YANKEE NUCLEAR POWER STATION
FINAL STATUS SURVEY REPORT

REPORT NO.: YNPS-FSS-SSS-01-00

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Section **Table of Contents** Page

Table List of Tables Page

List of Appendices

List of Attachments

(In the electronic version, every Table of Contents, Figures, Appendices and Attachments, as well as every mention of a Figure, Appendix or Attachment is a hyperlink to the actual location or document.)

List of Abbreviations and Acronyms

AL	Action Level
ALARA	As Low As Reasonably Achievable
c/d	Counts per Disintegration
DCGL	Derived Concentration Guideline Level
$DCGL_{EMC}$	DCGL for small areas of elevated activity
$DCGL_W$	DCGL for average concentration over a wide area, used with statistical tests
DQO	Data Quality Objectives
EMC	Elevated Measurement Comparison
ETD	Easy-to-Detect
FSS	Final Status Survey
FSSP	Final Status Survey Plan
GPS	Global Positioning System
H_o	Null Hypothesis
HSA	Historical Site Assessment
HTD	Hard-to-Detect
ISOCS	*In-situ* Object Counting System®
LBGR	Lower Bound of the Grey Region
LTP	License Termination Plan
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
PAB	Primary Auxiliary Building
QAPP	Quality Assurance Project Plan
QC	Quality Control
RCA	Radiological Controlled Area
RP	Radiation Protection
RSS	Reactor Support Structure
SFP	Spent Fuel Pool
VC	Vapor Container
VCC	Vertical Concrete Cask
VSP	Visual Sample Plan
YNPS	Yankee Nuclear Power Station

1.0 EXECUTIVE SUMMARY

A Final Status Survey (FSS) was performed of Survey Area SSS-01 in accordance with Yankee Nuclear Power Station's (YNPS) License Termination Plan (LTP). This FSS was conducted as a subsurface FSS with surface soil DCGLs.

1.1 Identification of Survey Area and Units

The SSS-01 Survey Area is comprised of statistical samples in subsurface soil in the industrial area footprint surveyed to a depth of 3 meters (or until refusal) with a total surface area of 14,375 m^2. The DQO process for this survey area is similar to the DQO process used for the other FSS at YNPS however, there were differences in design input parameters necessary to satisfy the objectives of the plan (e.g. sample collection methodology, sample location selection, investigation levels, etc.)

A map of the Survey Area in relation to the site is found in Attachment A.

1.2 Dates of Surveys

Table 1 Date of Surveys and DQOs

Survey Unit	Survey Start Date	Survey End Date	DQA Date
SSS-01-01	9/08/2006	9/12/2006	11/21/2006

1.3 Number and Types of Measurements Collected

The Final Status Survey Plan was developed for this Survey Unit in accordance with YNPS LTP and FSS procedures using the MARSSIM protocol. The planning and design of the survey plan employed the Data Quality Objective (DQO) process, ensuring that the type, quantity and quality of data gathered was appropriate for the decision making process and that the resultant decisions were technically sound and defensible. A total of 25 statistical soil samples were taken in the Survey Area, providing data for the non-parametric testing of the Survey Area. Furthermore, 10 biased sample locations were obtained in this area at various depths (up to 6 meters) based on characterization data and professional judgment. . There was no additional scanning involved with the subsurface sampling.

1.4 Summary of Survey Results

Following the survey, the data were reviewed against the survey design to confirm completeness and consistency, to verify that the results were valid, to ensure that the survey plan objectives were met Soil sample surveys indicated that none of the systematic measurements exceeded the $DCGL_W$, depicted in Attachment B. Retrospective power curves were generated and demonstrated that an adequate number of samples were collected to support the Data Quality Objectives. Therefore, the null hypothesis (H_o) (that the Survey Unit exceeds the release criteria) is rejected.

1.5 Conclusions

Based upon the evaluation of the data acquired for the FSS, SSS-01 meets the release requirements set forth in the YNPS LTP. The Total Effective Dose Equivalent (TEDE) to the average member of the critical group does not exceed 25 mRem per year, including that from groundwater. 10CFR20 Subpart E ALARA requirements have been met as well as the site release criteria for the administrative level DCGLs that ensure that the Massachusetts Department of Public Health's 10 mRem per year limit will also be met.

2.0 FSS PROGRAM OVERVIEW

2.1 Survey Planning

The YNPS FSS Program employs a strategic planning approach for conducting final status surveys with the ultimate objective to demonstrate compliance with the DCGLs, in accordance with the YNPS LTP. The DQO process is used as a planning technique to ensure that the type, quantity, and quality of data gathered is appropriate for the decision-making process and that the resultant decisions are technically sound and defensible. Other key planning measures are the review of historical data for the Survey Area and the use of peer review for plan development.

2.2 Survey Design

The DQO process for subsurface areas is similar to the DQO process used for other FSSs at YNPS. However, there are differences in design input parameters as necessary to satisfy the objectives of the plan. SSS-01 was performed under a documented survey plan developed using the DQO process. The level of effort with which the DQO process was used as a planning tool is commensurate with the Final Status Survey and the necessity of avoiding a decision error. This graded approach of defining data quality requirements is described in the YNPS LTP (i.e. FSSPs require decisions therefore additional effort is needed during the planning phase according to the level of risk of making a decision error and the potential consequences of making that error). The survey design includes the number, type and locations of soil

samples (as well as any judgmental assessments required) and instrumentation selection with the required sensitivities or detection levels. DCGLs are developed based on surface soil and are used to determine the minimum sensitivity required for the survey. Determining the acceptable decision error rates, the lower bound of the gray region (LBGR), statistical test selection and the calculation of the standard deviation and relative shift allows for the development of a prospective power curve plotting the probability of the Survey Unit passing FSS.

Evaluation of subsurface soil at YNPS uses a combination of systematic and biased measurements. Fixed-point sample locations use a random start, systematic grid. Biased sample locations are based upon professional judgment in areas more probable to have concentrations greater than the $DCGL_W$ (e.g. Spent Fuel Pit footprint, Radwaste area, etc.).

Statistical samples were obtained to a depth of 3 meters or refusal, whichever was reached first. Biased samples were taken at various depths up to 6 meters. The samples were homogenized over the entire depth of the core obtained and analyzed by gamma spectroscopy. The results were then compared to surface soil DCGLs and investigated as required.

2.3 Survey Implementation

Once the planning and development has been completed, the implementation phase of the FSS subsurface program begins. Grid points are identified for the soil samples, using Global Positioning System (GPS) coordinates whenever possible, consistent with the Massachusetts State Plane System and the biased soil sample locations are marked. Data is collected and any required investigations are performed.

2.4 Survey Data Assessment

The final stage of the FSS program involves assessment of the data collected to ensure the validity of the results and demonstrate achievement of the survey plan objectives. During this phase, the DQOs and survey design are reviewed for consistency between DQO output, sampling design and other data collection documents. A preliminary data review is conducted to include: checking for problems or anomalies, calculation of statistical quantities and preparation of graphical representations for data comparison. Statistical tests are performed, if required, and the assumptions for the tests are verified. Conclusions are then drawn from the data, and any deficiencies or recommendations for improvement are documented.

2.5 Quality Assurance and Quality Control Measures

YNPS FSS activities are implemented and performed under approved procedures, and the YNPS Quality Assurance Project Plan (QAPP) assures plans, procedures and

instructions have been followed during the course of FSS, as well as providing guidance for implementing quality control measures specified in the YNPS LTP.

3.0 SURVEY AREA INFORMATION

3.1 Survey Area Description

The SSS-01 Survey Area is comprised of the subsurface soil in the industrial area footprint. There is no classification associated with subsurface sampling; however the majority of the DQO's are consistent with that of a Class 1 area, with the exception that there is no surface area restriction. This unit has a total surface area of 14,375 m2. Soil was surveyed to a depth of 3m or until refusal.

A map of the Survey Area is found in Attachment A.

3.2 History of Survey Area

SSS-01 survey area is comprised of that portion of the industrial area as illustrated in Table 2-6 of the YNPS LTP. The area encompasses the entire RCA, as delineated in years 2004-2005. All structures were removed within the area leaving remnant partial concrete walls and slabs. The partial concrete walls and slabs were Final Status Surveyed to building surface DCGLs and the remaining open land areas were surveyed to surface soil DCGLs. After the successful FSS of the industrial area, SSS-01 was backfilled to final grade.

3.3 Division of Survey Area into Survey Units

The SSS-01 Survey Area is a single Survey Unit, SSS-01-01. A map of the Survey Area is found in Attachment A.

4.0 SURVEY UNIT INFORMATION

4.1 Summary of Radiological Data Since Historical Site Assessment (HSA)

4.1.1 Chronology and Description of Surveys Since HSA

The Table below provides a summary of surveys performed during the Final Status Survey of SSS-01.

Table 2 Dates of Surveys since HSA

Survey Unit	Survey Start Date	Survey End Date	Description
SSS-01-01	9/08/2006	9/12/2006	FSS Survey

4.1.2 Radionuclide Selection and Basis

During the initial DQO process, Co-60 and Cs-137 were identified as the radiological nuclides of concern for SSS-01-01. However, soil samples were evaluated for all LTP listed nuclides.

4.1.3 Scoping & Characterization

A default sigma of 0.3 was used in place of characterization data.

4.2 Basis for Classification

There is no classification associated with subsurface sampling; however the majority of the DQO's are consistent with that of a Class 1 area, with the exception that there is no surface area restriction.

4.3 Remedial Actions and Further Investigations

No investigations or remedial actions were required in SSS-01-01.

4.4 Unique Features of Survey Area

Survey Unit SSS-01-01 is unique in the fact that it is a subsurface survey unit.

4.5 ALARA Practices and Evaluations

No specific ALARA evaluation was warranted for the subsurface survey.

5.0 SURVEY UNIT FINAL STATUS SURVEY

5.1 Survey Planning

5.1.1 Final Status Survey Plan and Associated DQOs

The FSS for SSS-01 Survey Area was planned and developed in accordance with the LTP using the DQO process. Form DPF-8856.1, found in YNPS Procedure 8856, "*Preparation of Survey Plans*," was used to provide guidance and consistency during development of the FSS Plans. The FSS Plan can be found in Appendix A. The DQO process allows for systematic planning and is specifically designed to address problems that require a decision to be made in a complex survey design and, in turn, provides alternative actions.

The DQO process was used to develop an integrated survey plan providing the Survey Unit identification, sample size, and selected analytical techniques. The Sign Test was specified for non-parametric statistical testing for this Survey Unit, if required. The design parameters developed are presented below.

Table 3 Survey Area SSS-01 Design Parameters

Survey Unit	Design Parameter	Value	Basis
SSS-01-01	Survey Unit Area	14,375 m2	
	Number of Direct Measurements	Total: 25	α (Type I) = 0.05 β (Type II) = 0.05 σ: 0.3 (MARSSIM Default) Relative Shift: 1.67 DCGLw (Unity): 1 LBGR: 0.5
	Critical Value	17 for Sign test.	(25/2)+(1.645/2)*Square Root (25)
	Gridded Sample Area Size Factor	575m2	Area / Number of Samples (14375 m2/25)
	Sample Grid Spacing:	Triangular: 25.8m	Square Root (14375 m2/(0.866*25))
	Direct Measurement Investigation Level	> DCGLemc or > DCGLw + 3 Sigma	Consistent with a Class 1 Area.

5.1.2 Deviations from the FSS Plan as Written in the LTP

The FSSP design for a subsurface survey area does not have a requirement for scanning, and does not have an area limit.

5.1.3 DCGL Selection and Use

For the final evaluation of the SSS-01 Survey Area and throughout this report, the administrative acceptance criterion of 8.73 mRem per year has been set for Soil LTP-listed radionuclides.

Table 4 Soil DCGL Values

Nuclide	Soil 8.73 mr per year (pCi/g)	Nuclide	Soil 8.73 mr per year (pCi/g)
Co-60	1.4E+00	H-3	1.3E+02
Nb-94	2.5E+00	C-14	1.9E+00
Ag-108m	2.5E+00	Fe-55	1.0E+04
Sb-125	1.1E+01	Ni-63	2.8E+02
Cs-134	1.7E+00	Sr-90	6.0E-01
Cs-137	3.0E+00	Tc-99	5.0E+00
Eu-152	3.6E+00	Pu-238	1.2E+01
Eu-154	3.3E+00	Pu-239	1.1E+01
Eu-155	1.4E+02	Pu-241	3.4E+02
Am-241	1.0E+01	Cm-243	1.1E+01

5.1.4 Measurements

YNPS LTP Section 5.6.3.2.2 (Residual Radioactivity in Subsurface Soils) was used to determine the required number of statistical measurements. The quantity of statistical measurements collected for each unit is listed above in the table titled "Survey Area SSS-01 Design Parameters". Split samples and recounts are addressed under the quality control section 6.2. The SSS-01-01 soil sampling grid was developed as a systematic grid with spacing consisting of a triangular pitch pattern with a random starting point. Sample measurement locations are provided in Attachment A.

There was no scanning involved with the subsurface sampling.

5.2 Survey Implementation Activities

The Table below provides a summary of daily activities performed during the Final Status Survey of SSS-01.

Table 5 FSS Activity Summary for SSS-01

Survey Unit	Date	Activity
OOL-17-01	9/8/2006	Performed walk-down of Survey Unit
	9/8/2006	Established Isolation and Controls
	9/8/2006	Performed Job Hazard Analysis
	8/29/2006	Established DQOs
	8/29/2006	Generated FFS Sample Plans
	9/8/2006 to 9/12/2006	Performed Scans, and Direct measurements.
	11/21/2006	Performed DQA, FSS Complete

5.3 Surveillance Surveys

5.3.1 Periodic Surveillance Surveys

The Survey Area was not placed into a program for periodic surveillance surveys.

5.3.2 Resurveys

No resurveys were performed in SSS-01.

5.3.3 Investigations

No additional investigations were required for this Survey Area due to surveillance surveys.

5.4 Survey Results

Soil sample surveys indicated that SSS-01 had no systematic measurements that exceeded the $DCGL_W$, depicted in Attachment B. Retrospective power curves were generated and demonstrated that an adequate number of samples were collected to support the Data Quality Objectives. Therefore, the null hypothesis (H_o) (that the Survey Unit exceeds the release criteria) is rejected. There was no scanning involved with the subsurface sampling.

Table 6 Soil Sample Summary

Sample Description	SOF
SSS-01-01-001-F	0.02
SSS-01-01-002-F	0.06
SSS-01-01-003-F	0.05
SSS-01-01-004-F	0.05
SSS-01-01-005-F	0.09
SSS-01-01-006-F	0.08
SSS-01-01-007-F	0.03
SSS-01-01-008-F	0.04
SSS-01-01-009-F	0.04
SSS-01-01-010-F	0.06
SSS-01-01-011-F	0.11
SSS-01-01-012-F	0.18
SSS-01-01-013-F	0.04
SSS-01-01-014-F	0.05
SSS-01-01-015-F	0.18
SSS-01-01-016-F	0.15
SSS-01-01-017-F	0.08
SSS-01-01-018-F	0.08
SSS-01-01-019-F	0.09
SSS-01-01-020-F	0.11
SSS-01-01-021-F	0.05
SSS-01-01-022-F	0.04
SSS-01-01-023-F	0.06
SSS-01-01-024-F	0.06
SSS-01-01-025-F	0.07
Max	0.18
Average	0.08
Standard Deviation	0.04

5.5 Data Quality Assessment

The Data Quality Assessment phase is the part of the FSS where survey design and data are reviewed for completeness and consistency, ensuring the validity of the results, verifying that the survey plan objectives were met, and validating the classification of the Survey Unit.

The sample design and the data acquired were reviewed and found to be in accordance with applicable YNPS procedures DP-8861, "*Data Quality Assessment*"; DP-8856, "*Preparation of Survey Plans*"; DP-8857, "*Statistical Tests*"; DP-8865, "*Computer Determination of the Number of FSS Samples and Measurements*" and DP-8852, "*Final Status Survey Quality Assurance Project Plan*".

The Data Quality Assessment power curves, scatter, quantile and frequency plots are found in Attachment B. Posting Plots are found in Attachment A.

The sample concentrations were below the DCGLw and no sum-of-fractions were equal to or greater than one. The data set was within approximately three standard deviations with normal dispersion about the arithmetic mean. The data posting plot does not clearly reveal any systematic spatial trends. The quantile plot exhibits some asymmetry in the lower quartile and the frequency plot demonstrates a normal distribution. The survey maintained sufficient power to pass the unit and the data set verified the assumptions of the statistical test.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

6.1 Instrument QC Checks

There was no scanning involved with the subsurface sampling.

6.2 Split Samples and Recounts

Two split and two recount 'QC" samples were gathered and within tolerable limits in accordance with DP-8864,"*Split Sample Assessment for Final Status Survey*".

6.3 Self-Assessments

No self-assessments were performed during the FSS of SSS-01.

7.0 CONCLUSION

The FSS of SSS-01 has been performed in accordance with YNPS LTP and applicable FSS procedures. Evaluation of the soil sample data has shown none of the systematic soil samples exceeded the $DCGL_W$, depicted in Attachment B. Retrospective power curves were generated and demonstrated that an adequate number of samples were collected to support the Data Quality Objectives. Therefore, the null hypothesis (H_o) is rejected.

SSS-01 meets the objectives of the Final Status Survey.

Based upon the evaluation of the data acquired for the FSS, SSS-01 meets the release requirements set forth in the YNPS LTP. The Total Effective Dose Equivalent (TEDE) to the average member of the critical group does not exceed 25 mRem per year, including that from groundwater. 10CFR20 Subpart E ALARA requirements have been met as well as the site release criteria for the administrative level DCGLs that ensure that the Massachusetts Department of Public Health's 10 mRem per year limit will also be met.

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