LA-13527-PR
Progress Report

Area G Perimeter Surface-Soil and Single-Stage Water Sampling

Environmental Surveillance for Fiscal Years 1996 and 1997

Group: ESH-19

Los Alamos
NATIONAL LABORATORY

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Acronyms and Abbreviations

AA	atomic absorption
cpm	counts per minute
COPC	contaminant of potential concern
CST	Chemical Science and Technology Division, LANL
EPA	Environmental Protection Agency
ER	Environmental Restoration Project, LANL
ESH	Environment, Safety, and Health Division, LANL
FIDLER	field instrument for detection of low-energy radiation
FIMAD	Facility for Information Management and Display
FY	fiscal year
HASP	health and safety plan
HAZWOPER	hazardous waste operations
ICPMS	inductively coupled plasma mass spectral (analysis)
keV	kiloelectron volts (10^3 electron volts)
KPA	kinetic phosphorescence analysis
LANL	Los Alamos National Laboratory
MCA	multichannel analyzer
MDA	material disposal area
µg	microgram (10^{-6} grams)
µmhos	micromhos (10^{-6} ohms^{-1}, a measure of conductance)
µm	micrometer (10^{-6} meters)
NAD	North American datum
NMED	New Mexico Environment Department
OU	operable unit
pCi	Picocurie (10^{-12} curies)
RAS	Radioactivity/alpha spectroscopy
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
ROI	(spectral) region of interest
SOP	standard operating procedure
SW	solid waste
TA	technical area
TRU	transuranic (waste)
TWISP	Transuranic Waste Inspectable Storage Project
WILD	brand-name surveying station
WSS	Waste Site Studies

AREA G PERIMETER SURFACE SOIL
AND SINGLE-STAGE WATER SAMPLING
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Group: ESH-19

by

Marquis Childs and Ron Conrad

ABSTRACT

Hazardous and Solid Waste Group (ESH-19) personnel collected soil and single-stage water samples around the perimeter of Area G at Los Alamos National Laboratory (LANL) during FY96 and 97 to characterize possible radionuclide and metals movement out of Area G through surface water and entrained sediment runoff. Soil samples were analyzed for percent moisture, tritium, isotopic plutonium, americium-241, and cesium-137. The sediment portion of the single-stage water samples were analyzed for 13 metals (Ag, As, Ba, Be, Cd, Cr, Hg, Ni, Pb, Sb, Se, Ti, and Zn). Baseline or local background concentrations for future disposal operations were established for metals and radionuclides by a sampling program conducted in the proposed Area G development (formerly known as "expansion") area during FY93 and 94. The results from the FY 96 and 97 sampling were compared to these values. Considering the amount of low-level radioactive waste that has been disposed of at Area G, there is evidence of only low concentrations of radionuclides and metals on perimeter surface soils and sediments. Consequently, little radioactivity and only low metal concentrations are leaving the confines of Area G via the surface water runoff pathway. The results from the FY96 and 97 Area G perimeter sampling environmental surveillance program are similar to those from previous years; no significant increase or decrease in radionuclides or metals concentrations. See LANL reports: FY 93, LA-12986; FY94, LA-13165-PR; FY95, LA-13369-PR.

EXECUTIVE SUMMARY

Area G in Technical Area 54, has been the principal facility at Los Alamos National Laboratory for the storage and disposal of low-level, solid mixed, and transuranic (TRU) radioactive waste since 1957. Our investigation during FY96 and 97 focused on defining whether surface water has moved contaminated sediments out of the Area G site perimeter. Soil samples were analyzed for tritium, isotopic plutonium, americium-241 (Am-241), and cesium-137 (Cs-137). Thirteen metals—silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead, antimony, selenium, thallium and zinc—were analyzed on filtered-sediment fractions of the single-stage samples using standard analytical chemistry techniques (EPA SW-846).

During the two years of sampling discussed in this report, elevated levels of tritium (as high as 716,000 pCi/L) in soil were found for sampling sites adjacent to the tritium burial shafts located on the south-central perimeter of Area G. Additionally, tritium concentrations in soil as high as 38,300 pCi/L were detected adjacent to the TRU pads in the northeast corner of Area G. The majority of soil samples collected from sampling points surrounding the TRU pads and extending to the west were elevated in tritium concentration. Tritium concentrations in soils collected in FY96 were substantially different from those collected in FY97. The variation in the soil tritium concentrations can be attributed to the time of year when the samples were collected. The FY96 samples were collected in the middle of the summer when the percent of moisture in the soil was relatively low (0.1 to 8.1 %) and tritium flux was at a maximum. The FY97 samples were collected in March and these soil samples had a percentage of moisture from 2.8% to 27.3% and tritium flux was relatively low. We propose that the FY97 samples were substantially diluted with natural precipitation, resulting in lower tritium levels. It has been shown by ambient air measurements that tritium is emitted from Area G at higher levels in the summer than other times of the year. This may also be reflected in the higher soil tritium concentrations in FY96 as opposed to soil tritium concentrations measured in FY97. Two primary mechanisms, vapor-phase transport and capillary action, may allow tritium to move from the subsurface to surface soils.

Plutonium-238 (Pu-238) activities in FY96 soils ranged from 0.001–2.866 pCi/g, with an average concentration of 0.336 ± 0.734 pCi/g. Pu-238 activities in FY97 soils ranged from 0.002–4.890 pCi/g, with an average concentration of 0.437 ± 0.928 pCi/g. Pu-239 activities in FY96 soils ranged from 0.009 to 1.62 pCi/g, with an average of 0.177 ± 0.297 pCi/g. Pu-239 activities in FY97 soils ranged from 0.005 to 1.71 pCi/g, with an average of 0.290 ± 0.415 pCi/g. The locations of elevated plutonium readings were consistent with the history of plutonium disposal at Area G; the sampling stations adjacent to the TRU pads and the oldest disposal pits had the highest plutonium levels for both surface soil and single-stage sediment fraction samples. The two areas of elevated Am-241 activity reflected the elevated activities found for plutonium; the average values for Am-241 on soils were 0.69 ± 2.07 pCi/g, and 0.10 ± 0.14 pCi/g respectively for samples collected in FY96 and FY97. Cs-137 activities in soils had average values of 0.33 ± 0.32 pCi/g, and 0.28 ± 0.25 pCi/g respectively for samples collected in FY96 and 97. There was no perimeter area where soil concentrations of Cs-137 were significantly elevated.

For the 13 metals analyzed in the sediment fraction of the single-stage water samples, there were only minor elevated concentrations measured over the metal in soil concentrations in the baseline soils collected from the proposed Area G development area located immediately west of the active part of Area G. Of the 13 metals analyzed on the sediment fraction of 25 single-stage water samples collected around Area G, only 4% were outside the baseline. Because single-stage samples are collected during storm water runoff, the sediment fraction metal concentrations measured in these water samples should reflect the metal concentrations in surface soils situated in the watersheds above the locations of the single-stage sample bottles.

1.0 INTRODUCTION

Area G or Material Disposal Area (MDA) G, in Technical Area 54 (TA-54), has been the principal facility at Los Alamos National Laboratory (LANL or the Laboratory) for the storage and disposal of low-level, solid mixed, and TRU radioactive waste since 1957 (see Figure 1). From the standpoint of the surrounding environment, an important question is whether there has been an environmental impact outside of Area G due to the disposal and storage operations that have taken place within Area G. One aspect of this question is whether contamination associated with surface soil within Area G somehow migrates off-site. The two most likely pathways (ignoring the improbable groundwater pathway) for spread of contaminants from Area G surface sediments are airborne dispersion of particulate matter or gases and off-site movement of contaminated sediments and/or dissolved chemical compounds by surface water runoff.

This environmental surveillance investigation was carried out, in part, to ensure ongoing compliance with DOE Order 5400.1, "General Environmental Protection Program" (June 1990), and DOE Order 5820.2A, "Radioactive Waste Management" (September 1988).

Our investigation focuses principally on defining the potential pathway for the transport of contaminated sediment and storm water or other precipitation out of Area G. Extensive surface soil and storm-water-runoff sampling was initiated in FY93 around the perimeter of Area G and continued during FY96 and 97. Sampling locations were intentionally selected to best indicate whether contaminants were moving off-site via this pathway; thus, these sampling locations should be considered as locations most sensitive to possible contaminant migration outside of Area G. The data collected during FY96 and 97 can be used to

1. determine whether there has been movement of contaminants out of the site;
2. compare with baseline concentrations of constituents on soils sampled in an undisturbed area of TA-54 proposed for further development of Area G disposal operations;
3. compare with baseline concentrations established at the same locations during the FY93 sampling and to define contaminants of potential concern (COPCs) and locales for future Area G surveillance efforts; and
4. assist Area G Waste Management personnel attempts to engineer techniques to prevent off-site movement of contaminants by either indicating areas of concern or assessing effectiveness of engineering fixes already in place to preclude off-site movement of contaminants.

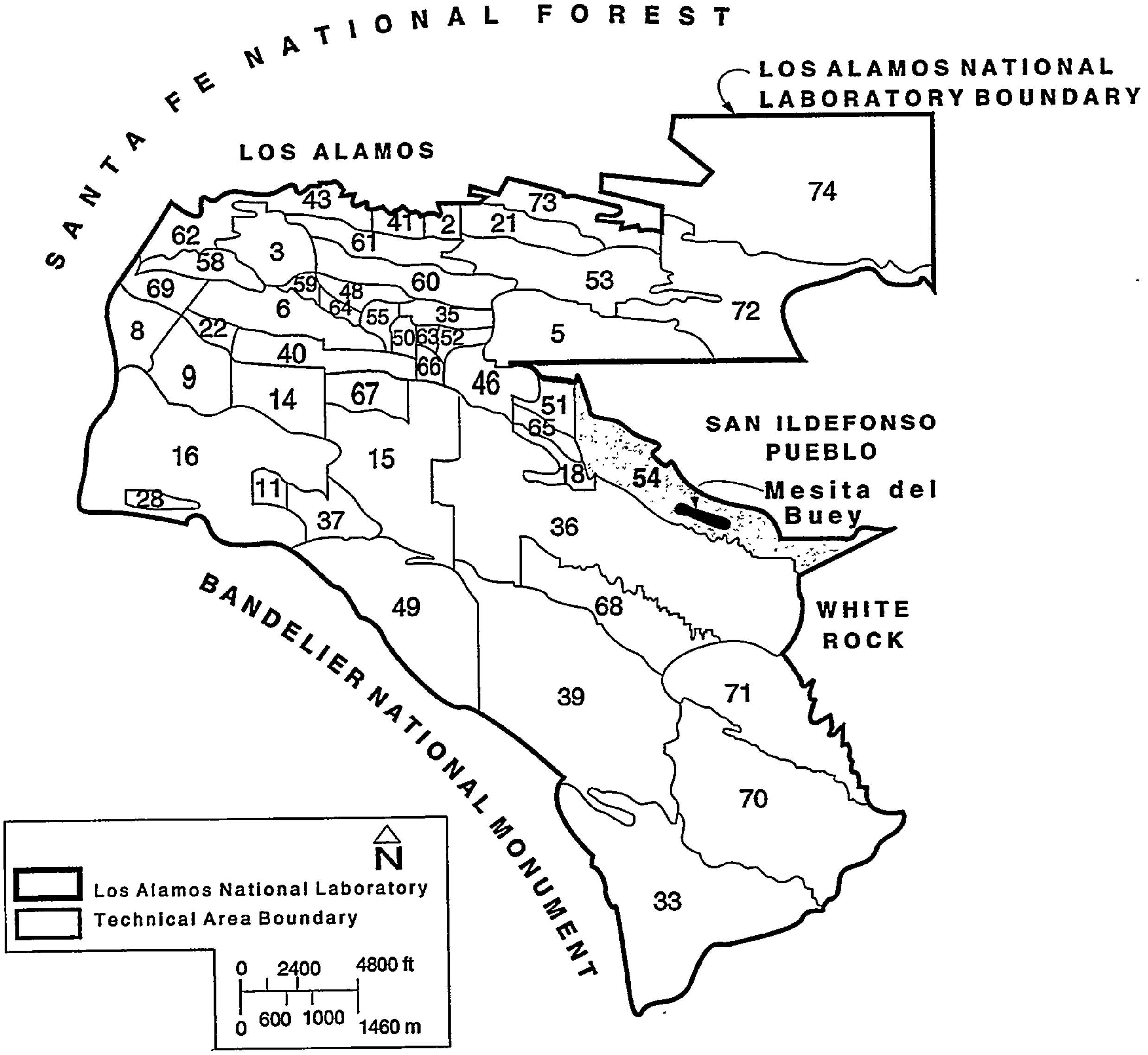

Figure 1: Location of TA-54 and Area G at Los Alamos National Laboratory. The 74 technical areas (TAs) of the Laboratory are shown here, with TA-54 located south of San Ildefonso Indian Reservation property. Area G (shaded in gray) runs along Mesita del Buey and parallels Pajarito Road.

The determination of sediment movement out of Area G via the surface water pathway is important because this is a major mechanism for disseminating nongaseous contaminants from the surface of Area G to outlying areas. Contamination of the ground surface of Area G (and formation of the surface soil source term for surface water runoff) may have resulted from

1. dispersion of material from active pits by natural phenomena and other anthropic activities;
2. movement of contaminated sediments off the TRU pads or other storage or disposal areas by wind, surface water runoff, mass wasting, or anthropic activities;
3. capillary action or vapor movement of buried, radioactive contaminants in pits and shafts to the surface;
4. inadvertent spills or discharges from facilities or vehicles handling contaminated materials;
5. dispersion of contaminants from trucks carrying waste into Area G;
6. transport of contaminants or contaminated materials from inactive pits, shafts, or pads to the surface by burrowing animals, vegetation, or anthropic activities; and
7. waste disposal of contaminated sediments on the ground surface.

Radioactive surface soil contamination at low levels has been documented within the confines of Area G, and it is important to determine if these contaminants are moving off the mesa top to areas where the public may be exposed or to where there may be a detrimental impact to the environment. In addition, metals on Area G soils have been found to have similar concentrations to metals on soils collected in the development area. To verify that elevated concentrations of metals are not migrating off of Area G, storm water runoff samples were collected and the sediment fraction analyzed for metals.

To this end, an extensive perimeter sampling network has been established at Area G (Figure 2, inside back cover pocket).

2.0 OBJECTIVES OF INVESTIGATION

The objectives of these investigations are to

1. define those perimeter locations at Area G where contaminants are expected to be found in surface soils or in established surface-water-runoff channels. The latter are determined by walking the site and detecting the small channels that are formed by surface water runoff originating in Area G;

2. quantify the levels of radioactive and RCRA regulated metal contaminants in surface soils (or single-stage sample sediment fraction) at Area G and compare to baseline levels from surface soil samples taken in adjacent, non-impacted locations;

3. provide contaminant concentration data that can be compared with analogous baseline data collected in the development area, if available; and

4. document whether contaminants (associated with sediments) are moving off-site through surface water runoff and compare to contaminant concentrations on samples collected from adjacent areas where disposal operations have not occurred.

Enhanced Area G perimeter surveillance is taking place on an annual basis in order to provide an up-to-date picture of existing radioactive (and other constituent) contamination in perimeter surface soils and surface water runoff. Ultimately, any measurable impacts on unimpacted adjacent areas can be documented by comparing these data with those from future surveillance efforts.

2.1 Areal and Temporal Extent

The investigation to define off-site migration of contaminants via the surface water pathway is limited to the near mesa top perimeter outside the fence of Area G, the hillsides directly below Area G, and one major drainage within the disposal area itself. Surface soil-sampling stations and single-stage water samplers were installed in small arroyos or rivulets incised into the hillsides around the perimeter of Area G. The single-stage locations are designed to sample runoff either on the mesa top (just outside the fence line) or at points before the runoff enters the bottom of either of the two adjoining canyons, Cañada del Buey or Pajarito Canyon. This microscale surface water runoff sampling complements the macroscale storm water runoff compliance sampling performed by the Water Quality and Hydrology Group (ESH-18) of the Environment, Safety, and Health Division (ESH).

This study is not intended to define potential contamination in the environment downstream from Area G. The sediments in the canyon bottoms, surface water, and ground water located downstream from Area G are all monitored on an annual basis by ESH-18, and the Canyons Focus Group within the Laboratory Environmental Restoration Project is undertaking an intensive investigation of the impacts to the canyons resulting from past Laboratory operations and waste disposal practices.

Based on available funding, this investigation will be performed yearly with annual reports being prepared to compare contemporary with historical data.

2.2 Data Needs

The data needs for the FY96, 97 perimeter surveillance study are

1. surface soil samples (0–6 in. deep) from existing runoff pathways located just outside the Area G perimeter fence and analyses of these samples for those constituents listed in Section 5.3; and

2. surface water-runoff samples collected with single-stage samplers from channels that were estimated to have significant runoff volumes originating in Area G and analyses of these surface water-runoff samples for constituents listed in Section 5.2.

The development area (formerly known as the expansion area) sites that were sampled in FY94 and 95 are located where no radioactive-waste disposal has occurred and in an location where Waste Management operations are expected to develop in the future. In FY94 a regular 100 × 100 ft grid was established in this area, just west of the old Area G gate (the area west of the shaded yellow expanse in Figure 2). The analytical data from 54 samples collected in this area will serve as baseline or preoperational concentrations for constituents of interest when disposal operations are initiated in this development area. This information is also presented in this paper to serve as one benchmark against which perimeter soil and water constituent concentrations will be compared.

3.0 HEALTH AND SAFETY TRAINING FOR WASTE SITE STUDY (WSS) PERSONNEL

All field work on this project was performed by members of the WSS team from ESH Division's Hazardous and Solid Waste Group (ESH-19). Each member of the team has received and is current with all the requisite health and safety training required to perform environmental sampling at Area G. This training includes HAZWOPER (Hazardous Waste Operations), Radiation Worker and General Employment Training. All field work was done following the guidelines of the WSS site-specific Health and Safety Plan (HASP) for Area G.

All members of the team also received radiation support personnel training, which allowed them to competently operate the ESP-1 beta/gamma and Model 139 alpha meters and to perform routine frisking and radiation screening operations.

In addition, each team member watched the Area G site-specific training video, was aware of the potential hazards associated with this sampling project, was apprised of the health and safety rules and guidelines under which Area G employees operate, and performed field duties according to the Area G in-house health and safety protocols. Each WSS team member formally checked in and out of Area G daily if the work was within Area G. Work outside the fence at Area G did not require formal check-in but entailed complying with the same health and safety protocols as required within Area G. Each field task was performed using the buddy system; at no time did team members undertake a task at Area G without another team member being present. Finally, all team members were also enrolled in an annual LANL medical surveillance program.

4.0 FIELD INVESTIGATION METHODS

Accepted techniques were used to identify and certify sampling locations, install sampling equipment, take samples, and make measurements on these samples. A summary of field protocols is found in the following sections.

4.1 Land Survey

A WILD-brand electronic-theodolite complete surveying station was used in the field. This equipment was used and field data were collected employing WILDsoft 2000 software for data reduction. Bill Kopp, a LANL technical staff member and professional engineer registered in the state of New Mexico, supervised all of the surveying for this project.

At all of the sampling locations (coordinates referenced to North American datum [NAD] 1983), an aluminum stake was placed to memorialize the position.

The unique sampling locations on the perimeter of Area G were coded as G-##-#. The first two numbers after "G" in the sequence refer to one of seventy permanent survey monuments, each of which is identified by a piece of rebar driven into the ground and tagged with an aluminum cap marked with the location number. These 70 monuments were originally installed in 1991 as part of the old A411 material disposal area (MDA) low-energy gamma, field instrument for detection of low-energy radiation (FIDLER) study to characterize potential movement of radioactive contaminants off-site. FIDLER readings are still taken on an annual basis at each of these 70 locations; the data collected in FY96, 97 are found in Appendix A of this report. For the perimeter surveillance study, the soil and single-stage sampling sites were numbered in reference to these 70 permanent, surveyed locations. For instance, two soil or combination soil/single-stage sampling sites are sited near monument MDA-24. These locations are identified by aluminum stakes with numbered tags G-24-1 and G-24-2.

The development area soil sampling 100× 00 ft grid was also memorialized by surveying in the locations. At each location, a 4-ft aluminum stake was pounded into the ground. Numbered brass tags attached to the stake describe the locations with the notation, G-X-##. The gridded locations are numbered consecutively from G-X-1 through G-X-55, excluding point G-X-7 which is sited off the edge of the mesa top.

On the map depicting the perimeter and development area surveillance locations (Figure 2), soil-sample points are in orange, single-stage water sample points are in blue, and the combination points where both surface soil and single-stage samples are collected are depicted in green. The development area grid points are represented by purple numbers. Belinda Scheber of the LANL Facility for Information Management and Display (FIMAD) team prepared this map.

4.2 Field Techniques

The following standard sampling and instrument procedures, adopted by the WSS team to collect soil and water samples and to make associated measurements, were used during this investigation:

Standard Operating Procedure (SOP) Number	Title
LANL-ER-SOP-01.02	Sample Containers and Preservation
LANL-ER-SOP-03.01	Land Surveying Procedures
LANL-ER-SOP-06.09	Spade and Scoop Method for Collection of Soil Samples
LANL-ER-SOP-06.29	Single-Stage Sampling for Surface Water Runoff
LANL-ER-SOP-10.04	MCA-465/FIDLER Instrument System
LANL-ESH-8-008	General Field Work
DOE GJ/TMC-07(83), UC-70A	"Procedures for Field Chemical Analyses of Water Samples," by Nic Korte and Dennis Ealey

Before soil samples were collected, 1 min. counts were made at the soil surface to define surface soil beta/gamma activity. These readings were made with an Eberline ESP-1 beta/gamma meter equipped with a pancake probe. The beta/gamma measurements were taken principally to define any potential radioactive hazards at sampling points. A typical soil-background level taken with the ESP-1 counter at Area G was 300 cpm.

4.3 Chain-of-Custody Procedure

In addition to the above SOPs, we followed procedure LANL-ESH-8-002, "Chain-of-Custody for Environmental Samples." In this project, each sample was handled under standard chain-of-custody procedures, using traceable forms, transfer signatures, and custody tape. Every sample was always kept within sight of one of the WSS team members or locked in a room or cooler to which only the WSS team members had keys. All samples requiring analytical chemistry services were delivered to the Chemical

Science and Technology Division's (CST's) Sample Receiving Facility Group (CST-3) located at SM-59-1, TA-59. CST-3 personnel took formal custody of the samples at that time. All FY96 and 97 samples were analyzed on-site at LANL.

5.0 SAMPLE ANALYSIS

The analytical chemistry data for samples referred to in this report are found in Tables 1–3.

5.1 Water Samples

The single-stage water samples were collected in 1-gal. polyethylene bottles. The bottles were collected as soon as possible after a storm event and brought back to TA-59.

5.2 Requested Analytical Services

5.2.1 Surface Soil Samples

The following analytical services were requested for soil samples taken during FY96 and 97:

1. isotopic plutonium by radioactivity/alpha spectroscopy (RAS),
2. tritium by distillation of soil moisture and scintillation counting,
3. cesium-137 and AM-241 by gamma spectroscopy,
4. percent moisture by gravimetric methods, and
5. metals extracted by EPA SW-846 Method 3050 followed by appropriate inductively coupled plasma spectrometer (ICP) or atomic absorption (AA) analytical techniques.

5.2.2 Single-Stage Water Samples

The sediment fraction of the storm water runoff samples were separated from the water fraction by first allowing the sediment to settle out. The water fraction was then decanted off until only wet sediment remained. The wet sediment was then allowed to air dry. The dry sediment was then forced through a 250 micron stainless steel screen to obtain the solid material that was to be analyzed for metals. The metals were extracted from the dried sediment fraction using SW-846 Method 3050 and analyzed by appropriate AA or ICP techniques.

Table 1: FY96 TA-54 Area G (OU 1148) Perimeter Soil Data (Sample locations can be found in Figures 2 through 5. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.)

Sample Location	Collection Date	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-29-1	7/25/96	4.6	70,200	0.08	0.20	0.022	0.019	0.041
G-29-2	7/25/96	5.6	316,400	0.14	0.54	0.022	0.029	0.052
G-29-3	7/25/96	4.6	716,000	0.19	0.43	0.002	0.013	0.015
G-30-1	7/25/96	1.7	47,400	0.61	0.18	0.011	0.009	0.020
G-31-1	7/25/96	4.4	47,400	0.20	0.73	0.014	0.048	0.062
G-31-2	7/25/96	1.5	118,700	0.00	0.21	0.012	0.015	0.028
G-31-3	7/25/96	4.0	27,500	1.07	0.20	0.006	0.009	0.015
G-32-1	7/25/96	8.1	14,100	0.02	1.10	0.007	0.054	0.061
G-32-2	7/25/96	3.9	8,600	0.13	0.37	0.007	0.054	0.060
G-32-3	7/25/96	2.3	8,000	0.16	0.23	0.007	0.027	0.034
G-34-4	7/25/96	3.8	1,600	1.10	0.24	0.025	0.053	0.078
G-34-5	8/8/96	5.0	1,500	0.13	0.08	0.022	0.061	0.083
G-34-7	8/8/96	2.6	1,500	0.16	0.10	0.001	0.017	0.018
G-34-9	8/8/96	4.6	1,300	1.08	0.14	0.004	0.011	0.015
G-34-10	8/8/96	3.3	1,700	1.08	1.75	0.079	1.620	1.699
G-34-13	8/8/96	2.2	1,400	0.90	0.12	0.112	0.015	0.127
G-38-2	7/25/96	2.3	19,900	0.32	0.18	0.051	0.452	0.503
G-39-1	7/25/96	2.3	2,700	13.10	0.11	0.590	0.168	0.758
G-39-2	7/25/96	0.1	1,600	0.11	0.10	0.031	0.052	0.083
G-40-1	8/7/96	3.6	1,900	0.55	0.61	2.650	0.763	3.413
G-40-2	8/5/96	4.4	1,500	0.15	0.09	0.511	0.074	0.585
G-41-2	8/7/96	2.7	1,900	0.76	0.29	1.810	0.180	1.990
G-42-1	7/25/96	1.6	2,500	0.27	0.34	0.654	0.661	1.316
G-42-6	8/5/96	6.2	4,600	0.14	0.13	0.113	0.130	0.243
G-44-7	8/5/96	6.9	13,900	0.21	0.46	0.208	0.178	0.385
G-45-4	8/5/96	4.0	18,500	0.37	0.44	0.571	0.320	0.892
G-45-5	8/5/96	5.2	18,500	0.50	0.34	0.243	0.428	0.672
G-45-6	7/26/96	2.8	34,300	0.09	0.03	0.059	0.042	0.101
G-45-7	7/26/96	2.9	38,300	0.02	0.18	0.246	0.119	0.366
G-46-1	8/5/96	6.1	23,000	1.09	0.49	2.866	0.314	3.180

(continued)

Table 1 (continued): FY96 TA-54 Area G (OU 1148) Perimeter Soil Data (Sample locations can be found in Figures 2 through 5. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.)

Sample Location	Collection Date	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-46-2	7/26/96	3.1	9,900	0.88	0.28	2.462	0.450	2.912
G-47-1	7/26/96	4.1	7,200	0.09	0.41	0.134	0.443	0.577
G-49-1	8/5/96	2.3	1,300	0.19	0.08	0.005	0.043	0.048
G-49-4	7/26/96	4.3	1,600	0.03	0.08	0.018	0.079	0.096
G-50-1	7/26/96	2.8	5,200	0.09	0.10	0.027	0.067	0.094
G-50-2	7/26/96	5.8	3,600	0.54	0.10	0.068	0.072	0.140
G-52-1	7/26/96	2.6	1,800	0.14	0.53	0.021	0.036	0.057
G-52-2	7/26/96	5.4	800	0.01	0.74	0.028	0.053	0.081
G-52-3	7/26/96	4.0	17,000	0.09	0.33	0.042	0.042	0.084
G-58-1	7/26/96	3.5	600	0.09	0.23	0.032	0.016	0.048

	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
Statistics:							
Mean	3.8	40385	0.67	0.33	0.345	0.181	0.526
Median	3.8	6200	0.18	0.23	0.031	0.054	0.089
Std. Dev.	1.6	121647	2.05	0.32	0.741	0.299	0.891
Max	8.1	716000	13.10	1.75	2.866	1.620	3.413
Min	0.1	600	0.00	0.03	0.001	0.009	0.015

Table 2: FY97 TA-54 Area G (OU 1148) Perimeter Soil Data (Sample locations can be found in Figures 2 through 5. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.)

Sample Location	Collection Date	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-29-01	3/19/97	10.7	8800	0	0.06	0.022	0.014	0.036
G-29-02	3/19/97	20.4	19300	-0.07	0.35	0.016	0.029	0.044
G-29-03	3/19/97	13.1	67400	-0.01	0.1	0.003	0.008	0.011
G-30-01	3/19/97	10.4	29600	0.04	0.27	0.036	0.019	0.054
G-31-01	3/19/97	26.5	111000	0.07	0.32	0.015	0.032	0.047
G-31-02	3/19/97	12.5	82600	0.04	0.1	0.006	0.005	0.011
G-31-03	3/19/97	11.5	19900	-0.05	0.11	0.005	0.007	0.013
G-32-01	3/19/97	13.6	31400	0.03	0.88	0.014	0.054	0.069
G-32-02	3/19/97	26.3	13800	-0.03	0.38	0.011	0.063	0.074
G-32-03	3/19/97	13.4	4900	-0.05	0.19	0.005	0.021	0.027
G-34-04	3/19/97	14.7	600	-0.07	0.14	0.019	0.031	0.050
G-34-07	3/19/97	6.4	1100	0.04	0.06	0.002	0.016	0.019
G-34-10	3/19/97	7.2	1400	0.26	0.87	0.037	1.205	1.242
G-34-13	3/19/97	9.3	2000	-0.05	0.13	0.141	0.056	0.198
G-38-02	3/20/97	11.6	22700	-0.01	0.18	0.055	0.630	0.685
G-39-01	3/20/97	3.7	1500	0.21	0.1	0.240	0.120	0.360
G-39-02	3/20/97	2.8	2300	0.01	0.00	0.045	0.085	0.130
G-40-01	3/20/97	7.6	800	0.16	0.12	0.790	0.450	1.240
G-40-02	3/20/97	7.9	900	0.00	0.16	2.400	0.156	2.556
G-41-02	3/20/97	12.1	600	0.15	0.32	0.780	1.710	2.490
G-42-01	3/20/97	16.5	1300	0.12	0.22	1.180	0.620	1.800
G-43-01	3/20/97	23.2	1300	0.36	0.4	1.280	0.380	1.660
G-44-07	3/20/97	16.1	1900	0.15	0.37	0.124	0.214	0.338
G-45-04	3/20/97	23.0	2500	-0.02	0.25	0.540	0.280	0.820
G-45-05	3/20/97	23.5	3100	0.18	0.44	0.230	0.550	0.780
G-45-06	3/20/97	18.8	2500	0.05	0.32	1.740	0.280	2.020
G-45-07	3/20/97	14.7	2800	0.04	0.08	0.570	0.220	0.790
G-46-01	3/20/97	19.2	6200	0.43	0.81	4.890	1.580	6.470
G-46-02	3/20/97	27.3	1000	0.21	0.23	1.860	0.930	2.790
G-47-01	3/20/97	12.1	2100	0.25	0.34	0.129	0.420	0.549

(continued)

Table 2 (continued): FY97 TA-54 Area G (OU 1148) Perimeter Soil Data (Sample locations can be found in Figures 2 through 5. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.)

Sample Location	Collection Date	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-48-02	3/20/97	9.8	1300	0.12	0.27	0.050	0.520	0.570
G-49-01	3/19/97	17.4	1200	0.01	0.03	0.032	0.314	0.346
G-49-04	3/19/97	18.9	900	0.16	0.03	0.018	0.100	0.118
G-50-01	3/19/97	17.0	500	0.43	0.21	0.057	0.161	0.218
G-50-02	3/20/97	21.5	1100	0.09	0.05	0.043	0.099	0.142
G-52-01	3/19/97	14.5	300	0.06	0.66	0.022	0.039	0.061
G-52-02	3/19/97	11.3	800	0.43	1.01	0.027	0.068	0.095
G-52-03	3/19/97	18.8	500	0.22	0.25	0.034	0.092	0.126
G-55-01	3/19/97	18.1	600	-0.03	0.21	0.002	0.013	0.015
G-58-01	3/19/97	9.8	100	-0.03	0.27	0.016	0.019	0.036

	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
Statistics:							
Mean	14.8	11365	0.10	0.28	0.437	0.290	0.727
Median	14.1	1700	0.05	0.23	0.040	0.100	0.170
Std. Dev.	6.2	23784	0.14	0.25	0.928	0.415	1.219
Max	27.3	111000	0.43	1.01	4.890	1.710	6.470
Min	2.8	100	-0.07	0.00	0.002	0.005	0.011

5.2.3 Laboratory Soil-Sample Preparation

Before the CST-9 soil analyses for radionuclides (excepting tritium), the soils were first dried overnight at 100°C and then sieved through a number 12 Tyler sieve to remove large-sized particles and foreign matter (twigs, grass, etc.). When the dried soil samples were analyzed for plutonium, these radionuclides were first extracted by a hot nitric acid/hydrofluoric acid leaching procedure that effectively dissolves the entire sample. Standard CST analytical chemistry procedures were then followed for separating, plating, and counting radionuclides.

For tritium analyses on soils, the soil moisture is distilled from the soil. This soil moisture is analyzed for tritium by scintillation counting.

6.0 DEVELOPMENT AREA BASELINE STUDY

An approximately 10-acre site directly west of active Area G has been identified as the location for the development of Waste Management disposal operations. Baseline surface soil and water chemistry data have been collected to define the ambient conditions before any operations are initiated in this area. This baseline data will not only be used in the future to define any impacts from the active operations that will be taking place in this area, but will serve in this study as baseline or local background for comparison to perimeter soil and surface water runoff samples collected during FY96 and 97 in the active part of Area G. A summary of the development area analytical chemistry data is found in Table 4. These data are used in box plots presented in Appendix B.

7.0 PERIMETER SOIL-SAMPLE RESULTS FOR CONSTITUENTS OF INTEREST

Figures 3 through 6 illustrate the distribution of radionuclides in surface collected on the perimeter of Area G. A discussion of individual constituents is found below.

7.1 Tritium

The analytical radiochemistry results for the soil samples are presented in Table 1. Figure 3 depicts the perimeter and development area tritium distributions for the soil tritium samples. Appendix B contains box plots depicting the distribution of tritium concentration on surface soils collected around the Area G perimeter in FY93 through 97 and compares tritium distributions with data from soil samples collected in the development area in FY94 and 95 (period used to collect samples and establish baseline).

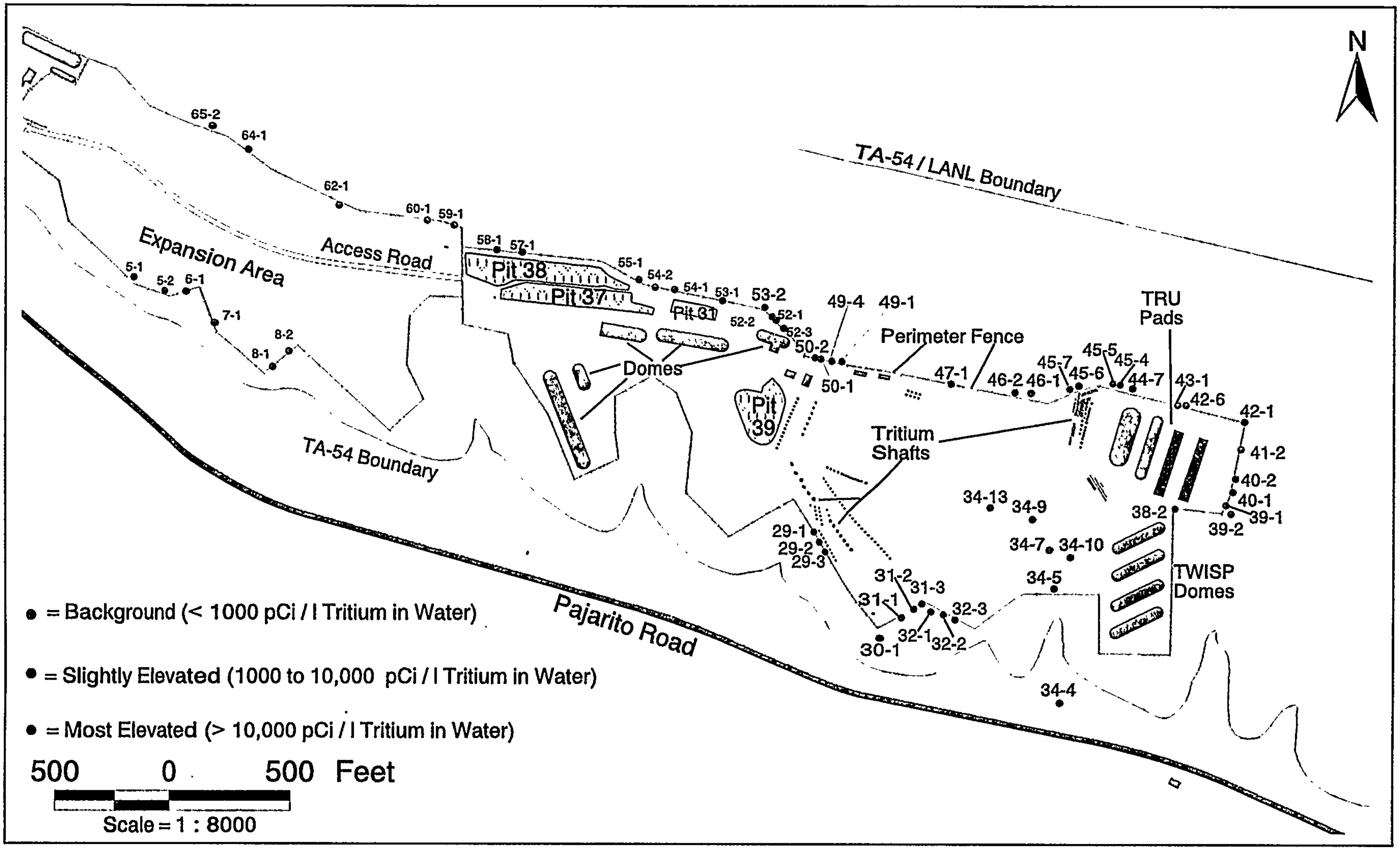

Figure 3: Tritium soil-sample locations and analytical results (FY 97) at Area G. The number is the sample location identification number, and the color represents its tritium concentration range (in picocuries per liter). There are three categories in the tritium concentration range: background (green), slightly elevated (blue), and most elevated (red). All the significant Area G landmarks and features are identified on the figure.

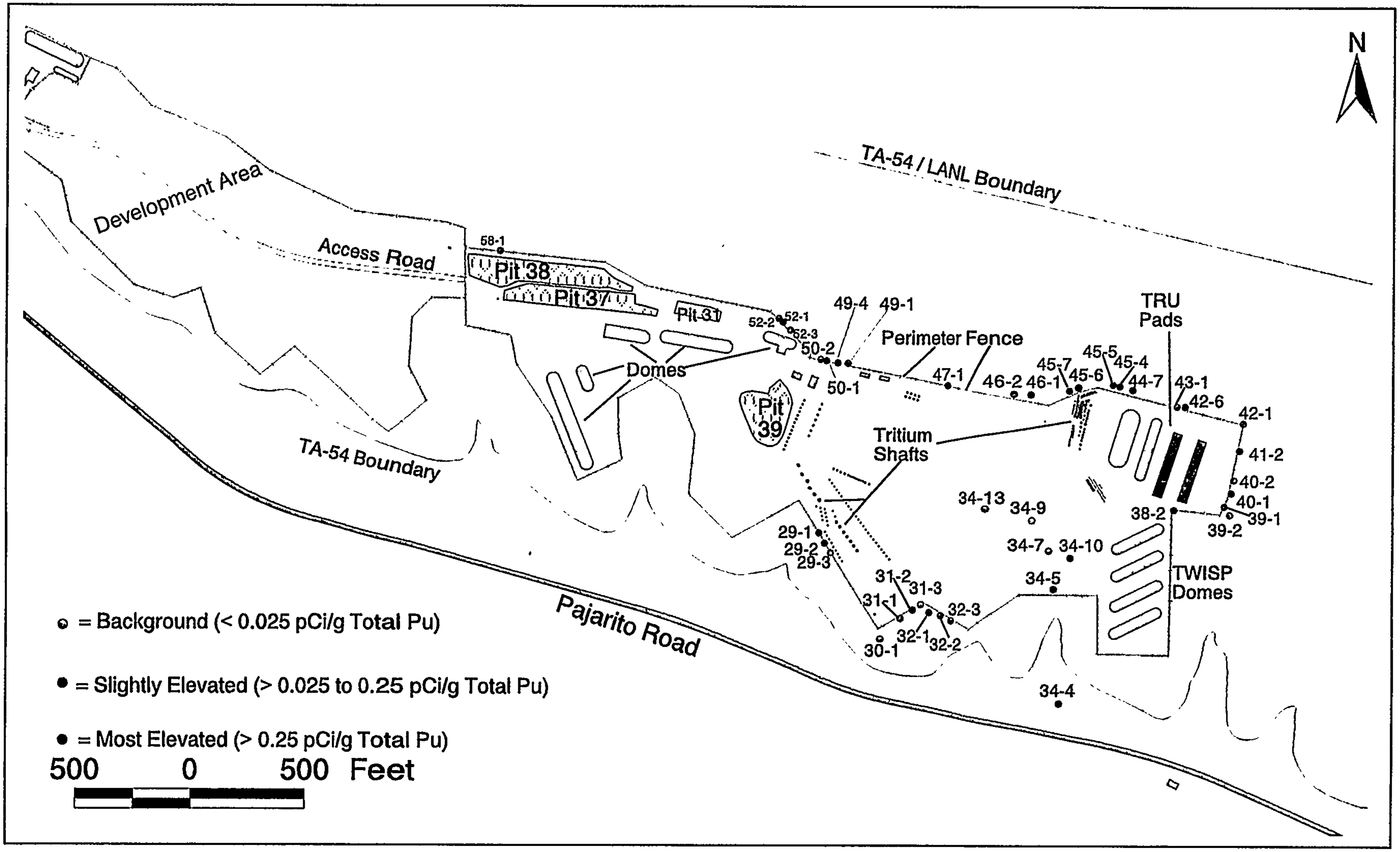

Figure 4: Total isotopic plutonium soil-sample locations and analytical results (FY97) at Area G. Color coding at each sampling location indicates whether total plutonium in soil from this location was background or below, slightly elevated above background, or most elevated above background. Several Area G landmarks are outlined and labeled for orientation: the perimeter fence line, active pits 37, 38, and 39, the expansion area to the west, and the transuranic waste pads (TRU Pads) and the Transuranic Waste Inspectable Storage Project (TWISP) to the east.

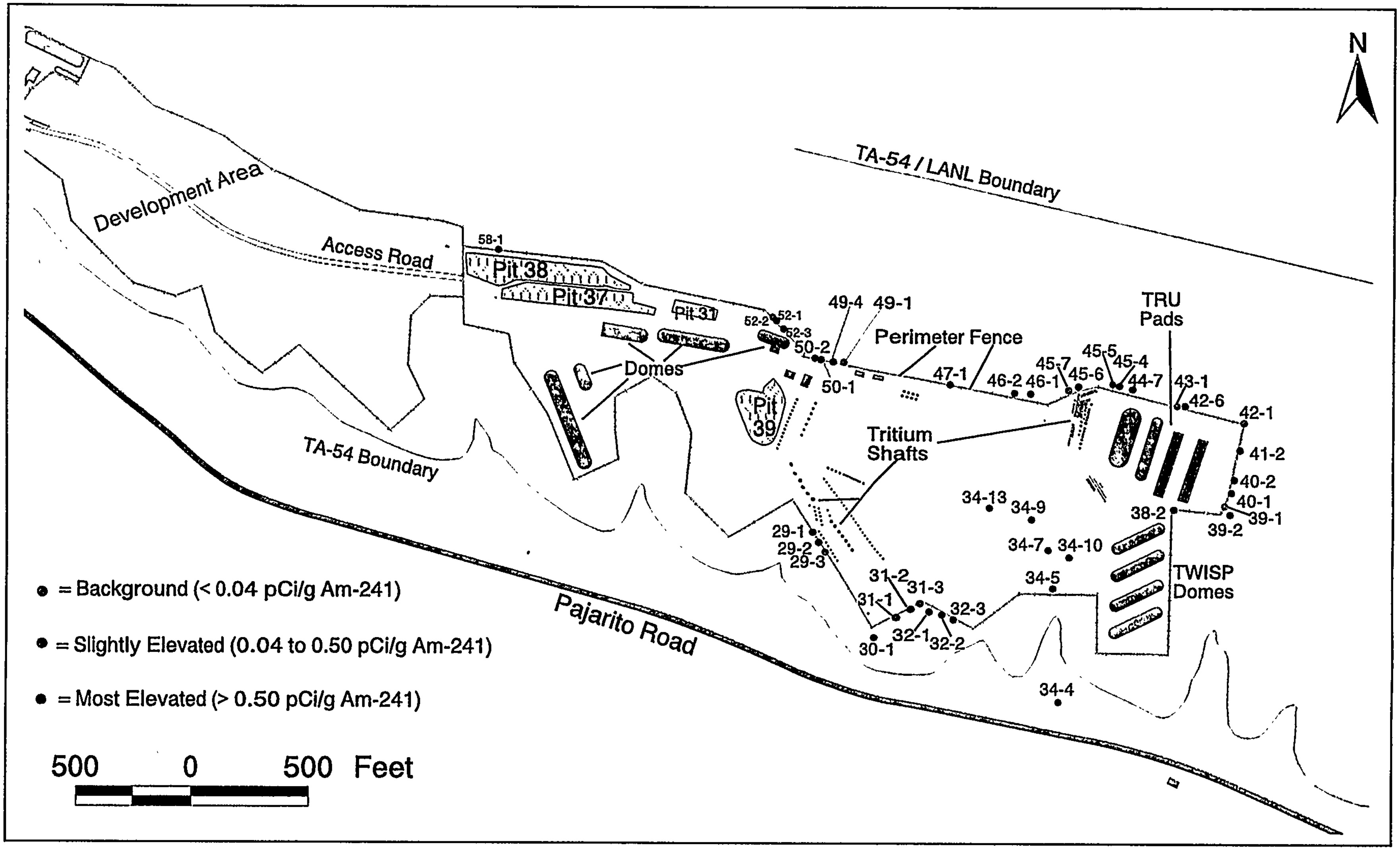

Figure 5: Am-241 soil-sample locations and analytical results (FY 97) at Area G. The color represents the americium concentration range (in pCi/g). There are three categories in the americium concentration range: background (green), slightly elevated (blue), and most elevated (red). All the significant Area G landmarks and features are identified on the figure.

From the perimeter soil sampling (those samples taken from locations in minor drainages into which sediments are expected to be carried and water to flow during a storm event), it is shown that there is elevated tritium activity in perimeter surface soils collected around the entire active portion of Area G. The tritium concentrations in soils collected in FY95 are, by and large, lower than analogous samples collected in FY94 and are more similar to samples collected in FY93 (see box plots comparing relative concentration distributions in Appendix B). Tritium on soil samples collected adjacent to the TRU pads and the tritium disposal shafts are most highly elevated over baseline in soil from sampling locations between monuments G-42 and G-51. These locations are along the northern edge of the TRU pads and adjacent to one set of tritium disposal shafts; they extend along the fence line to the west some 600 feet. To the east and south of the TRU pads (between monuments G-34 and G-41), the soil samples also show moderately elevated tritium activity. One isolated soil sample, G-38-02, on the perimeter at the south edge of the TRU pads had a relatively high tritium concentration (15,100 pCi/L). This particular soil sample also had elevated tritium concentrations during the FY93 and 94 sampling campaigns.

The locale for the most elevated perimeter soil tritium concentrations in FY96 is adjacent to a second series of tritium disposal shafts located on the Pajarito Canyon side of Area G and encompasses sample series G-27–32. Soil samples collected from this area in FY96 had tritium activities as high as 316,000 pCi/L. Figure 6 is a scatter plot depicting the soil tritium concentrations at analogous locations for the years FY95, 96, and 97. This figure indicates that the localized regions of elevated tritium concentrations on the perimeter of Area G were the same during these years, but soil tritium concentrations varied significantly from year to year. The significance of year-to-year measured soil tritium concentrations will be discussed.

Storm-water runoff (single-stage) samples were also collected at 25 locations but were analyzed only for metals. In the past, samples were collected and separated into water and sediment fractions. The water fractions were analyzed for tritium and the sediment fractions analyzed for isotopic plutonium This practice was not continued in FY96 and 97 because of lack of funding. Data from the hundreds of single-stage samples collected in the years 1993 through 1996 can be referenced to define the pattern of tritium and isotopic plutonium concentrations found in storm water runoff from Area G.

Tritium results for surface soils reflect the surface soil environment only at the time of the soil sampling. The ambient conditions at a particular location is one factor that will determine the concentration and availability of tritium at the time a sample is taken. When precipitation falls, soil-surface water interactions are generally limited to the top few inches of surface soils. At that time, tritium concentrations in the surface soil stratum could be altered by the precipitation resulting in

1. entrainment in water of available tritium by water running off of a particular location,

2. erosion away of tritium-bound sediments, or

3. a dilution effect resulting from tritium-deficient water being added to "soil moisture" containing the soil tritium.

It is known that on soil, tritium is incorporated into the associated water that is termed soil moisture When the laboratory prepares a soil sample for tritium analysis, soil moisture is distilled out of a weighed sample. The tritium measured in the distilled-off water is deemed to represent the tritium content of the soil and is reported as activity per liter of soil moisture. If it had recently rained or snowed before the sampling event or if the soil came from a location that was naturally damp (e.g., an area shaded from the sun) or where anthropic activities (such as a water truck's spraying on the ground surface) had impacted the soil, this added water to the natural soil moisture would cause a dilution of the tritium concentration on that soil that had a source resulting from disposal of tritium at Area G. Figures 3 and 6 illustrate the manifestation of this hypothesis. From year-to-year, the geographical regions of baseline, slightly elevated, and most elevated tritium concentrations on soils are the same. However, the absolute concentrations of tritium measured on soil over these time periods are shown to be generally different. In particular, Table 1 indicates that soil samples collected in March of 1997, when the soil was still relatively moist from the winter snow accumulation and spring rains, contained soil moisture generally greater than the soil moisture found in samples collected in the summer of 1996. And along with the higher soil moistures, it is evident that the tritium concentrations in FY97 soils are generally significantly lower that soil tritium concentrations for samples collected in the summer period of FY96. The other factor affecting soil tritium concentrations in the FY96 and 97 samples is that the tritium flux is greater during the hot summer months than it is during the remainder of the year.

By minimizing the period of time taken for the collection of all the samples, one can hopefully eliminate most of the local environmental impacts discussed above.

7.2 Uranium

Soil uranium data collected during FY93 through 95 indicates very little difference between Area G perimeter soil concentrations and background concentrations. For this reason, soil samples collected in FY96 and 97 were not analyzed for total uranium.

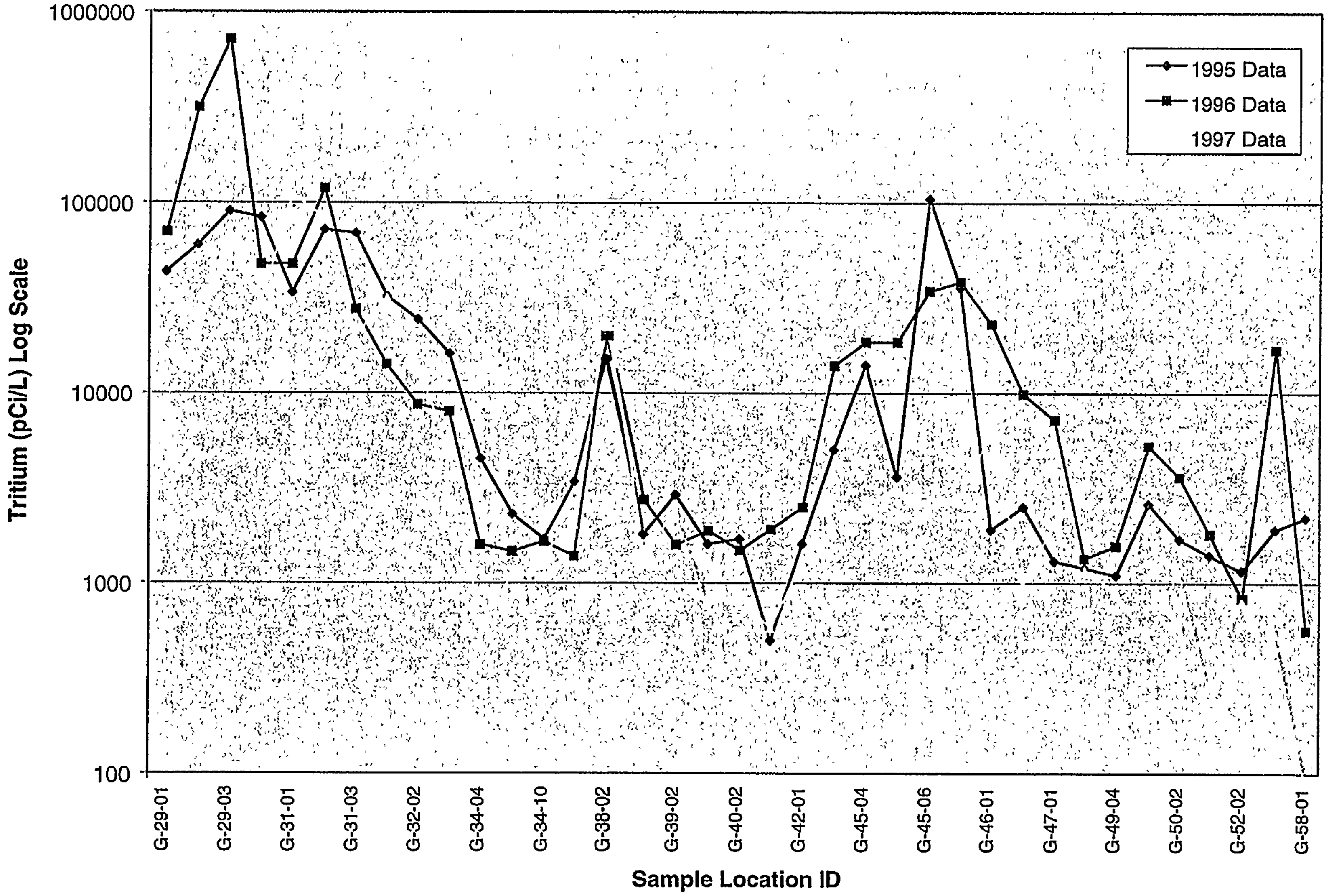

Figure 6: Scatter plot of Area G perimeter soil FY95, FY96 and FY97 soil tritium concentrations.

7.3 Plutonium Isotopes

During the FY96 and 97, perimeter surface soil sampling campaigns, 40 perimeter soil samples were collected and analyzed each year for isotopic plutonium (plutonium-238, -239, and -240). Plutonium-239 and -240 are reported as the sum of the activity of these two isotopes, but hereafter they will be referred to only as plutonium-239. The plutonium soil data are presented in Table 1. The plutonium-238 activities range from 0.001 pCi/g to 4.890 pCi/g. The average plutonium-238 activity is 0.0.336 ± 0.734 pCi/g in FY96 and 0.437 ± 0.928 pCi/g in FY97. For both years, the mean values are far above the median values because several samples have elevated plutonium concentrations and the frequency distribution plot is positively skewed. For plutonium-239, activities range from 0.005–1.710 pCi/g. The mean plutonium-239 activity for FY96 is 0.177 ± 0.297 pCi/g and for FY97 is 0.290 ± 0.415 pCi/g. The plutonium-239 data distribution is also positively skewed, with the median plutonium-239 value being lower than the mean concentration. For convenience, the sum of the plutonium isotope activity "total" for each sample is also presented in Table 1 (box plots of the total plutonium distribution on perimeter and expansion area surface soils collected in FY93, 94, 95, 96 and 97 are presented in Appendix B). In Figure 4, total plutonium isotope relative activity in perimeter soils collected in FY97 is plotted by location. Figure 4 shows that perimeter surface soils increase slightly in plutonium activity as one moves from the west of Area G (with little or no history of waste disposal or storage activity) to the east (where waste disposal or storage has occurred for the longest periods of time). The highest total plutonium activities are associated with the TRU pads and the vicinity of the lower numbered inactive disposal pits (location series G-38 to 46), with elevated readings also found to the west of the TRU pads along the northern edge of Area G up through location series G-50. There are other elevated plutonium readings from sites scattered around the perimeter, but these sites are found predominantly in the eastern half of Area G.

Because of lack of funding, no single-stage samples were collected in FY96 and 97 for isotopic plutonium analysis. If interested in this information for previous years, the reader can refer to report LA-13369-PR, published September, 1997.

7.4 Americium-241 (AM-241)

Am-241 is normally also detected when plutonium is found in soils because it is a direct radioactive decay product of plutonium. Corroboration of plutonium distribution in soils is possible by using the attendant Am-241 analytical results. Am-241 was analyzed by the gamma spectroscopy method for all soil samples collected at Area G in FY96 and 97. Table 1 includes the soil Am-241 results, whereas Figure 5 depicts the geographic distribution of the FY97 Am-241 readings (box plots depicting the Am-241 distribution in surface soils collected at perimeter and expansion area locations in FY93, 94, 95, 96 and 97 can be found in Appendix B). The FY96 and 97 Am-241 values for perimeter soils varied from not detectable to 13.10 pCi/g. The mean Am-241 concentration in soils was 0.69 ± 2.07 pCi/g in FY96 and 0.10 ± 0.14 pCi/g in FY97. The elevated reading of 13.10 pCi/g in FY96 occurred at location G-39-1. This number is considered to be an outlier since at this location in FY95, the Am-241 activity in soil was 0.03 pCi/g and in FY97 the value was 0.21 pCi/g. The mean FY96 Am-241 concentration is

Table 3: FY97 TA-54 Area G (OU 1148) sediment fraction data from single-stage samplers. Listed here are the metals concentrations in sediment filtered from the single-stage water samples.

Sample Location	Collection Date	Ag (µg/g)	As (µg/g)	Ba (µg/g)	Be (µg/g)	Cd (µg/g)	Cr (µg/g)	Hg (µg/g)	Ni (µg/g)	Pb (µg/g)	Sb (µg/g)	Se (µg/g)	Ti (µg/g)	Zn (µg/g)
G-6-01	8/18/97	<2.0 UJ	5.49	150.0	1.2	<0.90	12.0	<0.05	8.8	24.0	<0.3	<0.34	<0.3	74.0
G-10-02	8/6/97	<2.0 UJ	2.81	100.0	0.99	<0.90	8.5	<0.05	6.3	15.6	<0.3	0.36	0.3	90.0
G-11-01	8/6/97	<2.0 UJ	2.98	130.0	1.1	<0.90	9.5	<0.05	7.2	15.6	<0.3	<0.34	<0.3	140.0
G-14-06	6/24/97	<2.0 UJ	1.86	31.0	0.32	<0.90	3.7	<0.05	<4.0	13.3	<0.5	<0.38	<0.3	33.0
G-28-04	8/4/97	<2.0 UJ	1.64	71.0	0.75	<0.90	9.4	<0.05	4.1	9.2	<0.3	<0.34	<0.3	59.0
G-29-01	6/24/97	<2.0 UJ	1.5	64.0	0.66	<0.90	8.5	<0.05	4.5	10.0	<0.5	<0.38	<0.3	69.0
G-29-02	7/28/97	<2.0 UJ	1.79	67.0	0.73	<0.90	5.6	<0.05	<4.0	10.1	<0.3	<0.34	<0.3	170.0
G-30-01	8/4/97	<2.0 UJ	1.79	73.0	0.8	<0.90	10.0	0.07	4.6	7.5	0.6	<0.34	<0.3	70.0
G-32-01	6/24/97	<2.0 UJ	1.42	53.0	0.61	<0.90	10.0	<0.05	4.9	8.0	<0.5	<0.38	<0.3	45.0
G-32-01	7/28/97	6.7 J	3.22	99.0	1.0	<0.90	16.0	0.09	7.6	13.3	<0.3	<0.34	<0.3	85.0
G-34-11	8/4/97	<2.0 UJ	1.89	77.0	0.68	<0.90	5.4	<0.05	4.4	9.0	<0.3	<0.34	<0.3	41.0
G-39-04	6/24/97	<2.0 UJ	0.79	47.0	0.59	<0.90	7.9	<0.05	4.8	12.0	<0.5	<0.38	<0.3	60.0
G-39-04	7/18/97	<0.4 UJ	1.3	77.0	0.71	<0.30	6.6	<0.05	3.0	9.4	<0.3	<0.003	<0.3	65.0
G-39-04	8/4/97	<2.0 UJ	1.55	63.0	0.5	<0.90	4.8	<0.05	<4.0	10.6	<0.3	<0.34	<0.3	52.0
G-41-01	7/18/97	<0.4 UJ	1.04	64.0	0.54	<0.30	6.9	<0.05	4.0	14.2	<0.3	<0.003	<0.3	190.0
G-41-05	8/4/97	<2.0 UJ	1.12	80.0	0.69	<0.90	4.5	<0.05	4.1	9.0	<0.3	<0.34	<0.3	52.0
G-44-04	8/5/97	<2.0 UJ	3.81	100.0	0.88	<0.90	9.2	0.07	5.8	18.9	<0.3	<0.34	<0.3	64.0
G-44-05	8/5/97	<2.0 UJ	2.31	64.0	0.63	<0.90	7.1	0.06	5.0	18.3	<0.3	<0.34	<0.3	64.0
G-44-06	8/5/97	<2.0 UJ	2.16	75.0	0.67	<0.90	6.9	<0.05	4.6	15.2	<0.3	<0.34	<0.3	76.0
G-46-04	7/18/97	<0.4 UJ	2.07	60.0	0.64	<0.30	10.0	<0.05	6.9	7.7	<0.3	<0.003	<0.3	130.0
G-47-03	7/18/97	<0.4 UJ	1.16	40.0	0.43	<0.30	10.0	<0.05	5.4	14.7	<0.3	<0.003	<0.3	100.0
G-47-04	7/18/97	<0.4 UJ	0.75	38.0	0.46	<0.30	4.7	<0.05	<0.9	5.0	<0.3	<0.003	<0.3	45.0
G-51-03	7/29/97	<2.0 UJ	2.39	82.0	0.67	<0.90	7.7	<0.05	5.3	10.6	<0.3	<0.34	<0.3	51.0
G-60-01	8/18/97	<2.0 UJ	4.13	130.0	1.1	<0.90	12.0	0.05	8.4	16.3	<0.3	<0.34	<0.3	97.0
G-65-01	8/18/97	<2.0 UJ	5.13	150.0	1.1	<0.90	14.0	0.05	9.0	31.1	<0.3	<0.34	<0.3	65.0

Statistics:	Ag (µg/g)	As (µg/g)	Ba (µg/g)	Be (µg/g)	Cd (µg/g)	Cr (µg/g)	Hg (µg/g)	Ni (µg/g)	Pb (µg/g)	Sb (µg/g)	Se (µg/g)	Ti (µg/g)	Zn (µg/g)
Mean	NA	2.33	85.13	0.73	NA	8.33	NA	NA	13.95	NA	NA	NA	78.29
Median	NA	1.97	74.00	0.67	NA	7.80	NA	NA	13.01	NA	NA	NA	65.00
Std. Dev.	NA	1.49	52.65	0.33	NA	3.31	NA	NA	7.42	NA	NA	NA	44.66
Max	6.7	5.49	261.0	1.7	NA	16.00	0.07	9.0	31.1	NA	NA	NA	190.00
Min	NA	0.75	31.0	0.23	NA	3.02	NA	NA	5.0	NA	NA	NA	33.0

subsequently biased high because of the elevated outlier activity. An area with elevated Am-241 soil levels was found adjacent to the TRU pads in the area of series G-43 to 52. This location of elevated Am-241 reflects the elevated activities of plutonium in soils reported in section 7.3 (compare Figures 4 and 5).

7.5 Cesium-137 (Cs-137)

Cs-137 is another isotope of interest at Area G. All perimeter soils collected were analyzed by gamma spectroscopy for cesium-137, and these data are found in Table 1. As in previous years, the data indicate a fairly even distribution of Cs-137 in perimeter surface soils at Area G. Cs-137 activities in FY96 and 97 soils range from undetected to 1.75 pCi/g, with an average concentration in FY96 soils of 0.33 ± 0.32 pCi/g and in FY97 of 0.28 ± 0.25 pCi/g.

7.6 Metals

In a program begun in FY94 and continued in FY95, soil samples were collected on the perimeter of Area G for analysis of metals. These samples were submitted for EPA SW-846 Method 3050 extraction and metal analyses of Ag, As, Ba, Be, Cd, Cr, Hg, Ni, Pb, and Sb and Se. The soil metal data (LA-13369-PR) indicated no apparent contamination of Area G perimeter surface soils by any of the metals analyzed. It was suggested by the New Mexico Environment Department (NMED) that important additional information on metals at Area G could be obtained by collecting single-stage water samples, separating the sediment fraction, and analyzing the sediment fraction for metals. In FY97, we accomplished this task by the collection of 25 single-stage water samples and subsequent analysis of the sediment for the metals Ag, As, Ba, Be, Cd, Cr, Hg, Ni, Pb, Sb, Se, Tl and Zn. These data are presented in Table 3.

The following procedure was followed in prepping the single-stage sediment fraction for analysis. The sediment fraction of the storm water runoff samples was separated from the water fraction by first allowing the sediment to settle out. The water fraction was then decanted off until only wet sediment remained. The wet sediment was then air dried. The dry sediment was next forced through a 250-micron stainless steel screen to obtain the quantity that would be extracted and then analyzed for metals. The metals were extracted from the dry sediment using SW-846 method 3050 (a hot nitric /hydrochloric acid treatment).

Table 3 indicates that the metal concentrations in the sediment fractions of the storm water runoff samples reflect the metal concentrations in local surface soils from the development area.

8.0 STATISTICAL CONSIDERATIONS

Independent perimeter surface soil data sets are now available for FY93, through 97 and the Area G development area. It is appropriate to compare this information. The comparisons we choose to make are

1. whether the FY96 and 97 Area G perimeter soil chemistry data continue to be statistically different from the development area baseline data; and

2. whether the perimeter soil chemistry data collected in FY96 and 97 are statistically different from the analogous sample data collected in FY94 and 95.

It is expected that the soil data for several constituents (in particular, tritium, plutonium, and americium) for the perimeter G samples can be shown to be statistically different from the development area where disposal operations have not occurred.

On the other hand, a more difficult question may be determining whether, for example, the plutonium activity in perimeter soils at Area G is increasing, decreasing, or staying the same from year to year. Because concentration changes from year to year are expected to be small, one can use statistical techniques to assist in determining whether there truly are concentration changes of constituents on soil from one year to the next.

In Appendix B, the analytical chemistry data is summarized in box plots (pictorial descriptions of concentration distributions) to assist in making the two types of comparisons discussed above. The first comparison is to look at the constituents measured on perimeter soils and compare these concentrations with constituent concentrations measured on soil samples collected in the proposed Area G development area (defined as background). Surface soil samples were collected in this development area during FY94 and 95.

The second type of statistical assessment is done by comparing the constituent concentrations for FY96 and 97 with constituent concentrations for FY95 from analogous locations (for example, by comparing tritium concentrations on soils collected in FY96 and 97 to tritium concentrations on soils collected in FY95).

Box plots are used to depict concentration distributions and to assist in comparing the different data sets. Box plots give information on the median, interquantile range, and skewness; all of which help describe the distribution spread and normalcy. By placing the box plots on the same scale and in the same figure, we have an immediate impression of the differences and/or similarities of the distributions we are attempting to compare. Several considerations must be taken into account, however, in comparing year-to-year data in the box plots. First of all, there were 58 soil samples taken in FY95 as opposed to only 40 in both FY96 and 97. The FY95 samples included 18 more samples from locations away from the places where radioactive constituents have been measured at their most elevated levels. The average concentrations of radionuclides in these samples would be expected to be lower than in the subsequent years' set of samples which were deliberately taken adjacent to the operations that were known to yield elevated surface radionuclide contamination—the tritium shafts and the TRU pads. The second caution concerns soil tritium activities only. The time of year when soil samples are collected can grossly affect the measured soil tritium activities for that year's set of samples. The highest soil tritium activities have been found in samples taken in the driest part of the summer when the soil moisture percentage is minimized and evaporation rates (and tritium flux) are maximized. The soil samples taken in FY97 were taken in the early spring, not long after snow melt had occurred. These samples were more moist than samples taken in FY95 and 96 during the dry part of the summer.

9.0 CONCLUSIONS

In the following paragraphs, the results of the FY96 and 97 perimeter soil and single-stage water sampling performed at Area G are discussed.

9.1 Tritium

Tritium has unique chemical properties that distinguish it from most radionuclides. As an isotope of hydrogen, tritium can exchange with the normal hydrogen atoms in compounds such as water. From information gathered at many facilities where tritium is found, including LANL, we know that tritium can migrate some distance from its place of disposal. Tritium in the surface soils at Los Alamos has a wide distribution resulting from both fallout and Laboratory activities. Disposal of hundreds of thousands of curies of tritium in a series of pits, shafts, or pads occurred at Area G since this facility opened in 1957. A relatively unstable isotope, tritium has a half-life of 12.26 years, during which time half of the tritium transmutes into helium by emitting a low-energy beta particle.

An important question that needs to be addressed is that of the relationship between the tritium found in annual surface soil and water-runoff samples and the true distribution of tritium at the site. One long-term goal of this study is to better define the actual tritium distribution in surface soils (and possibly in the subsurface) at Area G by gathering these tritium concentration data over a period of years.

Except for inadvertent discharges of tritium to the ground surface, the major sources of surface tritium at Area G are tritium contaminated materials that have been disposed of (buried or emplaced) in one or another of the many shafts, pits, and pads at the site. We expect the probability of finding tritium on surface soils at elevated levels to be greatest in the proximity of these sources. Because ground disposal or storage of waste entails subsequent covering by natural tuffaceous material, one important question is, by what pathway does subsurface tritium migrate to the surface, so that it resides in soils and ultimately could be carried off-site? We have postulated two primary mechanisms for tritium transport to the surface: vapor-phase migration and capillary action. Secondary mechanisms would be evapotranspiration, transport to the surface via vegetative growth or burrowing animals, and anthropic activities such as excavation of tritium-contaminated soils, tuff, or waste.

Tritiated water (or other tritiated compounds with elevated vapor pressures) can migrate in the vapor phase from the subsurface to the surface. Upon reaching the surface layer of soils, the question is, does tritium simply vent into the atmosphere or is there a mechanism for it to attenuate with surface soils? Because tritium *is* found on surface soils, there must exist a viable mechanism for attenuation. The only obvious mechanisms for tritiated water vapor migrating upward (or laterally) to attenuate to surface soil sediments are condensation on the surface particles when encountering cooler temperatures (e.g., at night) and/or the tendency of very dry or salt-containing surface soils to temporarily absorb this water vapor.

A second pathway by which tritium could arrive at the surface (and have some residence time) would be capillary action. Capillary action is the phenomenon by which water rises in a tube (or a network of "tubes," as in packed soil) because of the difference in surface tension between the water molecules themselves and between the water molecules and the surface of the tube (or packed soil particles). Unlike water transported via the vapor phase, water transported by capillary action can also carry dissolved compounds. Thus, non-vapor phase tritium that exists as a dissolved chemical species can also migrate upwards to surface soils by capillary action.

By either of these two mechanisms (vapor-phase transport or capillary action) tritium could move from subsurface soils to surface soils. Tritium's residence time in surface soils is unknown because we do not know how the tritium migration rates from subsurface to surface soils compare to the rates of tritium removal from the surface by evaporation or by other mechanisms. We do know from tritium flux studies (where water vapor escaping from the ground surface is captured on silica gel and the tritium in the water measured) and ambient air monitoring that tritium is escaping in the vapor phase from the ground surface. We also know that more tritium escapes the surface during the hotter months. In addition to evaporation, the mechanisms by which tritium can be removed from surface soils are

1. exchange and runoff with surface water,

2. percolation back into the subsurface after a storm event,

3. air dispersion of surface soil particles (containing tritium) during periods of high winds,
4. evapotranspiration of tritium-containing water by vegetation, and
5. removal of tritium-containing materials by human or animal intervention.

These tritium dispersal mechanisms are important because the actual date and time a sample is taken (and concomitant measured tritium concentration) may be impacted by localized environmental effects. For example, during long dry periods one would expect the movement of tritium on subsurface soils to be from the subsurface to the surface, and ultimately away from the surface by one of the mechanisms mentioned above. If soil sampling occurred after a long dry period, the question is, would the tritium in the soil be higher or lower than the average value that would be found for that sampling point if samples were taken every day of the year? ESH-17 ambient air data indicates that tritium escapes the surface more readily during the hot months of the year. Or if soil samples were taken the day after a precipation event, would a lower than representative soil tritium concentration be expected because some of the tritiated surface soil were carried off by surface water runoff or because the tritium in the soil moisture was diluted by the rain water? These are difficult questions that may only be answered after many years of quality surface soil sampling.

After five years of systematic soil sampling at Area G, we see a pattern in the distribution of tritium in perimeter soils. By observing the map of Area G tritium concentrations on soil (Figure 3), it is evident from the FY97 data that there are specific regions of Area G where tritium concentrations are particularly elevated. These regions are predominantly in the areas adjacent to the TRU pads (between MDA stations G-42 and 51) and the tritium storage shafts (between MDA stations G-28 and 31). These tritium data, in fact, mirror the soil tritium data collected at the same locations from FY93 through 96. By examining the scatter plot in Figure 6, one can see that although the absolute tritium concentrations on soil collected in FY97 are much lower than the data for samples collected in FY96, the areas of high-, medium-, and low-tritium concentrations on surface soils are similar for the two years. This indicates that the mechanisms (and sources) supplying tritium to the surface soils are rather constant from year to year, and only the local environment and weather affect the absolute concentrations of tritium on the surface soils.

Additional data that supplement the soil information we collected at Area G are supplied by vegetation sampling done at several Area G locations. Fresquez et al. (1995), found elevated levels of tritium in vegetation collected at just those two locations of Area G where surface soils were most highly elevated in tritium—north of the TRU pads and west of the tritium shafts. In general, Fresquez found that vegetation collected from around Area G was generally elevated in radionuclide concentrations above analogous vegetation sample radioactive concentrations considered to be background.

By observing the box plots in Appendix B for the tritium distribution in soils collected in FY93–97, it is apparent that the tritium distributions in perimeter soils are different from and higher than the distribution of tritium in soils from the development area. This result was expected. Soil tritium concentrations in FY97 are much lower than those in FY96. This is anticipated since the FY97 samples were collected in March when the ground was still damp and tritium flux is relatively low, while the FY96 samples were collected during the heat of the summer when soils are dry and tritium flux is relatively high. The similarity of the soil tritium distribution in FY97 to FY95 may only be coincidental. In FY95, 18 more soil samples were taken in locations where historically the soil tritium concentrations are low. These low tritium concentrations would decrease the overall concentration profile for samples collected in FY95.

Unless more is learned about the surface soil tritium history, a sample taken at a particular moment can only provide a snapshot of the tritium surface concentration in soil at that particular time.

The flux effect or dependence on localized moisture content on soils may be minimized by taking all samples during a one- or two-day sampling period since, in this case, each sampling location would be subjected to similar atmospheric conditions. A narrow time-window sampling strategy would at least serve as a control for the seasonal and daily changes in the rate at which tritium is removed from the surface.

As sampling for tritium continues on a year-to-year basis, the relative distribution of soil tritium throughout Area G has become apparent.

9.2 Uranium

There is no apparent unnatural distribution of uranium in Area G perimeter soils indicating little or no impact from disposal or storage operations on uranium concentrations in surface soils. Soils sampled in FY96 and 97 were not analyzed for total uranium because data from FY93 through 95 indicate no significant elevation of uranium in surface soils. The mean concentration of uranium in FY95 soil samples is 2.67 ± 0.57 mg/g. The mean uranium concentration in the FY95 development area background soils (analyzed by the kinetic phosphorescence analysis [KPA] method) is 2.80 ± 0.40 mg/g. As previously mentioned in LA-13165-PR, during FY94, total uranium in perimeter soils was analyzed by ICPMS, and these data were biased high compared to total uranium concentrations generated by the KPA method.

9.3 Plutonium Isotopes

As stated in Section 7.3, the locations of elevated soil plutonium readings are consistent with the history of plutonium disposal at Area G. Figure 2 indicates that the lower-numbered, or older pits (1–24), all the disposal shafts, and the TRU pads are located in the eastern half of Area G. We assume that increased levels of contaminant concentrations in surface soils are directly related to the location, quantity, and date when material was disposed of in disposal units. That is, there is a greater probability of finding a contaminant adjacent to a disposal unit where large amounts of contaminants have been emplaced. Also, the longer a contaminant is held in a specific location, the higher the probability that this contaminant will be disseminated to its immediate surroundings. In fact, we find the highest plutonium activities in soils at the eastern end of Area G, especially adjacent to the TRU pads and inactive disposal pits 2–10.

We also observe a geographic correlation between elevated plutonium levels in perimeter soils and elevated levels of plutonium in the sediment fractions of the water samples (see report LA-13369-PR). Figure 4 (plutonium levels in perimeter soils) shows that the area adjacent to the TRU pads and inactive disposal pits 2–10 have the highest plutonium levels for both surface soil samples.

In Appendix B, box plots are presented that depict the distributions of the total plutonium concentrations in surface soil samples collected in FY95 through 97, as well as the comparable data for samples collected from the baseline development area. The box plots show the similarities of the FY95 through 97 total plutonium distributions and indicate that the distributions from all three years have higher concentrations and a wider distribution than the total plutonium in samples from the development area.

9.4 Am-241

As stated in Section 7.4, the tendency is to find elevated Am-241 levels in perimeter surface soil samples where there are elevated levels of plutonium isotopes. This trend is generally illustrated by comparing the data depicted in Figures 4 and 5. The box plots for the AM-241 distributions found in Appendix B indicate there is little statistical difference between the FY95 and 97 Am-241 data. The data from FY96 include a value from location G-39-1 that can be considered an outlier and of questionable validity. Location G-39-1 was also sampled in FY95 and 97 with respective Am-241 values of 0.03 and 0.21 pCi/g. The box plots do indicate that the Am-241 concentrations in soils collected from the active part of Area G in all three years are statistically different (greater) than the Am-241 concentrations in soil collected from the development area.

9.5 Cesium-137 (Cs-137)

Surface soils collected in FY96 and 97 exhibit Cs-137 activities similar to those for soils from the same locations collected in FY95. Likewise, the FY95 distribution of Cs-137 in perimeter soils is similar to that found in FY93 and FY94. There are no locales along the Area G perimeter where Cs-137 is found in soils in significantly elevated concentrations. The range and mean of Cs-137 concentrations in perimeter soils are very similar to the development area Cs-137 range and mean.

9.6 Metals

As reported in LA-13369-PR, the analytical chemistry results for soil metals collected in FY94 and FY95, when compared with the soil metals concentrations from the development area, indicate that there is very little or no impact on metal surface soil concentrations due to disposal or storage operations in the active part of Area G. Box plots were constructed for the three metals (barium, chromium, and lead) where there were enough values reported to yield a meaningful distribution. Values for the other metals were generally below detection limits. These box plots indicate similar distributions and metals concentrations for soil samples collected in FY94 and 95 and the development area soil samples. It was suggested by NMED personnel that a logical extension of the soil sampling for metals would be to collect storm water runoff samples via the single-stage sampling method, separate the sediment fraction, and analyze the sediment fraction for metals. The concentrations of metals in the sediment fraction should reflect the metal concentrations of the perimeter soils since the perimeter soil samples were taken in similar drainages to where single-stage samplers were placed. Box plots in the appendix comparing metals in perimeter soils, development area soils, and single-stage sampler sediment, indicate a similarity for these three data sets. It was only possible to construct box plots for those metals where there were enough real values to perform meaningful statistics. For those metals with a preponderance of nondetects, box plots were not constructed. The data indicate that metals are not migrating from Area G via the surface water pathway.

Table 4: FY 1994 and 1995 TA-54 Area G (OU 1148) Development Area (Baseline/Background) Soil Data

FY 1994 Data

Sample Location	Collection Date	Ag µg/g	As µg/g	Ba µg/g	Be µg/g	Cd µg/g	Cr µg/g	Hg µg/g	Ni µg/g	Pb µg/g	Sb µg/g	Se µg/g	Tl µg/g	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{234}U pCi/g	^{235}U pCi/g	^{238}U pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-X-6	7/29/94	<.69	2.9	159	1.2	<.52	8.1	<.02	<8.6	13	<.23	<.69	<.23	14.7	420	0.007	<.01	1.42	0.08	1.42	0.009	0.013	0.022
G-X-8	7/29/94	<.72	<2.2	65.8	<.54	<.43	4	<.02	<4.3	15	<.24	<.72	<.24	16.9	320	0.016	0.99	1.27	0.07	1.43	0.005	0.036	0.041
G-X-8R	7/29/94	<.7	<2.1	95.8	<.6	<.23	5.1	<.02	<4.4	14	<.23	<.7	<.23	17.9	300	0.014	1.01	1.79	0.08	1.88	0.005	0.043	0.048
G-X-9	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	13.4	120	0.008	0.64	1.43	0.1	1.43	0.002	0.023	0.025
G-X-10	7/29/94	<.71	<2.1	80.3	<.63	<.24	6.2	<.02	<5.7	11	<.24	<.71	<.24	15.1	710	0.007	<.16	1.36	0.04	1.54	0.007	0.019	0.026
G-X-12	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	11.2	370	0.014	1.2	1.38	0.06	1.52	0.003	0.051	0.054
G-X-13	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	12.7	280	0.008	<.16	1.23	0.07	1.39	0.002	0.009	0.011
G-X-16	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	15.6	260	0.015	0.62	1.55	0.08	1.58	0.002	0.042	0.044
G-X-19	7/29/94	<.66	<1.9	56.8	<.45	<.44	3.8	<.02	<2.6	9.9	<.22	<.66	<.22	8.7	260	0.008	0.34	1.06	0.05	1.11	0.002	0.012	0.014
G-X-21	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	9.7	250	0.008	0.32	1.18	0.06	1.38	0.001	0.016	0.017
G-X-24	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	12.1	380	0.027	<.23	2.02	0.09	1.91	0.005	0.149	0.154
G-X-26	7/29/94	<.67	2.2	67.1	<.56	<.34	4.5	<.02	<3.7	13	<.22	<.67	<.22	13	630	0.016	1.8	1.65	0.11	1.63	0.005	0.047	0.052
G-X-27	7/29/94	<.67	<2	85.1	<.5	<.22	4.7	<.02	<3.3	10	<.22	<.67	<.22	13.5	280	0.011	0.85	1.39	0.09	1.4	0.004	0.03	0.034
G-X-28	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	10.9	180	0.005	<.17	1.2	0.06	1.24	0.001	0.01	0.011
G-X-30	7/29/94	<.65	2.2	133	<.4	<.22	4.7	<.02	<4.2	11	<.22	<.65	<.22	9.6	350	0.008	0.62	1.57	0.12	1.51	0.002	0.025	0.027
G-X-33	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	11.5	340	0.014	1.32	1.7	0.04	1.78	0.004	0.054	0.058
G-X-37	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	7.6	510	0.007	0.47	1.25	0.07	1.23	0.002	0.023	0.025
G-X-38	7/29/94	<.62	2.2	62.2	<.75	<.52	7.2	<.02	<7.9	16	<.21	<.62	<.21	4.5	580	0.02	0.76	1.36	0.05	1.41	0.009	0.042	0.051
G-X-38R	7/29/94	<.62	4.8	136	<.68	<.53	7.4	<.02	<7.2	15	<.21	<.62	<.21	4.5	490	0.021	0.97	1.39	0.06	1.47	0.007	0.053	0.06
G-X-39	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	11.2	310	0.005	0.14	1.09	0.06	1.27	0.002	0.014	0.016

(ANP = Analysis not performed)

(continued)

Table 4 (continued): FY 1994 and 1995 TA-54 Area G (OU 1148) Development Area (Baseline/Background) Soil Data

FY 1994 Data (cont.)

Sample Location	Collection Date	Ag µg/g	As µg/g	Ba µg/g	Be µg/g	Cd µg/g	Cr µg/g	Hg µg/g	Ni µg/g	Pb µg/g	Sb µg/g	Se µg/g	Tl µg/g	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{234}U pCi/g	^{235}U pCi/g	^{238}U pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-X-43	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	12.1	280	0.005	<.17	1.63	0.1	1.8	0.004	0.012	0.016
G-X-44	7/29/94	<.63	3	261	<.85	<.59	7.5	<.02	<8.3	11	<.21	<.63	<.21	10.2	440	0.002	<.17	1.17	0.04	1.23	0.001	0.008	0.009
G-X-45	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	15	150	0.005	<.11	1.16	0.06	1.1	0.003	0.005	0.008
G-X-48	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	14.8	560	0.005	<.15	1.35	0.08	1.42	0.003	0.01	0.013
G-X-50	7/29/94	<.63	2.7	76.6	<.42	<.59	5.7	<.02	<3.5	19	<.21	<.63	<.21	4.4	450	0.008	<.15	1.75	0.09	1.77	0.004	0.017	0.021
G-X-51	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	10.7	410	0.003	<.16	1.06	0.06	1.23	0.001	0.001	0.002
G-X-53	7/29/94	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	12.5	280	0.011	<.15	1.01	0.04	0.94	0.003	0.028	0.031

FY 1995 Data

Sample Location	Collection Date	Ag µg/g	As µg/g	Ba µg/g	Be µg/g	Cd µg/g	Cr µg/g	Hg µg/g	Ni µg/g	Pb µg/g	Sb µg/g	Se µg/g	Tl µg/g	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	Total Uranium µg/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-X-1	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	8.04	-100	ANP	ANP	2.54	0.004	0.011	0.015
G-X-2	6/1/95	<1	2	61	0.61	<.4	4.3	0.03	<2	7.37	<.25	<.3	<.25	11.5	0.0	ANP	ANP	2.59	0.003	0.008	0.011
G-X-3	6/1/95	<1	1	34	0.45	<.4	2.8	<.04	<2	8	<.25	<.3	<.25	7.46	0.0	ANP	ANP	3.44	0.005	0.016	0.021
G-X-4	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	5.66	100	ANP	ANP	2.19	0.001	0.001	0.002
G-X-5	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	5.24	-300	ANP	ANP	2.19	0.037	0.052	0.089
G-X-11	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	12.4	-200	ANP	ANP	2.67	0.084	0.045	0.129
G-X-14	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	14.5	-400	ANP	ANP	2.57	0.064	0.04	0.104
G-X-15	6/1/95	<1	3	95	0.91	<.4	8.4	<.04	<2	9.5	<.25	0.3	<.25	13.7	0.0	ANP	ANP	2.67	0.006	0.012	0.018
G-X-17	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	16.4	-100	ANP	ANP	3.48	0.003	0.052	0.055
G-X-18	6/1/95	<1	3	82	0.71	<.4	8.8	<.04	<2	18.4	<.25	0.5	<.25	23.6	-400	ANP	ANP	2.76	0.002	0.031	0.033
G-X-20	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	15.0	100	ANP	ANP	2.82	0.004	0.022	0.026
G-X-20R	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	17.3	-100	ANP	ANP	2.72	0.068	0.088	0.156

(ANP = Analysis not performed)

(continued)

Table 4 (continued): FY 1994 and 1995 TA-54 Area G (OU1148) Development Area (Baseline/Background) Soil Data

FY 1995 Data (cont.)

Sample Location	Collection Date	Ag µg/g	As µg/g	Ba µg/g	Be µg/g	Cd µg/g	Cr µg/g	Hg µg/g	Ni µg/g	Pb µg/g	Sb µg/g	Se µg/g	Tl µg/g	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	Total Uranium µg/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-X-22	6/1/95	<1	3	99	0.71	<.4	9.4	0.04	<2	11.7	<.25	<.3	<.25	14.0	-200	ANP	ANP	2.67	0.02	0.005	0.025
G-X-23	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	9.29	-200	ANP	ANP	3.54	0.04	0.03	0.07
G-X-25	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	7.06	-300	ANP	ANP	3.22	0.008	0.015	0.023
G-X-29	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	11.2	-300	ANP	ANP	2.72	0.007	0.047	0.054
G-X-31	6/1/95	<1	2	86	0.65	0.4	6.8	0.05	<2	11.5	<.25	<.3	<.25	7.0	-200	ANP	ANP	2.45	0.004	0.016	0.02
G-X-32	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	13.4	-100	ANP	ANP	2.79	0.002	0.004	0.006
G-X-34	6/1/95	<1	4	89	0.79	<.4	10	<.04	<2	17.4	<.25	<.3	<.25	18.2	-200	ANP	ANP	2.76	0.05	0.04	0.09
G-X-35	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	8.86	0.0	ANP	ANP	3.80	0.009	0.023	0.032
G-X-36	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	16.7	-200	ANP	ANP	3.28	0.002	0.008	0.01
G-X-40	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	17.8	-100	ANP	ANP	3.21	0.047	0.046	0.093
G-X-41	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	22.3	-300	ANP	ANP	2.88	0.003	0.01	0.013
G-X-42	6/1/95	<1	4	85	0.71	<.4	9.3	<.04	<2	12.3	<.25	0.4	<.25	13.3	300	ANP	ANP	2.43	0.003	0.007	0.01
G-X-46	6/1/95	<1	3	100	0.59	<.4	6.8	<.04	<2	12	<.25	<.3	<.25	10.7	-200	ANP	ANP	2.35	0.002	0.005	0.007
G-X-47	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	16.4	-100	ANP	ANP	2.67	0.008	0.011	0.019
G-X-49	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	15.2	0.0	ANP	ANP	2.91	0.062	0.026	0.088
G-X-49R	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	15.4	-300	ANP	ANP	2.57	0.041	0.007	0.048
G-X-54	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	6.16	-200	ANP	ANP	2.41	0.033	0.01	0.043
G-X-55	6/1/95	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	ANP	5.73	-100	ANP	ANP	3.64	0.004	0.027	0.031

(ANP = Analysis not performed)

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APPENDIX A:

FIDLER PROBE MEASUREMENTS AT AREA G PERIMETER SITES

Environmental Surveillance for Fiscal Year 1995, 1996, and 1997

I. PURPOSE

A field instrument for the detection of low-energy radiation (FIDLER) probe was utilized during FY95, 96, and 97 to measure low-energy gamma and x-radiation on surface soils at 70 locations around the perimeter of Area G. These 70 locations were sited in 1991 at minor drainages emanating from Area G. They represent what are considered to be locations biased to receive surface water runoff (and associated sediments) from Area G during precipitation events. By calibrating the probe so it is measuring low-level gamma activity emanating from surface soils, one can determine whether there is elevated gamma activity on soils at specific sites located in small drainages around the perimeter of Area G. Upon measurement of low-energy gamma radiation on an annual basis at the MDA survey points, it may be possible to discern whether there are changes from year to year of the surface soils low-energy gamma activity and to receive an early warning of the movement of radioactive contaminants out of Area G.

The FIDLER measurements continue a practice of environmental surveillance done at radioactive material disposal areas (MDAs) located at LANL. Until 1991, a PHOSWICH instrument (with a detector composed of solid-state detectors arrayed as a "sandwich") was used to take these surface soil low-energy gamma measurements at Area G, and at that time 16 unsurveyed locations were the sites of the annual measurements. In 1991, 70 locations were surveyed in and permanent markers were established for standardizing the measurement points. In 1992, a FIDLER probe was obtained, and this probe was used to make the Area G low-energy gamma survey at the 70 locations. This procedure was continued in FY93, FY94, FY95, FY96, and FY97.

II. METHODOLOGY

A FIDLER probe (a thin layer sodium iodide crystal-photomultiplier tube assembly) in association with a multichannel analyzer (MCA) can focus in on a region of interest (ROI) of the low-energy gamma and x-ray spectrum that represents radionuclides of interest.

At Area G the radionuclides of interest are Am-241 (as an indicator for the presence of plutonium) and Cs-137. Am-241 is always found with plutonium, and because it has a strong peak (60 keV) in the low-energy gamma spectrum, it can be measured in the field with a FIDLER probe to serve indirectly as an indicator of the presence of Pu on surface soils. The ROI around the 60-keV peak is termed ROI 2. A second peak at 17 keV is surrounded by another region of interest, ROI 1, which is also indicative of the presence of Am/Pu. Cs-137 has a peak in the low-energy gamma spectrum at 32 keV. The ROI about the 32-keV peak is termed ROI 3.

The calibration of the instrument and measurements taken with the FIDLER are done in accordance with LANL-ER-SOP-10.04, FIDLER Instrument System.

During field measurements, the probe is situated in a fixed geometry in a tripod with the entry window of the probe 12.0 inches from the ground surface. At each of the 70 MDA survey locations (and 10 background soil points located immediately across the road from Area J), a 100-sec count is made for ROIs 1 and 2, and ROI 3. Three numbers are received at each survey point. These numbers are in units of $\mu Ci/m^2$ (microcurie per square meter) for ROIs 1 and 2, and counts per 100 sec for ROI 3. In the spreadsheet (Table A-1), the values of the regions of interest that reflect Am/Pu (ROIs 1 and 2) are listed for each survey point. The 100-sec count for ROI 3 (the Cs-137 ROI) is also listed.

III. RESULTS AND DISCUSSION

The 10 background soil location counts in FY95 yielded an average of 0 $\mu Ci/m^2$ and 0.70 $\mu Ci/m^2$ for ROIs 1 and 2, respectively, and 480 counts per 100 sec for ROI 3. By comparing these averages with the equivalent counts measured at each of the 70 MDA survey points, it is easy to see from Table A-1 that, except for MDA location number 1, the low-energy gamma activity for the 70 survey points around Area G is decidedly higher than the activity measured by the FIDLER for the three ROIs for the 10 background locations.

A scatter plot of the counts for ROI 2 for each MDA survey point taken in FY95, 96, and 97 is found in Figure A-1. The count results at two of these locations (MDA-17 and MDA-43) are definitively higher than the measurements at adjacent locations. It is not mere coincidence that these two MDA survey points are adjacent to radioactive waste storage domes. One dome (the one nearest MDA-17) is the mixed waste storage dome where thousands of drums of mixed waste are stored. The second dome is over TRU pad 3. The higher than expected gamma counts at these two MDA survey locations have been attributed to shine that originates from the waste storage domes. Shine can be thought of as gamma radiation emanating from a nonpoint source (such as a dome or pile of hot material). Shine manifests itself over a larger distance than the 1 ft distance between the FIDLER probe and the ground surface. That is, if shine exists at a particular MDA survey location, the FIDLER probe will add the shine gamma component to the gamma component emanating from the soil. By placing a shield between the suspected source of the shine or by pointing the probe opening away from the suspected source of the shine, one can determine (if one obtains lower 100-sec counts) that, in fact, the elevated low-energy gamma counts are due in part to shine. Also, a soil sample taken at this location would not exhibit any extraordinary gamma activity when measured at an off-site location because the soil itself is not the source of the gamma radiation. By following up on all three of these tests for shine, we determined that the high readings at MDA 17 and 43 were due to shine and not high-energy gamma activity on soils.

Table A-1: FY95, 96, and 97 FIDLER Counts of Low-Energy Gamma Activity around the Perimeter of Area G

MDA Survey Point	ROI 1/Pu (μCi/m^2) 1995	ROI 2/Am (μCi/m^2) 1995	ROI 1/Pu (μCi/m^2) 1996	ROI 2/Am (μCi/m^2) 1996	ROI 1/Pu (μCi/m^2) 1997	ROI 2/Am (μCi/m^2) 1997
G-1	0	0.503	0	0.662	0	0.089
G-2	0	0.610	0	0.773	0	0.869
G-3	0	0.734	0	0.773	0	0.931
G-4	0	0.628	0	0.839	0	0.910
G-5	0	0.734	0	0.773	0	0.931
G-6	0	0.684	0	0.839	0	0.910
G-7	0	0.692	0	0.773	0	0.952
G-8	0	0.702	0	0.817	0	0.910
G-9	0	0.755	0	0.817	0	0.952
G-10	0	0.776	0	0.928	0	1.130
G-11	0	0.734	0	0.839	0	1.070
G-12	0	0.758	0	0.950	0	1.130
G-13	0	0.797	0	0.883	0	1.110
G-14	0	0.795	0	1.060	0	1.240
G-15	0	0.839	0	1.010	0	1.280
G-16	0	0.850	0	0.972	0	1.360
G-17	0	1.280	0	1.280	0	1.630
G-18	0	0.906	0	1.060	0	1.240
G-19	0	0.902	0	0.994	0	1.320
G-20	0	0.906	0	1.060	0	1.490
G-21	0	0.860	0	0.994	0	1.300
G-22	0	0.998	0	1.260	0	1.630
G-23	0	0.986	0	1.060	0	1.530
G-24	0	0.869	0	1.060	0	1.320
G-25	0	0.881	0	0.996	0	1.280
G-26	0	0.813	0	0.972	0	1.220
G-27	0	0.776	0	0.871	0	1.220
G-28	0	0.943	0	1.030	0	1.670
G-29	0	0.965	0	1.200	0	1.420

(continued)

Table A-1 (continued): FY95, 96, and 97 FIDLER Counts of Low-Energy Gamma Activity around the Perimeter of Area G

MDA Survey Point	ROI 1/Pu (μCi/m^2) 1995	ROI 2/Am (μCi/m^2) 1995	ROI 1/Pu (μCi/m^2) 1996	ROI 2/Am (μCi/m^2) 1996	ROI 1/Pu (μCi/m^2) 1997	ROI 2/Am (μCi/m^2) 1997
G-30	0	0.857	0	0.950	0	1.070
G-31	0	0.628	0	0.817	0	1.090
G-32	0	0.902	0	1.030	0	1.240
G-33	0	0.795	0	0.883	0	1.170
G-34	0	0.797	0	0.883	0	1.170
G-35	0	0.813	0	0.906	0	1.320
G-36	0	0.734	0	0.861	0	1.260
G-37	0	0.795	0	0.817	0	1.110
G-38	0	0.943	0	1.100	0	1.170
G-39	0	0.832	0	1.030	0	1.050
G-40	0	1.000	0	1.060	0	1.300
G-41	0	0.944	0	1.060	0	1.260
G-42	0	1.050	0	1.190	0	1.400
G-43	0	2.390	0	1.300	0	2.580
G-44	0	1.590	0	2.070	0	1.860
G-45	0	1.380	0	1.830	0	1.340
G-46	0	0.998	0	1.120	0	1.030
G-47	0	0.776	0	0.839	0	1.130
G-48	0	0.797	0	0.902	0	1.070
G-49	0	0.776	0	0.908	0	1.050
G-50	0	0.734	0	0.928	0	1.010
G-51	0	0.860	0	0.906	0	1.170
G-52	0	0.839	0	1.010	0	1.440
G-53	0	1.020	0	1.280	0	1.460
G-54	0	1.130	0	1.630	0	1.590
G-55	0	1.000	0	1.630	0	1.730
G-56	0	0.881	0	1.080	0	1.420
G-57	0	0.839	0	1.300	0	1.170
G-58	0	0.797	0	1.080	0	1.030

(continued)

Table A-1 (continued): FY95, 96, and 97 FIDLER Counts of Low-Energy Gamma Activity around the Perimeter of Area G

MDA Survey Point	ROI 1/Pu ($\mu Ci/m^2$) 1995	ROI 2/Am ($\mu Ci/m^2$) 1995	ROI 1/Pu ($\mu Ci/m^2$) 1996	ROI 2/Am ($\mu Ci/m^2$) 1996	ROI 1/Pu ($\mu Ci/m^2$) 1997	ROI 2/Am ($\mu Ci/m^2$) 1997
G-59	0	0.755	0	1.060	0	0.972
G-60	0	0.776	0	0.883	0	0.972
G-61	0	0.734	0	1.010	0	0.931
G-62	0	0.739	0	0.861	0	0.993
G-63	0	0.734	0	0.928	0	0.910
G-64	0	0.776	0	0.769	0	0.910
G-65	0	0.702	0	0.817	0	0.890
G-66	0	0.755	0	0.906	0	0.972
G-67	0	0.702	0	0.928	0	0.931
G-68	0	0.692	0	0.662	0	0.786
G-69	0	0.680	0	0.685	0	0.869
G-70	0	0.671	0	0.773	0	0.890
BKG-1	0	0.797	0	0.906	NA	NA
BKG-2	0	0.671	0	0.772	NA	NA
BKG-3	0	0.671	0	0.795	NA	NA
BKG-4	0	0.650	0	0.707	NA	NA
BKG-5	0	0.608	0	0.707	NA	NA
BKG-6	0	0.650	0	0.729	NA	NA
BKG-7	0	0.776	0	0.883	NA	NA
BKG-8	0	0.755	0	0.817	NA	NA
BKG-9	0	0.734	0	0.795	NA	NA
BKG-10	0	0.692	0	0.751	NA	NA

Finally, the scatter plot (Figure A-1) indicates that, except for location MDA-1, all of the MDA survey point counts are elevated over background. From points 2–13 (moving from Area L to the old Area G gate), the counts are slightly elevated. From MDA survey points 14 through 44 (encompasses all the MDA survey points from the old gate through the TRU pads), there is a slow trend in gamma activity upward. From MDA survey points 45 through 55, the gamma activity trends first downward through MDA survey point 51, then upward through MDA survey point 55. Finally, from MDA survey points 56–70, the gamma activity trend is slowly downwards as the survey points proceed westward and out of Area G. It is difficult at this time to determine whether the trends in low-energy gamma radiation for the Area G MDA survey points are due to incremental increases or decreases in soil gamma activity or whether these trends are due to manifestations of area wide-shine that affects the individual soil gamma activities.

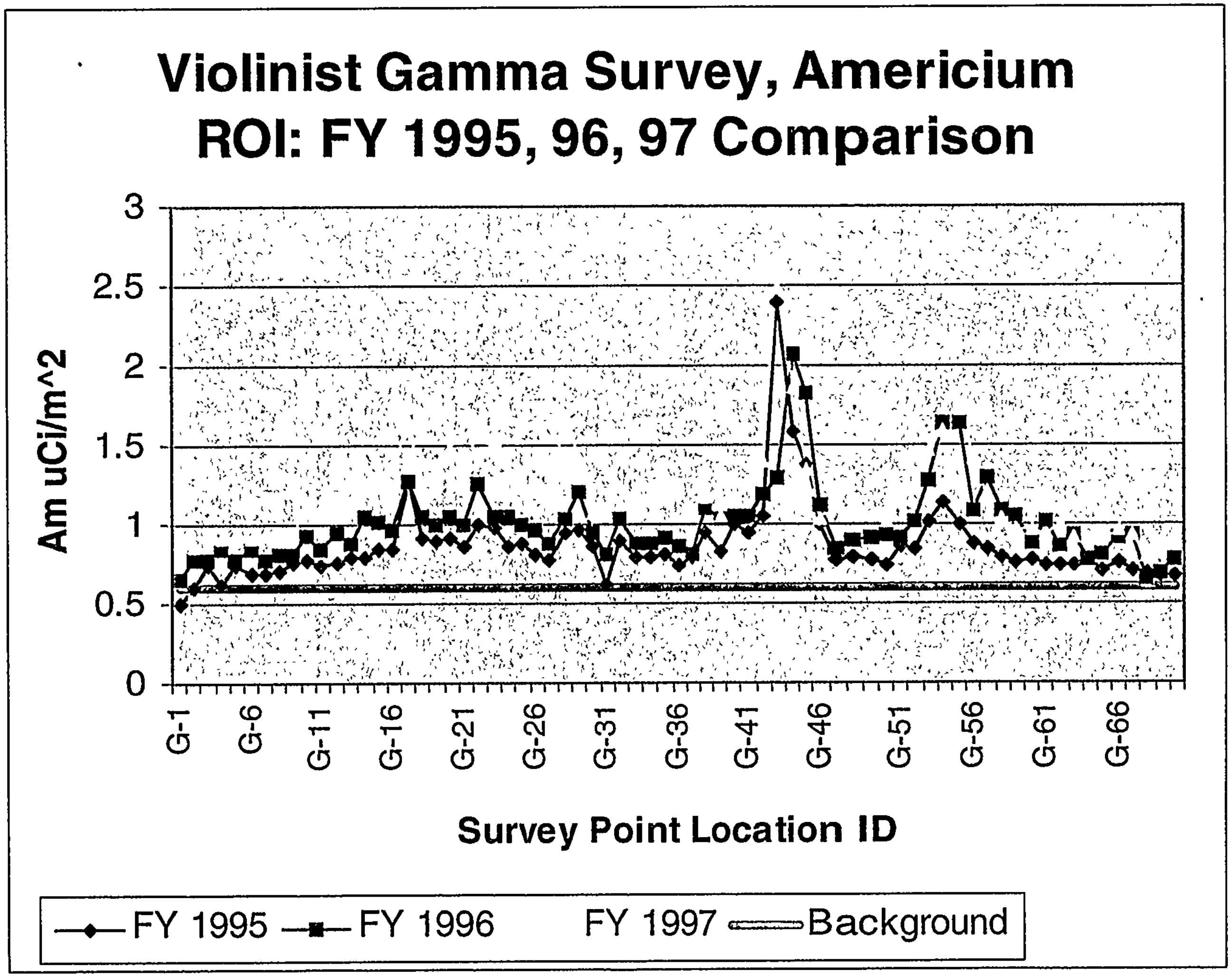
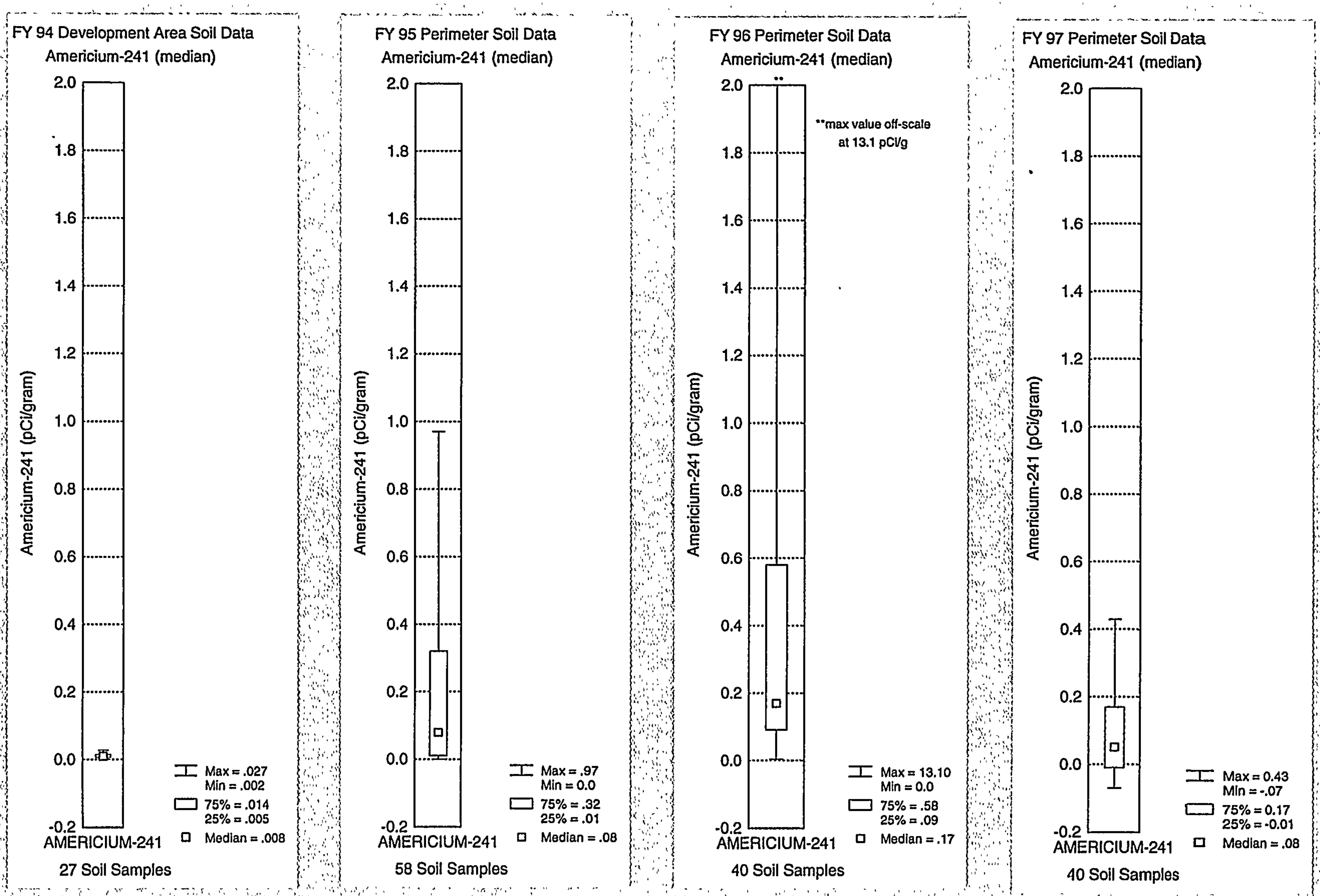


Figure A-1: Scatter plot of FY95, FY96, and FY97 FIDLER of low-energy gamma activity around the perimeter of Area G. Americium-241 (ROI 2) results are displayed in $\mu Ci/m^2$. The high values for locations G-17 and G-43 were shown to be due to shine artifacts.

APPENDIX B:

BOX PLOTS



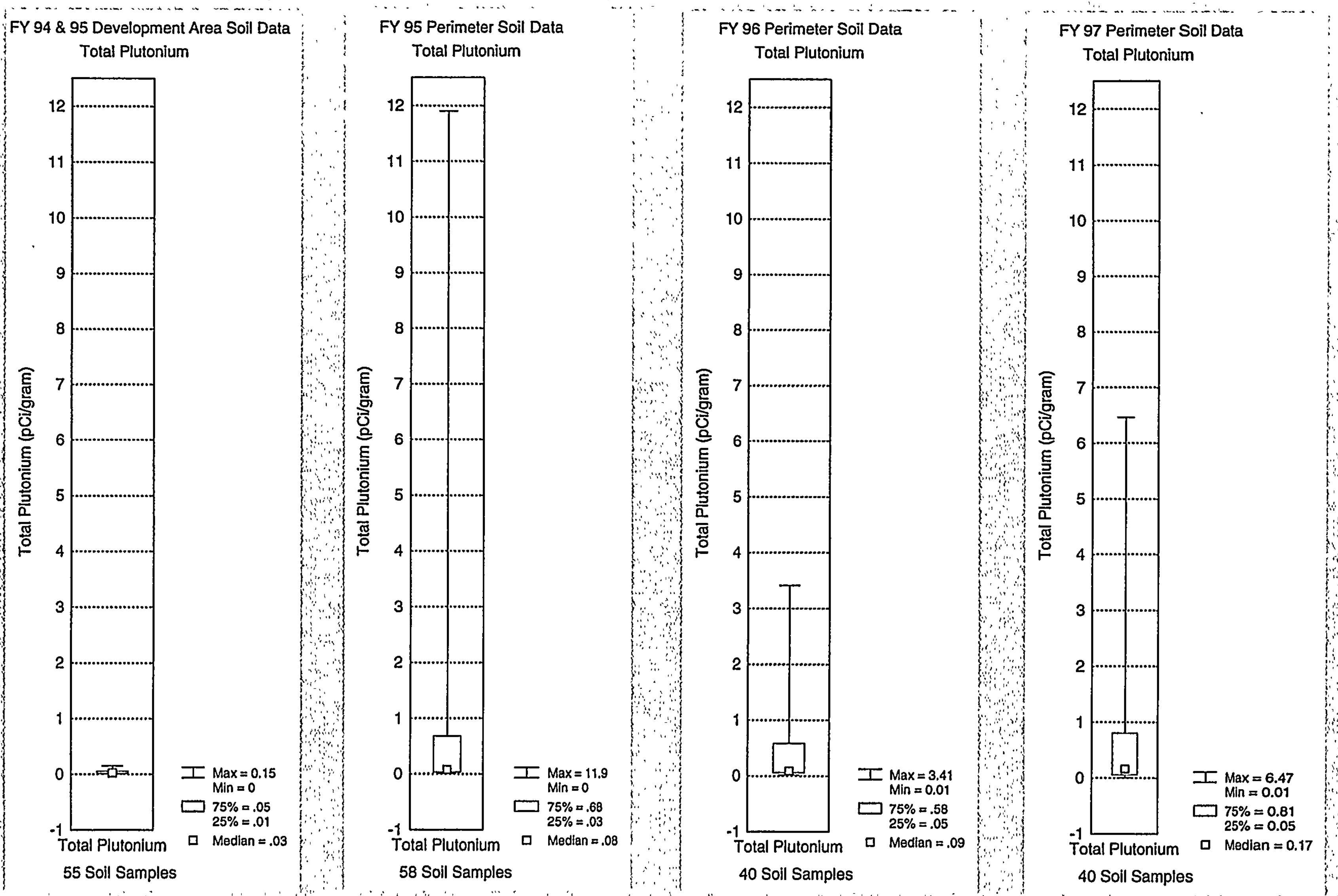
FY 94 Development Area Soil Data Americium-241 (median)

FY 95 Perimeter Soil Data Americium-241 (median)

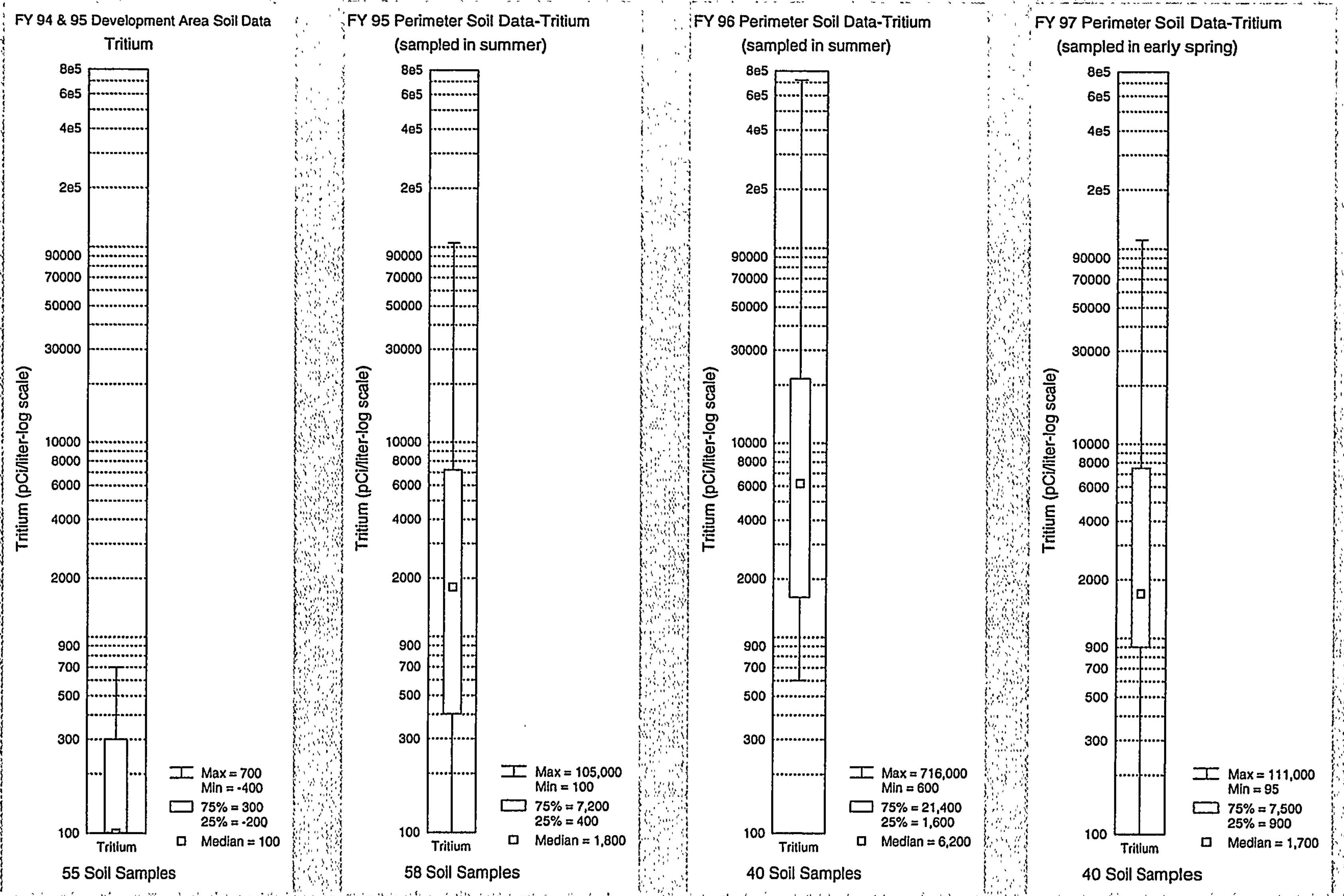
FY 96 Perimeter Soil Data Americium-241 (median)

FY 97 Perimeter Soil Data Americium-241 (median)

Area G Americium-241 Surface Soil Box Plot Comparisons



Area G Total Plutonium Surface Soil Box Plot Comparisons



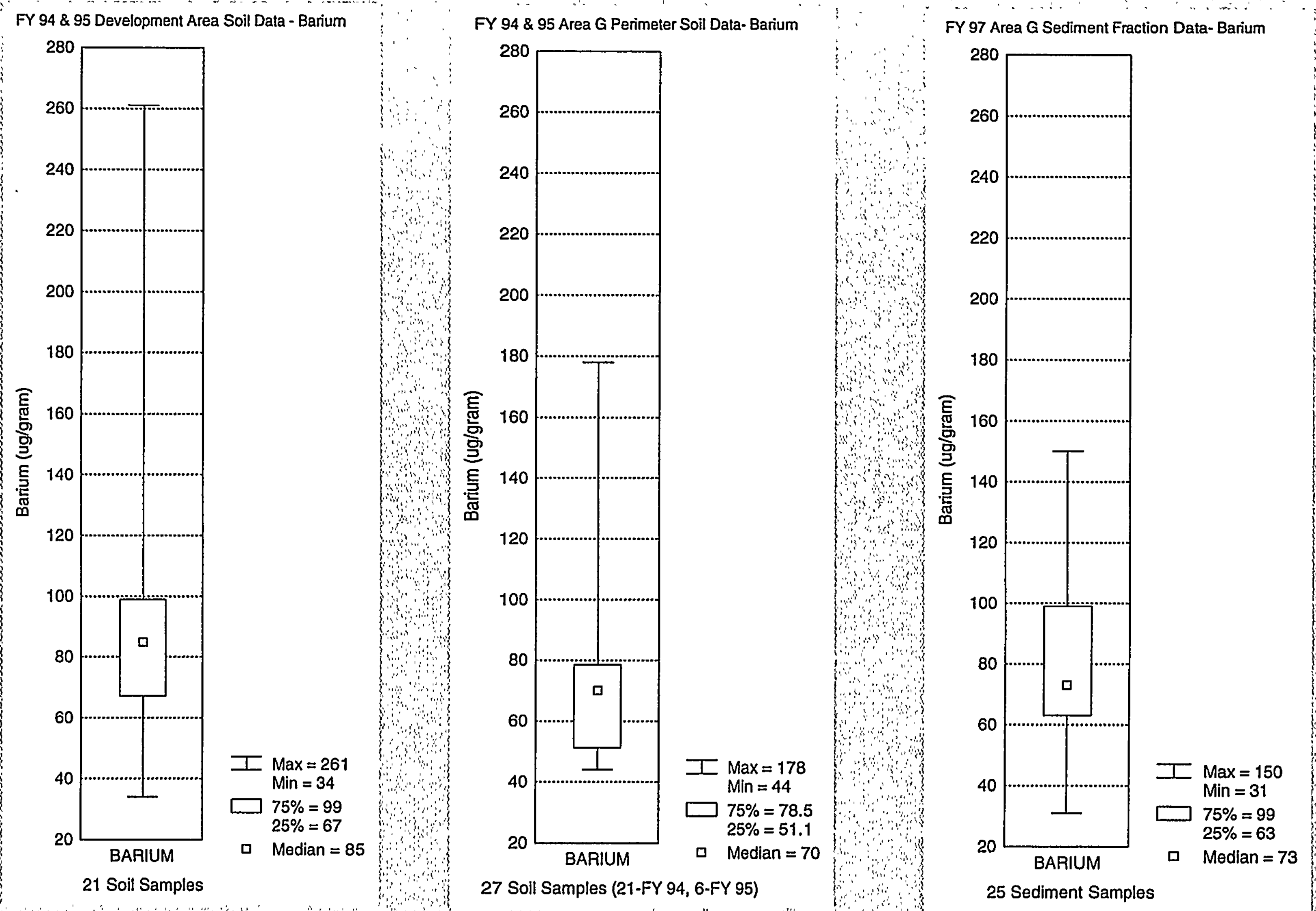
FY 94 & 95 Development Area Soil Data
Tritium

FY 95 Perimeter Soil Data-Tritium
(sampled in summer)

FY 96 Perimeter Soil Data-Tritium
(sampled in summer)

FY 97 Perimeter Soil Data-Tritium
(sampled in early spring)

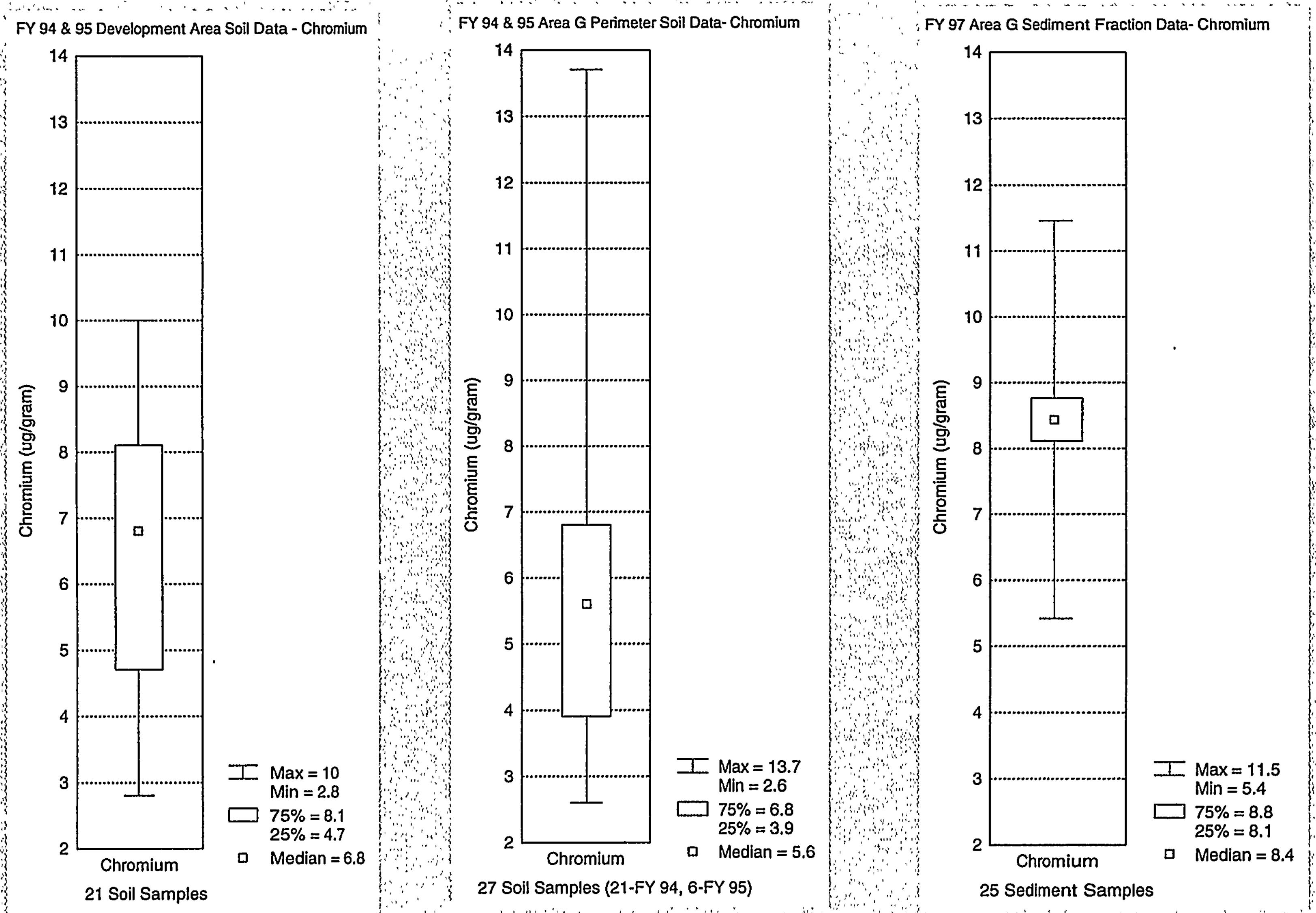
Area G Tritium Surface Soil Box Plot Comparisons


FY 94 & 95 Development Area Soil Data - Barium

FY 94 & 95 Area G Perimeter Soil Data- Barium

FY 97 Area G Sediment Fraction Data- Barium

Area G Barium Surface Soil Box Plot Comparisons



Area G Chromium Surface Soil Box Plot Comparisons