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Prepared By/Date		Dept.	Mail/Addr
P. Liddy	9-12-99	641	T038

Approvals	Date
P. Rutherford	9-13-99
S. Reeder	9-14-99
M. Lee	10-15-99

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Distribution

*	Name	Mail Addr.
*	J. Barnes	T038
*	R. Marshall	T038
*	P. Rutherford (5)	T038
*	M. Lee	T038
*	P. Waite	T038
*	P. Liddy	T038
*	R. Meyer	T038
*	R. McGinnis	T100
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Abstract
This document provides results of the Final Status Survey of the 17th Street Drainage Area at the Santa Susana Field Laboratory. All measurements confirm that the area meets the release limits approved by the Department of Energy and the State of California, Department of Health Services. Accordingly, the area is suitable for release for unrestricted use.

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Supporting Document
Summary of Change

Report	17th Street Drainage Area Final Status Survey	No. (RZI-RF) RS-00009 Page 1.1 of 70

Rev.	Summary of Change	Approvals and Date
A	Page 4, added: "The survey unit also passed the Wilcoxon Rank Sum test using the unity rule." Page 6, changed: PCI/g to pCi/g. Page 8, Section 3.2: omitted paragraph beginning from "Background Cs-137..." Replaced with "and other isotope DCGLs are provided in Reference 6.3 and Appendix B." Page 18, Section 3.9.5: added Sections 3.9.5.1 and 3.9.5.2. Page 19: Added under **Cs-137**, the reference to Tables B1 and B1.1 Page 19: Added Table 4: Background Dose Rate Levels Page 21, Section 4.2: Omitted paragraph beginning from "...detect if the....". Replaced with "test the Null Hypothesis for all isotopes combined. (see Tables C1 and C2). Page 21, Section 4.2: Omitted paragraph beginning from "For every isotope...." Replaced with "From Table C2, the sum of the Referenced area ranks is 720. This exceeds the Critical Value of 565 calculated from equation I.1 of Reference 6.1 for 22 SU area samples, 22 Reference area samples, and an α of 0.05. Hence the Null Hypothesis "that residual radioactivity concentrations exceed the reference criteria" is rejected. Page 21, Deleted Section 4.2, Sign Test Analysis,.Replaced with Section 4.2 Wilcoxon Rank Sum Test. Page 22, Section 5.0: Added "The survey unit also passed the multi-isotope Wilcoxon Rank Sum Test using the Utility Rule." Page23, Section 6.0: Omitted control number "3131500002 BCSSR". Replaced with "Bell Canyon Area Soil Sampling Report". Page 23, Added reference on *Bell Canyon Soil Sampling Report* to Reference Section. Page 26, Deleted Sign Test column on Table A.1: Ambient Gamma Exposure Chart. Page 26: Revised chart to reflect gross and net ambient exposure Measurements. Pages 29, 30, 32, 34, 36, 38, 42, 44, 46, 48, and 50. Deleted Sign Test column on Tables B.1 through B11, Page 30, Added Table B1.1 Cs-137 Re-analysis. Page 54, Added Table C1: WRS Analysis.	M. Lee 3/15/00 R. Rutherford 3-15-2000 R. Meyer 3/15/00 P. Liddy 3/15/2000

Supporting Document
Summary of Change

Rev.	Summary of Change	Approvals and Date
A	Page 55, Added Table C2 WRS Test Re-analysis. Page 56, Appendix D: Omitted "Characterization Report". Replaced with "1998 Soil Sample Results".	

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EXECUTIVE SUMMARY

On June 1, 1999, a MARSSIM final status survey was completed at the 17th Street Drainage Area confirming that the area meets release limits approved by the Department of Energy, and the Department of Health Services. Accordingly, the area is suitable for release for unrestricted use.

During 1998, a comprehensive decontamination and decommissioning effort was initiated in the 17th Street Drainage Area. After D&D efforts, a comprehensive final status survey of the area concluded in 1999. The final status survey classified the area into a Class I survey unit, since contamination had been identified, above the $DCGL_W$. This area comprised a 120-ft by 200-ft section of land. All measurements were tested statistically for compliance within the regulatory acceptable derived concentration guideline limits (DCGLs), and ambient exposure rates.

In all of the Class I area, the highest background subtracted ambient gamma measurement was 3 μR/hr (see Appendix A). A 100% qualitative surface radiation exposure survey found no detectable activity. The soil results proved all samples taken were well below the $DCGL_w$ for each radioisotope (see Appendix B). The survey unit also passed the multi-isotope Wilcoxon Rank Sum test using the unity rule (see Appendix C).

1.0 INTRODUCTION

The final status survey conducted by Rocketdyne Propulsion and Power for the 17th Street Drainage Area followed the protocols of the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), Reference 6.1. The objective of this survey was to demonstrate that no residual contamination remains that could result in any exposure or risk to current or future occupants.

2.0 FACILITY HISTORY

2.1 Background

At Rocketdyne Propulsion and Power, Santa Susana Field Laboratory, a natural rainwater channel is located in Area IV, south of the intersection of "G" Street and 17th Street. In 1962, a berm was constructed around the area to provide a 30-ft. by 30-ft hold-up pond. The pond was functional for many years. It cycled through periods of evaporative drying in summer seasons, and refilled during rainy seasons causing the low-lying area to be marshy. In subsequent years, the area became overgrown with shrubs and trees, and filled with silt.

In 1995, during the Area IV radiological survey, the pond area was found to be completely overgrown, marshy, and inaccessible. Soil from the drainage areas to the north and south of the pond area was sampled, but no contamination was found in those locations.

In 1997, during an assessment of historical aerial photos, the existence and location of the pond was identified and investigated. Several soil samples were taken in the area (which was then dry), and two of the soil samples indicated Cs-137 exceeding the cleanup standards by 50%. A radiation scoping survey was subsequently conducted in the pond area, and any locations found over the background limits were identified.

In 1998, the entire drainage area was cleared of shrubs and trees. The original bermed pond area was mapped, gridded and surveyed, including all upper flow intake to the pond; and lower discharge drainage out of the pond. The one-meter high, exposure measurements conducted did not exceed 18.4 μR/hr in a background of 15 μR/hr. Some elevated radiation measurements in localized areas at ground level were observed at a maximum of twice the background levels.

All locations exceeding ground level exposure rates of more than 5 μR/hr above background were identified and marked. All elevated radiation areas were sampled at varying depths of soil. However, most of the soil samples indicated naturally occurring radionuclides. Soil samples in areas immediately north and immediately south of the berm indicated levels of radionuclides above local background levels. Cs-137 was found at 2 pCi/g, which was less than the cleanup standard of 9.2 pCi/g. Th-228 was found at 6 pCi/g, which was close to the cleanup standard limit. Uranium isotopes were found at 4 pCi/g, which was less than the cleanup standard of 30 pCi/g. All uranium sample results showed ratios of uranium isotopes consistent with naturally occurring uranium.

There were no processed or enriched uranium isotopes found typical of the nuclear fuel used at the SSFL. Although thorium-228 was discovered at 6 pCi/g, its parent isotope thorium-232 was found at background levels of 1 pCi/g. Since this specific thorium isotope was not processed or used at the SSFL, the origin or cause of elevated thorium-228 is presently unknown.

Although the majority of the soil samples did not exceed cleanup standards, and did not pose a health risk, portions of the 17th Street Drainage area were excavated. Post excavation soil sampling showed that excavation had been effective in reducing soil concentrations much further below the cleanup standards. Prior sampling and remediation is described in Reference 6.2, and is included here in Appendix D. The results from Reference 6.2 demonstrated that the drainage channel both upstream and downstream of the bermed area undergoing a MARSSIM final release survey were indeed free of contamination.

2.2 Approach

Table 1 depicts the survey and remediation schedule for the 17th Street Drainage Area.

TASK	SCHEDULED DATE
Initial Soil Sampling	1995
Follow-up Soil Sampling	1997
Rocketdyne Characterization Survey	September 1998
Remediation	October 1998
Post-remediation Survey	November 1998
Rocketdyne Final Survey	June 1999
ORISE Verification Survey	October 1999
DHS Verification Survey	October 1999

TABLE 1: KEY MILESTONES

3.0 SURVEY DESIGN

The MARSSIM final status survey for the 17th Street Area followed the guidelines of the Rocketdyne Procedure R21-RF-RS00005 (see Reference 6.4). The objective of this survey was to demonstrate that no residual contamination remained that could result in any exposure or risk.

3.1 Identification of Radionuclides of Concern

The principle contaminant of concern at the 17th Street Drainage Area was Cs-137. Uranium and Thorium isotopes were also found in the soil but always with the accompanying presence of Cs-137. Cesium was used as a tracer for all potential contaminants and MDCs for the scanning portion of the survey (*refer to Section 3.9*) was based on the Cs-137 detectability. Soil sample analysis was performed for all gamma emitting radionuclides, Sr-90, Am-241 and isotopic Plutonium, Thorium, and Uranium.

3.2 Derived Concentration Guideline Limits ($DCGL_w$)

The objective of the survey was to demonstrate that residual contamination in excess of the derived concentration guideline limits (DCGLs) was not present at the site. The $DCGL_w$ for Cs-137 in soil is 9.2 pCi/g above background and other isotope DCGLs are provided in Reference 6.3 and Appendix B.

3.3 Classification of Areas Based on Contamination Potential

3.2.1 Impacted Areas

The impacted area was considered to be the area within geodetic land blocks L18 and L19 that surrounded the berm (*see Figure 1*). This is an area of 120 ft x 200 ft = 24,000 ft^2 (approximately 2230 m^2)

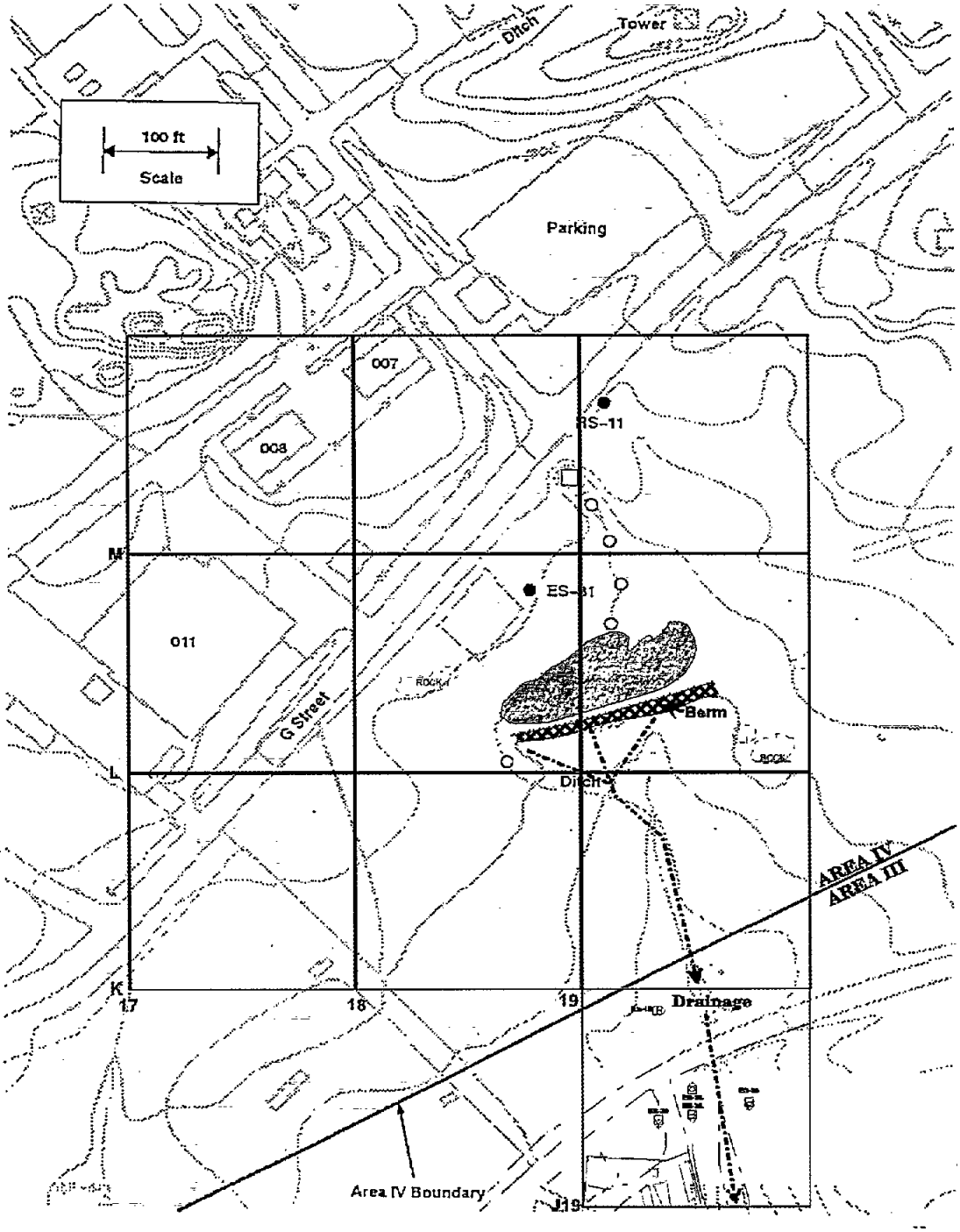


FIGURE 1: TOPIGRAPHICAL MAP OF 17TH STREET DRAINAGE AREA

CLASS I

The impacted area was determined to be the entire Class I area. The area is enclosed within four corners identified by Area IV's geodetic coordinate system as:

- Block L18 located North at 0-ft and East at 120-ft,
- Block L18 located North at120-ft and East at 120-ft,
- Block L19 located North at 0-ft and East at 120-ft, and
- Block L19 located North at 120-ft and East at 120-ft.

CLASS II

There are no Class II areas in this survey. Survey results reported in Appendix C demonstrated that no contamination exists in the drainage channel to the North and South of the identified Class I Survey Unit.

CLASS III

There are no Class III areas in this survey. Survey results reported in Appendix C demonstrated that no contamination exists in the drainage channel to the North and South of the identified Class I Survey Unit.

3.3.2 Non-Impacted Area

Areas surrounding the impacted area were surveyed in earlier projects (*see Reference 6.2*) and demonstrated to be non-contaminated. These surrounding areas were not part of the survey.

3.4 Identification of Survey Units

3.4.1 Area Classification

Roadmap-6, from the MARSSIM Manual, limits the maximum Survey Unit areas as shown in Table 2:

CLASSIFICATION	MAX SURVEY UNIT AREA
Class I	2,000 m^2
Class II	2,000 m^2 to 10,000 m^2
Class III	No limit

TABLE 2: AREA CLASSIFICATION

Figure 2 depicts the Class I area, which consisted of one survey unit of 24000- ft^2 (2230m^2). This diagram is an example, and not true to scale.

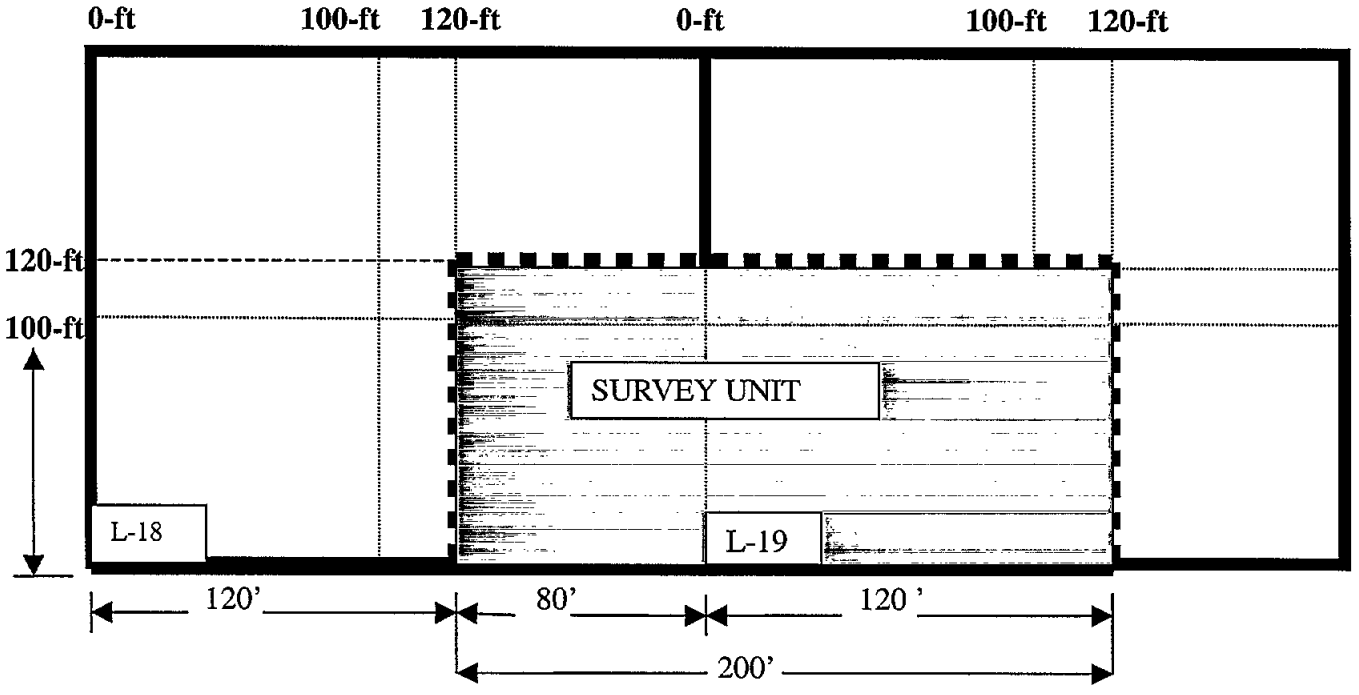


FIGURE 2: LOCATION OF SURVEY UNIT

3.5 Decision Objectives

- The objective of the survey was to achieve release of the area for unrestricted use.
- The null hypothesis (H_0) for the survey unit was that the residual radioactivity concentrations exceed the release criterion. The null hypothesis had to be rejected for the site to be released for unrestricted use.
- Acceptable decision error probabilities were α (regulatory risk) = 0.05 and β (users risk) = 0.05. Where Alpha (α) is defined as the probability that the known hypothesis will be rejected when in fact it is true (e.g. *a contaminated site is declared clean*). Beta (β) is defined as the probability that the null hypothesis will be accepted when in fact it is false (e.g. *a clean site is declared contaminated*).
- The derived concentration guideline limits (DCGLw) for the primary contaminant of concern (Cs-137) was 9.2 pCi/g, equivalent to an annual dose to a residential user of 15 mrem/year.
- The lower bound of the gray area (LBGR) used was *one half of the DCGLw* or 4.6 pCi/g of Cs-137.
- The regulator's risk (α) was established for the DCGLw.
- The user's (Rocketdyne) risk (β) was established at the LBGR.

3.5.1 Power Curve

The desired power curve indicated the gray region extended from 4.6 pCi/g to 9.2 pCi/g of Cs-137. The survey was designed for the statistical test to have a 95% power to decide the survey unit containing less than 4.2 pCi/g of Cs-137 met the release criterion. For the same test, a survey unit containing over 9.2 pCi/g of Cs-137 had less than 5% probability of being released.

3.6 Area Preparation

3.6.1 Number of Survey Units

There was a total of one (1), Class I, Survey Unit of 24,000-ft^2 (or each 2230 m^2). The number of surface soil samples taken was derived in Section 3.7.

Survey Unit 1 consists of 24,000-ft^2 (2230-m^2)

3.7 Analysis Procedures

3.7.1 Statistical Test

Since the gross (non-background subtracted) Cs-137 data are to be subjected to statistical test, the Wilcoxon Rank Sum test was used as recommended by MARSSIM.

3.7.2 Relative Shift

The shift Δ is the $DCGL_w$ minus the LBGR ($\Delta = DCGL_w - LBGR$). In other words, the shift was the width of the gray region. σ was the expected standard deviation of the measurements of the survey unit. Based on prior sampling of the land and excavations at the 17th Street Drainage Area, the σ for Cs-137 resulted in 3.39 pCi/g.

The **relative shift Δ/σ** was therefore (9.2 - 4.6)/3.39 = **1.4**

3.7.3 Number of Data Points (Soil Samples)

From Table 5.5 of Reference 6.1, the number of samples required for a relative shift of 1.4 and $\alpha = \beta = 0.05$ was 20. However, the Class I area (2230 m^2) was 11% larger than the recommended size of 2000 m^2. Therefore, the number of sample was adjusted accordingly to reflect this size difference. The adjusted number of samples was **22**. Locations of soil samples were also be obtained at these locations.

Total number of sample points required for 24,000 ft^2 (2230 m^2) was 22.

3.8 Reference Coordinate System

3.8.1 Sample Point Spacing

For the Survey Unit, the grid spacing and scan area between sample points (for a square grid) were calculated as follows:

Scan Area = A = 24,000 ft^2/22 = 1090.9-ft^2 = 101 m^2
L =√A = √1090.9= **33.02-ft** (10.06 meters) **distance apart**

In accordance with the MARSSIM Manual, *Survey Planning and Design*, page 5-38, "*Grid spacing should generally be rounded down to the nearest distance that can be measured in the field*". Therefore, the distance between sample points was 33-ft or 10 meters.

Distance (L) between sample points was 33-ft or 10 meters

3.8.2 Starting Point Coordinates

In order to designate the starting point of soil sample locations, a pair of random numbers was generated from Table 1.6 of the MARSSIM Manual, Reference 1. Rectangular coordinates from the southwest corner of the survey unit were then calculated by multiplying by the dimensions of the survey unit (120 ft x 200 ft). Survey unit coordinates were designated as follows:

0.707773 x 200 ft = 141.5 ft (43.1 m)
0.426444 x 120 ft = 51.1 ft (15.5 m)

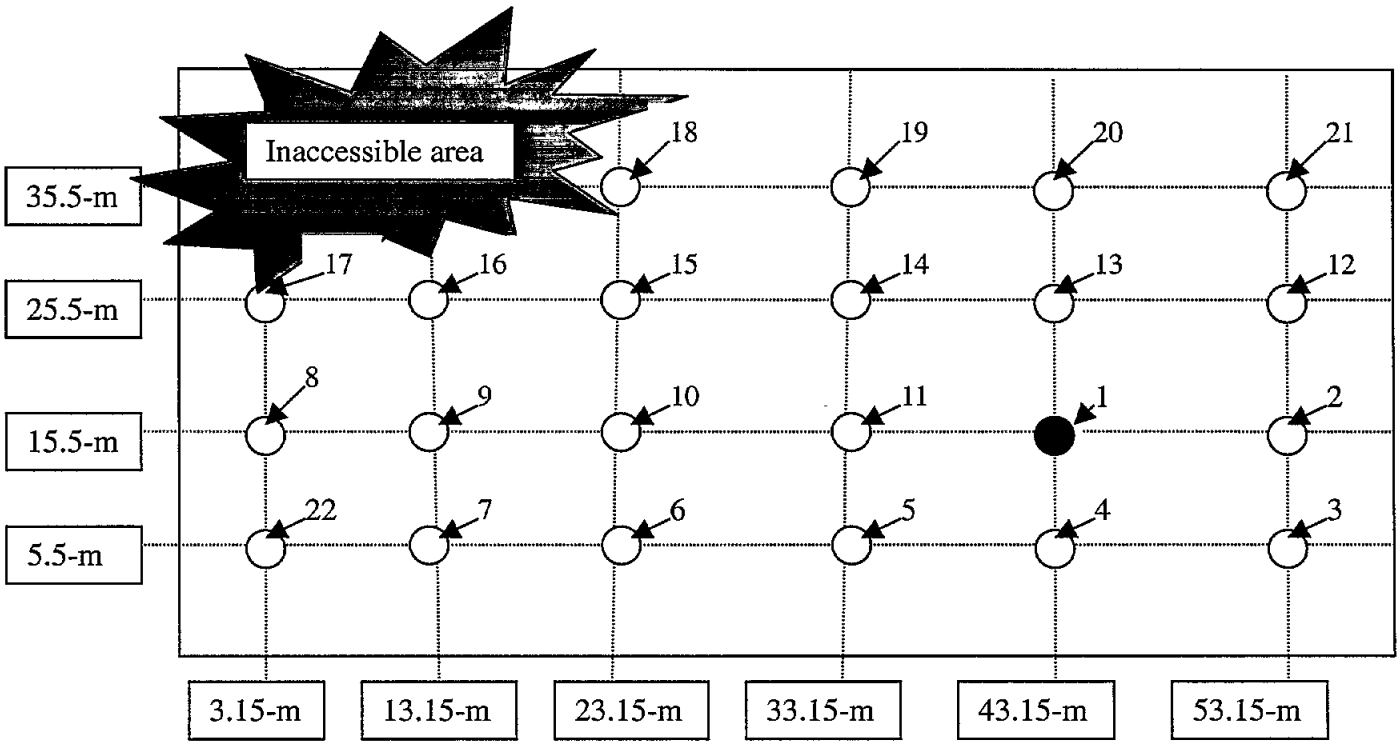
Starting from the southwest corner origin of the Survey Unit, the point of origin to begin measuring was:

Starting Point Coordinates
(X) East 141.5-ft (43.1meters)
(Y) North 51.1-ft (15.5 meters)

3.8.3 Spacing

In summary, a minimum of 22 soil samples was taken at 33-ft (or 10-m) distances apart; beginning at the (E141.5-ft, N51.1-ft) or (E43.1-m, N15.5-m) coordinates.

Figure 3 shows the soil locations in the Class I survey unit. Refer to Table 3 on page 16 for the identification numbers.



● =starting point Location number = 17S-99-00X, see page 16.

NOTE: SURVEY UNIT IS 200-FT BY 120-FT (60.9-M X 36.5-M). SAMPLE POINTS ARE 33-FT (10-M) DISTANCE APART.

FIGURE 3: SURVEY UNIT SOIL SAMPLE GRID

Table 3 shows the soil sample identification numbers attached to the sample location coordinates in Figure 3, page 15.

GRID COORDINATES (NORTH/EAST) METERS*	SOIL SAMPLE NUMBER
N15.5/E43.1	17S-99-0001
N15.5/E53.1	17S-99-0002
N5.5/E53.1	17S-99-0003
N5.5/E43.1	17S-99-0004
N5.5/E33.1	17S-99-0005
N5.5/E23.1	17S-99-0006
N5.5/E13.1	17S-99-0007
N5.5/E3.1	17S-99-0008
N15.5/E13.1	17S-99-0009
N15.5/E23.2	17S-99-0010
N15.5/E33.1	17S-99-0011
N25.5/E53.1	17S-99-0012
N25.5/E43.1	17S-99-0013
N25.5/E33.1	17S-99-0014
N25.5/E23.1	17S-99-0015
N25.5/E13.1	17S-99-0016
N25.5/E3.1	17S-99-0017
N35.5/E23.2	17S-99-0018
N35.5/E33.1	17S-99-0019
N35.5/E43.1	17S-99-0020
N35.5/E53.1	17S-99-0021
N5.5/E3.1	17S-99-0022
BLIND SPLIT FROM N15.5/E43.1	17S-99-0023
MATRIX SPIKE SAMPLE FROM N5.5/E53.1	17S-99-0024

* ORIGIN MEASURING FROM THE N0/E0 COORDINATE, SOUTHWEST CORNER OF THE SURVEY UNIT

TABLE 3: SOIL SAMPLE LOCATIONS

3.9 Instrumentation and Techniques

3.9.1 Required Scan MDC

Scanning of soil sample grids was performed to ensure small areas of contamination did not remain undetected. The $DCGL_W$ was calculated in RESRAD 5.6[1] using default of 10,000 m^2. Running RESRAD with smaller areas progressed to a relatively higher release criteria. From Table 5.6 of Reference 6.1, the area dose factor for 101 m^2 for Cs-137 is 1.4. Therefore the elevated measurement concentration $DCGL_{EMC}$ was: $DCGL_{EMC} = DCGL_W$ x Area Factor = 9.2 x 1.4 = 12.9 pCi/g

Required Scan MDC = 12.9 pCi/g

3.9.2 Actual Scan MDC

Surface scans were performed with a 1 in. x 1 in. NaI detector moving at 1 ft/sec. Actual scan MDC for this technique was calculated below following the procedure outlined in page 6-45 of MARSSIM, Reference 1.

Background = B = 3000 counts/min
Assumed hot spot dimensions = 1.5 ft x 1.5 ft
Assumed hot spot depth = 0.5 ft
Scan speed = 1 ft/sec
Observation interval = 1.5 sec
Delectability index 1.38
Surveyor efficiency 0.5
CPM/Exposure ratio = 215 cpm per µR/h

Minimum Detectable Count Rate (MDCR) =
$1.38 \times (3000 \times 1.5/60)^{0.5} / ((1.5/60) \times 0.5^{0.5}) = 676$ counts/min

Minimum Detectable Exposure Rate (MDE) = 676/215 = 3.1 µR/h

A microshield analysis was performed for the hot spot size defined above, for cesium-137 and its progeny barium-137 at a 1 pCi/g concentration and soil density of 1.4 g/cm3. The exposure rate at 2 in. from the surface was 0.3 µR/h.

Actual Scan MDC = 3.1/0.3 = **10.3 pCi/g**

Since the actual scan MDC of 10.3 pCi/g was less than the required scan MDC (or $DCGL_{EMC}$) of 12.9 pCi/g, the scanning technique was adequate for detecting hot spots above $DCGL_{EMC}$ between the soil sample locations. Therefore no adjustment to the number of soil samples to account for elevated activity was necessary.

3.9.3 Instrument Performance Check

Measurement integrity of the instruments was monitored throughout all parts of gamma surveys by periodic checks of the instrument's response to normal background radiation, and to a *Field Check Source.* A record of these instrument checks was maintained by the daily completion of Instrument Qualification Reports.

3.9.4 Environmental Calibration Site

A Reuters-Stokes ambient gamma exposure site was the location where the instrument calibration and efficiency checks were conducted. The detector was source checked at the 1-meter height, and remained the daily source check area throughout the Area 17th Street Drainage Area surveys.

3.9.5 Representative Reference Background Areas

3.9.5.1 Soil

When performing the WRS Test, samples from a "reference" background area to the immediate south of the Santa Susana Field Lab (SSFL) were used. These samples taken in 1998 are judged as representative since the geology and terrain are similar to the SSFL.

3.9.5.2 Exposure level

A series of background exposure levels were obtained around the entire survey unit area within grid blocks L-18, and L-19. This action assisted in determining the average and highest background levels where the survey was conducted.

3.9.6 Ambient Survey Detector Fixtures

To accurately obtain a 1-meter ambient gamma measurement at each sample point location, the sodium iodide detector was mounted on a lightweight PVC fixture. This fixture held the detector oriented towards the ground at a 1-meter height. Its use facilitated quick placement at each measurement location, while eliminating errors due to detector distance or orientation.

3.9.7 Walk-about Survey Detector Fixtures

During the walk-about survey, a sodium iodide detector probe was mounted at the end of a balanced boom, so the surveyor could sweep the probe over a large area while walking along the survey path. The fixture for this survey had a length of stainless steel tubing for the boom, with a bracket at one end to hold the detector upright to the ground, and a counterbalance weight at the other end. A shoulder strap was attached to the balance point of the fixture. The arrangement allowed the surveyor to sweep the detector over an area about 5 feet wide while walking a straight line.

3.10 Pre-survey Preparation

Brush was cleared from the survey unit prior to conducting the Final status survey.

4.0 SURVEY RESULTS

4.1 Class I Survey Results

4.1.1 Surface Exposure Rate

The average, gross surface walk-about exposure level observed was 3268 cpm (15.2 μR/hr). The maximum surface walk-about exposure level observed was 4050 cpm (18.8 μR/hr). When the background level of 2704 cpm (12.6 μR/hr) was subtracted for these values, the net average and maximum surface exposure levels were 564 cpm (2.6 μR/hr) and 1346 cpm (6.3 μR/hr) respectively.

4.1.2 Ambient Exposure Rate

The average, gross, 1-meter ambient exposure level observed was 3259 cpm (15.2 μR/hr). The maximum 1-meter ambient exposure level was 3719 cpm (17.3 μR/hr). When the background level of 2943 cpm (13.7 μR/hr) was subtracted from these numbers, the net average and maximum 1-meter ambient exposure levels were 316 cpm (1.5 μR/hr), and 776 cpm (3.6 μR/hr) respectively. Both these numbers are below the approved $DCGL_W$ of 5 μR/hr above background (see Appendix A).

Table 4 shows how the average background dose rates were established prior to conducting the survey.

BACKGROUND WALK-ABOUT DOSE RATES	BACKGROUND AMBIENT DOSE RATES
2682 cpm	2984 cpm
2720 cpm	2971 cpm
2770 cpm	2915 cpm
2713 cpm	2888 cpm
2739 cpm	3030 cpm
2633 cpm	2933 cpm
2652 cpm	2985 cpm
2736 cpm	2892 cpm
2709 cpm	2884 cpm
2682 cpm	2951 cpm
AVERAGE: 2704 cpm	**AVERAGE: 2943 cpm**
MAX: 2770 cpm	MAX:3030 cpm

TABLE 4: BACKGROUND DOSE RATE LEVELS

4.1.3 Soil Radioisotope Concentrations

Soil radioisotope concentrations are summarized in Appendix B. Note that some results are reported as negative. This is a common occurrence if the laboratory counter blank background count exceeds the sample count.

Cs-137

Initial Analysis

Fourteen samples were non-detect. Eight samples had detectable cesium between 0.63 and 1.9 pCi/gm (gross). All samples were below the of 9.2 pCi/gm (net) clean-up standard. (Refer to Table B1).

Reanalysis

It was observed that the initial gamma analysis reported very high MDAs for Cs-137 (0.2 to 0.4 pCi/gm). As a result, many samples were non-detect. Contact with the radiochemistry laboratory indicated that a small mass and low count time had been used. The laboratory was requested to reanalyze the original samples to achieve the contractually required MDA of 0.02 pCi/gm. Reanalysis results ranged from 0.01 to 2.93 pCi/gm (gross) with one non-detect. All samples were below the 9.2 pCi/gm (net) clean-up standard (see Table B.1.1).

Th-228

Thorium 228 results ranged from 1.07 to 2.61 pCi/gm (gross). These results are typical of background levels and below the 5 pCi/gm (net) clean-up standard.

Th-230

Thorium 230 results ranged from 0.87 to 2.7 pCi/gm (gross). These results are typical of background levels and below the 5 pCi/gm (net) clean-up standard.

Th-232

Thorium 232 results ranged from 0.87 to 1.65 pCi/gm (gross). These results are typical of background levels and below the 5 pCi/gm (net) clean-up standard.

U-234

Uranium 234 results ranged from 0.59 to 1.71 pCi/gm (gross). These results are typical of background levels and below the 30 pCi/gm (net) clean-up standard.

U-235/236

Uranium 235/236 results had 17 non-detects. Detectable U-235/236 in 5 samples ranged from 0.069 to 0.25 pCi/gm (gross). These results are typical of background levels and below the 30 pCi/gm (net) clean-up standard.

U-238

Uranium 238 results ranged from 0.56 to 2.01 pCi/gm (gross). These results are typical of background levels and below the 35 pCi/gm (net) clean-up standard

Isotopic Ratios of U-234 /U-238

Isotopic ratios of uranium 234/238 results ranged from 0.48 to 1.64 with an average of 1.07. This is typical of non-enriched, non-processed, naturally occurring uranium.

Pu-238
All plutonium 238 soil samples were non-detect.

Pu-239/240
All plutonium 239/240 soil samples were non-detect.

Am-241
All americium 241 soil samples were non-detect.

Sr-90
Twenty strontium 90 soil samples were non-detect. Two soil samples had detectable Sr-90 at 1.42 and 3.08 pCi/gm (gross). However, these samples are below the 36 pCi/gm (net) clean up standard.

4.2 Wilcoxon Rank Sum Test

The survey unit measurements were compared to the reference area measurements using the multi-isotope Wilcoxon Rank Sum (WRS) test designed to test the null hypothesis for all isotopes combined. Table C1 uses the original Cs-137 results, while Table C2 uses the reanalyzed Cs-137 results.

The reference area measurements used in the WRS test were taken from the 1998 Bell Canyon soil sampling project (see Reference 6.5). From Table C2 , the sum of the reference area ranks is 711. This exceeds the critical value of 565 calculated from equation I.1 of Reference 6.1 for 22 SU area samples, 22 reference area samples and an α of 0.05. Hence, the null hypothesis *"that residual radioactivity concentrations exceed the release criteria*" is rejected.

In simple terms, this means that the statistical test has demonstrated to a confidence level of 95% that residual radioactivity is below the clean-up standards.

5.0 CONCLUSION

All radiation exposure measurements and soil radioisotope concentrations were below the Department of Energy approved $DCGL_W$s. The survey unit also passed the multi-isotope Wilcoxon Rank Sum test using the unity rule. Based on the results of the investigations reported here, the 17th Street Drainage Area meets the Department of Energy approved acceptance criteria. The area is therefore suitable for release for "unrestricted use" with no radiological restrictions.

6.0 REFERENCES

6.1 Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), December 1997.

6.2 Rocketdyne Document, SHEA-016779, "17th Street Drainage Area-Characterization Surveys and Excavation", John Shao, December 21, 1998.

6.3 Rocketdyne Report N001SRR140131, "Approved Sitewide Release Criteria for Remediation of Radiological Facilities at SSFL", February, 1999.

6.4 Rocketdyne Procedure R21-RF-RS00005, "17th Street Drainage Area Final status survey Procedure", Patricia Liddy, July 21, 1999.

6.5 "Bell Canyon Area Soil Sampling Report, Ventura County, California, Volume 1", Ogden Environmental and Energy Services, Dixie A. Hambrick, October 1998.

APPENDIX A

AMBIENT GAMMA SURVEY RESULTS

Table A.1. Ambient Gamma Exposure

		GROSS		NET	
LOCATION	DATE	CPM	µR/hr	CPM*	µR/hr*
N15.5/E43.15	5/12/99	3173	14.8	230	1.1
N15.5/E53.15	5/12/99	3299	15.3	356	1.7
N5.5/E53.15	5/12/99	3193	14.9	250	1.2
N5.5/E43.15	5/12/99	3356	15.6	413	1.9
N5.5/E33.15	5/12/99	3306	15.4	363	1.7
N5.5/E23.15	5/12/99	3230	15.0	287	1.3
N5.5/E13.15	5/12/99	3200	14.9	257	1.2
N5.5/E3.15	5/12/99	3181	14.8	238	1.1
N15.5/E13.15	5/12/99	3719	17.3	776	3.6
N15.5/E23.15	5/12/99	3227	15.0	284	1.3
N15.5/E33.15	5/12/99	3212	14.9	269	1.3
N15.5/E53.15	5/12/99	3199	14.9	256	1.2
N15.5/E43.15	5/12/99	3336	15.5	393	1.8
N25.5/E33.15	5/12/99	3094	14.4	151	0.7
N25.5/E23.15	5/12/99	3372	15.7	429	2.0
N25.5/E13.15	5/12/99	3367	15.7	424	2.0
N25.5/E3.15	5/12/99	3214	14.9	271	1.3
N35.5/E23.15	5/12/99	3191	14.8	248	1.2
N35.5/E33.15	5/12/99	3018	14.0	75	0.3
N35.5/E43.15	5/12/99	3058	14.2	115	0.5
N35.5/E53.15	5/12/99	3487	16.2	544	2.5
N5.5/E3.15	5/12/99	3268	15.2	325	1.5
AVERAGE		**3259**	**15.2**	**316**	**1.5**

*** Background subtracted using a background of 2943 cpm [13.7 mR/hr]**

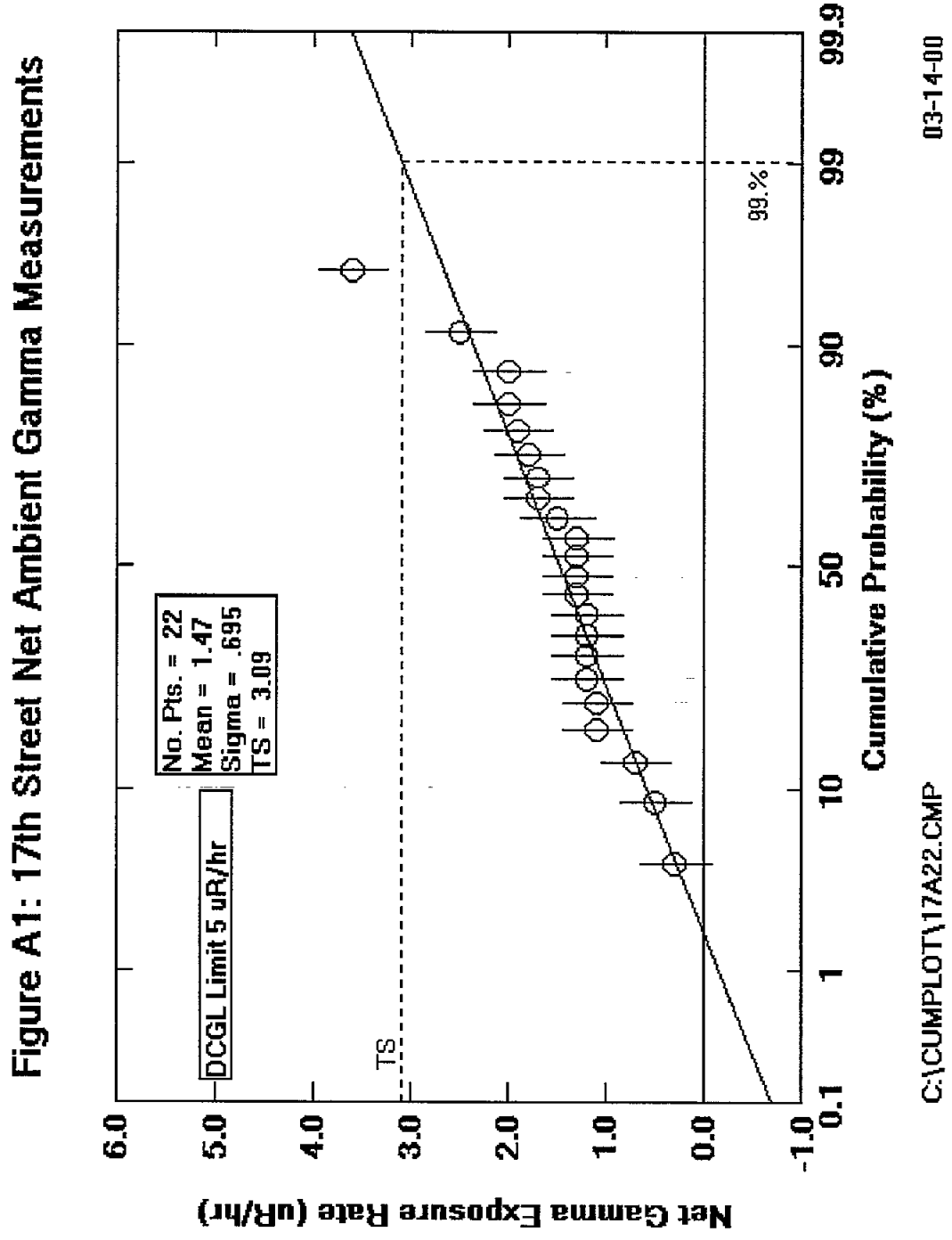


Figure A1: 17th Street Net Ambient Gamma Measurements
Net Gamma Exposure Rate (uR/hr)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-1.0
DCGL Limit 5 uR/hr
No. Pts. = 22
Mean = 1.47
Sigma = .695
TS = 3.09
TS
99.%
0.1
1
10
50
90
99
99.9
Cumulative Probability (%)
C:\CUMPLOT\17A22.CMP
03-14-00

APPENDIX B

SOIL SAMPLING RESULTS

Figure B1: Soil Sample for Cesium-137

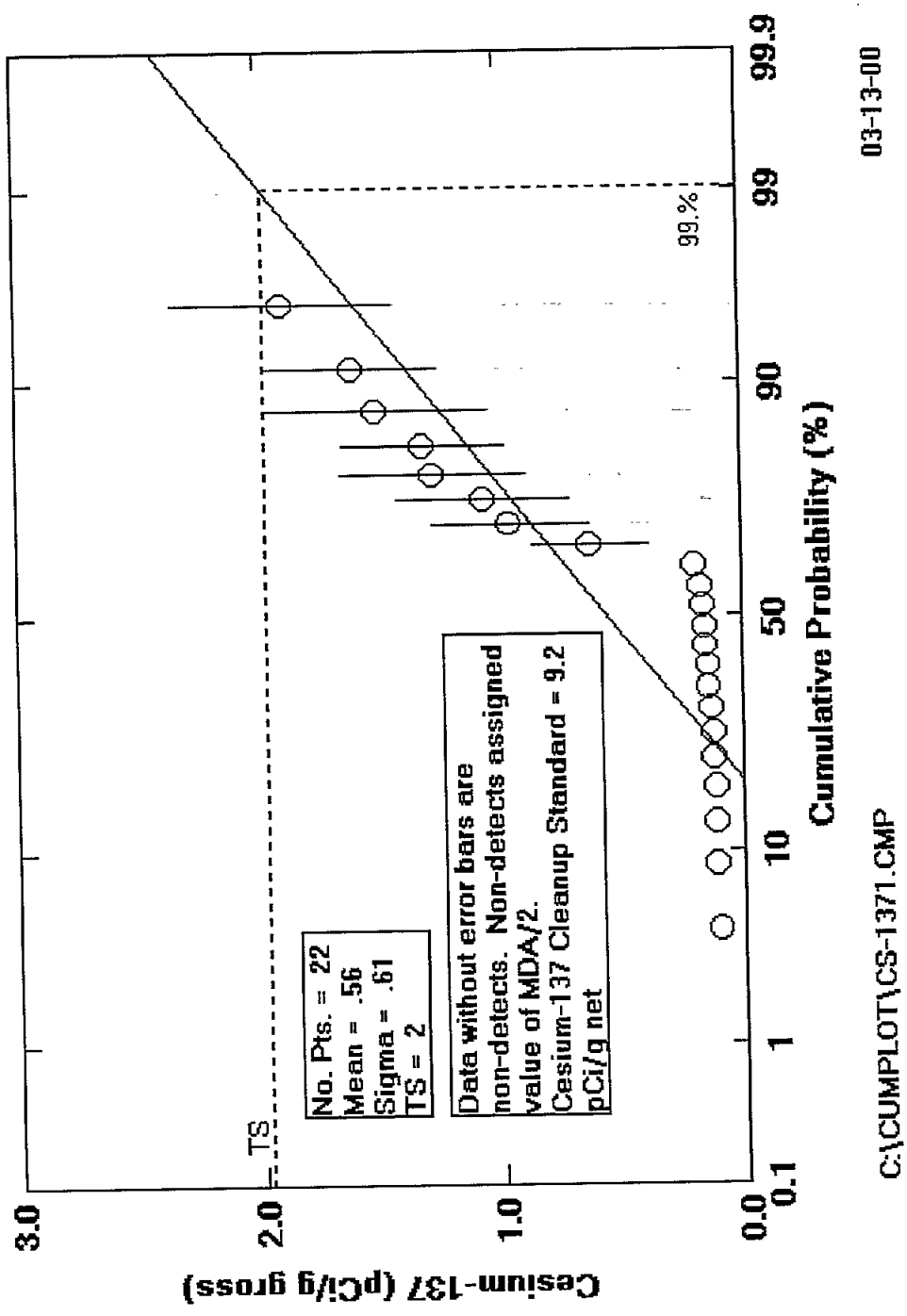


Table B1: Soil Samples for Cesium-137 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	0.15		ND	0.3
17S-99-0002	0.16		ND	0.31
17S-99-0003	0.13		ND	0.25
17S-99-0004	0.11		ND	0.22
17S-99-0005	0.96	0.33	-	0.32
17S-99-0006	0.17		ND	0.34
17S-99-0007	0.14		ND	0.28
17S-99-0008	0.13		ND	0.25
17S-99-0009	0.12		ND	0.23
17S-99-0010	0.18		ND	0.36
17S-99-0011	0.12		ND	0.24
17S-99-0012	0.12		ND	0.24
17S-99-0013	1.90	0.46	-	0.34
17S-99-0014	1.51	0.46	-	0.3
17S-99-0015	1.61	0.36	-	0.36
17S-99-0016	1.07	0.36	-	0.31
17S-99-0017	0.20		ND	0.39
17S-99-0018	0.15		ND	0.3
17S-99-0019	0.63	0.24	-	0.2
17S-99-0020	1.32	0.34	-	0.18
17S-99-0021	1.28	0.39	-	0.29
17S-99-0022	0.16		ND	0.32

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 9.2 pCi/gm net
ND = Non-detect. Gamma spec. results reported as <MDA. For the purposes of statistical analysis, non-detects are quantified as MDA/2.

FIGURE B1.1: CS-137 RE-ANALYSIS

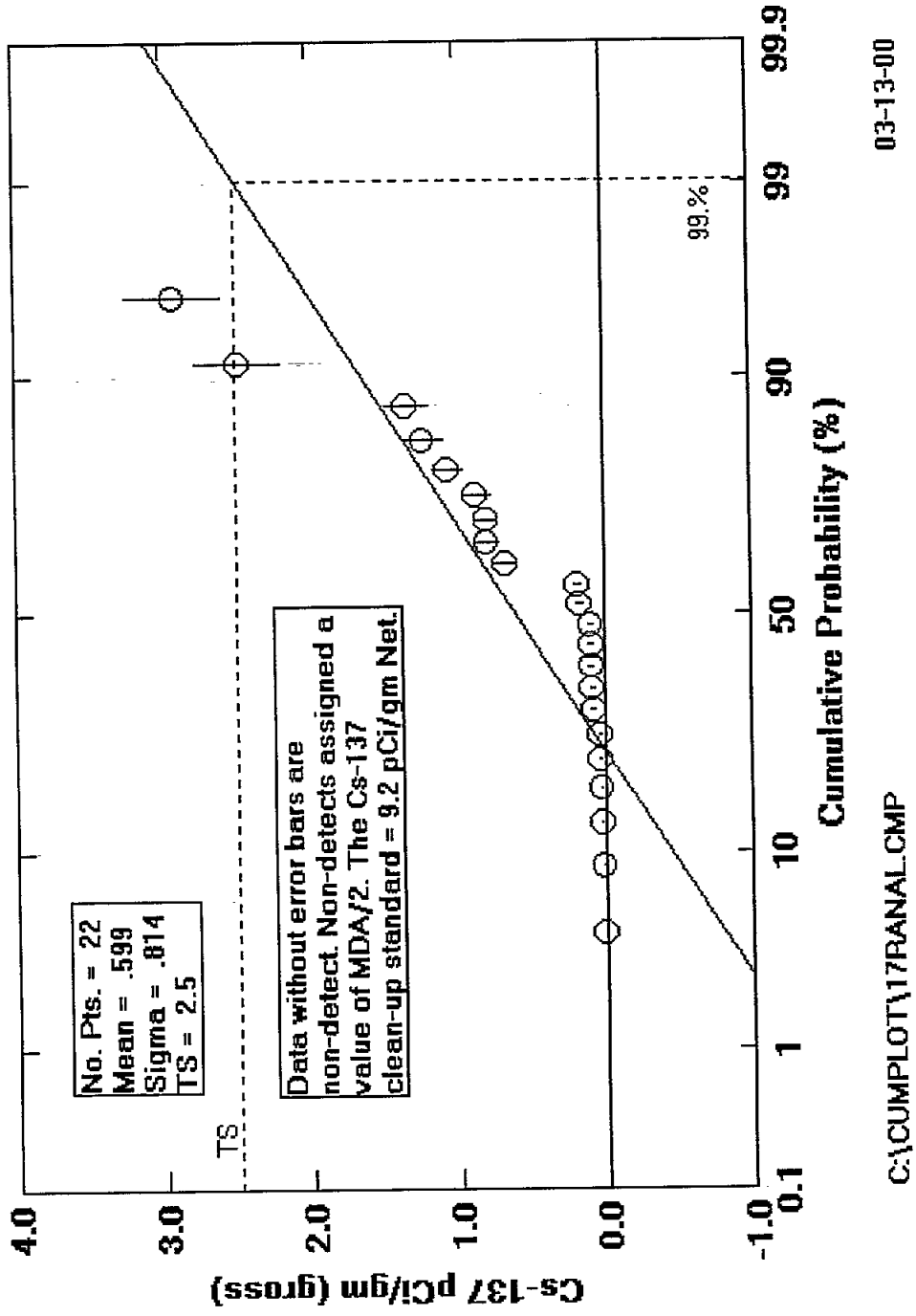


Table B1.1 Cesium-137 (pCi/g) Re-analysis

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	0.087	0.017		0.014
17S-99-0002	0.097	0.02		0.015
17S-99-0003	0.083	0.017		0.014
17S-99-0004	0.038	0.01		0.012
17S-99-0005	0.800	0.09		0.016
17S-99-0006	0.170	0.03		0.015
17S-99-0007	0.095	0.018		0.015
17S-99-0008	0.018	0.01		0.013
17S-99-0009	0.008		ND	0.015
17S-99-0010	0.100	0.02		0.014
17S-99-0011	0.042	0.012		0.013
17S-99-0012	0.870	0.1		0.014
17S-99-0013	2.930	0.33		0.022
17S-99-0014	2.490	0.3		0.015
17S-99-0015	1.340	0.15		0.015
17S-99-0016	0.800	0.08		0.018
17S-99-0017	0.190	0.03		0.015
17S-99-0018	0.032	0.013		0.015
17S-99-0019	0.670	0.08		0.015
17S-99-0020	1.060	0.11		0.022
17S-99-0021	1.230	0.14		0.018
17S-99-0022	0.030	0.01		0.012

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 9.2 pCi/gm net
ND = Non-detect. Gamma spec. results reported as <MDA. For the purposes of statistical analysis, non-detects are quantified as MDA/2

FIGURE B2: 17th St Soil Samples for Th-228

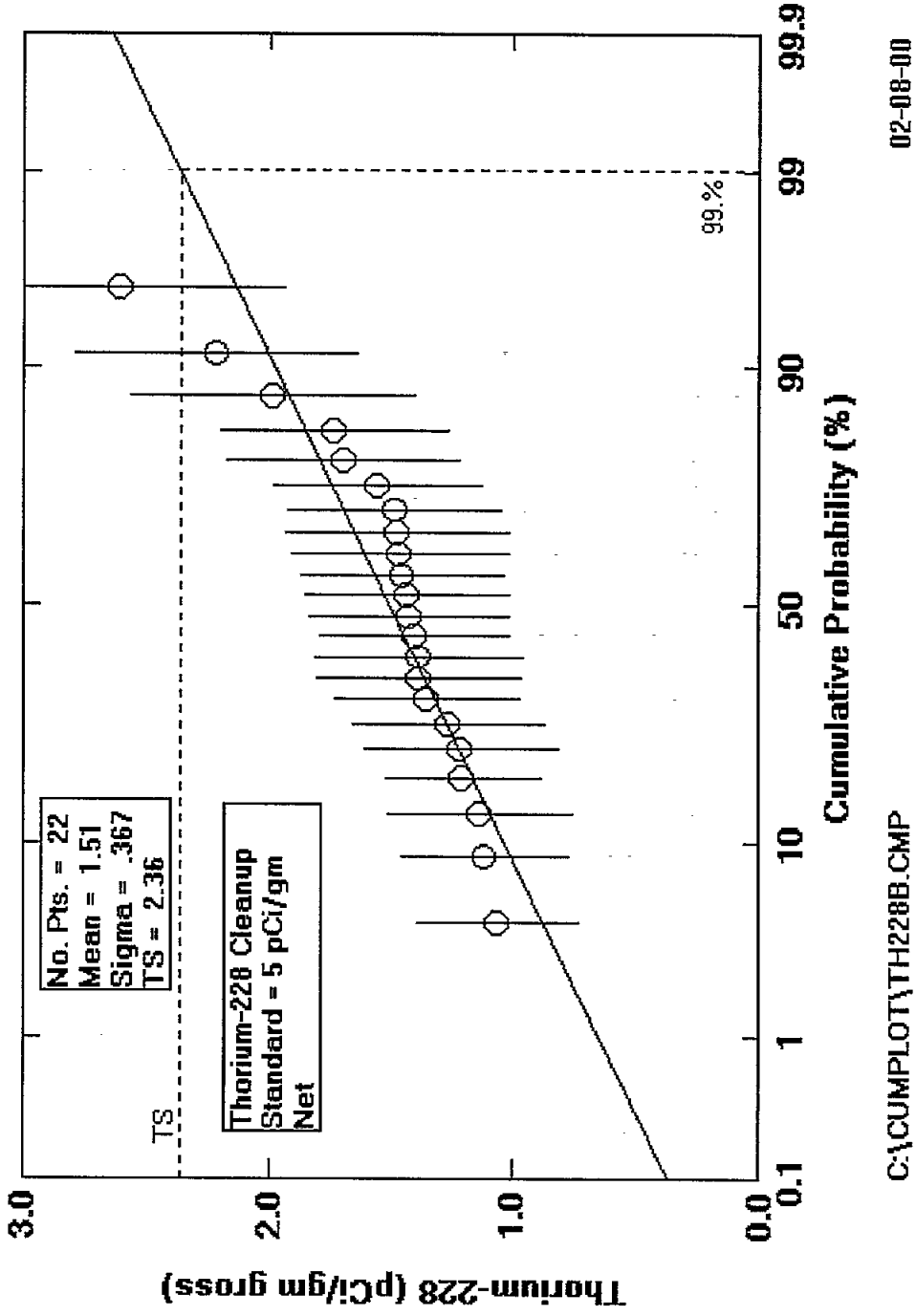


Table B2: Soil Samples for Thorium-228 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	1.47	0.45	-	0.081
17S-99-0002	1.21	0.32	-	0.079
17S-99-0003	1.36	0.38	-	0.070
17S-99-0004	1.70	0.48	-	0.100
17S-99-0005	1.74	0.47	-	0.059
17S-99-0006	1.22	0.40	-	0.140
17S-99-0007	1.27	0.40	-	0.120
17S-99-0008	1.39	0.42	-	0.110
17S-99-0009	1.39	0.43	-	0.130
17S-99-0010	1.44	0.42	-	0.100
17S-99-0011	1.12	0.34	-	0.110
17S-99-0012	1.49	0.44	-	0.100
17S-99-0013	1.48	0.46	-	0.120
17S-99-0014	1.41	0.39	-	0.089
17S-99-0015	2.22	0.58	-	0.100
17S-99-0016	1.99	0.58	-	0.140
17S-99-0017	1.14	0.38	-	0.120
17S-99-0018	1.07	0.33	-	0.086
17S-99-0019	1.43	0.41	-	0.092
17S-99-0020	1.56	0.43	-	0.070
17S-99-0021	2.61	0.67	-	0.100
17S-99-0022	1.46	0.42	-	0.120

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 5 pCi/gm net
ND = If result is less than MDA then result is non-detect.

FIGURE B3: 17th St Soil Samples for Th-230

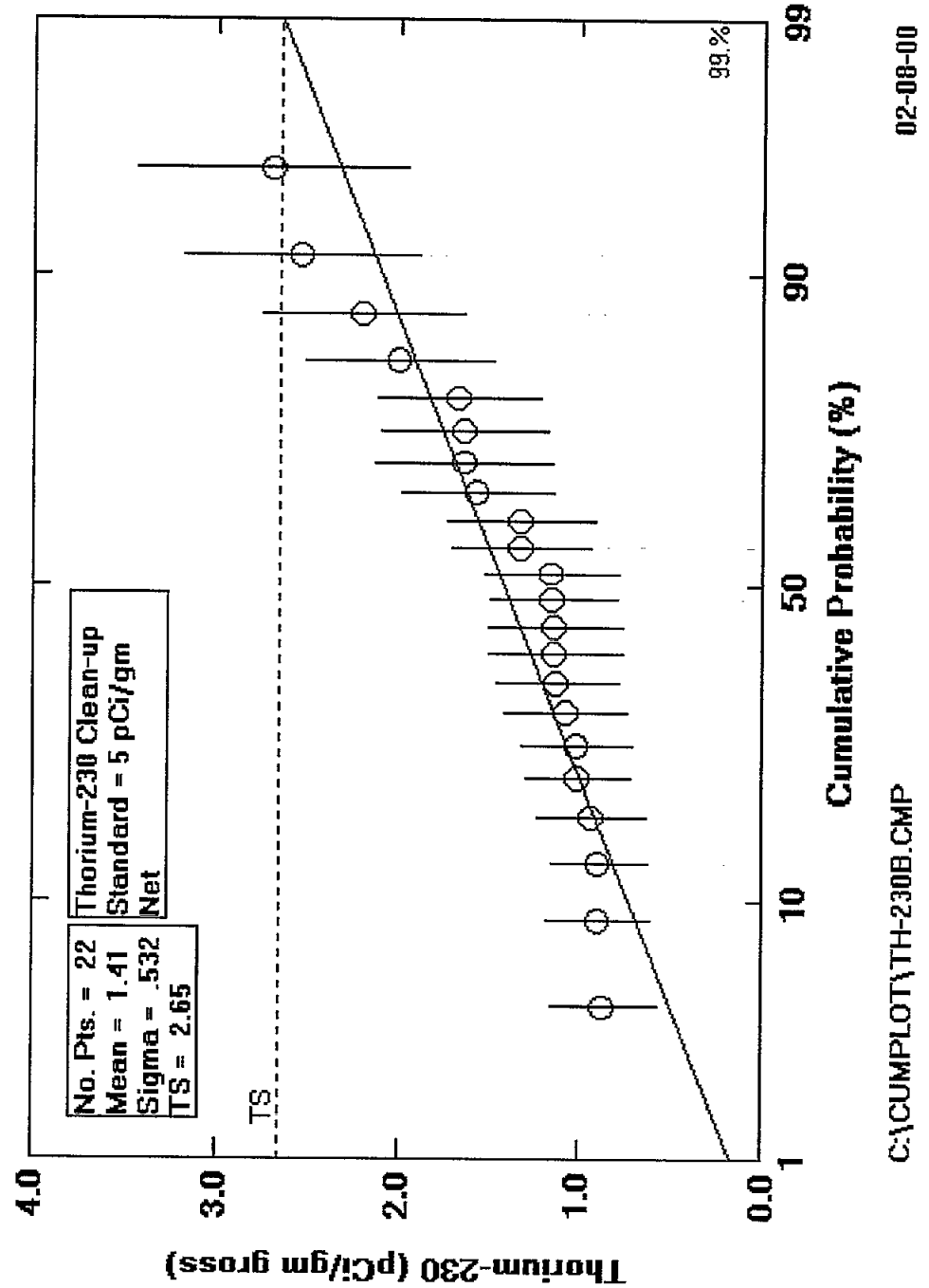


Table B3: Soil Samples for Thorium-230 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non- Detect ?	MDA
17S-99-0001	1.14	0.37	-	0.091
17S-99-0002	1.01	0.29	-	0.026
17S-99-0003	0.90	0.27	-	0.045
17S-99-0004	1.33	0.39	-	0.063
17S-99-0005	1.57	0.43	-	0.066
17S-99-0006	0.87	0.30	-	0.090
17S-99-0007	1.33	0.41	-	0.094
17S-99-0008	1.15	0.35	-	0.034
17S-99-0009	1.16	0.37	-	0.077
17S-99-0010	0.94	0.30	-	0.054
17S-99-0011	1.13	0.34	-	0.064
17S-99-0012	1.08	0.34	-	0.100
17S-99-0013	2.70	0.75	-	0.095
17S-99-0014	2.20	0.56	-	0.045
17S-99-0015	2.00	0.52	-	0.080
17S-99-0016	1.64	0.49	-	0.068
17S-99-0017	1.14	0.37	-	0.094
17S-99-0018	0.90	0.29	-	0.096
17S-99-0019	1.02	0.31	-	0.03
17S-99-0020	1.67	0.45	-	0.049
17S-99-0021	2.54	0.65	-	0.059
17S-99-0022	1.64	0.46	-	0.11

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 5 pCi/gm net
ND = If result is less than MDA then result is non-detect.

FIGURE B4: 17th St Soil Samples for Th-232

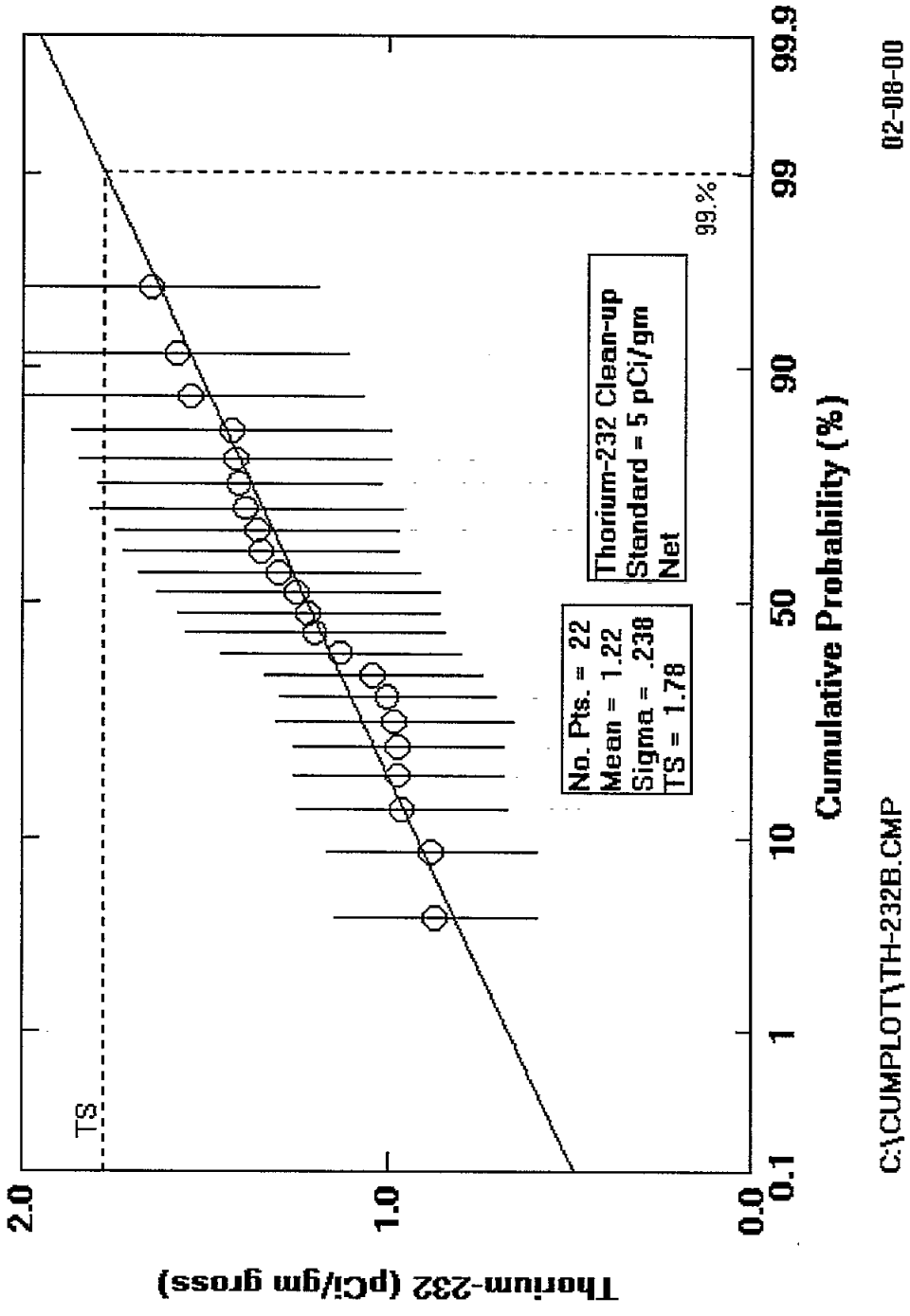


Table B4: Soil Samples for Thorium-232 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	1.39	0.43	-	0.099
17S-99-0002	0.97	0.29	-	0.046
17S-99-0003	1.41	0.39	-	0.053
17S-99-0004	1.65	0.46	-	0.053
17S-99-0005	1.13	0.33	-	0.072
17S-99-0006	0.98	0.33	-	0.068
17S-99-0007	1.42	0.43	-	0.037
17S-99-0008	0.88	0.29	-	0.034
17S-99-0009	1.25	0.39	-	0.076
17S-99-0010	1.36	0.39	-	0.064
17S-99-0011	1.20	0.36	-	0.030
17S-99-0012	1.30	0.39	-	0.058
17S-99-0013	1.54	0.47	-	0.041
17S-99-0014	1.04	0.30	-	0.064
17S-99-0015	1.35	0.38	-	0.062
17S-99-0016	1.58	0.47	-	0.110
17S-99-0017	1.43	0.44	-	0.040
17S-99-0018	0.87	0.28	-	0.091
17S-99-0019	1.00	0.30	-	0.053
17S-99-0020	0.96	0.29	-	0.057
17S-99-0021	0.97	0.29	-	0.071
17S-99-0022	1.22	0.36	-	0.092

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 5 pCi/gm
ND = If result is less than MDA then result is non-detect.

FIGURE B5: 17th St Soil Samples for U-234

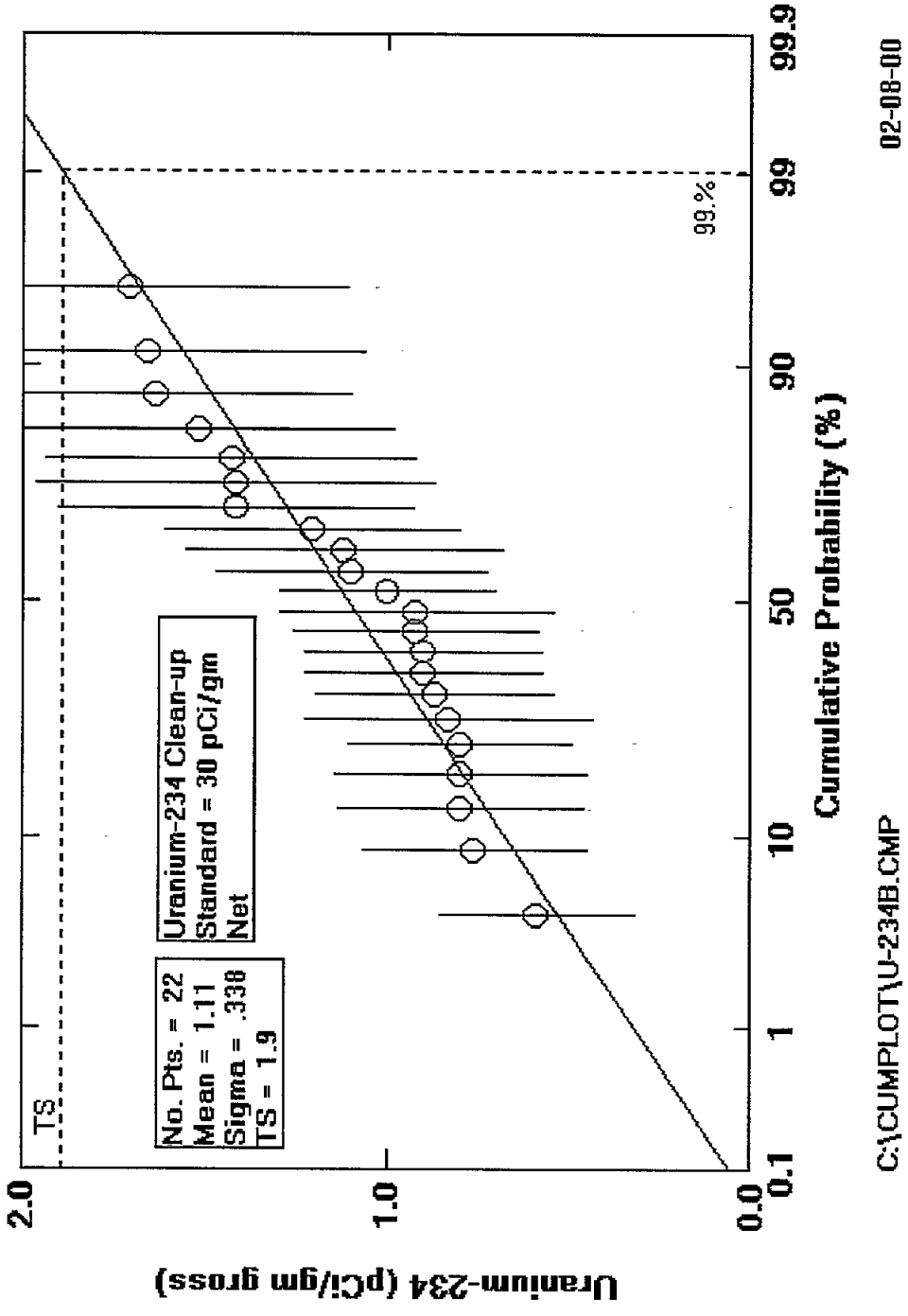


Table B5: Soil Samples for Uranium-234 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	1.10	0.38	-	0.078
17S-99-0002	1.66	0.60	-	0.160
17S-99-0003	0.80	0.34	-	0.140
17S-99-0004	0.90	0.33	-	0.110
17S-99-0005	1.64	0.54	-	0.059
17S-99-0006	0.76	0.31	-	0.100
17S-99-0007	1.12	0.44	-	0.070
17S-99-0008	0.59	0.27	-	0.061
17S-99-0009	0.87	0.33	-	0.097
17S-99-0010	0.92	0.38	-	0.180
17S-99-0011	0.83	0.40	-	0.093
17S-99-0012	1.42	0.55	-	0.180
17S-99-0013	1.52	0.54	-	0.140
17S-99-0014	1.43	0.51	-	0.130
17S-99-0015	1.71	0.60	-	0.110
17S-99-0016	1.42	0.49	-	0.110
17S-99-0017	0.92	0.34	-	0.055
17S-99-0018	1.00	0.30	-	0.030
17S-99-0019	1.21	0.41	-	0.097
17S-99-0020	0.80	0.31	-	0.054
17S-99-0021	0.80	0.35	-	0.190
17S-99-0022	0.90	0.33	-	0.052

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 30 pCi/gm net
ND = If result is less than MDA then result is non-detect.

FIGURE B6: 17th St Soil Samples for U-235/236

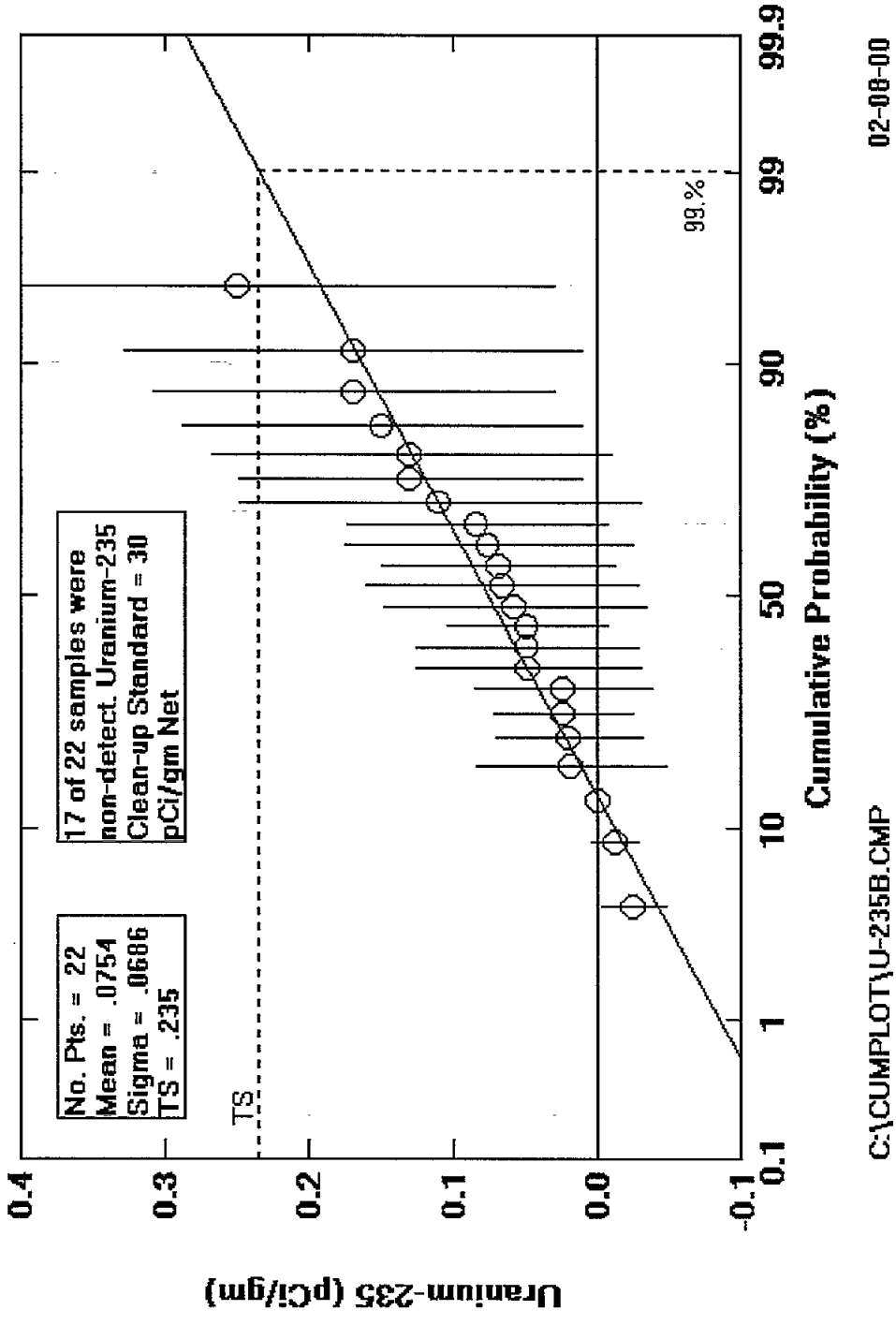


Table B6: Soil Samples for Uranium-235/236 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	0.069	0.082	-	0.063
17S-99-0002	0.170	0.160	-	0.095
17S-99-0003	0.024	0.062	ND	0.140
17S-99-0004	0.084	0.091	ND	0.110
17S-99-0005	0.150	0.140	ND	0.150
17S-99-0006	0.048	0.078	ND	0.130
17S-99-0007	0.058	0.092	ND	0.150
17S-99-0008	0.170	0.140	-	0.075
17S-99-0009	0.020	0.051	ND	0.120
17S-99-0010	-0.012	0.017	ND	0.170
17S-99-0011	0.250	0.220	-	0.110
17S-99-0012	0.110	0.140	ND	0.180
17S-99-0013	0.130	0.140	ND	0.190
17S-99-0014	0.076	0.100	ND	0.140
17S-99-0015	0.066	0.095	ND	0.090
17S-99-0016	0.049	0.078	ND	0.110
17S-99-0017	-0.025	0.023	ND	0.150
17S-99-0018	0.049	0.056	ND	0.065
17S-99-0019	0.130	0.120	-	0.095
17S-99-0020	0.000	0.000	ND	0.067
17S-99-0021	0.019	0.066	ND	0.180
17S-99-0022	0.024	0.048	ND	0.064

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 30 pCi/gm net
ND = If result is less than MDA then result is non-detect.

FIGURE B7: 17th St Soil Samples for U-238

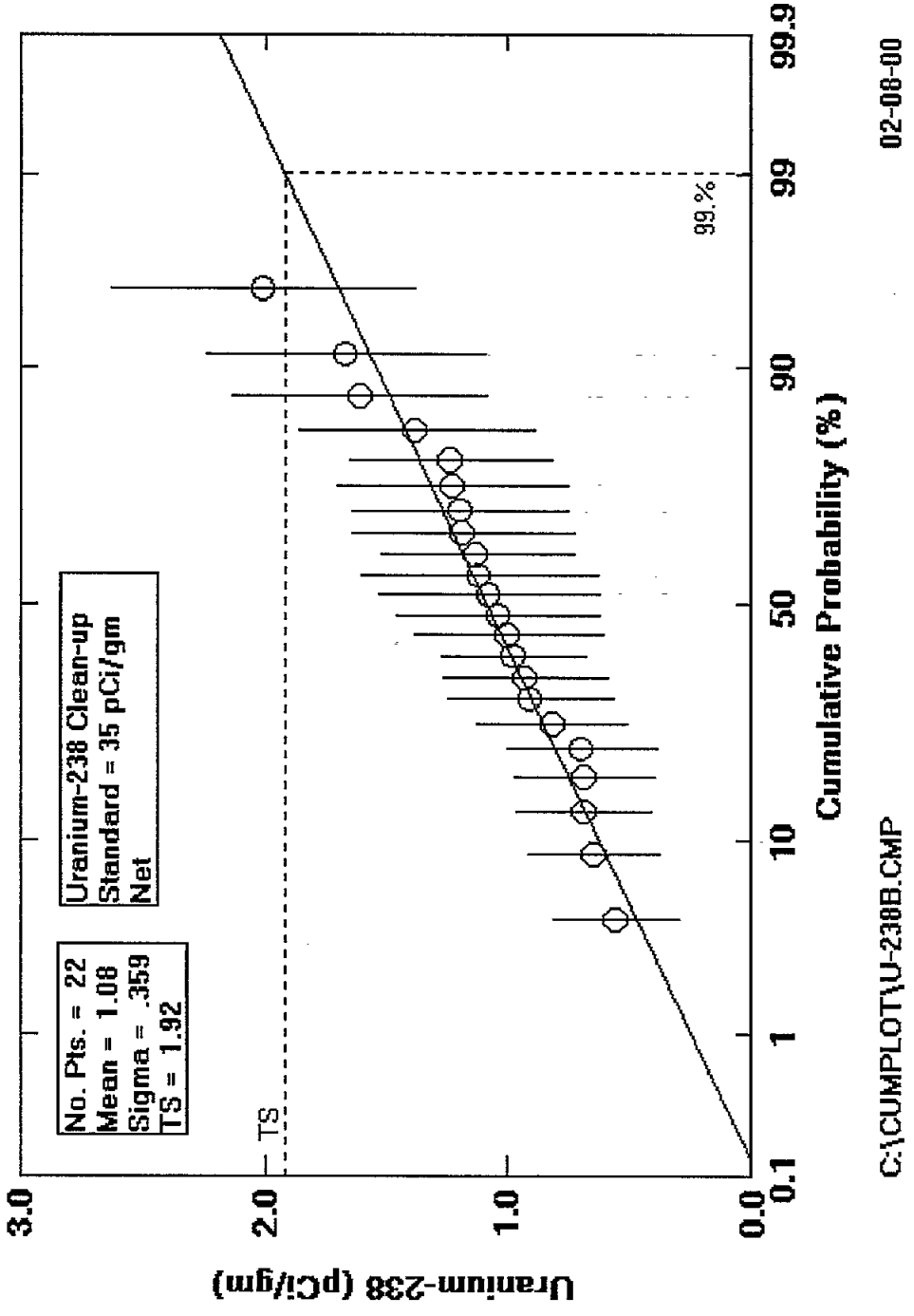


Table B7: Soil Samples for Uranium-238 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	0.930	0.340	-	0.050
17S-99-0002	1.230	0.480	-	0.160
17S-99-0003	0.700	0.310	-	0.120
17S-99-0004	0.820	0.310	-	0.086
17S-99-0005	2.010	0.630	-	0.059
17S-99-0006	0.690	0.290	-	0.100
17S-99-0007	1.190	0.460	-	0.070
17S-99-0008	0.560	0.260	-	0.061
17S-99-0009	0.650	0.270	-	0.055
17S-99-0010	1.000	0.390	-	0.150
17S-99-0011	1.120	0.490	-	0.160
17S-99-0012	1.080	0.460	-	0.150
17S-99-0013	1.200	0.450	-	0.120
17S-99-0014	1.380	0.490	-	0.110
17S-99-0015	1.040	0.420	-	0.072
17S-99-0016	1.610	0.530	-	0.100
17S-99-0017	0.690	0.280	-	0.055
17S-99-0018	0.980	0.300	-	0.030
17S-99-0019	1.240	0.420	-	0.077
17S-99-0020	1.130	0.400	-	0.096
17S-99-0021	1.670	0.580	-	0.160
17S-99-0022	0.910	0.340	-	0.091

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 35 pCi/gm net
ND = If result is less than MDA then result is non-detect.

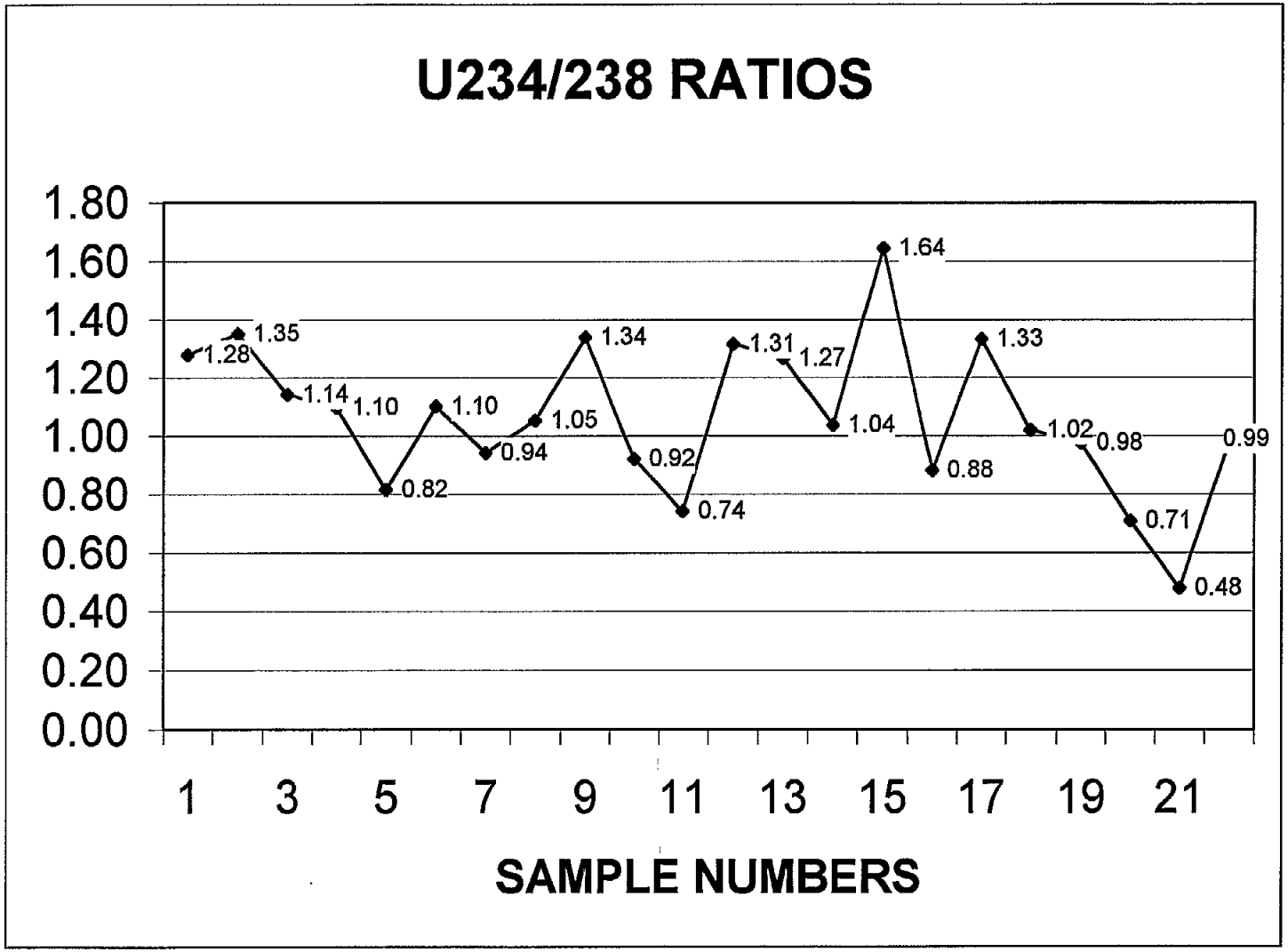


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TABLE B7.1: U234/238 RATIOS

Soil I.D.	U-234 RESULTS	U-238 RESULTS	Ratio U-234/238
17S-99-0001	0.87	0.68	1.28
17S-99-0002	1.66	1.23	1.35
17S-99-0003	0.80	0.70	1.14
17S-99-0004	0.90	0.82	1.10
17S-99-0005	1.64	2.01	0.82
17S-99-0006	0.76	0.69	1.10
17S-99-0007	1.12	1.19	0.94
17S-99-0008	0.59	0.56	1.05
17S-99-0009	0.87	0.65	1.34
17S-99-0010	0.92	1.00	0.92
17S-99-0011	0.83	1.12	0.74
17S-99-0012	1.42	1.08	1.31
17S-99-0013	1.52	1.20	1.27
17S-99-0014	1.43	1.38	1.04
17S-99-0015	1.71	1.04	1.64
17S-99-0016	1.42	1.61	0.88
17S-99-0017	0.92	0.69	1.33
17S-99-0018	1.00	0.98	1.02
17S-99-0019	1.21	1.24	0.98
17S-99-0020	0.80	1.13	0.71
17S-99-0021	0.80	1.67	0.48
17S-99-0022	0.90	0.91	0.99
AVERAGE	1.1	1.1	1.1
MAXIMUM	1.7	2.0	1.6
MINIMUM	0.6	0.6	0.5

FIGURE B8: 17th St Soil Samples for Pu-238

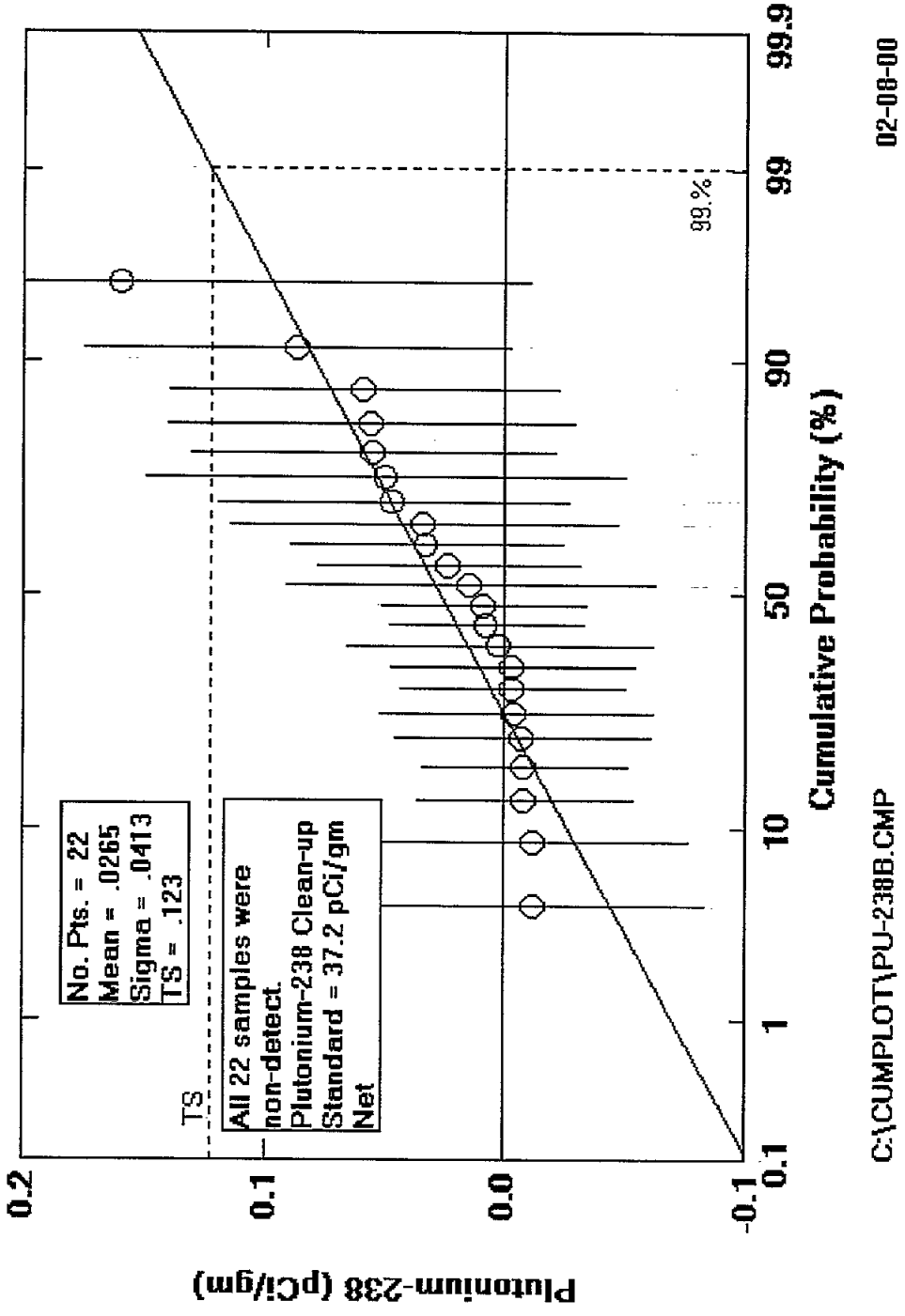


Table B8: Soil Samples for Pu-238 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	0.050	0.100	ND	0.220
17S-99-0002	-0.012	0.064	ND	0.210
17S-99-0003	0.009	0.043	ND	0.120
17S-99-0004	-0.012	0.070	ND	0.250
17S-99-0005	0.034	0.081	ND	0.180
17S-99-0006	0.008	0.041	ND	0.110
17S-99-0007	0.033	0.057	ND	0.120
17S-99-0008	0.047	0.073	ND	0.150
17S-99-0009	-0.004	0.057	ND	0.170
17S-99-0010	0.059	0.081	ND	0.130
17S-99-0011	-0.003	0.047	ND	0.200
17S-99-0012	-0.007	0.053	ND	0.170
17S-99-0013	-0.008	0.043	ND	0.160
17S-99-0014	-0.003	0.051	ND	0.120
17S-99-0015	0.056	0.085	ND	0.170
17S-99-0016	0.024	0.055	ND	0.120
17S-99-0017	0.015	0.077	ND	0.210
17S-99-0018	0.160	0.170	ND	0.290
17S-99-0019	-0.008	0.045	ND	0.160
17S-99-0020	0.087	0.089	ND	0.140
17S-99-0021	0.055	0.076	ND	0.120
17S-99-0022	0.003	0.064	ND	0.180

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 37.2 pCi/gm net
ND = If result is less than MDA then result is non-detect.

FIGURE B9: 17th St Soil Samples for Pu-239/240

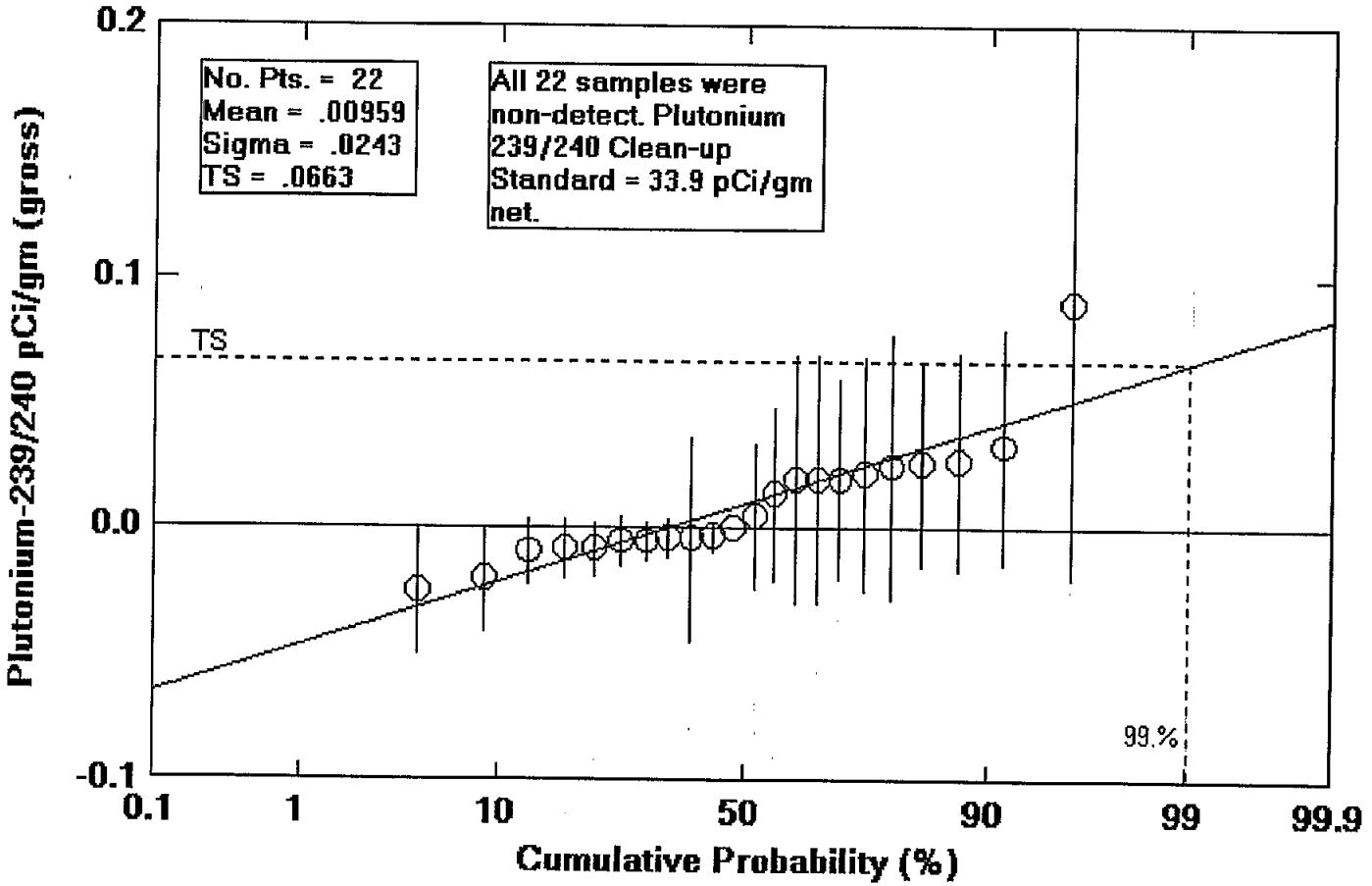


Table B9: Plutonium-239/240 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	-0.005	0.010	ND	0.120
17S-99-0002	0.020	0.040	ND	0.054
17S-99-0003	0.026	0.041	ND	0.069
17S-99-0004	-0.025	0.025	ND	0.210
17S-99-0005	0.020	0.050	ND	0.120
17S-99-0006	-0.005	0.008	ND	0.077
17S-99-0007	0.005	0.029	ND	0.086
17S-99-0008	-0.003	0.006	ND	0.075
17S-99-0009	0.025	0.053	ND	0.110
17S-99-0010	-0.009	0.013	ND	0.130
17S-99-0011	-0.004	0.008	ND	0.090
17S-99-0012	0.020	0.050	ND	0.120
17S-99-0013	-0.004	0.041	ND	0.130
17S-99-0014	0.000	0.000	ND	0.044
17S-99-0015	0.033	0.047	ND	0.045
17S-99-0016	0.027	0.044	ND	0.073
17S-99-0017	-0.020	0.021	ND	0.170
17S-99-0018	0.090	0.110	ND	0.180
17S-99-0019	-0.008	0.011	ND	0.110
17S-99-0020	0.022	0.047	ND	0.100
17S-99-0021	-0.008	0.012	ND	0.120
17S-99-0022	0.014	0.035	ND	0.082

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 33.9 pCi/gm net
ND = If result is less than MDA then result is non-detect.

FIGURE B10: 17th St Soil Samples for Am-241

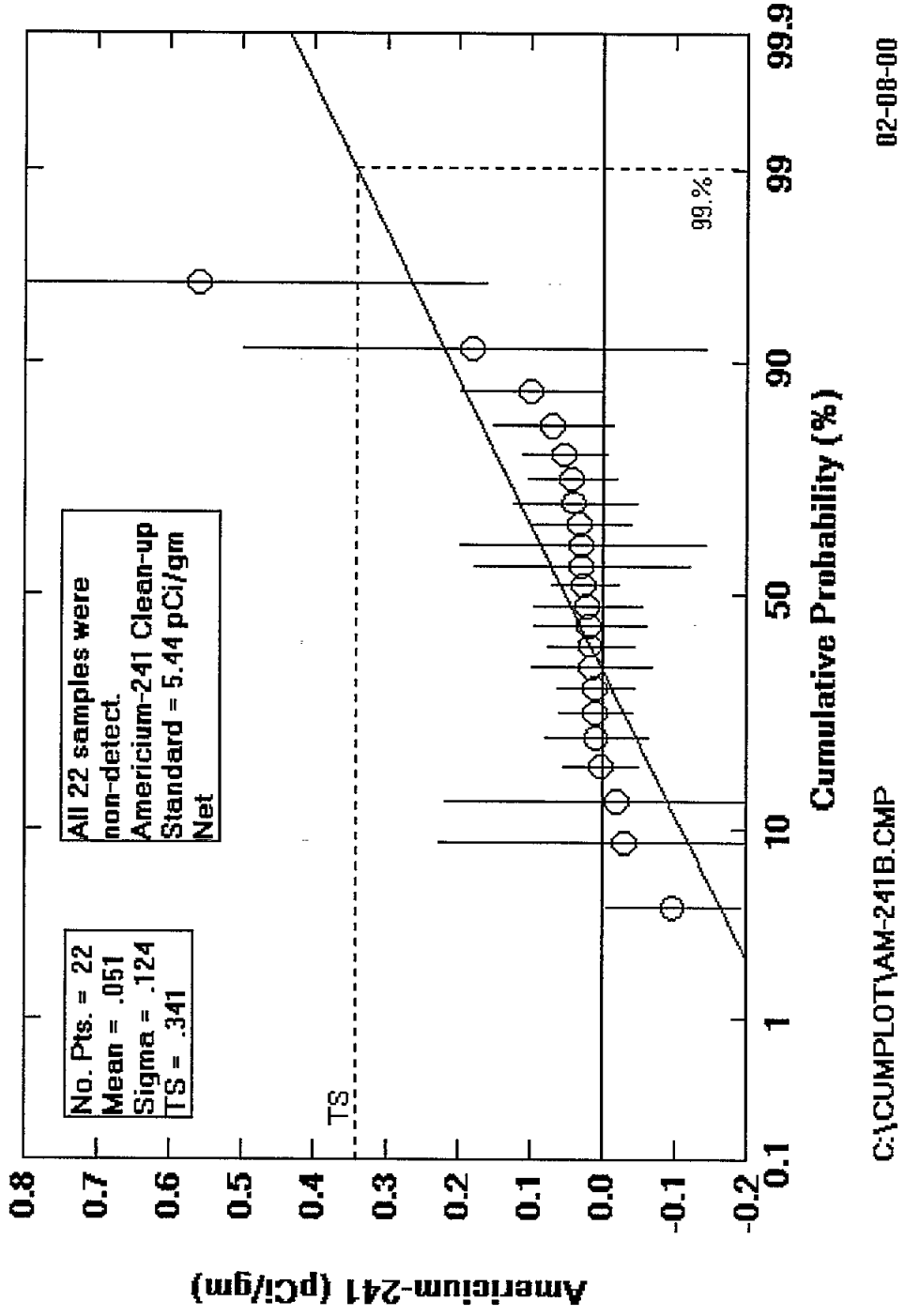


Table B10: Soil Samples for Americium-241 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	-0.020	0.240	ND	0.670
17S-99-0002	0.100	0.100	ND	0.120
17S-99-0003	0.040	0.085	ND	0.150
17S-99-0004	0.069	0.084	ND	0.110
17S-99-0005	0.010	0.052	ND	0.110
17S-99-0006	0.053	0.060	ND	0.070
17S-99-0007	0.016	0.084	ND	0.170
17S-99-0008	0.031	0.070	ND	0.130
17S-99-0009	0.042	0.062	ND	0.091
17S-99-0010	0.018	0.079	ND	0.150
17S-99-0011	0.003	0.052	ND	0.150
17S-99-0012	0.022	0.075	ND	0.180
17S-99-0013	0.011	0.054	ND	0.150
17S-99-0014	0.560	0.400	ND	1.120
17S-99-0015	0.180	0.320	ND	0.640
17S-99-0016	-0.030	0.260	ND	0.810
17S-99-0017	-0.096	0.092	ND	0.710
17S-99-0018	0.030	0.150	ND	0.420
17S-99-0019	0.030	0.170	ND	0.510
17S-99-0020	0.026	0.047	ND	0.092
17S-99-0021	0.017	0.060	ND	0.110
17S-99-0022	0.009	0.072	ND	0.160

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 5.44 pCi/gm net
ND = If result is less than MDA then result is non-detect.

FIGURE B11: 17th St Soil Samples for Sr-90

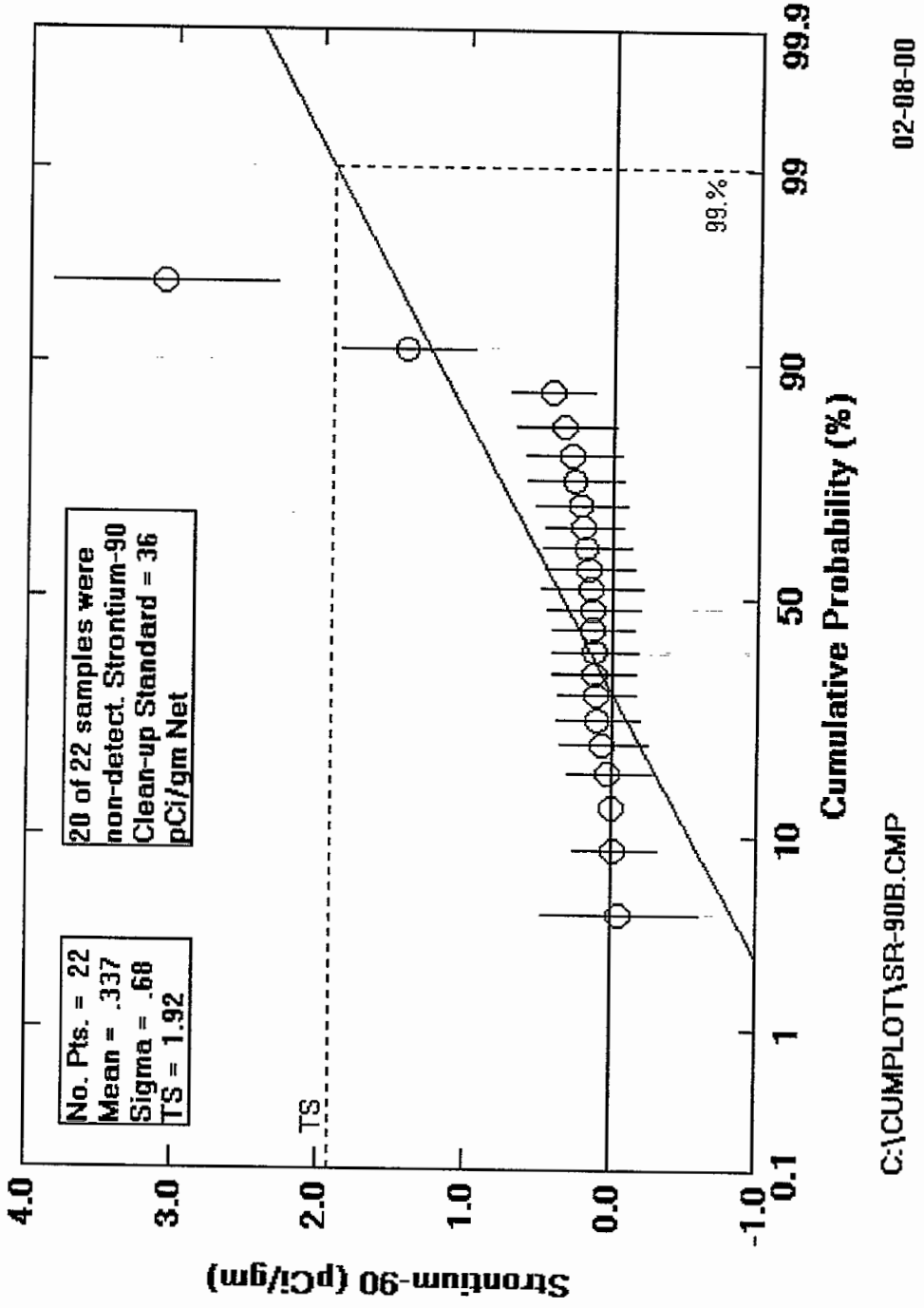


Table B11: Soil Samples for Strontium-90 (pCi/g)

Soil ID	Result	+/- 1 sigma error	Non-Detect ?	MDA
17S-99-0001	-0.060	0.540	ND	0.940
17S-99-0002	0.160	0.310	ND	0.520
17S-99-0003	0.220	0.320	ND	0.540
17S-99-0004	0.120	0.290	ND	0.490
17S-99-0005	0.100	0.290	ND	0.500
17S-99-0006	0.180	0.300	ND	0.510
17S-99-0007	3.080	0.770	-	0.670
17S-99-0008	0.330	0.340	ND	0.560
17S-99-0009	0.280	0.330	ND	0.550
17S-99-0010	0.130	0.320	ND	0.550
17S-99-0011	0.260	0.330	ND	0.550
17S-99-0012	0.120	0.300	ND	0.510
17S-99-0013	0.150	0.350	ND	0.600
17S-99-0014	0.000	0.000	ND	0.590
17S-99-0015	0.020	0.290	ND	0.510
17S-99-0016	0.200	0.270	ND	0.440
17S-99-0017	-0.020	0.290	ND	0.500
17S-99-0018	0.130	0.280	ND	0.470
17S-99-0019	0.060	0.300	ND	0.510
17S-99-0020	1.420	0.470	-	0.560
17S-99-0021	0.110	0.270	ND	0.460
17S-99-0022	0.420	0.290	ND	0.460

MDA = Minimum Detectable Activity
$DCGL_W$ = Derived Concentratration Guideline 36 pCi/gm net
ND = If result is less than MDA then result is non-detect.

APPENDIX C

WILCOXON RANK SUM TESTS

Table C1: 17th Street Soil Sampling
Wilcoxon Rank Sum Test

		Soil Concentrations (pCi/g)											Isotopic Fractions (concentration/DCGL)											Sum of Fractions	Adjusted Reference	Rank	Reference Area Rank
		Cs-137	Th-228	Th-230	Th-232	U-234	U-235	U-238	Pu-238	Pu-239	Am-241	Sr-90	Cs-137	Th-228	Th-230	Th-232	U-234	U-235	U-238	Pu-238	Pu-239	Am-241	Sr-90				
Sample Type	Sample ID	9.2	5	5	5	30	30	35	37.2	33.9	5.44	38															
S	17S-99-0001	0.150	1.47	1.14	1.39	1.10	0.069	0.93	0.05	-0.005	-0.02	-0.06	0.016	0.294	0.228	0.278	0.037	0.002	0.027	0.001	0.000	-0.004	-0.002	0.878	0.878	12	0
S	17S-99-0002	0.155	1.21	1.01	0.97	1.66	0.17	1.23	-0.012	0.02	0.1	0.16	0.017	0.242	0.202	0.194	0.055	0.006	0.035	0.000	0.001	0.018	0.004	0.774	0.774	4	0
S	17S-99-0003	0.125	1.36	0.90	1.41	0.80	0.024	0.7	0.009	0.026	0.04	0.22	0.014	0.272	0.180	0.282	0.027	0.001	0.020	0.000	0.001	0.007	0.006	0.810	0.810	7	0
S	17S-99-0004	0.110	1.70	1.33	1.65	0.90	0.084	0.62	-0.012	-0.025	0.069	0.12	0.012	0.340	0.266	0.330	0.030	0.003	0.023	0.000	-0.001	0.013	0.003	1.019	1.019	15	0
S	17S-99-0005	0.960	1.74	1.57	1.13	1.64	0.15	2.01	0.034	0.02	0.01	0.1	0.104	0.348	0.314	0.226	0.055	0.005	0.057	0.001	0.001	0.002	0.003	1.116	1.116	17	0
S	17S-99-0006	0.170	1.22	0.87	0.98	0.76	0.048	0.69	0.008	-0.005	0.053	0.18	0.018	0.244	0.174	0.196	0.025	0.002	0.020	0.000	0.000	0.010	0.005	0.694	0.694	2	0
S	17S-99-0007	0.140	1.27	1.33	1.42	1.12	0.058	1.19	0.033	0.005	0.016	3.08	0.015	0.254	0.266	0.284	0.037	0.002	0.034	0.001	0.000	0.003	0.086	0.982	0.982	14	0
S	17S-99-0008	0.125	1.39	1.15	0.88	0.59	0.17	0.56	0.047	-0.003	0.031	0.33	0.014	0.278	0.230	0.176	0.020	0.006	0.016	0.001	0.000	0.006	0.009	0.755	0.755	3	0
S	17S-99-0009	0.115	1.39	1.16	1.25	0.87	0.02	0.65	-0.004	0.025	0.042	0.28	0.013	0.278	0.232	0.250	0.029	0.001	0.019	0.000	0.001	0.008	0.008	0.837	0.837	9	0
S	17S-99-0010	0.180	1.44	0.94	1.36	0.92	-0.012	1	0.059	-0.009	0.018	0.13	0.020	0.288	0.188	0.272	0.031	0.000	0.029	0.002	0.000	0.003	0.004	0.835	0.835	8	0
S	17S-99-0011	0.120	1.12	1.13	1.20	0.83	0.25	1.12	-0.003	-0.004	0.003	0.26	0.013	0.224	0.226	0.240	0.028	0.008	0.032	0.000	0.000	0.001	0.007	0.779	0.779	5	0
S	17S-99-0012	0.120	1.49	1.08	1.30	1.42	0.11	1.08	-0.007	0.02	0.022	0.12	0.013	0.298	0.216	0.260	0.047	0.004	0.031	0.000	0.001	0.004	0.003	0.877	0.877	11	0
S	17S-99-0013	1.900	1.48	2.70	1.54	1.52	0.13	1.2	-0.008	-0.004	0.011	0.15	0.207	0.296	0.540	0.308	0.051	0.004	0.034	0.000	0.000	0.002	0.004	1.446	1.446	28	0
S	17S-99-0014	1.510	1.41	2.20	1.04	1.43	0.076	1.38	-0.003	0	0.56	0	0.164	0.282	0.440	0.208	0.048	0.003	0.039	0.000	0.000	0.103	0.000	1.287	1.287	19	0
S	17S-99-0015	1.610	2.22	2.00	1.35	1.71	0.066	1.04	0.056	0.033	0.18	0.02	0.175	0.444	0.400	0.270	0.057	0.002	0.030	0.002	0.001	0.033	0.001	1.414	1.414	25	0
S	17S-99-0016	1.070	1.99	1.64	1.58	1.42	0.049	1.61	0.024	0.027	-0.03	0.2	0.116	0.398	0.328	0.316	0.047	0.002	0.046	0.001	0.001	-0.006	0.006	1.255	1.255	18	0
S	17S-99-0017	0.195	1.14	1.14	1.43	0.92	-0.025	0.69	0.015	-0.02	-0.096	-0.02	0.021	0.228	0.228	0.286	0.031	-0.001	0.020	0.000	-0.001	-0.018	-0.001	0.794	0.794	6	0
S	17S-99-0018	0.150	1.07	0.90	0.87	1.00	0.049	0.98	0.16	0.09	0.03	0.13	0.016	0.214	0.180	0.174	0.033	0.002	0.028	0.004	0.003	0.006	0.004	0.663	0.663	1	0
S	17S-99-0019	0.630	1.43	1.02	1.00	1.21	0.13	1.24	-0.008	-0.008	0.03	0.06	0.068	0.286	0.204	0.200	0.040	0.004	0.035	0.000	0.000	0.006	0.002	0.845	0.845	10	0
S	17S-99-0020	1.320	1.56	1.67	0.96	0.80	0	1.13	0.087	0.022	0.026	1.42	0.143	0.312	0.334	0.192	0.027	0.000	0.032	0.002	0.001	0.005	0.039	1.088	1.088	16	0
S	17S-99-0021	1.280	2.61	2.54	0.97	0.80	0.019	1.67	0.055	-0.008	0.017	0.11	0.139	0.522	0.508	0.194	0.027	0.001	0.048	0.001	0.000	0.003	0.003	1.446	1.446	27	0
S	17S-99-0022	0.160	1.46	1.64	1.22	0.90	0.024	0.91	0.003	0.014	0.009	0.42	0.017	0.292	0.328	0.244	0.030	0.001	0.026	0.000	0.000	0.002	0.012	0.952	0.952	13	0
R	RH002	0.045	0.83	0.73	0.81	0.65	0.05	0.58	0	0	0	0.02	0.005	0.166	0.146	0.162	0.022	0.002	0.017	0.000	0.000	0.000	0.001	0.519	1.519	32	32
R	RH003	0.016	1.2	1.1	1.2	1	0.06	0.99	0	0	0	-0.01	0.002	0.240	0.220	0.240	0.033	0.002	0.028	0.000	0.000	0.000	0.000	0.765	1.765	43	43
R	RH004	0.01	0.67	0.47	0.67	1	0.05	0.94	0	0	0	-0.02	0.001	0.134	0.094	0.134	0.033	0.002	0.027	0.000	0.000	0.000	-0.001	0.424	1.424	26	26
R	RH005	0.009	1.1	1.4	0.89	0.41	0.03	0.48	0	0	0	0.01	0.001	0.220	0.280	0.178	0.014	0.001	0.013	0.000	0.000	0.000	0.000	0.707	1.707	42	42
R	RH006	0.150	1.1	0.97	0.96	1	0.067	0.98	0	0.01	0	0.03	0.016	0.220	0.194	0.192	0.033	0.002	0.028	0.000	0.000	0.000	0.001	0.687	1.687	41	41
R	RH007	0.089	1	0.92	1.1	1	0.07	1.1	0	0.01	0	-0.01	0.010	0.200	0.184	0.220	0.033	0.002	0.031	0.000	0.000	0.000	0.000	0.681	1.681	40	40
R	RH011	0.026	1	0.85	1	0.68	0.07	0.77	0	0	0	-0.09	0.003	0.200	0.170	0.200	0.029	0.002	0.022	0.000	0.000	0.000	-0.003	0.624	1.624	38	38
R	RH012	0.015	0.93	0.57	0.91	0.58	0.03	0.61	0.03	0	0	-0.06	0.002	0.186	0.114	0.182	0.019	0.001	0.017	0.001	0.000	0.000	-0.002	0.520	1.520	33	33
R	RH013	0.012	0.83	0.69	0.92	0.44	0.03	0.42	0.01	0	0	-0.08	0.001	0.168	0.138	0.184	0.015	0.001	0.012	0.000	0.000	0.000	-0.002	0.515	1.515	31	31
R	RH014	0.034	0.92	0.58	0.98	0.43	0.03	0.52	0	0	0	-0.03	0.004	0.184	0.116	0.196	0.014	0.001	0.015	0.000	0.000	0.000	-0.001	0.529	1.529	34	34
R	RH015	0.008	1	0.55	0.83	0.54	0.03	0.68	0	0	0	-0.04	0.001	0.200	0.110	0.166	0.018	0.001	0.019	0.000	0.000	0.000	-0.001	0.514	1.514	30	30
R	RH016	0.013	0.87	0.56	0.87	0.57	0.03	0.5	-0.01	0	0	-0.04	0.001	0.174	0.112	0.174	0.019	0.001	0.014	0.000	0.000	0.000	-0.001	0.494	1.494	29	29
R	RH021	0.008	0.88	0.83	1	0.57	0.03	0.55	0	0	0	-0.03	0.001	0.176	0.166	0.200	0.019	0.001	0.016	0.000	0.000	0.000	-0.001	0.576	1.576	36	36
R	RH025	0.007	0.7	0.59	0.54	0.49	0.03	0.51	0	0	0	0	0.001	0.140	0.118	0.108	0.016	0.001	0.015	0.000	0.000	0.000	0.000	0.399	1.399	24	24
R	RH026	0.007	0.87	0.7	0.98	0.79	0.06	0.88	0	0	0	-0.05	0.001	0.174	0.140	0.196	0.026	0.002	0.025	0.000	0.000	0.000	-0.001	0.563	1.563	35	35
R	RH030	0.014	1.2	0.71	1	0.73	0.04	0.68	0	0	0	-0.07	0.002	0.240	0.142	0.200	0.024	0.001	0.019	0.000	0.000	0.000	-0.002	0.627	1.627	39	39
R	RH031	0.013	1.3	1	1.5	0.72	0.05	0.67	0.01	0.01	0	-0.01	0.001	0.260	0.200	0.300	0.024	0.002	0.019	0.000	0.000	0.000	0.000	0.806	1.806	44	44
R	RH032	0.011	0.66	0.35	0.79	0.36	0.01	0.37	0.01	0.01	0	-0.09	0.001	0.132	0.070	0.158	0.012	0.000	0.011	0.000	0.000	0.000	-0.003	0.382	1.382	23	23
R	RH033	0.08	0.71	1.2	0.66	0.9	0.06	0.88	0	0	0	0.01	0.009	0.142	0.240	0.132	0.030	0.002	0.025	0.000	0.000	0.000	0.000	0.580	1.580	37	37
R	RH036	0.15	0.44	0.42	0.54	0.77	0.03	0.74	0.01	0	0	0.01	0.016	0.088	0.084	0.108	0.026	0.001	0.021	0.000	0.000	0.000	0.000	0.345	1.345	20	20
R	RH041	0.1	0.52	0.49	0.49	0.8	0.05	0.8	0	0	0	0.04	0.011	0.104	0.098	0.098	0.027	0.002	0.023	0.000	0.000	0.000	0.001	0.363	1.363	22	22
R	RH046	0.18	0.43	0.48	0.44	0.94	0.03	0.99	-0.01	0.02	0	0.04	0.020	0.086	0.096	0.088	0.031	0.001	0.028	0.000	0.001	0.000	0.001	0.352	1.352	21	21

Sum of Reference Ranks = WRS_R = **720**
Survey unit sample number = n= **22**
Reference area sample number = m= **22**
α = **0.05**
z = **1.645**
Critical Value = WRS_C = **565**

Table C2: 17th Street Soil Sampling
Wilcoxon Rank Sum Test With Re-analysis

		Soil Concentrations (pCi/g)											Isotopic Fractions (concentration/DCGL)											Sum of Fractions	Adjusted Reference	Rank	Reference Area Rank
		Cs-137	Th-228	Th-230	Th-232	U-234	U-235	U-238	Pu-238	Pu-239	Am-241	Sr-90	Cs-137	Th-228	Th-230	Th-232	U-234	U-235	U-238	Pu-238	Pu-239	Am-241	Sr-90				
Sample Type	Sample ID	9.2	5	5	5	30	30	35	37.2	33.9	5.44	35															
S	17S-99-0001	0.087	1.47	1.14	1.39	1.10	0.069	0.93	0.05	-0.005	-0.02	-0.06	0.009	0.294	0.228	0.278	0.037	0.002	0.027	0.001	0.000	-0.004	-0.002	0.871	0.871	11	0
S	17S-99-0002	0.097	1.21	1.01	0.97	1.66	0.17	1.23	-0.012	0.02	0.1	0.16	0.011	0.242	0.202	0.194	0.055	0.006	0.035	0.000	0.001	0.018	0.004	0.768	0.768	4	0
S	17S-99-0003	0.083	1.36	0.90	1.41	0.80	0.024	0.7	0.009	0.028	0.04	0.22	0.009	0.272	0.180	0.282	0.027	0.001	0.020	0.000	0.001	0.007	0.006	0.805	0.805	7	0
S	17S-99-0004	0.038	1.70	1.33	1.65	0.90	0.084	0.82	-0.012	-0.025	0.069	0.12	0.004	0.340	0.266	0.330	0.030	0.003	0.023	0.000	-0.001	0.013	0.003	1.011	1.011	15	0
S	17S-99-0005	0.800	1.74	1.57	1.13	1.64	0.15	2.01	0.034	0.02	0.01	0.1	0.087	0.348	0.314	0.226	0.055	0.005	0.057	0.001	0.001	0.002	0.003	1.098	1.098	17	0
S	17S-99-0006	0.170	1.22	0.87	0.98	0.76	0.048	0.69	0.008	-0.005	0.053	0.18	0.018	0.244	0.174	0.196	0.025	0.002	0.020	0.000	0.000	0.010	0.005	0.694	0.694	2	0
S	17S-99-0007	0.095	1.27	1.33	1.42	1.12	0.058	1.19	0.033	0.005	0.018	3.08	0.010	0.254	0.266	0.284	0.037	0.002	0.034	0.001	0.000	0.003	0.086	0.977	0.977	14	0
S	17S-99-0008	0.018	1.39	1.15	0.88	0.59	0.17	0.56	0.047	-0.003	0.031	0.33	0.002	0.278	0.230	0.176	0.020	0.006	0.018	0.001	0.000	0.006	0.009	0.743	0.743	3	0
S	17S-99-0009	0.008	1.39	1.16	1.25	0.87	0.02	0.65	-0.004	0.025	0.042	0.28	0.001	0.278	0.232	0.250	0.029	0.001	0.019	0.000	0.001	0.008	0.008	0.825	0.825	8	0
S	17S-99-0010	0.100	1.44	0.94	1.36	0.92	-0.012	1	0.059	-0.009	0.018	0.13	0.011	0.288	0.188	0.272	0.031	0.000	0.029	0.002	0.000	0.003	0.004	0.826	0.826	9	0
S	17S-99-0011	0.042	1.12	1.13	1.20	0.83	0.25	1.12	-0.003	-0.004	0.003	0.26	0.005	0.224	0.226	0.240	0.028	0.008	0.032	0.000	0.000	0.001	0.007	0.770	0.770	5	0
S	17S-99-0012	0.670	1.49	1.08	1.30	1.42	0.11	1.08	-0.007	0.02	0.022	0.12	0.095	0.298	0.216	0.260	0.047	0.004	0.031	0.000	0.001	0.004	0.003	0.958	0.958	13	0
S	17S-99-0013	2.930	1.48	2.70	1.54	1.52	0.13	1.2	-0.008	-0.004	0.011	0.15	0.318	0.296	0.540	0.308	0.051	0.004	0.034	0.000	0.000	0.002	0.004	1.558	1.558	34	0
S	17S-99-0014	2.490	1.41	2.20	1.04	1.43	0.076	1.38	-0.003	0	0.58	0	0.271	0.282	0.440	0.208	0.048	0.003	0.039	0.000	0.000	0.103	0.000	1.393	1.393	24	0
S	17S-99-0015	1.340	2.22	2.00	1.35	1.71	0.068	1.04	0.056	0.033	0.18	0.02	0.146	0.444	0.400	0.270	0.057	0.002	0.030	0.002	0.001	0.033	0.001	1.385	1.385	23	0
S	17S-99-0016	0.800	1.99	1.64	1.58	1.42	0.049	1.61	0.024	0.027	-0.03	0.2	0.087	0.398	0.328	0.316	0.047	0.002	0.046	0.001	0.001	-0.006	0.006	1.225	1.225	18	0
S	17S-99-0017	0.190	1.14	1.14	1.43	0.92	-0.025	0.69	0.015	-0.02	-0.096	-0.02	0.021	0.228	0.228	0.286	0.031	-0.001	0.020	0.000	-0.001	-0.018	-0.001	0.794	0.794	6	0
S	17S-99-0018	0.032	1.07	0.90	0.87	1.00	0.049	0.98	0.16	0.09	0.03	0.13	0.003	0.214	0.180	0.174	0.033	0.002	0.028	0.004	0.003	0.006	0.004	0.651	0.651	1	0
S	17S-99-0019	0.670	1.43	1.02	1.00	1.21	0.13	1.24	-0.008	-0.008	0.03	0.06	0.073	0.286	0.204	0.200	0.040	0.004	0.035	0.000	0.000	0.006	0.002	0.850	0.850	10	0
S	17S-99-0020	1.060	1.56	1.67	0.96	0.80	0	1.13	0.087	0.022	0.026	1.42	0.115	0.312	0.334	0.192	0.027	0.000	0.032	0.002	0.001	0.005	0.039	1.059	1.059	16	0
S	17S-99-0021	1.230	2.61	2.54	0.97	0.80	0.019	1.67	0.055	-0.008	0.017	0.11	0.134	0.522	0.508	0.194	0.027	0.001	0.048	0.001	0.000	0.003	0.003	1.440	1.440	27	0
S	17S-99-0022	0.030	1.46	1.64	1.22	0.90	0.024	0.91	0.003	0.014	0.009	0.42	0.003	0.292	0.328	0.244	0.030	0.001	0.026	0.000	0.000	0.002	0.012	0.938	0.938	12	0
R	RH002	0.045	0.83	0.73	0.81	0.65	0.05	0.58	0	0	0	0.02	0.005	0.166	0.146	0.162	0.022	0.002	0.017	0.000	0.000	0.000	0.001	0.519	1.519	31	31
R	RH003	0.016	1.2	1.1	1.2	1	0.06	0.99	0	0	0	-0.01	0.002	0.240	0.220	0.240	0.033	0.002	0.028	0.000	0.000	0.000	0.000	0.765	1.765	43	43
R	RH004	0.01	0.67	0.47	0.67	1	0.05	0.94	0	0	0	-0.02	0.001	0.134	0.094	0.134	0.033	0.002	0.027	0.000	0.000	0.000	-0.001	0.424	1.424	26	26
R	RH005	0.009	1.1	1.4	0.89	0.41	0.03	0.46	0	0	0	0.01	0.001	0.220	0.280	0.178	0.014	0.001	0.013	0.000	0.000	0.000	0.000	0.707	1.707	42	42
R	RH006	0.150	1.1	0.97	0.96	1	0.067	0.98	0	0.01	0	0.03	0.016	0.220	0.194	0.192	0.033	0.002	0.028	0.000	0.000	0.000	0.001	0.687	1.687	41	41
R	RH007	0.089	1	0.92	1.1	1	0.07	1.1	0	0.01	0	-0.01	0.010	0.200	0.184	0.220	0.033	0.002	0.031	0.000	0.000	0.000	0.000	0.681	1.681	40	40
R	RH011	0.026	1	0.85	1	0.88	0.07	0.77	0	0	0	-0.09	0.003	0.200	0.170	0.200	0.029	0.002	0.022	0.000	0.000	0.000	-0.003	0.624	1.624	38	38
R	RH012	0.015	0.93	0.57	0.91	0.58	0.03	0.61	0.03	0	0	-0.06	0.002	0.186	0.114	0.182	0.019	0.001	0.017	0.001	0.000	0.000	-0.002	0.520	1.520	32	32
R	RH013	0.012	0.83	0.69	0.92	0.44	0.03	0.42	0.01	0	0	-0.08	0.001	0.166	0.138	0.184	0.015	0.001	0.012	0.000	0.000	0.000	-0.002	0.515	1.515	30	30
R	RH014	0.034	0.92	0.58	0.96	0.43	0.03	0.52	0	0	0	-0.03	0.004	0.184	0.116	0.196	0.014	0.001	0.015	0.000	0.000	0.000	-0.001	0.529	1.529	33	33
R	RH015	0.008	1	0.55	0.83	0.54	0.03	0.68	0	0	0	-0.04	0.001	0.200	0.110	0.166	0.018	0.001	0.019	0.000	0.000	0.000	-0.001	0.514	1.514	29	29
R	RH016	0.013	0.87	0.56	0.87	0.57	0.03	0.5	-0.01	0	0	-0.04	0.001	0.174	0.112	0.174	0.019	0.001	0.014	0.000	0.000	0.000	-0.001	0.494	1.494	28	28
R	RH021	0.008	0.86	0.83	1	0.57	0.03	0.55	0	0	0	-0.03	0.001	0.176	0.166	0.200	0.019	0.001	0.016	0.000	0.000	0.000	-0.001	0.578	1.578	36	36
R	RH025	0.007	0.7	0.59	0.54	0.49	0.03	0.51	0	0	0	0	0.001	0.140	0.118	0.108	0.018	0.001	0.015	0.000	0.000	0.000	0.000	0.399	1.399	25	25
R	RH026	0.007	0.87	0.7	0.98	0.79	0.06	0.88	0	0	0	-0.05	0.001	0.174	0.140	0.196	0.026	0.002	0.025	0.000	0.000	0.000	-0.001	0.563	1.563	35	35
R	RH030	0.014	1.2	0.71	1	0.73	0.04	0.68	0	0	0	-0.07	0.002	0.240	0.142	0.200	0.024	0.001	0.019	0.000	0.000	0.000	-0.002	0.627	1.627	39	39
R	RH031	0.013	1.3	1	1.5	0.72	0.05	0.67	0.01	0.01	0	-0.01	0.001	0.260	0.200	0.300	0.024	0.002	0.019	0.000	0.000	0.000	0.000	0.806	1.806	44	44
R	RH032	0.011	0.66	0.35	0.79	0.36	0.01	0.37	0.01	0.01	0	-0.09	0.001	0.132	0.070	0.158	0.012	0.000	0.011	0.000	0.000	0.000	-0.003	0.382	1.382	22	22
R	RH033	0.08	0.71	1.2	0.66	0.9	0.06	0.86	0	0	0	0.01	0.009	0.142	0.240	0.132	0.030	0.002	0.025	0.000	0.000	0.000	0.000	0.580	1.580	37	37
R	RH036	0.15	0.44	0.42	0.54	0.77	0.03	0.74	0.01	0	0	0.01	0.016	0.088	0.084	0.108	0.026	0.001	0.021	0.000	0.000	0.000	0.000	0.345	1.345	19	19
R	RH041	0.1	0.52	0.49	0.49	0.8	0.05	0.8	0	0	0	0.04	0.011	0.104	0.098	0.098	0.027	0.002	0.023	0.000	0.000	0.000	0.001	0.363	1.363	21	21
R	RH046	0.18	0.43	0.48	0.44	0.94	0.03	0.99	-0.01	0.02	0	0.04	0.020	0.086	0.096	0.088	0.031	0.001	0.028	0.000	0.001	0.000	0.001	0.352	1.352	20	20

Sum of Reference Ranks = WRS_R = **711**
Survey unit sample number = n= **22**
Reference area sample number = m= **22**
α = **0.05**
z = **1.645**
Critical Value = WRS_C = **565**

APPENDIX D

1998 SOIL SAMPLE RESULTS

BOEING®

The Boeing Company
Rocketdyne Propulsion & Power

6633 Canoga Ave.
P.O. Box 7922
Canoga Park, CA 91309-7922

Date: December 21, 1998

No.: SHEA-016779

To: Philip Rutherford
D/641, 055, T487
(818)586-6140

From: John Shao
D/641, 055, T487
(818)586-8024

Subject: 17th Street Drainage Area - Radiation Characterization Surveys and Excavation

This report summarizes past and present soil sampling results, radiation characterization surveys, and soil excavation at the 17th Street Drainage Area.

1995 Soil Sampling and Radiation Survey Results

Soil samples from five locations were taken as part of the Area IV Characterization Survey (see Figure 1). The samples were sent to an outside laboratory for gamma spectroscopy, isotopic thorium, isotopic uranium, and strontium analyses. The analytical results indicated all five sampling locations were at background or slightly above background radiological activity (see Table 1), therefore, no remediation was deemed necessary at this time. Ambient gamma and walkabout surveys were conducted as shown in Figures B-89, B-97, and B-98 for grid blocks K19, L18, and L19 (from A4CM-ZR-0011). However, areas of dense inaccessible brush made a complete survey of the drainage area impossible.

1997 Soil Sampling Results

In 1997, seven locations were sampled and analyzed in-house for gamma spectroscopy during a subsequent radiation survey. The sampling results are shown in Table 1, and the locations are shown in Figure 1. Two of the samples (ENV-97-0035 & ENV-97-0036) contained Cs-137 levels above the release limit. However, as the 1998 characterization survey and soil sampling will show, all soil containing Cs-137 activity above the release limit was removed by the act of sampling in 1997. Three other samples (ENV-97-0049, ENV-97-0052, & ENV-97-0056) contained slightly above background Cs-137 and above background Th-232 daughters. These five sampling locations were included in the excavation that took place in 1998.

Radiation Characterization Survey (1998)

The area surveyed is outlined in Figure 2. Both walkabout and ambient gamma surveys were conducted in the area using two separate Ludlum 2221 1"x1" NaI detectors. The walkabout gamma survey was performed by swinging a NaI probe near the surface as the health physics technician walked the entire area. The 1-minute ambient gamma survey was measured at 1-meter height at 10-ft square grid spacing. Background measurements for both surveys were taken at Area IV's solar dish area.

A total of 66 hotspot locations were found during the walkabout survey (see Figure 2). A hotspot location is where the total gamma radiation is greater than 5 μR/hr over the background level. For this survey, a hotspot location was calculated to be ≥ 4100 counts per minute for the detector used.

The ambient gamma survey resulted in only one hotspot location (see Figure 3). This location (L19-20N-60E) was located next to hotspot #6 and was included in the excavation. The gross and net gamma survey data were also plotted using Cumplot Version 2.20[1] (see Figures 4 & 5). Two other locations (near hotspots #8 and #26) that exhibited net ambient gamma close to 5 μR/hr over the background were also excavated. In calculating the net gamma activity, daily background readings were subtracted from gross gamma activity.

Soil Sampling of Hotspots (1998)

A total of 13 representative surface walkabout hotspot locations were sampled and analyzed to characterize the hotspot areas (see Figure 2). Initially, samples from six hotspots were analyzed in-house using a Ge(Li) gamma spectrometer. Hotspot #7 was found to contain thorium and uranium daughters higher than background levels. In order to determine the actual thorium and uranium isotope concentrations, and to ascertain whether these isotopes were naturally occurring or not, samples from hotspot #7 and eight other hotspots were sent to Mountain States Analytical, Inc. for alpha isotopic analysis.

Table 2 summarizes the soil sampling results from in-house and outside laboratories. Hotspots #7, #13, #24, and #31 were found to contain above background Cs-137 levels as high as 2.11 pCi/g, but were below the release limit of 9.20 pCi/g. Hotspots #7 and #13 also contained high Th-228 concentrations at 6.24 and 4.01 pCi/g respectively (release limit is 5 pCi/g over background). To determine whether the Th-228 levels were natural background or not, the Th-228/Th-232 ratios were calculated for these two samples. Th-228/Th-232 ratios of hotspots #7 and #13 were 4.00 and 2.78 respectively, which indicated they were not natural (ratio of natural thorium ≅ 1). The parent isotope Th-232 was very typical of background at ≅ 1 pCi/g, therefore, the cause of elevated Th-228 (its daughter) is not apparent. Although the parent U-238 was somewhat elevated over typical background in some samples, the isotopic ratios of U-234/U-238 were all ≅ 1 indicating non-enriched, non-processed uranium.

Hotspots #7 #13, #24, and #31 and their surrounding areas were eventually excavated (see Figure 2). Although hotspot #1 also showed higher than natural Th-228/Th-232 ratio at 2.36, this location was not excavated because it contained low level of Th-228 (average = 1.84 pCi/g) and background level of Cs-137 (average = 0.21 pCi/g). The rest of the sampling locations were also not excavated because they were at background radiological activity.

Post-Excavation Sample Results (1998)

Table 3 lists the excavation areas and compares the results of radiological activity before and after excavation. The highest post-excavation Cs-137 activity is 0.72 pCi/g, or 8% of the cleanup standard of 9.20 pCi/g. Since isotopic thorium is not analyzed for in post-excavation samples, the post excavation Th-228 is calculated by averaging the Th-232 daughters and then comparing this average to the pre-excavation ratio of Th-228 to average Th-232 daughters. The highest post-excavation Th-228 is estimated to be 1.4 pCi/g, typical of background.

[1] Proprietary Software. Boeing

Summary

Several areas north of the berm were excavated because they had Cs-137 and Th-228 levels higher than background levels but below release limits. One area south of the berm was excavated because it contained Th-228 close to the release limit. The total area excavated was approximately 1400 ft^2. The volume of soil removed was approximately 2100 ft^3 or 78 yd^3. Results from post-excavation sampling indicate the excavated areas are now at levels well below the radiological release limits. Representative samples from other hotspot areas indicate only background or slightly above background levels of radiological activity. Therefore, the radiation remediation effort has been completed, and no further excavation is necessary.

If you have any questions regarding this report, please call me at (818) 586-8024.

John Shao

Radiation Safety

cc: James Barnes
Robert Hardy
Philip Horton
Rodney Meyer
17th Street Drainage Area File

Table 1.
17th Street Drainage Area
1995 and 1997 Soil Sampling Results

			Alpha Isotopic Results						Sr Results	Gamma Spectroscopy		
Sampling Year	Sample #	Depth (ft)	Th-228 (pCi/g)	Th-230 (pCi/g)	Th-232 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Sr-90 (pCi/g) (MDA=0.1)	Avg. of Th-232 daughters (pCi/g)	Avg. of U-238 daughters (pCi/g)	Cs-137 (pCi/g) (MDA=0.02)
1995	A4CM-95-0043	<0.5	0.81	0.66	0.81	0.62	0.02	0.65	<MDA	N/C	N/C	<MDA
	A4CM-95-0044	<0.5	0.68	0.63	0.60	0.70	0.04	0.67	<MDA	N/C	N/C	0.17
	A4CM-95-0045	<0.5	0.95	0.69	0.57	1.20	0.06	1.10	<MDA	N/C	N/C	0.67
	A4CM-95-0046	2.5	0.85	0.72	0.82	1.20	0.05	1.20	<MDA	N/C	N/C	0.09
	A4CM-95-0072	<0.5	0.85	0.94	0.59	0.60	0.03	0.58	<MDA	N/C	N/C	0.12
	A4CM-95-0073	2.5	1.10	0.72	0.94	0.98	0.06	0.74	<MDA	N/C	N/C	0.23
	A4CM-95-0074	<0.5	1.30	1.10	1.20	1.10	0.05	1.00	<MDA	N/C	N/C	0.07
1997	ENV-97-0035*	<0.5	-	-	-	-	-	-	-	1.50	1.50	13.50
	ENV-97-0036*	<0.5	-	-	-	-	-	-	-	2.00	1.40	14.90
	ENV-97-0049*	<0.5	-	-	-	-	-	-	-	4.00	3.00	1.49
	ENV-97-0050	<0.5	-	-	-	-	-	-	-	1.60	2.50	0.44
	ENV-97-0051	<0.5	-	-	-	-	-	-	-	1.00	2.20	0.25
	ENV-97-0052*	<0.5	-	-	-	-	-	-	-	2.70	2.00	1.60
	ENV-97-0056*	<0.5	-	-	-	-	-	-	-	5.50	3.00	1.02

* areas excavated in 1998
"-" means no data
MDA = minimum detectable activity
N/C = not calculated

Table 2.
17th Street Drainage Area
Hotspot Soil Sample Results (1998)

				Alpha Isotopic Results						Alpha Isotopic Ratios				Sr Results	Gamma Spec.
Hotspot #	Location	Depth (ft)	Sample #	Th-228 (pCi/g)	Th-230 (pCi/g)	Th-232 (pCi/g)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Th-228 / Th-232	U-234 / U-238	U-235 / U-238	Th-230 / U238	Sr-90 (pCi/g)	Cs-137 (pCi/g)
1	L19-7N-46E	<0.5	017-98-0016	2.12	0.91	0.90	2.49	0.02	2.49	2.36	1.00	0.01	0.37	0.92	0.17
		<0.5	017-98-0020 (dup. of 0016)	1.55	0.97	0.69	2.26	0.15	1.90	2.25	1.19	0.08	0.51	0.13	0.24
7*	L19-22N-63E	0 - 0.7	017-98-0005	6.24	2.12	1.56	2.74	0.37	2.42	4.00	1.13	0.15	0.88	-0.22	1.37
		0.7-1.3	ENV-98-251	-	-	-	-	-	-	-	-	-	-	-	0.78
		1.3 - 2	ENV-98-252	-	-	-	-	-	-	-	-	-	-	-	0.23
13*	L19-109N-105E	<0.5	017-98-0018	4.01	1.89	1.44	3.48	0.34	3.35	2.78	1.04	0.10	0.56	-0.12	1.07
15	L18-40N-169E	<0.5	017-98-0013	1.35	1.37	1.24	1.09	0.18	1.11	1.09	0.98	0.16	1.23	0.30	0.10
24*	L18-64N-175E	0 - 0.7	017-98-0002	2.15	2.69	1.94	4.28	0.21	3.70	1.11	1.16	0.06	0.73	-0.15	2.11
		0.7-1.3	ENV-98-248	-	-	-	-	-	-	-	-	-	-	-	1.01
		1.3 - 2	ENV-98-249	-	-	-	-	-	-	-	-	-	-	-	0.02
31*	L18-88N-178E	<0.5	017-98-0017	2.20	1.86	1.61	2.80	0.08	2.37	1.37	1.18	0.03	0.78	0.28	0.95
33	L18-6N-150E	<0.5	017-98-0014	0.95	0.78	0.78	1.97	0.16	2.63	1.22	0.75	0.06	0.30	0.30	0.01
40	K19-169N-26E	<0.5	ENV-98-254	-	-	-	-	-	-	-	-	-	-	-	0.25
47	K19-130N-44E	<0.5	017-98-0015	1.14	1.13	0.96	1.93	0.28	1.48	1.19	1.30	0.18	0.76	-0.11	0.14
49	K19-115N-62E	<0.5	ENV-98-255	-	-	-	-	-	-	-	-	-	-	-	<0.04
53	K19-80N-80E	<0.5	ENV-98-256	-	-	-	-	-	-	-	-	-	-	-	0.05
61	K19-41N-93E	<0.5	017-98-0019	1.15	1.11	1.15	1.93	0.13	1.78	1.00	1.08	0.07	0.62	0.00	0.05
65	K19-10N-105E	<0.5	ENV-98-253	-	-	-	-	-	-	-	-	-	-	-	0.11

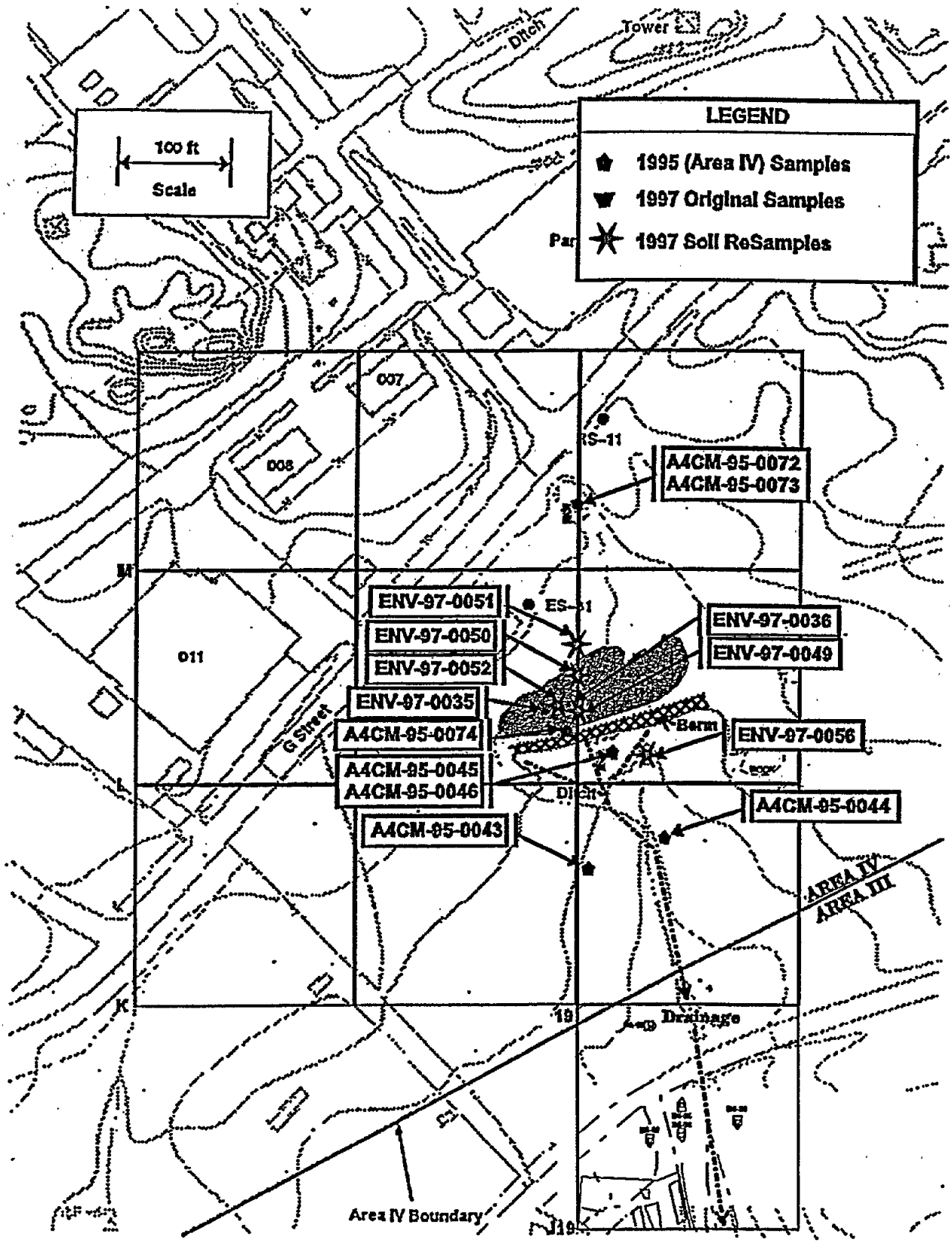
*locations included in the excavation
"-" means no data

Table 3.
17th Street Drainage Area
Pre- And Post-Excavation Soil Sample Results

			Pre-Excavation		Post-Excavation	
General Location	Hotspot #	Composite Sample Location	Radioisotope of Interest (pCi/g)	Sample #	Radioisotope of Interest (pCi/g)	Sample #
NORTH OF BERM	9,10	L19-66N-5E	-	-	Cs-137 = 0.39	ENV-98-263
	17,22,27,28	L18-57N-195E	-	-	Cs-137 = 0.49	ENV-98-261
	18,19,23,24*, 25,26,29	L18-65N-185E	Cs-137 = 2.11	017-98-0002	Cs-137 = 0.53	ENV-98-262
	20,21	L18-66N-195E	-	-	Cs-137 = 0.58	ENV-98-260
	30	L18-87N-190E	-	-	Cs-137 = 0.72	ENV-98-264
	31*	L18-88N-178E	Cs-137 = 0.95	017-98-0017	Cs-137 = 0.07	ENV-98-265
	32	L18-95N-179E	-	-	Cs-137 = 0.34	ENV-98-266
	11	L19-77N-51E	-	-	Cs-137 = 0.39	ENV-98-259
	12	L19-104N-106E	-	-	Cs-137 = 0.28 avg. of Th-232 daughters ≅ 1.1	ENV-98-268
	13*	L19-109N-105E	Cs-137 = 1.07 Th-228 = 4.01	017-98-0018	Cs-137 = 0.34 avg. of Th-232 daughters ≅ 1.0	ENV-98-269
SOUTH OF BERM	5,6,7*,8	L19-23N-62E	Cs-137 = 1.37 Th-228 = 6.24 avg. of Th-232 daughters ≅ 5.0	017-98-0005 ENV-98-250	Cs-137 = 0.06 Th-228 ≅ 1.4** avg. of Th-232 daughters ≅ 1.1	ENV-98-267

* hotspot sampled
** calculated Th-228 concentration (see text)
"-" means no sample taken

Figure 1
1995 and 1997 Soil Sampling Locations for 17th Street Drainage Channel



17st_f97.dsf
dahl 11/25/98

Figure 2

17th Street Drainage Area Soil Excavation and Sample Location

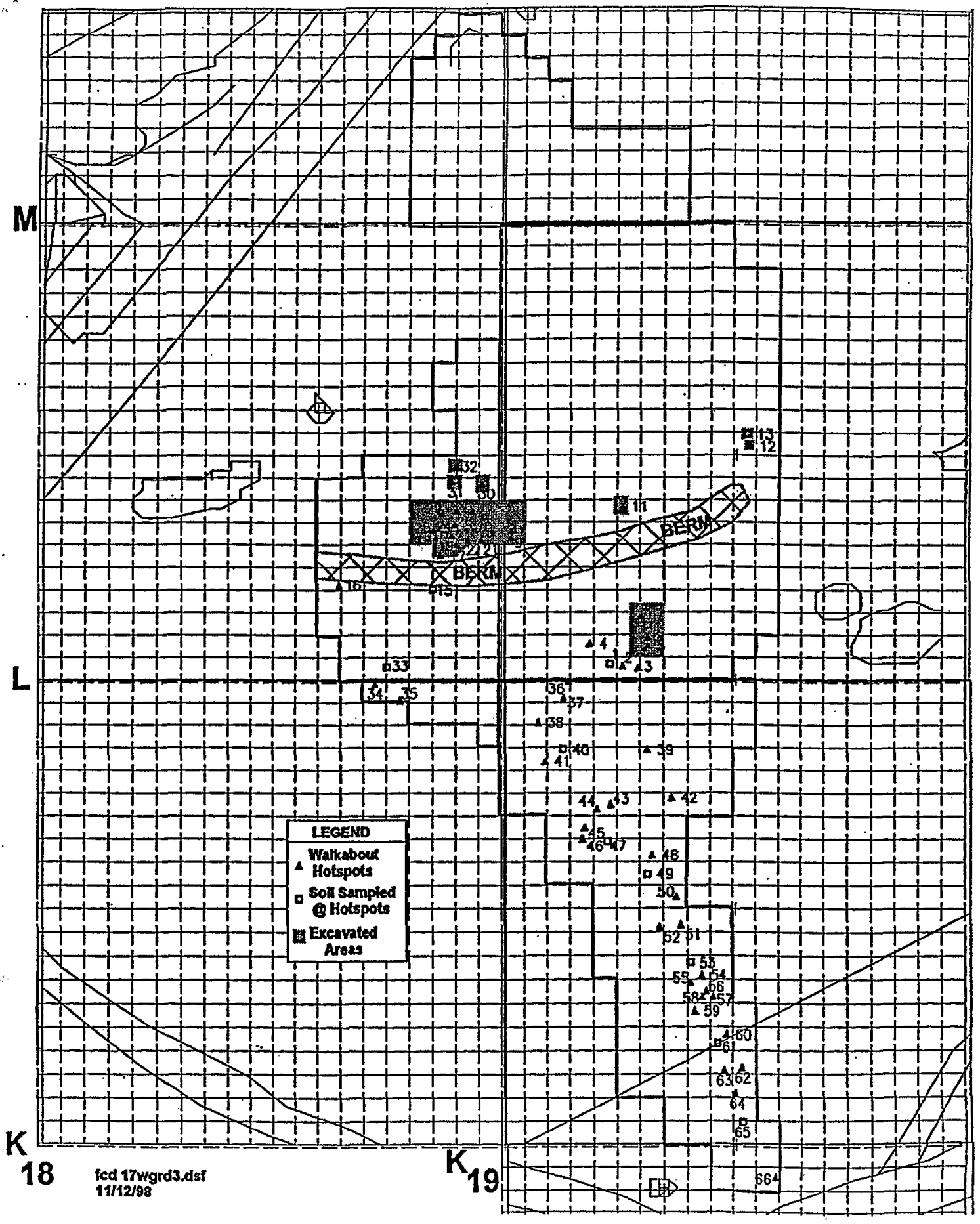


Figure 3

17th St. Drainage Area Ambient Gamma Survey (@ 1 meter)

Raw data converted to µR/h. Contour Intervals 2.0 µR/h. Data on 10 ft x 10 ft Grid.
Triangle indicates a reading = 18.4 µR/h and squares indicate < 18 µR/h. *(17wgrd1a.dsf)*

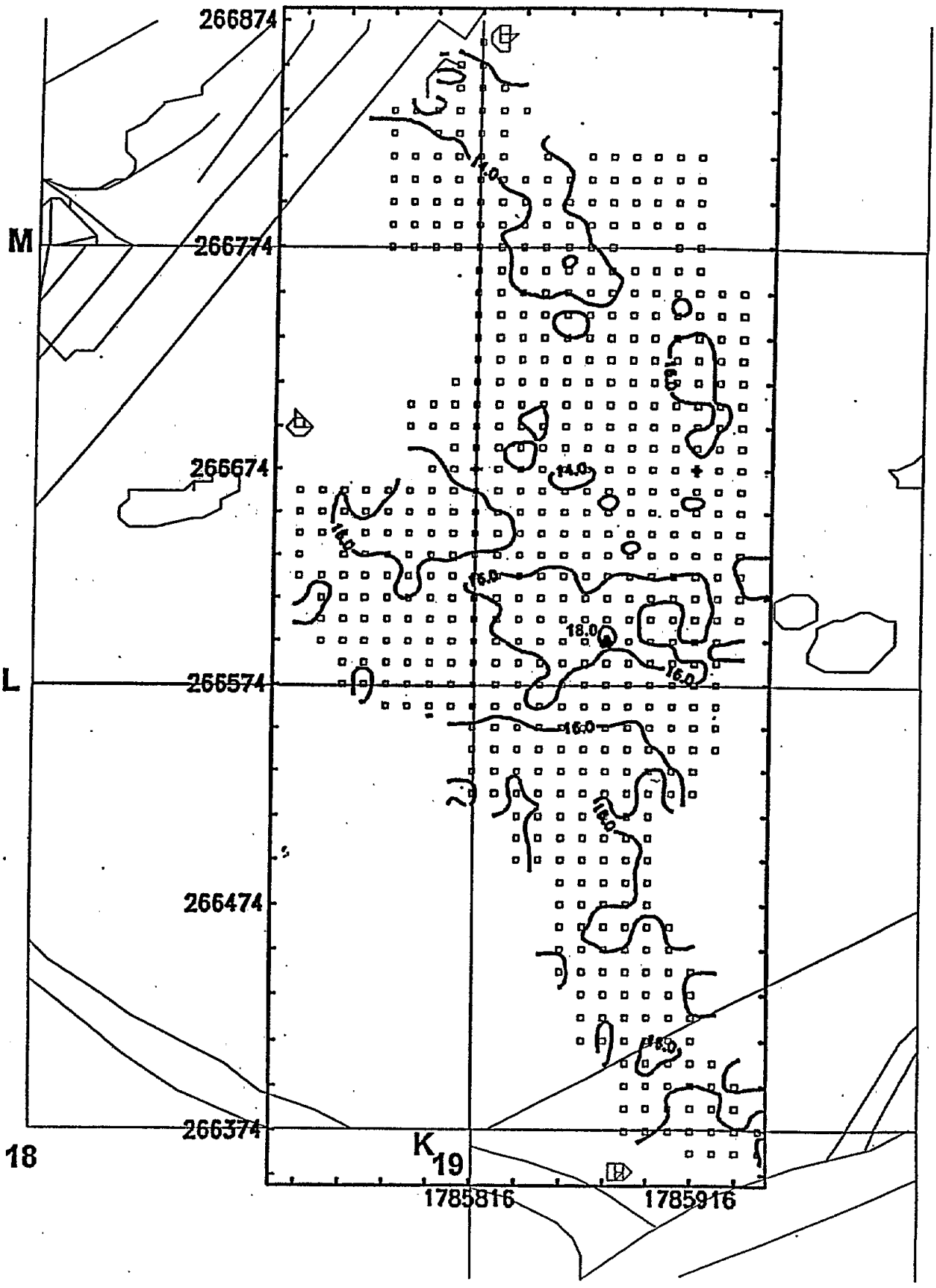


Figure 4
Gross Ambient 1-Meter Gamma Measurements (17th St.)

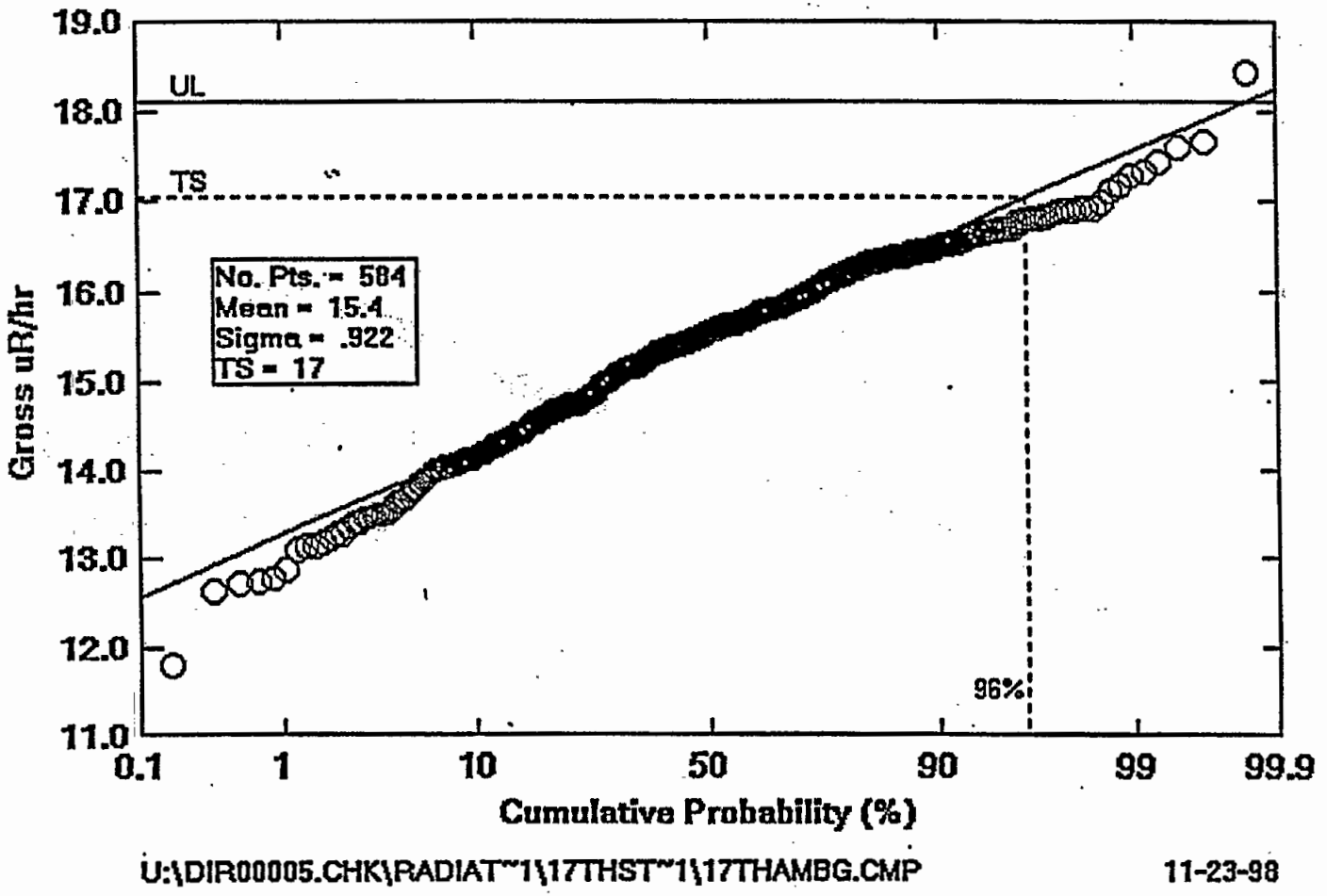


Figure 5
Net Ambient 1-Meter Gamma Measurements (17th St.)

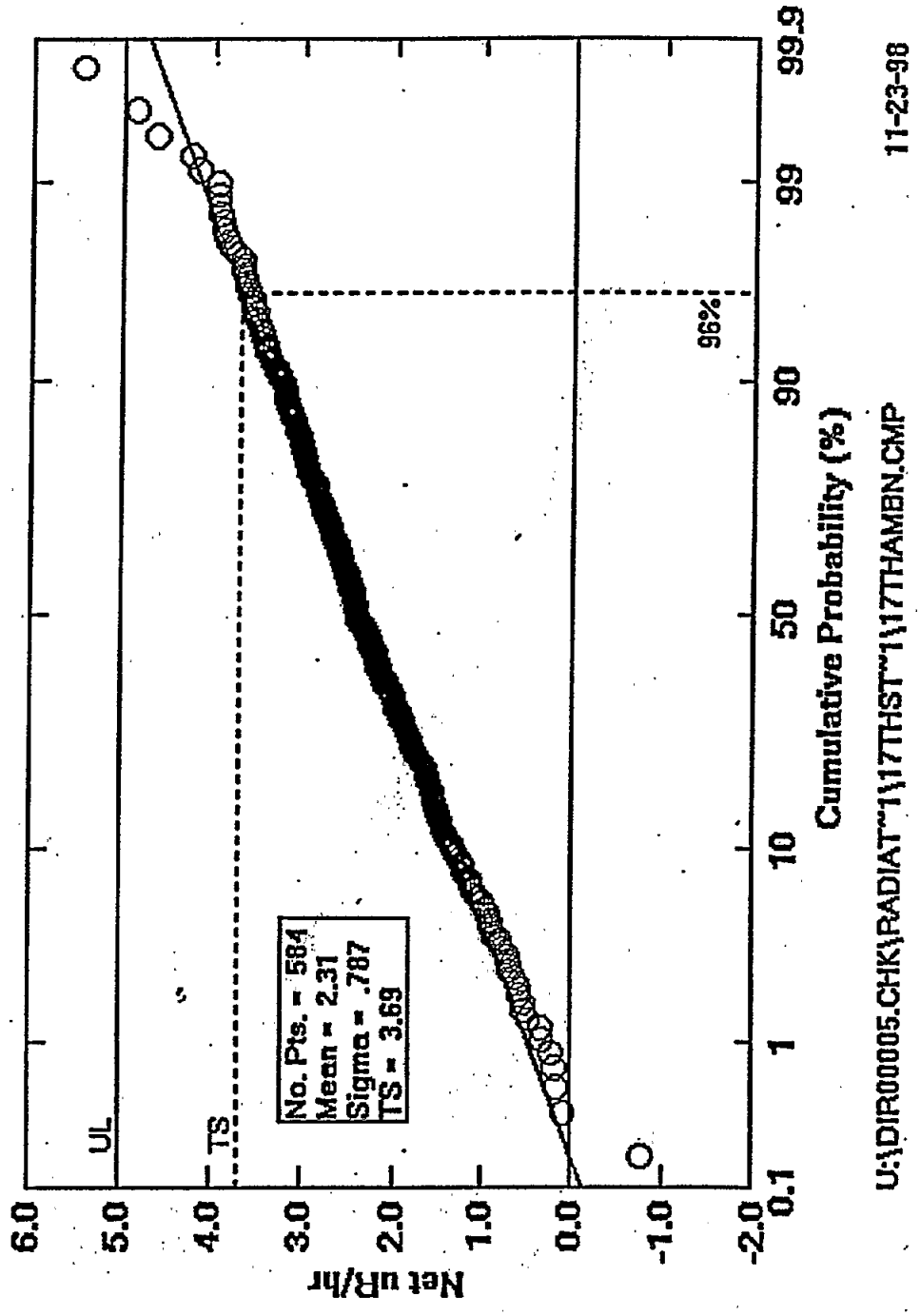
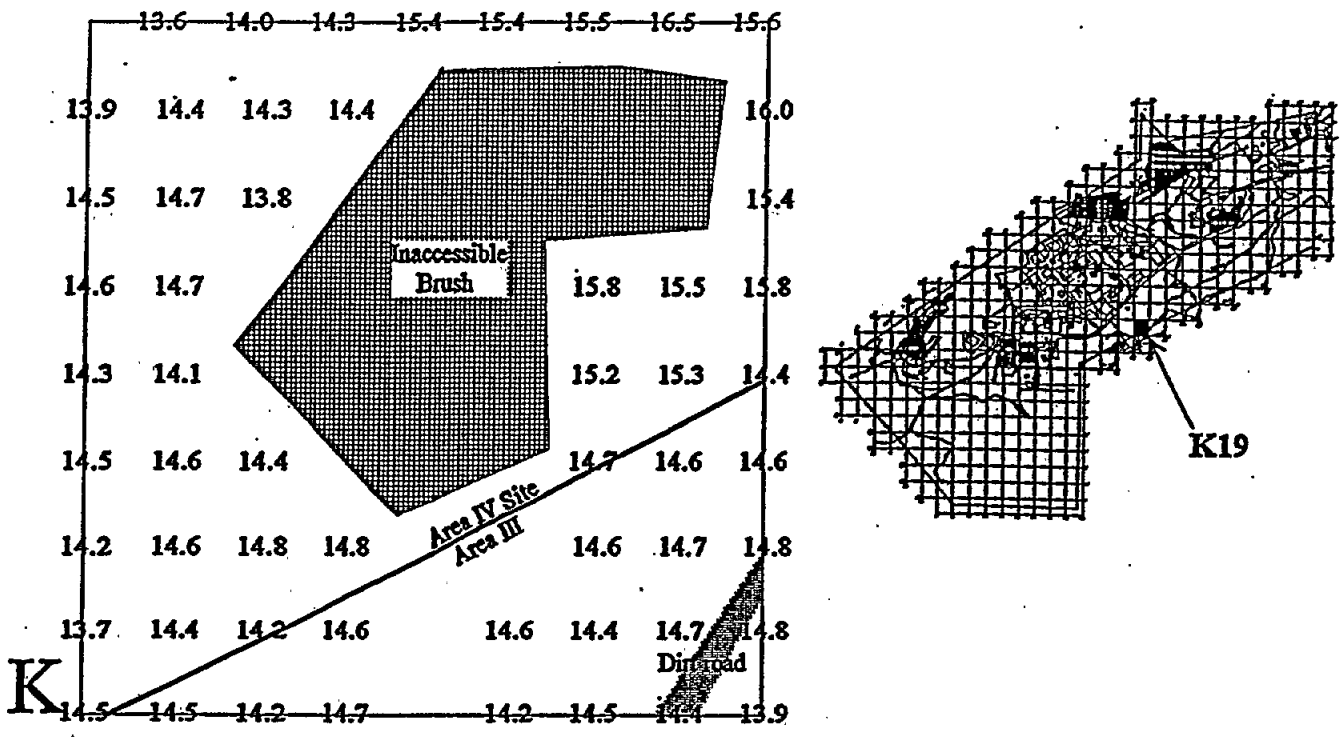


Figure B-89. Ambient Gamma Survey Results - Survey Block K19



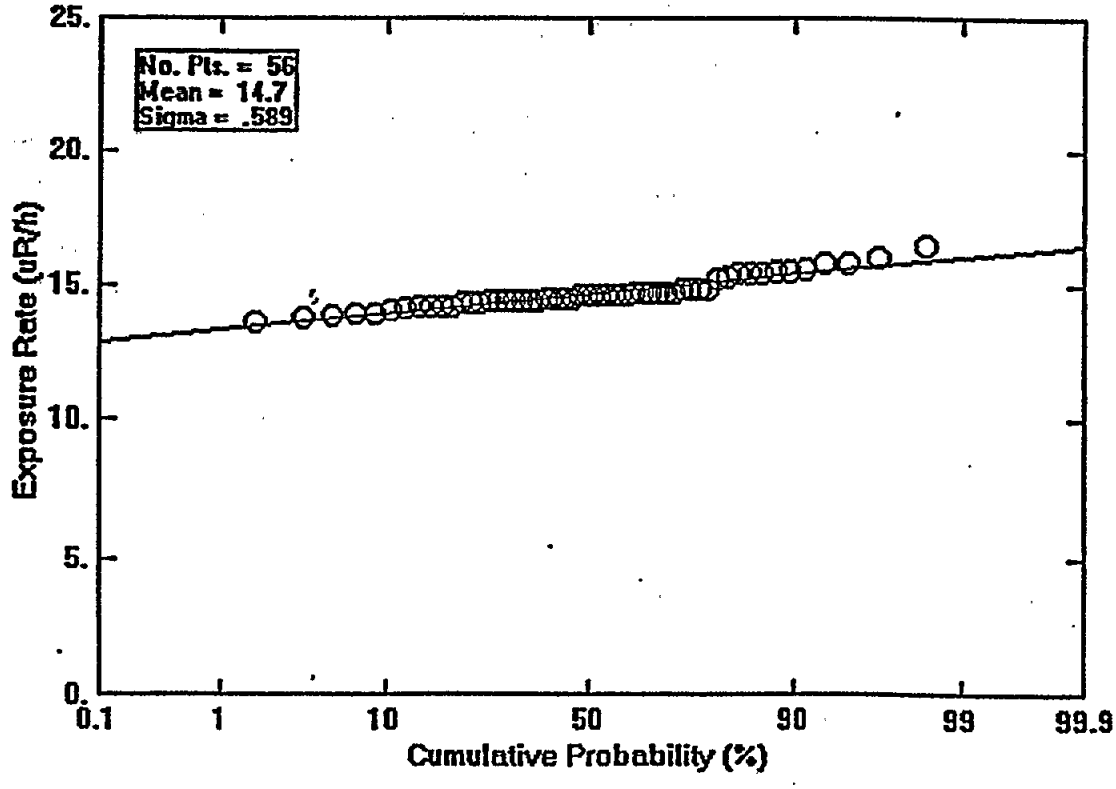
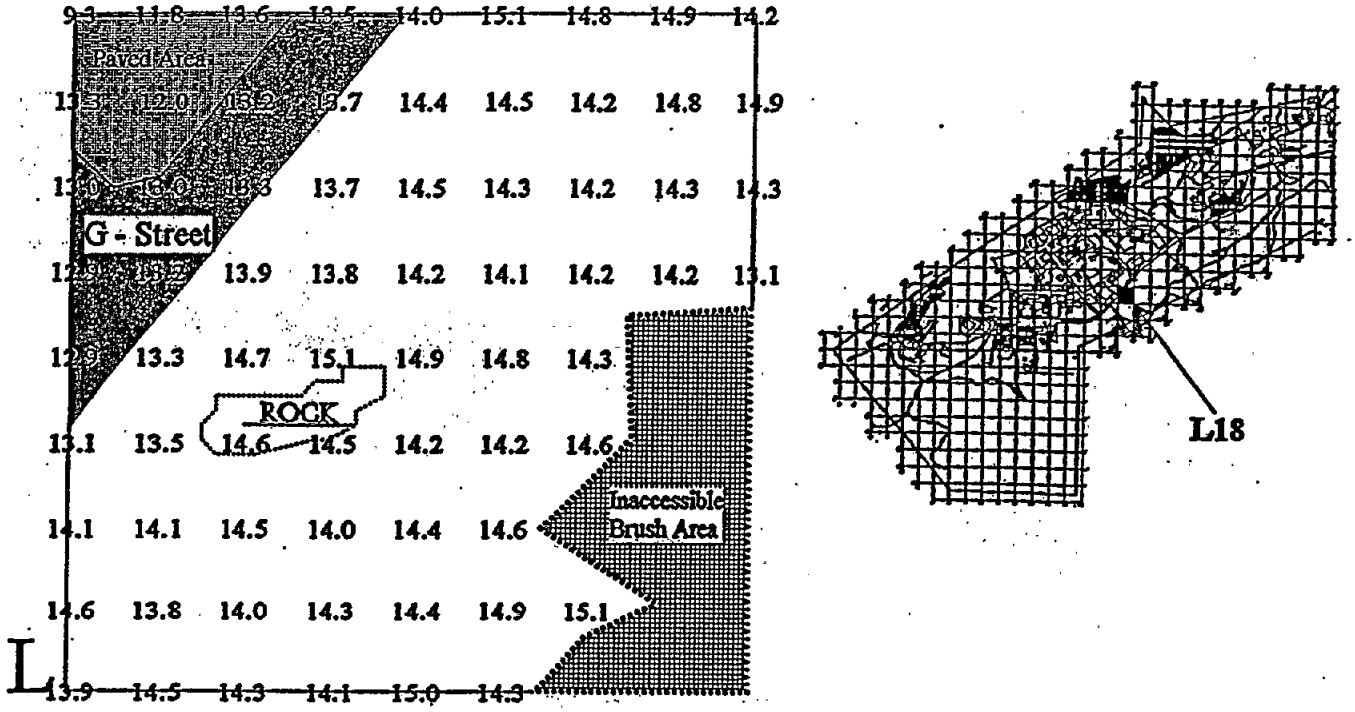


Figure B-97. Ambient Gamma Survey Results - Survey Block L18



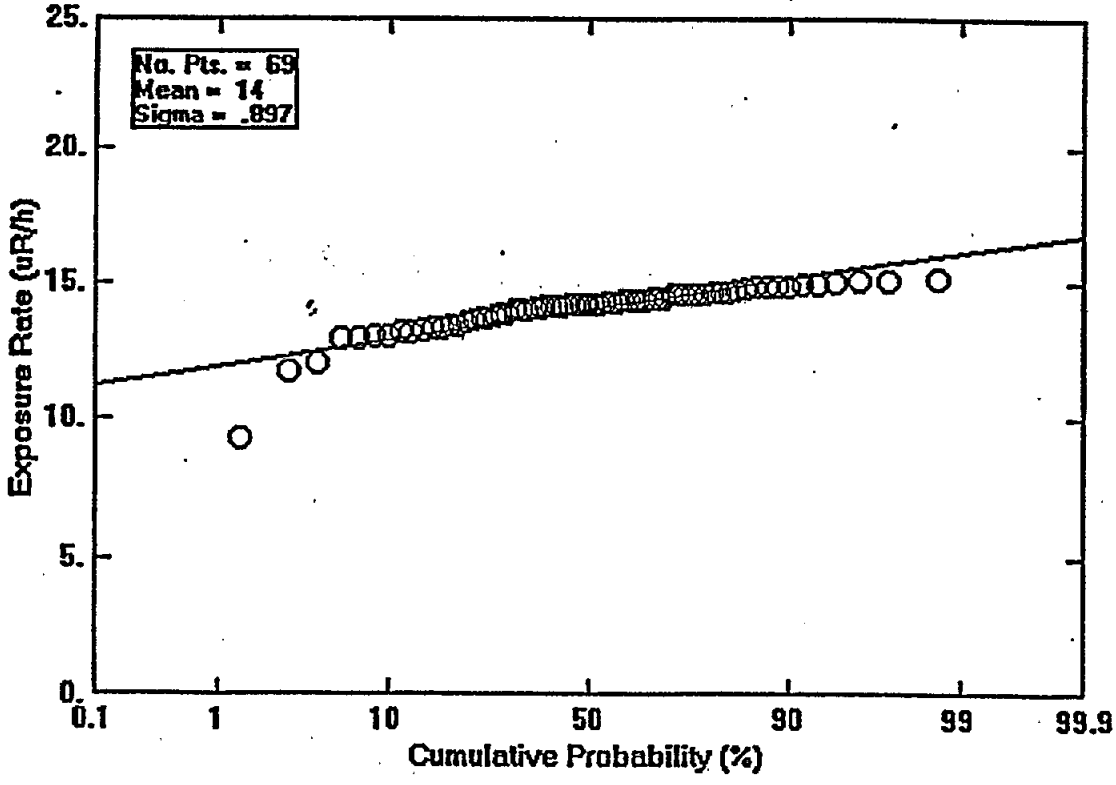


Figure B-98. Ambient Gamma Survey Results - Survey Block L19