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Characterization of Waste Streams and Suspect Waste from Largest Los Alamos National Laboratory Generators

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Abstract

A detailed waste stream characterization of four primary generators of low level waste at Los Alamos National Laboratory was performed to aid in waste minimization efforts. Data was compiled for these four generators from 1988 to the present for analyses. Prior waste minimization efforts have focused on identifying waste stream processes and performing source materials substitutions or reductions where applicable. In this historical survey, the generators surveyed included an accelerator facility, the plutonium facility, a chemistry and metallurgy research facility, and a radiochemistry research facility. Of particular interest in waste minimization efforts was the composition of suspect low level waste in which no radioactivity is detected through initial survey. Ultimately, this waste is disposed of in the LANL low level permitted waste disposal pits (thus filling a scarce and expensive resource with sanitary waste).

Detailed analyses of the waste streams from these four facilities, have revealed that suspect low level waste comprises approximately 50 percent of the low level waste by volume and 47 percent by weight. However, there are significant differences in suspect waste density when one considers the radioactive contamination. For the two facilities that deal primarily with beta emitting activation and spallation products (the radiochemistry and accelerator facilities), the suspect waste is much lower density than all low level waste coming from those facilities. For the two facilities that perform research on transuranics (the chemistry and metallurgy research and plutonium facilities), suspect waste is higher in density than all the low level waste from those facilities. It is theorized that the low density suspect waste is composed primarily of compactable lab trash, most of which is not contaminated but can be easily surveyed. The high density waste is theorized to be contaminated with alpha emitting radionuclides, and in this case, the suspect waste demonstrates fundamental limits in detection.

Introduction

Los Alamos National Laboratory (LANL) performs a wide spectrum of research on radioactive and non-radioactive materials in support of the United States Department of Energy (DOE). In the course of performing such work, solid low-level radioactive waste is generated and ultimately disposed of in the low-level waste disposal pits at LANL Technical Area 54 (TA-54), Area G. Due to the limited disposal volume (approximately 59,000 m^3 of pit volume remain as of July, 1995) and the large cost associated with low-level radioactive waste disposal, the Laboratory has a concerted waste minimization effort aimed at reducing waste volume laboratory wide.

Current building upgrades at the Chemistry and Metallurgy Research (CMR) facility will result in a dramatic increase of low-level waste generation. It is incumbent on the Laboratory to examine all waste streams and identify opportunities for waste reduction where technically and economically feasible. In this regard, the following study was performed to identify waste from four facilities (CMR, the Plutonium Facility, TA-48 and TA-53) and quantify the amount of suspect radioactive waste from those facilities. Suspect radioactive waste is waste that originates in a radioactive materials management area (RMMA) and therefore, the potential for radioactive contamination exists. However, radioassay and survey measurements on the material detect no radioactive contamination.

By quantifying the suspect radioactive material disposed at TA-54, Area G, waste management approaches can be developed to assure that the minimum amount of non-radioactive material is disposed of as low-level radioactive waste.

Low Level Waste Database

Los Alamos National Laboratory has an effective method of tracking all generated waste (transuranic, mixed transuranic, low-level, mixed low-level, and chemical). Generators must complete a Chemical Waste Disposal Request (CWDR) form for any waste to be disposed, treated or stored. This form is forwarded to the Waste Management Program, at which point, the form is verified for accuracy and completeness, and subsequently entered into the Waste Management waste tracking databases. These databases track the final disposition of each item of waste received. Volumes, weights, radionuclides, activities, location of waste generation and generator information submitted on the CWDR is entered into the databases. This provides for a centralized location with comprehensive data accessible to auditors, waste management and waste minimization programs.

Volume Data

From the low-level waste database, the total volume of solid low-level waste disposed of at TA-54, Area G in 1994 was 2963 m3 (Figure 1). The four facilities of interest in this study accounted for slightly more than 28 percent of the total volume. By far, the environmental restoration projects at the Laboratory are the single largest generator of low-level waste, however, the waste and waste type are highly dependent on the site and contamination of the site. For purposes of this study, the four facilities chosen represent a cross section of lab-wide activities.

Chemistry and Metallurgy Research Facility

The Chemistry and Metallurgy Research (CMR) facility has served as the primary special nuclear materials analytical laboratory for the Laboratory since 1952. The CMR facility is located in Technical Area 3 (TA-3). The three story structure contains approximately 550,000 ft^2 of floor space and is presently designated as a security "category 1" facility with a safety classification of "moderate hazard." The building consists of eight wings: the Administration Wing and Wings 1 through 5, 7, and 9. The Administration Wing contains office and conference room space occupied by the Chemical Science and Technology Division Office (CST-DO).

Operations

Wings 1 through 5, 7, and 9 house experimental facilities. The experimental facilities are occupied by personnel from several line organizations at the Laboratory. Approximately 48,0000 ft^2 of the first floor space is devoted to laboratories, and approximately the same amount of space is devoted to offices. The basement and attic spaces provide utility services to the first floor laboratories and offices. Some basement areas have been modified for use as laboratories since construction of the CMR facility in 1952. Each wing is designed to operate independently with its own electrical power distribution and ventilation systems. Wing 9, which contains the hot cell facilities for the CMR, was added in 1960.

Waste Profile

Low-level waste arising from standard operations at the CMR facility consist primarily of contaminated and potentially contaminated laboratory equipment, personal protective equipment (PPE), and laboratory waste products. Currently, the CMR building is undergoing extensive upgrades. Due to these upgrades, CMR low-level waste now includes construction and building debris (electrical conduit, water pipes, ventilation ductwork, etc.) originating in radioactive materials management areas (RMMAs). Typically, the upgrades waste is packaged in SEG B-25 boxes (2.66 m^3).

Radionuclides present in CMR waste can include virtually any radionuclide found at the Laboratory. However, most waste items contain either fission products (primarily ^{137}Cs and ^{125}Sb) or plutonium contaminated materials and their progeny (^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{241}Am, ^{237}Np, ^{233}Pa and ^{237}U). Most waste items contain either fission products or plutonium, often both. The form of contamination is very dependent on the origination point of the waste.

The Plutonium Facility

The LANL Plutonium Processing Facility is located at TA-55 and occupies a 30 acre location with 70 structures. Only the Plutonium Building (PF-4) and the Health Physics Assay Laboratory (HPAL) contain nuclear materials. Each area is designated as an RMMA. PF-4 is a two story, 151,000 ft^2 building, with support equipment in the basement and laboratory rooms divided among four wings on the main floor. The major laboratory rooms contain over 300 gloveboxes for the handling of plutonium, uranium and other nuclear materials.

Operations

The Residue Processing Group (NMT-2) develops and proves processing technology for plutonium and other actinides through both aqueous and molten salt based technologies. This group supports the LANL Plutonium Facility by recovering and purifying plutonium scrap residues and converting it to on oxide or metal that can be used or placed in long-term storage.

The Advanced Technologies Group (NMT-6) conducts fundamental and applied research in actinide chemistry. This group focuses on new and emerging separation technologies and on improving existing technologies.

The Waste Management and Environmental Compliance Group (NMT-7) handles the hazardous and radioactive waste materials generated at TA-55 while assuring that the facility complies with all environmental requirements, including those regulating waste, water and air discharges.

Waste Profile

Virtually all items disposed of as low-level radioactive waste from TA-55 over the past seven years have been described as being contaminated with plutonium and plutonium progeny (primarily ^{241}Am) only. The only exceptions have been for disposals of spent radioactive calibration sources. Most waste items are described as either compactable boxed room trash (consisting of small lab items, PPE, paper, etc.) or building debris (wood, plastic, metal, paper, rubber, glass, waste rags, absorbed liquids, equipment, concrete and general building debris).

Technical Area 48

TA-48 is a Laboratory site used for the study of nuclear properties of radioactive materials by using analytical and physical chemistry. Measurements of radioactive substances are made and hot cells are used for remote handling of radioactive materials.

Operations

The hot cell facility includes a number of laboratories and rooms within building RC-1 at TA-48. This area is used to process targets irradiated in the proton beam at the Los Alamos Meson Physics Facility (LAMPF) for production of medical radioisotopes. There are large amounts of radioactive materials present in the hot cells within the facility. Virtually all materials present in the facility are beta/gamma emitters; by policy, large amounts of alpha emitters are not handled by the facility.

The alpha cell area is the primary area at TA-48 used for plutonium and uranium research. This area is segregated from the hot cell. Waste from this area accounts for a very small percentage of the total waste emanating from TA-48.

Other laboratories at TA-48 consist of radiochemistry laboratories used for the characterization of very low levels of radioactive contamination. Waste generated from the processing of research environmental samples has not included suspect radioactive waste over the past seven years.

Waste Profile

Two primary waste forms dominate the waste generated by TA-48. Waste originating from the hot cell areas accounts for more than 80 percent of the waste. This waste is typically compactable lab trash (PPE, paper, plastic, etc.) and is typically contaminated with radionuclides identical to those seen in waste from TA-53 (see below). The radioactivity is easily detected, and very often, waste that is contaminated contains large amounts of activity.

The second waste form comes from plutonium based work in the alpha cell area. Recently, 67 two cubic foot boxes from this area were assayed. Of the 67 boxes, 27 boxes were found to have measurable amounts of transuranic radionuclides (^{241}Am, ^{238}Pu and ^{239}Pu) and nearly all had measurable amounts of ^{137}Cs, ^{85}Sr and ^{95m}Tc. In only one box was there contamination from only transuranic radionuclides.

Technical Area 53

Located within TA-53 is the Los Alamos Meson Physics Facility (LAMPF). LAMPF is a high energy particle accelerator facility that produces protons, neutrons, and subatomic particles for use in basic research, isotope production, radiochemistry, solid-state physics research, and accelerator technology.

Operations

The accelerator and beam tube provide a primary beam of 800 MeV protons at an average current of one milliampere for basic nuclear and elementary particle physics research. Positive and negative hydrogen ions are generated and injected into a high voltage dome. A low density plasma is produced and protons are extracted and accelerated through a potential field. The beams are steered and focused into the linear accelerator drift tube, and finally into the side coupled cavity linear accelerator stage, then switched by bending and quadrapole magnets to various experimental areas.

Experimental Area A conducts experiments for particle physics and nuclear structure studies. Pions, muons, and protons are produced and used in a variety of experiments. Using the highest intensity main proton beam from the accelerator, the spectrometers in Experimental Area A measure particle scattering from interactions of the proton beam with targets located along the beam line to determine number, type, direction, momentum, velocity and electrical charge.

Experimental Area B conducts experiments in the Neutron Physics Laboratory using a medium resolution spectrometer. A negative ion beam is divided with one portion generating a polarized neutron beam by charge interchange in a deuterium target which is delivered to experiments in the neutron area. The other portion of the negative ion beam is delivered to the External Proton Beam line where it is accessible for experimental setups.

Experimental Area C house the High Resolution Proton Spectrometer (HRS). It measures the scattering of protons from nuclei and the production of other particles resulting from the incident protons. The HRS can also measure the spin of scattered particles.

Waste Profile

The majority of radioactive waste generated by TA-53 consists of activation and spallation products. These radionuclides are produced when high energy particles collide with matter. Nuclear capture and scattering mechanisms subsequently result in the production of radioactive material. The radionuclides produced are dependent on the scattering and capture cross-sections of the target material. In general, activation of iron accounts for the majority of the activity contaminating waste at TA-53.

Past radioassay activities conducted for the Laboratory's Solid Radioactive Waste Management Group (CST-14) on waste packages from LAMPF and the Los Alamos Neutron Scattering Center (LANSC) have shown that the common radionuclides contained in the waste packages are strong gamma emitters that are readily detectable by commercially available detection systems. The primary radionuclides include ^{7}Be, ^{56}Co, ^{60}Co, ^{54}Mn and numerous hafnium, lutetium and europium isotopes.

Database Analysis

Information from all low-level waste disposal requests from the low-level waste database for the CMR facility over the past seven years were analyzed for each of the facilities. Since 1994, the term "suspect radioactive" is no longer allowed for waste disposals. Therefore, any waste package with radionuclide activity averaging less than 2 nCi is considered as suspect in the 1994-1995 timeframe.

Since 1988, the four facilities have disposed of 6639 low-level waste packages with 1829 of the packages containing suspect radioactive waste. The total volume disposed over the same time period is 14,762 m^3 with suspect waste accounting for 7726 m^3.

CMR

The data (summarized in Figure 2) shows that approximately 49 percent of all waste packages from the CMR facility since 1988 have been suspect low-level. A total volume of 5978 m^3 of low-level waste has been disposed since 1988 with 3704 m^3 being suspect low-level waste. As a point of reference, Pit 38 at TA-54, Area G (the largest low-level radioactive waste disposal pit at the Laboratory) has a total capacity of approximately 37000 m^3 below the spill line. The amount of suspect waste from the CMR facility over the past seven years amounts to approximately 10% of the volume of the <u>largest</u> disposal pit at LANL.

Every CMR item considered to be suspect over the past seven years, has, in theory, been contaminated with transuranic radionuclides. Virtually every suspect item has been described in the database as building debris. These items are among the hardest to survey and swipe for contamination, and therefore, it is not surprising that little or no actual values are assigned to these items.

The Plutonium Facility

Figure 3 shows the summarized data for the Plutonium Facility since 1988. The volume of low-level waste disposed at TA-54, Area G is approximately 3570 m3 with 1910 m3 containing suspect radioactive materials.

Figure 4 shows data for CMR and the Plutonium Facility waste. From the data, it appears as if suspect package density is significantly higher than the average density of all waste from these facilities. Because the majority of suspect waste from these facilities tends to be building debris, the packages tend to be larger and more dense than laboratory trash. Building debris surfaces are typically very irregular with much of the likely contaminated surface inaccessible for swipes/smears and direct survey (i.e. ductwork, plumbing and electrical conduit). These waste items tend to be disposed of in SEG B-25 waste boxes rather than 55 gallon drums. The resulting package cannot be counted on the facilities' drum counters. Furthermore, the detection capabilities for B-25 waste contaminated with plutonium is quite poor. Therefore, if the waste is not grossly contaminated with large amounts of plutonium, the waste will likely be listed as suspect waste. Figures 5 and 6 show the detection limits for the waste management High Purity Germanium Detector and a 2000 pound B-25 box.

An interesting trend can also be seen in Figure 4. The density of all waste from these facilities has increased steadily over the past four years (package weight data is only available since 1991). This is most likely due to waste minimization efforts to reduce the volume of waste from these facilities. Efforts have been made to pack waste more efficiently with less void space.

TA-48

Figure 7 shows the summarized data for TA-48. A total of 1017 packages accounting for 2001 m^3 of low-level waste have been disposed of at TA-54, Area G since 1988 with 423 packages (1174 m^3) being classified as suspect radioactive waste. The majority of suspect waste packages are described as lab trash and lab equipment with activation and fission product suspect contamination.

TA-53

Data for TA-53 is strikingly similar to that of TA-48. A total of 654 packages totaling 3213 m^3 of low-level waste have been disposed of at TA-54, Area G. Suspect radioactive low-level waste accounts for 198 packages with a total volume of 939 m^3 since 1988. The data is summarized in Figure 8.

Unlike the data for CMR and the Plutonium Facility, data for TA-48 and TA-53 shows that suspect waste tends to be lower in density than all low-level waste. The waste is typically laboratory trash and, in theory, is contaminated with gamma emitting activation products.

Because of the nature of the activation and spallation processes, radioactive contamination at TA-48 and TA-53 is expected to consist of fixed contamination of target and beam-line materials. It is very likely that cellulosic materials used in the handling of target and beam-line activities are not contaminated.

Conclusions and Recommendations

CMR and the Plutonium Facility

Both the CMR and Plutonium facilities are among the Laboratory leaders in waste characterization capabilities. Due to the nature of the suspect contaminated waste, it is not likely that current state-of-the-are detection equipment will meet any reasonable criteria for free release. Furthermore, due to the widespread contamination in these aging facilities, most building materials due tend to exhibit low levels of fixed radioactive contamination. Waste reduction efforts for these facilities should concentrate on decontamination and material compaction rather than detection and free release.

TA-48 and TA-55

Because the majority of suspect low-level radioactive materials are low density cellulosics, a materials segregation and characterization program may be used to verify that cellulosic materials are cleared for free release. Currently, waste box counters are capable of minimum detectable concentrations of less than 1 pCi/g (based on ^{73}As and a 200 s count time). If even one-half of the suspect contaminated cellulosics can be free released as non-radioactive, the volume saved would be approximately 150 m^3 annually from these two facilities alone. This method of characterization and free release would require guidance and approval from DOE for volume contaminated materials (similar to methods used in the nuclear power industry).

FIG. 1

1994 Waste Generators at Los Alamos National Laboratory

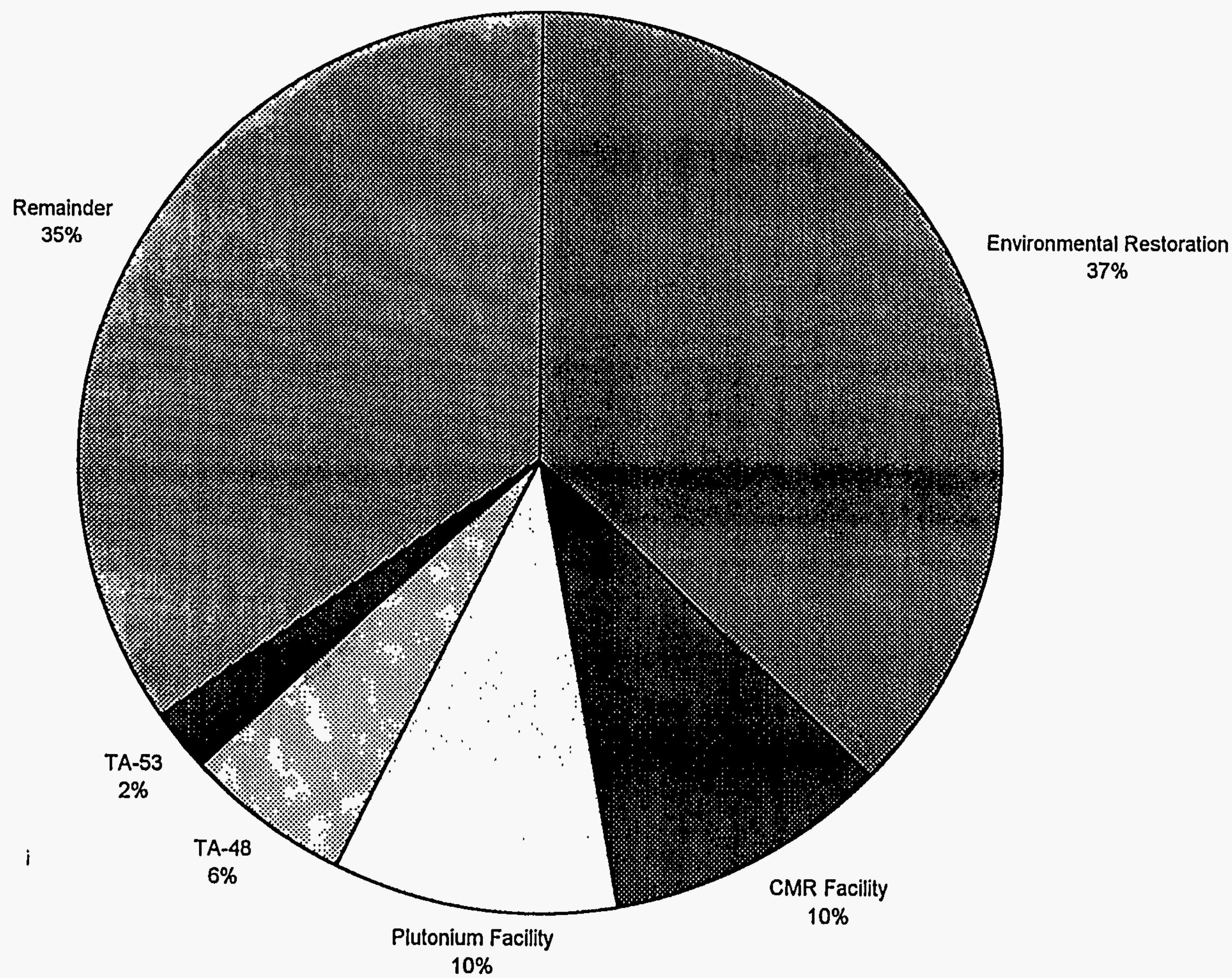


FIG. 2

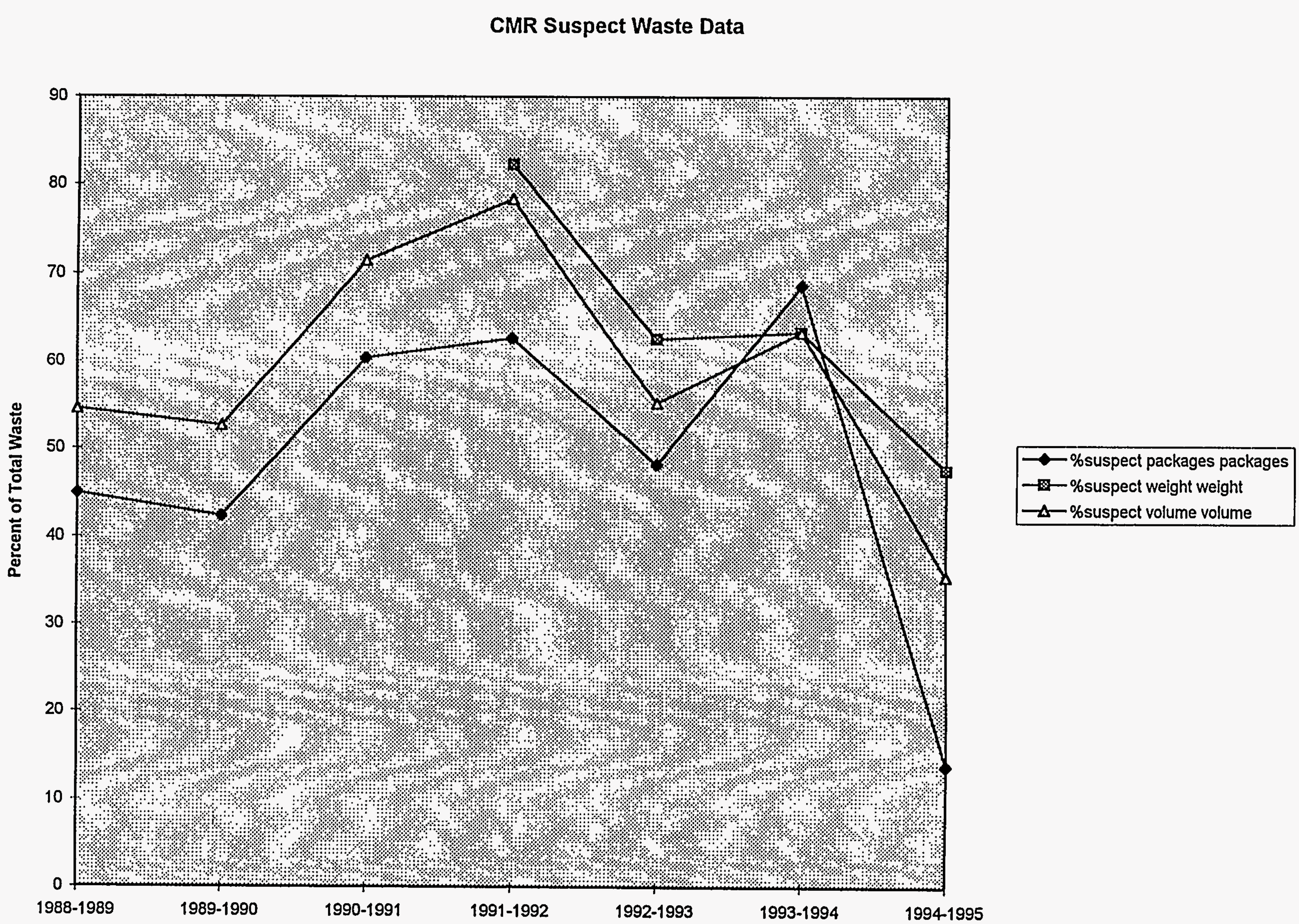
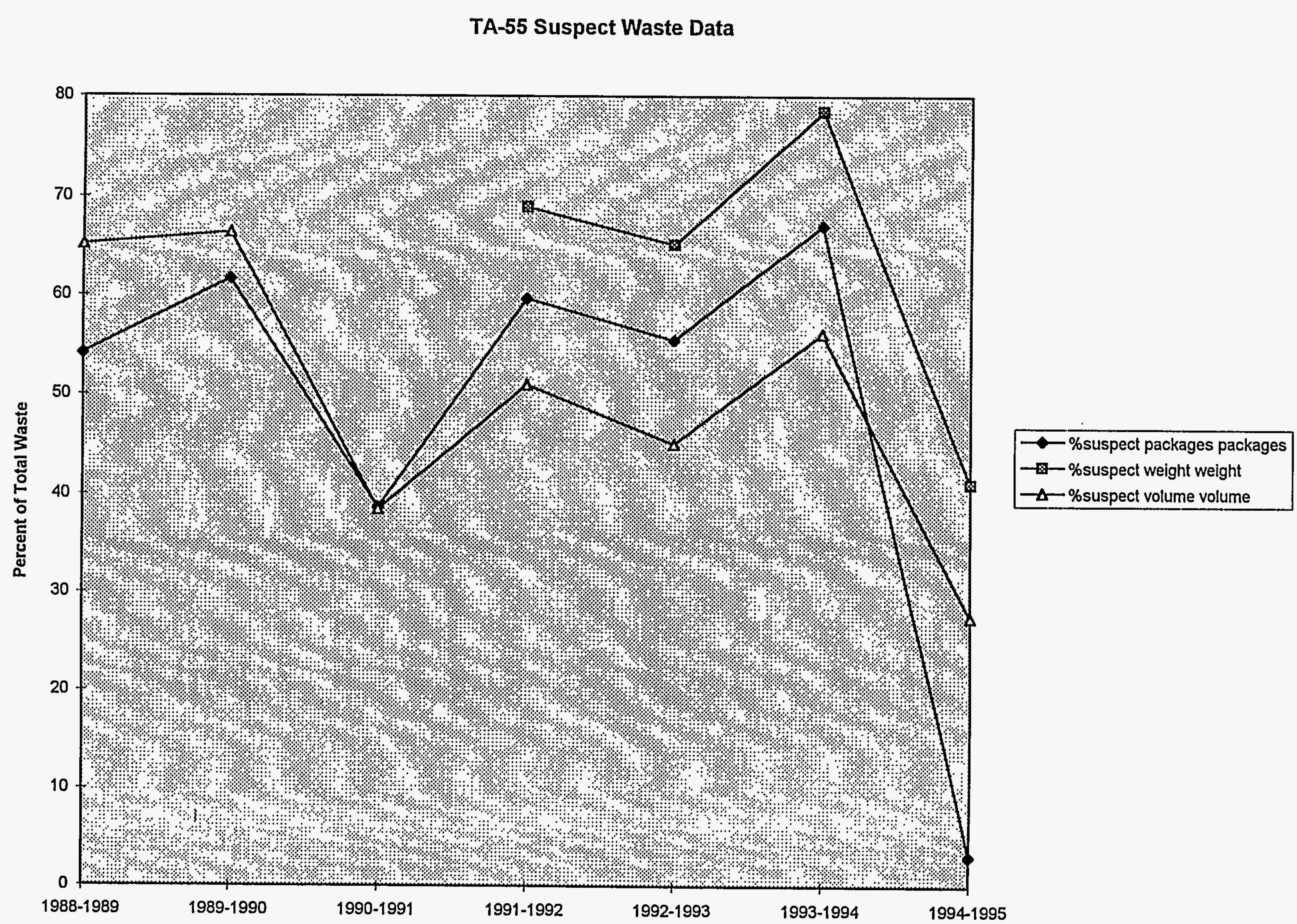
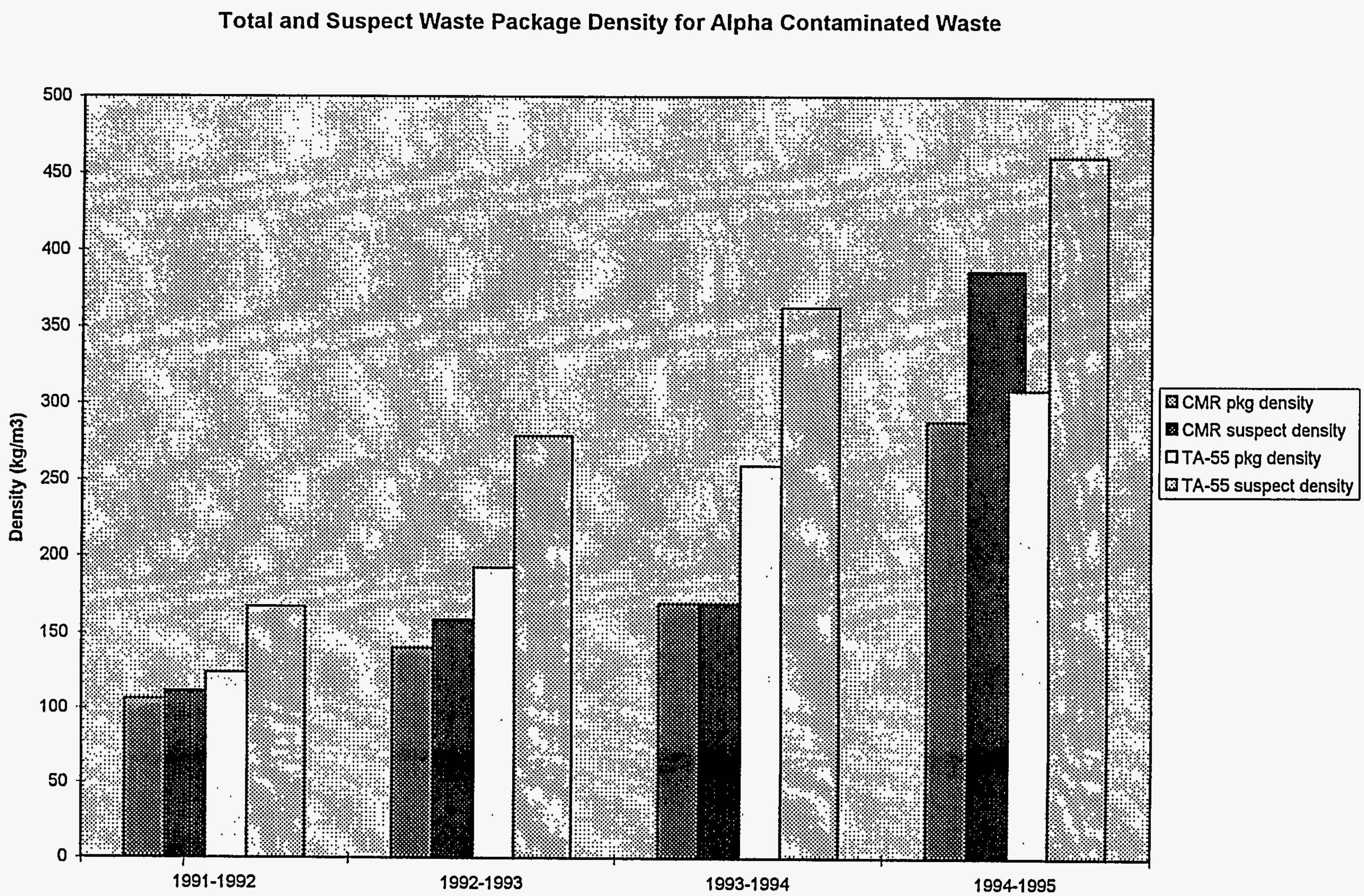

CMR Suspect Waste Data
90
80
70
60
50
40
30
20
10
0
Percent of Total Waste
1988-1989
1989-1990
1990-1991
1991-1992
1992-1993
1993-1994
1994-1995
%suspect packages packages
%suspect weight weight
%suspect volume volume

FIG. 3



TA-55 Suspect Waste Data
Percent of Total Waste
80
70
60
50
40
30
20
10
0
1988-1989
1989-1990
1990-1991
1991-1992
1992-1993
1993-1994
1994-1995
%suspect packages packages
%suspect weight weight
%suspect volume volume

FIG. 4



Total and Suspect Waste Package Density for Alpha Contaminated Waste
Density (kg/m3)
500
450
400
350
300
250
200
150
100
50
0
1991-1992
1992-1993
1993-1994
1994-1995
CMR pkg density
CMR suspect density
TA-55 pkg density
TA-55 suspect density

FIG. 5

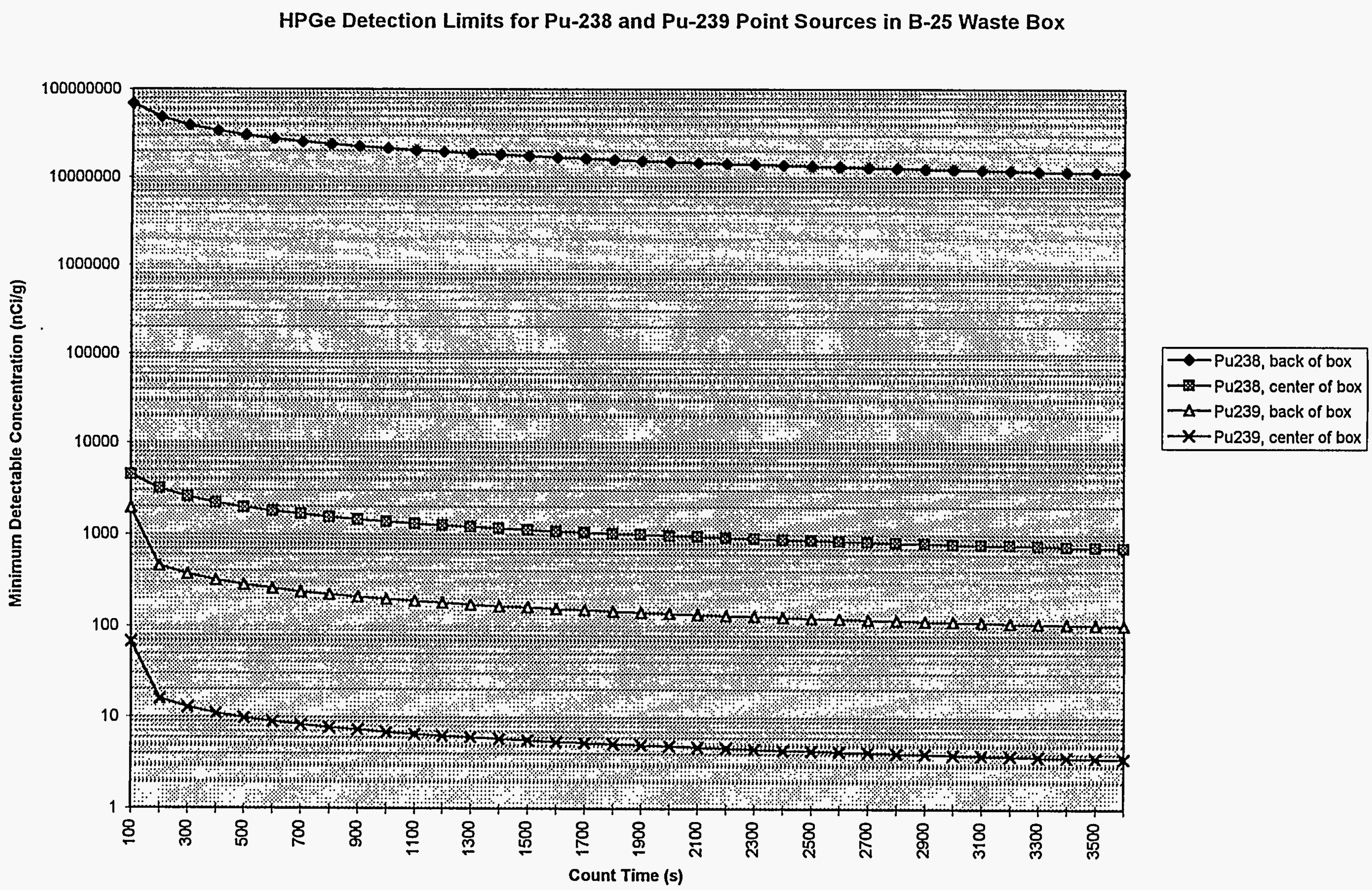

HPGe Detection Limits for Pu-238 and Pu-239 Point Sources in B-25 Waste Box
Minimum Detectable Concentration (nCi/g)
100000000
10000000
1000000
100000
10000
1000
100
10
1
100
300
500
700
900
1100
1300
1500
1700
1900
2100
2300
2500
2700
2900
3100
3300
3500
Count Time (s)
Pu238, back of box
Pu238, center of box
Pu239, back of box
Pu239, center of box

FIG. 6

HPGe Detection Limits for Cs-137, Pu-238 and Pu-239 Point Sources in Back of B-25 Waste Box

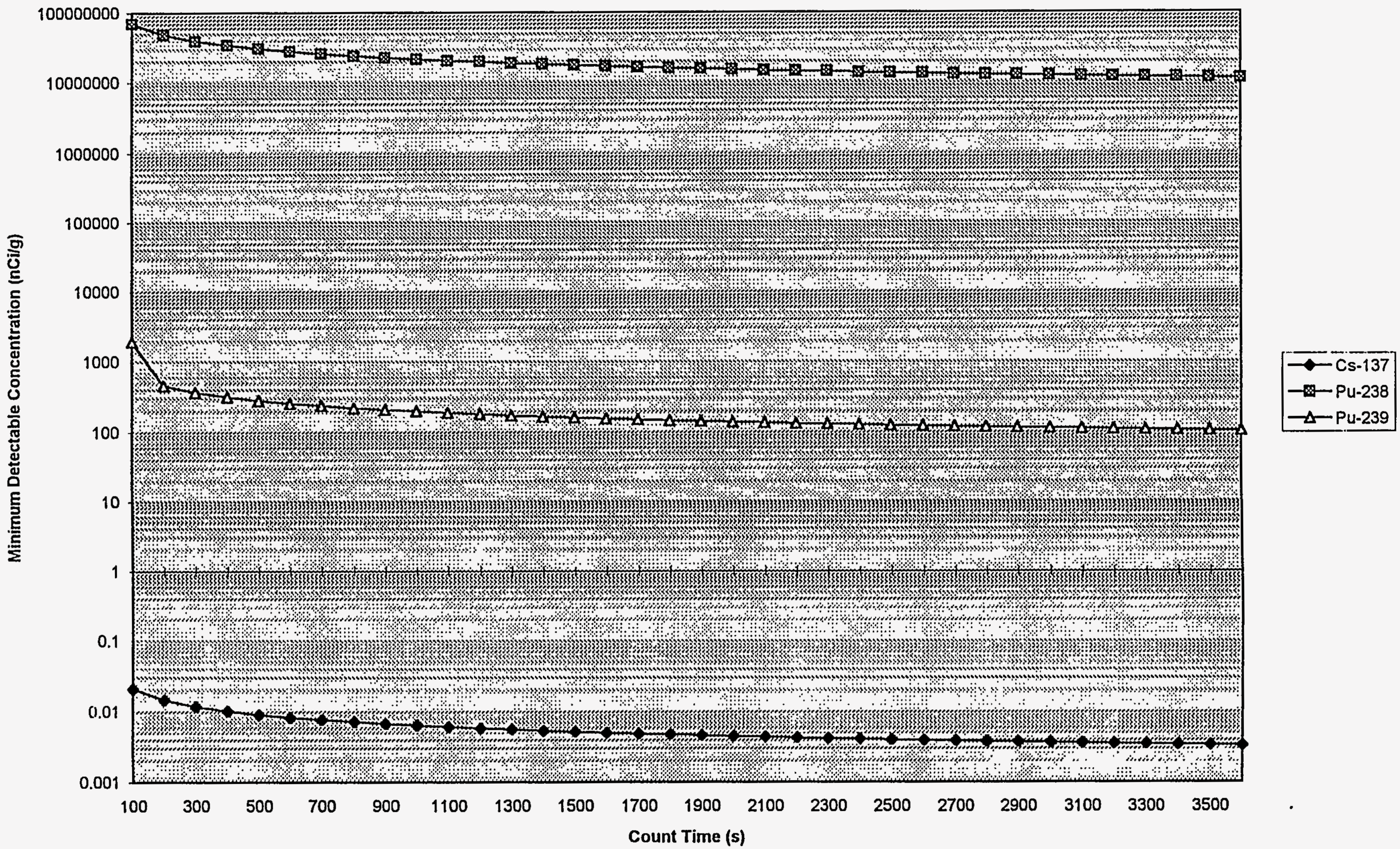


FIG. 7

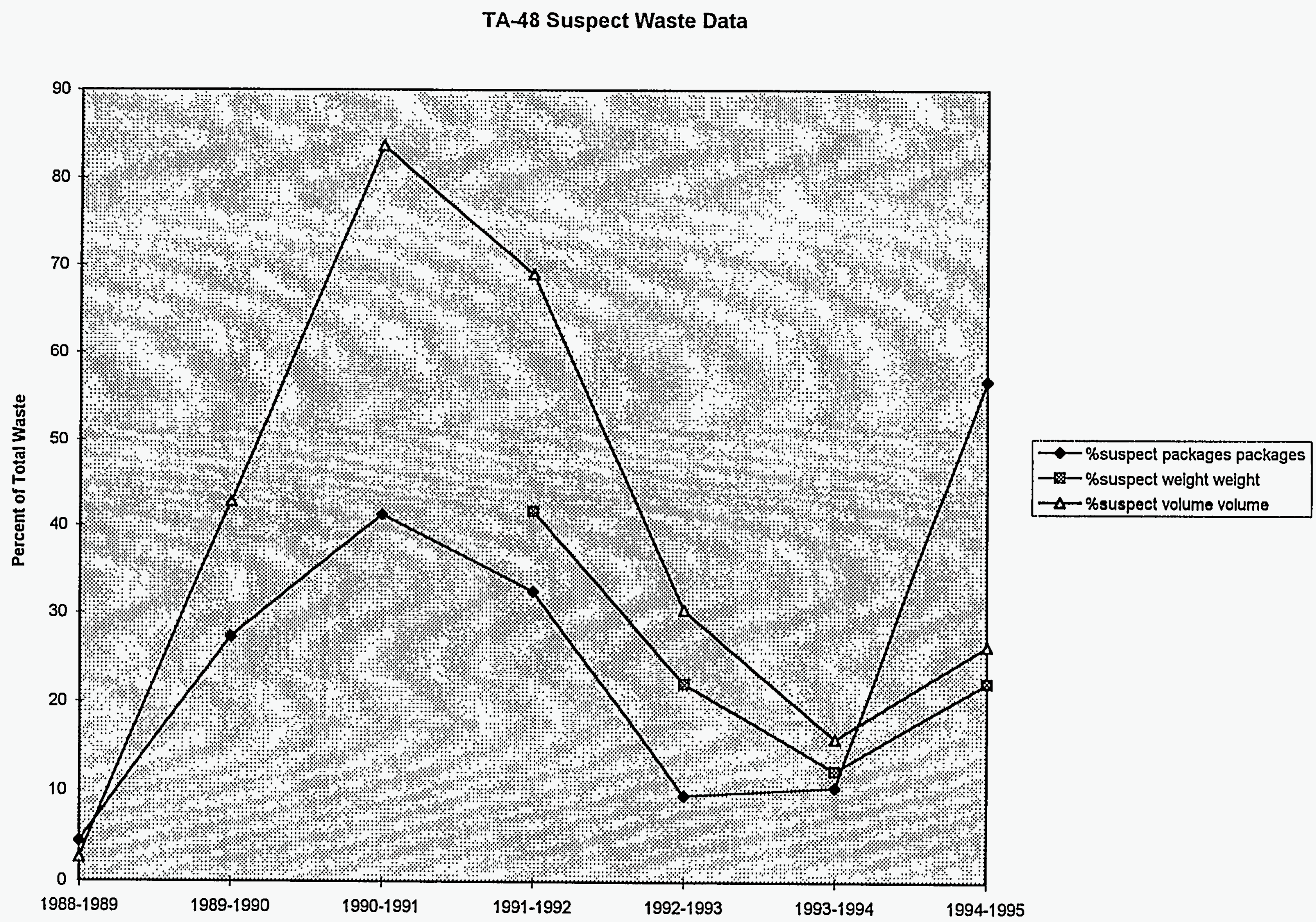

TA-48 Suspect Waste Data
Percent of Total Waste
90
80
70
60
50
40
30
20
10
0
1988-1989
1989-1990
1990-1991
1991-1992
1992-1993
1993-1994
1994-1995
%suspect packages packages
%suspect weight weight
%suspect volume volume

FIG. 8

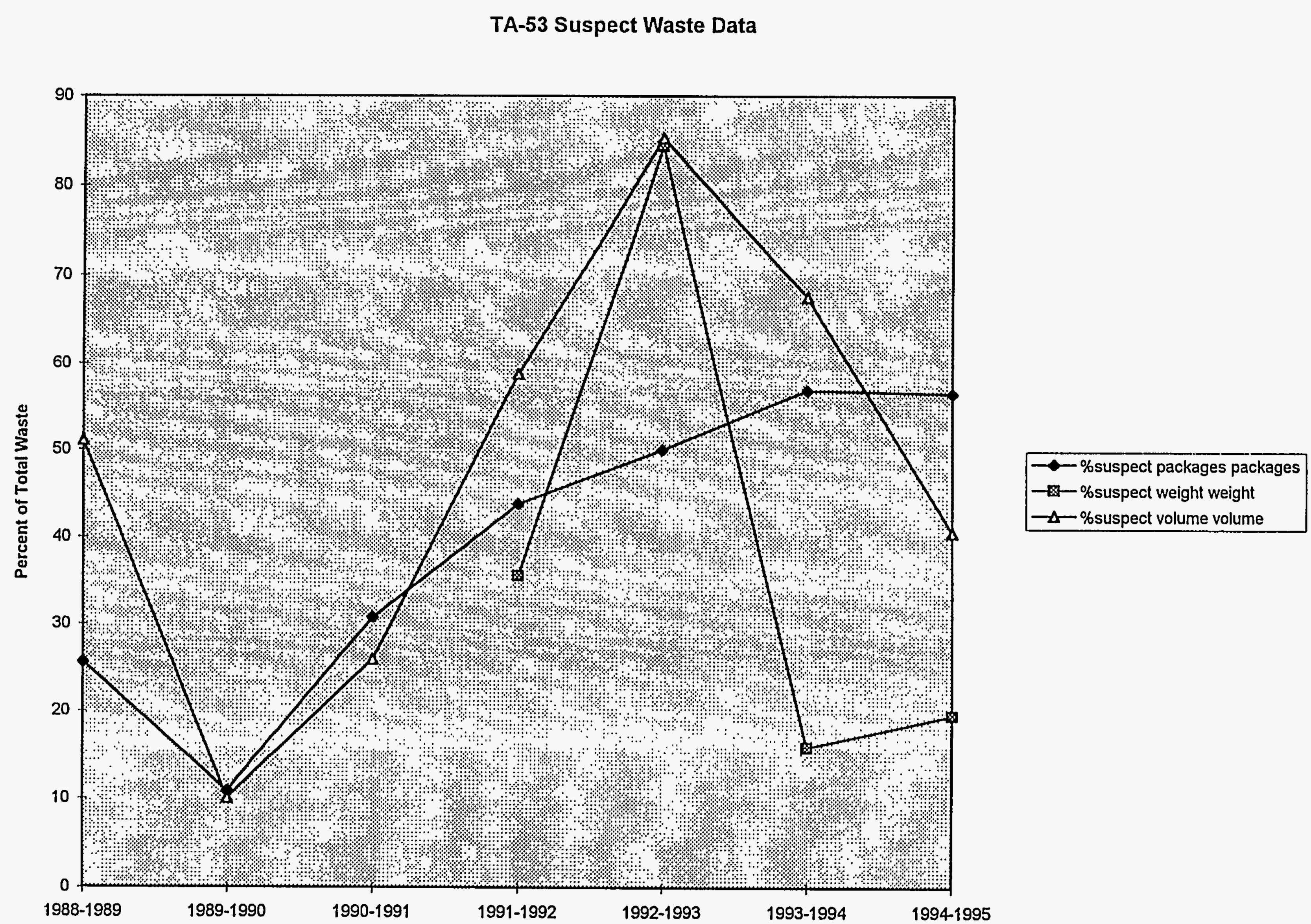

TA-53 Suspect Waste Data
Percent of Total Waste
90
80
70
60
50
40
30
20
10
0
1988-1989
1989-1990
1990-1991
1991-1992
1992-1993
1993-1994
1994-1995
%suspect packages packages
%suspect weight weight
%suspect volume volume

Fig. 9

Total and Suspect Waste Package Density for Beta Contaminated Waste