MAINE YANKEE
FINAL STATUS SURVEY RELEASE RECORD
FR-0111 YARD WEST EXCAVATIONS
SURVEY UNIT 5

Prepared By:	Dee Anderson **FSS Engineer** - Signature D. ANDERSON Printed Name	Date: 12/21/04
Reviewed By:	Larry N. Dockins **FSS Specialist** - Signature Larry N. Dockins Printed Name	Date: 12/21/04
Reviewed By:	**Independent Review** - Signature WJ Cooper Printed Name	Date: 12/21/04
Approved By:	**Superintendent, FSS** - Signature George Pillsbury Printed Name	Date: 12/21/04
Approved By:	**FSS, MOP** - Signature JAMES R. PARKER Printed Name	Date: 12/22/04

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A. SURVEY UNIT DESCRIPTION

FR 0111 Yard West Excavations Survey Unit 5 consisted of sub-surface soils within the Restricted Area back yard southwest of the former Containment Building. The survey unit was located at coordinates 407,450 N and 623,700 E using Maine State Coordinate System (West Zone) NAD 1927. It was bounded on the east by FR 0111 Survey Unit 4, on the northeast by the concrete slab left from the Equipment Hatch, on the south by FR 0111 Survey Unit 7 and the Forebay, and on the west by FR 0111 Survey Unit 6. The location of the 1119.2 m^2 survey unit in relation to the Containment Building and the surrounding FR 0111 survey units is shown on map FR0111U5-SITE (Attachment 1).

Survey Unit 5 contained a large hole with an average diameter of 7 meters and an approximate depth of 3 meters in the southeast portion of the survey unit. Removal of a portion of the storm drain system left a trench that traversed the north section of the survey unit. Additional contributors to the uneven terrain included the demolition and removal of the Refueling Water Storage Tank (RWST), the RWST heater and the concrete foundations on which the systems had been constructed. A profile of the terrain levels and excavated depths is shown on map FR0111U5-INFO (Attachment 1).

B. SURVEY UNIT DESIGN INFORMATION

During the operating life of the plant, leaks occurred from the RWST heater and associated component cooling piping to the environs within the Restricted Area. Characterization activities identified several surface and sub-surface locations with elevated activity greater than the DCGL. As a result, this survey unit met the requirements for a Class 1 area and was designated as such, in accordance with the LTP Revision 3, Table 5-1C.

The survey unit design parameters for FR 0111 Survey Unit 5 are shown in Table 1. Given a relative shift of 0.8, it was determined that 40 direct measurements were required for the Sign Test. Because the measurement locations were based on a systematic square grid with a random start point, the N=40 design led to a survey unit map with 41 locations. The direct point locations are illustrated on map FR0111U5-DIRECTS (Attachment 1). Direct measurements consisting of soil samples collected from required locations were analyzed with laboratory gamma spectroscopy instrumentation.

In accordance with the LTP, scans covering 100% of the 1,119.2 m^2 area were required for the Class 1 survey unit. This was accomplished by use of an *in situ* gamma spectroscopy detector configured at a 3-meter distance from the surface to obtain approximately 28-m^2 fields of view to a depth of 15 centimeters. Locations of the 60 survey scans are shown on map FR0111U5-SCANS.

Additional ISOCS scans incorporated evaluations based on four geometries including horizontal, vertical, round hole and trench. The additional scans were performed as follows:

- 1 vertical scan was collected over the hole in the southeast portion of the survey unit with the ISOCS detector positioned at the top plane of the hole. The approximate location of the scan is shown on map FR0111U5-HOLE.

- 13 scans were performed on vertical surfaces of the drain pipe trench. The detector was positioned horizontally at 2 meters from the vertical surface to obtain overlapping 12-m^2 fields of view. Eleven measurements were performed on the vertical soil of the trench wall while 2 measurements were centered on exposed vertical ledge. The scans are illustrated on map FR0111U5-VERTICAL.

- 6 scans were performed on vertical surfaces of the remaining equipment hatch concrete slab along the northeast boundary of the survey unit. The detector was positioned horizontally at 2 meters from the concrete surface to obtain overlapping 12-m^2 fields of view. The measurements are provided on map FR0111U5-CONCRETE.

- 12 vertical scans were performed on the floor surfaces of the drain pipe trench, using a "U-channel" geometry. The detector was positioned 2 meters above the surface plane to obtain overlapping 24-m^2 fields of view. The measurements are illustrated on map FR0111U5-TRENCH.

The combination of all ISOCS scans conservatively ensured greater than 100% scan coverage of all exposed surfaces within Survey Unit 5. The survey instruments used are listed by model and serial number in Attachment 2 (Table 2-1). Scan MDCs are also listed in Attachment 2 (Table 2-2) and are compared to the DCGL, the investigation level, and the $DCGL_{EMC}$. As shown in this table, the scan MDC is less than the scan investigation level in all cases, thus providing high confidence (95% or higher) that an elevated area would be detected in the scanning process. Further, since the investigation level was always less than the design $DCGL_{EMC}$, no EMC sample size adjustment was necessary.

TABLE 1

SURVEY UNIT DESIGN PARAMETERS

Survey Unit	Design Criteria	Basis
Area	1,119.2 m^2	Class 1, < 2,000 m^2
Number of Direct Measurements Required	40	Based on LBGR of 1.2 pCi/g, sigma[1] of 1.33 pCi/g, and a relative shift of 0.8. Type I = Type II = 0.05
Sample Area	27.98 m^2	1,119.2 m^2 / 40 = 27.98 m^2
Sample Grid Spacing	5.29 m	$(27.98)^{1/2}$
Scan Grid Area	ISOCS scan various distance	See Section B
Area Factor	1.77	Class 1 Area, LTP Table 6-12
Scan Area	1,119.2 m^2	Class 1 Area – 100%
Scan Investigation Level	See Table 2-2	Reference Attachment 2
DCGL	2.39 pCi/g Cs-137 0.86 pCi/g Co-60	LTP Revision 3, Table 6-11 (Reference 4)
Design $DCGL_{EMC}$	4.23 pCi/g Cs-137 1.52 pCi/g Co-60	DCGL x Area Factor for Class 1 survey unit, per LTP Section 5.6.3

C. SURVEY RESULTS

A total of 41 direct measurements were performed in Survey Unit 5. All direct measurements were below the DCGL. The results are presented in Table 2.

ISOCS gamma scans were performed at 61 locations using an investigation level of 1.0 pCi/g Cs-137 and 0.36 pCi/g Co-60. In addition, ISOCS gamma scans were performed at 19 locations using an investigation level of 2.2 pCi/g Cs-137 and 0.8 pCi/g Co-60. ISOCS gamma scans were performed at 12 locations using an investigation level of 1.0 pCi/g Cs-137 and 0.5 pCi/g Co-60. The gamma scans were performed for a sufficient count time to achieve a Minimum Detectable Activity of approximately 25% of the DCGL. All identified activity levels were below the investigation levels. Therefore, no investigations were required.

[1] LTP Revision 3, Table 5-1C for RCA Yard West, R0100.

TABLE 2
DIRECT MEASUREMENTS

Sample Number	Cs-137 (pCi/g)	Uncertainty (pCi/g)	Co-60 (pCi/g)	Uncertainty (pCi/g)	Unitized Value of Unity Rule
FR0111051S001	< 5.73E-02		< 5.33E-02		8.60E-02
FR0111051S002	< 4.26E-02		< 4.13E-02		6.58E-02
FR0111051S003	< 5.38E-02		< 4.74E-02		7.76E-02
FR0111051S004	< 4.85E-02		< 4.93E-02		7.76E-02
FR0111051S005	< 5.38E-02		< 5.66E-02		8.83E-02
FR0111051S006	< 6.01E-02		< 6.70E-02		1.03E-01
FR0111051S007	**2.09E-01**	3.64E-02	< 5.63E-02		1.53E-01
FR0111051S008	< 4.85E-02		< 5.56E-02		8.49E-02
FR0111051S009	< 4.64E-02		< 4.65E-02		7.35E-02
FR0111051S010	< 5.09E-02		< 5.02E-02		7.97E-02
FR0111051S011	**2.94E-01**	4.69E-02	< 5.63E-02		1.89E-01
FR0111051S012	< 6.81E-02		< 5.06E-02		8.73E-02
FR0111051S013	**9.97E-01**	9.56E-02	**1.59E-01**	4.88E-02	6.02E-01
FR0111051S014	**6.22E-01**	6.07E-02	< 4.72E-02		3.15E-01
FR0111051S015	< 5.20E-02		< 5.23E-02		8.26E-02
FR0111051S016	< 4.80E-02		< 5.30E-02		8.17E-02
FR0111051S017	**1.22E-01**	3.45E-02	< 4.85E-02		1.07E-01
FR0111051S018	**6.57E-01**	6.87E-02	< 6.52E-02		3.51E-01
FR0111051S019	**4.70E-01**	5.90E-02	< 5.08E-02		2.56E-01
FR0111051S020	**1.23E+00**	1.02E-01	< 5.95E-02		5.86E-01
FR0111051S021	< 4.88E-02		< 5.46E-02		8.39E-02
FR0111051S022	< 4.96E-02		< 5.60E-02		8.59E-02
FR0111051S023	**3.74E-01**	4.76E-02	< 5.21E-02		2.17E-01
FR0111051S024	< 6.81E-02		< 7.79E-02		1.19E-01
FR0111051S025	**3.62E-01**	4.88E-02	< 5.73E-02		2.18E-01
FR0111051S026	< 7.40E-02		< 6.87E-02		1.11E-01
FR0111051S027	< 6.79E-02		< 6.54E-02		1.04E-01
FR0111051S028	**9.64E-02**	3.26E-02	< 5.21E-02		1.01E-01
FR0111051S029	< 7.86E-02		< 8.43E-02		1.31E-01
FR0111051S030	< 5.25E-02		< 5.13E-02		8.16E-02
FR0111051S031	**4.09E-01**	5.92E-02	< 6.79E-02		2.50E-01
FR0111051S032	< 6.15E-02		< 6.38E-02		9.99E-02
FR0111051S033	**1.06E-01**	3.56E-02	< 7.28E-02		1.29E-01
FR0111051S034	< 6.54E-02		< 5.93E-02		9.63E-02
FR0111051S035	< 4.46E-02		< 4.71E-02		7.34E-02
FR0111051S036	**2.63E-01**	4.72E-02	< 5.63E-02		1.76E-01
FR0111051S037	**1.58E+00**	1.22E-01	< 6.92E-02		7.43E-01
FR0111051S038	< 8.43E-02		< 6.46E-02		1.10E-01
FR0111051S039	< 5.38E-02		< 4.89E-02		7.94E-02
FR0111051S040	**2.09E-01**	4.75E-02	< 6.86E-02		1.67E-01
FR0111051S041	< 5.89E-02		< 5.05E-02		8.34E-02
Mean	**2.30E-01**		**5.99E-02**		**1.66E-01**
Median	**6.81E-02**		**5.60E-02**		**1.03E-01**
Standard Dev.	**3.43E-01**		**1.84E-02**		**1.53E-01**
Range	**4.26E-02 to 1.58E+00**		**4.13E-02 to 1.59E-01**		**6.58E-02 to 7.43E-01**

"<" indicates MDA value. Bold indicates positive detection value.

It should be noted that the Co-60 DCGL of 0.86 pCi/g is an "adjusted DCGL" and can be derived from the unitized dose for surface soil, LTP Table 6-7 and the updated dose model in the activated concrete related license amendment (References 3 and 4). The Co-60 DCGL for surface soil is 1 pCi/g x 10/6.58 mrem/y (from LTP Table 6-7) or 1.52 pCi/g Co-60. This DCGL is further limited by the dose contribution allowed for surface soil only in the basement fill model per LTP Section 6 Attachment IX (revised LTP Table 6-11) in the activated concrete license amendment. Thus, the Co-60 adjusted DCGL is 1.52 pCi/g x 5.63/10 mrem/yr or 0.86 pCi/g.

D. SURVEY UNIT INVESTIGATIONS PERFORMED AND RESULTS

No investigations were required.

E. SURVEY UNIT DATA ASSESSMENT

An analysis of the direct sample measurement results, including the mean, median, standard deviation, and sample result range, is provided in Table 2. Of the 41 soil samples collected, 16 identified Cs-137 activity below the DCGL value of 2.39 pCi/g while 1 sample identified Co-60 activity below the DCGL value of 0.86 pCi/g. All other values were below the MDA. Identified sample activities or Minimum Detectable Activities are listed in Table 2. The mean and median activities were less than the DCGL for both Co-60 and Cs-137. The highest reported value was less than 75% of the unitized DCGL.

For illustrative purposes, as indicated in LTP Section 5.9.3, a simplified general retrospective dose estimate can be calculated from the average residual contamination level by subtracting the mean fallout Cs-137 value (0.19 pCi/g)[2] for disturbed soil from the survey unit sample mean activity (0.23 pCi/g). Taking into account the average residual contamination level for Co-60, the annual dose rate would equate to 0.49 mrem/year[3]. However, for purposes of demonstrating compliance with the radiological criteria for license termination and the enhanced State criteria, background activity was not subtracted from the soil sample analysis activity values.

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[2] See Attachment E to Maine Yankee Procedure PMP 6.7.8 (Reference 5).

[3] This annual dose equivalent is based on LTP Table 6-11 which shows the RA contaminated soil contribution (for soils contaminated at the DCGL) to be 5.63 mrem/y. Therefore, the annual dose rate would equate to

$$Annual\ Dose\ Rate = 5.63x\left(\frac{0.23-0.19}{2.39}+\frac{0.0599}{0.86}\right) = 0.49\ mrem/y$$

F. ADDITIONAL DATA EVALUATION

Attachment 4 provides additional data evaluation associated with this Survey Unit, including relevant statistical information. Based on survey unit direct measurement data, this attachment provides the Sign Test Summary, Quantile Plot, Histogram, and Retrospective Power Curve.

1. The Sign Test Summary provides an overall summary of design input (Table 1) and resulting calculated values used to determine the required number (N) of direct measurements (per LTP Section 5.4.2). The Sign Test Summary is a separate statistical analysis that also calculates the mean, median, and standard deviation of the direct measurements.

   The critical value and the result of the Sign Test are provided in the Sign Test Summary table, as well as a listing of the key release criteria. As is shown in the table, all of the key release criteria were clearly satisfied for the FSS of this survey unit.

2. The Quantile Plot was generated from the unity value data listed in Table 2. The data set and plot are consistent with expectations for a Class 1 survey unit. All of the measurements are below the DCGLs for land inside the restricted area. The highest direct measurement (S037) was less than 75% of the unitized DCGL.

3. A Histogram Plot was also developed based on the unity values. This plot shows a log-normal distribution with three outliers.

4. A Retrospective Power Curve was constructed, based on FSS results. The curve shows that this survey unit having a mean residual activity at a small fraction of the DCGL has a high probability ("power") of meeting the release criteria. Thus, it can be concluded that the direct measurement data support rejection of the null hypothesis, providing high confidence that the survey unit satisfied the release criteria and that the data quality objectives were met.

G. CHANGES IN INITIAL SURVEY UNIT ASSUMPTIONS ON EXTENT OF RESIDUAL ACTIVITY

The survey was designed as a Class 1 land survey area; the FSS results were consistent with that classification. The direct measurement sample standard deviation was less than the design sigma. Thus, a sufficient number of sample measurements were taken and no additional measurements were required.

H. LTP CHANGES SUBSEQUENT TO SURVEY UNIT FSS

The FSS of Survey Unit 5 was designed, performed and evaluated in mid 2004. The design was performed to the criteria of the LTP Revision 3 (References 2 and 4). No subsequent LTP changes with potential impact to this survey unit need to be evaluated.

I. CONCLUSION

The FSS of this survey unit was designed based on the LTP designation as a Class 1 area. The survey design parameters are presented in Table 1. The required number of direct measurements was determined for the Sign Test in accordance with the LTP. As presented in Table 2, all direct measurements were less than the DCGLs of 2.39 pCi/g Cs-137 and 0.86 pCi/g Co-60.

A Sign Test Summary analysis demonstrated that the Sign Test criteria were satisfied. The direct measurement sigma was determined to be less than that used for design, thus indicating that a sufficient number of samples was taken.

The Retrospective Power Curve shown in Attachment 4 confirmed that sufficient samples were taken to support rejection of the null hypothesis, providing high confidence that the survey unit satisfied the release criteria and the data quality objectives were met. Attachment 4 also revealed that direct measurement data represented essentially a log-normal distribution with three outliers.

The scan survey design for this survey unit was developed in accordance with the LTP Revision 3 Addenda (Reference 2 and 4) with significant aspects of the design discussed in Section B and Table 1. ISOCS scans performed at a distance of 3 meters in a systematic grid pattern throughout the survey unit did not identify activity above the scan investigation levels of 1.0 pCi/g Cs-137 and 0.36 pCi/g Co-60. Scans conducted on vertical trench walls, trench floors, and vertical concrete surfaces did not identify activity above the scan investigation levels of 2.2 pCi/g Cs-137 and 0.8 pCi/g Co-60 for those scans performed at a distance of 2 meters.

It is concluded that FR 0111 Survey Unit 5 meets the release criteria of 10CFR20.1402 and the State of Maine enhanced criteria.

J. REFERENCES

1. Maine Yankee License Termination Plan, Revision 3, October 15, 2002 and Addenda provided by Maine Yankee letter to the NRC, MN-02-061, dated November 26, 2002

2. NRC letter to Maine Yankee, dated February 28, 2003

3. Maine Yankee letter to the NRC, MN-03-049, dated September 11, 2003 (LTP Supplement to LTP Revision 3)

4. Issuance of License Amendment No. 170, NRC letter to Maine Yankee, dated February 18, 2004

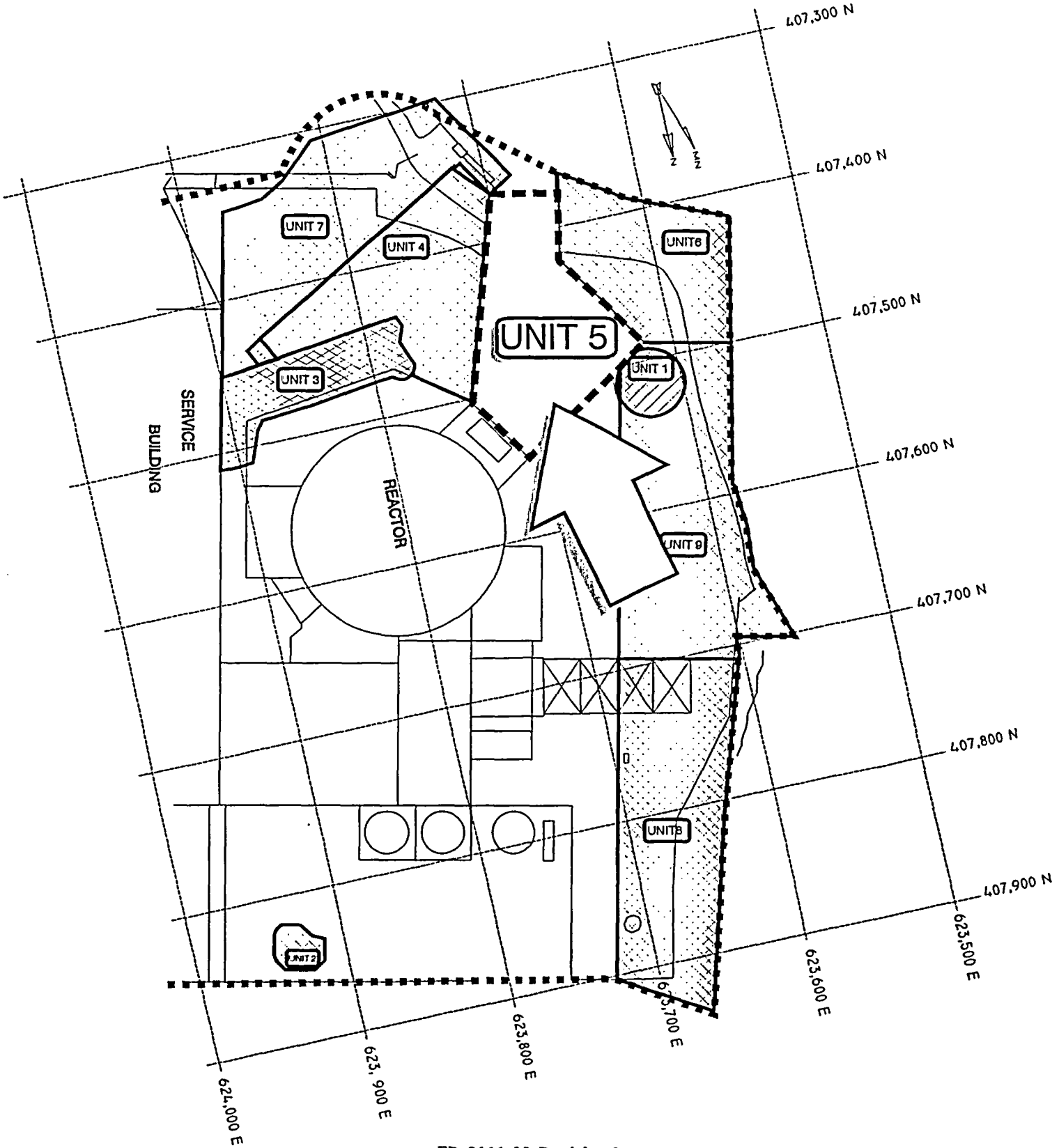
5. Maine Yankee Procedure PMP 6.7.8, FSS Data Processing and Reporting, Attachment E, Approach for Dealing With Background Radioactivity for Maine Yankee Final Status Surveys

6. Maine Yankee Calculation EC-003-04

Attachment 1

Survey Unit Maps

Maine Yankee Decommissioning Team	***Maine Yankee Decommissioning Project Survey Map***	Map ID# FR0111U5-SITE
Survey Type: Characterization Turnover ■ Final Status Survey	Survey Area Name: Site Locator	
	Prepared By: Larry N. Dockins Date: 12/13/04	



Maine Yankee Decommissioning Team

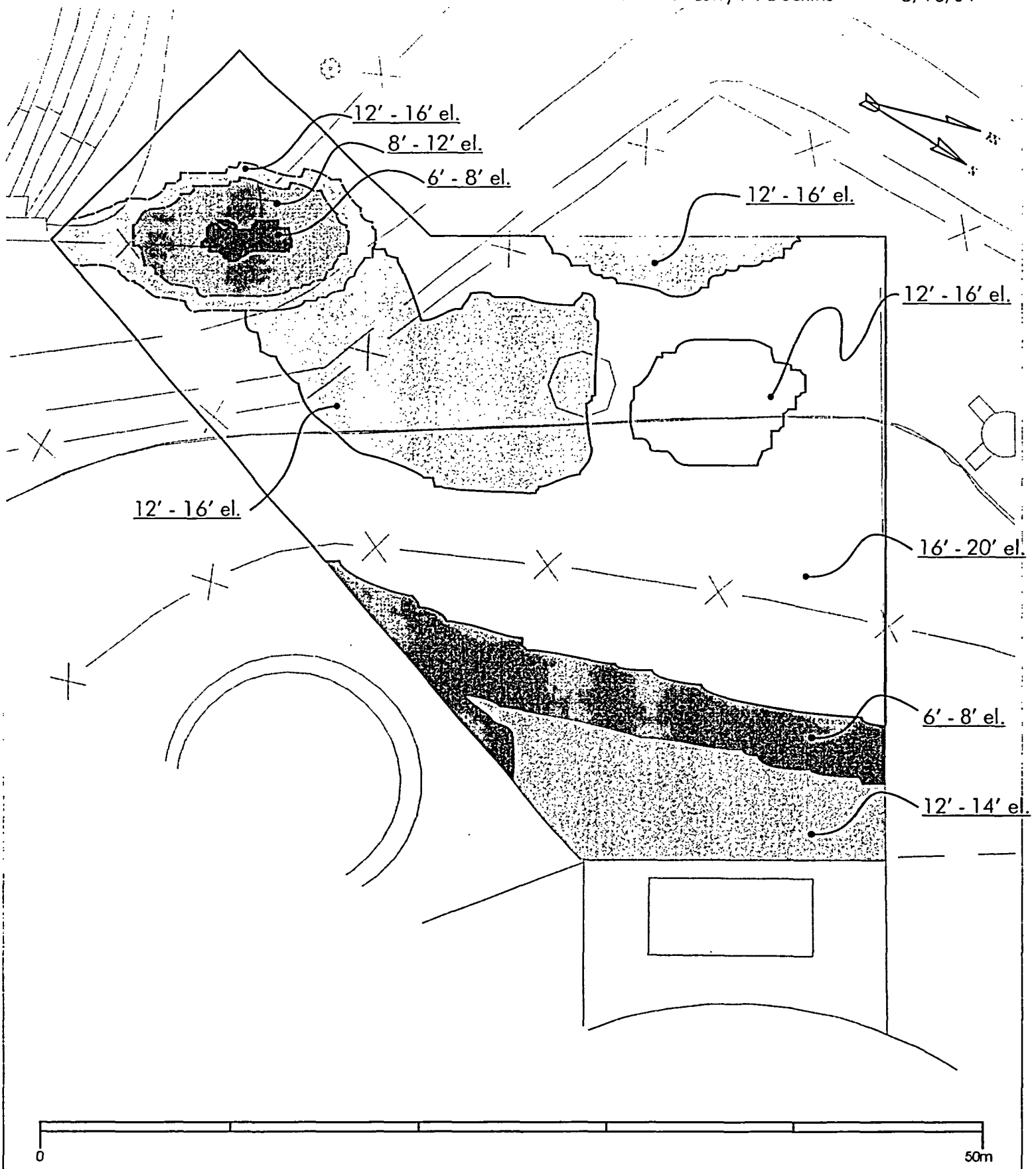
Maine Yankee Decommissioning Project Survey Map

Map ID# FR0111U5-INFO

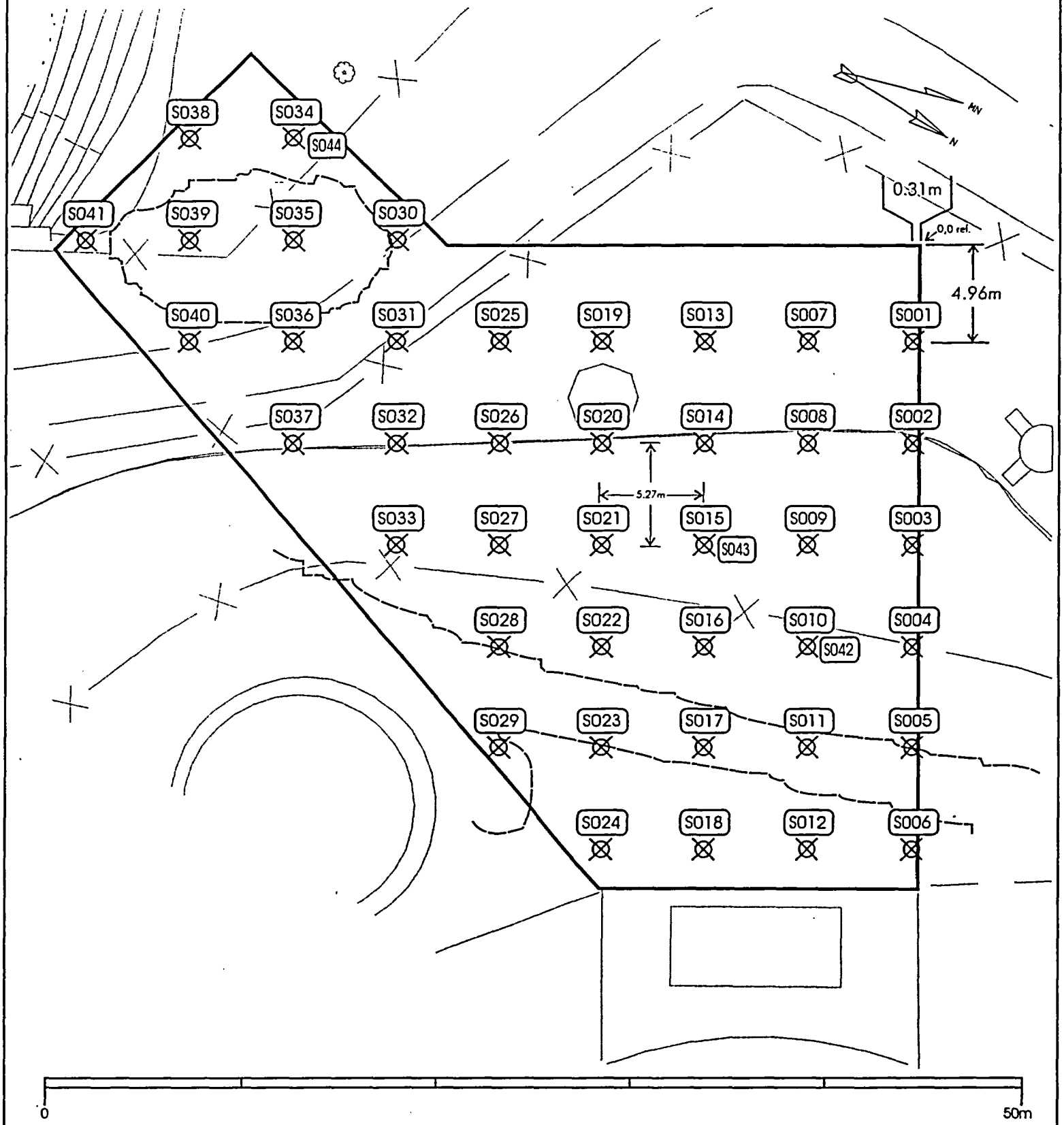
Survey Type: Characterization Turnover ■ Final Status Survey

Survey Area Name: Excavation Depths

Prepared By: Larry N. Dockins Date: 8/16/04



Maine Yankee Decommissioning Team	***Maine Yankee Decommissioning Project Survey Map***	Map ID# FR0111U5-DIRECTS
Survey Type: Characterization Turnover ■ Final Status Survey	Survey Area Name: Directs - Volumetrics	
	Prepared By: Larry N. Dockins Date: 8/11/04	



Maine Yankee
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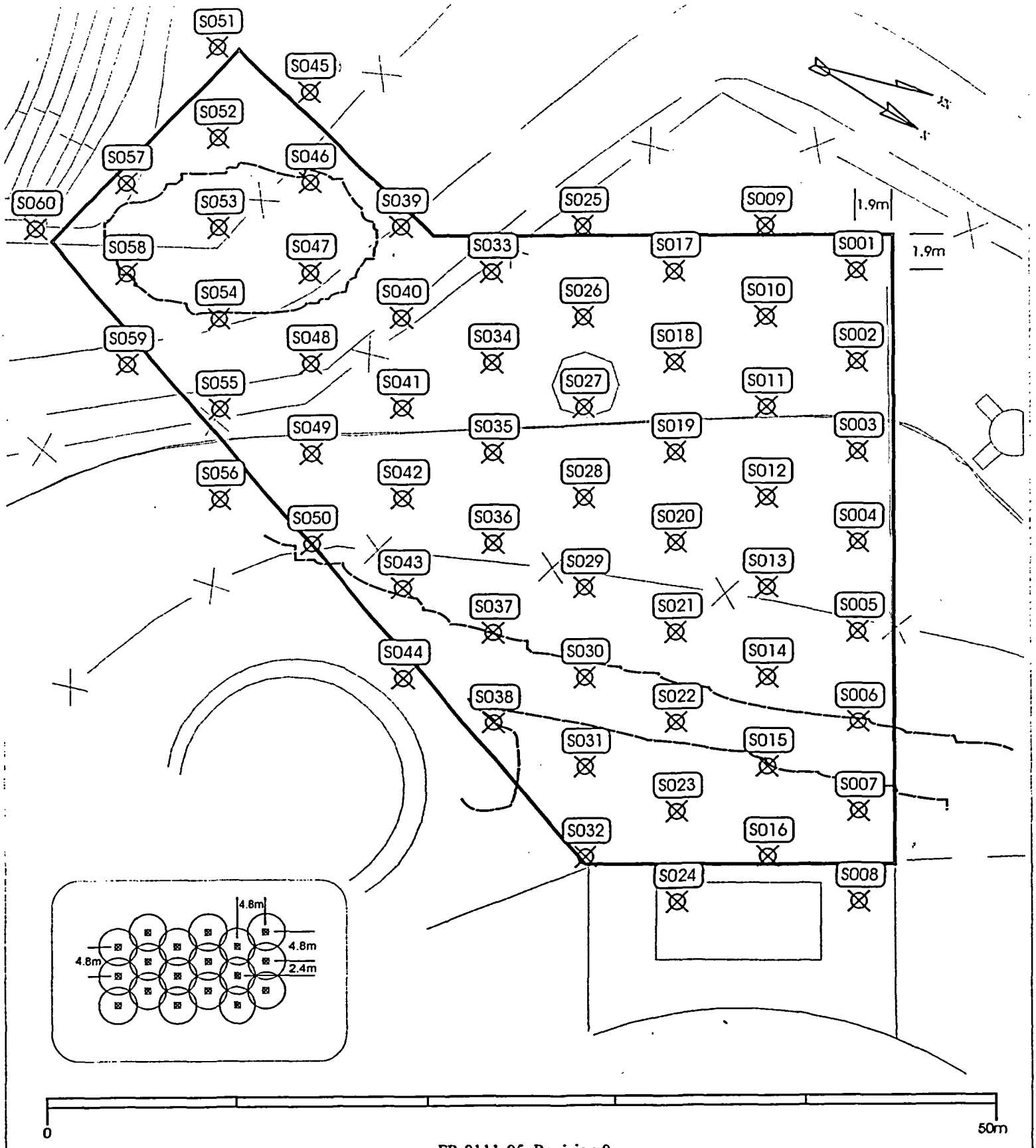
Maine Yankee Decommissioning Project Survey Map

Map ID# FR0111U5-SCANS

Survey Type: Characterization Turnover ☒ Final Status Survey

Survey Area Name: Area Scans - ISOCS

Prepared By: Larry N. Dockins Date: 8/14/04



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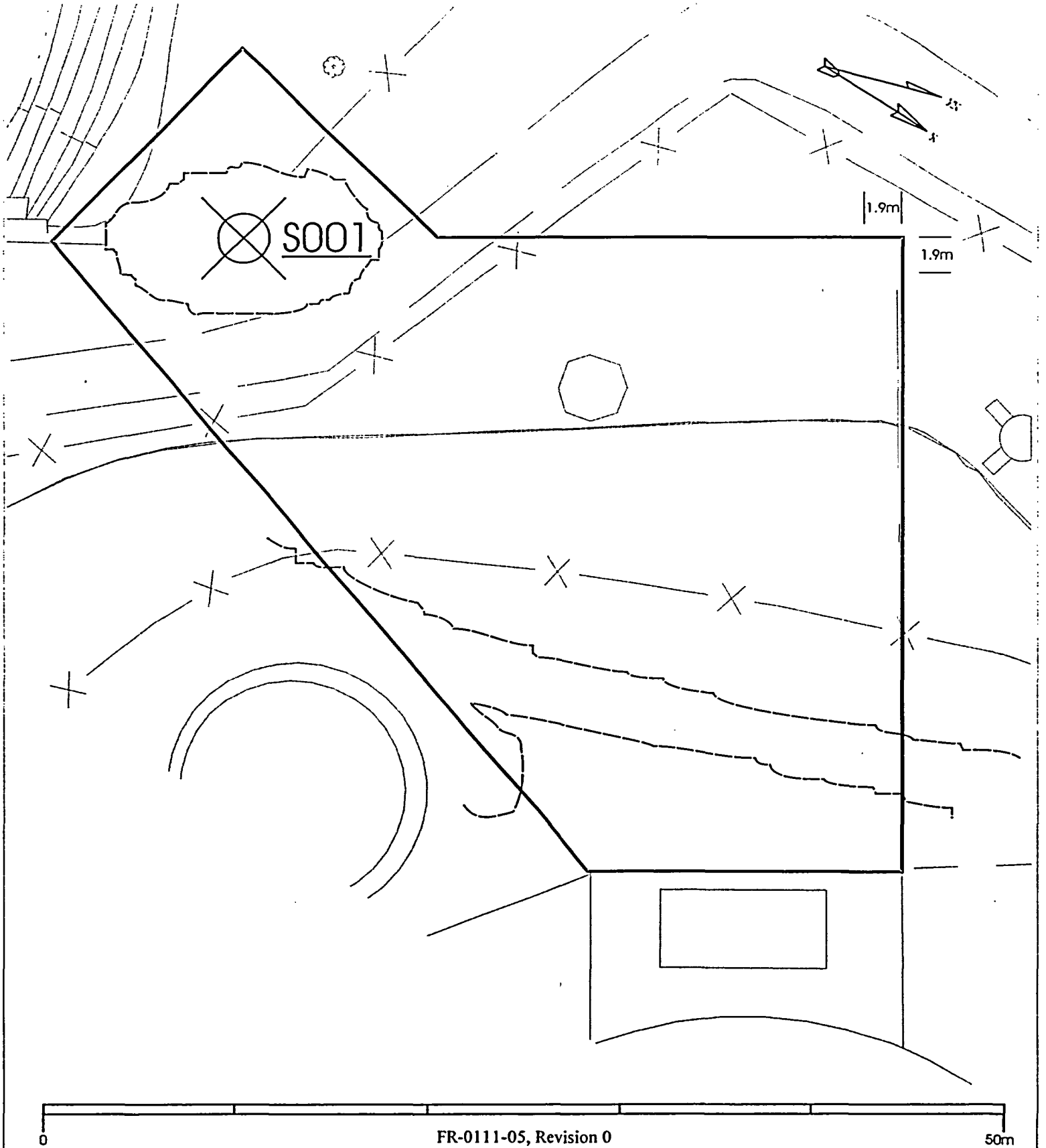
Maine Yankee Decommissioning Project Survey Map

Map ID# FR0111U5-HOLE

Survey Type: Characterization Turnover ☒ Final Status Survey

Survey Area Name: Hole Scan (180° collimator)

Prepared By: Larry N. Dockins Date: 8/16/04



Maine Yankee Decommissioning Team

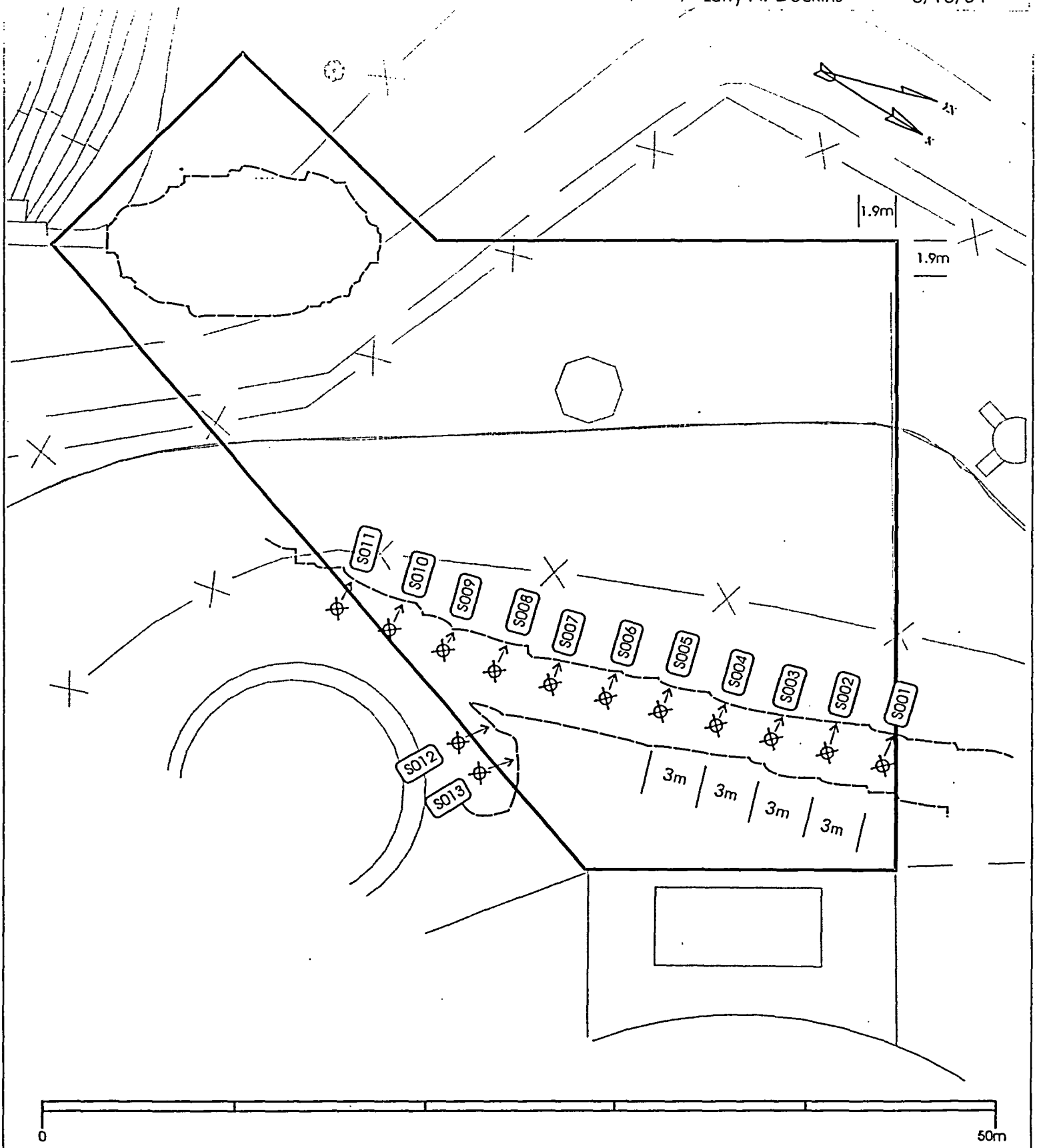
Maine Yankee Decommissioning Project Survey Map

Map ID# FR0111U5-VERTICAL

Survey Type: Characterization Turnover ■ Final Status Survey

Survey Area Name: Vertical Scan Locations

Prepared By: Larry N. Dockins Date: 8/16/04



Note: S001 -S011 centered on vertical surface above trench level(13.5' el.). S012 & S013 centered on the exposed vertical ledge.

Maine Yankee Decommissioning Team

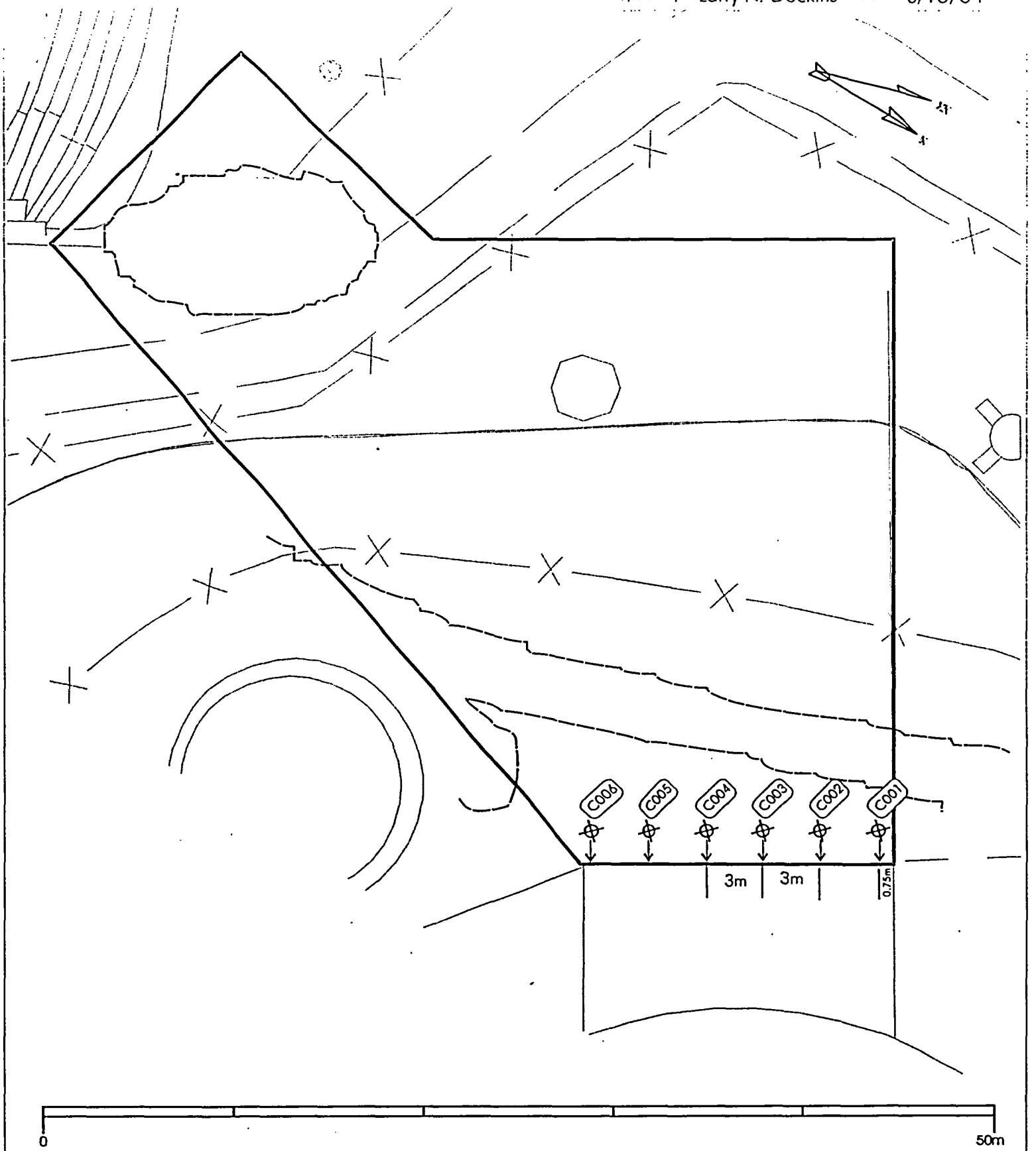
Maine Yankee Decommissioning Project Survey Map

Map ID# FR0111U5-CONCRETE

Survey Type: ☐ Characterization ☐ Turnover ☒ Final Status Survey

Survey Area Name: Concrete Scan Locations

Prepared By: Larry N. Dockins Date: 8/16/04



Note: C001 - C006 centered on exposed vertical concrete surfaces below the 17'el.

Maine Yankee Decommissioning Team

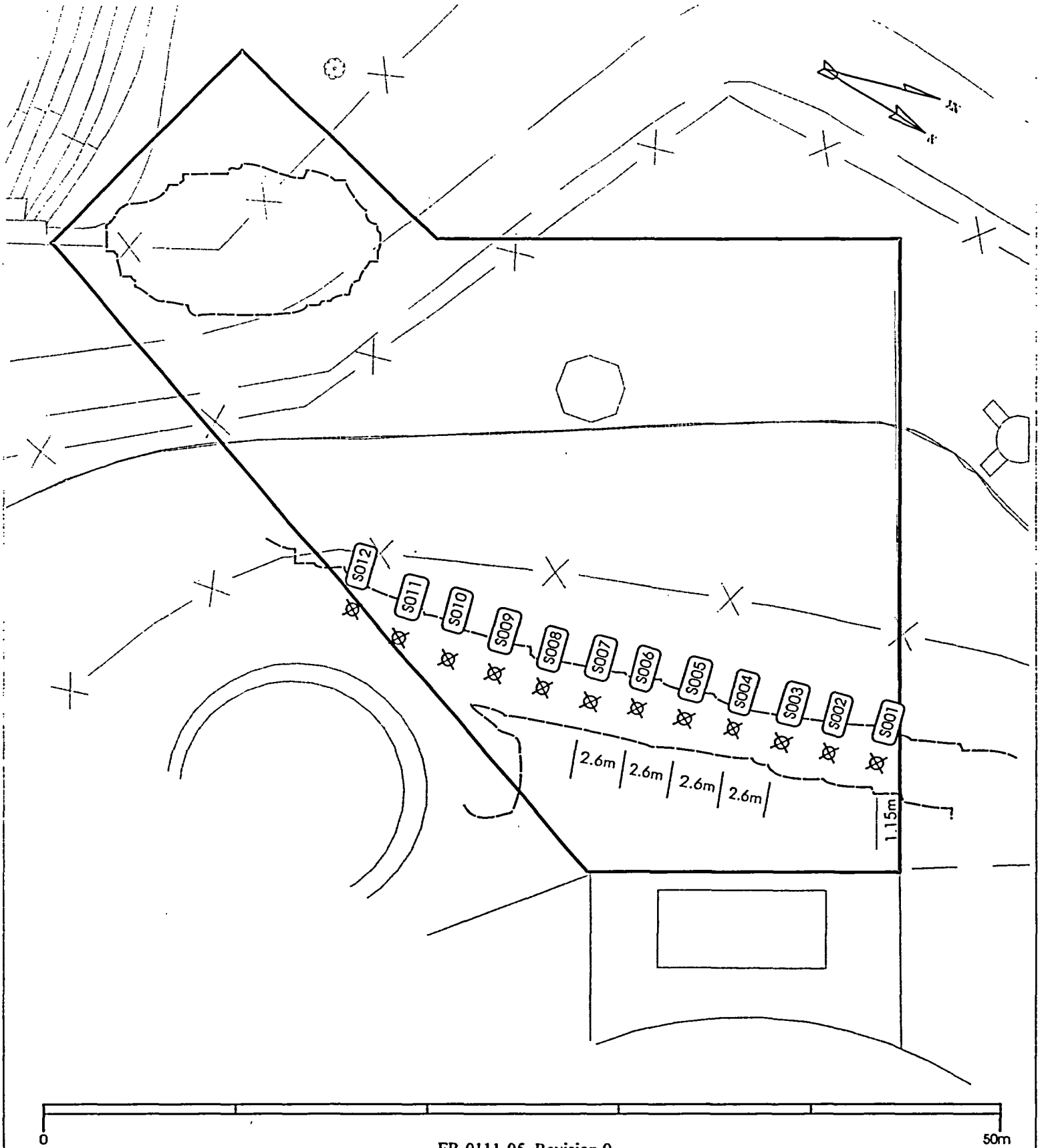
Maine Yankee Decommissioning Project Survey Map

Map ID# FR0111U5-TRENCH

Survey Type: Characterization Turnover ■ Final Status Survey

Survey Area Name: Trench Scan Locations

Prepared By: Larry N. Dockins Date: 8/16/04



Attachment 2

Survey Unit Instrumentation

TABLE 2-1

INSTRUMENT INFORMATION

ISOCS Detectors (Field Measurements)

Detector Number	MDC (pCi/g)
7722	0.1 to 0.4
7607	0.1 to 0.4

HPGe Detectors (Laboratory Analysis)

Detector Number	MDC (pCi/g)
FSS1	0.04 to 0.11
FSS2	0.04 to 0.11

TABLE 2-2

INSTRUMENT SCAN MDC, DCGL, INVESTIGATION LEVEL AND $DCGL_{EMC}$

Detector	Instrument	Comments
Scan MDC	ISOCS: 0.1 to 0.4 pCi/g	~ 25% DCGL
DCGL	2.39 pCi/g Cs-137 0.86 pCi/g Co-60	Approved DCGL for land areas inside the Restricted Area, (Reference 4)
Investigation Level (ISOCS @ 3 m)	1.0 pCi/g Cs-137 0.36 pCi/g Co-60	Reference 6
Investigation Level (ISOCS @ 2 m)	2.2 pCi/g Cs-137 0.8 pCi/g Co-60	Reference 6
Investigation Level (ISOCS trench)	1.0 pCi/g Cs-137 0.5 pCi/g Co-60	
Design $DCGL_{EMC}$	4.23 pCi/g Cs-137 1.52 pCi/g Co-60	DCGL x Area Factor for Class 1 survey unit, per LTP Section 5.6.3

Attachment 3

Investigation Table

(No Investigations Required)

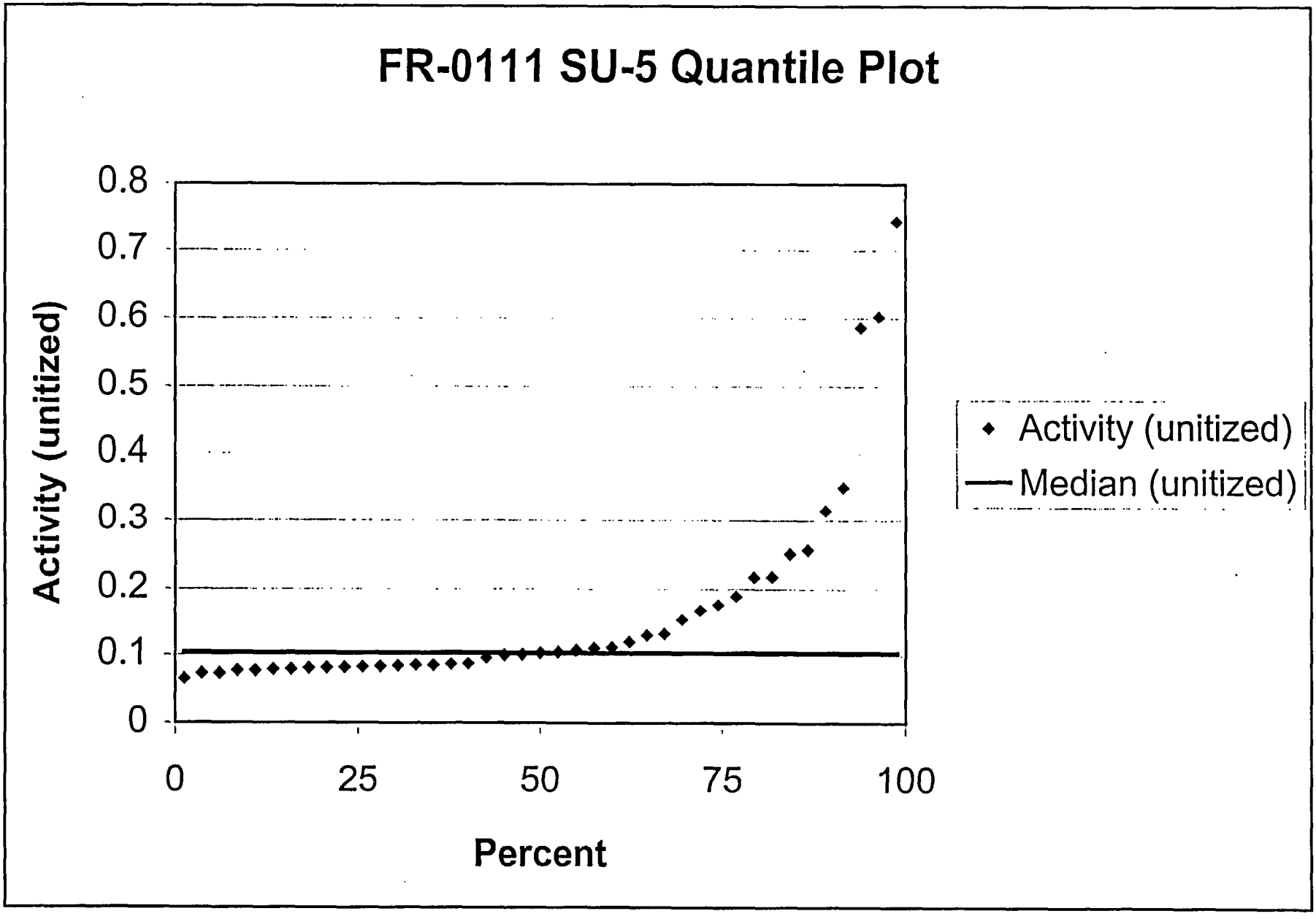
Attachment 4

Statistical Data

Survey Package FR0111 Unit 5 UNITY Soil Sign Test Summary

Evaluation Input Values		Comments
Survey Package:	FR0111	Yard West Excavations
Survey Unit:	05	
Evaluator:	DA	
$DCGL_w$:	1.00E+00	Unity
$DCGL_{emc}$:	1.77E+00	AF x Unity
LBGR:	5.00E-01	50% of DCGL
Sigma:	5.56E-01	Unitized (1.33 pCi/g / 2.39 pCi/g)
Type I error:	0.05	
Type II error:	0.05	
Nuclide:	UNITY	
Soil Type:	N/A	
Calculated Values		**Comments**
$Z_{1-\alpha}$:	1.645	
$Z_{1-\beta}$:	1.645	
Sign p:	0.788145	
Calculated Relative Shift:	0.8	
Relative Shift Used:	0.8	Uses 3.0 if Relative Shift is >3
N-Value:	33	
N-Value+20%:	40	
Sample Data Values		**Comments**
Number of Samples:	41	
Median:	1.03E-01	
Mean:	1.66E-01	
Net Sample Standard Deviation:	1.53E-01	
Total Standard Deviation:	1.53E-01	Sum of samples and reference
Maximum:	7.43E-01	
Sign Test Results		**Comments**
Adjusted N Value:	41	
S+ Value:	41	
Critical Value:	26	
Sign test results:	Pass	
Criteria Satisfaction		**Comments**
Sufficient samples collected:	Pass	
Maximum value <$DCGL_w$:	Pass	
Median value <$DCGL_w$:	Pass	
Mean value <$DCGL_w$:	Pass	
Maximum value <$DCGL_{emc}$:	Pass	
Total Standard Deviation <=Sigma:	Pass	
Criteria comparison results:	Pass	
Final Status		**Comments**
The survey unit passes all conditions:	Pass	Survey Unit Passes

FR0111-SU5-SoilSign-UNITY.xls 12/14/04 12:14 PM


FR-0111 SU-5 Quantile Plot
Activity (unitized)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
25
50
75
100
Percent
Activity (unitized)
Median (unitized)

One-Sample T-Test Report

Page/Date/Time 2 12/8/04 2:37:35 PM
Database
Variable C2

Plots Section

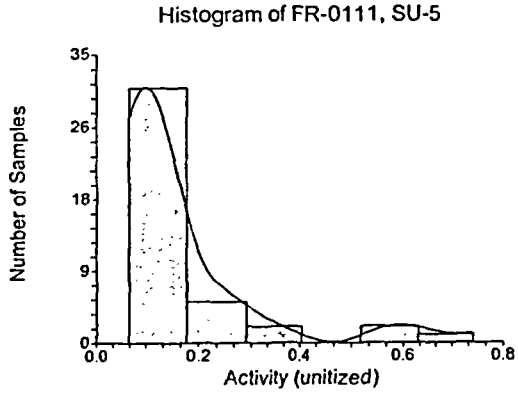


Chart Section