DEC DSHM BPR Report 98-1

RADIOLOGICAL SURVEY

FOR

VILLAGE OF MT. KISCO and RICHARD'S LUMBER

former Canadian Radium and Uranium Corporation

MT. KISCO, NEW YORK

JULY 1998

New York State Department of Environmental Conservation
Division of Solid & Hazardous Materials
Bureau of Pesticides & Radiation
50 Wolf Road, Room 402
Albany, NY 12233-7255

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Radiological Survey
for
Village of Mt. Kisco & Richard's Lumber
Mt. Kisco, New York

Prepared by: _____ Date: 7/9/98
John A. Kadlecek, Ph.D., Project Director

Prepared by: William T. Varcasio Date: 7/9/98
William T. Varcasio, Project Manager

Prepared by: Timothy B. Rice Date: 7/10/98
Timothy B. Rice, Field Manager

Reviewed by: Barbara A. Youngberg Date: 7/14/98
Barbara A. Youngberg, Section Chief
Radiation Section

Reviewed by: Paul J. Merges Date: 7/14/98
Paul J. Merges, Ph.D., Director
Bureau of Pesticides and Radiation

List of Acronyms

bkg.	background
cpm	counts per minute
DEC	New York State Department of Environmental Conservation
DOH	New York State Department of Health
EPA	United States Environmental Protection Agency
HPGe	high purity germanium
mCi	milliCurie = 1 one thousandth of a Curie. 1 Curie = 3.7×10^{10} decays per second
NaI	sodium iodide
pCi/g	unit of activity - 1 pCi/g means 2.22 decays / minute in 1 gram of material
rf	radio frequency
SR	stationary receivers
TAGM	technical administrative guidance memorandum
USRADS	Ultrasonic Ranging and Data System

notation: Some of the numbers in this report are relatively large (e.g., hundreds of thousands) but do not have more than 1 or 2 digits that are significant. For this reason, we use the exponential notation. For example: 12000 might be written as 1.2×10^4 where the exponent 4 is the power of 10 that should be multiplied by the rest of the number.

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Executive Summary

Property owned by the Village of Mt. Kisco, New York was contaminated with radium by the previous owner (Canadian Radium and Uranium Corporation). The character of the radioactive material suggests that it may be product related and may have been disposed of as part of operations at Canadian Radium. The Village requested New York State assistance to determine if the radioactive material remaining on the site would limit choices for land use. The Department of Environmental Conservation (DEC) agreed to assist the Village by conducting a surficial survey of the property and, where possible, to determine the amount and extent of the radioactive contamination. Another part of the former Canadian Radium site is now owned by Richard's Lumber and Building Materials Center. DEC offered to include the Richard's Lumber property in the survey and the offer was accepted. Both properties were surveyed during September and October 1997. This document is the report of the results of our work.

Mt Kisco Property

Contamination was found over one large area (about 4000 to 5000 ft^2) and a few smaller areas. On the Mt. Kisco property, the highest concentrations of radium observed were a few hundred picocuries/gram (pCi/g) and most of the contamination is in the top one-foot of soil. The distribution suggests that material containing radium was placed on the surface and then the area was leveled.

A new road (Railroad Avenue) was built where one of the Canadian Radium buildings once stood. The limited soil sampling done near the road shows elevated radium a few feet below the surface. The distribution of radioactive material near the road would be consistent with movement of soil as part of the destruction of the building and construction of the road. No sampling through the road surface was attempted, so further characterization work will be needed in the road right-of-way.

Richard's Lumber

The survey indicated that radioactive materials were present under the parking lot, but no samples were taken through the asphalt. Further characterization is needed in the area between Railroad Avenue and the Richard's Lumber main sales building.

The highest concentration of radium at the site was found just north of Railroad Avenue (about 6000 pCi/g). A large part of the main outside storage area is contaminated with radium not only near the surface (under the item 4 aggregate cover), but also within some soil profiles to depths of about four feet.

A few sampling locations also had evidence of organic contamination at or near the bottom of the soil profile. Survey data suggests that the contamination stopped abruptly at the edges of the paved areas. It will be necessary to sample through the driveways (between the yard area and the railroad tracks and between the yard area and a storage building) to confirm this interpretation of the data.

General comments

Radioactive material (principally radium) resulting from operations at Canadian Radium was found at significant concentrations on both properties. Elevated radium was found on about one-fourth of the area surveyed. The area north of Railroad Avenue (Richard's Lumber) has the highest concentrations observed and the distribution of the material tends to be at greater depths. The data presented here will help the property owners, in cooperation with New York State, to determine what actions are necessary, consistent with future uses of the land.

1. Introduction

The Village of Mt. Kisco, New York, owns property at the intersection of Kisco Avenue and Railroad Avenue. This property had been contaminated with radium by a previous owner. As the Village considered proposed uses for the property, it contacted the New York State Department of Health to determine if the presence of radium would limit some of the possible uses. The Department of Health referred the question to the Department of Environmental Conservation. While some data were available and it was well established that radium was present in the soil, the data were not sufficient to characterize either the amount or extent of the radium. DEC offered to use its instrumentation and expertise to create a data set adequate to characterize the radium on site where access was possible and manual techniques could be used to obtain soil samples. DEC offered to include in the survey land owned by Richard's Lumber. This property, also part of Canadian Radium, was known to be contaminated with radium. Both offers were accepted by the respective owners. This report describes the work done, the results of the measurements, and recommendations that follow from this work.

1A Objective

The purposes of this radiation survey on the site once owned by Canadian Radium and Uranium Corporation in the Village of Mt. Kisco, New York, were to:

- locate and delineate the horizontal extent of radioactive materials located near the surface,
- provide a general description of the vertical distribution of the radionuclides, and
- identify the radionuclides present on site.

This survey was to provide the information necessary to characterize the site for radionuclide contamination to the extent possible without major excavation. Where the data taken is sufficient, we will present an example of how we apply site-specific cleanup criteria; where questions remain about the extent of contamination or where access at this time was impractical, the data taken will provide the basis for a second set of measurements to complete the characterization. The survey was performed during the period September 29 to October 9, 1997.

1B. Site Location

The Canadian Radium and Uranium Corporation site was located at what is now the intersection of Kisco Avenue and Railroad Avenue in the Village of Mt. Kisco, New York (latitude 41° 12', longitude 73° 43'). Along Kisco Avenue, this intersection is about 0.17 miles north of the intersection of West and East Main St. and 0.6 miles south of the Saw Mill River Parkway. Railroad Avenue is a short (0.03 mile) road between Kisco Avenue and the Conrail rail lines. See Figures 1 and 2 for a regional map and an immediate area map.

The site extends about 300 feet south and 360 feet north of Railroad Avenue, bordered by Conrail railroad tracks to the east and Kisco Avenue to the west. One part of the original site

FIGURE 1

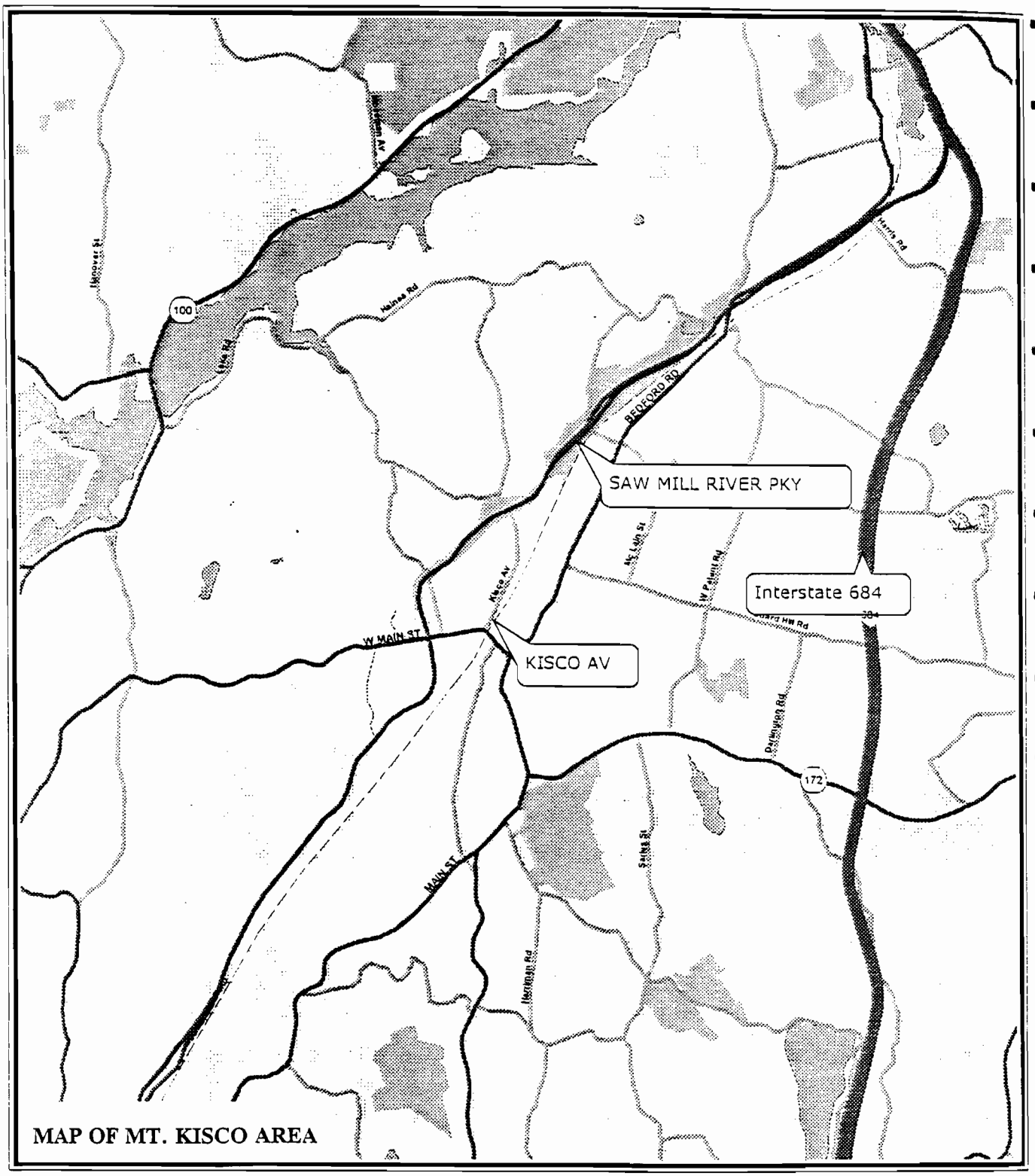
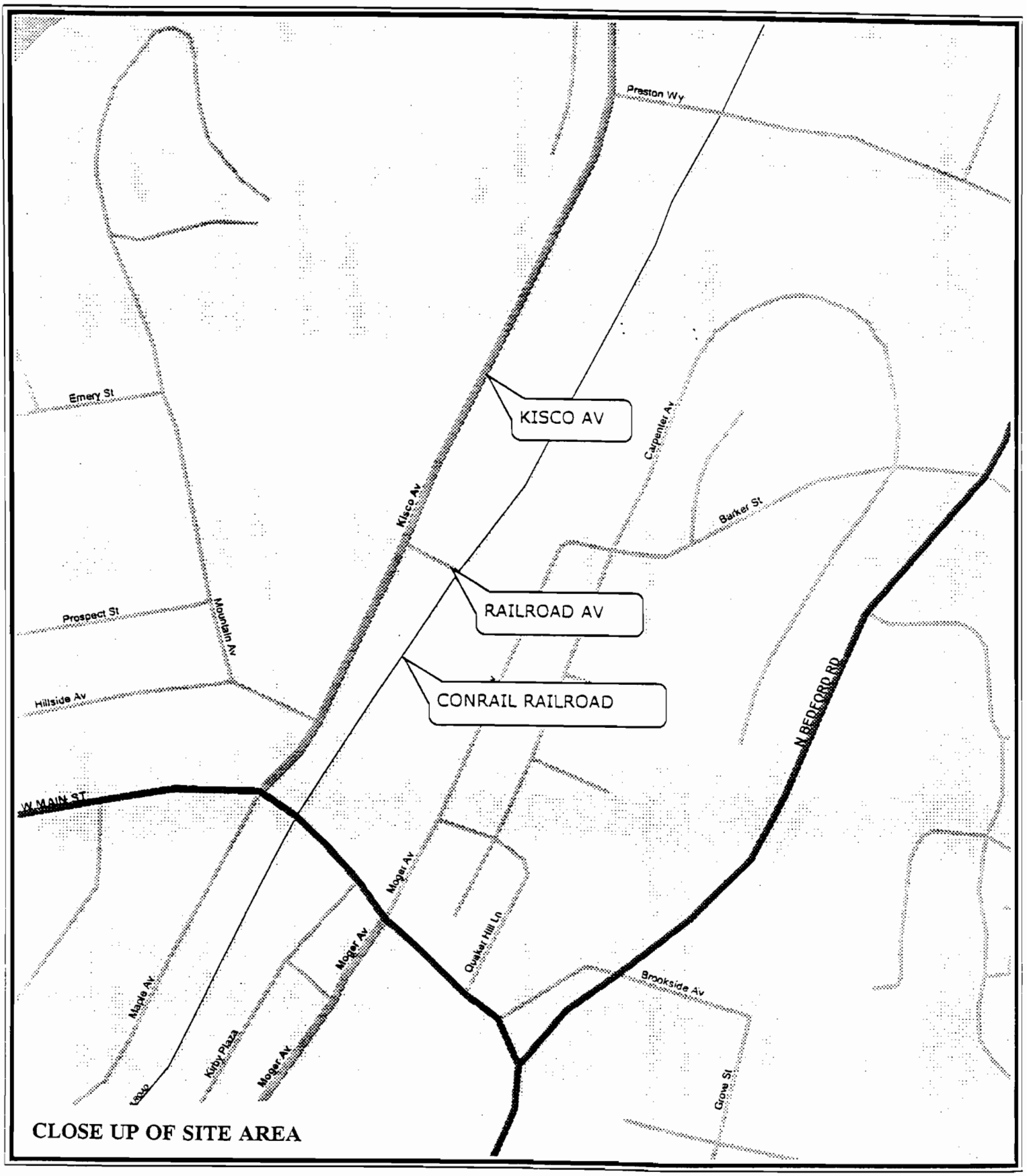

SAW MILL RIVER PKY
Interstate 684
KISCO AV
W MAIN ST
MAIN ST
BEDFORD RD
100
172
MAP OF MT. KISCO AREA

FIGURE 2


Preston Wy
Emery St
KISCO AV
Carpenter Av
Kisco Av
Barker St
RAILROAD AV
Prospect St
Mountain Av
CONRAIL RAILROAD
Hillside Av
N BEDFORD RD
W MAIN ST
Moger Av
Quaker Hill Ln
Brookside Av
Maple Av
Kirby Plaza
Moger Av
Moger Av
Grove St
CLOSE UP OF SITE AREA

(located south of the Railroad Avenue) is owned by the Village of Mt. Kisco. Most of the lot is within a wooden fence and is mowed by the Village. The other part (located north of Railroad Avenue) is owned by Richard's Lumber and Building Materials Center (Richard's Lumber -105 Kisco Avenue) which is a lumber supply company. Most of the open area is covered by an aggregate material (item 4) and is used for storage of materials sold by the lumber company. Richard's Lumber has one large building and several storage buildings/sheds which are used for the business. See Figure 3 for a sketch showing the important reference points of the site.

1C Site History

Canadian Radium and Uranium Company recovered uranium and other radioactive elements from uranium-bearing sludge and old instrument and watch dials. This work began as part of the Federal Government's Manhattan Engineering District (Manhattan Project). From 1943 to the 1950s, the primary product was uranium; then until closure, radium became the principal product. In 1966, the facility buildings were decontaminated and demolished. The most contaminated demolition material was disposed of by Nuclear Diagnostic Laboratories (sent to the West Valley Low Level Radioactive Waste burial site - private communication to P.J. Merges from J.M. Matusek) while the less contaminated demolition material was disposed of in the Croton Point Sanitary Landfill. As part of urban renewal efforts in the area, a new street (Railroad Avenue) was constructed where the Canadian Radium and Uranium Company building once stood. For further information on the cleanup and closeout surveys, see: Matusek, J. M. Decontamination and Demolition of the Canadian Radium & Uranium Corporation Facility, and Final Report for the Mount Kisco Urban Renewal Agency, Isotopes, Inc., A Teledyne Company. January 19, 1968.

1D Radiation Surveys Performed After Initial Site Cleanup

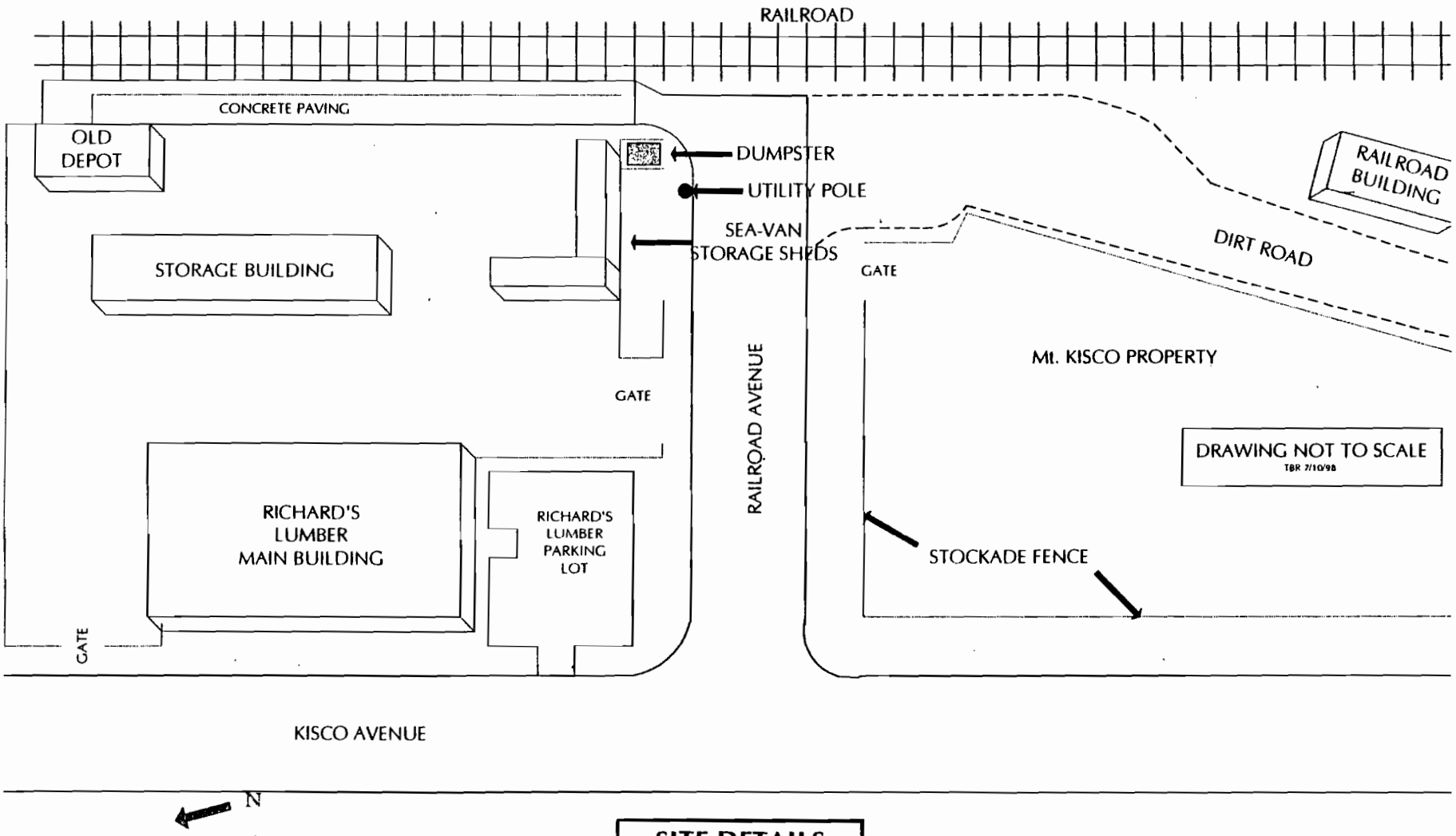
On April 20, 1979, a reporter from a local newspaper obtained radiation measurements from the site using what was described as a Geiger counter. Dose rates, measured one inch above the ground, were reported to be as high as 420 μR/hr.

On August 10, 1993, DEC made a brief survey of part of the Canadian Radium site, primarily to determine if any areas with elevated exposures could be found. The survey identified two such areas. Soil cores were collected from these areas. The highest radionuclide concentrations measured were Pb210 at 280 pCi/g and Ra226 at 240 pCi/g in one sample from two to four inches below the surface.

In September 1993, the State of New York Department of Health, Bureau of Environmental Radiation Protection, with cooperation from the Westchester County Health Department, conducted a survey of the former Canadian Radium site. The survey included measurements of gamma ray exposures and radon levels at Richard's Lumber. Background radiation

readings were about 10 μR/hr. No readings greater than this were observed inside the Richard's Lumber building. Elevated gamma readings were found outside the buildings, particularly in the storage area south of the old depot building. The maximum value observed was 240 μR/hr. No resuspension of site map radioactive particulates was observed. Finally, radon levels inside Richard's Lumber were higher than average for residential structures in the Village (the highest reading at Richard's Lumber was 9.8 pCi/l compared with 2.3 pCi/l for the Village average), but were about the same as the maximum indoor values observed within the Village. No restrictions on employee access to the property were recommended, but the State Health Department advised that further construction on site should be curtailed until more data is available to assess the extent of the contamination.

In 1994, the U.S. Environmental Protection Agency (EPA) conducted an inspection to measure radon levels, collect air and soil samples, and measure exposure rates. The purpose of the investigation was to determine if conditions required immediate action and if the site was eligible for long-term remediation under the Federal Superfund Program. Elevated exposure rate measurements were observed on both the northern (10 - 700 μR/hr) and southern (10 - 240 μR/hr) portions of the site property. Ra226 concentrations (soil samples were taken from the top 1.5 feet) ranged from 3 to 150 pCi/g. All of the radon measurement were below EPA's guideline (4 pCi/l) and the air samples collected at the site did not detect any suspension of radioactive contamination. EPA concluded that the site was not a potential for inclusion in the National Priorities List and therefore was not eligible for long-term remediation. For further information on the EPA investigation, see: Final Site Inspection Report Canadian Radium and Uranium Corporation Mount Kisco, Westchester County, New York. EPA Report No.: 8003-272 Rev. No.: 1. Volumes 1 &2. December 12, 1994.



SITE DETAILS

FIGURE 3

2. Survey and Sampling

2A. USRADS Description

The radiation detection equipment used to survey the site consisted of: two Ludlum model 2221 meters fitted with two Ludlum model 44-10 2x2 NaI probes, and a Bicron μRem meter. The Ludlum meters measure count rate; they count the number of gammas entering the NaI detectors each second. During the survey, the detectors were kept near the surface of the soil to measure the flux of gammas coming from the ground. The Bicron instrument simulates average exposure to humans and was kept at about one meter above the ground. The purpose of the rest of the instrumentation used during the project was to greatly increase the number of measurements that could be made and to store the data for interpretation later.

The Ultrasonic Ranging And Data System (USRADS) incorporates standard gamma radiation survey instruments into an integrated system. This system determines the location of the surveyor and stores the location and the meter outputs once every second in the field computer. While the survey is in progress, these values can be viewed in real time. This system enables us to collect much more data, compared with standard survey techniques, often approaching 100% coverage of a site.

The heart of the system consists of a data pack mounted on a backpack that is carried by the surveyor and data processing software in the base computer. Standard survey meters are mounted on the backpack and their outputs are sent directly into the data pack. To determine the location of the surveyor, the system uses the difference in transmission speed between ultrasonic and radio frequency (rf) signals. Stationary receivers (SRs) are mounted on tripods and are placed throughout the survey area. When each SR receives the ultrasonic signal, it sends an rf signal to the base computer. When this rf signal is received at the base computer, a stop signal is created for that particular SR. The time differences between the beginning of the cycle (rf signal at time = 0) and the arrival of the second rf signal at the base computer (one from each SR that "heard" the ultrasonic signal) determines the time-of-flight of the ultrasonic signal from the data pack to the individual SRs. The times-of-flight are converted to distances and then standard triangulation techniques are used to determine the location of the back pack within the survey area. This process is repeated once each second. The rf signal from the data pack to the base computer is encoded with the survey instrument data for the previous second. We verify that instrument readings as they appear on the instrument and in the field computer are the same. All this data is then displayed on the field computer screen as it is received, showing how thoroughly the area was covered by the surveyor, and the appropriate range for the value of each radiation instrument reading is shown by operator selected colors on the computer screen. This allows for real-time evaluation of the data so that missed areas can be identified and properly measured while the survey is in progress.

2B. Field Survey

The site required minimal vegetation clearing, but movement of debris or lumber yard product

was necessary to increase the coverage of the survey. The Village of Mt. Kisco and Richard's Lumber provided this assistance.

All surveys were performed using two 2" x 2" sodium iodide (NaI) detectors mounted on a survey pole and held within three inches of the ground surface, and one μRem survey meter mounted one meter above the ground on the backpack. The use of two essentially identical instruments provides a highly reliable method of verifying the data. To the extent possible, given obstructions on the site, parallel survey paths approximately three to four feet apart were walked within each survey area. The operator would slowly swing the detectors one to two feet on either side of the line being walked. In some areas where the data display on the computer indicated a possible presence of contamination, the surveyor was directed by the computer operator to walk over the area a second time using paths perpendicular to the initial ones to better define where contaminants were present.

There are size limitations to an individual survey, so seven separate area setups were used to complete the survey. Two composite surveys were created; one includes all of the Mt. Kisco property, Railroad Avenue, and the parking lot for Richard's Lumber; the other survey was over the area in use by Richard's Lumber. The individual surveys ranged in size from about 1/4 acre to 1+ acre. Some of the pictures taken during this survey show the survey in progress - see Appendix I.

2C. Soil sampling

The survey data gives an indication of the presence of gamma emitting radionuclides near the surface (in this case, the readings will be dominated by the radioactive material in approximately the top foot of soil). It does not identify the radionuclides nor does it "see" the presence of radionuclides a few feet below the surface. These problems are solved by taking soil samples and then analyzing them by gamma spectrometry to determine which radionuclides are present in the soil and at what concentrations. We start at the surface and sample down the soil column in increments to create a profile of the radionuclides present in the column.

236 soil samples (and one water sample) were taken from 42 sampling locations: 24 locations were from property south of Railroad Avenue, 17 north of Railroad Avenue, and one background (east of tracks - across from Mt. Kisco property). Most sampling locations were selected because USRADS measurements indicated that some radioactive material was in the immediate area; a few locations were selected to determine if areas where no radioactive materials were detected were free of contamination. Samples were collected using pre-cleaned hand tools (trowels, post hole diggers, pry bars and corers) to minimize amount of material disturbed. Each increment of soil (e.g., 0"-6") was placed on a separate sheet of plastic where it was hand mixed with a trowel. Small aliquots were taken randomly from within the pile (totaling ≥ 500 ml) for analysis by gamma spectrometry. The containers were tightly closed and were labeled with sample location, depth, date, and time.

After each increment of soil was removed, we obtained a one-minute count at the bottom of the hole using a 2x2 NaI detector and count rate meter. This data gives us a rough idea of the location of any contamination within the soil profile. At most locations, we continued digging until: (1) we encountered refusal, (2) the collected sample showed background like activity, or (3) we reached the limit of the hand tool access - about five feet below the surface. Refusals at some locations were caused by large concrete pieces, rock, or wood. If the hole profile counts suggested that we may be in an uncontaminated region, we checked the last sample taken from the hole using a shielded 2x2 NaI detector counting for ten minutes. The purpose of these sample counts was to provide a field verification that no significant contamination was present in the sample. If this test failed to show background level count rates, we continued sampling at that location, if possible. These shielded detector counts were done when DOH staff were on site to assist. This gamma count in the field was done for most of the samples from the Mt. Kisco property. After sampling was completed at a location, the remaining soil from each increment was returned to the hole in the reverse order as it was removed (i.e., last out - first in, etc.).

3. Results

3A Gamma survey

The results of the gamma survey are displayed in two forms, track maps and area maps. On track maps the one-second readings from each instrument are shown on the appropriate figure as dots at the proper site location. The values are displayed as colors in these figures, but the actual meter readings as transmitted by the data pack are stored in the field computer.

There are two sources of location error introduced during the survey process: (1) The detectors were held just in front of the individual doing the survey and the locating antenna was on the backpack. This difference was about two feet and will create a bias in the location of the detectors relative to the "location" of the backpack. We usually walk back and forth across a site in a serpentine fashion, so on successive passes this bias will be in opposite directions, as presented on the map. (2) The other problem associated with determining location is triangulation error. This error is minimized by using a running average for the location at each point (three data points are used - the calculated position of the previous data point, the given data point, and the following point). From experience, we have found that usually this contribution to the error is smaller than the bias.

Area maps identify contiguous "blob" shaped areas of elevated cpm values that are above some user defined limit. The areas displayed depend on:

1. the cpm threshold selected - all identified areas will have some data points with cpm greater than the threshold. For Mt. Kisco, the threshold is 20000 cpm, or at least twice background count rates; for Richard's Lumber, the threshold is 30000 cpm for the reason that the site has a generally higher count rate. Use of the lower threshold

causes the software to include most of the site into one area, thus losing the detailed shape of the more contaminated part of the site,

2. the minimum area requirement (before an area with elevated readings can be identified, it must have an area of at least 10 ft^2), and

3. the homogeneity of the nearby meter readings. For those points near the area boundaries, the values of nearby data points can have an effect on exactly where the line will be drawn.

These area maps will summarize the dominant features of those parts of the site where elevated
radiation levels were observed.

The colors used in these displays were chosen to suggest multiples of site background. Count rates commonly found on site where no radium was placed were about ten thousand cpm. All materials on site (fill soils, original soil, gravel, pavement, rocks, etc.) emit some radiation and all will be different, so it is hard to create only one description of "site background". Even though some count rates are lower, we have found that the value of about ten thousand cpm means that no significant radium placed on site was observed. We will use this value as a definition of the background count rate. According to gamma spectrometry data (discussed later in the report), Ra226 is the dominant radionuclide present as a contaminant on the site. When the survey instrument count rates increased above background, radium is what was measured. The range of colors can be used as an indication of the amount of radium present in the nearby soil.

- The color black was used when the cpm < 10000, which means that no significant radium was observed.
- Green: 10000 < cpm < 15000 indicates that waste containing radium has possibly been detected, particularly toward the upper end of the color range.
- Light blue: 15000 < cpm < 20000 should be interpreted as radium has likely been detected.
- Dark blue: 20000 < cpm < 30000 is a clear indication of radium present.
- Yellow: 30000 < cpm < 40000 and red/brown: 40000 < cpm < 50000 show increased radium present.
- Red: 50000 < cpm < 100000 indicates where the higher radium activities are seen.
- Pink: cpm > 100000 identifies where the highest radium activities were observed at greater than ten times background.

It should be noted that most gammas will not be observed if they have to pass through much more than about one foot of soil. This means that whatever count rate was measured, it tells us something about conditions in the nearest foot, or a little more, of soil.

One set of maps is presented for Mt. Kisco, another for Richard's Lumber. These maps are composites of several individual surveys. The same track map information is shown in an expanded scale in Appendix G where we have presented maps of the individual surveys.

3A.a Track Maps / Area Maps for Mt. Kisco

coordinate system: x = 0 at 2 feet from fence paralleling Railroad Avenue,
y = 0 at 5 feet from fence along east side of property
y axis parallel to fence which is parallel to Railroad Avenue

Track Maps - Mt. Kisco

Figure 4 shows the area south of Railroad Avenue; Railroad Avenue itself (x coordinate is between about 22 and about 50 feet); and the sidewalk, grass area, and the parking area between Railroad Avenue and Richard's Lumber building. The Mt. Kisco part of the site will include Railroad Avenue and everything south of the road. (Note: for logistical reasons, during the survey we included part of the property owned by Richard's Lumber in the surveys done for the Mt. Kisco part of the site. Those parts which are north of Railroad Avenue will be discussed in the next section).

Observations:

- Within the fenced part of the property we observed one large relatively continuous area (about 4000 ft^2 ±). The highest readings were $4x10^5$ cpm (found in the pink color range). Around the large area were several small areas suggesting lower activities might be present (the blue ranges). At the south end (to the left in the figure), several light blue areas were observed. These areas may be the result of Ra226 contamination (perhaps at depth) or may be due to radiation inherent in soil and fill materials on the site. This question can be answered with a few additional soil samples from these areas. A brush pile is present at the southern end of the area within the fence. We walked over the brush pile up to the fence at the south end of the property (does not show up on the survey) and found no elevated readings either during this survey or during a pre-survey investigation, but we were not able to survey the soil surface under the pile.
- Between Railroad Avenue and the wooden fence, we observed a narrow strip of contaminated soil just south of the road. Highest readings were about $5x10^4$ cpm in one and about $3x10^4$ in the other The shape suggests that this material might be where it is because of work done during construction of the road.
- Railroad Avenue itself showed count rates that were lower than background soils because of absorption by the road surface material. It will be necessary to sample below the road and base material to determine if the road itself is acting as a shield for contamination at depth.
- Between the fence and the tracks we observed three small areas just east of the fence - each less than 100 ft^2 in size. The southern part of the access road has lower than background counts, but a narrow, slightly elevated area is observed just east of the road. A manual survey over this area and a couple of soil sampling locations are needed to determine if radium is the cause.

The individual survey track maps for Mt. Kisco are shown in Appendix G.

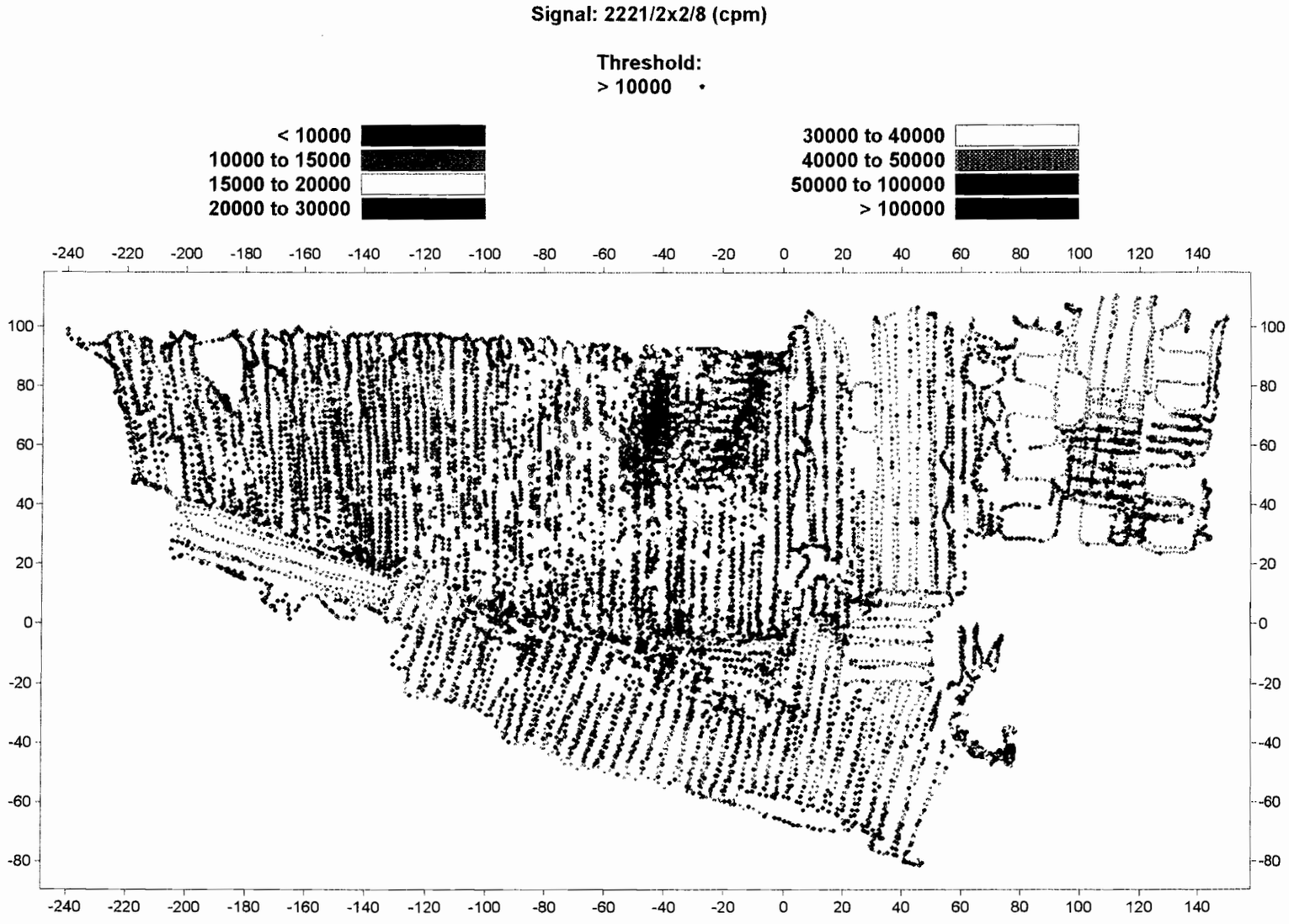

Signal: 2221/2x2/8 (cpm)
Threshold:
> 10000
< 10000
10000 to 15000
15000 to 20000
20000 to 30000
30000 to 40000
40000 to 50000
50000 to 100000
> 100000
-240 -220 -200 -180 -160 -140 -120 -100 -80 -60 -40 -20 0 20 40 60 80 100 120 140
100 80 60 40 20 0 -20 -40 -60 -80

FIGURE 4

Area Maps - Mt Kisco

Seven areas were identified and are shown in Figure 5 . They are identified on the figure as A - F.
(H through J are north of railroad avenue and will be discussed as part of the Richard's Lumber property).

Area A is the largest, has the highest average readings, and has the highest activities observed on the Mt. Kisco part of the site. Area D is a small area near Area A and possibly resulted from the same disposal and grading process suspected to have created Area A. Areas B, C, and E are just east of the fence along the edge of the gravel driveway. Areas F and G are along the southern edge of Railroad Avenue. Both NaI detectors used for the survey identified the same areas.

Shown in Table 1 is the statistical information obtained from each of the two NaI detectors (top row of data taken from detector DEC ID #7, the second row from detector DEC ID #8).

Table 1 Statistical information for areas of interest - Mt. Kisco

Area	square feet	# of survey points in area	minimum cpm	maximum cpm	average cpm	standard deviation
A #7	4040	2658	9540	358140	45650	46642
#8	4492	2881	9660	388860	45117	50360
B	35	48	7800	28080	16786	5374
	42	52	8760	31200	17619	5502
C	124	175	7380	46620	15655	6877
	110	150	7200	43740	16496	6838
D	15	43	6660	22200	13200	5347
	22	13	17520	25500	21762	2317
E	66	69	7320	25080	16742	4076
	96	101	8160	28800	16149	4253
F	70	83	7800	58800	21790	10749
	71	78	7800	51540	23444	11450
G	80	44	13800	27360	20352	2690
	25	21	14880	23640	19854	2304

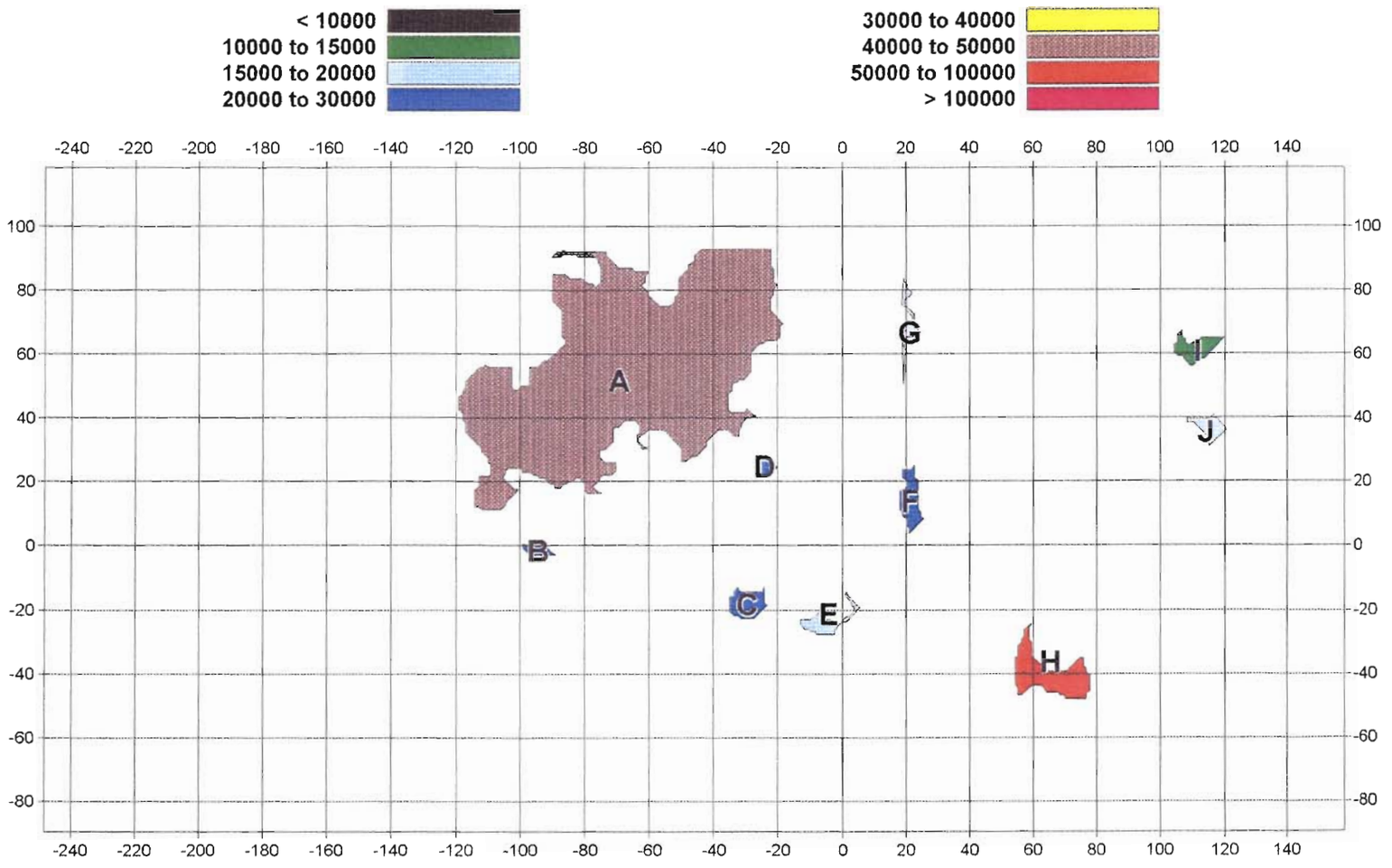

Signal: 2221/2x2/8 (cpm)
Threshold:
> 20000
< 10000
10000 to 15000
15000 to 20000
20000 to 30000
30000 to 40000
40000 to 50000
50000 to 100000
> 100000
A
B
C
D
E
F
G
H
I
J

FIGURE 5

The different detectors generally give similar results for area average count rates (column 6). The notable exception is the smallest area (Area D). The inherent random noise of a few data points near the perimeters of an area can make changes in their shapes and the number of points included in the area. For large areas, only a relatively few points are near the perimeter; however, for small areas, most of them are. For this reason, small area shapes tend to be less precisely defined and the results from the two detectors will tend to have larger differences. However, given the uses of this data, the differences between pairs of measurements will have little effect, if any, on decisions about the significance of this contamination. The differences in the table give a rough estimate of the reproducibility of the measurements.

3A.b Track Maps / Area Maps for Richard's Lumber

coordinate system: x = 0 at west edge of pavement along a narrow grate (storm water catch basin). A second grate is 55.1 ft. north of x = 0.
y = 0 at west edge of paved driveway along the east side of the property
x axis parallel to paved driveway along east side or property

Track Maps - Richard's Lumber

Data obtained from north of railroad avenue is presented on two figures - the northernmost part of Figure 4 (see page 20) and the rest of the survey is shown in Figure 6.

Two areas on Figure 4 are of interest.

- The top, right-hand corner of the figure shows data that was taken from over a parking lot. The northernmost part of the survey is next to the Richard's Lumber building. The locations of cars are noted by the areas not surveyed. In the parking lot, two areas with elevated readings are noted. The count rates are not high (a few data points are above $3x10^4$ cpm) but since the radiation is coming through the surface of the parking lot, this may be an indication that higher Ra226 activities might be found below the surface. The very small area of elevated readings next to the building may or may not be significant.
- At the lower, right-hand corner (just north of Railroad Avenue, particularly near the dumpster), we found the highest count rates anywhere on the site.

Referring now to Figure 6. The area of this part of the survey is bounded by storage sheds on the south, a chain link fence on the east and north end of the property, and the paved driveway and a storage to the west. Four surveys were done for this part of the site and the composite figure is presented here. The data gap in the lower right corner of Figure 6 is where the old railroad depot/storage building is located.

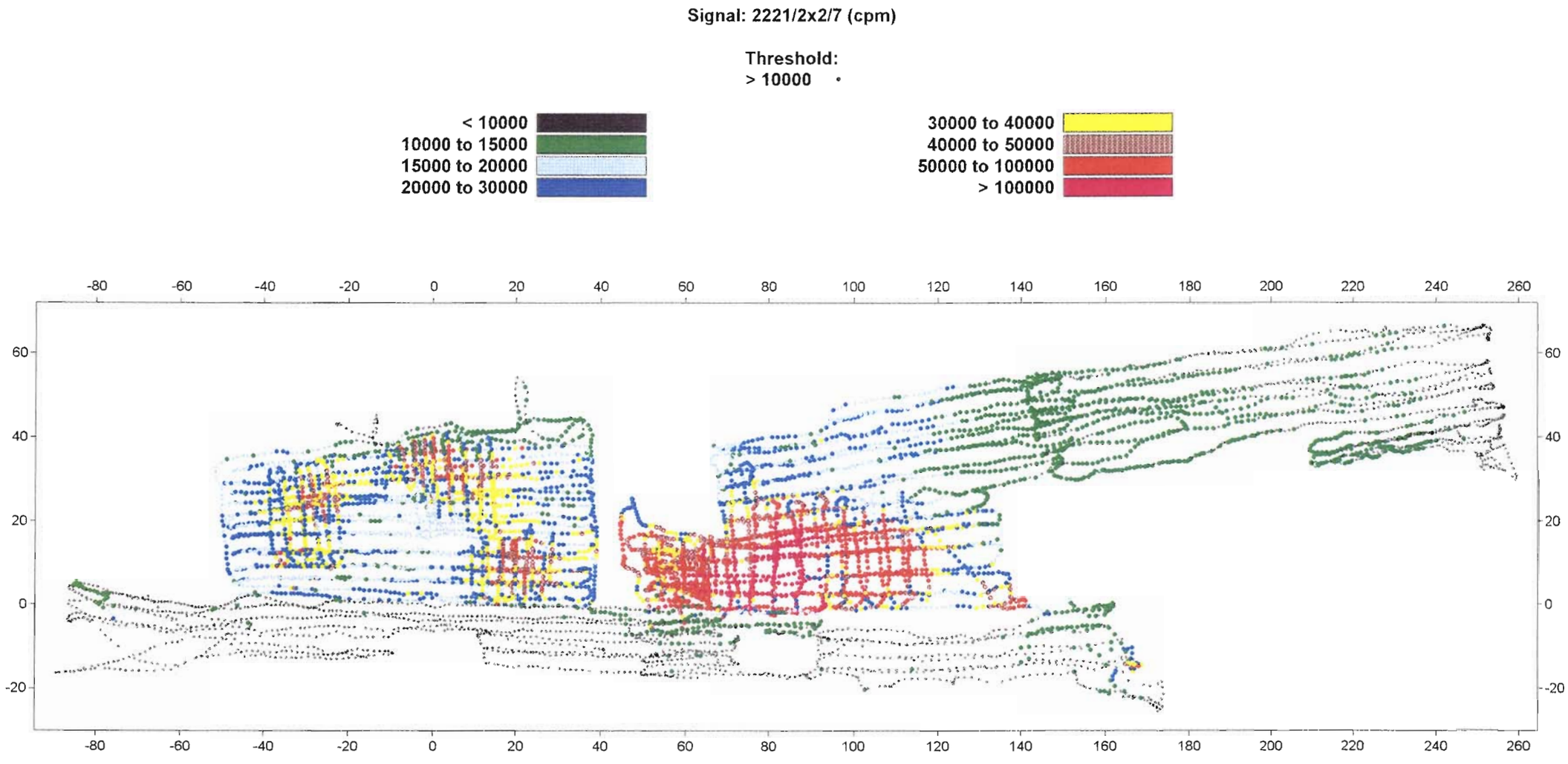

Signal: 2221/2x2/7 (cpm)
Threshold:
> 10000
< 10000
10000 to 15000
15000 to 20000
20000 to 30000
30000 to 40000
40000 to 50000
50000 to 100000
> 100000
-80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200 220 240 260
60 40 20 0 -20

FIGURE 6

Of particular interest:

- The driveway on the east of the survey area (bottom of figure) shows no elevated readings although clear evidence of radium starts next to the driveway. It will be necessary to sample from below the driveway to determine if radium is present. Elevated readings shown at the north end of this driveway were located incorrectly. They should be along the eastern edge of the old depot building. The x coordinate is approximately correct, but the y coordinate is too far east by about 15 feet. This happens if the USRADS data pack is carried too far outside the area where the SRs are located. It is appropriate to revisit this area near the old depot and to survey the whole east side of the building.
- The bulk of the outside area where lumber is stored (-50 feet < x <140 feet, and 0 feet < y < 40 feet) shows significant contamination. The unsurveyed area, 40 feet < x < 70 feet, was covered with large stones or other product too difficult to move. As will be seen in the section on soil profiles (Section 3C), the data show that Ra226 contamination extends to depths well below what is seen by the survey at some locations.
- The area immediately west of the old railroad depot building (now used for storage) shows no near-surface contamination.

The individual survey maps for Richard's Lumber are shown in Appendix G.

Area Maps - Richard's Lumber

Referring to Figure 5 (page 20), we observe three identified areas, two in the parking lot just south of the main Richard's Lumber building (Areas I and J) and one near the east end of Railroad Avenue near the dumpster (Area H).

Referring to Figure 7 (the composite of the Richard's Lumber surveys), the nature of the near-surface contamination in the lumber yard area is different from the rest of the site. Most of the site with x coordinates between -40 and +140 and y coordinates between 0 and 40 shows elevated meter readings. One group of data (Area A) combines three elevated spots; the other group (Area B) has roughly a rectangular shape. Shown in Table 2 is the statistical information for these Areas.

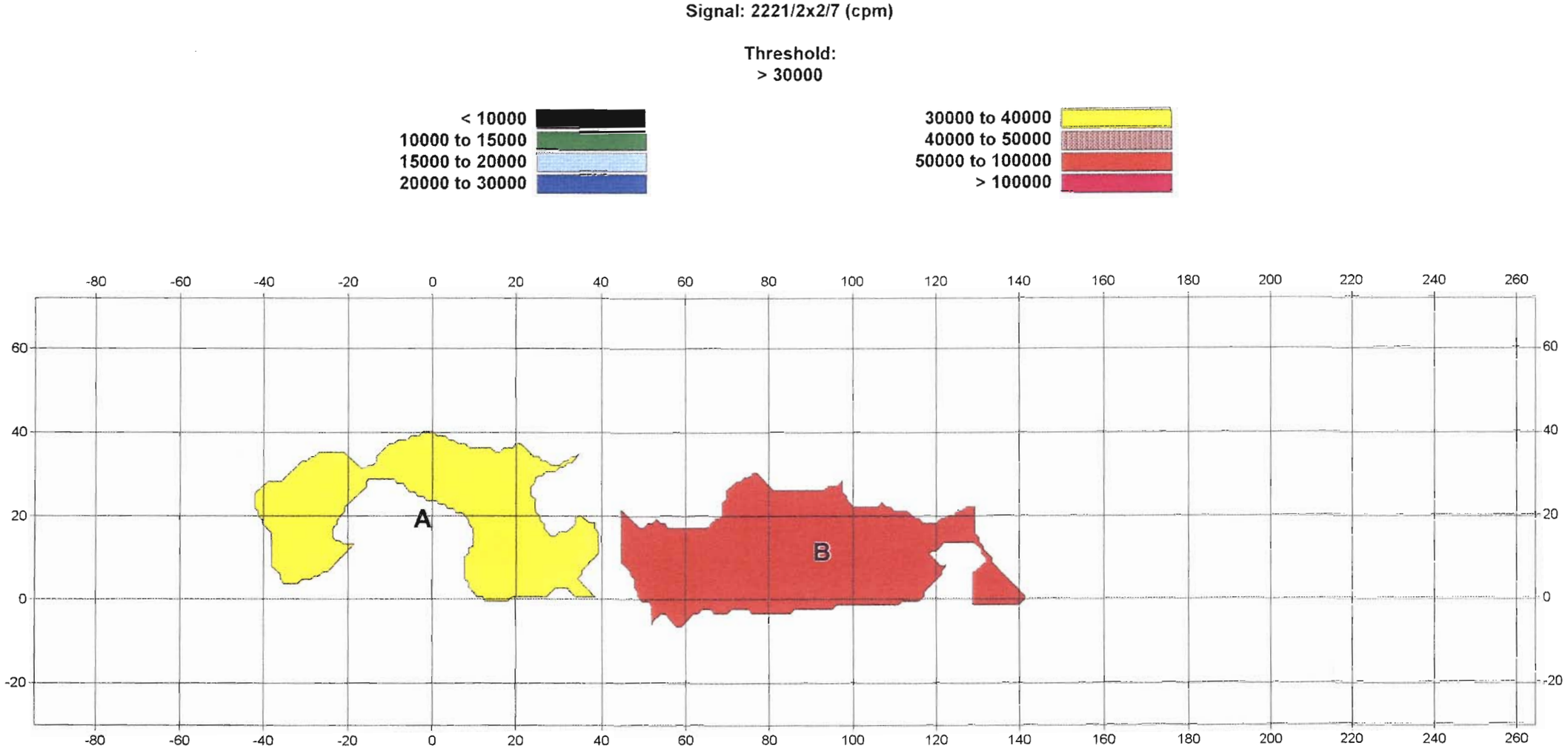

Signal: 2221/2x2/7 (cpm)
Threshold:
> 30000
< 10000
10000 to 15000
15000 to 20000
20000 to 30000
30000 to 40000
40000 to 50000
50000 to 100000
> 100000
A
B
-80 -60 -40 -20 0 20 40 60 80 100 120 140 160 180 200 220 240 260
60 40 20 0 -20

FIGURE 7

Table 2 Statistical Information for areas of interest - Richard's Lumber

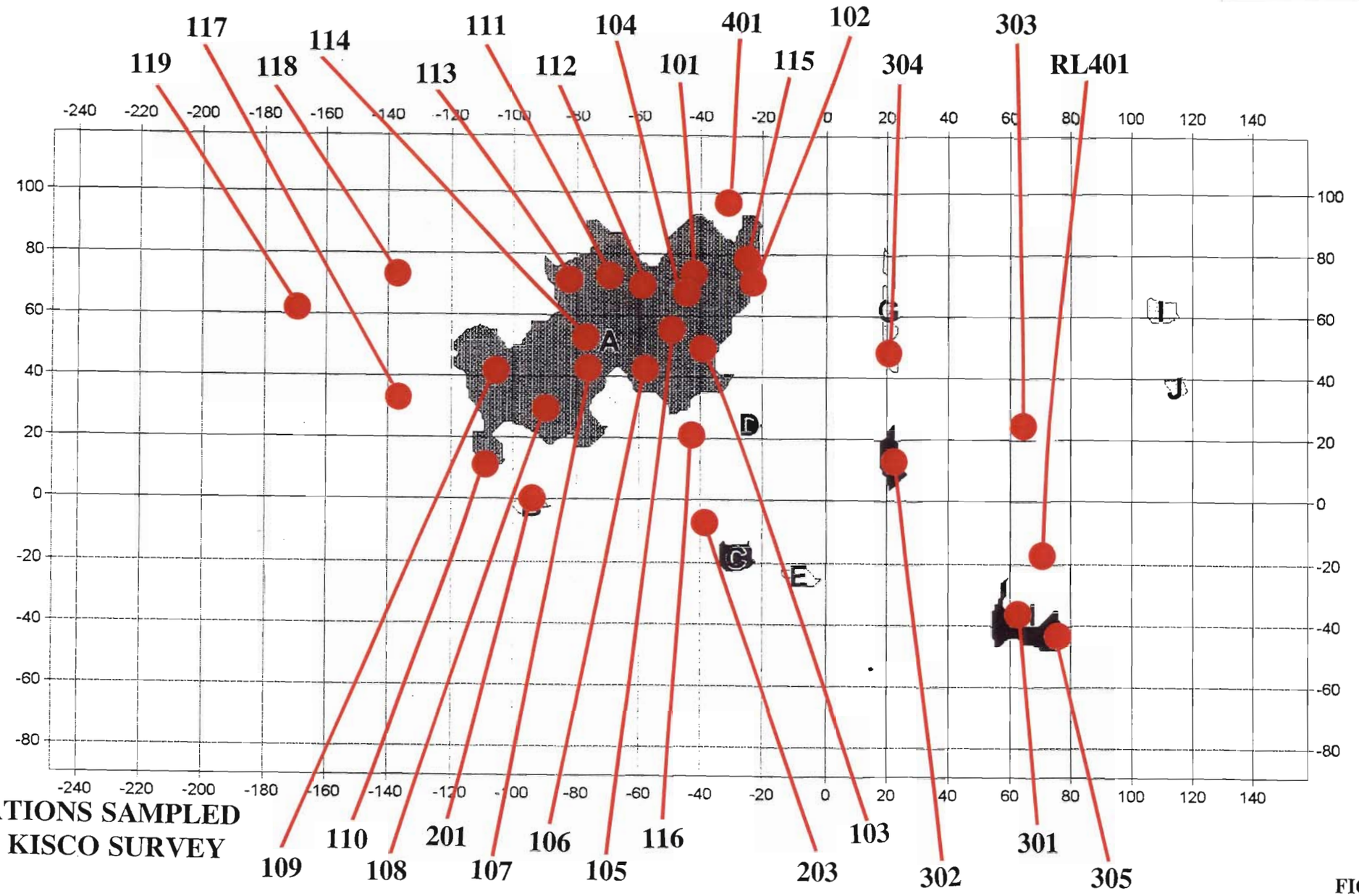
Area	square feet	# of survey points in area	minimum cpm	maximum cpm	average cpm	standard deviation
from Figure 4 (page 20)						
H	139	276	9840	1123320	110278	203045
	158	298	8520	808920	101997	174932
I	63	59	6180	35580	14762	8384
	69	65	6360	37500	15190	8526
J	28	29	10680	29280	18155	5415
	44	47	8940	29520	17417	5936
from Figure 6 (page 24)						
A	1544	1599	8280	117840	32457	11486
	1632	1659	8580	130680	33479	11845
B	1939	1831	7560	328260	70610	53218
	2039	1866	7860	319800	70057	52404

3B. Soil Sample Locations

Shown in Figure 8 and Figure 9 are black and white copies of the respective Area Maps from the Mt. Kisco survey and the Richard's Lumber survey. Added to these figures are the locations where soil samples were taken. The actual coordinates (relative to the specific survey) are given in the activity data summaries in Appendix A. Each location is marked with a three-digit number (first digit is the individual survey number, the second two digits are sequential numbers of samples taken within the area of that survey).

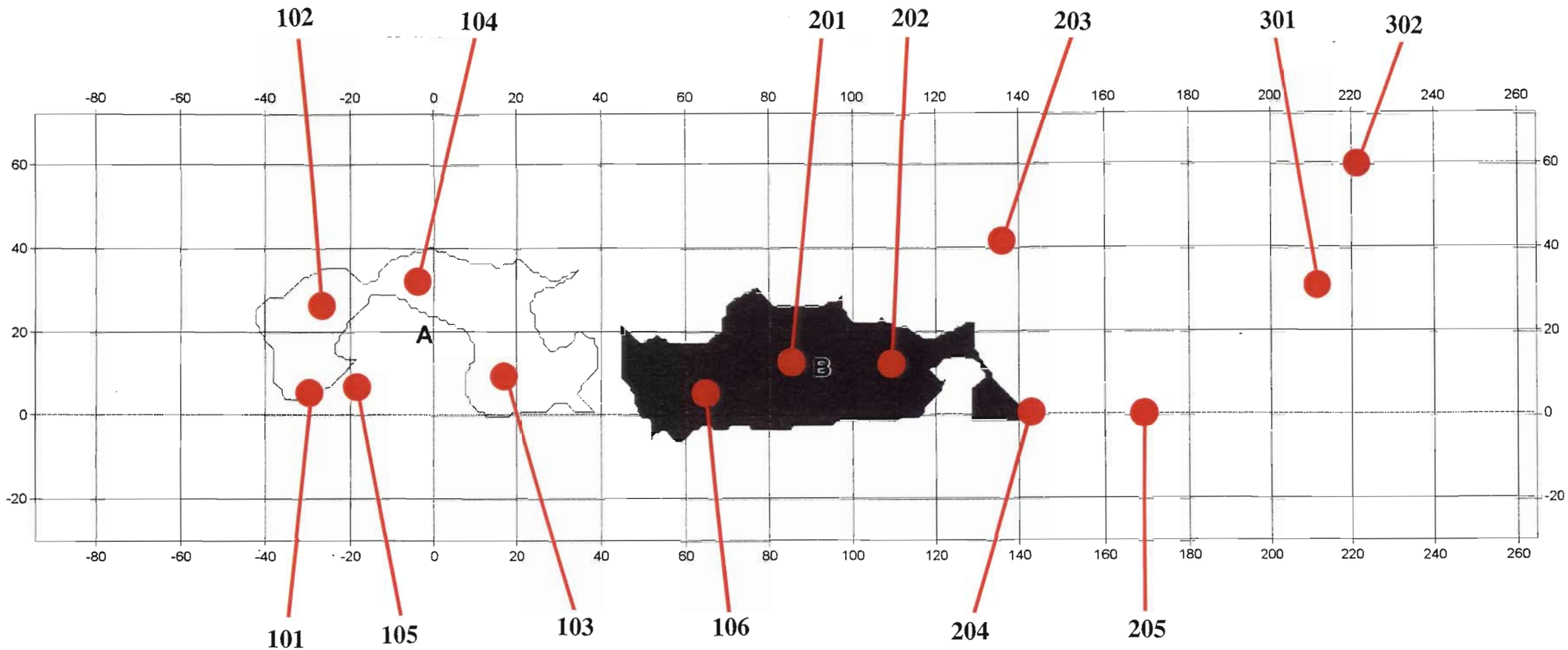
3C. Soil Profiles of Ra226 activity

Most of the wastes from processes involving naturally occurring radionuclides are found in three radioactive decay series - uranium, thorium and actinium. A representation of the uranium decay series is shown in Appendix B. The figure provides a graphical description of how different radionuclides present on this site are related (see particularly Ra226 and the other radionuclides resulting from the decay of Ra226). Also listed in the figure are the gammas used to determine the concentrations of the radionuclides in the soil. Included in Appendix B are the decay series for thorium and actinium. It will be shown that no thorium series radionuclides were found above background concentrations, but a portion of the actinium series was observed in some samples, although not at the high activities noted for Ra226.



LOCATIONS SAMPLED
MT. KISCO SURVEY

FIGURE 8



LOCATION SAMPLED
RICHARD'S LUMBER SURVEY

FIGURE 9

Ra226 has only one gamma with a moderate intensity. Unfortunately, U235 has a gamma with an energy close to the Ra226 energy. If the entire uranium chain is in equilibrium (assuming no enrichment of uranium), then about half of the gamma counts at that energy will come from each radionuclide. In those samples contaminated with significant amounts of radium, the relative contribution from U235 becomes less important. To completely avoid this problem, we use gammas from the decay products of Ra226 decay as indirect measurements of its concentration in the soil. The daughters Pb214 and Bi214 have multiple, easy-to-detect gammas. The concentrations of Ra226 and its decay products are calculated from measurements of the count rates of the individual gammas that are given off during decay. They are shown in Appendix A. The samples were counted either in the DEC lab or buy Thermo NUtech.

3C.a. Activity profile

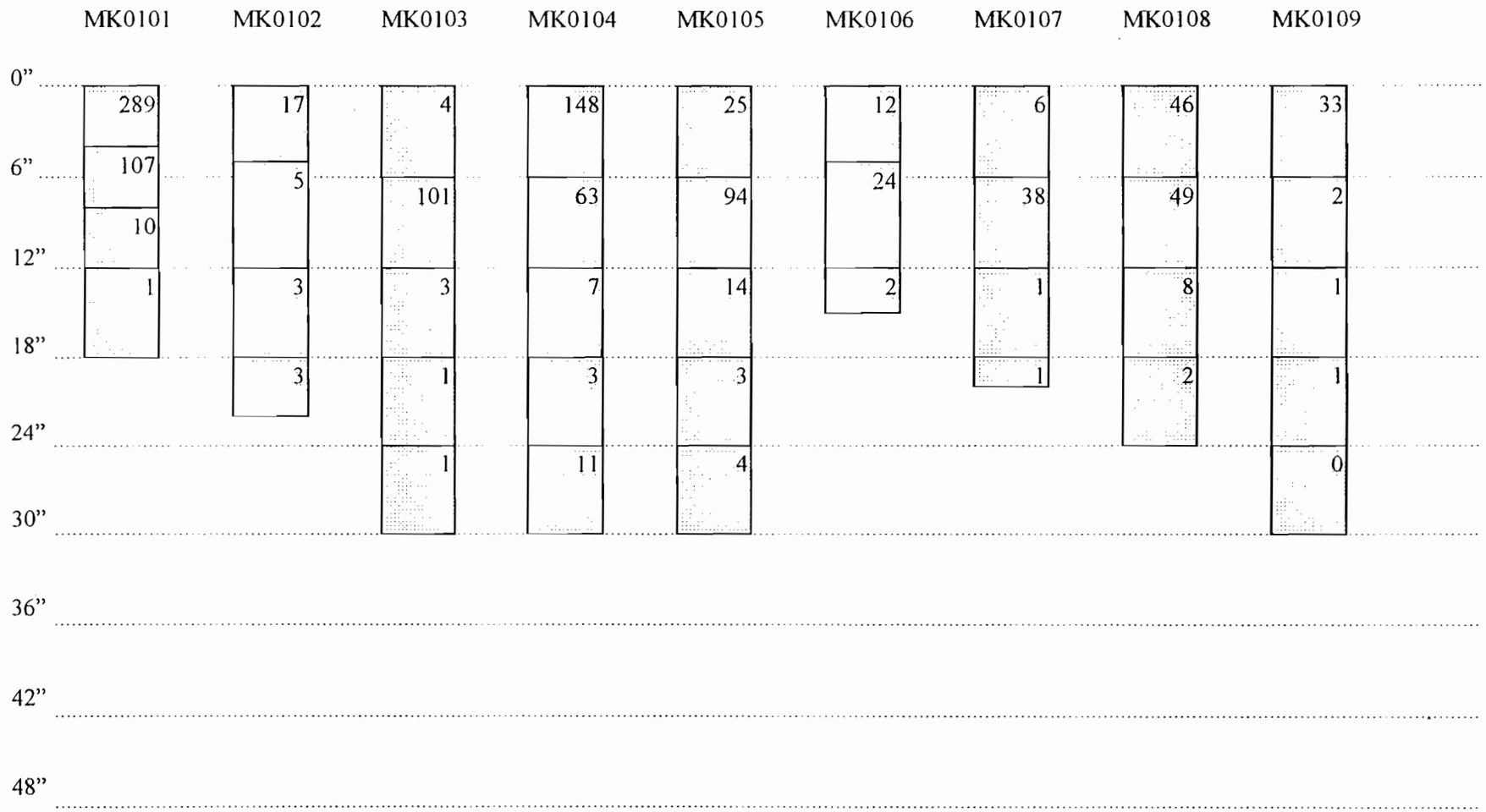
In the Ra226 data summary shown below, we will present averages of the measurements of Bi214 and Pb214 as surrogates for Ra226. The radium decay series will be in equlibrium so we can take advantage of the strong, interference-free, gammas from the bismuth and lead. For most samples, measurements of between 5 and 8 gammas were averaged to obtain the estimated Ra226 activity. These averages are presented in Figure 10 (pages 31 - 35).

The sampling locations are presented sequentially. The identification number has six characters: the first two indicate either Mt. Kisco (MK) or Richard's Lumber (RL). The next two digits are the survey number - MK01 refers to the first survey on the Mt. Kisco property. The last two digits identify the sampling location within that survey. For example: MK0109 can be read as sampling location #9 from the first survey on the Mt. Kisco property. The x-y coordinates (units in feet) for each sampling location are shown on the data summary pages (Appendix A). The coordinates refer to the Mt. Kisco survey if the location identifier starts with MK. They refer to the Richard's Lumber survey if the location identifier starts with RL.

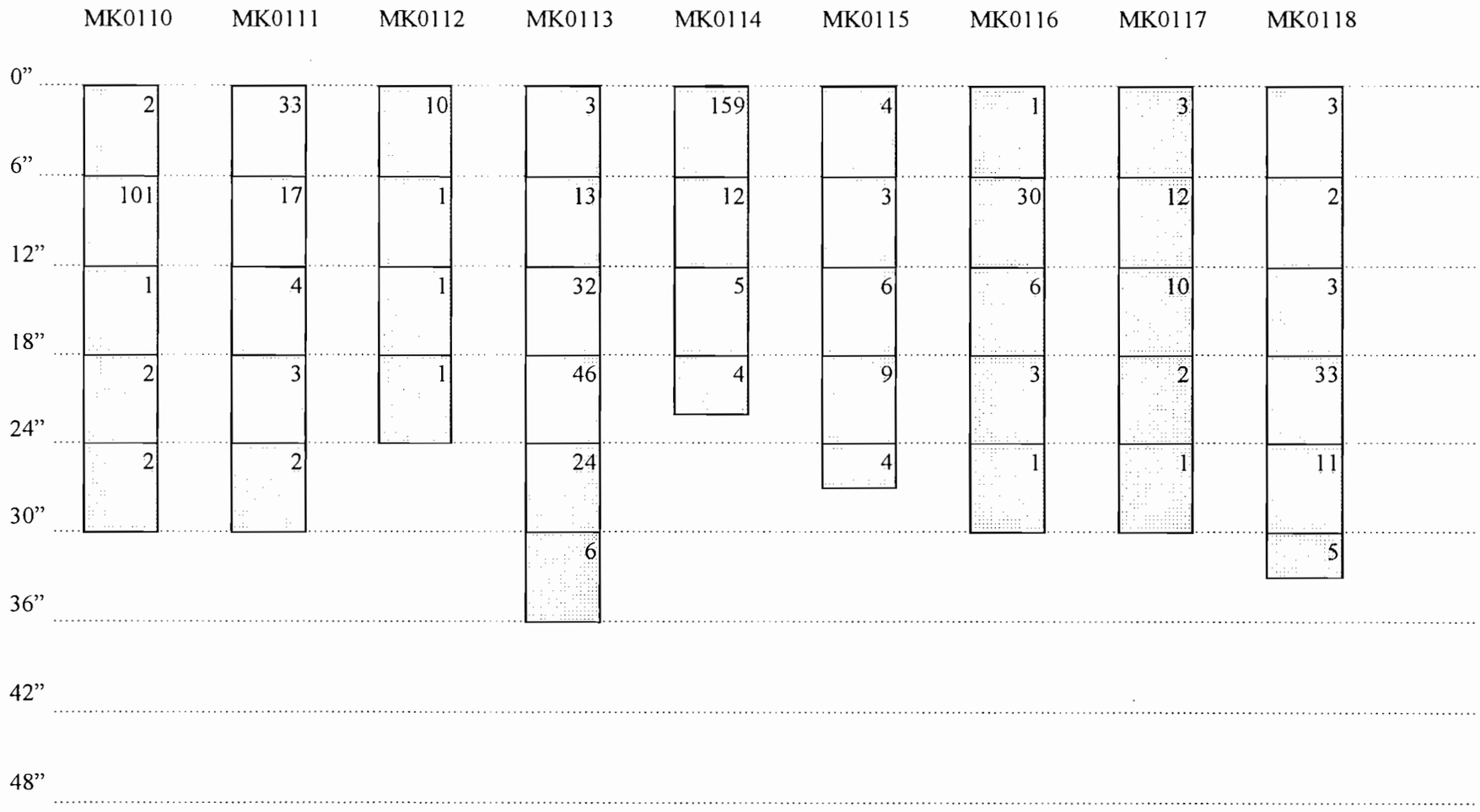
From one to ten samples were taken from a given location. Locations with only a few samples usually meant that we could not dig deeper with hand tools (refusal at the bottom of the hole) or we concluded that further digging was not necessary. At the other extreme, it was not possible to obtain samples from depths greater than about 4½ feet.

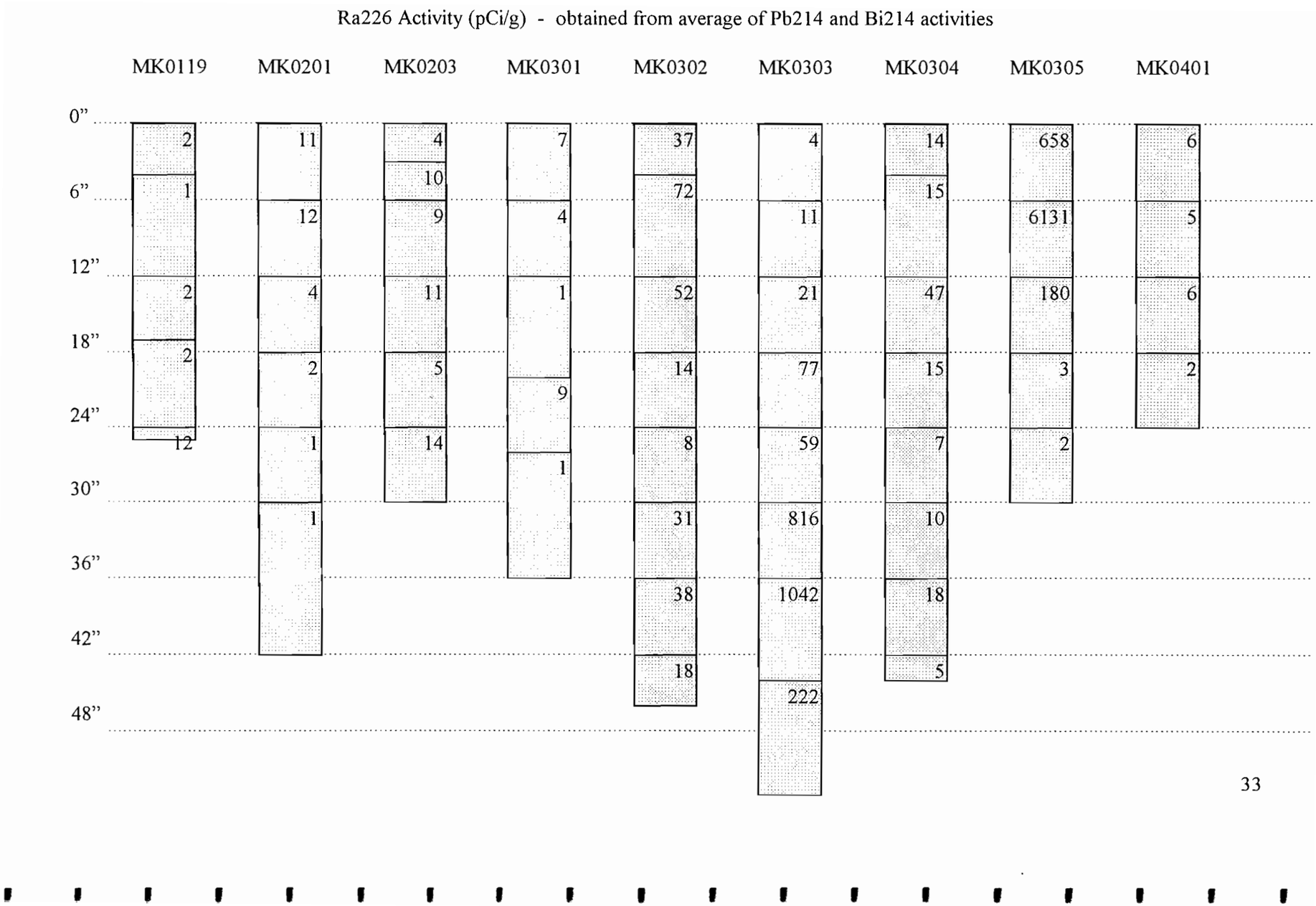
Shown in figure 10 are the vertical extents of each sample. Along the left side of the page are depths in inches with a dotted line across the page at six-inch intervals. The box for each sample indicates the depth range from which it was taken. For example: location MK0101 has four samples, 0 to 4", 4 to 8", 8 to 12", and 12 to18" deep. The number within each box is the estimated Ra226 activity in pCi/g. Values range from 1 pCi/g to $6x10^3$ pCi/g.

Figure 10 Ra226 Activity (pCi/g) - obtained from average of Pb214 and Bi214 activities

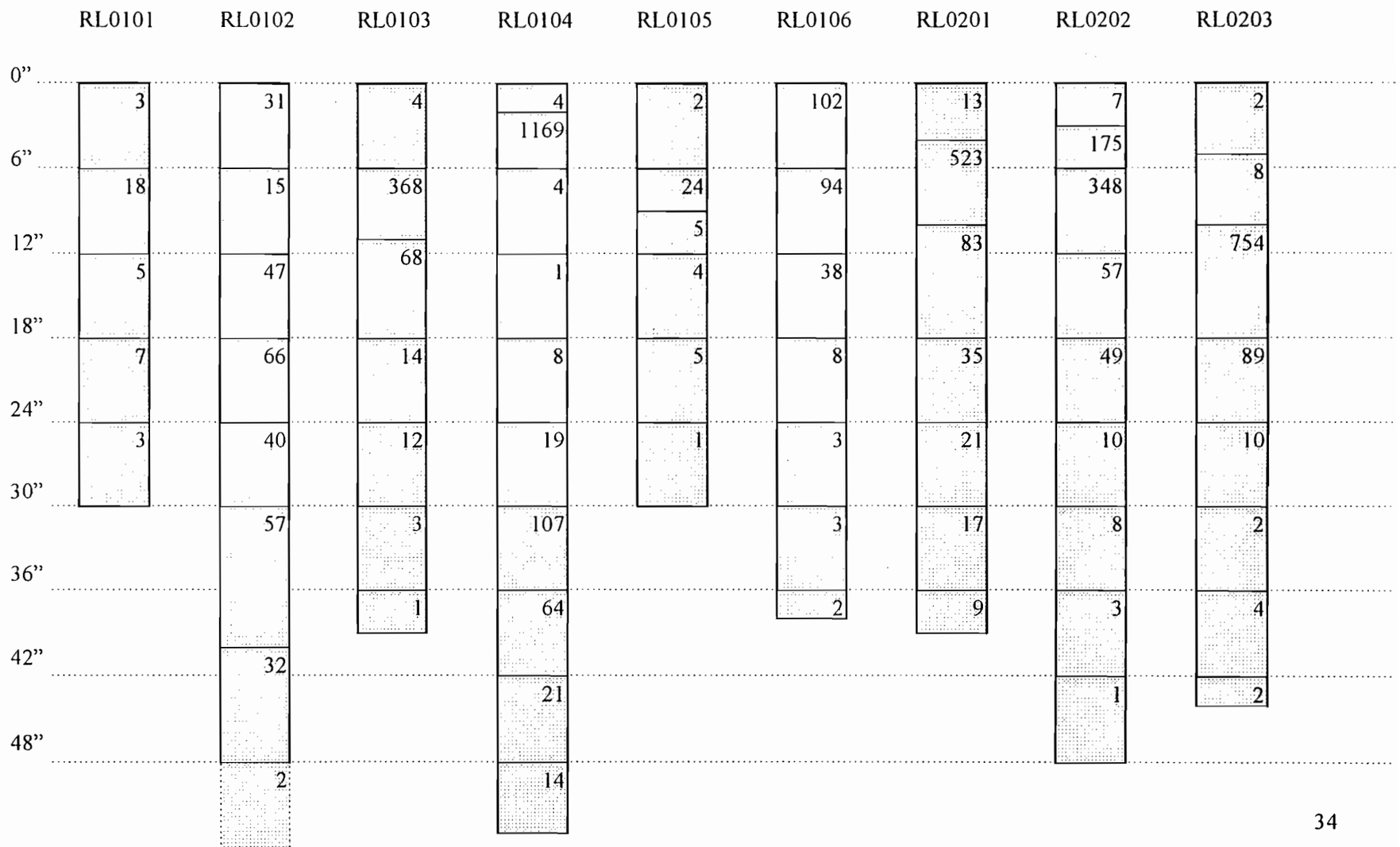


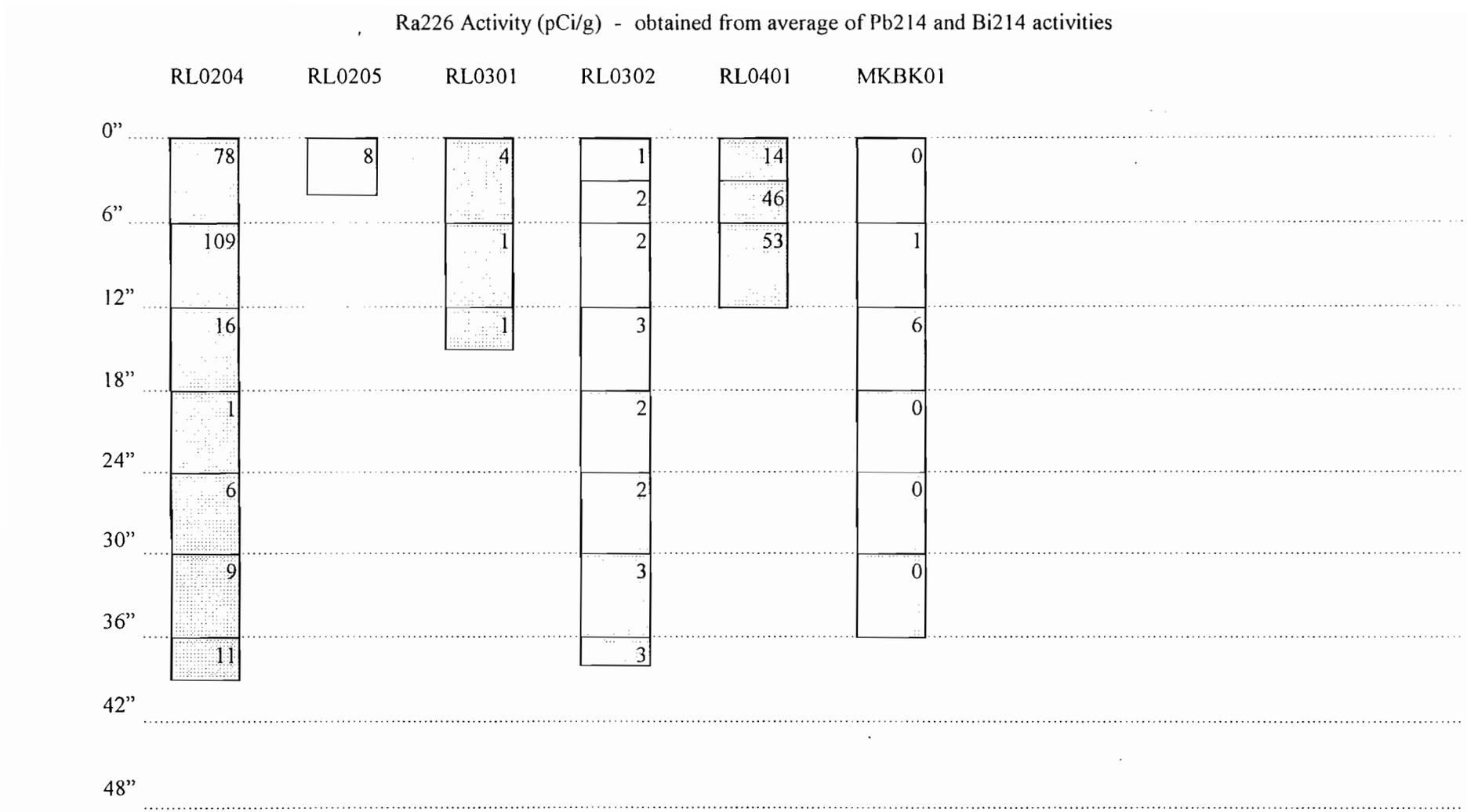
Ra226 Activity (pCi/g) - obtained from average of Pb214 and Bi214 activities




Ra226 Activity (pCi/g) - obtained from average of Pb214 and Bi214 activities
MK0119
MK0201
MK0203
MK0301
MK0302
MK0303
MK0304
MK0305
MK0401
0"
6"
12"
18"
24"
30"
36"
42"
48"
2
1
2
2
12
11
12
4
2
1
1
4
10
9
11
5
14
7
4
1
9
1
37
72
52
14
8
31
38
18
4
11
21
77
59
816
1042
222
14
15
47
15
7
10
18
5
658
6131
180
3
2
6
5
6
2

Ra226 Activity (pCi/g) - obtained from average of Pb214 and Bi214 activities



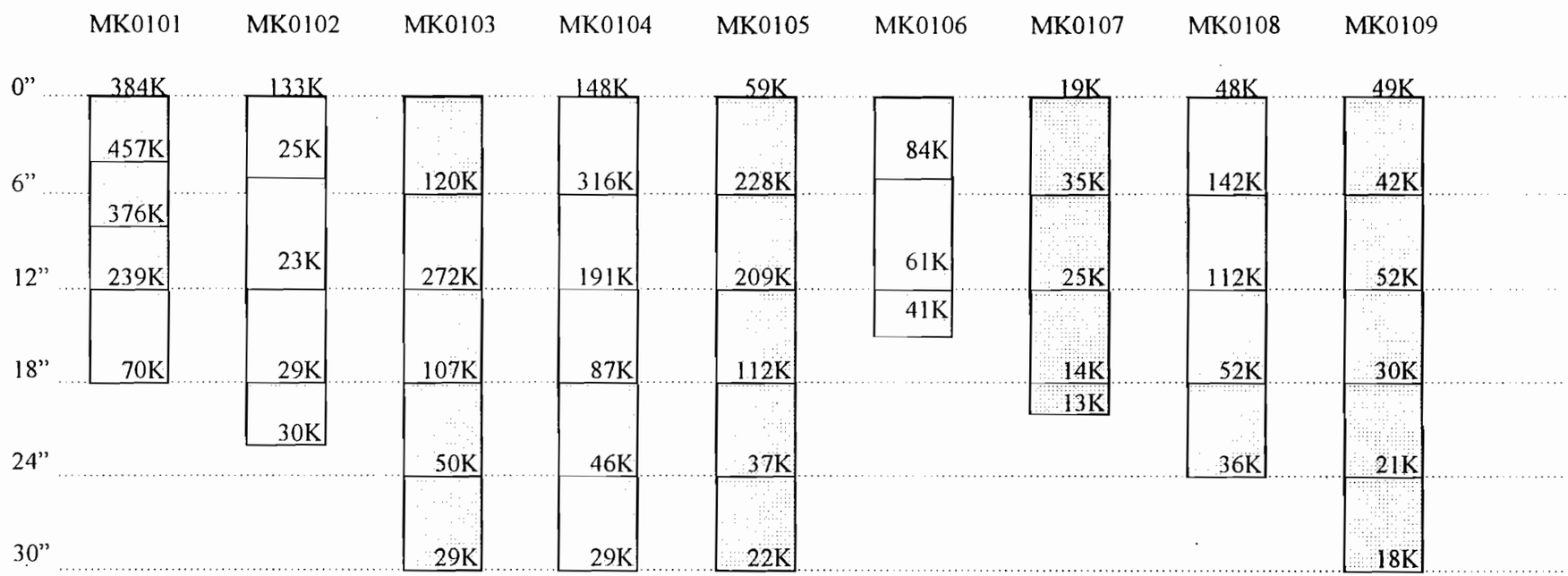

Ra226 Activity (pCi/g) - obtained from average of Pb214 and Bi214 activities
RL0204
RL0205
RL0301
RL0302
RL0401
MKBK01
0"
6"
12"
18"
24"
30"
36"
42"
48"
78
109
16
1
6
9
11
8
4
1
1
1
2
2
3
2
2
3
3
14
46
53
0
1
6
0
0
0

3C.b Count rate profile

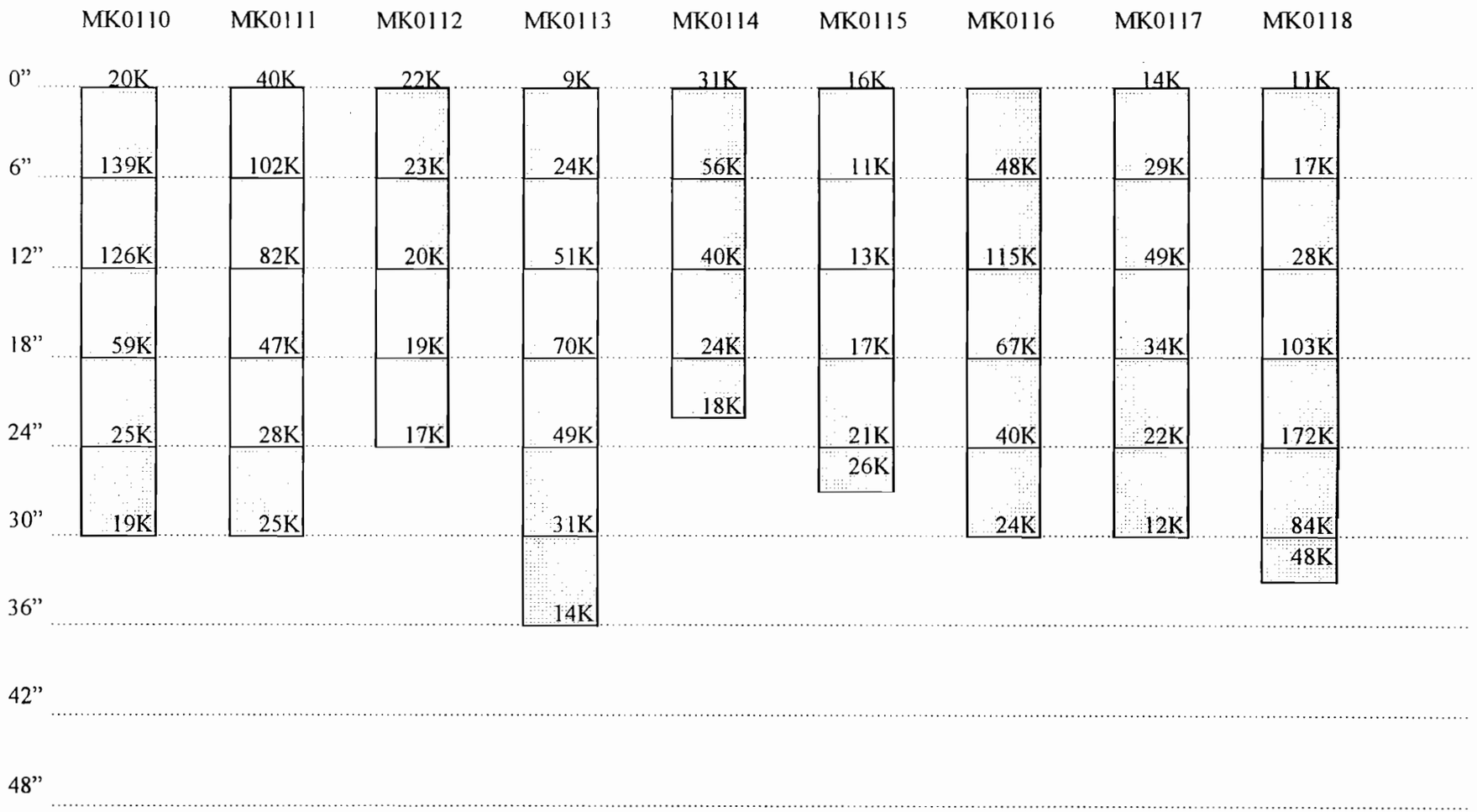
As a location was sampled, we obtained one-minute count rates at the bottom of the hole after each soil increment was removed. These count rates are shown in Figure 11, pages 37 to 41. The same format was used as for the activities (shown in Figure 10).

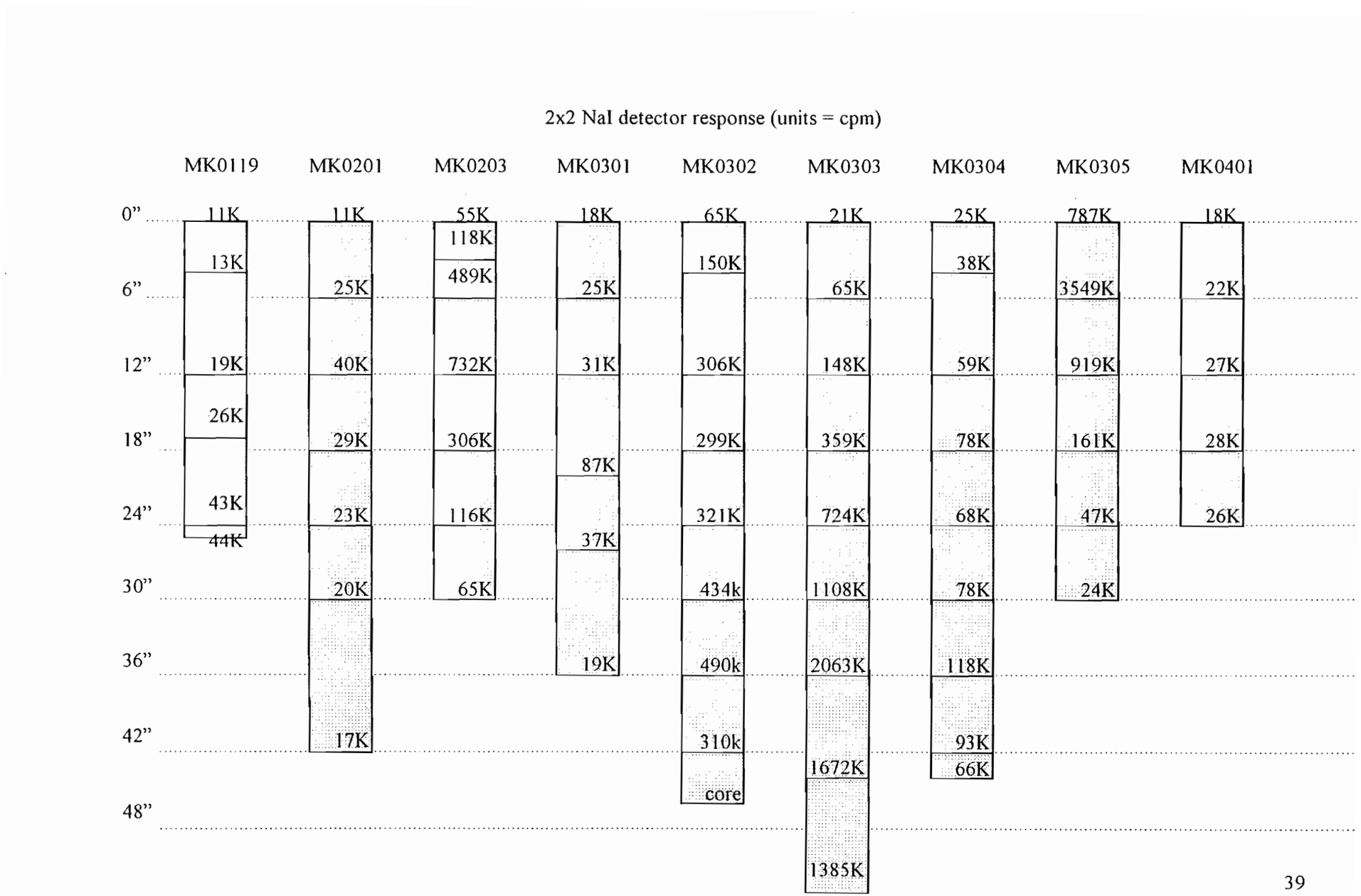
The counts observed are influenced by the amount of radioactive material in the nearby soil. We expect while the two profiles should be qualitatively similar, the two measurements detect different things. The activity measurement applies to material in the sampled soil increment only, but the count rate measurement "sees" what is in the nearby soil. Very near the surface, there is less nearby soil so the count rate tends to increase as we go deeper independent of any change in radioactive material. Also, the radioactive material on this site is not uniformly distributed; hence, the concentration of radium within the sample is not necessarily the same as that found in the nearby soil. The two measurements are in general agreement at most locations but, at a few of them, the measurements do not seem consistent. It is possible that the measurements are all correct and an explanation can be found; however, further sampling may be needed at these locations. A brief description of our findings at each soil sampling location is presented in Appendix F.

Figure 10 Soil Profile of 2x2 NaI detector response (in cpm) for each sample location

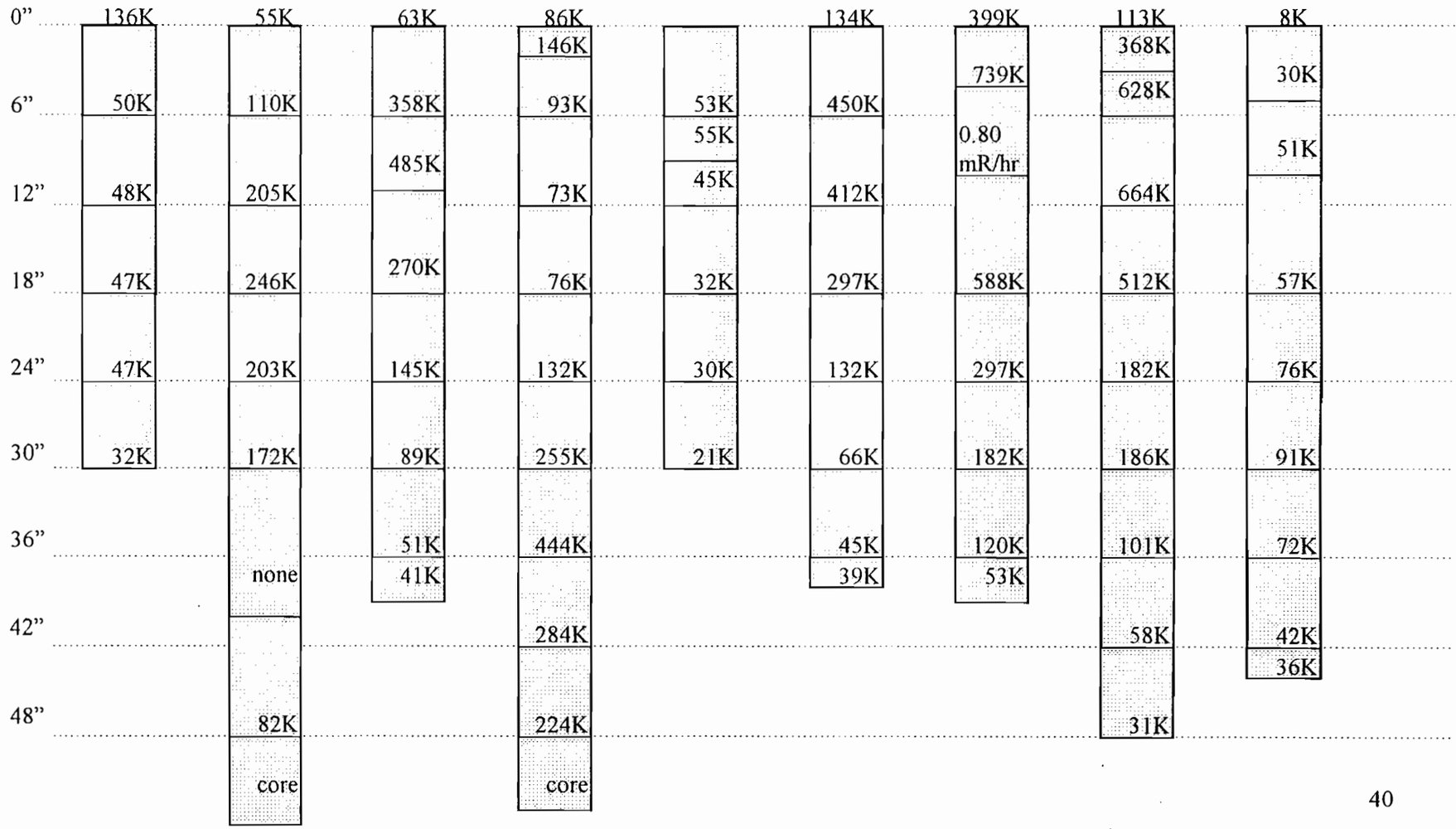


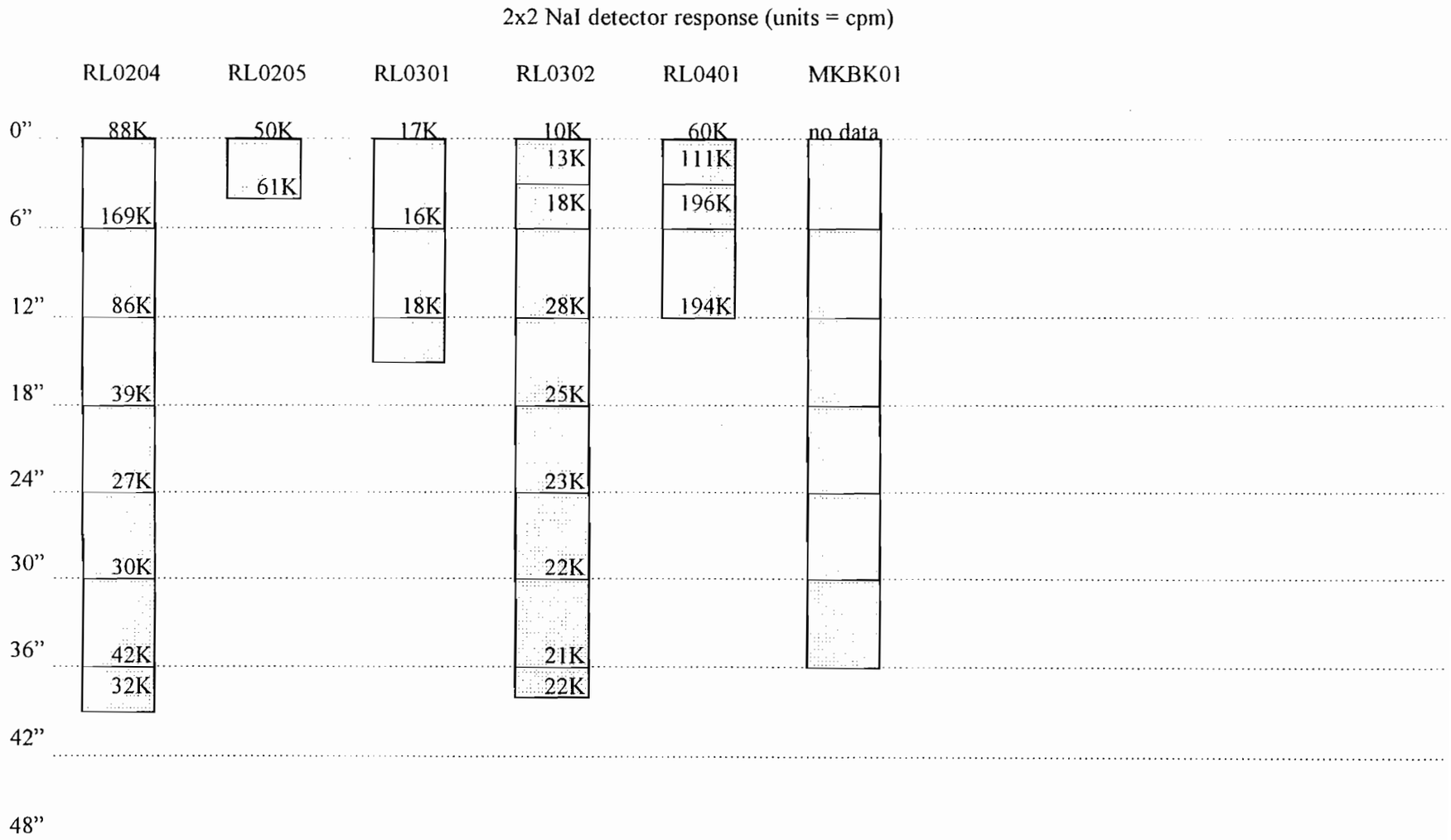
2x2 NaI detector response (units = cpm)




2x2 NaI detector response (units = cpm)
MK0119
MK0201
MK0203
MK0301
MK0302
MK0303
MK0304
MK0305
MK0401
0”
6”
12”
18”
24”
30”
36”
42”
48”
11K
13K
19K
26K
43K
44K
11K
25K
40K
29K
23K
20K
17K
55K
118K
489K
732K
306K
116K
65K
18K
25K
31K
87K
37K
19K
65K
150K
306K
299K
321K
434k
490k
310k
core
21K
65K
148K
359K
724K
1108K
2063K
1672K
1385K
25K
38K
59K
78K
68K
78K
118K
93K
66K
787K
3549K
919K
161K
47K
24K
18K
22K
27K
28K
26K

2x2 NaI detector response (units = cpm)




2x2 NaI detector response (units = cpm)
RL0204
RL0205
RL0301
RL0302
RL0401
MKBK01
0"
6"
12"
18"
24"
30"
36"
42"
48"
88K
169K
86K
39K
27K
30K
42K
32K
50K
61K
17K
16K
18K
10K
13K
18K
28K
25K
23K
22K
21K
22K
60K
111K
196K
194K
no data

3C.c Discussion of activity and count rate profiles

In the following discussion, the activity and count rate profile data are consistent unless otherwise noted.

South of Railroad Avenue

Fifteen sample locations (MK0101 to MK0115) were from within Area A (see Figure 5 - page 22 for the visual representation of the area). At most locations, the two data sets are in good agreement. They show that most of the radium is found in about the top foot of soil. Exceptions to these statements are in MK0114 where the surface activity seems high for the count rate measurement and MK0113 which has clear contamination down to 30 inches.

Four more sample locations (MK0116 to MK0119) from within the fence were selected where the survey did not detect any contamination. Slightly elevated radium was found at all locations, but it was not detected in the survey either because it was too deep or because the activities were low.

Two sample locations were chosen between the fence and the railroad tracks. MK0201 was within Area B and showed only slightly elevated radium. MK0203 was from an area where background was expected, but it showed slightly elevated activities throughout the 30-inch profile. The high count rates are inconsistent with the activity measurements for this location. This problem may be resolved by resampling this location. Area C and Area E were identified in the survey as having above-background count rates, but they were not sampled for this survey. They should be included in the work plan when further sampling is done.

Two sample locations (MK0302 and MK0304) were from between the fence and Railroad Avenue (Areas G and F). Both showed moderate activity throughout most of the nearly four-foot profiles. Meter readings suggest that contamination may exist below the depths to which we sampled.

One sample location was west of the fence along Kisco Avenue (MK0401). It showed little activity throughout both profiles.

North of Railroad Avenue

Four locations along the north edge of Railroad Avenue were sampled. MK0303 near the gate to Richard's Lumber showed significant contamination between 2.5' and 4' and RL0401 found radium down to one foot (the limit of the sampling) but it is likely that radium extends to greater depths. The area will need to be revisited. Two locations were from within Area H; the one on the west edge of the Area (MK0301) showed little radium, but at the other (MK0305 near the dumpster) we found the highest activities on the site.

Thirteen sample locations were from the unpaved area between the main lumber yard buildings and west of the railroad tracks.

Five sample locations were from within or near Area A (see Figure 9 - page 29 for visual representation of Area A sample locations - Richard's Lumber survey). Locations RL0101, RL0103, and RL0105 (the location near A) are from the eastern part of the sampled area and all show the radium limited to the top two feet of soil. Locations RL0102 and RK0104, from the west part of the Area A show clear evidence of radium down to about four feet. RL0104 shows evidence of a layer of radium contamination below about two feet. Two inconsistencies between data sets were noted: the surface count rate seems high for near-background radium concentrations in RL0101 and the high reported activity near the surface in RL0104 would seem to require a higher count rate in that part of the profile. For the RL0104 location, the gravel layer on the surface will provide some shielding to any radium in the soil, but the area should be checked. An additional sample location should be taken from the "hole" in the middle of Area A to check to see if high activities exist at depth.

Four sample locations were from Area B (see Figure 9 - page 29). The two locations on the east part of the Area (RL0106 and RL0204) have radium only in the top 1½'. At the other two locations, the dominant contamination is in the top1½', but observable contamination extends down to about three feet.

One location was sampled where no radium was expected (RL0203 northwest of Area B). While no radium was present near the surface, elevated concentrations were found between 1 and 2½'; however, the activity between 10" and 18" is high given the count rate profile data. Additional sample locations are needed in this area to determine if radium is present at depth too great to be seen during the survey.

The sample location near the southeast corner of the old depot building (RL0205) was not deep enough. This location needs to be resampled. Depending on the results of the survey on the east side of the depot, additional sample locations in the area may be needed.

Two locations were sampled near the north end of the site and west of the old depot building (RL0301 and RL0302). No radium was expected and none was found.

Background Sample

One location (east of the tracks, opposite the Mt. Kisco property) was sampled. Activities were low except for the 12"-18" sample. The observed values less than 1 pCi/g radium activity are typical for background levels. Possible reasons for the higher activity in the one sample are: cross contamination at the laboratory, some geological feature with a naturally elevated radium concentration, or contamination spread from another area.

3C.d Average Ra226 activities shown in one-foot increments

Field soil sampling protocol was based on 6" increments to establish the vertical profile of radionuclides within the soil column. This resolution is necessary to identify layering in the contamination profile. In general, this procedure was followed. If we noted that the soil composition obviously changed, then we might (depending on staff judgment) adjust the increment break to separate different soil types into different samples. To help in interpreting overall site conditions, it is useful to put all vertical profile information on the same scale. We chose one-foot increments as an appropriate way to summarize where the contamination is located. The samples within each one foot increment were weighted by their relative depths within that increment.

Average Ra226 activity (pCi/g) in one-foot increments:

South of Railroad Avenue

	0-12"	12'24"	24-36"	36-48"	>48"
within fence					
MK0101	135	1 —	no		
MK0102	10	2	no		
MK0103	53	2	1	no	
MK0104	106	5	11 —	no	
MK0105	50	9	4 —	no	
MK0106	18	2 —	no		
MK0107	22	1 —	no		
MK0108	48	5	no		
MK0109	18	1	1 —	no	
MK0110	52	2	2 —	no	
MK0111	25	4	2 —	no	
MK0112	6	1	no		
MK0113	8	39	15	no	
MK0114	86 ?	5	no		
MK0115	4	8	4 —	no	
MK0116	16	5	1 —	no	
MK0117	8	11	1 —	no	
MK0118	3	18	8 —	no	
MK0119	1	2	12 —		
east of fence					
MK0201	12	3	1	no	
MK0203 ?	8	8	14 —		
north of fence					
MK0302 ?	60	33	20	30 —	
MK0304	14	31	8	15 —	no
MK0401	6	4	no		

— means only part of the range was sampled.
no - means that there is no evidence of contamination in this range based on meter readings at the bottom of the hole.
? - means there are questions about the data. The reasons are listed in profile comparison discussion in Appendix F.

All one-foot averaged activities greater than 50 pCi/g are found in the top layer.

Meter readings taken at the bottom of the hole can "see" significant concentrations of Ra226 in at least the next foot down. At all sampling locations within the fence except one, the data suggest that no radium waste is likely to be found below four feet from the surface. One sample (MK0119) is unclear, but the count rate data may also be an indication of radium off to the side of the sampling hole. One of the sample locations east of the fence (MK0203) showed a high count rate but a low activity. This area should be resampled to resolve this issue. At the two locations just south of Railroad Avenue (MK0302 and MK0304), sampling to greater depths will be needed to determine the vertical extent of the radium.

North of Railroad Avenue

	0-12"	12-24"	24-36"	36-48"	>48"
MK0301	6	4	1 —	no	
MK0303	8	49	438	842	yes
MK0305	3395	92	2 —	no	
RL0101	11	6	3 —	no	
RL0102	23	57	49	40	no
RL0103	161	41	2 —	no	
RL0104	392 ?	5	63	18	yes
RL0105	8	5	1 —	no	
RL0106	98	23	3	2 —	no
RL0201	280	59	19	9 —	no
RL0202	220	53	9	2	no
RL0203	130	422 ?	6	3 —	no
RL0204	94	9	8	11 —	no
RL0205	8 —				
RL0301	3	1 —	no		
RL0302	2	3	3	3 —	no
RL0401	42				

— means only part of the range was sampled
no - means that there is no evidence of contamination in this range based on meter readings at the bottom of the hole.
yes - means that there is evidence that some contamination may be found in the next increment
? - means there are questions about the data. The reasons listed in profile comparison discussion.

The highest Ra226 activities are found on this part of the site - see particularly MK0305, near the dumpster.

At several locations, significant Ra226 activities are found at depths greater than one foot. For example: just north of Railroad Avenue (MK0303, MK0305), and at several locations under the storage area (e.g. RL0102, RL0104, RL0201, RL0202, and RL0203).

At two locations the data suggest that we have not sampled to the bottom of the contamination (MK0303, and RL0104). At two locations (RL0205 and RL0401) we did not sample deep enough to answer that question.

Background

location east of tracks, opposite Mt. Kisco property

	0-12"	12-24"	24-36"
MKBK01	1	3	0

3C.e Results - Other radionuclides present in the samples:

K40 (range from 3 to 21 pCi/g) is a naturally occurring radionuclide and is not a contaminant. Thorium chain radionuclides (about 1 pCi/g) occur naturally in soils at about this activity.

Cs137 is present in some samples at fallout background levels. This radionuclide is not reported in Appendix A since the activities are so low.

U235 observed in some samples and is believed to be at the naturally occurring abundance for uranium. Uranium appears to be at background levels.

Actinium series radionuclides from Th227 down have been observed at a few tens of pCi/g levels in some samples. Elevated actinium series radionuclides are not necessarily correlated with the Ra226 activities, suggesting separate waste streams. The highest activity observed was about 60 pCi/g in location MK0303. See Appendix A for the results of the gamma spectrometry. The gammas of interest tend to be hard to resolve because of low intensity or interference, so if the radionuclides are present at only a few pCi/g or less, we may not be able to quantify them. This is particularly true for those samples analyzed by Thermo NUtech because their resolution was 1 keV/channel, whereas DEC's resolution was 0.5 keV/channel. For many samples we can only state that these radionuclides are, or possibly are, present.

Site history documents prepared during previous surveys at this site indicated that separations for actinium were done by Canadian Radium and Uranium Corporation. Ac228 found in the thorium series (and daughters) would have decayed by now; however, Ac227 found in the actinium series (half life = 22 years) may be the source of the radionuclides we observe. If the separations had occurred in about 1950, only about 20% of the original radioactive material would remain. Doses from radium will be much larger than from radionuclides in the actinium series. Unless significantly larger activities of actinium series radionuclides are found in any future possible investigations, they will not have an important role in making decisions about future uses of the site.

3C.f Results - Water sample

A small accumulation of water seeped into the bottom of sampling location RL0102 after several hours. A sample of this water was collected for gross alpha and beta analysis, and gamma spectrometry. The results are shown in Appendix A. Some comments about the results:

- In the unfiltered water, gross alpha = $6x10^2$ pCi/l, Unfiltered gross beta = $4x10^2$ pCi/l. These results should not be used because they are likely to include some contaminated soil that fell to the bottom of the hole from higher in the soil profile.
- Filtered water gross alpha, gross beta, and Ra226 alpha spectrometry results are consistent with a Ra226 activity of about 12 pCi/l. Where we obtained the water sample, water recharge rates are very low. It should be noted that the EPA drinking water standard is 3 pCi/l for Ra226 and is 15 pCi/l for gross alpha. While our one sample results are suspect, it is possible that, when properly analyzed, this water may exceed this standard.
- The gamma spectrometry analysis of the filtered sample is not internally consistent, but there are two reasons why this could occur; the Ra226 = $2x10^2$ pCi/l measurement may contain an interference from U235 and there is likely to be considerable radon loss between the Ra226 and the daughters (their activity = $5x10^1$).
- The gamma spectrometry result is not consistent with the alpha spectrometry result.

During this site characterization, only one sample location had water at the bottom, so we have only one water sample. Also the results are internally inconsistent. We are, therefore, treating this sample as suggestive of possible water table contamination. This work was not able to resolve the question about possible water contamination. When future sampling extends into the saturated zone, water samples need to be taken and analyzed for gross alpha, alpha spectrometry for Ra226, and gamma spectrometry for Ra226 and daughters.

Results - organic analysis of soil sample

At several sampling locations on Richard's Lumber, we noticed a solvent odor near the bottoms of holes. We provided a soil sample (sampling location RL0202 at three to four feet down) to DEC Region 2 for analysis. The results reported were:

	ppm (ug/g)
Toluene	0.98
o,p-xylene	1.1
o-xylene	7.7
n-propylbenzeze	11.
1,3,5-Trimethylbenzene	17.
4-isopropyltoluene	4.6
1,2,4-Trimethylbenzene	25.
n-Butylbenzene	20.

This data suggests that one possible source of these organics is solvents (degreasers). They are not at high concentrations and are not a current exposure problem, but a work plan for future sampling should include analysis for these species. The reported concentrations are above cleanup limits, so possible remediation may have to deal with both types of wastes. If these are petroleum wastes, STARS memo #1 cleanup standards will apply. If they are solvent wastes, then DEC TAGM 4046 cleanup limits apply.

3D. Estimated Ra226 activity on Mt. Kisco Property

There is one condition which, if met, allows us to relate survey readings to the amount of radium in the soil. This condition is that essentially all the radium is relatively near the surface so that the radium would be observed by our survey instruments. To be strictly correct, this would mean that the radium would have to be within the top few inches of soil, which is not the case anywhere on site. Within the fence on the Mt. Kisco property, we can say that most of the radium is found within the top foot of soil (noting that this statement does not apply to two of the sampling locations). The distribution of Ra226 is not ideal, but it should be close enough that we can make a reasonable estimate of how much soil has an average radium concentration above some specified limit. This is an important question to address, since the answer will provide guidance on what is involved in the different options that should be considered for future uses of the property. Only the area within the fence on the Mt. Kisco property has the characteristics that allow us to make this estimate.

There are two approaches that we can use to estimate the relationship between meter readings and Ra226 soil concentrations.

- Approach 1 is to compare the average count rates in areas calculated the way we did in section 3A with the average Ra226 soil concentration for those sampling locations within the area. This is the large-scale view.
- Approach 2 is the small-scale view, where we compare average count rates from a few points near each sampling location with the radium concentration for that location.

Approach 1 - develop a relationship between average count rates for a selected area with the average Ra226 concentration for all soil sampling locations within the area.

When we identified areas containing radium at clearly above-background levels (Figures 5 and 7), we selected a threshold count rate that would exclude those areas where the survey suggested that the radium in the soil might be present, but if it was near the surface, it would be at activities that have little significance. However, for the purpose of developing this relationship, we use higher thresholds, creating smaller (potentially more homogenous) areas with higher average count rates. Of course, it is necessary to have soil sample data from within these areas. It then is possible to calculate a relationship between average count rate and soil activity. As will be shown later, once we identify an average soil activity that can remain on site, we can then use this relationship as a tool to select those parts of the site (if any) that have count rates that exceed our cleanup guidance.

There are a couple of potential problems with these calculations. One assumption implicit in creating the relationship is that the soil sample(s) is(are) representative of the area. Given the non-homogeneity of radium in the soil, this assumption may seem not well founded; however, to the extent it is not, that problem should show up as scatter in the points used to create the relationship.

Another concern is the uniqueness of a given set of measurements. During the survey, measurements were made using two independent detector/instrument combinations. The centers of the detectors were about 15 ½ cm apart so they "saw" somewhat different parts of the site, but since the detectors were moved in unison, the data from the two detectors cannot be considered from independent surveys. However, because of how we conducted the survey, we had a visual indication of how two independent surveys would compare. Over selected parts of the site, we performed one set of paths, then performed a second set of paths that were perpendicular to the first. The areas identified by the two separate surveys were very close to the same. The differences in the surveys were caused primarily by the two location biases discussed in section 3A. They were instrument response in a moving survey and the offset between detectors and locating antenna. Area boundaries calculated in the software may differ by a couple of feet at any given location, but identified areas will have the same general shape. We expect that a repeated survey would reproduce this one to about the above mentioned uncertainty. It should be noted that possible differences between the results of different surveys will be much less than the uncertainty inherent in any associated dose estimates or any soil removal actions should they be needed.

Listed in Table 3 are the identified areas, their associated average cpm, the one-foot average activity for as many sampling locations that could be found in each area, and the sample location number(s) used to obtain the activity values. For example: when the threshold was set at 10000 cpm, data from detector #7 resulted in an area of 173 ft^2 with a cpm average count rate of $133x10^3$ cpm, and two sample locations were within the area giving an average of 120 pCi/g radium concentration in the top foot of soil.

Table 3 Mt.Kisco

Areas of contamination - average cpm from survey - average Ra226 activities

Two detectors (DEC instrument identification numbers 7 and 8) were used to conduct the survey; area statistics were calculated for each detector. Errors shown are the "error of the mean"

Areas with thresholds > $1x10^5$ cpm:

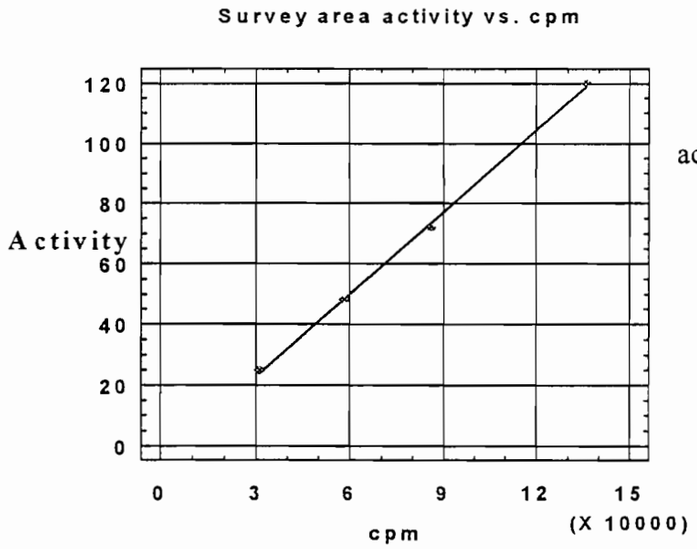
detector #7 area average	detector #8 area average	detector #7 cpm average	detector #8 cpm average	pCi/g 1 ft. activity	locations used
172.5 ft^2	176.5 ft^2	$132.8\pm3.4x10^3$	$138.9\pm4.0x10^3$	120	1, 4

Areas with thresholds > $5x10^4$ cpm

detector #7 area average	detector #8 area average	detector #7 cpm average	detector #8 cpm average	pCi/g 1 ft activity	locations used
25.0 ft^2	39.5 ft^2	$45.1\pm3.0x10^3$	$48.7\pm2.0x10^3$	no sampling locations in area	
18.5	18.0	$57.4\pm3.1x10^3$	$58.2\pm3.4x10^3$	48	8
42.0	64.5	$47.0\pm1.9x10^3$	$47.1\pm1.8x10^3$	question about activity data	
30.0	37.0	$29.5\pm2.3x10^3$	$31.7\pm2.4x10^3$	25	11
573.5	584.0	$85.5\pm2.2x10^3$	$89.3\pm2.4x10^3$	72	1, 3, 4, 5, 6

Shown in Figure 12 are activities in the top foot of soil from Table 3 vs. average cpm. The differences between the two detectors have no practical significance, so in the figure we present the average of both detectors. The error of the means of the cpm averages is not large (all < 10%); however, we do not know how well the averaged soil samples represent the average radium in the areas. The data shown in Figure 12 should be linear, and it is, but the quality of the fit is extremely fortuitous. In the large areas, where the count rates showed considerable variation, it seems unlikely that an individual soil sampling location selected would represent average contamination within each area. This expectation is shown to be true. Five sampling locations were within the large area, and the mean deviation from the average was 32 pCi/g, suggesting a relatively broad distribution of activities is likely in large areas, consistent with the broad distributions in cpm. However, in smaller areas, we expect that individual sample locations will do a better job of representing the areas than they would in large areas because the range of cpm values is much smaller. Shown to the right of Figure 11 is the least squares fit linear equation to the data. We have used this relationship to estimate average activity in those areas where no samples were taken.

Figure 12



activity (pCi/g) = 0.0009 x cpm - 4

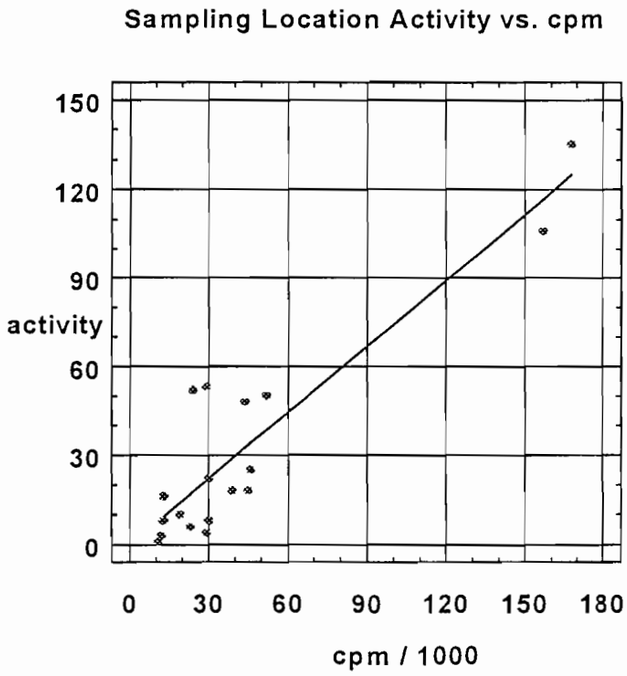
To further explain how the process might proceed, let us assume that some parts of the site will have radium concentrations that exceed cleanup guidance levels for plausible future uses of the property. Once that average activity has been established, the average area count rate can be obtained from the equation in Figure 12. The data shown in the survey maps can then be used to define those areas that exceed the cleanup guidance. This is done by setting the threshold properly (like what was done in Table 3) and then estimate the area that would be included. Also, we can estimate the volume of material that is involved as well as the total amount of radium. For that part of the Mt. Kisco property within the fence, nearly all of the contaminated

material is within the one large area shown on the survey maps and only some fraction of this area might need to be removed. Calculations to test this procedure have been done and data from both detectors give essentially the same results.

Approach 2 - develop a relationship between cpm values near each sampling location with the Ra226 concentration at that location.

An alternative way to use the data set is to consider only those count rate values which were obtained very near to each of the sampling locations. We can compare an average count rate based on just the survey data taken within a couple of feet of each sampling location with the appropriate Ra226 concentration. This approach uses the survey data set differently from how it was used in Approach 1. If the two different scales over which the survey data are averaged give similar results then either approach should be equally valid. The appropriateness of the assumptions used in Approach 1 can be tested by Approach 2 - the physical processes being measured are the same, but the size of the areas being averaged is different. Approximately ten survey data points nearest each sampling location were averaged. As was done above for the large areas, we plotted the one-foot activities vs. these cpm averages. The result is shown in Figure 13 which happens to be very similar to the results shown in Approach 1.

Figure 13



activity (pCi/g) = 0.00075 x cpm - 0.1

If we use the equations derived for the data in the two Figures 12 and 13 to estimate the average cpm value associated with a given radium concentration, we obtain essentially the same cpm values for both of the approaches described here. The procedure illustrated here makes it possible to determine if, and how much, remediation is necessary. The procedure to be followed is: start with an area average soil activity as a cleanup guidance (see section 4B for a discussion of how this is done), read off the area average cpm, and rerun the software to calculate those areas that exceed that cpm.

3E. Modeling

The approach we now use to calculate cleanup guidance is described in the Department of Environmental Conservation's "Cleanup Guidelines for Soil Contaminated with Radioactive Materials, Division of Solid and Hazardous Materials," Technical Administrative Guidance Memorandum 4003 (TAGM 4003). It says that the maximally exposed individual, using the property in some conservative but plausible way, will not receive more that 10 mrem/y from the residual contamination. If this condition is met, the site is unconditionally released. If any plausible use must be excluded to meet the 10 mrem/y dose value (e.g. the property needs a deed restriction to prevent excavation below some depth to prevent high-activity soils from being brought to the surface), then one option that may be considered is to release the property conditionally. The remainder of this section is an exercise designed to explain to the property owners how we apply TAGM 4003. The final decision about what, if any, actions are needed will be made after the property owners have the opportunity to consider their options and the community has a chance to comment.

Ra226 has a relatively long half-life and, though slightly soluble, is likely to remain on site for many years. However, we need to consider only the estimated doses from land use scenarios that may be applied to the present time since the doses only decrease with time. We interpret plausible land uses to mean current land use (or similar uses), proposed uses if different from current use (e.g. open space converted to commercial using conventional construction techniques), or other reasonable uses of the land that are suitable for the property. To illustrate this selection process, an example of what is not a plausible use would be subsistence farming; therefore, it would not be considered.

Another part of the scenario selection is to determine what exposure pathways are possible. Examples of some that are possible are direct exposure, inhalation of dirt, or ingestion of soil. Some that would not be appropriate for this site would be ingestion of a significant fraction of a person's food raised on site or, probably, drinking water from a well on site. The water issue needs an additional comment. If it is established that any sufficiently productive potable water source is too far from the contamination (the radium would not migrate to the aquifer or any surface water source in sufficient concentration to create a significant dose), then the water pathway would not be included. If, however, it is reasonable to conclude that radium would make it to the water, then concentrations would need to be estimated and potential doses included in the 10 mrem/y guidance.

Suppose that, after all the discussions are concluded, we agree that one plausible use would be commercial activity. The assumptions that might be appropriate for modeling this scenario are:

- An on grade building is constructed over the contaminated area.
- The contamination is mostly in the top one foot of soil (that is the case within the fence south of railroad avenue).
- The site preparation plus floor would contribute at least six inches of cover.
- An individual worked the conventional work week over the contaminated soil.
- City water is available and used.

The result of the modeling exercise is a dose rate (mrem/y) as a function of radium concentration in the soil. It is then simple to calculate the soil average radium concentration which would be expected to cause a dose rate of 10 mrem/y, given the assumptions in the scenario selected.

We do not mean that every area with concentrations greater than the derived concentration must be removed; rather, it is an average concentration over a soil area that is consistent with how an individual might be expected to use the area. Also, this concentration is the soil average that would apply after any soil was removed, if any, and after construction would be completed. It should be noted that contamination on site needs to be completely addressed - we cannot leave high concentrations of radium that exist at depth if future construction could increase the average near the surface to levels that would violate the 10 mrem/y value. It is possible to take advantage of necessary disturbances of the soil consistent with the scenario, but not for burying or leaving the contamination since future activity on site could bring the radium to the surface. The intent, when applying our guidance, is to be logical and consistent.

This discussion was intended to present a realistic example of conditions within the fence although more scenario possibilities will need to be examined. This example shows the process of how to estimate which soils might need to be removed. DEC expects to work with all interests to resolve remaining issues at this site.

If a contaminated area is very small, two more considerations will be applied: time and ALARA. If it is not possible to spend much time over the contaminated area, then to treat the area as though it was large would not be correct. Some assumptions are needed about how much time one individual would spend over whatever contamination exists in the area of use. We also must consider the As Low As Reasonably Achievable principle - which simply stated is that if a significantly contaminated area is present and it is easy to remove, it should be. An example of a possible application of the ALARA principle might be the small contamination area near the dumpster.

4. Recommendations

Interim actions - land use restrictions

Doses to workers or visitors to the site as it is used now are not significant. The site location where the dose rate is the highest is a small area near the Richard's Lumber dumpster (just north of Railroad Avenue). Time spent at this location is small; therefore, the accumulated dose is also small. However, consideration should be given to removal of the highest activity material in this area since it is near the surface and is subject to spreading if the soil is disturbed.

Some further characterization work remains for parts of the site. Until this work is completed, we recommend that no excavation be done where either surface or sub-surface radium has been found, or where insufficient data is available as outlined in Appendix H.

Additional field work to complete the characterization.

The USRADS survey has identified most of the area on site where radium near the surface can be found. Areas that could not be surveyed are small and can be checked manually. These areas are shown in Figure 14 and are outlined in Appendix H.

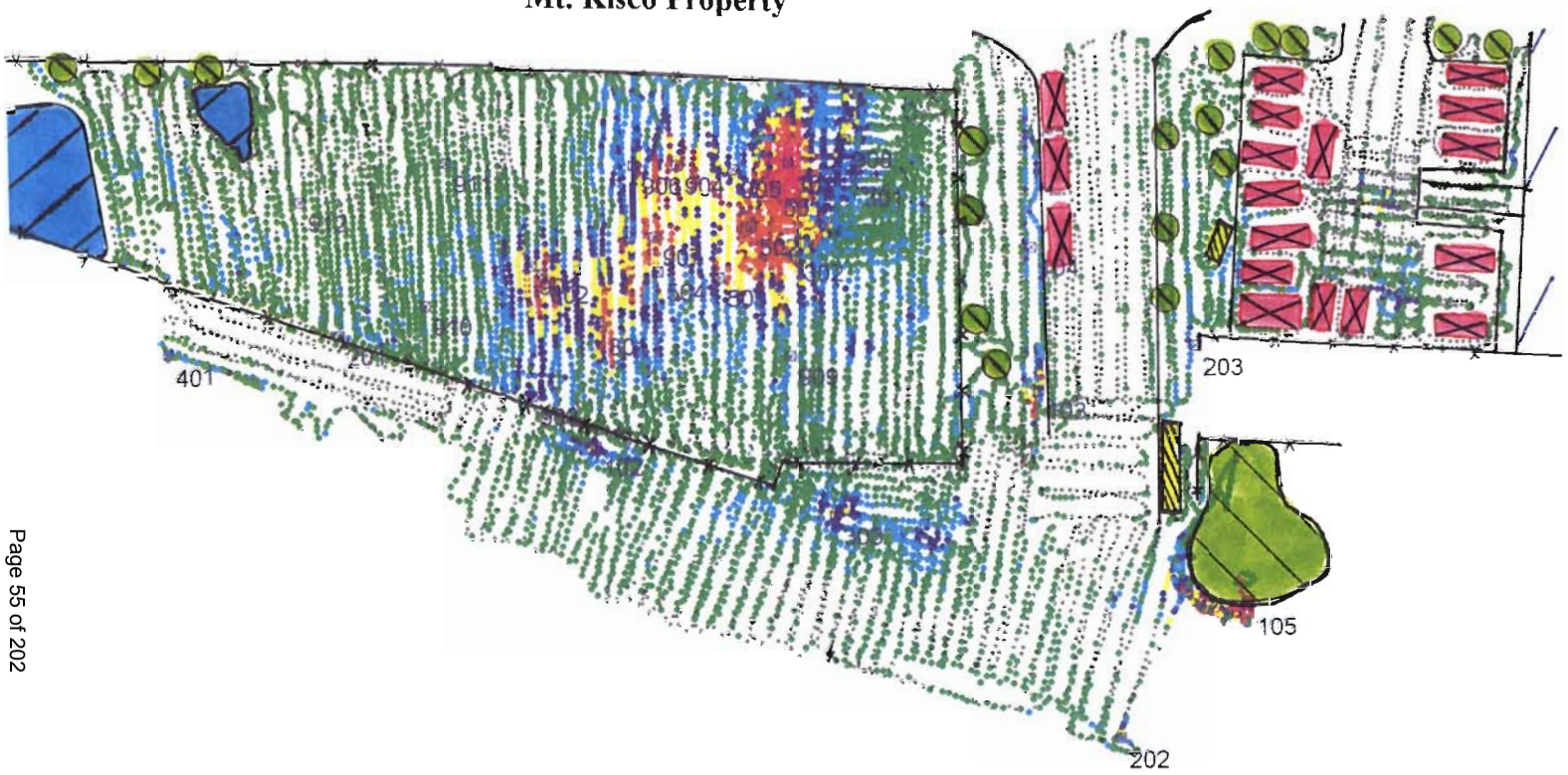
Soil samples were obtained from throughout the site. However, there are areas that need additional samples to better define the extent of the radium contamination. We propose that about 30 locations be sampled. Some of them are in areas where we surveyed and the same manual techniques can be used. Others would require equipment capable of sampling through asphalt (parking lots, roads or driveways. A listing of proposed locations is presented in Appendix H and are shown in Figure 15 and Figure 16.

Next steps

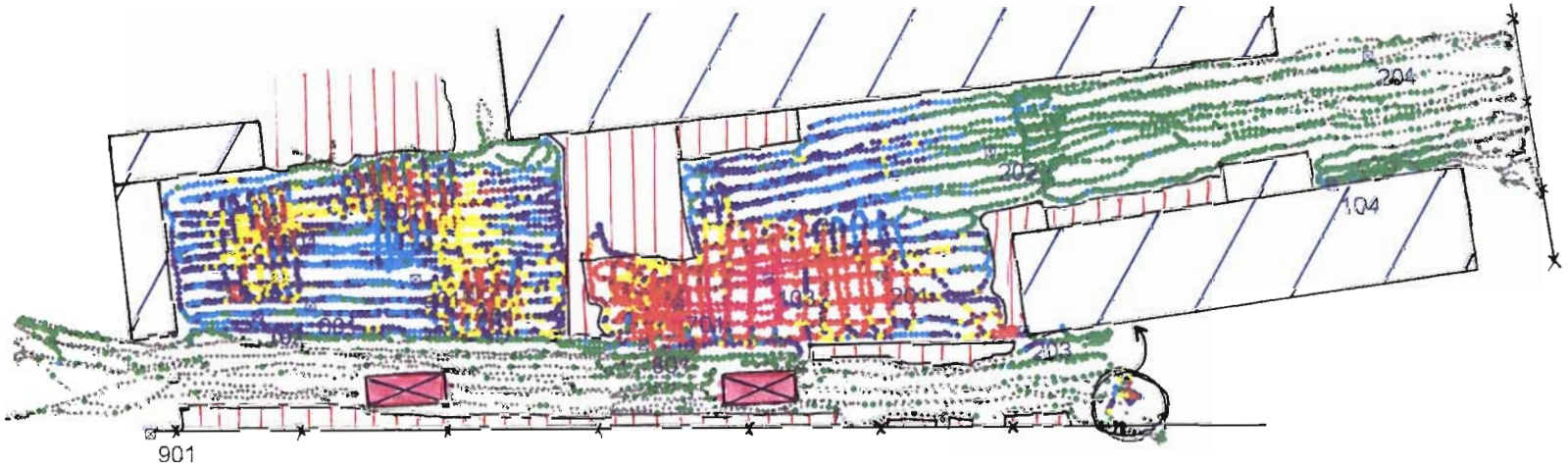
Significant radium contamination is present on both Mt. Kisco and Richard's Lumber properties. What needs to be done about the radioactive material will depend on how these properties will be used. The procedure now to be followed is for the landowners to consider possible land uses (current and future) of their properties. Based on these uses, DEC will estimate plausible doses to users of the properties when sufficient data is available. The area within the fence (Mt. Kisco property) is nearly ready for this process to begin. Where the data is insufficient to estimate doses, arrangements will have to be made to complete the data set before questions about land use can be resolved.

Work plans will need to be developed which describe the final characterization steps and how any necessary soil removal will be done to remediate the site consistent with the guidance given in TAGM 4003. These plans will need to be provided to DEC for review and approval. Finally, any soil removed from the site will have to be disposed of at a facility licensed to accept radium contaminated waste.

Mt. Kisco Property



Richard's Lumber

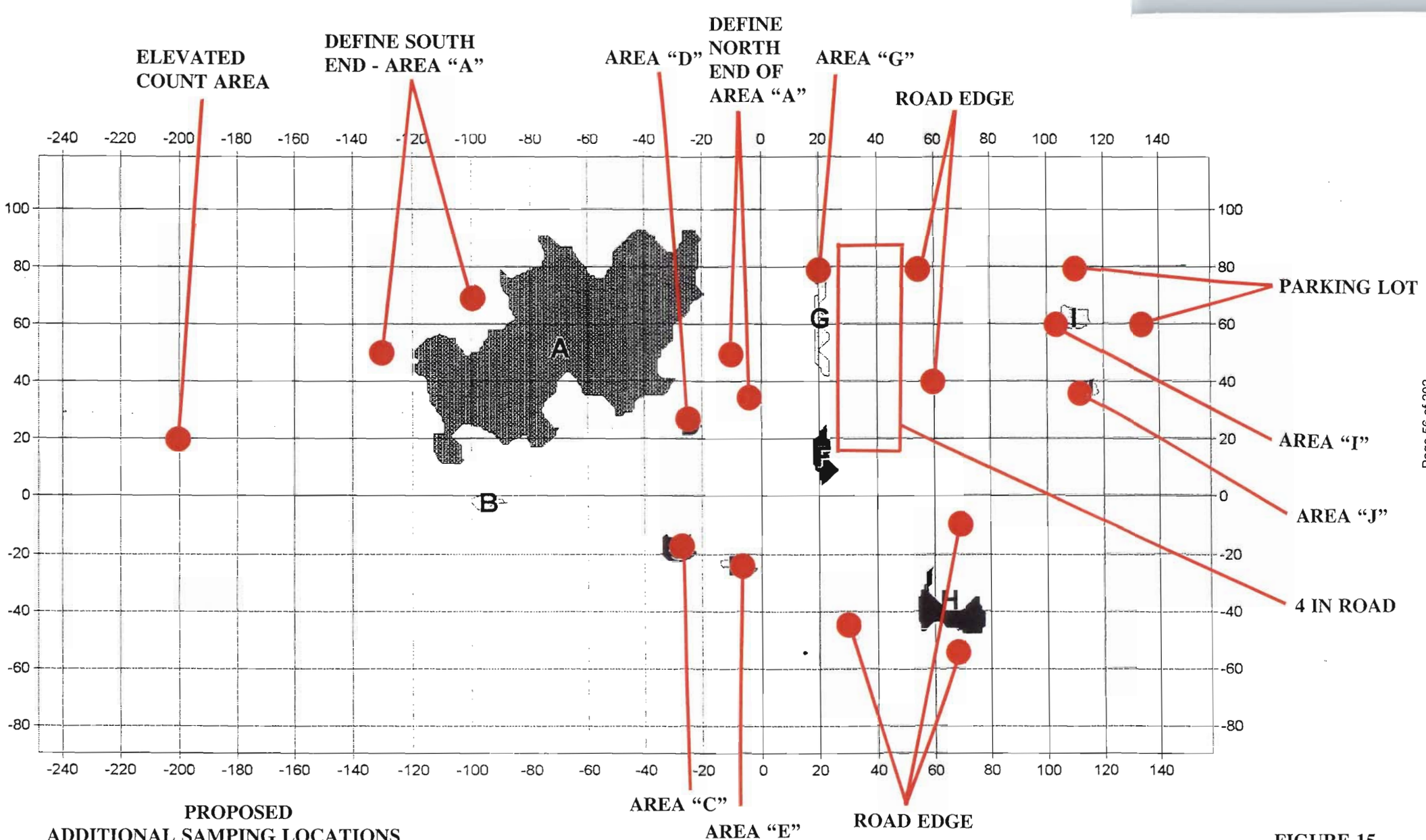


Explanation of Areas Not Covered by USRADS Survey

Description Key

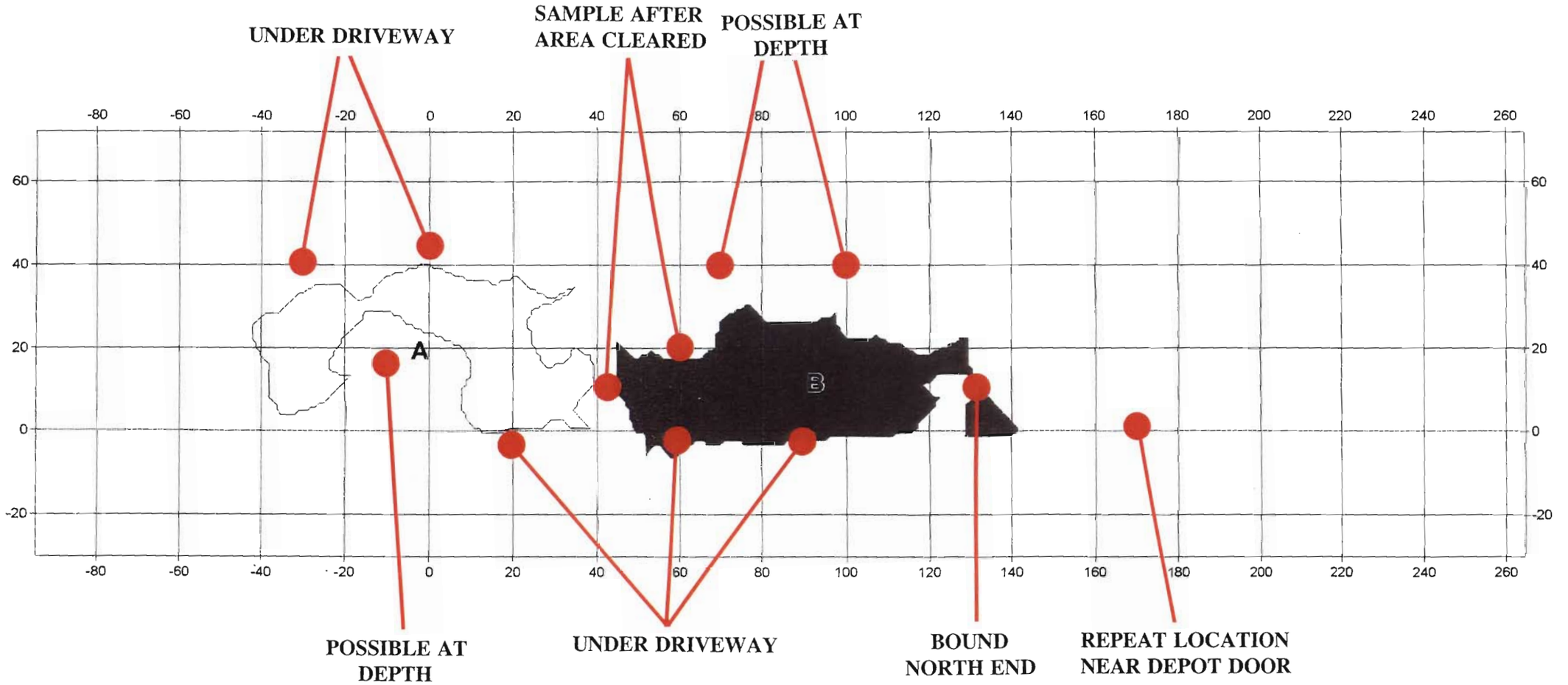
- Structure
- Vehicle
- Building Material
- Tree
- Brush Pile
- Misc.

FIGURE 14



PROPOSED
ADDITIONAL SAMPING LOCATIONS
MT. KISCO SURVEY

FIGURE 15



PROPOSED ADDITIONAL SAMPLING LOCATION RICHARD'S LUMBER

FIGURE 16

Appendix A
Soil Gamma Spectroscopy Results

Explanation of gamma spectroscopy data

Row 1 sample identification numbers
Row 2 date of analysis

In column 1 are the identified radionuclides and the gamma energies used to determine the activities

The activities for each radionuclide that we were able to quantify are shown in the remaining columns. If the value is not underlined, the sample was analyzed by DEC. If the value is underlined, the sample was analyzed by Thermo NUtech.

One sample (RL0203C) was counted by Thermo NUtech on a low energy detector, designed to detect gammas with energies less than about 400 keV. The results are reported in italics and underlined. They are about twice the activities reported in the conventional analysis. We believe that the low energy detector results are not correct.

If the word "no" is shown in the table, then no gamma peak could be seen in the spectrum at that energy.
If the word "yes" is shown, then a gamma peak can be observed, but its intensity is so low that quantification is difficult.
If the word "possible" is shown, then a gamma peak at that energy cannot be excluded, but its presence is not certain.

Comments relevant to sample analysis done be the contract lab
About half of the samples were analyzed by Themo NUtech (Oak Ridge, TN). Their procedures differed from DEC's in several significant ways, although we believe that for most of the important radionuclides, the results will be equivalent.

- When the lab received our samples, they were dried, ground to powder and mixed. Their container for counting was filled with an aliquot of the sample. The container was sealed for three weeks before counting.
- Their resolution is 1 keV/channel, (DEC's is 0.5 keV/channel) which means that resolving some adjacent peaks is not possible. This is not a problem for Ra226 and its daughters.
- The contract lab uses fewer gammas when determining activities than does DEC.
- The data as supplied does not include spectral plots for use in visually checking the spectra for possible errors.
- Counting errors are reported at 3 sigma, we report ours at 1 sigma. This does not affect the activity values, just the reported counting uncertainty. The counting error listed for Ra226 seems much too large - the reason not yet determined.

Mt. Kisco Sample Location # 2 in Survey # 1 @ x = -24 y = 69

	MK0102A 12/24/97	MK0102B 12/24/97	MK0102C 12/24/97	MK0102D 12/24/97
K40	12.3±1.9	10.7±1.8	11.5±1.6	10.9±1.8
Ra226[1] + U235	29±54	7±14	4±8	6±11
Pb214				
351.9	17±2	4.8±1.0	2.8±0.5	3.6±0.7
295.2	16±2	5.0±1.0	2.8±0.5	3.2±0.7
242.0	yes	yes	yes	yes
785.9	yes	yes	no	yes
Bi214				
609.3	16±2	4.8±0.7	2.6±0.4	3.6±0.7
1764.5	17±2	5.4±1.0	3.1±0.6	3.7±0.7
1120.3	18±2	4.9±0.9	2.7±0.5	2.8±0.7
1238.1	yes	yes	yes	yes
Pb210	no	4.1±1.5	no	no
Ac228				
911.1	0.5±0.4	0.5±0.2	0.5±0.2	0.6±0.2
Pb212				
238.6	no	0.8±0.2	0.6±0.1	0.5±0.1
Tl208				
chain	0.4±0.4	0.8±0.2	0.8±.2	0.5±0.2
U235[1] (+ Ra223)				
143.8	yes	no	no	no
Th227				
236.0	no	no	no	no
256.3	possible	no	no	no
Ra223				
269.5	possible	possible	possible	no
154.2	possible	no	no	no
323.9	no	no	no	no
Rn219				
271.2	possible	possible	possible	no
401.8	1.3±1.3	no	no	no
Pb211				
404.8	no	no	no	no
832.0	no	no	no	no
427.1	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Appendix A
Soil Gamma Spectroscopy Results

Explanation of gamma spectroscopy data

Row 1 sample identification numbers
Row 2 date of analysis

In column 1 are the identified radionuclides and the gamma energies used to determine the activities

The activities for each radionuclide that we were able to quantify are shown in the remaining columns. If the value is not underlined, the sample was analyzed by DEC. If the value is underlined, the sample was analyzed by Thermo NUtech.

One sample (RL0203C) was counted by Thermo NUtech on a low energy detector, designed to detect gammas with energies less than about 400 keV. The results are reported in italics and underlined. They are about twice the activities reported in the conventional analysis. We believe that the low energy detector results are not correct.

If the word "no" is shown in the table, then no gamma peak could be seen in the spectrum at that energy.
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- The contract lab uses fewer gammas when determining activities than does DEC.
- The data as supplied does not include spectral plots for use in visually checking the spectra for possible errors.
- Counting errors are reported at 3 sigma, we report ours at 1 sigma. This does not affect the activity values, just the reported counting uncertainty. The counting error listed for Ra226 seems much too large - the reason not yet determined.

Mt. Kisco Sample Location # 1 in Survey # 1 @ x = -42 y= 73

	MK0101A 12/24/97	MK0101A2 12/24/97	MK0101B 12/24/97	MK0101C 12/24/97	MK0101D 12/24/97
K40	12.1±4.7	8.1±4.1	10.0±2.4	10.3±1.6	14.5±2.2
Ra226[1] + U235	371±680	372±682	128±24	13±24	3±6
Pb214					
351.9	289±54	288±54	106±18	9.5±1.7	1.3±0.3
295.2	278±47	275±47	103±19	9.0±1.8	1.2±0.3
242.0	yes	yes	yes	yes	yes
785.9	yes	yes	yes	yes	yes
Bi214					
609.3	275±34	272±34	102±15	9.0±1.3	1.2±0.3
1764.5	315±41	307±40	118±15	10.9±1.7	1.4±0.5
1120.3	297±34	293±34	108±13	9.9±1.4	1.2±0.4
1238.1	yes	yes	yes	yes	possible
Pb210	202±27	202±27	48±35	no	no
Ac228					
911.1	yes	no	yes	0.6±0.3	1.4±0.4
Pb212					
238.6	no	no	1.1±0.4	0.9±0.2	1.1±0.2
Tl208					
chain	no	no	no	0.9±0.2	yes
U235[1] (+ Ra223)					
143.8	yes	yes	no	no	no
Th227					
236.0	yes	yes	yes	no	no
256.3	yes	yes	no	no	no
Ra223					
269.5	yes	yes	yes	possible	possible
154.2	yes	yes	yes	no	no
323.9	37±10	29±9	2.3±4.1	no	possible
Rn219					
271.2	yes	yes	yes	yes	possible
401.8	yes	yes	no	no	no
Pb211					
404.8	possible	possible	6±5	no	no
832.0	yes	yes	7±4	no	no
427.1	yes	yes	yes	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 2 in Survey # 1 @ x = -24 y = 69

	MK0102A 12/24/97	MK0102B 12/24/97	MK0102C 12/24/97	MK0102D 12/24/97
K40	12.3±1.9	10.7±1.8	11.5±1.6	10.9±1.8
Ra226[1] + U235	29±54	7±14	4±8	6±11
Pb214				
351.9	17±2	4.8±1.0	2.8±0.5	3.6±0.7
295.2	16±2	5.0±1.0	2.8±0.5	3.2±0.7
242.0	yes	yes	yes	yes
785.9	yes	yes	no	yes
Bi214				
609.3	16±2	4.8±0.7	2.6±0.4	3.6±0.7
1764.5	17±2	5.4±1.0	3.1±0.6	3.7±0.7
1120.3	18±2	4.9±0.9	2.7±0.5	2.8±0.7
1238.1	yes	yes	yes	yes
Pb210	no	4.1±1.5	no	no
Ac228				
911.1	0.5±0.4	0.5±0.2	0.5±0.2	0.6±0.2
Pb212				
238.6	no	0.8±0.2	0.6±0.1	0.5±0.1
Tl208				
chain	0.4±0.4	0.8±0.2	0.8±.2	0.5±0.2
U235[1] (+ Ra223)				
143.8	yes	no	no	no
Th227				
236.0	no	no	no	no
256.3	possible	no	no	no
Ra223				
269.5	possible	possible	possible	no
154.2	possible	no	no	no
323.9	no	no	no	no
Rn219				
271.2	possible	possible	possible	no
401.8	1.3±1.3	no	no	no
Pb211				
404.8	no	no	no	no
832.0	no	no	no	no
427.1	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 3 in Survey # 1 @ x = -40 y = 49

	MK0103A 12/24/97	MK0103B 12/24/97	MK0103C 12/24/97	MK0103D 12/24/97	MK0103E 12/24/97
K40	10.4±1.6	8.8±2.8	8.4±1.4	8.3±1.5	8.9±1.4
Ra226[1] + U235	9±16	106±194	4±8	1±2	1±2
Pb214					
351.9	4.6±0.6	95±18	3.1±0.6	0.8±0.2	0.5±0.1
295.2	4.6±0.6	92±16	2.8±0.6	0.6±0.3	0.5±0.2
242.0	yes	yes	yes	yes	no
785.9	yes	yes	possible	no	no
Bi214					
609.3	4.3±0.5	96±12	2.7±0.4	0.8±0.2	0.6±0.1
1764.5	4.7±0.8	114±15	3.1±0.6	0.7±0.3	0.7±0.3
1120.3	3.9±0.7	110±13	3.0±0.6	0.6±0.3	0.7±0.3
1238.1	yes	yes	yes	no	no
Pb210	no	65±10	no	no	no
Ac228					
911.1	0.4±0.2	yes	0.8±0.2	0.6±0.2	0.6±0.2
Pb212					
238.6	no	no	0.9±0.2	0.6±0.2	1.0±0.2
Tl208					
chain	0.3±0.1	no	0.7±0.2	0.5±0.2	0.6±0.1
U235[1] (+ Ra223)					
143.8	yes	yes	no	no	no
Th227					
236.0	possible	yes	no	no	no
256.3	no	yes	no	no	no
Ra223					
269.5	possible	yes	no	no	no
154.2	no	yes	no	no	no
323.9	no	7±5	no	no	no
Rn219					
271.2	possible	yes	possible	possible	no
401.8	no	no	no	no	no
Pb211					
404.8	no	no	no	no	no
832.0	no	possible	no	no	no
427.1	no	yes	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Appendix B
Decay Series of Radionuclides Found at the Site

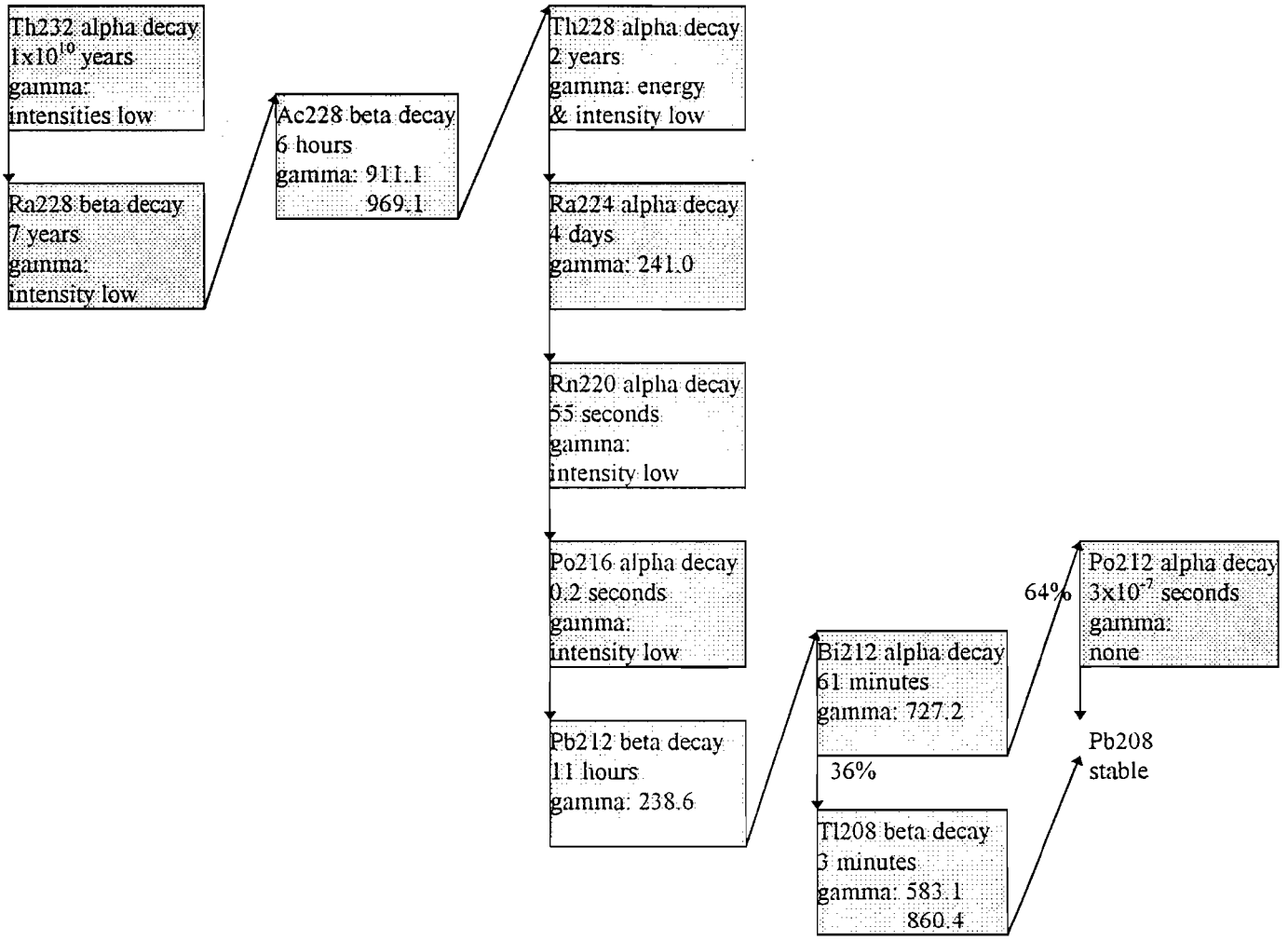
Shown in the three following figures are the decay schemes of the radionuclides found at this site. Each radionuclide is shown in a shaded box. The first entry is the name of the radionuclide and how it decays. The second line shows the half life (the time when half of the radionuclide will decay and become the next radionuclide in the series). For example: it would take 1600 years for radium now on site to decay to half the amount that is there now. It would become stable lead (Pb206). For the purposes of this work, we will treat the site as though radioactive decay was the only mechanism of loss of radium from the site. The rest of the information in the box gives the gamma energies that we look for (or the reasons why we are not able to detect them). The energies are given in keV. For ecample: there are four gammas that we use to calculate the activity of Pb214 in the soil - 242.0, 295.2, 351.9, and 785.9 keV. There are more gammas, but these are the most intense four and they are all easy to detect.

The arrow leaving a box points to the radionuclide created by the decay. In the natural environment all of the radionuclides of a chain have the same decay rate (formation rate = decay rate) as the initial nuclide - hence the series members would all be in equilibrium.

On the Canadian Radium site, members of all three decay chains were found:

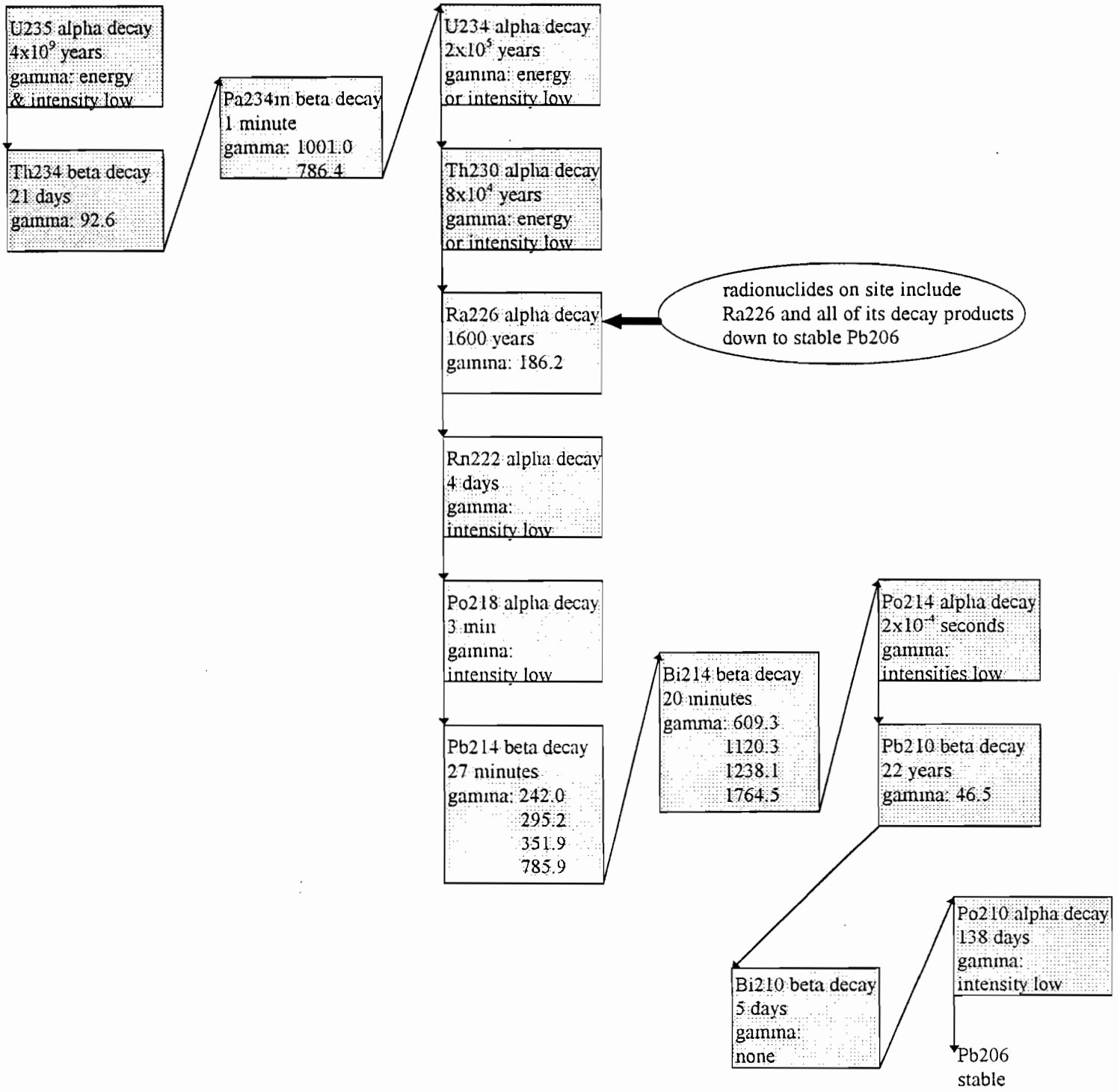
- The thorium series is in equilibrium and is at background levels.
- Radium contamination (Ra226) is part of the uranium series. It is the primary radioactive contamination at the site. All the radionuclides which result from the decay of Ra226 will be in equilibrium.
- Members of the actinium series, starting with Th227, have been observed in some of the samples that also contained significant Ra226. When these radionuclides are observed, they are not in a fixed ratio to the Ra226 activity. This data suggests that the series from Th227 on down is in equilibrium, but that this part of the series is not in equilibrium with the beginning of the series.

Thorium Decay Series

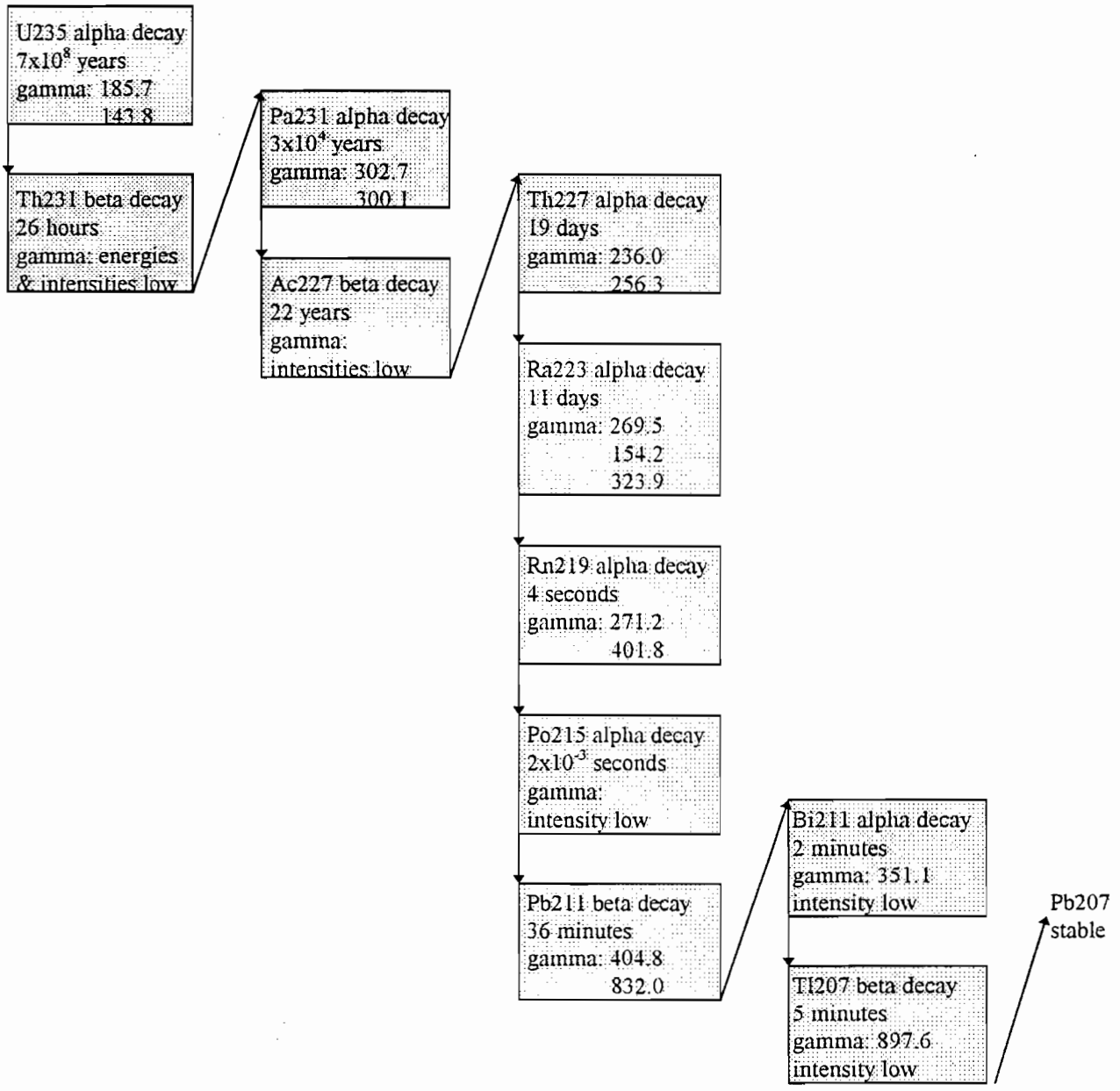


Activities of all radionuclides in the thorium chain did not exceed background levels.

Uranium Decay Series



Actinium Decay Series



We have observed part of the Actinium series, starting with Th227, in some samples. Activities as high as a few tens of pCi/g have been observed. The start of the series, U235, has not been observed at elevated activities.

Mt. Kisco Sample Location # 4 in Survey # 1 @ x= -45 y = 67

samples counted on 11/14/97

	MK0104A	MK0104B	MK0104C	MK0104D	MK0104E
K40	11.5±1.0	12.2±0.9	16.5±1.1	15.3±1.1	11.3±1.0
Ra226[1]	185±5	80±3	9±1	3.3±1.4	13.3±1.3
+ U235	151±11[2]				
Pb214					
351.9	148±3	62±1	6.8±0.3	2.4±0.2	10.9±0.4
295.2	147±4	63±2	6.5±0.3	2.7±0.2	10.8±0.5
242.0	152±4	63±2	7.0±0.4	3.1±0.3	11.1±0.7
785.9	138±8	60±5	7±2		
Bi214					
609.3	135±3	57±1	6.2±0.3	2.6±0.2	10.4±0.4
1764.5	157±4	65±2	7.3±0.6	2.8±0.4	12.0±0.9
1120.3	147±2	66±1	6.0±0.5	2.4±0.4	11.4±0.7
1238.1	147±3	56±5	6.7±1.0	3.4±0.8	11.8±1.3
Pb210	yes	yes	yes	yes	yes
Ac228					
911.1	no	1.2±0.2	1.4±0.4	1.1±0.3	0.6±0.3
Pb212					
238.6	0.8±0.1	0.8±0.1	1.4±0.1	1.3±0.1	0.7±0.1
Tl208	0.21±0.04	0.28±0.04	0.40±0.05	0.41±0.05	0.25±0.05
chain	0.6±0.1	0.8±0.1	1.1±0.1	1.1±0.1	0.7±0.1
U235[1]	(+ Ra223)				
143.8	2.1±0.6	yes			
Th227					
236.0	6.9±0.4	2.7±0.4			
256.3	5.6±0.6	yes			
Ra223					
269.5	6.4±0.8	2.8±0.5			
154.2	4±2	3.2±1.5			
323.9	5±3	2.1±1.7			
Rn219					
271.2	6.8±0.5	3.2±0.4			
401.8	5.4±0.5	2.0±0.5			
Pb211					
404.8	yes	4±2			
832.0	yes	3±2			
427.1	no	no			

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] Subtracting [U235] = 2.6 pCi/g from the 186 keV peak.

Mt. Kisco Sample Location # 5 in Survey # 1 @ x = -51 y = 56

samples counted on 12/16/97

	MK0105A	MK0105B	MK0105C	MK0105D	MK0105E
K40	12.2±1.0	9.3±1.0	12.9±0.6	16.1±0.9	12.8±0.7
Ra226[(1)] + U235	28±2	117±6	16.0±0.8	4.0±0.5	6.1±0.6
Pb214					
351.9	25.3±0.7	95±2	13.7±0.3	2.6±0.1	4.2±0.2
295.2	24.3±0.8	93±2	13.4±0.4	2.7±0.2	4.2±0.2
242.0	25.5±1.0	97±2	13.9±0.5	3.2±0.2	4.6±0.3
785.9	23±4	94±8	15±2	2.8±0.9	
Bi214					
609.3	22.8±0.6	85±2	12.5±0.3	2.5±0.1	3.9±0.2
1764.5	27±1	99±3	14.4±0.6	3.1±0.3	4.2±0.4
1120.3	24.8±0.9	91±2	13.1±0.4	2.5±0.3	3.8±0.3
1238.1	25±2	96±3	14.6±0.8	2.4±0.5	4.0±0.6
Pb210	yes	yes	yes	yes	yes
Ac228					
911.1	0.6±0.3	1.1±0.5	0.8±0.1	1.4±0.1	1.0±0.1
Pb212					
238.6	0.7±0.1	1.1±0.1	0.8±0.4	1.4±0.1	0.9±0.1
Tl208	0.19±0.04	0.20±.05	0.25±0.03	0.44±0.04	0.30±0.03
chain	0.5±0.1	0.6±0.1	0.7±0.1	1.2±0.1	0.8±0.1
U235					
143.8	possible	possible	possible	no	no
Th227					
236.0	1.1±0.3	5.8±0.6	0.9±0.2	no	possible
256.3	1.0	5.8±1.3	yes	no	no
Ra223					
269.5	yes	4.2±0.7	yes	possible	possible
154.2	possible	5±2	0.8±0.6	no	yes
323.9	no	4±3	no	no	no
Rn219					
271.2	yes	4.9±0.5	yes	possible	possible
401.8	yes	2.6±0.8	0.5±0.3	no	no
Pb211					
404.8	possible	yes	1.0±0.8	no	no
832.0	no	yes	possible	no	no
427.1	no	yes	yes	no	no
766.5	no	no	no	no	no

[(1)] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 6 in Survey # 1 @ x = -60 y = 43

samples counted on 12/02/97

	MK0106A	MK0106B	MK0106C
K40	8.2±1.5	7.3±1.5	9.3±1.5
Ra226[1] + U235	13±24	31±57	3±6
Pb214	11±2[2]	23±3[2]	1.6±0.4[2]
351.9			
295.2			
242.0			
785.9			
Bi214	12±1[2]	24±1[2]	1.8±0.2[2]
609.3			
1764.5			
1120.3			
1238.1			
Pb210			
Ac228	0.5±0.2[2]	0.9±0.3[2]	0.8±0.2[2]
911.1			
Pb212	0.4±0.1[2]	0.8±0.2[2]	0.8±0.2[2]
238.6			
Tl208 chain	0.5±0.2[2]	0.7±0.2[2]	0.9±0.2[2]
U235			
143.8			
Th227			
236.0			
256.3			
Ra223			
269.5			
154.2			
323.9			
Rn219			
271.2			
401.8			
Pb211			
404.8			
832.0			
427.1			

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] Data taken from contract lab summary data sheets.

Mt. Kisco Sample Location #7 in Survey # 1 @ x = -75 y = 45

	MK0107A 1/15/98	MK0107B 1/15/98	MK0107C 1/15/98	MK0107D 1/15/98
K40	10.3±0.8	13.2±0.9	11.8±0.5	13.5±0.8
Ra226[1] + U235	9±1	48±2	2.4±0.6	1.5±0.4
Pb214				
351.9	6.2±0.2	37±1	0.9±0.1	1.2±0.1
295.2	6.1±0.3	38±1	0.9±0.1	1.0±0.1
242.0	6.7±0.4	38±1	1.3±0.1	1.4±0.1
785.9	yes	35±4	no	yes
Bi214				
609.3	5.9±0.2	36±1	0.9±0.1	1.0±0.1
1764.5	6.3±0.5	40±4	1.3±0.2	1.3±0.2
1120.3	6.0±0.4	38±1	1.0±0.1	1.4±0.2
1238.1	6.5±0.8	39±2	1.0±0.3	1.5±0.4
Pb210	yes	yes	yes	no
Ac228				
911.1	1.1±0.1	0.7±0.3	0.8±0.1	0.7±0.1
Pb212				
238.6	1.2±0.1	0.8±0.1	0.8±<0.1	0.8±0.1
Tl208	0.37±0.4	0.20±0.4	0.25±0.02	0.26±0.03
chain	1.0±0.1	0.6±0.1	0.7±0.1	0.7±0.1
U235 (+ Ra223)				
143.8	no	no	no	no
Th227				
236.0	no	possible	no	no
256.3	no	no	no	no
Ra223				
269.5	yes	no	yes	yes
154.2	possible	possible	possible	no
323.9	no	no	no	no
Rn219				
271.2	yes	no	possible	possible
401.8	no	no	no	no
Pb211				
404.8	no	no	no	no
832.0	no	no	no	no
427.1	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 8 in Survey # 1 @ x = -91 y = 30

samples counted on 12/10/97

	MK0108A	MK0108B	MK0108C	MK0108D
K40	10.2±1.0	11.0±1.1	11.2±0.9	11.2±0.8
Ra226[1] + U235	56±3	60±3	11±1	2.9±0.5
Pb214				
351.9	46±1	49±1	8.5±0.3	2.0±0.1
295.2	45±1	49±1	8.3±0.3	1.9±0.2
242.0	46±2	48±2	8.5±0.5	2.3±0.2
785.9	48±6	46±6	6±2	possible
Bi214				
609.3	43±1	45±1	8.0±0.1	1.8±0.1
1764.5	49±2	51±2	8.8±0.7	2.3±0.3
1120.3	47±1	49±2	8.3±0.6	2.0±0.3
1238.1	44±2	46±6	7±1	2.2±0.6
Pb210	yes	yes	yes	yes
Ac228				
911.1	0.6±0.2	0.5±0.4	0.8±0.3	0.6±0.2
Pb212				
238.6	0.6±0.1	0.6±0.1	0.7±0.1	0.7±0.1
Tl208	0.21±0.04	0.21±0.05	0.27±0.4	0.21±0.3
chain	0.6±0.1	0.6±0.1	0.8±0.1	0.6±0.1
U235				
143.8	no	no	no	no
Th227				
236.0	no	no	no	no
256.3	no	no	no	no
Ra223				
269.5	no	no	possible	no
154.2	no	no	no	no
323.9	no	no	no	no
Rn219				
271.2	no	no	possible	no
401.8	no	no	no	possible
Pb211				
404.8	no	no	no	no
832.0	no	no	no	no
427.1	no	possible	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 9 in Survey # 1 @ x = -106 y = 44

samples counted on 12/02/97

	MK0109A	MK0109B	MK0109C	MK0109D	MK0109E
K40	7.0±2.0	7.8±1.4	9.2±1.5	11.7±1.8	10.1±1.5
Ra226[1] + U235	39±73	4±7	1±3	3±5	1±3
Pb214	32±6[2]	2.3±0.5[2]	0.7±0.3[2]	1.6±0.4[2]	0.5±0.2[2]
351.9					
295.2					
242.0					
785.9					
Bi214	33±3[2]	2.5±0.3[2]	0.9±0.2[2]	1.4±0.2[2]	0.4±0.1[2]
609.3					
1764.5					
1120.3					
1238.1					
Pb210					
Ac228	0.8±0.7[2]	0.7±0.2[2]	0.6±0.2[2]	0.6±0.2[2]	0.5±0.1[2]
911.1					
Pb212	1.0±0.3[2]	0.9±0.2[2]	0.7±0.2[2]	0.7±0.2[2]	0.6±0.1[2]
238.6					
Tl208	1.2±0.3[2]	0.7±0.2[2]	0.8±0.2[2]	0.6±0.2[2]	0.4±0.1[2]
chain					
U235					
143.8					
Th227					
236.0					
256.3					
Ra223					
269.5					
154.2					
323.9					
Rn219					
271.2					
401.8					
Pb211					
404.8					
832.0					
427.1					

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] Data taken from contract lab summary data sets.

Mt. Kisco Sample Location # 10 in Survey # 1 @ x = -109 y = 12

	MK0110A 12/02/97	MK0110B 12/10/97	MK0110B2 12/10/97	MK0110C 12/10/97	MK0110D 12/10/97	MK0110E 12/10/97
K40	4.2±0.8	7.2±2.4	6.9±2.8	12.1±1.8	9.8±1.5	10.5±1.6
Ra226[1] + U235	2±4	121±223	123±226	1±3	4±8	4±8
Pb214	1.5±0.3[2]					
351.9		95±24	98±24	0.8±0.2	2.1±0.4	2.1±0.3
295.2		97±20	95±20	1.0±0.3	2.2±0.5	1.9±0.4
242.0		yes	yes	yes	yes	yes
785.9		yes	yes	no	no	no
Bi214	1.6±0.2[2]					
609.3		98±15	97±15	0.8±0.2	1.9±0.3	1.9±0.3
1764.5		106±15	105±15	0.8±0.3	2.2±0.5	2.1±0.5
1120.3		109±14	108±15	1.0±0.3	2.3±0.6	1.6±0.6
1238.1		yes	yes	no	possible	possible
Pb210		93±14	98±15	no	no	no
Ac228	0.3±0.1[2]					
911.1		possible	possible	0.7±0.2	0.7±0.2	no
Pb212	0.2±0.1[2]					
238.6		0.6±0.3	0.6±0.2	0.6±0.1	0.7±0.1	0.8±0.1
Tl208 chain	0.2±0.1[2]	1.0±0.6	no	0.4±0.2	0.7±0.2	0.7±0.2
U235						
143.8		no	no	no	no	no
Th227						
236.0		no	no	no	no	no
256.3		no	no	no	no	no
Ra223						
269.5		no	no	possible	possible	no
154.2		yes	no	no	no	no
323.9		no	no	no	no	no
Rn219						
271.2		no	no	possible	possible	possible
401.8		no	no	no	no	no
Pb211						
404.8		no	no	no	no	no
832.0		no	no	no	no	no
427.1		no	yes	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] Data taken from contract lab summary data sheets

Mt. Kisco Sample Location # 11 in Survey # 1 @ x = -70 y = 73

samples counted on 12/4/97

	MK0111A	MK0111B	MK0111C	MK0111D	MK0111E1	MK0111E2
K40	11.1±0.9	9.8±0.9	15.5±0.8	14.4±0.9	11.5±0.9	11.7±0.9
Ra226[1] + U235	44±4	20.4±1.3	5.4±0.6	5.1±1.3	3.5	3.4±1.1
Pb214						
351.9	33.2±0.8	16.6±0.5	4.4±0.2	2.7±0.1	1.6±0.1	1.4±0.1
295.2	33.0±1.0	16.2±0.5	4.4±0.2	2.8±0.2	1.4±0.1	1.4±0.2
242.0	34.5±1.3	17.9±0.8	4.6±0.2	3.5±0.2	2.3±0.2	1.7±0.2
785.9	37±5	18±3	4.0±1.6	possible	possible	no
Bi214						
609.3	31.2±0.7	15.4±0.4	4.0±0.2	2.5±0.1	1.5±0.1	1.4±0.1
1764.5	34.4±1.4	18.5±0.9	4.7±0.4	2.9±0.4	1.9±0.3	1.6±0.3
1120.3	32.9±1.1	17.4±0.8	4.2±0.3	2.8±0.3	1.4±0.3	1.4±0.3
1238.1	34.2±1.9	17.1±1.3	3.7±0.6	present	1.2±0.4	
Pb210	yes	yes	yes	yes	no	no
Ac228						
911.1	0.8±0.4	0.7±0.3	1.3±0.1	1.4±0.2	1.3±0.2	1.2±0.2
Pb212						
238.6	0.8±0.1	1.1±0.1	1.5±0.1	1.5±0.1	1.3±0.1	1.2±0.1
Tl208	0.14±0.05	0.35±0.05	0.53±0.04	0.45±0.04	0.41±0.04	0.45±0.05
chain	0.4±0.1	1.0±0.1	1.5±0.1	1.2±0.1	1.1±0.1	1.3±0.1
U235						
143.8	no	no	no	no	no	no
Th227						
236.0	possible	possible	no	possible	possible	no
256.3	no	no	no	no	no	no
Ra223						
269.5	possible	possible	possible	possible	possible	possible
154.2	no	no	no	no	no	no
323.9	no	no	no	no	no	no
Rn219						
271.2	possible	no	no	possible	possible	possible
401.8	no	no	no	no	no	no
Pb211						
404.8	possible	no	no	no	no	no
832.0	no	no	no	no	no	no
427.1	no	no	no	no	no	no
766.5	no	no	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 12 in Survey # 1 @ x = -56 y = 71

	MK0112A 12/23/97	MK0112B 12/30/97	MK0112C 12/22/97	MK0112D 12/22/97
K40	15.0±1.0	13.4±0.8	14.9±0.9	10.9±0.7
Ra226[1] + U235	12.4±1.0	0.8[2]	1.1±0.4	1.0±0.4
Pb214				
351.9	9.7±0.3	1.2±0.1	0.8±0.1	0.7±0.1
295.2	9.9±0.3	1.2±0.1	0.5±0.1	0.7±0.1
242.0	11.1±0.6	1.7±0.2	yes	yes
785.9	12±3	yes	no	no
Bi214				
609.3	9.2±0.3	1.0±0.1	0.6±0.1	0.7±0.1
1764.5	10.9±0.7	1.6±0.3		0.9±0.2
1120.3	9.0±0.6	1.4±0.2	0.6±0.2	0.7±0.2
1238.1	10.8±1.0	1.3±0.4		
Pb210	yes	no	no	yes
Ac228				
911.1	0.6±0.1	0.6±0.2	1.1±0.2	0.9±0.2
Pb212				
238.6	0.5±0<.1	0.7±0.1	1.0±0.1	0.9±0.1
Tl208	0.18±0.03	0.21±0.3	0.34±0.03	0.26±0.3
chain	0.5±0.1	0.6±0.1	0.9±0.1	0.7±0.1
U235				
143.8	no	yes	no	possible
Th227				
236.0	yes	no	no	no
256.3	possible	no	no	no
Ra223				
269.5	yes	possible	possible	possible
154.2	possible	no	no	no
323.9	possible	no	no	no
Rn219				
271.2	yes	possible	possible	possible
401.8	no	no	no	no
Pb211				
404.8	no	no	no	no
832.0	no	no	no	no
427.1	no	no	no	no
766.5	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] U235 estimated from a small 143.8 keV peak was subtracted from the 186 keV peak. The remainder was assigned to Ra226. Propagated error will be significant.

Mt. Kisco	Sample Location #13 in Survey # 1	@ x = -82 y = 72				
	MK0113A 1/22/98	MK0113B 1/21/98	MK0113C 1/21/98	MK0113D 1/22/98	MK0113E 1/22/98	MK0113F 1/23/98
K40	12.8±0.9	13.3±0.3	6.6±0.2	8.2±0.9	10.5±0.8	12.7±0.8
Ra226[1] + U235	4.1±0.6	16.4±0.5	39±1 39[2]	58±2 46±2[3]	31±3	9.2±0.7
Pb214						
351.9	3.2±0.2	12.7±0.3	32.1±0.7	47±1	25±1	6.4±0.2
295.2	3.3±0.2	12.8±0.3	32.0±0.8	46±1	24±1	5.9±0.3
242.0	3.8±0.3	13.6±0.4	33.0±0.9	47±2	26±1	6.8±0.4
785.9	yes	13.7±0.7	33±1	43±5	31±4	yes
Bi214						
609.3	3.2±0.2	11.8±0.2	29.9±0.6	43±1	22.4±0.5	5.8±0.2
1764.5	3.4±0.4	13.5±0.4	34.0±0.9	49±2	26±1	7±1
1120.3	2.8±0.3	12.7±0.2	32.4±0.4	45±1	23±1	5.8±0.4
1238.1	3.5±0.7	12.7±0.3	32.6±0.5	46±2	24±1	5.6±0.7
Pb210	yes	yes	yes	yes	yes	yes
Ac228						
911.1	0.6±0.2	0.8±<0.1	0.8±<0.1	1.0±0.4	0.8±0.2	0.9±0.1
Pb212						
238.6	0.6±<0.1	0.9±<0.1	0.7±<0.1	1.1±0.1	0.9±0.1	0.8±0.1
Tl208	0.21±0.03	0.27±0.01	0.21±0.01	0.27±0.05	0.20±0.04	0.27±0.03
chain	0.6±0.1	0.7±<0.1	0.6±<0.1	0.7±0.1	0.6±0.1	0.8±0.1
U235 (+ Ra223)						
143.8	possible	yes	yes	0.75	yes	yes
Th227						
236.0	no	0.16±0.02	1.05±0.05	4.0±0.3	1.1±0.3	yes
256.3	no	0.18±.04	0.95±0.07	3.1±0.4	1.3±0.6	no
Ra223						
269.5	possible	yes	1.1±0.1	3.3±0.6	yes	yes
154.2	no	0.4±0.2	1.4±0.3	4±2	1.5±1.0	0.6±3.7
323.9	no	yes	0.9±0.3	3±2	yes	no
Rn219						
271.2	possible	yes	1.24±0.07	3.1±0.3	yes	possible
401.8	no	yes	1.22±0.1	2.7±0.5	1.0±0.7	no
Pb211						
404.8	no	yes	yes	5±2	yes	no
832.0	no	no	1.5±0.4	2±2	possible	no
427.1	no	no	yes	possible	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] Essentially all of the 144 keV peak belongs to Ra223, therefore little interference from U235 in Ra226 peak.

[3] Assuming [Ra223] = 3.1 pCi/g, the [U235] = 0.75 pCi.g, which contributes about 20% of the counts in the 186 keV peak.

Mt. Kisco	Sample Location #14 in Survey # 1 @ x = -76 y = 54			
	MK0114A	MK0114B	MK0114C	MK0114D
	1/16/98	1/15/98	1/16/98	1/16/98
K40	11.1±1.2	10.3±0.2	15.6±0.8	17.0±0.8
Ra226[1] + U235	185±6	13.5±0.3	6.0±0.7	5.0±0.6
Pb214				
351.9	158±4	11.2±0.3	4.8±0.2	3.7±0.1
295.2	159±4	11.1±0.3	4.5±0.2	3.8±0.2
242.0	159±5	12.1±0.3	5.1±0.3	4.2±0.2
785.9	150±10	11.7±0.6	9±2	yes
Bi214				
609.3	148±3	10.7±0.2	4.6±0.2	3.4±0.1
1764.5	171±5	12.5±0.4	5.2±0.4	4.1±0.3
1120.3	158±2	11.6±0.2	5.1±0.4	3.5±0.3
1238.1	158±4	12.0±0.6	4.2±0.6	3.6±0.5
Pb210	yes	yes	yes	yes
Ac228				
911.1	1.2±0.5	1.0±<0.1	1.3±0.1	1.5±0.1
Pb212				
238.6	0.9±0.1	1.0±<0.1	1.4±0.1	1.5±0.1
Tl208	0.24±0.05	0.33±0.01	0.50±0.04	0.48±0.04
chain	0.7±0.1	0.9±<0.1	1.4±0.1	1.3±0.1
U235 (+ Ra223)				
143.8	no	yes	possible	no
Th227				
236.0	yes	0.14±0.04	possible	no
256.3	possible	0.15±0.08	no	no
Ra223				
269.5	possible	yes	yes	possible
154.2	no	0.4±0.2	no	no
323.9	no	no	no	no
Rn219				
271.2	possible	yes	possible	possible
401.8	no	possible	possible	no
Pb211				
404.8	no	no	no	no
832.0	no	no	no	no
427.1	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location #15 in Survey # 1 @ x = -30 y = 79

	MK0115A 12/29/97	MK0115B 12/29/97	MK0115C 12/29/97	MK0115D 12/29/97	MK0115E 12/29/97
K40	14.9±2.4	10.4±1.6	10.4±1.7	10.2±1.6	9.7±1.4
Ra226[1] + U235	5±10	6±11	8±15	12±23	5±10
Pb214					
351.9	4.7±1.5	3.4±0.4	6.2±1.2	10±2	3.7±0.5
295.2	4.1±1.3	4.0±0.5	5.9±1.1	9.0±1.8	3.7±0.5
242.0	yes	yes	yes	yes	yes
785.9	no	yes	no	possible	possible
Bi214					
609.3	4.5±0.9	3.1±0.4	5.8±0.8	9.0±1.3	3.2±0.4
1764.5	4.7±1.1	3.7±0.7	5.9±1.0	10±2	3.8±0.7
1120.3	4.2±1.0	3.1±0.6	6.7±1.0	9.4±1.4	3.5±0.7
1238.1	no	yes	yes	yes	yes
Pb210	no	no	4.4±1.5	no	no
Ac228					
911.1	0.8±0.3	0.5±0.1	0.6±0.2	0.4±0.3	0.6±0.2
Pb212					
238.6	0.9±0.3	0.5±0.1	no	0.6±0.2	0.4±0.1
Tl208					
chain	0.9±0.3	0.7±0.1	0.6±0.1	0.6±0.2	0.6±0.1
U235 (+ Ra223)					
143.8	no	no	no	no	no
Th227					
236.0	no	no	no	yes	no
256.3	no	no	no	yes	no
Ra223					
269.5	possible	possible	possible	possible	possible
154.2	no	no	no	yes	possible
323.9	no	no	no	2±1	no
Rn219					
271.2	possible	possible	possible	possible	possible
401.8	no	no	no	2±1	no
Pb211					
404.8	no	no	no	no	no
832.0	no	no	no	2±1	no
427.1	no	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location #16 in Survey # 1 @ x = -41 y = 23

	MK0116A 12/26/97	MK0116B 12/26/97	MK0116C 12/26/97	MK0116D 12/26/97	MK0116E 12/27/97
K40	8.5±1.5	10.2±2.0	11.1±1.6	11.8±2.0	14.4±2.0
Ra226[(1)] + U235	1.5±2.9	35±6	10±18	3±6	1±2
Pb214					
351.9	1.3±0.3	30±5	6.4±1.2	2.9±0.6	1.0±0.2
295.2	1.2±0.3	28±5	6.0±1.2	2.5±0.5	1.2±0.2
242.0	yes	yes	yes	yes	yes
785.9	yes	yes	yes	no	no
Bi214					
609.3	1.5±0.3	29±4	6.1±0.9	2.6±0.5	1.0±0.2
1764.5	1.7±0.4	33±5	7.5±1.2	2.8±0.6	1.2±0.3
1120.3	1.5±0.4	30±4	6.5±1.0	2.8±0.6	1.0±0.5
1238.1	yes	yes	yes	possible	possible
Pb210	no	17±15	10±8	no	no
Ac228					
911.1	0.2±0.1	0.7±0.4	0.7±0.3	0.7±0.3	1.0±0.3
Pb212					
238.6	0.2±0.1	0.6±0.2	0.7±0.2	0.6±0.2	1.1±0.2
Tl208					
chain	possible	0.7±0.3	0.4±0.3	0.7±0.2	0.9±0.2
U235 (+ Ra223)					
143.8	no	yes	possible	no	no
Th227					
236.0	no	yes	yes	yes	no
256.3	no	yes	no	no	no
Ra223					
269.5	no	yes	yes	possible	possible
154.2	no	yes	yes	yes	no
323.9	no	no	0.8±0.9	no	no
Rn219					
271.2	no	yes	yes	possible	possible
401.8	no	5±2	no	0.7±0.7	no
Pb211					
404.8	no	no	no	no	no
832.0	no	no	no	no	no
427.1	no	no	no	no	no

[(1)] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 17 in Survey # 1 @ x = -137 y = 36

	MK0117A 12/31/97	MK0117B 12/30/97	MK0117C 12/30/97	MK0117D 12/31/97	MK0117E 12/30/97
K40	9.8±0.2	12.1±0.8	8.8±0.7	7.9±0.8	7.8±0.7
Ra226[1] + U235	4.1±0.2	14.3±1.0	12.9±0.9	2.4±0.6	2[2]
Pb214					
351.9	3.0±0.1	12.0±0.3	10.0±0.3	2.0±0.1	1.0±0.1
295.2	3.0±0.1	12.0±0.4	9.6±0.4	2.0±0.2	1.0±0.1
242.0	3.4±0.1	12.4±0.6	10.7±0.5	2.20.2	1.6±0.2
785.9	3.2±0.3	13±3	yes	no	no
Bi214					
609.3	2.7±0.1	10.9±0.3	9.1±0.3	1.7±0.1	0.9±0.1
1764.5	3.3±0.1	14±2	10.1±0.6	2.5±0.4	1.4±0.3
1120.3	3.0±0.1	11.7±0.6	10.1±0.5	2.1±0.3	1.1±0.2
1238.1	3.1±0.1	11.5±1.0	9.4±0.9		0.8±0.3
Pb210	yes	yes	yes	no	yes
Ac228					
911.1	0.6±<0.1	0.5±0.2	0.9±0.1	0.7±0.1	0.6±0.1
Pb212					
238.6	0.6±0<.1	0.5±<0.1	0.9±0.1	0.8±0.1	0.6±0.1
Tl208	0.21±0.01	0.13±0.3	0.31±0.4	0.26±0.4	0.21±0.03
chain	0.6±<0.1	0.4±0.1	0.9±0.1	0.7±0.1	0.6±0.1
U235					
143.8	possible	no	no	no	no
Th227					
236.0	yes	no	no	no	no
256.3	no	no	no	no	no
Ra223					
269.5	possible	possible	possible	possible	possible
154.2	possible	possible	no	no	no
323.9	no	no	no	no	no
Rn219					
271.2	no	no	no	no	possible
401.8	no	no	no	no	no
Pb211					
404.8	no	no	no	no	no
832.0	no	no	no	no	no
427.1	no	no	no	no	no
766.5	no	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] This sample is low level background like, which usually means that the 186 keV peak is roughly half Ra226 and roughly half U235. Assume the Ra226 activity is about 1 pCi/g.

Mt. Kisco Sample Location # 18 in Survey # 1 @ x = -131 y = 73

samples counted on 11/25/97

	MK0118A	MK0118B	MK0118C	MK0118D	MK0118E	MK0118F
K40	11.0±1.0	11.3±1.0	12.9±1.0	11.2±1.1	8.9±0.9	11.3±1.0
Ra226[(1)] + U235	5.1±0.8	2.9	3.9	40.3±2.3	13.9±1.3	6.9±1.0
Pb214						
351.9	2.8±0.2	1.9±0.1	2.4±0.2	32.5±0.9	10.8±0.4	5.0±0.2
295.2	3.0±0.2	2.0±0.2	2.5±0.2	32.8±1.0	10.9±0.5	5.0±0.3
242.0	2.9±0.3	2.2±0.2	3.0±0.3	32.8±1.4	11.7±0.7	5.9±0.4
785.9	3.0±1.4	no	no	36.9±2.3	14.7±3.6	no
Bi214						
609.3	2.5±0.2	1.7±0.1	2.3±0.2	31.0±0.8	10.7±0.4	4.7±0.2
1764.5	3.4±0.5	1.9±0.4	2.8±0.4	34.4±1.7	11.3±0.9	4.7±0.6
1120.3	2.9±0.4	2.2±0.3	2.6±0.4	33.0±1.3	11.0±0.7	5.0±0.5
1238.1	2.3±0.7	no	no	35.0±2.3	11.0±1.3	5.5±1.0
Pb210	no	no	no	yes	yes	yes
Ac228						
911.1	0.7±0.3	0.7±0.3	0.7±0.3	1.3±0.5	0.8±0.3	1.0±0.3
Pb212						
238.6	0.7±0.1	0.7±0.1	0.6±0.1	0.9±0.1	0.8±0.1	1.0±0.1
Tl208	0.21±0.04	0.22±0.04	0.24±0.04	0.31±0.06	0.35±0.05	0.32±0.05
chain	0.6±0.1	0.6±0.1	0.7±0.1	0.9±0.2	1.0±0.1	0.9±0.1
U235						
143.8	no	no	no			
Th227						
236.0						
256.3						
Ra223						
269.5		possible				
154.2			no			
323.9						
Rn219						
271.2		possible				
401.8		no				
Pb211						
404.8						
832.0						
427.1						

[(1)] Uses the branching ration for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 19 in Survey # 1 @ x = -170 y = 63

	MK0119A 12/10/97	MK0119B 12/10/97	MK0119C 12/10/97	MK0119D 12/10/97	MK019E 12/10/97
K40	9.0±1.6	11.0±1.7	10.8±1.6	11.7±2.0	10.1±1.8
Ra226[1] + U235	2±4	2±3	2±3	4±8	17±31
Pb214					
351.9	1.7±0.4	1.2±0.3	1.8±0.2	2.4±0.5	12±3
295.2	1.7±0.4	0.7±0.3	1.3±0.3	2.1±0.5	11±2
242.0	yes	no	yes	yes	yes
785.9	possible	no	no	yes	yes
Bi214					
609.3	1.5±0.3	1.2±0.2	1.5±0.2	2.6±0.5	11±2
1764.5	1.7±0.5	1.2±0.4	1.4±0.4	2.9±0.6	11±2
1120.3	1.6±0.4	1.6±0.5	1.7±0.5	2.5±0.6	13±2
1238.1	yes	yes	yes	yes	yes
Pb210	no	0.3±1.2	no	no	11±3
Ac228					
911.1	0.7±0.2	0.8±0.3	0.6±0.2	0.7±0.3	0.6±0.4
Pb212					
238.6	0.5±0.1	0.7±0.2	0.6±0.1	0.5±0.1	no
Tl208					
chain	0.5±0.2	0.7±0.2	0.4±0.2	0.7±0.2	no
U235					
143.8	no	no	no	no	no
Th227					
236.0	no	no	no	no	no
256.3	no	no	no	no	no
Ra223					
269.5	possible	possible	possible	possible	no
154.2	no	no	no	no	no
323.9	no	no	no	no	no
Rn219					
271.2	no	possible	possible	possible	no
401.8	no	no	no	no	no
Pb211					
404.8	no	no	no	no	no
832.0	no	no	no	no	no
427.1	no	no	no	no	no

[1] Uses the branching ration for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

	Mt. Kisco	Sample Location #1 in Survey # 2		@ x = -94 y = 2		
	MK0201A	MK0201B	MK0201C	MK0201D	MK0201E	MK0201F
	1/21/98	1/20/98	1/21/98	1/21/98	1/21/98	1/21/98
K40	9.6±0.7	11.6±0.3	12.4±0.9	11.3±0.8	10.4±0.7	3.6±0.6
Ra226[1] + U235	13.6±0.9	14.6±0.4 13.6±0.04[2]	5.4±0.7	2.9±0.6	1.9±0.4	2.5±0.6
Pb214						
351.9	11.5±0.3	11.5±0.3	3.9±0.2	1.5±0.1	0.8±0.1	1.5±0.1
295.2	11.1±0.4	11.5±0.5	4.0±0.2	1.3±0.1	0.9±0.1	1.4±0.2
242.0	12.0±0.5	12.2±0.3	4.3±0.3	1.8±0.2	1.4±0.2	1.8±0.2
785.9	12±2	11.9±0.3	no	possible	no	no
Bi214						
609.3	10.4±0.3	10.7±0.2	3.8±0.2	1.4±0.1	0.8±0.1	1.3±0.1
1764.5	11.9±0.7	12.4±0.3	4.7±0.5	1.7±0.3	0.9±0.2	1.4±0.7
1120.3	11.2±0.5	11.4±0.2	4.2±0.4	1.6±0.2	0.9±0.2	1.4±0.3
1238.1	12.3±1.0	11.4±0.2	3.6±0.8	1.7±0.5	yes	
Pb210	yes	yes	yes	yes	yes	yes
Ac228						
911.1	0.8±0.1	0.9±<0.1	1.1±0.3	1.3±0.1	0.9±0.1	0.8±0.2
Pb212						
238.6	0.9±0.1	0.9±<0.1	0.9±0.1	1.3±0.1	0.9±0.1	0.7±0.1
Tl208	0.25±0.04	0.29±0.01	0.31±0.04	0.48±0.05	0.27±0.04	0.240.04
chain	0.7±0.1	0.8±<0.01	0.9±0.1	1.3±0.1	0.7±0.1	0.7±0.1
U235 (+ Ra223)						
143.8	no	0.06	no	possible	possible	no
Th227						
236.0	possible	0.21±0.04	no	possible	no	no
256.3	no	possible	no	possible	no	no
Ra223						
269.5	possible	yes	yes	possible	possible	possible
154.2	possible	0.8±0.2	no	possible	no	no
323.9	no	yes	no	no	no	no
Rn219						
271.2	possible	yes	possible	possible	possible	possible
401.8	no	yes	no	no	no	no
Pb211						
404.8	no	yes	no	no	no	no
832.0	no	yes	no	no	no	no
427.1	no	no	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] Assume [Ra223] = 0.21 pCi/g which suggests [U235] = 0.064 pCi/g. Subtracting the U235 from the 186 keV peak, the resulting activity for Ra226 is 13.6 pCi/g.

	Mt. Kisco	Sample Location # 3 in Survey # 2		@ x = -39 y = -7		
	MK0203A 1/08/98	MK0203B 1/07/98	MK0203C 12/05/97	MK0203D 12/05/97	MK0203E 12/05/97	Mk0203F 12/05/97
K40	9.8±0.6	10.7±0.2	9.9±1.5	7.9±1.4	9.2±1.5	9.0±1.8
Ra226[1] + U235	5.0±0.5	12.7±0.4 10[2]	14±26	13±25	7±13	18±34
Pb214						
351.9	3.7±0.1	9.5±0.2	8.5±1.8	11±2	5.4±0.6	13±3
295.2	3.9±0.2	9.6±0.2	8.5±1.6	11±2	5.3±0.7	14±3
242.0	3.5±0.2	9.8±0.3	yes	yes	yes	yes
785.9	yes	10.0±0.5	possible	possible	possible	yes
Bi214						
609.3	3.5±0.1	8.8±0.2	8.1±1.1	10±2	4.9±0.6	13±2
1764.5	3.7±0.3	10.1±0.3	9.9±1.5	12±2	5.5±0.9	15±2
1120.3	3.6±0.3	9.5±0.1	9.2±1.3	11±2	5.2±0.9	14±2
1238.1	3.6±0.5	9.7±0.2	yes	yes	possible	yes
Pb210	yes	yes	6.4±2.3	no	no	16±3
Ac228						
911.1	0.4±0.1	0.6±<0.1	0.7±0.3	possible	0.8±0.3	possible
Pb212						
238.6	0.5±<0.1	0.6±<0.1	no	0.6±0.2	no	0.8±0.2
Tl208	0.10±0.02	0.19±0.008				
chain	0.3±0.1	0.5±<0.1	0.5±0.2	0.6±0.2	0.7±0.2	0.8±0.2
U235 (+ Ra223)						
143.8	no	0.16[2]	no	no	no	no
Th227						
236.0	possible	0.26±0.02	no	no	no	no
256.3	no	0.17±0.03	no	no	no	no
Ra223						
269.5	no	yes	possible	possible	possible	possible
154.2	no	no	no	no	no	yes
323.9	no	no	no	no	no	no
Rn219						
271.2	no	yes	possible	possible	possible	possible
401.8	no	0.18±0.07	no	no	no	no
Pb211						
404.8	no	yes	no	no	no	no
832.0	no	yes	no	no	no	no
427.1	no	no	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] Subtracting 0.2 pCi/g Ra223 from the 144 keV peak to get the [U235] = 0.16 pCi/g, then subtracting the U235 from the 186 keV peak, we estimate the [Ra226] to be 10 pCi/g. Error propagation was not done.

Mt. Kisco Sample Location # 1 in Survey # 3 @ x = 62 y = -31

	MK0301A 1/28/98	MK0301B 1/28/98	MK0301C 1/28/98	MK0301D 1/28/98	MK0301E 1/28/98
K40	13.7±0.8	12.2±0.8	13.6±1.0	11.7±0.8	5.9±0.6
Ra226 note [1]	8.8±1.4	6±1	2	13.1±0.9	3±1
Pb214					
351.9	6.5±0.2	4.3±0.2	0.8±0.1	9.5±0.3	1.4±0.1
295.2	6.4±0.3	4.3±0.2	0.7±0.1	9.4±0.4	1.5±0.1
242.0	7.0±0.4	4.7±0.3	1.2±0.2	10.3±0.5	1.9±0.2
785.9	6±2	yes	yes	10±2	yes
Bi214					
609.3	5.8±0.2	4.1±0.2	0.7±0.1	8.6±0.3	1.2±0.1
1764.5	7.4±0.4	4.4±0.4		9.3±0.6	0.9±0.2
1120.3	6.6±0.4	4.2±0.4	1.1±0.2	9.2±0.5	1.4±0.2
1238.1	6.3±0.8	4.2±0.6		9.6±0.9	
Pb210	yes	no	no	yes	yes
Ac228					
911.1	0.6±0.1	0.6±0.2	0.5±0.2	0.6±0.2	1.1±0.1
Pb212					
238.6	0.6±<0.1	0.6±<0.1	0.5±<0.1	0.8±0.1	1.1±0.1
Tl208	0.20±0.03	0.18±0.03	0.15±0.03	0.19±0.03	0.33±0.04
chain	0.6±0.1	0.5±0.1	0.4±0.1	0.5±0.1	0.9±0.1
U235					
143.8	possible	no	no	possible	possible
Th227					
236.0	yes	possible	no	yes	no
256.3	no	no	no	no	no
Ra223					
269.5	yes	yes	possible	possible	possible
154.2	no	no	no	possible	no
323.9	possible	no	no	no	no
Rn219					
271.2	yes	possible	no	possible	yes
401.8	yes	no	no	no	no
Pb211					
404.8	no	no	no	no	no
832.0	no	no	no	no	no
427.1	no	no	no	no	no

[1] Ra226 activity after U235 (assume all 143.8 keV peak belongs to U235) is subtracted. Some part of the 143.8 keV peak may belong to Ra223. Therefore, the actual Ra226 should be between the two values reported.

Mt. Kisco Sample Location # 2 in Survey # 3 @ x = 22 y = 14

	MK0302A 1/08/98	MK0302B 1/08/98	MK0302C 12/27/97	MK0302D 12/27/97	MK0302E 12/27/97	MK0302F 12/29/97	MK0302G 12/29/97	Mk0302H 12/29/97
K40	12.5±0.9	11.3±0.6	15.9±3.1	10.2±1.9	8.8±1.7	10.9±2.0	8.8±2.0	10.6±1.8
Ra226[1]	45±2	94±3	74±136	17±31	11±20	49±90	53±98	28±52
+ U235	42[2]	72[3]						
Pb214								
351.9	38±1	76±2	54±6	15±3	9±2	33±4	38±7	19±3
295.2	37±1	70±2	52±6	13±3	8±2	30±3	36±6	17±3
242.0	37±1	73±2	yes	yes	yes	yes	yes	yes
785.9	36±4	72±4	yes	yes	possible	yes	yes	yes
Bi214								
609.3	33±1	66±1	49±6	13±2	8±1	29±3	36±4	17±3
1764.5	40±2	77±2	55±7	16±3	9±2	32±4	40±5	20±3
1120.3	36±1	71±1	51±6	13±2	8±1	31±4	38±5	18±2
1238.1	37±2	71±2	yes	yes	yes	yes	yes	yes
Pb210	yes	yes	60±36	no	no	no	29±5	17±15
Ac228								
911.1	0.6±0.1	0.6±0.1	1.2±0.9	possible	0.6±0.3	possible	0.8±0.6	1.0±0.3
Pb212								
238.6	0.7±0.1	0.7±<0.1	0.8±0.4	no	0.4±0.1	no	no	0.8±0.2
Tl208	0.13±0.03	0.23±0.02						
chain	0.4±0.1	0.7±0.1	no	0.8±0.4	0.6±0.3	0.7±0.3	0.7±0.2	0.8±0.3
U235 (+ Ra223)								
143.8	0.2[2]	1.4[3]	possible	yes	no	yes	possible	yes

Th227								
236.0	4.9±0.3	15.4±0.5	yes	no	no	yes	yes	possible
256.3	5.1±0.5	14.5±0.6	no	no	no	yes	yes	no
Ra223								
269.5	5.1±0.5	14.2±0.5	yes	yes	possible	yes	yes	yes
154.2	7.0±1.4	16±1	yes	yes	possible	yes	yes	possible
323.9	4±2	12±1	7±4	no	no	7±3	4±3	2±2
Rn219								
271.2	5.8±0.4	15.7±0.5	yes	yes	possible	yes	yes	yes
401.8	4.2±0.5	14.2±0.6	7±2	no	1.8±1.4	possible	5±2	3±1
Pb211								
404.8	7±2	17±1	11±5	no	no	no	10±4	4±3
832.0	4±2	17±2	9±5	no	no	yes	8±5	2±2
427.1	yes	yes	yes	no	no	no	yes	yes

(1) Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.
(2) Subtracting 5 pCi/g Ra223 from the 144 keV peak to get the [U235] = 0.17 pCi/g, then subtracting the U235 from the 186 keV peak, we estimate the [Ra226] to be 42 pCi/g. Error propagation was not done.
(3) Subtracting 15 pCi/g Ra223 from the 144 keV peak to get the [U235] = 1.4 pCi/g, then subtracting the U235 from the 186 keV peak, we estimate the [Ra226] to be 72 pCi/g. Error propagation was not done.

Mt. Kisco Sample Location # 3 in Survey # 3 @ x = 63 y = 25

	MK0303A 12/22/97	MK0303B 12/11/97	MK0303C 12/10/97	MK0303D 12/22/95	MK0303E 12/18/97	MK0303E2 1/29/98	MK0303F 12/17/97	MK0303G[4] 12/16/97	MK0303H 12/15/97
K40	11.5±1.0	14.2±0.3	13.4±0.3	12.2±0.3	9.0±0.3	10.3±0.8	14.2±0.5	12.4±0.7	14.3±0.4
Ra226	5.5±0.8	13.5±0.4	25±1	89±2	76±3	80±3	1001±24	1322±30	261±7
note [1]			23±1[3]		74±3[2]		888±24	1052±30	236±7
Pb214									
351.9	3.6±0.2	10.8±0.2	20.2±0.4	76±2	63±2	54±1	826±18	1079±24	218±5
295.2	3.5±0.2	10.8±0.3	20.1±0.5	76±2	63±2	54±2	817±20	1189±26	218±5
242.0	4.4±0.3	11.4±0.3	21.0±0.5	78±2	64±2	54±2	833±21	1105±28	221±6
785.9		13.5±0.4	21.8±0.8	78±2	63±2	55±5	827±16	1110±21	224±5
Bi214									
609.3	3.3±0.2	10.1±<0.1	18.9±0.4	72±2	58±2	50±1	753±15	1023±20	207±4
1764.5	4.0±0.4	11.7±<0.1	22.0±0.6	82±2	74±3	59±2	864±21	1175±28	241±6
1120.3	4.0±0.4	10.9±0.2	20.2±0.2	78±1	63±1	54±1	804±7	1103±10	224±2
1238.1	4.5±0.7	11.0±0.2	20.9±0.3	77±1	60±1	57±2	805±7	1107±9	226±2
Pb210	yes	yes	yes	yes	yes	yes	yes	yes	yes
Ac228									
911.1	0.8±0.2	0.8±<0.1	1.1±<0.1	1.7±0.1	0.7±0.1	0.5±0.3	0.8±0.1	0.6±0.2	0.9±0.1
Pb212									
238.6	0.8±0.2	0.8±<0.1	1.1±<0.1	1.7±<0.1	0.7±0.1	0.7±0.1	0.6<0.1	0.6±0.1	0.7±<0.1
Tl208	0.23±0.04	0.25±0.01	0.35±0.01	0.59±0.02	0.23±0.01	0.26±0.05	0.21±0.2	yes	0.23±0.01
chain	0.6±0.1	0.7±<0.1	1.0±<0.1	1.6±0.1	0.6±<0.1	0.7±0.1	0.6±0.1		0.6±<0.1

U235									
143.8	no	yes	yes	yes	0.1	yes	yes	15±2	1.5±0.2
Th227									
236.0		0.3±0.1	0.7±0.1	1.4±0.1	1.5±0.1	1.9±0.2	52±2	52±2	4.5±0.1
256.3		0.2±0.1	0.6±0.1	1.2±0.1	1.4±0.1	1.7±0.4	46±1	45±2	3.3±0.2
Ra223									
269.5		yes	0.7±0.1	1.5±0.1	1.7±0.1	yes	48±1	47±1	4.3±0.2
154.2	no	yes	yes	yes	yes	2.2±1.3	yes	yes	yes
323.9		0.3±0.1	0.4±0.2	0.9±0.4	1.7±0.4	possible	48±2	50±2	4.8±0.8
Rn219									
271.2		yes	yes	1.6±0.1	1.7±0.1	yes	53±1	53±2	4.9±0.2
401.8		0.2±0.1	0.6±0.1	1.1±0.1	1.4±0.2	3.0±1.4	49±1	51±2	4.4±0.2
Pb211									
404.8		0.3±0.2	yes	yes	yes	no	yes	yes	yes
832.0		0.3	1.1±0.2	1.8±0.5	2.3±0.4	no	41±1	63±3	6.9±0.8
427.1		possible	yes	yes	yes	possible	yes	yes	yes

(1) Ra226 activity after U235 (assume all 143.8 keV peak belongs to U235) is subtracted. Some part of the 143.8 keV peak may belong to Ra223. Therefore, the actual Ra226 should be between the two values reported.
(2) If [Ra223] = 1.6 pCi/g, then [U235] = 0.1 pCi/g and 2% of the 186 keV gammas are due to U235
(3) If [Ra223] = 0.65 pCi/g, then [U235] = 0.1 pCi/g and 6 % of the 186 keV gammas are due to U235
(4) Correction made to sample weight 7/22/98. (correction factor was 0.8)

Mt. Kisco Sample Location # 4 in Survey # 3 @ x = 21 y = 51

	MK0304A 12/05/97	MK0304B 12/05/97	MK0304C 12/02/97	MK0304C2 12/02/97	MK0304D 12/02/97	MK0304E 12/02/97	MK0304F 12/02/97	MK0304G 12/02/97	MK0304H 12/02/97
K40	10.5±1.7	9.3±1.5	11.2±2.3	12.7±2.4	11.2±1.8	9.5±1.6	10.4±1.6	10.4±1.9	9.3±1.4
Ra226[1] + U235	19±35	21±38	92±169	74±135	20±37	18±18	15±28	23±43	10±18
Pb214			45±5[2]	45±5[2]	14±3[2]	6.6±1.3[2]	9.7±1.9[2]	18±3[2]	5.3±0.7[2]
351.9	14±3	15±2							
295.2	14±3	14±2							
242.0	yes	yes							
785.9	yes	no							
Bi214			49±3[2]	48±3[2]	15±1[2]	7.5±0.7[2]	10.7±0.9[2]	18±3[2]	5.5±0.4[2]
609.3	13±2	14±2							
1764.5	16±3	17±2							
1120.3	14±2	15±2							
1238.1	yes	possible							
Pb210	15±12	no							
Ac228			0.7±0.5[2]	1.1±0.5[2]	0.7±0.2[2]	0.7±0.2[2]	0.5±0.2[2]	0.7±0.4[2]	0.6±0.2[2]
911.1	0.6±0.3	0.6±0.4							
Pb212			1.8±0.4[2]	1.9±0.4[2]	0.4±0.1[2]	0.2±0.1[2]	0.3±0.1[2]	0.7±0.2[2]	0.6±0.2[2]
238.6	0.5±0.2	no							
Tl208 chain	0.6±0.3	0.8±0.3	0.7±0.2[2]	0.5±0.2[2]	0.7±0.2[2]	0.7±0.2[2]	0.5±0.2[2]	0.7±0.4[2]	0.6±0.2[2]
U235 (+ Ra223)									
143.8	yes	possible							

Th227		
236.0	yes	possible
256.3	no	possible
Ra223		
269.5	yes	yes
154.2	yes	possible
323.9	2.2±1.3	1.8±1.4
Rn219		
271.2	yes	yes
401.8	2.2±1.2	no
Pb211		
404.8	2.5±2.3	no
832.0	2±2	possible
427.1	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 5 in Survey # 3 @ x = 76 y = -43

	MK0305A 1/13/98	MK0305B 1/13/98	MK0305C 1/14/98	MK0305D 12/29/97	MK0305E 12/29/97
K40	11.1±1.5	3.3±2.1	12.9±0.8	11.7±1.8	6.1±1.1
Ra226[(1)] + U235	741±11	7143±179	212±6	4±7	1.3±2.7
Pb214					
351.9	637±14	6012±129	176±4	2.7±0.5	2.1±0.4
295.2	645±15	6063±147	179±5	2.6±0.5	1.9±0.5
242.0	649±16	6130±156	183±5	yes	yes
785.9	666±20	6247±115	177±7	yes	yes
Bi214					
609.3	617±12	5674±112	168±3	2.6±0.4	1.9±0.3
1764.5	705±17	6571±158	195±5	2.5±0.6	2.4±0.6
1120.3	666±7	6150±51	181±2	2.3±0.7	1.8±0.5
1238.1	677±8	6197±45	182±3	yes	possible
Pb210	yes	yes	yes	1.9±1.3	no
Ac228					
911.1	possible	no	1.0±0.4	0.7±0.2	yes
Pb212					
238.6	0.2±0.1	no	0.8±0.1	0.9±0.2	0.5±0.1
Tl208	no	no	0.26±0.03		
chain			0.7±0.1	0.8±0.2	0.6±0.2
U235 (+ Ra223)					
143.8	possible	no	no	no	no
Th227					
236.0	yes	no	no	no	no
256.3	no	no	no	no	no
Ra223					
269.5	yes	no	no	possible	possible
154.2	no	no	no	no	no
323.9	no	no	no	no	no
Rn219					
271.2	possible	no	no	possible	possible
401.8	possible	no	no	no	no
Pb211					
404.8	no	no	no	no	no
832.0	no	no	no	no	no
427.1	no	no	no	no	no

[(1)] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Mt. Kisco Sample Location # 1 in Survey # 4 @ x = 48 y = 96

	MK0401A 1/09/98	MK0401B 1/12/98	MK0401C 12/29/97	MK0401D 12/29/97
K40	11.0±0.7	12.5±0.3	14.9±2.4	10.9±1.5
Ra226[1] + U235	6..9±0.7	6.7±0.2 6.6±0.2 [2]	10±19	5±9
Pb214				
351.9	5.8±0.2	5.1±0.1	6±2	2.4±0.3
295.2	5.7±0.3	5.0±0.1	6±2	2.5±0.4
242.0	6.3±0.4	5.5±0.2	yes	no
785.9	yes	4.9±0.4	yes	no
Bi214				
609.3	5.3±0.2	4.7±0.1	6±1	2.2±0.3
1764.5	6.1±0.5	5.4±0.2	6±1	2.5±0.5
1120.3	5.4±0.4	5.1±0.1	5±1	2.6±0.5
1238.1	5.2±0.7	5.1±0.2	possible	no
Pb210	yes	yes	no	no
Ac228				
911.1	0.6±0.2	0.7±<0.1	0.8±0.4	0.6±0.2
Pb212				
238.6	0.8±<0.1	0.7±<0.1	0.8±0.3	no
Tl208	0.18±0.03	0.23±0.009		
chain	0.5±0.1	0.6±<0.1	0.8±0.4	0.6±0.2
U235 (+ Ra223)				
143.8	possible	yes	no	no
Th227				
236.0	yes	0.25±0.02	yes	no
256.3	no	0.20±0.03	no	no
Ra223				
269.5	possible	yes	possible	no
154.2	no	0.3±0.1	no	no
323.9	no	possible	no	no
Rn219				
271.2	possible	yes	possible	possible
401.8	no	0.2±0.1	no	no
Pb211				
404.8	no	yes	no	no
832.0	no	possible	no	no
427.1	no	possible	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] If [Ra223] = 0.23 pCi/g, then U = 0.1 pCi/g, whence Ra226 contributed 98.6% of the counts in the 186 keV peak.

Richard's Lumber Sample Location # 1 in Survey # 1 @ x = -31 y = 6

counted on 12/19/97

	RL0101A	RL0101B	RL0101C	RL0101D	RL0101E
K40	15.7±0.9	13.3±1.0	8.6±0.7	7.2±0.8	8.0±0.7
Ra226 + U235[1]	4.2±0.6	23±2	7±1	10±2	4.2±0.6
Pb214					
351.9	3.2±0.2	17.3±0.5	5.2±0.2	7.0±0.3	2.9±0.2
295.2	3.2±0.2	17.1±0.6	5.4±0.3	6.6±0.4	2.9±0.2
242.0	3.4±0.3	18.7±0.8	5.0±0.3	7.2±0.2	3.4±0.3
785.9	3.3±1.4	20±4	yes	8±3	possible
Bi214					
609.3	2.9±0.1	15.8±0.5	4.6±0.2	6.2±0.3	2.6±0.2
1764.5	4.0±0.4	18±1	5.8±0.5	8±2	3.5±0.4
1120.3	3.0±0.3	16.8±0.8	5.0±0.4	6.9±0.6	2.8±0.4
1238.1	3.3±0.5	19±2	3.9±0.6	7±1	2.3±0.6
Pb210	no	yes	yes	yes	yes
Ac228					
911.1	0.7±0.2	0.8±0.3	0.4±0.2	1.1±0.2	1.0±0.1
Pb212					
238.6	0.7±0.1	0.9±0.1	0.3±<0.1	1.4±0.1	0.9±0.1
Tl208	0.17±0.03	0.24±0.04	0.11±0.03	0.33±0.04	0.32±0.4
chain	0.5±0.1	0.7±0.1	0.3±0.1	0.9±0.1	0.9±0.1
U235					
143.8	yes	no	no	possible	no
Th227					
236.0	no	possible	yes	possible	no
256.3	no	possible	no	no	no
Ra223					
269.5	yes		yes	possible	possible
154.2	no	possible	yes	possible	no
323.9	no	no	no	no	no
Rn219					
271.2	yes	possible	no	possible	possible
401.8	no	2.0±0.5	no	no	no
Pb211					
404.8	no	no	no	no	no
832.0	no	no	no	no	no
427.1	no	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Richard's Lumber Sample Location # 2 in Survey # 1 @ x = -28 y = 27

	RL0102A 1/06/98	RL0102B 12/29/97	RL0102C 12/29/97	RL0102D 1/06/98	RL0102E 12/29/97	RL0102E2 12/29/97	RL0102F 12/29/97	RL0102G 12/29/97	RL0102H 10/28/97	RL0102H2 10/28/97
K40	12.5±0.9	8.1±1.8	10.0±2.4	10.5±0.3	7.8±2.2	9.7±2.3	8.9±2.6	5.7±2.2	4.4±2.3	5.5±2.1
Ra226[1] + U235	36±3	20±37	58±107	83±2	48±89	47±86	74±137	44±81	2.2±0.5	2.0±0.5
Pb214									1.6±0.4[3]	1.9±0.5[3]
351.9	30.7±0.8	14±3	47±8	66±2	40±8	39±8	57±11	32±6		
295.2	30.8±0.9	15±3	45±8	66±2	38±7	38±7	58±10	32±6		
242.0	31.7±1.1	yes	yes	67±2	yes	yes	yes	yes		
785.9	34±4	yes	yes	69±2	yes	yes	yes	yes		
Bi214										
609.3	28.9±0.7	14±2	45±7	61±1	38±7	38±7	56±7	30±4		
1764.5	33±1	17±3	51±7	69±2	43±7	44±7	57±8	34±5		
1120.3	31.8±0.9	16±2	48±6	66±1	40±5	39±5	58±7	31±4		
1238.1	29±2	yes	yes	66±1	yes	yes	yes	yes		
Pb210	yes	11±3	31±24	yes	no	no	29±7	22±24		
Ac228										
911.1	0.9±0.3	no	1.1±0.4	1.0±0.1	yes	yes	1.3±0.7	1.1±0.6		
Pb212										
238.6	0.9±0.3	0.7±0.2	0.6±0.3	1.1±<0.1	0.8±0.4	0.8±0.3	no	1.2±0.3		
Tl208	0.14±0.4			0.34±0.2						
chain	0.4±0.1	0.5±0.2	1.2±0.3	0.9±<0.1	1.1±0.3	no	1.3±0.4	1.4±0.4	0.4±0.3[3]	0.3±0.3[3]
U235 (+ Ra223)										
143.8	possible	no	no	0.1[20]	no	no	no	no		

Th227								
236.0	1.5±0.3	no	no	1.9±0.1	no	no	no	no
256.3	possible	no	no	1.9±0.1	no	no	no	no
Ra223								
269.5	yes	possible	possible	2.0±0.1	no	possible	possible	no
154.2	yes	yes	yes	yes	no	possible	possible	no
323.9	no	2.4±2.0	no	1.8±0.5	no	no	no	no
Rn219								
271.2	possible	possible	possible	2.1±0.1	no	possible	possible	no
401.8	0.7±0.9	0.9±0.8	2.0±2	1.7±0.1	no	1.3±1.9	no	no
Pb211								
404.8	yes	possible	no	yes	possible	no	no	no
832.0	yes	possible	no	2.5±0.6	no	no	no	no
427.1	no	no	no	possible	no	no	no	no

(1) Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.
(2) Subtracting 1.9 pCi/g Ra223 from the peak, only 14% of the counts remain. These were attributed to U235.
(3) Data taken from contract lab summary sheets - individual gamma results not presented.

RL0102G1 + RL0102G2 composite water sample taken from hole at the 48" depth

	Gross Alpha	Gross Beta
	Units - pCi/l	
Unfiltered	617±30	399±16
duplicate	618±30	415±17
Filtered	62±6	62±5
duplicate	63±6	63±5

	Ra226 by alpha spec
Filtered	12±3
duplicate	13±3

Note: When Ra226 decays, 5 alphas are generated (Ra226, Rn222, Po218,Po214, and Po210). The filtered gross alpha results are approximately 5 times the Ra226 activity, suggesting that Ra226 is the primary alpha emitter in the sample.

	Gamma Spec Filtered water
	Units - pCi/l
Ra226	209±440
duplicate	184±382
Pb214	63±18
duplicate	51±18
Bi214	44±19
duplicate	56±19

Richard's Lumber Sample Location # 3 in Survey # 1 @ x=17 y = 10

samples counted on 12/08/7

	RL0103A	RL0103B	RL0103B recount 12/9/97	RL0103C	RL0103D	RL0103E	RL0103F	RL0103G
K40	18±1	10.8±1.7	9.7±0.4	7.0±1.0	14.9±1.0	6.8±1.0	11.0±0.8	12.3±0.2
Ra226	5.0±0.6	444±13	440±11	78±3	19±2	17±2	3.3±0.6	1.7±0.1
note [1]		365±17	342±12					
Pb214								
351.9	4.1±0.2	368±8	371±9	67±2	14.1±0.4	11.5±0.4	2.4±0.1	1.1±<0.1
295.2	4.1±0.2	365±10	368±9	66±2	13.7±0.5	12.0±0.5	2.1±0.2	1.0±<0.1
242.0	4.3±0.3	376±11	377±10	67±2	14.8±0.7	12.7±0.7	2.9±0.2	1.4±<0.1
785.9	yes	358±19	378±8	71±8	10±3	15±4		1.3±<0.1
Bi214								
609.3	3.6±0.2	341±7	344±7	63±2	13.1±0.4	10.8±0.4	2.0±0.1	1.0±<0.1
1764.5	4.1±0.4	387±10	388±9	70±3	14.9±0.8	14.8±0.9	3.0±0.9	1.3±0.1
1120.3	4.2±0.4	365±5	365±3	68±2	12.9±0.7	11.4±0.8	2.7±0.3	1.1±<0.1
1238.1	3.2±0.7	358±7	368±9	69±3	13.0±1.2	12.2±1.4	2.7±0.6	1.0±0.1
Pb210	yes	yes	yes	yes	yes	yes	no	yes
Ac228								
911.1	0.5±0.2	2±1	1.0±0.1	yes	0.8±0.3	1.0±0.4	0.7±0.1	0.7±<0.1
Pb212								
238.6	0.5±<0.1	1.1±0.2	1.01±<0.1	0.3±0.1	0.9±0.1	1.1±0.1	0.7±0.1	0.7±<0.1
Tl208	0.16±0.03	yes	0.33±0.02	0.19±0.05	0.25±0.04	0.25±0.5	0.20±0.03	0.21±0.01
chain	0.4±0.1		0.9±<0.1	0.5±0.1	0.7±0.1	0.7±0.1	0.6±0.1	0.6±<0.1

	RL0103A	RL0103B	RL0103B	RL0103C	RL0103D	RL0103E	RL0103F	RL0103G
U235[1]								
143.8	no	4.6±0.7	5.9±0.5	yes	possible	yes		0.10±0.02
Th227								
236.0	yes	21±1	21±1	yes	0.7±0.3	yes	possible	yes
256.3	no	19±1	18±1	yes	yes	no	possible	possible
Ra223								
269.5	yes	20±2	20.5±0.3	2.2±0.9	yes	yes	yes	yes
154.2	no	yes	yes	no	yes	possible		yes
323.9	no	12±5	19±1	2±2	no	no	possible	no
Rn219								
271.2	yes	21±2	21.8±0.6	yes	yes	yes	yes	possible
401.8	no	20±2	20.0±0.5	no	possible	no		no
Pb211								
404.8	no	yes	yes	no	yes	no		possible
832.0	no	23±9	24±2	possible	possible	no		possible
427.1	no	25±16	yes	no	no	no		no
766.5	no	possible	no	no	no	no		no

[1] Ra226 activity after U235 (assume all 143.8 keV peak belongs to U235) is subtracted. Some part of the 143.8 keV peak may belong to Ra223. Therefore, the actual Ra226 should be between the two values reported.

Richard's Lumber Sample Location #4 in Survey #1 @ x = -4 y = 34

	12/29/97 RL0104A	12/29/97 RL0104B	12/29/97 RL0104C	12/29/97 RL0104D	12/29/97 RL0104E	12/29/97 RL0104F	12/29/97 RL0104G	12/29/97 RL0104G 2nd count	12/29/97 RL0104H	12/29/97 RL0104I	12/29/97 RL0104J
K40	21±3	8±2	11±2	12±2	10±2	9±2	6±3	7±3	8±2	11±2	4±2
Ra226 note(1)	7±13	1482±2719	4±8	0.5±1.6	11±20	26±48	134±247	129±237	77±141	29±53	18±33
Pb214											
351.9	3.4±1.1	1192±223	3.8±0.7	0.5±0.2	8±1	19±4	106±20	107±20	65±7	21±4	14±3
295.2	3.6±1.1	1218±206	3.5±0.7	0.6±0.2	7±1	19±3	106±18	105±18	64±7	21±4	15±3
242.0	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
785.9	possible	yes	possible	no	yes	yes	yes	yes	yes	yes	no
Bi214											
609.3	3.3±0.7	1108±137	3.4±0.5	0.8±0.2	7±1	18±2	103±13	104±13	61±7	21±3	13±2
1764.5	3.7±1.0	1179±151	3.9±0.7	0.8±0.3	8±1	19±3	111±15	112±15	69±8	23±3	16±3
1120.3	3.8±1.0	1150±131	3.4±0.7	0.9±0.3	8±1	21±3	109±13	111±13	63±7	20±3	13±2
1238.1	possible	yes	yes	no	yes	yes	yes	yes	yes	yes	no
Pb210	no	1000±131	no	no	no	15±5	110±16	122±17	no	no	no
Ac228											
911.1	0.7±0.4	no	0.5±0.2	0.6±0.2	1.7±0.3	1.6±0.5	yes	yes	1.0±0.8	1.2±0.4	no
Pb212											
238.6	0.8±0.3	no	0.5±0.1	0.7±0.1	1.9±0.4	2.0±0.4	no	no	no	1.0±0.3	0.7±0.3
Tl208											
chain	1.0±0.4	no	0.6±0.2	0.5±0.1	1.7±0.3	1.6±0.4	0.8±3	0.8±0.3	0.8±0.2	1.3±0.5	0.7±0.3

	RL0104A	RL0104B	RL0104C	RL0104D	RL0104E	RL0104F	RL0104G	RL0104G	RL0104H	RL0104I	RL0104J
U235[1]											
143.8[2]	no	possible	no	no	no	no	no	no	no	no	no
Th227											
236.0	no	no	no	no	no	no	no	no	no	no	no
256.3	no	no	no	no	no	no	no	no	no	no	no
Ra223											
269.5	possible	no	possible	no	possible	possible	possible	possible	possible	possible	no
154.2	no	no	possible	no	no	no	possible	possible	yes	possible	no
323.9	no	no	no	no	no	no	9±5	6±4	5±3	no	no
Rn219											
271.2	no	no	no	no	possible	possible	possible	possible	possible	possible	no
401.8	no	no	no	no	no	no	no	no	no	no	no
Pb211											
404.8	no	no	no	no	no	no	no	no	possible	no	no
832.0	no	no	no	no	no	no	no	no	4±6	no	no
427.1	no	possible	no	no	no	no	no	no	no	no	no

[1] Peak at 186 keV contains both Ra226 and U235. At elevated radium concentrations, the U235 contribution is not significant. The contract lab numbers give a very high estimate of the error (2 standard deviations). The activities seem reasonable by comparison with radium daughters, but the error has a problem.

[2] If significant Ra223 is present (greater than a few pCi/g), most of the 144 keV peak comes from Ra223 (144.2 keV) not from U235 (143.8 keV).

Richard's Lumber Sample Location # 5 in Survey # 1 @ x = -19 y = 8

	RL0105A 1/6/98	RL0105B 12/31/97	RL0105C 12/31/97	RL0105D 12/31/97	RL0105E 1/6/98	RL0105F 1/6/97
K40	19.5±1.0	11.3±0.9	11.5±0.8	10.7±0.7	8.6±0.9	13.3±1.0
Ra226[1] + U235	3±1	29.9±0.5	6.1±0.7	5.0±0.6	6.3±0.8	yes
Pb214						
351.9	2.3±0.1	23.7±0.6	4.3±0.2	3.7±0.2	5.1±0.8	0.8±0.1
295.2	2.0±0.2	24.3±0.8	4.4±0.2	3.5±0.2	5.1±0.3	0.6±0.1
242.0	2.8±0.2	25±1	4.8±0.3	3.7±0.3	5.4±0.4	yes
785.9	yes	22±4	6±2	yes	yes	no
Bi214						
609.3	2.1±0.1	22.3±6	4.1±0.2	3.6±0.2	4.7±0.3	0.7±0.1
1764.5	2.0±0.7	26±1	5.4±0.4	4.3±0.4	5.9±0.6	1.0±0.3
1120.3	2.4±0.5	23.3±0.9	4.3±0.4	3.6±0.3	4.5±0.5	0.7±0..2
1238.1		25±2	4.0±0.7	3.4±0.6	4±1	
Pb210	yes	yes	yes	yes	yes	no
Ac228						
911.1	0.6±0.2	1.6±0.2	0.8±0.1	0.5±0.1	1.2±0.2	0.9±0.1
Pb212						
238.6	0.6±0.1	1.4±0.1	0.9±0.1	0.6±<0.1	1.5±0.1	0.8±0.1
Tl208	0.21±0.03	0.48±0.05	0.32±0.03	0.18±0.03	0.53±0.06	0.28±0.04
chain	0.6±0.1	1.3±0.1	0.9±0.1	0.5±0.1	1.5±0.2	0.8±0.1
U235						
143.8	no	possible	possible	no	no	no
Th227						
236.0	no	yes	yes	no	no	possible
256.3	no	yes	no	no	no	no
Ra223						
269.5	no	0.7±0.3	yes	possible	possible	possible
154.2	no	0.5±0.3	no	no	no	no
323.9	no	no	no	no	no	no
Rn219						
271.2	possible	0.9±0.2	yes	no	no	no
401.8	no	0.4±0.3	no	no	no	no
Pb211						
404.8	no	possible	no	no	no	no
832.0	no	no	no	no		no
427.1	no	no	no	no	no	no
766.5	no	no	no	no	no	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Richard's Lumber Sample Location # 6 in Survey #1 @ x = 65 y = 7

	RL0106A 1/12/98	RL0106B 1/13/98	RL0106C 12/24/97	RL0106D 12/24/97	RL0106E 12/24/97	RL0106F 12/26/97	RL0106F2 12/26/97	RL0106G 12/26/97
K40	8.5±0.9	10.0±1.0	7.2±2.3	9.2±1.5	7.4±1.4	7.5±1.6	7.6±1.7	10.2±1.6
Ra226[1] + U235	120±4	117±4	49±90	11±20	4±8	6±10	3±6	4±8
Pb214								
351.9	101±2	94±2	37±7	7.3±1.3	2.4±0.5	2.7±0.6	2.8±0.6	2.2±0.4
295.2	102±3	94±3	37±6	7.2±1.4	2.2±0.6	2.6±0.6	2.6±0.6	2.3±0.4
242.0	103±3	97±3	yes	yes	yes	yes	yes	yes
785.9	99±7	92±7	yes	yes	no	no	yes	no
Bi214								
609.3	95±2	87±2	36±5	7.2±1.1	2.5±0.5	2.7±0.6	2.5±0.5	2.2±0.4
1764.5	109±3	99±3	42±6	7.9±1.3	2.8±0.7	3.1±0.8	3.4±0.8	2.8±0.6
1120.3	100±2	93±2	39±5	7.9±1.2	2.9±0.8	2.5±0.7	2.8±0.7	2.0±0.5
1238.1	101±3	95±3	yes	yes	possible	possible	possible	possible
Pb210	yes	yes	31±5	no	no	no	no	no
Ac228								
911.1	0.7±0.2	0.9±0.5	1.4±0.7	0.9±0.3	1.3±0.4	2.0±0.4	1.4±0.5	1.2±0.3
Pb212								
238.6	0.7±0.1	0.9±<0.1	no	0.7±0.5	1.2±0.2	1.7±0.3	1.4±0.3	1.2±0.3
Tl208	0.22±0.04	0.25±0.05						
chain	0.6±0.1	0.7±0.1	1.3±0.3	1.0±0.2	yes	1.4±0.4	1.6±0.4	1.3±0.3
U235 (+ Ra223)								
143.8	yes [2]	yes	no	no	no	no	no	no

Th227								
236.0	8.0±0.4	2.5±0.1	no	no	no	no	no	no
256.3	6.8±0.6	2.3±0.8	no	no	no	no	no	no
Ra223								
269.5	7.2±0.8	yes	no	possible	no	possible	possible	possible
154.2	9±2	yes	no	no	no	no	no	no
323.9	6±3	possible	no	no	no	no	no	no
Rn219								
271.2	7.5±0.5	yes	possible	possible	no	possible	possible	possible
401.8	6.7±0.7	2±2	no	no	no	no	no	no
Pb211								
404.8	yes	yes	no	no	no	no	no	no
832.0	7±3	no	no	no	no	no	no	no
427.1	yes	no	no	no	no	no	no	no

(1) Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.
(2) Peak is mostly (to the counting errors) Ra223

Richard's Lumber Sample Location # 1 in Survey # 2 @ x = 85 y = 13

	RL0201A 1/08/98	RL0201B 1/08/98	RL0201C 1/28/98	RL0201D 1/29/98	RL0201E 1/29/98	RL0201F 1/29/98	RL0201G 12/29/97
K40	16.2±0.8	10.6±0.4	10.1±0.3	9.5±0.6	10.3±0.9	6.9±0.8	6.3±1.3
Ra226[1] + U235	17±1	620±15 614±15[2]	101±3 100±3[3]	42±2	27±2	22±1	15±28
Pb214							
351.9	13.3±0.3	526±12	84±2	34±1	21±1	16.2±0.4	9.2±1.1
295.2	13.3±0.4	519±13	84±2	35±1	22±1	16.9±0.6	9.1±1.1
242.0	14.2±0.6	519±14	86±2	35±1	22±1	17.6±0.8	yes
785.9	15±2	535±11	82±2	40±1	21±4	18±3	yes
Bi214							
609.3	12.3±0.3	486±10	78±2	32±1	20±1	15.3±0.4	8.6±1.0
1764.5	13.6±0.6	552±14	87±2	36±1	22±1	17.6±0.9	10.3±1.4
1120.3	13.0±0.5	522±5	83±1	35±1	21±1	16.3±0.7	9.7±1.3
1238.1	13.4±0.9	524±4	83±1	35±1	22±2	16.3±1.3	yes
Pb210	yes	yes	yes	yes	yes	yes	on
Ac228							
911.1	0.7±0.1	0.9±0.1	0.9±0.1	1.0±0.1	1.1±0.2	0.9±0.2	1.0±0.2
Pb212							
238.6	1.0±0.1	1.1±<0.1	1.0±0.3	1.1±0.1	1.2±0.1	1.2±0.1	0.8±0.2
Tl208	0.31±0.03	0.33±0.019	0.31±0.013	0.32±0.03	0.33±0.04	0.36±0.05	
chain	0.9±0.1	0.9±0.1	0.9±<0.1	0.9±0.1	0.9±0.1	1.0±0.1	1.0±0.2
U235 (+ Ra223)							
143.8	no	0.2 [2]	0.1[3]	possible	possible	possible	no

Th227							
236.0	yes	32±1	2.8±0.1	yes	yes	yes	no
256.3	no	29±1	2.4±0.1	yes	0.9±0.5	no	no
Ra223							
269.5	yes	30±1	2.8±0.1	yes	yes	yes	no
154.2	no	yes	yes	possible	1.0±0.6	yes	no
323.9	no	30±1	2.7±0.5	no	no	no	no
Rn219							
271.2	possible	34±1	3.1±0.1	yes	yes	yes	no
401.8	possible	31±1	2.8±0.2	possible	no	no	no
Pb211							
404.8	no	yes	no	possible	no	possible	no
832.0	no	39±2	3.5±0.6	no	no	no	no
427.1	no	yes	possible	no	no	no	no

(1) Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.
(2) If we assume [Ra223] = 31.5 pCi/g, U235 = 0.2 pCi/g, hence Ra226 = 99% of 186 keV peak.
(3) If we assume [Ra223] = 2.8 pCi/g, U235 = 0.08 pCi/g, hence Ra226 = 99% of 186 keV peak.

Richard's Lumber Sample Location # 2 in Survey # 2 @ x = 111 y = 13

12/04/97

	RL0202A	RL0202A2	RI0202B	RL0202C	RL0202D	RL0202E	RL0202F	RL0202G	RL0202H	RL0202I
K40	7.2±1.4	6.9±1.4	8.0±2.7	10.5±3.8	6.7±2.3	6.9±2.4	5.6±1.1	7.7±1.5	12.1±1.8	14.5±2.1
Ra226[1] + U235	9±17	12±22	195±357	351±665	68±125	58±107	13±24	13±24	3±6	1±3
Pb214 351.9 295.2 242.0 785.9	7±1[2]	7±1[2]	164±30[2]	317±59[2]	54±10[2]	48±9[2]	9.6±1.9[2]	8.0±1.5[2]	2.4±0.5[2]	0.8±0.3[2]
Bi214 609.3 1764.5 1120.3 1238.1	8±1[2]	8±1[2]	181±14[2]	363±25[2]	58±4[2]	49±3[2]	10.3±0.8[2]	8.5±0.7[2]	2.6±0.3[2]	1.0±0.2[2]
Pb210										
Ac228 911.1	0.9±0.3[2]	0.9±0.2[2]			1.0±0.5[2]	1.3±0.5[2]	1.0±0.2[2]	1.0±0.3[2]	0.8±0.2[2]	0.6±0.2[2]
Pb212 238.6	1.0±0.2[2]	0.9±0.2[2]					1.0±0.2[2]	1.4±0.3[2]	0.8±0.2[2]	0.6±0.1[2]
Tl208 chain	1.0±0.2[2]	1.0±0.2[2]	1.4±0.6[2]		1.1±0.3[2]	1.1±0.3[2]	1.0±0.2[2]	1.0±2[2]	1.0±0.2[2]	0.6±0.2[2]
U235 (+ Ra223) 143.8										

Th227	8±2[2]	15±5[2]	3±1[2]
236.0			
256.3			
Ra223			
269.5			
154.2			
323.9			
Rn219	8±4[2]	10±3[2]	3±2[2]
271.2			
401.8			
Pb211			
404.8			
832.0			
427.1			

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.
[2] Results taken from summary data table - no run output sent from contract lab.

Richard's Lumber Sample Location # 3 in Survey # 2 @ x = 136 y = 41

	RL0203A 12/10/97	RL0203B 12/03/97	Rl0203B2 12/02/97	RL0203C 12/02/97	RL0203D 12/02/97	RL0203E 12/03/97	RL0203F 12/03/97	RL0203G 12/03/97	RL0203H 12/03/97
K40	7.3±1.5	9.3±1.5	9.1±1.5	6.8±4.6	8.1±2.1	8.8±1.6	8.4±1.5	5.6±1.0	5.1±1.0
Ra226[1] + U235	4±8	10±18	10±18	911±1669 *1796±3310*	101±186	12±22	5±10	7±12	5±9
Pb214									
351.9	2.1±0.4	7.6±1.3	7.6±1.3	745±81 *1340±161*	90±18	9.8±2.0	2.6±0.4	3.6±0.5	2.2±0.4
295.2	2.0±0.4	6.9±1.3	7.3±1.4	732±80 *1422±144*	84±15	9.2±1.8	2.3±0.4	3.5±0.5	2.1±0.5
242.0	yes	yes	yes	yes	yes	yes	yes	yes	yes
785.9	no	no	yes	yes	yes	yes	no	yes	yes
Bi214									
609.3	2.3±0.5	7.2±1.1	7.5±1.1	716±78	85±15	9±2	2.1±0.3	3.5±0.4	2.1±0.4
1764.5	2.8±0.8	8.0±1.3	9.1±1.4	813±86	98±15	11±2	2.2±0.5	3.7±0.7	2.9±0.6
1120.3	2.2±0.7	7.3±1.1	8.1±1.2	763±80	86±11	10±2	2.2±0.5	3.7±0.6	2.2±0.5
1238.1	possible	yes	yes	yes	yes	yes	possible	possible	possible
Pb210	no	no	no	no *1108±204*	no	no	no	no	no
Ac228									
911.1	0.8±0.3	0.5±0.2	0.6±0.2	no *18±8*	no	0.6±0.2	1.1±0.3	0.9±0.2	0.7±0.2
Pb212									
238.6	1.0±0.2	0.4±0.1	0.4±0.1	1.0±0.7	no	0.4±0.1	1.7±0.2	1.3±0.2	0.9±0.2
Tl208 chain	1.0±0.3	0.6±0.1	0.6±0.1	no	1.0±0.3	0.7±0.2	1.0±0.2	1.2±0.2	1.0±0.2

U235 (+ Ra223)									
143.8	no	possible	no	possible	possible	no	no	no	no
Th227									
236.0	no	no	no	yes *69±15*	yes	no	no	no	no
256.3	no	no	no	no *75±18*	no	no	no	no	no
Ra223									
269.5	possible	possible	possible	yes	yes	no	no	possible	possible
154.2	no	no	no	yes	possible	possible	no	no	no
323.9	no	no	no	45±12 *72±23*	no	no	no	no	no
Rn219									
271.2	possible	possible	possible	yes	yes	no	possible	possible	no
401.8	no	no	no	34±6 *32±10*	no	no	no	no	no
Pb211									
404.8	no	no	no	88±17	no	no	no	no	no
832.0	no	no	no	47±13	yes	no	possible	no	no
427.1	possible	no	no	yes	possible	no	no	no	no

(1) Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Richard's Lumber Sample Location # 4 in Survey # 2 @ x = 143 y = 1

	RL0204A 12/04/97	RL0204B 12/04/97	RL0204C 12/05/97	RL0204D 12/05/97	RL0204D2 12/05/97	RL0204E 12/05/97	RL0204F 12/04/97	RL0204G 12/04/97
K40	10.7±2.8	12.3±3.1	15.8±2.3	11.0±1.6	10.2±1.5	11.9±1.8	14.5±2.3	13.9±2.1
Ra226[1] + U235	89±164	126±232	25±47	2±4	3±5	10±18	11±20	12±23
Pb214	74±14[2]	104±19[2]	15±2[2]				8.6±1.2[2]	11.2±1.5[2]
351.9				1.4±0.3	1.4±0.3	6.1±1.1		
295.2				1.3±0.3	1.3±0.3	6.4±1.2		
242.0				no	yes	yes		
785.9				no	no	yes		
Bi214	80±5[2]	112±8[2]	16±1[2]				8.8±0.8[2]	11.1±0.9[2]
609.3				1.2±0.2	1.2±0.2	5.9±0.9		
1764.5				1.3±0.4	1.0±0.5	7.7±1.3		
1120.3				1.3±0.5	1.4±0.7	6.1±1.0		
1238.1				no	yes	yes		
Pb210				0.9±1.0	possible	no		
Ac228	0.8±0.8[2]	0.9±0.6[2]	0.7±0.4[2]				0.7±0.3[2]	0.9±0.3[2]
911.1				0.3±0.2	0.6±0.2	0.4±0.3		
Pb212			0.5±0.2[2]				0.3±0.2[2]	0.6±0.1[2]
238.6				0.3±0.1	0.3±0.1	0.4±0.1		
Tl208 chain	0.7±0.2[2]		0.7±0.2[2]	0.3±0.2	0.4±0.2	0.7±0.2	0.8±0.2[2]	0.8±0.2[2]
U235 (+ Ra223)								
143.8				no	no	no		

Th227			
236.0	no	no	no
256.3	no	no	no
Ra223			
269.5	no	no	no
154.2	no	no	no
323.9	no	no	2±2
Rn219			
271.2	no	no	no
401.8	no	no	no
Pb211			
404.8	no	no	no
832.0	no	no	no
427.1	no	no	no

(1) Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.
(2) Data obtained from contract lab summaries - complete sample analysis sheets not sent.

Richard's Lumber Sample Location # 5 in Survey # 2 @ SE corner Depot Bldg

	RL0205A 12/10/97
K40	9.9±1.7
Ra226[1] + U235	15±27
Pb214	
351.9	8.9±1.0
295.2	8.4±1.1
242.0	yes
785.9	possible
Bi214	
609.3	8.2±1.0
1764.5	8.8±1.3
1120.3	8.2±1.2
1238.1	yes
Pb210	no
Ac228	
911.1	possible
Pb212	
238.6	no
Tl208	
chain	0.5
U235 (+ Ra223)	
143.8	no
Th227	
236.0	no
256.3	no
Ra223	
269.5	possible
154.2	no
323.9	no
Rn219	
271.2	possible
401.8	no
Pb211	
404.8	no
832.0	no
427.1	no

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Richard's Lumber Sample Location # 1 in Survey # 3 @ x = 212 y = 33

samples counted on 12/04/97

	RL0301A	RL0301B	RL0301C
K40	7.1±1.2	18.9±2.5	16.5±2.2
Ra226 + U235[1]	8±14	1±3	1±3
Pb214	4.3±0.6[2]	0.9±0.4[2]	1.0±0.3[2]
351.9			
295.2			
242.0			
785.9			
Bi214	3.4±0.3[2]	1.1±0.2[2]	1.1±0.2[2]
609.3			
1764.5			
1120.3			
1238.1			
Pb210			
Ac228	0.7±0.2[2]	1.0±0.2[2]	1.0±0.2[2]
911.1			
Pb212	0.7±0.1[2]	0.8±0.2[2]	0.9±0.2[2]
238.6			
Tl208			
chain	0.6±0.1[2]	0.8±0.2[2]	0.9±0.2[2]
U235			
143.8			
Th227			
236.0			
256.3			
Ra223			
269.5			
154.2			
323.9			
Rn219			
271.2			
401.8			
Pb211			
404.8			
832.0			
427.1			

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

[2] Data taken from contract lab summary only.

Richard's Lumber Sample Location # 2 in Survey # 3 @ x = 221 y = 62

	RL0302A 12/5/97	RL0302B 12/05/97	RL0302C 12/05/97	RL0302D 12/05/97	RL0302E 12/05/97	RL0302F 12/05/97	RL0302G 12/05/97	RL0302H 12/05/97
K40	14.6±2.0	8.3±1.3	12.0±1.9	8.7±1.3	11.0±1.7	8.4±1.3	13.3±2.0	12.8±1.8
Ra226[(1)] + U235	possible	3±5	3±7	4±8	3±7	4±7	4±7	7±13
Pb214								
351.9	0.5±0.2	1.9±0.4	2.5±0.6	2.8±0.5	2.1±0.4	2.2±0.4	2.8±0.4	3.2±0.4
295.2	0.3±0.3	1.8±0.4	2.2±0.5	2.6±0.5	2.0±0.4	2.7±0.5	2.7±0.5	3.1±0.5
242.0	yes	yes	yes	yes	yes	yes	yes	yes
785.9	no	possible	possible	no	possible	yes	no	no
Bi214								
609.3	0.8±0.2	1.8±0.4	2.4±0.4	2.6±0.4	1.9±0.3	2.3±0.3	2.9±0.5	2.9±0.4
1764.5	1.0±0.4	2.2±0.4	2.7±0.7	3.2±0.6	2.5±0.6	2.9±0.6	2.6±0.6	3.8±0.8
1120.3	1.0±0.6	2.0±0.4	2.8±0.8	2.7±0.7	2.1±0.6	2.4±0.6	2.8±0.8	3.2±0.8
1238.1	no	yes	yes	no	possible	possible	possible	no
Pb210	no	no	4±2	no	2±1	no	no	no
Ac228								
911.1	1.4±0.3	0.8±0.2	1.1±0.3	0.8±0.2	0.6±0.2	0.7±0.2	0.8±0.2	no
Pb212								
238.6	1.3±0.2	0.8±0.2	no	0.7±0.2	0.8±0.2	0.6±0.1	0.9±0.2	1.1±0.2
Tl208								
chain	1.2±0.3	0.8±0.2	0.8±0.4	0.6±0.2	0.8±0.2	0.6±0.2	0.7±0.2	0.9±0.3
U235 (+ Ra223)								
143.8	no	no	no	no	no	no	no	no

Th227								
236.0	no	no	no	no	no	no	no	no
256.3	no	no	no	no	no	no	no	no
Ra223								
269.5	no	no	no	possible	no	possible	no	possible
154.2	no	no	no	no	no	no	no	no
323.9	no	no	no	no	no	no	no	no
Rn219								
271.2	possible	no	possible	possible	no	possible	no	possible
401.8	no	no	no	no	no	no	no	no
Pb211								
404.8	no	no	no	no	no	no	no	no
832.0	no	no	no	no	no	no	no	no
427.1	no	no	no	no	no	no	no	no

(1) Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.

Richard's Lumber Sample Location # 1 in Survey # 4 @ x = 70 y = 20
Mt. Kisco grid

	RL0401A 12/5/97	RL0401B 12/02/97	RL0401C 12/02/97
K40	10.9±1.6	8.4±2.1	9.7±2.1
Ra226[1] + U235	28±51	55±102	62±114
Pb214		43±8[2]	50±9[2]
351.9	14±2		
295.2	14±2		
242.0	yes		
785.9	yes		
Bi214		48±4[2]	54±4[2]
609.3	13±2		
1764.5	14±2		
1120.3	14±2		
1238.1	possible		
Pb210	no		
Ac228		1.1±0.4[2]	1.2±0.4[2]
911.1	0.5±0.4		
Pb212		0.7±0.3[2]	0.6±0.2[2]
238.6	no		
Tl208 chain	0.4±0.3	1.2±0.3[2]	1.2±0.3[2]
U235 (+ Ra223)			
143.8	no		
Th227			
236.0	no		
256.3	no		
Ra223			
269.5	possible		
154.2	no		
323.9	no		
Rn219			
271.2	possible		
401.8	no		
Pb211			
404.8	no		
832.0	no		
427.1	no		

[1] Uses the branching ratio for Ra226 even though some U235 is likely to be present. Will overestimate Ra226 activity.
[2] Data taken from contract lab summary data sheets. Sheets do not show individual gammas used to calculate average activity.

Appendix C
Sample Collection Field Log

Information recorded in the field log book is reproduced here.

Soil increments are indicated by the letters A, B, C, ... , starting with A at the surface.

The depth of the samples are given in inches (e.g., 0-4 means 0 to 4 inches from the surface)

MK0101 Immediately south of debris pile in north west corner of town property

A	0-4	
B	4-8	color change 5-6" black to brown, stones @ 5" deep - 1-4" in size
C	8-12	stones, broke up with bar
D	12-18	stones + rocks + sand + brick pieces at bottom, broke up with bar

MK0102 soil on north side of debris pile

A	0-5	loose dark soil under pile of debris
B	5-12	brown sand 2-5" stones
C	12-18	same as above
D	18-22	brown sand, hit concrete slab

MK0103 south east of debris pile

A	0-6	mixed pea size gravel to 5", brown sand, soil
B	6-12	soil changed from brown to lower density black at about 10"
C	12-18	black soil with numerous 4-8" rocks
D	18-24	black soil with few rocks
E	24-30	same as above

MK0104 grassy covered soil south east of debris pile

A	0-6	dark brown soil, some rocks
B	6-12	dark brown soil, more rocks
C	12-18	brown soil, more rocks
D	18-24	brown soil, becoming significantly lighter at 24", some rocks
E	24-30	black soil

MK0105 about 30 feet south east of debris pile, grass covered soil

A	0-6	dark brown soil with rocks
B	6-12	black soil with some rocks
C	12-18	light black soil with some rocks
D	18-24	
E	24-30	

MK0106 south east of debris pile

A	0-5	soil + road base fill, soil change at bottom
B	5-12	dark soil
C	12-15	dark soil, large rock stopped further digging by hand

MK0107

A	0-6	dark brown soil with small stones
B	6-12	brown black soil with stones
C	12-18	dark soil
D	18-20	stones cause refusal

MK0108 middle of site - near east fence, DEC meter

A 0-6	brown/black soil with small stones
B 6-12	black soil with stones
C 12-18	brown sandy soil with stones
D 18-24	same as above

MK0109 DEC meter

A 0-6	black soil + 1-3" rocks
B 6-12	black soil changing to brown
C 12-18	brown soil with brick and glass fragments
D 18-24	black soil changing to grayish brown sand
E 24-30	gray sandy soil

MK0110 next to east fence, about 22' from opening in fence

A 0-6	crushed stone and brown soil, at bottom changes to black soil
B 6-12	black soil and large stones
C 12-18	redish brown sandy clay and some rocks
D 18-24	redish brown sandy clay and some large rocks
E 24-30	redish brown sandy clay and silt

MK0111

A 0-6	brown fill changing to back at bottom
B 6-12	black fill
C 12-18	break up rock layer + gray soil
D 18-24	same as above, changing to sand at bottom
E 24-30	gray / brown sand

MK0112 DEC meter

A 0-6	gray gravel with 1-6" stones
B 6-12	gray gravel with 1-5" stones
C 12-18	gray gravel with stones
D 18-24	gray gravel fill changing to black gravel

MK0113 DOH meter

A 0-6	brown soil with rocks top
B 6-12	black soil
C 12-18	coal ash black + specks of coal that shine + building material + brick chips
D 18-24	black soil + rock
E 24-30	black to brown sand/gravel
F 30-36	brown sand

MK0114 DOH meter

A 0-6	brown/black soil with stones
B 6-12	dark soil with stones
C 12-18	gravel and stones, #3 road bed material
D 18-22	gravel stones, road bed

MK0115 DOH meter

A 0-6	brown sand fill
B 6-12	fill brown with stones
C 12-18	fill brown
D 18-24	same as above
E 24-30	brown soil fill, rocks caused refusal

MK0116 DEC meter

A 0-6	road bed fill, at bottom find plastic and tree parts
B 6-12	dark soil, surface fill not present
C 12-18	brown soil, sandy, lots of rocks
D 18-24	brown soil to 21", then darker soil, numerous rocks
E 24-30	black soil, fewer rocks

MK0117

A 0-6	dark brown with 1-2.5" stones
B 6-12	black soil with stones
C 12-18	black soil with stones, pea to 1"
D 18-24	black soil changing to brown with stones and bricks
E 24-30	black dirt mostly, black ash? layer at bottom

MK0118

A 0-6	brown gravel with stones
B 6-12	brown sand
C 12-18	brown soil/sand, rock on bottom of hole
D 18-24	sand, gravel, black top pieces
E 24-30	black/brown soils, finish sampling with hand auger
F 30-33	brown soil, collect with hand auger

MK0119

A 0-4	brown gravel, stones to 1.5"
B 4-12	brown sandy soil with bits of brick and stones
C 12-17	sandy brown bits of coal, small rocks
D 17-24	soil - dark gray to black
E 24-25	black/gray concrete + brick material, refusal at bottom

MK0201 easement between fence and tracks

A 0-6	road bed gravel with stones, gray-black
B 6-12	black soil with rock
C 12-18	black soil with stones 3-4"
D 18-24	black soil with stones
E 24-30	black gravel - gray clay
F 30-42	coal ash

MK0203 drive area east of fence

A 0-3	compacted driveway fill (item 4)
B 3-6	black soil with numerous stones and crushed rock
C 6-12	black soil with several large rocks, wire was found
D 12-18	black soil with several large rocks, 1" pipe running through side of hole
E 18-24	black soil with rocks and coal, petroleum smell
F 24-30	black soil and wood, refusal at top of what seems to be old orangeburg pipe

MK0301 east side of Richard's Lumber near utility pole

A 0-6	soil gravel raised about 6" from ground level
B 6-12	brown sand
C 12-20	gray-tan sand
D 20-26	black-brown-black
E 26-36	black coal ash with soil

MK0302 about 18" from curb on south side of Railroad Ave. just west of gate to town property

A 0-4	brown/black soil with a few small rocks
B 4-12	brown sand
C 12-18	brown sand, hole was moved 6" due to rock
D 18-24	brown sand
E 24-30	brown sand very loose consistency
F 30-36	brown sand, extremely loose, encountered another large rock, so angled hole to south-east, same gray clay and black organic matter
G 36-42	damp silt-sand with some pockets of clay and ashes
H 42-48	clay (use auger to obtain sample from multiple auger holes)

MK0303 Richard's Lumber - south near picnic table and sidewalk

A 0-6	sand
B 6-12	sand and stones, brown
C 12-18	brown to gray
D 18-24	gray with stones
E 24-30	gray brown
F 30-36	brown - dark brown
G 36-44	dark brown to brown sand
H 44-53	sandy - light brown

MK0304 south side of Railroad Avenue, about 2 feet from curve

A 0-4	brown sandy soil
B 4-12	brown sandy soil with debris (brick, glass, clay)
C 12-18	same as above
D 18-24	brown soil with rocks and debris
E 24-30	brown sandy soil with rocks and debris (hit curb stone)
F 30-36	brown sandy soil with rocks and clay
G 36-42	brown sandy and black clay
H 42-46	black clay with stones, sandy soil, lots of larger rocks, unable to sample deeper

MK0305 near dumpster

A 0-6	black soil with stones (contact 300 uRem/hr)
B 6-12	black soil with rocks (contact 3500 uRem/hr)
C 12-18	brown sand stones
D 18-24	brown sand - black soil / material
E 24-30	black coal ash

MK0401 outside fence on Kisco Avenue, about 2 feet out from post #6, use DEC meter

A 0-6	sand fill stones
B 6-12	same as above
C 12-18	same as above
D 18-24	brown sand, fill rocks, refusal on curb obstruction

RL0101 rear of Richard's Lumber

A 0-6	gravel and stone
B 6-12	gravel and stone 1-2 ½ inch
C 12-18	road bed and rail bed stone 3"
D 18-24	black coal ash, asphalt
E 24-30	black coal ash

RL0102

A 0-6	black soil with stones
B 6-12	brown soil with stones
C 12-18	black soil, building material
D 18-24	same as above
E 24-30	black soil with road bed stone
F 30-40	
G 40-48	railroad timbers, black soil, hit ground water
H a,b	two cores (48 to < 72 inches)
GW1,GW2	two ground water samples collected at 48 inches

RL0103

A 0-6	gray gravel fill to black fill at bottom
B 6-12	black fill to black fill containing brick at bottom
C 12-18	dark fill with brick parts
D 18-24	brick with some soil fill
E 24-30	dark soil fill with some brick
F 30-36	clay / sand
G 36-39	clay, refuse in wood at bottom

RL0104 about 6 feet from pavement on east side and about 6 feet south of utility pole

A 0-2	gravel/sand fill material
B 2-6	black soil and rocks with nails, wire etc. mixed in. Very compacted.
C 6-12	brown soil, sand, stones
D 12-18	brown sandy soil, few stones
E 18-24	crushed cinder block and soil, pieces of brick and cinderblock
F 24-30	appears to be cinder block and mostly coal ash
G 30-36	black damp soil appear to be mixed with ash
H 36-42	dark black soil and ash, strong petroleum smell
I 42-48	same as above
J 28-54	same as above, collect with auger

RL0105 about 6 feet from pavement, about 20 feet south of utility pole

A 0-6	compacted gravel / sand fill
B 6-9	three inch layer of dark black soil / fill
C 9-12	brown sandy soil with 2-3" stones near bottom
D 12-18	brown sandy soil with 2-3" stones, (old rail bed)
E 18-24	brown sandy soil with 2-3" stones to ash, glass and wood
F 24-30	started as black soil (ash), ended as gray brown silty sand with some clay

RL0106

A 0-6	top half is gray gravel fill, bottom half is black fill
B 6-12	black fill
C 12-18	same as above
D 18-24	brown sandy fill, some brick and rock
E 24-30	black / brown fill, some rock
F 30-36	black fill, petroleum smell
G 36-38	black fill, refuse on wood, neither pry bar or auger of much use.

RL0201

A 0-4	gray gravel with stones
B 4-10	dark granular soil 800 urem/hr (250-300 urem/hr at surface of sample)
C 10-18	black with stones
D 18-24	black soil
E 24-30	same as above
F 30-36	black soil, petroleum smell
G 36-39	black soil

RL0202 about 30 feet south of old train depot

A 0-3	road surface fill, numerous rocks
B 3-6	black soil some rock, wood, trash
C 6-12	black soil, some rocks and brick parts
D 12-18	black soil, large rock and brick fragments
E 18-24	black soil, large rocks and brick fragments, possibly ash
F 24-30	black soil, ash and rocks
G 30-36	same as above
H 36-42	black soil and ash to gray sand at bottom
I 42-48	gray sand, strong petroleum smell

RL0203

A 0-5	road gravel
B 5-12	black soil with stones
C 12-18	same as above
D 18-24	same as above
E 24-30	same as above
F 30-36	
G 36-42	black soil
H 42-44	black soil, refusal on rocks at bottom of hole

RL0204

A 0-6	loose black soils and rock
B 6-12	loose black soil and rock, changes to brown sand at about 11 inches
C 12-18	loose brown sand, large rocks
D 18-24	same as above
E 24-30	same as above
F 30-36	loose brown sand and rocks, changing to darker color soil
F 36-39	dark black soil and rock, refusal on building footing

RL0205 about 30 feet north of south east corner of old railroad building

A 0-4	sandy

RL0301 about 5 feet north of loading dock on west side of building

A 0-6	brown soil with some rock
B 6-12	same as above
C 12-15	same as above, refusal on rock at bottom

RL0302 north of northernmost door on west side of old depot, about 5 feet from pavement

A 0-3	compacted driveway fill (item 4)
B 3-6	black soil, rocks, glass, brick, ash, etc
C 6-12	same as above
D 12-18	same as above
E 18-24	black soil, rock, brick, glass, changing to brown sand at about 22 inches.
F 24-30	mix of black soil and sand with rocks, possibly old rail bed
G 30-36	mixed gray soil and brown sand, numerous stones, rail bed
H 36-38	rail bet bottom of hole keeps collapsing

RL0401

A 0-3	sandy gray material
B 3-6	gray material
C 6-12	gray material, refusal on concrete slab

Appendix D

DEC Gamma Counting Facility
Calibration Data

The calibration standard used by DEC is a mixed radionuclide standard, prepared by Amershand (March 1996) to resemble our usual counting geometry and with a density similar to many of our dried soil samples. This standard was run every day when samples were analyzed. The energy calibration and efficiency determinations used to obtain measured gamma energies and the associated activities are shown in Figure D1.

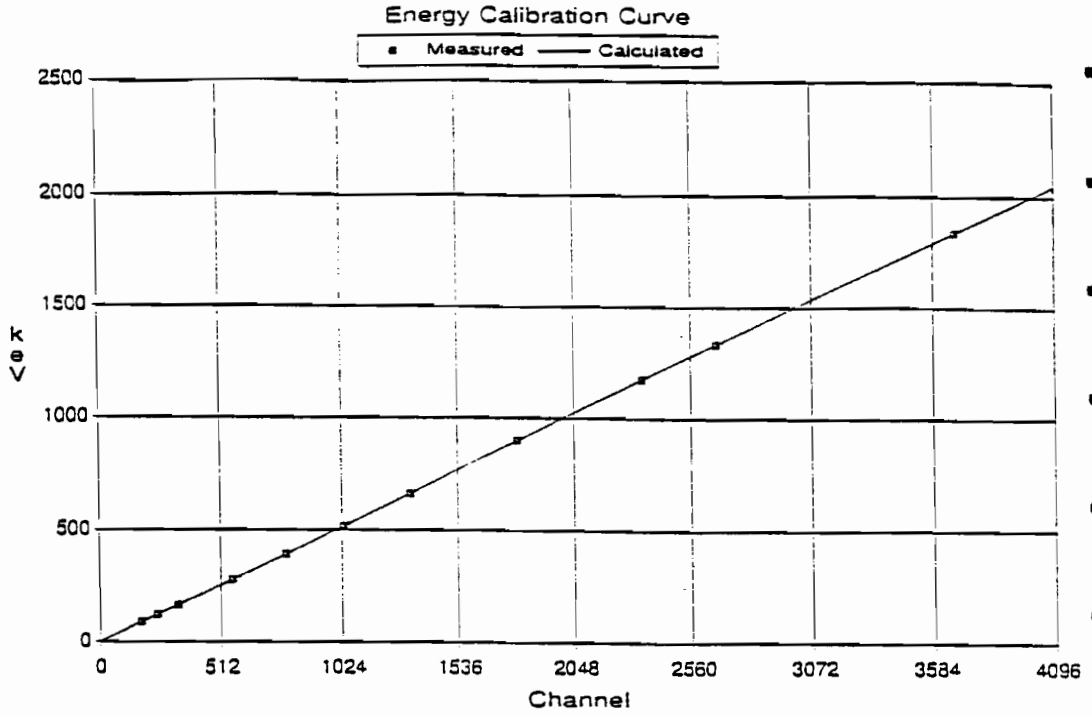
The calibration standard is nearing the end of its useful life, because the shortest lived radionuclides are becoming more difficult to observe. Fifteen-minute count times were used for these calibration runs. They were adequate to locate peaks and to determine if the system was functioning properly.

The calibration data are presented in pairs of numbers (energy in keV followed by activity in pCi/g) in Table D1 for the nine gammas in the standard. Co60 and Y88 each have two gammas which are used for calibration. Shown at the top of each page are the expected values of energy (Nuclide Identification Catalog for Gamma Emitters and Alpha Emitters. ORAU 88/K-3) and the activities as supplied by the manufacturer.

- Of the 180 measurements of gamma energies, 92% were within 0.1 keV, 7% at 0.2 keV, and one measurement at 0.3 keV. This level of confidence is sufficient to allow us to associate radionuclides with measured gamma energies if they agree within 0.2 keV.
- The calibration standard as prepared has an uncertainty of 5% in reported activities. Data set average activities are within about 5% of the respective reported values. .

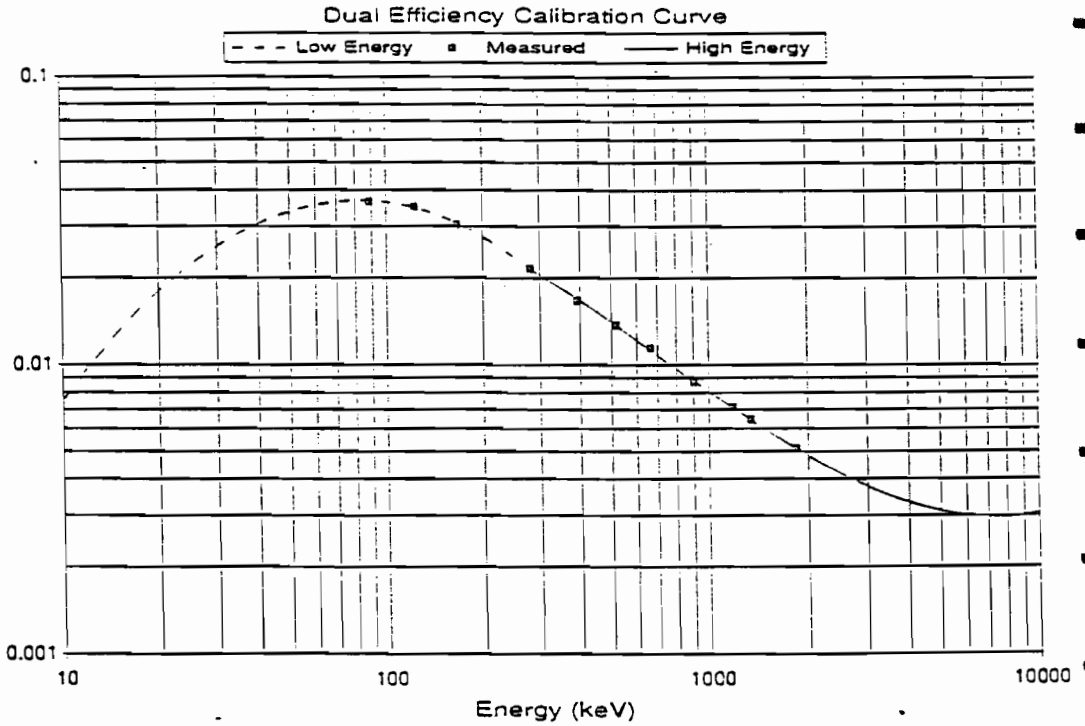
However, the activities of the most precisely measured radionuclides (they are the ones with the longest half-lives) suggest a bias on the high side of about 4%. This same bias was noted in the series of measurements done before this set of samples and has remained constant throughout the time period when these samples were analyzed. Correcting the data for this bias does not significantly change the results, but it exists and we knew about it, so we applied a correction factor of 0.96 to all measured soil sample activities.

The measured activities for each of the calibration radionuclides are shown in Figure D2 . The legend on the figure lists the radionuclides and gives the gamma energy used for calibration. No time dependence or drift in counting efficiency is noted in this data set.



Datasource: DET01
Energy = -5.939e-01 keV +5.004e-01*Ch -5.377e-08*Ch^2
FWHM = 5.412e-01 keV +3.657e-02*E^1/2
Lo Tail = 6.798e-01 keV +6.328e-04*E

FIGURE D1



Datasource: DET01
ln(Eff) = -1.028e+01 +3.165e+00*ln(E) -3.590e-01*ln(E)^2
ln(Eff) = -1.493e+01 +6.286e+00*ln(E) -1.069e-00*ln(E)^2 +5.363e-02*ln(E)^3

	Co57		Co60		Y88		Cd109		Sn113		Cs137		Ce109	
	Energy	Activity	Energy	Activity	Energy	Activity	Energy	Activity	Energy	Activity	Energy	Activity	Energy	Activity
expect	122.1	49.5	1173.2	257.3	898.0	424.4	88.0	1297	391.7	211.4	661.6	221.6	165.9	60.0
expect			1332.5	257.3	1836.0	424.4								
1997														
11/14	122.1	54.2	1173.1	268.5	897.9	413.6	88.0	1314	391.7	230.8	661.6	234.0	165.9	66.0
			1332.3	267.5	1835.9	452.4								
11/25	122.1	52.3	1173.2	267.6	898.1	405.9	88.0	1327	391.8	196.5	661.7	232.7	165.9	54.7
			1332.4	269.4	1836.1	444.4								
12/04	122.0	52.4	1173.0	267.0	897.8	458.7	88.0	1306	391.6	209.2	661.6	231.9	165.9	56.3
			1332.3	273.6	1835.8	432.2								
12/08	122.0	49.5	1173.1	269.6	897.9	416.6	88.0	1311	391.7	199.3	661.6	234.7	165.8	59.6
			1332.3	267.9	1836.0	456.8								
12/10	122.0	50.3	1173.1	268.9	898.0	415.4	88.0	1306	391.6	206.1	661.6	232.7	165.8	64.1
			1332.4	271.8	1836.0	461.3								
12/15	122.1	50.7	1173.1	266.8	898.0	425.4	88.0	1301	391.8	202.2	661.6	233.2	165.8	54.5
			1332.4	272.5	1836.0	461.4								
12/16	122.1	51.9	1173.1	266.7	898.0	448.4	88.0	1309	391.7	207.6	661.6	234.7	165.8	54.3
			1332.4	271.3	1836.1	488.6								
12/19	122.0	51.8	1173.1	269.2	898.0	431.2	88.0	1301	391.6	225.3	661.6	232.4	165.8	64.2
			1332.4	270.1	1835.9	453.8								
12/22	122.0	51.4	1173.0	266.2	898.0	403.4	88.0	1323	391.7	207.7	661.6	232.1	165.8	59.5
			1332.3	270.3	1835.8	428.8								
12/30	122.1	50.5	1173.1	267.3	898.0	441.8	88.0	1298	391.7	201.1	661.6	233.1	165.9	58.9
			1332.4	272.3	1836.0	428.9								
1998														
01/06	122.0	51.1	1173.1	269.4	898.0	460.4	88.0	1334	391.7	219.1	661.6	233.6	165.9	57.2
			1332.4	270.9	1835.9	409.4								
01/09	122.0	53.9	1173.3	269.2	898.1	435.0	88.0	1303	391.7	235.8	661.7	234.0	165.8	63.7
			1332.5	269.9	1836.2	516.4								
01/12	122.1	53.6	1173.4	269.3	898.3	497.0	88.0	1300	391.8	223.9	661.8	233.7	165.9	61.4
			1332.7	267.1	1836.4	393.3								

	Co57		Co60		Y88		Cd109		Sn113		Cs137		Ce109	
	Energy	Activity	Energy	Activity	Energy	Activity	Energy	Activity	Energy	Activity	Energy	Activity	Energy	Activity
expect	122.1	49.5	1173.2	257.3	898.0	424.4	88.0	1297	391.7	211.4	661.6	221.6	165.9	60.0
expect			1332.5	257.3	1836.0	424.4								
01/14	122.1	51.0	1173.3	267.4	898.0	482.2	88.0	1300	391.8	168.1	661.7	232.2	165.8	60.1
			1332.6	267.2	1836.3	479.7								
01/16	122.0	51.9	1173.1	263.7	898.0	410.8	88.0	1307	391.7	226.8	661.6	232.4	165.8	57.7
			1332.3	270.4	1835.9	456.6								
01/20	122.1	53.2	1173.3	266.7	898.1	405.8	88.1	1306	391.8	202.5	661.7	231.3	165.9	58.0
			1332.5	268.9	1836.1	426.7								
01/22	122.0	50.9	1173.1	268.1	898.0	403.2	87.9	1311	391.7	228.7	661.6	234.1	165.7	66.0
			1332.4	268.8	1836.1	442.0								
01/23	122.0	50.3	1173.1	266.1	898.0	449.5	88.0	1298	391.7	197.4	661.6	234.3	165.8	69.6
			1332.4	269.8	1836.0	437.4								
01/28	122.0	53.2	1173.1	268.3	897.9	415.3	88.0	1294	391.6	196.7	661.6	232.7	165.8	59.6
			1332.4	269.4	1835.9	437.9								
01/29	122.0	51.1	1173.1	265.6	897.9	421.8	88.0	1307	391.6	223.8	661.6	231.6	165.9	67.7
			1332.4	269.8	1835.9	421.1								

Averages measured values of calibration standard compared with (expected values)

	activity		energy
Co57	51.8 ± 1.3 (49.5) pCi.g	at	122.04 ± 0.04 (122.1) keV
Co60	267.6 ± 1.5 (257.3) pCi.g	at	1173.1 ± 0.1 (1173.2) keV
	269.9 ± 1.8 (257.3) pCi.g	at	1332.4 ± 0.1 (1332.5) keV
Y88	432 ± 27 (424.4) pCi.g	at	898.0 ±0.1 (898.0) keV
	446 ± 28 (424.4) pCi.g	at	1836.0 ± 0.2 (1836.0) keV
Cd109	1308 ± 10 (1297) pCi.g	at	88.00 ± 0.03 (88.0) keV
Sn113	210 ± 4 (211.4) pCi.g	at	391.7 ± 0.1 (391.7) keV
Cs137	233.1 ± 1.0 (221.6) pCi.g	at	661.63 ± 0.06 (661.6) keV
Ce109	61 ± 5 (60.0) pCi.g	at	165.84 ± 0.06 (165.9) keV

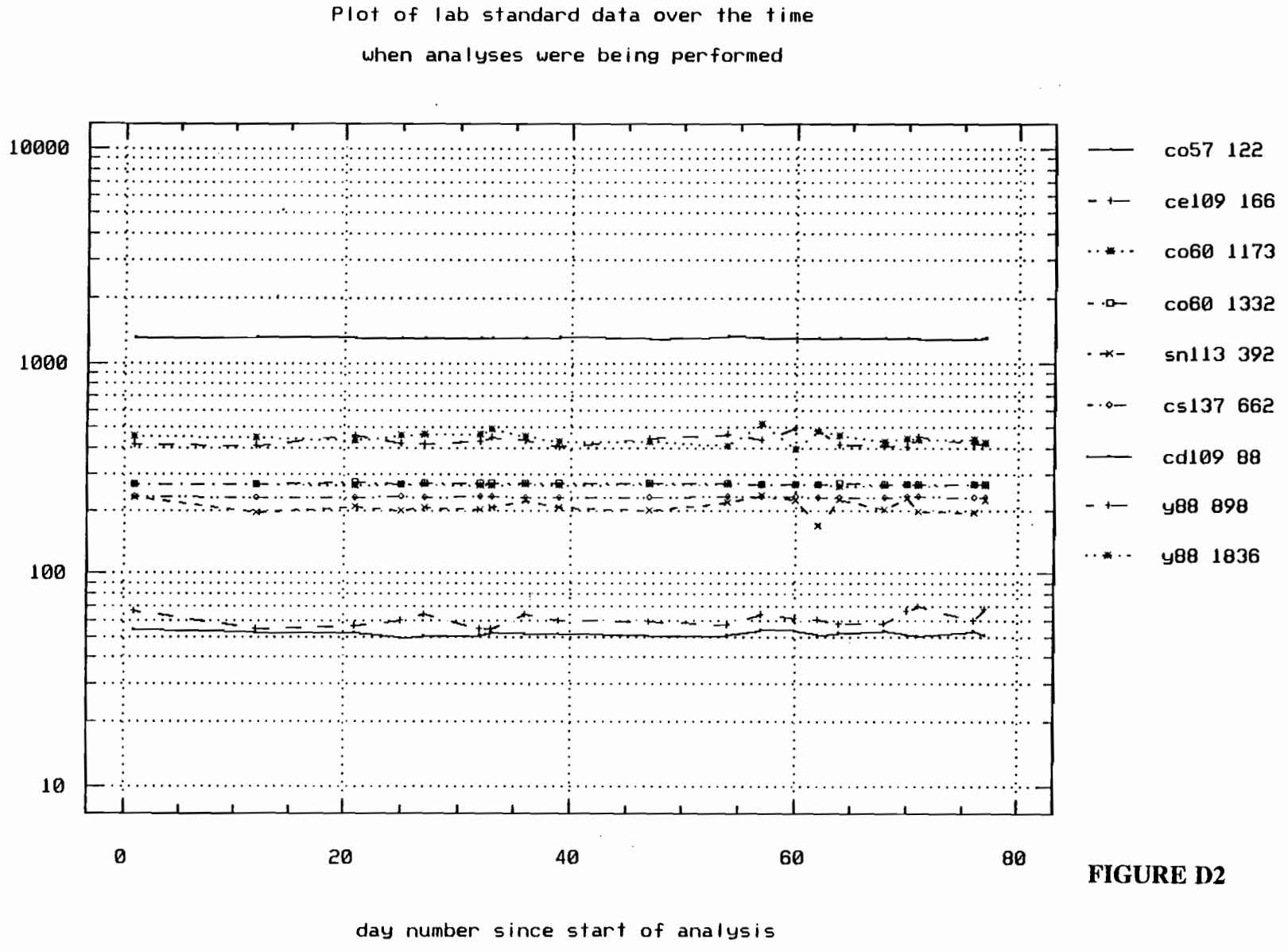

Plot of lab standard data over the time
when analyses were being performed
10000
1000
100
10
activity (pCi/g)
0
20
40
60
80
day number since start of analysis
co57 122
ce109 166
co60 1173
co60 1332
sn113 392
cs137 662
cd109 88
y88 898
y88 1836

FIGURE D2

Appendix E

DEC Sample Analysis Procedures

Samples were dried at 67-70 °C for a minimum of three days, but more commonly for about one week. After drying, the tubs were covered, weighed, and sealed with electrical tape. At least two weeks elapsed before samples were counted. This delay insured that if equilibrium between Ra226 and its daughters did not persist because of loss of Rn222 during the drying process, the equilibrium would be reestablished before the sample was counted.

The counting system used by DEC is a thin window 3" high purity GeLi detector with supporting electronics and software (Genie-PC) manufactured by Canberra. Most samples were counted for one hour; some were counted overnight resulting in counting times up to 20 hours. The Canberra software searches the resulting gamma spectra for peaks, identifies the energies of the detected gammas, and associates radionclides with those gammas that are found in its library. System background (counts that are present in the absence of a sample) is subtracted from the gamma spectrum and radionuclide activities are reported for each gamma that the software identifies. We manually perform this step if the software does not associate a correct radionuclide with an observed gamma.

Corrections to gamma spectroscopy data

Self absorption

The calibration standard used at the lab has a density of 1.0 g/cm^3. Most samples have densities a little over 1, but range from about 0.9 to about 1.6 g/cm^3. Densities different from the standard will have an effect on absorption of gammas, particularly the low energy ones. All gamma counts obtained for our samples are scaled to this standard to determine the activities. It is likely that the samples will not have the same density as the standard and they will not have the same composition as the standard. Hence, a correction to the gamma counts must be made to account for differences in self absorption between the samples and the standard.

Definitions:
Given a material of unspecified composition with:
density ρ (g/cm^3)
mass absorption coefficient μ (cm^2/g)
thickness of material between source and detector x (cm)
total activity in sample A (pCi)

the transmission equation is:

$$c = c_0 \cdot \exp(-\mu\rho x)$$

where c_0 = counts from nuclides in the soil sample at location x if soil sample between detector and location x did not absorb/scatter any of the gammas directed toward detector (this is equivalent to the per unit volume or per unit mass source which can be expressed as differentials),
and c = counts that are detected from the per unit volume/mass source of radionuclides at location x in the soil sample.

Consider a 1-D model of a homogeneous soil sample + detector. Efficiency of the detection system is taken to be 1 since we are considering only those gammas which are headed toward the detector - in one case some gammas will be absorbed/scattered by the soil, in the other case nothing is in the way so all gammas emitted in the direction of the detector will be counted.

Define C_0 = counts from entire sample if self absorption did not exist. This is just integration of c_0 over the whole sample.
Define C = counts actually measured from the soil sample.

From an incremental element of length dx, the observed count rate will be:

$$dC = C_0 \cdot (dx / L) \cdot \exp(-\mu\rho x)$$

where dx = increment of 1-D soil sample
and dx/L = fraction of C_0 contributing to counts from increment dx

Integrating from 0 to L:

$$C = \int (C_0 / L) \cdot \exp(-\mu\rho x) \cdot dx$$

$$C = (C_0 / L) \cdot (-1/\mu\rho) \cdot \exp(-\mu\rho x)$$

evaluated at x=0 and x=L.

$$C = (C_0 / L\mu\rho) \cdot [1 - \exp(-\mu\rho L)]$$

Therefore, to get C_0 from the measurement of C, multiply C by the self absorption correction factor F, where:

$$F = L\mu\rho / [1 - \exp(-\mu\rho L)].$$

note: in counting we will be needing the self absorption from both the sample and from the calibration standard, since it is the ratio in self absorption that matters, not the actual value.

This work based on the reference:
M.E. Ketto, Determination of Photon Self-absorption Corrections for Soil Samples, Appl. Radiat. Isot., Vol. 42, No. 9, pp 835-839, 1991; Int, J. Radiat. Appl. Instrum. Part A.

We can simplify the expression for F (also change the notation slightly)

Let h = height of sample/standard in 500 ml tub (cm)
ρ = density of sample (g/cm^3)
μ = mass attenuation coefficient (cm^2/g)
$z = \mu\rho h$

$$F = z / (1 - \exp(-z)$$

expanding the exponential

$$F = z / (1 - \{1 - z + z^2/2! - z^3/3! + x^4/4 - \cdots\})$$
$$\cong 1 / (1 - z/2 + z^2/6 - z^3/24 + z^4/120)$$ drop higher order terms
$$\cong 1 + z/2 + x^2/12 - z^4/720$$ carry out the division

we can drop the last term because in most cases is $z < 1$ (even at the low energy end of the calibrated spectrum and for very dense samples $z <$ about 2).

Therefore, use the following expression to calculate self absorption in either a sample or a standard.

$$F \cong 1 + \frac{\mu\rho h}{2} + \frac{(\rho\mu h)^2}{12}$$

Note: μ is energy dependent so it is necessary to determine F for samples and for the standard for each gamma used to determine sample activity. Shown in the following Table are mass attenuation coefficients for some materials of interest. We do not have μ for soils, however, over the energy range of interest (> about 150 keV and < about 1800 keV) the values for most materials (e.g. concrete and SiO_2) are very similar. For ease in computation we fit a simple expression to the concrete μ values to obtain the values in the empirical column. The empirical result to be used for soils is:

$$\mu = 1.2634 / (\text{energy}^{0.4341})$$

where energy units are keV.

Now we have all the information needed to calculate the sample self absorption F_{sample}. Note: this calculation applies to soils only, if the sample was water, different mass attenuation coefficients should be used (see for example: μ for H_2O - page150 in The Heath Physics and Radiological Health Handbook, 1002). The choice of function was rather arbitrary, but we wanted to keep it simple. The fit selected agreed with the published values for concrete by better than 4%. Since we do not have a μ for any specific sample anyway, a few percent uncertainty is of the same order as using a μ from the wrong material. A few percent uncertainty in a correction which is almost always less than about 20% of the measured value will not be the largest contribution to measurement uncertainty.

Table 1
Mass Attenuation Coefficients μ (cm^2/g)
ref (μ values from Health Physics and Radiological Health Handbook - 1992 ed.)

Energy	Concrete	empirical	SiO_2	Bakelite	
(keV)	μ	μ	μ	μ	F_{std}
80	0.195	0.189	0.178	0.163	1.55
100	0.167	0.171	0.158	0.155	1.51
150	0.138	0.144	0.135	0.139	1.46
200	0.124	0.127	0.123	0.128	1.42
300	0.107	0.106	0.106	0.111	1.36
400	0.0955	0.0938	0.0952	0.0997	1.32
500	0.0872	0.0851	0.0869	0.0911	1.29
600	0.0806	0.0786	0.0804	0.0843	1.26
800	0.0708	0.0694	0.0707	0.0741	1.23
1000	0.0637	0.0630	0.0636	0.0666	1.21
1500	0.0519	0.0528	0.0518	0.0542	1.17
2000	0.0448	0.0466	0.0447	0.0465	1.14

Using the known geometry of the standard and the μ for bakelite, we can calculate the self absorption of the standard at the energies listed in the Table above. We then did an empirical fit to the F_{std} values and derived an energy dependent expression for the amount of self absorption in the standard:

$$F_{std} = 3.567 / (\ln(\text{energy}))^{0.5586}$$

The formulas we used to correct for self absorption in soils are:

$F = F_{sample} / F_{std}$

$F_{sample} = 1 + (\mu\rho h)/2 + (\mu\rho h)^2/12$

where $\mu = 1.2634 / (\text{energy})^{0.4341}$

ρ = sample density

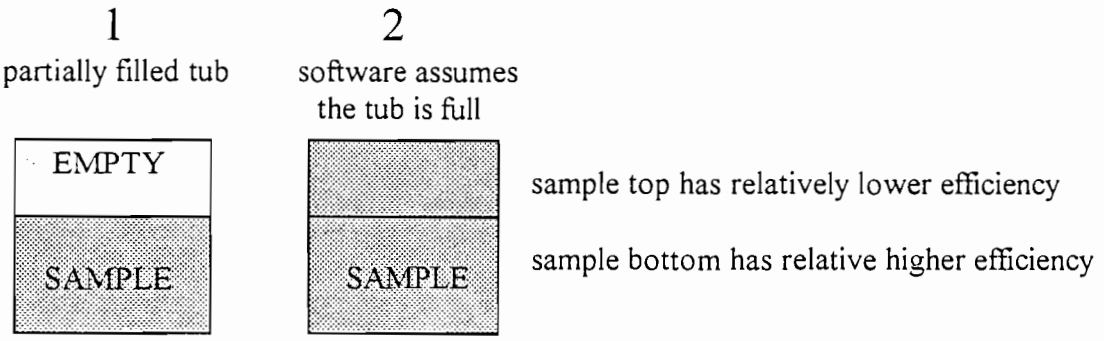
h = sample in counting tub

$F_{std} = 3.567 / (\ln(\text{energy}))^{0.5586}$

sample geometry

The only calibrated geometry for soil and water samples is a full 500 ml tub (average radius = 5.4 cm, depth of sample = 5.6 cm). Whenever possible, we attempt to approximate the calibrated, but sometimes we are unable to obtain this much sample material or, when the sample is dried, its depth in the tub may shrink. In this data set, the differences between sample volume and standard volume range from -7% to + 16%.

The efficiency of counting for each increment of sample volume will depend on its location relative to the detector, so if the sample volume does not match the volume of the calibration standard, a significant error will be introduced. This presentation documents the procedures used to obtain the geometry correction to be applied to samples that do not fill the tub used for counting. Consider the following figure:



A full tub is defined as one that is filled to the same height as is the standard. If a tub is less than full, the net efficiency of the material counted is higher than it would be if the tub was full. There is less sample being counted, but the higher efficiency gives an activity that is too high for the

material in the tub. The software assumes that the tub was full, so we need to determine the true activity.

counts in case 1 ≡ counts in case 2

activity (1) * eff (partial tub) = activity in (2) * eff (full tub)

where eff = (counts/sec) / gammas/sec)

$$\text{activity (1)} = \text{activity (2)} * \frac{\text{eff (full tub)}}{\text{eff (partial tub)}}$$

hence, the corrected activity decreases if the tub is less than properly filled. Likewise, if the tub is filled to a greater depth than is the standard, the corrected activity is greater than the reported value.

Measurements to determine relative efficiencies throughout the tub

A point check source of Cs^{137} was used to measure the relative counting efficiency of specific points throughout the volume of the tub. All measurements were then normalized to the count rate when the source was at the bottom-center of the tub.

Assumptions: 1) the tub is symmetric about the detector vertical axis
this will be true (to within about 2 mm) because the tub just fits in a mirinelli beaker
which fits snugly over the detector.
2) the efficiency within the detector is symmetric about the vertical axis

All measurements were made in one plane bounded by the vertical axis of the tub, the bottom of the tub, the radius = 4 cm (as close to the side of the tub as it was possible to get), and 5.38 cm above the bottom of the tub. Data was obtained at 52 locations within this plane. The locations used were all combinations of: radius = 0, 1, 2, 3, and 4 cm; and heights of the bottom of the check source above the bottom of the inside of the tub = 0, 0.08, 0.16, 0.40, 0.63, 0.98, 1.53, 2.23, 2.78, 3.38, 4.03, 4.06, and 5.38 cm. Given the complicated dependence of efficiency on all these locations ($1/r^2$ dependence does not apply), we chose to obtain the relative efficiencies empirically. As long as whatever three dimensional functions chosen can reproduce the measurements and if they are well behaved for interpolation and extrapolation, errors in the correction will be small relative to sample counting errors

We have accumulated equivalent data using Co^{60}, Na^{22}, and Co^{57} to determine the energy dependence of this correction. There should be a second order effect that the "shape" of the detector may be different for different gamma energies. The data is still to be analyzed.

Counting times of two minutes were used at each location. Each day the 0,0 location was repeated for use in calculating relative efficiency. The results are shown in Table E1.

Table E1 - Measurements of pointwise relative efficiency with tub counts per second (upper number), and relative efficiency (lower number)

height above tub bottom (cm)	radius within tub (cm) 0	1	2	3	4
0.00	1499	1424	1176	860	574
	1	0.950	0.785	0.574	0.383
0.08	1369	1324	1127	822	554
	0.913	0.883	0.752	0.548	0.370
0.16	1313	1243	1049	757	508
	0.872	0.825	0.697	0.503	0.337
0.40	1206	1134	969	727	496
	0.801	0.753	0.643	0.483	0.329
0.63	1053	1008	865	640	458
	0.716	0.684	0.587	0.434	0.311
0.98	938	905	792	623	458
	0.630	0.608	0.532	0.419	0.308
1.53	760	732	656	534	408
	0.511	0.492	0.441	0.359	0.274
2.23	591	569	511	429	343
	0.397	0.382	0.343	0.288	0.231
2.78	470	463	425	368	305
	0.320	0.315	0.289	0.251	0.208
3.38	391	384	358	313	270
	0.263	0.258	0.241	0.211	0.182
4.03	342	320	303	275	238
	0.218	0.215	0.204	0.185	0.160
4.68	276	270	255	231	207
	0.186	0.182	0.172	0.156	0.139
5.38	235	231	220	202	183
	0.158	0.156	0.148	0.136	0.123

The data should be symmetric about the vertical tub axis so only functions with 1st derivatives = 0 at r = 0 were chosen. Also, relatively simple functions were used, so that the computer integrations could be checked manually.

Use the function:

$$eff_{r,z} = C_1 + C_2 * r^2 + C_3 * r^4$$

where C_i are functions of height (h)
and r = radius

The program STATGRAPHICS PLUS was used to calculate the values of the coefficients.

Shown in Table E2 are the values of the coefficients obtained at each value of h
As a reality check, the value of C_1 should reproduce the measured values along the vertical axis. Shown after the calculated value of C_1 is the absolute value of the percent difference between the calculated and measured values.

Table E2

height above std. deviation tub bottom (cm)	C_1	|% dif|	C_2	C_3	r-squared	residual
0.00	1.00322	0.3	-0.05933	0.001285	0.9999	0.0031
0.08	0.92324	1.1	-0.04843	0.000856	0.9986	0.0087
0.16	0.87431	0.3	-0.05001	0.001024	0.9997	0.0039
0.40	0.79834	0.3	-0.04240	0.000818	0.9999	0.0024
0.63	0.71982	0.6	-0.03812	0.000779	0.9991	0.0050
0.98	0.63326	0.5	-0.02769	0.000457	0.9997	0.0025
1.53	0.51133	0.1	-0.01925	0.000275	0.9998	0.0014
2.23	0.39681	0.1	-0.01427	0.000243	0.9999	0.0003
2.78	0.32182	0.6	-0.00868	0.000095	0.9990	0.0015
3.38	0.26430	0.5	-0.00662	0.000090	0.9986	0.0013
4.03	0.21851	0.2	-0.00372	0.000005	0.9997	0.0004
4.68	0.18571	0.0	-0.00387	0.000060	0.9998	0.0003
5.38	0.15824	0.1	-0.00278	0.000037	0.9998	0.0002

The same procedure was used to obtain the dependence of the C_i on height (h) of sample in the tub.

The equations used: were $C_1 = K_{11} + K_{12} * \exp(K_{13} * h) + K_{14} * h^{1/2}$

$$C_2 = K_{21} + K_{22} * \exp(K_{23} * h)$$

$$C_3 = K_{31} * \exp(K_{32} * h)$$

where K_{ij} are constants from the fit
and h = height above tub base.

Shown in Table E3 are the values of K_{ij}.

Table E3
Values of K_{ij}

K_{11} = 0.45477	K_{21} = -0.00151	K_{31} = 0.001139
K_{12} = 0.53784	K_{22} = -0.05430	K_{32} = -0.82155
K_{13} = -0.55705	K_{23} = -0.70687	
K_{14} = -0.14358		
r-squared = 0.999	= 0.992	= 0.961
residual std. dev. = 0.0079	= 0.0018	= 0.00009

The integral used to calculate the relative efficiency of 50 different sample heights (with values of h = 0.12, 0.24, 0.36,...,6 cm) - see Table E4 and Figure E1

Table E4
counting efficiency as a function of sample height

sample height (cm)	relative counting efficiency	sample height (cm)	relative counting efficiency
0.12	0.468	3.12	0.316
0.24	0.454	3.24	0.312
0.36	0.443	3.36	0.308
0.48	0.434	3.48	0.304
0.60	0.425	3.60	0.300
0.72	0.418	3.72	0.296
0.84	0.411	3.84	0.293
0.96	0.404	3.96	0.289
1.08	0.398	4.08	0.286
1.20	0.392	4.20	0.282
1.32	0.386	4.32	0.279
1.44	0.380	4.44	0.275
1.56	0.375	4.56	0.272
1.68	0.370	4.68	0.268
1.80	0.365	4.80	0.265
1.92	0.360	4.92	0.262
2.04	0.355	5.04	0.259
2.16	0.350	5.16	0.256
2.28	0.346	5.28	0.253
2.40	0.341	5.40	0.249
2.52	0.337	5.52	0.246
2.64	0.332	5.64	0.243
2.76	0.328	5.76	0.240
2.88	0.324	5.88	0.238
3.00	0.320	6.00	0.235

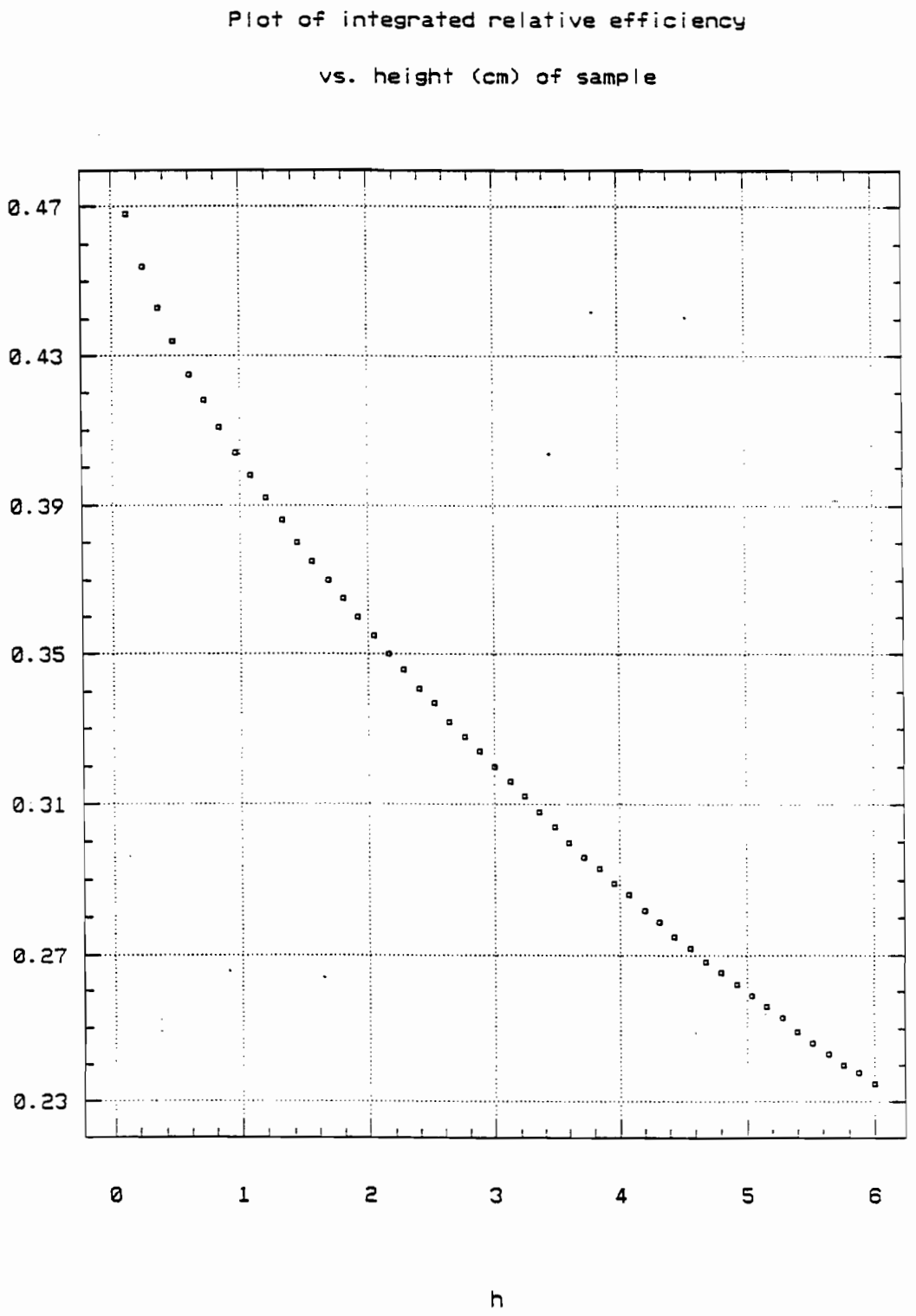

Plot of integrated relative efficiency
vs. height (cm) of sample
0.47
0.43
0.39
0.35
0.31
0.27
0.23
0
1
2
3
4
5
6
h

FIGURE E1

Example: suppose the sample height is 5.0 cm. The height of the standard = 5.6 cm. Therefore, the correction to be applied to this sample is 0.244/0.260 = 0.94.

System background

The gamma spectrum analysis software is set up to automatically subtract background peaks that exist even when is no sample is present. To duplicate this condition, we placed a tub filled with distilled water where the sample tubs normally rest and counted for about one day. The water is there to approximately account for absorption of counting system gammas that would normally occur in the sample. We observe up to a few tens of counts / hour from about 15 or so peaks. They are associated with the uranium and thorium series, K40, or xrays. The system background count rates are not high and they would have an effect only on essentially clean soil samples. Since these peaks are subtracted, no system background effects remain in the data set.

Appendix F
Comparison of Activity and Count Rate Profile

Presented here are brief descriptions of our findings at each soil sampling location

south of railroad avenue

locations inside of fenced area

- samples from within identified Area A (see Figure 4 for definition of Area A)

MK0101 significant activity mostly found in top foot of soil
MK0102 activity limited to thin layer on surface
MK0103 activity found in layer 6-12 inches below surface
MK0104 activity mostly found in top foot of soil
MK0105 activity mostly in lower part of the top foot of soil
MK0106 activity mostly near the 6 inch depth
MK0107 activity found in layer 6-12 inches below surface
MK0108 activity found in layer 6-12 inches below surface
MK0109 activity found within top 6 inch layer
MK0110 activity found in layer 6-12 inches below surface
MK0111 activity found in top foot of soil
MK0112 little activity found in top 6 inches of soil
MK0113 activity found throughout 6-30 inch range, peaking near 18 inches deep
MK0114 activity mostly in top 6 inches (0-6 inch activity seems high for count rate data)
MK0115 little activity found

comment: most activity is within the top foot of soil. Exception is location MK0113 which has clear contamination down to 30 inches

- area where survey failed to show contamination - location is east of Area A

MK0116 activity mostly in thin layer near the 12 inch depth

comment: nothing in top 6+ inches and low level of contamination explains survey result

- area where survey failed to show contamination - locations are south of Area A

MK0117 little activity found in 6-18 inch range
MK0118 activity found mostly between 18-30 inch depth, peaking near 20 inches deep
MK0119 little activity found at bottom of hole - between 24 inches and refusal at 25 inches.

comment: MK0117 and MK0118 have essentially no contamination near surface MK0117 has low level activity down about one foot, MK0118 is the only location (except location 13) with contamination below 18 inches. MK0119 clean except for possibly something in refusal layer. Results consistent with survey.

locations between fence and railroad tracks

- sample from within identified Area B (see Figure 4 for definition of Area B)

MK0201 little activity found in top foot of soil

comment: survey showed some contamination which was consistent with activity values.

- sample from within identified Area C (see Figure 4 for definition of Area C)

MK0203 little activity found at various depths, but count rates suggest significant activity should be found about 3-20 inches. Perhaps activity near hole but relatively less activity in samples.

comment: results of survey and activity measurements not consistent, unless significant activity off to the side of hole. Need to examine this area again.

locations between fence and railroad avenue

MK0302 activity found throughout profile, peaking near 12 inches and also near 36 inches

MK0304 activity found throughout profile, peaking near 18 inches and near 36 inches

comment: some contamination found at depth, apparently in two layers

location just outside of fence on west side of property

MK0401 little activity found

comment: contamination in Area A not observed outside of fence

North of Railroad Avenue

locations along north edge of railroad avenue

- no contaminated area identified by software

MK0303 activity found throughout profile, substantial activity found below 30 inches. Contamination may be deeper than we sampled

comment: even though the software did not identify a contaminated area at this location, the survey did indicate a small area of higher values near this location. This area is near the gate to the paved area leading from Railroad Avenue along the east side of the main Richard's Lumber building. The parking lot showed small areas of slightly elevated readings through the asphalt. Need to investigate if this sample is characteristic of the larger area.

- samples from within Area H (see Figure 4 for definition of Area H)

MK0301 little activity, some near surface and at about 20 inches (this location is near southwest corner of area H)

MK0305 substantial activity in top 18 inches, particularly within 6-12 inches

comment: MK0305 has **very significant contamination** near the surface (this location is near the dumpster)

- area west of dumpster surveyed manually because of thick vegetation

RL0401 activity found in 3-12 inch range.

comment: activity likely deeper than the 12 inches sampled

locations between main lumber yard building and railroad tracks

- samples from within Area A (see Figure 6 for definition of Area A)

RL0101 little activity mostly in 6-12 inches (surface count rate seems high for low activity near surface)
RL0102 activity found in top 48 inches, mostly within 12-48 inches
RL0103 significant activity in 6-12 inches
RL0104 significant activity found in 2-6 inches (not observed in count rate data), also in 24-48 inch range
RL0105 activity found in 6-9 inch range

comment: the two samples on the west side of Area A (RL0102 and RL0104) have contamination at depth, whereas other samples along east side of Area A have contamination limited mostly to the top 18 inches.

- samples from within Area B (see Figure 6 for definition of Area B)

RL0106 activity mostly in top 18 inches
RL0201 activity in 4-36 inch range, significant activity in 4-10 inch level
RL0202 activity mostly in 3-30 inch range, significant activity 3-12 inch range
RL0204 activity found mostly in top foot of soil

comment: significant activity at all locations, particularly in the top18 inches.

- no contaminated area found - just north of Area B

RL0203 significant activity in 10-20 inch range (not observed in count rate data)

comment: low activity in top of soil column may explain why not made part of an identified area, but question remains about the high activity in the 10-18 inch sample that was not observed in the count rate data.

- sample from near old depot

RL0205 little activity found - but only top 4 inches sampled due to obstructions at that location (location on map is not correct. Location is actually along the east side of old railroad depot building). The instrument readings are correct, but too few receivers heard the backpack to position the data correctly

comment: the top 4 inches has low activity, but sampling to greater depth is needed.

- no contaminated area found along the west side of the old depot

RL0301 little activity found
RL0302 little activity found

comment: both activity and survey measurements showed no indications of radioactive material

background activity found in 12-18 inches. No reason suggested. Propose to sample same area again to verify the observed profile and to select another off site location for sampling.

Appendix G
Detailed Plots of Individual Surveys

The figures in this appendix show the data obtained from the individual surveys. They show the same information that is in the composite survey figures, but they present the data in an expanded scale. These figures are useful when examining the details of individual surveys. The presentation format is the same as used in the main text of this document.

The numbering system used to label each survey can be interpreted as shown below:

MK or RL - The survey is associated with either Mt. Kisco or Richard's Lumber combined survey.

- Sequential survey area for the associated combined survey.

- The survey date by month and day(eliminated in the RL surveys).

(B) - The capital letters in parentheses indicate the sequential data processing version of the print out.

i.e., MK01930(B) is the first Mt. Kisco survey, performed on 9/30/97, in the second data processing version.

Included in this data set are the readings obtained from dose rate measurements. The data is acquired from a bicron μrem/hr instrument. This instrument is not as useful for locating areas of radioactivity as are the count rate instruments used for the survey, but it is valuable for estimating doses to individuals using the site. It was carried on the backpack and measures the dose rate at about 1 meter above the surface. Background levels for dose rate are on the order of 10 μrem/hr. The area that would seem to be most representative of area background is the dirt area within the fence (Mt. Kisco property) where no elevated radium concentrations were found.

The instrument was in calibration and was working properly up to 28 μrem/hr. During the survey, the instrument range setting was such that all readings greater than 28 μrem/hr were recorded in the computer as 28 μrem/hr. We tend to use this instrument setting because resolution is better over the dose range that is typically up to a few times background. Upon review of the data, we decided that additional measurements were needed to bound the upper end of the dose rate range.

On November 7, 1997 we returned to the site and re-measured those areas where the bicron data were stored incorrectly. There are three of them: the primary area within the fence (MK01), near the

dumpster (MK03), and in the lumber storage area (RL01 and RL02). These are the same areas where the 2x2 NaI detectors had the highest readings. We walked over the areas, paused at regular intervals throughout each area and recorded the meter readings. The data are shown below.

Location: highest count rate area within fence - survey number MK01
Area: about 30 feet by 40 feet
Use: open grass
Number of readings: 13 Average: 30 μrem/hr Maximum: 85 μrem/hr

Location: area near and under dumpster - survey number MK03
Area: about 10 feet by 15 feet
Use: dumpster in active use by Richard's Lumber
Number of readings: 13 Average: 33 μrem/hr Maximum: 70 μrem/hr

Location: northeast of rock pile to south of old depot building - survey number RL01 and RL02
Use: storage of lumber
Number of readings: 36 Average: 60 μrem/hr Maximum: 155 μrem/hr

SURVEY MK01930(B)

Figure G1-G3 show the results of Survey MK01930(B). The data for these figures came from two 2x2 NaI detectors (DEC ID #7 and #8) and the Bicron. The units for #7 and #8 are count/min, the units for the Bicron are μrem/hr.

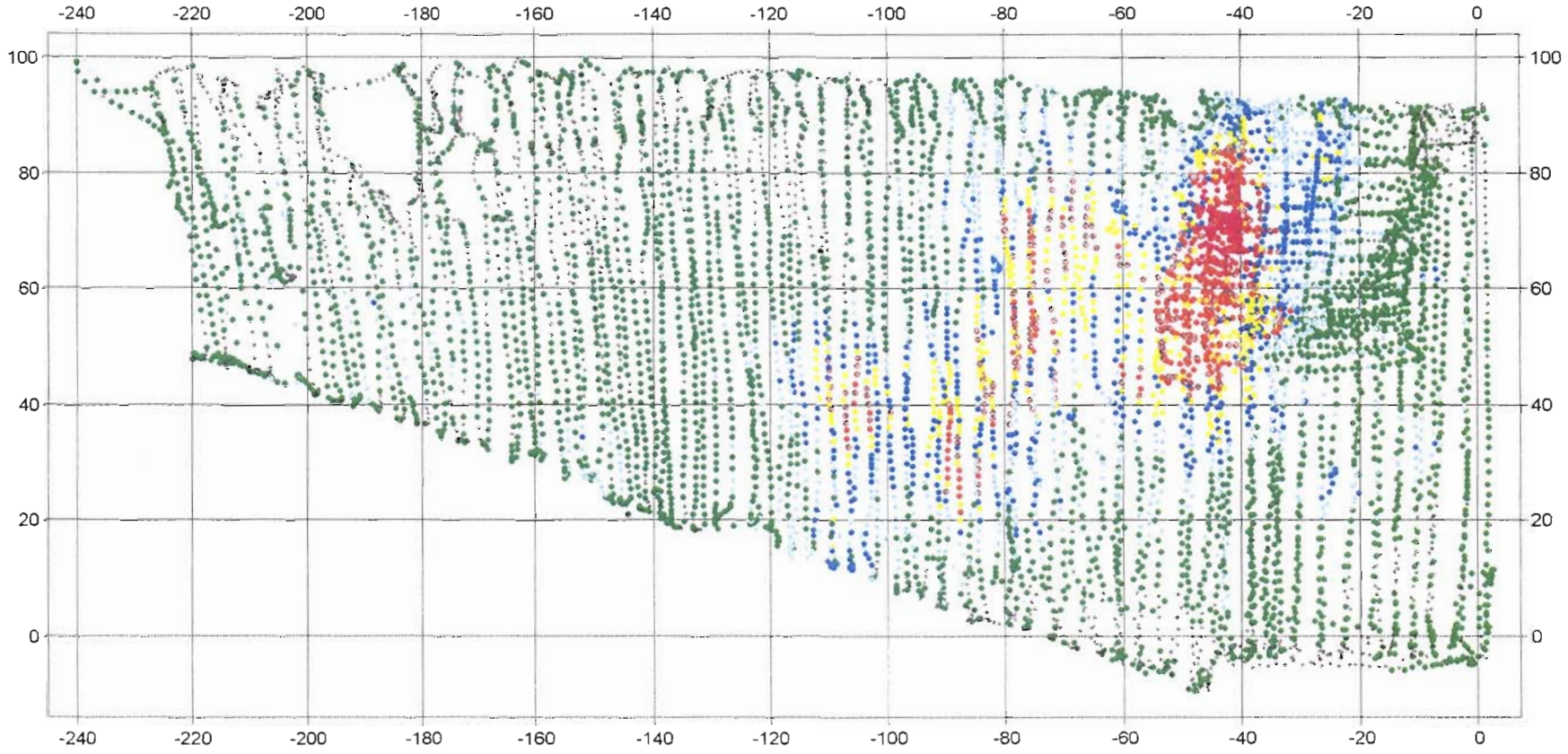
This survey area encompasses all of the area within the Mt. Kisco fenced in property that was accessible for coverage with the USRADS. The entire northern, western and eastern borders of this survey are delineated by a stockade-style fence. The southern border of the survey is bounded by a large brush pile. The access gate is located at approximately x=5, y=0. However, there were several sections of fence that had either fallen or been removed along both the northern and eastern portions of the property. The western edge runs parallel with Kisco Ave., the northern edge is parallel with Railroad Ave., and the eastern edge runs parallel with the railroad tracks.

USRADS Analyze v1.49i Track Map

Site: MK01930 (B) **Signal: 2221/2x2/7 (cpm)** **Time: 08:34:16 09/30/97**

Threshold:
> 10000

< 10000	30000 to 40000
10000 to 15000	40000 to 50000
15000 to 20000	50000 to 100000
20000 to 30000	> 100000



USRADS Analyze v1.49i Track Map

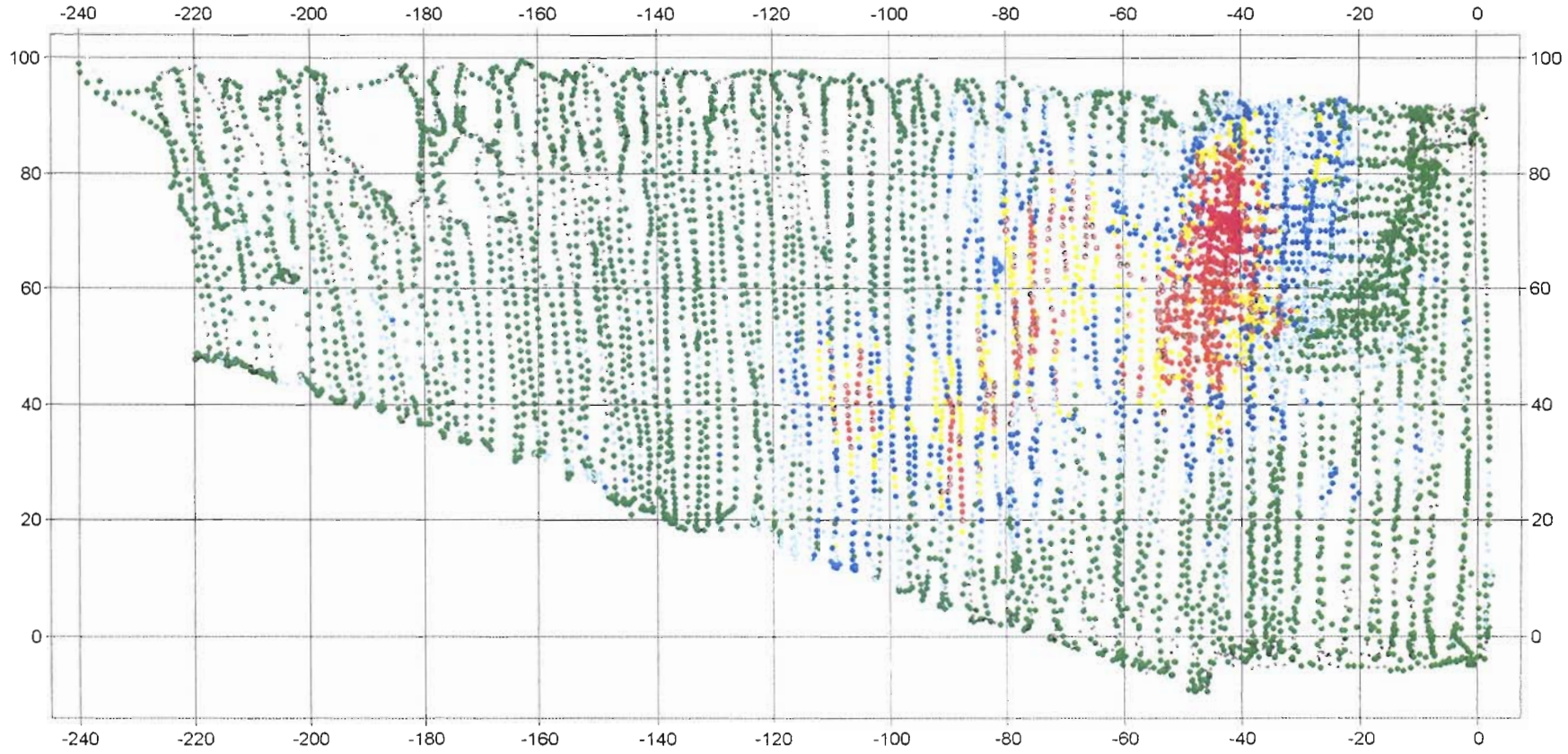
Site: MK01930 (B)

Signal: 2221/2x2/8 (cpm)

Time: 08:34:16 09/30/97

Threshold:
> 10000

< 10000
10000 to 15000
15000 to 20000
20000 to 30000
30000 to 40000
40000 to 50000
50000 to 100000
> 100000

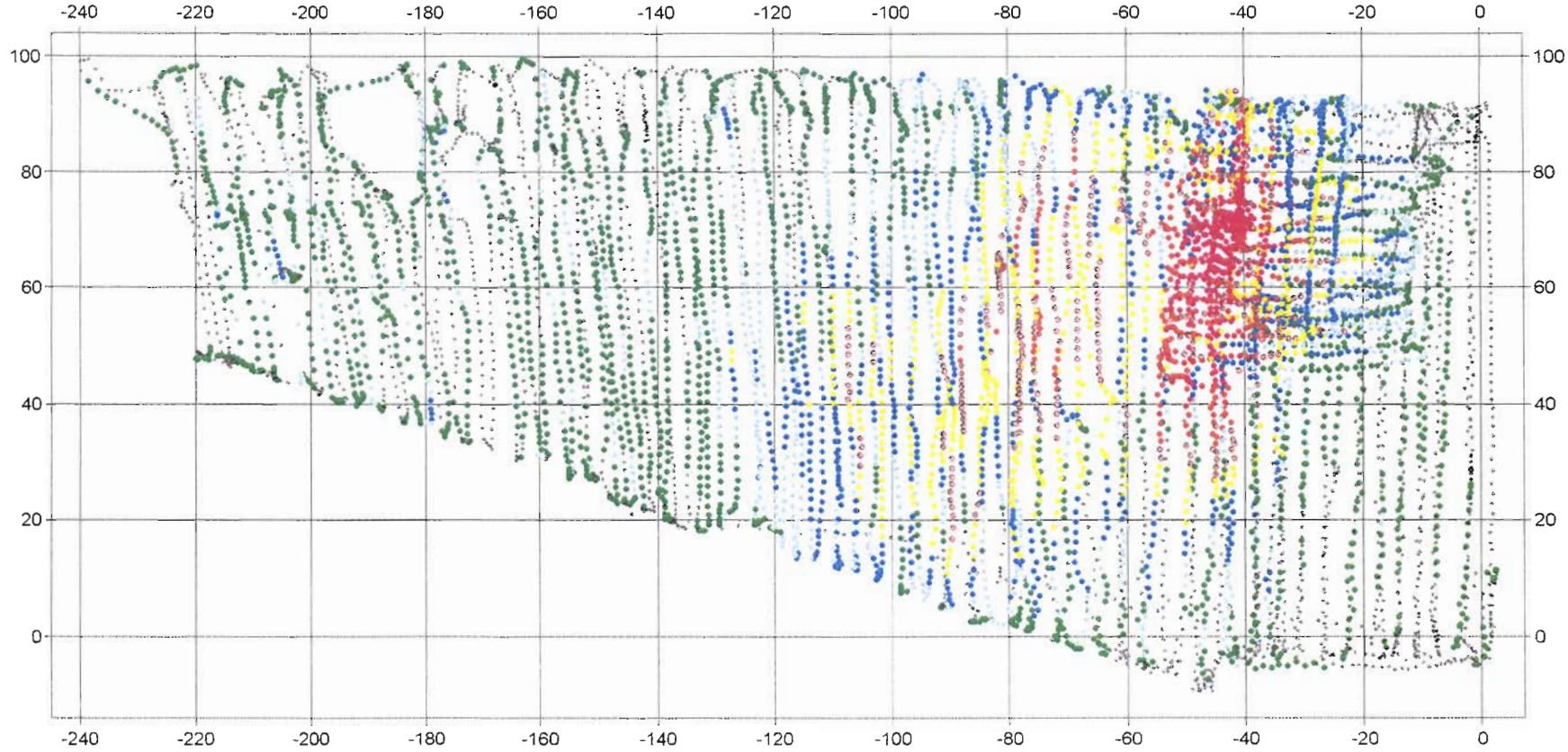


USRADS Analyze v1.49i Track Map

Site: MK01930 (B) **Signal: Bicron (uRem)** **Time: 08:34:16 09/30/97**

Threshold:
> 10

< 10	18 to 22
10 to 12	22 to 26
12 to 14	26 to 28
14 to 18	> 28



SURVEY MK02101(B)

Figures G4-G6 show the results of Survey MK02101(B) . The data for these figures came from two 2x2 NaI detectors (DEC ID #7 and #8) and the Bicron.

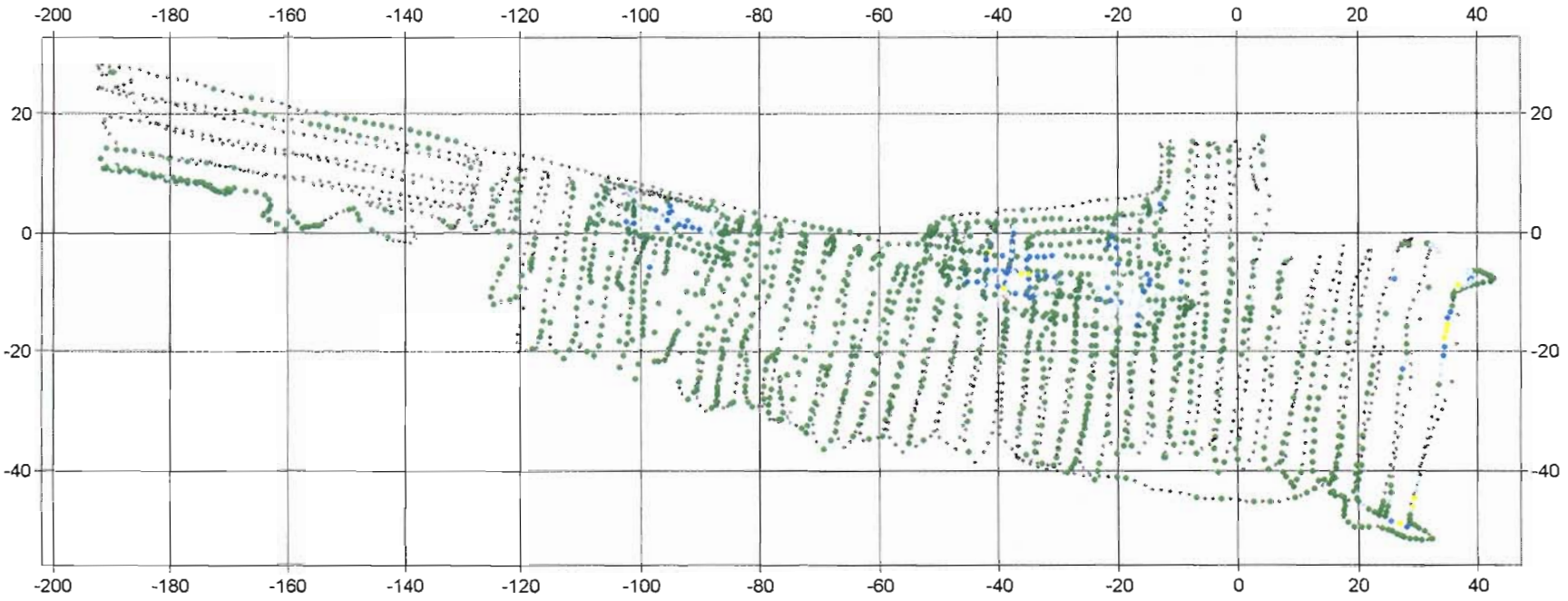
This survey area encompasses all of the area to the east of the Mt. Kisco fenced in property that was accessible for coverage with the USRADS. It also covers the far eastern end of Railroad Ave. The data points located at approximately x=40, y=-8 are immediately adjacent to the utility pole near the Richard's Lumber dumpster. The right angle formed by the survey tracks near x=-12, y=8 delineate the northeast corner of the fenced property. The western edge runs adjacent to the eastern fence line of that property. The eastern edge runs roughly parallel with the railroad tracks and either stops at the railbed ballast, or sooner in the case of interfering debris or vegetation.

USRADS Analyze v1.49i Track Map

Site: MK02101 (B) **Signal: 2221/2x2/7 (cpm)** **Time: 08:29:45 10/01/97**

Threshold:
> 10000 •

< 10000	30000 to 40000
10000 to 15000	40000 to 50000
15000 to 20000	50000 to 100000
20000 to 30000	> 100000



USRADS Analyze v1.49i Track Map

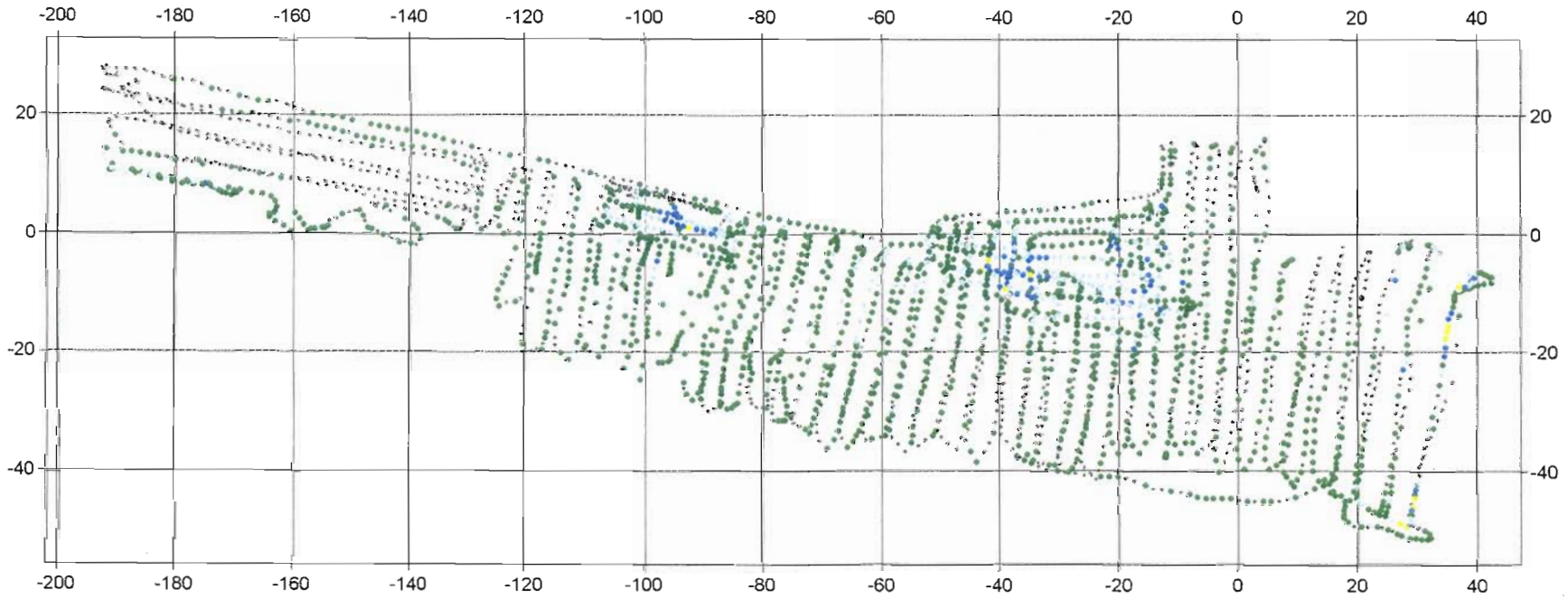
Site: MK02101 (B)

Signal: 2221/2x2/8 (cpm)

Time: 08:29:45 10/01/97

Threshold:
> 10000 •

< 10000	30000 to 40000
10000 to 15000	40000 to 50000
15000 to 20000	50000 to 100000
20000 to 30000	> 100000



USRADS Analyze v1.49i Track Map

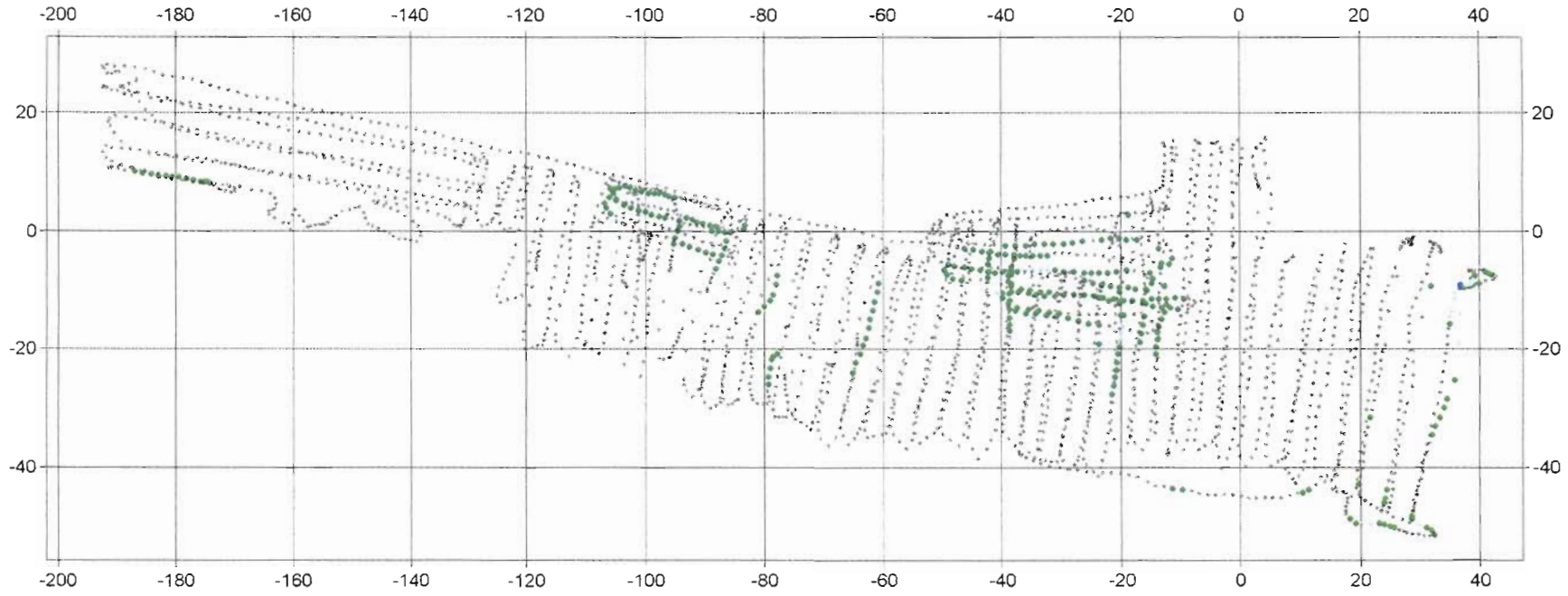
Site: MK02101 (B)

Signal: Bicron (uRem)

Time: 08:29:45 10/01/97

Threshold:
> 10 •

< 10	18 to 22
10 to 12	22 to 26
12 to 14	26 to 28
14 to 18	> 28



SURVEY MK03101(B)

Figures G7-G9 show the results of Survey MK03101(B) . The data for these figures came from two 2x2 NaI detectors (DEC ID #7 and #8) and the Bicron.

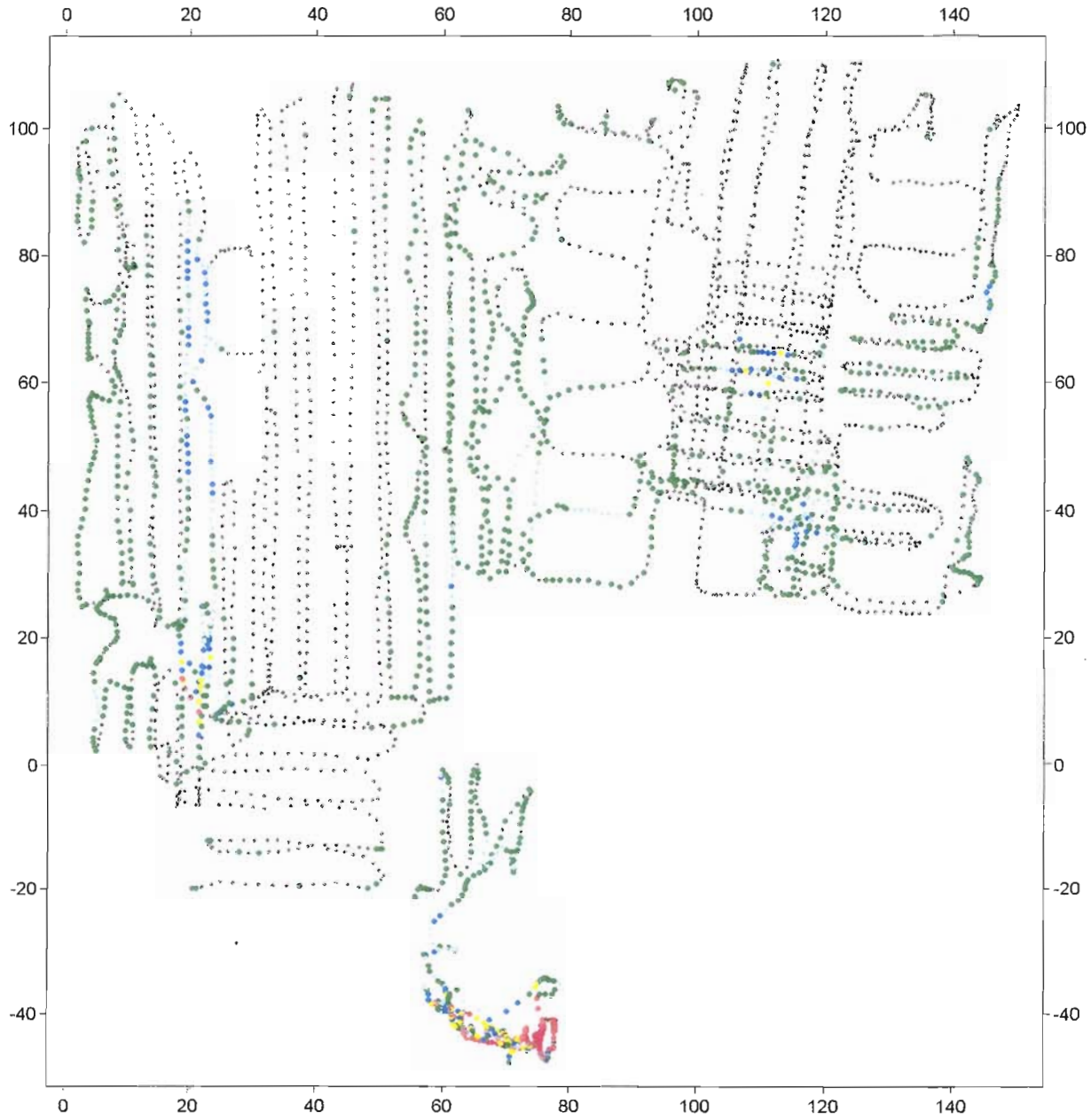
This survey area encompasses all of the area to the north of the Mt. Kisco fenced in property, up to the main Richard's Lumber building, that was accessible for coverage with the USRADS. It includes most of Railroad Ave., the grass and side walks on either side of the street, the Richard's Lumber southern parking lot, and a portion of the vegetated area between Railroad Ave. and the lumber storage yard at the back of the Richard's property. The roughly rectangular gaps in the survey indicate the location of parked automobiles. The data points at approximately x=75, y-40 are directly in front of the Richard's Lumber dumpster. The row of data points at approximately x=62, and running between approximately y= 10 and y=25, indicate the location of the access gate for the driveway that extends from Railroad Ave., along behind the main Richard's Lumber building.

USRADS Analyze v1.49i Track Map

Site: MK03101 (B) Signal: 2221/2x2/7 (cpm) Time: 14:17:10 10/01/97

Threshold:
> 10000 •

< 10000
10000 to 15000
15000 to 20000
20000 to 30000
30000 to 40000
40000 to 50000
50000 to 100000
> 100000



10343.5862

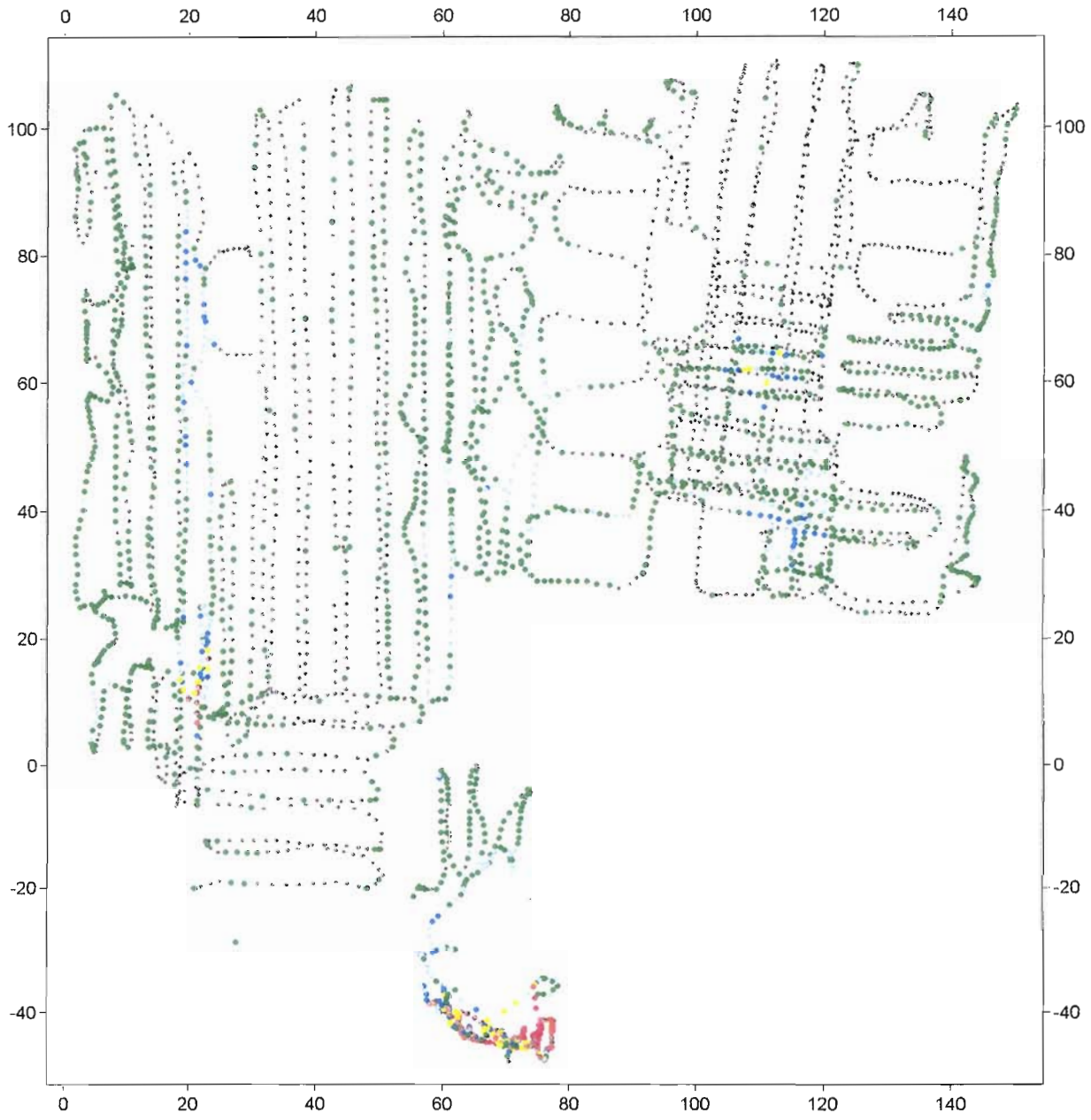
1 of 1

USRADS Analyze v1.49i Track Map

Site: MK03101 (B) Signal: 2221/2x2/8 (cpm) Time: 14:17:10 10/01/97

Threshold:
> 10000 •

< 10000
10000 to 15000
15000 to 20000
20000 to 30000
30000 to 40000
40000 to 50000
50000 to 100000
> 100000



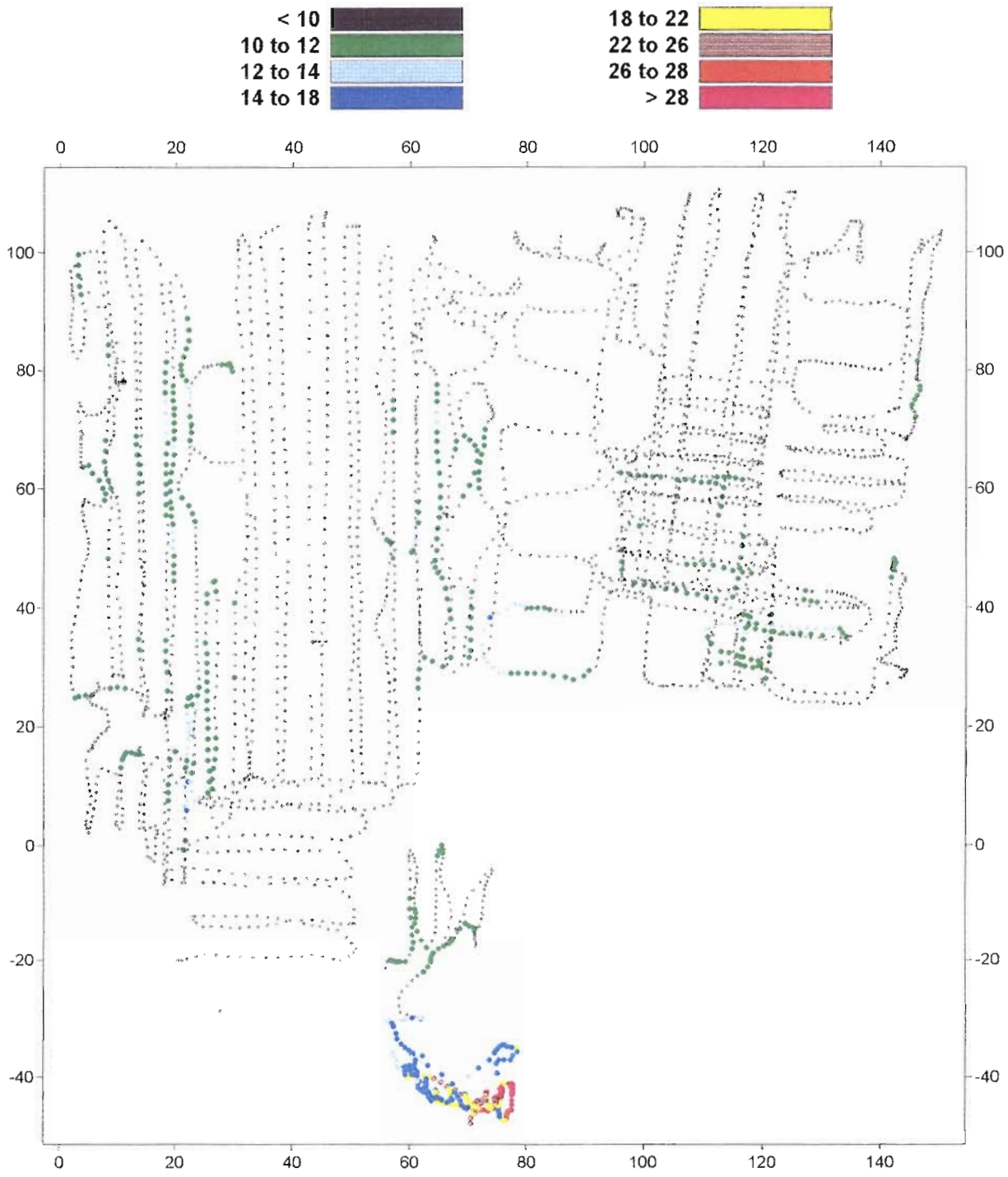
10343.6044

1 of 1

USRADS Analyze v1.49i Track Map

Site: MK03101 (B) **Signal:** Bicron (uRem) **Time:** 14:17:10 10/01/97

Threshold:
> 10 °



10343.6099

1 of 1

SURVEY RL01(B)

Figures G10-G12 show the results of Survey RL01(B) . The data for these figures came from two 2x2 NaI detectors (DEC ID #7 and #8) and the Bicron.

This survey area encompasses the southern portion of the Richard's Lumber storage yard. The right angle formed by the lines of survey points running along x=50 and y=35 indicate the fronts of the sea-van storage structures at the southern end of the area. The bottom portion of the survey represents the concrete paved access drive along the eastern edge. The gap in the survey in the north west corner, and along the line x=40, represent areas inaccessible due to the presence of stockpiled stone and roofing material not moved for the survey. The western edge is generally bounded by a blacktop paved area covered with supplies.

USRADS Analyze v1.49i Track Map

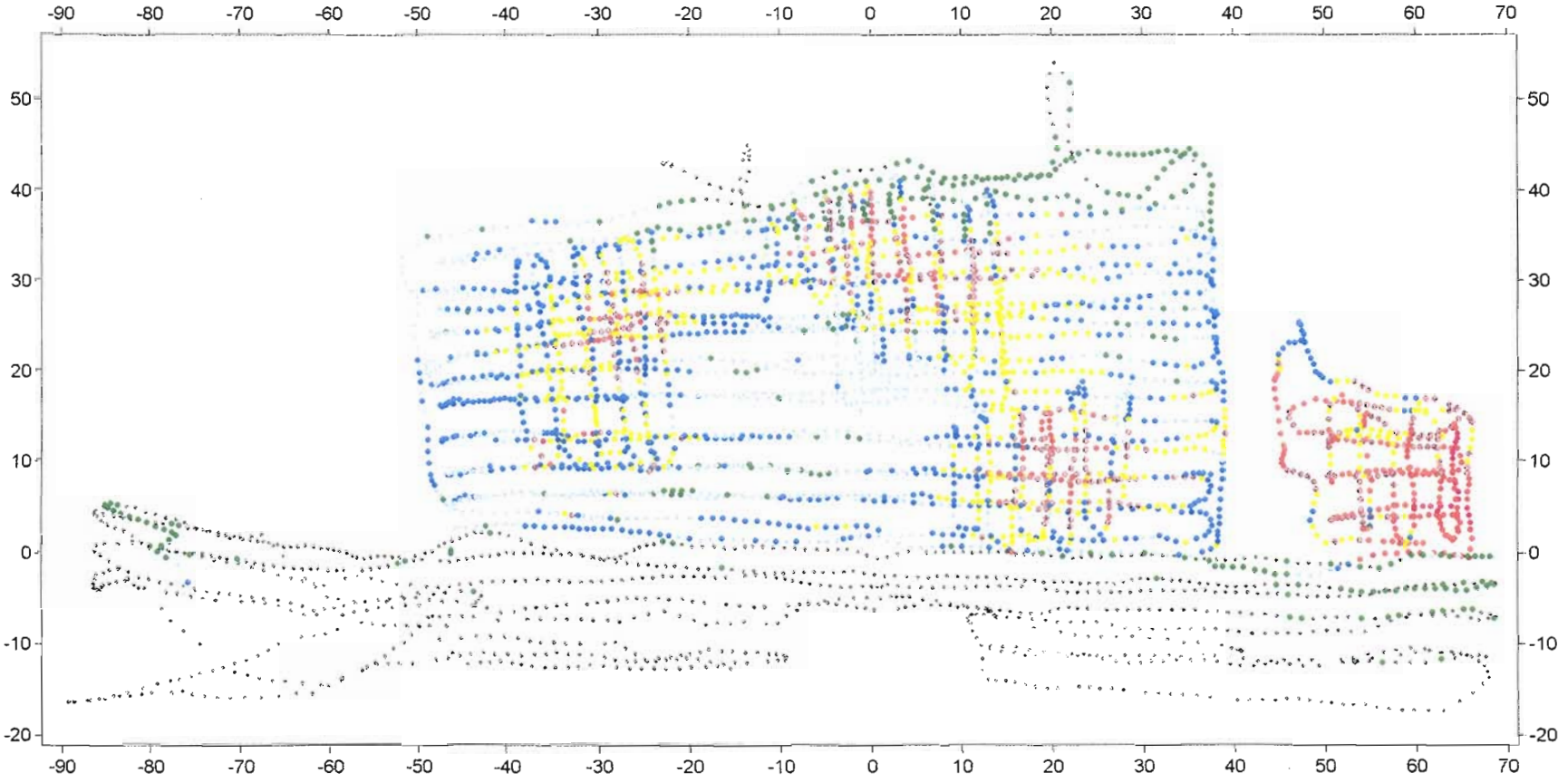
Site: RL01 (B)

Signal: 2221/2x2/7 (cpm)

Time: 13:20:37 10/02/97

Threshold:
> 10000

< 10000
10000 to 15000
15000 to 20000
20000 to 30000
30000 to 40000
40000 to 50000
50000 to 100000
> 100000



10343.6147

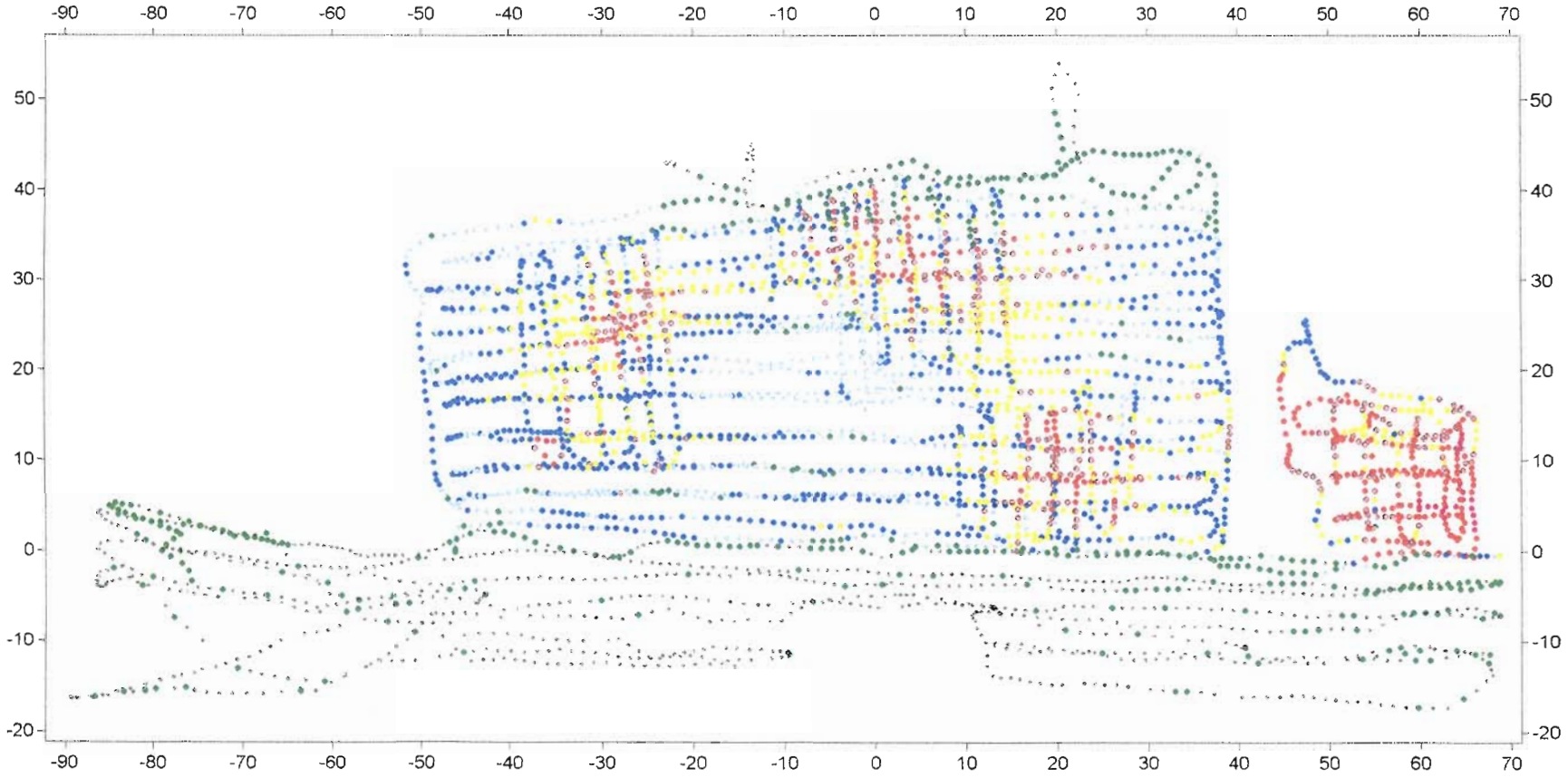
1 of 1

USRADS Analyze v1.49i Track Map

Site: RL01 (B) **Signal: 2221/2x2/8 (cpm)** **Time: 13:20:37 10/02/97**

Threshold:
> 10000

< 10000	30000 to 40000
10000 to 15000	40000 to 50000
15000 to 20000	50000 to 100000
20000 to 30000	> 100000

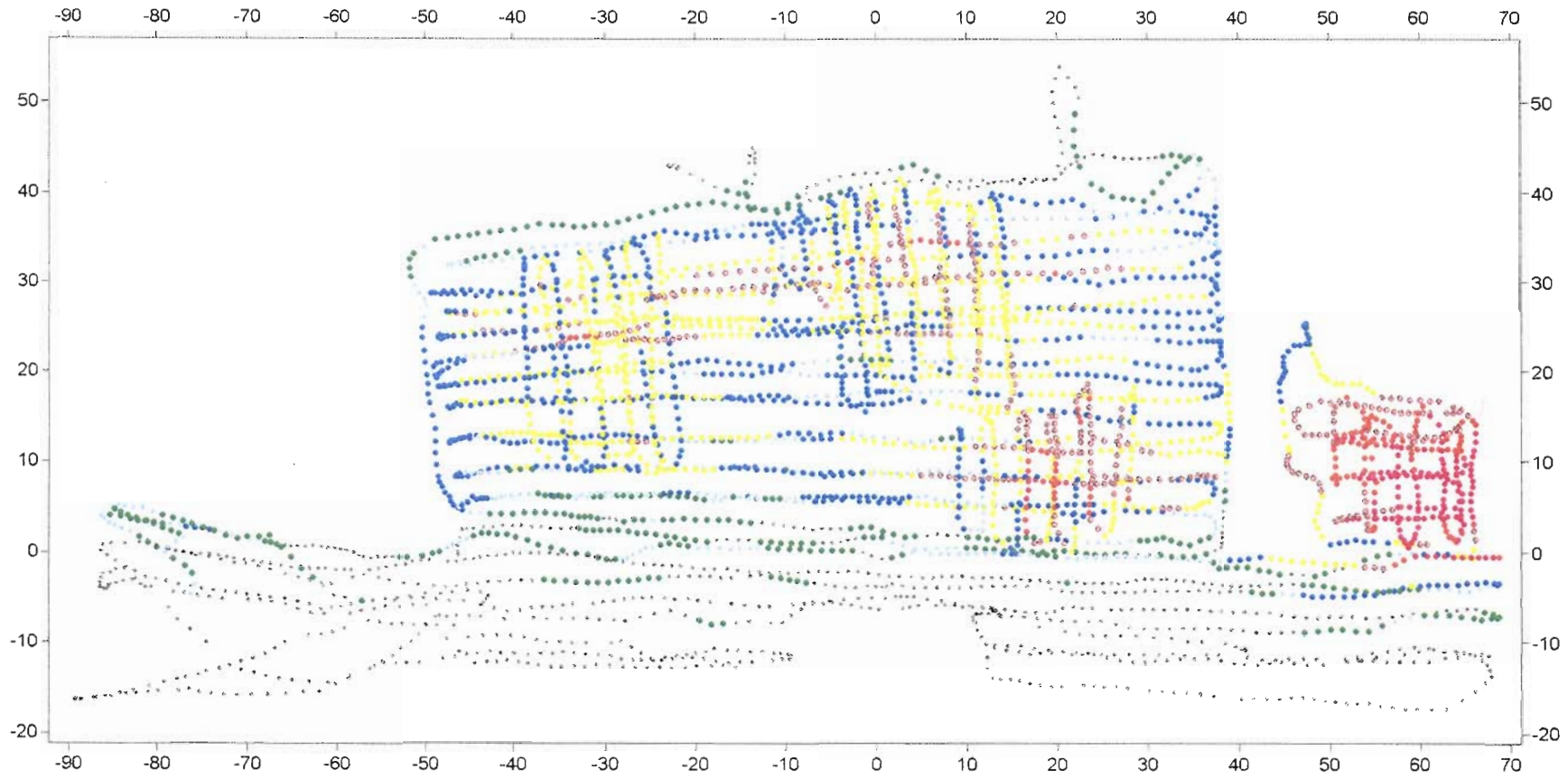


USRADS Analyze v1.49i Track Map

Site: RL01 (B) **Signal: Bicron (uRem)** **Time: 13:20:37 10/02/97**

Threshold:
> 10 °

< 10	18 to 22
10 to 12	22 to 26
12 to 14	26 to 28
14 to 18	> 28



10343.6265

SURVEY RL02(A)

Figures G13-G15 show the results of Survey RL02(A) . The data for these figures came from two 2x2 NaI detectors (DEC ID #7 and #8) and the Bicron.

This survey area encompasses the northern portion of the Richard's Lumber storage yard. The bottom portion of the survey represents the concrete paved access drive along the eastern edge. The gap in the survey in the north-center portion of the survey represents the southern end of the old railroad depot, now used as a storage building by Richard's Lumber. The western edge is generally bounded by the back of a lumber storage shed. The gap at x=80, y=10 is caused by the survey support vehicle. The gap roughly along the line y = 0 is due to the presence of building supplies not moved for the survey. The data points in the extreme north east corner of the survey have been misplaced due to location problems caused by loss of communication with most of the SR's, due to interference by the old depot building. In reality, they should be located at the front of the depot, at approximately x=165, y=0. The gap at the south west corner is caused by the same pile of stone noted in the description for survey RL01(B).

USRADS Analyze v1.49i Track Map

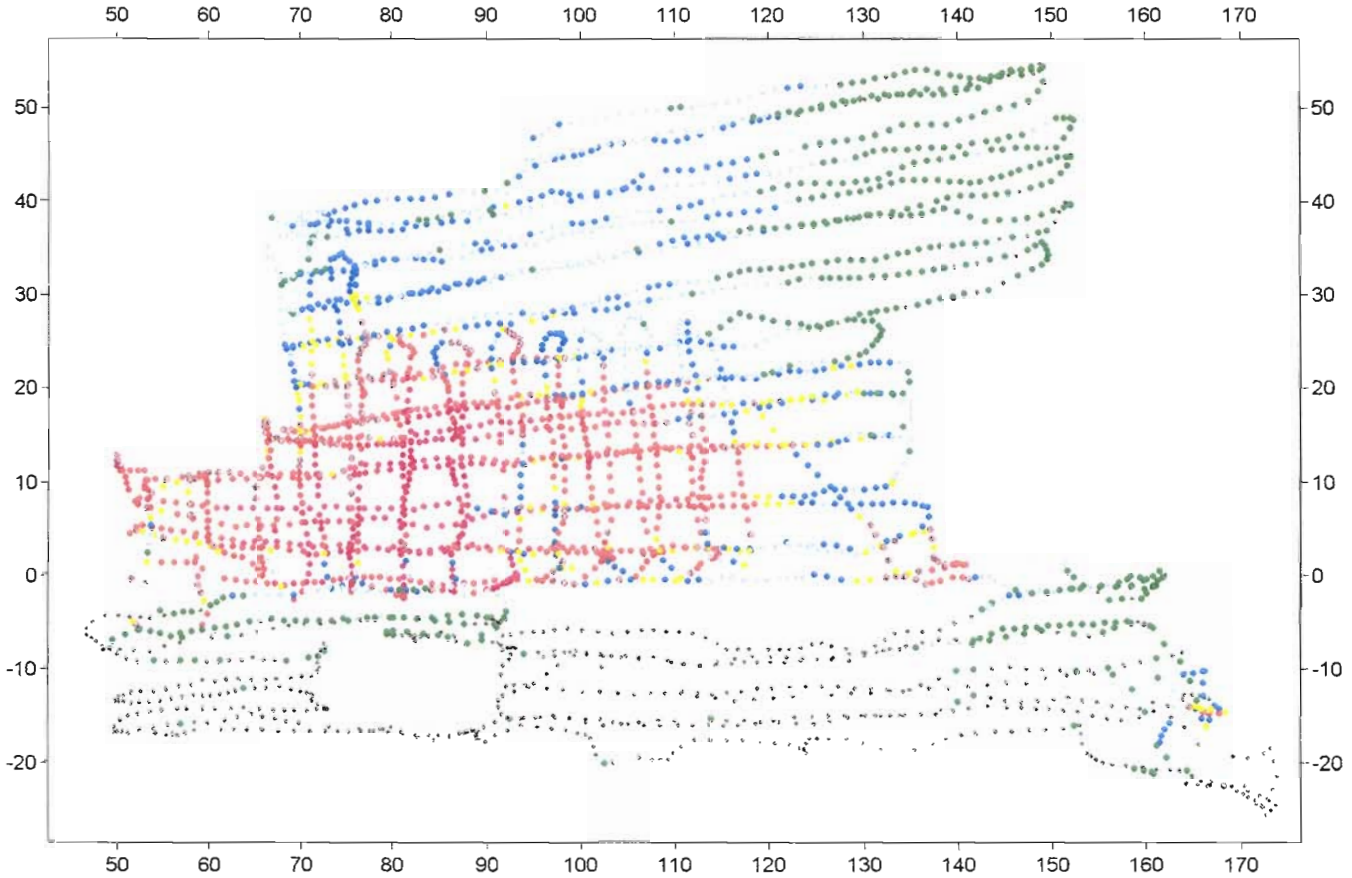
Site: RL02 (A)

Signal: 2221/2x2/7 (cpm)

Time: 12:50:27 10/06/97

Threshold:
> 10000

< 10000
10000 to 15000
15000 to 20000
20000 to 30000
30000 to 40000
40000 to 50000
50000 to 100000
> 100000



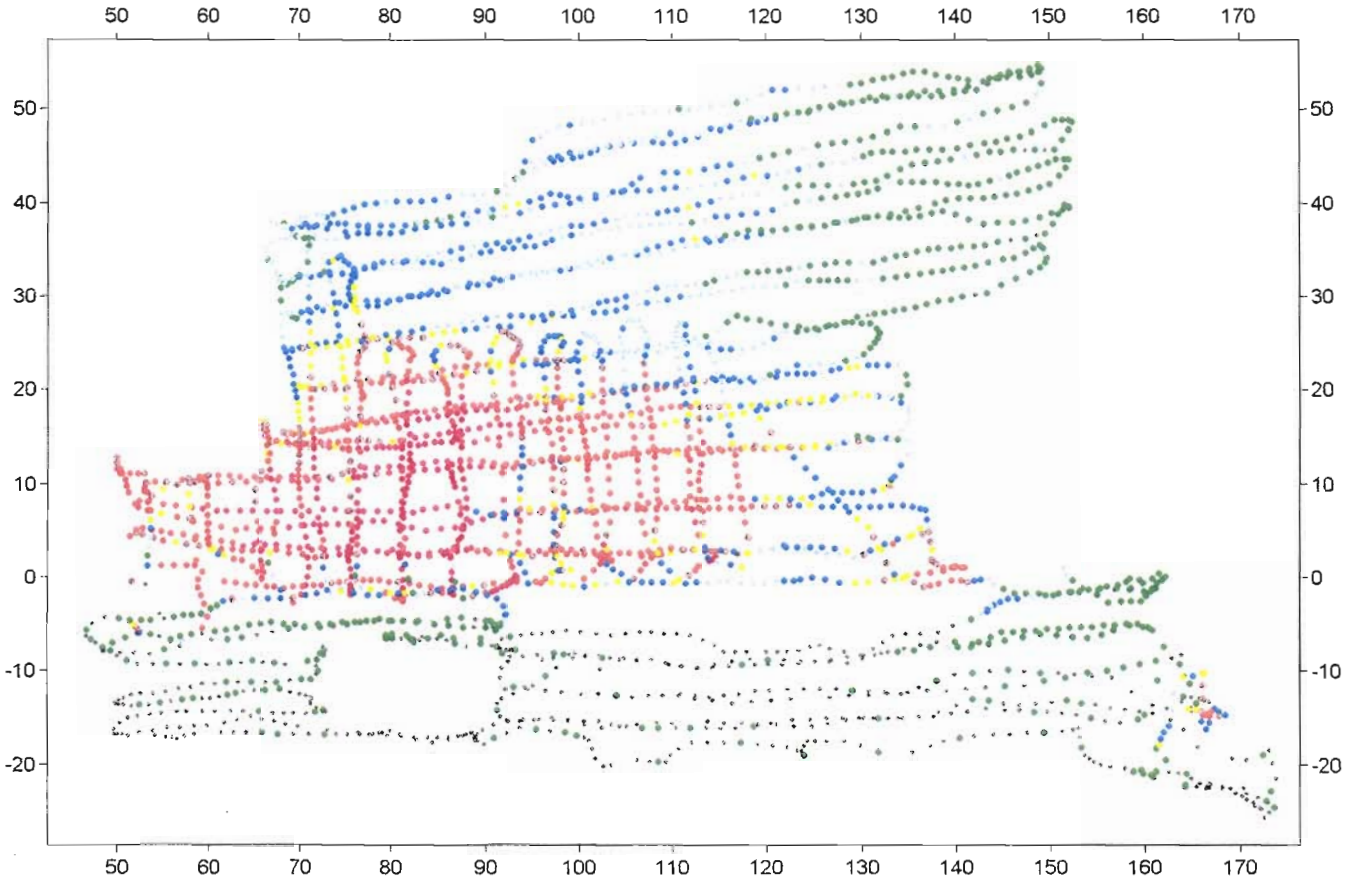
10343.6330

USRADS Analyze v1.49i Track Map

Site: RL02 (A) **Signal: 2221/2x2/8 (cpm)** **Time: 12:50:27 10/06/97**

Threshold:
> 10000

< 10000	30000 to 40000
10000 to 15000	40000 to 50000
15000 to 20000	50000 to 100000
20000 to 30000	> 100000



10343.6330

USRADS Analyze v1.49i Track Map

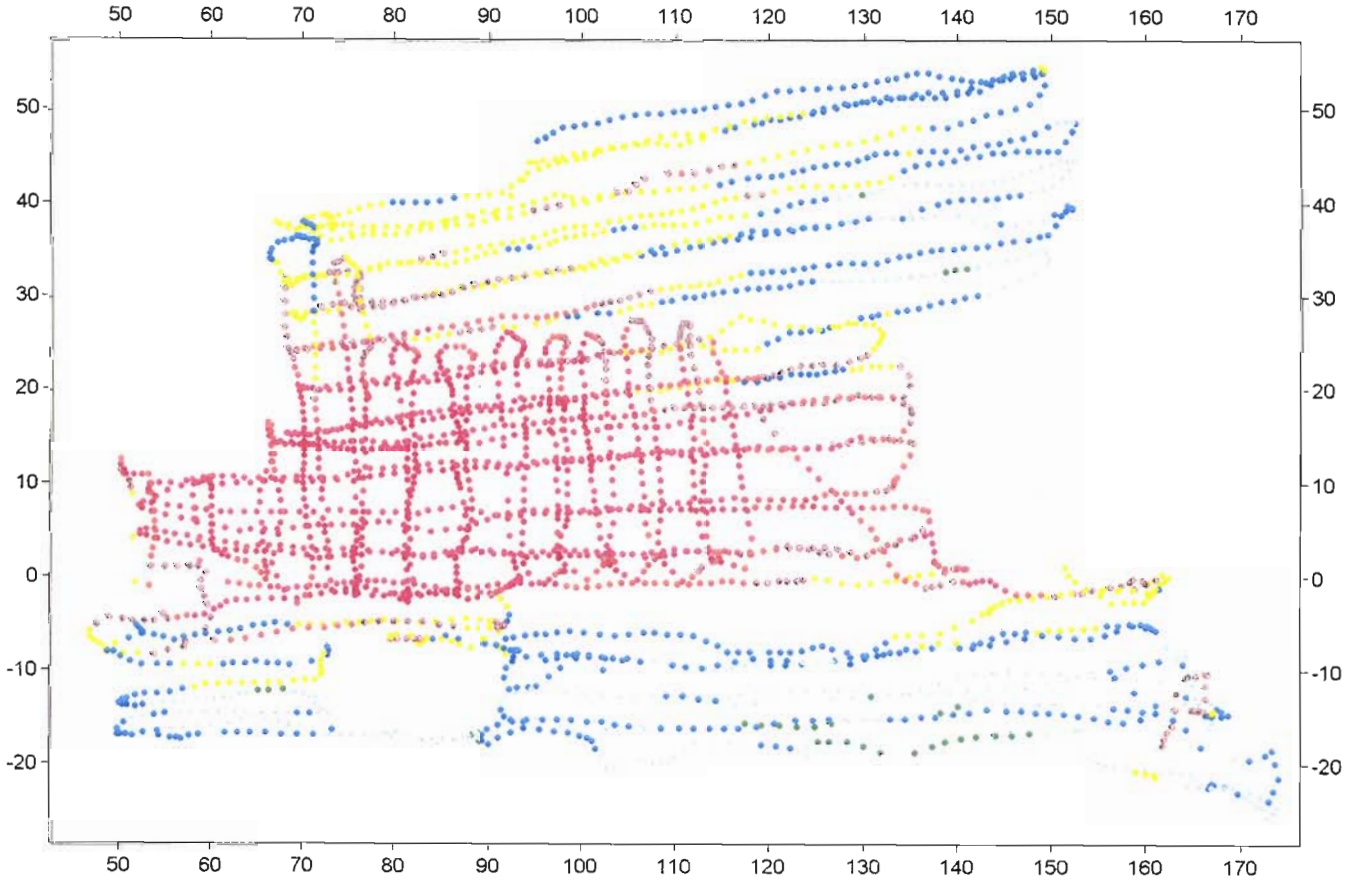
Site: RL02 (A)

Signal: Bicron (uRem)

Time: 12:50:27 10/06/97

Threshold:
> 10

< 10
10 to 12
12 to 14
14 to 18
18 to 22
22 to 26
26 to 28
> 28



10343.6330

SURVEY RL03(A)

Figures G16-G18 show the results of Survey RL03(A) . The data for these figures came from two 2x2 NaI detectors (DEC ID #7 and #8) and the Bicron

This survey area encompasses the portion of the Richard's Lumber storage yard located along the western side of the old depot. The bottom portion of the survey represents the depot and attached loading docks. The northern edge is a chain link fence. The western edge represents the back of a storage building and a paved storage area. The southern end abuts survey RL02(A).

USRADS Analyze v1.49i Track Map

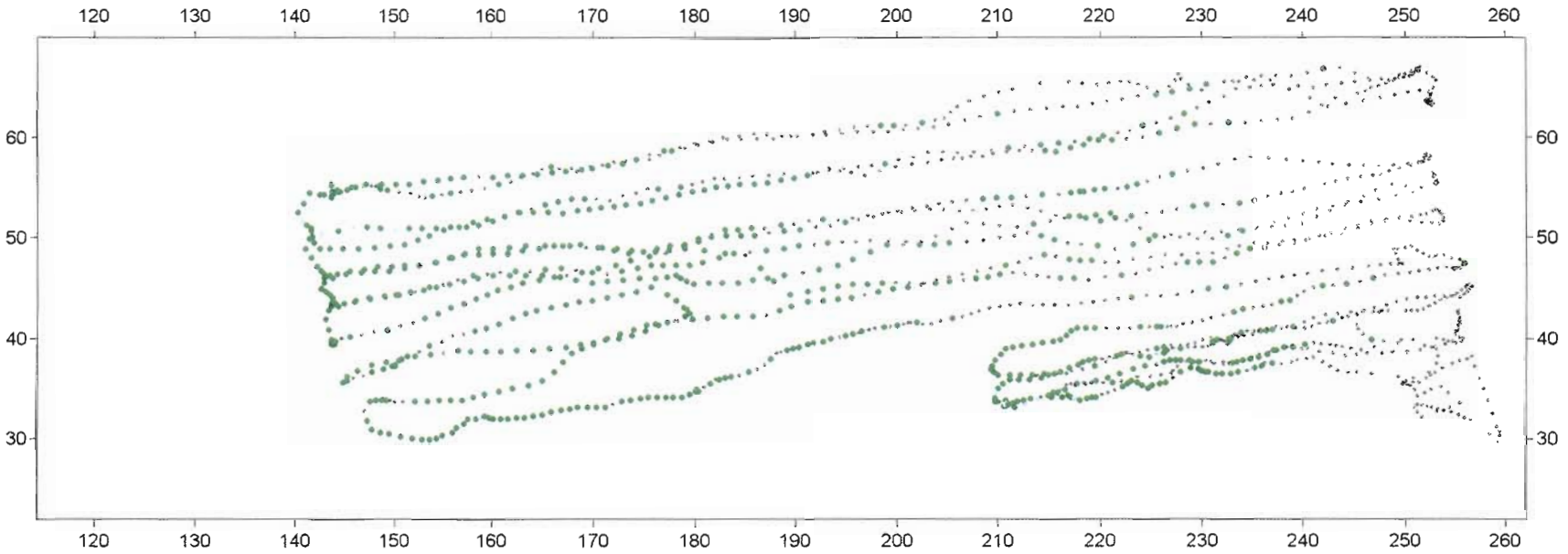
Site: RL03 (A)

Signal: 2221/2x2/7 (cpm)

Time: 11:18:11 10/07/97

Threshold:
> 10000 •

< 10000	30000 to 40000
10000 to 15000	40000 to 50000
15000 to 20000	50000 to 100000
20000 to 30000	> 100000

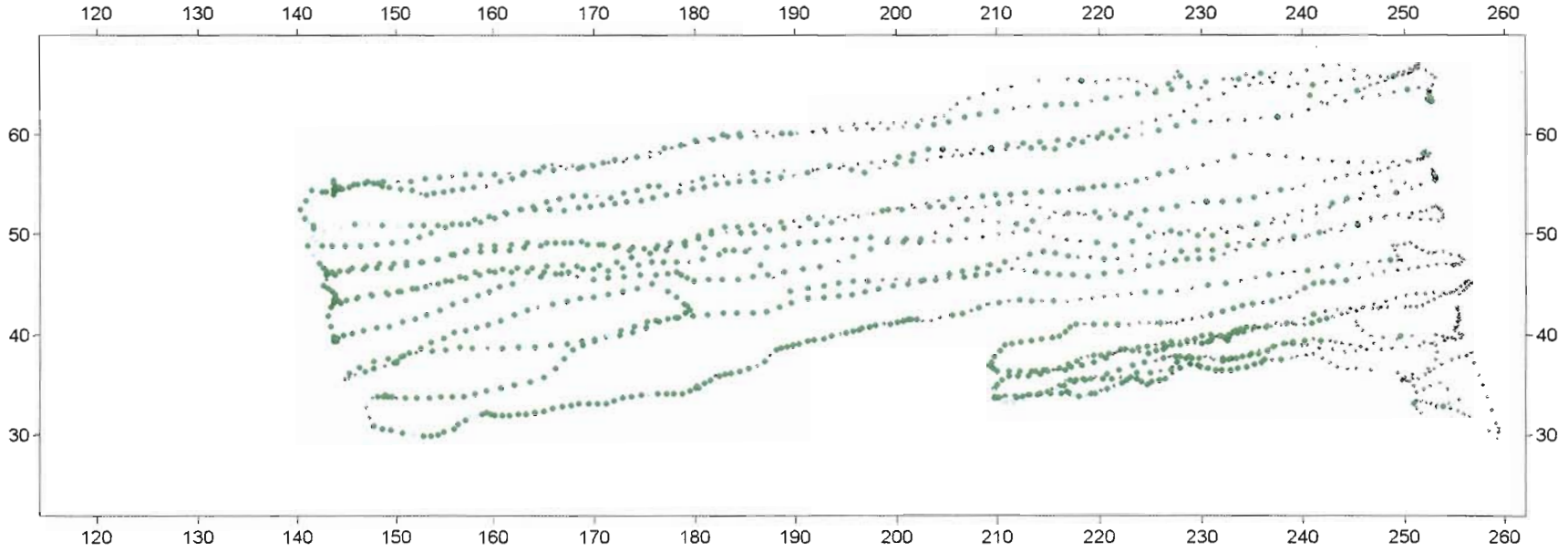


USRADS Analyze v1.49i Track Map

Site: RL03 (A) **Signal: 2221/2x2/8 (cpm)** **Time: 11:18:11 10/07/97**

Threshold:
> 10000

< 10000	30000 to 40000
10000 to 15000	40000 to 50000
15000 to 20000	50000 to 100000
20000 to 30000	> 100000



USRADS Analyze v1.49i Track Map

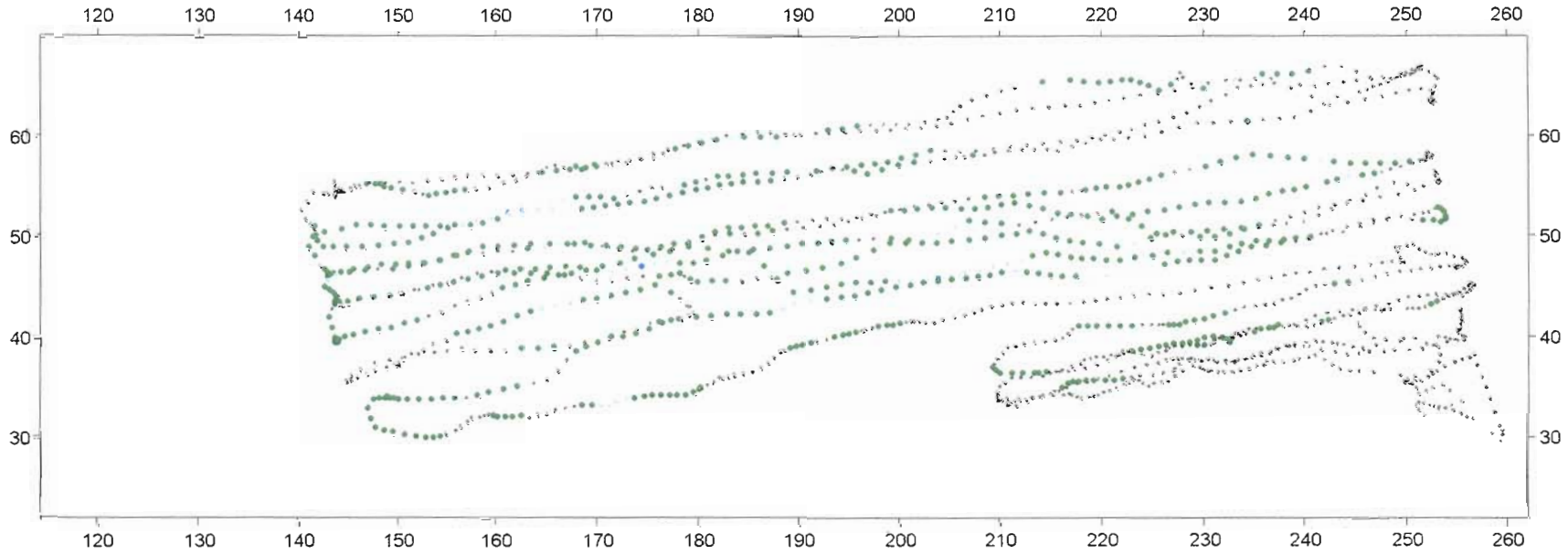
Site: RL03 (A)

Signal: Bicron (uRem)

Time: 11:18:11 10/07/97

Threshold:
> 10 •

< 10	18 to 22
10 to 12	22 to 26
12 to 14	26 to 28
14 to 18	> 28



Appendix H
Areas Not Surveyed

Listed here are the locations that were not surveyed and the reasons why. In some locations additional work is needed, but for surveys, manual techniques are sufficient.

Mt. Kisco survey area

1) Within fenced area:

Brush pile ($x \approx -230$, $y \approx 55$). We observed a slight increase in count rate on the north side of the pile, but this could be simply natural soil differences. We manually surveyed around the pile and observed no significant increase in count rate. Given the relatively large size of the area, we recommend that the pile be moved and a manual survey be done.

Brush pile ($x \approx -190$, $y \approx 90$). No above background count rates expected, and no further surveys seem needed.

2) East of fence:

Vegetation ($x \approx -200$, $y \approx 10$). Between the gravel driveway and the tracks is a mound of dirt covered with vegetation. Manual surveys showed slightly elevated readings and they were observed along the east most pass in the survey. A manual survey should be done on the mounded dirt and soil samples should be taken.

3) West of fence:

The area between the fence and Mt. Kisco Avenue was manually surveyed and no elevated readings were observed except just west of the most contaminated area within the fence. This may be only ground shine. The soil sample taken in this area showed low (≈5 pCi/g) radium. No further surveys in this area seem needed.

4) North of fence:

Trees north of fence ($x \approx 5$). The unsurveyed areas are small and data shown is adequate.

Cars in road ($x \approx 25$). Railroad avenue does not show elevated readings, so further survey of the road surface is not needed. Because of the elevated reading just south of the road, some cores taken from beneath the road are needed.

Trees north of road ($x \approx 65$). The unsurveyed areas are small and data shown is adequate.

Cars in Richard's Lumber parking lot. Elevated readings were observed, particularly on the east end of the lot. This area should be surveyed more completely when the cars are not parked in the lot. Coring below the parking lot is needed to determine the extent of contamination.

Driveway just east of parking lot ($y \approx 10$). The driveway should be manually surveyed, particularly at the southern end.

Tree and brush ($x \approx 80$, $y \approx -20$). Elevated readings are found to the south and east of this area. A manual survey is needed in this area.

Driveway east of dumpster ($x \approx 70$, $y \approx -60$). This area was manually surveyed. No elevated readings were observed.

The area west of the dumpster could not be surveyed successfully because of the vegetation.

Also, the area near $x = 30$, $y = -45$ showed elevated readings - the survey should be expanded to include these areas.

Eastern most extent of survey ($x \approx 40$, $y \approx -80$). This area is along the edge of the rail right-of-way. It was at the east most part of the survey where positioning became a problem. Extend survey north and south from this point, parallel to tracks.

Richard's Lumber survey area

1) Storage sheds ($x \approx -60$, $y \approx 20$ and $x \approx -30$, $y \approx 40$) are adjacent to elevated readings. It will be necessary to survey the areas under the sheds.

2) The wood and stone piles ($x \approx 45$, $y \approx 30$) are near elevated readings. It will be necessary to survey under the piles of wood and stone.

3) Along the east side of the old depot building was a narrow strip of soil. It was at the north most extent of the survey where positioning became a problem. It will be necessary to survey east of the depot building, particularly the south east corner and near doorways.

Proposed Additional Sampling Locations

Some additional radium concentration data is needed before dose estimates can be modeled.

Mt. Kisco property: using the Mt. Kisco survey coordinate system

Within the fence:

The four sample locations that were from areas where the survey suggested no radium present all had some - it just wasn't at the surface. The following approximate locations should be sampled - refer to Figure 13. The same manual sampling techniques used during this study are reasonable.

$x = -100$, $y = 70$

$x = -130$, $y = 50$

x = -10, y = 50
x = -25, y = 25
x = -5, y = 35

East of the fence:
The following locations should be sampled:
x = -200, y = 20
x = -5, y = -25
x = -30, y = -15
x = 40, y = -80

North of the fence, right-of-way for Railroad Avenue:
The survey found radium on both sides of the road. Since the road is on top of what was once the Canadian Radium building, perhaps radioactive material was disposed of in and around the building. We were not able to dig below where we found radium, so manual techniques are not adequate. Even though the road showed no evidence of radium, sample cores need to be taken there to determine if radium is present at depth. The following locations should be sampled:
x = 20, y = 80
four locations within the paved area of the road, randomly chosen

additional cores near the road at,
x = 55, y = 80
x = 60, y = 40
x = 70, y = -10
x = 30, y = -45
x = 70, y = -50

Richard's Lumber:
Parking lot north of Railroad Avenue (Use Mt. Kisco survey).
No samples were taken from this area but given that the survey suggests slightly elevated readings, the parking lot will need to be sampled. Three locations suggested by the survey are:
x = 115, y = 35
x = 110, y = 60
possible additional cores at
x = 110, y = 80
x = 135, y = 60

Changing to the Richard's Lumber survey coordinate system - see Figure 14.

No elevated readings were observed over the paved driveway on the east side of the property,

however, just off the driveway to the west, significant count rates were observed. It will be necessary to determine if radium is located at depth under the driveway. Propose sampling locations at about:
x = 20, y = -5
x = 60, y = -5
x = 90, y = -5

The storage area has been surveyed except for where it was impractical to move the material while this survey was in progress (40 < x < 70). Propose two additional sample locations from about:
x = 45, y = 10
x = 60, y = 20
The contaminated area appears to end at the west side of the storage area (see x = 0 and y = 40). For the same reason as above, it is necessary to confirm that no radium is under the paved driveway along the east side of the building. Propose two additional sample locations at about
x = -30, y = 40
x = 0, y = 45
The location already sampled that is nearest the last proposed sample went to 52 inches from the surface. It showed a thin contaminated layer near the surface and another layer about two foot thick at depth. We were not able to sample below the contaminated volume, so for at least this part of the site, it will be necessary to at least 5 feet below the surface. The water table was noted at about four feet, so water sampling will have to be included as part of the characterization. Near the bottom of several of the sampling locations in this general area, the samples had a strong organic smell. The extent of possible hazardous material contamination needs to be investigated during this second phase of sampling.
The following additional sampling locations are proposed:
x = -10, y = 15
x = 100, y = 40
x = 70, y = 30
x = 130, y = 10
The survey showed elevated readings in front on a loading dock door on the east side of the old depot building. (The position of these measurements on the track maps is incorrect). An additional sample location is proposed for:
x = 165, y = 0
If any contamination is found, east of the depot, additional sampling under the driveway may be needed.

Appendix I
Photographs of Site and Survey

1. Intersection of Kisco Ave. & Railroad Ave., Richard's Lumber is on the N. side of RR Ave. (right of flatbed) Town of Mt. Kisco property located on south side of Railroad Ave. — looking northeast
2. Northern end of Mt. Kisco property — looking west toward Kisco Avenue
3. South eastern end of Mt. Kisco property — looking south
4. East side of Mt. Kisco property — looking south
5. East side of MK property, prior to survey — looking north at back of Richard's Lumber
6. Richard's Lumber north of Railroad Ave. — looking north, note dumpster
7. Richard's Lumber before survey — looking north along rear driveway
8. Richard's Lumber before survey — looking west, note pile of stone at center
9. Richard's Lumber before survey — looking north, note roofing material - not moved for survey
10. Northern end of Mt. Kisco Town Property — looking north before moving of brush, debris, and soil.
11. Northeast corner of Mt. Kisco Town Property — note gate at left
12. USRADS survey MK01 - Mt. Kisco property facing west side along Kisco Ave. — note moved pile of debris
13. USRADS survey MK01 - Mt. Kisco property 19 Sample Locations — looking south
14. Sample loc. MK0115 - about 2' of debris pile was removed before sampling
15. Sample location MK0302, south side of Railroad Ave., near gate to Town Property. — (see photo 11)
16. View down hole for sample location MK0302. Note large stones & deeper obstruction that appeared to be worked, smooth stones.

17. Sample location MK0305, "dumpster Area east end of Railroad Ave., soil sample at location of maximum surface reading with a 2"x 2" NaI.

18. Sample location MK0304 - south side of Railroad Ave., ½ way down the street. Note double layer of worked, smooth stone with beveled edges.

19. Area at east end of Railroad Ave., north side. note main Richard's Lumber building

20. Area at east end of Railroad Ave., north side, west of dumpster Area.

21. USRADS survey MK02, west side of RR tracks — looking south

22. USRADS survey MK03, Railroad Ave. and Richard's Lumber — looking north

23. USRADS survey MK04, west of MK01

24. Sample location MK0401, west of MK01

25. South end of Richard's Lumber RR Bldg. Before USRADS survey RL02 — lumber at center moved for survey

26. West side of RR building taken before survey

27. USRADS survey RL01 - Rear of Richard's Lumber — looking south

28. Sample location RL0102 on Richard's Lumber property — looking southwest

29. Sample location RL0204 - southeast corner of old RR bldg.

30. Sample location RL0104 - typical soil on Richard's Lumber property

31. Sample location RL0301 - west side of RR bldg.

32. Background sample MKBK01 collected from Mt. Kisco Municipal parking lot, 24' S. of utility pole 13

3. South eastern end of Mt. Kisco property

2. Northern end of Mt. Kisco property

1. Intersection of Kisco Ave. & Railroad Ave., Richard's Lumber is on the N. side of RR Ave. (right of flatbed) Town of Mt. Kisco property located on south side of Railroad Ave.

4. E. side of Mt. Kisco property

5. E. side of MK property, prior to survey

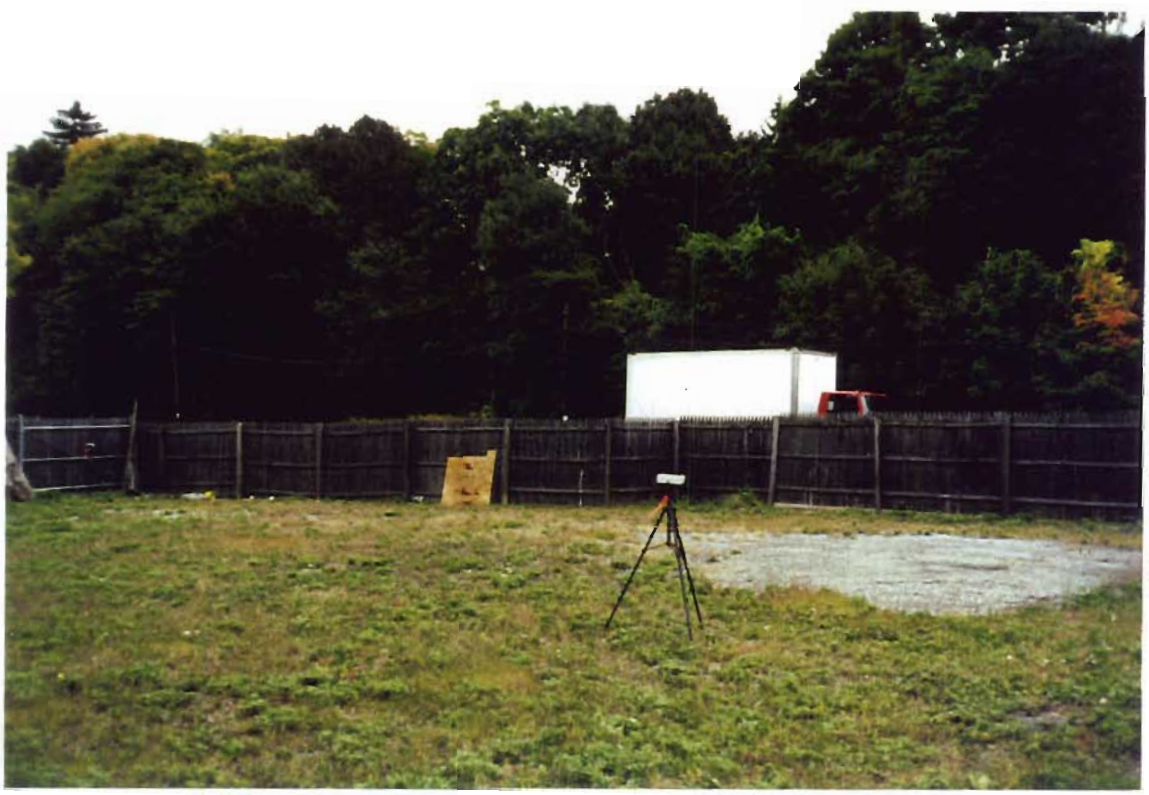
6. Richard's N. of Railroad Ave.

7. Richard's Lumber before survey

8. Richard's Lumber before survey

9. Richard's Lumber before survey

10. Southern end of Mt. Kisco Town Property, prior to moving of brush, debris, and soil.



11. South eastern end of Mt. Kisco Town Property,

12. USRADS survey MK01 - Mt. Kisco property
West side along Kisco Ave.
Moved pile of debris

13. USRADS survey MK01 - Mt. Kisco property
19 Sample Locations

14. Sample loc. MK0115 - 2' of Debris was removed pile befor sampling

15. Sample location MK0302, S. side of Railroad Ave., near gate to Town Property. Sampled to 48" in depth.

16. View down hole for sample location MK0302. Note large stones & deeper obstruction that appeared to be worked, smooth stones.

17. Sample location MK0305, "Dumpster Area" E. end of Railroad Ave., soil sample @ location of maximum surface reading with a 2"x 2".

18. Sample location MK0304 - S. side of Railroad Ave., ½ way down the street. Note double layer of worked, smooth w/ beveled edges.

19, Area at E. end of Railroad Ave., N. side

20. Area at E. end of Railroad Ave., N. side,
West of Dumpster Area. RL04

21. USRADS survey MK02, W. side of RR tracks

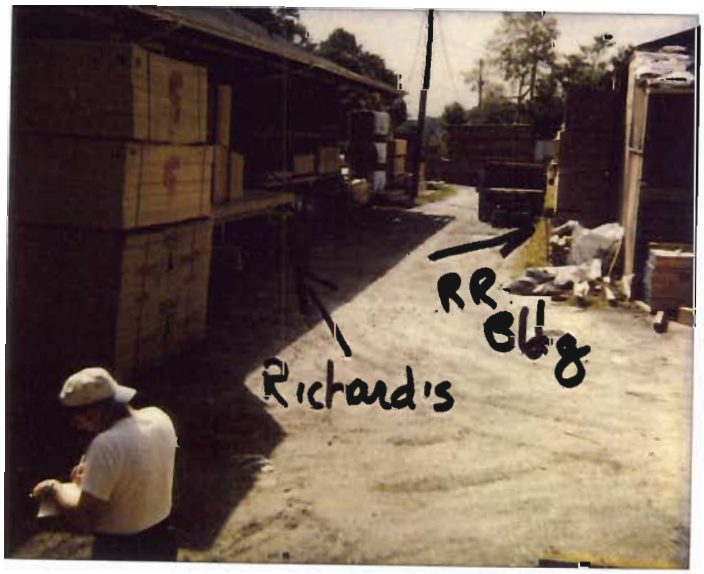
22. USRADS survey MK03, Railroad Ave. and Richard's Lumber

23. USRADS survey MK04, west of MK01

24. Sample location MK0401, west of MK01

25. S. end of Richard's Lumber RR Bldg.
Before USRADS survey RL02

KL02



26. W. side of RR building taken before survey

27. USRADS survey RL01 - Rear of Richard's Lumber

28. Sample location RL0102 on Richard's Lumber propert

29. Sample location RL0204 - S.E. corner of old RR bldg.

30. Sample location RL0104 - Typical soil on Richard's Lumber property

31. Sample location RL0301 - W. side of RR bldg.

32. Background sample MKBK01 collected from MT. Kisc Muncipial paking lot, 24' S. of utility pole 13

Appendix J
Quality Control Measurements

Discussion of field check source measurements - USRADS

Each day field work was done, background and source checks were performed using the USRADS system. The work plan called for this check to be performed before survey work started and after the work was completed. A Cs137 check source was placed in a jig that held the source midway between the two 2x2 NaI detectors and, in a separate run, on the face of the Bicron. A third run, with no check source near the detectors, was performed to gather background data. These measurements were done near where current surveys were being performed, so small differences in background readings are likely. An automated procedure built into USRADS involved counting for 100 seconds, sending one value each second to the controller. If the communication link between the backpack and the controller does not fail, 100 values are recorded for each check. As seen in the table below, all runs have at least 94 values (see columns labeled "number").

The background / source check data set is shown below. It consists of 10 separate runs. Thirteen more runs were made, however, the data was not stored in the computer. The system appeared to be working properly - count sequences started on command, the counting cycle (100 data points) was completed, and information was stored on disc. Later, when we checked the data, the values we were interested in were missing. Either communication or set up problems (not apparent in any other measurements) caused the situation.

The data that was successfully captured shows no difference in detector performance in the three days

Table J1 - Average count rates (background and source check) ± one standard deviation for two 2x2 NaI detectors (DEC #7 and #8) and Bicron

	background				source check			
	#7 cpm	#8 cpm	Bicron μrem/hr	number	#7 cpm	#8 cpm	"background" Bicron[(2)]	number
Mt. Kisco survey								
10/1/97	$9.7\pm0.8\times10^3$	$9.9\pm1.0\times10^3$	6.1±0.8	100	$5.4\pm0.2\times10^4$	$5.4\pm0.2\times10^4$	6.4±0.8	94
10/1/97[(1)]	$9.9\pm0.8\times10^3$	$10.1\pm1.0\times10^3$		100				
10/1/97	$9.8\pm0.9\times10^3$	$10.1\pm1.1\times10^3$	6.8±1.3	100	$5.2\pm0.2\times10^4$	$5.2\pm0.2\times10^4$	6.6±1.1	99
10/1/97[(1)]	$9.8\pm0.9\times10^3$	$10.2\pm1.0\times10^3$		100				
Richard's Lumber survey								
10/6/97	$7.9\pm0.7\times10^3$	$8.7\pm1.2\times10^3$	8.3±0.8	94	$5.1\pm0.2\times10^4$	$4.8\pm0.2\times10^4$	7.8±1.0	100
10/7/97	$8.1\pm0.7\times10^3$	$8.3\pm1.2\times10^3$	7.2±0.9	98	$5.2\pm0.2\times10^4$	$5.1\pm0.2\times10^4$	6.7±0.9	100

[(1)] Data in these two rows are reported as background. Actually they were taken as part of the source check for the Bicron. The Cs^{137} check source was held against the face of the Bicron detector. The distance between the Bicron and the 2x2 NaI detectors was at least 1 meter, meaning the influence of the source on the 2x2 NaI data will be small.

[(2)] This is the reverse of the situation described in the footnote above. The source was near the 2x2 NaI detectors so it will have little effect on the Bicron readings.

Comments:

1) Background 2x2 NaI data are about 1.8×10^3 lower for the Richard's Lumber surveys. The reason for this is that the measurements were made over the paved driveway on the east side of the property. The Bicron data, however, are about one μrem/hr higher. The reason for this is that the 2x2 NaI detectors are resting on the ground, whereas, the Bicron was held above the ground where it "saw" more of the contaminated soil near the driveway.

2) We conclude that the instruments responses on the three days for which we have data are the same. The survey started 9/29/97 (two days before the first recorded data) and ended 10/7/97 (the last date of recorded data).

Discussion of field check source measurements - 2x2 NaI detector used for count rate profiles during soil sampling (DEC #25)
Sixteen background/source checks were made during the soil sampling part of the project period (9/30/97 - 10/9/97). The purpose of these measurements is to monitor instrument performance. These measurements, along with the quality control data, are used to check if instrument field response is consistent with the response at the time of calibration.

Background = 8.0×10^3 cpm standard deviation = 2.0×10^3
Source check = 224×10^3 cpm standard deviation = 9.1×10^3

Plots of these data are shown in Figure J1. The abscissa is just the order of the measurements, essentially equivalent to time. The background data taken later in the project tend to be higher (about 3.5×10^3 cpm) than data taken initially. This is consistent with higher concentrations of Ra226 in the area when the measurements were taken. We chose to do field QC checks near where we were performing surveys, for logistical reasons. Differences of this order cannot be interpreted as an indication of instrument response change. The source check data do not show a time dependence.

Discussion of office check source measurements - Instrument control charts.

Before and after an instrument is taken into the field, it is background and source checked using a Cs^{137} check source that is kept in the office. All instruments have been calibrated by the manufacturer less than one year before this survey. When an instrument is returned after calibration, a series of 20 measurements of background and source check are made over a period of a few days. These values are used to define an average and acceptable range of operation. We use 3 standard deviations as the allowed range.

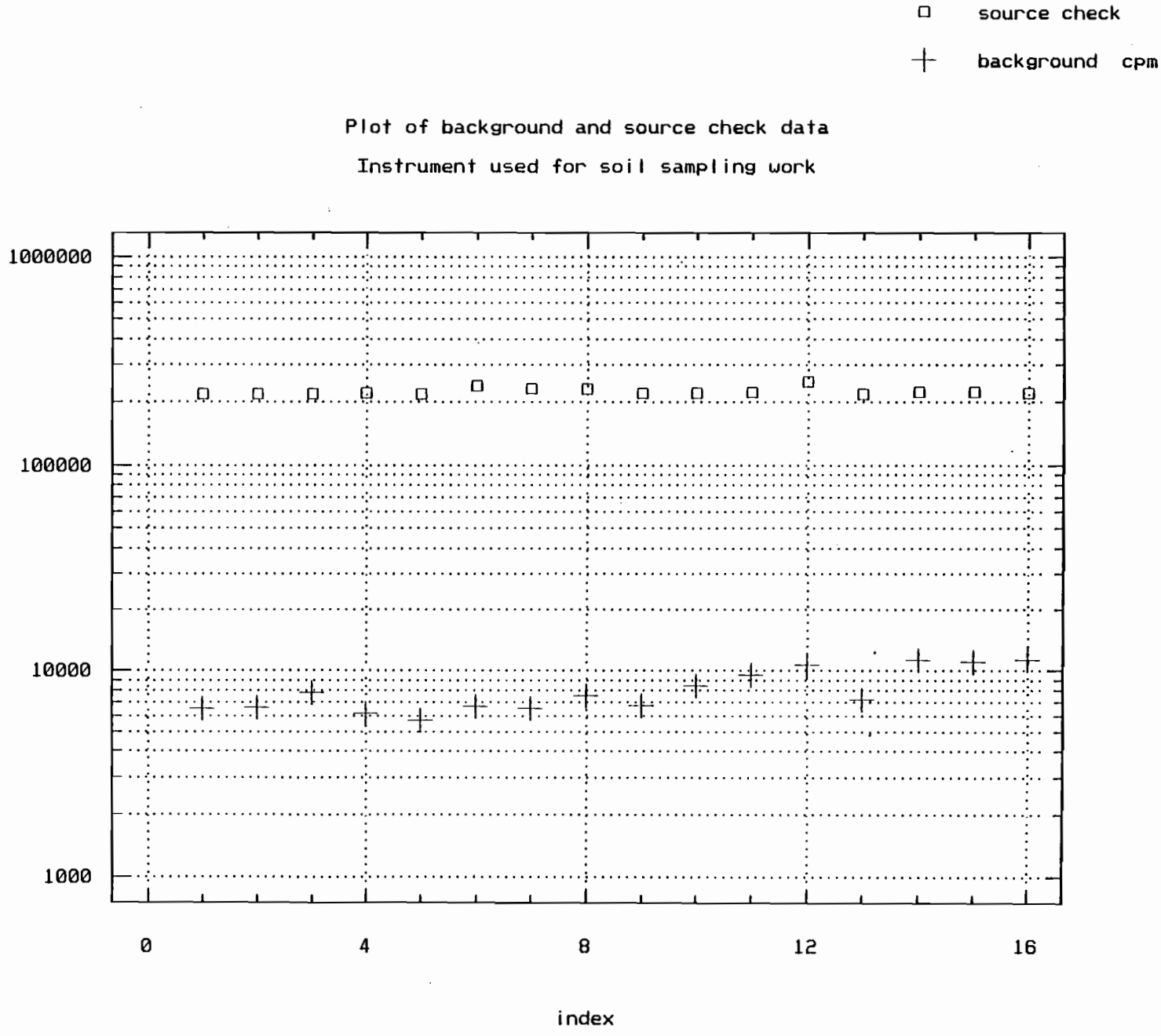

source check
background cpm
Plot of background and source check data
Instrument used for soil sampling work
1000000
100000
10000
1000
0
4
8
12
16
index

FIGURE J1

Table J2 - Instrument control chart data

	Before		After		Expected range is ± 3 std dev.	
	Background	Source	Background	Source	Background	Source
#7	6823 cpm	119849	7420	126883[1]	6753 - 7581	119845 - 121651
#8	6751 cpm	118984	6894	119006	6431 - 7889	117266 - 119305
Bicron	6 µrem/hr	950	6	900	2.3 - 10.3	860 - 1063
#25	6748 cpm	140559	11254	125571[2]	6308 - 7874	140194 - 142446

[1] For detector #7, the source check after the survey was 4% high. Subsequent source checks of the instrument were all within the allowed range for proper operation. No reason for the higher value suggested, but the difference is not large enough to affect interpretation of our results.

[2] The check source used in the office is not taken into the field. A second source is taken into the field for extended projects. Both sources are nominally 1 µ Ci. However, the age of the field source is less. The ratio of the count rates of the two sources is 0.569 (office/field). The field source was mistakenly used to check in the instrument after the project. The actual measurement was 220820 cpm, but when corrected by the ratio, the scaled value is shown in the table. This value is 10% below the expected range. The higher background counts obtained after the project is attributed to check sources being too near the detector during the count.

For detector #8, all measurements were within the expected range.