Assessment of Impacts of the

Revised Radon Limit in Table 2 of

Appendix B to 10 CFR Part 20

on Uranium Recovery Licensees

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I. Introduction

A. Background

The value for Rn-222 with daughters in Table 2 of Appendix B to 10 CFR Part 20 applicable to unrestricted areas has been lowered from 3E-9* microcuries per milliliter to 1E-10, a factor of 30 less. The usual unit for Rn-222 concentrations in the field is picocuries per liter (pCi/l). These Part 20 values equate to 3 pCi/l and 0.1 pCi/l, respectively. The 0.1 pCi/l value was calculated to give 50 millirem/year effective dose equivalent. Given this ratio, the new 100 millirem/year limit for members of the public in Part 20 corresponds to 0.2 pCi/l. The limited case-by-case option in the revised Part 20 of 500 millirem/year corresponds to 1.0 pCi/l. For perspective, note that the Environmental Protection Agency's (EPA's) standards for Title I sites being reclaimed by the Department of Energy (DOE) include a value of 0.5 pCi/l for reclaimed sites at the site boundary and EPA cites national average outdoor levels of 0.2 pCi/l. The current EPA action level for indoor radon is 4 pCi/l. Table 1 provides a summary of the Rn-222 limits and units.

The 100 millirem limit in revised Part 20 applies to all exposures from activities under a licensee's control. Case-by-case exemptions permitted under §20.301(c) of the revised Part 20 to allow exposures of up to 500 millirem must similarly include all exposures. For uranium

*3E-9 means 3 X 10-9.

recovery licensees, this means that direct gamma external exposures from uranium daughters and all internal contributions from all radionuclides and pathways must be added together and compared to the limit. Based on a NRC staff cursory review of data in a 1984 report on NRC licensee compliance with 40 CFR Part 190, contributions from external exposures and whole body equivalent doses from other radionuclides should be less than 20 millirem per year to the nearest real person for all licensees and less than 10 for most licensees. (Part 190 excludes radon so the report was useful only for the nonradon contributions from natural uranium, Th-230, Ra-226, and direct gamma. The report also did not include New Mexico licensees since the program was not returned to NRC until 1986.) The comparison included using the lower concentrations in the revised Part 20 for radionuclides such as natural uranium to be sure that radon was the dominant concern.

Since radon appears to be dominant, only radon data was collected, with one exception (see Kerr McGee, site 11 in Section III). However, this exception indicates that radon may not be dominant or the only problem. Further, EPA has informed NRC staff that recent risk assessments for both NRC and Agreement State licensed mills done as part of ongoing Clean Air Act (CAA) rule development showed that all mills could meet a 10 millirem effective dose equivalent limit for the nonradon air emissions. In any case, assessment of the radon levels provides an indication of the potential magnitude of the impacts.

B. Purpose

The primary purpose of this assessment was to determine whether existing and readily available data could be used to assess whether uranium recovery licensees could comply with the new limit of 0.1 pCi/l for Rn-222 in Table 2 of Appendix B to 10 CFR Part 20 at the site boundary or comply with values of 0.2 pCi/l or 1.0 pCi/l at the site boundary or at the location of the nearest or maximum exposed real person.

C. Summary

Readily available industry generated Rn-222 data on 11 uranium recovery facilities and one thorium/rare earth facility were collected and analyzed. The ten uranium mills are either operating or in standby status and the in situ facility is operating. Table 2 provides a summary of the Rn-222 concentrations for 1987 and 1988 for the 12 facilities. (Values for other years and more details on the site-specific information is presented for each site in the text.) Average annual net concentrations for the site boundary, the nearest resident, and other reported locations are given in the first six columns. Annual average background values are given in the last two columns. Analysis of the data revealed a number of uncertainties, including background Rn-222 values ranging from 0.1 to 6.9 pCi/l, apparent contributions from sources other than the mill and tailings, varying quantities of tailings, varying sizes and status of impoundments, values near detection limits, and uncertainties in sampling locations. The finding was that none of the sites are likely to be able to consistently measure and meet a Rn-222 limit of 0.1 pCi/l.

A finding concerning compliance with a 1.0 pCi/l limit is complicated by the difficulties with the data. Figures 1 and 2 are charts presenting net annual Rn-222 concentration data from the 12 facilities examined.

Figure 1 shows 1987 data and Figure 2, 1988. The facilities are designated by the same number on each chart. For each facility, data from Table 2 on site boundary values, nearest resident, and other off site locations are shown. However, for some sites, no data were available for the year (i.e., facility 7 in 1987 and facility 9 in 1988) or no data for one or more of the three categories were available. Where multiple values or ranges were involved, the values shown represent the maximum deviation for a given category or worst case. In 1987, only two sites exceeded 1 pCi/l and in 1988, five exceeded 1 pCi/l. Thus, it appears that the majority of the mills may be able to meet a limit of 1.0 pCi/l. In situ facilities (based on fully operational 1988 data for facility 8) may have to modify operations to meet a limit of 1.0 pCi/l. The thorium facility (facility 11) is in the process of being decommissioned and is a special case.

The effort also led to conclusions that current measurement and calculational practices are not adequate to address compliance with the revised Part 20 as submitted to the Commission in SECY-88-315 and that this preliminary assessment may need to be followed by more comprehensive evaluation of potential impacts, monitoring programs, and development of additional guidance.

II. Overview of information sources

The information sources for this assessment included representatives of NRC's Uranium Recovery Field Office (URFO), who have the licensing and inspection responsibilities for NRC's uranium recovery licensees. URFO collected monitoring information and data from dockets, surveyed several licensees, and provided personal views and input. NRC conducts no independent radon monitoring. Representatives of the American Mining Congress (AMC) that were contacted included Jim Gilchrist, Lew Cook, and Tony Thompson. All AMC data was provided by Mr. Gilchrist. Mr. Cook works for Cheveron in Texas and is Chairman of an AMC uranium group. Agreement State officials in Texas (Department of Health and Bureau of Radiation Control) were also contacted for input and data. Texas has a number of operating conventional mills and commercial _in situ_ facilities. No summaries of licensee radon data were available from Texas and Texas does not do independent radon monitoring. Texas does conduct confirmatory monitoring for other radionuclides, but a summary report was in progress and not available. No summary reports for previous years were available. EPA's CAA background document, which should provide EPA's basis for risk estimates for uranium mills for both radon and other radionuclides, was not consulted and the matter was not discussed with EPA.

III. Radon data

A. Introduction

Monitoring programs imposed by license conditions generally include the monitoring locations, radionuclides to be monitored, requirements for continuous radon monitoring, and other matters. 10 CFR 40.65 requires that licensees report environmental monitoring reports every six months. NRC licensees generally conduct radon monitoring, by quarters, using alpha track etch methods. Although background locations are included in licensee programs, the gross results are usually compared to the existing limit of 3 pCi/l to avoid uncertainties in true background and contributions from unlicensed sources (e.g., mine vents).

There are no existing NRC reports or other summary documents which address current measured radon levels at licensed sites. In order to minimize the impacts on URFO and AMC staff, only readily available and typical data were requested and the assessment in this document is not a formal finding of compliance or noncompliance with any limit.

There are 19 conventional mills licensed by NRC. Only eight of these are operating or in standby with the option to resume operations. Data from each of the eight and for two Agreement State licensed sites are discussed in the next section. Data from an operating NRC-licensed commercial <u>in situ</u> uranium recovery facility were also obtained and are presented in the next section (see facility 8.).

The amount of tailings at the licensed sites varies over a wide range. Figure 3 from a July 1987 staff briefing lists both NRC and Agreement State licensed mills by state and provides estimates of the amount of tailings as of July 1985. The values range from 0 to 33 million tons. The number of impoundments containing these quantities of tailings and their size and shape also vary considerably from site to site. Several sites have single impoundments and others have four or more impoundments in use and in various stages of closure. At some older sites, tailings were also used to construct dams and embankments.

B. Specific sites

1. UMETCO, White Mesa, UT

The White Mesa mill operates on a regular basis and reflects the current state-of-the-art in tailings management. For example, the impoundments are all lined and are fairly small (e.g., about 40 acres). The program meets the current work practice standards in the existing EPA CAA regulations in Subpart W of 40 CFR Part 61. All three existing impoundments are water covered or filled, which minimizes radon releases. The impoundments now contain about 2.2 million tons of tailings. (This site is listed under Energy Fuels in Figure 3.) The operator has a request pending with EPA for at least one additional impoundment. The data and analysis provided are the most complete of all data obtained.

In Figure 4, the licensee shows the gross or ambient Rn-222 levels for the various monitoring stations over a three year period. This figure graphically illustrates the fluctuations in ambient Rn-222 levels and suggests how difficult demonstrating compliance by measuring concentrations will be for a value as low as 0.1 pCi/l. Only one gross level was this low and it was not the background location. This type of fluctuation is common in all the data obtained. Detection limits are generally about 0.1 pCi/l also.

The notes to Table 3 describe the locations of the monitoring sites, BHV-1 to BHV-6, indicated in Figure 4. The primary purpose of Table 3 is to present the average annual net Rn-222 concentrations. (In determining compliance with 10 CFR Part 20, annual averaging is used and the contribution from the licensee's operations and activities is compared to the limits.) Data from the second quarter of 1985 through the end of 1988 were used to calculate the values in Table 3. The values for the northern border (BVH-1) range from 0 to 0.3 pCi/l. The nearest resident measurements are reflected by BVH-2 and BVH-6 and range from 0 to 0.5 pCi/l. The uncertainties in interpreting monitoring results are illustrated by the results. For example, different values were obtained for samplers on the same power pole for the nearest resident (BVH-2 and BHV-6). BVH-2 is consistently lower than the duplicate. Also, the nearest resident is further away from the site in the same direction but the values for the site border (BHV-1) are generally lower.

2. Rio Algom, Lisbon, UT

The Rio Algom mill is an operating facility. Data for the last quarter of 1987 and first three quarters of 1988 were obtained for three monitoring locations. EM-1 is designated as downwind but the exact location was not provided. EM-4 is designated as the nearest resident at a distance of 1.7 miles. EM-6 is designated as background at a distance of 6.0 miles. Averaging and subtraction of background resulted in the following values in pCi/l:

	EM-1 (net) (downwind)	EM-4 (net) (nearest resident)	EM-6 (background)
1987	-0.2	-0.2	(0.4)
1988	0.1	0.0	(0.2)

3. Atlas, Moab, UT

The Atlas mill is an older mill with a single large impoundment. It is in a standby status. Background values of Rn-222 range from 0.2 to 0.8 pCi/l and releases from site activities range from 2 to 5 pCi/l. No information on annual averages was provided. The site is somewhat unique for a western site in that it is not remote. Public and private land including a tourist business facility are adjacent to the site and it is across the road from the entrance to Arches National Park.

4. Pathfinder, Shirley Basin, WY

The Pathfinder mill was in continuous operation over the period reported. Multiple ponds are used and are water covered. The tailings management is judged to be good, but not state-of-the-art. The site now has about 7.1 million tons of tailings. Gross Rn-222 data for the years 1982 through the first three quarters of 1988 were provided and are presented in Figure 5 and in Table 4. The results of calculating annual averages and trying to determine net values are presented in Table 4. Data were provided on the highest reported gross or ambient concentrations, the lowest gross concentrations, and background for the entire period. Figure 5 indicates no particular pattern to the gross data and emphasizes the high background values. A value for location 2R described as downwind in the northwest direction was provided for 1988 also. The highest gross values may or may not be the same location. The lowest gross values are for the same location which is also close to the nearest resident. The nearest resident is 3.5 miles northwest. The background location is 0.75

miles south. The annual average gross values are shown in Table 4, as well as the net value obtained by subtracting background from the gross averages. An additional entry obtained by subtracting the low gross from the high gross is also shown. This range emphasizes the difficulty in sorting out the contributions from a licensee's activities and determining a true background. The predominant wind is from the WSW which suggests that a background location almost a mile to the south is not unreasonable on the face of it.

5. Pathfinder, Lucky Mc, WY

The Pathfinder Lucky Mc mill operated through February 1988. The prevailing wind direction is from the SSE. Data from the third and fourth quarters of 1987 and all four quarters of 1988 were provided for three locations: A-4, A-5, and A-1. Location A-4 was described as down wind one mile NNE. Location A-5 is the nearest resident and is 1.5 miles east of the site. A-1 is designated background and is six miles west. The change to standby had no discernible effect on the concentrations. Averaging the quarterly data and subtracting background resulted in the following values in pCi/l:

	A-4 (net) (downwind)	A-5 (net) (nearest resident)	A-1 (background)
1987	0.5	0.0	(1.3)
1988	-0.1	-0.1	(1.3)

6. Western Nuclear, Split Rock, WY

The Western Nuclear mill has been shut down for several years. The existing impoundments are drying out and currently have no interim earth covers. The site started operations in 1958 and represents the older tailings management practices. Gross Rn-222 data for 1981 through 1988 were provided and are plotted in Figure 6. The highest gross reading for each quarter, the lowest gross reading, and background were included. The highest and lowest locations were not provided. The designated background location is also the nearest resident. The data are also presented and analyzed in Table 5 in a manner similar to that used for Pathfinder, Shirley Basin. The average high and low gross values are given and the net obtained by subtracting the designated background from the high and low averages is shown. Average background is also provided. (Note that less than values were averaged as equal to the designated value for all sites.) The net for the high locations ranged from less than 0.2 to 0.6 pCi/l. As Figure 6 shows, the levels are decreasing but factors such as potential changes in monitoring or sampling methods and site activities were not provided. (Note that grab samples instead of continuous sampling were used at some sites in the past, but have not been used for several years.) The net for the low gross locations was either zero or a negative value, indicating problems with true background, competing or intermediate contributions, meteorological uncertainties, or other factors. The results of subtracting the low gross from the high gross is shown for perspective and to provide consistently positive results.

7. Quivira, Ambrosia Lake, NM

The Quivira site is currently in standby status. This site contains the largest quantities of tailings (33 million tons). Over a dozen assorted evaporation and settling ponds and impoundments are at the site but only two impoundments are used for the tailings. The area is a very developed mining area as indicated on Figure 7. Figure 7 was included to illustrate the complexity of the environments for some of these sites. Although the map is an old one and reflects previous owners, it shows at least four mines in the area which are circled and labeled A - D in pen and ink. There are also several underground mine exhaust vents in the area. The mine venting helps reduce the Rn levels in the mines and thus reduce mine worker exposures. It also shows the monitoring locations for the data in Table 6.

Table 6 includes data for the years 1984 and 1988. The facility was in normal operations in 1984 and standby in 1988. The gross concentrations for each quarter for a boundary location, nearest resident, and background are provided. The annual averages and net values are indicated. The 1984 data shows that the average concentration at the boundary location is 3.9 pCi/l which exceeds the current value in 10 CFR Part 20 (3 pCi/l). The concentration for the closest resident is more than twice the Part 20 limit (i.e., 8.1 pCi/l). The 1984 nearest resident was the elderly original landowner for much of the area who chose to remain in the center of all the mining, hauling, and milling activities. No one currently lives at the location. The 1988 boundary value also exceeds the current limit. The 1988 closest resident concentration is lower than background. Sorting out the radon contributions from the mines, other industrial activities, and uranium rich outcrops from the mill's contribution at such a site is difficult and was not addressed in the information provided. It may not be possible to sort although some clarification may be possible, depending on operational status of surrounding facilities, meteorological conditions, etc.

8. Wyoming Mineral, Irigaray, WY

The commercial in situ facility near Irigaray Ranch began operations in August 1987. In situ mining involves injecting solvents into the underground ore bodies, dissolving the uranium and daughters in the ore body, and pumping the fluid back to the surface for processing. No tailings are created as in conventional milling where the ore is removed, crusned, and chemically processed. Evaporation ponds are used and some sludges are produced. The major source of radon is off-gassing from the solution storage tanks. After the solutions are brought to the surface, the solutions are off-gassed before processing to reduce occupational exposures in the enclosed processing facilities. In situ and other nonmilling production account for about half of the domestic uranium production.

Table 7 provides annual averages for operational releases for the two years of operation at six locations. The locations of the monitoring sites are described in the table. Note, however, that IR-5 is background and the nearest resident. The net concentrations for unrestricted areas range from -0.1 to 1.7 pCi/l and are consistently above 0.1, with the single exception of the IR-6 net value for 1988. The different values for IR-4 may indicate the uncertainty in duplicate sampling at the same location, but the circumstances for the two results were not provided. This data is sufficiently consistent to indicate that current practices in operations at in situ facilities or demonstrating compliance or both will have to be further evaluated and probably modified for this category of uranium recovery licensee.

9. Cotter, Cannon City, CO

The average gross Rn-222 concentrations for 1987 at ten locations for the Cotter mill were provided by AMC. The Cotter mill is an Agreement State licensee in standby status. Table 8 lists the values and indicates the general locations. The first four locations are at the site boundary and the remainder are in the north or northwest directions. The predominant wind direction was not provided, but all four directions are covered at the site boundary. The gross values show an interesting pattern if you follow the values given for the north. North is slightly higher (by 0.1 pCi/l) at the boundary than the other directions. At 0.5 miles north (location 5), the concentration has fallen from 0.88 to 0.58 pCi/l. At 1.7 miles north (location 9), the gross concentration has dropped further to 0.4 pCi/l. However, at four miles north (location 10), the gross concentration has increased to 0.78 pCi/l. Background was not specified so two surrogates were used: locations 9 and 10. Location 9 has the lowest gross value and location 10 is furthest away. Since the average concentration at location 10 is high, most of the net values using this location as background were negative. Positive net results were obtained using location 9 and ranged from 0.1 to 0.5 pCi/l. Since the monitoring locations track the north and northwest directions, the prevailing wind direction is probably in these directions and neither location may be appropriate.

10. Homestake, Grants, NM

The Homestake mill near Grants is another site with large quantities of tailings (about 22 million tons in 1985). There are several impoundments, including an inoperative tailings pile. Table 9 and Figure 8 present the data provided on six locations for 1987 and 1988. The gross quarterly values are given in the first two columns of Table 9, the annual averages determined from these quarterly values are shown in the next two columns, and the net concentrations obtained by subtracting the designated background from the average gross are provided in the last two columns. The gross values plotted in Figure 8 and listed in Table 9 are of interest to illustrate the magnitude and pattern of fluctuations from quarter to quarter. For example, the radon levels vary from 1.0 to 5.3 pCi/l in 1987 at location 5 and the measured levels range from 0.8 to 6.7 pCi/l and thus dwarf a limit of 0.1 pCi/l. It was known that the location designated as background was not an appropriate location and URFO has asked the licensee to provide a more appropriate choice. All the net values, except for the nearest resident, are negative using the designated background. The gross concentrations near the nearest resident (location 5) are the highest reported (average values of 3.4 pCi/l), even higher than the perimeter gross concentrations in the same direction (location 1). The perimeter concentrations were less than half the values for location 5.

This site and others with inactive impoundments pose additional difficulties in determining compliance with 10 CFR Part 20. Many impoundments are in the process of being closed to Appendix A of 10 CFR Part 40 closure design standards. Radon releases from these impoundments undergoing closure (i.e., drying out uncovered or with interim earth covers of a foot or two of soil) would normally be considered contributions to the "operational" releases. However, once closed to the closure standards, the radon contributions should not be counted in operational releases. Moreover, the standards for closing impoundments were developed specifically for this purpose and are different from 10 CFR Part 20. Neither EPA standards nor NRC regulations provide radon concentration limits or doses as design standards for closing Title II licensed impoundments. A flux is specified by both EPA and NRC, which cannot be easily translated to air concentrations or doses. For Title I sites, EPA provides the option for a 0.5 pCi/l concentration at the site boundary, as noted earlier. This situation will be an ongoing problem for most mills as they meet EPA CAA requirements in 40 CFR Part 61 for phasing out old impoundments and using smaller new impoundments or phased disposal.

11. Kerr McGee, West Chicago, IL

Data on the Kerr McGee facility provides potentially useful contrast from the previous uranium recovery sites. The site operated to recover thorium and rare earths rather than uranium. It is a more humid site and located in a more urban location. The site will undergo final closure once the issues of State assumption of regulatory authority and the final decommissioning alternative are settled. The tailings have an interim cover. The recent drought prompted placement of an earth cover. Exemptions from certain of the existing Part 20 limits may have been necessary in the past.

Table 10 presents the average Rn-222 values for five locations. Although the site processed thorium and Rn-220 would normally be the radionuclide present as a decay product, the wastes contain significant quantities of Ra-226. Thus Rn-222 is also significant. The values represent the average over 14 quarters. The gross ranges were also provided. The net values obtained using the designated background value ranged from 0.2 to 1.4 pCi/l. There is very little buffer zone between the tailings and the unrestricted area. The distances range from 50 to 600 feet, probably measured from the center of the tailings. The highest value is for the west where a distance of 50 feet is given. The error or standard deviations indicated for the gross values emphasize the variations and difficulty in interpretation. The deviations exceed the average values for three of the five locations. The ranges cited for all the locations, including background, vary over an order of magnitude for this Midwest site and all are at least 0.2 pCi/l.

The average concentrations for Pb-212 and natural thorium for 1988 were provided by the NRC project manager in NMSS. The Pb-212 value given was 2.5E-10 microcuries/milliliter (μCi/ml) and the thorium value was 2.3E-14 μCi/ml. These values compare to the limits in the current Part 20 and the revised Part 20 as follows:

	1988 value µCi/ml	Current µCi/ml	Fraction	Revised µCi/ml	Fraction
Pb-212	2.5E-10	S: 6E-10 I: 7E-10	0.4 0.4	D: 5E-11	5
Th_{nat}	2.3E-14	S: 2E-12 I: 2E-12	0.01 0.01	no entry	
Th-230	2.3E-14 surrogate	S: 8E-14 I: 3E-13	0.3 0.08	W: 2E-14 Y: 3E-14	1.1 0.8
Th-232	2.3E-14 surrogate	S: 1E-12 I: 1E-12	0.02 0.02	W: 4E-15 Y: 6E-15	6 4

In the table, S means soluble. I means insoluble; and D, W, and Y are classes of radioactive materials, which refer to their retention (approximately days, weeks, or years) in the pulmonary region of the lung. The fractions in the table represent the measured value divided by the 10 CFR Part 20, Appendix B, Table 2 values (e.g. 2.5E-10 divided by 6E-10 = 0.4). The revised Part 20 has no natural thorium limit so the entries for Th-230 and Th-232 are shown for comparison purposes. The fractions for Th-230 and Th-232 were obtained by using the natural thorium value as a surrogate. Natural thorium is a mixture of these two isotopes, with Th-232 usually dominant. No information on the isotopic mix or solubility or class was provided. Since the site is in an urban area, fence-line compliance will be required for the most part. The comparison does suggest that the new Part 20 values will not be met.

12. Cheveron Resources, Panna Maria, TX

The Panna Maria uranium mill site is located about 50 miles south of San Antonio, TX. A single large tailings pile of roughly 160 acres has been used at this Agreement State licensed site. Open pit mining has been conducted at the site. The mining permit boundary is an irregular shape extending from the impoundment in generally the northern and western directions. Information on the exact locations of the mines is not available but at least one is less than 1500 feet away from the impoundment. The prevailing wind is out of the SSE. The annual rainfall is about 33" distributed fairly evenly over the year. The evaporation rate is about 60" a year. The older portions of the impoundment are covered with about one to two feet of Caliche clay. The calcium rich clay was run through the acid mill cycle for neutralization. The recent operational history includes running fairly rich ore (0.5% uranium oxide) from April 1986 to March 1988. Since March 1988, ores of about 0.25% uranium oxide have been processed. Plans are to operate at least through 1992. Monitoring is by track etch.

Table 11 presents Rn-222 data for 1987 and three quarters of 1988 for eight locations. The approximate distances and orientation of the eight locations are also indicated in Table 11.

Figure 9 graphically presents the gross data from Table 11. The E 9200' location is near the town of Panna Maria (number 7 in Table 11) and is background. Location 8 is near the Town of Hobson. Other potential sources of radon for Location 8 are the Everest _in situ_ operation about 2 miles south of Hobson (and three miles from the mill site) and an ore unloading station. Location 6 (NW 2000') is the residence likely to involve the maximum exposures to a member of the public. (Location 3 is physically closer but is upwind.) Figure 9, like the other figures, illustrates the complexity of radon monitoring. For example, the 1987 peaks generally follow each other, except for the background location which peaked in the second, not the third quarter.

The values at the NW edge of the impoundment are lower than those 2000' away. The gross quarterly values range over an order of magnitude, even in this higher rainfall climate.

The net average annual off-site values ranged from -0.07 to 0.77 pCi/l. The net values for the highest member of the public (Location 6) are 0.12 pCi/l for 1987 and 0.23 for 1988. Thus, the Rn-222 levels would appear to meet a 1 pCi/l limit, but not a 0.1 or 0.2 pCi/l limit.

IV. Other issues raised

The various parties contacted and staff identified a major new issue and several directly related and indirectly related issues. The major new issue was questions about the percent daughter equilibrium represented by the Table 2 values. Directly related issues included compliance options other than measurement and impacts on rare earth facilities. Indirect issues included the potential impacts and implications for EPA CAA standards under development, clear definition of which sources of radon a licensee must consider, and the precedent the limits set for States regulating naturally occurring and accelerator produced materials (NARM).

The equilibrium issue is directly related to the magnitude of the table entry for Rn-222. Based on discussions with the developers of the revisions to Part 20, the entry of 1E-8 μCi/ml for no daughters present represents the theoretical limit of of zero percent. The entry of 1E-10 μCi/ml for use with daughters present represents the theoretical limit of 100%. The 100% situation does not exist in nature. The AMC noted that EPA assumed percentages in the 30 to 40 range in CAA supporting documents.

The occupational entries for Rn-222 include working levels options. Working levels reflect the per cent equilibrium. The AMC provided no specific data on percentages at mills for this preliminary effort. (Percentages less than 100% would result in Table 2 values greater than 1E-10 μCi/ml to give the same dose as 1E-10 μCi/ml at 100% equilibrium.)

Options for demonstrating compliance other than measurements are viewed as unproven and complex. There are no standardized approaches or models for calculating exposures. Determining the input source terms is very uncertain even if accepted models existed. Difficulties with changing nearest real person or potentially maximum exposed individuals were noted.

As the Pb-212 and natural thorium data for the Kerr McGee facility illustrate, the potential impacts on rare earth licensees may be significant. These licensees process ores and other materials to extract minerals other than uranium or thorium. However, the input materials, process solutions, and waste contain uranium and thorium as unwanted contaminants. The source material content (combined weight of uranium and thorium) must exceed 0.05% by weight or no NRC license would be required. Once a licensee is required, however, compliance with the dose limits is required.

The potential impacts and implications of the new values for the various naturally occurring alpha emitting radionuclides and perhaps other radionuclides on compliance with developing EPA CAA standards was identified as a new issue. EPA is considering options with very low dose limits for individual members of the public. The same concentrations of radionuclides that represent borderline compliance with existing limits would represent orders of magnitude higher doses using the new methodology and table values in revised Part 20. How these new doses will impact EPA risk estimates and compliance plans is not clear. Certainly, if licensees have difficulty demonstrating compliance with limits ranging from 50 to 500 millirem using the new values, limits much lower than these limits will present even more problems.

The 0.1 pCi/l limit for radon is sufficiently low that a clear understanding of which sources must be considered becomes important. The AMC noted that sources such as off gassing from well water with high radium content could be in this range. The well water might be used in the industrial operation but not be a part of the licensed activities. For example, a licensee using a sealed source as a gauge may use well water with high radium and other mineral content. The water would not be associated with the gauge but additional radon would be released from the water to the enclosed facility and exhausted from ventilation systems. Concern was expressed that Part 20 be absolutely clear concerning the status of such releases.

Although 10 CFR Part 20 is not binding on State programs for NARM activities such as phosphogypsum production, the States generally follow NRC's lead. Thus, the limits in Table 2 and other provisions of Part 20 will likely be incorporated by most of the States for these activities as well. The Texas regulatory staff now responsible for uranium recovery licensing and similar NARM activities was generally unaware that the 100 millirem value for members of the public was changed from a reference level to a limit in the proposed final Part 20. The Texas staff also had not focused on the changes in Table 2 or their impacts, but they were concerned by the precedent and potential impacts on the Texas program in both the NARM and uranium recovery areas.

V. Conclusions

The quality of the measured data and the uncertainties resulting from factors such as multiple contributions, poorly defined locations and prevailing winds, measurement uncertainties, and natural background fluctuations make any findings difficult. However, the following discussion draws some preliminary conclusions. Conclusions addressing the primary purpose are presented first and are followed by other findings.

1. Issue: Can uranium recovery facilities meet a 0.1 pCi/l limit for Rn-222 at the restricted/unrestricted boundary?

CONCLUSION: None of the facilities are likely to be able to measure or consistently meet 0.1 pCi/l.

2. Issue: Can uranium recovery facilities meet 100 millirem per year or a 0.2 pCi/l concentration limit for Rn-222 at the site boundary or nearest real person?

CONCLUSION: The quality of the data makes it difficult to conclude that licensees could consistently measure or meet 0.2 pCi/l at either location. The UMETCO and Wyoming Mineral data are judged to be the most definitive. The UMETCO mill site boundary and nearest resident annual net concentrations ranged from 0 to 0.3 pCi/l during 1985 - 1988. Thus, annual average releases would meet 0.2 pCi/l at times. The Wyoming *in situ* site data indicates restricted/unrestricted boundary average net concentration values of 0.8 to 1.7 pCi/l consistently exceeding a limit of 0.2 pCi/l. Since the nearest resident is also background, no nearest person conclusions are possible for the *in situ* data.

3. Issue: Can uranium recovery facilities meet a 1.0 pCi/l concentration limit for Rn-222 at the site boundary or nearest real person?

CONCLUSION: The data suggest that newer and smaller facilities such as UMETCO may be able to consistently meet a 1.0 pCi/l limit at the site boundary and beyond. Several other facilities (e.g., Rio Algom, Western Nuclear, Cotter and Panna Maria) also appear to be able to meet a limit of 1.0 pCi/l at the site boundary and beyond. Sites with negative net concentrations can be construed to meet the standard also. The *in situ* facility could not. Many older facilities may have difficulty meeting or would clearly not meet the 1.0 pCi/l value at either location. As noted initially, the 1.0 pCi/l equivalency to 500 millirem/year was based on a simple ratio using the Table 2 values. The Table 2 value includes conservatisms such as 100% equilibrium and 100% occupancy. In performing more realistic dose evaluations on a site-specific basis, licensees could use more realistic assumptions to calculate doses to real persons at least two to four times lower from the same outdoor concentration levels. If licensees meet or nearly meet 1.0 pCi/l levels, these types of factors should provide sufficient margin to account for other radionuclides and pathways and remain within 500 millirem/year. These more realistic factors might enable some licensees to meet the 100 millirem/year limit as well. But in each case, licensees will have to prepare specific applications involving additional information and analyses and regulatory staff will have to evaluate the site-specific proposals.

4. Issue: Are current radon measurement practices adequate to address compliance with the revised 10 CFR Part 20?

CONCLUSION: No. Current NRC guidance in Regulatory Guide 4.14 calls for 0.2 pCi/l detection limits. Staff understands that the 0.1 pCi/l value represents current state-of-the-art detection limits in the field. Further, the repeated negative net concentrations illustrate problems with establishing true background. Multiple sources of radon are not sorted out. The 0.1 and 0.2 pCi/l values are masked by statistical fluctuations.

5. Issue: Can existing source term estimates and calculational techniques be used to demonstrate compliance with the revised 10 CFR Part 20?

CONCLUSION: No. Additional guidance providing acceptable methods, models, and assumptions will be needed. Guidance on determining per cent equilibrium will also be needed.

6. Issue: Is this preliminary assessment adequate or should the issue be addressed more fully?

CONCLUSION: The issue should be addressed more fully. This assessment illustrates the difficulties and uncertainties but does not resolve the basic issue of impacts of fully implementing the rule. Since the data do not permit a definitive answer on the ability of the industry to continue to operate under the new regulation, additional evaluation is needed. Issues such as the contributions from other radionuclides, how to deal with radon from closed impoundments, potential impacts on other source material licensees such as rare earth processors, alternative technologies for handling radon releases at <u>in situ</u> facilities, and other matters need more careful attention. The ongoing EPA regulation development under the CAA may significantly change EPA's requirements for these facilities and the supporting information may be an important information resource for any additional efforts.

Table 1: Directory of Rn-222 limits and units

New Part 20, daughters present (50 mrem/yr effective dose equivalent)	0.1 pCi/liter or 1E-10 μCi/ml
100 mrem/yr effective* dose equivalent	0.2 pCi/liter
Title I reclaimed site at boundary	0.5 pCi/liter
500 mrem/yr effective* dose equivalent	1.0 pCi/liter
Current Part 20 - unrestricted air	3 pCi/liter or 3E-9 μCi/ml
EPA action level for radon in homes	4 pCi/liter
New Part 20, no daughters present	10 pCi/liter or 1E-8 μCi/ml

*Assuming no external contribution or other radionuclides (e.g. no U or Th) and using ratio based on 0.1 pCi/l = 50 mrem.

Table 2: Summary of Rn-222 concentrations in pCi/liter

	Net values						Background	
	Boundary		Nearest		Other			
	87	88	87	88	87	88	87	88
NRC Data								
1. UMETCO	.3	.1	.3& .5	.0 .4	.2& .6	.3 &.9	.7	.5
2. Rio Algom	-	-	-.2	0	-.2	.1	.4	.2
3. Atlas	2 to 5						.2 to .8	
4. Pathfinder Shirley Basin	-	-	-1.9	-.2	-.9	.1 &.3	2.5	1.0
5. Pathfinder Lucky MC	-	-	0	-.1	.5	-.1	1.3	1.3
6. Western Nuclear	-	-	<.2	<.2	<.3	<.2	<.2	<.2
7. Quivira	-	5.9	-	-.7	-	-	-	3.4
8. Wyoming Mineral	.8	1.7	.6	1.3	.4 to .9	-.1 to .9	.6	1.3
AMC Data								
9. Cotter	.5	-	-	-	.1 to .5	-	.4	-
10. Homestake	-.2 to -1.0	.0 to -.6	.8	1.7	-.2	0	2.6	1.7
11. Kerr McGee (14 quarter averages)	.3 to 1.4		-		.3		.4	
12. Cheveron, Panna Maria	-	-	.1	.2	-.1 to .8	-.1 to .7	.3	.4

Table 3: UMETCO
White Mesa Mill, UT

Radon levels i ,Ci/liter

Monitoring Sites	Net annual averages 1985	1986	1987	1988
BHV-1	0	0	.3	.1
BHV-2	0	.1	.3	0
BHV-6 (Dup for BHV-2)	0	.2	.5	.4
BHV-3 (Background)	(.1)	(.3)	(.7)	(.5)
BHV-4	.1	-.1	.2	.3
BHV-5	.2	.3	.6	.9

Notes:

BHV-1: Northern border of property. 1 mile north of mill area.
BHV-2: Nearest Residence. 3 miles north of mill, 2 miles from mill boundary.
BHV-3: Background at Black Mesa. 3.5 miles west of mill area.
BHV-4: 3000 feet south of nearest tailings cell.
BHV-5: 1000 feet south east from ore stockpile.
BHV-6: Duplicate on same power pole as BHV-2.

BHV-1, 4, and 5 are within mill property boundaries.

Predominant wind direction is to the southwest (25%) and to the northeast (25%).

Table 4: Pathfinder, Shirley Basin, WY
Averaged radon data in pCi/liter

Location	1982	1983	1984	1985	1986	1987	1988
1. Highest reported concentration*							
gross	1.2	1.2	1.3	.9	.8	1.6	1.3
net**	-.1	.6	0	-1.1	-.8	-.9	.3
2. Lowest reported and nearest resident (7R)							
gross	1.2	.4	.6	.5	.5	.6	.8
net	-.1	-.2	-.7	-1.5	-1.1	-1.9	-.2
(Hi gross-Lo gross)	(0)	(.6)	(.7)	(.4)	(.3)	(1.0)	(.5)
3. Down wind NW (2R)							
gross	-	-	-	-	-	-	1.1
net	-	-	-	-	-	-	0.1
4. Background (4R)	1.3	.6	1.3	2.0	1.6	2.5	1.0

*Variable location
**Net is gross-background

Table 5: Western Nuclear, Split Rock, WY
Averaged radon data in pCi/liter

Location	1981	1982	1983	1984	1985	1986	1987	1988
1. Highest reported concentration								
gross	1.1	1.0	1.1	.8	.6	<.5	<.5	.4
net	.5	.6	.6	.3	.2	<.3	<.3	<.2
2. Lowest reported concentration								
gross	.6	.2	<.1	.2	.2	<.2	<.2	.2
net	0	-.2	-.4	-.3	-.2	0	0	0
(Hi gross -Lo gross)	(.5)	(.8)	(1.0)	(.6)	(.4)	(<.3)	(<.3)	(.2)
3. Background (nearest resident)	.6	.4	.5	.5	.4	<.2	<.2	<.2

Table 6: Quivira, Ambrosia Lake, NM

Radon concentrations in pCi/l

Time	Boundary location	Closest resident	Background
	During normal operations - 1984 Gross Values		
1st Quarter	10.49 ± 0.7	22.30 ± 1.1	3.01 ± 0.3
2nd Quarter	4.48 ± 0.2	7.10 ± 0.4	1.21 ± 0.2
3rd Quarter	6.47 ± 0.3	8.47 ± 0.6	2.48 ± 0.3
4th Quarter	5.55 ± 0.4	5.97 ± 0.4	4.64 ± 0.4
	Average 6.75 ± 0.4	Average 10.96 ± 0.6	Average 2.84 ± 0.3
	Range 4.48 - 10.49	Range 7.10 - 22.3	Range 1.21 - 4.64
	Net: 3.9 pCi/l	Net: 8.1 pCi/l	
	During standby operations - 1988 Gross Values		
1st Quarter	4.6 ± 0.8	2.2 ± 0.4	2.1 ± 0.4
2nd Quarter	7.4 ± 1.0	2.7 ± 0.4	1.7 ± 0.3
3rd Quarter	9.5 ± 1.1	1.8 ± 0.3	2.8 ± 0.6
4th Quarter	15.7 ± 1.6	4.0 ± 0.8	6.9 ± 1.0
	Average 9.3 ± 1.1	Average 2.7 ± 0.5	Average 3.4 ± 0.6
	Range 4.6 - 15.7	Range 1.8 - 4.0	Range 1.7 - 6.9
	Net: 5.9 pCi/l	Net: -0.7 pCi/l	

Table 7: Wyoming Mineral, Irigaray Ranch, WY

Commercial *in situ*
radon levels in pCi/liter

	Operational releases Average net	
Location	1987	1988
IR-1 (Downwind of restricted area)	.8	1.7
IR-3 (Upwind of restricted area)	1.0	.9
IR-4 (North Road)	.9	.2
IR-4 (North Road Q.A.)	.5	.4
IR-5 (Irigaray Ranch)* (background)	(.6)	(1.3)
IR-6 (Ridge Road S.E.)	.4	-.1

*Nearest resident as well as background

Table 8: Cotter, Cannon City, CO

Rn-222 concentrations in pCi/liter

Location	1987 Average gross	Net using locations 9 & 10 as background*	
		9	10
1. N boundary	.88	.5	.1
2. E boundary	.78	.4	0
3. S boundary	.68	.3	-.1
4. W boundary	.8	.4	0
5. 0.5 miles N	.58	.2	-.2
6. 0.5 miles W	.48	.1	-.3
7. 1.0 miles NW	.47	.1	-.3
8. 1.5 miles NW	.48	.1	-.3
9. 1.7 miles N	.4	-	-.4
10. 4.0 miles N	.78	.3	-

*Background not specified. Predominant wind direction not specified. Location 9 is lowest, 10 is further away.

Source of gross data: Telecon with AMC 2/10/89.

Table 9: Homestake, Grants, NM

Rn-222 concentrations in pCi/liter

Location	Quarterly Gross 1987	Quarterly Gross 1988	Average 1987	Average 1988	Net 1987	Net 1988
1. N outer perimeter, mill area	.8 1.3 2.3 2.1	1.3 1.2 1.1 -	1.6	1.2	-1.0	-.5
2. NE outer perimeter, mill area	.9 .9 1.1 4.4	1.4 1.1 1.4 -	1.8	1.3	-.8	-.4
3. Control, mill area	2.4 1.1 1.6 4.3	1.7 1.9 1.6 -	2.4	1.7	-.2	0
3(a). E outer perimeter, mill area	1.4 1.4 1.8 3.4	1.3 1.2 .8 -	2.0	1.1	-.6	-.6
4. Background, mill area	1.0 1.4 2.5 5.3	1.8 1.9 1.4 -	2.6	1.7	-	-
5. N of nearest resident mill area	2.6 1.4 2.9 6.7	4.4 2.1 3.8 -	3.4	3.4	.8	1.7

Source of gross data: Telecon with AMC 2/10/89

Table 10: Kerr McGee, West Chicago, IL

Fourteen quarter average Rn-222 concentrations in pCi/liter

Location	Gross	Gross range	Net
1. Fence 300 feet E	.69 ± .9*	.2 to 3.6	.3
2. Onsite 500 feet N	.69 ± .5	.2 to 2.3	.3
3. Fence 50 feet W	1.8 ± 1.9	.3 to 7.7	1.4
4. Fence 600 feet S	.6 ± .7	.2 to 2.7	.2
5. Background 1.5 miles	.4 ± .2	.2 to .8	-

*Uncertain statistical methods used. No clarification requested.
Source of gross data: Telecon with AMC 2/10/89

Table 11: Cheveron Resources, Panna Maria, TX

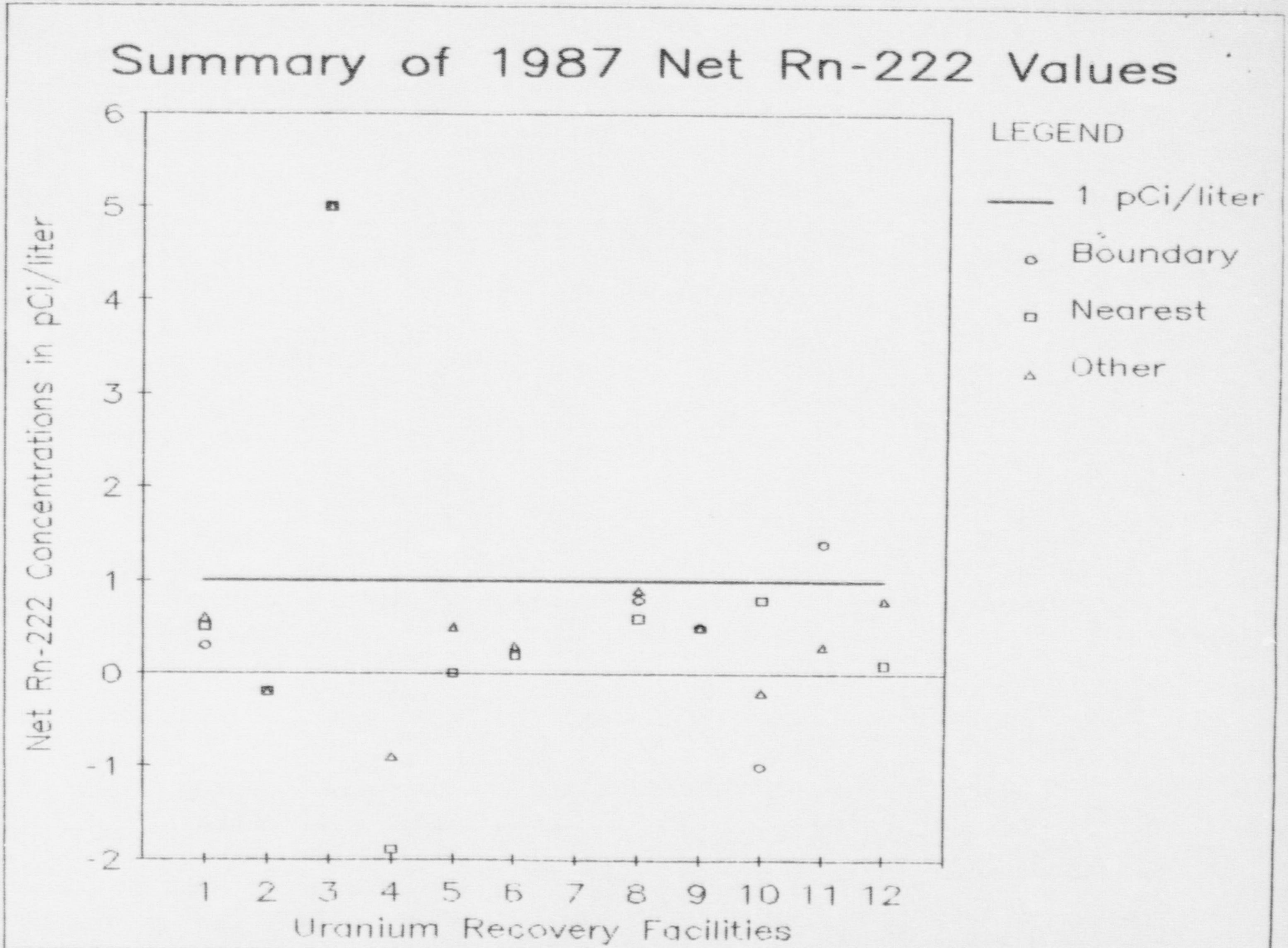
Rn-222 concentrations in pCi/liter

Location	Quarterly Gross 1987	Quarterly Gross 1988	Average Gross 1987	Average Gross 1988	Net* 1987	Net* 1988
1. Edge of pile, NW	.3 .4 .5 .5	.4 .9 .9 -	.43	.73	.1	.33
2. Edge of pile, SE	.2 .1 .4 .5	.3 .1 .9 -	.3	.43	-.03	.03
3. North ~ 1,000 feet	.1 .1 .6 .3	.3 .2 .5 -	.28	.33	-.05	-.07
4. South ~ 300 feet	.1 .2 1.0 .3	.3 .2 1.7 -	.4	.73	.07	.33
5. West ~ 4,000 feet	.2 .5 3.1 .4	.6 .8 2.0 -	1.1	1.1	.77	.7
6. NW ~ 2,000 feet	.1 .2 1.0 .5	.3 .3 1.3 -	.45	.63	.12	.23
7. East ~ 9,200 feet	.2 1.0 .6 .5	.3 .2 .7 -	.33	.4	-	-
8. West ~ 8,200 feet	.2 .3 2.5 .6	.5 .7 .5 -	.9	.6	.57	.2

* Using location 7 as background.

Source of gross data: Telecon with AMC 3/23/89

Figure 1



Summary of 1987 Net Rn-222 Values
LEGEND
1 pCi/liter
Boundary
Nearest
Other
Net Rn-222 Concentrations in pCi/liter
6
5
4
3
2
1
0
-1
-2
1 2 3 4 5 6 7 8 9 10 11 12
Uranium Recovery Facilities

Figure 2

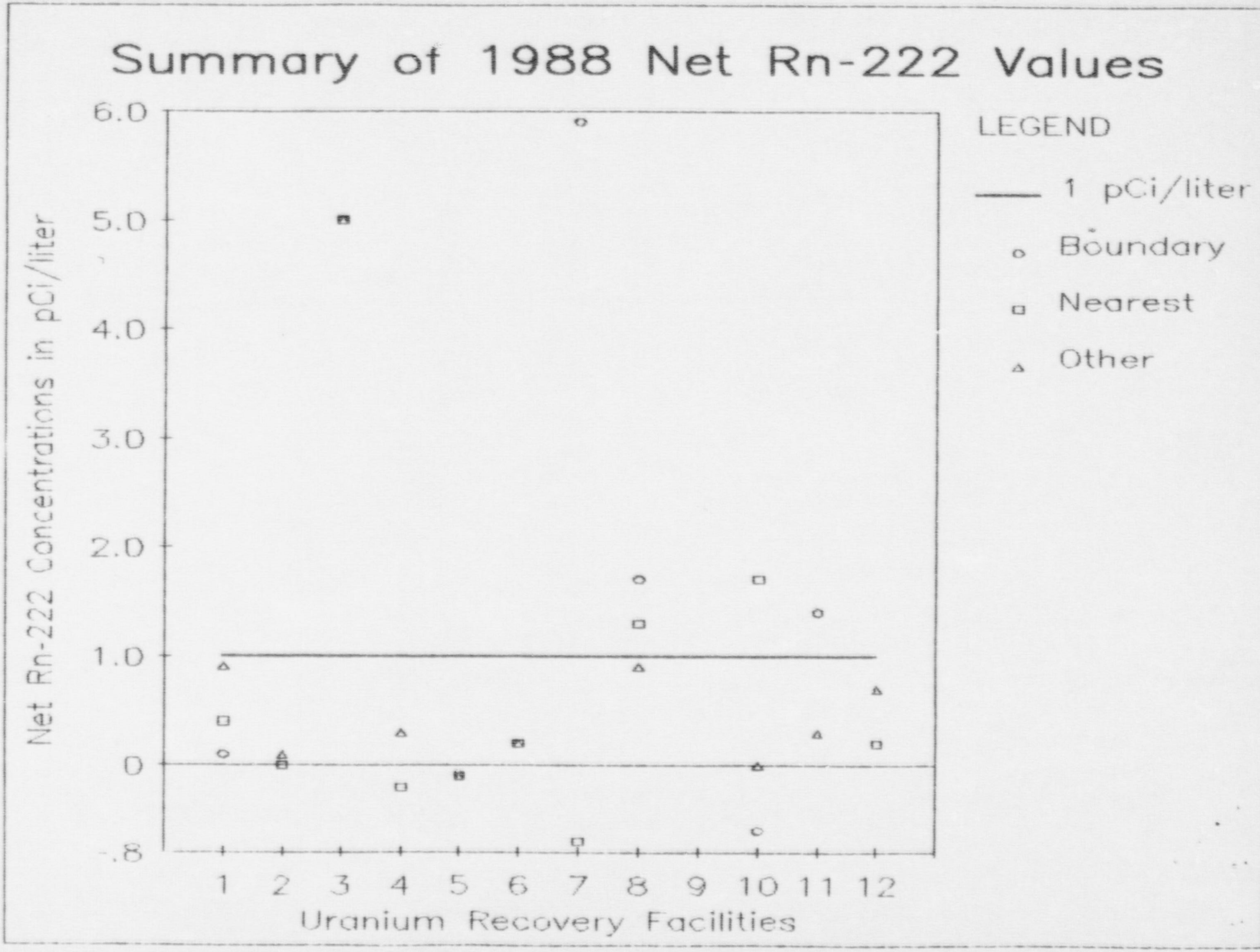

Summary of 1988 Net Rn-222 Values
Net Rn-222 Concentrations in pCi/liter
6.0
5.0
4.0
3.0
2.0
1.0
0
-.8
1
2
3
4
5
6
7
8
9
10
11
12
Uranium Recovery Facilities
LEGEND
1 pCi/liter
Boundary
Nearest
Other

Figure 3

URANIUM MILL TAILINGS AT ACTIVE SITES
(as of July 1985)

State	Mill		Tailings (millions of tons)	
New Mexico	Anaconda	Bluewater	23.6	
	Homestake	Grants	21.8	
	Quivira	Ambrosia Lake	33.0	
	Sohio	L-Bar	2.1	
	UNC	Church Rock	3.5	
				84.0
Wyoming	American Nuclear	Gas Hills	5.9	
	Exxon	Highland	7.2	
	Minerals Exploration	Sweetwater	1.0	
	Pathfinder	Lucky Mc	9.5	
	Pathfinder	Shirley Basin	5.8	
	Petrotomics	Shirley Basin	6.3	
	Rocky Mountain	Bear Creek	5.0	
	Umetco	Gas Hills	9.2	
	Western Nuclear	Split Rock	7.7	
				57.6
Utah	Atlas	Moab	10.5	
	Energy Fuels	White Mesa	1.5	
	Plateau	Shootaring	0.0	
	Rio Algom	Lisbon	3.0	
				15.0
Texas	Chevron	Panna Maria	4.6	
	Conoco	Conquista	8.8	
	Exxon	Felder	0.4	
				13.8
Colorado	Cotter	Canon City	2.2	
	Umetco	Uravan	10.3	
				12.5
Washington	Dawn	Ford	3.0	
	Western Nuclear	Sherwood	2.9	
				5.9
South Dakota	TVA	Edgemont	2.0	2.0
		GRAND TOTAL		190.8

Figure 4

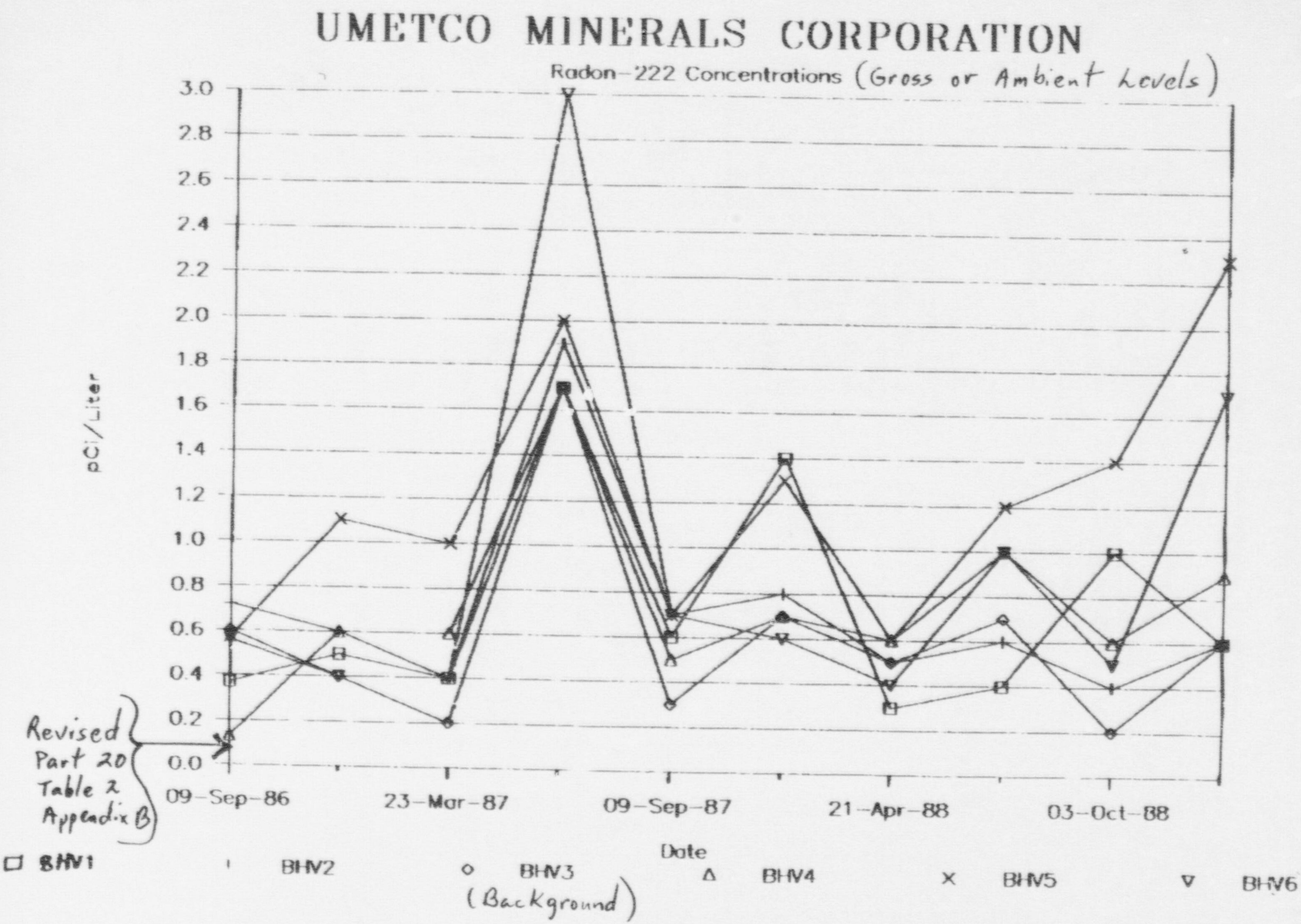
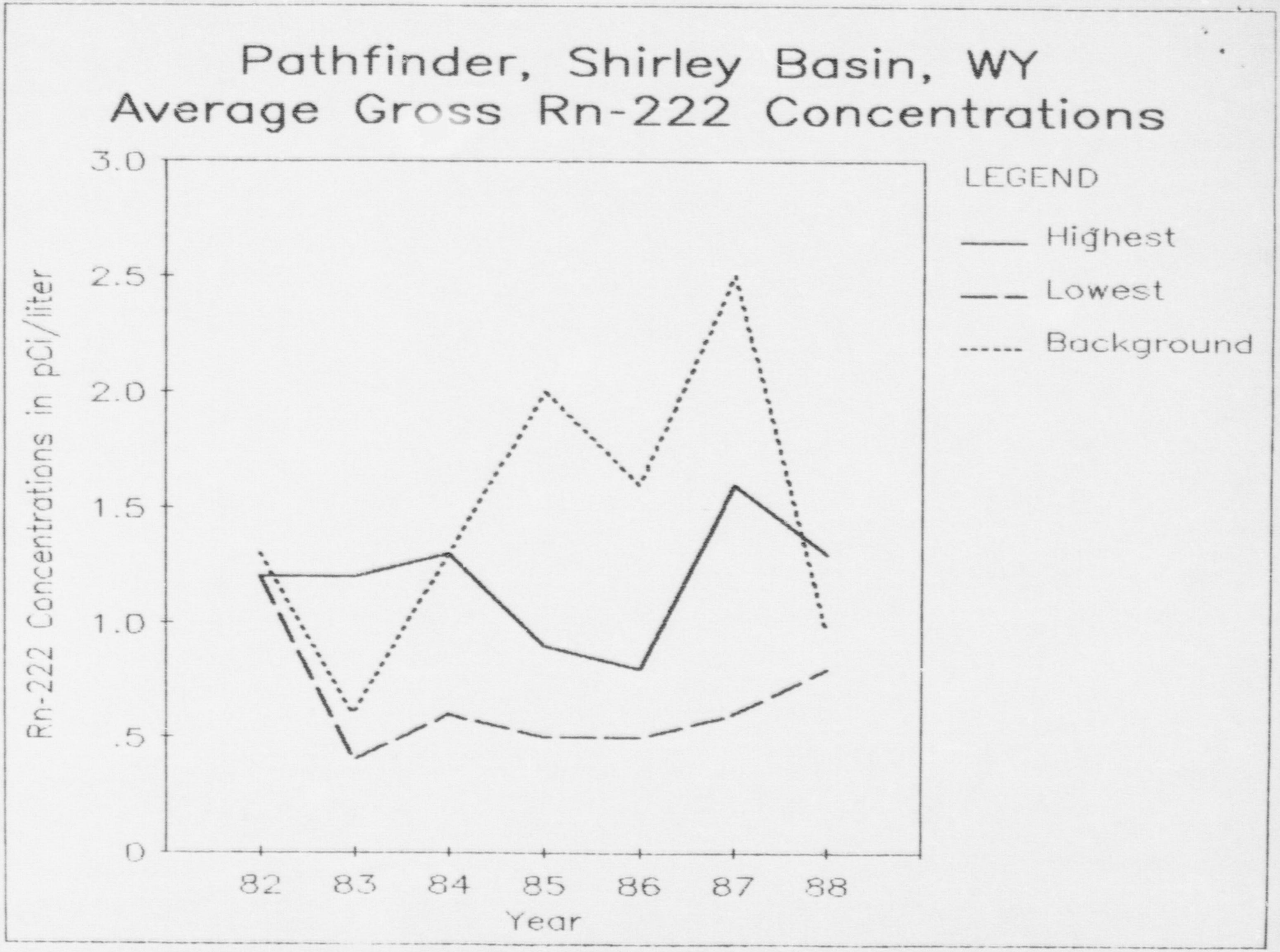
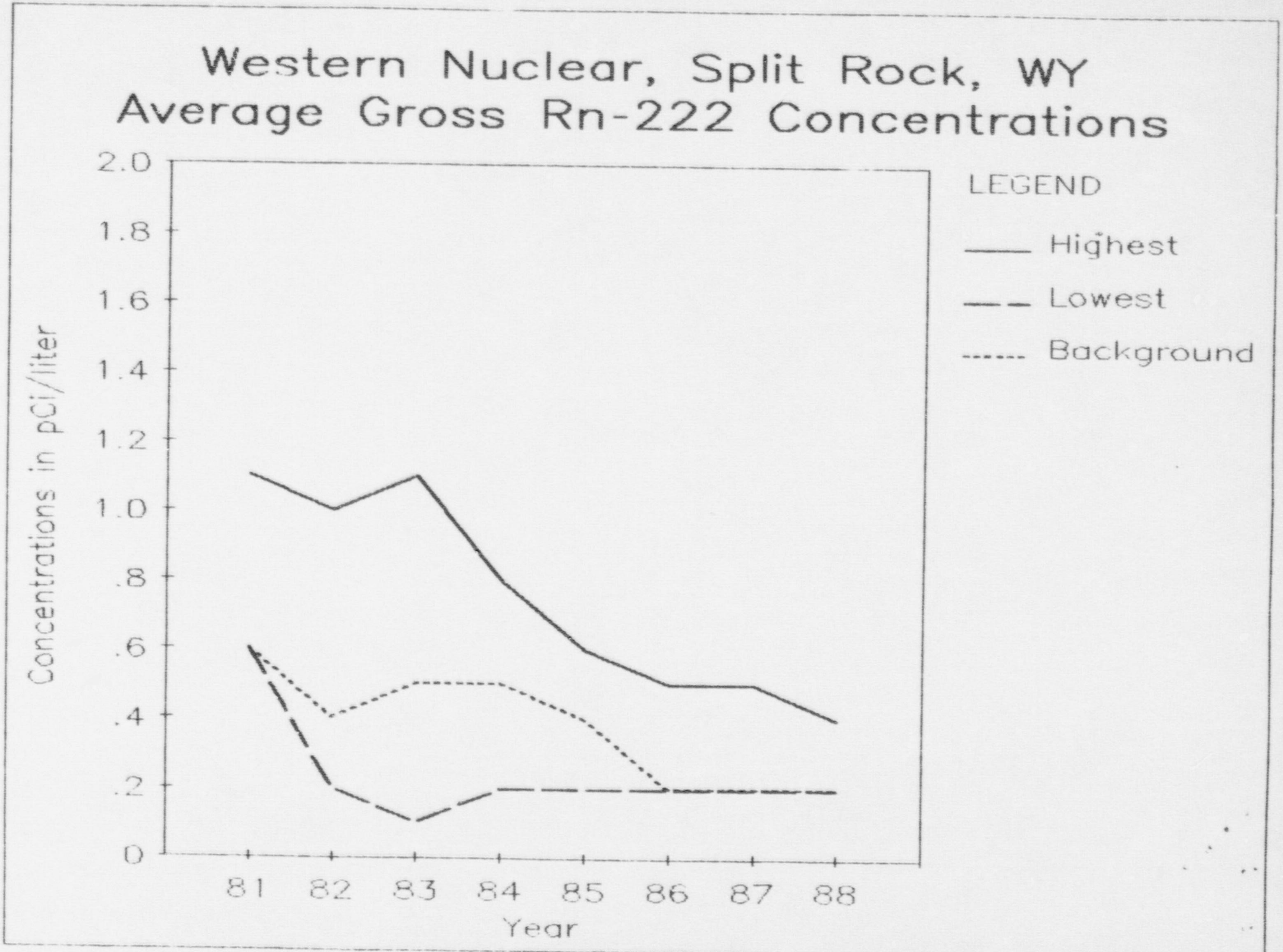

UMETCO MINERALS CORPORATION
Radon-222 Concentrations (Gross or Ambient Levels)
pCi/Liter
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Revised Part 20 Table 2 Appendix B
09-Sep-86
23-Mar-87
09-Sep-87
21-Apr-88
03-Oct-88
Date
BHV1
BHV2
BHV3
(Background)
BHV4
BHV5
BHV6

Figure 5



Pathfinder, Shirley Basin, WY
Average Gross Rn-222 Concentrations
Rn-222 Concentrations in pCi/liter
3.0
2.5
2.0
1.5
1.0
.5
0
82
83
84
85
86
87
88
Year
LEGEND
Highest
Lowest
Background

Figure 6


Western Nuclear, Split Rock, WY
Average Gross Rn-222 Concentrations
Concentrations in pCi/liter
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
0
81
82
83
84
85
86
87
88
Year
LEGEND
Highest
Lowest
Background

Note: A, B, C + D are mines

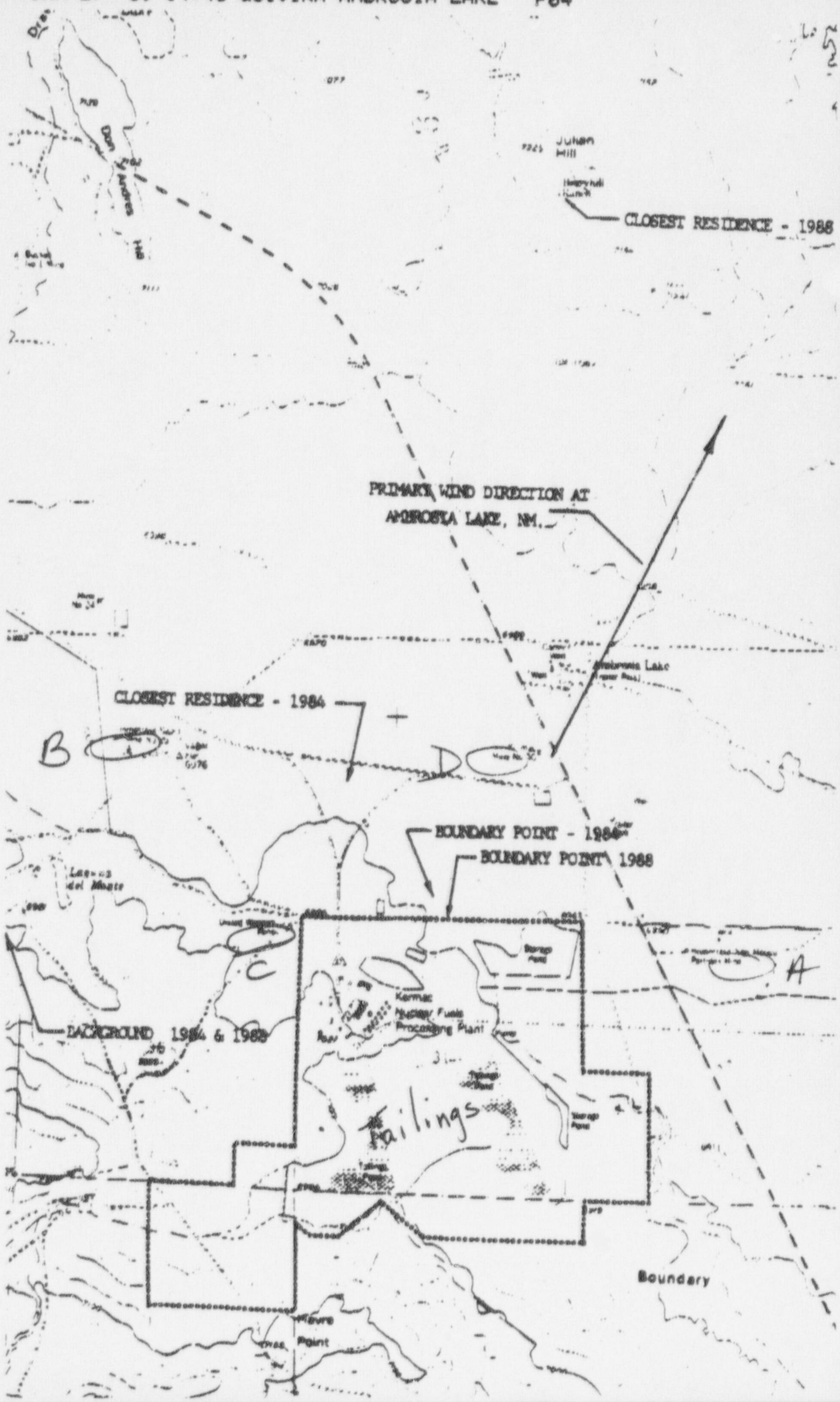


Figure 7: Map of Quivira, Ambrosia Lake, Site

Figure 8

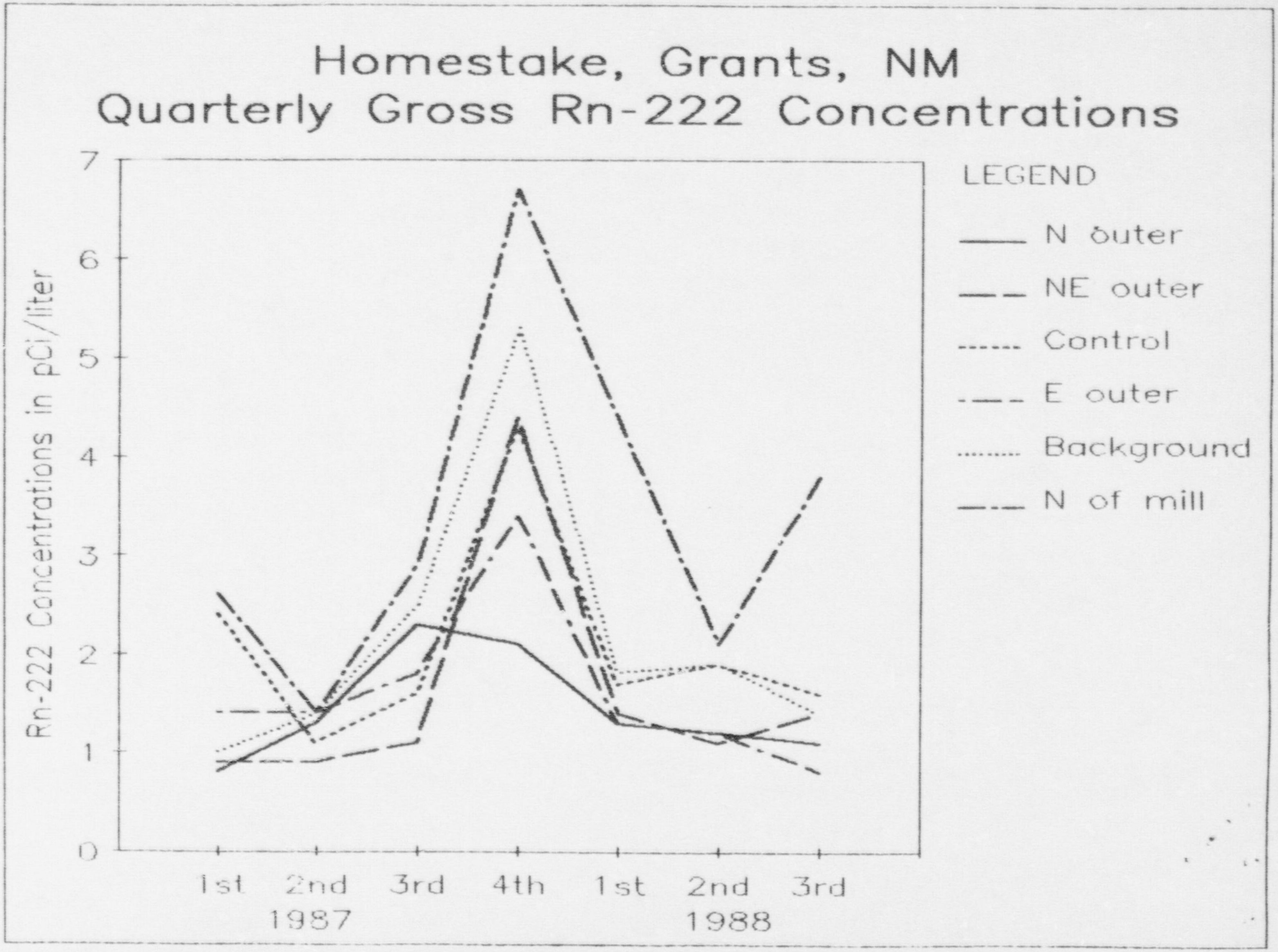
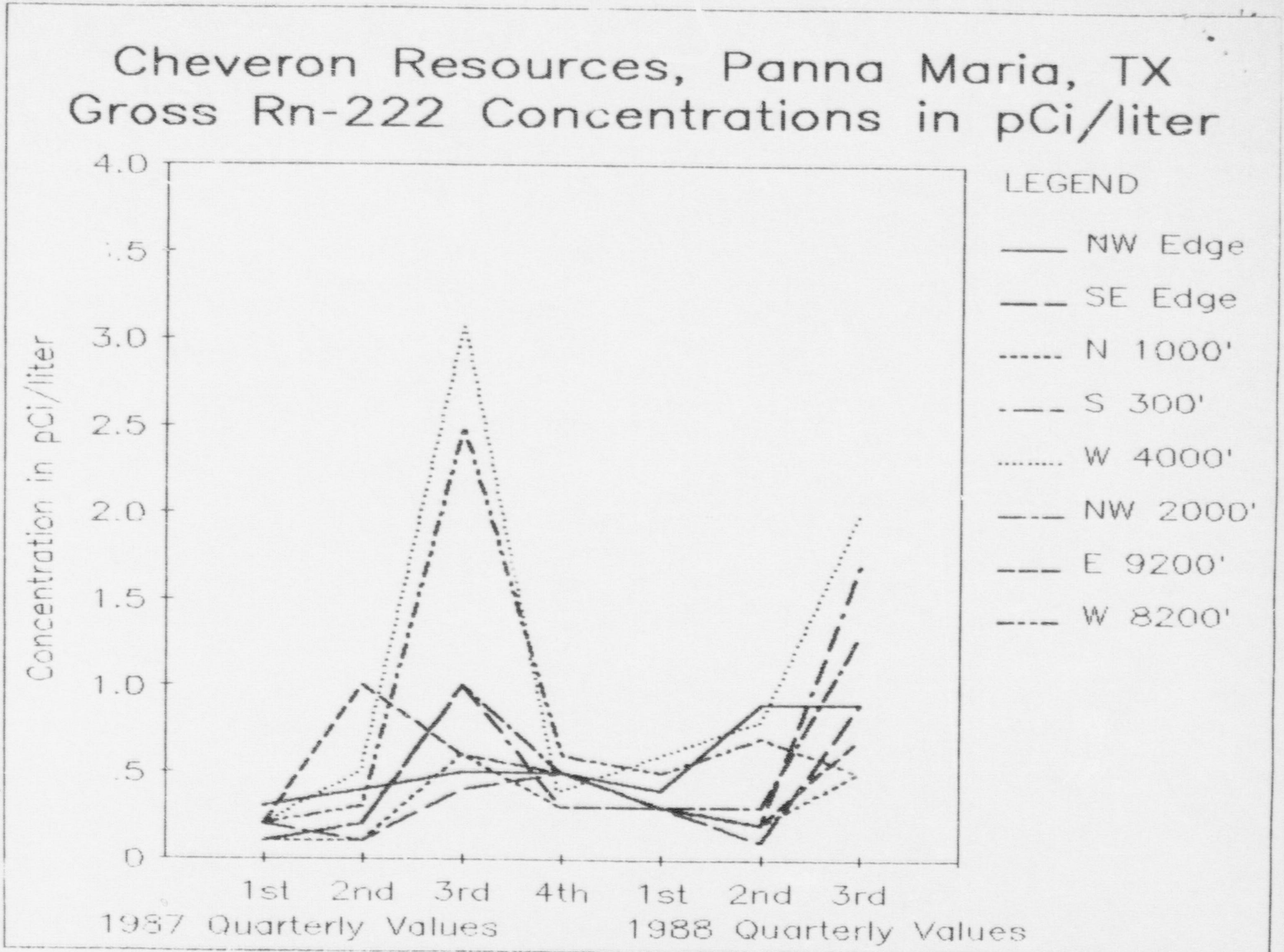

Homestake, Grants, NM
Quarterly Gross Rn-222 Concentrations
Rn-222 Concentrations in pCi/liter
0
1
2
3
4
5
6
7
1st
2nd
3rd
4th
1st
2nd
3rd
1987
1988
LEGEND
N outer
NE outer
Control
E outer
Background
N of mill

Figure 9



Cheveron Resources, Panna Maria, TX
Gross Rn-222 Concentrations in pCi/liter
Concentration in pCi/liter
4.0
.5
3.0
2.5
2.0
1.5
1.0
.5
0
1st
2nd
3rd
4th
1st
2nd
3rd
1987 Quarterly Values
1988 Quarterly Values
LEGEND
NW Edge
SE Edge
N 1000'
S 300'
W 4000'
NW 2000'
E 9200'
W 8200'