2153

PROJECT SPECIFIC PLAN

FOR

AREA 1, PHASE I

REMEDIAL ACTION WORK PLAN

COMPARABILITY STUDY, PART B

PROJECT NUMBER 50.03.40.03

October 18, 1996

INFORMATION ONLY

Prepared by

Fluor Daniel Fernald

Prepared for

U.S. Department of Energy
Fernald Field Office

Under Contract DE-AC05-92OR21972

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PROJECT SPECIFIC PLAN
FOR AREA 1, PHASE I
REMEDIAL ACTION WORK PLAN
COMPARABILITY STUDY, PART B
PROJECT NUMBER 50.03.40.03
October 18, 1996

APPROVAL:

10/18/96

Keith Nelson, Project Lead — Date
Soil Characterization Excavation Project

10-18-96

Don Kalar, Quality Assurance — Date
Soil Characterization Excavation Project

10/18/96

Karen Voisard, Team Coach — Date
Program Development & Records

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-2
WBS NO.: 50.03.40.03	Page 1 of 2
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 4/7/97

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Field Change Notice:

2153

This variance extends the Comparability Study, Part B, to establish a HPGe Field Quality Control Point. The point is located North of the Sewage Treatment Plant, at Station #15 (50349-03) northing 480391.4131 and easting 1351675.862.

Section 1.2 Scope originally scoped the Comp Study, Part B to be conducted at 10 selected areas and for data to be collected using RTRAK, HPGe, soil and air temperature measurements, physical soil samples and surface moisture-density gauge measurements. This variance extends the Comp. Study to 11 locations, limits the readings to HPGe, air temperature, and soil moisture readings, and extends the PSP to include humidity readings, if able to be acquired. Air temperature will be secured by calling the site weather station (readings updated each minute) to acquire the temperature instead of suspending the thermometer in the air using a stake and a string as indicated in Section 2.3 Temperature Measurements in the PSP. Humidity will be recorded using a field humidity measuring devise until the site weather station humidity measuring equipment is repaired.

Justification:

INFORMATION ONLY

Establishment of the HPGe Field Quality Control Point will enable the Project Lead to establish control charts for HPGe detector systems under varying environmental conditions. These control charts will document for the Regulatory Agency how the HPGe system handles a range of environmental variables.

Location #15 from the PSP Determination of the Optimal RTRAK Detector Speed and Acquisition Time, Project Number 50.03.49, was chosen as the HPGe Field Quality Control Point because it has a HPGe reading of approximately 80 ppm U 238 (moisture corrected). The 80 ppm reading is close to the Final Remediation Level for Total Uranium of 82 ppm.

This portion of the study will continue until the Project Lead indicates an adequate volume of data has been acquired.

Test Set Up and Documentation:

1) HPGE systems will be physically labeled 1-4 (temporary marking). A crosswalk between the system number and the computer and detector serial number will be recorded before the testing begins.

2) An HPGe system will be comprised of the same Detector and Computer. Detectors and computers will NOT be switched between systems during the test.

3) If an HPGe system fails morning calibration test/ or goes out of service, the unit will not be used for this portion of the study. Another unit will be randomly chosen by the HPGe operator to fill in for the day's readings

4) A binder will be established for this portion of the study with dividers for each day of the study. The binder will contain a copy of the HPGe and Troxler Daily Calibration Logs, Field Logs, and a printout of the HPGe readings. The binder will be updated daily.

CONTINUED ON PAGE 2...

X IF REQD	VARIANCE/FCN APPROVAL	DATE	X IF REQD	VARIANCE/FCN APPROVAL	DATE
X	QUALITY ASSURANCE	K Spiroke	X 4-7-97	PROJECT MANAGER	4/7/97
	DATA QUALITY MANAGEMENT		X	FIELD MANAGER	
	ANALYTICAL CUSTOMER SUPPORT			OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

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QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

CONTINUED FROM PAGE 1...

Morning and Afternoon Readings:

1) HPGe 15 minute readings, at 1 meter detector height (no 30 cm height readings). No duplicates (1 per 20 readings) will be collected.

2) HPGe readings will be collected in the early morning and in the late afternoon to acquire data during the coolest and warmest times of the day.
   a-System #1 will record both readings on Mondays
   b-System #2 will record both readings on Tuesdays
   c-System #3 will record both readings on Wednesdays
   d-System #4 will record both readings on Thursdays

3) Field log to indicate which machine (1-4) is being used to collect the data for each reading, each day.

4) Record Troxler soil moisture readings. If the soil is too moist to conduct a Troxler moisture reading, the soil will be assumed to be saturated and noted on the logs. NO moisture cores to be taken, this would remove the Control Point needed to conduct the test.

5) Note vegetation presence/absence, air temperature, and humidity (if possible).

REQUESTED BY: Joan White JHW 4/7/97 Date: 4/7/97

JHW 4/7/97

VARIANCE / FIELD CHANGE NOTICE	V/F50.03.40.03-3
WBS NO.: 50.03.40.03	Page 1 of 11
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 4/28/97

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Justification:
This variance to the Comparability Study, Part B, Rev. 0 PSP is needed to set up a test designed to compare HPGe detector radium-226 measurements to physical sample measurements when the concentration of radium-226 is near the FRL.

Field Change Notice:
This variance extends the Comparability Study, Part B, to establish 6 HPGe radium-226 study areas (see Figure 1). At these 6 study points, HPGe readings, Troxler moisture/density readings, soil and temperature readings, humidity readings, physical samples, and descriptions of the physical samples will be collected over 6 areas in the South Field (see attached map). The study is intended to determine the comparability of HPGe readings and physical samples in the range of 1-3 and 4-5 pCi/g radium concentrations (data has already been collected for the 0.5-1.0 pCi/g range earlier in the Comparability Study, Part B, Rev 0).

Section 1.2 Scope originally scoped the Comparability Study, Part B to be conducted as a test for radiological constituents at 10 selected areas, and for data to be collected using NaI, HPGe, soil and air temperature measurements, physical soil samples and surface moisture-density gauge measurements. Variance number 50.03.40.03-2 already extended the study to include Area # 11, to test the comparability of HPGe measurements to physical sample analysis results in concentrations of total uranium near the FRL. This variance to the PSP further extends the study to include Areas12-17, and extends the study to include humidity readings and soil sample physical descriptions, and excludes the RTRAK NaI measurements.

INFORMATION ONLY

Locations #12-17 (see Figure 1) were selected because previous sampling data exhibited concentrations of radium-226 in the soil in the required target ranges of 1-5 pCi/g at these locations. These target ranges are near the FRL for radium-226 (1.7 pCi/g).

Data to be collected:
1) All HPGe and physical sample locations will be surveyed using the Global Positioning System or the Total Station survey instrument. (See Table 1 for listing of sample location coordinates).

2) Air temperature at the time of HPGe readings will be obtained by calling the site weather station (readings updated each minute) to acquire the temperature instead of suspending the thermometer in the air in the test area using a stake and a string as indicated in Section 2.3 Temperature Measurements in the PSP.

3) Soil temperature will be taken by using a thermometer inserted into the soil as required in Section 2.3 Temperature Measurements in the PSP.

4) Daily humidity will be recorded using a field humidity measuring device until the site weather station humidity measuring equipment is repaired.

5) HPGe readings will be taken at only the 1 meter height. Three readings will be taken at the same location at the same height to check for repeatability of results. Preliminary Comparability Study Part B tests have indicated that taking measurements at the 30 cm height is of no additional value to the study, therefore only the 1 meter height will be collected in Areas 12-17.

CONTINUED ON FOLLOWING PAGE:

X IF REQD	VARIANCE/FCN APPROVAL	DATE	X IF REQD	VARIANCE/FCN APPROVAL	DATE
X	QUALITY ASSURANCE R. Guide	4-28-97	X	PROJECT MANAGER	04/28/97
	DATA QUALITY MANAGEMENT		X	FIELD MANAGER Mike Tuck	4/28/97
	ANALYTICAL CUSTOMER SUPPORT			OTHER Chris Smith	4/28/97
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

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PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

2153

CONTINUED FROM PRECEDING PAGE:

6) HPGe readings at a given location will be taken first in the morning and repeated at the same location again in the afternoon. If the two HPGe readings at any given location are within 8 hours of each other, only one Troxler Moisture/Density reading will be needed; if the two HPGe readings at any given location are further than 8 hours apart or if humidity conditions changed (rain), then a second Troxler Moisture/Density reading will be needed. Preliminary Comparability Study Part B tests have indicated considerable variability in radon fluctuations during the span of a day. To capture this variability, HPGe readings will be collected in the morning and again in the afternoon.

7) HPGe file numbers will contain the designator PBC (Part B Comparability) and be followed by the Area Designation. For example, PBC-12 for Area 12.

8) Moisture/density measurements will be taken with the Troxler gauge. If the soil is too moist to conduct a Troxler moisture/density reading, a moisture core will be taken for onsite laboratory for moisture content analysis. Moisture cores will be collected after all HPGe measurements at a given test location are completed (to avoid removing any contamination in the HPGe read areas).

9) Physical samples will be collected after all HPGe measurements and Troxler/moisture measurements (or moisture cores) are collected at a given test Area.

10) Physical samples will be collected from 0-4" in depth at the density indicated on the attachments. The area will be cleared of surface vegetation by removing the grass with a gloved hand, while being careful not to remove surface soil. Medium designation Areas have a total of 11 samples to be collected (including duplicate). High Designation Areas have a total of 16 samples to be collected (including duplicate). (See Table 2 for Sample Numbers).

11) A duplicate physical sample will be collected in each test Area. The duplicate is designated on the attached Comparability Study, Part B Sample Summary for Area 12 through Area 17. Duplicates will be collected and homogenized in accordance with SMPL-01.

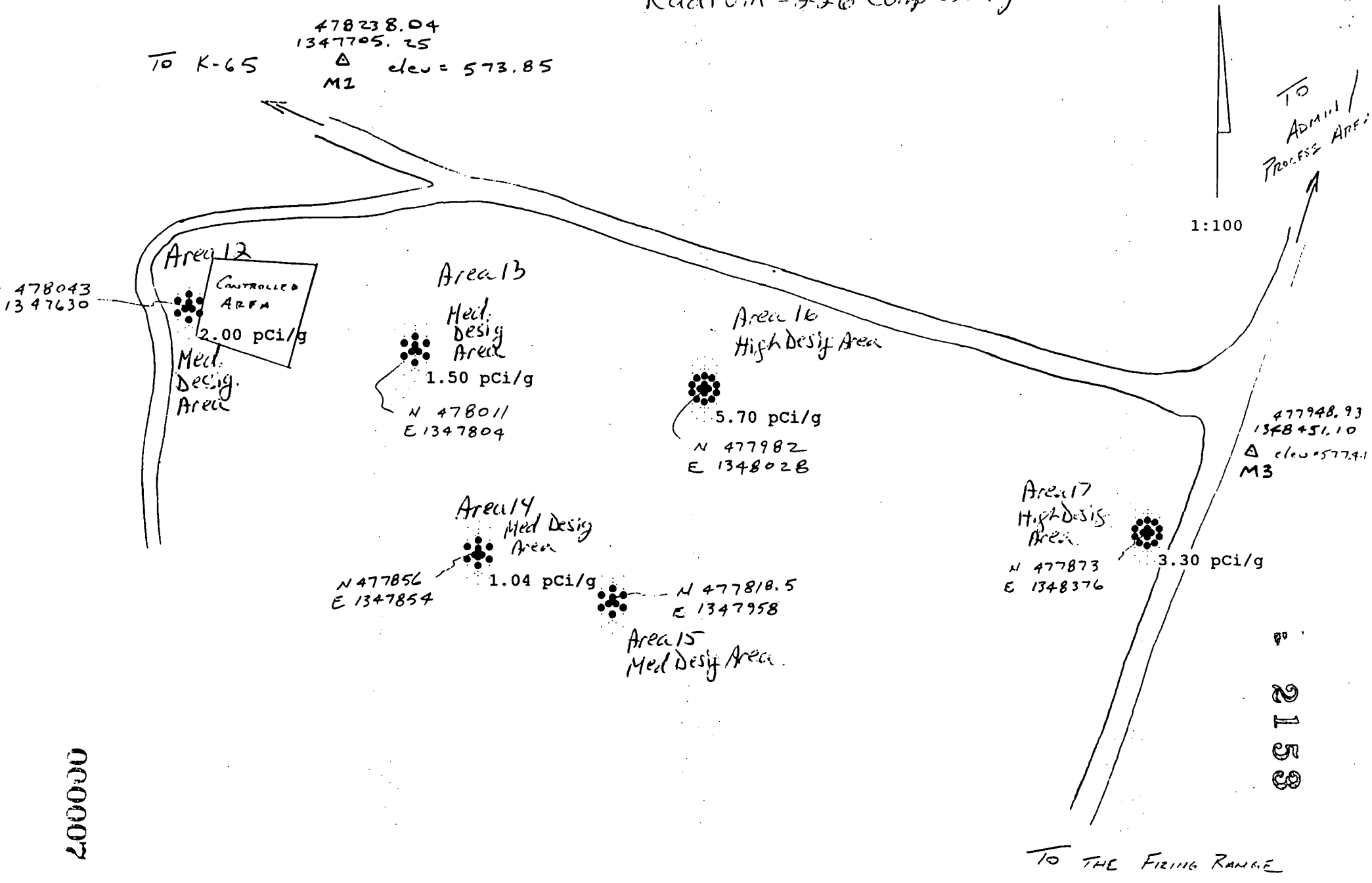
D, C 4/29/97

12) Samples will be analyzed to ASL-~~B~~ for radium-226 using alpha spec at the onsite lab.

13) If reusable sampling equipment is used, a rinseate sample will be collected for every 20 tools decontaminated.

REQUESTED BY: Joan White JW Date: 4/28/97

Areas 12 through Area 17
South Field
Radium-226 Comp Study



NOTE: COORDINATES INDICATE CENTER OF SAMPLE LAYOUT (EXCEPTING FOR MONUMENT M1 & M3)

Figure 1

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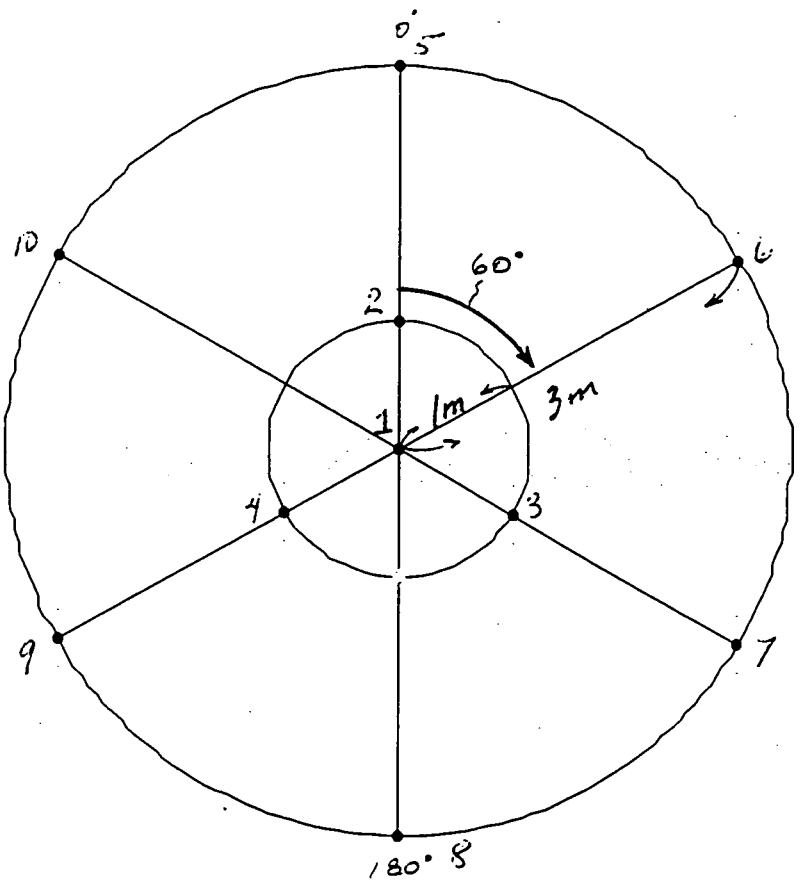
2158

1:5



Areas 12, 13, 14, 15
Medium Designation Sample Layout

Figure 2

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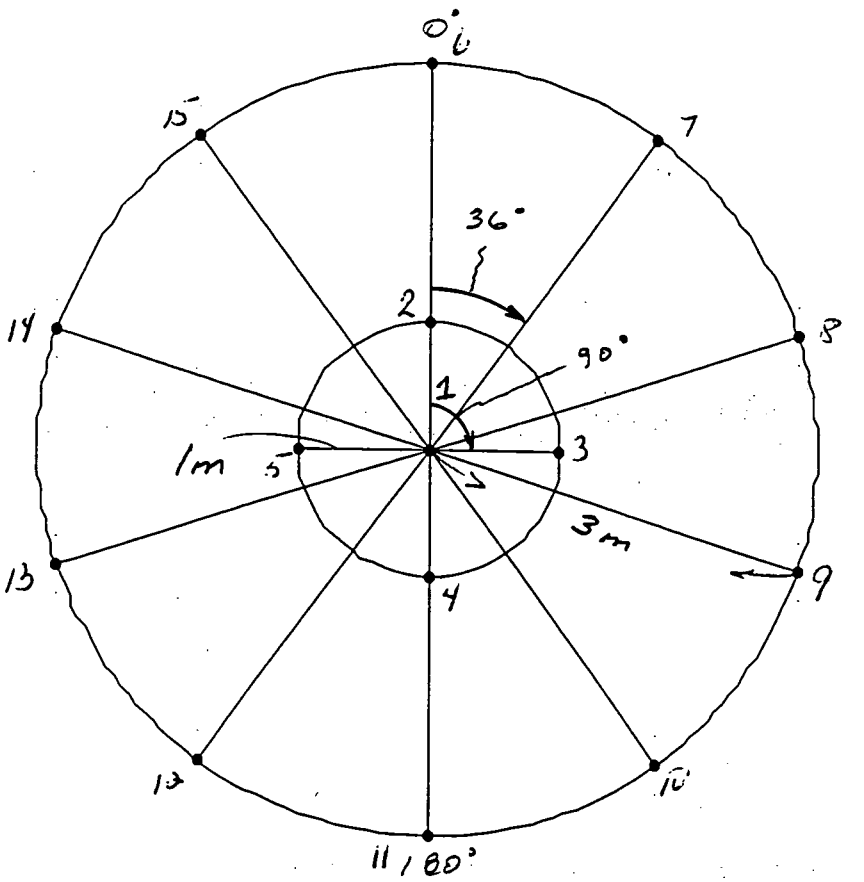

Areas 16, 17
High Designation Sample Layout

000009

Figure 3

TABLE 1- AREAS 12 THROUGH 17 SAMPLE COORDINATES RADIUM-226 COMPARABILITY STUDY

2153

AREA #/SAMPLE POINT	POINT #	NORTHING/EASTING
AREA 12 PBC-12-1	2	478043.0000 1347630.0000
PBC-12-5	19	478052.8400 1347630.0000
PBC-12-2	20	478046.2800 1347630.0000
PBC-12-6	21	478047.9200 1347638.5217
PBC-12-7	22	478038.0800 1347638.5217
PBC-12-3	23	478041.3600 1347632.8406
PBC-12-8	24	478033.1600 1347630.0000
PBC-12-9	25	478038.0000 1347621.4783
PBC-12-4	26	478041.3600 1347627.1594
PBC-12-10	27	478047.9200 1347621.4783
	28 NUMBER DELEATED	NA
AREA 13 PBC-13-1	3	478011.0000 1347804.0000
PBC-13-5	29	478020.8400 1347804.0000
PBC-13-2	30	478014.2800 1347804.0000
PBC-13-6	31	478015.9200 1347812.5217
PBC-13-7	32	478006.0800 1347812.5217

AREA 13 (CONTINUED) PBC -13-3	33	478009.3600 1347806.8406
PBC-13-8	34	478001.1600 1347804.0000
PBC-13-9	35	478006.0800 1347795.4783
PBC-13-4	36	478009.3600 1347801.1594
PBC-13-10	37	478015.9200 1347795.4783
AREA 14 PBC-14-1	1	477856.0000 1347854.0000
PBC-14-2	9	477859.2800 1347854.0000
PBC-14-5	10	477865.8400 1347854.0000
PBC-14-8	11	477846.1600 1347854.0000
	12 DELEATED	NA
PBC-14-6	13	477860.9200 1347862.5217
PBC-14-7	14	477851.0800 1347862.5217
PBC-14-3	15	477854.3600 1347856.8406
PBC-14-4	16	477854.3600 1347851.1594
PBC-14-9	17	477851.0800 1347845.4783
PBC-14-10	18	477860.9200 1347845.4783
AREA 15 PBC-15-1	8	477818.5006 1347958.000

AREA 15 (CONTINUED) PBC-15-2	52	477821.7806 1347958.0000
PBC-15-5	53	477828.3406 1347958.0000
PBC-15-6	54	477823.4206 1347996.5217
PBC-15-7	55	477813.5806 1347966.5217
PBC-15-3	56	477816.8606 1347960.8405
PBC-15-4	57	477816.8606 1347955.1594
PBC-15-9	58	477813.5806 1347949.4783
PBC-15-10	59	477823.4206 1347949.4783
PBC-15-8	60	477808.6606 1347958.000
AREA 16 PBC-16-1	5	477982.0000 1348028.0000
	NUMBERS 61-64 INCLUSIVE NOT USED	
PBC-16-2	65	477985.2800 1348028.0000
PBC-16-6	66	477991.8400 1348028.0000
PBC-16-7	67	477989.9607 1348033.7838
PBC-16-8	68	477985.0407 1348037.3584
PBC-16-9	69	477978.9593 1348037.3584
PBC-16-10	70	477974.0393 1348033.7838

AREA 16 (CONTINUED) PBC-16-11	71	477972.1600 1348028.0000
PBC-16-4	72	477978.7200 1348028.0000
PBC-16-12	73	477974.0393 1348022.2162
PBC-16-13	74	477978.9593 1348018.6416
PBC-16-14	75	477985.0407 1348018.6416
PBC-16-15	76	477989.9607 1348022.2162
PBC-16-3	77	477982.0000 1348031.2800
PBC-16-5	78	4777982.0000 1348024.7200
AREA 17 PBC-17-1	4	477873.0000 1348376.0000
PBC-17-2	38	477876.2800 1348376.0000
PBC-17-6	39	477882.8400 1348376.0000
PBC-17-7	40	477880.9607 1348381.7838
PBC-17-8	41	477876.0407 1348385.3584
PBC-17-9	42	477869.9593 1348385.3584
PBC-17-10	43	477865.0393 1348381.7838
PBC-17-11	44	477863.1600 1348376.0000
PBC-17-12	45	477865.0393 1348370.2162

AREA 17 (CONTINUED) PBC-17-13	46	477869.9593 1348366.6416
PBC-17-14	47	477876.0407 1348366.6416
PBC-17-15	48	477880.9607 1348370.2162
PBC-17-3	49	477873.0000 1348379.2800
PBC-17-4	50	477869.7200 1348376.0000
PBC-17-5	51	477873.0000 1348372.7200

TABLE 2 AREAS 12 THROUGH 17 SOUTHFIELD RADIUM-226 COMPARABILITY STUDY

			Location and Number of Samples					
Area #	Area Location	Area Designation	Center	1 Meter Circle	3 Meter Circle	Duplicate Sample	Total	Sample Numbers
12	West side of Southfield	Medium	1	3	6	1	11	PBC-12-1, PBC-12-2, PBC-12-3, PBC-12-4, PBC-12-5, PBC-12-6, PBC-12-7, PBC-12-8, PBC-12-9, PBC-12-10, PBC-12-11 (PBC-12-11 is a duplicate of PBC-12-5)
13	NW-Center side of Southfield	Medium	1	3	6	1	11	PBC-13-1, PBC-13-2, PBC-13-3, PBC-13-4, PBC-13-5, PBC-13-6, PBC-13-7, PBC-13-8, PBC-13-9, PBC-13-10, PBC-13-11 (PBC-13-11 is a duplicate of PBC-13-7)
14	SW-Center side of Southfield	Medium	1	3	6	1	11	PBC-14-1, PBC-14-2, PBC-14-3, PBC-14-4, PBC-14-5, PBC-14-6, PBC-14-7, PBC-14-8, PBC-14-9, PBC-14-10, PBC-14-11 (PBC-14-11 is a duplicate of PBC-14-1)
15	South Center side of Southfield	Medium	1	4	10	1	11	PBC-15-1, PBC-15-2, PBC-15-3, PBC-15-4, PBC-15-5, PBC-15-6, PBC-15-7, PBC-15-8, PBC-15-9, PBC-15-10, PBC-15-11 (PBC-15-11 is a duplicate of PBC-15-4)
16	North-Center side of Southfield	High	1	4	10	1	16	PBC-16-1, PBC-16-2, PBC-16-3, PBC-16-4, PBC-16-5, PBC-16-6, PBC-16-7, PBC-16-8, PBC-16-9, PBC-16-10, PBC-16-11, PBC-16-12, PBC-16-13, PBC-16-14, PBC-16-15, PBC-16-16 (PBC-16-16 is a duplicate of PBC-16-10)
17	East side of Southfield	High	1	4	10	1	16	PBC-17-1, PBC-17-2, PBC-17-3, PBC-17-4, PBC-17-5, PBC-17-6, PBC-17-7, PBC-17-8, PBC-17-9, PBC-17-10, PBC-17-11, PBC-17-12, PBC-16-13, PBC-17-14, PBC-17-15, PBC-17-16 (PBC-17-16 is a duplicate of PBC-17-16)

Shaded sample numbers indicate duplicates

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2153

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-4
WBS NO.: 50.03.40.03	Page 1 of 1
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 5/2/97

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Field Change Notice:

2153

Variance Comparability Study Part B Rev. 0, number 50.03.40.03-3 dated 4/28/97, identified a duplicate sample to be taken in Area 17 at PBC-17-16. A verbal variance was given on ~~5/2/97~~ to move the duplicate location to PBC-17-15.
5/1/97 JHW 5/2/97

INFORMATION ONLY

Justification:

An error was made in identifying PBC-17-16 as a duplicate of itself. PBC-17-16 is not a location. It is only the number designation of the duplicate. The highest sample location number was 15. Therefore the duplicate was taken from PBC-17-15.

Requested by Joan White 5/2/97

X IF RED	VARIANCE/FAN APPROVAL	DATE	X IF RED	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	5-2-97	X	PROJECT MANAGER	05/02/97
	DATA QUALITY MANAGEMENT		X	FIELD MANAGER	5-2-97
	ANALYTICAL CUSTOMER SUPPORT			OTHER	5/2/97
	OTHER			OTHER	

VARIANCE/FAN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

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PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-5
WBS NO.: 50.03.40.03	Page 1 of 7
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 5/12/97

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Field Change Notice:

Test Areas 18 and 19 are located in the in the Sludge Drying Beds of the Sewage Treatment Plant located in the Eastern portion of the FEMP site. These Test Areas were chosen as locations for this comparability study through survey type HPGe screening reading and Troxler Moisture readings taken in this area the week of May 5, 1997. Eight locations were read at the 1 meter height for 15 minutes (See Figure 1). Based on these readings 2 Test Areas were chosen for further study (between locations 1 and 2, and between locations 3 and 4). These Test Areas were chosen because there concentration of total uranium is near OSDF WAC and the Test Areas are expected to have sufficient amount of sludge from which to collect a sample. In the most northern locations there was no sludge at all. There is expected to be about 4" of sludge in the most southern locations.

Area 18- between locations 1 (230 pCi/g) and location 2 (321 pCi/g) unmoisture corrected (690 ppm - 963 ppm)
Area 19- between locations 3 (315 pCi/g) and location 4 (212 pCi/g) unmoisture corrected (945 ppm - 636 ppm)

INFORMATION ONLY

These Test Areas will be measured in accordance with the Comparability Study PSP Rev 0 as High Designation Areas (above 200 ppm Total Uranium). The following activities will be conducted:

1- Surveying will be conducted for the HPGe locations and sample locations using the Global Positioning System (GPS) or the Total Station. Test Area locations will be marked with a survey flag and coordinates recorded in the Sitewide Environmental Database.

2-Air temperature (Site Communication Center temperature reading is acceptable), dried sludge temperature (acquired by placing a thermometer in the ground), and humidity readings (either taken in the field or received from the Site Communications Center is acceptable) will be recorded for each day that HPGe and NaI readings are being conducted.

3-HPGe readings will be collected at the center point in Test Area 18 and 19 (See Figure 2). Two HPGe readings will be taken at the 1 meter height and two readings will be taken at the 30 cm heights. Each reading will be conducted for 15 minutes (900 seconds). One duplicate will be taken at either of the two heights at one of the 3 Areas.

4-A Troxler Moisture reading of the dried sludge will be taken at the HPGe reading locations in Test Area 18, and 19. Moisture cores will only be taken if Troxler readings are unable to be conducted due to media inconsistency.

5-Static NaI readings will be conducted at each of the HPGe locations, or as close as to the HPGe locations as accessible. The readings will be collected in the static mode for 15 minutes (900 seconds). One duplicate NaI reading will be taken at one of the 3 Test Areas. If the Test Area is accessible to the RTRAK, the RTRAK will be used. If the Test Area is inaccessible to the RTRAK, a portable NaI system could be employed. If any NaI detector readings are impossible to obtain, the requirement to perform NaI readings will be dropped. If the NaI readings are taken on a different day than the HPGe/Troxler Moisture readings, the Troxler Moisture readings will be repeated over the HPGe location being read by the NaI that day.

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6-Physical samples: A grid containing 15 sample locations will be set up within each of the two designated Test Areas. One duplicate sample, identified as Sample #16 will be taken at one of the 15 designated points chosen at random in each of the two designated Test Areas (See Table 1). Sampling will be performed in accordance with procedure SMPL-01, Rev.1. The samples will be collected from 0-4" (if sufficient dried sludge media is present) using a 2" or 3" diameter stainless steel or plastic liner core sampler (SMPL-01, Rev.1, Section 6.8). If field conditions make this method impractical, the media can be collected with an auger (Section 6.6) or a scoop (Section 6.3). The gravel assumed to be underlying the sludge is not to be included in the sample. The duplicate sample will be collected in accordance to SMPL-21, Rev.0, Section 6.5.6. The duplicate core and the original adjacent sample core will be divided in half vertically and opposite halves will be combined to create two separate samples. The original core tubes used to collect the soil will be used as the final sample containers. The sample numbers will have the designators PBC (Part B Comparability) and the Test Area being sampled. For example location number 1 in Area 18 will be identified as PBC-18-1. Physical sample coordinates are identified on Table 2.

2153

7- Field Activity Logs (FALs) will reference this variance number 50.03.40.03-5.

8-Laboratory analysis: Analytical analysis for these samples is considered to be at ASL B as specified in the PSP/DQO. However, due to special task specific analysis requirements, the lab QC must include a matrix spike which is not included in ASL B. Analysis will be conducted by the on-site or off-site laboratory for Total Uranium by alpha spectroscopy to ASL D. ASL D analysis is being requested so matrix spikes will be performed. The current The high organic content of the samples will need matrix spikes to get better quality control. If the samples are analyzed on-site, no ASL D data package will be generated. If the samples are analyzed off-site, an ASL D package can be requested. No data data validation needs to be performed for the samples.

Justification:

Establish Test Areas 18 and 19 in the Sludge Drying Beds (Sewage Treatment Plant) for the purpose of generating additional data to establish the comparability of HPGe and NaI, compared to physical sample results for Total Uranium readings at various levels up to approximately the Onsite Disposal Facility (OSDF) Waste Acceptance Criteria (WAC) of 1030 ppm Total Uranium.

Requested by: Joan White 5/12/97

X IF RED	VARIANCE/FAN APPROVAL	DATE	X IF RED	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	5-13-97	X	PROJECT MANAGER	05/13/97
	DATA QUALITY MANAGEMENT		X	FIELD MANAGER	5-13-97
	ANALYTICAL CUSTOMER SUPPORT		X	Field Manager Real Time Monitoring	5/12/97
	OTHER			OTHER	5/13/97

VARIANCE/FAN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

000018

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

TABLE 1

AREAS 18 AND 19 SLUDGE DRYING BEDS
COMPARABILITY STUDY

			Location and Number of Samples					
Area #	Area Location	Area Designation	Center	1 Meter Circle	3 Meter Circle	Duplicate Sample	Total	Sample Numbers
18	North of SE Corner	High	1	4	10	1	16	PBC-18-1, PBC-18-2, PBC-18-3, PBC-18-4, PBC-18-5, PBC-18-6, PBC-18-7, PBC-18-8, PBC-18-9, PBC-18-10, PBC-18-11,PBC-18-12, PBC-18-13,PBC-18-14, PBC-18-15, PBC-18-15 PBC-18-16 (PBC-18-16 is a duplicate of PBC-18-5)
19	SE Corner	High	1	4	10	1	16	PBC-19-1, PBC-19-2, PBC-19-3, PBC-19-4, PBC-19-5, PBC-19-6, PBC-19-7, PBC-19-8, PBC-19-9, PBC-19-10, PBC-19-11, PBC-19-12, PBC-19-13, PBC-19-14, PBC-19-15, PBC-19-16 (PBC-19-16 is a duplicate of PBC-19-12

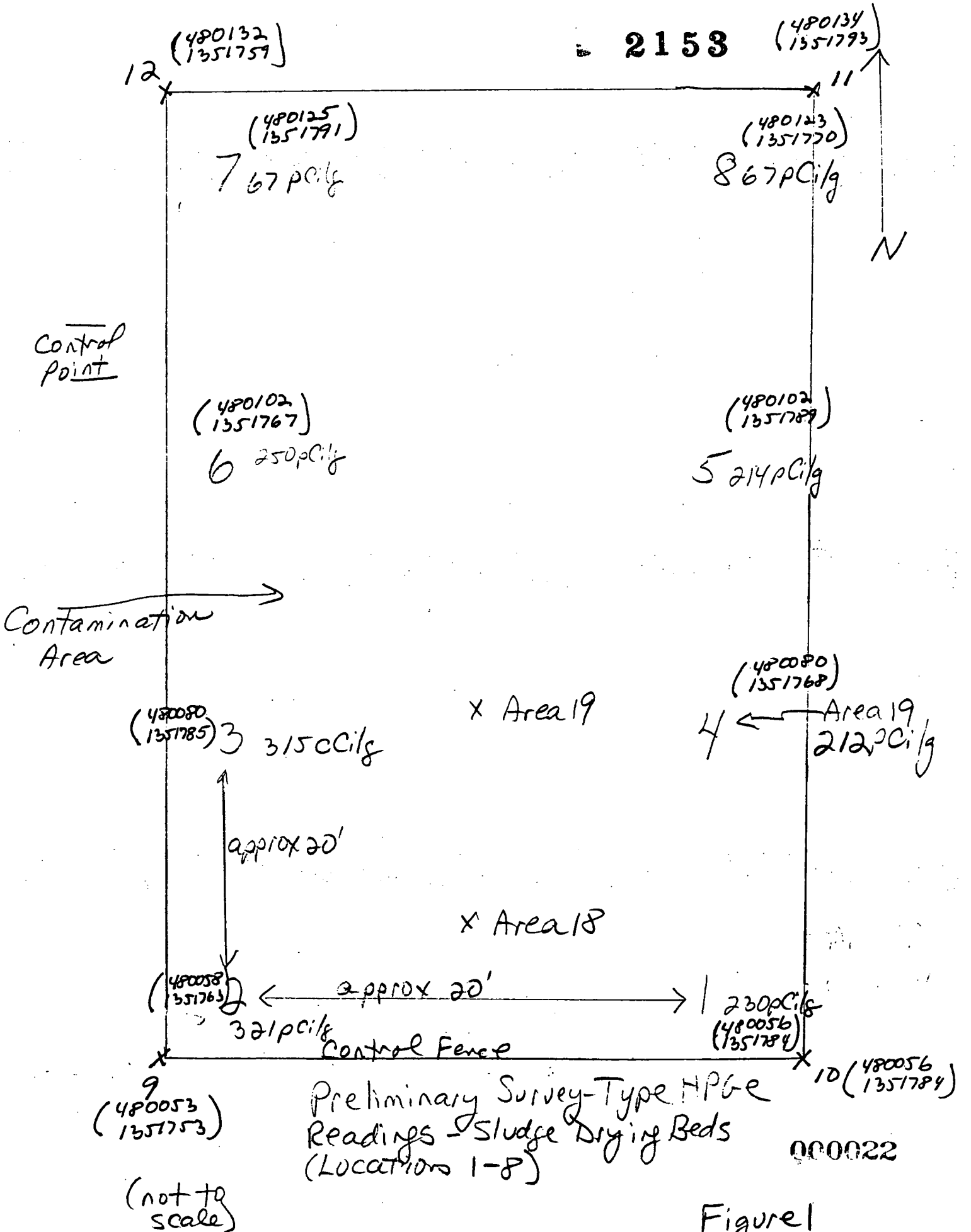
Shaded sample numbers indicate duplicates

000019

TABLE 2
AREAS 18 AND 19 SLUDGE DRYING BEDS, SEWAGE TREATMENT PLANT

AREA NUMBER SAMPLE POINT NUMBER	MAP POINT NUMBER	NORTHING/EASTING
AREA 18		
PBC-18-1	1	480061.62/1351774.355
PBC-18-2	2	480065.48/1351774.69
PBC-18-3	3	480061.29/1351778.17
PBC-18-4	4	480057.855/1351773.895
PBC-18-5	5	480062.175/1351770.535
PBC-18-6	6	480071.445/1351775.38
PBC-18-7	7	480068.94/1351781.015
PBC-18-8	8	480063.715/1351783.800
PBC-18-9	9	480057.64/1351783.21
PBC-18-10	10	480053.195/1351779.315
PBC-18-11	11	480051.92/1351773.585
PBC-18-12	12	480054.35/1351767.89
PBC-18-13	13	480059.515/1351764.755
PBC-18-14	14	480065.56/1351765.495
PBC-18-15	15	480070.365/1351769.38
PBC-18-16	DUPLICATE OF POINT 5	480062.175/1351770.535
AREA 19		
PBC-19-1	1	480081.82/1351776.385
PBC-19-2	2	480077.82/1351775.955
PBC-19-3	3	480082.37/1351772.54
PBC-19-4	4	480085.805/1351776.915
PBC-19-5	5	480081.48/1351775.500
PBC-19-6	6	480072.12/1351775.500

PBC-19-7	7	480074.64/1351769.915
PBC-19-8	8	480079.915/1351766.66
PBC-19-9	9	480085.77/1351767.475
PBC-19-10	10	480090.09/1351771.175
PBC-19-11	11	480091.63/1351777.15
PBC-19-12	12	480089.195/1351783.06
PBC-19-13	13	480084.045/1351785.97
PBC-19-14	14	480077.81/1351785.225
PBC-19-15	15	480073.315/1351781.335
PBC-19-16	DUPLICATE OF POINT 12	480089.195/1351783.06
END OF TABLE		

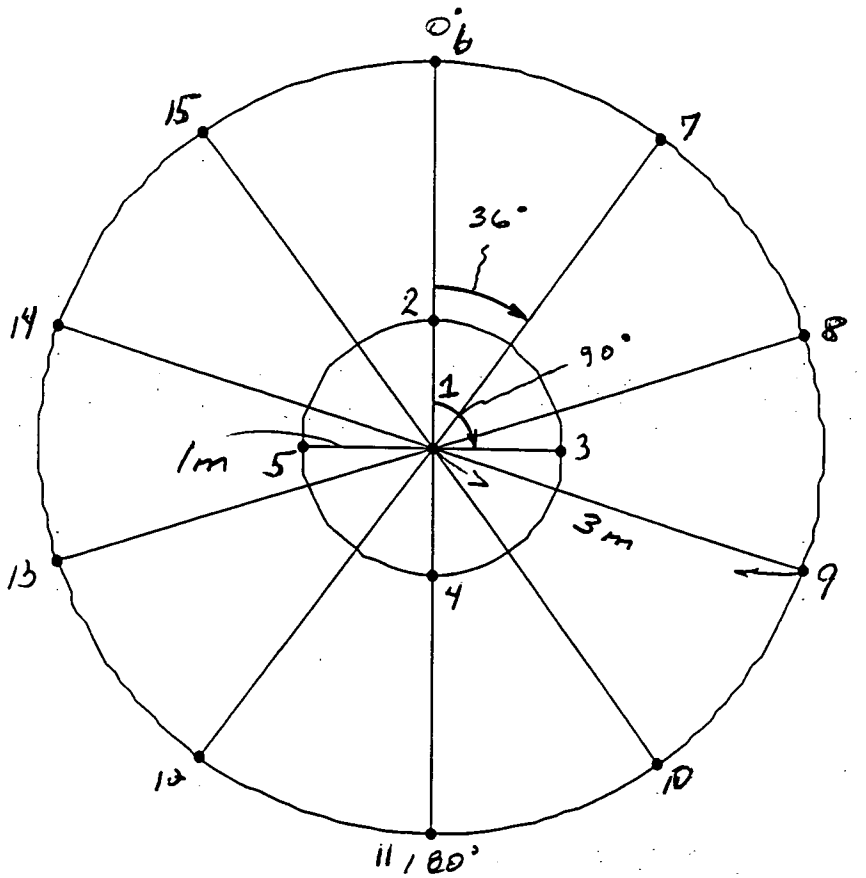


Preliminary Survey-Type HPGe Readings - Sludge Drying Beds (Locations 1-8)

(not to scale)

Figure 1

1:5



Areas 18+19

High Designation Sample Layout

Lime Sludge Beds
Sewage Treatment Plant

Figure-2

VARIANCE / FIELD CHANGE NOTICE

V/F 50.03.40.03-6

WBS NO.: 50.03.40.03 Project / Document #: 20701-RP-000024

Page 1 of 1

PROJECT TITLE: Part B Comparability Study Rev 0 8/6/97

Date: 08/01/97

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Field Change Notice:

2153

The purpose of this variance is to add HPGe detector No. 40743 to the QC Control Point Study being conducted on a daily basis at point 500349-15 just north of the Sewage Treatment Plant. Beginning with detector No. 30687, the detectors will be utilized one each day, incorporating detector No. 40743. If a non-work day or a weekend interrupts the study, technicians will pick up where they left off using the next detector in series.

This variance replaces Variance 50.03.40.03-1 requiring detector No. 30687 (#1) to be used on Monday, 30716 (#2) to be used on Tuesday, etc.

Justification:

In order for detector No. 40743 to collect data that is scientifically defensible, it must be QC "checked" with the other detectors at the QC Control point (500349-15).

INFORMATION ONLY

REQUESTED BY: Mike Heinen MJH Date: 08/01/97

X IF REQD	VARIANCE/FCN APPROVAL	DATE	X IF REQD	VARIANCE/FCN APPROVAL	DATE
X	QUALITY ASSURANCE R. Fuike	8-5-97	X	PROJECT MANAGER	08/05/97
	DATA QUALITY MANAGEMENT		X	FIELD MANAGER J H Wheeler	8/6/97
	ANALYTICAL CUSTOMER SUPPORT		X	Field Characterization Manager J H Wheeler	8/6/97
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

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PROJECT MANAGER:	DOCUMENT CONTROL: Esther Dittmer	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-7
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #: 20701-RP-~~001~~ 0001	Page 1 of 3
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 8/6/97

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Justification:

To assist in interpretation of HPGe control chart data, physical sampling is required. Physical sampling will enable the Project Lead to determine the effects of varying environmental conditions on reported HPGe concentration values.

Field Change Notice:

This variance extends the type of measurements at the HPGe Field Quality Control Point area, as established in variance 50.03.40.03-2, to include physical soil sampling for laboratory analysis of radiologicals. The Field Quality Control Point is designated as station #15 in Area 11 of the RTRAK Applicability Study (PSP 50.30.49) and is located North of the Sewage Treatment Plant at a northing of 480391.4131 and easting of 1351675.862.

Variance 50.03.40.03-2 originally established the HPGe Field Quality Control Point measurement data to include HPGe, air temperature, soil moisture, and humidity. This variance extends the PSP to include physical sampling for the determination of total Uranium, Thorium-232, Radium-226, Cesium-137, and Potassium-40 concentrations.

Test Setup and documentation:

In addition to the requirements as outlined in PSP 50.03.40.03 section 2, the following guidance will be followed:

1) The area sampling pattern will be designated as a Medium Contamination Sampling Pattern area (C-2) as described in section 2.4. Area 11 station #15 (PSP 50.03.49) will serve as sample point #1 of 10 in the pattern. The attachment to this variance has been provided to display the sample location layout.

2) Each sample point will be located and staked prior to sampling in accordance with section 2.4.2.

3) Location numbering will utilize the following system: RTRAK Baseline Study (RBS) followed by the area number (11) followed by the sample location number (1 through10).

   Example: Sample point 1 will be designated as RBS-11-1.

4) Quality assurance samples will include one field duplicate in the area as described in section 2.4.4. The duplicate sample will be at sample location #5 and will be numbered as: RBS-11-5D.

5) The sample core dimensions will be 3-inches in diameter at a collection depth of 0-4-inches in accordance with section 2.4.2.

6) Laboratory sample preparation by the onsite laboratory will be in accordance with section 2.4.5 with extreme emphasis on sample blending. The sample shall be thoroughly homogenized. The preparer shall ensure there are no visible heterogeneities evident.

7) All samples will be collected at and analyzed to ASL B. In addition, laboratory matrix spikes shall be performed.

8) The sample analyte list of Table 2-2 section 2.4.2 will be modified to exclude analysis for Radium-228.

9) Isotopic Uranium, Thorium-232, and Radium-226 will be analyzed by alpha spectroscopy, Potassium-40 and Cesium-137 will be analyzed by gamma spectroscopy.

10) This variance will be referenced on all Field Activity Daily Log sheets.

REQUESTED BY: Dale Seiller Date: 8/5/97

INFORMATION ONLY

X IF REQD	VARIANCE/FCN APPROVAL	DATE	X IF REQD	VARIANCE/FCN APPROVAL	DATE
X	QUALITY ASSURANCE	8-7-97	X	PROJECT MANAGER	08/07/97
	DATA QUALITY MANAGEMENT		X	FIELD MANAGER	8/7/97
	ANALYTICAL CUSTOMER SUPPORT			OTHER	8/7/97
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

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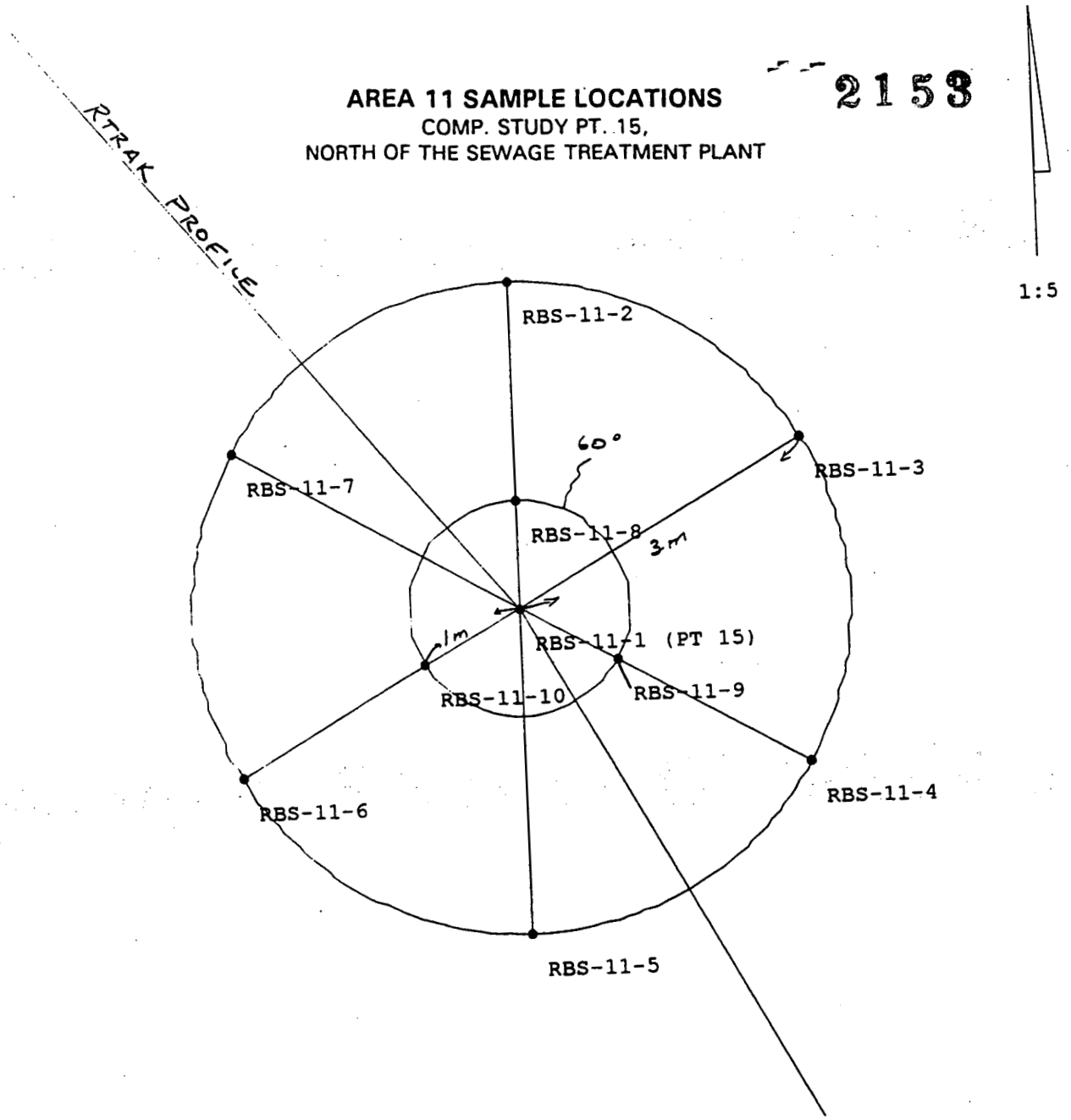
PROJECT MANAGER:	DOCUMENT CONTROL: Esther Dittmer	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

ATTACHMENT
50.03.40.03-7

8/6/97
GRID.CGI

2153

AREA 11 SAMPLE LOCATIONS
COMP. STUDY PT. 15,
NORTH OF THE SEWAGE TREATMENT PLANT



NORTHING	EASTING	DESCRIPTION
480391.4131	1351675.8618	RBS-11-1 (PT 15)
480401.2531	1351675.8618	RBS-11-2
480396.3331	1351684.3835	RBS-11-3
480386.4931	1351684.3835	RBS-11-4
480381.5731	1351675.8618	RBS-11-5
480386.4931	1351667.3401	RBS-11-6
480396.3331	1351667.3401	RBS-11-7
480394.6931	1351675.8618	RBS-11-8
480389.7731	1351678.7023	RBS-11-9
480389.7731	1351673.0212	RBS-11-10

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-8
WBS NO.: 50.03.40.03, Project Number 20701-0001	Page 1 of 2
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 11/13/97

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Field Change Notice:

This variance extends Variance 50.03.40.03-2 of the Comparability Study Part B, to perform an ADDITIONAL test at the HPGe Field Quality Control Point for a period of 20 test intervals. This additional test will call for the collection of data at 3 detector heights at 2 collection times. The test will be collected twice a day until a minimum of 20 collection times are completed. In addition a moisture reading using the Troxler (no moisture core permitted), a temperature, and humidity reading (if possible) will be collected for the read area each time the test is performed.. One detector will be used for the test since one detector is permanently mounted to the tripod which extends to the lowest height.

Test Set Up

1) FIRST-Record one Troxler soil moisture reading before each test begins. If the soil is too moist to conduct a Troxler moisture reading, the soil will be assumed to be saturated and noted on the logs. NO MOISTURE CORES WILL BE TAKEN, this would remove the Control Point needed to conduct the test.

INFORMATION ONLY

2) SECOND - The detector will be set up at a detector height of 15 cm and a 5 minute and 15 minute read collected.

3) THIRD - The detector will be set up at a detector height of 1 meter and a 5 minute and 15 minute read collected.

4) FOURTH - The detector will be set up at a detector height of 31 cm and a 5 minute and 15 minute read collected. The 31 cm reading will be recorded last to ensure the more critical 15 cm and 1 meter readings are collected in the event rain begins.

5) No duplicate HPGe readings will be collected, since the 20 tests in themselves is a duplicate.

6) Note vegetation presence/absence, air temperature, and humidity (if possible).

7) The sample description will include the detector number, detector height, run time, area, point #, date, mR (microR reading) and run number. The sample number will be 500349-15-1 through 20. (500349 is the project number, 15 stands for Field Quality Control Point 15, 1 through 20 stands for test readings 1 through 20).

Justification:

This additional test at the control point will collect data to determine the difference in pCi/g (if any) between readings collected at 5 minute count time vs the customary 15 minute count time, and to determine the difference in pCi/g (if any) between data collected at a 15 cm detector height vs the customary 31 cm and 1 meter detector heights.

If the test shows no significant differences between the 5 minute and the 15 minute data, and between the 15 cm data and the 31/100 cm data, the 5 minute read time and the 15 cm detector height will be considered an option for use in the Soils Remediation Project for VAC soil identification.

CONTINUED ON FOLLOWING PAGE....

ORIGINAL

X IF REQD	VARIANCE/FCN APPROVAL	DATE	X IF REQD	VARIANCE/FCN APPROVAL	DATE
X	QUALITY ASSURANCE	11-13-97	X	PROJECT MANAGER	11/13/97
	DATA QUALITY MANAGEMENT		X	Characterization and Sampling Manager	11/13/97
	ANALYTICAL CUSTOMER SUPPORT			OTHER	11/13/97
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

2153

CONTINUED FROM PAGE 1...

The test data will be compared to data collected at the Field Quality Control Station collected since April 1997 to help determine if significant differences occur.

The Field Control Point is located North of the Sewage Treatment Plant, at Station #15 (50349-15) northing 480391.4131 and easting 1351675.862. The HPGe Field Quality Control Point has a HPGe reading of approximately 80 ppm U 238 (moisture corrected).

REQUESTED BY: Joan White Date: 11/13/97

ORIGINAL

000029

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-9
WBS NO.: 50.03.40.03, Project Number 20701-0001	Page 1 of 2
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 11/25/97

.RIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Field Change Notice:

Cease collecting data under Variance 50.03.40.03-8.

Justification:

This variance ends the test being performed under Variance 50.03.40.03-8 after completion of 10 sets of data. The test called for 20 sets of test data collected at 3 detector heights at 2 collection times. After collecting and analyzing 9 sets of data (data attached), the correlation between the data detector heights and collection times has been established. Completion of the remaining 10 sets of data is not necessary.

INFORMATION ONLY

REQUESTED BY: Joan White JHW Date: 11/24/97

X IF REQD	VARIANCE/FCN APPROVAL	DATE	X IF REQD	VARIANCE/FCN APPROVAL	DATE
X	QUALITY ASSURANCE RJ Fiske	11-25-97	X	PROJECT MANAGER J White for Chris Sutton	11/25/
	DATA QUALITY MANAGEMENT		X	Characterization and Sampling Manager J White	11/25/97
	ANALYTICAL CUSTOMER SUPPORT			OTHER	11/25/97
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

ORIGINAL

2153

	A	B	C	D	E	F
1		Total Uranium, Wet W		2, Wet Wt. (p	Wet Wt. (p	6, Wet Wt. (p
2		15 cm, 300 sec. data				
3		N=	9			
4		Ave=	71.85	0.88	10.36	1.00
5		SD=	2.41	0.03	0.27	0.17
6		15 cm, 900 sec. data				
7		N=	9			
8		Ave=	71.32	0.85	10.36	0.99
9		SD=	1.71	0.02	0.25	0.16
10		31 cm, 300 sec. data				
11		N=	9			
12		Ave=	70.69	0.87	10.34	1.03
13		SD=	2.81	0.03	0.45	0.17
14		31 cm, 900 sec. data				
15		N=	9			
16		Ave=	69.89	0.86	10.33	1.01
17		SD=	1.73	0.03	0.25	0.16
18		100 cm, 300 sec. data				
19		N=	9			
20		Ave=	67.06	0.83	10.08	1.00
21		SD=	3.04	0.04	0.30	0.21
22		100 cm, 900 sec. data				
23		N=	9			
24		Ave=	65.76	0.83	10.03	0.98
25		SD=	2.43	0.02	0.16	0.19

Page 2 of
Variance 50.03, 40.03-9

VARIANCE / FIELD CHANGE NOTICE	V/F50.03.40.03-10
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #: 20701-0001	Page 1 of 3
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 12/8/97

VARIANCE / FIELD CHANGE NOTICE (Include justification): 2153

Justification: This variance to the Comparability Study, Part B, Rev 0. PSP is necessary to provide additional data points for total uranium analysis at WAC levels. This data will provide a statistical basis for data already collected where uranium contamination in soil is heterogeneously dispersed.

Field Change Notice: This variance extends the Comparability Study, Part B study areas to include two (2) additional areas within the Drum Bailing Area which exhibit heterogeneous uranium contamination in the soil. These areas will be designated as areas 20 and 21.

Sampling and measurement strategy for these two areas will be as outlined in the following area specific section of this variance. All measurement and sample locations will be surveyed and marked. Every effort should be made to collect physical samples from each area on the same day as the HPGe measurements are made. HPGe measurements should not be taken until the soil has dried after a rain. HPGe measurements should not be made until after 12:00 p.m. to avoid possible radon interferences and for consistency with other HPGe measurements made for comparability purposes. A geologist's description of each sample location as required in section 2.4.2 of the original PSP is not required for this variance. Field sample homogenization will be performed as outlined in section 6.6 of procedure SMPL-21.

Area 20 This area corresponds to Segment five (5) of the RTRAK Applicability Study Addendum (20701-RP-0002). One (1) HPGe measurement and duplicate will be taken at 1 meter and 1 foot for a total of four (4) measurements at northing 481719.84 and easting 1350515.992. This point is designated as point #1 and the HPGe acquisition time will be 900 seconds. The measurement identification numbers will be designated using the sequence of the following example:
PBC-20-1-2-B-G

INFORMATION ONLY

Where:

- PBC = Part B Comparability
- 20 = Area 20
- 1 = Measurement point #1
- 2 = The second measurement at this point (duplicate)*
- A = Detector height (A=15cm, B=31cm, C=1M)
- G = Gamma

The example identifies the second measurement taken in area 20 at point #1 at a detector height of 31cm.

* The duplicates will be the second and fourth measurements.

Fifteen (15) physical samples will be collected plus one (1) duplicate following the sampling pattern of Figure 2-5 in the Comparability Study PSP. Physical samples will be taken after HPGe measurements are completed. Sample number PBC-20-1 will correspond to the measurement point listed above for the HPGe measurements. Samples will be taken at a depth interval of 0-4 inches using either a 2 or 3 inch diameter core. All sample cores will have the same core diameter, either 2 or 3 inches. The laboratory method of analysis will be Bromo-PaDAP at ASL D with no data validation. TPUs at 1.96 sigma will be reported with the data. **Because these samples have the potential to be heterogeneous, extra care shall be taken when homogenizing and grinding the samples.** Moisture will be determined at the laboratory. No field moisture measurements will be taken. Data will be reported in FACTS on a wet weight basis. Section 2.4.3 and Table G-1 of the Comparability Study PSP provides sample identification labeling guidance. The sample identification numbers will be PBC-20-1 thru PBC-20-16. The duplicate will be collected from sample location PBC-20-2 and will be identified as PBC-20-16. A minimum of one rinsate sample shall be collected.

ORIGINAL RB 000032

REQUESTED BY: Joan White Date: 12/8/97

Area 21 This area corresponds to Segment one (1) of the RTRAK Applicability Study Addendum (20701-RP-0002). Figure 1 of this variance shows the measurement and sample grid system to be used in this study area. One (1) HPGe measurement and duplicate will be taken at 1 meter and 1 foot for a total of four measurements at grid point 27. Point 27 is the designated center of the grid at northing 481667.06 and easting 1350514.149. One (1) HPGe measurement and duplicate will be taken at the 1 foot detector height at grid points 14, 17, 37, and 40 for a total of two measurements at each location. The measurement identification numbers will be designated using the sequence of the following example.

PBC-21-1-2-B-G Where:

- PBC = Part B Comparability
- 21 = Area 21
- 1 = Measurement point #1
- 2 = The second measurement at this point (duplicate)*
- A = Detector height (A = 15cm, B = 31cm, C = 1M)
- G = Gamma

2153

The example identifies the second measurement taken in area 21 at point #1 at a detector height of 31cm.

* The duplicates will be the even number measurements.

Physical samples will be taken at the grid points as indicated in Figure 1 of this variance. Physical samples will be taken after HPGe measurements are completed. Samples will be taken at a depth of 4 inches using either a 2 or 3 inch diameter core. All sample cores will have the same core diameter, either 2 or 3 inches. The laboratory method of analysis will be Bromo-PaDAP at ASL D with no data validation. TPUs at 1.96 sigma will be reported with the data. **Because these samples have the potential to be heterogeneous, extra care shall be taken when homogenizing and grinding the samples.** Moisture will be determined at the laboratoy. No field moisture measurements will be taken. Data will be reported in FACTS on a wet weight basis. Section 2.4.3 and Table G-1 of the Comparability study PSP provide sample identification labeling guidance. The sample point identification numbers will be PBC-21-1 thru PBC-21-53. Duplicate samples will be collected from locations PBC-21-1, PBC-21-40, and PBC-21-51 and will be identified as PBC-21-54, PBC-21-55, and PBC-21-56 respectively. A minimum of one rinsate sample shall be collected.

X IF	VARIANCE/FCN APPROVAL	DATE	X IF REQD	VARIANCE/FCN APPROVAL	DATE
X	QUALITY ASSURANCE	12-11-97	X	PROJECT MANAGER	12/12/97
	DATA QUALITY MANAGEMENT		X	FIELD MANAGER	12/15/97
	ANALYTICAL CUSTOMER SUPPORT		X	Real-time Manager	12/11/97
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Esther Dittmer	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

2153

Measurement/Sample grid for Area 21

1:10

POINT #27 (481667.06, 1350514.149)

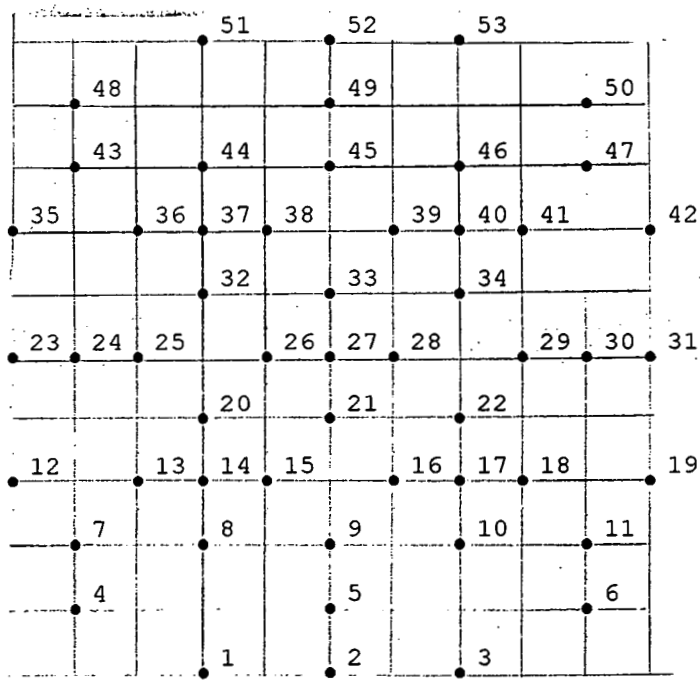


Figure 1

ORIGINAL

VARIANCE / FIELD CHANGE NOTICE	V/F50.03.40.03-11
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #: 20701-0001	Page 1 of 4
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 5/12/98

VARIANCE / FIELD CHANGE NOTICE (Include justification): 2153

Justification:
This variance to the Comparability Study, Part B, Rev 0. PSP is necessary to collect data to determine the degree of gamma photon attenuation due to grass presence within the field of view of an HPGe detector. The test will measure gamma energy detected by the HPGe detector at 4 grass heights (simulating various grass heights under typical field conditions) at three detector heights. If the results of the test determine that grass height significantly affects gamma ray attenuation then a grass attenuation correction factor will be developed. Wait until dew is dry before starting, if possible.

Field Change Notice:
This variance extends the Comparability Study, Part B to perform an additional test to determine the effect of grass on HPGe measurements. The test will consist of collecting several HPGe measurements at the test location in one day to eliminate the effects of any environmental variables such as moisture, temperature, and humidity from the test results. The test will be conducted at a location chosen in A1P2 adjacent to the field quality control point. The coordinates of the location are northing 480327.66 and easting 1351739.59. The test area extends outwards approximately 21 feet in all directions from the test location (Figure 1). This area was chosen for the height of the grass (currently thigh high) and for its homogeneous distribution of the primary radiological constituents of concern.

Test Procedure:

INFORMATION ONLY

Step 1. MARK THE AREA - Mark the location for detector placement. Mark the field of view using stakes extending out in a 21 foot radius from the detector location. To ensure a 21 foot radius is achieved, stakes are to be placed out 29 feet in each direction from the center point. Mark a smaller 6 feet by 6 feet square within the field of view area. This is where the grass is to be collected as indicated in Step 6 of this variance.

Step 2. COLLECT INITIAL MOISTURE MEASUREMENT - Prior to collecting any HPGe measurements, record one Troxler soil moisture reading. The description of this measurement is GTP-1-G.

Step 3. MEASURE THE GRASS HEIGHT - Measure the grass height at 4 random locations within the field of view and average the four measurements. The average will represent the grass height for the grass level being tested. Record the four individual grass heights and the average grass height on the Field Activity Data Log.

Step 4. RECORD ENVIRONMENTAL CONDITIONS - Record the temperature and the humidity (humidity is important to determine if dew is present which might affect the gamma measurements). Note in Field Activity Data Log if any visible dew is present on the grass.

Step 5. COLLECT HPGe MEASUREMENT - Set up the HPGE detector in the center of the test location and collect one 15 minute spectra each from a height of 100 cm, 31 cm, and 15 cm (approx. 6 inches).

Step 6. CUT THE GRASS TO THE NEXT TEST HEIGHT - Cut the grass to the next grass height to be tested. Collect all the cut grass to the extent possible from the 6 foot by 6 foot area previously marked (see Step 1), and remove the remaining cut grass from the test area. Place the grass from the 6 feet X 6 feet test area in a plastic bag, seal the bag tightly to reduce moisture loss, and label the bag with the grass bag description number (see Grass Bag Description Number System below). Note in the field activity data log the effectiveness of removing the cut grass, estimate the percent of cut grass actually collected, and the collection method used. Cut grass can be removed by rake, blower or other equipment, as needed.

Step 7. REPEAT STEPS 3 THROUGH 6 - Repeat steps 3 through 6 until data from each of the following grass heights has been collected:

A = As found (approximately thigh high).
B = Approximately knee high.
C = Approximately 6 inches high.
D = As low as possible without disturbing surface soil (care must be taken to not remove any surface soil since this may remove and surface constituents of concern and affect the test results).

Step 8. GRASS SAMPLE MOISTURE ANALYSIS - Each bag of grass will be taken to the analytical lab for weighing. Each bag will be weighed to determine an approximate wet weight mass of grass from the 6 feet X 6 feet test area. The sum of all the weights from all the grass heights will indicate the total grass mass, while the individual bag weights will indicate the mass of grass at each grass height. An aliquot of grass from each bag will be collected as representative of the bag contents, weighed (when wet), then dried, and weighed again (when dry).

Step 9. COLLECT FINAL MOISTURE MEASUREMENT - After all spectra are collected, record one Troxler soil moisture reading. The description of this measurement is GTP-2-G.

HPGe Numbering System:

2153

The sample description for the HPGe measurements collected will be "GTP" (Grass Test Point) followed by the grass height (A, B, C, or D) , followed by the approximate detector height in cm (100, 31, 15) followed by 1 (for the first measurement), followed by the letter G (for gamma). This gives a description of GTP-C-31-1-G for the 1st measurement at a grass height of approximately 6 inches with the detector height of 31 cm. If a second measurement needs to be collected at the same grass height and detector height, it would receive the number 2 (GTP-C-31-2-G). A listing of the HPGe numbers to be used is as follows:

At grass height "A" :
GTP-A-15-1-G (15 cm height detector)
GTP-A-31-1-G (31 cm height detector)
GTP-A-100-1-G (100 cm height detector)

At grass height "B":
GTP-B-15-1-G (15 cm height detector)
GTP-B-31-1-G (31 cm height detector)
GTP-B-100-1-G (100 cm height detector)

At grass height "C":
GTP-C-15-1-G (15 cm height detector)
GTP-C-31-1-G (31 cm height detector)
GTP-C-100-1-G (100 cm height detector)

At grass height "D":
GTP-D-15-1-G (15 cm height detector)
GTP-D-31-1-G (31 cm height detector)
GTP-D-100-1-G (100 cm height detector)

One duplicate HPGe reading will be collected during the test. If the duplicate is collected at GTP-C-31-1-G, the duplicate will called GTP-C-31-1-G-D.

GRASS BAG NUMBERING SYSTEM:
The grass bag numbering system for the grass collected will be "GTP" followed by the letter in Step 7 above that correlates to the grass height before it was cut, followed by the letter G. The first bag of grass collected will then have the description GTP-A-G, the second bag of grass collected will be GTP-B-G and the third bag will be GTP-C-G.
If more than one bag of grass is collected for each grass height, the bags will have the same number and will indicate they are Bag 1 of 2, Bag 2 of 2, and so on.

REQUESTED BY: Joan White Date: 12/11/97

000036

ORIGINAL

V/F 50.03.40.03 (continued)

X IF	VARIANCE/FCN APPROVAL	DATE	X IF REQD	VARIANCE/FCN APPROVAL	DATE
X	QUALITY ASSURANCE Frank Thompson	5-13-95	X	PROJECT MANAGER [illegible]	5/13/95
	DATA QUALITY MANAGEMENT			FIELD MANAGER	
X	ANALYTICAL CUSTOMER SUPPORT Bill Westerman		X	Real-time Manager [illegible]	5/13/95
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO	REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Esther Dittmer	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
FIELD MANAGER:	OTHER:	OTHER:

ORIGINAL

2153

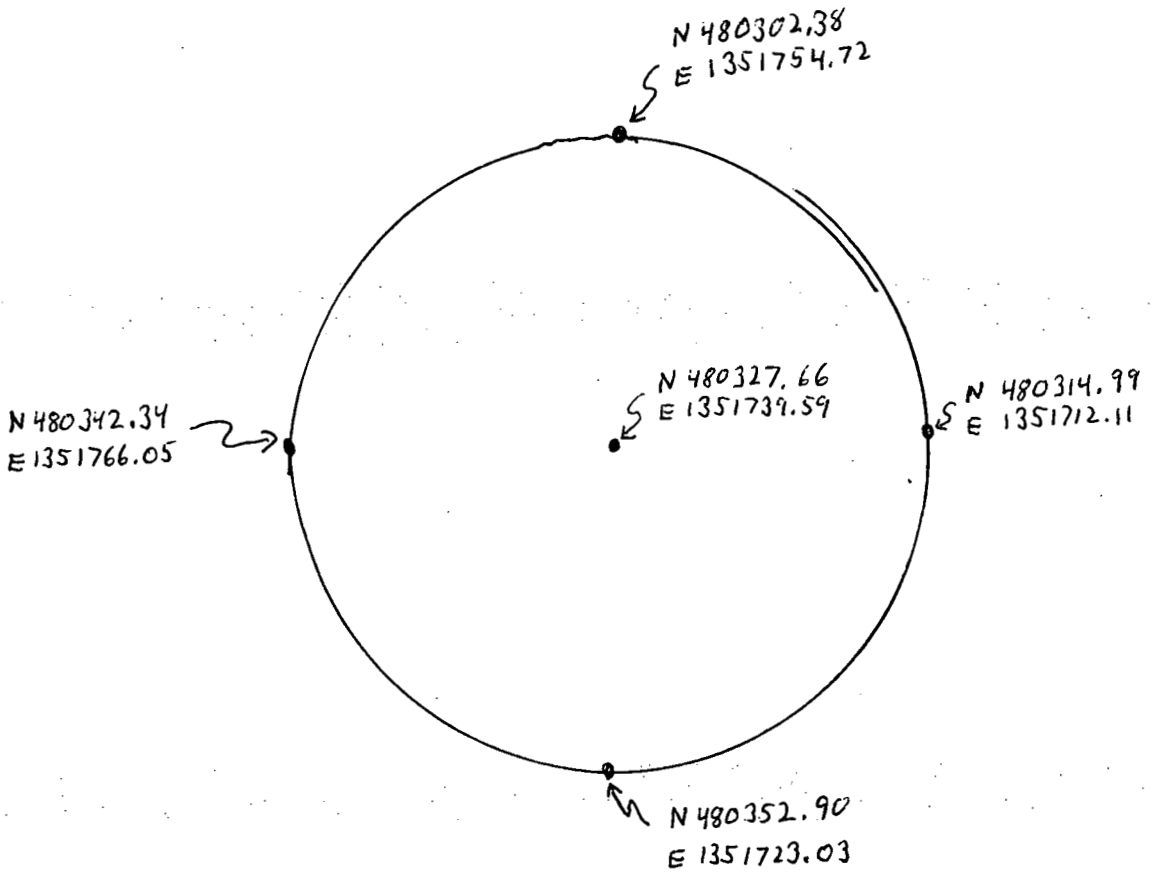


FIGURE 1 Grass Test Point

ORIGINAL

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-12
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #20701-001	Page 1 of 1
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 6/18/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Field Change Notice:

2153

This variance modifies variance 50.03.40.03-2 of the Comparability Study, Part B which established the Field Quality Control Point (FCC) and identified how the measurements were to be collected and at what frequency the measurements were to be collected.

This variance removes the requirement to collect one HPGe measurement at the FCC TWICE a day and replaces it with the requirement to collect one HPGe measurement at the FCC ONCE a day prior to the day's data collection data to ensure the HPGe system is operating within tolerance limits under the current environmental conditions. The measurement only needs to be made on days in which we are collecting data for production or for study purposes.

INFORMATION ONLY

Justification:

The HPGe Field Quality Control Point was established over a year ago to collect a year's worth of data showing the effects of various environmental conditions on HPGe system response. This data was collected and presented in a report to the regulators entitled User Guidelines Measurement Strategies, and Operational Factors for Deployment of In-Situ Gamma Spectrometry at the Fernald Site, Dated April 1998, Rev. A, Document # 20701-RP-0006. The study has been completed and there is no longer a need to collect environmental data for the study.

The FCC is being used as a measurement location for the generation of control charts to verify the HPGe systems are operating within controls established under procedure ADM-16 In-Situ Gamma Spectrometry Quality Control Measurements.

ORIGINAL

REQUESTED BY: Joan White DATE: 6/18/98

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	6-22-98	X	PROJECT MANAGER	6/22/98
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr	6/22/98
	ANALYTICAL CUSTOMER SUPPORT			OTHER	
	OTHER			OTHER Chris Simon	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

000039

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

VARIANCE / FIELD CHANGE NOTICE	VF/50.03.40.03-13
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #20701-001	Page 1 of 2
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 6/24/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Justification:
Several HPGe readings will be taken on the east and north side of Soil Pile 5 (SP5) in an attempt to determine the best way of distinguishing between shine (background radiation) and soil contamination.

2153

Field Change Notice:
Operation of the HPGes will be in accordance with EQT-23.

The general steps to be taken the day of the test are as follows:

1. Perform pre-operational checks on the detectors to be used.
2. Determine and mark the measurement points
3. Obtain a Troxler moisture indication of each point
4. Obtain a reading from the Field Quality Control point (point 15).
5. Perform the measurements at the designated points.
6. Obtain at least one duplicate measurement for every 20 designated measurements.
7. Perform post operational checks on the detectors.

INFORMATION ONLY

ORIGINAL

The guidelines for determining the measurement points are:

1. Attempt to get four readings spaced along a path running from the background interference (T-hoppers) and SP5. The last measurement will be on top of SP5 but must be close enough to the side to avoid the hillside from shielding the detector form the T-hoppers. NOTE, it may only be possible to get three points due to excessive background, rough terrain, and the above mentioned shield criteria.

2. Points will be marked out along approximately 4 of these path.

Continued on following page....

REQUESTED BY: Joan White DATE: 6/24/98

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE RAtriske	7-1-98	X	PROJECT MANAGER [signature]	7/1/98
	DATA QUALITY MANAGEMENT		X	Real-time Program Mg [signature]	7/1/98
	ANALYTICAL CUSTOMER SUPPORT			OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

Most measurements will be taken at a detector height of 1 meter. At least two points will also have measurement taken at 31cm in order to determine the effect of detector height on shine.

The sample description will be SH-X-H-1-G, where X is the sequential numbering of points to be measured during this test, H indicates the detector height in cm (ie. 100 for 1m), and the next one indicates the first measurement at that height and location. Duplicates or additional samples at that point and height will be numbered with the next sequential number.

2153

Modifications to locations, heights or other conditions may be made in the field by the field supervisor based on preliminary analysis of data, background radiation readings, or other factors noted during the test. All conditions and modifications will be noted in a field activity log and the entire test will be summarized in a test summary after the collection is complete.

VARIANCE / FIELD CHANGE NOTICE	VF/50.03.40.03-14
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #20701-001	Page 1 of 7
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 7/1/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Justification:

Conducted the shine test set up in Variance 50.03.40.03-13. The following is the field data as collected in the test.

Field Change Notice:

Various High Purity Germanium (HPGe) samples were collected at Soil Pile 5 (SP5) on June 18, 1998 for the purpose of evaluating potential methods to compensate for elevated background radiation (shine). The parameters that were varied include, location, detector height, and detector shielding. No reasonable means of placing a shadow shield between the detector and the source of background was available during the test.

A - Locations

In order to determine the shine at SP5 as a function of location, samples were taken at various points. A map of these points is included as attachment A. The locations of the points were selected to attempt to obtain a relatively straight line from the source of shine (T-hoppers) to the top of SP5. Four points were picked along the line that were approximately 50 feet apart. These distances varied due to the rough terrain. Three of these straight-line paths were selected. Due to the layout of the T-hoppers and the soil pile two of these lines intersected so only one point was gathered there (point 8) to represent both lines.

INFORMATION ONLY

Continued on following pages....

ORIGINAL

REQUESTED BY: Joan White DATE: 7/1/98

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	7/1/98	X	PROJECT MANAGER	7/1/98
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr	7/1/98
	ANALYTICAL CUSTOMER SUPPORT			OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

B -Other variables

In order to determine the effect of detector height two different detector heights were used at two separate locations (point 1 and point 5). Two spectra 113 and 114 were obtained from point 5 at a detector height of 1 meter and 31 cm. respectively. Points 1 and 5 were selected because the background radiation levels at those points were some of the highest and point 9 and 10 had various debris in the field of view. Some of the debris showed indications of being contaminated.

Four separate samples were taken at point 1. Spectra numbers 1465, and 1466 were taken at a detector height of 1 meter and 31 cm. respectively. Spectra numbers 1467, and 1468 were taken at a detector height of 31 cm. and 1 meter respectively. The later two spectra had a shield plate attached to the bottom of the detector. The purpose of the plate was to shield a large portion of the field of view from the detector without shielding the shine. Since on an individual spectrum, shine resembles contamination buried beneath a uncontaminated surface, the shielded reading can be compared with the unshielded reading to distinguish between these two conditions. Point one was selected because the shine was high and a low energy U-238 peak (93kev) was present on the 1m unshielded spectrum. The shield consisted of a 0.5 inch steel plate. The shielding properties of the plate was determined later in a low background area (T-305), by measuring a Eu source with and without the shield in place. Table 2 shows the net counts determined from these measurements

C - Misc. Information

Two detector systems were used for the test. Detector 30716 connected to dart (MCA) 186, and detector 31204 connected to dart 173. Below is a list of which spectra were collected with each detector.

2153

TABLE 1

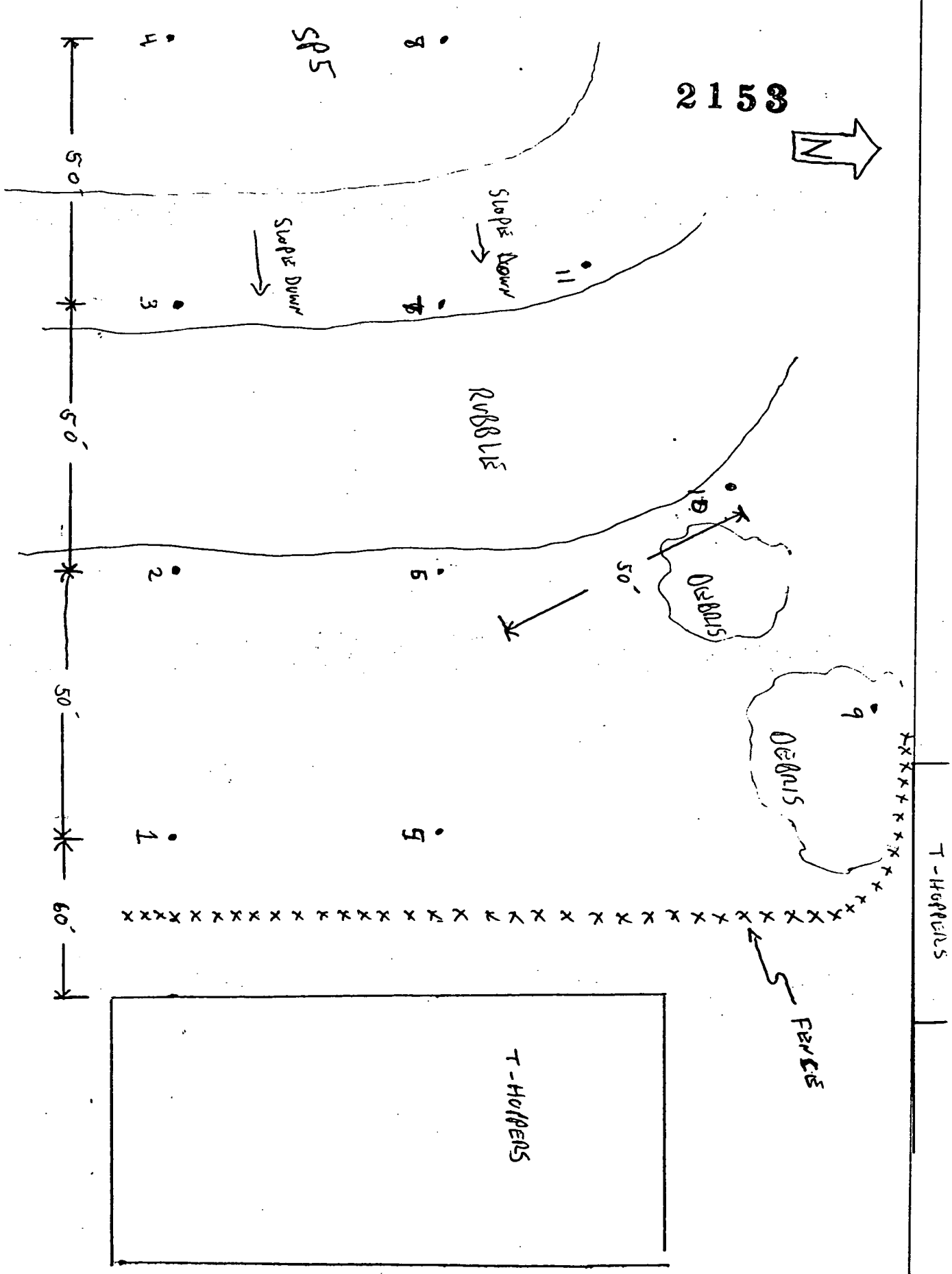
Sample point	Spectra number	Detector height	Detector number	comments
1	1465	1 m	30716	
1	1466	31cm	30716	
1	1467	31cm	30716	shield in place
1	1468	1m	30716	shield in place
2	112	1m	31204	rouble in field of view
3	1473	1m	30716	
4	117	1m	31204	
5	113	1m	31204	
5	114	31 cm	31204	
6	115	1m	31204	rouble in field of view
7	1472	1m	30716	
8	118	1m	31204	
9	1469	1m	30716	contaminate d debris in field of view
10	116	1m	31204	contaminate d debris in field of view
11	1470	1m	30716	
11	1471	1m	30716	Duplicate

All spectra were collected for 300 sec. (5 min.)
Temperature during the test was 88.8 degrees F. Humidity was 57% according to the met-tower, technicians conducting the test believe this indication to be in error.

2153

TABLE 2

Distance from detector to source = 1 meter, 5 min. reads		
Kev	Net Peak Area	
	Unshielded	Shielded
1408.47	13839	8331
779.27	12043	6279
121.70	75345	7327



22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

ATTACHMENT A

Project Name and No.: Soil Pile 5 Shine Test

uR meter S/N: Cal. Due Date: Check Source ID No.: Am-241 #535-2-3; Cs-137 #535-3-1; Co-60 #535-3-5

Detector S/N: 31204

Technician/Analyst (names and badge): L. McDonie! 76498

Multi-Channel Analyzer S/N: 173

Weather Conditions: Overcast, humid

PRE-OPERATION CHECK			
keV	Channel	Resolution	Net Peak Area
59.5	157.53	1.02	15638
661.6	1764.20	1.60	45884
1332.5	3553.94	2.28	24758

POST OPERATION CHECK			
keV	Channel	Resolution	Net Peak Area
59.5	157.30	1.07	15054
661.6	1765.32	1.62	45906
1332.5	3556.54	2.24	24741

Location	Run/File Number	Acq. Time	Duration	Det. Ht.	µR/hr	Excavation Level 1	2	3	>3	Comments
T-305	111.chn	~~1144~~	120s	1m	N/A	N/A				Pre Op Check
SH-2-100-1G	112.CHN	1121	300	1m	35	1				
SH-5-100-1G	113.CHN	1436	300	1m	60	1				
SH-5-100-1G	114.CHN	1446	300s	3km	50	1				
SH-6-100-1G	115.CHN	1457	300s	1m	25	1				
SH-10-100-1G	116.CHN	1513	300s	1m	35	✓				
SH-4-100-1G	117.CHN	1602	300s	1m	20	✓				
SH-8-100-1G	118.CHN	1611	300s	1m	20	✓				
T-305	119.CHN	1708	120s	1m	N/A	N/A				Post Op Ck

Variance 50.03.40.05-14

page 6 of 7

000047

FS-F-4781 (8/14/97)

Supervisor Signature _____ Date _____

TROXLER M STURE/DENSITY WORKSHE

Variance 50.03.40.03-14 page 7 of 7

PAGE 1 OF _

DATE: 6-18-98

PROJECT NAME/NO.: Soil Pile fire Shine Test

CONTROL NO.: 721

PREPARED BY (NAME/BADGE): Roger Knight III 2153

REVIEWED BY (NAME/BADGE):

GENERAL LOCATION: Soil Pile fire

WEATHER CONDITIONS: Sunny / Humid

AIR TEMPERATURE:

CALBRATION STANDARD

Moisture: 672 -0.1% P Density: 2632 -0.5% P

GAUGE SERIAL NO.: 26711

Test No.	Sample Location	Depth	% Moisture	Wet Density	Dry Density	Time
1	500349-15G	B/S	31.3	99.3	75.6	0853
2	SH-1	B/S	18.2	91.0	77.0	0923
3	SH-5	B/S	20.5	118.7	98.6	0926
4	SH-2	B/S	17.4	116.1	98.9	0928
5	SH-6	B/S	25.3	121.8	97.2	0930
6	SH-10	B/S	19.2	119.2	100.0	0933
7	SH-9	B/S	11.9	123.9	110.7	0934
8	SH-8	B/S	19.8	110.7	92.4	0938
9	SH-4	B/S	18.3	109.1	92.2	0939
10	SH-3	B/S	12.8	107.5	95.2	0941
11	SH-11	B/S	19.3	116.5	97.7	0942
12	SH-7	B/S	19.4	97.7	81.8	0944

Remarks:

000048

FS-F-1850 (03-07-97)

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-15
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #20701-001	Page 1 of 2
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 7/7/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Justification:

The Troxler soil moisture/density gauge contains radioactive sources which emit gamma rays and neutrons. These radioactive sources have the potential to interfere with RTRAK or HPGe in-situ gamma spectrometry measurements if the Troxler and gamma tools are in the field at the same time in close proximity. The sampling and feasibility testing of the Zeltex KJE-100 Infrared Moisture Meter (refered to in this variance as IR moisture meter) will be performed under this variance in an attempt to identify a soil moisture meter which does not have the potential to adversely effect in-situ gamma spectrometry measurements. If a replacement moisture meter which does not require radioactive sources to operate can be identified, use of the Troxler gauge can be discontinued or minimized.

2158

INFORMATION ONLY

Field Change Notice:

This variance covers the collection of soil samples for the purpose of testing the feasibility of using an the IR moisture meter as a replacement for the Troxler Soil Moisture/Density gauge. Details of the feasibility testing of the IR moisture meter are also included in this variance.

SOIL SAMPLING: Two soil samples will be collected from each of two areas within the A2PI Southern Waste Units of the Fernald site: the Interceptor Ditch and the Inactive Flyash Pile (IFP). Each soil sample shall consist of approximately 500 grams on a wet weight or "as is" basis. The depth of the soil sample shall be from 0 to 6 inches. The samples will be identified as IFP 1&2 and INT 1&2. The soil samples shall be delivered to the FEMP Analytical Laboratory where the feasibility testing will be done.

ORIGINAL

LABORATORY TEST PLAN: Samples will be dispensed into aluminum drying pans, soil weights will be recorded and percent moisture readings will be calculated, and a direct reading with the IR moisture meter will betaken (initial moisture readings will be purely for general informational purposes). To start the feasibility testing of the IR moisture meter, sufficient water will be added to saturate each soil sample. Initial sample weights and moisture readings will be recorded. The samples will be dried in a conventional laboratory oven at 200 to 300 degrees Celsius for 30 to 60 minutes. The samples will be removed from the oven, weighed, and a % moisture calculated. Then direct readings with the IR moisture gauge will be recorded. This process will be repeated until no further weight loss due to moisture evaporation occurs. The oven temperature and/or the length of the drying intervals may be adjusted so that the moisture weight loss during each drying interval is not too large or too small. The percent moisture of each sample calculated after each drying period will be correlated with the IR moisture meter readings to develop a "calibration curve" for each soil sample. Average values of the readings from the duplicate samples from each location will be used to develop the calibration curve.

FIELD TEST PLAN: Once the IR moisture meter calibration curve for the soil at the IFP and Interceptor Ditch has been established, the IR moisture meter will be taken to the IFP and Interceptor Ditch and used to obtain field readings in each of these areas to field test the calibration curve. These IR moisture readings will be compared to Troxler soil moisture readings obtained at the same location at the same time. If a good comparison is obtained, the tool will be procured for use.

FUTURE CALIBRATION CURVES: Before the tool can be used in any other area other than the IFP or Interceptor Ditch, IR moisture meter calibration curves for the particular area soil will need to be made and field tested.

000049

REQUESTED BY: Ray Danahy DATE: 7/7/98

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE

X	QUALITY ASSURANCE Mary Eleton	7/7/98	X	PROJECT MANAGER	7/7/98
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr. Joan H. White	7/7/98
X	ANALYTICAL CUSTOMER SUPPORT R. J. Donaly	7/7/98		OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO	REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-16
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #20701-001	Page 1 of 3
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 7/15/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Justification

The HPGe (high purity germanium) Core Counter is being developed to analyze soil cores in the field for WAC determination by collecting real-time gamma spectroscopy data for total uranium on the soil encased in plastic cores liners. The core counter consists of a standard HPGe detector and a lead shielded structure into which the soil core is inserted. The HPGe detector is the same instrument currently used in the field to measure gamma emitting radiological COCs (Constituents Of Concern) for Waste Acceptance Criteria (WAC) and soil precertification.

2153

This test will compare the moisture corrected measurements obtained by the HPGe Core Counter on prepared 9 inch Macro Core Soil Samples made from archived soil samples, to both βγ frisker readings and laboratory analysis of the same prepared 9 inch Macro Core Soil Samples.

Field Change Notice

Using archived soil samples (currently in jars) from previous sample collection events, prepare 9 inch Macro Core soil cores and perform bench scale measurements of the HPGe Core Counter. Initially, 7 prepared 9 inch Macro Core Soil Samples are planned for analysis, however more may be prepared and analyzed to fully test the system.

INFORMATION ONLY

1 - Retrieve Archive Soil Samples - retrieve samples of interest from archive storage building (see list on Page 2 of this variance).

2 - Composite Archive Soil Samples - Archived soil samples were collected in 6-inch increments using the Geoprobe® Dual-Tube method and are containerized in 500 milliliter plastic jars. Using a bench HPGe (not HPGe Core Counter), measure each containerize core sample. Group the samples into sets of three based upon the similarity of the bench HPGe measurements. Homogenize soil sample sets according to procedure SMPL-01 Solids Sampling to obtain sufficient volume to fill a plastic Macro-Core tube 9 inches long (an estimated three archive samples will be required). Document on a Field Activity Log (FAL) the sample numbers combined (from the list on Page 2 of this variance)

ORIGINAL

(continued on following page....)

REQUESTED BY: Dean Shanklin DATE: 7/15/98

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE R. Linke	7-15-98	X	PROJECT MANAGER	7/15/98
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr. Joan H White	7/15/98
X	ANALYTICAL CUSTOMER SUPPORT R. J. Donahey	7/15/98		OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER: 000051
QUALITY ASSURANCE:	OTHER:	OTHER:

Continued from preceding page..... 2153

The archive soil samples may contain fragments of construction material such as wood, brown glass, clear glass, etc. Ensure construction material is included in the homogenized Macro Core Soil Sample. Lithologic logs for the samples identified on Page 2 of this variance indicated that the construction material in the Southern Waste Unit (SWU) was contaminated and contributed significantly to the high βγ frisker readings recorded for the sample cores in the field.

Conduct and record βγ frisker readings of the combined homogenized soil (from the three samples in each sample set) prior to placing the soil in the Macro Core tubes. Fill the core tubes with the homogenized soil minimizing void spaces by tamping soil into the tube using a clean rod (ceramic, glass, stainless steel, or other approved material).

3 - Collect Moisture Measurement - Collect Infra Red (IR) moisture meter readings on the exposed soil of each uncapped Macro Core Soil Sample, if instrument is available for use. If no IR moisture measurement is able to be made, the % moisture value obtained from the laboratory analysis of the Macro Core Soil Sample material will be applied to the HPGe Core Counter measurement to yield a moisture corrected measurement.

4 - Seal and Label Macro Core Soil Sample - Cap and tape both ends of the filled Macro Core Soil Sample and label it using the acronym "HPGe Counter" followed by a consecutive sample number (e.g., 1, 2, 3" etc). Obtain FACTS labels for on-site total uranium analysis by Bromo Padap and ICPMS Methods. In addition, the Macro Core Soil Sample will be analyzed by the Gamma Spec Method if laboratory capacity is availability. The FACTS label is to indicate the Macro Core Soil Sample is a solid matrix with 6 month holding time and is to be analyzed to ASL B). Analytical data is to be sent to Chris Sutton.

5 - Acquire Core Counter Measurement - Prior to use, the operator will ensure the HPGe detector chosen for use in the HPGe Core Counter has a current calibration in accordance with procedure EQT-22 High Purity Germanium Detector In-Situ Efficiency Calibration and has met the QC requirements identified in procedure ADM-16 In-Situ Gamma Spectroscopy Quality Control Measurements. Measurements will be performed on each Macro Core Soil Sample using the HPGe Core Counter system according to Procedure EQT-35 Soil Core Sample Counting System. Detector count time will be 5 minutes live time.

6 - Quality Control Measurements - At least one duplicate measurement will be made during the bench scale test. The duplicate measurement will be made with the same HPGe detector immediately after the initial measurement, at the same location on the Macro Core Soil Sample. Each HPGe Core Counter measurement will be reviewed for the QC parameters identified on the Checklist for Verification of Quality Control (QC) and Data Review Elements for HPGe Measurements.

7 - Submit Macro Core Soil Sample to Laboratory for Analysis - Submit Macro Core Soil Samples to the on-site laboratory for total uranium analysis.

8 - Perform Data Comparison - Compare the Macro Core Soil Sample βγ frisker readings, moisture corrected HPGe Core Counter measurements, and analytical laboratory results to determine effectiveness of the HPGe Core Counter.

9 - Data Management - All HPGe and sample data collected for this bench scale test will be sent to the Environmental Data Base (SED).

Archive Soil Sample I.D.	Beta / Gamma Counts (ccpm)
SWU-5-22B-51	1000
SWU-5-22-51	1000
SWU-5-23B-49	200
SWU-5-24-47	100
SWU-5-24A-49	300
SWU-5-24B-49	400
SWU-5-26-46	0
SWU-5-26-47	300
SWU-5-26A-46	0
SWU-5-26A-47	150

000052

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2153

SWU-5-26A-48	200
SWU-5-26A-50	400
SWU-5-26A-51	450
SWU-5-27-48	200
SWU-5-31A-49	200
SWU-5-31A-50	1000
SWU-5-33-54	650
SWU-5-36-48	450
SWU-5-36-49	450
SWU-5-36-50	450
SWU-5-36-51	400
SWU-5-37-53	200

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-17
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #20701-001	Page 1 of 3
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 8/5/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Justification

The HPGe (high purity germanium) Core Counter is being developed to analyze soil cores in the field for WAC determination by collecting real-time gamma spectroscopy data for total uranium on the soil encased in plastic cores liners. The core counter consists of a standard HPGe detector and a lead shielded structure into which the soil core is inserted. The HPGe detector is the same instrument currently used in the field to measure gamma emitting radiological COCs (Constituents Of Concern) for Waste Acceptance Criteria (WAC) and soil precertification.

Two different sized core liners are currently used at the FEMP. Variance 50.03.40.03-16 describes the bench scale testing of the core counter for the larger diameter macro-core tubes (1 5/8 inch inner diameter). **This variance describes the bench scale test for the dual tube cores (1 1/8 inch inner diameter).** Excess soil from the same archive samples used to make the bench scale test cores for the macro-core tube test in Variance 50.03.40.03-16 will be used to make the bench scale test cores for the dual-tube test to be conducted under this Variance.

During the dual-tube core bench scale test a correlation will be developed between moisture corrected HPGe measurements collected on the dual-tube cores in the Core Counter, and laboratory total uranium analyses of the same material subsequently removed from the dual-tube cores. Also, a correlation between the β/γ frisker readings on the dual-tube cores and the laboratory analyses of the soil in these cores will be attempted. The preparation and analysis of composite samples made from archived soil samples is described below. These composite core samples will be used in the bench scale test to verify the accuracy of the HPGe Core Counter dual-tube calibration curve.

Field Change Notice

Using archived soil samples (currently in jars) from previous sample collection events, prepare 5 to 7 dual-tube soil cores and perform bench scale measurements of the HPGe Core Counter. Initially, 5 to 7 dual-tube core samples are planned for analysis, however more may be prepared and analyzed to fully test the system. Some of the actions described below have already been performed as part of Variance 50.30.40.03-16.

(continued on following page....)

REQUESTED BY: Joan White DATE: 8/5/98

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE R. Drake	8-12-98	X	PROJECT MANAGER	
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr Joan H White	8/12/98
X	ANALYTICAL CUSTOMER SUPPORT R. J. Danely	8/12/98		OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

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PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:
		ORIGINAL

Cor tinued from preceding page.....

2153

1 - Retrieve Archived Soil Samples - retrieve samples of interest from archive storage building (see list on Page 3 of this variance).

2 - Composite Archived Soil Samples - Archived soil samples were collected in 6-inch increments using the Geoprobe® Dual-Tube method and are containerized in 500 milliliter plastic jars. Using an HPGe detector to semi-quantitatively measure each container, group the containers into sets of three to four based upon the similarity of the HPGe uranium measurements. Mix the individual components to crudely homogenize the soil in each set according to procedure SMPL-01 Solids Sampling to obtain sufficient volume to fill a 9 inch plastic dual-tube core cylinder. Document on a Field Activity Log (FAL) the sample numbers combined (from the list on Page 3 of this variance) The archived soil samples may contain fragments of construction material such as wood, brown glass, clear glass, etc. Ensure construction material is included in the homogenized soil samples. Lithologic logs for the samples listed below indicate that the construction material in the Southern Waste Unit (SWU) was contaminated and contributed significantly to the high β/γ frisker readings recorded for the sample cores in the field.

3 - Collect Moisture Measurements - Collect Infra Red (IR) moisture meter readings on the exposed soil of each uncapped core soil sample, if instrument is available for use. If the IR moisture meter is not available, the % moisture value obtained from the laboratory analysis of the soil samples will be applied to the HPGe Core Counter measurements to yield moisture corrected core counter results.

4 - Fill, Seal and Label Dual-Tube Core Soil Samples - Fill each dual-tube core with the blended soil from a single set. Tamp the soil in the tube to eliminate voids and air spaces as much as possible. Cap and tape both ends of each tube after filling. Label each dual-tube core to provide positive identification. Obtain FACTS labels for on-site percent moisture and total uranium analysis by three techniques: Bromo Padap, ICP/mass spectrometry, and gamma spectrometry. The FACTS label is to indicate the dual-tube core soil sample is a solid matrix with 6 month holding time and is to be analyzed to ASL B. Analytical data are to be sent to Chris Sutton. After sealing the soil into the dual-tube cores conduct and record β/γ frisker readings of each dual-tube core.

5 - Acquire Core Counter Measurements - Prior to use, the operator will ensure the HPGe detector selected for use has a current calibration in accordance with procedure EQT-22 High Purity Germanium Detector In-Situ Efficiency Calibration and has met the QC requirements identified in procedure ADM-16 In-Situ Gamma Spectroscopy Quality Control Measurements. Measurements will be performed on each dual-tube core soil sample using the HPGe Core Counter system according to Procedure EQT-35 Soil Core Sample Counting System. Detector count time will be at least 5 minutes live time.

6 - Quality Control Measurements - At least one duplicate measurement will be made during the bench scale test. The duplicate measurement will be made with the same HPGe detector immediately after the initial measurement, at the same location on the dual tube core cylinder. Each HPGe Core Counter measurement will be reviewed for the QC parameters identified on the Checklist for Verification of Quality Control (QC) and Data Review Elements for HPGe Measurements.

7 - Submit Dual-Tube Core Soil Samples to Laboratory for Analysis - Submit dual-tube core bench scale test soil samples to the on-site laboratory for total uranium and percent moisture analyses.

8 - Perform Data Comparisons - Compare the dual-tube core bench scale soil sample β/γ frisker readings, moisture corrected core counter measurements, and analytical laboratory results to determine the accuracy of the HPGe Core Counter dual-tube calibration curve.

9 - Data Management - All HPGe and sample data collected for this dual-tube core bench scale test will be sent to the Sitewide Environmental Data Base (SED).

Continued from preceding page.....

The following archived samples will be retrieved and used for the preparation of composite dual tube core samples:

Archived Soil Sample I.D.	Beta / Gamma Counts (ccpm)
SWU-5-22B-51	1000
SWU-5-22-51	1000
SWU-5-23B-49	200
SWU-5-24-47	100
SWU-5-24A-49	300
SWU-5-24B-49	400
SWU-5-26-46	0
SWU-5-26-47	300
SWU-5-26A-46	0
SWU-5-26A-47	150
SWU-5-26A-48	200
SWU-5-26A-50	400
SWU-5-26A-51	450
SWU-5-27-48	200
SWU-5-31A-49	200
SWU-5-31A-50	1000
SWU-5-33-54	650
SWU-5-36-48	450
SWU-5-36-49	450
SWU-5-36-50	450
SWU-5-36-51	400
SWU-5-37-53	200

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-18
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #20701-001	Page 1 of 9
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 8/5/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Justification

The Troxler soil moisture/density gauge contains radioactive sources which emit gamma rays and neutrons. These radioactive sources have the potential to interfere with RTRAK or HPGe in-situ gamma spectrometry measurements. If a replacement moisture meter which does not require radioactive sources to operate can be identified, use of the Troxler gauge can be discontinued, thereby reducing personnel radiation exposure. Variance V/F 50.03.40.03-15 to the Part B Comparability Study outlined a soil sampling and feasibility test plan designed to determine the suitability of the Zeltex KJT100 Infra-red moisture meter as a replacement for the Troxler moisture/density gauge. Since it has no radioactive sources in it, this moisture meter does not have the potential to adversely effect in-situ gamma spectrometry measurements.

Field Change Notice

The purpose of this variance is to compile the results of the feasibility testing of the Zeltex KJT100 infra-red moisture meter, to summarize the results and to state the conclusions of the study. This variance also describes deviations from the test plan as outlined in Variance V/F 50.03.40.03-15.

The following specific tasks were performed as described below.

1. The Zeltex KJT100 moisture meter was calibrated with soil of the same type that would be encountered during the field test.
   - A. A six inch core sample from each area where the field test was to be conducted was collected and delivered to the FDF Analytical Laboratory for use in calibrating the IR moisture meter.
   - B. The laboratory oven temperature was set at approximately 210° C. The temperature setting was not critical.
   - C. An operational check of the laboratory balance was performed as required by Analytical Laboratory procedures.
   - D. Disposable aluminum drying pans - one for each sample used in the calibration - were weighed and labeled.
   - E. 100 to 200 grams of soil was added to each drying pan and the total weights were recorded.
   - F. Enough water was added to each sample to saturate the soil and the total weights were recorded.
   - G. Using the instrument manufacturer's instruction manual, absorbance readings were obtained with the KJT100 moisture meter at four different locations on each sample. The four readings and the time that they were taken were recorded on the calibration data form. The average of the four readings was also recorded. The completed calibration data form is attached to this variance.

INFORMATION ONLY

(continued on following page....)

REQUESTED BY: Ray Danahy

ORIGINAL

DATE: 8/31/98

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE R. Franks	9-1-98	X	PROJECT MANAGER Chris Smith	8/31/98
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr. Jean White	8/31/98
X	ANALYTICAL CUSTOMER SUPPORT R. J. Danahy	8/31/98		OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

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2153

NOTE: The process of calibrating the IR moisture meter consists of determining the correlation between the average absorbance (as determined by comparing the amount of IR radiation reflected from the surface of a sample at several specific wavelengths) and its calculated percent moisture.

H. After performing the initial absorbance readings, each sample was placed into the laboratory oven for five to ten minutes. The time was not critical; but it had to be long enough to evaporate between one and five grams of water from each sample.

I. After the five to ten minute drying period, the samples were removed from the drying oven. Each sample was placed on the balance and allowed to cool for approximately two minutes until the weight stabilized. The weight of the sample and another set of 4 absorbance measurements as described in step G were recorded.

J. Steps G, H, and I were repeated until the samples were completely dry. Complete dryness was attained when the weight of the samples did not change from one drying period to the next. After each drying cycle, four IR meter readings were recorded and the samples were weighed.

K. After all the moisture had been evaporated from each sample, the percent moisture in the sample at each step in the drying process was calculated by using the formula:

$$PM = 100 * \frac{\{\text{Soil + Pan Wet Weight}\} - \{\text{Soil + Pan Final Dry Weight}\}}{\{\text{Soil + Pan Initial Wet Weight}\} - \text{Pan Weight}}$$

L. Using the instrument manufacturer's instruction manual, the absorbance and percent moisture data were entered into the KJT 100 memory and the instrument was used to calculate a "best fit" calibration curve. The instrument has the capability to automatically select the best fit curve from a linear, quadratic of cubic equation.

2. <u>After calibration was complete, field measurements of soil moisture were performed at two locations as follows</u>:

A. The field measurements were performed roughly at the same field locations from which the calibration soil samples were collected. These locations were the Inactive Fly Ash Pile (IFP) and the Interceptor Ditch (INT) in the Southern Waste Units.

B. At each location, a Troxler moisture gauge measurement was performed and results were recorded.

C. At each location, the KJT 100 IR moisture meter was used in accordance with the manufacturer's instruction manual to obtain soil moisture readings at three closely spaced points on the ground surface. The average of these three readings was taken as the surface soil moisture value for each location.

D. Also at each location, a two inch deep depression was scraped in the soil and the KJT 100 measurements were repeated. Once again, readings were taken at three closely spaced points and the average of these readings was recorded.

E. A six inch deep core sample was also collected from each location. The core samples were submitted to the Analytical Laboratory with a request for percent moisture analyses.

3. <u>The following data were gathered from the three techniques in order to evaluate the suitability of the KJT 100 soil moisture meter as a replacement for the Troxler moisture gauge</u>.

A. Attachments 1 and 2 to this variance contain the measurement data on which the calibration curves were based. Separate calibration curves were derived for the inactive fly ash pile material and the interceptor ditch soil. Each attachment consists of one page of handwritten data recorded during the KJT100 calibration and a second page which is spreadsheet computations of percent moisture based on the handwritten data.

B. The data in Attachments 1 and 2 resulted in the following linear calibration equations. These calibration equations were stored in different memory channels of the KJT100 moisture meter and were used as the basis of the soil moisture readings obtained during the field test at the Inactive Fly Ash Pile and the Interceptor Ditch.

Calibration equation for soil in Interceptor Ditch

$$\% \text{ Moisture} = 26.7027 * ABS + 1.92022$$

Calibration equation for material in Inactive Fly Ash Pile

$$\% \text{ Moisture} = 253.739 * ABS + 2.16876$$

where ABS = KJT100 absorbance reading

C. Attachments 3 and 4 to this variance contain laboratory results and field results respectively of the feasibility testing of the KJT100 moisture meter. These results are summarized below.

<u>NOTE</u>: The field Troxler moisture gauge readings have been converted from a "dry weight" basis to a "wet weight" basis to facilitate comparison with the other results.

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2153

Sample ID	Location	Troxler % Moisture	Zeltex KJT100 % Moisture Surface	2 In. Deep	Average	Lab % Moisture
IFP-MT-1	Flyash Pile	9.09	6.87	16.29	11.6	24.2
IFP-MT-2	Flyash Pile	18.5	11.76	13.41	12.6	33.0
IFP-MT-3	Interceptor Ditch	12.5	11.79	13.74	12.8	14.3
IFP-MT-4	Interceptor Ditch	15.5	14.29	15.11	14.7	17.9

4. Data evaluation and conclusions

When evaluating the data above, it should be recognized that the three measurement techniques provide slightly different measurements. The Troxler gauge uses the thermalization of neutrons from a source within the gauge to determine the soil moisture. The more moisture that is present in the soil, the greater the fraction of neutrons that will be slowed down by collisions with water molecules. The reflected neutrons that are detected by the Troxler gauge can penetrate the soil to a depth of approximately eight inches, assuming a typical soil density of 1.5 g/cm^3 and a typical soil moisture of 20%. So the Troxler moisture reading represents soil moisture averaged over an eight inch depth. The soil core samples analyzed in the laboratory had a depth of six inches, and so the laboratory moisture represents an average over a six inch depth. The KJT100 meter reads the surface moisture since there is little penetration of the infra-red radiation into the soil. When considered in this light, it is reasonable to define a difference of five percent or less on an absolute scale as good agreement between any two results. Using this definition, it can be stated that there is generally good agreement among all three techniques for the samples from the Interceptor Ditch, and there is generally poor agreement among the three techniques for the Inactive Fly Ash Pile. However, the Troxler and infra-red measurements agree more closely with one another than do the lab measurements from the fly ash pile. The difference between the average Troxler reading and the average KJT100 reading in the fly ash material is only 1.7% absolute. The lab measurements for the soil from the Interceptor Ditch are biased high relative to the other techniques, but the bias is well within the 5% acceptance range. Because of the limited time and experience with the infra-red moisture meter and the limited data set, it is not possible to determine the reasons for the large discrepancies between the fly ash moisture measurements. Although it is not evident from the data, there could have been errors in the calibration of the infra-red moisture meter or in any of the three measurement techniques. It is possible that the core samples happened to include a moisture pocket that was not visible from the surface, thus accounting for the anomalously high lab moisture for the fly ash. Alternatively there may have been something unusual about the material in the Inactive Fly Ash Pile that make it unsuitable for infra-red moisture measurements. However, it is clear from the data above that the Zeltex KJT100 moisture meter generates results which are in good agreement with results from the other two techniques when measuring soil, as opposed to fly ash. The vast majority of moisture measurements in the future will be performed in soil, rather than fly ash. The soil data above leads to the conclusion that the Zeltex KJT100 soil moisture meter would be a suitable replacement for the Troxler density/moisture gauge..

V/F 50.03.40.03-18
page 4 of 9

(ATTACHMENT 1 page 1 of 2)

CALIBRATION INFORMATION
ZELTEX KJ~~E~~T 100 INFRARED MOISTURE METER

Analyst: R. J. DANAHY **Date:** AUG. 8, 1998

Sample ID: IFP-1

	Initial Weight grams	Final Dry Wght grams
pan + soil + water added	138.79	N/A
pan + soil	112.93	
pan	3.89	3.89

water weight = (soil + pan) wet weight - (soil + pan) dry weight
% Moisture = 100 * (water weight / initial soil wet weight)

Time	Absorbance					Weight	Calculated
	X_1	X_2	X_3	X_4	X_{AVE}	(soil + pan) g	% Moisture
10:20	0.1210	0.1236	0.1249	0.1129		138.79	
10:29	0.1098	0.1137	0.0983	0.1071		132.00	
10:35	0.0940	0.0970	0.0938	0.0980		127.65	
10:41	0.0824	0.0846	0.0886	0.0862		123.85	
10:47	0.0905	0.0914	0.0756	0.0749		120.26	
10:53	0.0813	0.0750	0.0731	0.0824		116.61	
11:00	0.0597	0.0679	0.0643	0.0743		111.95	
11:06	0.0497	0.0545	0.0667	0.0309		108.45	
11:12	0.0119	0.0266	0.0269	0.0163		105.68	
11:18	0.0113	0.0169	0.0104	0.0091		103.24	
11:24	0.0064	0.0068	0.0088	0.0077		100.79	
11:30	0.0072	0.0065	0.0071	0.0062		98.35	
11:36	0.0099	0.0077	0.0072	0.0063		96.67	
11:42	0.0057	0.0049	0.0072	0.0058		95.44	
11:48	0.0037	0.0049	0.0038	0.0040		94.08	
11:54	0.0048	0.0054	0.0027	0.0045		92.96	
12:00	0.0025	0.0027	0.0025	0.0033		92.31	
12:19	0.0024	0.0019	0.0008	0.0021		91.08	
12:39	0.0010	0.0008	0.0013	0.0003		90.96	
X 14:02	0.0016	0.0016	0.0008	0.0007		91.16	

OVEN SETTING ~~450~~ = 180°C X DID NOT USE THIS DATA POINT
425 = 210°C

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2153

V/F 50.03.40.03-18
pages 8 of 9

(ATTACHMENT 1 page 2 of 2)

CALIBRATION INFORMATION
ZELTEX KJT 100 INFRARED MOISTURE METER

Analyst: Raymond J. Danahy

Date: Aug. 8, 1998

Sample ID: IFP-1

CAL EQUATION PARAMETERS STORED IN CH 1
A_0 = 2.16876
A_1 = 253.739
SE = 2.430

water weight = (soil + pan) wet weight - (soil + pan) dry weight
% Moisture = 100 * (water weight / initial soil wet weight)

	Initial Weight grams	Final Dry Wght grams
pan + soil + water added	138.79	N/A
pan + soil	112.93	90.96
pan	3.89	3.89

Time	Absorbance					Weight	Calculated
	X_1	X_2	X_3	X_4	X_{AVE}	(soil + pan) g	% Moisture
10:20	0.1210	0.1236	0.1249	0.1129	0.1206	138.79	35.46
10:29	0.1098	0.1137	0.0983	0.1071	0.1072	132.00	30.42
10:35	0.0940	0.0970	0.0938	0.0980	0.0957	127.65	27.20
10:41	0.0824	0.0846	0.0886	0.0862	0.0855	123.85	24.38
10:47	0.0905	0.0814	0.0756	0.0749	0.0806	120.26	21.72
10:53	0.0813	0.0750	0.0731	0.0824	0.0780	116.61	19.01
11:00	0.059 7	0.0679	0.0643	0.0743	0.0688	111.95	15.56
11:06	0.0497	0.0545	0.0667	0.0309	0.0505	108.45	12.97
11:12	0.0119	0.0266	0.0269	0.0163	0.0204	105.68	10.91
11:18	0.0113	0.0169	0.0104	0.0091	0.0119	103.24	9.10
11:24	0.0064	0.0068	0.0088	0.0077	0.0074	100.79	7.29
11:30	0.0072	0.0065	0.0071	0.0062	0.0068	98.35	5.48
11:36	0.0099	0.0077	0.0072	0.0063	0.0078	96.67	4.23
11:42	0.0057	0.0049	0.0072	0.0058	0.0059	95.44	3.32
11:48	0.0037	0.0049	0.0038	0.0040	0.0041	94.08	2.31
11:54	0.0048	0.0054	0.0027	0.0045	0.0044	92.96	1.48
12:00	0.0025	0.0027	0.0025	0.0033	0.0028	92.31	1.00
12:19	0.0024	0.0019	0.0008	0.0021	0.0018	91.08	0.09
12:39	0.0010	0.0008	0.0013	0.0003	0.0009	90.96	0.00

DATA POINT NOT USED TO DERIVE CAL EQUATION

2153

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W/F 50.03.40.03-18
page 6 of 9

(ATTACHMENT 2 page 1 of 2)

2153

CALIBRATION INFORMATION
ZELTEX KJ~~E~~T 100 INFRARED MOISTURE METER

000062

Analyst: R. J. DANAHY **Date:** AUG. 8, 1998

Sample ID: INT - 1

	Initial Weight grams	Final Dry Wght grams
pan + soil + water added	190.25	N/A
pan + soil	163.58	
pan	3.93	3.93

water weight = (soil + pan) wet weight - (soil + pan) dry weight
% Moisture = 100 * (water weight / initial soil wet weight)

	Time	Absorbance					Weight	Calculated
		X_1	X_2	X_3	X_4	X_{AVE}	(soil + pan) g	% Moisture
	10:17	0.6181	0.6235	0.6268	0.6168		190.25	
	10:26	0.5954	0.5975	0.6050	0.6107		185.51	
	10:32	0.5795	0.5536	0.5685	0.5806		181.55	
	10:38	0.5720	0.5455	0.5560	0.5584		177.97	
	10:44	0.5493	0.5372	0.5458	0.5546		174.80	
	10:50	0.5111	0.5179	0.5172	0.5081		171.56	
	10:57	0.4147	0.4096	0.3816	0.3736		167.55	
	11:03	0.1580	0.1837	0.1429	0.1411		164.65	
	11:09	0.0727	0.0841	0.0874	0.0969		162.26	
	11:15	0.0504	0.0512	0.0686	0.0526		160.07	
	11:21	0.0382	0.0492	0.0543	0.0498		157.68	
	11:27	0.0265	0.0368	0.0424	0.0344		155.30	
	11:33	0.0309	0.0403	0.0320	0.0291		153.69	
	11:39	0.0452	0.0316	0.0266	0.0288		152.30	
	11:45	0.0269	0.0222	0.0225	0.0268		151.05	
	11:51	0.0186	0.0183	0.0264	0.0219		150.10	
	11:57	0.0303	0.0175	0.0130	0.0112		149.43	
	12:15	0.0695	~~0.0340~~ 0.0170	0.0039	0.0019		148.73	
	12:35	0.0038	0.0016	0.0012	0.0024		148.60	
X	13:58	0.0098	0.0087	0.0114	0.0135		148.81	

OVEN SETTING ~~450~~ = ~~180~~°C X DID NOT USE THIS DATA POINT

V/F 50.03.40.03-18
page 7089

(ATTACHMENT 2 page 2 of 2)

CALIBRATION INFORMATION
ZELTEX KJT 100 INFRARED MOISTURE METER

Analyst: Raymond J. Danahy

Date: Aug. 8, 1998

Sample ID: INT-1

CAL EQUATION PARAMETERS STORED IN CH 11
$A_0 = 1.92022$
$A_1 = 26.7027$
$SE = 2.263$

water weight = (soil + pan) wet weight - (soil + pan) dry weight
% Moisture = 100 * (water weight / initial soil wet weight)

	Initial Weight grams	Final Dry Wght grams
pan + soil + water added	190.25	N/A
pan + soil	163.58	148.60
pan	3.93	3.93

Time	Absorbance					Weight (soil + pan) g	Calculated % Moisture
	X_1	X_2	X_3	X_4	X_{AVE}		
10:17	0.6181	0.6235	0.6268	0.6168	0.6213	190.25	22.35
10:26	0.5954	0.5975	0.605	0.6107	0.6022	185.51	19.81
10:32	0.5795	0.5536	0.5685	0.5806	0.5706	181.55	17.68
10:38	0.572	0.5455	0.556	0.5584	0.5580	177.97	15.76
10:44	0.5493	0.5372	0.5458	0.5546	0.5467	174.80	14.06
10:50	0.5111	0.5179	0.5172	0.5081	0.5136	171.56	12.32
10:57	0.4147	0.4096	0.3816	0.3736	0.3949	167.55	10.17
11:03	0.158	0.1837	0.1429	0.1411	0.1564	164.65	8.61
11:09	0.0727	0.0841	0.0874	0.0969	0.0853	162.26	7.33
11:15	0.0504	0.0512	0.0686	0.0526	0.0557	160.07	6.16
11:21	0.0382	0.0492	0.0543	0.0498	0.0479	157.68	4.87
11:27	0.0265	0.0368	0.0424	0.0344	0.0350	155.30	3.60
11:33	0.0309	0.0403	0.032	0.0291	0.0331	153.69	2.73
11:39	0.0452	0.0316	0.0266	0.0288	0.0331	152.30	1.99
11:45	0.0269	0.0222	0.0225	0.0268	0.0246	151.05	1.31
11:51	0.0186	0.0183	0.0264	0.0219	0.0213	150.10	0.81
11:57	0.0303	0.0175	0.013	0.0112	0.0180	149.43	0.45
12:15	0.0095	0.0177	0.0039	0.0019	0.0083	148.73	0.07
12:35	0.0038	0.0016	0.0012	0.0024	0.0023	148.60	0.00

X

DATA POINT NOT USED TO DERIVE CAL EQUATION

f:\excel\moistcalint

000063

PP 29 1 5 3

VF 50.03.40.03-18 - page 8 of 9

ATTACHMENT 3 - 2153

Author: William Westerman at FNST-04
Date: 8/14/98 1:46 PM
Priority: Normal
TO: Ray Danahy, Dave Gill at FDMA-01, Dean Shanklin at FNST-01
CC: Chris Sutton
Subject: PER CENT MOISTURE RESULTS FOR COMP STUDY

FACTS ID	CUSTOMER ID	RESULT (% H2O)
200337367	IFP-MT-1	24.2
68	2	33.0
69	3	14.3
70	4	17.9

ANALYTICAL LABORATORY PERCENT MOISTURE RESULTS

KJT 100 FEASIBILITY TESTING

VF-50.03, V0.03-18 page 9 of 9

ATTACHMENT 4

Author: David Allen at FNST-06
Date: 8/11/98 8:11 AM
Priority: Normal
TO: Ray Danahy at FNST-04
CC: Joan White at FNST-02, David Allen, Dale Seiller
Subject: New Moisture detector

2153

Ray,
Below are the numbers for the moisture gauge test we did yesterday. All the information is recorded in the Field Activity Log.

Location: IFP-MT-1
Flyash Pile
Trox.: 10.0 → 9.09
IR detector: 6.87 (surface) 16.29 (at 2" depth)

Location: IFP-MT-2
Flyash Pile
Trox.: 22.7 → 18.5
IR detector: 11.76 (surface) 13.41 (at 2" depth)

Location: IFP-MT-3
Intercepter Ditch
Trox.: 14.3 → 12.5
IR detector: 11.79 (surface) 13.74 (at 2" depth)

Location: IFP-MT-1 ← should be IFP-MT-4 per conversation with Dave Allen
Intercepter Ditch
Trox.: 18.4 → 15.5
IR detector: 14.29 (surface) 15.11 (at 2" depth)

The moisture cores are being taken to the Lab today.
Call me if you have any questions.

Also per conversation with Dave Allen, troxler gauge readings have NOT been converted to a wet weight basis. Wet weight troxler readings are listed in red ink beside the printed troxler readings

$$\% WB = 100 \cdot \frac{\% DB}{100 + \% DB}$$

	TROXLER (WET WEIGHT)	IR METER (WET WEIGHT) SURFACE	AVE	2 INCH	LAB (WET WEIGHT) 6 INCH CORE
IFP-MT-1	9.09	6.87	11.6	16.29	24.2
2	18.5	11.76	12.6	13.41	33.0
3	12.5	11.79	12.8	13.74	14.3
4	15.5	14.29	14.7	15.11	17.9

9/1/98

DRAWING LIST

2153

CWO NO.	PROJ. NO	REV.	DOC. NO.	DOCUMENT NAME	DATE	DOC. TYPE	STATUS
NA	20710	0	92X-5900-X-00415	PROJECT TITLE SHEET	8/20/98	DWG	CFC
NA	20710	0	92X-5900-X-00418	DRAWING INDEX	8/20/98	DWG	CFC
NA	20710	0	92X-5900-X-00420	LEGEND AND GENERAL NOTES	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00421	CIVIL EXISTING CONDITIONS PLAN	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00428	MASTER KEY PLAN	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00432	SITE/GRADING/UTILITY PLAN SEDIMENT BASIN 1	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00436	SITE/GRADING/UTILITY PLAN	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00459	CIVIL TRAFFIC PLAN	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00461	SEDIMENT BASIN 1 SECTIONS AND DETAILS	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00466	SITE/GRADING/UTILITY PLAN CONVEYANCE CHANNEL PLAN	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00467	CIVIL EROSION AND SEDIMENT CONTROL NOTES AND DETAILS	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00468	CIVIL MATERIAL TRACKING PLAN	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00469	CIVIL DETAIL SHEET	8/20/98	DWG	CFC
NA	20710	0	92X-5900-G-00477	CIVIL ACCESS CONTROL SECTOR 1	8/20/98	DWG	CFC

VARIANCE / FIELD CHANGE NOTICE	V/50.03.40.03-19
WBS NO.: 50.03.40.03 Project Document #20701-001	Page 1 of 2
PROJECT TITLE: Comparability Study, Part B. Rev. 0	Date: 8/31/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Justification

RTRAK/RSS and HPGe in-situ gamma spectrometry work is planned for early FY99 to identify surface soils containing above-WAC concentrations of total uranium in the Area 7 Silos Project Area. To ensure usable data is obtainable, a "shine" test will be conducted prior to WAC data collection. The proximity of the silos to the areas under investigation are a concern due to the possible effects of "shine" on the data. The concern with shine is threefold:

a. Uncollided gamma photon fluence significantly increases background in the low energy (<100 keV) portion of the gamma spectrum, thereby masking low energy gamma photons emitted by uranium-238

b. Gamma photons emitted by radioactive progeny of thorium-232 in Silo 3 may possibly result in anomalously high concentrations of thorium-232

c. Gamma photons emitted from radium-226 radioactive daughters may result in anomalously high concentrations of radium-226. While high concentrations of radium-226 and thorium-232 are not of concern relative to WAC exceedances *per se*, they do affect the determination of total uranium by RTRAK/RSS. This is because the RTRAK/RSS calibration equations for total uranium contain correction terms for interferences from radium-226 and thorium-232. High concentrations of shine from radium-226 daughters could cause erroneously high concentrations of total uranium to be determined, while high concentrations of shine from thorium-232 could cause low concentrations of total uranium to be determined.

INFORMATION ONLY

This variance describes a study to ascertain the possible effects of shine on HPGe and RTRAK/RSS data. The study follows the guidance provided in Section 4.12 (Shine) of the document entitled "User Guidelines, Measurement Strategies, and Operational Factors for Deployment of *In-situ* Gamma spectrometry at the Fernald site"

ORIGINAL

Field Change Notice

The following measurements should be performed prior to making any of the in-situ gamma spectrometry measurements to be used for WAC decisions.

1. Six HPGe measurements will be made at increasing distance from Silo 1. The first measurement will be made at the base of the berm of Silo 1, while the other five

(continued on following page.....)

REQUESTED BY: Chris Sutton DATE: 8/31/98

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	9-1-98	X	PROJECT MANAGER	9/1/98
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr	9/1/98
	ANALYTICAL CUSTOMER SUPPORT			OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

Continued from preceding page.....

Measurements will be made at 50 ft intervals extending in a line due east of Silo 1 into Area F. If possible, the measurements should be performed as two sets of three measurements, with each set of three measurements being performed simultaneously. The measurements should be made at a 1.0 ft detector height with a 15 minute data acquisition time. The measurements should be made in the early afternoon to avoid possible high concentrations of radon accumulating near the ground surface in the morning. One duplicate measurement will be collected.

2. Immediately following the two sets of measurements, the RSS should be walked along a profile from the base of the berm for Silo 1 through the locations of each of the HPGe measurement points. This will allow possible shine effects on sodium iodide data to be tied to HPGe measurements at the same detector height. RSS measurements should be taken using a 4 second data acquisition time with a 1.0 mph forward speed.

3. Four HPGe measurements will be made at increasing distance from Silo 3. The first measurement will be made 10 ft. from the base of Silo 3, while the remaining three will be made at 50 ft intervals extending in a line going northeast of the first measurement. If possible, the measurements should be performed as two sets of two measurements. The measurements should be made at a 1.0 ft detector height with a 15 minute data acquisition time. The measurements should be made in the afternoon. One duplicate measurement will be collected.

4. Immediately following the four HPGe measurements, the RSS should be walked along a profile extending 10 ft from the base of Silo 3 through the locations of each of the HPGe measurements. This will allow possible shine effects on sodium iodide data to be tied to HPGe measurements at the same detector height. RSS measurements should be taken using a 4 second data acquisition time with a 1.0 mph forward speed.

The above studies will allow the following types of information to be delineated:

a. Whether or not a trend of decreasing uranium concentration with increasing distance from the silos is present.
b. How fast the uncollided photon fluence contribution to background falls off as a function of distance from the silos.
c. Whether or not a trend of decreasing radium-226 concentration as a function of distance from the silos is evident, and whether or not possible high radium-226 concentration affect sodium iodide detector data.
d. Whether or not thorium-232 shine exists relative to silo 3, and whether or not such shine affects sodium iodide detector data.

HPGe and RSS Measurement Locations

HPGe measurement identifications for this study will be as follows: A7-S-XG-D, where A7 = Area 7; S = Shine Test; X = sequential gamma measurement numbers; G = Gamma; and D = Duplicate (if applicable). RSS shine study measurements will be as follows: A7-S-next sequential batch number.

Sample IDs and coordinates are given below.

Silo 1	Northing	Easting
A7-S-1G	480341.26	1347132.27
A7-S-2G	480431.26	1347182.27
A7-S-2G-D	480431.26	1347182.27
A7-S-3G	480431.26	1347232.27
A7-S-4G	480431.26	1347282.27
A7-S-5G	480431.26	1347332.27
A7-S-6G	480431.26	1347382.27
A7-S-next sequential batch number		

Silo 3		
A7-S-7G	480793.26	1347062.47
A7-S-8G	480829.57	1347097.66
A7-S-9G	480864.28	1347132.97
A7-S-9G-D	480864.28	1347132.97
A7-S-10G	480900.03	1347168.47
A7-S-next sequential batch number		

VARIANCE / FIELD CHANGE NOTICE	50.03.40.03-20
WBS NO.: 50.03.40.03 Project Document #20701-001	Page 1 of 2
PROJECT TITLE: Comparability Study, Part B. Rev. 0	Date 10/20/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Justification

2153

RTRAK/RSS and HPGe in-situ gamma spectrometry work is planned for early FY99 to identify surface soils containing above-WAC concentrations of total uranium in the Area 7 Silos Project Area. To ensure usable data is obtainable, "shine" tests are being conducted prior to WAC data collection. The proximity of the silos to the areas under investigation are a concern due to the possible effects of "shine" on the data. Previous experiments have demonstrated that the "shine" within the measurement areas primarily consists of collided gamma rays which contribute to the spectrum background by increasing the magnitude of the continuum beneath the regions of interest corresponding to the uranium gamma rays. This high background increases the uncertainty associated with the determination of net counts within the region of interest. There is concern that such high uncertainty may make it difficult to obtain reliable RSS measurements in some locations near the silos.

RSS results from initial shine studies contained a large number of measurements for which the net counts per second in the uranium region were less than zero. This was attributed to a combination of the low uranium concentrations identified using the HPGe and the high backgrounds in the uranium region of interest resulting from the high flux of collided gamma rays. In order to determine how this would effect measurements near WAC, it is necessary to simulate measurements of higher uranium concentrations. This can be done be using uranium sources placed on the RSS housing at locations that will cause the RSS to respond as if it were measuring soils with uranium concentrations near WAC.

INFORMATION ONLY

This variance describes a study designed to determine whether high backgrounds would cause uranium results to be biased low at concentrations near WAC and, if such biases are observed, at what instrument dead times the bias would make the results of measurements unacceptable. Because the detector and electronics used in the RTRAK are identical to those in the RSS, any conclusions drawn for this study will be applicable to both the RSS and the RTRAK.

Field Change Notice

The following measurements should be performed prior to making any RTRAK/RSS measurements to be used for WAC decisions:

ORIGINAL

(continued on following page.....)

Requested by: David Yesso Date: 10/20/98

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	10-21-98	X	PROJECT MANAGER	
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr	10/20/98
	ANALYTICAL CUSTOMER SUPPORT			OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

Continued from preceding page.....

1. While the RSS is in a low background area, position a normal enrichment uranium source on or near the RSS detector housing in positions to simulate an RSS response as if the following uranium concentrations were being detected: 500, 700, 1000, and 1300 ppm. The RSS responses need to be only approximately equal to the listed concentrations because the information needed is the relative change in response with changes in the system dead time. Note the source position for each uranium concentration.

2. Transport the RSS to the area near Silo 1. Securely place the uranium source in position on the RSS housing for one of the four uranium concentration levels. Move the RSS along a path traversing regions of varying dead time. The dead time across the path should vary from approximately 30% or less to 60% or more. This will allow the determination of the maximum dead time at which the uranium concentrations can be measured reliably. RSS measurements should be taken using a 4 second data acquisition time with a 1.0 mph travel speed.

3. Repeat the measurements described in paragraph 2 for the other three uranium concentration levels.

The above measurements will allow the following types of information to be determined:

a. Whether uranium concentrations at near WAC levels can be reliably measured in high "shine" locations.
b. The level of dead time at which measurements of near-WAC uranium concentrations become unreliable.

Measurement Locations

Measurement locations will be identified in the field and must meet the following criteria:

a. The measurements must be in the vicinity of the silos.
b. The measurements must be made in an area with a high background consisting primarily of collided gamma rays.
c. The RSS path must traverse locations of varying dead time, ranging from 30% or less to 60% or greater.
d. RSS data collected for this test will be identified with the name A7-S-next sequential batch number (S = Shine).

VARIANCE / FIELD CHANGE NOTICE	50.03.40.03-21
WBS NO.: 50.03.40.03 Project Document #20701-001	Page 1 of 4
PROJECT TITLE: Comparability Study, Part B. Rev. 0	Date 10/26/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Justification

This Variance establishes the first field test of the HPGe Core Counter and Zeltex Moisture Meter. Data from this test will be used to compare the WAC decision determined through use of the HPGe Core Counter and Zeltex Moisture Meter, with the WAC decision determined through laboratory analysis of soil cores, for the same interval.

The HPGe Core Counter is a new tool recently developed by the Real Time Instrumentation Measurement Program (RTIMP) to assist with making WAC decisions on soil intervals obtained by Geoprobe Cores (both macro-core and dual-tubes). The HPGe Core Counter utilizes the same HPGe detector system used for making WAC decisions on surface in-situ soils. The HPGe core counter was calibrated and bench scale tested under Variances 50.03.40.03-16&17 to the Comparability Study Part B, Rev 0.

The Zeltex Moisture Meter is an infra-red meter bought to provide quick and accurate soil moisture measurements on "in-situ" soils, and subsurface soils obtained from Geoprobe cores. The moisture meter was successfully tested and calibrated under Variances 50.03.40.03-15&18 to the Comparability Study Part B, Rev 0.

INFORMATION ONLY

Field Change Notice

A - Channel Loading the Zeltex Moisture Meter to Plant 9 Subsurface Soils:

The soil used to channel load the Zeltex Moisture Meter will come from cores extracted from beneath Plant 9 to ensure the moisture meter correlation curve is appropriate for the soils under investigation. If clay and sand soil is encountered under Plant 9, a separate curve will be made for each type of soil and loaded into separate channels in the meter.

B - Securing Soil to Conduct the Core Counter Test:

The soil cores used to conduct the field test of the core counter will come from beneath Plant 9, collected under the PSP for Area 3 Pre-Design Investigation of Plant 9, Number 20200-PSP-0002, Section 1.2 Scope.

Continued on following page.....

Requested by: Joan White Date: 10/26/98

X IF	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	11-2-98	X	PROJECT MANAGER	10/30/98
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr	10/30/98
	ANALYTICAL CUSTOMER SUPPORT Raymond J. Danaher	10/30/98		OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

DISTRIBUTION

000071

PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

ORIGINAL

.... Continued from preceding page

2153

C - Core Labeling:

1- Each full, unopened Geoprobe 4' core liner will be given to the gamma operator (by the field geologist or sampling technician) with the following information marked on the core liner:
a - the Boring number (ex. 12390)
b - the depth interval (4' - 8')
c - subsurface depth intervals marked (adjusted for expansion or contraction of the soil)

Note: an actual 6" subsurface interval may be represented by 8" of soil media in expansive clays, or 4" of soil media in compressive clays.

D -Beta/Gamma Screen of Each Core Liner Interval:

Prior to placing the core liner in the core counter, the gamma operator will perform a beta-gamma screen on each marked core liner interval, and mark the corrected counts above background ON the core liner interval (background will be noted on the Field Activity Log). The frisker measurement will be collected over a 360 degree surface of the core and the highest value located with a marking (such as a large dot).

E - Operation of the Core Counter:

Note:- Operation of the Core Counter will be conducted in accordance with RTIMP operating procedure EQT-35 Soil Core Sample Counting System. Prior to operating the Core Counter, all HPGe performance checks will be conducted in accordance with operating procedures EQT-22 High Purity Germanium Detector in-Situ Efficiency Calibration, EQT-23 High Purity Germanium Detectors, and ADM-16 In-Situ Gamma Spectrometry Quality Control.

1 - Core counter measurements will be performed while the core liner IS INTACT, before it is opened or cut into sample intervals.

2 - The core liner will be inserted into the core counter shallow end first. The side of the core with the highest frisker reading will be placed facing the detector. Care will be taken to ensure each interval marked on the core liner is within the field of view of the detector as the operator progresses down the core. In the event a 6" subsurface interval is represented by an 8" core liner interval of soil (in expansive clay situations) the gamma operator may acquire two core counter measurements on that 8" interval to ensure coverage of the full 8" of soil by moving the core liner slightly between measurements. The decision to take one or two measurements on the 8" soil interval will be made based on the frisker readings (if the frisker reading on that depth interval is variable, two core counter measurements will be collected to ensure full coverage, if the frisker reading on that depth interval is fairly consistent, then only one core counter measurement may be taken. If two core counter measurements are taken, the data from each measurement will be processed individually and the data added together to make an average of the interval.

3- Count time will be 5 minutes live time, as specified in the operating procedure EQT-35.

4 - Those core liner intervals identified as potentially exceeding WAC will be marked with an X or an adhesive type label.

G - Operation of the Zeltex Moisture Meter:

Note: Operation of the Zeltex Moisture Meter will be conducted in accordance with RTIMP operating procedure EQT-39 Zeltex Moisture Meter.

1 - Moisture measurements will be collected AFTER the core counter measurement is collected. After cores are opened by a field geologist, one moisture measurement will be collected on each measured core counter interval. The moisture measurement will be taken on exposed soil at the end of a core segment or anywhere along the length of the segment.

Continued on following page.....

.... Continued from preceding page

I - Core Counter Measurement Labeling:

1 - Core Counter Measurements on Plant 9 subsurface soils will follow the numbering system: P9CC-Boring #-XG-D.

Where:
P9 = Plant 9
CC = Core Counter Test
X = sequentially numbered gamma measurements (beginning with 1 for each boring)
G = gamma measurement
D = duplicate gamma measurement (1 in 20)

J - Duplicates:

One duplicate Core Counter measurement will be collected for every 20 measurements made to determine the reproducibility of core counter measurements.

K - Documenting the Test:

To ensure adequate information is collected for drawing conclusions from this test, the form attached to this variance will be completed. *The form is to be completed in addition to the forms required by the operating procedures.*

L - Documenting Changes:

Any changes in operation of either the Core Counter, the Zeltex Moisture Meter, or this variance required for the conducting of this test will be documented on a Field Activity Log.

M - Criteria for Measuring Test Success:

The test is being conducted to test both the core counter and the moisture meter. The effect of both instruments on the data will be assessed separately.

1 - The criteria for measuring test success of the Core Counter will be two fold:

a - A linear regression line drawn through a plot of laboratory total uranium data (wet weight basis vs calculated wet weight total uranium (from HPGe measurement) shall have a correlation coefficient greater than 90%.

b - The average relative percent difference between each pair of laboratory measurements and HPGe measurements (on a wet weight basis) shall be 35% or less. The relative percent difference is defined in Section 3.0 of the 1997 Comparability Study.

2 - The criteria for measuring test success of the Zeltex Moisture Meter will be two fold:

a - A linear regression line drawn through a plot of laboratory total uranium data (dry weight basis vs calculated dry weight total uranium (from HPGe measurement) shall have a correlation coefficient greater than 90%. (This will mean the moisture correction applied from the Zeltec Moisture Meter is good).

b - The average relative percent difference between each pair of laboratory measurements and HPGe measurements (on a dry weight basis) shall be 35% or less. The relative percent difference is defined in Section 3.0 of the 1997 Comparability Study.

Continued on following page.....

.....Continued from preceding page

PLANT 9 SUBSURFACE SOIL
HPGe CORE COUNTER & ZELTEX MOISTURE METER TEST

Completed by/Date: Checked by/Date: Page:

CORE COUNTER MEASUREMENT NUMBER	GEOLOGIST'S DEPTH INTERVAL/TOTAL LENGTH (adjusted for expansion or contraction)	BETA/ GAMMA FRISKER Corrected Counts Above Background	ZELTEX% MOISTURE/ SOIL TYPE	INTERVAL EXCEEDS WAC THRESHOLD (Corrected for moisture)	COMMENTS
EXAMPLE: P9CC-Boring#-1G	EXAMPLE: 36"-44" / 8"	EXAMPLE: X CCPM	EXAMPLE: 10% / CLAY	EXAMPLE: Yes/No	EXAMPLE: Two Core Counter Measurements acquired on 8" core interval

000074

VARIANCE / FIELD CHANGE NOTICE	50.03.40.03-22
WBS NO.: 50.03.40.03 Project Document #20701-001	Page 1 of 2
PROJECT TITLE: Comparability Study, Part B. Rev. 0	Date 11/7/98

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Justification

This Variance along with Variance 50.03.40.03-21 establishes the first field test of the HPGe Core Counter and Zeltex Moisture Meter. Under Variance 50.03.40.03-21 HPGe Core Counter data and Zeltex Moisture Meter Data was collected for the test. Under this variance specific Geoprobe soil core intervals will receive laboratory analysis.

Several Geoprobe soil borings were collected under PSP for Area 3 Predesign Investigation of Plant 9, Rev. A (20200-PSP-002). Selected soil intervals from those borings will receive laboratory analysis by SCEP under Rev. 1 of the same PSP. Those intervals NOT analyzed by SCEP, but needed for the HPGe Core Counter test, WILL be analyzed under this variance and will be submitted to sample receiving under separate chain of custody. The samples will be identified using the sample identifications provided in the PSP and analyzed for total uranium to ASL B, at the on-site laboratory, using the ICPMS method.

Data from this test will be used to compare the WAC total uranium decision determined through use of the HPGe Core Counter and Zeltex Moisture Meter, with the WAC total uranium decision determined through laboratory analysis of soil cores, for the same interval.

INFORMATION ONLY

Field Change Notice

Analyze the following core intervals for total uranium:

Boring Number	Core Interval
12390	10-16"
12390	16-22"
12390	22-28"
12390	28-34"
12390	34-42"
12390	42-51"
12390	51-57"

ORIGINAL

Continued on following page.....

Requested by: Joan White Date: 11/7/98

X IF	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	11-5-98	X	PROJECT MANAGER	11/5/98
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr	11/5/98
	ANALYTICAL CUSTOMER SUPPORT		X	OTHER	11-5-98
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

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QUALITY ASSURANCE:	OTHER:	OTHER:

.... Continued from preceding page

2153

Boring Number	Core Interval
12390	57-63"
12390	63-69"
12390	69-75"
12390	75-82"
12390	82-88"
12390	88-94"
12390	94-100"
12390	100-106"
12390	106-112"
12390	112-118"
12390	118-124"
12390	124-130"
12390	130-136"
12390	136-142"
12390	142-144"

Boring Number	Core Interval
12398	12-18"
12398	18-24"
12398	24-30"
12398	30-36"
12398	36-42"
12398	42-48"

Boring Number	Core Interval
12395	42-48"
12395	48-54"
12395	54-60"
12395	60-66"
12395	66-72"
12395	72-78"

VARIANCE / FIELD CHANGE NOTICE	50.03.40.03-23
WBS NO.: 50.03.40.03 Project Document #20701-001	Page 1 of 2
PROJECT TITLE: Comparability Study, Part B. Rev. 0	Date 1/19/99

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Justification

This Variance describes a test to determine the angular efficiency of an HPGe detector at a 1 meter detector height, at 5 distances from the detector, using known sources.

2153

Field Change Notice

1- Select one detector characterized in accordance with EQT-22, and energy calibrated in accordance with EQT-23 for use in the study, and record the detector number.

2 - Select a location on the asphalt pad in the proximity to T-305 and survey the location to acquire its X and Y position coordinates, and record the position coordinates.

INFORMATION ONLY

3 - Set the HPGe detector at the 1 meter detector height over the surveyed location. Collect one 15 minute measurement (using no sources) to obtain a background reading.

4 - Set the 4 calibration sources (Am-241, Cs-137, Co-60, and Eu-152) immediately under the detector snout at "GROUND ZERO" and obtain a 15 minute count. If the dead time exceeds 20% with all the sources this close to the detector, repeat the measurement with only the Am-241, Cs-137 and Co-60 in place, and then with only the Eu-152 in place. Various combination of the sources can be tried to reduce the dead time to below 20%. Care must be taken to ensure the sources are put in the same location if several measurements are collected. If the sources are separated, indicate which sources were measured with each 15 minute measurement. Obtain a GPS position on the source location.

5 - Leaving the detector in place, and at the same height, move the sources out 1 METER in a straight line from the last position source, and obtain a 15 minute count. At one meter from the detector snout, the dead time should not exceed 20%. If it does, proceed with separating the sources as described in Item 4. Obtain a GPS position on the source location.

Continued on following page.....

Requested by: Joan White Date: 1/19/99

X IF	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	1-18-99	X	PROJECT MANAGER	1/18/99
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr	1/19/99
	ANALYTICAL CUSTOMER SUPPORT			OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

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PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

.... Continued from preceding page

2153

6 - Leaving the detector in place, and at the same height, move the sources out another 1 meter in a straight line from the last position source so that the sources are now at the 2 METER LOCATION, and obtain a 15 minute count. Collect a DUPLICATE measurement at this location. Obtain a GPS position on the source location.

7- Leaving the detector in place, and at the same height, move the sources out 2 meters in a straight line from the last position source so that the sources are now at the 4 METER LOCATION, and obtain a 15 minute count. Obtain a GPS position on the source location.

8 - Finally, leaving the detector in place, and at the same height, move the sources out 2 meters in a straight line from the last position source so that the sources are now at the 6 METER LOCATION, and obtain a 15 minute count. Obtain a GPS position on the source location.

9 - Record this variance number on the paperwork associated with this test.

10 - No moisture meter measurement and no radon measurements are required with this test.

11 - Measurements will be numbered using the following numbering system:

A5CS-PB-X-D
Where A5 = Area 5
CS = Comparability Study
PB = Part B (of Comp Study)
X = Sequential measurement number
D = Duplicate

12 - For clarity, the position of the detector relative to the sources is shown by the following diagram:
Where Z = detector location and the vertical lines represent the source distances from the detector where measurements will be collected.

```
Z
|----------|---------|--------------------|-------------------|
0m       1m       2m                 4m                 6m
```

VARIANCE / FIELD CHANGE NOTICE	50.03.40.03-24
WBS NO.: 50.03.40.03 Project Document #20701-001	Page 1 of 1
PROJECT TITLE: Comparability Study, Part B. Rev. 0	Date 1/25/99

VARIANCE / FIELD CHANGE NOTICE (Include justification):

2153

Justification

This Variance supplements Variance 50.03.40.03-23. The Am-241 measurements at 4 meters and 6 meters from the detector were too weak at only a 15 minute count (no 59.5keV peak present). The Am-241 source will be recounted for 1 hour at both the 4 meter and 6 meter distances in an attempt to get more counts.

Field Change Notice

1 - Using the same detector employed in Variance 50.03.40.03-23 collect a 1 hour spectrum using the Am-241 peak at both the 4 meter and 6 meter source locations identified in the reference Variance. The detector height is 1 meter.

2 - Use the same numbering system identified in the reference Variance, beginning with the next sequential measurement number.

3 - Record this variance number on the paperwork associated with this test.

INFORMATION ONLY

Requested by: Joan White Date: 1/25/99

X IF	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	1-25-99	X	PROJECT MANAGER	1/25/99
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr	1/25/99
	ANALYTICAL CUSTOMER SUPPORT			OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

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PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

ORIGINAL

VARIANCE / FIELD CHANGE NOTICE	V/F 50.03.40.03-25
WBS NO.: 50.03.40.03 PROJECT/DOCUMENT #20701-001	Page 1 of 3
PROJECT TITLE: Comparability Study, Part B, Rev. 0	Date: 2/23/99

VARIANCE / FIELD CHANGE NOTICE (Include justification):

Justification

2153

The RTIMP quality assurance program, as outlined in procedure ADM-16, "In-Situ Gamma Spectrometry Quality Control", requires that the accuracy and potential bias of in-situ HPGe detector measurements be assessed annually by an intercomparison between HPGe field measurements and laboratory analysis of physical samples. This variance describes the manner in which physical samples will be collected and analyzed and how the laboratory analysis results will be compared to in-situ HPGe data. Completion of the work described in this variance will fulfill the requirement for the annual intercomparison between laboratory analyses and HPGe field measurements.

Field Change Notice

- SCRAPE VEGETATION OFF SURFACE, RJD 2/24/99

1. Ten soil samples will be collected in a circular pattern as shown in the figure attached to this variance. An eleventh sample, a duplicate, will also be collected at sample point 3. The duplicate sample shall be homogenized in accordance with procedure SMPL-01, "Solids Sampling." Each sample shall consist of a 3-inch diameter core sample of depth 0 to 6 inches.
2. The coordinates of each sampling location are provided on the attached figure. Samples shall be numbered with a 4 letter designator, RTAI (which stands for Real Time Annual Intercomparison), followed by a 2 digit designator for the year of the intercomparison (in the present instance, 99), and then followed by a number designating the particular location in the bull's-eye pattern from which the soil was collected. For example, the seventh sample collected during the 1999 annual intercomparison study would be designated RTAI-99-7. When a duplicate sample is collected, it will be numbered as described above, with the addition of a "D" on the end of the sample identification number to denote that this is a duplicate sample.
3. Instructions to the laboratory shall specify that the entire sample must be dried and its percent moisture must be determined. Each sample must also be blended prior to performing other laboratory analyses.
4. All samples shall be submitted for laboratory analysis at Analytical Support Level D. The following laboratory analyses shall be requested:

Analyte	Analytical Technique
Total Uranium	Gamma Spectrometry, ICP/mass spectrometry
Thorium-232	Gamma Spectrometry, Alpha Spectrometry
Radium-226	Gamma Spectrometry, Alpha Spectrometry

INFORMATION ONLY

ORIGINAL

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REQUESTED BY: Chris Sutton DATE: 2/17/99

X IF REQD	VARIANCE/FAN APPROVAL	DATE	X IF REQD	VARIANCE/FAN APPROVAL	DATE
X	QUALITY ASSURANCE	2-24-99	X	PROJECT MANAGER	2/23/99
	DATA QUALITY MANAGEMENT		X	Real-time Program Mgr	2/23/99
X	ANALYTICAL CUSTOMER SUPPORT Bill Westerman	2/23/99		OTHER	
	OTHER			OTHER	

VARIANCE/FCN APPROVED [X]YES [ ]NO

REVISION REQUIRED: [ ]YES [x]NO

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PROJECT MANAGER:	DOCUMENT CONTROL: Michelle Tudor	OTHER:
QUALITY ASSURANCE:	OTHER:	OTHER:

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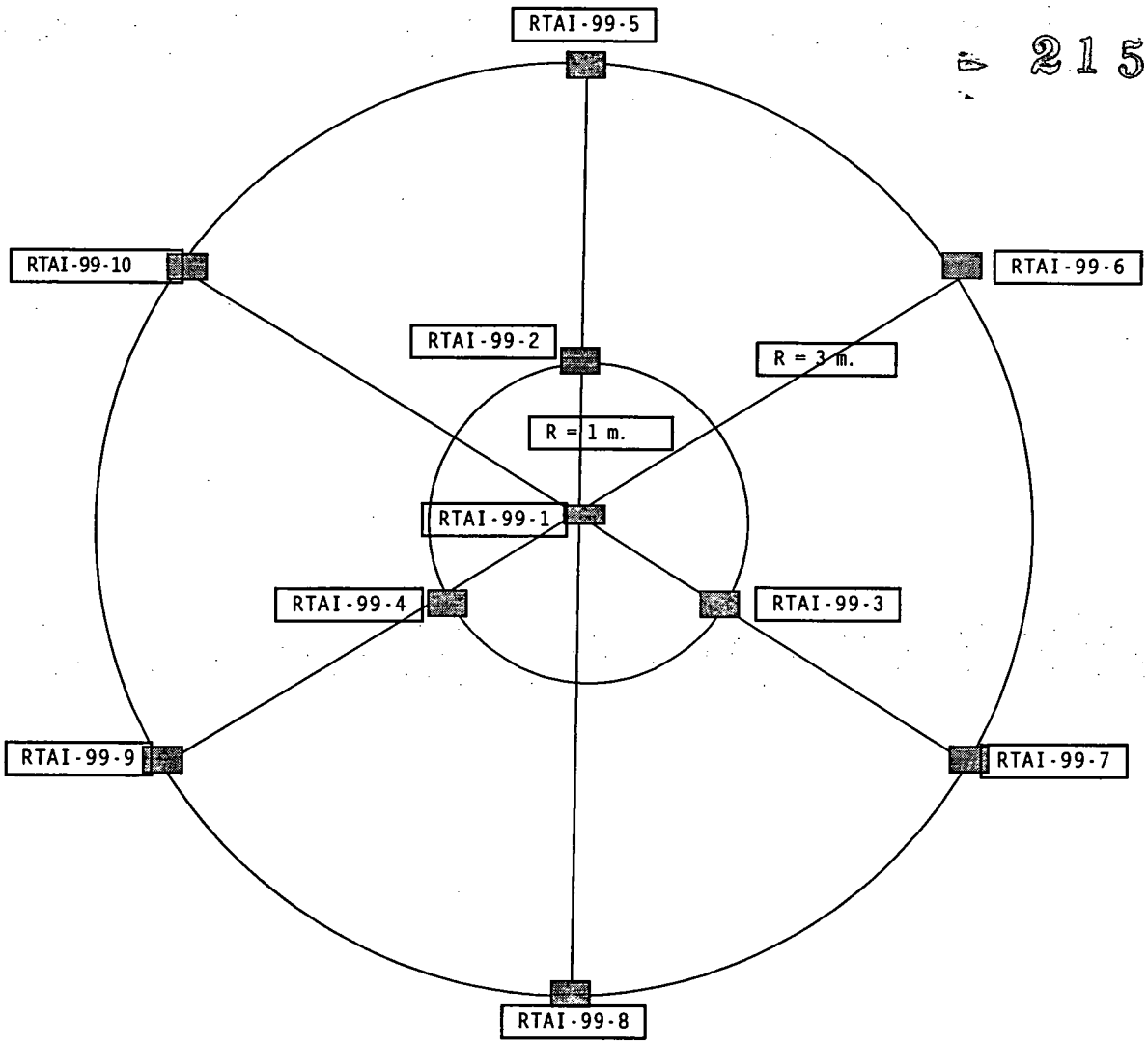
2153

5. After the completion of laboratory analyses, RTIMP personnel shall compare laboratory analysis results to the FCS control chart means for daily HPGe measurements obtained at the FCS. The comparison shall be conducted as described in RTIMP procedure ADM-16, section 6.9. The acceptance criteria for the annual intercomparison are also specified in ADM-16, section 6.9.

FIGURE 1
RTIMP ANNUAL INTERCOMPARISON BETWEEN IN-SITU HPGe AND LABORATORY RESULTS
SAMPLE COLLECTION LOCATIONS
Field Quality Control Station (North of Sewage Treatment Plant)

2153



Coordinates of Sample Collection Points

NORTHING	EASTING	SAMPLE IDENTIFICATION NUMBER
480391.4131	1351675.8618	RTAI-99-1
480394.6931	1351675.8616	RTAI-99-2
480389.7731	1351678.7023	RTAI-99-3
480389.7731	1351678.7023	RTAI-99-3D
480389.7731	1351673.0212	RTAI-99-4
480401.2531	1351675.8618	RTAI-99-5
480396.3331	1351684.3835	RTAI-99-6
480386.4931	1351684.3835	RTAI-99-7
480381.5731	1351675.8618	RTAI-99-8
480386.4931	1351667.3401	RTAI-99-9
480396.3331	1351667.3401	RTAI-99-10

TABLE OF CONTENTS

2153

SECTION	TITLE	PAGE
1.0	INTRODUCTION	1
1.1	Purpose	1
1.2	Scope	1
1.3	Key Project Personnel	2
2.0	SAMPLING PROGRAM	3
2.1	NaI Detector Measurements	3
2.2	HPGe Measurements	4
2.3	Temperature Measurements	4
2.4	Physical Soil Sampling	4
2.4.1	Physical Sampling Area Preparation	5
2.4.2	Physical Sample Collection	5
2.4.3	Sample Identification	6
2.4.4	Quality Assurance Samples	7
2.4.5	Laboratory Sample Preparation	7
2.5	Surface Moisture-Density Gauge Measurements	7
2.5.1	Area Preparation	7
2.5.2	Surface Moisture Measurements	8
2.5.3	Surface Density Measurements	8
2.6	Surveying	8
3.0	QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS	8
3.1	Project Requirements for Self-Assessments, Surveillances	8
3.2	Field Changes to the Field Implementation Plan	9
3.3	Applicable Procedures and Standard Methods	9
4.0	EQUIPMENT DECONTAMINATION	9
5.0	HEALTH & SAFETY	9
6.0	DISPOSITION OF WASTES	10
7.0	DATA MANAGEMENT	10

LIST OF TABLES

2153

TABLE	TITLE	PAGE
1-1	Key Project Personnel	2
2-1	Area Designations	5
2-2	Part B Comparability Study: Analyte List	6

LIST OF APPENDICES

APPENDIX	TITLE
A	Data Quality Objectives
B	Proposed Part B Comparability Study Test Locations
C	Physical Sampling Patterns
D	Weighted Average of Samples
E	ASTM D 3017-88: Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
F	ASTM D 2922-91: Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
G	Table G-1, Comparability Study, Part B Sample Summary

1.0 INTRODUCTION

2153

1.1 PURPOSE

This Project Specific Plan (PSP) describes the field sampling activities and identifies analyses to be performed in support of the Area 1 Phase I Remedial Action Work Plan (RAWP) Comparability Study, Part B. Sampling and analysis activities shall be consistent with the Sitewide Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Quality Assurance Project Plan (SCQ), and Data Quality Objectives (DQO) SL-025 (Appendix A).

A evaluation of soil radiation detector systems at the Fernald Environmental Management Project (FEMP) in 1994 indicated that the high purity germanium detector (HPGe) and sodium iodide (NaI) detector systems performed best for site-specific conditions. Further testing conducted in 1995 evaluated the detector systems usefulness for detecting total uranium. The results from these tests were deemed favorable and prompted the planning of additional site-specific comparability studies to be conducted as described below.

The goals of this project are to:

1) Collect data under controlled conditions as a validation of in-situ gamma systems for use in precertification and certification sampling.

2) Compare output obtained with the gamma detector systems with physical sample analytical data obtained from the detector read area in a variety of contaminated FEMP locations (Part B).

3) Evaluate the accuracy and repeatability of the systems in actual field conditions.

4) Record field variables such as counting time, detector height, and from environmental variables such as moisture levels, soil density, vegetation, and contamination distributions.

5) Determine if certification decisions at the Certification Unit (CU) level are acceptable when basing decisions on either in-situ measurements or laboratory analysis.

1.2 SCOPE

The sampling program for this project will utilize in-situ measurements and on-site laboratory analysis of soil samples as described in Section 2 of this PSP. Data collection will be conducted in ten selected areas illustrated in Appendix B. The selection of theses areas has been based on the level and type of contamination, accessability, and the ability of these areas to achieve the goals as stated above. Area locations have been determined by the Project Lead. Data collection will be divided into five stages identified as: 1) NaI detector measurements, 2) HPGe measurements, 3) soil and air temperature measurements, 4) physical soil sampling, 5) surface moisture-density gauge measurements, and 6) surveying.

In-situ measurements inside each of the ten selected areas will be performed using the NaI detector, HPGe, thermometer, and surface moisture-density gauge. NaI detector measurements will be completed first followed by HPGe measurements. Surface moisture-density gauge measurements, physical sampling, and temperature measurements will be performed after detection measurements. All measurements and sampling shall be completed within a 2-hour time period for each area.

Immediately after in-situ HPGe measurements have been taken, 6 to 15 physical soil samples (sample quantities will be area specific) for isotopic analysis of radiological constituents will be collected beginning at the same fixed point and radiating outward in a predetermined pattern as described in Section 2 of this PSP and illustrated in Appendix C. One duplicate sample will be collected from each area. Adjacent to each physical sample location, a surface moisture-density gauge measurement will be taken in addition to soil temperature readings. Air temperature will be monitored at each area during sample collection.

Analysis of the data will involve the comparison of the NaI detector and HPGe measurements to a weighted average calculation of the physical sample analytical results. The weighted considerations per distance from the point under the detector and the detector height are listed in Appendix D. Results of soil moisture, density, temperature measurements, and field quality assurance results will be used to complete the comparison analysis.

1.3 KEY PROJECT PERSONNEL

The team members of the Soil Characterization and Excavation Project (SCEP), Project Development and Reports (PDR), and Soil and Miscellaneous Media Projects (SMMP) listed in Table 1-1 below are key project personnel.

TABLE 1-1

KEY PROJECT PERSONNEL

TITLE	PRIMARY	ALTERNATE
Project Lead	Keith Nelson	Steve Davis
Project Engineer	Jim Schwing	Steve Davis
Project Coordinator	Dean Shanklin	Karen Voisard
Field Sampling Lead	Mike Frank	June Love
Laboratory Contact	Bill Westerman	Jenny Vance
Quality Assurance Contact	Keith Payne	Harold Swiger
Analytical Lead	Al Bacon	Don Luken
Data Management Contact	Jeff Maple	Susan Marsh
Real Time Analytical Supervisor	Steve Davis	Jim Schwing
Health & Safety Contact	Ray Webber	Mike Davis

2.0 SAMPLING PROGRAM

Data collection will be conducted in 10 selected areas having the dimensions of 33 by 33 ft (10 by 10 m). Each area will be mowed and raked prior to the start of field activities. Area locations are illustrated in Appendix B. Data collection will be divided into six stages identified as:

1) NaI Detector Measurements
2) HPGe Measurements
3) Soil and Air Temperature Measurements
4) Physical Soil Sampling
5) Surface Moisture-Density Gauge Measurements
6) Surveying

In-situ measurements at each area will be performed using the NaI detector, HPGe, standard thermometer, and surface moisture-density gauge. NaI detector measurements will be conducted first followed by HPGe measurements. The collection of soil and temperature measurements, physical sampling, and surface moisture-density gauge measurements will then follow. All measurements and sampling shall be completed within a 2-hour time period for each area.

The surface moisture-density gauge contains two sealed sources - an 8 millicurie glass-bead source of cesium-137 to provide gamma radiation for the density measurement and a forty millicurie americium-241:beryllium source yielding 70,000 neutrons per second for the moisture determination. These sources will affect the performance of both the NaI and HPGe detector systems and must be kept away from the measurement site when the detector systems are in use. A distance of 1000 ft (305 m) should be maintained unless otherwise directed by the Project Lead.

Coordinates and elevations of each sample location will be surveyed by SMMP personnel using Geodimeter survey instrumentation. The Global Positioning System (GPS) will not be used for sample location determination.

HPGe measurements will be performed from both 0.98 ft (30 cm) and 3.28 ft (1 m) above a fixed point on the ground surface. Immediately after in-situ measurements have been taken, 6 to 15 physical soil samples for isotopic analysis of primary radiological constituents will be collected. Sample collection will begin at the same fixed point and radiate outward in a predetermined pattern (Appendix C). Adjacent to each physical sample location, a surface moisture-density gauge measurement and a soil temperature measurement will be taken. Area-specific air temperatures will be monitored and recorded during each sampling event.

Technicians will create a simple table on the Field Activity Log to record temperature, moisture, density, and sample information, and time associated with each physical sampling location. In addition, a Sample Collection Log shall be completed to document all necessary sample information.

2.1 NaI DETECTOR MEASUREMENTS

The surface moisture-density gauge must be maintained a distance of 1000 ft (305 m) or more from the measurement site to minimize adverse influences to the NaI detector's performance.

Data collection will begin through the use of the NaI detector for each 33 by 33 ft (10 by 10 m) square area following the requirements contained within the draft procedure EQT-30, *Operation of the Sodium Iodide (NaI) Detection System.* Complete coverage for each area will be completed using static and mobile measurements.

Repeated measurements using the NaI detector may be taken as per the direction of the Project Lead.

2.2 HPGe MEASUREMENTS

The surface moisture-density gauge must be maintained a distance of 1000 ft (305 m) or more from the measurement site to minimize adverse influences to the HPGe detector's performance.

Following the completion of NaI detector measurements, the area will be prepared to collect measurements using the HPGe. Operation of the detector should follow the requirements contained within Procedure EQT-23, *Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors*. The center of the 33 by 33 ft (10 by 10 m) square area will be determined and marked using a rope measuring greater than 33 ft (10 m) in length and basic geometry skills. HPGe device will be located directly above this center. From this lateral point, two sets of measurements shall be performed. Measurement heights will be at 0.98 ft (30 cm) and 3.28 ft (1 m) directly above the center point. Count times for each data collection event will be approximately 15 minutes.

Repeated measurements using the HPGe detector may be taken as per the direction of the Project Lead.

2.3 TEMPERATURE MEASUREMENTS

A single air and soil temperature measurement will be taken and recorded in the Field Activity Log for each physical soil sample taken. Measurements shall be recorded to the nearest 0.1°C. Two thermometers shall be employed to satisfy the requirements of the temperature measurements. The first thermometer shall be used to measure air temperature and shall be suspended in the air by means of a string attached to a stake or similar apparatus. The stake or similar apparatus shall be located inside the 33 by 33 ft (10 by 10 m) test area. The center of the thermometer shall be placed 3.28 ft (1 m) above the ground surface and shall be protected from the influences of direct sunlight and wind. The air thermometer shall be set up prior to the collection of physical soil samples.

The second thermometer shall be used to measure in-situ soil temperatures. It shall be of sufficient design to be inserted into the ground without requiring a pilot hole. The base of the thermometer shall be inserted 4 inches below the ground's surface and be capable of obtaining an accurate soil temperature. The soil thermometer shall be inserted into the soil adjacent to the location from which each physical soil sample will be taken and prior to the collection of each sample.

Both air and soil temperature measurements and the time the measurements were taken shall be recorded on the Field Activity Log immediately after the collection of each physical soil sample.

2.4 PHYSICAL SOIL SAMPLING

Each of the ten areas will be identified as a Low, Medium, High, or Heterogeneous Contamination Areas and have been assigned an arbitrary identification number from one to ten. Table 2-1 summarizes the area designations. This designation will determine the number of physical samples that will be collected from each

area and the sample lay-out (Appendix C) that will be followed in the field to identify the location of each physical sample. Data collection will begin in the low contamination areas and conclude in the high contamination areas.

Physical samples shall be collected and submitted for on-site/off-site laboratory analysis. The analytes are listed in Table 2-2. For all areas, the first sample will be taken directly below the HPGe setup location. Sampling will then proceed in a radially outward in one of three patterns. For areas designated as Low, Sampling Pattern C-1 (Appendix C) will be followed. For areas designated as Medium, Sampling Pattern C-2 (Appendix C) will be followed. For areas designated as High or Heterogeneous, Sampling Pattern C-3 (Appendix C) will be followed.

TABLE 2-1

AREA DESIGNATIONS

Area Designation	Contamination Level	Areas by Identification Number
Low	0 - 80 ppm Total Uranium	1, 8, 9
Medium	80 - 200 ppm Total Uranium	2, 4, 5, 6
High	> 200 ppm Total Uranium	3, 7
Heterogeneous	Varied	10

2.4.1 Physical Sampling Area Preparation

Prior to the start of field activities, all areas will be mowed and raked clean by Restoration Services Organization Personnel. No additional area preparation is required. All existing vegetation will remain in place and will be collected as part of the soil sample.

2.4.2 Physical Sample Collection

Each sample location and sample material will be field-screened using a pancake Geiger-Mueller detector and results will be recorded on the Sample Collection Log and Field Activity Log. The sample label will be completed with sample collection information and the technicians will complete a Field Activity Log, Sample Collection Log, and Chain of Custody/Request for Analysis (COC).

Technicians will use a clean polybutyrate liner with or without a split barrel sampler (as conditions require) to collect a 0 to 4-inch deep by 3-inch diameter core of soil. The Project Sample Lead may alter dimension specifications as dictated by field conditions or laboratory requirements. The liner will serve as the sample container and be capped at both ends, using prefitted plastic caps, after filling. Liners 12 inches in length may be used to collect a 0 to 4-inch deep sample without cutting to a 4-inch length. Technicians will ensure accurate depth by measuring and recording the depth at which the liner (or split barrel sampler) is inserted into the soil.

Failure to collect a physical sample due to encountering an obstruction (e.g., rock or debris) shall prompt the technician to attempt to collect a physical sample adjacent to the original location. Methodology as described in Procedure SMPL-01, *Solids Sampling* shall be followed as directed by the Field Sampling Lead.

A geologist shall describe the soil adjacent to each sample location on the Field Activity Log. The description shall include the sample color and percent organic material, clay, sand, and gravel.

Each physical soil sampling location shall be staked for survey purposes. The sample identification number shall be inscribed on each stake.

TABLE 2-2

PART B COMPARABILITY STUDY: ANALYTE LIST

ANALYTE	SAMPLE MATRIX	LAB	ASL	HOLDING TIME	METHOD/ CONTAINER
Isotopic Uranium	Solid	On/Off-Site	B	6 Months	Capped Liner
Radium-226	Solid	On/Off-Site	B	6 Months	
Radium-228	Solid	On/Off-Site	B	6 Months	
Isotopic Thorium	Solid	On/Off-Site	B	6 Months	
Cesium-137	Solid	On/Off-Site	B	6 Months	
Potassium-40	Solid	On/Off-Site	B	6 Months	

2.4.3 Sample Identification

All samples collected by SMMP Technicians will be assigned a unique sample number supplied by the Field Sampling Lead. This unique sample number shall appear on the COC and used to identify the sample during analysis, data entry, and data management . A prefix will be added to each sample number to identify why and where the sample was collected. The prefix will begin with the project and area identification number followed by the sample location number as shown on the Physical Sampling Patterns in Appendix C. Sample numbers will begin with a "PBC" (Part B Comparability) followed by a "-" and the area number (1 through 10) followed by a "-" and sample location number. Example: PBC-3-12 is the sample number for Part B Comparability, Area 3, Sample Number 12 (Refer to Table G-1, Comparability Study, Part B Sample Summary, in Appendix G).

The technician shall enter the sample collection information into the appropriate blocks on the sample label, Field Activity Log, Sample Collection Log, and Chain of Custody/Request for Analysis (COC).

2.4.4 Quality Assurance Samples

Quality assurance samples shall be collected in the form of field duplicates of physical soil samples. Sampling frequency will be one per area for a total of 10. Duplicate samples shall be collected next to the primary sample location in the same manner as described in Section 2.4. The Field Sampling Lead shall determine duplicate sample locations. Duplicate sample identification numbers shall be given a blind sample number by assigning the next sampling number for the specific area. Duplicated sample numbers are listed in Appendix G.

2.4.5 Laboratory Sample Preparation

Upon receipt of the physical sample, the on-site/off-site laboratory shall:

1) Remove, weigh, and record all sample material (including any organic matter) in the sample core tube and place it in a disposable aluminum pan. The analyst performing this step shall describe the appearance of each sample.

2) Dry the entire sample at 105° to 112° C for at least 8 hours to constant weight.

3) Calculate and record the percent moisture content of the sample.

4) Grind the entire sample until all material passes through a 1mm sieve.

5) Blend the sample either by hand or machine.

6) Remove the necessary aliquot for analysis and archive the remaining sample material.

2.5 SURFACE MOISTURE-DENSITY GAUGE MEASUREMENTS

Surface moisture-density gauge measurements will be taken to determine soil moisture content and soil density within each area. Measurements will be taken in-situ and adjacent to each physical sample location. For areas of concern having a depth of less than 3.4 in (9 cm) the backscatter method will be used. For areas of concern having a depth greater than 3.4 in (9 cm) the direction transmission method will be used. Unless directed otherwise by the Project Lead, the backscatter method will be employed for use under this PSP. The method of measurement shall be recorded in the Field Activity Log.

Technicians shall calibrate the surface moisture-density gauge as per ASTM Procedures listed in Appendix E and F. The method to be used (backscatter or direct transmission) will be selected. Unless directed otherwise by the Project Lead, the backscatter method will be employed for use under this PSP.

2.5.1 Area Preparation

Technicians shall note in the Field Activity Log the condition of the sampling area to include disturbances due to excavation, vehicle traffic, etc. Using a clean stainless steel trowel (and other tools as deemed applicable by the Field Sampling Lead), the SMMP Technician will remove all vegetative, loose, and disturbed material, and remove additional material as necessary to reach the

top of the vertical interval to be tested/sampled. Technicians will take care not to remove any soil if the surface vegetation is removed.

A horizontal area of sufficient size to accommodate the surface moisture-density gauge will be prepared. The area should be planed smooth so as to obtain maximum contact between the soil and the instrument. The prepared area should be approximately twice as large as the base of the instrument. The maximum void beneath the instrument that can be tolerated shall not exceed 0.125 in (3 mm) (refer to ASTM procedures in Appendices for further discussion on void definition and tolerances). Native fines of similar water content can be used to fill existing voids. The total area filled in shall not exceed 10 percent of the bottom area of the instrument. Several trial seatings may be required to achieve these conditions. Preparation activities shall be recorded in the Field Activity Log.

2.5.2 Surface Moisture Measurements

As per ASTM D 3017-88 (Appendix E) the instrument will be seated firmly on the prepared surface. Place the source in the proper position and take a count for the normal measurement period. Determine the ratio of the reading to the standard count. From this ratio and the calibration and adjustment data, determine the in-place water content per unit volume. Record field observations, readings, time, etc. on the Field Activity Log as appropriate.

2.5.3 Surface Density Measurements

As per ASTM D 2922-91 (Appendix F) the instrument will be placed firmly on the prepared surface. Keep all other radioactive sources away from the gauge to avoid affecting the measurement (i.e.; so as not to affect the readings). Secure and record one or more reading for the normal measurement period in the instrument position. Record field observations, readings, time, etc. on the Field Activity Log as appropriate.

2.6 SURVEYING

State planar coordinates and mean sea level elevations for each physical sample location will be surveyed by SMMP personnel using Geodimeter survey instrumentation. Survey activities will be conducted after the completion of physical sampling for each area.

3.0 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

3.1 PROJECT REQUIREMENTS FOR SELF-ASSESSMENTS, SURVEILLANCES

Self-assessment and independent assessments of work processes and operations shall be undertaken to assure quality of performance. Self-assessment shall be performed by the Soil and Water Projects Division, and shall encompass technical and procedure requirements. Such self-assessment may be conducted at any point in the project.

An independent assessment may be performed by the FEMP QA organization by conducting a surveillance. One or more surveillance may be conducted, consisting of monitoring/observing on-going project activity and

work areas to verify conformance to specified requirements. Surveillances shall be planned and documented in accordance with Section 12.3 of the SCQ.

3.2 FIELD CHANGES TO THE FIELD IMPLEMENTATION PLAN

Prior to the implementation of field changes, the Project Coordinator and field Sampling Lead shall be informed of the proposed field changes. Once the Project Coordinator has obtained written approval from the Project Lead and QA Representative for the field changes to the PSP, the field changes may be implemented. Field changes to the PSP shall be noted in the applicable project field logbook and on a Variance Request Form. QA must receive the completed Variance Request form, which includes the signatures of the Project Coordinator, Project Lead, and the Quality Assurance Representative, within 10 days of the granting of the verbal approval.

3.3 APPLICABLE PROCEDURES AND STANDARD METHODS

Sample collection under this PSP shall follow the requirements outlined within the following procedures and standard methods:

ADM-02, Field Project Prerequisites
EQT-30, Operation of the Sodium Iodide (NaI) Detection System
EQT-23, Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors
SMPL-01, Solids Sampling
SMPL-21, Field Quality Control Samples (Draft)
ASTM D 2922-91: Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017-88: Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

4.0 EQUIPMENT DECONTAMINATION

Sampling equipment shall be decontaminated prior to transport to the sample field site and after all sampling is completed to limit the introduction of contaminants from equipment to sampled media and to protect worker safety and health. The sampler core tip (if used), barrel, and the liner will be cleaned per Level I of the SCQ prior to use or as directed by the Field Sampling Lead. The barrel portion of the sampler will be wiped down after each use to remove visible soil or material. Wet decontamination will not be necessary because the barrel does not contact the sample when using a liner.

5.0 HEALTH & SAFETY

SMMP Technicians shall conform to precautionary surveys performed by the personnel representing the Utility Engineer, Industrial Hygiene, and Radiological Control. Concurrence to applicable safety permits (indicated by the signature of each SMMP Sampling Technician assigned to this project) is expected by SMMP Sampling Technicians in the performance of their assigned duties.

The SMMP Field Sampling Lead will ensure that each SMMP Technician performing sampling related to this project has read the Project-Specific Health Plan and Safety Matrix (PSHSM) identified as CON-MTX-1039, dated May 1996, and the applicable surveys that protect worker safety and health. SMMP Technicians who

do not sign these documents shall not participate in the execution of sampling activities related to the completion of assigned project responsibilities. A copy of applicable safety permits/surveys issued for worker safety and health shall be posted at each sample location and at the completion of the project, the completed forms shall be submitted for incorporation into the project record files.

6.0 DISPOSITION OF WASTES

During completion of sampling activities, SMMP Technicians may generate contact wastes and decontamination waste. Following completion of sampling, the SMMP Technicians shall place contact wastes into properly labeled bags and disposed of in accordance with appropriate FEMP waste management policies. Waste materials determined to be free of contaminations will be disposed of in an on-site uncontrolled access dumpster. Excess sample material shall be returned to the ground at the sampling location.

7.0 DATA MANAGEMENT

Information collected during the investigation will be properly managed following completion of the field activities. As specified in Section 5.1 of the SCQ, sampling teams shall describe daily activities on the Field Activity Log sufficient for the sampling team to reconstruct a particular situation without reliance on memory. Sample collection logs shall be completed according to instructions specified in Appendix B of the SCQ.

Electronically recorded data from the NaI detector, HPGe, and Geodimeter survey instrumentation shall be downloaded to separate disks at the end of each day. Disks will be download into the LAN (Local Area Network). Once on the LAN, the Data Management Contact will perform an evaluation of the data and then produce an error file and a zipped archive file of the data. Once complete, the data will be sent to the loader where it will be loaded onto the Oracle system and error logs will be generated. The data will then be made available to users through both the GIS (Graphical Information System) and MS (Microsoft) Access software.

Paper-generated data from documents such as the Field Activity Log, Gamma Spectrometry Field Worksheet, Geodimeter Survey Worksheet, and Sample Collection Log shall undergo an internal QA/QC review by the SMMP Technicians. Copies will be generated and delivered to the Data Management Contact who will perform an evaluation of the data and create the appropriate links between the electronically recorded data and the paper-generated data. Additional data entry fields may need to be created to handle soil moisture, density, and temperature measurements and the data will then be input into the Oracle System. Data entry personnel shall be informed of the field reporting format of the generated soil moisture, density, and temperature measurements. The data will be made available to users through both the GIS and MS Access Software.

APPENDIX A

DATA QUALITY OBJECTIVES

2153

Fernald Environmental Management Project

Data Quality Objectives

Title: Site Soils In-situ Comparability Study

Number: SL-025

Revision: 0

Draft Date: 10/15/96

Contact Name: Steve Davis

Approval:

DQO Coordinator — Date:

William D. Kelley

Approval:

Project Manager — Date:

Keith A. Nelson

Rev. #	0				
Draft:	10/15/96				

Data Quality Objectives
Site Soils In-situ
Comparability Study

1.0 Statement of Problem

The DQO team consists of a project lead, a field lead, a statistician, a lead radiological chemist, a geologist/site cell representative for WAC attainment issues, a sampling supervisor, a nondestructive assay supervisor, a data management lead, a gamma spectroscopy expert, and a representative from the DOE Environmental Measurements Lab.

The use of in-situ devices for measuring isotopic uranium, radium and thorium is desired in order to optimize time and resources during soil characterization. The Soils Remediation Project (SRP) requires a controlled study of the potential application for certification testing of in-situ analyses consisting of a combination of in-situ high purity germanium (HPGe) detectors, a mobile sodium iodide system (RTRAK, and a field densitometer for information on soil density and percent moisture. The study needs to determine the accuracy and repeatability of the systems in actual field conditions, assess possible impacts to the system from environmental variables such as moisture levels, soil density, soil temperature, vegetation and contamination distributions, evaluate the effects of variables such as detector height, platform speed, alarm thresholds, and potential operator bias, and determine if certification decisions at the Certification Unit (CU) level can be made that meet the sensitivity and precision requirements of the site; ultimately an assessment will be made if certification decisions are comparable when based on in-situ measurements compared to decisions based on laboratory analyses.

This study needs to complete field data collection and the statistical analysis in time for submission of the comparability study report to U.S. EPA by March 1997, and a certification report to U.S. EPA. by April 1997. The study of in-situ methodologies is necessary prior to submission of subsequent certification plans that incorporate the full use of these systems. Confidence with the in-situ methodologies is required to support technical justification for their use, resulting in acceptance and confidence by stakeholders and regulators.

2.0 Identify the Decision

The primary decision to be made from results of this study is a determination of the capabilities of the in-situ measurement systems. This information must be specific and detailed enough such that decisions can be made on the applicability of this technology to prospective future certification and/or classification studies on site soils for radiological analyses.

3.0 Inputs That Affect the Decision

The radiological constituents of concern are the primary radiological contaminants: isotopic uranium, isotopic thorium, isotopic radium, as well as cesium-137. The Action Levels defining the minimum detection capability and maximum resolution are the FRLs for the site soils. These levels are the highest contaminant levels that can be tolerated while still allowing the ability to meet certification and other regulatory requirements, as well as achieving the mandated level of public safety. (See table B-2 for a list of contaminants of concern and corresponding action levels).

The analytical media include soil, sediment, and organic material in the compositions typically encountered on the site.

The following key factors have been identified based on 1994 and 1995 studies using this and similar instrumentation, and the collected data must encompass the expected ranges to be encountered for each of these factors:

- Analyte concentration range
- Soil type
- Soil temperature
- Soil density
- Soil percent moisture
- environmental conditions impacting the instrumentation (rain, snow, temperature, vegetation)
- environmental conditions impacting the operators (temperature, precipitation)

Collected data must be in a format able to be analyzed statistically to provide relevant information that can be used to predict the results of future applications of the detector systems.

4.0 The Boundaries of the Situation

The population parameters of concern in this study are all of the inputs that impact certification decisions that would be made if based on separate but parallel in-situ and laboratory data.

The scale of decision making will be on the level of the certification unit (CU) as

defined in the Area 1, Phase I work plan.

The action triggering radiological concentrations will be the limits listed in Table B-2. These limits are based on the Final Remediation Levels (FRLs). These define the minimum required sensitivity and minimum resolution to still allow certification decisions to be made, regulatory criteria to be complied with, and public safety to be maximized.

The time period of this study is limited to the start of the Area 1, Phase I remediation project (Fall 1996) until the delivery of the certification report in early 1997.

5.0 Decision Rule

From the previous section inputs, the following is determined to be true: data collected must encompass the range of environmental conditions (rain, snow, temperature, vegetation) potentially impacting either the equipment or the operator. Additionally data collected must encompass the expected range of soil media, soil density, soil temperature, percent moisture, and analyte concentration ranges.

If the lab and field methods do not encompass the required ranges, or the data is not definitive enough to predict whether the methodology will operate successfully, erroneous usage decisions may be made. Alternative actions will be that certification decisions will be rely more heavily on data obtained from laboratory-based analysis of physical samples.

6.0 Limits on Decision Errors

A) Is the collected data sufficient to determine the capabilities of the in-situ methodology?

False negative error

In this situation, it is determined that there is not sufficient data to assess the operating capabilities of the in-situ methodology, when in actuality the data is sufficient. This error would result in more testing work being performed, and hence increased cost and delays in the certification decision.

False positive error

A false positive error would imply that the determination is made that there is sufficient data to determine how the in-situ methodology functions, when in actuality there is not.

In this case, a false positive is of greatest concern. The false positive could result in

an area being certified as attaining the FRLs, when it in fact exceeds the FRLs. Alternately, a false positive could result in an area being classified incorrectly as not in compliance with the FRLs, thus resulting in increased cost and closure delays.

B) A statistical comparison of planned in-situ measurements with parallel laboratory results will be used to evaluate the completeness of the data collection effort.

7.0 Design for Obtaining Quality Data

7.1 Sample Collection

Data collection will be conducted in a minimum of ten selected areas having the dimensions of 10 by 10 meters (33 by 33 feet). The selection will be based on the level and type of contamination, accessability, and the ability to achieve the goals as stated above. Area locations are illustrated in Table 2. Data collection will be divided into four different stages identified as:

- RTRAK Measurements
- HPGe Measurements
- Surface Moisture-Density Gauge Measurements/Physical Sampling
- Soil temperature readings

In-situ measurements inside each of the ten selected area will be performed by the RTRAK, HPGe, and surface moisture-density gauge. RTRAK measurements will be conducted first followed by HPGe measurements. Surface moisture-density gauge measurements and physical sampling will be performed at the same time. All measurements and sampling will be completed within one day's time for each area. Coordinates of each sample location will be surveyed by Soil and Miscellaneous Media Projects (SMMP) personnel, using Geodimeter survey instrumentation in order for precision to be maintained.

HPGe measurements will be performed from both 30 cm (1 ft) and 1 m (3.3 ft) above a fixed point on ground surface. Immediately after in-situ measurements have been taken, 6 to 15 physical soil samples (for isotopic analysis) will be collected beginning at the same fixed point and radiating outward in a predetermined pattern. Adjacent to each physical sample location, one or more surface moisture-density gauge measurement will be taken. Soil temperature will also be measured.

Each of the ten areas will be mowed and excessive debris removed by FEMP Site Personnel prior to the start of sampling and measurements.

7.2 QC Considerations

Laboratory analyses will be performed using the methodology and QC analyses

specified for ASL B in the SCQ.

A rinsate blank of one of the casings will be collected and analysed prior to collection of the environmental samples, to ensure that these casings are not sources of contamination. If contamination is detected in this rinsate, the Project Manager in conjunction with applicable quality assurance analytical personnel will be responsible for determining the impacts on the project, and if necessary identifying and implementing an alternate container preparation or sampling technique that will insure data quality is not impacted. Field QC samples will also include field duplicates, collected with a frequency of one per 20 or one per matrix, whichever is more frequent, with the field and project leads determining matrix differentiations

7.3 Independent Assessment

Self-assessment and independent assessments of work processes and operations shall be undertaken to assure quality of performance. Self-assessment shall encompass technical and procedural requirements. Such self-assessment may be conducted at any point in the project.

Independent assessment shall be performed by the Fernald Environmental Management Project (FEMP) QA organization by conducting Surveillances. Surveillances shall be planned and documented in accordance with Section 12.3 of the SCQ.

7.4 Applicable Procedures

Sample collection under the PSP shall follow the requirements outlined within the following procedures:

ADM-02, Field Project Prerequisites
ASTM D 2922-91: Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 3017-88: Standard Test Method for Water Content of Soil and Rock in place by Nuclear Methods (Shallow Depth)
EP-SMS-002, Field Quality Control Samples
EQT-22, Characterization of Gamma Sensitive Detectors
EQT-23, Operation of ADCAM Series Analyzers with Gamma Sensitive Detectors
EQT-30, Operation of the RTRAK Vehicle Sodium Iodide (NaI) Detection System
SMPL-01, Solids Sampling
PSP for Area 1 Phase 1, Remedial Action Work Plan for Comparability Study, Part B, Section 2.0

APPENDIX A

DATA QUALITY OBJECTIVE SUMMARY

Data Quality Objectives
Site Soils
In-Situ Comparability Study

1A Task/Description: Comparability Sampling Analysis

1.B Project Phase: (Put an X in the appropriate selection.)

RI ☐ FS ☐ RD ☐ RA ☒ R,A ☐ OTHER

1.C. DQO No.: SL-025 DQO Reference No.: N/A

---

2. ☐ Media Characterization: (Put an X in the appropriate selection.)

Air ☐ Biological ☐ Groundwater ☐ Sediment ☐ Soil ☒

Waste ☐ Wastewater ☐ Surface water ☐ Other (specify) _____

---

3. Data Use with Analytical Support Level (A-E): (Put an X in the appropriate Analytical Support Level selection(s) beside each applicable Data Use.)

Site Characterization
A ☒ B ☒ C ☐ D E ☐

Risk Assessment
A ☐ B ☐ C ☐ D ☐ E ☐

Evaluation of Alternatives
A ☐ B ☐ C ☐ D ☐ E ☐

Engineering Design
A ☐ B ☐ C ☐ D ☐ E ☐

Monitoring during remediation activities
A ☐ B ☐ C ☐ D ☐ E ☐

Other
A ☐ B ☐ C ☐ D ☐ E ☐

4.A. Drivers: Area 1 Phase 1 Remedial Action Work Plan (RAWP), Applicable or Relevant and Appropriate Requirements (ARARs) and Operable Unit 5 Record of Decision (ROD)

4.B. Objective: Determine whether the in-situ methods used for radiological contamination are comparable with fixed laboratory analyses for providing accurate soils' data, and whether they are of sufficient accuracy and precision to be used for soil certification.

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5. Site Information (Description)

The OU2 and OU5 RODs have identified areas at the FEMP that require remediation activities. The RODs specify that the soils in these areas will be comply with the FRLs. Certification will be necessary for areas of the site with soils that have been remediated to demonstrate that the residual soils do not contain contamination exceeding these levels. Use of in-situ testing would provide significant time and cost savings, if the resulting data is of sufficient quality and repeatability.

6.A. Data Types with appropriate Analytical Support Level Equipment Selection and SCQ Reference (Place an "X" to the right of the appropriate box or boxes selecting the type of analysis or analyses required. Then select the type of equipment to perform the analysis if appropriate. Please include a reference to the SCQ Section.)

1. pH	☐	2. Uranium	☐	3.BTX	☐
Temperature	☒*	Full Radiologic	☒**	TPH	☐
Specific Conductance	☐	Metals	☐	Oil/Grease	☐
Dissolved Oxygen	☐	Cyanide	☐		
Technetium-99		Silica	☐		
4. Cations	☐	5. VOA (specify)	☐	6. Other	☒***
Anions	☐	BNA	☐		
TOC	☐	Pesticides	☐		
TCLP	☐	PCB	☐		
CEC	☐				
COD	☐				

* soil and ambient air temperature at individual sample locations
** See Attached List
*** Density and % moisture

6.B. Equipment Selection and SCQ Reference

	Equipment Selection	Refer to SCQ Section
ASL A	RTRAK, HPGe, Densitometer	SCQ Section: App B, Table 1
ASL B	Per SCQ	SCQ Section: App B, Table 1
ASL C		SCQ Section:
ASL D		SCQ Section:

ASL E _____ SCQ Section: _____

7.A. Sampling Methods: (Put an X in the appropriate selection.)

Biased ☐ Composite ☐ Environmental ☐ Grab ☒ Grid ☒

Intrusive ☒ Non-Intrusive ☐ Phased ☐ Source ☐

DQO Number: SL-025

7.B. Sample Work Plan Reference: The DQO is being established prior to completion of the work plan.

Background samples: Area 1 Phase 1 Remedial Action Work Plan

7.C. Sample Collection Reference:

Sample Collection Reference: Per SCQ

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8. Quality Control Samples: (Place an "X" in the appropriate selection box.)

8.A. Field Quality Control Samples:

Trip Blanks	☐	Container Blanks	X **
Field Blanks	☐ **	Duplicate Samples	X
Equipment Rinsate Samples	☐ **	Split Samples	☐
Preservative Blanks	☐	Performance Evaluation Samples	☐

Other (specify) ** Rinsates of the casings will be analyzed for applicable analytes of concern to prequalify the casings as not containing contaminant levels that would impact the levels of concern. Rinsates will also be performed for cutting shoes where they are utilized. Other field blanks and rinsates are not applicable to this type of sampling analysis.

8.B. Laboratory Quality Control Samples:

Method Blank	☒	Matrix Duplicate/Replicate	X
Matrix Spike	☒	Surrogate Spikes	☐

Other (specify) _____

9. Other: Please provide any other germane information that may impact the data quality or gathering of this particular objective, task or data use.

Sample density will be dependent upon the class of Certification Unit for an area. Proposed Certification Unit designation will be included in Project Specific Plans for each area sequentially undergoing certification.

APPENDIX B

CONSTITUENTS OF CONCERN

TABLE B-1

AREA DESIGNATIONS

Area Designation	Contamination Level	Areas by Identification Number
Low	0 - 80 ppm Total Uranium	1, 8, 9
Medium	80 - 200 ppm Total Uranium	2, 4, 5, 6, 10
High	> 200 ppm Total Uranium	3, 7

TABLE B-2
SUMMARY OF SITE SOIL CONSTITUENTS OF CONCERN

Analytical Suites	Site Soil Contaminants of Concern	Certification Level (FRL)
Primary COCS		
Gamma discernable radiological	Uranium-238	6.7 mg/kg FRL [1, 2]
	Uranium-Total	20 mg/kg FRL [3]
	Radium-226	1.7 P.I./g FRL [4]
	Radium-228	1.8 P.I./g FRL [4]
	Thorium-228	1.7 P.I./g FRL [4]
	Thorium-230	280 P.I./g FRL [4]
	Thorium-232	1.5 P.I./g FRL [4]
	Cesium-137	1.4 P.I./g FRL [5]

1 Uranium-238 value is based on the OU5 Draft ROD (8/1/1995) FRL for uranium-total in the FEMP process area, assuming the natural distribution of uranium isotopes

2 OU5 Draft ROD (8/1/1995) FRLs are listed: goals are 5.0 mg/kg based on ALARA

3 20 mg/Kg limit is the OU5 Draft ROD (8/1/1995) FRL for the process area. FRL is 50 mg/Kg for the site as a whole

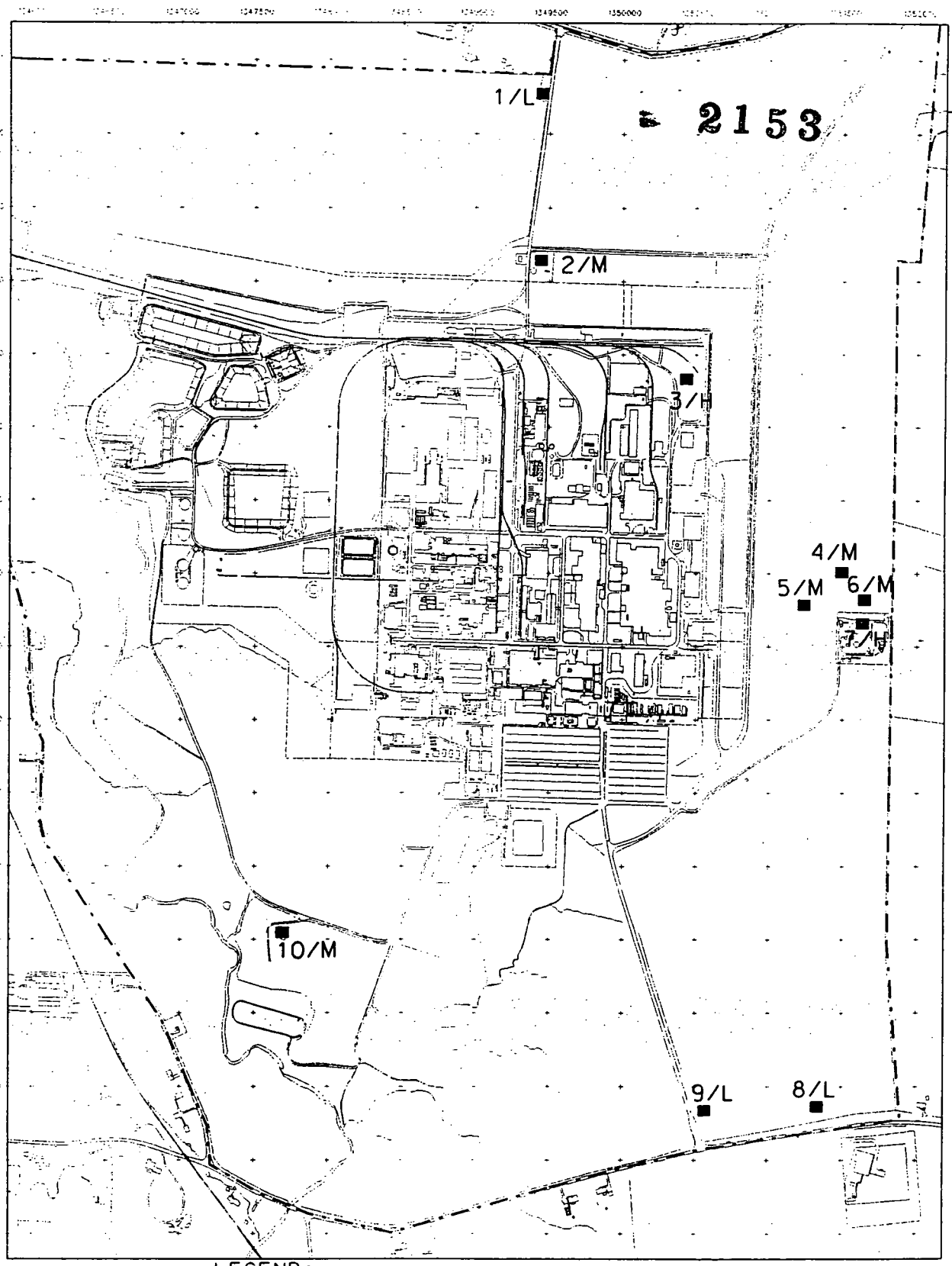
4 OU5 Draft ROD (8/1/1995) FRLs are listed: goals are 1.0 mg/kg based on ALARA

5 OU5 Draft ROD (8/1/1995) FRL is listed: goal is 0.05 P.I./g based on ALARA

APPENDIX B

Proposed Part B Comparability Study Test Locations

/SRDIG/DGN/MAP/HOR/DPTH/SL83_080.DGN FER 9/8/96 STATE PLANAR COORDINATE SYSTEM 1983



LEGEND:

FEMP BOUNDARY

L LOW
M MEDIUM
H HIGH

000111

SCALE

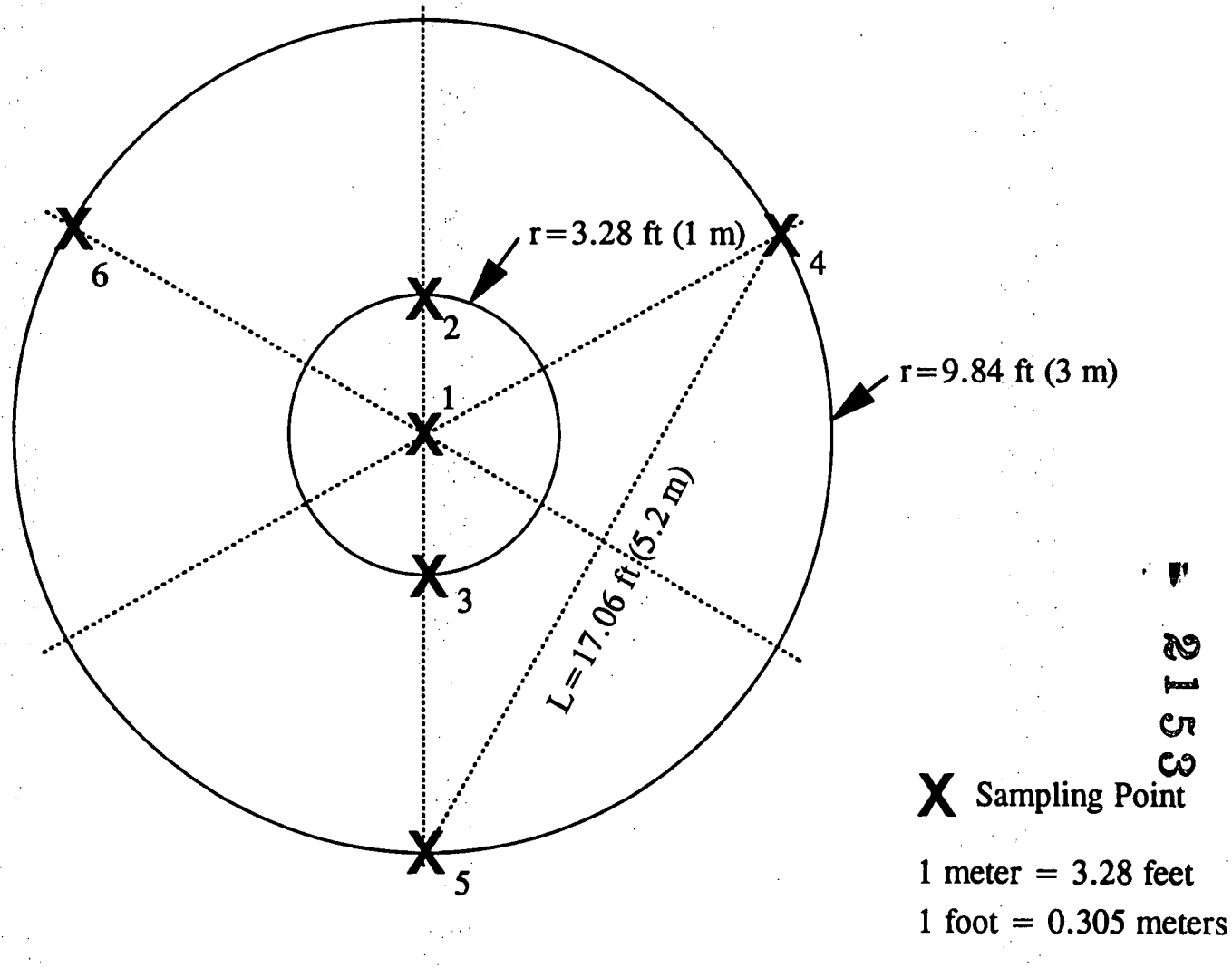
350 175 0 350 FEET

DRAFT

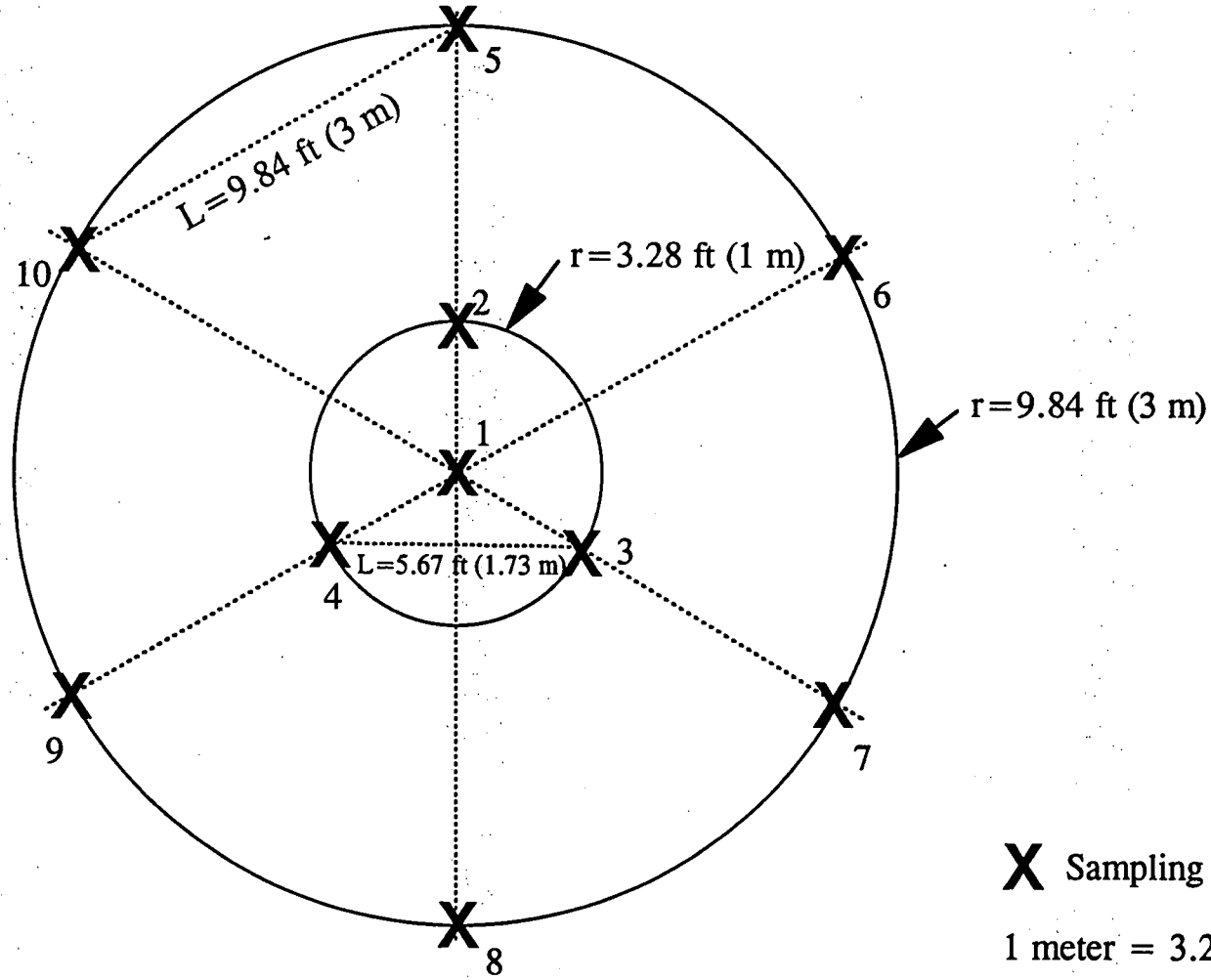
PROPOSED PART (B) COMPARABILITY STUDY TEST LOCATIONS

APPENDIX C

PHYSICAL SAMPLING PATTERNS



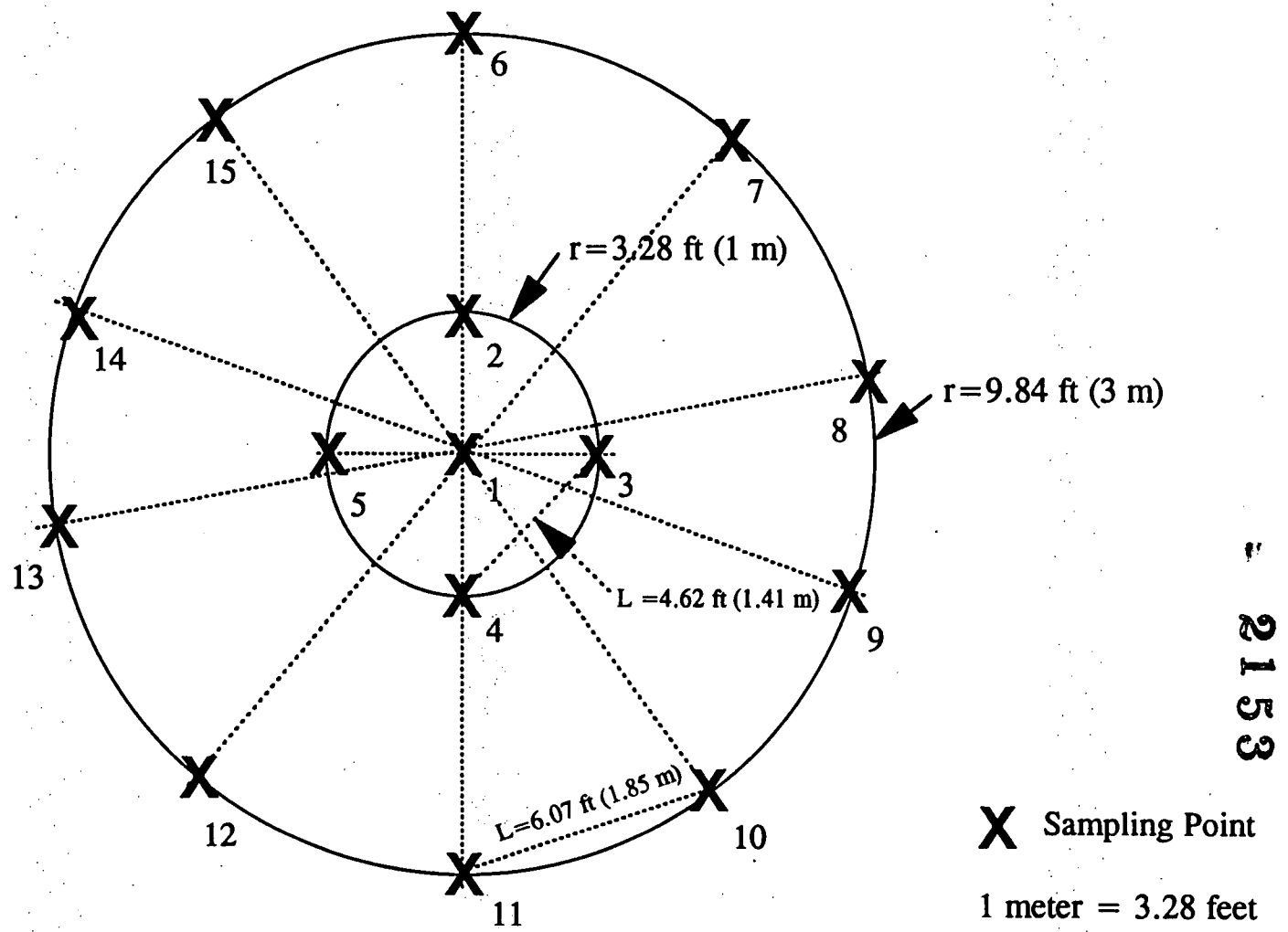
C-1, Low Designation (6-Point) Sampling Pattern For Areas 1, 8, and 9



X Sampling Point

1 meter = 3.28 feet
1 foot = 0.305 meters

C-2, Medium Designation (10-Point) Sampling Pattern For Areas 2, 4, 5, and 6



C-3, High and HeterogeneousDesignations (15-Point) Sampling Pattern For Areas 3, 7, and 10

APPENDIX D

WEIGHTED AVERAGE OF SAMPLES

TABLE D-1

WEIGHTED AVERAGE-6 SAMPLE SCHEME, LOW RANGE (0-80 ppm U)

Number of Samples	Horizontal Distance From Point Under Detector (m)	Detector Height = 30 cm		Detector Height = 1 m	
		Weight (per sample)	Weight (per circle)	Weight (per sample)	Weight (per circle)
1	0	0.49	0.49	0.1	0.1
2	1	0.165	0.33	0.18	0.36
3	3	0.06	0.18	0.18	0.54
6	Totals		1.00		1.00

TABLE D-2

WEIGHTED AVERAGE-10 SAMPLE SCHEME, MEDIUM RANGE (80-200 ppm U)

Number of Samples	Horizontal Distance From Point Under Detector (m)	Detector Height = 30 cm		Detector Height = 1 m	
		Weight (per sample)	Weight (per circle)	Weight (per sample)	Weight (per circle)
1	0	0.49	0.49	0.1	0.1
3	1	0.11	0.33	0.12	0.36
6	3	0.03	0.18	0.09	0.54
10	Totals		1.00		1.00

TABLE D-3

WEIGHTED AVERAGE-15 SAMPLE SCHEME, HIGH RANGE (>200 ppm U)

Number of Samples	Horizontal Distance From Point Under Detector (m)	Detector Height = 30 cm		Detector Height = 1 m	
		Weight (per sample)	Weight (per circle)	Weight (per sample)	Weight (per circle)
1	0	0.49	0.49	0.1	0.1
4	1	0.083	0.33	0.09	0.36
10	3	0.018	0.18	0.054	0.54
15	Totals		1.00		1.00

APPENDIX E

ASTM D 3017-88: Standard Test Method for Water Content of Soil and Rock in place by Nuclear Methods (Shallow Depth)

Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)[1]

This standard is issued under the fixed designation D 3017; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

[ε1] NOTE—Editorial changes were made and Section 12 added editorially September 1993.

1. Scope

1.1 This test method covers the determination of water content of soil and rock by the thermalization or slowing of fast neutrons where the neutron source and the thermal neutron detector both remain at the surface.

1.2 The water content in mass per unit volume of the material under test is determined by comparing the detection rate of thermalized or slow neutrons with previously established calibration data.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound equivalents may be approximate.

1.3.1 It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and of force (lbf). This implicitly combines two systems of units, that is, the absolute system and the gravitational system. This standard has been written using the absolute system for water content (kilograms per cubic metre) in SI units. Conversion to the gravitational system of unit weight in lbf/ft^3 may be made by multiplying by 0.06243 or in kN/m^3 by multiplying by 9.807. The recording of water content in pound-force per cubic foot should not be regarded as non-conformance with this standard although the use is scientifically incorrect.

1.4 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 1556 Test Method for Density of Soil in Place by the Sand-Cone Method[2]

D 2167 Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 2922 Test Methods for Density of Soil and Soil Aggregate and Rock in Place by Nuclear Methods (Shallow Depth)[2]

D 2937 Test Method for Density of Soil in Place by the Drive-Cylinder Method[2]

D 4643 Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method[2]

D 4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles[2]

3. Significance and Use

3.1 The test method described is useful as a rapid, nondestructive technique for the in-place determination of water content of soil and rock.

3.2 The test method is used for quality control and acceptance testing of compacted soil and rock for construction and for research and development. The non-destructive nature allows repetitive measurements at a single test location and statistical analysis of the results.

3.3 The fundamental assumptions inherent in the test method are that the hydrogen present is in the form of water as defined by Method D 2216, and that the material under test is homogeneous.

3.4 Test results may be affected by chemical composition, sample heterogeneity, and, to a lesser degree, material density and the surface texture of the material being tested. The technique also exhibits spatial bias in that the apparatus is more sensitive to water contained in the material in close proximity to the surface and less sensitive to water at deeper levels.

4. Interferences

4.1 The chemical composition of the sample may dramatically affect the measurement and adjustments may be necessary. Hydrogen in forms other than water, as defined by Method D 2216, and carbon will cause measurements in excess of the true value. Some chemical elements such as boron, chlorine, and minute quantities of cadmium will cause measurements lower than the true value.

4.2 The water content determined by this test method is not necessarily the average water within the volume of the sample involved in the measurement. The measurement is heavily influenced by the water content of the material closest to the surface. The volume of soil and rock repre-

[1] This test method is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

sented in the measurement is indeterminate and will vary with the water content of the material. In general, the greater the water content of the material, the smaller the volume involved in the measurement. At 160 kg/m³ (10 lbf/ft³), approximately 50 % of the typical measurement results from the water content of the upper 50 to 75 mm (2 to 3 in.).

4.2.1 If samples of the measured material are to be taken for purposes of correlation with other test methods or rock correction, the volume measured can be approximated by a 200-mm (8 in.) diameter cylinder located directly under the center line of the fast neutron source and thermal neutron detector. The height of the cylinder to be excavated is approximated by:

Moisture Content		Cylinder Height		Volume	
kg/m³	lbf/ft³	mm	in.	m³	ft³
80	5	250	10	0.0079	0.29
160	10	200	8	0.0063	0.23
240	15	150	6	0.0047	0.17
320	20	125	5	0.0039	0.15
400	25	112	4.5	0.0035	0.13
480	30	100	4	0.0031	0.12

NOTE 1—The volume of field compacted material sampled by the test can effectively be increased by repeating the test at immediately adjacent (vertically or horizontally) locations and averaging the results.

4.3 Other neutron sources must not be within 8 m (25 ft) of equipment in operation.

5. Apparatus

5.1 While exact details of construction of the apparatus may vary, the system shall consist of:

5.1.1 *Fast Neutron Source*—A sealed mixture of a radioactive material such as americium or radium and a target material such as beryllium.

5.1.2 *Slow Neutron Detector*—Any type of slow neutron detector such as boron trifluoride or helium-3 proportional counter.

5.1.3 *Readout Device*—A suitably timed scaler(s). Usually the readout device will contain the high-voltage supply necessary to operate the detector, and low-voltage power supply to operate the readout and accessory devices.

5.1.4 *Housing*—The source, detector, readout device, and power supply shall be in housings of rugged construction which shall be water and dust resistant.

5.1.5 *Reference Standard*—A block of hydrogeneous material for checking equipment operation and to establish conditions for a reproducible count rate.

5.1.6 *Site Preparation Device*—A steel plate, straightedge, or other suitable leveling tools which may be used to plane the test site to the required smoothness.

5.2 Calibrate apparatus in accordance with Annex A1.

5.3 Determine the precision of the apparatus in accordance with Annex A2.

6. Hazards

6.1 This equipment utilizes radioactive materials which may be hazardous to the health of the users unless proper precautions are taken.

6.2 Effective operator instruction together with routine safety procedures such as source leak tests, recording and evaluation of film badge data, use of survey meters, etc., are a recommended part of the operation of equipment of this type.

7. Standardization

7.1 All nuclear water content instruments are subject to long-term aging of the radioactive source, detectors, and electronic systems, which may change the relationship between count rate and water content. To offset this aging, instruments are calibrated as a ratio of the measurement count rate to a count rate made on a reference standard. The reference count rate should be in the same or higher order of magnitude than the range of measurement count rates over the useful water range of the equipment.

7.2 Standardization of equipment on the reference standard is required at the start of each day's use and a permanent record of these data shall be retained. The standardization shall be performed with the equipment located at least 8 m (25 ft) away from other gages and clear of large masses of water or other items which may affect the gage readings.

7.2.1 Turn on the instrument and allow for stabilization in accordance with the manufacturer's recommendations. If the instrument is to be used either continuously or intermittently during the day, it is generally best to leave it in the "power on" condition to prevent having to repeat the stabilization. This will provide more stable, consistent results.

7.2.2 Using the reference standard take at least four repetitive readings at the normal measurement period and obtain the mean. If available on the instrument, or measurement at a period of four or more times the normal period is acceptable. This constitutes one standardization check.

7.2.3 If the value obtained above is within the limits stated below, the equipment is considered to be in satisfactory condition and the value may be used to determine the count ratios for the day of use. If the value obtained is outside these limits, another standardization check should be made. If the second standardization check is within the limits, the equipment may be used, but if it also fails the test the equipment shall be adjusted or repaired as recommended by the manufacturer.

$$N_s \leq N_o + \frac{2.0\sqrt{N_o}}{\sqrt{F}}$$

and

$$N_s \geq N_o - \frac{2.0\sqrt{N_o}}{\sqrt{F}}$$

where:

N_s = value of current standardization check (7.2.2) on reference standard,

N_o = average of the past four values of N_s taken for prior usage, and

F = value of prescale (A2.2.1).

7.3 The value of N_s will be used to determine the count ratios for the current day's use of the equipment. If, for any reason, measured water content becomes suspect during the day's use, perform another standardization.

8. Procedure

8.1 Standardize the instrument (Section 7).

8.2 Select a location for test where the instrument is

000120

osition will be at least 250 mm (10 in.) away from any ertical projection.

8.3 Prepare the test site in the following manner:

8.3.1 Remove all loose and disturbed material, and remove additional material as necessary to reach the top of the vertical interval to be tested. Surface drying and the spatial bias should be considered in determining the depth at which the instrument is to be seated.

8.3.2 Prepare a horizontal area, sufficient in size to accommodate the instrument, by planing to a smooth condition so as to obtain maximum contact between the instrument and material being tested. If the instrument base is to be placed below the surrounding surface, the horizontal area shall be at least twice the area of the base of the instrument. If the depression is greater than 25 mm (1 in.), the condition in 8.2 must be met by clearing a larger area.

8.3.3 The placement of the instrument on the surface of the material to be tested is critical to the successful determination of water. The optimum condition is total contact between the bottom surface of the instrument and the surface of the material being tested. The maximum void beneath the instrument shall not exceed approximately 3 mm (1/8 in.). Use native fines of similar water content or dry quartz sand to fill voids and level the excess with a rigid plate or other suitable tool. The total area filled shall not exceed 10 % of the bottom area of the instrument.

8.4 Proceed with the test in the following manner:

8.4.1 Seat the instrument firmly, place the source in the proper position and take a count for the normal measurement period.

8.4.2 Determine the ratio of the reading to the standard count (Section 7). From this ratio and the calibration and adjustment data, determine the in-place water content per unit volume (Note 2).

NOTE 2—Some instruments have built-in provisions to compute the ratio, the water content per unit volume with adjustments, the dry density, and the water content in percent of dry density (or dry unit weight).

8.5 If the volume tested as defined in 4.2.1 is insufficient for the size of rock contained in the soil (refer to Test Method D 4718), take additional tests at adjacent locations and average the results (Note 3).

NOTE 3—The water content value obtained should be compared to other water contents obtained for similar soils and conditions. The presence of a large rock particle or void in the soil being tested may give an unrepresentative value of water content. If the value is unusually high or low, another determination of water content should be performed. To avoid preparation of another test site, the gage may be repositioned (such as rotating the gage 90°) at the original site.

9. Calculation

9.1 Calculate the water content, w, in percent of dry density (or dry unit weight) of soil as follows:

$$w = \frac{M_m \times 100}{\rho_d} \quad (3)$$

or

$$w = \frac{M_m \times 100}{\rho - M_m} \quad (4)$$

where:

w = water content, percent of dry density,
M_m = water content, kg/m^3 (lbf/ft^3),
ρ_d = dry density of soil (kg/m^3) or dry unit weight (lbf/ft^3), and
ρ = wet (total) density of soil (kg/m^3) or wet unit weight (lbf/ft^3).

10. Report

10.1 The report shall include the following:

10.1.1 Make, model, and serial number of the test device,

10.1.2 Standard count and adjustment data for the date of the tests,

10.1.3 Name of the operator,

10.1.4 Test site identification,

10.1.5 Visual description of material tested,

10.1.6 Count rate for each reading, if applicable,

10.1.7 Water content in kg/m^3 or lbf/ft^3,

10.1.8 Wet and dry densities in kg/m^3 or unit weights in lbf/ft^3,

10.1.9 Water content in percent of dry density or dry unit weight.

11. Precision and Bias

11.1 The precision and bias of this test method has not been determined. While the instrument precision (repeatability on the same sample) of 4 kg/m^3 (0.25 lbf/ft^3) is required and the procedure provides a means of removing the bias, no methods are available that provide sufficiently accurate values of the water content of in-place soil and rock against which the precision and bias for the procedure and operator variance can be determined.

12. Keywords

12.1 compaction test; construction control; density; field control; inspection; moisture content; moisture control; nuclear methods; nuclear moisture; quality control; soil moisture; test procedure; water content

ANNEXES

(Mandatory Information)

A1. CALIBRATION

A1.1 *Calibration Curves*—Calibration curves, tables, or equations shall be established or verified once each year by determining by test the nuclear count rate of at least two samples of different known water content. This data may be plotted or equations determined to create tables or computer programs for conversion of count data to water content. The method and test procedures used in obtaining the count rate (or ratio as defined in Section 7) to establish the calibration relationship must be the same as those used for measuring the water content of the material to be tested. The water

content of materials used to establish the calibration must vary through a range to include the water content of materials to be tested and be in the density range of 1600 to 2240 kg/m³ (100 to 140 lbf/ft³). Due to the effect of chemical composition, the calibration supplied by the manufacturer with the apparatus will not be applicable to all materials. It shall be accurate for mixes of silica sand and water; therefore, the calibration must be checked and adjusted, if necessary, in accordance with A1.3.

A1.2 *Calibration Standards*—Calibration standards may be established using any of the following methods. Prepared containers or standards must be large enough to not change the observed count rate (or ratio as defined in Section 7) if made larger in any dimension.

NOTE A1.1—Dimensions of approximately 610 mm long by 460 mm wide by 360 mm deep (approximately 24 by 18 by 14 in.) have proven satisfactory.

A1.2.1 Prepare a homogeneous standard of hydrogenous materials having an equivalent water content determined by comparison (using a nuclear instrument) with a saturated silica sand standard prepared in accordance with A1.2.2. A metallic density standard as defined in Test Methods D 2922 is a convenient zero water content standard.

A1.2.2 Prepare containers of compacted material with a percent water content determined by oven dry (Method D 2216) and a wet density calculated from the mass of the material and the inside dimensions of the container. The water content may be calculated as follows:

$$M_m = \frac{\rho \times w}{100 + w} \qquad \text{(A1.1)}$$

where:

M_m = water content, kg/m³ or lbf/ft³,
w = water content, percent of dry mass, and
ρ = wet (total) density, kg/m³ or lbf/ft³.

A1.2.3 Where neither of the previous calibration standards are available, the instrument may be calibrated by using a minimum of four selected test sites in an area of a compaction project where a homogenous material has been placed at several different water contents. The test sites shall represent the range of water contents over which the calibration is to be used. At least four replicate nuclear measurements shall be made at each test site. The density at each site shall be measured by making four closely spaced determinations with calibrated equipment in accordance with Test Methods D 2922, Test Method D 1566, Test Method D 2167, or Test Method D 2937. The water content of each of the density tests shall be determined by Method D 2216. Use the mean value of the replicate readings as the calibration point value for each site.

A1.3 *Calibration Adjustments:*

A1.3.1 The calibration of newly acquired or repaired instruments shall be verified and adjusted prior to use. Calibration curves shall be checked prior to performing tests on materials that are distinctly different from material types previously used in obtaining or adjusting the calibration. Sample materials may be selected by either A1.3.1.1 or A1.3.1.2. The amount of water shall be within ±2 % of the water content established as optimum for compaction. Determine the water content in kg/m³ or lbf/ft³ by Eq. A1.1. A microwave oven or direct heater may be utilized for drying materials which are not sensitive to temperature, in addition to the methods listed in A1.2.3. A minimum of four comparisons is required and the mean of the observed differences used as the correction factor.

A1.3.1.1 Container(s) of compacted material taken from the test site may be prepared in accordance with A1.2.2.

A1.3.1.2 Test site(s) on the compacted material may be selected in accordance with A1.2.3.

A1.3.2 The method and test procedures used in obtaining the count rate (or ratio as defined in Section 7) to establish the error must be the same as those used for measuring the water content of the material to be tested.

A1.3.3 The mean value of the difference between the moisture content of the test samples as determined in A1.3.1.1 or A1.3.1.2 and the values measured with the instrument shall be used as a correction to measurements made in the field. Some instruments utilizing a microprocessor may have provision to input a correction factor that is established by the relative values of water content as a percentage of dry density, thus eliminating the need to determine the difference in mass units of water.

A2. DETERMINING PRECISION OF APPARATUS

A2.1 The precision of the apparatus at a water content of 160 kg/m³ (10 lbf/ft³) shall be better than 4 kg/m³ (0.25 lbf/ft³) at the manufacturer's stated period of time for the measurement (Note A2.1). Other timing periods may be available (usually multiples of four of the normal period) which may be used where higher or lower precisions are desired for statistical purposes. The precision shall be determined by the procedure defined in 5.2.1 or 5.2.2.

NOTE A2.1—While 1 min is the usual timing period and may be used for the comparison of various apparatus, the intent of the test method is to require a measurement period that produces the stated precision for all acceptance testing.

A2.2 The precision of the apparatus is determined from the slope of the calibration response and the statistical deviation of the count (detected neutrons) for the period of measurement, as follows:

$$P = \frac{\sigma}{S}$$

where:

P = apparatus precision in water content (kg/m³ or lbf/ft³),
σ = standard deviation in counts per measurement period, and
S = slope in change in counts per measurement period divided by the change in water content (kg/m³ or lbf/ft³).

A2.2.1 The count per measurement period shall be the total number of thermal neutrons detected during the timed period. The displayed value must be corrected for any prescaling which is built into the apparatus. The prescale value (F) is a divisor which reduces the actual value for the

rpose of display. The manufacturer will supply this value other than 1.0.

A2.2.2 The standard deviation in counts per measurement period shall be obtained as follows:

$$\sigma = \frac{\sqrt{C}}{\sqrt{F}}$$

ere:

= standard deviation in counts per measurement period,

= counts per measurement period (before prescale correction) at a water content of 160 kg/m^3 (10 lbf/ft^3), and

= value of prescale (A2.2.1).

A2.2.3 The counts per measurement period (before prescale correction) shall be obtained form the calibration curve, tables or equation.

A2.2.4 The slope of calibration response in counts per measurement period (before prescale correction) at a water content of 160 kg/m^3 (10 lbf/ft^3) shall be determined from the calibration curve, tables, or equation.

A2.3 The precision shall be computed by determining the standard deviation of at least 20 repetitive measurements (instrument not moved after the first measurement) on material having a water content of 130 to 190 kg/m^3 (8.1 to 11.9 lbf/ft^3). In order to perform this procedure, the resolution of the count display, calibration response, or other method of displaying water content must be equal to or better than ±1 kg/m^3 or 0.1 lbf/ft^3.

The American Society for Testing and Materials takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.

This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

APPENDIX F

ASTM D 2922-91 Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

2153

Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)[1]

This standard is issued under the fixed designation D 2922; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

These methods have been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This test method covers the determination of the total or wet density of soil and soil-rock mixtures by the attenuation of gamma radiation where the source and detector(s) remain on the surface (Backscatter Method) or the source or detector is placed at a known depth up to 300 mm (12 in.) while the detector(s) or source remains on the surface (Direct Transmission Method).

1.2 The density in mass per unit volume of the material under test is determined by comparing the detected rate of gamma radiation with previously established calibration data.

1.3 The values tested in SI units are to be regarded as the standard. The inch-pound equivalents may be approximate.

1.4 It is common practice in the engineering profession to concurrently use pounds to represent both a unit of mass (lbm) and a unit of force (lbf). This implicitly combines two separate systems of units; that is, the absolute system and the gravitational system. It is scientifically undesirable to combine the use of two separate sets of inch-pound units within a single standard. This standard has been written using the gravitational system of units when dealing with the inch-pound system. In this system the pound (lbf) represents a unit of force (weight). However, the use of balances or scales recording pounds of mass (lbm), or the recording of density in lbm/ft^3 should not be regarded as nonconformance with this standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific Hazard statements, see Section 6.

2. Referenced Documents

2.1 *ASTM Standards:*

D 698 Test Method for Moisture-Density Relations of Soil and Soil-Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in. (305-mm) Drop[2]

D 1556 Test Method for Density of Soil In-Place by the Sand-Cone Method[2]

D 1557 Test Method for Moisture-Density Relations of Soil and Soil-Aggregate Mixtures Using 10-lb (4.54-kg) Rammer and 18-in. (457-mm) Drop[2]

D 2167 Test Method for Density of Soil In-Place by the Rubber-Balloon Method[2]

D 2216 Method for Laboratory Determination of Water (Moisture) Content of Soil, Rock, and Soil-Aggregate Mixtures[2]

D 2937 Test Method for Density of Soil In-Place by the Drive-Cylinder Method[2]

D 3017 Test Method for Water Content of Soil and Rock In-Place by Nuclear Methods (Shallow Depth)[2]

D 4253 Test Method for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table[2]

D 4643 Method for Determination of Water Content by the Microwave Oven Method[2]

D 4718 Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles[2]

D 4944 Test Method for Field Determination of Water (Moisture) Content of Soil by the Calcium Carbide Gas Pressure Tester Method[3]

D 4959 Test Method for Determination of Water (Moisture) Content by Direct Heating Method[3]

3. Significance and Use

3.1 The test method described is useful as a rapid, nondestructive technique for the in-place determination of density of soil and rock.

3.2 The test method is suitable for quality control and acceptance testing for construction and for research and development applications.

3.3 The nondestructive nature of the test allows repetitive measurements to be made at a single test location.

4. Interferences

4.1 The chemical composition of the sample may affect the measurement, and adjustments may be necessary.

4.2 The test method exhibits spatial bias in that the instrument is more sensitive to the density of the material in close proximity to the surface (Backscatter Method only).

NOTE 1—The nuclear gauge density measurements are somewhat biased to the surface layers of the soil being tested. This bias has largely been corrected out of the direct transmission method and any remaining bias is insignificant. The backscatter method is still more sensitive to the material within the first several inches from the surface.

[1] These test methods are under the jurisdiction of ASTM Committee D-18 on Soil and Rock and are the direct responsibility of Subcommittee D18.08 on Special and Construction Control Tests.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

4.3 Oversize rocks or large voids in the source-detector path may cause higher or lower density determination. Where lack of uniformity in the soil due to layering, rock or voids is suspected, the test volume site should be dug up and visually examined to determine if the test material is representative of the full material in general and if rock correction (see 9.6) is required.

4.4 The sample volume is approximately 0.0028 m^3 (0.10 ft^3) for the Backscatter Method and 0.0057 m^3 (0.20 ft^3) for the Direct Transmission Method when the test depth is 15 cm (6 in.). The actual sample volume is indeterminate and varies with the apparatus and the density of the material. In general, the higher the density the smaller the volume.

5. Apparatus

5.1 *Nuclear Gauge*—An electronic counting instrument, capable of being seated on the surface of the material under test, and which contains:

5.1.1 A sealed source of high energy gamma radiation such as cesium or radium.

5.1.2 *Gamma Detector*—Any type of gamma detector such as a Geiger-Mueller tube(s).

5.2 *Reference Standard*—A block of material used for checking instrument operation and to establish conditions for a reproducible reference count rate.

5.3 *Site Preparation Device*—A plate, straightedge, or other suitable leveling tool which may be used for planning the test site to the required smoothness, and in the Direct Transmission Method, guiding the drive pin to prepare a perpendicular hole.

5.4 *Drive Pin*—A pin of slightly larger diameter than the rod in the Direct Transmission Instrument, used to prepare a hole in the material under test for inserting the rod.

5.5 *Drive Pin Extractor*—A tool that may be used to remove the drive pin in a vertical direction so that the pin will not distort the hole in the extraction process.

5.5.1 A slide hammer, with a drive pin attached, may also be used both to prepare a hole in the material to be tested and to extract the pin without distortion to the hole.

6. Hazards

6.1 This equipment utilizes radioactive materials that may be hazardous to the health of the users unless proper precautions are taken. Users of this equipment must become familiar with applicable safety procedures and government regulations.

6.2 Effective user instructions together with routine safety procedures, such as source leak tests, recording and evaluation of film badge data, etc., are a recommended part of the operation and storage of this instrument.

7. Calibration

7.1 Calibration of the instrument will be in accordance with Annex A1.

8. Standardization and Reference Check

8.1 Nuclear gauges are subject to long-term aging of the radioactive source, detectors, and electronic systems, which may change the relationship between count rate and material density. To offset this aging, the gauge may be calibrated as the ratio of the measured count rate to a count rate made on a reference standard or to an air-gap count (for the backscatter air-gap technique, see 9.5.1.3). The reference count rate should be of the same order of magnitude as the measured count rate over the useful density range of the instrument.

8.2 Standardization of the gauge shall be performed at the start of each day's work, and a permanent record of these data shall be retained. Perform the standardization with the gauge located at least 8 m (25 ft) away from other sources of radioactive material, and clear of large masses or other items which may affect the reference count rate.

8.2.1 If recommended by the instrument manufacturer to provide more stable and consistent results: (1) turn on the gauge prior to use to allow it to stabilize, (2) leave the power on during the use of the gauge for that day.

8.2.2 Using the reference standard, take at least four repetitive readings at the normal measurement period and determine the mean. If available on the gauge, one measurement period of four or more times the normal period is acceptable. This constitutes one standardization check.

8.2.3 If the value obtained above is within the limits stated below, the gauge is considered to be in satisfactory condition, and the value may be used to determine the count ratios for the day of use. If the value is outside these limits, allow additional time for the gauge to stabilize, make sure the area is clear of sources of interference, and then conduct another standardization check. If the second standardization check is within the limits, the gauge may be used, but if it also fails the test, the gauge shall be adjusted or repaired as recommended by the manufacturer. The limits are as follows:

$$|N_s - N_o| \leq 2.0 \sqrt{N_o/F}$$

where:

N_s = value of current standardization count,

N_o = average of the past four values of N_s taken for prior usage, and

F = value of prescale. [The prescale value (F) is a divisor which reduces the actual value for the purpose of display. The manufactor will supply this value if other than 1.0.] Some instruments may have provisions to compute and display these values.

8.2.3.1 If the instrument standardization has not been checked within the previous three months, perform at least four new standardization checks, and use the mean as the value for N_o.

8.3 Use the value of N_s to determine the count ratios for the current day's use of the instrument. If for any reason the measured density becomes suspect during the day's use, perform another standardization check.

9. Procedure for Field Use

9.1 Standardize the gauge. (See Section 8.)

9.2 Select a test location. If the gauge will be closer than 250 mm (10 in.) to any vertical mass that might influence the result, such as in a trench or alongside a pipe, follow the manufacturer's correction procedure.

9.3 Remove all loose and disturbed material. Remove additional material as necessary to reach the material that represents a valid sample of the zone or stratum to be tested. Surface drying and spatial bias should be considered in

determining the depth of material to be removed.

9.4 Plane or scrape a smooth horizontal surface so as to obtain maximum contact between the gauge and the material being tested. The placement of the gauge on the surface of the material to be tested is always important, but is especially critical to the successful determination of density when using the *backscatter* method. The optimum condition in all cases, is total contact between the bottom surface of the gauge and the surface of the material being tested. To correct for surface irregularities, use of native fines or fine sand as a filler may be necessary. The depth of the filler should not exceed approximately 3 mm (⅛ in.) and the total area filled should not exceed 10 % of the bottom area of the instrument. The maximum depth of any void beneath the gauge that can be tolerated without filling shall not exceed approximately 3 mm (⅛ in.). Several trial seatings may be required to achieve these conditions.

9.5 Proceed with the test in the following manner:

9.5.1 *Backscatter Procedure:*

9.5.1.1 Seat the gauge firmly on the prepared test site.

9.5.1.2 Keep all other radioactive sources away from the gauge to avoid affecting the measurement so as not to affect the readings.

9.5.1.3 Secure and record one or more readings for the normal measurement period in the backscatter position.

NOTE 2—When using the backscatter air-gap procedure, follow the instrument manufacturers instructions regarding apparatus set up. Take the same number of readings for the normal measurement period in the air-gap position as in the standard backscatter position. Determine the air-gap ratio by dividing counts per minute obtained in the air-gap position by counts per minute obtained in standard backscatter position.

9.5.1.4 Determine the ratio of the reading to the standard count or to the air gap count. From this count ratio and the appropriate calibration and adjustment data, determine the in-place wet density.

9.5.2 *Direct Transmission Procedure:*

9.5.2.1 Make a hole perpendicular to the prepared surface using the guide and the hole-forming device 5.4, or by drilling if necessary. The hole shall be of such depth and alignment that insertion of the probe will not cause the gauge to tilt from the plane of the prepared area. The depth of the hole must be deeper than the depth to which the probe will be placed. The guide shall be the same size as the base of the gauge, with the hole in the same location on the guide as the probe on the gauge. The corners of the guide are marked by scoring the surface of the soil. The guide plate is then removed and any necessary repairs are made to the prepared surface.

9.5.2.2 Proceed with testing in the following manner:

9.5.2.3 Set the gauge on the soil surface, carefully aligning it with the marks on the soil so that the probe will be directly over the pre-formed hole.

9.5.2.4 Insert the probe in the hole.

9.5.2.5 Seat the gauge firmly by rotating it about the probe with a back and forth motion.

9.5.2.6 Pull gently on the gauge in the direction that will bring the side of the probe against the side of the hole that is closest to the detector (or source) location in the gauge housing.

9.5.2.7 Keep all other radioactive sources away from the gauge to avoid affecting the measurement.

9.5.2.8 Secure and record one or more readings for the normal measurement period.

9.5.2.9 Determine the ratio of the reading to the standard count. From this count ratio and the appropriate calibration and adjustment data, determine the in-place wet density.

NOTE 3—Some instruments have built-in provisions to compute the ratio, wet density, and to enter an adjustment bias. Additionally some instruments may have provisions to measure and compute moisture content, and dry density.

9.6 If the volume tested as defined in 4.4 has excess oversize material with respect to the limitations in the appropriate Test Methods D 698, D 1557 or D 4253, then a correction for wet density (unit weight) and water content must be applied. This correction will be done in accordance with Practice D 4718. This test method requires sampling from the actual test volume.

9.6.1 If samples of the measure material are to be taken for purposes of correlation with other test methods or rock correction, the volume measured can be approximated by a 200 mm (8 in.) diameter cylinder located directly under the center line of the radioactive source and detector(s). The height of the cylinder to be excavated will be the depth setting of the source rod when using the Direct Transmission method or approximately 75 mm (3 in.) when using the Backscatter Method.

9.6.2 An alternative to the correction for oversize particles, that can be used with mass density methods or minimal oversize situations, involves multiple tests. Tests may be taken at adjacent locations and the results averaged to get a representative value. Comparisons need to be made to evaluate whether the presence of a single large rock or void in the soil is producing unrepresentative values of density. Whenever values obtained are questionable, the test volume site should be dug up and visually examined.

10. Calculation of Results

10.1 The in-place wet density is determined as outlined in 9.5. If dry density is required, the in-place water content shall be determined using either gravimetric samples and laboratory determination of water content (Test Methods D 2216, D 4643, D 4959, D 4944), or an instrument which determines water content by neutron thermalization (Test Method D 3017).

10.1.1 If the water content is determined by nuclear methods, Test Method D 3017, subtract the kg/m³ (lbf/ft³) of moisture from the kg/m³ (lbf/ft³) of wet density, and obtain dry density in kg/m³ (lbf/ft³).

10.1.2 If the water content is determined by other methods, and is in the form of percent, proceed as follows:

$$\rho_d = \frac{100\rho_m}{100 + W}$$

where:

ρ_d = dry density in kg/m³ (lbf/ft³),
ρ_m = wet density in kg/m³ (lbf/ft³), and
W = water as a percent of the dry mass.

11. Report

11.1 The report shall include the following:

11.1.1 Standardization and adjustment data for the date of the tests.

000127

11.1.2 Make, model and serial number of the test instrument.

11.1.3 Name of the operator(s).

11.1.4 Test site identification.

11.1.5 Visual description of material tested.

11.1.6 Test mode (backscatter or direct transmission) and test depth (if applicable).

11.1.7 Wet and dry densities in kg/m^3 or unit weights in lb/ft^3.

11.1.8 Water content in percent of dry mass or dry unit weight.

12. Precision and Bias

12.1 *Precision:*

12.1.1 Data are being evaluated to determine the precision of this test method. In addition, Subcommittee D18.08 is seeking pertinent data from users of the test method.

12.1.2 An instrument count precision of 8 kg/m^3 (0.5 lbf/ft^3) for the Backscatter Method and 4 kg/m^3 (0.25 lbf/ft^3) Direct Transmission Method are typical on a material of approximately 2000 kg/m^3 (125 lbf/ft^3) density, with a measurement time of one minute.

12.1.2.1 Instrument count precision is defined as the change in density that occurs corresponding to a one standard deviation change in the count due to the random decay of the radioactive source. The density of the material and the time period of the count must be stated. It may be determined from a series of 20 or more counts taken without moving the instrument, or alternately from the calibration data using the assumption that σ is equal to the $\sqrt{\text{count}}$ at that density. The count must be the true instrument count corrected for any pre-scaling (see 8.2.3).

$$P = \frac{\sigma}{S}$$

where:

P = instrument precision in density (kg/m^3 or lbf/ft^3)

σ = one standard deviation of the count

S = the slope of the calibration curve at the defined density value.

12.2 *Bias:*

12.2.1 There is no accepted reference value for this test method, therefore, bias cannot be determined.

13. Keywords

13.1 density; field density; nuclear methods

ANNEX

(Mandatory Information)

A1. CALIBRATION

A1.1 Verify or re-establish calibration curves, tables, or equation coefficients at least once every 12–18 months and after all major repairs which may affect the instrument geometry.

A1.2 The instrument shall be calibrated in such a way as to produce a calibration response within ± 16 kg/m^3 (± 1.0 lbf/ft^3) on blocks of materials (standards) of established densities. (This calibration may be done by the manufacturer, the user, or an independent vendor.) Nuclear instrument response is influenced by the chemical composition of measured material. This response must be taken into account in establishing the assigned standard block density. The densities of materials used to establish or verify the calibration should extend through a range representative of the density of the materials to be tested. The density of these material standards shall be determined to an accuracy of ± 0.2 %.

A1.3 Sufficient data shall be taken on each density standard to ensure an instrument count precision of at least one-half the instrument count precision required for field use. The data may be presented in the form of a graph, table, equation coefficients, or stored in the gauge, to allow covering the count rate data to material density.

A1.4 The method and test procedures used in establishing the calibration count rate data shall be the same as those used for obtaining the field count rate data.

A1.5 The material type, actual density and assigned standard block density of each calibration standard used to establish or verify the instrument calibration shall be stated as part of the calibration data.

A1.6 The standards shall be of sufficient size to not change the count rate if enlarged in any dimension. Minimum surface dimensions of approximately 610 mm long by 430 mm wide (24 × 17 in.) have proven satisfactory. For the Backscatter Method a minimum depth of 230 mm (9 inches) is adequate; for the Direct Transmission Method the depth shall be at least 50 mm (2 in.) deeper than the deepest rod depth. A larger surface area may be required for the Backscatter Air-Gap technique. Minimum surface dimensions may be reduced slightly if the standards are adjacent to a dense material.

A1.7 The most successful standards that have been established for accurate calibration have been made of aluminum magnesium, aluminum/magnesium, granite and limestone. These standards have been used in combination with each other and with historical curve information to produce accurate and reliable calibration.

A1.7.1 Standards of soil, rock, and concrete that have the characteristics of reproducible uniformity are difficult to prepare. These standards may be of use for some special calibration or field calibration where local site material chemistry or background situation require special adaptation.

000128

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This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, 1916 Race St., Philadelphia, PA 19103.

APPENDIX G

SAMPLE SUMMARY

TABLE G-1

COMPARABILITY STUDY, PART B SAMPLE SUMMARY

Area #	Area Location	Area Designation	Location and Number of Samples					Sample Numbers*
			Center	1 Meter Circle	3 Meter Circle	Duplicate Sample	Total	
1	North of Fire Training Facility	Low	1	2	3	1	7	PBC-1-1, PBC-1-2, PBC-1-3, PBC-1-4, PBC-1-5, PBC-1-6, PBC-1-7
2	Fire Training Facility	Medium	1	3	6	1	11	PBC-2-1, PBC-2-2, PBC-2-3, PBC-2-4, PBC-2-5, PBC-2-6, PBC-2-7, PBC-2-8, PBC-2-9, PBC-2-10, PBC-2-11
3	Old Scrap Metal Pile Area	High	1	4	10	1	16	PBC-3-1, PBC-3-2, PBC-3-3, PBC-3-4, PBC-3-5, PBC-3-6, PBC-3-7, PBC-3-8, PBC-3-9, PBC-3-10, PBC-3-11, PBC-3-12, PBC-3-13, PBC-3-14, PBC-3-15, PBC-3-16
4	Northwest of Sewage Treatment	Medium	1	3	6	1	11	PBC-4-1, PBC-4-2, PBC-4-3, PBC-4-4, PBC-4-5, PBC-4-6, PBC-4-7, PBC-4-8, PBC-4-9, PBC-4-10, PBC-4-11
5	West of Sewage Treatment	Medium	1	3	6	1	11	PBC-5-1, PBC-5-2, PBC-5-3, PBC-5-4, PBC-5-5, PBC-5-6, PBC-5-7, PBC-5-8, PBC-5-9, PBC-5-10, PBC-5-11
6	North of Sewage Treatment	Medium	1	3	6	1	11	PBC-6-1, PBC-6-2, PBC-6-3, PBC-6-4, PBC-6-5, PBC-6-6, PBC-6-7, PBC-6-8, PBC-6-9, PBC-6-10, PBC-6-11
7	Sewage Treatment	High	1	4	10	1	16	PBC-7-1, PBC-7-2, PBC-7-3, PBC-7-4, PBC-7-5, PBC-7-6, PBC-7-7, PBC-7-8, PBC-7-9, PBC-7-10, PBC-7-11, PBC-7-12, PBC-7-13, PBC-7-14, PBC-7-15, PBC-7-16
8	South Side of East Field	Low	1	2	3	1	7	PBC-8-1, PBC-8-2, PBC-8-3, PCB-8-4, PCB-8-5, PCB-8-6, PBC-8-7
9	Near South Access Entrance	Low	1	2	3	1	7	PBC-9-1, PBC-9-2, PBC-9-3, PBC-9-4, PBC-9-5, PBC-9-6, PBC-9-7
10	Old Fly Ash Pile Area	Hetero-geneous	1	3	6	1	16	PBC-10-1, PBC-10-2, PBC-10-3, PBC-10-4, PBC-10-5, PBC-10-6, PBC-10-7, PBC-10-8, PBC-10-9, PBC-10-10, PBC-10-11, PBC-10-12, PBC-10-13, PBC-10-14, PBC-10-15, PBC-10-16

* PBC-10-16: Designates duplicate sample number.

001131