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Action Program (FUSRAP)

Maywood Chemical Company Superfund Site

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Informal note to Jeff Gratz

MAYWOOD SITE - CHARACTERIZATION OF SOIL SAMPLES FROM THE MAYWOOD CHEMICAL COMPANY SITE

Enclosed for your information and use is a copy of the subject document.

If you have any questions, please contact me at (615) 576-5724.

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CHARACTERIZATION OF SOIL SAMPLES FROM THE MAYWOOD CHEMICAL COMPANY SITE

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NAREL

National Air and Radiation Environmental Laboratory

17 March 1993

CHARACTERIZATION OF SOIL SAMPLES FROM THE MAYWOOD CHEMICAL COMPANY SITE

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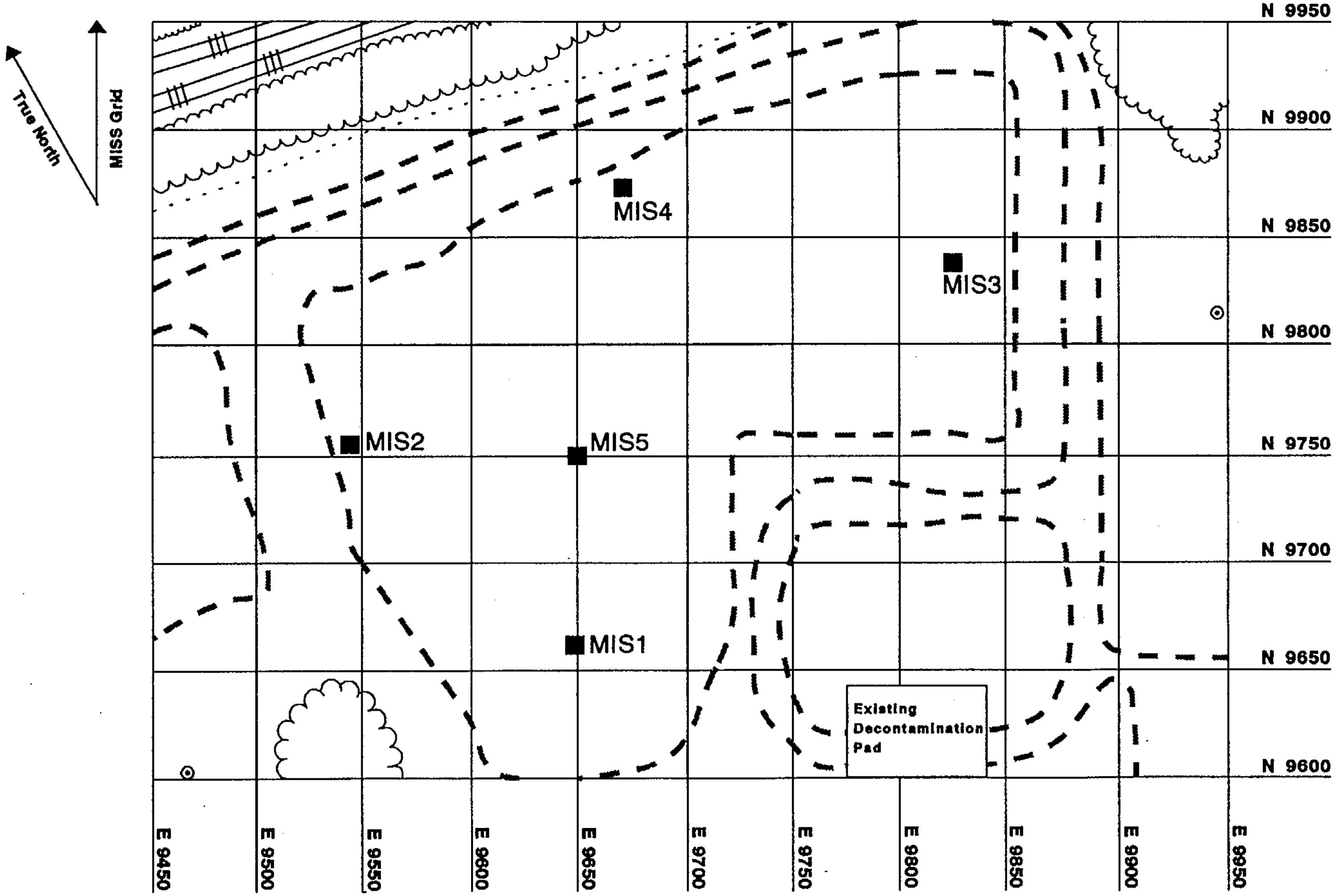
- The fine sand, silt, and clay-size particles can be removed from all but two of the soils tested using size separation techniques, resulting in the separation and collection of up to 80% of the original material. The cleaned soil fraction contains less than 5 pCi/g of thorium-232, uranium-238, radium-226 or radium-228 radioactivity.

- The levels of radioactivity, organic compounds, pesticides, and metals transferred to the wash water in these tests are below the limits established in 40 CFR part 261.

FIGURE 1



Maywood FUSRAP Site Sampling Locations for Samples MIS1-MIS5

2.0 Particle Size Distribution

2.1 WHOLE SOIL

NAREL received twenty soil samples for study. The samples were visually inspected and the beta/gamma radioactivity measured using a Geiger/Muller tube. The five borehole samples collected from the pile were labelled MIS for Maywood Interim Storage Site. The fifteen samples collected from the site were labelled MV for Maywood Vicinity. The descriptions of samples MV1-MV15 are listed in Table 1. After initial screening for gross radioactivity, each sample was thoroughly mixed and dried at 60°C. Each sample was then analyzed for radioactivity by gamma spectroscopy as described in Section 3.1 prior to further analysis and alpha spectroscopy as described in Section 3.2.

2.2 VIGOROUS WASH

Each whole soil sample was vigorously washed before further analysis (SCA91a). The vigorous washing process liberates small contaminated particles from larger uncontaminated particles and reduces the size of colloidal material. The wash water from each sample was analyzed for radioactivity by gamma spectroscopy as described in Section 3.1 and for chemical contaminants as described in Section 4.0.

2.3 WET SIEVING

After vigorous washing, samples MIS1-MIS5 were fractionated according to particle size using ASTME standard test sieves (SCA91b). The samples were separated at 6.3 mm (¼"), 0.30 mm (50 mesh), 0.15 mm (100 mesh), and 0.075 mm (200 mesh). Samples MV3-MV5, MV7-MV12, MV14, and MV15 were separated as described above, with additional fractionation at 1.18 mm (16 mesh), 0.60 mm (30 mesh), 0.106 mm (140 mesh), 0.053 mm (270 mesh), and 0.045 mm (325 mesh) to provide additional particle-size distribution information. The resulting fractions were dried at 60°C, analyzed for radioactivity as described in Section 3.0, and analyzed petrographically as described in Section 5.0.

2.4 VERTICAL-COLUMN HYDROCLASSIFICATION

Vertical-column hydroclassification is a method for separating contaminated soils by size,

3.0 Radiochemical Analysis

3.1 GAMMA SPECTROSCOPY

Each whole soil sample, particle size fraction, and wash water was analyzed for gamma emitting radionuclides using high-purity germanium detectors (EPA80). Three separate aliquots of each of the 15 whole soil samples collected from the site were analyzed to obtain average radionuclide concentrations for that sample location. Two aliquots of each of the five borehole samples of the pile, which constituted the entire sample, were analyzed for gamma emitting radionuclides. The sample size for each analysis is listed in Tables 2-1 through 2-25. The samples were counted for a maximum of 1000 minutes. The major radionuclides identified in the samples were radium-226 and radium-228. Tables 2-1 through 2-25 list the radium results for each gamma analysis along with the 2-sigma counting uncertainty. Gamma spectroscopy was performed on heavy mineral fractions, separated as described in Section 5.0, containing sufficient material (10 g or more) for the analysis. These results are listed in Table 8. When no radioactivity was detected, the minimum detectable concentration (MDC) is listed.

3.2 ALPHA SPECTROSCOPY

Aliquots of each whole soil sample, particle size fractions from samples MIS2 (sieved), MV1, MV6, MV8, MV13, and heavy mineral fractions from MV1 were solubilized in hot acid mixtures. The sample size for each analysis is listed in Tables 3-1 through 3-7. Uranium was extracted from the mixture, coprecipitated with lanthanum fluoride carrier, and analyzed by alpha spectroscopy (EPA84). Thorium was separated by ion-exchange chromatography, coprecipitated with lanthanum fluoride carrier, and analyzed by alpha spectroscopy (EPA84). The uranium-238 and thorium-232 results are listed in Tables 3-1 through 3-7.

Sample MIS2 was selected as representative of the samples from the Maywood pile for individual size fraction analysis based on the sample appearance and radionuclide concentrations found in the whole soil. Samples MV1 and MV6 were selected for individual size fraction analysis because of the relatively high levels of radium remaining in each of the size fractions. The particles between .020 and .045 mm separated from sample MV1 were not analyzed by alpha spectroscopy because all the size fraction was used for the heavy mineral separation. Samples MV8 and MV13 were selected as representative of the average

4.0 Chemical Contaminants

The determination of the particle size distribution of arsenic in the Maywood soil was requested as part of this project. In order to comply with disposal requirements for the wash water used in these experiments, it was necessary to perform several analyses on selected sample fractions. The different analyses performed are described in this section.

4.1 VOLATILE ORGANIC COMPOUNDS

The composite wash water sample from samples MIS1-MIS5 was analyzed for volatile organic compounds using EPA Method 8240. The results of this analysis are listed in Table 4.

4.2 PESTICIDES

The composite wash water sample from samples MIS1-MIS5 was analyzed for pesticides using EPA Methods 8080 and 8140. The results of this analysis are listed in Table 5.

4.3 METALS

The composite wash water sample from samples MIS1-MIS5 was analyzed for the 22 Target Analyte List (TAL) metals and mercury using inductively coupled plasma. The results of this analysis are listed in Table 6-1. The eleven individual particle size fractions for sample MV13 ranging from greater than 6.3 mm (+6.3 mm) through smaller than .020 mm and greater than .010 mm (-.020/+.010 mm) were analyzed for the 22 TAL metals plus boron and molybdenum. The results of these analyses are listed in Table 6-2. Sample MV13 was selected as representative of the soil on the Maywood site. The smallest size fractions, -.010/+.005 mm, -.005/+.002 mm, and -.002 mm, were not analyzed because the concentrations of radionuclides in these fractions were greater than could be accepted by the U.S. Army Corps of Engineers Laboratory performing the analyses.

4.4 ARSENIC

Arsenic was identified as a potential problem at the Maywood FUSRAP site. In addition to the specific size fractions analyzed for arsenic as described above, samples MV2-MV15 were

5.0 Petrographic Analysis

Petrographic examination was performed on the Maywood FUSRAP site samples in accordance with the Office of Radiation and Indoor Air (ORIA) Characterization Protocol for Radioactive Contaminated Soils (EPA92). The purpose of this examination is to determine the physical properties and waste forms of the radioactive contaminants and the distribution of the waste forms within the various size fractions. The physical properties of the soils are used to assist in the assessment of selected remediation methods.

The samples were separated by size as described in Section 2.0. The heavy (more dense) minerals in the -0.30/+0.15 (or -0.25/+0.15 for hydroclassified fractions), -0.15/+0.106, -0.106/+0.075, -0.075/+0.053, -0.053/+0.045, and -0.045/+0.020 mm fractions for each sample were separated by the sink-float method using a solution of sodium polytungstate with a density of 2.89 g/cc (CAL87). The density separations for heavy minerals facilitate the identification of waste forms and indicate the potential for separating radioactive material using density techniques.

The composition of the gravel (+6.3 mm) and the coarse sand (-6.3/+0.60 mm) size material was determined by megascopic (visual) methods. The sand and coarse silt-size material (-0.60/+0.045 mm) was examined using both binocular and polarizing petrographic microscopes. Heavy mineral fractions from this size range were also inspected with the petrographic microscope. A statistical count of 150 to 300 particles was obtained from each size fraction and each heavy mineral fraction. The fine silt and clay-size particles (-0.045 mm) were analyzed by x-ray diffraction. The average mineral composition for each sample is listed in Table 9-1 for the Maywood site samples and Table 9-2 for the Maywood pile samples. The results of the petrographic examinations of the individual size fractions for samples MV1-MV15 are listed in Tables 10-1 through 10-15. The average composition of the heavy mineral fractions for the Maywood site samples are listed in Table 11. Table 11-1 shows the average composition in the sand size particles, while Table 11-2 shows the average composition in the silt size particles.

6.0 Discussion

6.1 GAMMA SPECTROSCOPY

Each whole soil sample, particle size fraction, wash water, and selected heavy mineral fractions were analyzed for gamma emitting radionuclides using high-purity germanium detectors. The results listed in Tables 2-1 through 2-25 show the radium-226 and radium-228 activities for each analysis. No artificially produced radionuclides were detected, and no significant levels of other radionuclides were detected other than the decay products of uranium-238 and thorium-232.

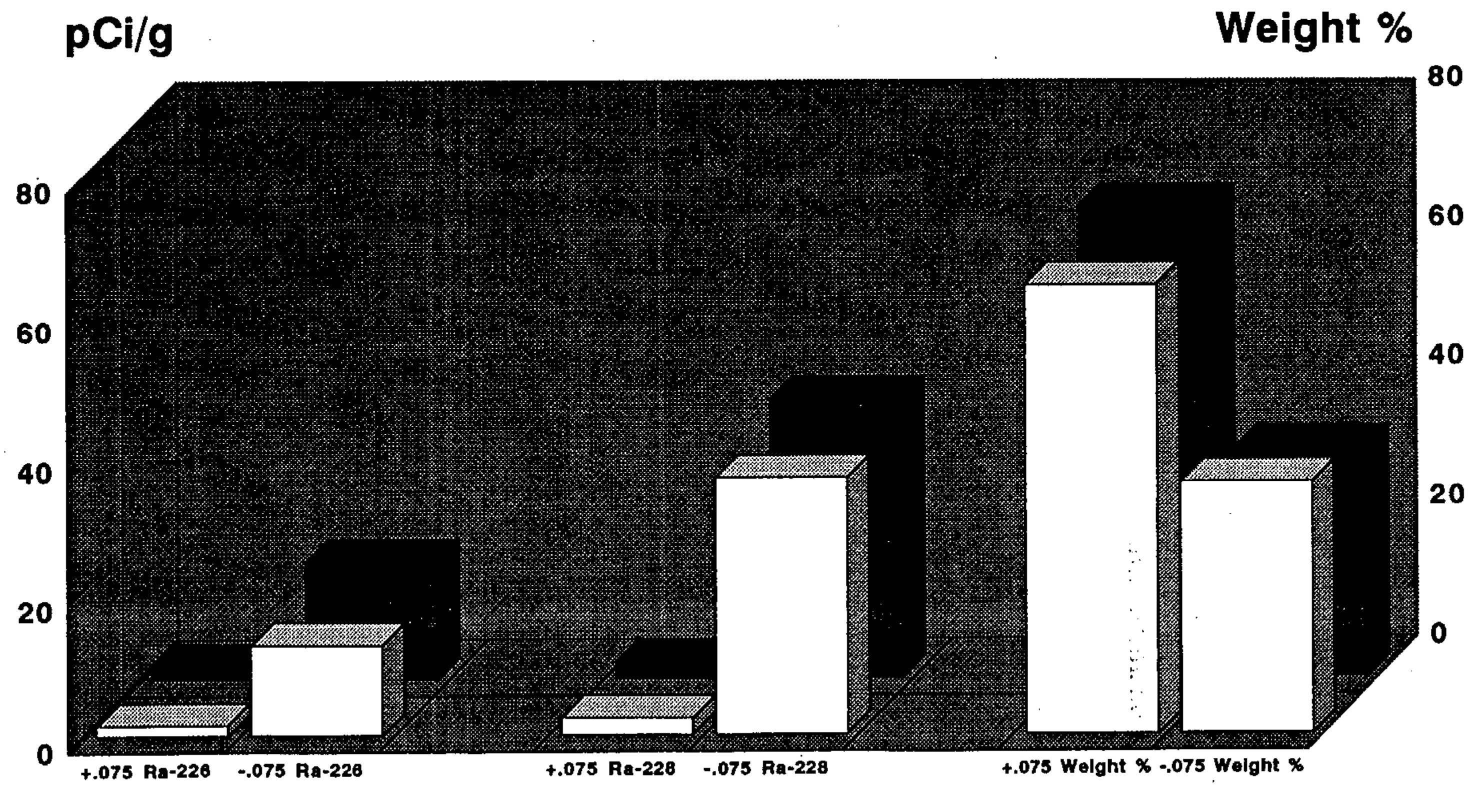
The radium-226 concentration calculation is based on the 186 keV gamma ray with an intensity of 3.28% (DOE81). The radium-228 concentration calculation is based on the 911 (27.7% intensity) and 969 keV (16.6% intensity) gamma rays. A minimum detectable concentration of 0.2 pCi/g for each radionuclide is achieved for most measurements.

The concentrations of radionuclides detected in the whole soil samples varied from 0.604 pCi/g radium-228 in sample MV7 to 259 pCi/g radium-228 in sample MV1. The background levels for the Maywood FUSRAP site are estimated to be approximately 1-1.5 pCi/g radium-226 and 1 pCi/g radium-228. This estimate is based on the lowest radionuclide concentrations measured for the twenty samples. The average concentrations for samples MV2-MV15 are 3.0 pCi/g radium-226 and 4.5 pCi/g radium-228, calculated from the mean activities for the whole soil samples. The average radionuclide concentrations for the borehole samples MIS1-MIS5 are 6.3 pCi/g radium-226 and 17 pCi/g radium-228.

Every sample tested indicates that the majority of the radioactivity is associated with the silt and clay-size particles. Sample MV13 contains an average of 4.36 pCi/g radium-228 in the particles greater than .045 mm in diameter (weighted mean based on fraction weight), but the particles less than .002 mm in diameter contain 64.6 pCi/g, almost fifteen times that amount. Similar increases in radionuclide concentrations for the smallest particle sizes are seen in all of the samples tested, even samples MV1 and MV6 where the radionuclide concentrations in the coarser particles remain above 5 pCi/g.

Figure 2 compares the gamma spectroscopy results for the wet sieved fractions of sample MIS1 to the gamma spectroscopy results for the hydroclassified fractions of the same sample

FIGURE 2
Maywood FUSRAP Site
Wet Sieving versus Hydroclassification



Hydroclassification ■	1.63	16.6		2.24	40		67.3	32.7
Wet Sieve □	1.47	12.8		2.42	36.6		64.1	35.9

Separation at .075 mm
Sample MIS1

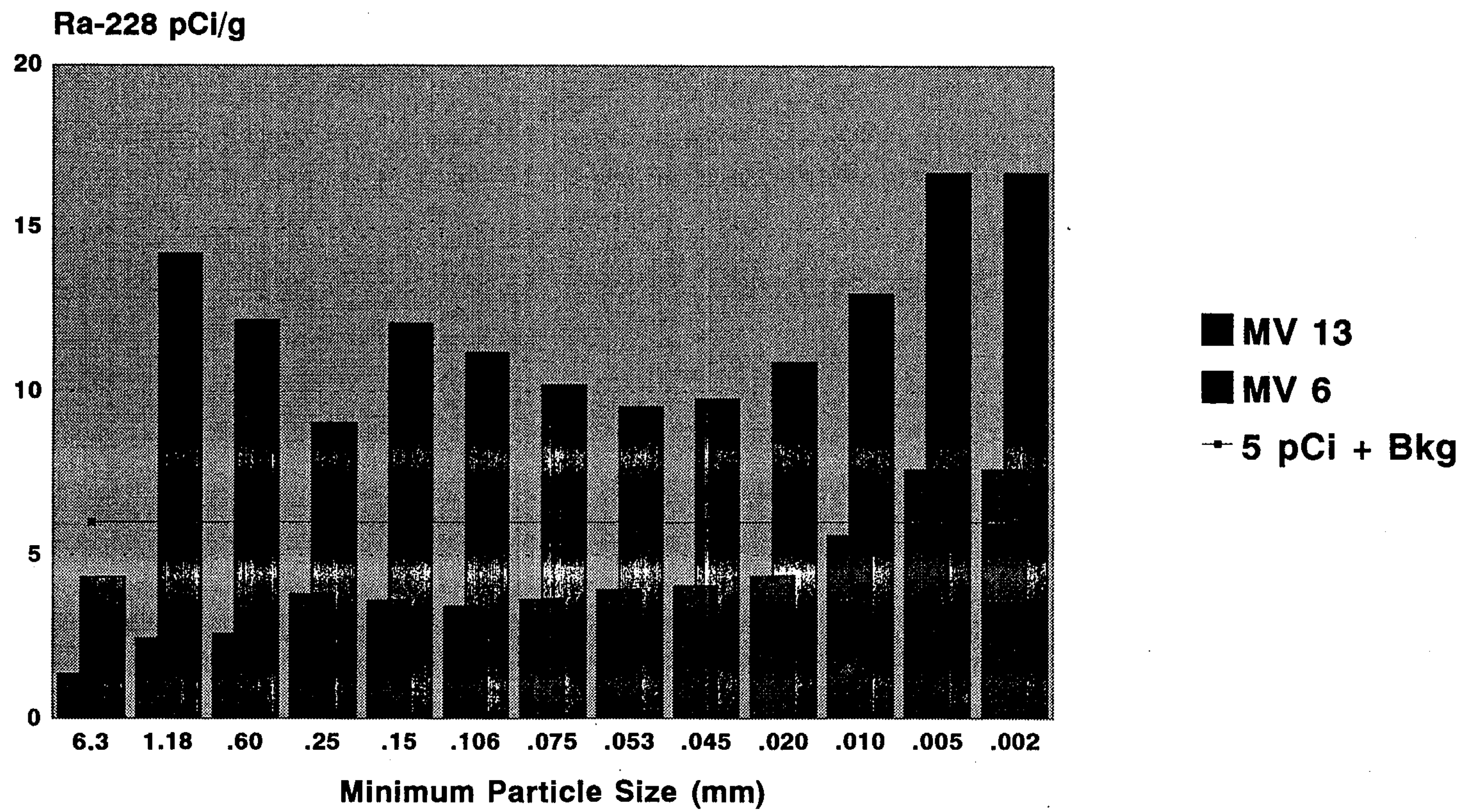
May 1991

(see Tables 2-16 and 2-17). The average concentrations of radium-226 and radium-228 were calculated for a simulated particle size separation at .075 mm (200 mesh), along with the weight percent that would be found in each fraction. The results show that 64.1% of the soil would have the radium-228 concentration reduced from 23.2 pCi/g to 2.42 pCi/g through the use of soil washing and sieving, while 67.3% of the soil would be reduced to 2.24 pCi/g through the use of soil washing and hydroclassification separation techniques. The difference between the two methods is less than the combined uncertainties in the sample selection, the radiation measurements, and the weight measurements. The total uncertainty in these measurements is estimated to be ±10%.

The radium-228 concentration is equal to or greater than the radium-226 concentration for most of the samples analyzed. As the radioactivity in a sample fraction approaches background, the radium-228 concentration approaches the radium-226 concentration. As the radioactivity in a sample fraction increases, the ratio of radium-228 concentration to radium-226 concentration increases. This ratio is as high as 7.4:1 for the -.15/+.106 mm particles separated from sample MV1, but is generally less than 2:1 for other samples. Most examples discussed involve the radium-228 concentration, because this is generally the higher of the two radionuclide concentrations.

Figure 3 is a graph showing the average radium-228 concentration of all particles greater than a given particle diameter for samples MV6 and MV13. If the soil were separated at the indicated particle size, the oversize material would contain the radium-228 concentration indicated. This graph can be used to predict whether a particular soil can be remediated using particle size separation by finding the smallest particle size separation that produces an oversize fraction concentration below the cleanup standards for the site. Figure 3 has a horizontal line at 5 pCi/g above background, or 6 pCi/g. This is an arbitrary cleanup standard that is presented here only to illustrate the use of this figure. Figure 3 shows that particle size separation of sample MV6 at 6.3 mm would produce a remediated fraction with a concentration below the cleanup criterion. Table 2-6 lists the weight percent of the sample that could be remediated as 2.37%. Any size separation below 6.3 mm would produce a remediated fraction with a concentration above the cleanup criterion. MV13, however, shows that a particle size separation at 0.010 mm produces an oversize fraction with a radium-228 concentration of 5.61 pCi/g. Summing the weight percents for the particle sizes listed in Table 2-13 illustrates that 89.7% of the material could be remediated for this sample.

FIGURE 3
MAYWOOD FUSRAP SITE
Ra-228 in Oversize Particle Fraction



Samples MV6 and MV13
January 1993

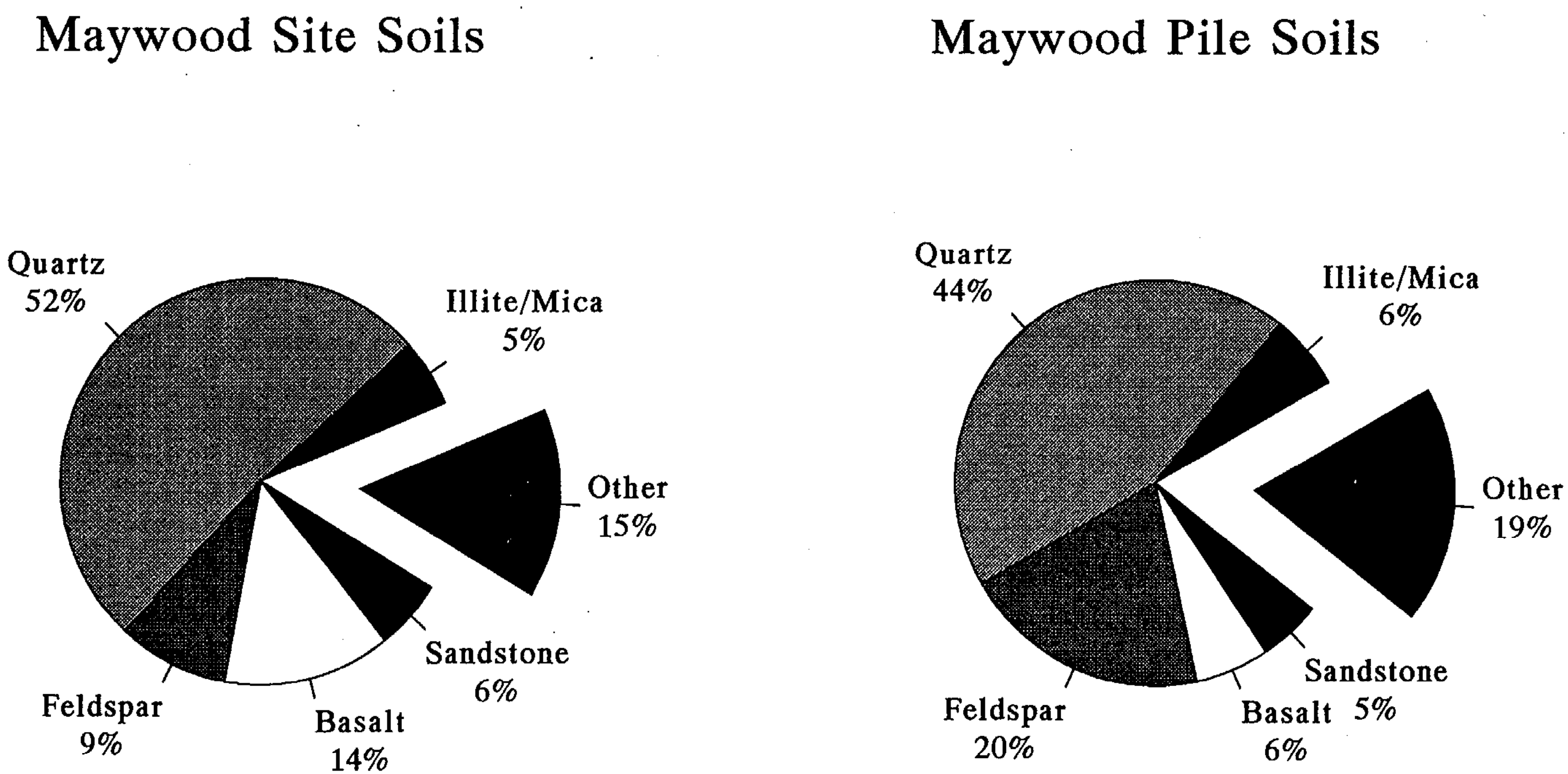
6.2 ALPHA SPECTROSCOPY

Each whole soil sample and selected particle size fractions were analyzed for alpha emitting radionuclides. The purpose of these measurements was to determine the equilibrium conditions for the uranium-238 and thorium-232 decay series. By measuring the parent radionuclides, uranium-238 and thorium-232, and the long lived daughter radionuclides, radium-226 and radium-228, respectively, the equilibrium conditions can be determined. The results of the alpha and gamma spectroscopy analyses are compared in Tables 3-1 through 3-7.

The largest source of error in the measurement of the alpha emitting radionuclides is sample aliquoting. The alpha spectroscopy measurement technique is limited by two factors: sample size and sample radionuclide concentration. If the sample size is too large, it is difficult to perform the chemical purification procedure. If the radionuclide concentrations are too high, the detectors can be contaminated and will require replacement. The samples analyzed by alpha spectroscopy were limited to a maximum of one gram of sample and a maximum of 10 pCi per nuclide being measured. The sample size for the gamma analysis was generally 500-1000 times greater than the sample size for the alpha analysis. The large sample aliquot analyzed by gamma spectroscopy, generally the entire sample or sample fraction, reduces the uncertainties associated with analyzing extremely small aliquots of the sample by alpha spectroscopy. This means that the results from the gamma spectrometry analyses are more representative of the whole sample than the results from the alpha spectroscopy analyses.

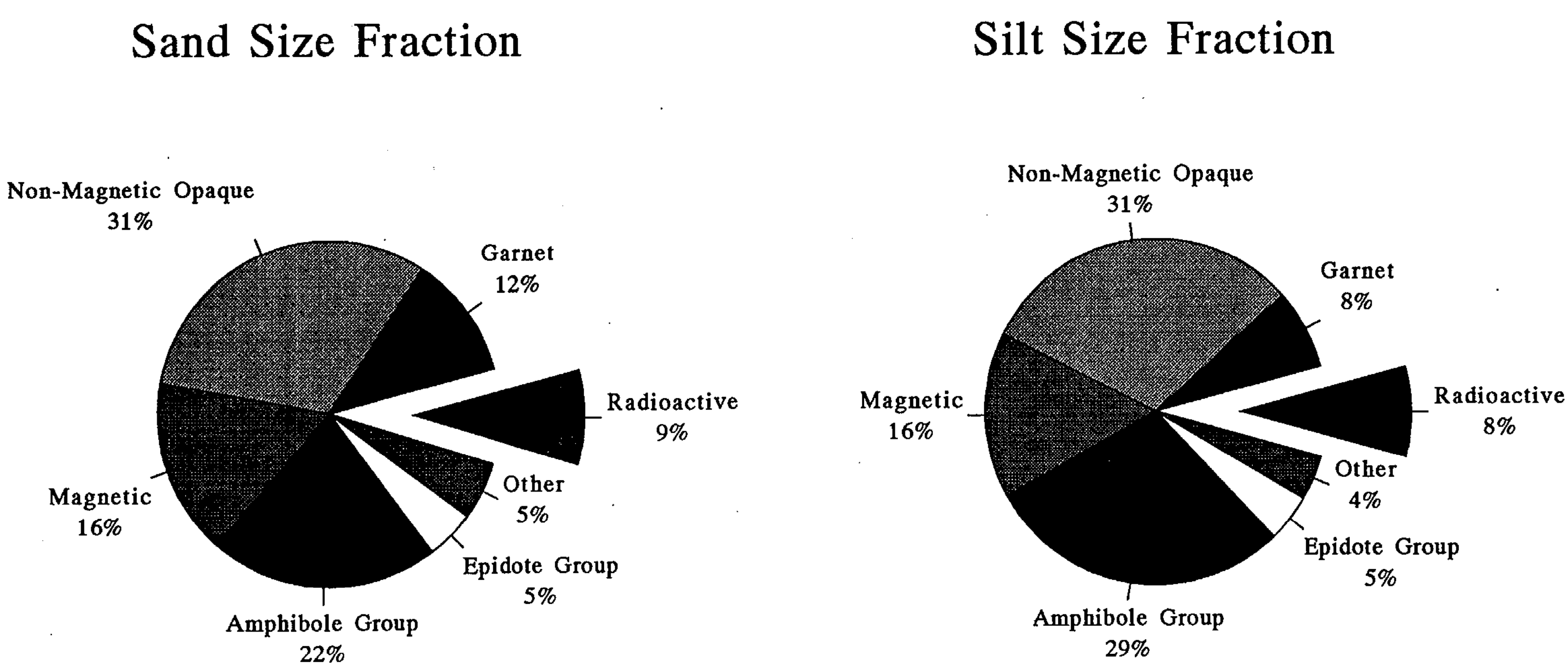
The comparison between the alpha and the gamma analyses for the whole soil samples demonstrates that radium-228 and thorium-232 are in equilibrium; that is, the radium-228 concentration is equal to the thorium-232 concentration. Sample MV1 contains almost twice as much thorium-232 as radium-228, but this is probably due to aliquoting errors from the small sample size analyzed for alpha spectroscopy. The individual size fractions from MV1 show that the sample is in equilibrium (Table 3-2). The equilibrium of uranium-238 and the radium-226 is more difficult to determine. Some samples, such as MV1, have virtually identical measurement values, 106 pCi/g uranium-238 and 107 pCi/g radium-226. Other samples contain considerably less uranium-238 than radium-226, such as 2.41 pCi/g and 6.17 pCi/g, respectively, for sample MV13. All the samples show that the uranium-238 concentration is equal to or less than the radium-226 concentration. In each case, using the radium concentration to estimate the concentration of the parent radionuclide will produce a conservative result.

FIGURE 4
Average Percent Composition of Maywood FUSRAP Site



Other material includes granitic rock, heavy minerals, chlorite, kaolinite and minor additional material.

FIGURE 5
Average Percent Composition of Heavy Mineral Fraction



Radioactive heavy minerals include monazite and zircon.
Other heavy minerals include artificial augite (samples MV4 and MV10), rutile, and minor additional.

MV1-MV15 are listed in Table 11-1 (-.30/+.075 mm) and Table 11-2 (-.075/+.045 mm).

Coarse Fractions (greater than 0.6 mm)

The coarse fractions are those greater than 0.6 mm. These fractions can be readily examined visually for their composition and physical properties. In this investigation, the coarse material includes those particles greater than 6.3 mm (gravel) and those particles between 0.60 mm and 6.3 mm. The weight percent of the coarse fractions in the 15 samples averages 24 percent with ranges between 12 and 57 percent. Except for homogeneous quartz and feldspar, the composition is unique to the coarse fractions with very minor occurrence in the median or fine fractions. Radioactivity in these coarse fractions is usually background or minimal in relation to the finer fractions (Tables 2-1 through 2-15). Samples MV1 and MV6 are the only coarse fractions that contain radionuclide concentrations greater than 5 pCi/g.

The following observations were made during the petrographic examination of the samples, and are based on the experience of the petrographer:

- Rock Groups: Granitic, basalt, sandstone, quartzite, and minor coal are predominantly subrounded to subangular, dense particles typically with background radioactivity. An analysis of the rocks, quartz, and man-made materials from sample MV1 was conducted for radium-226 and radium-228. Calculations from the data for the +1.18 mm particles show that less than 5% of the radioactivity in the coarse fraction of sample MV1 is contained in these three groups (Table 8, MV1 +1.18 mm). This material has few pores, vugs, or fractures that might mechanically retain radioactive fines.

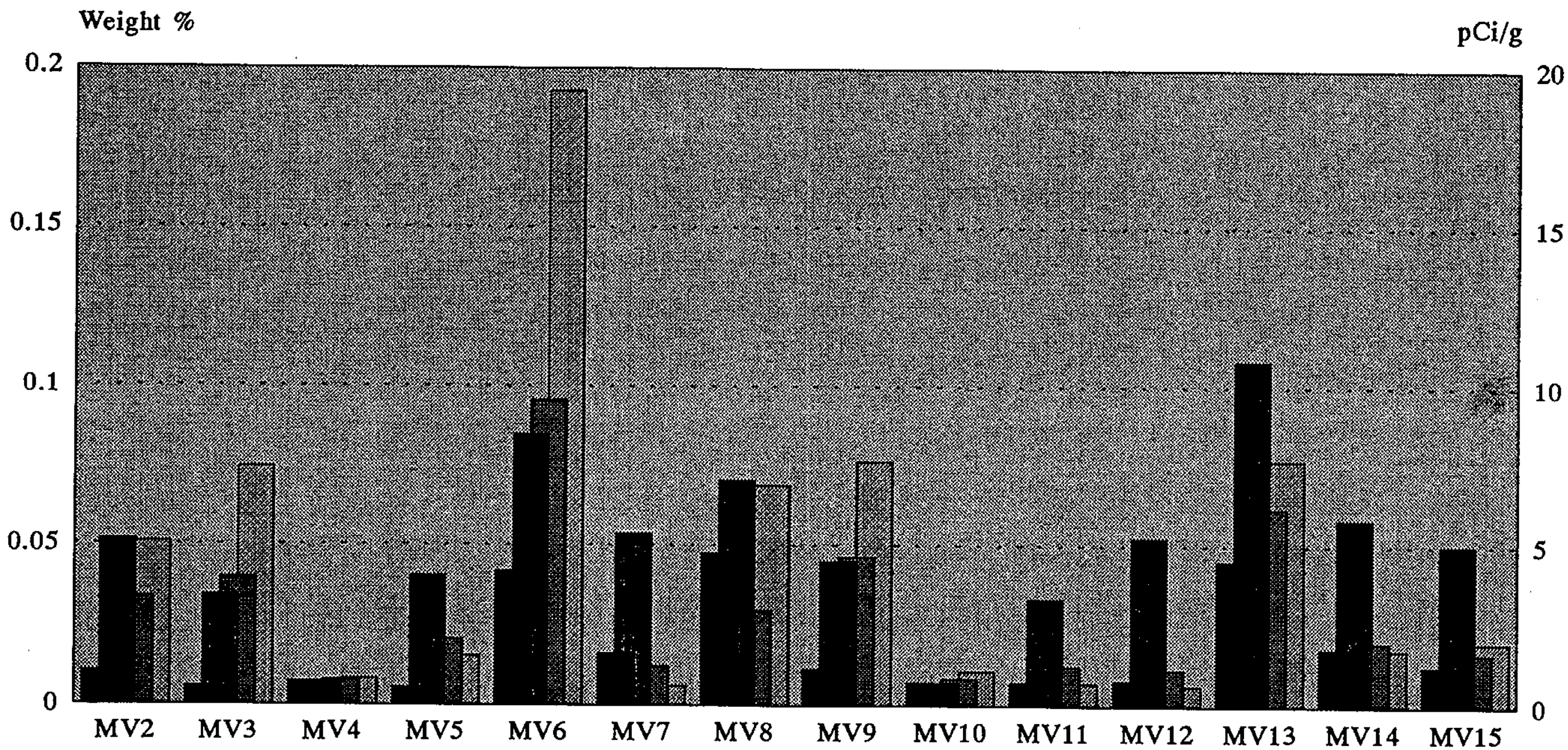
- Furnace-fired cinder/slag particles comprise from a few percent to more than half of some coarse fractions (Tables 10-1 through 10-15). These particles range from predominantly subrounded, porous, lightweight, and structurally weak material to particles tending toward more flat and less equidimensional shape and with denser, less porous structure. Most of these particles contain levels of radioactivity slightly above background because of minor amounts of uraninite that normally occur in coal and are retained in coal ash cinders. Radionuclide concentrations above 5 pCi/g that occur in samples MV1 and MV6, however, appear related to associated thorium extraction precipitates found in the samples. These precipitates may be mechanically retained in pores or fractures of the cinders and slag particles. An analysis of the cinder/slag material from sample MV1 was performed for radium-226 and radium-228 (Table 8, MV1 +1.18 mm). Almost 50% of the radioactivity in the coarse fraction from sample MV1 is found in these particles.

- Feldspar particles comprise from 5 to 20 percent of the medium fraction (Tables 10-1 through 10-15). These particles are fresh to slightly weathered with essentially equidimensional particle shape. The particles are generally hard and durable with a density similar to quartz and generally free of radioactivity as observed for the quartz particles discussed above (Table 8, MV1 -.25/+.15 mm Light Minerals).

- Heavy minerals (greater than 2.89 specific gravity) generally comprise from 2 to 6 percent of the median fractions (Tables 10-1 through 10-15). Radionuclide concentrations range from negligible in sample MV4 to highly significant in sample MV1 (Table 8). Radionuclide concentrations are proportional to the amounts of monazite and zircon, two radioactive minerals. Figure 6 shows the relationship between monazite and zircon and the radionuclide concentrations in the samples. The information in Figure 6 is compiled from the information found in Tables 2-1 through 2-15, Tables 10-1 through 10-15, and Tables 11-1 through 11-2. In general, the higher the levels of monazite and zircon in the sample, the higher the concentrations of radium-226 and radium-228. Radionuclide concentrations are near background levels in soil samples MV2, MV4, MV5, MV7, MV10, MV11, MV12, MV14, and MV15. Radionuclide concentrations above 5 pCi/g occur in samples MV3, MV6, MV8, MV9, and MV13, with significant levels in MV1. Samples MV4 and MV10 are exceptional in containing 10 to 20 percent heavy minerals but lacking in radioactivity. Figure 7 shows two photographs of the silt size heavy mineral fractions from samples MV10 (top) and MV13 (bottom). The photograph of sample MV10 reveals that the heavy minerals are predominantly artificial augite, with no monazite or zircon present. The mineral augite is not native to the Maywood soil. The augite particles in the photomicrograph are seen to be fractured and layered. The visual appearance of the particles shows that the augite was artificially produced, probably as boiler slag (KR42). Since the artificial augite contains little radioactivity, its presence in the absence of monazite and zircon likely explains the exceptional nature of samples MV4 and MV10. The photograph of the heavy mineral particles from sample MV13 shows several particles of monazite and zircon. Table 11-2 shows that 17% of the heavy minerals in sample MV13 are monazite and zircon, while MV10 contains less than 0.5% of either mineral. Monazite is the principal ore mineral of thorium. The amount of thorium oxide in the mineral varies between 3 and 10 percent, while uranium is approximately 10 percent of the thorium by weight. Monazite has a specific gravity between 4.7 and 5.5 g/cc, and a hardness of 5.0 to 5.5 using Moh's scale. Zircon is a zirconium silicate with up to 4 percent substitution of thorium or uranium for zirconium in the mineral structure. Zircon has a specific gravity between 3.9 and 4.8 g/cc and a hardness of 7.5 using Moh's scale. For comparison gold is 19.3/3.0, iron is 7.9/5.0, and diamond is 3.5/10.0 for specific gravity and hardness, respectively. The percentage distribution of the heavy minerals in order of abundance is generally opaques, amphibole group, garnet, epidote group, zircon, monazite, rutile, and minor amounts of other minerals. Samples MV4 and MV10 are exceptions in containing predominantly augite and minor opaque magnetite. The heavy mineral particles are generally dense, hard, and durable. In sample MV1, the radioactivity is likely related

FIGURE 6

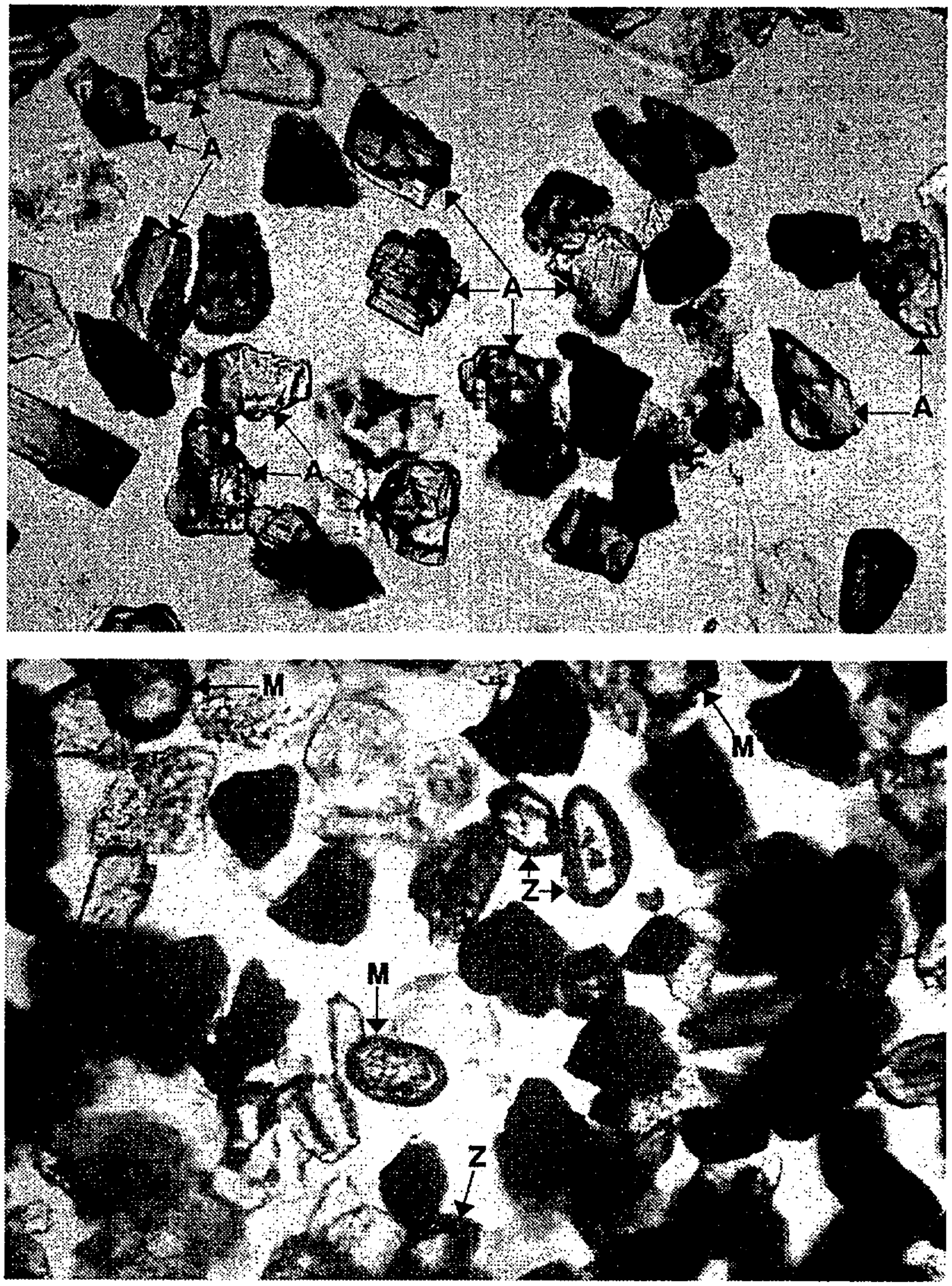
Maywood FUSRAP Site -.30/+.045 mm Particles
Percent Monazite and Zircon vs. Ra-226 and Ra-228 Activity



	MV2	MV3	MV4	MV5	MV6	MV7	MV8	MV9	MV10	MV11	MV12	MV13	MV14	MV15
Monazite %	0.0106	0.0058	0.0074	0.0053	0.0418	0.0163	0.0476	0.0114	0.007	0.0073	0.008	0.04524	0.018	0.0126
Zircon %	0.0515	0.0342	0.0074	0.0403	0.0847	0.0537	0.0704	0.0449	0.007	0.0333	0.0525	0.1081	0.0583	0.05
Ra-226 pCi/g	3.36	3.98	0.808	2.06	9.54	1.22	2.95	4.65	0.854	1.234	1.14	6.17	2.01	1.66
Ra-228 pCi/g	5.08	7.44	0.835	1.54	19.3	0.617	6.88	7.63	1.09	0.708	0.637	7.68	1.78	2.01

Sample MV1 could not be shown on the same scale as the other samples.
Monazite = .2675%, Zircon = .7955%, Ra-226 = 107 pCi/g, and Ra-228 = 241 pCi/g.

FIGURE 7



Photomicrographs of -.053/+.045 mm heavy mineral particles separated from samples MV10 (top) and MV13 (bottom). The heavy mineral particles in sample MV10 are predominantly boiler slag and artificial augite (A). The augite is imperfectly formed with jagged edges. The heavy minerals in sample MV13 contain radioactive monazite (M) and zircon (Z) as well as the indigenous host material.

to calcium-thorium orthophosphate compounds produced as precipitates from the thorium extraction processes (see discussion of gypsum/carbonate material in the section on Coarse Fractions). The radioactivity in sample MV6 is probably related to the calcium-thorium orthophosphate as well: Figure 8 shows two photographs of the heavy minerals found in the -.60/+.25 mm particles of sample MV1. The top photograph shows a particle of calcium - thorium orthophosphate centered in the picture surrounded by particles of monazite and zircon. The bottom photograph shows the high concentration of monazite and zircon particles found in this sample.

- Man-made cinder/slag, concrete, glass, and gypsum/carbonate comprise from trace amounts to 5 percent of the median size fractions of soil (Tables 10-1 through 10-15). The physical properties of these materials are highly variable, but based on the appearance of the particles, they are probably similar to the same types of particles separated in the coarse fractions. For example, gypsum/carbonate is soft, less durable, generally structurally weak, and found in the coarse fractions of samples MV1 and MV6, which exhibit radionuclide concentrations above background levels. The radioactivity in MV1 (Table 8, MV1 +1.18 mm Gypsum/Carbonate) and MV6 in these coarse fractions appears related to thorium orthophosphate compounds incorporated in this material from the thorium extraction materials occurring at these sample locations.

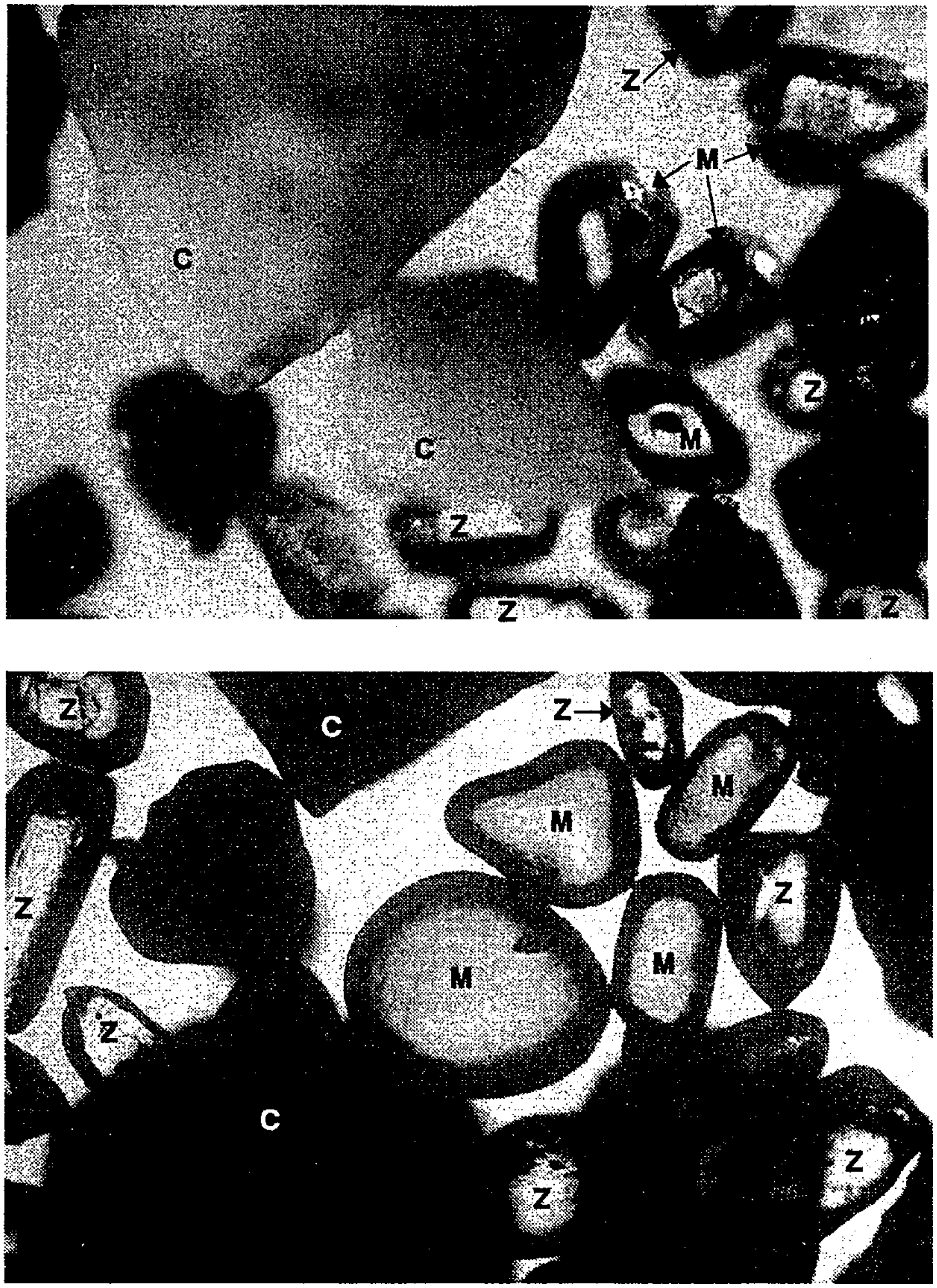
- Clay minerals in the particle size fractions between .045 and .053 mm include trace amounts of illite/mica, chlorite, and kaolinite (Tables 10-1 through 10-15). Their significance with regard to potential radionuclide concentrations is discussed in the fine fraction section.

Fine Fractions (particles less than .045 mm)

The fine fractions comprise all the bulk particles less than .045 mm for all the soil samples. The fine fraction mineral composition was determined by analysis of x-ray diffractograms in accordance with the ORIA Soil Characterization Protocol (EPA92). The physical properties of particles, while not directly observed by this method, may be inferred to be generally similar to the physical properties observed in the particle description of sand and coarse silt (median fractions) with the petrographic and binocular microscope. The reported percentages of mineral composition for the fine fractions are also more qualitative because of the limitations of the x-ray diffraction method when several mineral phases occur together.

The weight percent of the samples for the fine fractions range between 19 and 63 percent with an average of 30 percent (Tables 10-1 through 10-15). Mineral composition for the majority of the samples is, in decreasing order of abundance: quartz, feldspar, clay minerals

FIGURE 8



Photomicrographs of -.60/+.25 mm heavy mineral particles separated from sample MV1. The top photograph shows the radioactive minerals monazite (M) and zircon (Z) mixed with calcium-thorium orthophosphate (C) under reflected light. The bottom photograph shows the same types of particles using transmitted light.

(illite, chlorite, kaolinite, montmorillonite), heavy minerals, and very minor amounts of other minerals. The exceptions are samples MV1, MV2, and MV6 that contain gypsum, anhydrite, calcite, dolomite, and calcium-thorium orthophosphate and other industrial compounds. The quantity of these materials could not be sufficiently developed for the MV1 fines because of inadequate x-ray diffractograms. However, their presence is discernable in the coarse fractions (see discussion on page 17). The gamma analysis of gypsum/carbonate particles picked from the +1.18 mm sieve size material revealed elevated levels of radium-226 and radium-228 (Table 8, MV1 +1.18 mm).

The clay minerals comprise between 20 and 55 percent of the fine fractions (Tables 10-1 through 10-15). The general order of abundance of the clay minerals, except for two samples (MV4 and MV10), are illite, chlorite, and kaolinite; illite constitutes half of the clay mineral suite. The clay mineralogy of samples MV4 is MV10 are generally similar in that montmorillonite makes up approximately 50 percent of the clay minerals for these two samples (Tables 10-4 and 10-10). The remaining illite, chlorite, and kaolinite are in similar proportions as described for the other samples.

The highest radionuclide concentration occurs in the smallest particle size fraction for each of the samples tested except for sample MV2 (Tables 2-1 through 2-15). The -.002 mm particles separated from sample MV2 were organic material that floated away from the host material. For this sample the -.005/+.002 mm particles show the highest radionuclide concentrations. The possible causes of these radionuclide concentrations based on these samples are presented below.

1. Samples MV1 and MV6: The 947 pCi/g (MV1) and 85.4 pCi/g (MV6) of radium-228 in these samples is probably a result of (a) the solid calcium-thorium orthophosphate compound produced in the thorium extraction process and (b) adsorbed thorium on clay mineral surfaces. The presence of calcium-thorium orthophosphate is documented in the larger size particles and would conceivably be present in the fine fractions as well. None of the clay minerals identified by x-ray diffraction contain thorium, so surface adsorption of the ion is the most reasonable explanation for the presence of radioactivity in these fractions. It is also possible that monazite may contribute to the total radioactivity, although it is not discernable on x-ray diffractograms because of interferences from the spectra of the other clay minerals. Additional evaluation using scanning electron microscope SEM/EDX measurements would help determine if monazite is a possible source of the radioactivity.

Common examples of the above are:

- sieving (screening),
- classification,
- gravity separation, and
- flotation.

All of these processes are used extensively in the mining industry, and are commonly performed with soil slurried in water.

Screening is the physical separation of particles on the basis of size. The separation is achieved by passing the material through a uniformly perforated surface, or sieve. Particles larger than the sieve openings are retained on the surface as oversize or plus (+) material. Particles smaller than the sieve openings pass through the sieve as undersize or minus (-) material. Samples MIS1-MIS5, MV3-MV5, MV7-MV12, MV14, and MV15 were tested using standard sieves. The results listed in Tables 2-3 through 2-5, 2-7 through 2-12, 2-14 through 2-16, 2-18, 2-20, 2-22, and 2-24 show that sieving can be successfully applied to the Maywood soils with recovery of clean soil ranging from 60% for sample MV3 to 81% for samples MV8 and MV10.

Classification is the separation of particles according to their settling rate in a fluid, usually water. Settling rate is a function of particle density and shape as well as particle size. The hydroclassification tests performed in this study were designed to evaluate the effectiveness of classification as a particle separation process for the Maywood soils. The results in Tables 2-2, 2-13, 2-17, 2-19, 2-21, 2-23, and 2-25 show that classification can be successfully applied to the Maywood soils with recovery of clean soil ranging from 37% for sample MV2 to 79% for sample MV13. Figure 2 shows that similar results can be obtained using either sieving or classification for the Maywood soils.

Gravity separation methods are based on the density of the particles. The only density analysis performed as part of this study was the heavy liquid separation for petrographic analysis. The identification of monazite and zircon as the major source of radioactivity in the sand size material suggests that a density separation of these minerals would reduce the radioactivity of the sand size particles. The difference between the densities of monazite and zircon, which range from 3.9 and 5.5 g/cc, and the average density of the soil particles, Information about particle liberation is required to determine the optimum washing process for use with the Maywood soils. A vigorous wash was used for the analyses in this report, further tests would be required to determine the attrition/scrubbing procedure that would be most effective as part of the volume reduction process.

Chemical extraction can also be considered for volume and/or radioactivity reduction of the Maywood soils. If the goal of chemical extraction is to remove the monazite and zircon, the residue left from a conventional sulfuric acid or sodium hydroxide extraction will produce radium contaminated residues and may yield chemical waste products more hazardous than the original soil (GR84). Samples MV1 and MV6 also contain calcium-thorium orthophosphate precipitates. This material is probably insoluble residue left from a previous extraction process and may prove difficult to further extract. Additional research using different extractants may indicate a beneficial chemical extraction process.

8.0 References

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9.0 APPENDIX A

MAYWOOD SOIL SAMPLE HISTORY

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The Maywood, New Jersey, FUSRAP site comprises the DOE owned Maywood Interim Storage Site (MISS) and 82 vicinity properties. There is also an interim waste storage pile on the MISS which contains approximately 35000 yd^3 of contaminated soil removed from vicinity properties in remedial operations. Of the twenty Maywood soil samples discussed in this report, five were characterized for potential treatability by NAREL in 1991. These were all taken from the MISS pile at locations shown in Figure 1, and are designated MIS1-MIS5. The results of the 1991 study indicate that a 65% volume reduction might be attainable for the MISS pile soils using particle separation treatment, and a decision was made to conduct further characterization studies at NAREL with a wider range of Maywood samples.

At the time the samples were collected in early 1992, there were more than five hundred 55-gallon drums of drill cuttings from Maywood soil sampling boreholes in storage at the MISS and samples for the Maywood (NAREL) characterization study were selected from these to represent a range of contaminant levels, soil types, and locations on properties with the largest volumes of contaminated soil. Fifteen samples were selected and are designated MV1-MV15 for this report. Sample MV10 is a duplicate of MV4 and MV11 is a duplicate of MV7 although these samples were not identified as duplicates when provided to NAREL. Most of the drums contained soil from a number of boreholes so that there was a range of commingled contaminant concentrations vertically within boreholes, and laterally between boreholes at different locations. Table A lists sample numbers, BNI (Bechtel) storage drum numbers, the Maywood property name, and borehole numbers from which the drill cuttings in the sampled drum were obtained. The coordinates in Table A are the easting and northing survey locations for each borehole represented in the samples. The locations from which the fifteen samples were collected are shown as numbered squares on the maps in Figure 9 through Figure 13. Drill cuttings from some of the boreholes were placed in more than one storage drum and these are shown by multiple numbers at these locations. No locations are marked for samples MV10 and MV11 since these are duplicates of MV4 and MV7.

The range of values for thorium-232, radium-226, and uranium-238 are the laboratory radionuclide analysis results for the soil core samples collected at the indicated borehole locations. The complete analytical data are listed in the Maywood Remedial Investigation Report, and in the numerous individual survey reports for the Maywood properties, which are all part of the Administrative Record for the site. Many of the analytical results were near background levels, and therefore, for most of the samples, the NAREL whole soil gamma spectroscopy results for radium-226 and radium-228 are less than the radium-226 and thorium-232 maxima for borehole drill cuttings included in the samples.

TABLE A
Maywood Soil Sample History Data for Samples MV1-MV15

					Range of Values (pCi/g)			NAREL Whole Soil (pCi/g)		
Sample ID	BNI Drum	Location	Borehole #	Coordinates	Th-232	Ra-226	U-238	Ra-226	Ra-228	Comments
MV1	85	MISS	50C	E10250 N9850	16 - 504	3.2 - 237	<30 - <180	107	241	Sandy, silty, some frozen chunks, 25% plastic sheeting
			51C	E10250 N9950	18 - 637	<9 - 36	<46 - <218			
MV2	104	MISS	71C	E9270 N9755	<9 - 324	<3 - 28	<20 - 21	3.36	5.08	Very sandy, some small chunks, 25% plastic sheeting
			72R	E9965 N9060						
			73R	E9875 N9015						
			74R	E9800 N9065						
			75R	E9800 N9130						
			76C	E9740 N9100	<4 - 353	<2 - 11	<10 - <138			
			77C	E9930 N8980	2 - <6	1 - <4	<8 - <15			
			78C	E10035 N9135	3 - <8	<2 - <6	<11 - <18			
			79R	E9670 N9150						
			80C	E9550 N9350	<2 - 36	<2 - 7	<8 - <69			
			81R	E9550 N9280						
			82C	E9600 N9300	<3 - 137	<2 - 8	<16 - 60			
			83C	E9475 N9350	<4 - 42	<3 - 4	<11 - <34			
			84C	E9500 N9400	<3 - 172	1 - 19	<7 - <101			
			85C	E9415 N9430	<4 - 16	<3 - <5	4 - <24			
			86C	E9600 N9500	<4 - 53	2 - <6	<15 - <40			
MV3	114	MISS	69C	E10005 N9420	2 - 6	1 - 4	<7 - <15	3.98	7.44	Sandy, a lot of large frozen chunks, limited sample, one can sent
			70R	E10065 N9175						
			71C	E9270 N9755	<9 - 324	<3 - 28	<20 - 21			

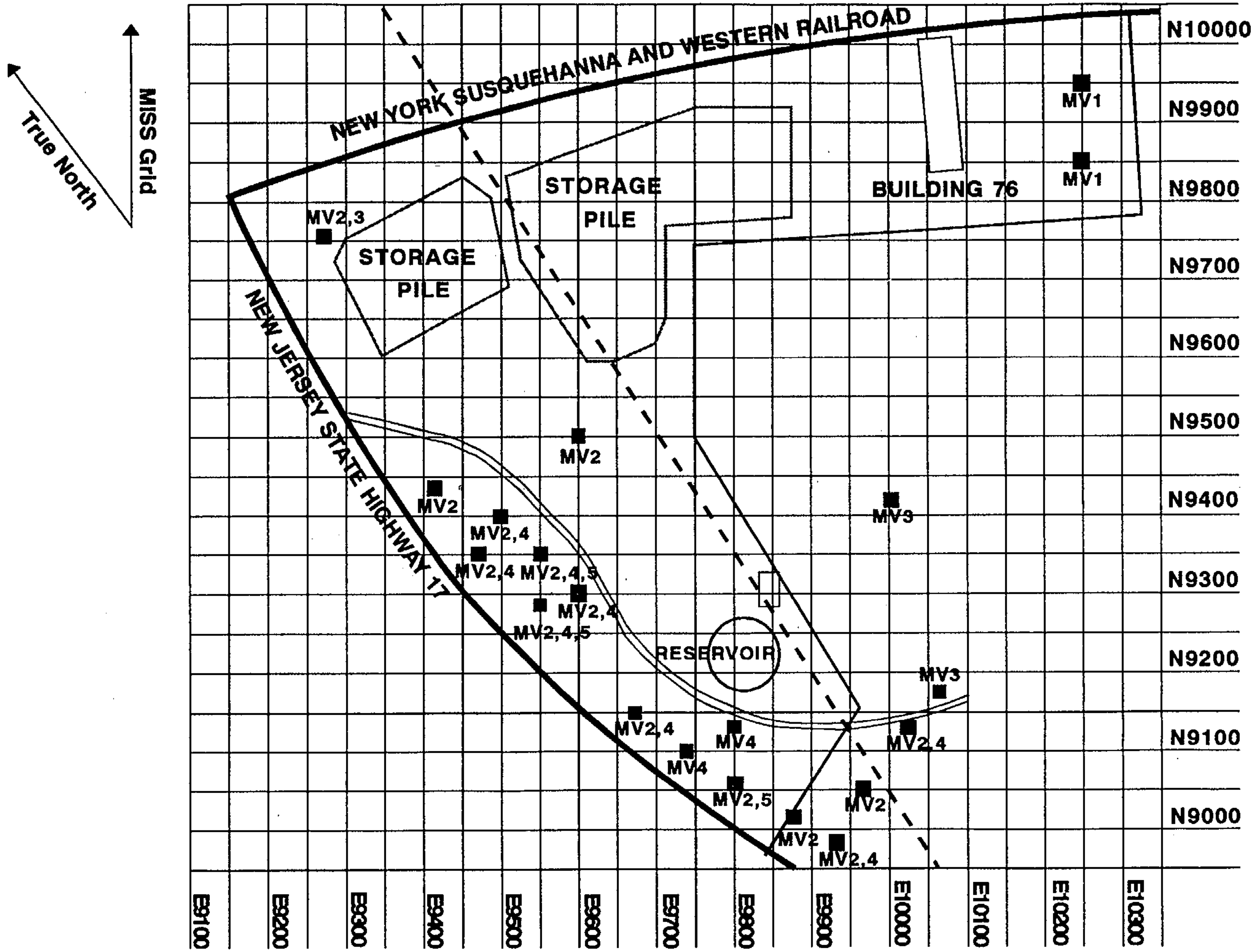
TABLE A (cont.)
Maywood Soil Sample History Data for Samples MV1-MV15

					Range of Values (pCi/g)			NAREL Whole Soil (pCi/g)		
Sample ID	BNI Drum	Location	Borehole #	Coordinates	Th-232	Ra-226	U-238	Ra-226	Ra-228	Comments
MV4	116	MISS	75R	E9800 N9130				.808	.835	Damp, dark soil, some large frozen chunks, plenty of sample
			76C	E9740 N9100	<4 - 353	<2 - 11	<10 - <138			
			77C	E9930 N8980	2 - <6	1 - <4	<8 - <15			
			78C	E10035 N9135	3 - <8	<2 - <6	<11 - <18			
			79R	E9670 N9150						
			80C	E9550 N9350	<2 - 36	<2 - 7	<8 - <69			
			81R	E9550 N9280						
			82C	E9600 N9300	<3 - 137	<2 - 8	<16 - 60			
			83C	E9475 N9350	<4 - 42	<3 - 4	<11 - <34			
			84C	E9500 N9400	<3 - 172	1 - 19	<7 - <101			
MV5	117	MISS	76C	E9740 N9100	<4 - 353	<2 - 11	<10 - <138	2.06	1.54	Damp, dark, fine soil, some frozen chunks
			80C	E9550 N9350	<2 - 36	<2 - 7	<8 - <69			
			81R	E9550 N9280						
MV6	234	Sears	325C	E11415 N8485	<3 - 87	<4 - 16	<13 - 40	9.54	19.3	No observation, sampled 2/18/92, plastic sheeting in drum
MV7	246	Sears	327C	E11085 N8635	<4 - 61	1 - 13	<9 - <88	1.22	.617	No observation, sampled 2/18/92, plastic sheeting in drum
MV8	248	Sears	327C	E11085 N8635	<4 - 61	1 - 13	<9 - <88	2.95	6.88	No observation, sampled 2/18/92, plastic sheeting in drum
			330C	E11350 N9000	<3 - <16	<4 - 5	<13 - <56			
MV9	349	Sears	326C	E10800 N8500	<4 - 34	<2 - 5	<9 - <75	4.65	7.63	No observation, sampled 2/18/92, plastic sheeting in drum
			327C	E11085 N8635	<4 - 61	1 - 13	<9 - <88			

TABLE A (cont.)
Maywood Soil Sample History Data for Samples MV1-MV15

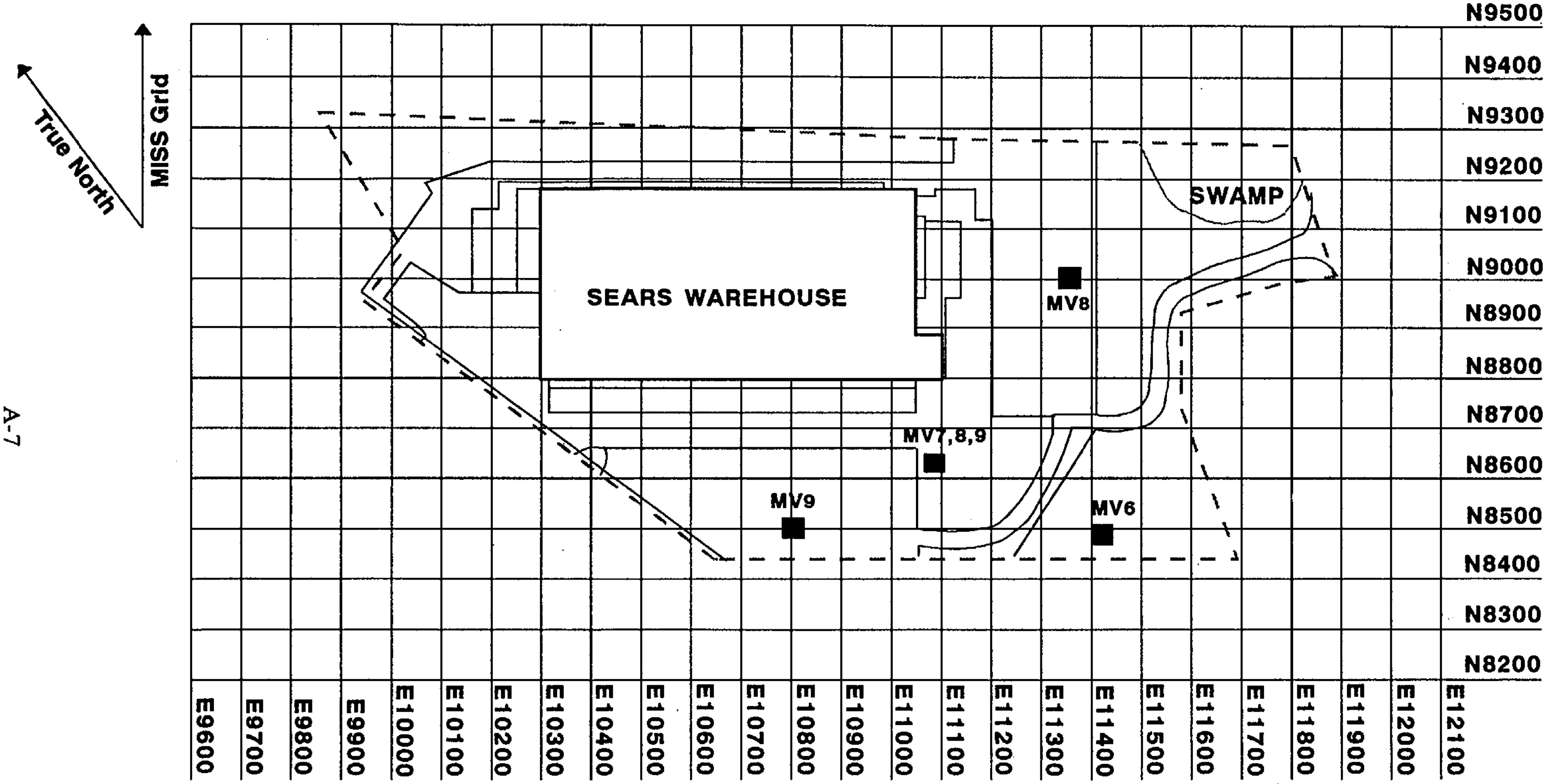
Sample ID	BNI Drum	Location	Borehole #	Coordinates	Range of Values (pCi/g) Th-232	Range of Values (pCi/g) Ra-226	Range of Values (pCi/g) U-238	NAREL Whole Soil (pCi/g) Ra-226	NAREL Whole Soil (pCi/g) Ra-228	Comments
MV10	116	MISS	75R	E9800 N9130				.854	1.09	Duplicate of Sample MV4
			76C	E9740 N9100	<4 - 353	<2 - 11	<10 - <138			
			77C	E9930 N8980	2 - <6	1 - <4	<8 - <15			
			78C	E10035 N9135	3 - <8	<2 - <6	<11 - <18			
			79R	E9670 N9150						
			80C	E9550 N9350	<2 - 36	<2 - 7	<8 - <69			
			81R	E9550 N9280						
			82C	E9600 N9300	<3 - 137	<2 - 8	<16 - 60			
			83C	E9475 N9350	<4 - 42	<3 - 4	<11 - <34			
			84C	E9500 N9400	<3 - 172	1 - 19	<7 - <101			
MV11	246	Sears	327C	E11085 N8635	<4 - 61	1 - 13	<9 - <88	1.23	.708	Duplicate of sample MV7
MV12	137	Fed Ex	125					1.12	.637	Very fine, sandy, orange-brown color
			126R	E11200 N8200						
MV13	213	NJ Vehicle	209					6.17	8.56	
			260R	E1400 N1500	1.1 - 1.8	0.8	<5.7 - <6.3			Sandy, silty, crumbly, best sample, from overpack drum
			261R	E1400 N1400						
MV14	479	Stepan	237R	E10120 N9720				2.01	1.66	Sandy, darker brown, some small frozen chunks with ice
			238R	E10150 N9710						
			239R	E10267 N9685						
MV15	507	Stepan	296C	E10745 N10003				1.66	2.01	Fine, sandy, orange color, very crumbly
			297C	E10550 N9998						

FIGURE 9



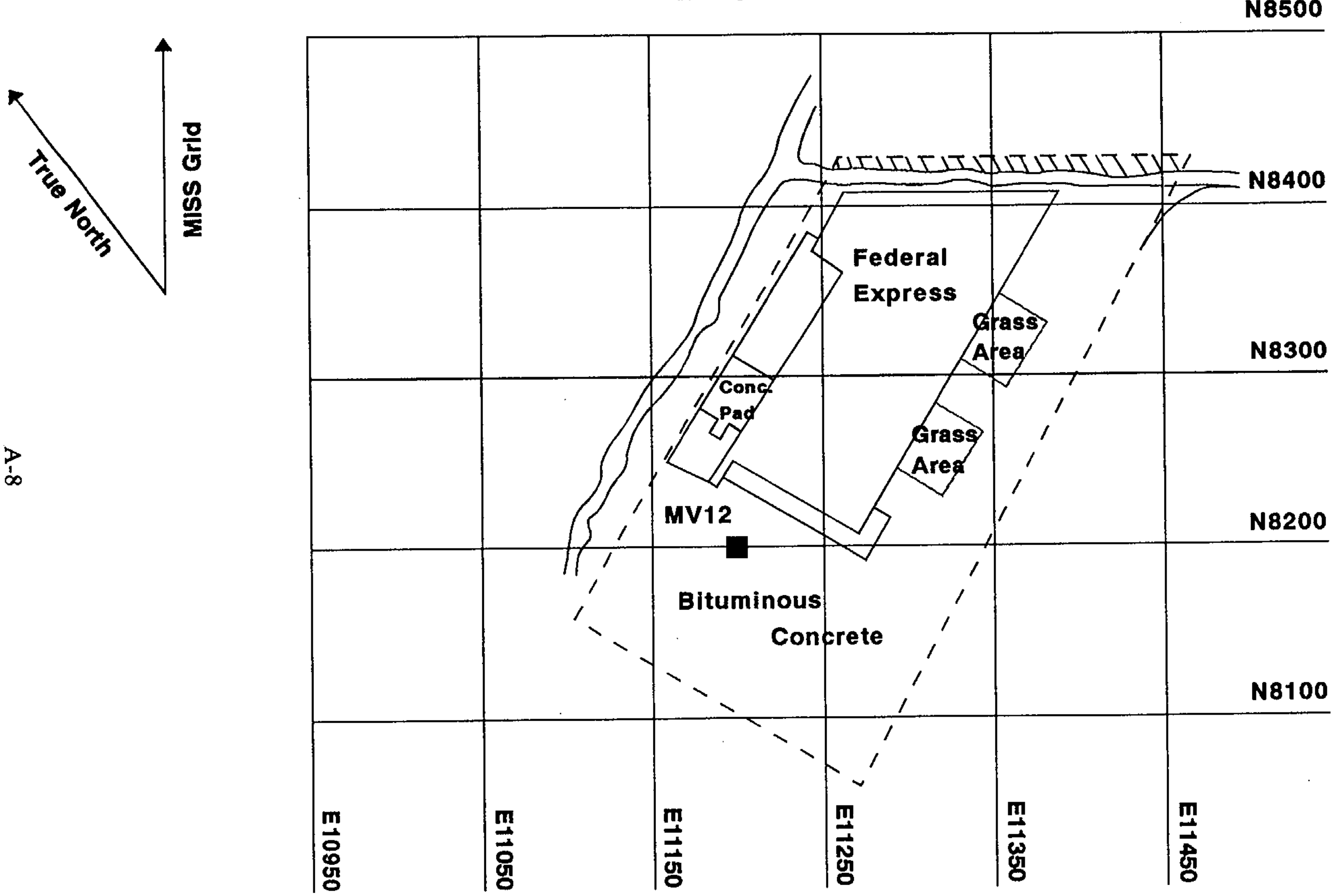
Borehole locations for Samples MV1, MV2, MV3, MV4, and MV5 at the MISS

FIGURE 10



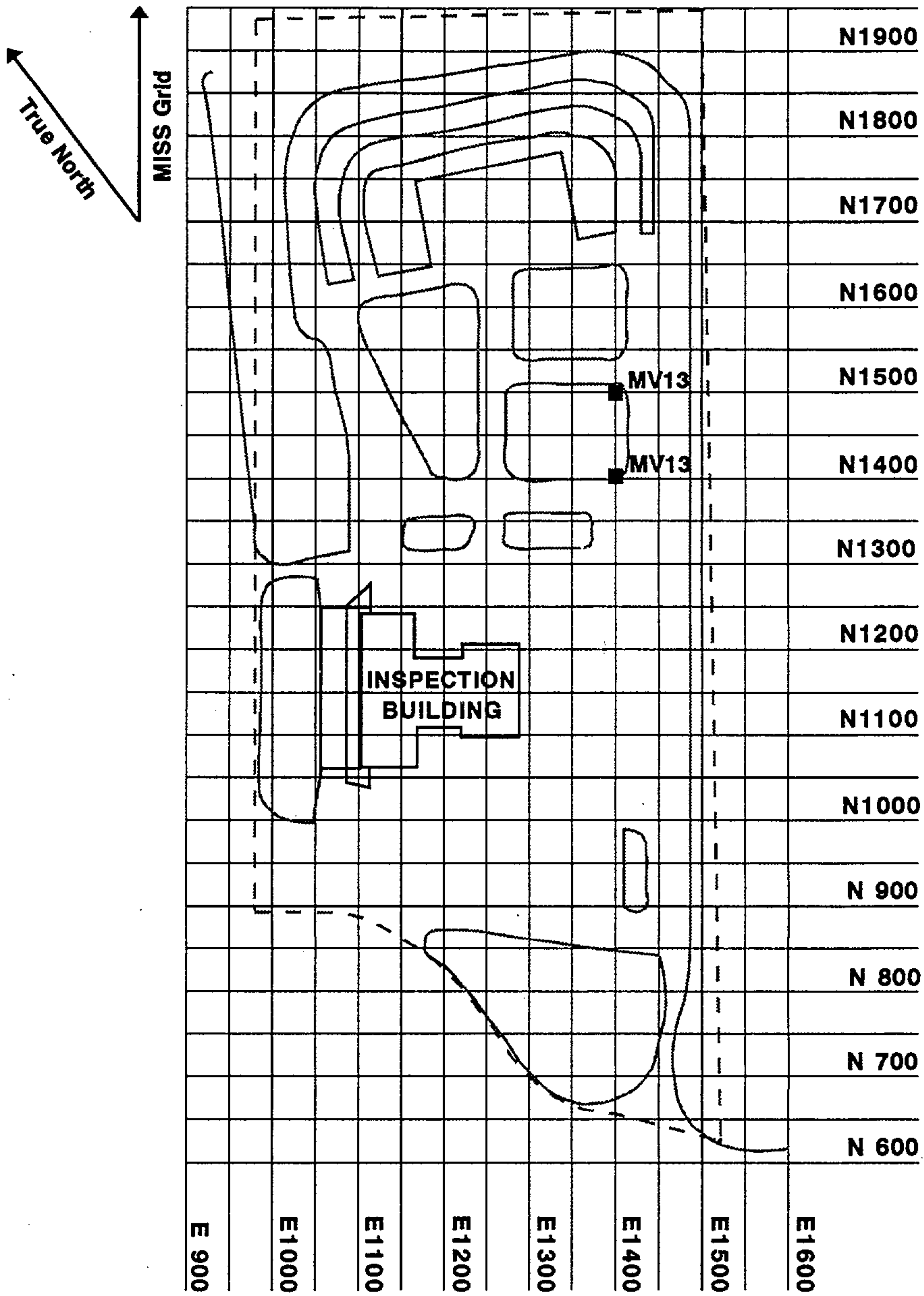
Borehole Locations for Samples MV6, MV7, MV8, and MV9 at the Sears Property

FIGURE 11



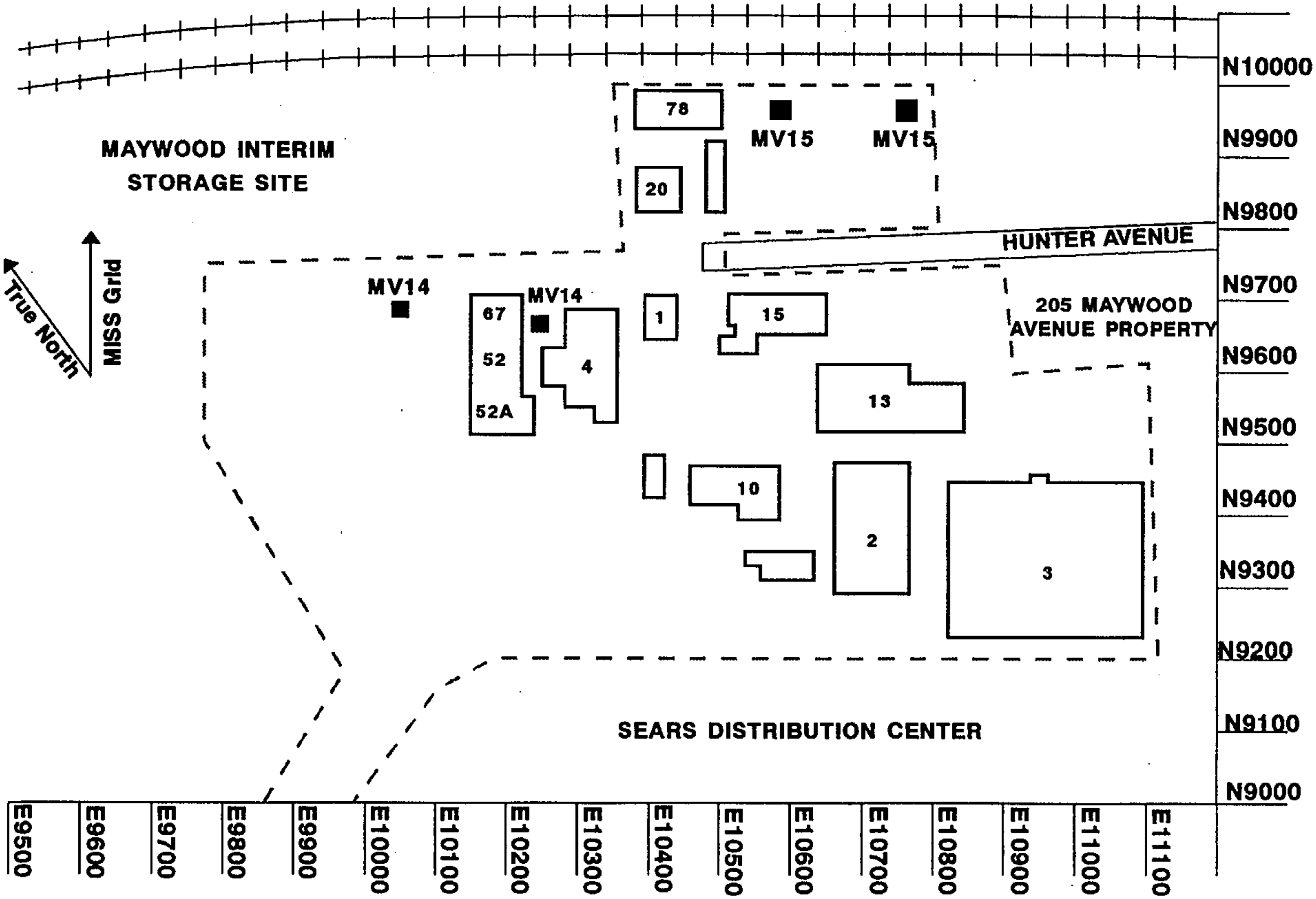
Borehole Location for Sample MV12 at the Federal Express Property

FIGURE 12



Borehole Locations for Sample MV13 at the New Jersey Vehicle Inspection Station Property

FIGURE 13



Borehole Locations for Samples MV14 and MV15 at the Stepan Property

10.0 APPENDIX B

DATA TABLES

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TABLE 2-1
MAYWOOD SITE SAMPLE MV1
Hydroclassified/Sedimented (-.045 mm)

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	511.0	109±2.45	259±0.36	4
Whole Soil	-	-	539.0	107±2.92	234±0.39	4
Whole Soil	-	-	559.0	105±2.18	231±0.36	4
+6.3	189.67	6.29	189.67	27.7±4.00	117±.811	<.5
-6.3/+1.18	158.27	5.24	158.27	29.7±4.28	184±1.01	<.5
-1.18/+.60	126.86	4.20	126.86	38.9±3.50	131±.873	3
-.60/+.25	152.79	5.06	152.79	68.4±5.16	216±1.25	9
-.25/+.15	735.79	24.39	420.20	65.5±4.26	269±.930	8
-.15/+.106	460.06	15.25	460.06	24.8±3.88	184±.663	5
-.106/+.075	243.87	8.08	243.87	67.6±4.99	163±.860	4
-.075/+.053	135.92	4.50	135.92	57.0±5.54	250±1.22	3
-.053/+.045	76.52	2.54	76.52	62.1±6.77	278±2.32	2
-.045/+.020	117.25	3.89	116.21	61.0±4.20	300±.950	1
-.020/+.010	222.64	7.38	221.92	134±3.96	624±.875	<.5
-.010/+.005	143.22	4.75	141.42	235±5.23	807±1.21	<.5
-.005/+.002	254.37	8.43	249.54	268±6.68	947±1.21	0
-.002	0.00	0.00	-	-	-	-
Wash Water[4]	-	-	1.0 Liter	<83.4	21.6±7.45	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-2
MAYWOOD SITE SAMPLE MV2
Hydroclassified/Sedimented (-.045 mm)

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	379.00	3.17±.410	4.29±.066	1
Whole Soil	-	-	355.00	3.65±.670	5.34±.094	1
Whole Soil	-	-	319.00	3.25±.480	5.61±.078	1
+6.3	110.69	5.58	110.69	1.41±.701	1.03±.121	0
-6.3/+1.18	72.50	3.65	31.89	3.41±2.17	1.58±.343	0
-1.18/+.60	52.52	2.65	30.21	2.07±2.05	1.87±.328	0
-.60/+.25	158.78	8.00	158.78	1.20±.902	2.93±.210	0
-.25/+.15	72.72	3.66	51.47	5.96±2.07	1.58±.537	7
-.15/+.106	91.59	4.62	33.96	2.70±1.95	5.18±.381	4
-.106/+.075	81.53	4.11	31.23	2.69±2.28	4.68±.435	3
-.075/+.053	73.88	3.72	29.42	<6.06	3.92±.622	3
-.053/+.045	19.55	0.99	12.00	3.44±3.88	5.85±.893	1
-.045/+.020	174.66	8.80	174.66	3.70±.729	5.40±.167	1
-.020/+.010	251.90	12.70	251.28	3.56±.957	5.56±.205	1
-.010/+.005	418.33	21.08	216.24	4.63±1.10	6.90±.211	<.5
-.005/+.002	405.11	20.42	209.47	4.19±.931	6.95±.195	<.5
-.002	0.47	.024	0.47	<94.8	<29.3	0
Wash Water[4]	-	-	1.0 Liter	<120	<21.9	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-4
MAYWOOD SITE SAMPLE MV4
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	710.90	.712±.173	.777±.021	4
Whole Soil	-	-	640.00	.849±.212	.729±.030	4
Whole Soil	-	-	643.20	.864±.222	.998±.029	4
+6.3	931.69	35.06	688.05	.248±.266	.459±.042	<.5
-6.3/+1.18	481.64	18.12	481.64	.652±.434	.285±.059	<.5
-1.18/+.60	110.07	4.14	110.07	<.819	.265±.085	<.5
-.60/+.30	111.00	4.18	111.00	.733±.539	.270±.081	<.5
-.30/+.15	139.02	5.23	139.02	<.753	<.167	14
-.15/+.106	117.64	4.43	117.64	.426±.423	.404±.079	19
-.106/+.075	93.53	3.52	50.69	1.06±1.16	.585±.187	20
-.075/+.053	66.53	2.50	48.08	1.26±1.23	1.04±.199	19
-.053/+.045	59.79	2.25	46.88	1.47±1.22	1.27±.227	20
-.045	546.59	20.57	394.06	2.23±.592	2.48±.136	2
Wash Water[4]	-	-	1.0 Liter	<76.8	<13.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-5
MAYWOOD SITE SAMPLE MV5
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	547.90	1.92±.265	1.55±.034	3
Whole Soil	-	-	562.20	2.04±.257	1.59±.038	3
Whole Soil	-	-	595.30	2.23±.357	1.47±.045	3
+6.3	154.68	7.09	154.68	4.10±1.03	2.34±.193	<.5
-6.3/+1.18	142.83	6.54	142.83	2.47±.744	1.65±.151	2
-1.18/+.60	153.71	7.04	153.75	.723±.586	.668±.102	2
-.60/+.30	422.22	19.34	422.22	.502±.402	.536±.069	2
-.30/+.15	429.31	19.67	429.31	.865±.547	.582±.094	2
-.15/+.106	193.71	8.87	193.71	.821±.506	.999±.098	4
-.106/+.075	111.08	5.09	111.08	1.54±.585	1.30±.122	5
-.075/+.053	72.42	3.32	45.56	2.06±1.47	1.76±.284	4
-.053/+.045	47.33	2.17	45.67	2.51±1.24	1.94±.221	4
-.045	455.64	20.87	325.10	6.34±.788	6.19±.150	3
Wash Water[4]	-	-	1.0 Liter	<80.7	<17.1	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-7
MAYWOOD SITE SAMPLE MV7
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	567.20	1.24±.223	.604±.031	2
Whole Soil	-	-	590.50	1.29±.200	.617±.027	2
Whole Soil	-	-	589.20	1.14±.209	.631±.025	2
+6.3	160.01	6.91	160.01	.706±.744	.288±.105	0
-6.3/+1.18	212.42	9.17	212.42	.624±.308	<.108	1
-1.18/+.60	101.41	4.38	101.41	<.942	.263±.081	1
-.60/+.30	195.26	8.43	195.26	<.563	<.104	1
-.30/+.15	317.67	13.72	317.67	.456±.298	.213±.045	4
-.15/+.106	206.52	8.92	206.52	.521±.338	.303±.051	4
-.106/+.075	106.08	4.58	106.08	1.14±.664	.518±.103	5
-.075/+.053	172.42	7.44	172.42	1.75±.709	.576±.109	5
-.053/+.045	60.91	2.63	49.12	<2.07	.729±.195	4
-.045	783.20	33.82	409.70	2.33±.434	1.20±.073	1
Wash Water[4]	-	-	1.0 Liter	<119	<23.0	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-8
MAYWOOD SITE SAMPLE MV8
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	689.20	3.15±.399	7.05±.060	2
Whole Soil	-	-	708.90	2.67±.401	6.40±.070	2
Whole Soil	-	-	685.60	3.04±.406	7.20±.059	2
+6.3	456.20	16.45	456.20	.472±.549	.852±.097	0
-6.3/+1.18	380.51	13.72	380.51	2.29±.746	3.37±.154	1
-1.18/+.60	115.95	4.18	115.95	.693±.629	2.15±.143	1
-.60/+.30	239.90	8.65	239.90	1.00±.542	1.63±.087	1
-.30/+.15	404.33	14.57	404.33	1.55±.596	3.89±.117	4
-.15/+.106	223.89	8.07	223.89	5.55±1.42	12.5±.289	3
-.106/+.075	115.33	4.16	115.33	4.79±1.06	12.6±.292	3
-.075/+.053	131.75	4.75	131.75	3.61±.843	8.88±.200	2
-.053/+.045	50.06	1.80	43.58	2.37±2.14	8.89±.444	5
-.045	524.39	18.90	369.14	5.87±1.84	24.0±.446	2
Wash Water[4]	-	-	1.0 Liter	<122	<21.0	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-9
MAYWOOD SITE SAMPLE MV9
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	651.40	4.98±.393	7.81±.061	2
Whole Soil	-	-	660.20	4.57±.376	7.64±.060	2
Whole Soil	-	-	611.00	4.40±.518	7.43±.097	2
+6.3	698.61	31.72	698.61	.915±.306	.988±.050	0
-6.3/+1.18	184.28	8.37	184.28	1.51±.810	2.91±.187	<.5
-1.18/+.60	74.32	3.37	50.77	1.30±1.26	2.15±.276	<.5
-.60/+.30	123.85	5.62	123.85	1.29±.592	1.60±.120	<.5
-.30/+.15	210.34	9.55	210.34	1.67±.624	3.75±.132	2
-.15/+.106	136.09	6.18	136.09	3.18±.887	8.74±.227	5
-.106/+.075	104.20	4.73	104.20	3.28±1.62	9.31±.350	4
-.075/+.053	67.51	3.07	49.65	3.03±1.57	6.99±.356	5
-.053/+.045	60.26	2.74	43.03	3.87±1.99	7.81±.373	6
-.045	542.93	24.65	392.89	15.2±.824	24.5±.147	5
Wash Water[4]	-	-	1.0 Liter	<76.5	<14.8	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-10
MAYWOOD SITE SAMPLE MV10
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	614.00	1.07±.231	1.36±.039	4
Whole Soil	-	-	635.20	.741±.271	.970±.044	4
Whole Soil	-	-	644.20	.751±.203	.946±.030	4
+6.3	1121.6	43.93	726.89	.343±.202	.266±.030	0
-6.3/+1.18	363.57	14.24	363.57	.241±.297	.259±.054	0
-1.18/+.60	78.21	3.06	61.53	<1.56	<.428	0
-.60/+.30	80.37	3.15	50.48	<1.68	<.393	0
-.30/+.15	114.35	4.48	114.35	<.849	.349±.072	21
-.15/+.106	85.16	3.34	44.03	1.58±1.51	.614±.233	21
-.106/+.075	76.14	2.98	44.06	2.31±2.34	<.867	21
-.075/+.053	99.23	3.89	99.23	1.18±.663	.950±.119	11
-.053/+.045	48.97	1.92	46.02	<2.15	1.48±.225	14
-.045	485.70	19.02	353.47	2.42±.675	3.63±.126	5
Wash Water[4]	-	-	1.0 Liter	<76.0	<14.5	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-11
MAYWOOD SITE SAMPLE MV11
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	521.70	1.34±.238	.729±.035	4
Whole Soil	-	-	543.40	1.21±.229	.732±.032	4
Whole Soil	-	-	553.10	1.13±.234	.663±.035	4
+6.3	232.60	10.12	232.60	.469±.316	.307±.050	0
-6.3/+1.18	190.82	8.30	190.82	.490±.293	.299±.047	0
-1.18/+.60	89.68	3.90	57.62	<1.70	<.508	0
-.60/+.30	175.74	7.64	175.74	<.660	<.235	<.5
-.30/+.15	282.22	12.28	282.22	.366±.282	.203±.046	4
-.15/+.106	203.29	8.84	203.29	.444±.434	.314±.062	5
-.106/+.075	140.28	6.10	140.28	1.26±.501	.419±.086	5
-.075/+.053	85.07	3.70	50.53	1.95±2.16	.675±.336	6
-.053/+.045	84.01	3.65	47.47	<1.91	.917±.213	6
-.045	815.23	35.46	391.34	.459±.453	1.29±.074	5
Wash Water[4]	-	-	1.0 Liter	<87.8	<16.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-13
MAYWOOD SITE SAMPLE MV13
Hydroclassified/Sedimented (-.045 mm)

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	578.00	6.07±.563	8.09±.099	2
Whole Soil	-	-	582.00	5.68±.413	8.17±.090	2
Whole Soil	-	-	529.00	6.77±.540	9.41±.091	2
+6.3	225.58	7.41	225.58	1.43±.520	1.36±.095	0
-6.3/+1.18	233.84	7.68	233.84	2.76±.615	3.50±.125	<.5
-1.18/+.60	117.57	3.86	117.57	2.59±.812	3.09±.162	<.5
-.60/+.25	362.77	11.91	362.77	2.13±.801	5.78±.182	<.5
-.25/+.15	538.16	17.67	538.16	1.63±.461	3.28±.096	3
-.15/+.106	459.57	15.09	459.57	2.16±.501	2.81±.088	4
-.106/+.075	237.67	7.81	237.67	4.37±.998	5.50±.187	4
-.075/+.053	180.59	5.93	180.59	5.82±.997	7.47±.193	3
-.053/+.045	44.97	1.48	42.00	9.13±3.02	10.9±.687	3
-.045/+.020	131.60	4.32	127.19	2.03±.711	9.43±.135	3
-.020/+.010	200.52	6.58	197.46	4.08±1.73	21.4±.458	3
-.010/+.005	162.18	5.33	161.12	17.9±1.57	41.6±.292	5
-.005/+.002	121.78	4.00	120.73	15.1±1.94	38.8±.470	2
-.002	28.43	0.93	24.44	31.5±3.08	64.6±.780	<.5
Wash Water[4]	-	-	1.0 Liter	<90.5	<17.6	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-15
MAYWOOD SITE SAMPLE MV15
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	610.30	1.70±.229	1.91±.042	3
Whole Soil	-	-	607.90	1.80±.277	2.05±.041	3
Whole Soil	-	-	623.60	1.47±.207	2.08±.041	3
+6.3	436.64	17.46	436.64	.990±.491	1.06±.075	0
-6.3/+1.18	208.34	8.33	208.34	1.42±.426	.945±.076	0
-1.18/+.60	97.94	3.92	97.94	.512±.506	.512±.084	0
-.60/+.30	188.88	7.55	188.88	.584±.528	.426±.095	0
-.30/+.15	371.12	14.84	371.12	.481±.403	.627±.072	2
-.15/+.106	197.29	7.89	197.10	.887±.486	1.17±.098	5
-.106/+.075	107.90	4.31	107.90	1.35±.643	1.55±.129	4
-.075/+.053	151.10	6.04	151.10	2.22±.701	2.07±.123	4
-.053/+.045	55.82	2.23	46.36	4.84±2.38	2.50±.395	3
-.045	686.07	27.43	394.62	4.50±.459	5.28±.089	5
Wash Water[4]	-	-	1.0 Liter	<87.7	<15.0	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-16
MAYWOOD PILE SAMPLE MIS1
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	436.7	8.65±1.13	23.2±.232	4
+6.3	18.08	4.1	18.08	2.08±1.83	2.93±.322	-
-6.3/+.30	123.74	28.3	123.74	1.84±.220	2.46±.098	-
-.30/+.15	67.45	15.4	47.24	1.51±.908	2.14±.193	6.4
-.15/+.075	56.23	12.9	42.68	3.05±2.26	6.44±.451	8.6
-.075/+.045	46.29	10.6	45.96	15.0±2.10	38.1±.762	7.7
-.045	100.44	23.0	100.44	21.0±2.31	55.4±.554	N/A
Wash Water[4]	-	-	1.0 Liter	<18	<7.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-18
MAYWOOD PILE SAMPLE MIS2
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	461.5	6.05±.726	19.1±.191	4
+6.3	89.05	19.3	43.66	.653±.542	1.11±.155	N/A
-6.3/+.30	96.32	20.9	96.32	1.42±.583	3.17±.222	N/A
-.30/+.15	65.83	14.3	41.91	2.41±.530	2.31±.208	2.6
-.15/+.075	55.57	12.0	42.27	.698±.824	1.22±.134	4.8
-.075	152.81	33.1	148.78	13.0±1.56	41.1±.411	N/A
Wash Water[4]	-	-	1.0 Liter	<18	<7.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-19
MAYWOOD PILE SAMPLE MIS2
Hydroclassified

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	489.7	7.45±1.12	19.0±.569	N/A
+6.3	60.23	12.3	40.26	7.60±2.81	2.73±.382	N/A
-6.3/+.25	109.69	22.4	109.69	<1.20	1.30±.156	N/A
-.25/+.15	82.27	16.8	44.61	.760±.532	1.56±.172	N/A
-.15/+.075	64.15	13.7	42.57	1.71±.479	2.99±.180	N/A
-.075	151.32	30.9	148.33	14.5±.578	44.8±.448	N/A
Wash Water[4]	-	-	1.0 Liter	<18	<7.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-20
MAYWOOD PILE SAMPLE MIS3
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	379.0	5.40±.432	12.8±.128	3
+6.3	43.91	11.6	43.91	2.22±.888	1.89±.189	N/A
-6.3/+.30	80.06	21.1	42.58	1.02±1.10	1.58±.143	N/A
-.30/+.15	52.76	13.9	40.19	2.39±.765	1.74±.226	2.1
-.15/+.075	47.92	12.6	42.85	3.26±.945	4.96±.347	3.8
-.075	142.10	37.5	138.52	10.8±.539	27.9±.279	N/A
Wash Water[4]	-	-	1.0 Liter	<18	<7.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-22
MAYWOOD PILE SAMPLE MIS4
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	490.5	6.13±.796	17.0±.341	4
+6.3	73.27	14.9	41.76	1.54±1.17	1.50±.180	N/A
-6.3/+.30	103.73	21.1	103.73	.720±.461	1.55±.108	N/A
-.30/+.15	66.57	13.6	40.84	<.415	2.12±.176	2.4
-.15/+.075	62.18	12.7	43.15	1.64±1.17	4.70±.282	4.2
-.075	166.04	33.9	162.71	13.1±1.05	37.1±.371	N/A
Wash Water[4]	-	-	1.0 Liter	<18	<7.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-23
MAYWOOD PILE SAMPLE MIS4
Hydroclassified

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	500.49	5.32±1.60	15.4±.308	N/A
+6.3	143.64	28.7	143.64	1.10±.494	1.32±.185	N/A
-6.3/+.25	81.08	16.2	43.18	.833±.675	1.41±.183	N/A
-.25/+.15	68.57	13.7	41.55	2.49±.846	4.01±.201	N/A
-.15/+.075	61.06	12.2	42.86	2.30±1.43	4.26±.255	N/A
-.075	134.63	26.9	128.54	13.8±1.10	40.5±.405	N/A
Wash Water[4]	-	-	1.0 Liter	<18	<7.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-24
MAYWOOD PILE SAMPLE MISS5
Sieved

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	343.8	4.53±.680	11.2±.224	3
+6.3	25.04	7.3	21.08	1.67±.952	.536±.182	N/A
-6.3/+.30	85.78	25.0	42.66	.900±1.07	1.85±.185	N/A
-.30/+.15	56.87	16.5	42.18	1.75±.438	1.73±.173	2.1
-.15/+.075	43.26	12.6	43.11	1.99±1.85	4.31±.387	4.3
-.075	118.51	34.5	117.85	10.3±.617	25.5±.255	N/A
Wash Water[4]	-	-	1.00 Liter	<18	<7.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 2-25
MAYWOOD PILE SAMPLE MIS5
Hydroclassified

Particle Size (mm)	Fraction Weight (g)	Weight Percent	Weight Analyzed (g)	Ra-226 (pCi/g)[1,2,3]	Ra-228 (pCi/g)[1,2,3]	Heavy Mineral Weight Percent
Whole Soil	-	-	351.17	5.30±1.54	13.9±.278	N/A
+6.3	30.55	8.7	21.44	2.81±.647	2.42±.241	N/A
-6.3/+.25	83.58	23.8	43.67	<1.20	1.50±.180	N/A
-.25/+.15	54.78	15.6	41.25	1.90±.797	1.54±.200	N/A
-.15/+.075	42.14	12.0	42.04	1.56±.688	2.37±.237	N/A
-.075	127.83	36.4	125.84	9.13±1.10	23.7±.474	N/A
Wash Water[4]	-	-	1.0 Liter	<18	<7.4	-

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).
3 Ra-226 represents the radionuclide concentration of the U-238 decay chain, and Ra-228 represents the radionuclide concentration of the Th-232 decay chain.
4 Radionuclide concentrations in pCi/L of water.

TABLE 3-1
MAYWOOD CHEMICAL COMPANY SITE
WHOLE SOIL
ALPHA AND GAMMA SPECTROSCOPY RESULTS

Soil ID	U-238 (pCi/g)[1,2]	Ra-226 (pCi/g)[1,2]	Th-232 (pCi/g)[1,2]	Ra-228 (pCi/g)[1,2]	Wt. Analyzed Alpha (g)	Wt. Analyzed Gamma (g)
MV1	106±1.50	107±3.21	439±10.2	241±14.5	.0526	1609
MV2	1.70±.355	3.36±.605	3.10±.170	5.08±.711	.7890	1053
MV3	1.47±.318	3.98±.597	6.48±.207	7.44±.670	.8987	1597.6
MV4	.602±.219	.808±.218	.706±.071	.835±.142	.9430	1994.1
MV5	1.17±.238	2.06±.350	1.71±.115	1.54±.062	.8779	1705.4
MV6	5.35±.544	9.54±2.10	19.6±.542	19.3±.386	.5143	1454
MV7	.516±.152	1.22±.220	.541±.066	.617±.031	.8602	1746.9
MV8	1.28±.313	2.95±.413	8.33±.257	6.88±.413	.9603	2083.7
MV9	1.50±.289	4.65±.512	8.99±.271	7.63±.153	.9496	1922.6
MV10	.432±.140	.854±.273	.812±.078	1.09±.229	.8749	1893.4
MV11	.649±.187	1.23±.234	.808±.088	.708±.042	.8212	1618.2
MV12	.646±.181	1.14±.274	.473±.070	.637±.045	.7856	1739.7
MV13	2.41±.435	6.17±.555	5.73±.217	7.68±.768	.9693	1689
MV14	1.12±.302	2.01±.362	1.76±.124	1.78±.249	.9436	1811.1
MV15	.747±.213	1.66±.282	2.59±.152	2.01±.101	.8576	1841.8
MIS1	4.70±.799	8.44±.928	17.7±1.06	23.8±.238	.7421	453.57
MIS2	3.60±.396	6.05±.726	15.6±.780	19.1±.191	.6931	461.5
MIS3	3.02±.393	5.40±.432	11.0±.660	12.8±.128	.8414	379.0
MIS4	3.48±.348	6.13±.796	14.2±.710	17.0±.341	.8054	490.5
MIS5	2.76±.304	4.53±.680	11.7±.702	11.2±.224	.7845	343.8

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).

TABLE 3-2
MAYWOOD SOIL MV1
ALPHA AND GAMMA SPECTROSCOPY RESULTS
Hydroclassified/Sedimented (-.045 mm)

Particle Range (mm)	U-238 (pCi/g)[1,2]	Ra-226 (pCi/g)[1,2]	Th-232 (pCi/g)[1,2]	Ra-228 (pCi/g)[1,2]	Wt. Analyzed Alpha (g)	Wt. Analyzed Gamma (g)
Whole Soil	106±1.50	107±3.21	439±10.2	241±14.5	.0526	1609
+6.3	28.6±.535	27.7±4.00	237±4.73	117±.811	.1061	189.67
-6.3/+1.18	30.9±.500	29.7±4.28	178±4.70	184±1.01	.0628	158.27
-1.18/+.60	37.3±.920	38.9±3.50	131±3.12	131±.873	.1081	126.86
-.60/+.25	21.7±.354	68.4±5.16	103±3.79	216±1.25	.0594	152.79
-.25/+.15	56.8±.520	65.5±4.26	348±6.96	269±.930	.0551	420.20
-.15/+.106	26.7±.266	24.8±3.88	66.3±3.44	184±.663	.0426	460.06
-.106/+.075	35.8±.380	67.6±4.99	139±4.87	163±.860	.0538	243.87
-.075/+.053	47.3±.610	57.0±5.54	198±5.80	250±1.22	.0698	135.92
-.053/+.045	67.0±.388	62.1±6.77	237±9.03	278±2.32	.0294	76.52
-.045/+.020	N/A	61.0±4.20	N/A	300±.950	N/A	116.21
-.020/+.010	170±.328	134±3.96	614±28.0	624±.875	.0080	221.92
-.010/+.005	191±.359	235±5.23	625±26.9	807±1.21	.0090	141.42
-.005/+.002	179±.363	268±6.68	704±28.7	947±1.21	.0095	249.54

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).

TABLE 3-3
MAYWOOD SOIL MV1 HEAVY MINERAL
ALPHA AND GAMMA SPECTROSCOPY RESULTS

Particle Range (mm)	U-238 (pCi/g)[1,2]	Ra-226 (pCi/g)[1,2]	Th-232 (pCi/g)[1,2]	Ra-228 (pCi/g)[1,2]	Wt. Analyzed Alpha (g)	Wt. Analyzed Gamma (g)
-1.18/+.60	136±.330	N/A	1720±34.1	N/A	.01184	N/A
-.60/+.25	214±.254	330±43.8	1530±53.4	2430±14.9	.004328	N/A
-.25/+.15	227±.221	401±28.5	1730±59.6	1950±12.8	.003748	10.17
-.15/+.106	239±.277	N/A	1830±52.3	N/A	.005076	N/A
-.106/+.075	225±.237	N/A	1780±92.2	N/A	.003992	N/A
-.075/+.053	250±.172	N/A	2330±109	N/A	.002340	N/A
-.053/+.045	281±.136	N/A	2430±142	N/A	.001220	N/A
-.045/+.020	223±.146	N/A	2080±110	N/A	.001806	N/A

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).

TABLE 3-4
MAYWOOD SOIL MV6
ALPHA AND GAMMA SPECTROSCOPY RESULTS
Hydroclassified/Sedimented (-.045 mm)

Particle Range (mm)	U-238 (pCi/g)[1,2]	Ra-226 (pCi/g)[1,2]	Th-232 (pCi/g)[1,2]	Ra-228 (pCi/g)[1,2]	Wt. Analyzed Alpha (g)	Wt. Analyzed Gamma (g)
Whole Soil	5.35±.544	9.54±2.10	19.6±.542	19.3±.386	.5143	1454
+6.3	2.07±.662	4.45±2.03	1.66±.115	4.33±.416	1.0319	31.29
-6.3/+1.18	5.65±.543	6.85±1.23	12.5±.500	17.7±.333	.5023	107.62
-1.18/+.60	4.11±.859	5.03±2.31	10.4±.288	7.84±.442	1.1091	39.67
-.60/+.25	1.21±.352	1.88±.881	2.43±.163	4.84±.199	1.1039	162.07
-.25/+.15	1.83±.290	8.80±3.43	5.89±.489	26.6±.750	.3686	58.69
-.15/+.106	1.79±.470	3.42±1.00	5.61±.259	8.33±.242	1.0469	134.28
-.106/+.075	1.75±.518	2.73±.741	6.09±.287	6.13±.173	1.0027	151.37
-.075/+.053	2.05±.514	3.27±.801	6.92±.246	6.72±.179	1.0183	169.85
-.053/+.045	4.14±.673	6.46±2.24	12.1±.355	13.5±.555	.8029	35.71
-.045/+.020	4.27±.571	9.41±1.75	14.6±.455	15.8±.363	.6335	214.65
-.020/+.010	7.27±.613	13.0±.981	27.9±.783	26.0±.213	.4056	189.52
-.010/+.005	13.5±.617	22.0±2.47	54.7±1.68	50.2±.578	.2007	152.72
-.005/+.002	21.1±.709	16.9±3.24	98.0±2.54	78.0±1.02	.1313	85.38
-.002	26.6±.608	37.5±3.25	132±3.12	85.4±.940	.1194	17.92

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).

TABLE 3-6
MAYWOOD SOIL MV13
ALPHA AND GAMMA SPECTROSCOPY RESULTS
Hydroclassified/Sedimented (-.045 mm)

Particle Range (mm)	U-238 (pCi/g)[1,2]	Ra-226 (pCi/g)[1,2]	Th-232 (pCi/g)[1,2]	Ra-228 (pCi/g)[1,2]	Wt. Analyzed Alpha (g)	Wt. Analyzed Gamma (g)
Whole Soil	2.41±.435	6.17±.555	5.73±.217	7.68±.768	.9693	1689
+6.3	.720±.197	1.43±.520	.983±.102	1.36±.095	.9596	225.58
-6.3/+1.18	1.60±.372	2.76±.615	5.12±.251	3.50±.125	.9093	233.84
-1.18/+.60	1.89±.377	2.59±.812	1.27±.104	3.09±.162	.9084	117.57
-.60/+.25	.541±.144	2.13±.801	4.48±.193	5.78±.182	.7653	362.77
-.25/+.15	.514±.151	1.63±.461	3.19±.154	3.28±.096	.8095	538.16
-.15/+.106	.755±.206	2.16±.501	.950±.074	2.81±.088	1.0230	459.57
-.106/+.075	2.52±.472	4.37±.998	3.90±.189	5.50±.187	.8987	237.67
-.075/+.053	2.62±.474	5.82±.997	7.69±.279	7.47±.193	.9504	180.59
-.053/+.045	4.67±.744	9.13±3.02	7.12±.283	10.9±.687	1.0028	42.00
-.045/+.020	4.07±.739	2.03±.711	9.74±.323	9.43±.135	.7564	127.19
-.020/+.010	11.4±.878	4.08±1.73	21.7±.641	21.4±.458	.4516	197.46
-.010/+.005	17.3±.756	17.9±1.57	41.1±1.19	41.6±.292	.2602	161.12
-.005/+.002	17.8±.888	15.1±1.94	41.5±1.04	38.8±.470	.3226	120.73
-.002	22.2±.674	31.5±3.08	50.6±1.60	64.6±.780	.1645	24.44

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).

TABLE 3-7
MAYWOOD SOIL MIS2
ALPHA AND GAMMA SPECTROSCOPY RESULTS
Sieved

Particle Range (mm)	U-238 (pCi/g)[1,2]	Ra-226 (pCi/g)[1,2]	Th-232 (pCi/g)[1,2]	Ra-228 (pCi/g)[1,2]	Wt. Analyzed Alpha (g)	Wt. Analyzed Gamma (g)
Whole Soil	3.60±.396	6.05±.726	15.6±.780	19.1±.191	.7421	461.5
-6.3/+.30	.361±.571	1.42±.583	.234±.048	3.17±.222	.9467	96.32
-.30/+.15	.248±.064	2.41±.530	.357±.064	2.31±.208	.7005	41.91
-.15/+.075	.716±.122	.698±.824	1.35±.136	1.22±.134	.7848	42.27
-.075	9.24±.761	13.0±1.56	46.4±1.87	41.1±.411	.6400	148.78

1 The uncertainty represents the 95% confidence level based on the sample count (2-sigma error).
2 A less than symbol (<) indicates that the sample concentration is below the minimum detectable concentration (MDC).

TABLE 4

VOLATILE ORGANIC ANALYSIS
OF THE
WASH WATER COMPOSITE
FROM THE
MAYWOOD CHEMICAL COMPANY PILE
SAMPLES MIS1-MIS5

Compound Name	Method Blank (ppb)	Composite Sample (ppb)
acetone	<10	17
ethyl benzene	< 5	< 5
methylene chloride	< 2	< 5
methyl ethyl ketone	<10	<10
toluene	< 5	< 5
xylene (total)	< 5	< 5

TABLE 5

PESTICIDE ANALYSIS OF THE WASH WATER COMPOSITE FROM THE MAYWOOD CHEMICAL COMPANY PILE SAMPLES MIS1-MIS5

Compound Name	Method Blank (ppb)	Composite Sample (ppb)
aldrin	<0.5	<0.5
alpha-BHC	<0.5	<0.5
beta-BHC	<0.5	<0.5
gamma-BHC (lindane)	<0.5	<0.5
delta-BHC	<0.5	<0.5
chlordane	<1	<1
4,4'-DDT	<0.5	<0.5
4,4'-DDE	<0.5	<0.5
4,4'-DDD	<0.5	<0.5
dieldrin	<0.5	<0.5
alpha-endosulfan	<0.5	<0.5
beta-endosulfan	<0.5	<0.5
endosulfan sulfate	<0.5	<0.5
endrin	<0.5	<0.5
endrin aldehyde	<1	<1
heptachlor	<0.5	<0.5
heptachlor epoxide	<0.5	<0.5
toxaphene	<1	<1
disulfoton	<0.8	<0.8
famphur	<0.8	<0.8
methyl parathion	<0.8	<0.8
parathion	<0.8	<0.8
phorate	<0.8	<0.8
sulfotep	<0.8	<0.8
thionazin	<0.8	<0.8
o,o,o-triethylphosphorothioate	<0.8	<0.8

TABLE 6-1

METAL ANALYSIS
OF THE
WASH WATER COMPOSITE
FROM THE
MAYWOOD CHEMICAL COMPANY SITE PILE
SAMPLES MIS1-MIS5

Metal	Method Blank (ppm)	Composite Sample (ppm)
Aluminium	<.04	.15
Antimony	<.03	<.03
Arsenic	<.04	<.04
Barium	<.002	.031
Beryllium	<.001	<.001
Cadmium	<.005	<.005
Calcium	.14	420
Chromium	<.01	.02
Cobalt	<.02	<.02
Copper	.01	.04
Iron	.02	.04
Lead	<.03	.03
Magnesium	.03	7.6
Manganese	<.002	.026
Mercury	<.001	<.001
Nickel	<.02	<.02
Potassium	<1	12
Selenium	<.06	<.06
Silver	<.005	<.005
Sodium	<.2	5.5
Thallium	<.04	<.04
Vanadium	<.01	<.01
Zinc	.006	.017

TABLE 6-2
METAL ANALYSIS
MAYWOOD SAMPLE MV13

Metal	Det.Limit (mg/kg)	Whole Soil	+6.3	-6.3/+1.18 (mg/kg)	-1.18/+.60 (mg/kg)	-.60/+.25 (mg/kg)	-.25/+.15 (mg/kg)	-.15/+.106 (mg/kg)	-.106/+.075 (mg/kg)	-.075/+.053 (mg/kg)	-.053/+.045 (mg/kg)	-.045/+.020 (mg/kg)	-.020/+.010 (mg/kg)
Arsenic	.2		4.9	4.8	3.9	1.6	1.3	1.1	3.1	5.4	8.3	6.3	16
Aluminium	8		9900	9900	3600	1700	1600	1300	3200	4700	6300	3200	10000
Antimony	20		<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Barium	1		58	58	150	13	14	22	83	160	220	150	410
Beryllium	1		1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Boron	2		21	15	8	4	4	4	6	9	11	150	11
Cadmium	1		<1	<1	<1	<1	<1	<1	<1	<1	<1	14	<1
Calcium	20		23000	20000	6100	1700	1600	2300	4500	8100	12000	9500	19000
Chromium	2		20	14	11	6	5	6	13	30	58	100	130
Cobalt	2		9	6	2	<2	<2	<2	2	3	4	29	8
Copper	1		28	42	18	3	2	2	8	16	30	35	76
Iron	2		19000	15000	8200	3600	3300	4300	6100	8100	9800	7100	19000
Lead	6		<6	<6	8	14	6	11	16	35	42	65	96
Magnesium	20		5900	5900	1500	570	600	590	1100	1600	2000	1300	3000
Manganese	1		300	90	90	34	32	38	72	120	180	140	320
Molybdenum	2		3	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Nickel	4		18	17	8	<4	<4	<4	5	7	10	<4	20
Potassium	160		2500	3000	1300	540	540	210	1000	1500	1800	470	1400
Selenium	20		<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Silver	2		<2	<2	<2	<2	<2	<2	6	<2	<2	<2	<2
Sodium	20		850	870	200	97	79	48	160	250	330	4300	690
Thallium	40		<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40
Vanadium	1		24	18	10	5	5	6	10	15	20	17	34
Zinc	1		25	32	21	9	10	11	24	39	57	13	140

TABLE 7

MAYWOOD CHEMICAL COMPANY SITE
ARSENIC ANALYSIS

Sample ID	Arsenic in Soil (mg/kg)	Arsenic i (µg/
MV1	N/A	<
MV2	10	7
MV3	4.9	4
MV4	10	3
MV5	23	2(
MV6	15	1(
MV7	4.6	4
MV8	5.0	1
MV9	6.7	7
MV10	11	3
MV11	3.9	4
MV12	2.8	<
MV13	6.0	6
MV14	4.0	<
MV15	5.7	2-
Composite from MIS1-MIS5	N/A	<

Table 9-2
Average Percent Mineral Composition[1] of Soil from the Maywood Chemical Company Pile

COMPOSITION	MIS1 %	MIS2 %	MIS3 %	MIS4 %	MIS5 %	Whole Soil %
Granitic Rock	1	6	-	2	2	2
Sandstone/Siltstone	3	1	12	7	-	5
Basalt	3	13	4	8	8	6
Quartzite	2	-	2	1	2	4
Quartz	42	43	45	44	44	44
Feldspar	30	21	18	15	16	20
Heavy Minerals[2]	4	4	3	4	3	3
Illite	4	3	6	7	11	6
Chlorite	2	2	3	2	4	2
Kaolinite	2	2	2	2	2	2
Calcite	1	T	1	1	T	1
Other[3]	6	5	3	7	8	5

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-1
Mineral Composition[1] and Weight Percent of Sample MV1, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY							AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.25	-.25/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045/ .020	-.020/ +.010	-.010/ +.005	-.005/ +.002	-.002	
Weight Percent	6	5	4	5	25	15	8	5	3	4	7	5	8	-	
PERCENT COMPOSITION															
Gypsum/Carbonate	12	17	19	10	5	T	T	T	-	-	-	-	-	-	4
Basalt	3	T	T	-	-	-	-	-	-	-	-	-	-	-	T
Sandstone	44	20	9	2	-	-	-	-	-	-	-	-	-	-	4
Quartz	5	7	41	67	79	87	91	92	88	60	45	50	40	-	65
Feldspar	-	1	5	4	5	5	5	5	10	20	20	20	20	-	8
Cinder/Slag	21	32	13	7	3	3	T	-	-	-	-	-	-	-	5
Heavy Minerals[2]	T	T	3	9	8	5	4	3	2	1	T	T	-	-	3
Illite/Mica	-	-	-	-	-	-	-	-	-	10	20	15	25	-	5
Chlorite	-	-	-	-	-	-	-	-	-	5	10	10	10	-	2
Kaolinite	-	-	-	-	-	-	-	-	-	4	5	5	5	-	1
Coal	1	10	5	1	-	-	-	-	-	-	-	-	-	-	1
Concrete	9	10	-	-	-	-	-	-	-	-	-	-	-	-	1
Other[3]	5	3	5	T	T	T	T	T	-	-	-	-	-	-	1

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-2

Mineral Composition[1] and Weight Percent of Sample MV2, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY							AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.25	-.25/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045/ +.020	-.020/ +.010	-.010/ +.005	-.005/ +.002	-.002	
Weight Percent	5	4	3	8	4	4	4	4	1	9	13	21	20	T	
PERCENT COMPOSITION															
Gypsum	T	7	10	10	4	2	2	2	5	20	30	30	25	10	19
Basalt	68	20	T	-	-	-	-	-	-	-	-	-	-	-	4
Sandstone	16	15	T	-	-	-	-	-	-	-	-	-	-	-	1
Quartz	5	8	74	85	80	85	86	85	82	60	35	20	10	15	43
Feldspar	T	T	3	3	7	8	8	10	12	10	10	20	20	20	8
Cinder/Slag	4	27	13	2	2	1	1	T	-	-	-	-	-	-	2
Heavy Minerals[2]	-	-	-	-	7	4	3	3	1	1	1	T	T	T	1
Illite/Mica	-	-	-	-	-	-	-	-	T	5	15	20	30	30	13
Chlorite	-	-	-	-	-	-	-	-	T	4	5	5	10	10	4
Kaolinite	-	-	-	-	-	-	-	-	T	T	4	5	5	10	3
Coal	2	11	T	T	-	-	-	-	-	-	-	-	-	-	1
Other[3]	5	12	T	T	T	T	T	T	T	T	T	-	-	5	1

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-5
Mineral Composition[1] and Weight Percent of Sample MV3, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045	
Weight Percent	3	5	5	11	15	6	6	7	3	39	
PERCENT COMPOSITION											
Granitic Rock	5	1	T	-	-	-	-	-	-	-	T
Basalt	1	3	2	T	-	-	-	-	-	-	T
Sandstone	80	65	5	T	T	-	-	-	-	-	6
Quartz	11	25	89	94	90	82	84	84	83	43	64
Feldspar	-	-	T	5	8	15	12	12	12	20	12
Cinder/Slag	3	5	3	T	T	-	-	-	-	-	1
Heavy Minerals[2]	-	1	1	1	2	3	4	4	5	2	3
Illite/Mica	-	-	-	-	-	-	-	T	T	15	6
Chlorite	-	-	-	-	-	-	-	T	T	10	4
Kaolinite	-	-	-	-	-	-	-	T	T	5	2
Other[3]	T	T	T	T	T	T	T	T	T	5	2

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-4
Mineral Composition[1] and Weight Percent of Sample MV4, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.-75	-.075/ +.053	-.053/ +.045	-.045	
Weight Percent	35	18	4	4	5	4	4	3	2	21	
PERCENT COMPOSITION											
Granitic Rock	T	5	2	1	-	-	-	-	-	-	1
Basalt	81	87	43	8	T	-	-	-	-	-	46
Sandstone	19	3	2	-	-	-	-	-	-	-	7
Quartz	T	2	50	87	82	75	72	71	70	28	26
Feldspar	-	1	3	4	4	6	8	10	10	10	4
Cinder/Slag	T	2	T	T	T	T	-	-	-	-	T
Heavy Minerals[2]	T	T	T	T	14	19	20	19	20	2	4
Illite/Mica	-	-	-	-	-	-	-	T	T	20	4
Chlorite	-	-	-	-	-	-	-	-	T	5	1
Kaolinite	-	-	-	-	-	-	-	-	T	5	1
Montmorillonite	-	-	-	-	-	-	-	-	T	25	5
Other[3]	T	T	T	T	T	T	T	T	T	5	1

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-5
Mineral Composition[1] and Weight Percent of Sample MV5, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045	
Weight Percent	7	7	7	19	20	9	5	3	2	21	
PERCENT COMPOSITION											
Granitic Rock	2	T	-	-	-	-	-	-	-	-	1
Sandstone	6	8	T	-	-	-	-	-	-	-	1
Quartz	T	15	88	91	92	89	88	85	86	42	68
Feldspar	-	-	T	4	5	6	6	10	10	10	5
Cinder/Slag	92	75	8	3	1	1	1	1	T	-	13
Heavy Minerals[2]	T	2	2	2	2	4	5	4	4	3	3
Illite/Mica	-	-	-	-	-	-	-	-	-	10	2
Chlorite	-	-	-	-	-	-	-	-	-	20	4
Kaolinite	-	-	-	-	-	-	-	-	-	10	2
Other[3]	T	T	2	T	T	T	T	T	T	5	1

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-6

Mineral Composition[1] and Weight Percent of Sample MV6, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY							AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.25	-.25/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045/ +.020	-.020/ +.010	-.010/ +.005	-.005/ +.002	-.002	
Weight Percent	2	7	4	10	5	8	8	11	3	13	12	10	5	2	
PERCENT COMPOSITION															
Sandstone	22	4	2	-	-	-	-	-	-	-	-	-	-	-	1
Quartz	9	12	76	90	84	86	86	86	84	60	44	60	15	10	63
Feldspar	-	-	T	2	6	8	10	12	15	24	40	25	30	30	16
Cinder/Slag	69	66	22	8	2	2	2	-	-	-	-	-	-	-	8
Heavy Minerals[2]	-	-	-	-	8	4	2	2	1	1	1	1	T	T	2
Illite/Mica	-	-	-	-	-	-	-	-	-	5	5	4	25	25	3
Chlorite	-	-	-	-	-	-	-	-	-	5	5	5	25	25	3
Kaolinite	-	-	-	-	-	-	-	-	-	5	5	5	5	5	2
Other[3]	T	18	T	-	-	-	-	-	-	T	T	T	T	5	2

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-7
Mineral Composition[1] and Weight Percent of Sample MV7, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045	
Weight Percent	7	9	4	8	14	9	5	7	3	34	
PERCENT COMPOSITION											
Granitic Rock	12	10	2	T	-	-	-	-	-	-	2
Basalt	54	50	5	2	T	-	-	-	-	-	9
Sandstone	26	7	3	1	-	-	-	-	-	-	3
Quartz	3	28	86	93	91	88	85	85	86	30	56
Feldspar	-	-	1	3	5	8	10	10	10	14	8
Cinder/Slag	T	1	T	T	T	T	-	-	-	-	T
Heavy Minerals[2]	-	1	1	1	4	4	5	5	4	1	2
Asphaltic Road Metal	5	3	2	T	T	T	T	T	T	T	1
Illite/Mica	-	-	-	-	-	-	-	T	T	40	14
Chlorite	-	-	-	-	-	-	-	-	-	10	3
Kaolinite	-	-	-	-	-	-	-	-	-	5	2
Other[3]	T	T	T	T	T	T	T	T	T	-	T

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, staurolite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

T[illegible] 10-[illegible]

Mineral Composition[1] and Weight Percent of Sample MV8, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045	AVERAGE TOTAL PERCENT
Weight Percent	17	15	4	9	16	8	4	5	2	20	
PERCENT COMPOSITION											
Granitic Rock	7	2	2	1	-	-	-	-	-	-	2
Basalt	41	50	16	6	-	-	-	-	-	-	16
Sandstone	31	34	8	2	-	-	-	-	-	-	11
Quartz	2	5	64	85	90	91	89	88	88	26	47
Feldspar	-	T	2	4	6	6	8	10	10	24	8
Cinder/Slag	1	2	3	1	T	T	T	T	T	T	1
Heavy Minerals[2]	-	1	1	1	4	3	3	2	5	2	2
Asphaltic Road Metal	17	5	3	T	T	T	T	T	T	T	4
Illite/Mica	-	-	-	-	-	-	-	-	T	30	6
Chlorite	-	-	-	-	-	-	-	-	-	5	1
Kaolinite	-	-	-	-	-	-	-	-	T	3	T
Other[3]	1	1	1	T	T	T	T	T	T	10	2

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-5

Mineral Composition[1] and Weight Percent of Sample MV9, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045	
Weight Percent	32	8	3	6	10	6	5	3	3	24	
PERCENT COMPOSITION											
Granitic Rock	-	1	T	T	-	-	-	-	-	-	T
Basalt	67	76	67	15	2	-	-	-	-	-	31
Sandstone	19	5	T	T	-	-	-	-	-	-	6
Quartz	1	12	27	80	89	88	88	88	86	25	36
Feldspar	-	-	1	2	5	5	7	7	8	30	11
Cinder/Slag	9	4	4	2	2	2	1	T	T	-	4
Heavy Minerals[2]	-	T	T	T	2	5	4	5	6	5	2
Asphaltic Road Metal	3	2	1	1	T	T	T	-	-	-	1
Illite/Mica	-	-	-	-	-	-	-	-	-	30	7
Chlorite	-	-	-	-	-	-	-	-	-	5	1
Kaolinite	-	-	-	-	-	-	-	-	-	5	1
Other[3]	1	-	-	-	-	-	-	-	-	-	T

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10

Mineral Composition[1] and Weight Percent of Sample MV10, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045	
Weight Percent	44	14	3	3	5	3	3	4	2	19	
PERCENT COMPOSITION											
Granitic Rock	-	T	5	T	-	-	-	-	-	-	T
Basalt	90	92	74	12	-	-	-	-	-	-	55
Sandstone	10	5	1	-	-	-	-	-	-	-	5
Quartz	-	3	20	83	74	74	74	84	81	25	21
Feldspar	-	-	T	5	5	5	5	5	5	10	4
Cinder/Slag	-	-	T	T	T	-	-	-	-	-	T
Heavy Minerals[2]	-	-	-	-	21	21	21	11	14	5	4
Illite/Mica	-	-	-	-	-	-	-	-	-	20	4
Chlorite	-	-	-	-	-	-	-	-	-	5	1
Kaolinite	-	-	-	-	-	-	-	-	-	5	1
Montmorillonite	-	-	-	-	-	-	-	-	-	25	5
Other[3]	T	T	T	T	T	T	T	T	T	5	T

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-11

Mineral Composition[1] and Weight Percent of Sample MV11, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045	
Weight Percent	10	8	4	7	12	9	6	4	4	36	
PERCENT COMPOSITION											
Granitic Rock	7	10	T	-	-	-	-	-	-	-	2
Basalt	70	30	8	2	T	-	-	-	-	-	10
Sandstone	18	20	3	T	-	-	-	-	-	-	1
Quartz	2	20	84	93	88	85	85	89	89	30	52
Feldspar	-	-	5	5	8	10	10	15	15	25	15
Cinder/Slag	T	T	T	T	-	-	-	-	-	-	T
Heavy Minerals[2]	-	-	-	T	4	5	5	6	6	5	4
Asphaltic Road Metal	3	T	-	-	-	-	-	-	-	-	T
Illite/Mica	-	-	-	-	-	-	-	-	-	20	8
Chlorite	-	-	-	-	-	-	-	-	-	10	4
Kaolinite	-	-	-	-	-	-	-	-	-	10	4
Other[3]	T	T	-	-	-	-	-	-	-	-	T

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, staurolite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10-15

Mineral Composition[1] and Weight Percent of Sample MV13, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY							AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.25	-.25/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045/ +.020	-.020/ +.010	-.010/ +.005	-.005/ +.002	-.002	
Weight Percent	7	8	4	12	18	15	8	6	1	4	7	5	4	1	
PERCENT COMPOSITION															
Granitic Rock	3	2	1	1	-	-	-	-	-	-	-	-	-	-	1
Basalt	27	29	2	T	-	-	-	-	-	-	-	-	-	-	4
Sandstone	38	29	3	T	-	-	-	-	-	-	-	-	-	-	5
Quartz	1	20	83	86	80	88	86	87	77	40	40	55	30	55	64
Feldspar	-	-	T	5	5	8	10	10	20	40	30	15	30	10	10
Cinder/Slag	5	7	3	5	5	T	T	T	T	-	-	-	-	-	3
Heavy Minerals[2]	-	T	T	T	3	4	4	3	3	3	3	5	2	T	2
Asphaltic Road Metal	26	11	8	3	7	-	-	-	-	-	-	-	-	-	5
Illite/Mica	-	-	-	-	-	-	-	-	-	5	17	20	20	20	4
Chlorite	-	-	-	-	-	-	-	-	-	7	10	5	18	15	2
Kaolinite	-	-	-	-	-	-	-	-	-	T	T	T	T	T	T
Other[3]	T	2	-	-	-	-	-	-	-	5	T	T	T	T	T

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Table 10
Mineral Composition[1] and Weight Percent of Sample MV14, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045	
Weight Percent	35	18	4	4	5	4	4	3	2	21	
PERCENT COMPOSITION											
Granitic Rock	1	2	T	T	-	-	-	-	-	-	1
Basalt	32	29	3	T	-	-	-	-	-	-	17
Sandstone	35	31	2	T	-	-	-	-	-	-	18
Quartz	2	8	79	92	93	90	90	88	90	55	36
Feldspar	-	-	T	2	3	5	5	7	7	20	5
Cinder/Slag	25	25	12	4	2	2	-	-	-	-	14
Heavy Minerals[2]	T	T	1	1	2	3	5	5	3	5	2
Asphaltic Road Metal	5	5	2	T	-	-	-	-	-	-	3
Illite/Mica	-	-	-	-	-	-	-	-	-	10	2
Chlorite	-	-	-	-	-	-	-	-	-	5	1
Kaolinite	-	-	-	-	-	-	-	-	-	5	1
Other[3]	T	1	1	1	T	-	-	-	-	-	T

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

T 10-

Mineral Composition[1] and Weight Percent of Sample MV15, Maywood, New Jersey

	GRAVEL	SAND						SILT/CLAY			AVERAGE TOTAL PERCENT
Sieve Size	+6.3 mm	-6.3/ +1.18	-1.18/ +.60	-.60/ +.30	-.30/ +.15	-.15/ +.106	-.106/ +.075	-.075/ +.053	-.053/ +.045	-.045	
Weight Percent	18	8	4	8	15	8	4	6	2	27	
PERCENT COMPOSITION											
Granitic Rock	T	T	T	T	T	-	-	-	-	-	T
Basalt	47	20	5	2	T	-	-	-	-	-	10
Sandstone	42	39	6	-	-	-	-	-	-	-	11
Quartz	1	6	70	92	89	85	84	85	87	35	50
Feldspar	-	-	5	5	7	8	10	10	10	30	12
Cinder/Slag	7	18	4	5	2	2	2	1	-	-	4
Heavy Minerals[2]	-	-	-	-	2	5	4	4	3	5	3
Illite/Mica	-	-	-	-	-	-	-	-	-	15	4
Chlorite	-	-	-	-	-	-	-	-	-	10	3
Kaolinite	-	-	-	-	-	-	-	-	-	5	1
Coal	1	15	5	-	-	-	-	-	-	-	2
Other[3]	2	2	1	T	T	T	T	-	-	-	T

T Trace amount, 0.1 to 0.5%.

1 Average sample composition is based on the sum of the weighted means of the material composition of the individual size fractions.

2 Heavy minerals include in order of abundance, the amphibole group, garnet, the epidote group, monazite, zircon, rutile, stauralite, hypersthene, tourmaline, and minor others. Monazite and zircon are radioactive.

3 Other components include coal, ceramic material, glass, concrete, and wood materials.

Percent Heavy Mineral Composition[1] of Heavy Mineral Fraction Between 0.30 mm and 0.075 mm (Sand) Grain Size for Maywood, NJ[2]

COMPOSITION	MV1	MV2	MV3	MV4	MV5	MV6	MV7	MV8	MV9	MV10	MV11	MV12	MV13	MV14	MV15
Non-Magnetic Opaque	17	33	40	1	38	27	39	19	24	T	38	33	27	30	42
Magnetic	7	22	6	12	17	17	12	17	30	16	12	22	14	20	17
Amphibole Group	20	18	21	T	15	28	18	26	20	6	23	23	29	21	19
Garnet	2	10	17	T	16	11	15	15	12	T	10	11	13	13	10
Epidote Group	4	3	5	T	5	4	6	5	4	T	5	4	4	5	6
Zircon	37	10	2	T	2	8	3	6	3	T	1	2	6	4	3
Monazite	12	2	T	T	T	3	1	4	1	T	T	T	2	1	1
Rutile	1	1	1	T	T	1	T	1	1	T	T	1	2	T	1
Augite	T	T	6	84	4	T	4	1	2	74	6	1	1	2	1
Other[1]	T	1	2	3	3	1	2	6	3	4	5	3	2	4	1

T Trace amount, 0.1 to 0.5%.

1 Other components include basalt, tourmaline, hypersthene, calcium, thorium, and orthophosphate compounds.

2 Samples MV1, MV2, MV6, and MV13 range from 0.25 mm to 0.075 mm for the sand-sized particles.

Percent Heavy Mineral Composition[1] of Heavy Mineral Fraction Between 0.075mm and 0.045mm (Silt) Grain Size for Maywood, NJ

COMPOSITION	MV1	MV2	MV3	MV4	MV5	MV6	MV7	MV8	MV9	MV10	MV11	MV12	MV13	MV14	MV15
Non-Magnetic Opaque	33	27	42	T	44	27	35	22	16	T	33	29	30	27	37
Magnetic	12	25	5	14	19	6	10	21	30	15	10	19	10	18	17
Amphibole Group	36	35	19	T	10	47	29	28	24	1	33	28	37	30	21
Garnet	4	5	14	T	9	2	10	5	10	T	10	7	8	6	8
Epidote Group	2	1	6	T	2	7	6	6	6	T	3	7	4	4	5
Zircon	6	4	4	T	7	5	4	7	7	T	5	4	10	7	7
Monazite	5	1	1	T	1	4	1	5	1	T	1	1	7	3	1
Rutile	2	1	1	T	1	1	2	2	1	T	1	1	2	T	2
Augite	T	T	6	85	5	T	2	1	2	84	4	3	2	2	1
Other[1]	T	1	2	1	2	1	1	1	3	1	T	1	T	3	1

T Trace amount, 0.1 to 0.5%.

1 Other components include basalt, tourmaline, hypersthene, calcium, thorium, and orthophosphate compounds.