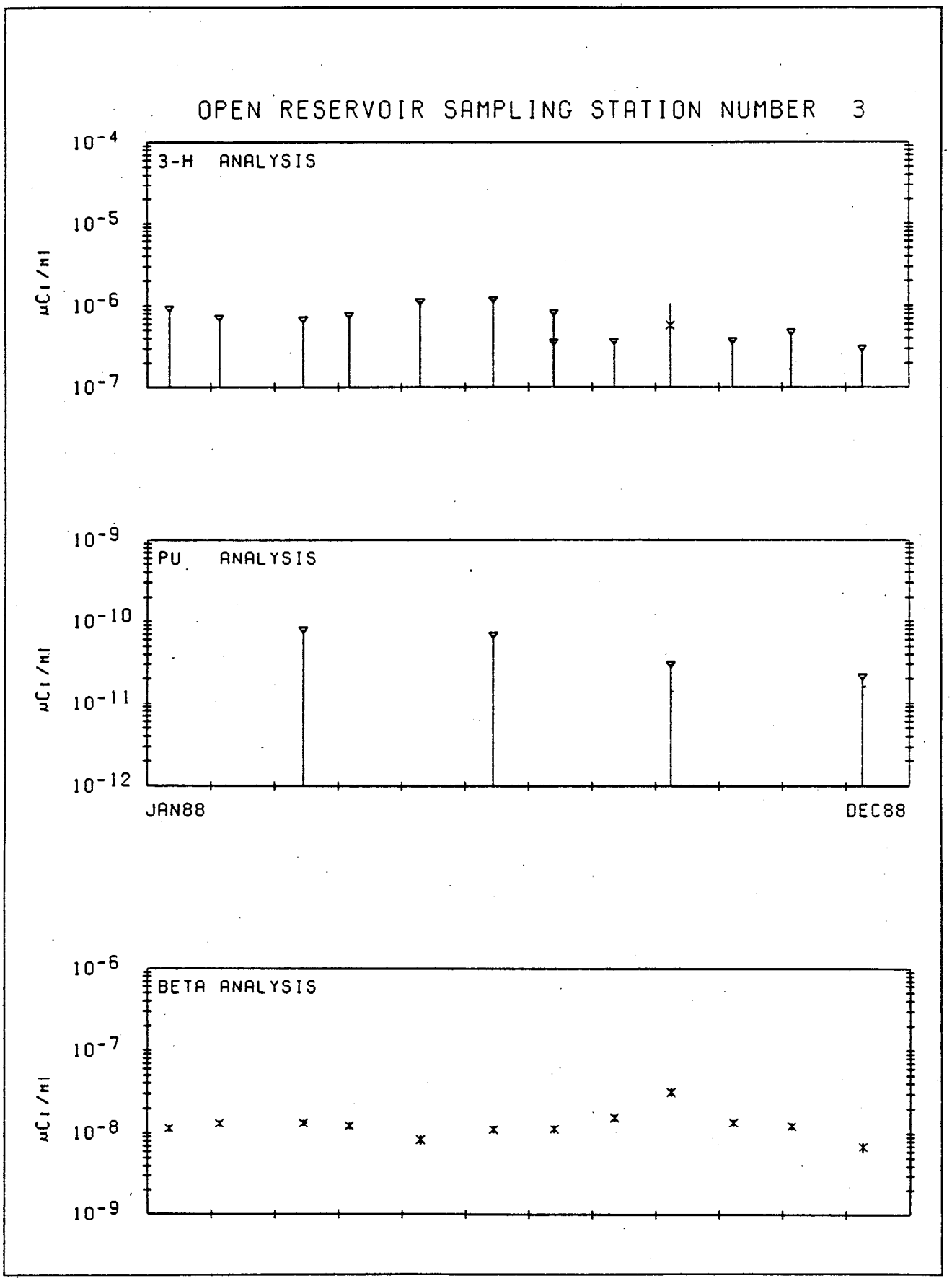
Open Reservoir Sampling Locations

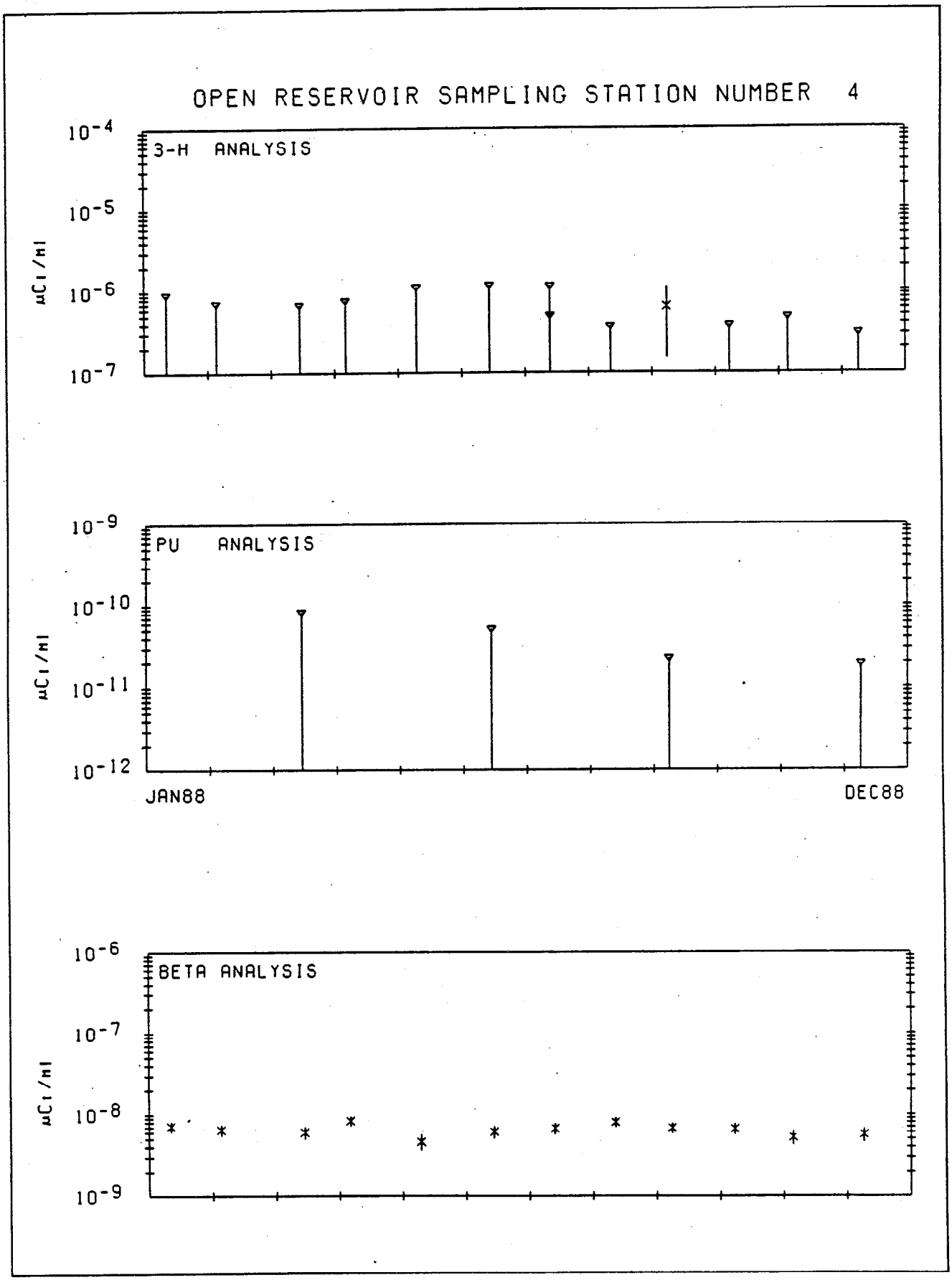
Station	Location
1	Area 2 Well 2 Reservoir
2	Area 3 Well A Reservoir
3	Area 5 Well 5B Reservoir
4	Area 5 Well UE5c Reservoir
5	Area 6 Well 3 Reservoir
6	Area 6 Well C1 Reservoir
8	Area 18 Camp 17 Reservoir
11	Area 20 Well 20A Reservoir
12	Area 23 Swimming Pool
16	Area 19 Well U19c Reservoir
17	Area 25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

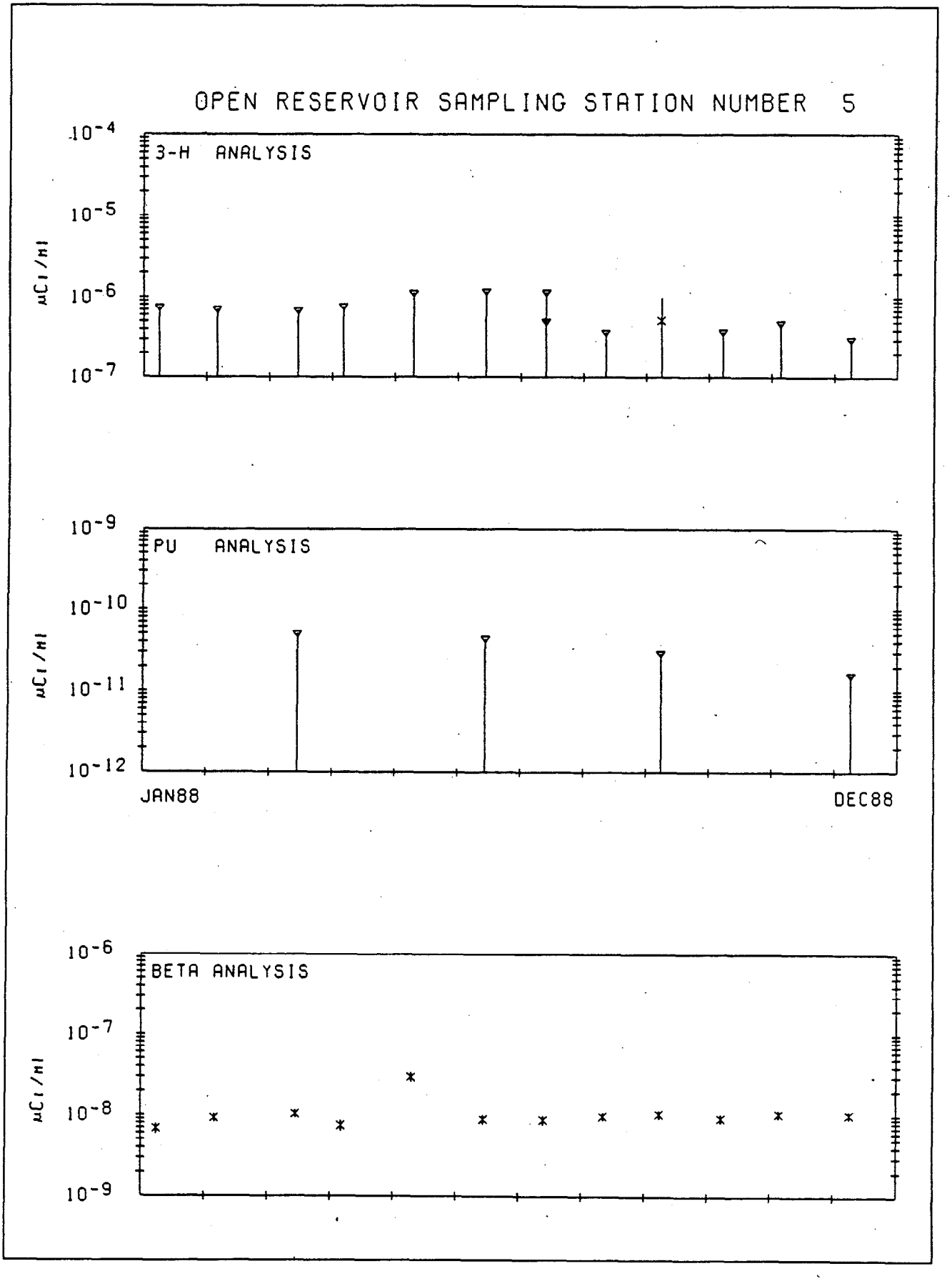
APPENDIX D

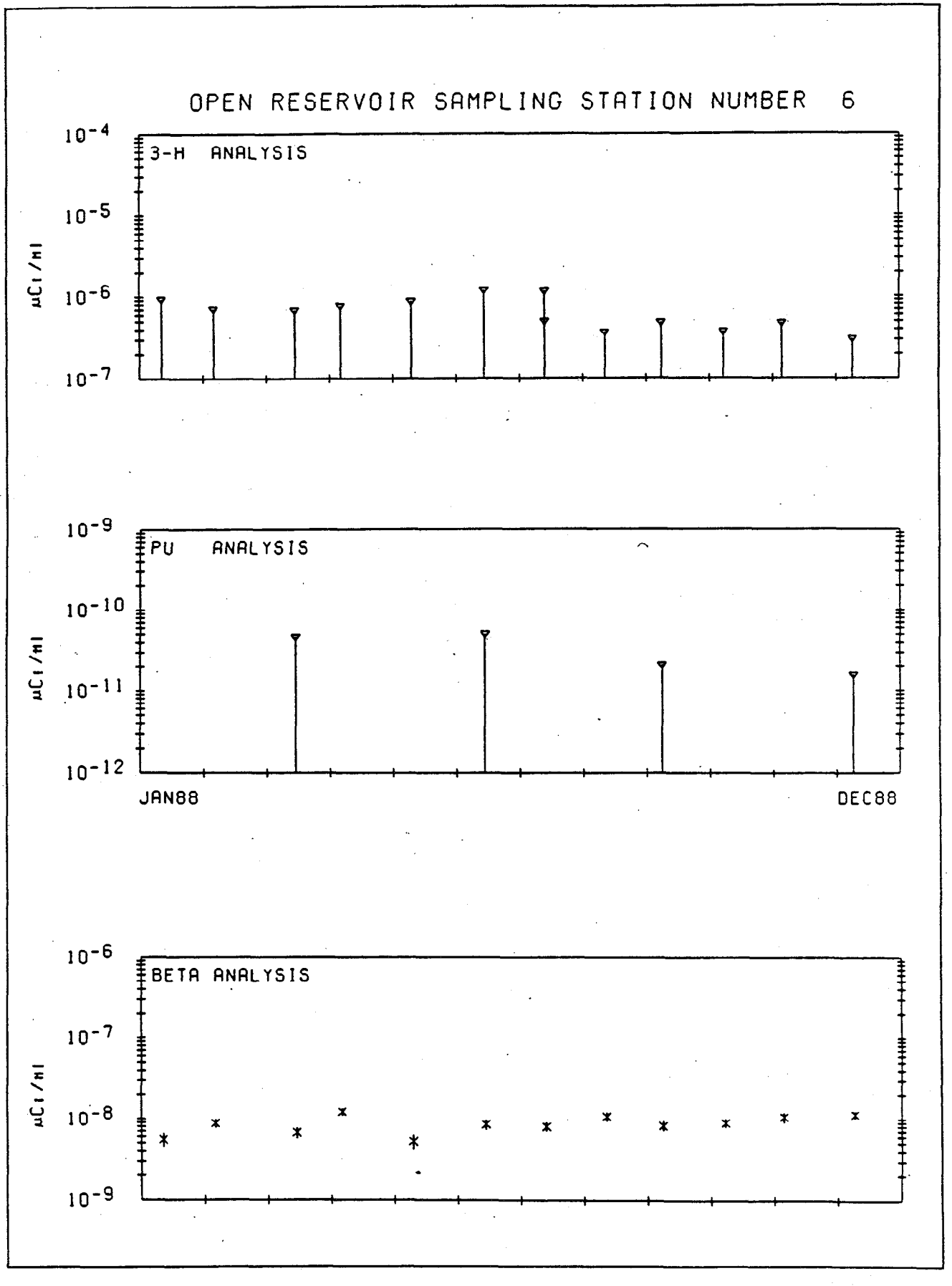

OPEN RESERVOIR SAMPLING STATION NUMBER 1
3-H ANALYSIS
10-4
10-5
10-6
10-7
µCi/ml
PU ANALYSIS
10-9
10-10
10-11
10-12
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10-6
10-7
10-8
10-9
µCi/ml

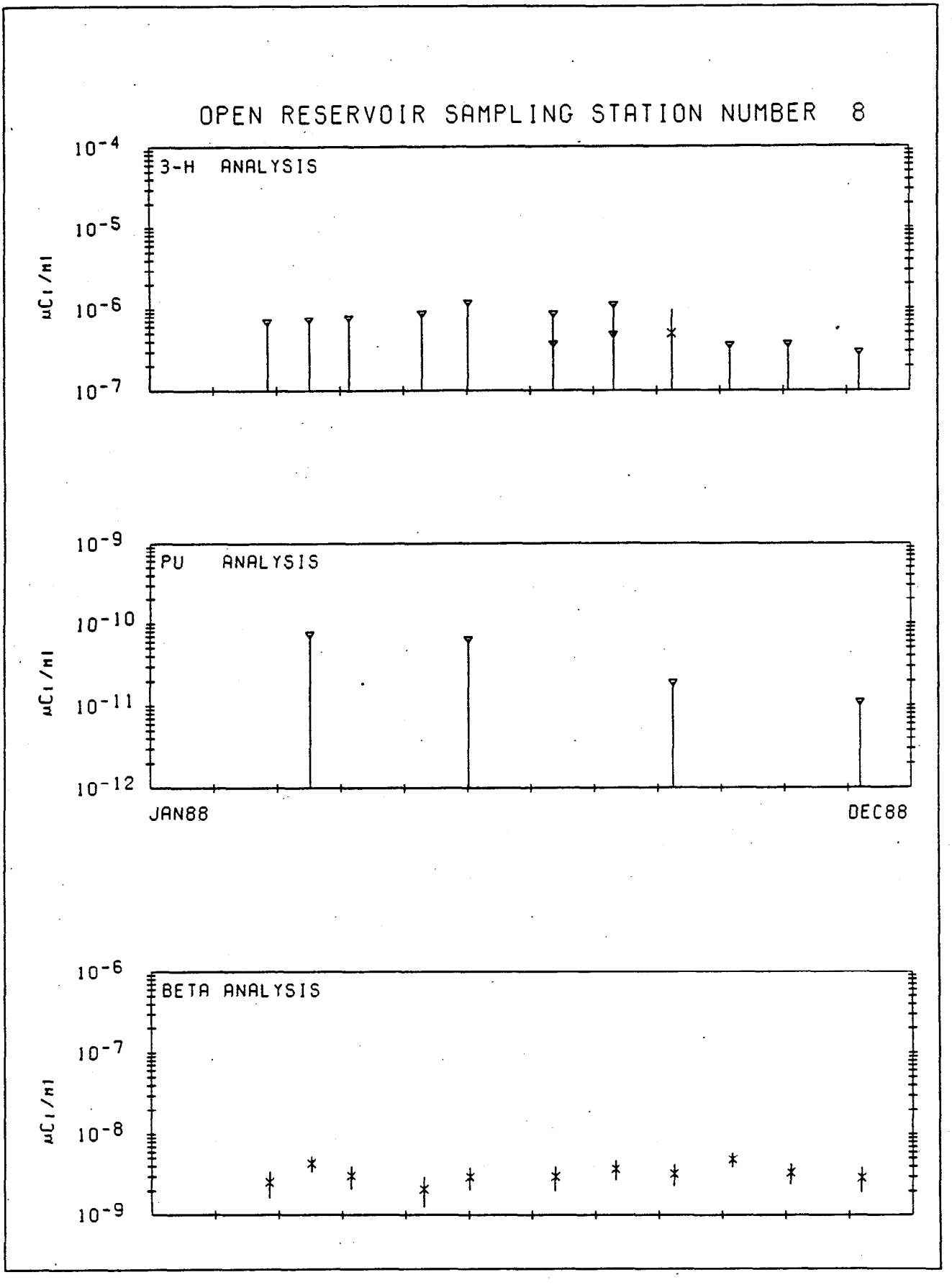

OPEN RESERVOIR SAMPLING STATION NUMBER 2
3-H ANALYSIS
10-4
10-5
10-6
10-7
µCi/ml
PU ANALYSIS
10-9
10-10
10-11
10-12
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10-6
10-7
10-8
10-9
µCi/ml

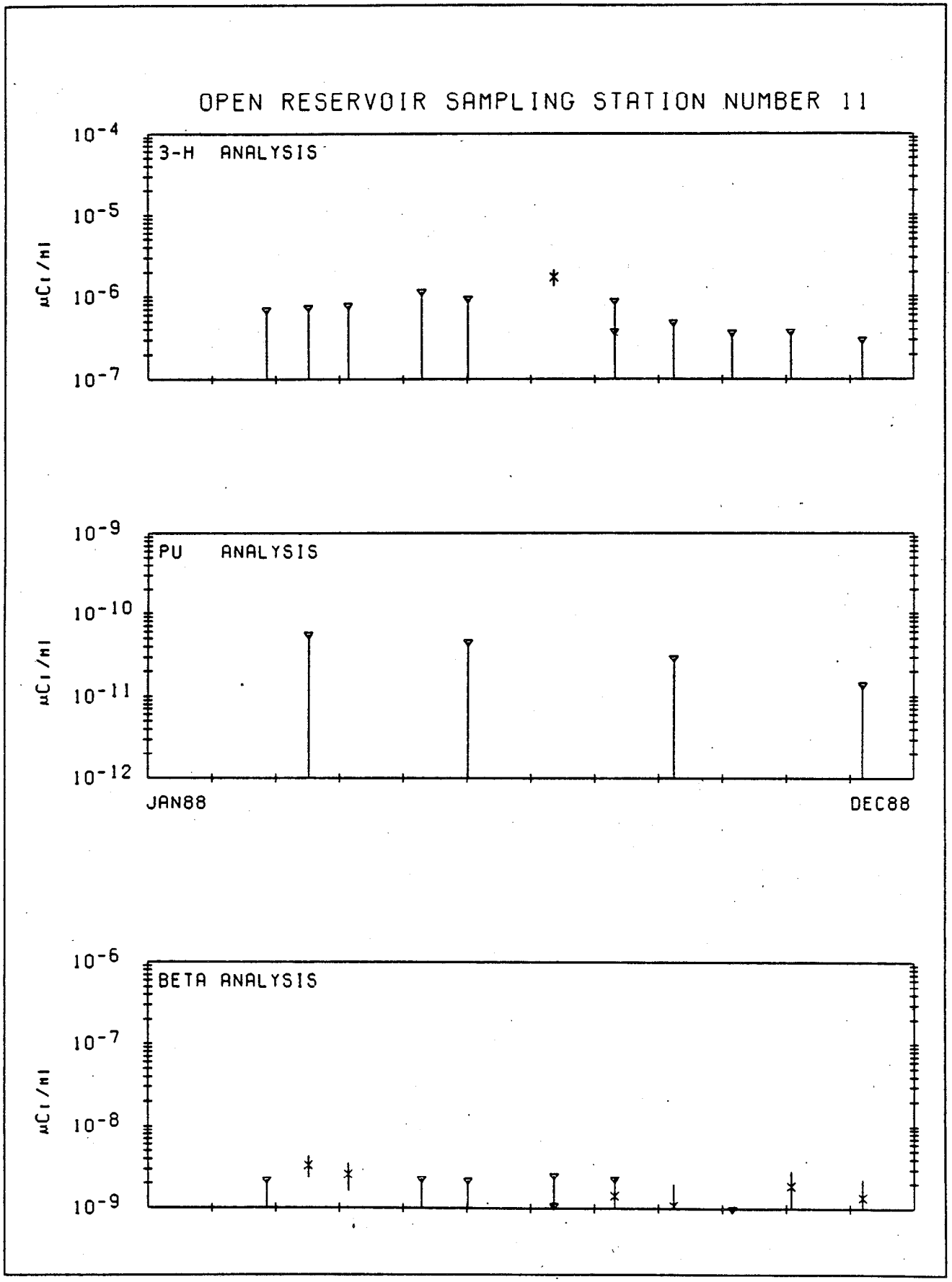

OPEN RESERVOIR SAMPLING STATION NUMBER 3
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

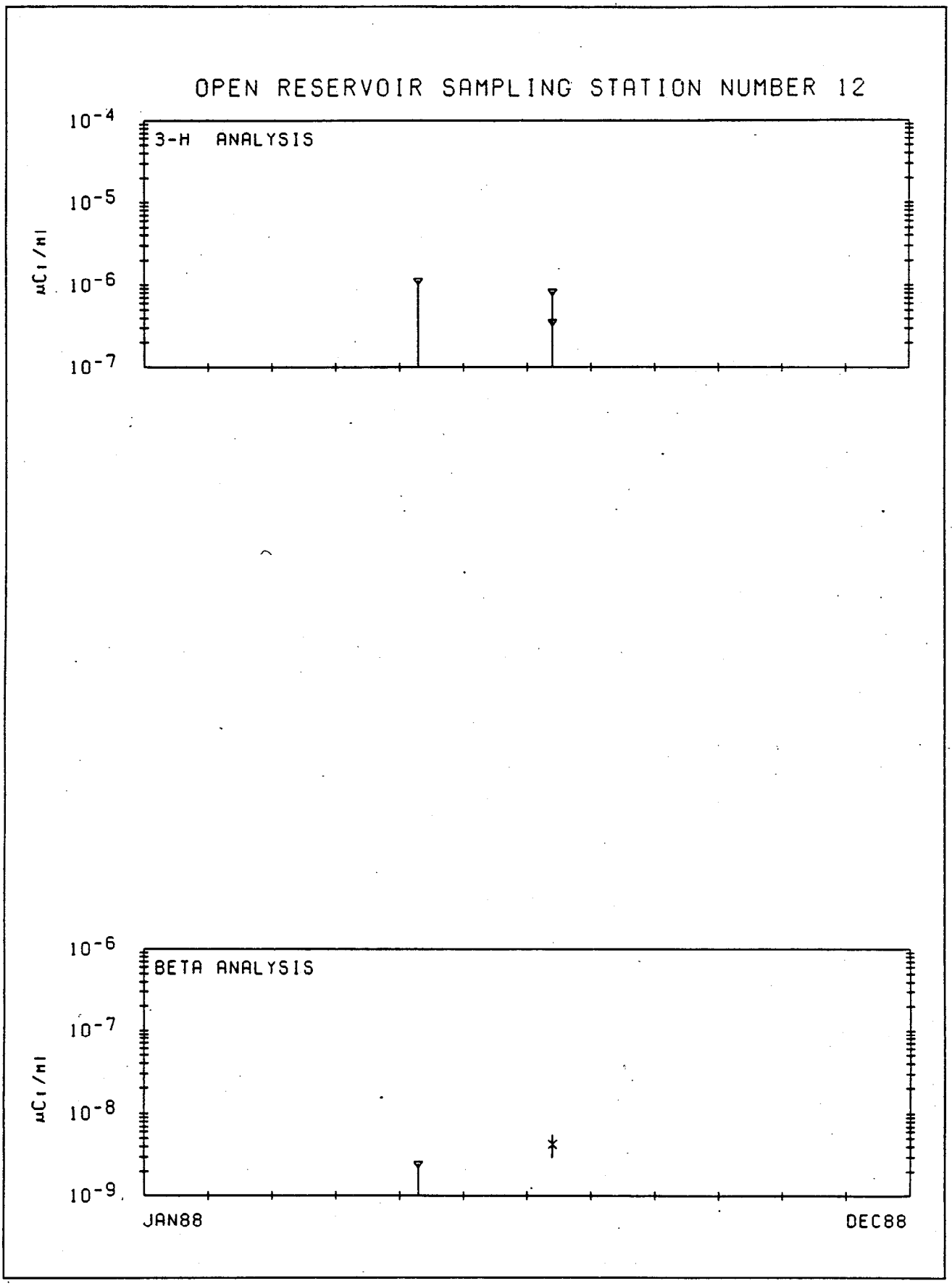

OPEN RESERVOIR SAMPLING STATION NUMBER 4
3-H ANALYSIS
µCi/ml
10-4
10-5
10-6
10-7
PU ANALYSIS
µCi/ml
10-9
10-10
10-11
10-12
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10-6
10-7
10-8
10-9

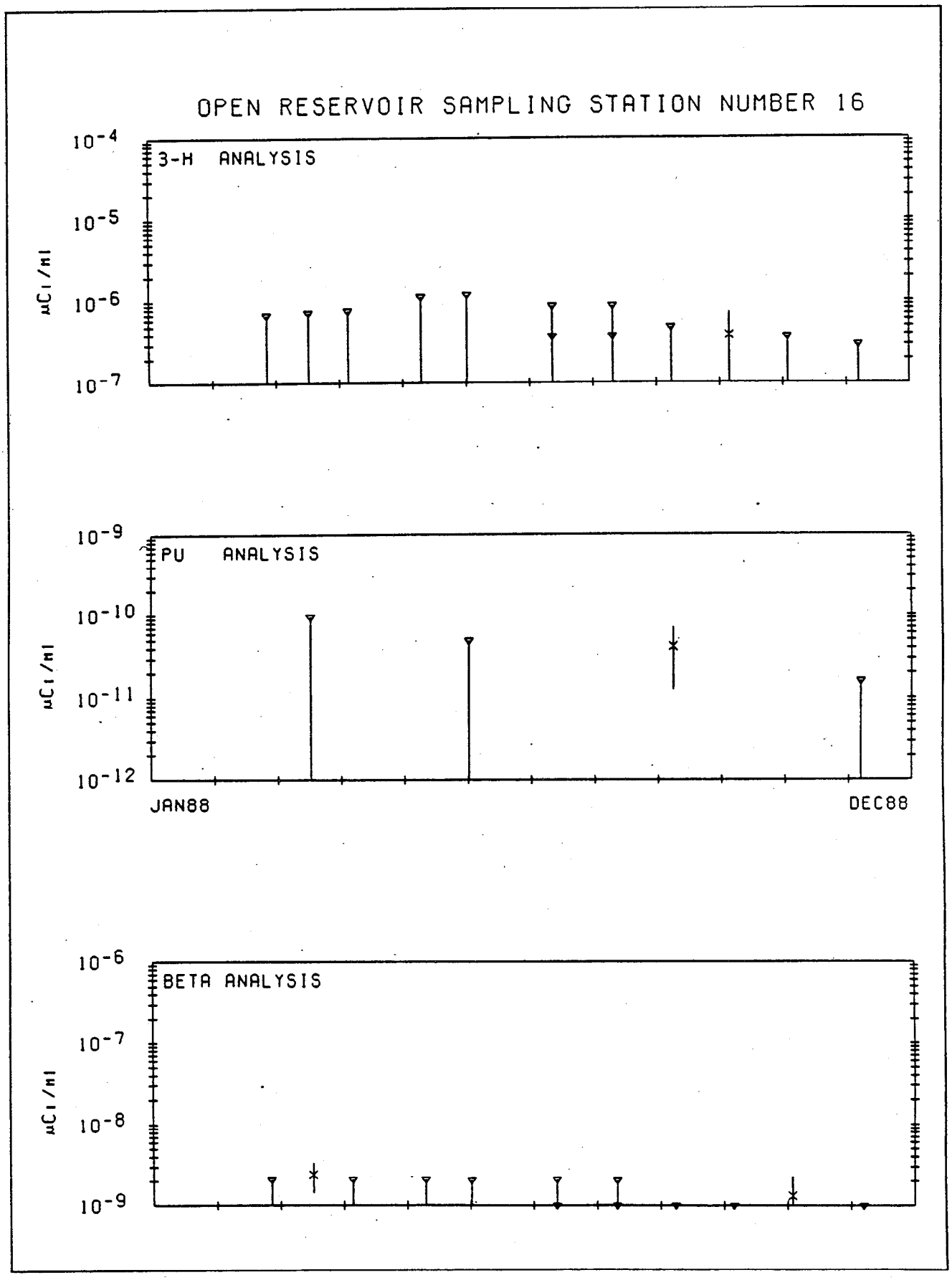

OPEN RESERVOIR SAMPLING STATION NUMBER 5
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

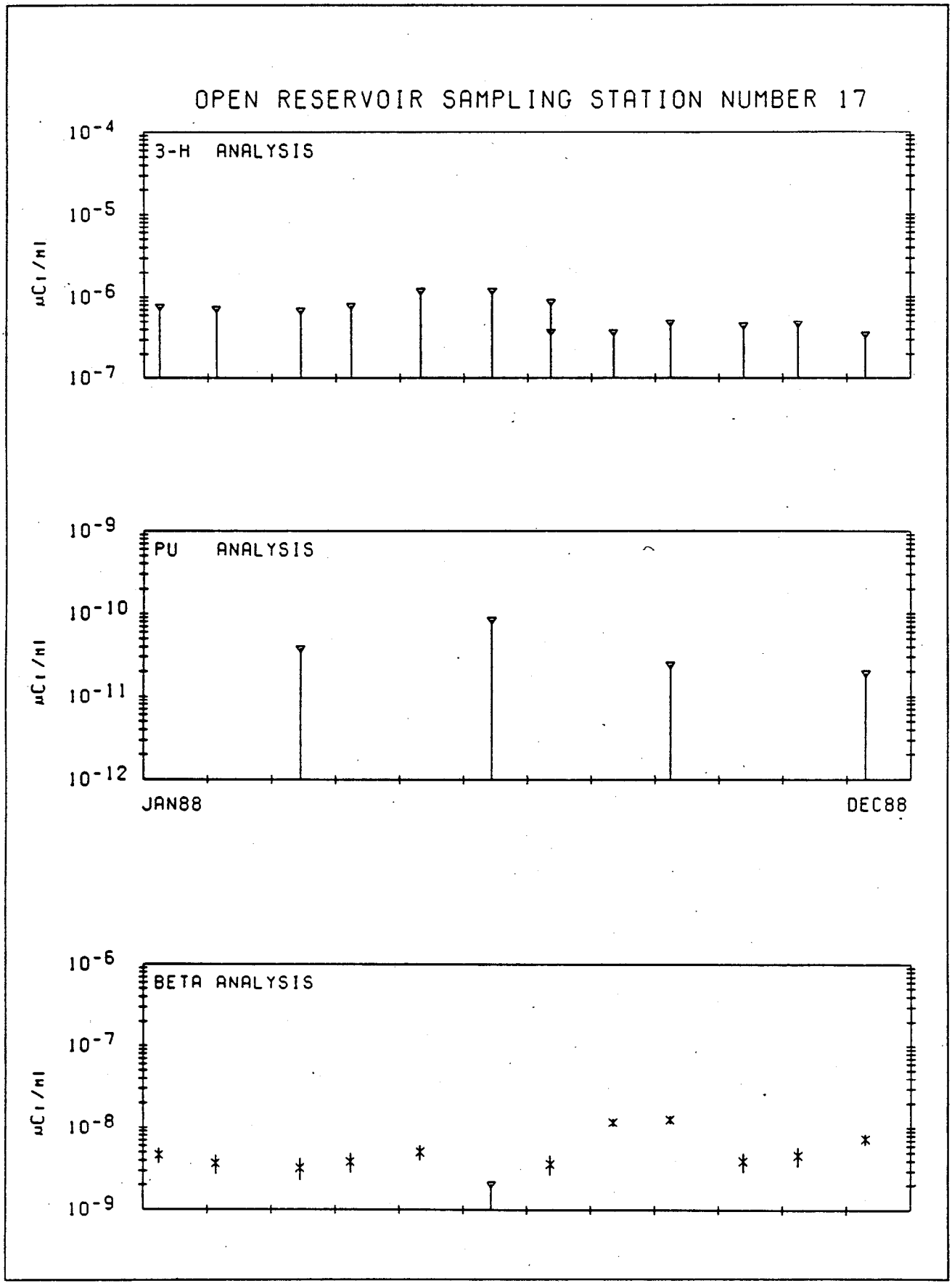

OPEN RESERVOIR SAMPLING STATION NUMBER 6
3-H ANALYSIS
µCi/ml
10-4
10-5
10-6
10-7
PU ANALYSIS
µCi/ml
10-9
10-10
10-11
10-12
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10-6
10-7
10-8
10-9

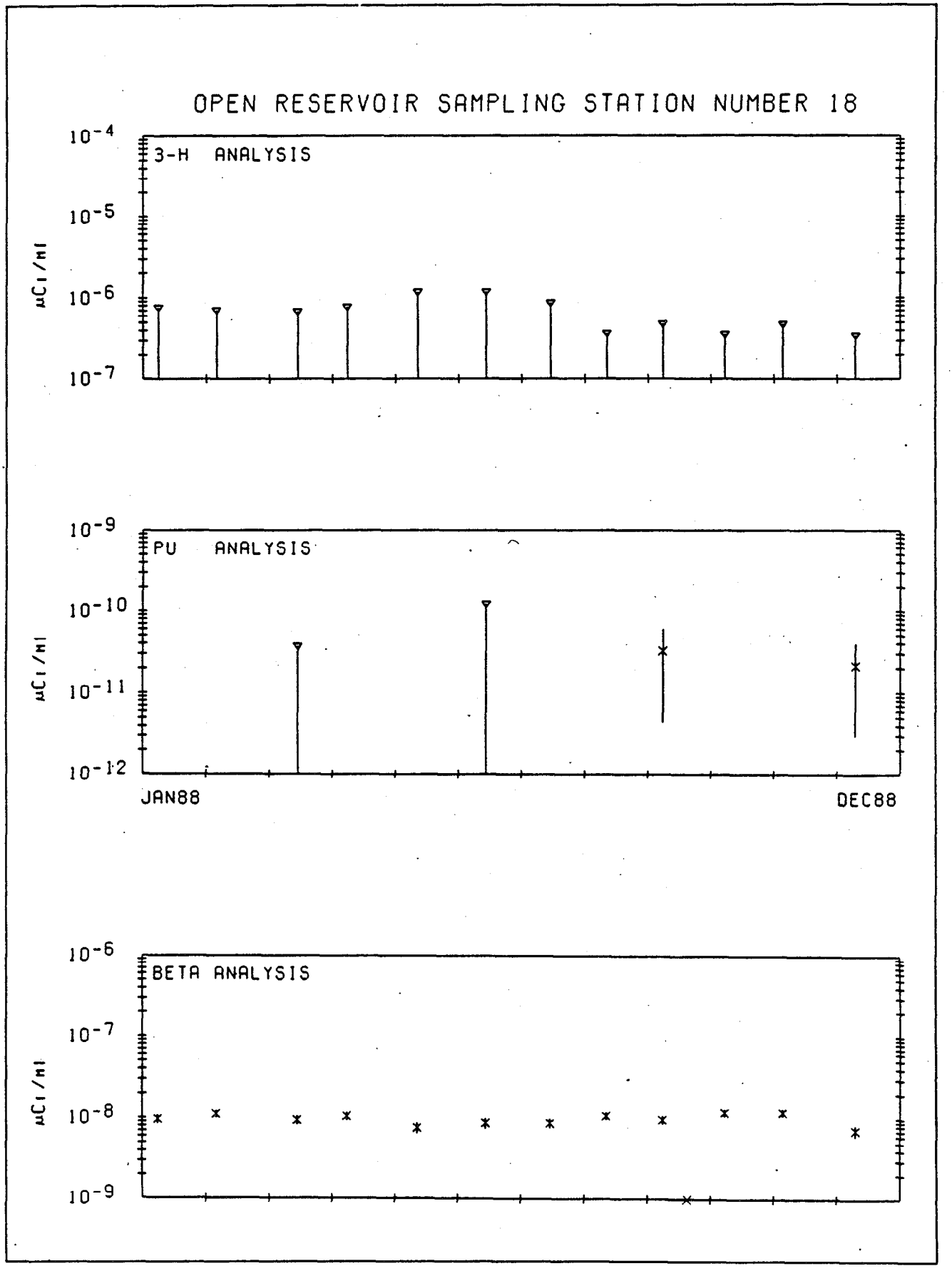

OPEN RESERVOIR SAMPLING STATION NUMBER 8
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

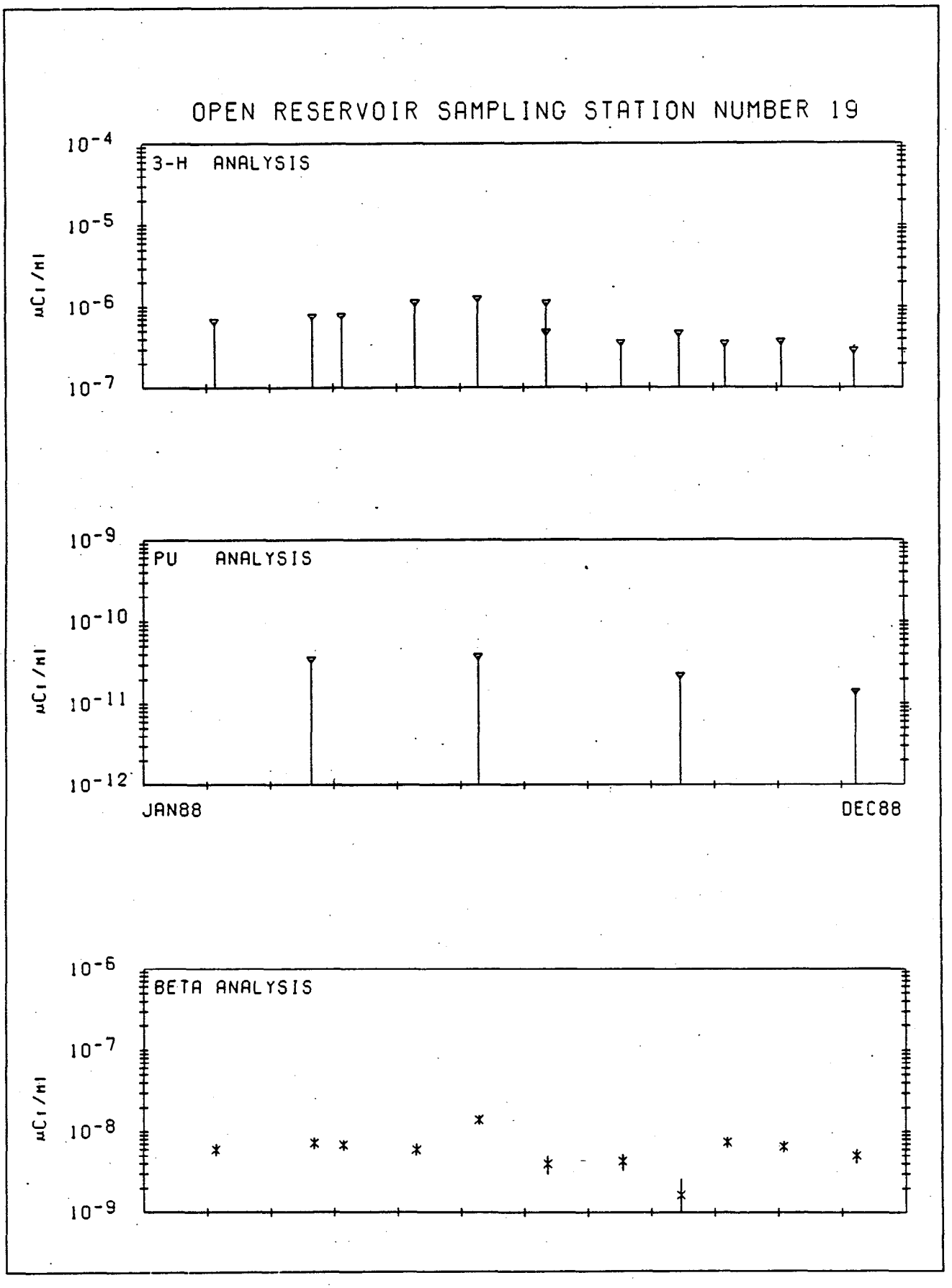

OPEN RESERVOIR SAMPLING STATION NUMBER 11
3-H ANALYSIS
µCi/ml
10-4
10-5
10-6
10-7
PU ANALYSIS
µCi/ml
10-9
10-10
10-11
10-12
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10-6
10-7
10-8
10-9

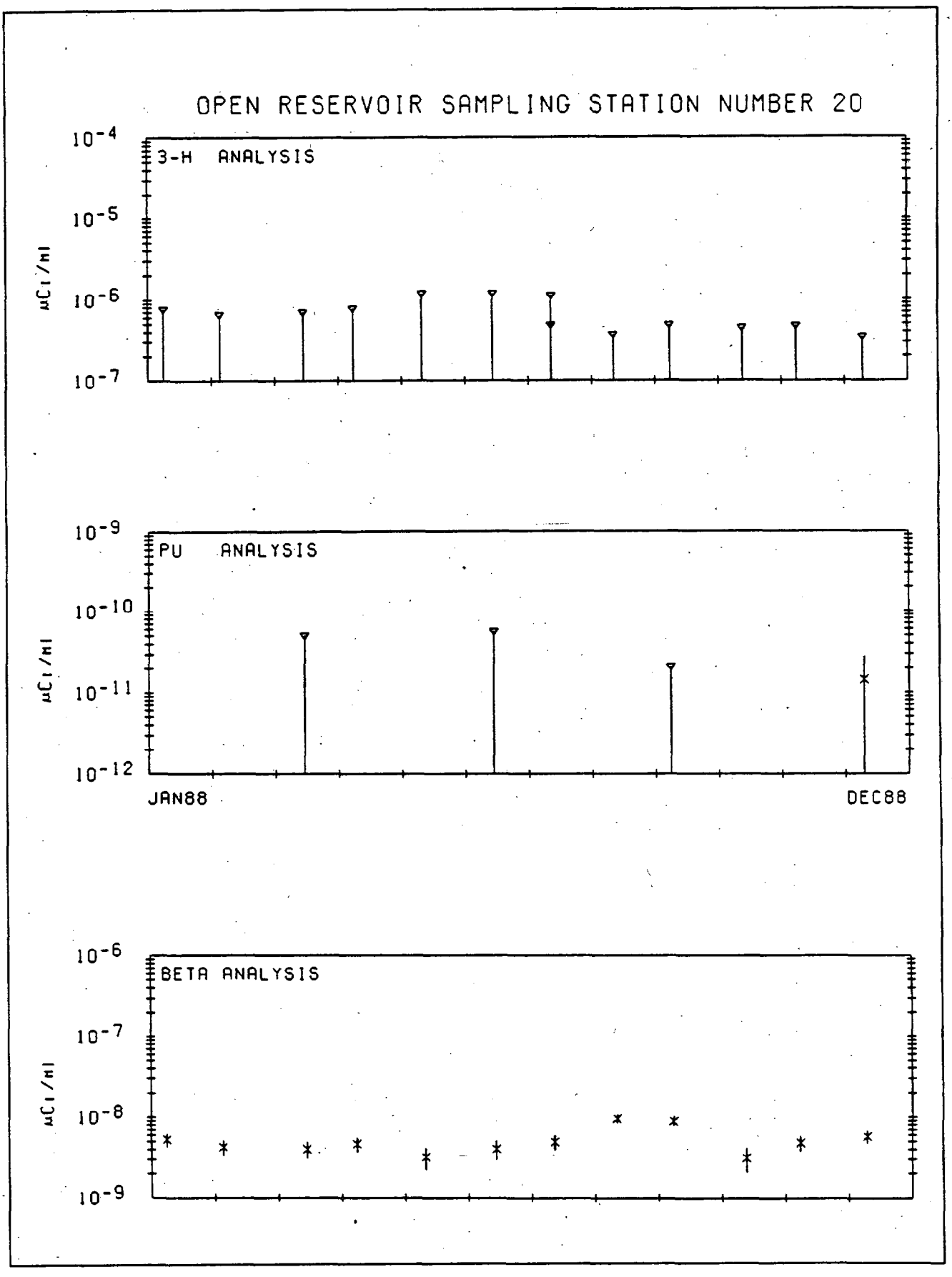

OPEN RESERVOIR SAMPLING STATION NUMBER 12
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml
JAN88
DEC88


OPEN RESERVOIR SAMPLING STATION NUMBER 16
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


OPEN RESERVOIR SAMPLING STATION NUMBER 17
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


OPEN RESERVOIR SAMPLING STATION NUMBER 18
3-H ANALYSIS
µCi/ml
10-4
10-5
10-6
10-7
PU ANALYSIS
µCi/ml
10-9
10-10
10-11
10-12
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10-6
10-7
10-8
10-9


OPEN RESERVOIR SAMPLING STATION NUMBER 19
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


OPEN RESERVOIR SAMPLING STATION NUMBER 20
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

APPENDIX E

NTS Environmental Monitoring

Natural Spring Stations and Plots

SYMBOLS

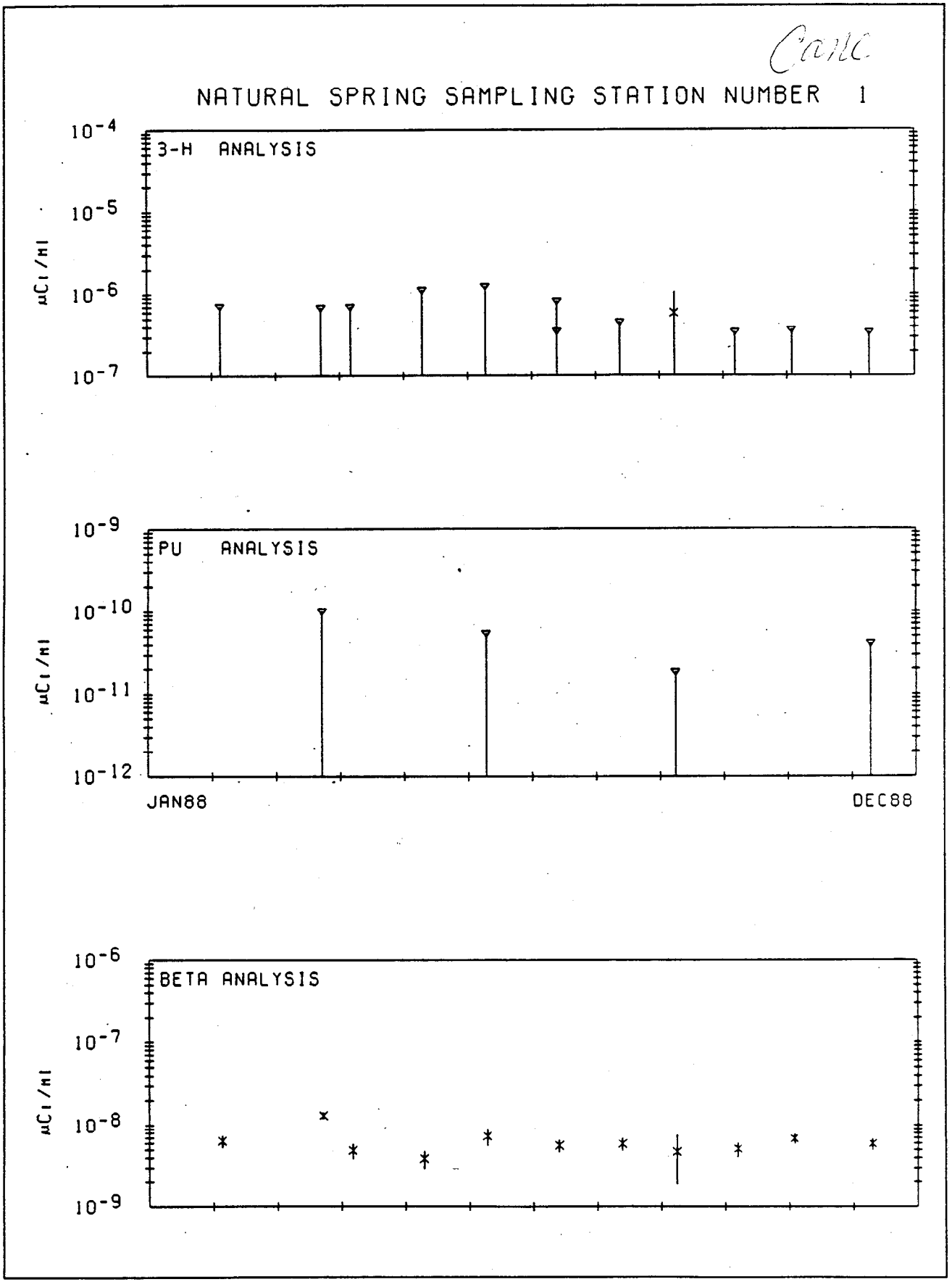
Several symbols are used in Appendix E to denote the data points. The plots display the gross beta, ^{239}Pu and ^{3}H data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits.

APPENDIX E

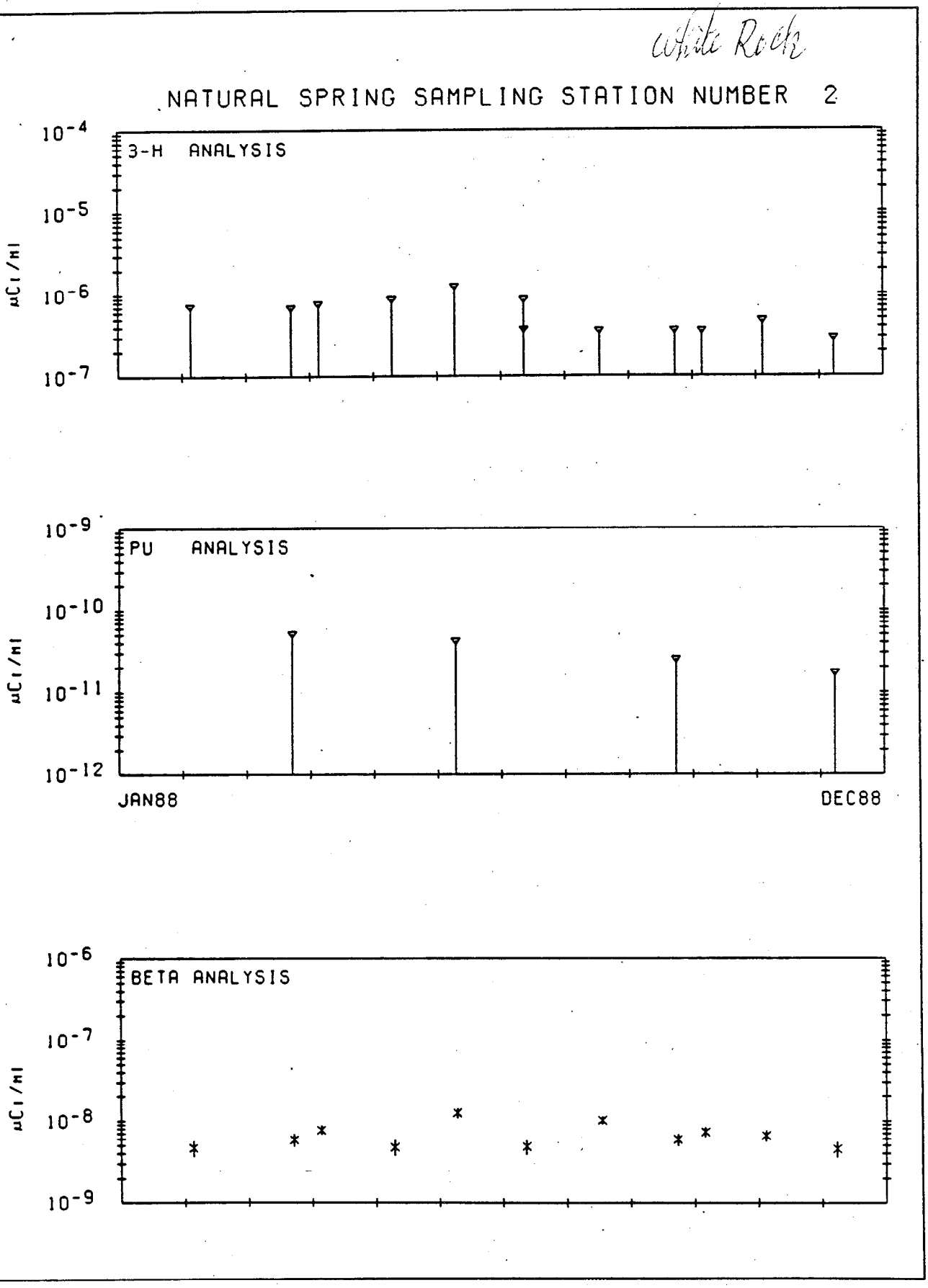
NTS Environmental Monitoring

Natural Spring Sampling Locations

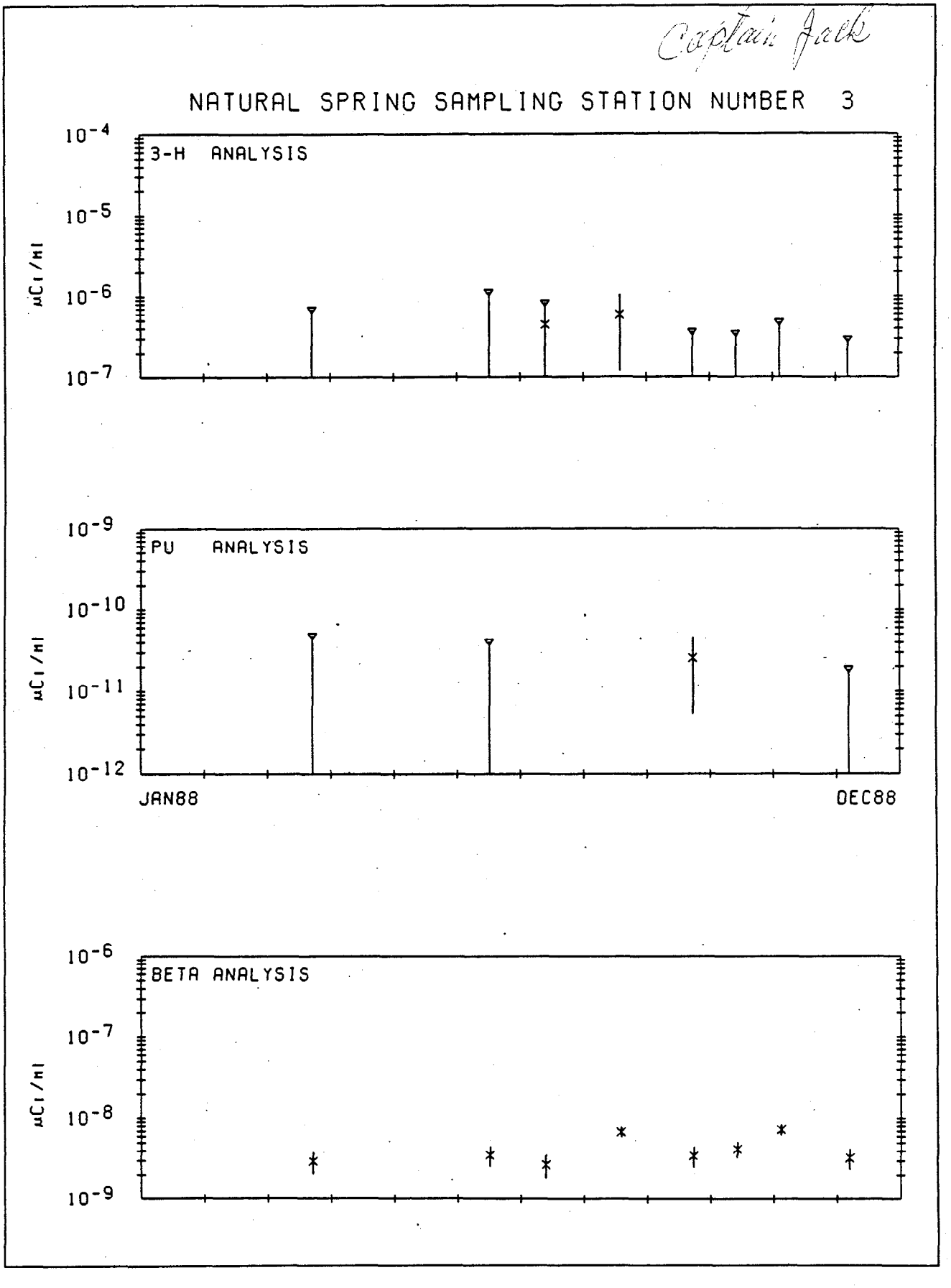
Station	Location
1	Area 5 Cane Spring
2	Area 12 White Rock Spring
3	Area 12 Captain Jack Spring
4	Area 12 Gold Meadows Pond
6	Area 15 Tub Spring
7	Area 29 Topopah Spring
8	Area 7 Reitmann Seep
9	Area 16 Tippipah Spring


NATURAL SPRING SAMPLING STATION NUMBER 1
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml

White Rock

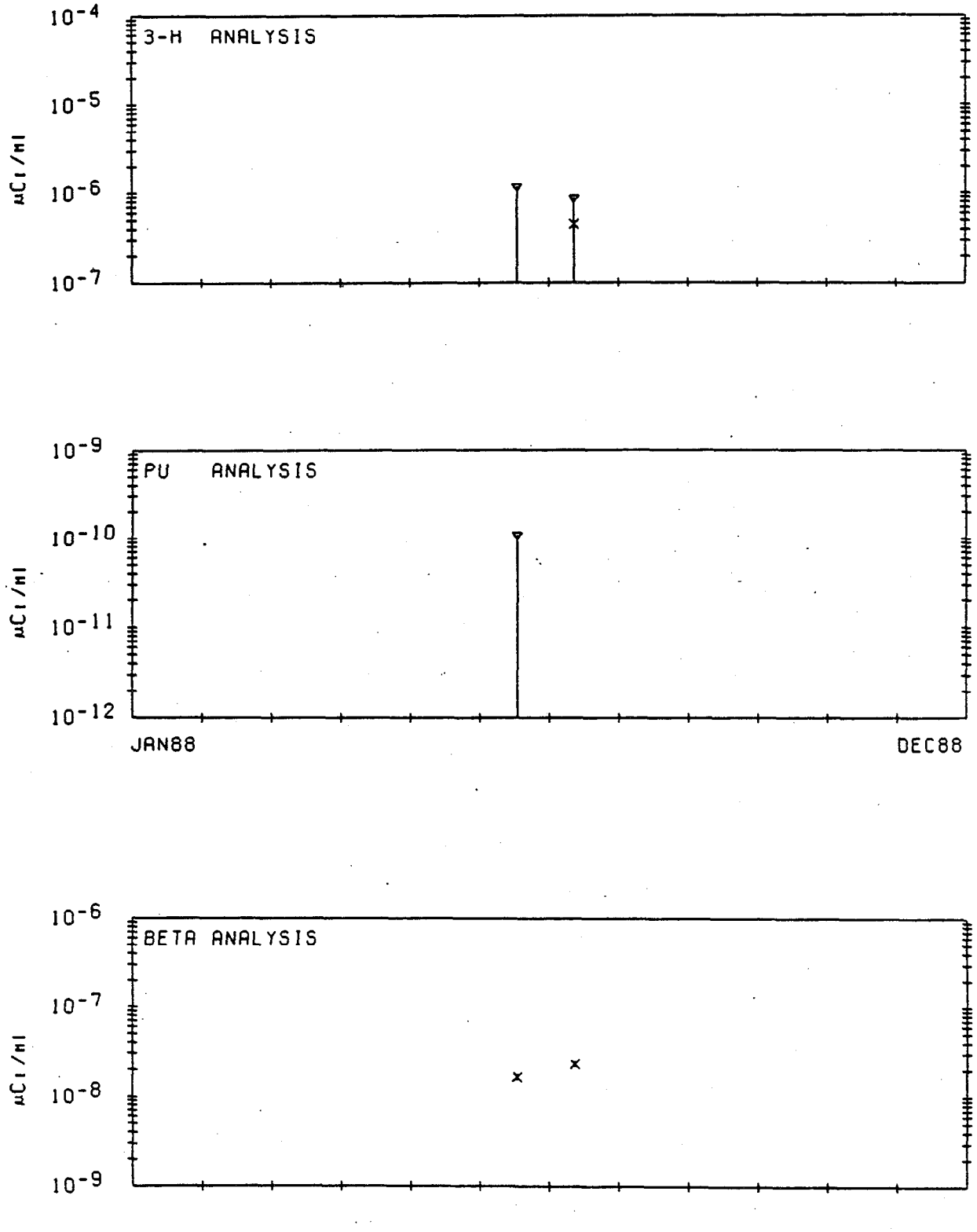

NATURAL SPRING SAMPLING STATION NUMBER 2
3-H ANALYSIS
10-4
10-5
10-6
10-7
µCi/ml
PU ANALYSIS
10-9
10-10
10-11
10-12
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10-6
10-7
10-8
10-9
µCi/ml

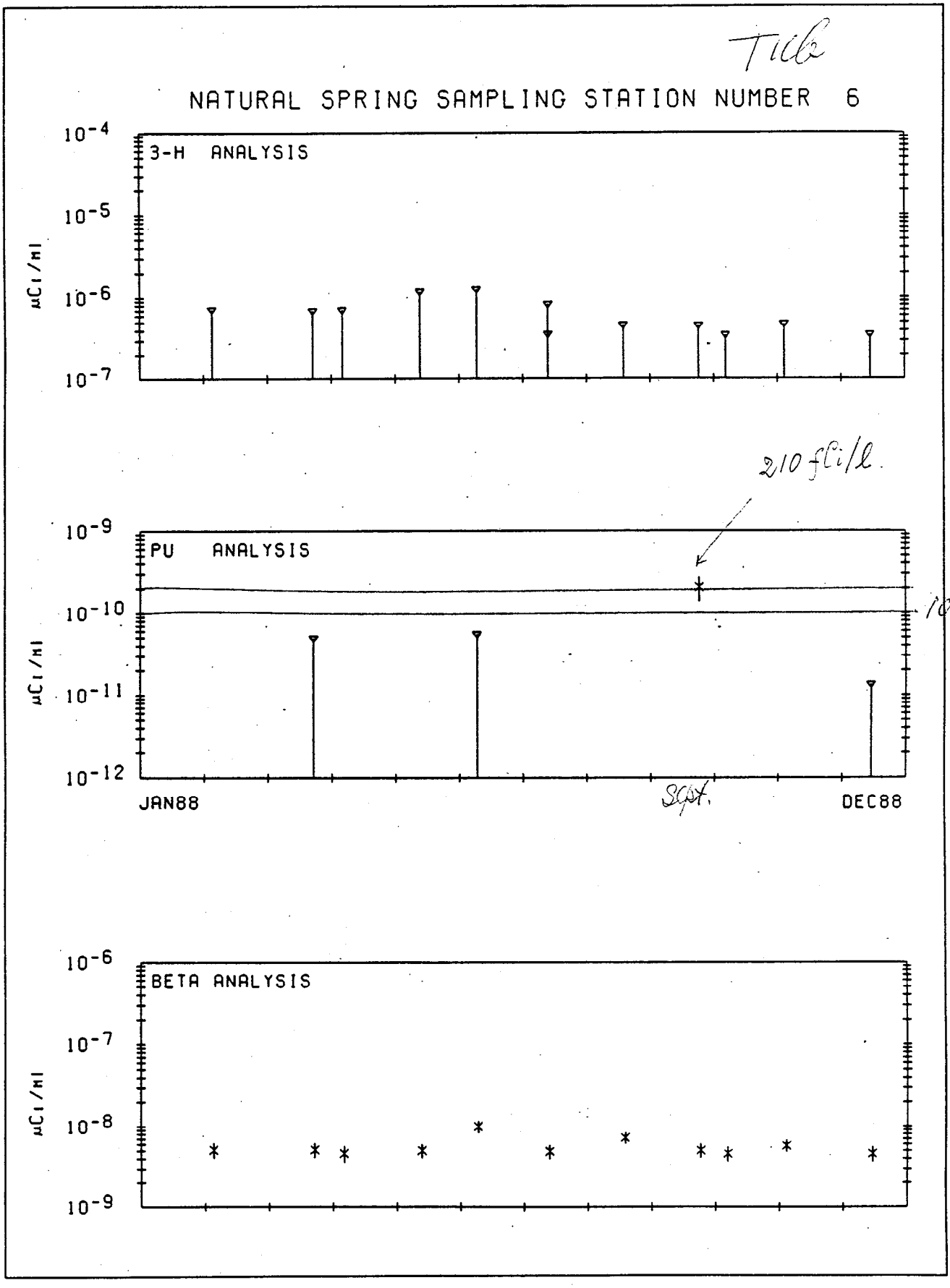
Captain Jack



Gold Meadows

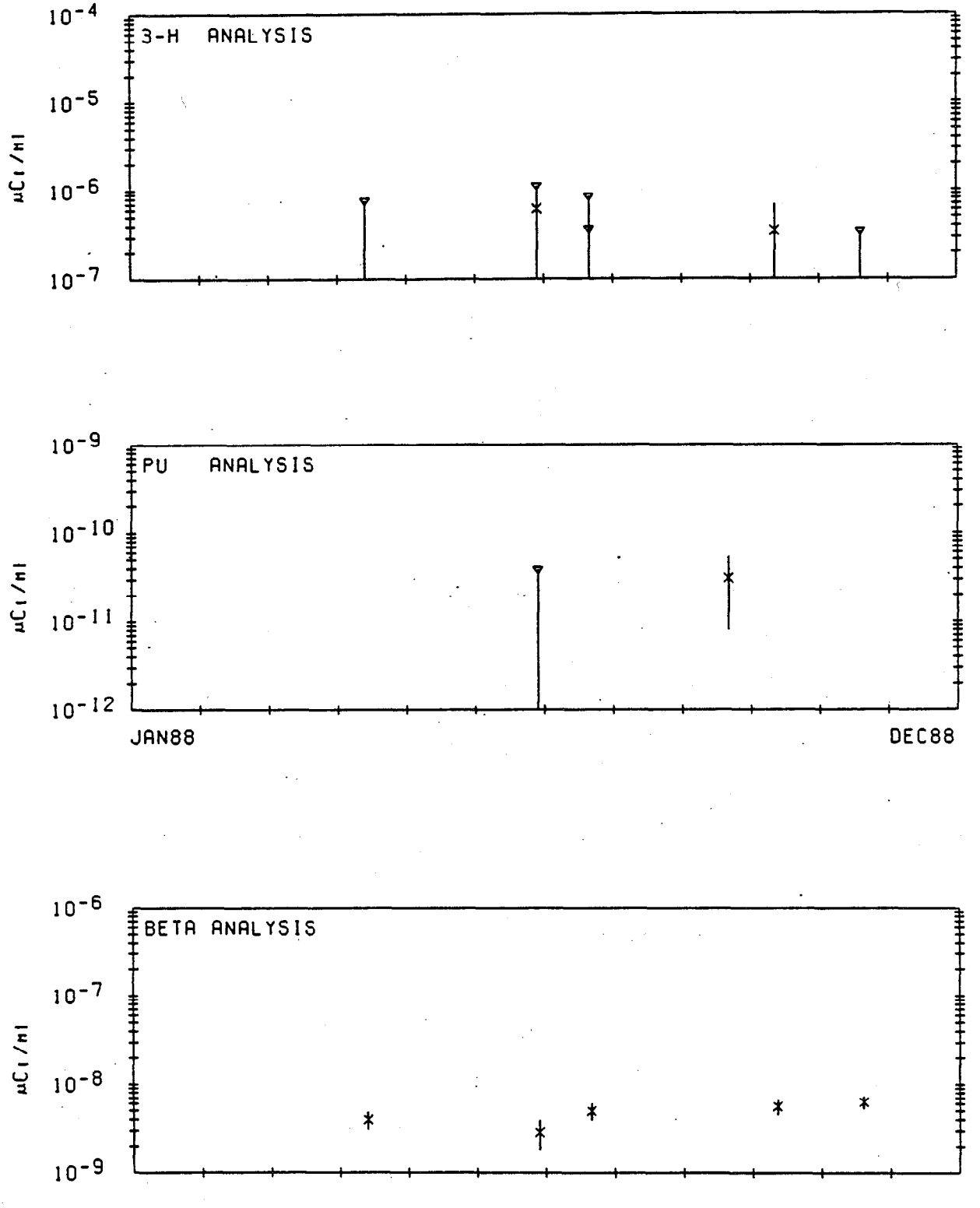
NATURAL SPRING SAMPLING STATION NUMBER 4

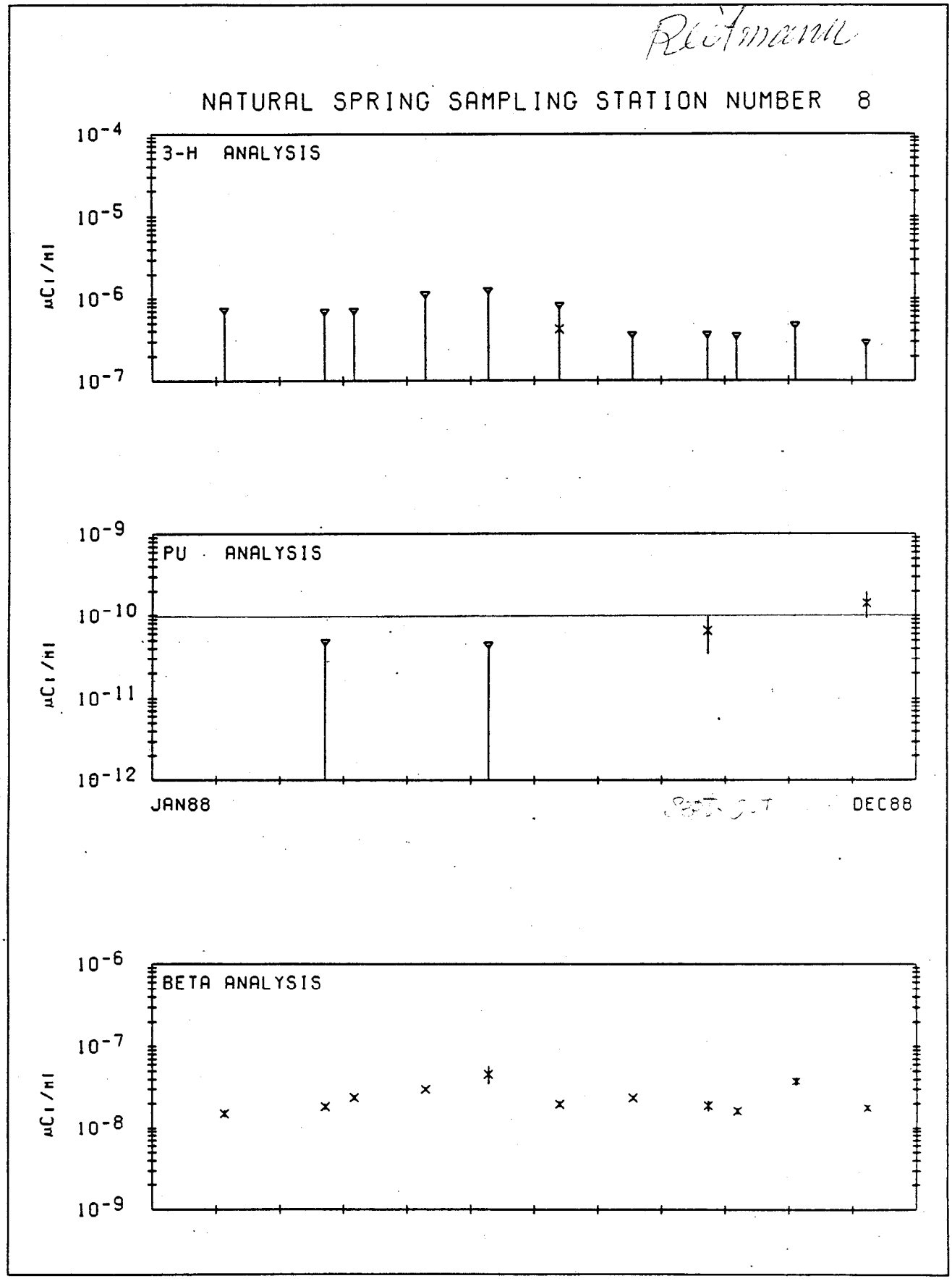



Tick
NATURAL SPRING SAMPLING STATION NUMBER 6
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
210 fCi/l.
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
100 pCi/l
JAN88
SEPT.
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}

Topopah

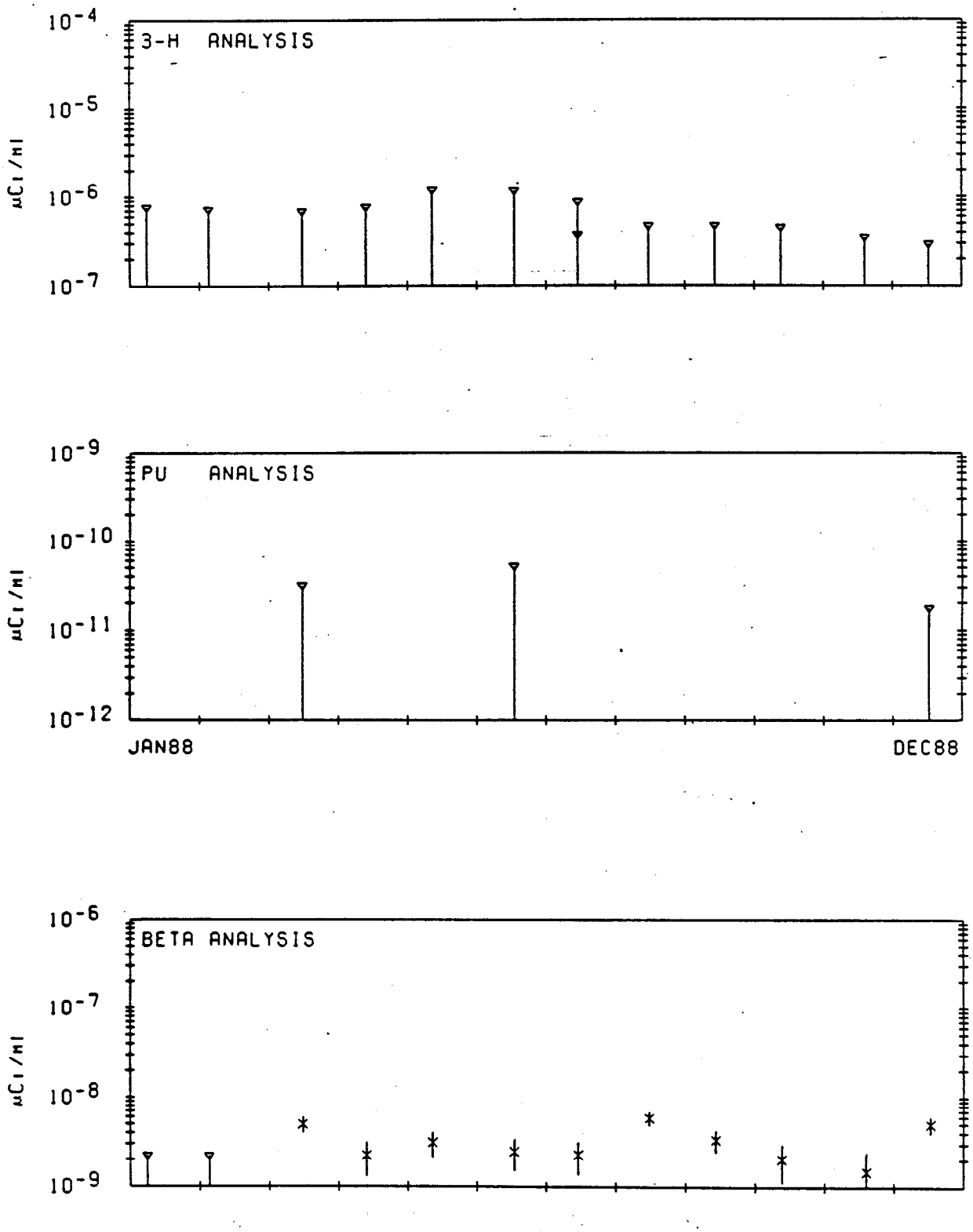
NATURAL SPRING SAMPLING STATION NUMBER 7




Rectangle
NATURAL SPRING SAMPLING STATION NUMBER 8
3-H ANALYSIS
µCi/ml
10-4
10-5
10-6
10-7
PU ANALYSIS
µCi/ml
10-9
10-10
10-11
10-12
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10-6
10-7
10-8
10-9

Tippipah

NATURAL SPRING SAMPLING STATION NUMBER 9



APPENDIX F

NTS Environmental Monitoring

Contaminated Pond Stations and Plots

SYMBOLS

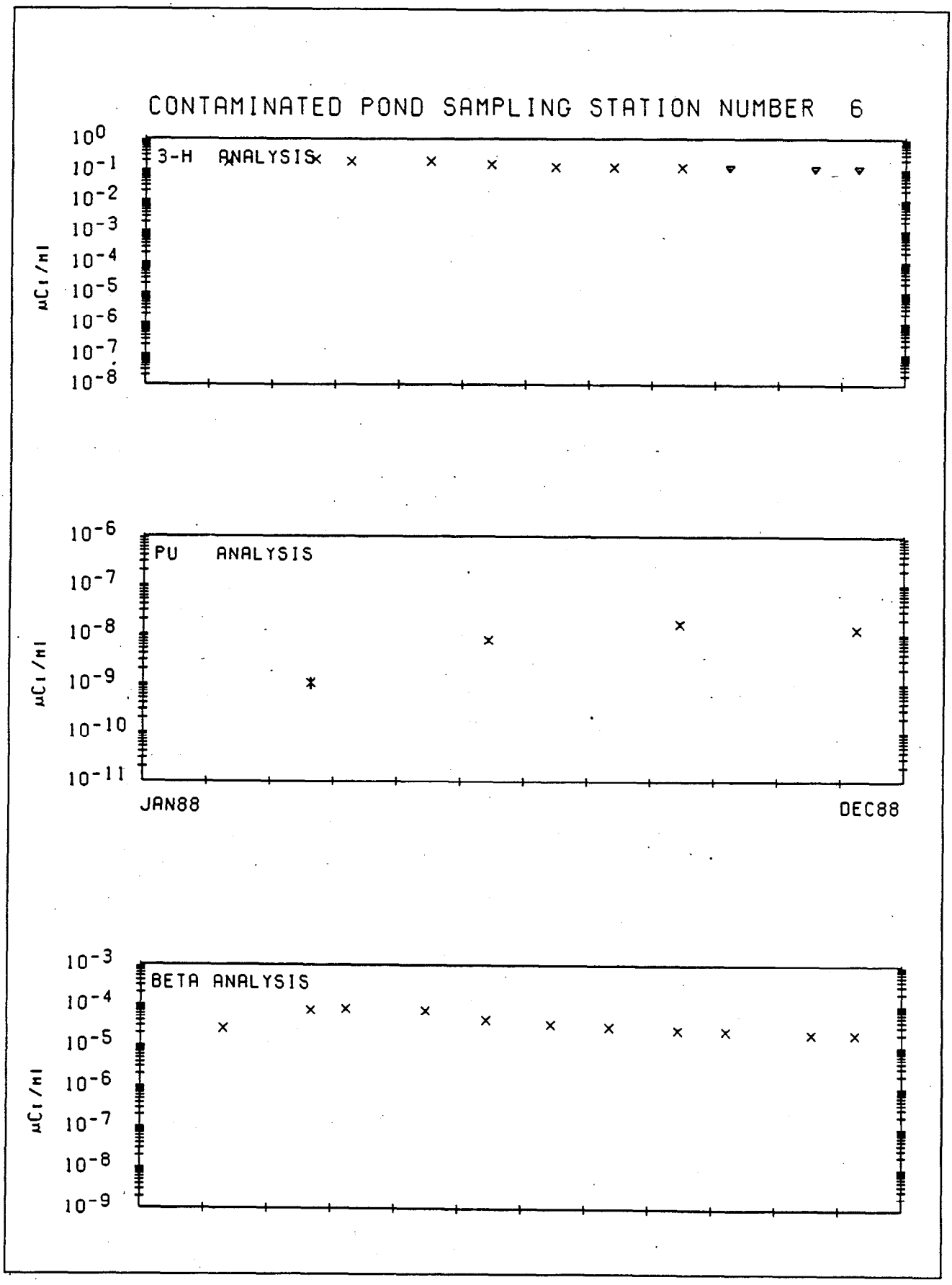
Several symbols are used in Appendix F to denote the data points. The plots display the gross beta, ^{239}Pu and ^{3}H data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits.

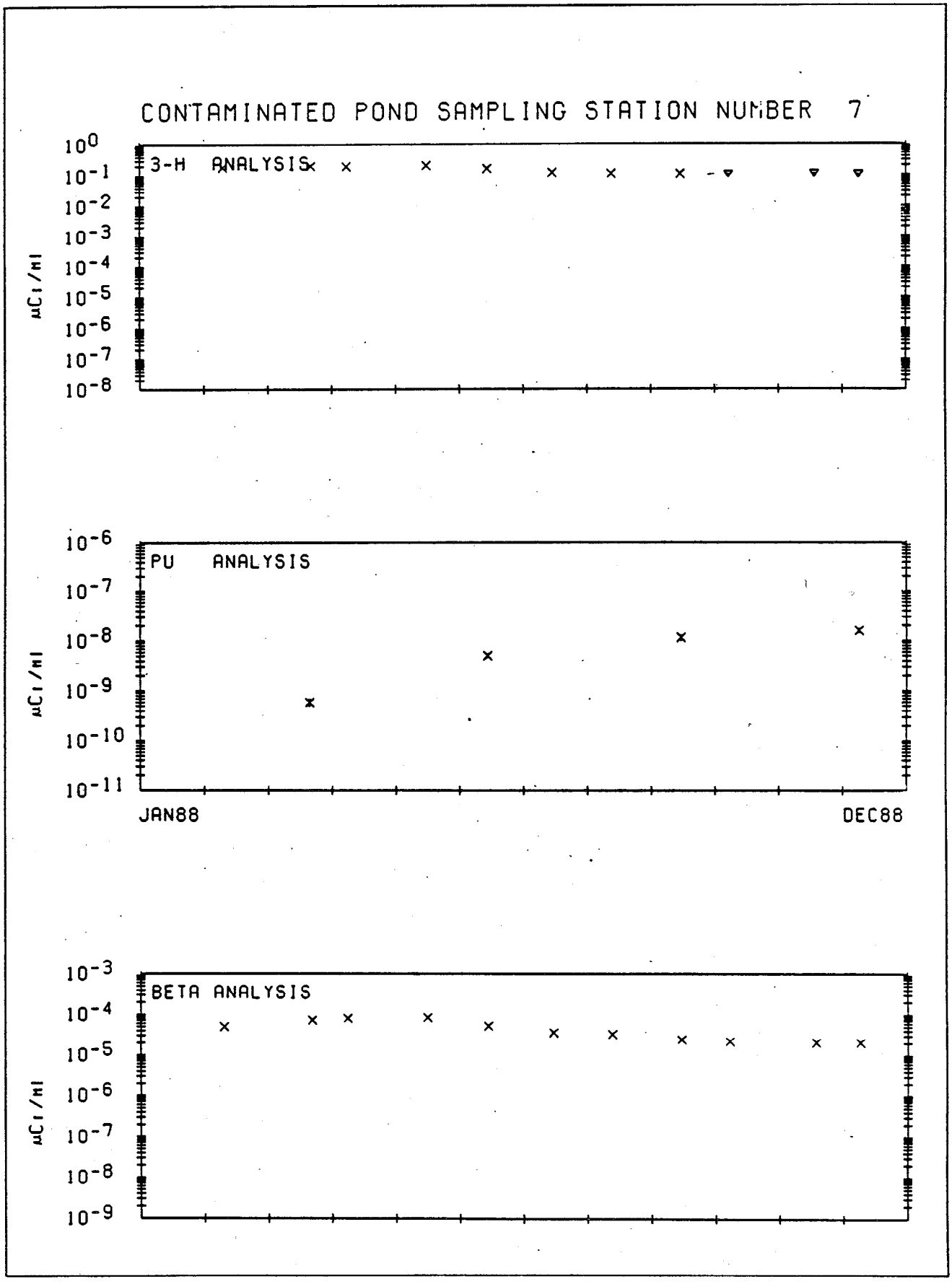
APPENDIX F

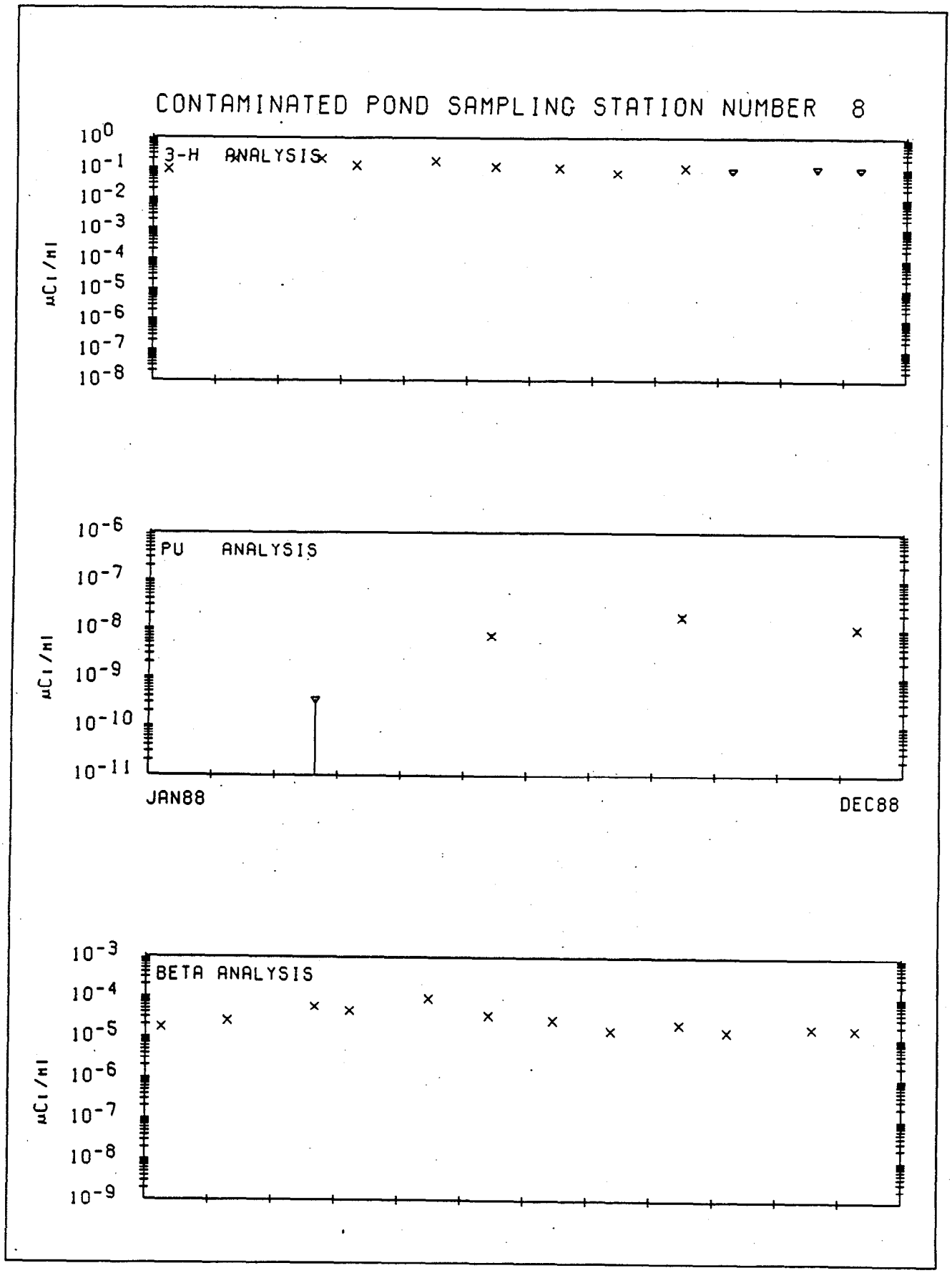
NTS Environmental Monitoring

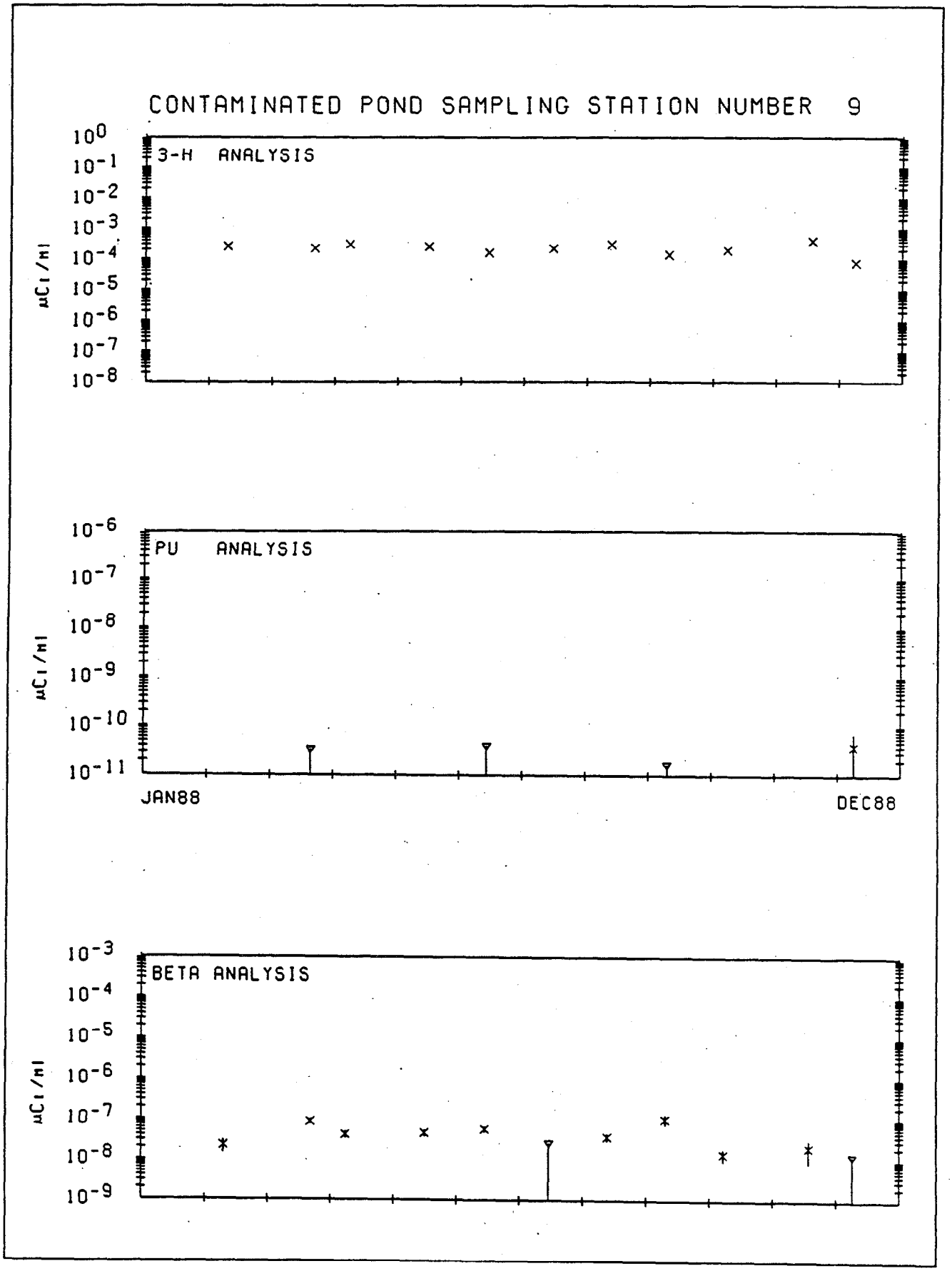
Contaminated Pond Sampling Locations

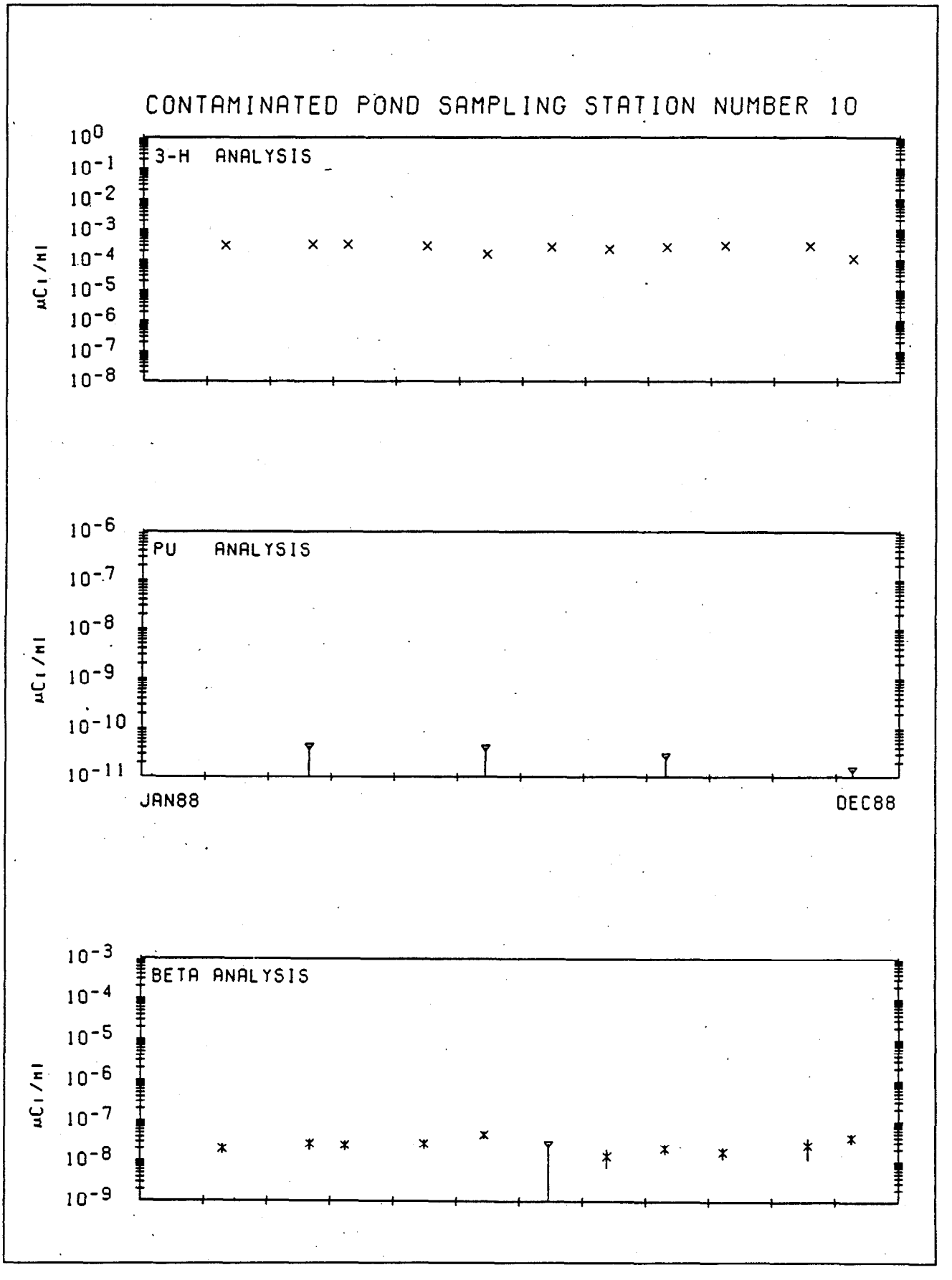
Station	Location
6	T Tunnel Pond No. 1
7	T Tunnel Pond No. 2
8	T Tunnel Effluent
9	N Tunnel Pond No. 1
10	N Tunnel Pond No. 2
11	N Tunnel Pond No. 3
12	N Tunnel Effluent
13	Yucca Waste Pond
14	E Tunnel Effluent
15	H & S Sump

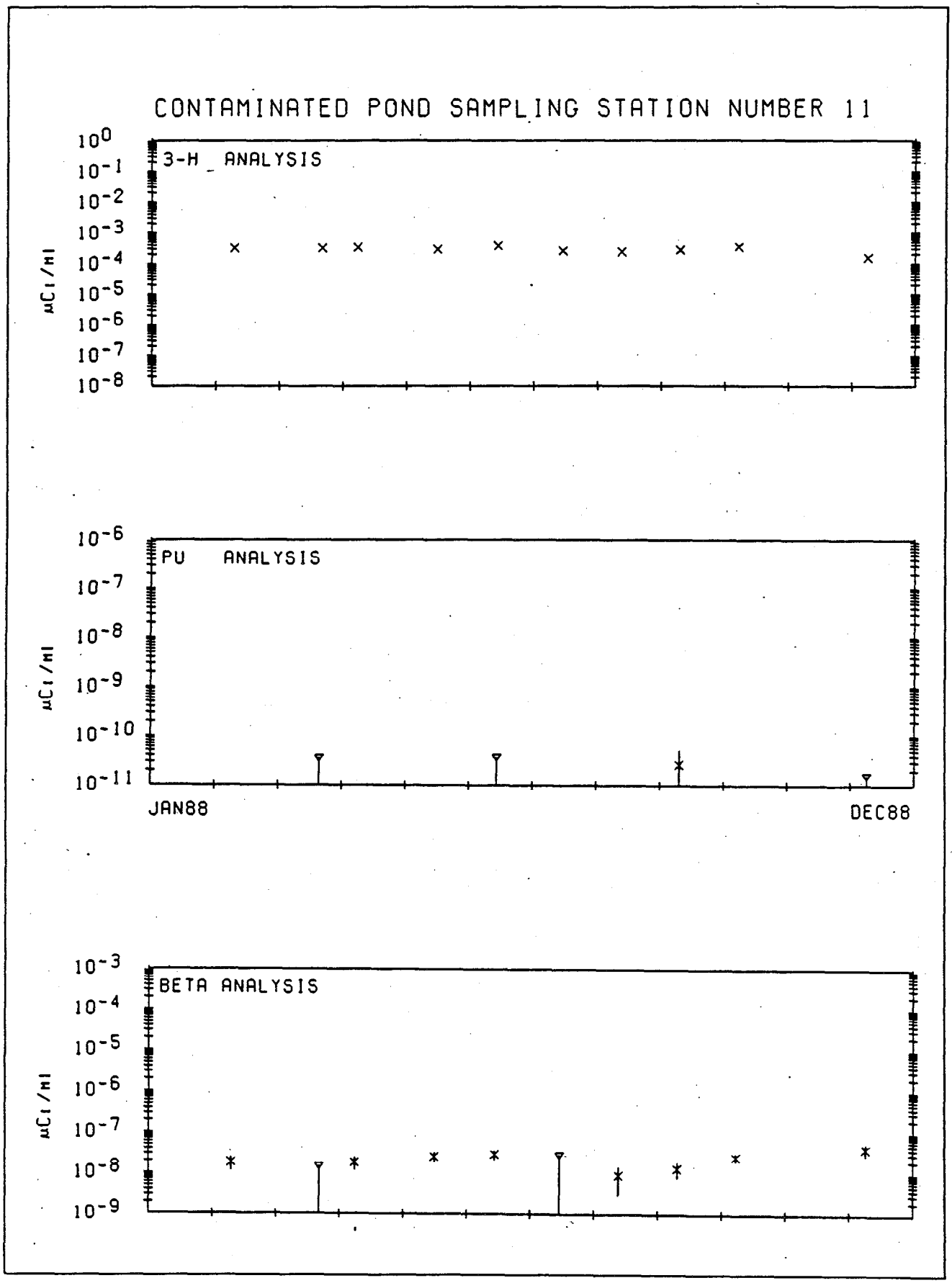

CONTAMINATED POND SAMPLING STATION NUMBER 6
3-H ANALYSIS
µCi/ml
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS
µCi/ml
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9

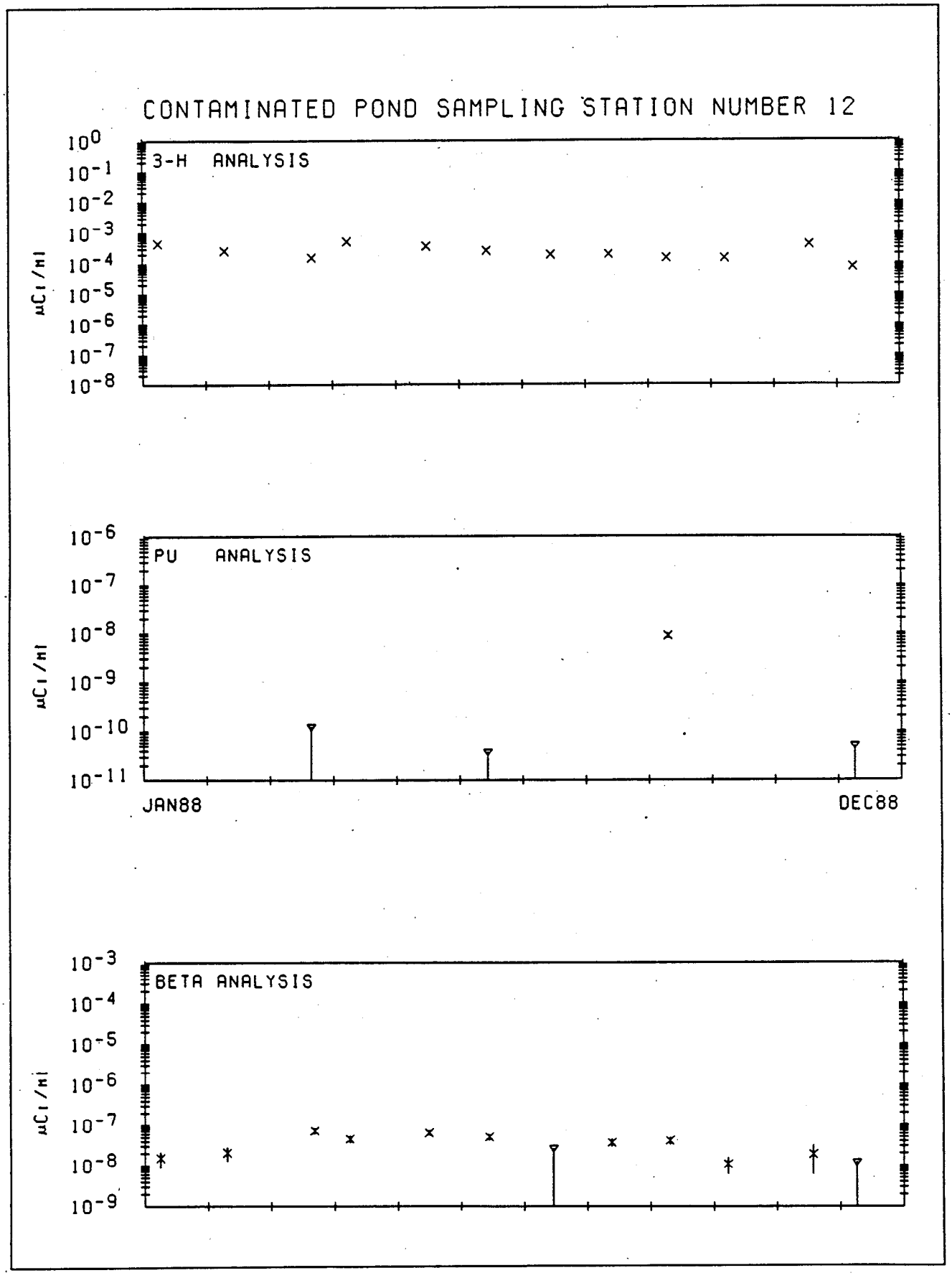

CONTAMINATED POND SAMPLING STATION NUMBER 7
3-H ANALYSIS
µCi/ml
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS
µCi/ml
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9

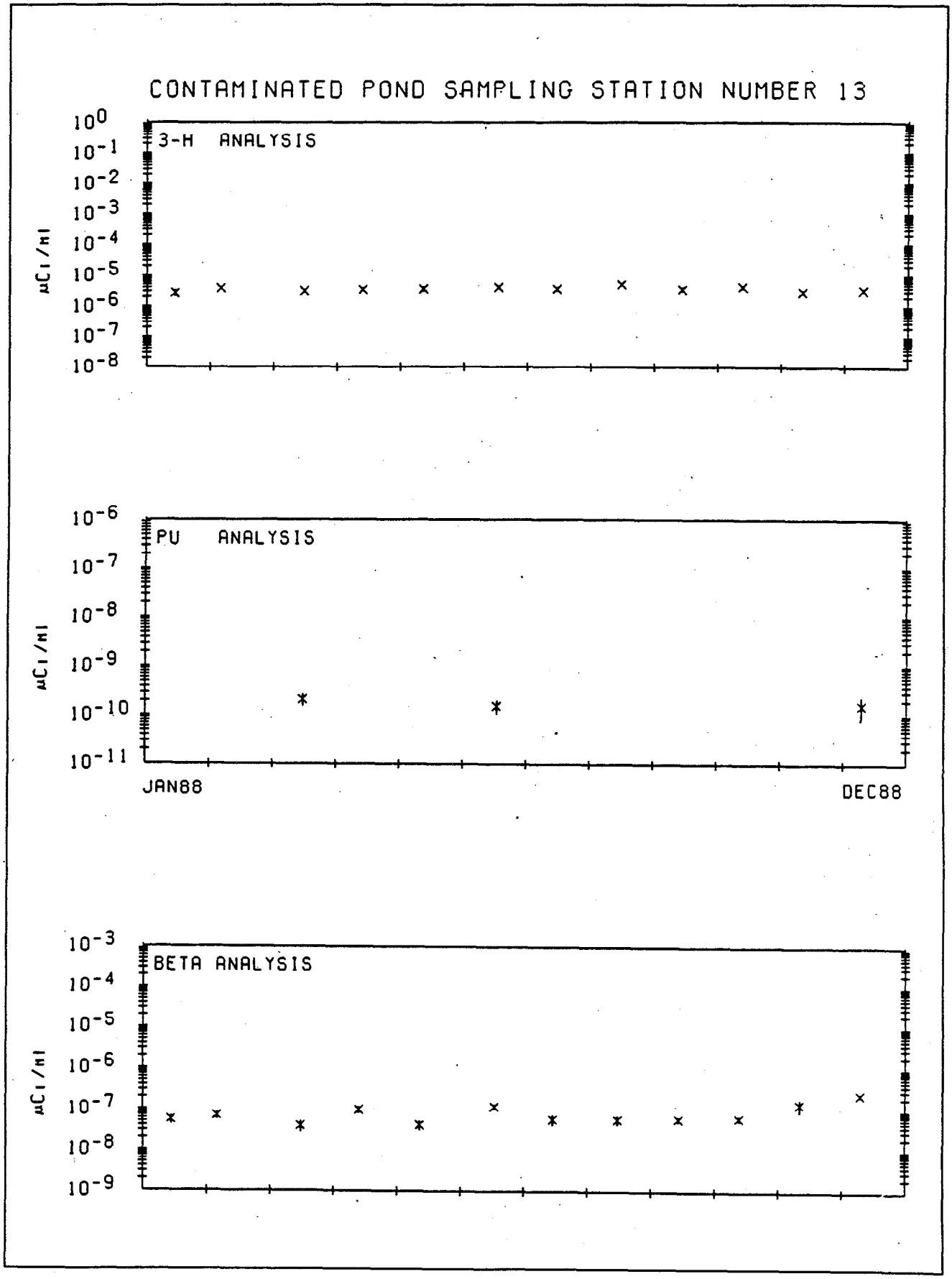

CONTAMINATED POND SAMPLING STATION NUMBER 8
3-H ANALYSIS
µCi/ml
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS
µCi/ml
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9

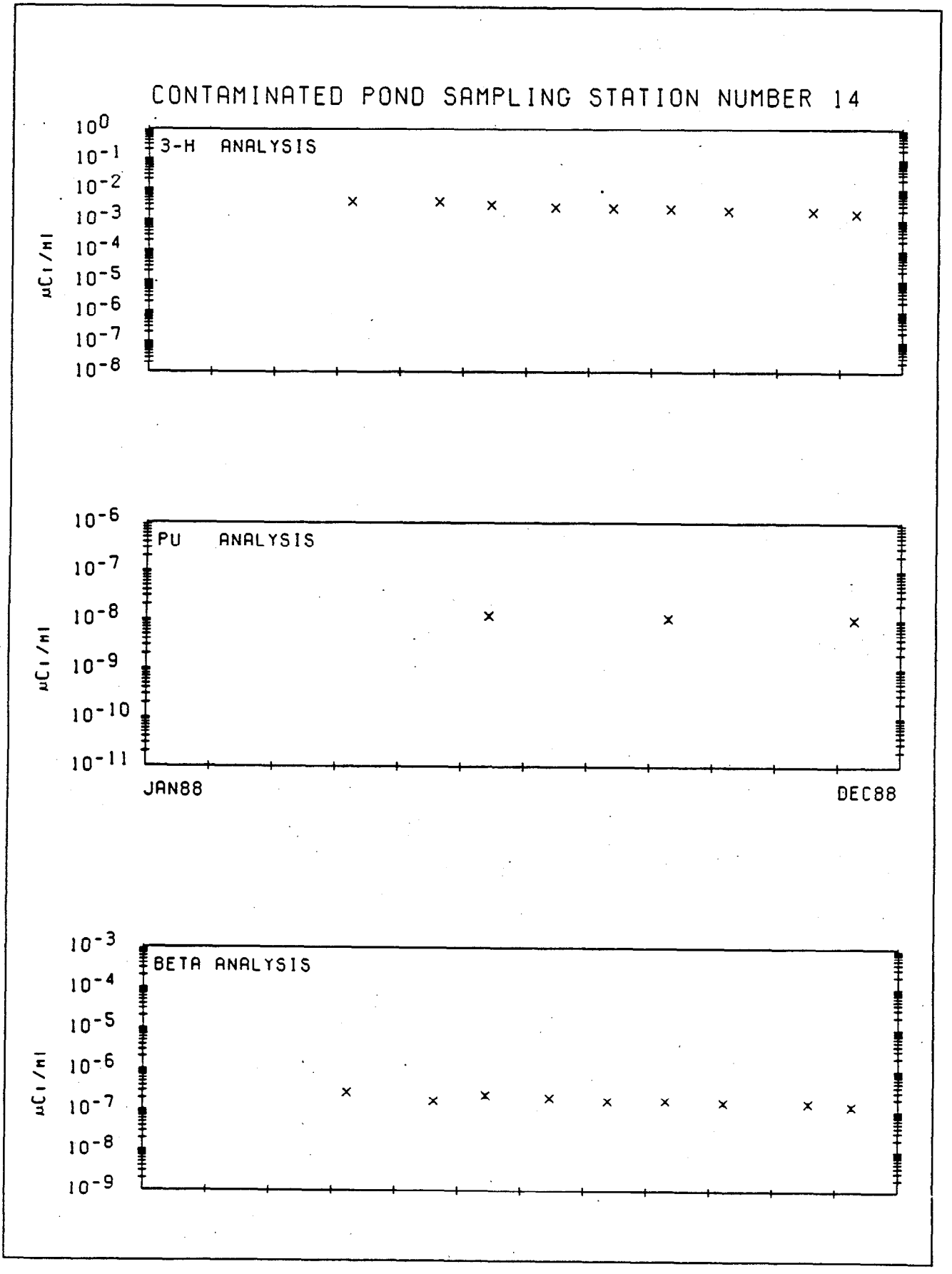

CONTAMINATED POND SAMPLING STATION NUMBER 9
3-H ANALYSIS
µCi/ml
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS
µCi/ml
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9

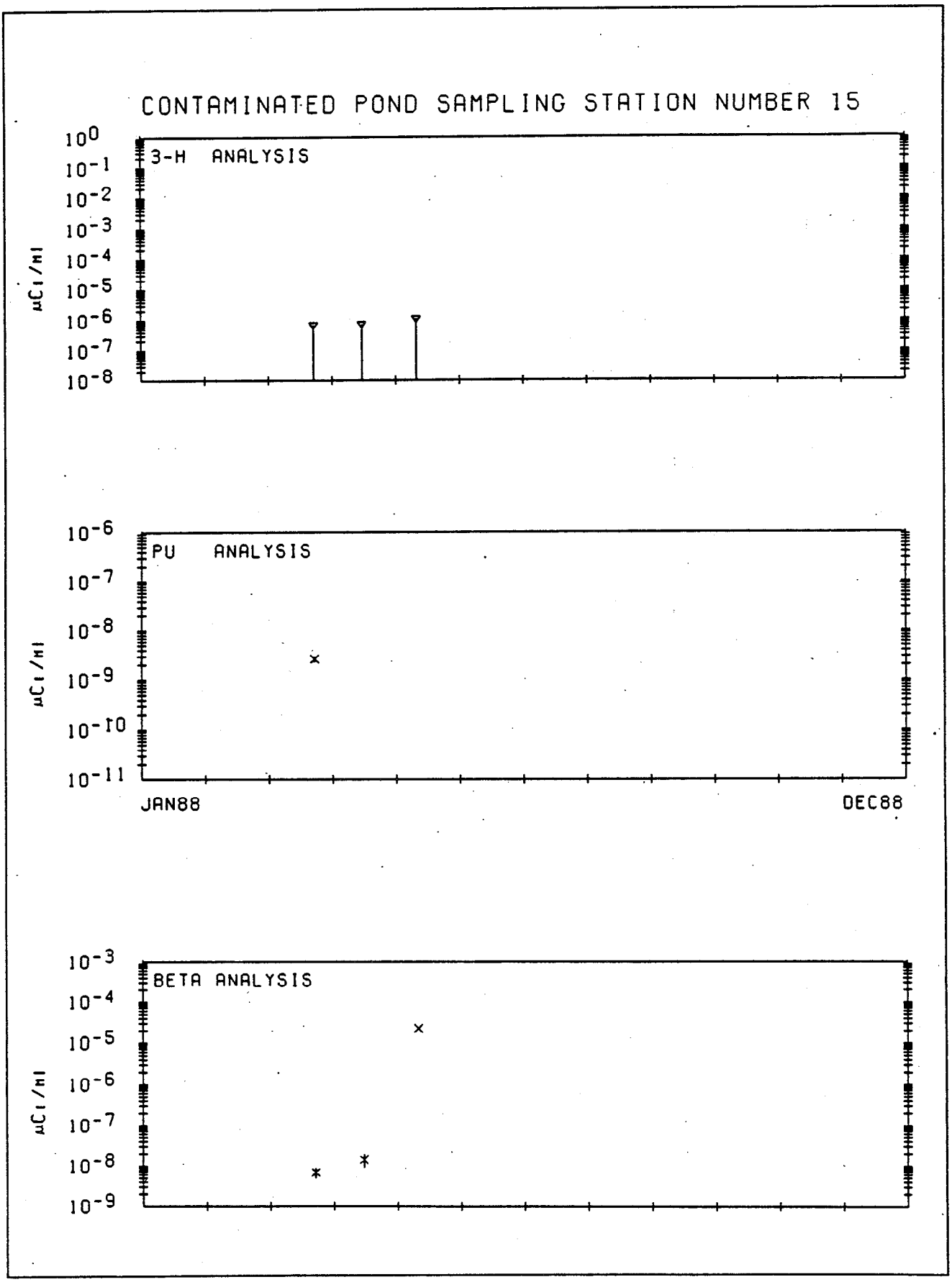

CONTAMINATED POND SAMPLING STATION NUMBER 10
3-H ANALYSIS
µCi/ml
10^0
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
PU ANALYSIS
µCi/ml
10^-6
10^-7
10^-8
10^-9
10^-10
10^-11
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9


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
JAN88
DEC88
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
JAN88
DEC88
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
JAN88
DEC88
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
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9


CONTAMINATED POND SAMPLING STATION NUMBER 15
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
JAN88
DEC88
BETA ANALYSIS
µCi/ml
10^-3
10^-4
10^-5
10^-6
10^-7
10^-8
10^-9

APPENDIX G

NTS Environmental Monitoring

Effluent Pond Stations and Plots

SYMBOLS

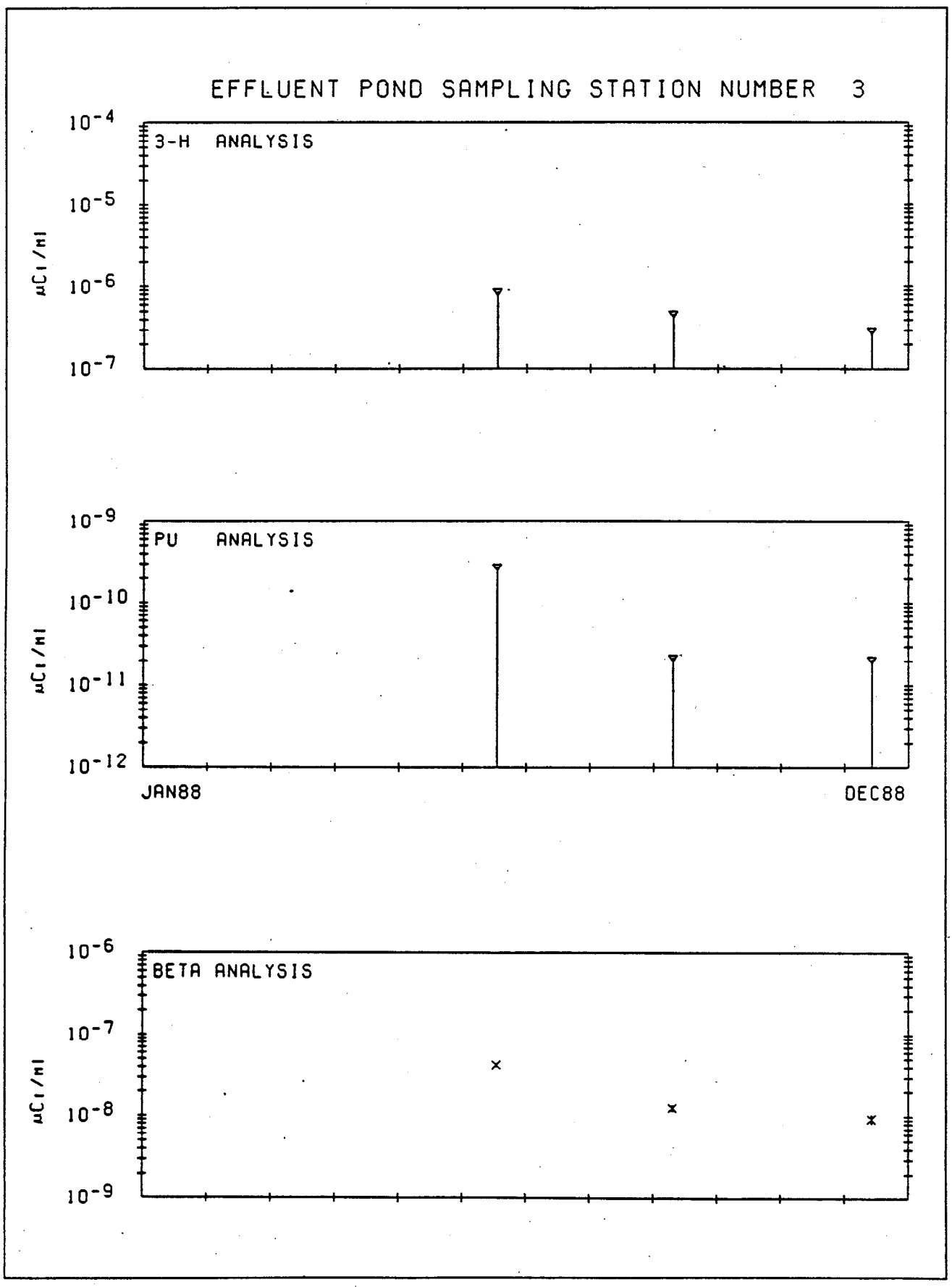
Several symbols are used in Appendix G to denote the data points. The plots display the gross beta, ^{239}Pu and ^{3}H data for each station. A two-sigma error bar is also added to the data points and in all of the plots a delta with a line to the bottom of the plot signifies a result below detection limits.

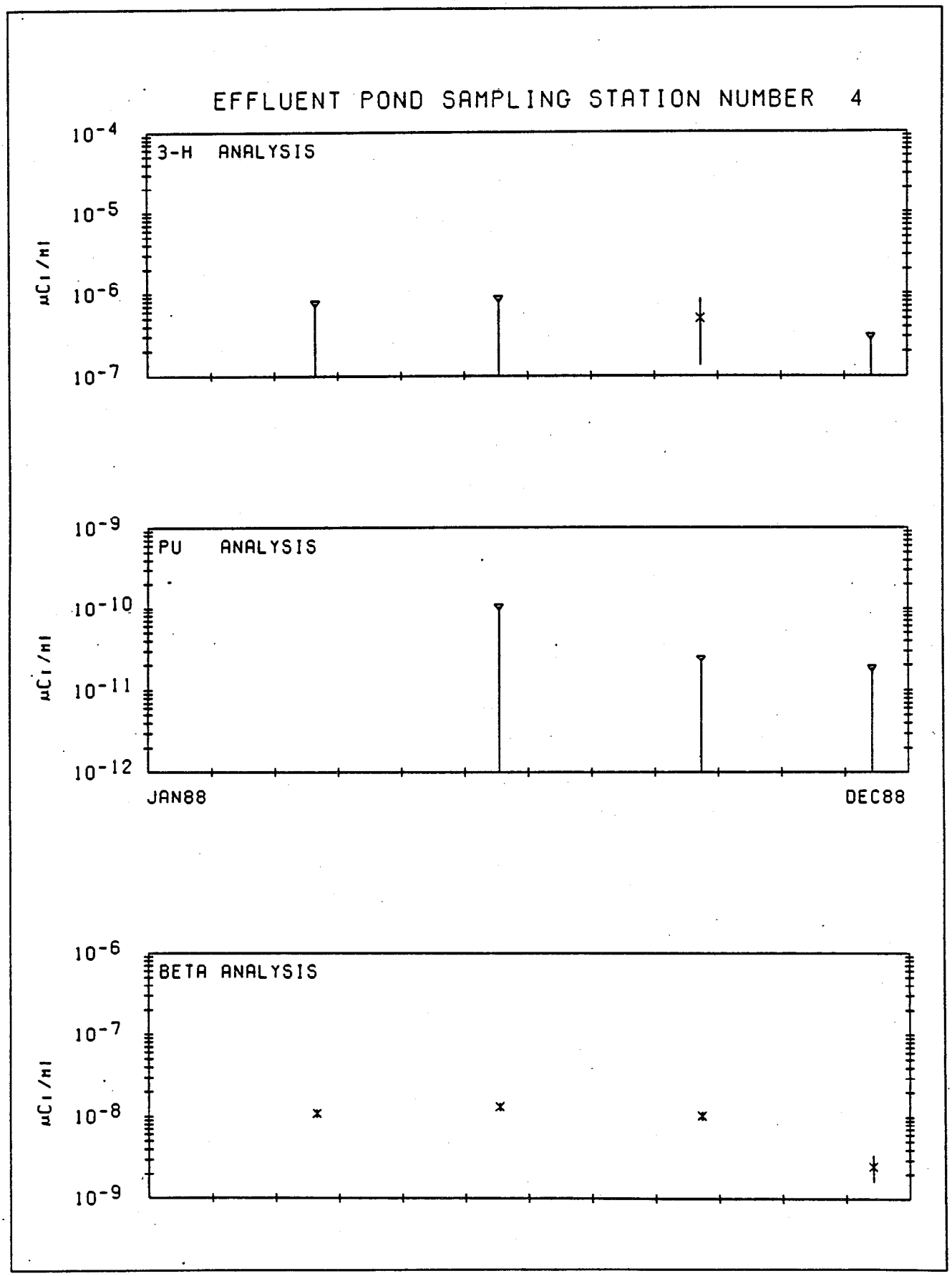
APPENDIX G

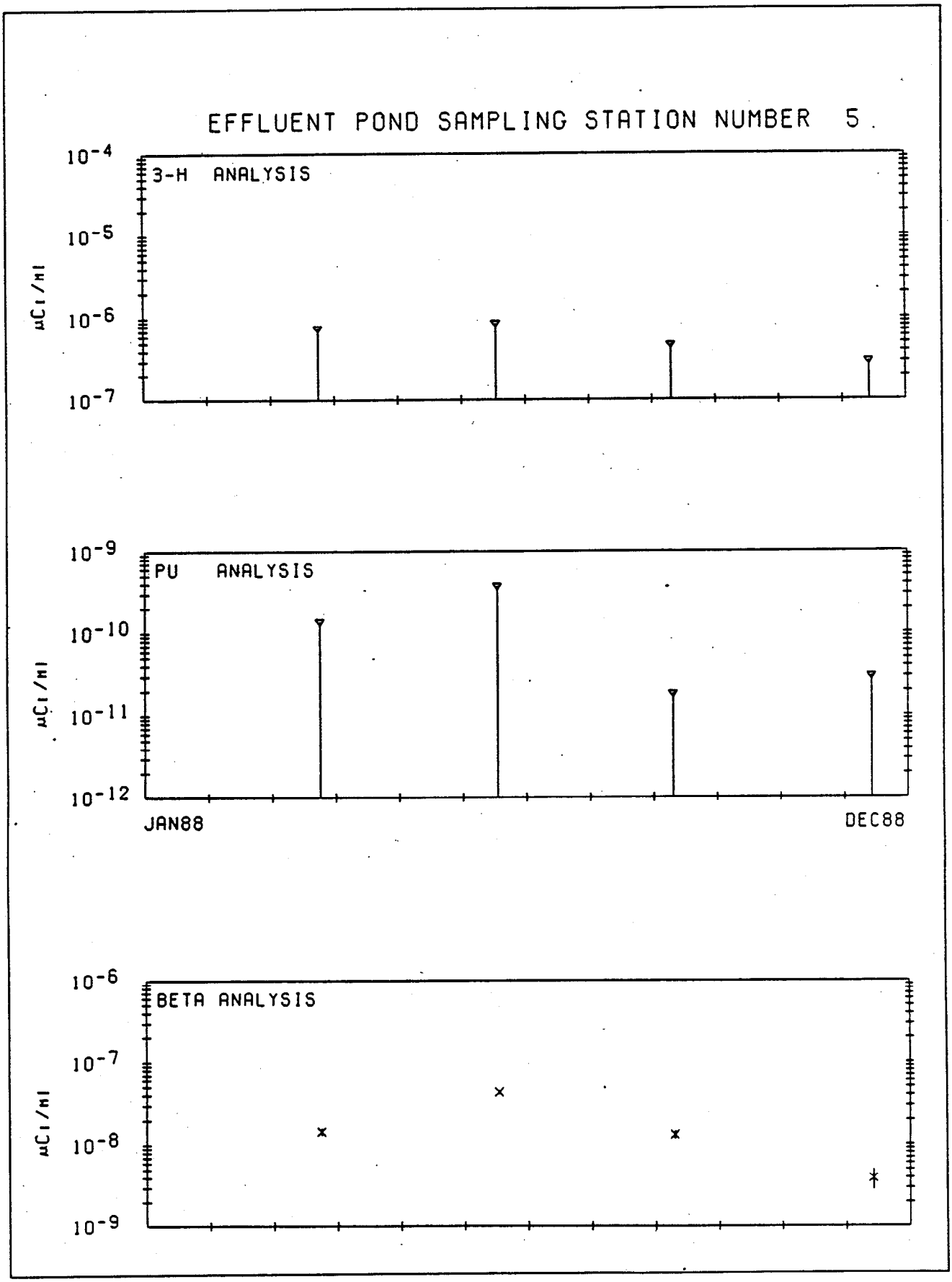
NTS Environmental Monitoring

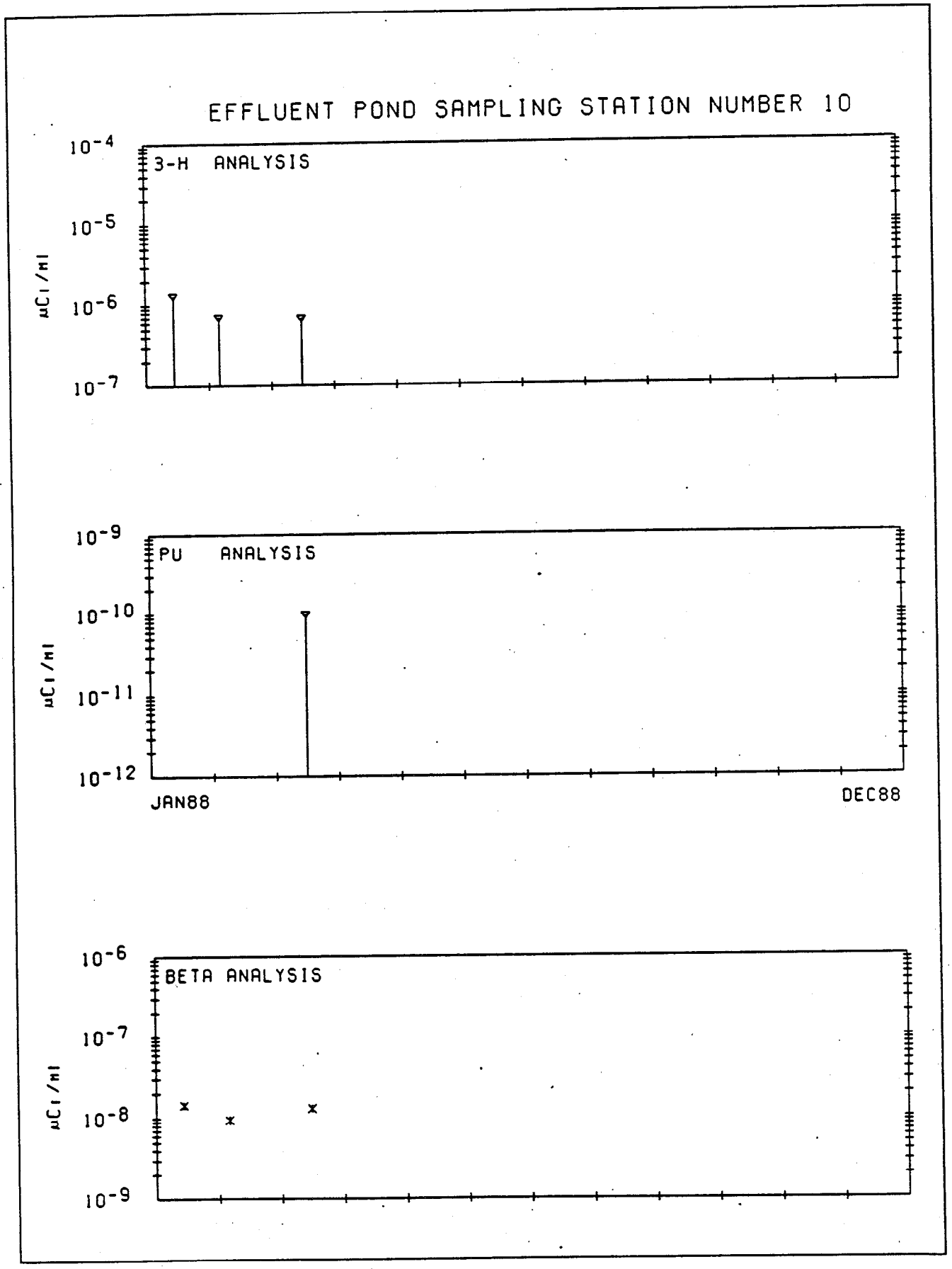
Effluent Ponds Sampling Locations

Station	Location
3	Area 6 Final Effluent Pond
4	Area 12 Sewage Pond
5	Area 23 Final Effluent Pond
10	Area 6 Yucca Steam No. 2


EFFLUENT POND SAMPLING STATION NUMBER 3
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


EFFLUENT POND SAMPLING STATION NUMBER 4
3-H ANALYSIS
10-4
10-5
10-6
10-7
µCi/ml
PU ANALYSIS
10-9
10-10
10-11
10-12
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10-6
10-7
10-8
10-9
µCi/ml


EFFLUENT POND SAMPLING STATION NUMBER 5
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml


EFFLUENT POND SAMPLING STATION NUMBER 10
3-H ANALYSIS
10^{-4}
10^{-5}
10^{-6}
10^{-7}
µCi/ml
PU ANALYSIS
10^{-9}
10^{-10}
10^{-11}
10^{-12}
µCi/ml
JAN88
DEC88
BETA ANALYSIS
10^{-6}
10^{-7}
10^{-8}
10^{-9}
µCi/ml