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Attachment 1
Haddam Neck Plant
Final Status Survey (FSS) Final Report – Phase V

December 2006

Connecticut Yankee Atomic Power Company
Haddam Neck Plant
Final Status Survey Report – Phase V
December 2006

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TABLE OF CONTENTS

1.0 Introduction ... 3
1.1 Executive Summary ... 3
1.2 Phased Submittal Approach ... 7
2.0 FINAL STATUS SURVEY Program Overview ... 11
2.1 Survey Planning ... 13
2.2 Survey Design ... 18
2.3 Survey Implementation ... 21
2.4 Survey Data Assessment ... 22
2.5 Quality Assurance and Quality Control Measures ... 23
3.0 Site Information ... 25
3.1 Site Description ... 25
3.2 Survey Area/Unit Description ... 27
3.3 Summary of Historical Radiological Data ... 29
3.4 Conditions at the Time of Final Status Survey ... 33
3.5 Identification of Potential Contaminants ... 33
3.6 Radiological Release Criteria ... 35
4.0 Final Status Survey Protocol ... 35
4.1 Data Quality Objectives ... 35
4.2 Survey Unit Designation and Classification ... 41
4.3 Background Determination ... 41
4.4 Final Status Survey Plans ... 41
4.5 Survey Design ... 41
4.6 Instrumentation ... 43
4.7 Survey Methodology ... 48
4.8 Quality Control Surveys ... 49
5.0 Survey Findings ... 50
5.1 Survey Data Conversion ... 51
5.2 Survey Data Verification and Validation ... 52
5.3 Evaluation of No. of Sample and Measurement Locations in SUs ... 53
5.4 Comparison of Findings with Derived Concentration Guideline Levels ... 53
5.5 USNRC/Independent Verification Team Findings ... 54
6.0 Summary ... 54
7.0 References ... 54
8.0 Appendices ... 58

LIST OF TABLES

1-1 Phase V Survey Unit Classification and Description List 5

2-1 Derived Concentration Guideline Levels for Soil 15

2-2 HNP LTP Compliance Equation 5-1 Values and Actual Soil Dose 16

2-3 FSS Area Classifications 18

2-4 Easy-to-Detect (ETD) and Hard-to-Detect (HTD) Radionuclides 19

4-1 Action Levels 38

4-2 Number of Samples for FSS 42

4-3 SPA-3 Technical Details and Specifications... 43

4-4 Ambient Background Count Rates, Associated MDCR's and Investigation Levels 44

4-5 Scan Coverage 48

4-6 Summary of Total Area Scanned 48

5-1 Summary of Statistical Analysis for Soil Samples 51

LIST OF FIGURES

1-1 Phase V Submittal 6

1-2 FSS Final Report Phased Submittal Areas 10

2-1 FSS Organizational Chart 12

1.0 INTRODUCTION

1.1 Executive Summary

The purpose of this Final Status Survey (FSS) Final Report is to provide a summary of the survey results and the overall conclusions, which demonstrate that the Connecticut Yankee Atomic Power Company's Haddam Neck Plant (HNP) site, or portions of the site, meets established criteria for release for unrestricted use. The FSS results provided herein only address the dose component due to soil as provided in the HNP License Termination Plan (LTP) (Reference 7.1) compliance Equation 5-1. The remaining two components, present and future groundwater, were bounded on an individual survey unit basis as discussed in Integrated Site Closure (ISC) memo 06-024, "Initial Target Operational DCGLs for CY" (Reference 7.2).

This report also documents that the FSS activities were performed consistent with the guidance provided in the HNP LTP; NUREG-1575, "Multi-Agency Radiation Survey and Site Investigation Manual" (MARSSIM) (Reference 7.3); HNP program document ISC-GQP-00001-003, "Final Status Survey Quality Assurance Plan" (Reference 7.4); HNP procedure GPP-GGGR-R5120-002, "Final Status Survey Program (RPM5.1-00)" (Reference 7.5); and, various station implementing procedures.

This FSS Final Report has been written consistent with the guidance provided in NUREG-1757, Vol. 2, "Consolidated NMSS Decommissioning Guidance-Characterization, Survey, and Determination of Radiological Criteria" (Reference 7.6); MARSSIM; and, the requirements specified in GPP-GGGR-R5122-001, "Preparation of Final Status Survey Reports (RPM 5.1-22)" (Reference 7.7).

To facilitate the data management process, as well as overall project management, FSS Final Reports will incorporate multiple Survey Unit Release Records. Survey Unit Release Records are complete and unambiguous records of the as-left radiological status of specific survey units. Sufficient data and information are provided in each Survey Unit Release Record to enable an independent re-creation and evaluation at some future time of both the survey activities and the derived results.

This report contains a compilation of eleven (11) Survey Unit Release Records that are within the Phase V scope. The Phase V FSS Final Report specifically addresses eleven (11) lowland survey areas of the HNP site that total approximately 66 surface acres in size (266,224 m^2). Table 1-1 provides a listing of all survey units addressed in this report including the classification and general description for each. Figure 1-1 depicts the locations of the survey units in relation to the HNP site, as well as, survey unit boundaries.

All FSS activities essential to data quality have been implemented and performed under approved procedures. Trained individuals, using appropriate sampling equipment and laboratory equipment that is sensitive to the suspected contaminants, performed the FSS of the Phase V survey units.

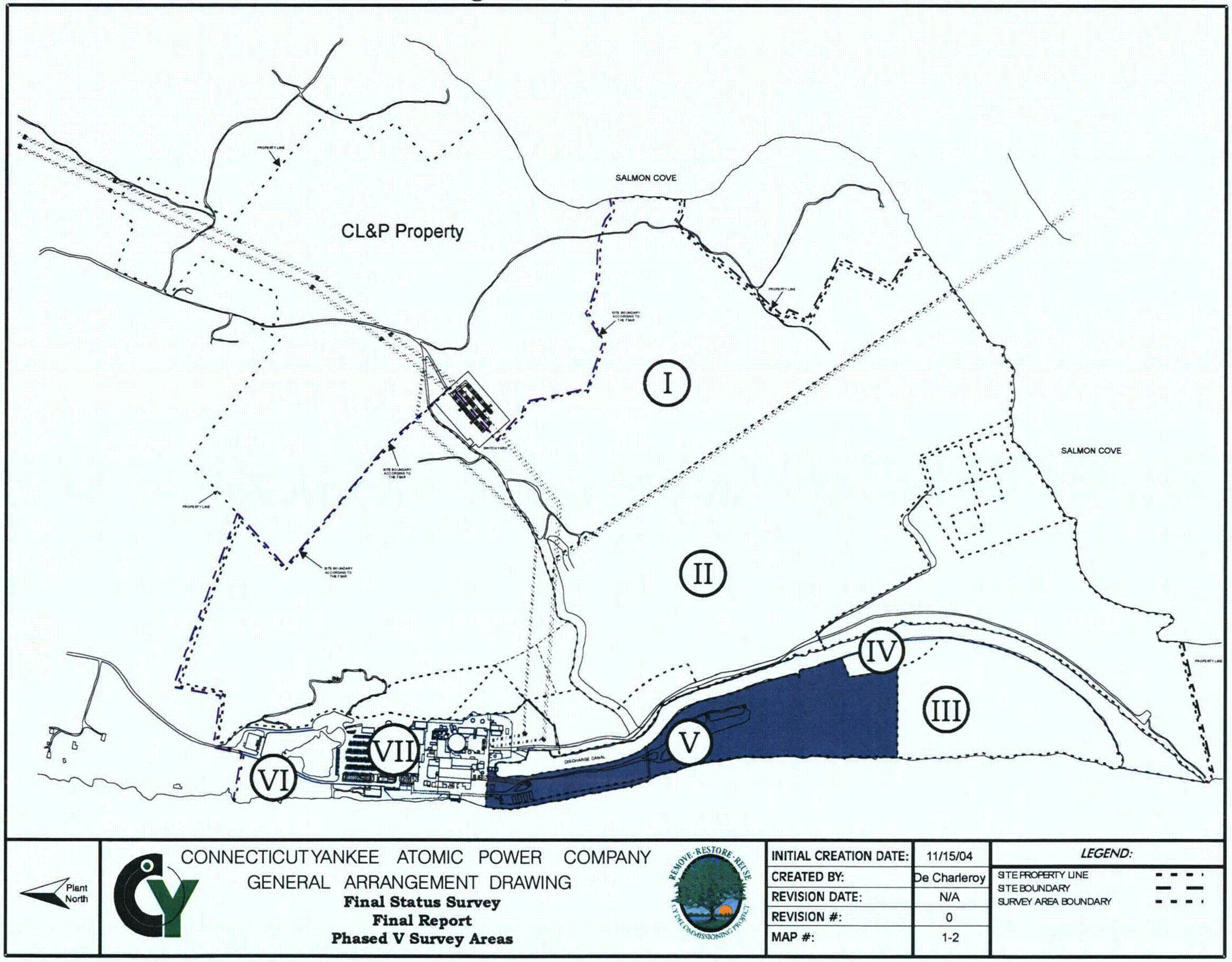
The survey data for all Phase V survey units demonstrate that the dose from residual radioactivity in soil is less than the dose target set for the soil portion of the maximum annual dose criterion for license termination for unrestricted use specified in 10CFR20.1402 (see Table 2-2). The additional requirement of 10CFR20.1402 that all residual radioactivity be reduced to levels that are As Low As Reasonably Achievable (ALARA) has been satisfied.

Table 1-1 Phase V Survey Unit Classification and Description List

Survey Area	Survey Unit	Class	General Description of the Survey Unit (1)
9520	0001	2	Southwest Site Storage Area, surface area (9,777 m^2)
9520	0002	2	Southwest Site Storage Area, surface area (9,720 m^2)
9520	0003	2	Southwest Site Storage Area, surface area (8,106 m^2)
9520	0004	1	Southwest Site Storage Area, surface area (1,985 m^2)
9520	0005	1	Southwest Site Storage Area, surface area (1,887 m^2)
9530	0001	2	Central Peninsula, surface area (5,753 m^2)
9530	0002	2	Central Peninsula, surface area (6,438 m^2)
9530	0003	2	Central Peninsula, surface area (6,438 m^2)
9530	0004	3	Central Peninsula, surface area (83,777 m^2)
9805	0000	C	Subsurface Area Associated With The Peninsula (excluding Survey Unit 9531), subsurface area (130,380 m^2)
9807	0000	B	Subsurface Area Associated With The Southwest Site Storage Area, subsurface area (1,983 m^2)

(1) Refer to Section 3.2 for a more detailed description.

Figure 1-1, Phase V Submittal



1.2 Phased Submittal Approach

To minimize the incorporation of redundant historical assessment and other FSS program information, and to facilitate potential phased releases from the current license, FSS Final Reports will be prepared and submitted in a phased approach. HNP estimates that a total of seven (7) FSS Final Reports will be submitted during the decommissioning project (see Figure 1-2 for locations of phased submittal areas).

Phase I FSS Final Report

On April 29, 2004, HNP submitted a request to release a portion of the HNP site (Reference 7.8) from the 10CFR50 License (DPR-61). Specifically, the request addressed the removal and release of the East Site Grounds (Survey Area 9532), a non-impacted area, from the Part 50 License. In accordance with Section 1.4.2 of the HNP LTP, and the USNRC Safety Evaluation dated November 25, 2002 (Reference 7.9), HNP determined the proposed action would have no adverse impact on the ability of the site in aggregate to meet 10CFR20, Subpart E, criteria for unrestricted release. The request did not contain a FSS Final Report for Survey Area 9532, because this area was classified as non-impacted. The site release and removal of Survey Area 9532 from the site was approved by the USNRC on September 01, 2004 (Reference 7.10).

Phase II FSS Final Report

On March 8, 2005, HNP submitted a request to release a portion of the HNP site (Reference 7.11) from the 10CFR50 License (DPR-61). Specifically, the request addressed the removal and release of the fourteen (14) surface survey units, and one (1) subsurface survey unit, which collectively made up the area defined as Phase II. In accordance with Section 1.4.2 of the HNP LTP, and the USNRC Safety Evaluation dated October 5, 2005 (Reference 7.12), HNP determined the proposed action would have no adverse impact on the ability of the site in aggregate to meet 10CFR20, Subpart E, criteria for unrestricted release. The request contained an FSS Final Report covering all of the areas involved. The site release and removal of Phase II from the site was approved by the USNRC on February 28, 2006 (Reference 7.13).

Phase III FSS Final Report

On May 4, 2006, HNP submitted the Phase III FSS Report (Reference 7.14). This submittal included the FSS release records for a total of seven (7) surface survey units. In response to verbal comments and communications with the USNRC staff, four (4) survey unit release records were revised to further clarify specific technical issues. Revision

1 of the Phase III report and the associated revised release records were submitted to the USNRC on September 9, 2006 (Reference 7.15).

Phases IV

On November 29, 2006, HNP submitted the Phase IV FSS Report (Reference 7.16). This submittal comprised the FSS release records for a total of sixteen (16) surface survey units, and included the pond and discharge canal survey areas. Two (2) of the sixteen (16) survey units were permanent wetland areas, the balance were water covered locations. Sediments were sampled in these areas by performing direct push sample coring to the appropriate depths to meet the dose model.

Phases V

The subject of this report.

Phases V, VI and VII Final Reports

As discussed above, HNP anticipates at least two (2) additional FSS Final Report submittals. Below is a list of the remaining survey areas, grouped by phase, with the approximate submittal date. Details on the number, description and location of survey units within each survey area can be found in Chapter 2 of the HNP LTP.

The schedule and identity of survey areas included in each of the remaining submittals were developed based on a review of the demolition and Final Status Survey schedule, as well as in consideration of USNRC review requirements. The demolition schedule, including the cleanup of demolition debris to permit access for FSS, is dynamic and subject to continued refinement in logic, durations, and completion dates. It is HNP's intent to maintain the basic submittal milestone schedule provided below. However, because of potential changes in the decommissioning schedule, it is possible that additional, interim submittals will be filed with the USNRC with the goal of providing Survey Unit Release Records as soon as possible to support the agency's review, as well as HNP's goals regarding the release of site lands from the license.

Phase VI FSS Final Report Submittal scheduled for February 2007

(15 Release Records)

- 9304-0001 Southwest Protected Area Grounds
- 9304-0002 Southwest Protected Area Grounds
- 9504-0000 Bypass Road and Secondary Parking Lot
- 9506-0000 North Site Grounds (Non-Protected Area)
- 9512-0000 Northwest Site Grounds (Non-Protected Area)
- 9522-0001 Southeast Site Grounds (Non-Protected Area)

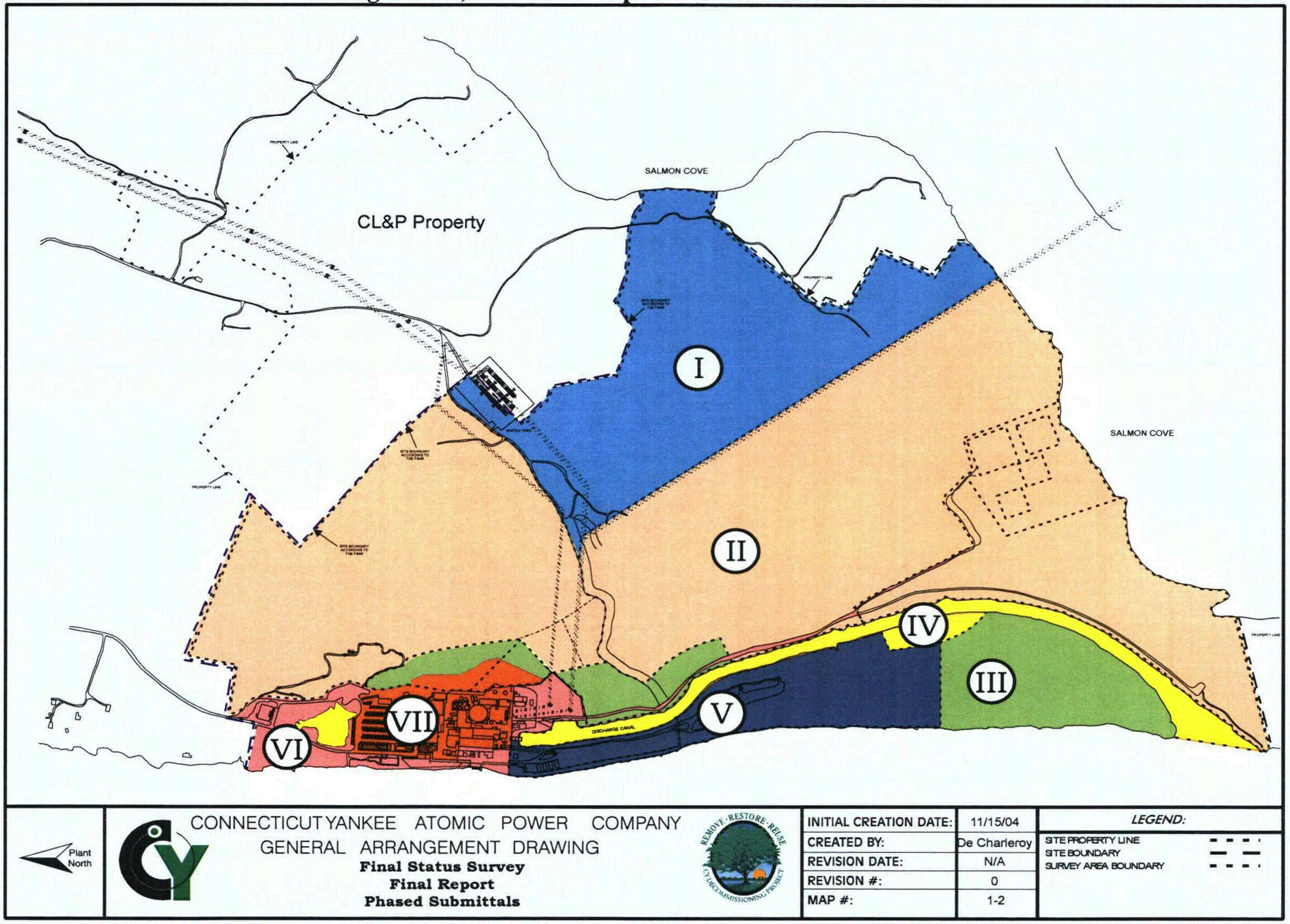
- 9522-0002 Southeast Site Grounds (Non-Protected Area)
- 9522-0003 Southeast Site Grounds (Non-Protected Area)
- 9522-0004 Southeast Site Grounds (Non-Protected Area)
- 9522-0005 Southeast Site Grounds (Non-Protected Area)
- 9522-0006 Southeast Site Grounds (Non-Protected Area)
- 9522-0007 Southeast Site Grounds (Non-Protected Area)
- 9539-0001 ISFSI Haul Road
- 9539-0002 ISFSI Haul Road
- 9804-0000 Subsurface Soils Associated with 9522

Phase VII FSS Final Report Submittal scheduled for May 2007

(19 Release Records)

- 9302-0000 Northwest Protected Area Grounds
- 9306-0000 South Central Protected Area Grounds
- 9312-0001 Northeast Protected Area Grounds
- 9312-0002 Northeast Protected Area Grounds
- 9312-0003 Northeast Protected Area Grounds
- 9312-0004 Northeast Protected Area Grounds
- 9312-0005 Northeast Protected Area Grounds
- 9312-0006 Northeast Protected Area Grounds
- 9312-0007 Northeast Protected Area Grounds
- 9312-0008 Northeast Protected Area Grounds
- 9312-0009 Northeast Protected Area Grounds
- 9312-0010 Northeast Protected Area Grounds
- 9313-0000 Central site Grounds
- 9514-0000 Primary Parking Lot
- 9527-0001 East Mountain Side
- 9527-0002 East Mountain Side
- 9801-0000 Subsurface Soils in Radiologically Controlled Area
- 9802-0000 Subsurface Soils Associated with 9308
- 9803-0000 Subsurface Soils Located North of Industrial Area

Figure 1-2, FSS Final Report Phased Submittal Areas



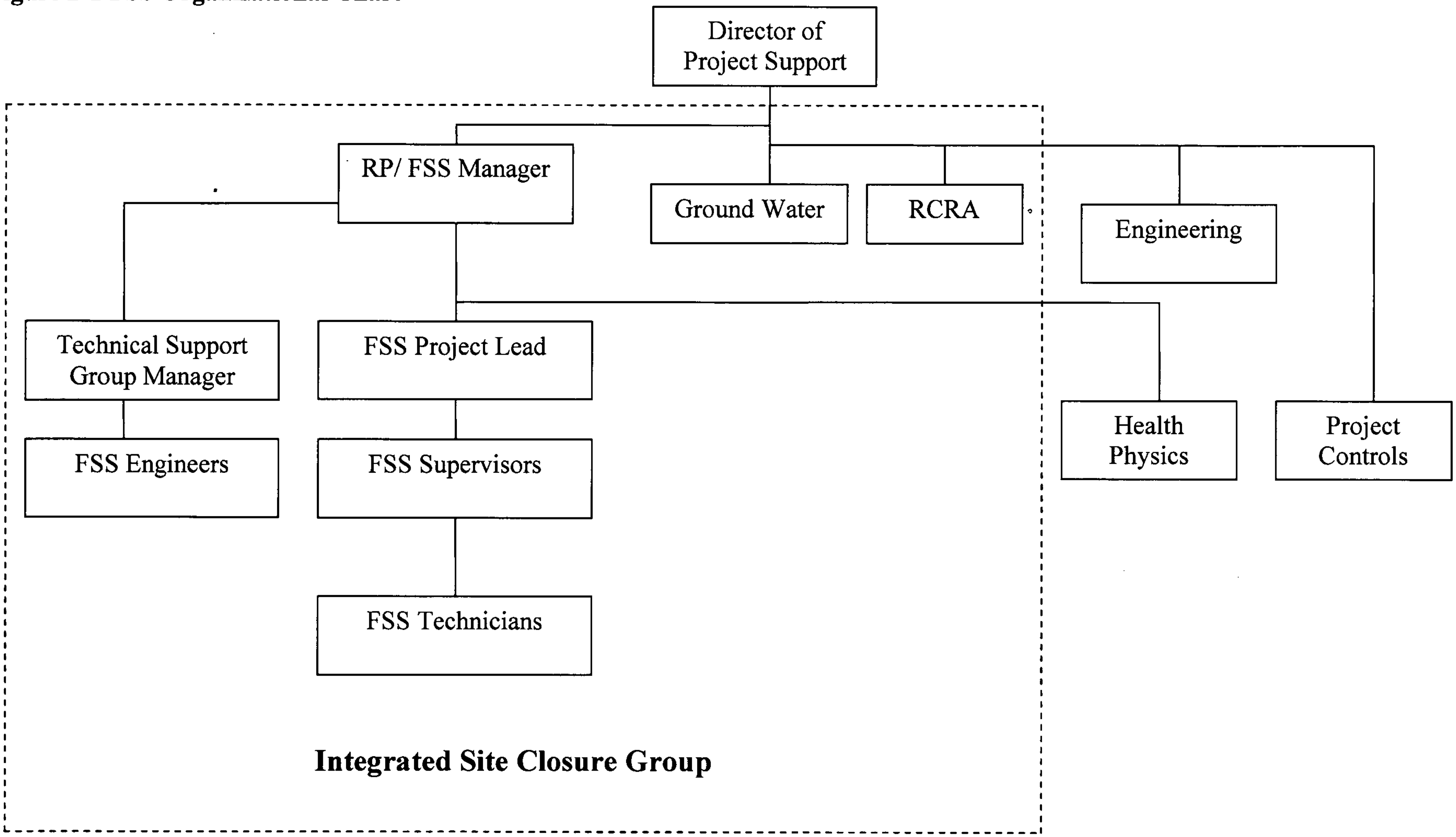
2.0 FINAL STATUS SURVEY PROGRAM OVERVIEW

The FSS Program consists of the methods used in planning, designing, conducting, and evaluating FSS activities at the HNP site to demonstrate that the premises are suitable for release in accordance with the criteria for decommissioning in Title 10CFR20, Subpart E. The actual FSS serves as a key element to demonstrate that:

- Dose from residual radioactivity is less than the maximum annual dose criterion for license termination for unrestricted use as specified in Title 10CFR20.1402 - that is, the residual radioactivity that is distinguishable from background radiation results in a Total Effective Dose Equivalent (TEDE) to an average member of a critical group that does not exceed twenty five (25) millirem per year (25 mrem/yr); and,
- All residual radioactivity at the site is reduced to levels that are As Low as Reasonably Achievable (ALARA) in accordance with Title 10CFR20.1402.

To implement the FSS Program as provided in Reference 7.5, and MARSSIM, HNP established an organization within Integrated Site Closure with sufficient management and technical resources to fulfill project objectives and goals. The FSS organization was responsible for the safe completion of all activities related to FSS necessary to obtain the radiological release for unrestricted use of the HNP site. Approved site procedures directed this process to ensure consistent implementation and adherence to applicable requirements. Figure 2-1 provides an organizational chart of the FSS organization and its relationship within the Project Support Directorate.

Figure 2-1 FSS Organizational Chart



2.1 Survey Planning

After termination of commercial operations, the initial development and planning phase started in 1997 with the characterization and Historical Site Assessment (HSA) processes that continued until submittal of the License Termination Plan in 2000. The HSA consisted of a review of site historical records regarding plant incidents, radiological survey documents, operations and maintenance records, plant modification documents, and both routine and special reports submitted by HNP to various regulatory agencies. Along with the HSA, interviews with site personnel, both past and present, reviews of historical site photos and extensive area inspections were performed to meet the following objectives:

- To develop the information to support FSS design including the development of Data Quality Objectives (DQOs) and survey instrument performance standards;
- To develop the initial radiological information to support decommissioning planning including building decontamination, demolition, and waste disposal;
- To identify any unique radiological or health and safety issues associated with decommissioning;
- To identify the potential and known sources of radioactive contamination in systems, on structures, in surface or subsurface soils, and in ground water;
- To divide the HNP site into manageable areas or units for survey and classification purposes; and,
- To determine the initial classification of each survey area or unit as non-impacted or impacted Class 1, 2, or 3 as defined in MARSSIM or Class A, B, or C for subsurface soils (below 15 cm) as described in the HNP LTP.

DQOs developed and implemented during the initial phase of planning directed all data collection efforts. The DQOs are qualitative and quantitative statements derived from the DQO process that clarify technical and quality objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors used as the basis for establishing the quality and quantity of data needed to support decisions. This process, described in MARSSIM, and procedure GGGR-R5111-002, "Preparation of Final Status Survey Plans (RPM 5.1-11)" (Reference 7.17), is a series of graded, planning steps found to be effective in establishing criteria for data quality and developing survey plans.

Used extensively during FSS, the DQO approach consists of the following seven steps:

- **State the Problem-**
- **Identify the Decision-**
- **Identify the Inputs to the Decision-**
- **Define the Boundaries of the Decision-**
- **Develop a Decision Rule-**
- **Specify Tolerable Limits on Decision Errors-**
- **Optimize the Design for Obtaining Data-**

A fundamental precursor to survey design is to establish a relationship between the release criteria and some measurable quantity. This is done through the development of Derived Concentration Guideline Levels (DCGLs). The DCGLs represent average levels of radioactivity, above background levels, presented in terms of surface or mass activity concentrations. Chapter 6 of the HNP LTP describes in detail the modeling used to develop the DCGLs for soil (called Base Case Soil DCGL), existing groundwater radioactivity, and future groundwater radioactivity from building basements and footings.

A reduction to the Base Case Soil DCGLs provided in Chapter 6 of the HNP LTP must be performed to ensure compliance with the release criteria of twenty five (25) mrem/yr TEDE when all three pathways (soil, existing groundwater and future groundwater) are potentially present. Chapter 5 of the HNP LTP shows a compliance formula, Equation 5-1, for including the total dose from the three pathways. The reduced quantity becomes the Operational DCGL, whose relationship to the Base Case Soil DCGL is shown by Equation 5-2 of the HNP LTP. Table 2-1 provides a listing of the Base Case and required MDC values.

Table 2-1 Derived Concentration Guideline Levels for Soil

Radionuclide	**Base Case Soil DCGL (pCi/g)**	**Required MDC (pCi/g)**
	(25 mrem/yr)	**(1.0 mrem/yr)**
H-3	4.12E+02	1.65E+01
C-14	5.66E+00	2.26E-01
Mn-54	1.74E+01	6.96E-01
Fe-55	2.74E+04	1.10E+03
Co-60	3.81E+00	1.52E-01
Ni-63	7.23E+02	2.89E+01
Sr-90	1.55E+00	6.20E-02
Nb-94	7.12E+00	2.85E-01
Tc-99	1.26E+01	5.04E-01
Ag-108m	7.14E+00	2.86E-01
Cs-134	4.67E+00	1.87E-01
Cs-137	7.91E+00	3.16E-01
Eu-152	1.01E+01	4.04E-01
Eu-154	9.29E+00	3.72E-01
Eu-155	3.92E+02	1.57E+01
Pu-238	2.96E+01	1.18E+00
Pu-239/240	2.67E+01	1.07E+00
Pu-241	8.70E+02	3.48E+01
Am-241	2.58E+01	1.03E+00
Cm-243/244	2.90E+01	1.16E+00

(1) **Bold** indicates those radionuclides considered to be Hard-to-Detect (HTD).

The compliance equation of the HNP LTP Equation 5-1, equates the total dose to three (3) components, soil dose, existing groundwater dose and future groundwater dose. This report contains only the results of the FSS that addresses the dose due to soil. To calculate DCGLs, dose models were developed to relate levels of residual radioactivity to potential dose. In the HNP LTP, Equation 5-1 expresses the total dose (H_{Total}) from all three (3) media, which is shown below:

H_{Total} can be expressed as:

$$H_{Total} = H_{Soil} + H_{Existing\,GW} + H_{FutureGW} \quad \text{(HNP LTP Equation 5-1)}$$

The total dose, H_{Total}, under the LTP criteria is twenty five (25) mrem/yr TEDE from all three (3) components. The allowable total dose under the CTDEP radiological remediation standard for the HNP is nineteen (19) mrem/yr TEDE. Therefore, the value for H_{Total} is effectively nineteen (19) mrem/yr for all survey units. To determine the H_{Soil} (the dose equivalent for the Operational DCGLs) one must subtract the existing and future groundwater dose values as shown below.

$$H_{Soil} = H_{Total} - H_{ExistingGW} - H_{FutureGW} \quad \text{(Operational DCGL dose equivalent)}$$

The present and future groundwater terms were bounded on an individual survey unit basis as discussed in Integrated Site Closure (ISC) memo 06-024, "Revised Target Operational DCGLs/Dose Targets for CY" (Reference 7.2). Table 2-2 summarizes the HNP Equation 5-1 values for each of the survey units discussed in this report. Table 2-2 also shows the actual soil dose equivalent based on the survey unit data analyses.

Table 2-2 HNP LTP Compliance Equation 5-1 Values and Actual Soil Dose

Survey Unit	Existing Ground Water Dose (mrem/yr) (1)	Future Ground Water Dose (mrem/yr) (1)	Allowable Soil Dose (mrem/yr) (2)	Actual Soil Dose (mrem/yr) (3)
9520-0001	2	0	17	0.29
9520-0002	2	0	17	0.32
9520-0003	2	0	17	0.44
9520-0004	2	0	17	0.15
9520-0005	2	0	17	0.56
9530-0001	2	0	17	0.35
9530-0002	2	0	17	0.27
9530-0003	2	0	17	0.78
9530-0004	2	0	17	0.47
9805-0000	2	0	17	0.08
9807-0000	2	0	17	0.47

(1) These bounding values were taken from ISC memo 06-024, "Initial Target Operational DCGLs for CY" (Reference 7.2); the maximum allowable groundwater dose is 8 mrem/yr to meet the HNP LTP release criteria for unrestricted use.

(2) The Operational DCGL dose equivalent meets the release criteria for unrestricted use, as agreed to with the CTDEP, of 19 mrem/yr plus ALARA.

(3) The average dose from residual radioactivity in soil following FSS.

The development of information to support decommissioning planning and execution was accomplished through a review of all known site radiological and environmental records. Much of this information was consolidated in the "Results of Scoping Surveys" (Reference 7.18); "Augmented Characterization Survey Report" (Reference 7.19); "Characterization Report" (Reference 7.20); "Historical Site Assessment Supplement (HSA)" (Reference 7.21); and, in files containing copies of records maintained pursuant to Title 10CFR50.75(g)(1). These documents are discussed further in applicable sections of this report.

An initial objective of site characterization and HSA was to correlate the impact of a radiological event to physical locations on the plant site and to provide a means to correlate subsequent survey data. To satisfy these objectives, the FSS organization divided the site into large, manageable areas and assigned a unique four digit System Survey Code (e.g. Survey Area 9528) to each area. The area designations form the basis for the survey units presented in Table 1-1 of this report. Physically, survey area boundaries made use of logical physical boundaries and site landmarks (paved roads, fences, stone walls) or were determined through the integration of Global Positioning System (GPS) equipment with commercially available mapping software using coordinates consistent with the Connecticut State Plane System, North American Datum (NAD) 1927.

Upon completion of survey area assignment, the FSS organization began the task of initial classification and establishing the initial set of survey units. Classification, as described in MARSSIM, is the process by which an area or survey unit is described according to its radiological characteristics and potential for residual radioactivity. Not all areas of the site had the same potential for residual radioactivity. Residual radioactivity could be evenly distributed over a large area, appear as small areas of elevated activity or a combination of both. In some cases, there may be no residual radioactivity in a survey unit. Therefore, the adequacy and effectiveness of the FSS process depends upon properly classified survey units to ensure that areas with the highest potential for contamination receive a higher degree of survey effort.

A survey area may consist of one or more survey units. A survey unit is a physical area consisting of structures or land areas of a specified size and shape that would be subjected to a FSS. Survey units were limited in size based on classification, exposure pathway modeling assumptions, and site-specific conditions. Particular attention was given to survey unit boundaries and surface areas to ensure building foundation footprint coverage. Utilization of this method of classification and size limitation ensures that each area was assigned an adequate number of data points. The surface area limits provided in MARSSIM were used to establish the initial set of survey units for the HNP LTP. For identification, survey units were assigned the area four-digit code and a sub-code to designate the unit within the survey area (e.g. Survey Unit 9528-0002). Table 2-3 provides an outline for classification and area limits.

Table 2-3 FSS Area Classifications

Survey Unit Classification		**Surface Area Limit**	**Contamination Potential**
Class 1	Structures: (floor area)	Up to 100 m^2	Highest
	Land Area:	Up to 2,000 m^2	
Class A	Subsurface:	No limit	
Class 2	Structures: (floor area)	100 m^2 to 1,000 m^2	Moderate
	Land Area:	2,000 m^2 to 10,000 m^2	
Class B	Subsurface:	No limit	
Class 3	Structures: (floor area)	No limit	Lowest
	Land Area:		
Class C	Subsurface		

Several survey units have undergone reclassification prior to FSS. Verification and change to increase the class (more restrictive) can be performed at anytime prior to FSS. New sample results or emergent data may require evaluation and reclassification to more restrictive criteria. Final classification was performed in conjunction with the preparation of the FSS plan, thus indicating all issues of classification are resolved.

2.2 Survey Design

Final status surveys for the HNP surface soils and structures are designed following HNP procedures, Section 5 of the HNP LTP and MARSSIM guidance using an integrated approach and combinations of fixed measurements, traditional scanning surveys, and other advanced survey methods, as appropriate, to evaluate survey units relative to their applicable release criteria.

Another important facet of the DQO process is to identify the radionuclides of concern and determine the concentration variability. During characterization and in preparation for FSS, the HNP Radiochemistry Lab, using gamma spectroscopy, analyzed soil samples collected from random and biased locations in the survey units for Easy-to-Detect (ETD) radionuclides (Table 2-4). The on-site results were augmented, in most cases, by analyses performed by an off-site laboratory for both ETD radionuclides and Hard-to-Detect (HTD) radionuclides (Table 2-4). Characterization indicated that Cs-137 and/or Co-60 would be the primary radionuclides of concern for survey design and FSS for a majority of the areas submitted in this report. Applied statistically, these data were used to determine the number of samples required to achieve adequate sample design.

Although the HNP LTP only required a minimum of 5% (for subsurface soil samples), typically 10% of all the soil samples, and in some cases a higher percentage, were analyzed for HTD by the off-site laboratory. Strontium-90 was the most prevalent HTD radionuclide identified in samples.

Most radionuclides could be screened out or excluded from the survey design under HNP LTP Section 5.4.7.2. Radionuclide screening or de-selection is a process where an individual radionuclide or aggregate may be considered insignificant and eliminated from the FSS. The criteria for de-selection are concentrations less than 5% for individual radionuclides and less than 10% for aggregates. Exceptions to this are discussed in applicable sections of this FSS Final Report and associated Survey Unit Release Records. Consistent with Equation 5-7 of the HNP LTP, the 5% rule for single radionuclides or 10% rule for multiple radionuclides is conservative relative to the process presented in Title 10CFR20 in which radionuclides that contribute less than 10% to dose, and where the aggregate does not exceed 30%, are not required to be included in dose assessment.

Table 2-4 Easy-to-Detect (ETD) and Hard-to-Detect (HTD) Radionuclides

Radionuclide (1)	Type	When Analyzed	Analysis
H-3	HTD	AS NEEDED	Liquid Scintillation
C-14	HTD	AS NEEDED	Liquid Scintillation
Mn-54	ETD	ALWAYS	Gamma Spectroscopy
Fe-55	HTD	AS NEEDED	Liquid Scintillation
Co-60	ETD	ALWAYS	Gamma Spectroscopy
Ag-108m	ETD	ALWAYS	Gamma Spectroscopy
Ni-63	HTD	AS NEEDED	Liquid Scintillation
Sr-90	HTD	AS NEEDED	Liquid Scintillation
Nb-94	ETD	ALWAYS	Gamma Spectroscopy
Tc-99	HTD	AS NEEDED	Liquid Scintillation
Cs-134	ETD	ALWAYS	Gamma Spectroscopy
Cs-137	ETD	ALWAYS	Gamma Spectroscopy
Eu-152	ETD	ALWAYS	Gamma Spectroscopy
Eu-154	ETD	ALWAYS	Gamma Spectroscopy
Eu-155	ETD	ALWAYS	Gamma Spectroscopy
Pu-238	HTD	AS NEEDED	Alpha Spectroscopy

Pu-239/240	HTD	AS NEEDED	Alpha Spectroscopy
Pu-241	HTD	AS NEEDED	Liquid Scintillation
Am-241 (2)	ETD	ALWAYS	Gamma Spectroscopy Alpha Spectroscopy
Cm-243/244	HTD	AS NEEDED	Alpha Spectroscopy
(1) **Bold** indicates those radionuclides considered to be Hard-to-Detect (HTD).			
(2) Americium-241 can be analyzed by gamma and alpha spectroscopy and is considered to be Easy to Detect (ETD); the preferred result is the alpha spectroscopy's when both analyses are performed.			

Soil sample locations were determined randomly for Class 3 survey units, or by a triangular systematic grid with a random starting point for Class 1 and 2 survey units using commercially available software.

Soil sample locations were identified in North American Datum (NAD) 1927 coordinates and were loaded into the GPS software. The FSS plan provided a map and GPS positions to FSS field supervision for reference.

In each survey unit, a minimum of five (5) percent of the samples were collected for quality control analysis such as "splits" or duplicates. All survey units passed the quality control acceptance criteria.

Off-site laboratories were chosen to perform ETD and HTD analysis of samples collected during FSS. Laboratory analysis results were reported as actual calculated results. Results reported as <MDC (i.e., less than minimum detectable concentration) were not accepted for FSS. Sample report summaries included unique sample identification, analytical method, radioisotope, result and uncertainty of two standard deviations, laboratory data qualifiers, units and required MDC.

A consideration of survey design was the need to use "surrogates." In lieu of analyzing every sample for HTDs, the development and application of surrogate ratio DCGLs is an accepted industry practice to assay HTD radionuclides. Surrogate ratios allow for expedient decision making in characterization, remediation planning or FSS design.

Briefly described, a surrogate is a mathematical ratio where an ETD radionuclide concentration is related to a HTD radionuclide concentration, such as Cs-137 to Sr-90. From the analytical data, a ratio is developed and applied in the survey scheme for samples taken in the area. The result is referred to as the surrogate DCGL. Details and applications of this method are provided in Section 5.4.7.3 of the HNP LTP. Surrogates were not required or used for the survey units covered by this FSS Final Report.

Some portion of the Cs-137 and Sr-90 found in the soil samples is certainly attributed to "background" or fallout; however, the DQO process assessed the application of media specific radiation background and ambient area radiation background to specific survey areas and units. Based upon the DQO process, the FSS planning determined that background subtraction would not be applied during the survey of the land areas included in this submittal.

2.3 Survey Implementation

Starting in November 2001, FSS plans were developed to guide the physical work of FSS implementation for each survey unit. Some of the tasks included in the implementation were:

- Verification and validation of personnel training as required by procedure GPP-GGGR-R5400-000 "Site Closure Training Program (RPM 5.4-0)" (Reference 7.22);
- Implementation of a work control process including applicable health and safety procedures under GGGC-00001-004, "Work Plan and Inspection Record" (Reference 7.23);
- Determination of the amount of samples required to meet survey DQOs as described in GGGR-R5112-001, "Determination of the Number Samples for Final Status Survey (RPM 5.1-12)" (Reference 7.24);
- Determination of the overall survey design and objectives including where measurements or samples are to be made or collected, generation of detailed maps of the survey area showing the measurement and sample locations, and investigation levels and corrective actions under procedure (RPM 5.1-11) (Reference 7.17);
- Maintaining Quality Assurance and Quality Control requirements (e.g., replicate measurements or samples) in accordance with procedure GPP-GGGR-R5124-000, "Split Sample Assessment for Final Status Survey (RPM 5.1-24)" (Reference 7.25) and the FSSQAP;
- Providing accountability and sample integrity for sample submission to approved laboratories as provided in procedure GPP-GGGR-R5104-003, "Chain of Custody for Final Status Survey Samples (RPM 5.1-5)" (Reference 7.26); and,
- Application of the Operational DCGLs in conjunction with the unity rule, when applicable, to sample results in accordance with the Data Quality Assessment (DQA) process as detailed in procedure GGGR-R123-000, "Data Quality Assessment (RPM 5.1-23)" (Reference 7.27).

The FSS implementation and completion process resulted in the generation of field logs, and radionuclide specific analysis. Data were stored electronically on the HNP network server.

2.4 Survey Data Assessment

Prior to proceeding with data evaluation and assessment, the assigned FSS Engineer resolves and documents discrepancies between the data quality or the data collection process and the applicable requirements.

The DQA process is an evaluation method used during the assessment phase of FSS to ensure the validity of FSS results and demonstrate achievement of the survey plan objectives. The first step in the data assessment process converts all of the survey results to DCGL units. The individual measurements and sample concentrations are compared to the Operational DCGL in conjunction with the unity rule, when applicable, for evidence of small areas of elevated activity or results that are statistical outliers relative to the rest of the measurements. When practical, graphical analyses of survey data that depicts the spatial correlation of the measurements were used.

To demonstrate that survey data fulfills the radiological release criteria, FSS planning incorporated hypothesis testing and probabilistic sampling distributions to control decision errors during data analysis. Hypothesis testing is a process based on the scientific method that compares a baseline condition to an alternate condition. The baseline condition is technically known as the null hypothesis. Hypothesis testing rests on the premise that the null hypothesis is true and that sufficient evidence must be provided for rejection. In designing the survey plan, the underlying assumption, or null hypothesis was that residual activity in the survey unit exceeded the release criteria. Rejection of the null hypothesis would demonstrate that residual activity was at or below the release criteria objective of the FSS.

Hypothesis testing was performed by applying the Sign Test on the sample data associated with the survey unit. The Sign Test is considered a one-sample statistical test that compares sample data directly to the release criteria. Combined with an effective sampling scheme, passing the Sign Test constitutes satisfying the release criteria. Selection of the Sign Test is prudent and conservative in the assumption that the radionuclides being considered are not present in background or are at levels at a small fraction of the applicable release criteria. Reference areas and reference samples are not needed, thus simplifying the FSS. Furthermore, any background contribution (e.g., Cs-137 from atmospheric weapons testing) in the sample increases the likelihood of failing the survey unit, or requiring investigation, which is conservative. If the release criteria were exceeded, or if results indicated the need for additional data points, appropriate further actions were implemented usually through the issue of an addendum to the FSS plan.

Probabilistic sampling was the preferred method to select a sample so that each item in the population being studied had a known likelihood of being included in the sample. Probabilistic sampling included simple random sampling, where every sample had the same chance of being included, or systematic random sampling, where samples were arranged in order and a random starting point was selected.

2.5 Quality Assurance and Quality Control Measures

Quality assurance and control measures were employed throughout the Final Status Survey process to ensure that all decisions were based on data of acceptable quality. Quality assurance and control measures were applied to ensure:

- The plan was correctly implemented as prescribed;
- DQOs were properly defined and derived;
- All data and samples were collected by individuals with the proper training following approved procedures;
- All collected data were validated, recorded, and stored in accordance with approved procedures;
- All required documents were properly maintained; and,
- Corrective actions were prescribed, implemented and tracked as necessary.

The off-site laboratories used for analysis of the samples collected during FSS maintain Quality Assurance Plans designed for their facility. HNP reviews these plans, as required by the "Quality Assurance Program for the Haddam Neck Plant (CYQAP)," (Reference 7.28) and the FSSQAP, prior to selection of a laboratory for FSS sample analysis to ensure standards are acceptable. The on-site laboratory was not used to analyze FSS samples used for non-parametric statistical sampling.

The Integrated Site Closure organization maintains a formal, stand alone training program for FSS technicians and FSS Supervision. The training program relates to, but is independent of, the Health Physics Department training program. All FSS technicians met the requirements of the American National Standards Institute, ANSI N18.1-1971, "Selection and Training of Nuclear Plant Personnel", or were junior technicians working under the direct supervision of an ANSI N18.1-1971 qualified Technician and/or FSS supervision. Supervisory and technical support personnel had sufficient education, experience and certification to qualify personnel and perform assigned duties. Some lead Site Closure personnel have had additional training in MARSSIM implementation; and some were certified by the American Board of Health Physics.

The Site Closure Group has established a Curriculum Advisory Committee (CAC) - a training committee – that is comprised of Site Closure Management, a Training Coordinator and Site Closure lead personnel. The CAC is responsible for department training implementation, including review and approval of new training such as required reading (knowledge measures) and On-the-Job (OJT) training and Task Qualification Records (performance measures), revision of existing training, and designation of personnel as OJT Trainers, Evaluators and Subject Matter Experts. The objective of the CAC is to establish effective training and qualifications programs and ensure the appropriate design, development and implementation of the Site Closure training program.

During 2006, three (3) Quality Surveillance Reports (QSRs) were produced on activities related to FSS. In general, these reports were performed to evaluate the adequacy of the implementation of regulatory and HNP LTP and FSS requirements.

QSR-06-01-CY (Reference 7.29) performed during January of 2006, concluded that a sampling of the Survey Unit Release Records to be submitted in Phase III met the HNP LTP and FSS programmatic requirements.

QSR-06-007 (Reference 7.30) performed during October of 2006, concluded that a sampling of the Survey Unit Release Records to be submitted in Phase III and Phase IV were consistent with the HNP LTP and FSS programmatic requirements.

QSR-06-008 (Reference 7.31) performed from November of 2006, to December of 2006, concluded that a sampling of the Survey Unit Release Records to be submitted in Phase V were consistent with the HNP LTP and FSS programmatic requirements.

All findings from the QSRs, audits and assessments were corrected and systematic controls implemented as of the publication date of this report.

During 2006, one (1) Quality Assurance Audit was performed covering activities specific to the FSS/CY LTP. The purpose of the audit and associated surveillances was to verify that the licensee was appropriately implementing the programs, processes and procedures which satisfy the requirements of the License Termination Plan and associated regulatory requirements.

AUDIT CY-06-A05-01 (Reference 7.32) performed during May of 2006 covered FSS activities including a sampling of the implementation of FSS activities covered in Release Records to be submitted in Phase IV. The audit concluded that all areas examined met applicable requirements and were satisfactory.

As of early December, the Integrated Site Closure has performed three Self Assessments for 2006. As required by the FSSQAP (Reference 7.4) Self Assessments are performed on a periodic basis to ensure that the FSS program conforms to the requirements of the LTP and implementing procedures.

SCA-06-01 (Reference 7.33), performed in April 2006, was performed as a follow-up to Condition Report (CR) 05-781 (Reference 7.34). The issues identified involved soil sample collection, particularly samples used for quality control. The Self Assessment provided recommendations for improvement.

SCA-06-02 (Reference 7.35) performed in August, 2006, noted that personnel and staffing changes had been implemented since major FSS field activities were last performed. In anticipation of an increase in FSS field activities going forward, the Self Assessment sought to determine what lessons could be learned from recent FSS field activities, identify and correct deficiencies and further ensure Site Closure readiness for FSS.

SCA-06-03 (Reference 7.36) performed in November, 2006, was performed as an investigation of the cause of Condition Report (CR) 06-0223 (Reference 7.37). The CR identified an issue with split sample agreement. The Self Assessment observed that media homogenization for samples from the pond and discharge canal was made more difficult due to the large and varying quantities of clay to fine grained media collected from coring at these locations. In addition, moisture content, aliquot size and varying organic content further hampered the sample homogenization efforts. Recommendations for improvement included improving the briefing process with regards to split sample processing and employing the use of a mechanical sieve. The recommendations for improvement were implemented as of November 2006.

3.0 SITE INFORMATION

3.1 Site Description

Haddam Neck Plant, owned by Connecticut Yankee Atomic Power Company, is located on the east bank of the Connecticut River, approximately twenty-one (21) miles south-southeast of Hartford.

The site consists of approximately five hundred twenty five (525) acres, with a minimum distance overland from the reactor containment to the site boundary of one thousand seven hundred and forty feet (1,740 ft), and the distance to the nearest residence is over two thousand feet (2,000 ft).

The plant incorporated a 4-loop closed-cycle pressurized water type Nuclear Steam Supply System (NSSS); a turbine generator and electrical systems; engineered safety features; radioactive waste systems; fuel handling systems; instrumentation and control systems; the necessary auxiliaries; and structures to house plant systems and other on-site facilities. HNP was designed to produce 1,825 MW of thermal power and 590 MW of gross electrical power.

Westinghouse Electric Corporation was responsible for design and fabrication of all nuclear steam supply and auxiliary systems and equipment, as well as design and supply of all secondary plant mechanical and electrical equipment, which it normally manufactures. Stone and Webster Engineering Corporation were responsible for site development, design of buildings and secondary systems, and all plant construction. Each of these contractors was responsible to HNP for tasks performed in their respective areas of design and construction. Pre-operational plant checkout, core loading, plant start-up and operation were the responsibility of HNP.

On December 4, 1996, HNP permanently shut down after approximately 28 years of operation. On December 5, 1996, HNP notified the USNRC of the permanent cessation of operations at the HNP site and the permanent removal of all fuel assemblies from the Reactor Pressure Vessel and their placement in the Spent Fuel Pool. Following the cessation of operations, HNP began the decommissioning of the site. The Post Shutdown Decommissioning Activities Report (PSDAR) (Reference 7.38) was submitted, in accordance with Title 10CFR50.82 (a)(4), on August 22, 1997, and was accepted by the USNRC. On January 26, 1998, HNP transmitted an Updated Final Safety Analysis Report (UFSAR) (Reference 7.39) to reflect the plant's permanent shutdown status, and on June 30, 1998, the USNRC amended the HNP Facility Operating License to reflect the plant condition. On October 19, 1999, the HNP Facility Operating License was amended to reflect the decommissioning status of the plant and long-term storage of the spent fuel in the spent fuel pool. Additional licensing basis documents were also revised and submitted to reflect long-term fuel storage in the spent fuel pool (Defueled Emergency Plan, Security Plan, QA program, and Operator Training Program).

In 1997, in accordance with NUREG/CR-5849 (Reference 7.40) initial site characterization was implemented. In 1999, following the guidelines of MARSSIM, initial characterization was completed. The information developed during the initial HNP characterization program represented a radiological assessment based on the knowledge and information available at the end of 1999.

3.2 Survey Area/Unit Description

The following information is a description of each survey unit at the time of FSS from August through October 2006 (additional detail is provided in the Survey Unit Release Records). During this period, the approximately sixty-six (66) acres of open land areas of the HNP site received a FSS.

The HNP site maintains a reference coordinate system based on GPS coordinates consistent with the Connecticut State Plane System. A benchmark was established as an origin for documenting survey efforts and results. The benchmark, an accessible iron pin located in the main parking lot, was established during the setup and calibration of the base station for the GPS receiver. The benchmark is also provided on Figure 1 of the attached Release Records to this FSS Final Report.

Survey Unit 9520-0001

Survey Unit 9520-0001 (Southwest Site Storage Area) is designated as Class 2 and consists of 9,777 m^2 (2.4 acres) of uninhabited open land located approximately 740 feet from the reference coordinate system benchmark used at HNP. The survey unit is relatively level open space in the north end of the peninsula. The restoration of the peninsula for FSS had removed most of the surface interference in the survey unit.

Survey Unit 9520-0002

Survey Unit 9520-0002 (Southwest Site Storage Area) is designated as Class 2 and consists of 9,720 m^2 (2.4 acres) of uninhabited open land located approximately 1,167 feet from the reference coordinate system benchmark used at HNP. The survey unit is relatively level open space in the north end of the peninsula. The restoration of the peninsula for FSS had removed most of the surface interference (small trees, dense brush, and invasive phragmite – a tall common plant that grows in large colonies) in the survey unit.

Survey Unit 9520-0003

Survey Unit 9520-0003 (Southwest Site Storage Area) is designated as Class 2 and consists of 8,106 m^2 (2.0 acres) of uninhabited open land located approximately 1,661 feet from the reference coordinate system benchmark used at HNP. The survey unit is relatively level open space in the north end of the peninsula. The restoration of the peninsula for FSS had removed most of the surface interference (small trees, dense brush, and invasive phragmite) in the survey unit.

Survey Unit 9520-0004

Survey Unit 9520-0004 (Southwest Site Storage Area) is designated as Class 1 and consists of 1,985 m^2 (0.5 acres) of uninhabited open land located approximately 1,860 feet from the reference coordinate system benchmark used at HNP. The survey unit was initially included in Survey Unit 9520-0003, a Class 2 survey unit. However, in March of 2006, Co-60 and Cs-137 were identified in subsurface soils in sufficient quantities to warrant radiological remediation. Radiological remediation was performed in July 2006. A new Class 1 survey unit, Survey Unit 9520-0004, was established to bound the area of remediation. The survey unit is relatively level open space in the north end of the peninsula. The restoration of the peninsula for FSS had removed most of the surface interference (small trees, dense brush, and invasive phragmite) in the survey unit.

Survey Unit 9520-0005

Survey Unit 9520-0005 (Southwest Site Storage Area) is designated as Class 1 and consists of 1,887 m^2 (0.5 acres) of uninhabited open land located approximately 1,661 feet from the reference coordinate system benchmark used at HNP. The survey unit was initially included in Survey Unit 9520-0003, a Class 2 survey unit. In October of 2006, Co-60 was identified in soil in sufficient concentrations to warrant a Class 1 designation for a new Survey Unit, 9520-0005 within the original boundaries of 9520-0003. The survey unit is relatively level open space in the north end of the peninsula. The restoration of the peninsula for FSS had removed most of the surface interference (small trees, dense brush, and invasive phragmite) in the survey unit.

Survey Unit 9530-0001

Survey Unit 9530-0001 (Central Peninsula) is designated as Class 2 and consists of 5,753 m^2 (1.4 acres) of uninhabited open land located approximately 2,294 feet from the reference coordinate system benchmark used at HNP. The survey unit is set within Survey Unit 9530-0004, a Class 3 survey unit. The survey unit is relatively level open space in the middle of the peninsula. The restoration of the peninsula for FSS had removed most surface interference in the survey unit; however, there were some trees and brush remaining in the area.

Survey Unit 9530-0002

Survey Unit 9530-0002 (Central Peninsula) is designated as Class 2 and consists of 6,438 m^2 (1.6 acres) of uninhabited open land located approximately 2,900 feet from the reference coordinate system benchmark used at HNP. The survey unit is set within Survey Unit 9530-0004, a Class 3 survey unit. The survey unit is relatively level open space in the middle of the peninsula. The restoration of the peninsula for FSS had removed most of the surface interference (invasive phragmite) in the survey unit.

Survey Unit 9530-0003

Survey Unit 9530-0003 (Central Peninsula) is designated as Class 2 and consists of 6,438 m^2 (1.6 acres) of uninhabited open land located approximately 3,160 feet from the reference coordinate system benchmark used at HNP. The survey unit is set within Survey Unit 9530-0004, a Class 3 survey unit. The survey unit is relatively level open space in the middle of the peninsula. The restoration of the peninsula for FSS had removed most of the surface interference (invasive phragmite) in the survey unit.

Survey Unit 9530-0004

Survey Unit 9530-0004 (Central Peninsula) is designated as Class 3 and consists of 83,777 m^2 (21 acres) of uninhabited open land located approximately 2,100 feet from the reference coordinate system benchmark used at HNP. The survey unit is relatively level open space in the middle of the peninsula. The restoration of the peninsula for FSS has removed some surface interference in the survey unit.

Survey Unit 9805-0000

Survey Unit 9805-0000 (Subsurface Area Associated With The Peninsula) is designated as Class C (subsurface classification) and consists of 130,380 m^2 (32 acres) of uninhabited open land located approximately 750 feet from the reference coordinate system benchmark used at HNP. The subsurface survey unit is within the physical boundary of surface Survey Unit 9520-0004. The survey unit does not include the 1,983 m^2 associated with the land area of Survey Unit 9807-0000, a separate subsurface area, which is located within Survey Area 9805. The restoration of the peninsula for FSS has removed some of the surface interference in the survey unit.

Survey Unit 9807-0000

Survey Unit 9807-0000 (Subsurface Area associated with the Southwest Site Storage Area) is designated as Class B (subsurface) and consists of 1,983 m^2 (0.5 acres) of uninhabited open land located approximately 1,860 feet from the reference coordinate system benchmark used at HNP. The surface land unit that resides above this subsurface survey unit is relatively level open space of the peninsula. The restoration of the peninsula for FSS has removed all of the surface interference in the survey unit.

3.3 Summary of Historical Radiological Data

The site historical radiological data for HNP includes the results of the scoping surveys completed in 1998, augmented characterization surveys in 1999, a characterization report in 2000, a historical site assessment supplement in 2001, characterization surveys, and remedial action surveys performed up to the time of FSS.

3.3.1 Scoping Surveys

The purpose of the scoping survey was to establish early in the decommissioning process, the necessary areas requiring remediation and to what extent. Details of the scoping surveys are provided in the Reference 7.18. The scoping survey identified 140 events that could have potentially contaminated the facility outside of the Radiological Control Area (RCA). From the 140 identified events, the scoping survey report listed those events most likely to have impacted the HNP site outside the RCA. These events were:

- Leak from the Radioactive Water Storage Tank (RWST) heater valve in November 1973 that contaminated the storm drain system;
- Multiple waste gas tank rupture disc actuations in the 70's;
- Various leaks in the steam generator blowdown waste discharge line and the service water effluent line under the Primary Auxiliary Building (PAB) floor in the 1976 to 1980 time period;
- Contamination of the yard area around the Borated Water Storage Tank (BWST) from leaks in the circulating water heater line in 1978;
- Unplanned radioactive release from the degasifier through the plant stack in December 1979;
- Leak from a cracked weld seam in the auxiliary building exhaust duct to the main stack in September 1981;
- Draining of the Spent Fuel Pool (SFP) heat exchanger to an uncontrolled drain that emptied into the 115 kV switchyard trench in April 1984;
- Resin liner overflows in 1984;
- Sediment dredged out of discharge canal was stored in boneyard burm [sic] area [dredge spoils area] in 1986;
- Drain hose spill of contaminated water to yard area in August 1987;
- Contaminated water from radioactive waste processing dumped into an uncontrolled drain that emptied into the 115 kV switchyard trench in February 1989;

- Spill of component cooling water to the storm drain in March 1990;
- Leak from the refueling water storage tank in September 1990;
- Spill from the reactor coolant system to the pipe trench in August 1991; and,
- Waste material disposed of at on-site permitted landfill in south east corner of site starting in 1974.

3.3.2 Characterization Surveys

The characterization of radiological and hazardous materials conditions of all areas of the HNP site, an initial task in the plant decommissioning and license termination process, centered around four main objectives:

- Determine the nature and extent of contamination;
- Provide the basis for initial classification of areas;
- Provide a basis for remediation planning, including recommendations for additional surveys or samples; and
- Provide input into the FSS design.

Following plant shutdown at the end of 1996, it was determined that there was a need for additional surveys to better define the scope of radioactivity or "characterization" in several on-site areas. To fill this gap, surveys were conducted in plant areas along with the sampling and analysis of environmental media that included ground water, paved surfaces outside the RCA and soils suspected of containing radioactive materials. The coalescence of this data, as well as all available site data, occurred during the development of the HSA. The HSA consisted of a review of plant operational records since initial license approval, a review of events that have potential impact on decommissioning activities compiled in accordance with Title 10CFR50.75(g)(1), and interviews with present and former employees regarding events and activities that impact license termination.

The results of the HSA identified radiological conditions or events that impacted the HNP. These events fall into several categories:

- Normal plant operation that affected systems, components and building surfaces that are designed to contain radioactive material. Examples of these are the reactor coolant system, residual heat removal pumps and building areas such as sumps and pipe vaults;

- The discharge and runoff of radiological effluents to the canal;
- Operational events that occurred in which radioactive materials were released from ventilation, and waste processing systems. Examples are elevated readings on the Primary Auxiliary Building roof and owner controlled hillside locations east of the plant; and,
- Leakage of water containing radioactive material that was documented historically. Incidents of this nature included leaking lines under the PAB drumming room floor, overflowing of a manhole just east of the Service Building and leakage from radioactive liquid storage tanks.

The summary information developed during the HSA process was evaluated concurrently with the information provided in the "NRC Historical Review Team Report – Radiological Control and Area Contamination Issues at Haddam Neck" (Reference 7.41), dated March 26, 1998, to assure completeness of the historical data.

The Characterization Report provided an assessment of the radiological and hazardous material conditions for each of the site buildings and subsections of the site grounds at a specific point in time. A listing of the areas was provided in the table of contents, along with the area identification number(s) and the area's initial classification in accordance with the criteria established in MARSSIM. Site maps were provided to locate the areas and the respective survey area number(s). A report for each area contained a description (boundaries) of the area, known radiological and hazardous material information, impacted systems within an area and recommendations for further samples or surveys. Buildings assumed to remain in support of spent fuel storage activities, were not included (i.e. not considered at that time to be part of the HNP LTP as they would remain under license, to store the spent fuel).

As suggested in the Characterization Report, and discussed in the applicable HNP LTP and Survey Unit Release Records, additional characterization surveys would be needed to aid in the FSS plan design.

3.3.3 Remedial Action Surveys

All survey areas submitted in this FSS Final Report were evaluated in accordance with Health Physics Department Technical Support Document (TSD) BCY-HP-0078, "ALARA Evaluation of Soil Remediation in Support of Final Status Survey (Reference 7.42)." This evaluation determined that remediation beyond that required to satisfy the release criteria to be unnecessary, and that the remaining residual radioactivity in soil was ALARA.

During the phase of decommissioning and surveying covered by this FSS Final Report, remedial action and a Remedial Action Survey (RAS) were performed on two (2) survey units (9520-0005 and 9807-0000). It was determined that the remediation was completed when the concentrations of residual radioactivity within the survey unit were below the Operational DCGLs.

3.4 Conditions at the Time of Final Status Survey

The survey areas discussed in this FSS Final Report are open land areas. Construction activities were complete, and the areas were turned over to Integrated Site Closure for the implementation of isolation and controls. Clearing of heavy brush and invasive phragmite was performed prior to FSS to improve safety and facilitate survey and sampling.

Prior to FSS, areas ready for survey were isolated and controlled under procedure GGGR-R5116-002, "Area Preparation for Final Status Survey Activities RPM 5.1-16." (Reference 7.43) This included posting of the areas as well as notifications to site personnel. Permission to enter and work in these areas had to be obtained from FSS Supervision. Obvious postings of the boundaries in the areas controlled public access; however, the impact of public access to the final radiological condition of the areas was considered minimal to nonexistent.

3.5 Identification of Potential Contaminants

In general, the identification of potential contaminants was accomplished through the review of plant operating records, radiological surveys and laboratory analysis for ETD and HTD radionuclides. During characterization, a portion of the soil samples collected from areas that would undergo FSS were sent to an off-site laboratory for HTD analysis. The HTD analysis usually included chemical separation or other advanced methods of detection not available at HNP.

Removal of material and restoration of the peninsula for FSS has been ongoing since 2000 starting with the radiological release of the South Access Point and several abandoned trailers. The collapse of the Radioactive Material(s) Area (RMA) boundary and removal of subsurface commodities has produced a large data set that has helped characterize the radiological contaminants of concern and extent of contamination.

In 2006, utilities were being removed as part of the decommissioning effort on the Upper Peninsula. Construction debris including Asbestos Containing Material (ACM) was identified and remediated. Radiological assessments were performed on the excavated soil and debris. In addition to the ACM, several objects were also identified that had detectable radioactivity. Two pieces of angle iron were located in a water utility trench in adjacent Survey Unit 9530-0004. Most of the work involved two areas adjacent to Survey Unit 9530-0001. Some of the excavated spoils from these areas were temporarily stored in Survey Unit 9530-0001 during the investigation.

To assess the extent of this condition, supplemental characterization consisting of geophysical (electro-magnetic high resolution metal detection) surveys and test pitting was conducted on the peninsula. Most of the geophysical survey data was collected from the upper and central portion of the peninsula, as this is where the majority of industrial support and storage activities were known to have taken place. However, portions of the lower peninsula were surveyed to confirm that this area was not used for equipment storage or debris burial. The geophysical survey was meant to screen for the presence or absence of buried metallic objects.

Geophysical surveying was completed in four separate phases during the spring of 2006. Following the geophysical survey, suspect areas were targeted for test pitting to confirm the presence of metal and characterize the nature of the geophysical responses (e.g., objects that could be the size of a portion of a 55-gallon drum). Chemical samples were collected based on observations made during test pitting, and radiological assessment surveys were performed on all encountered debris and test pit soils. A total of 130 test pit locations were performed on the peninsula, thirty-four (34) test pits completed during the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) program (Reference 7.44), eighty-eight (88) test pits to characterize the geophysical survey anomalies, and eight (8) additional test pits at the request of the CTDEP (Reference 7.45).

The radiological assessments and characterization surveys identified Cs-137 and Co-60 as the primary radionuclides of concern. Other radionuclides, from both the ETD and HTD list provided in Table 2-4, have been identified in survey areas covered under this FSS Final Report. It is very likely that many of these are false positives and were counted as positive detects because the criterion used at HNP is highly conservative. The HNP criterion for accepting as a positive detection was any reported result greater than two standard deviations uncertainty. In almost every case, radionuclides that were considered detected by the HNP criterion, were reported in concentrations that were less than the MDC. All the radionuclides listed in Table 2-4 were included in the DQO process when designing an FSS plan and during the DQA when reviewing the adequacy of the FSS plan.

3.6 Radiological Release Criteria

The radiological release criteria is based on Title 10CFR20, Subpart E, where dose from residual radioactivity that is distinguishable from background radiation results in a TEDE to an average member of a critical group that does not exceed twenty five (25) mrem/yr; and, all residual radioactivity is reduced to levels that are ALARA. The HNP LTP had established DCGLs (e.g., Base Case Soil DCGLs) to demonstrate compliance with the release criterion of less than or equal twenty five (25) mrem/yr.

A reduction to the Base Case Soil DCGLs had to be performed to ensure compliance with the release criterion of 25 mrem/yr TEDE when all three (3) pathways (soil, existing groundwater and future groundwater) are potentially present. The reduced quantity is the Operational DCGL which was administratively set in accordance with the values listed in Table 2-2.

4.0 FINAL STATUS SURVEY PROTOCOL

4.1 Data Quality Objectives

The DQO process as outlined in Section 2.1 of this report was applied for each FSS Plan and contains basic elements common to all FSS plans at HNP. A general outline of those elements presented in the HNP FSS plans are as follows:

- STATE THE PROBLEM

  The problem: To demonstrate that the level of residual radioactivity in a survey unit including any areas of elevated activity does not exceed the release criterion.

  Stakeholders: The primary stakeholders interested in the answer to this problem are HNP, the CTDEP and the USNRC.

  The Planning Team: The planning team consisted of the Integrated Site Closure personnel. The primary decision maker was the assigned FSS Engineer. The FSS Engineer obtained input from HNP Project Support on issues relating to schedule and costs.

  Schedule: The approximate time to complete an FSS plan and collect field data. Constraints and other activities that may have limited access to areas or hamper survey and sampling were also addressed.

  Resources: The primary resources needed to determine the answer to the problem were ANSI N18.1-1971 qualified Health Physics Technicians to perform fieldwork, FSS Engineers to prepare the plan, generate maps, coordinate field activities and evaluate data. An off-site laboratory would be needed to analyze the samples and provide quality radionuclide specific results.

- IDENTIFY THE DECISION

  Principal Study Question: Does the average concentration of residual radioactivity in the survey unit exceed the release criteria?

  Alternate Actions: Alternative actions include failure of the survey unit, remediation, reclassification and no action.

  The Decision: If the survey unit fails to demonstrate compliance with the release criteria, then the survey unit is not ready for release for unrestricted use.

- IDENTIFY THE INPUTS TO THE DECISION

  Information Needed: New measurements of sample media would be needed to determine the concentration and variability of the radionuclides present at the site at the time of final status survey, the extent of any areas of elevated activity, and the results of statistical outliers relative to the rest of the measurements.

  Source of the Information: A review of historical information, 10CFR50.75(g)(1) files, and radiological surveys providing an indication of the potential for contamination.

  Sampling and Analysis Methods to Meet the Data Requirements: The media consisted of surface soil, that is, the soil collected to 15 cm (6 inches) depth for nine (9) of the eleven (11) survey units. The samples were collected with new or decontaminated tools to minimize cross-contamination between sampling. Judgmental samples were taken in the area where remedial action had occurred or deemed necessary by the FSS Engineer based on past events and process knowledge. Samples were sent to an approved off-site laboratory. Results exceeding the investigation level were verified and evaluated as necessary.

  The media included subsurface soil, that is, the soil below the top 15 cm (6 inches) depth up to a depth of 3 meters or bedrock, whichever was reached first, for two (2) of the eleven (11) survey units. Subsurface soil was collected using direct push equipment to obtain cores to the required depth. The media was removed from the core on-site, was homogenized and a sample was obtained from the mixture. The cores were collected with new or decontaminated tools to minimize cross-contamination between sampling.

  Analyses included radionuclide specific measurements to identify and quantify the ETD and HTD radionuclides listed in Table 2-4.

Laboratory analysis results included actual calculated results. Results reported as <MDC were not accepted for FSS. Results included reporting error, observed MDC and data qualifiers as appropriate.

Determining the Operational DCGL: Table 2-1 lists twenty (20) radionuclides potentially present at the site. Derived Concentration Guideline Levels (DCGLs) were calculated for each of the radionuclides listed based on a limit of twenty five (25) mrem/yr USNRC dose limit and a CTDEP dose limit of nineteen (19) mrem/yr. To calculate DCGLs, dose models were developed to relate levels of residual radioactivity to potential dose. The DCGLs were developed for exposures from three (3) potential media, which is residual radioactivity in soil, existing groundwater contribution, and future groundwater contribution. In the HNP LTP, Equation 5-1 expresses the total dose (H_{Total}) from all three (3) media, which is shown below:

H_{Total} can be expressed as:

$$H_{Total} = H_{Soil} + H_{Existing\,GW} + H_{FutureGW} \qquad \text{(HNP LTP Equation 5-1)}$$

The dose contribution from the existing groundwater and future groundwater contamination, the second and third components of HNP LTP Equation 5-1, are addressed on a survey unit basis as shown in Table 2-2.

Following characterization, the data was evaluated to determine if any of the twenty listed radionuclides would be present in quantities greater than 5% of the applicable individual Operational DCGL or an aggregate concentration exceeding 10%. If multiple radionuclides were assumed present (e.g., Cs-137, Co-60) then the individual Operational DCGLs would be used in conjunction with the unity rule to demonstrate compliance.

As verification, a minimum of 5% of the samples required for compliance were analyzed for all radionuclides listed in Table 2-4. Any radionuclides listed in Table 2-4 verified present in FSS samples were included in the assessment of data and incorporated into the decision process as necessary.

A decision to use or not use surrogate DCGLs was evaluated based on radionuclide analysis. During Phase V FSS, no surrogates were used.

Survey and Analysis Methods to Meet the Data Requirements: The HNP LTP requires that MDCs for fixed measurements (samples are considered fixed measurements) be as far below the DCGL as possible. A value of 10% is the desired level of sensitivity with up to 50% of the DCGL being acceptable. The MDCs for soil samples were typically less than 10% of the Operational DCGL.

All activities fall under the FSSQAP. This plan requires, among other things, the use of trained technicians, calibrated instruments and procedures. In addition to these requirements, a minimum of 5% of the required number of samples were selected for QC evaluation which consisted of field replicate splits.

Based on survey unit class, an elevated measurement comparison test (EMC) was sometimes applicable. The EMC test is applicable and was designed for all Class 1 survey units. For each Class 1 survey unit, direct measurements above the Operational DCGL were bounded for area extent and evaluated using the EMC test.

The EMC test does not apply for Class 2 or Class 3 units.

Basis for Determining the Action Level: The Action Level provides the criterion used during the decision process for choosing among alternative actions (e.g., whether to take action or not to take action or whether to choose Action 1 versus Action 2). The Action Levels associated with implementing the HNP LTP are based on regulatory requirements and are linked to the evaluation of FSS data.

The first step in evaluating FSS data for a given survey unit was to draw simple comparisons between the measurement results and the release criterion, which for FSS, is identified with the Operational DCGL used in conjunction with the unity rule, when applicable. The result of these comparisons would be one (1) of four (4) conclusions shown in Table 4-1.

Table 4-1 Action Levels

Evaluation Result	Conclusion
A plant-related radionuclide other than those planned for has been detected.	Re-evaluate the Operational DCGL
All reported concentrations are less than the Operational DCGL (1)	No further action required, the survey unit meets the release criterion
The average concentration is less than the Operational DCGL (1) but an individual sample exceeds Operational DCGL (1)	Conduct the Sign Test

Table 4-1 Action Levels

Evaluation Result	Conclusion
The average concentration exceeds Operational DCGL (1)	Implement alternative actions, the survey unit does not meet the release criterion

(1) Used in conjunction with the unity rule, when applicable.

- DEFINE THE BOUNDARIES OF THE SURVEY.

  Boundaries of the survey: The actual physical boundaries as stated for each survey unit.

  Temporal boundaries: Estimated times and dates for the survey. Sampling in a survey unit was normally performed only during daylight and dry weather.

  Constraints: The most common constraints were the weather, water level and overgrowth that limited personnel access to survey and some sample locations.

- DEVELOP A DECISION RULE

  The following decision rule was developed to define a logical process for choosing among alternative actions for the principal study questions associated with each survey unit. The decision rule is based on the Action Levels listed in Table 4-1.

  The Decision: If the average concentrations for the radionuclides of interest exceed the Operational DCGLs or the Sign Test fails, then the survey unit is not ready for release for unrestricted use.

- SPECIFY TOLERABLE LIMITS ON DECISION ERRORS

  The Null Hypothesis: Residual radioactivity in the survey unit exceeds the release criteria.

  Type I Error: This is the α error. This is the error associated with incorrectly concluding that the null hypothesis was rejected. The HNP LTP has set the α error at 0.05 (5%) unless prior approval is granted from the USNRC to use a less restrictive value. Therefore, a value of 0.05 (5%) was used for survey planning and data assessment for FSS.

  Type II Error: This is the β error. This is the error associated with incorrectly concluding that the null hypothesis was accepted. A value of 0.05 (5%) was used for survey planning and data assessment for these survey units.

  The Lower Bound of the Gray Region (LBGR): The LBGR is set or adjusted during the optimization phase of the DQO process.

Relative Shift (Δ/σ): The relative shift will be maintained within the range of 1.0 and 3.0 by adjusting the LBGR in accordance with Reference 7.14.

- OPTIMIZE DESIGN

  Type of statistical test: The Sign Test was selected as the statistical test for FSS.

  The Sign Test is conservative as it increases the probability of incorrectly accepting the null hypothesis (i.e., the conclusion would have been the survey unit does not meet the release criteria) and would not require the selection or use of a background reference area. This approach was also conservative since it included background Cs-137 as part of the sample set (Reference 7.46).

  Number of samples for non-parametric statistical sampling: The number of samples for non-parametric statistical sampling was determined using Reference 7.24. The LBGR was set to obtain a relative shift in the range of 1 and 3. The locations of the samples were determined using Visual Sample Plan (VSP) software in accordance with procedure RPM 5.1-14, "Identifying and Marking Locations for Final Status Survey" (Reference 7.47) and the appropriate grid spacing for the assigned class (i.e. random or systematic). VSP was created by Pacific Northwest National Laboratory (PNNL) for the United States Department of Energy.

  Number of judgmental samples and locations: The selection of judgmental or biased samples was at the discretion of the FSS Engineer. Locations chosen for sampling were usually areas of interest (obvious disturbance of soil, collection points from run-off and erosion, small piles, trenches, etc).

  Number of scan areas and location: Scan survey areas locations were based on the conditions found during the area inspection or historic evaluation. The amount of scan coverage was based on the potential for small areas of elevated radioactivity. The LTP does not require scanning of subsurface survey units.

  Number of samples for Quality Control: The number of quality control samples usually exceeded 10% percent of the sample set. The locations for split samples was selected randomly from the set of samples for non-parametric statistical testing using the Microsoft® Excel RAND function.

  Investigation Levels: Investigation levels are established in the HNP LTP for the various classifications. Investigation levels prompted additional survey and analysis to identify areas of elevated activity and ensure proper classification. In one instance, an investigation resulted in the creation of a new Class 1 survey unit, Survey Unit 9520-0005. The investigation level for a soil sample measurement includes individual radionuclide results greater than the Operational DCGL used in conjunction with the unity rule. For scan measurements, the investigation level is determined as a function of ambient background level.

Power Curve: A Prospective Power Curve was generated using COMPASS, a software package developed under the sponsorship of the USNRC for implementation of the MARSSIM in support of the decommissioning license termination rule (10 CFR 20, Subpart E). The result of the COMPASS computer run showed adequate power for all the Phase V FSS designs.

4.2 Survey Unit Designation and Classification

Procedure RPM 5.1-10, "Survey Unit Classification," (Reference 7.48) defines the decision process for classifying an area in accordance with the HNP LTP and MARSSIM. During the FSS of areas submitted for Phase V FSS Final Report one (1) survey unit was subdivided and reclassified.

4.3 Background Determination

During FSS area scanning, ambient backgrounds were determined and the "elevated" reading limit for that scan area was established by the technician. Each Survey Unit Release Record discusses scan area readings (instrument readings for each scan area is enclosed with each release record in the appendixes).

4.4 Final Status Survey Plans

The level of effort associated with planning a survey is based on the complexity of the survey and nature of the hazards. To assist the Site Closure FSS Engineers when preparing survey plans to support FSS, guidance is provided in Reference 7.14.

4.5 Survey Design

4.5.1 Determination of Number of Data Points

The number of samples was determined in accordance with Reference 7.24. A summary of survey design data points is provided in Table 4-2.

Table 4-2- Number of Samples for FSS

Survey Unit	Survey Design Samples	Biased Samples (1)	Investigation Samples
9520-0001	15	4	7
9520-0002	15	5	4
9520-0003	15	5	4
9520-0004	15	-----	2
9520-0005	15	2	14
9530-0001	15	2	1
9530-0002	15	2	-----
9530-0003	15	1	-----
9530-0004	15	3	7
9805-0000	15	5	-----
9807-0000	25	-----	-----

(1) The number of biased samples was determined during the DQO process and augmented as necessary by addendums to the FSS plan.

4.5.2 Sample Locations

Locations of the samples were determined using VSP in accordance with Reference 7.47. VSP was verified and validated by Health Physics Technical Support Document (TSD) BCY-HP-0079, "Use and Verification of Visual Sample Plan" (Reference 7.50). The TSD contains documentation including a user's manual for VSP Version 2.0 and verification documentation.

VSP software imports a topographical map of the selected survey area and, once provided with the number of required samples, type of grid pattern (triangular or square), and the starting point for the grid pattern (random starting point), then develops the survey design and designates the sample location coordinates based on the Connecticut State Plane System. The coordinates are then imported into the GPS for use in finding the sample location in the field.

For those locations where access was impractical or unsafe, the location was either moved within a fixed radius of the original point (e.g., 3 meters) or an alternate random sample location was generated. In either case, the decision to relocate a sample location was documented in the Daily Survey Journal (a detailed log of field activities).

4.6 Instrumentation

The DQO process evaluates the ability of the instrument to measure radioactivity at levels below the applicable DCGL. Referred to by the FSS plan, this evaluation is documented in Reference 7.52. Detector sensitivities are also discussed in Section 5.7 of the HNP LTP.

4.6.1 Detector Efficiencies

The Eberline E-600 survey instrument coupled with the SPA-3 high sensitivity gamma detector was selected as the primary radiation detection instrumentation for FSS surveys at HNP. Efficiencies for the SPA-3 Sodium Iodide probe are demonstrated during calibration as the ability to respond as expected when exposed to a gamma radiation field from a National Institute of Standards and Technology (NIST) traceable Cs-137 source. If the response is within an acceptable range, then the detector is placed in service; otherwise, the instrument is considered "Out of Service" and sent for evaluation and repair. This method is described in procedure GGGR-R4206-003 RPM 4.2-14, "Calibration of the Eberline SPA-3 Smart Probe" (Reference 7.53).

4.6.2 Detector Sensitivities

Instrument DQOs include a verification of the ability of the survey instrument to detect the radiation(s) of interest relative to the Operational DCGL. DQOs established that the E-600 with the SPA-3 scintillation probe, operated in the data-logging, rate-meter mode, set to audio response, met the detection criteria needed to perform FSS surveys. Table 4-3 provides specifications for the SPA-3 detector.

Table 4-3 - SPA-3 Technical Details and Specifications

Application	High sensitivity gamma measurements
Detector Type	2-inch diameter by 2-inch thick NaI(Tl) (5.1 centimeter x 5.1 centimeter)
Operating Voltage	1,000 volt nominal
Dead Time	14 μs nominal
Background Sensitivity	~ 1.2 Mcpm/mR/h (Cs-137)
Energy Range	~ 60 keV to 2 MeV
Operating Temperature	-22° to +140° F (-30° to +60° C)

Table 4-3 - SPA-3 Technical Details and Specifications

Application	High sensitivity gamma measurements
Housing	Aluminum body
Connector	CJ-1
Size	2.63 inch diameter x 11.13 inch long (6.7centimeter x 28.3 centimeter)
Weight	3.4 lbs. (1.5 kg)

Detector sensitivity, or the ability to detect radionuclides of interest at levels acceptable for FSS, is derived as a function of the application of the DQO process, from vendor specifications, instrument calibration, survey technique and a determination of background and Minimum Detectable Count Rate (MDCR).

Unless noted otherwise in the Survey Unit Release Records, before performing FSS of land areas, a scanning investigation level was established for each sample location and judgmental scan area based upon the ambient background levels at the location. The investigation level was determined using Reference 7.52, which provided the MDCR and investigation level relative to the ambient background count rate. The scanning investigation level was equal to the MDCR plus the ambient background count rate. The methodology was consistent with guidance provided in NUREG-1507, "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions" (Reference 7.54).

The background level was determined by holding the detector at arms length and at waist height near the scan location and the reading logged. The investigation level was determined and scanning was performed. An instrument response above the investigation level required investigation and additional sampling. Typical ambient background levels and corresponding investigation levels are provided in Table 4-4.

Table 4-4 – Ambient Background Count Rates, Associated MDCR's and Investigation Levels

Background (cpm)	MDCR (cpm)	Investigation Level
2500	714	3214
3000	782	3782
3500	845	4345
4000	903	4903
4500	958	5458

Table 4-4 – Ambient Background Count Rates, Associated MDCR's and Investigation Levels

Background (cpm)	MDCR (cpm)	Investigation Level
5000	1010	6010
5500	1059	6559
6000	1106	7106
6500	1152	7652
7000	1195	8195
7500	1237	8737
8000	1278	9278
8500	1317	9817
9000	1355	10355
9500	1392	10892
10000	1428	11428
10500	1464	11964
11000	1498	12498
11500	1532	13032
12000	1565	13565
12500	1597	14097
13000	1629	14629
13500	1660	15160
14000	1690	15690
14500	1720	16220
15000	1749	16749
15500	1778	17278
16000	1807	17807
16500	1835	18335
17000	1862	18862
17500	1890	19390
18000	1916	19916
18500	1943	20443
19000	1969	20969
19500	1995	21495
20000	2020	22020
20500	2045	22545
21000	2070	23070
21500	2094	23594

Table 4-4 – Ambient Background Count Rates, Associated MDCR's and Investigation Levels

Background (cpm)	MDCR (cpm)	Investigation Level
22000	2119	24119
22500	2143	24643
23000	2166	25166
23500	2190	25690
24000	2213	26213
24500	2236	26736
25000	2259	27259
25500	2281	27781
26000	2303	28303
26500	2325	28825
27000	2347	29347
27500	2369	29869
28000	2390	30390
28500	2411	30911
29000	2433	31433
29500	2453	31953
30000	2474	32474
30500	2495	32995
31000	2515	33515
31500	2535	34035
32000	2555	34555
32500	2575	35075
33000	2595	35595
33500	2614	36114
34000	2634	36634
34500	2653	37153
35000	2672	37672
35500	2691	38191
36000	2710	38710
36500	2729	39229
37000	2748	39748
37500	2766	40266
38000	2785	40785
38500	2803	41303

Table 4-4 – Ambient Background Count Rates, Associated MDCR's and Investigation Levels

Background (cpm)	MDCR (cpm)	Investigation Level
39000	2821	41821
39500	2839	42339
40000	2857	42857

4.6.3 Instrument Maintenance and Control

Control and accountability of survey instruments were maintained to assure the quality and prevent the loss of data. Health Physics Technicians performing field survey activities and assessing the data collected were trained in the use and control of the instruments applicable to the tasks they were performing. Training consisted of reading required procedures and On-the-Job Training.

The E-600 remained in the custody of assigned technicians, and positive control was maintained, until collected data had been downloaded. Log sheets and other forms used to record field data remained in the custody of the responsible individual, and positive control was maintained, until the instrument was returned to secure storage. Procedure RPM 5.2-1, "Setup and Operation of the E-600 Digital Survey Instrument for Scoping, Characterization and Final Status Surveys," (Reference 7.55) provided details on the instrument for field use.

4.6.4 Instrument Calibration

Instruments were calibrated using NIST traceable sources using approved procedures and instructions. Instrument calibration and repair history were documented for each instrument and probe. Instrument integrity and operation was checked prior to use and issue. Only trained and qualified personnel repaired, calibrated or tested FSS instrumentation.

Instrument response checks were performed prior to use, at the completion of the survey, and prior to data download. An instrument failing a response check was removed from service. In addition, an investigation was performed to determine if collected data was corrupt. Instrument source and performance checks were documented for each instrument.

4.7 Survey Methodology

4.7.1 Scan Surveys

The HNP LTP specifies the minimum amount of scanning required for each class (See Table 4-5). The total fraction of scanning coverage was determined for each survey unit during the DQO process with the amount, and location(s) based on the likelihood of finding elevated activity during FSS.

Table 4-5 - Scan Coverage

Survey Unit Classification	Required Scanning Coverage Fraction
Class 1	100%
Class 2	10% to 100%
Class 3	Judgmental
Class B (subsurface)	None
Class C (subsurface)	None

Scan areas were walked down and marked out grid fashion using paint or flags. The scan areas were staked out using GPS in most cases. The scan areas were divided into manageable 1-meter wide strips with variable lengths depending on the size of the scan area and the location. The strips are then mapped, flagged as a row 1-meter wide by the strip length long, and scanned 100% of the available area. The instrument was operated in the rate meter mode with the audio response enabled. During the scan, the probe was positioned as close to the ground as possible and was moved at a scan speed of about 0.5 meters per second. Areas with elevated readings were marked and evaluated, and in most cases additional sampling was performed. Table 4-6 provides a summary of the area scanned during FSS.

Table 4-6 –Summary of Total Area Scanned

Survey Unit	Survey Unit Classification	Area in Square Meters	Area Scanned in Square Meters	Percentage Scanned
9520-0001	2	9,777	4,889	50
9520-0002	2	9,720	3,888	40
9520-0003	2	8,106	1,621	20
9520-0004	1	1,985	1,985	100
9520-0005	1	1,887	1,887	100
9530-0001	2	5,753	863	15

Table 4-6 –Summary of Total Area Scanned

Survey Unit	Survey Unit Classification	Area in Square Meters	Area Scanned in Square Meters	Percentage Scanned
9530-0002	2	6,438	773	12
9530-0003	2	6,438	773	12
9530-0004	3	83,777	4,189	5
9805-0000	B	N/A	N/A	N/A
9807-0000	C	N/A	N/A	N/A

For random and biased sample locations, the scan area for samples was a circle of one (1) meter radius around the sample flag. The instrument was operated in the rate meter mode with the audio response enabled. During the scan, the probe was positioned as close to the ground as possible and was moved at a scan speed of about 0.5 meters per second. When applicable, the sample location was moved, and the sample was collected, from the area exhibiting elevated readings.

During the scanning, the technician recorded data in the Daily Survey Journal. This log documented field activities and other information pertaining to the FSS.

The LTP does not require scanning for subsurface survey units.

4.7.2 Soil Sampling

Measurement locations were identified in North American Datum (NAD) 1927 coordinates that were supplied to the FSS field supervisor. Surface soil samples were collect by hand, using radiologically clean equipment between samples. Subsurface core samples were collected using direct push technology to collect composite samples up to a depth of three (3) meters.

4.7.3 Total Surface Contamination Measurements

"Total Surface Contamination Measurements" refers to the FSS of structural surfaces such as walls, floors and ceilings. During this phase of FSS and submittal, no areas containing structures subject to FSS were surveyed.

4.8 Quality Control Surveys

Reference 7.25 establishes a method for evaluating QC split samples collected in support of FSS. QC split sample data was assessed on criteria taken from the USNRC Inspection Manual, Inspection Procedure 84750, "Radioactive Waste Treatment and Effluent and Environmental Monitoring," March 1994 (Reference 7.51).

A minimum of five percent (5%) of the sample locations used in the FSS design were selected randomly using the Microsoft® Excel "RANDBETWEEN" function and submitted as "splits." All splits taken during FSS were field replicates, that is, samples obtained from one location, homogenized, divided into separate containers and treated as separate samples. These samples were used to assess errors associated with sample heterogeneity, sample methodology and analytical procedures. It was desirable that when analyzed, there would be agreement between the splits resulting in data acceptance. When there is not agreement between the samples, the FSS Engineer evaluated the magnitude and impact on FSS plan design, and the need to perform confirmatory sampling. When the FSS Engineer has determined that the discrepancy affects quality or is detrimental to the FSS program then the discrepancy warranted the issuance of a Condition Report (Reference 7.25).

To maintain the quality of the FSS, isolation and control measures are implemented until there is no risk of recontamination from decommissioning or the survey area has been released from the license. Following FSS, until the area is released, a semi-annual surveillance will be performed on the survey units covered by this FSS Final Report. The surveillance will include an inspection of area postings, inspection of the area for signs of dumping or disturbance and some sampling from selected locations, when warranted. In the event that isolation and control measures are compromised, a follow-up survey may be performed after evaluation.

5.0 SURVEY FINDINGS

Reference 7.27 provides guidance to Site Closure personnel to interpret survey results using the DQA process during the assessment phase of FSS. Although intended for FSS activities, the DQA process could be used for other radiological data collection activities (e.g., characterization and remedial action surveys). The extent to which of the DQA process applies for these surveys would be commensurate with the objectives of the particular survey.

The DQA process is the primary evaluation tool to determine that data are of the right type, quality and quantity to support the objectives of the sample plan (e.g., FSS Plan and the requirements of the HNP LTP). The five steps of the DQAs process are:

- Review the sample plan Data Quality Objectives (DQOs) and the survey design;

- Conduct a preliminary data review;
- Select the statistical test;
- Verify the assumptions of the statistical test, and,
- Draw conclusions from the data.

Data validation descriptors described in MARSSIM Table 9.3 were used during the DQA process to verify and validate collected data as required by the FSSQAP.

5.1 Survey Data Conversion

During the data conversion, the FSS Engineer will evaluate raw data for problems or anomalies encountered during the FSS plan activities (sample collection and analysis, handling and control, etc.) including the following:

- Recorded data;
- Missing values;
- Deviation from established procedure; and,
- Analysis flags.

Once resolved, initial data conversion, which is part of preliminary data review was performed and consists of converting the data into units relative to the release criteria (i.e., pCi/g), and calculating basic statistical quantities (e.g., mean, median, standard deviation). Table 5-1 provides a summary of the data analysis for each survey unit of Phase V. The individual FSS Release Records covered by this FSS Final Report provide additional detail.

Table 5-1 - Summary of Statistical Analysis for Soil Samples

Survey Unit	Class	Mean Concentration (pCi/g)	Standard Deviation (pCi/g)	Actual Soil Dose from Cs-137 (mrem/yr)
9520-0001	2	9.07E-02	8.12E-02	0.29
9520-0002	2	1.03E-01	8.16E-02	0.32
9520-0003	2	9.32E-02	5.88E-02	0.44
9520-0004	1	4.64E-02	2.79E-02	0.15
9520-0005	1	8.08E-02	5.34E-02	0.56
9530-0001	2	1.09E-01	5.40E-02	0.35
9530-0002	2	8.63E-02	5.20E-02	0.27
9530-0003	2	2.48E-01	1.18E-01	0.78
9530-0004	3	1.48E-01	1.07E-01	0.47

Table 5-1 - Summary of Statistical Analysis for Soil Samples				
Survey Unit	**Class**	**Mean Concentration (pCi/g)**	**Standard Deviation (pCi/g)**	**Actual Soil Dose from Cs-137 (mrem/yr)**
9805-0000	B	2.72E-02	2.64E-02	0.08
9807-0000	C	1.49E-01	6.98E-01	0.47

5.2 Survey Data Verification and Validation

Items supporting DQO sample design and data were reviewed for completeness and consistency. This includes:

- Classification history and related documents;
- Site description;
- Survey design and measurement locations;
- Analytic method, detection limit and that the required analytical method(s) were adequate for the radionuclides of concern;
- Sampling variability has been provided for the radionuclides of interest;
- QC measurements have been specified;
- Survey and sampling result accuracy has been specified;
- MDC or Minimum Detectable Activity (MDA) limits have been provided;
- Field conditions for media and environment are assessed.

Documentation, as listed, was reviewed to verify completeness and that it is legible:

- Field and analytical results;
- Chain-of-custodies;
- Daily Survey Journals;
- Instrument downloads; and,
- Measurement results relative to measurement location.

After completion of these previously mentioned tasks, a Preliminary Data Review record was initiated. This record serves to verify that all data are in standard units in relation to the DCGLs and requires the calculation of the statistical parameters needed to complete data evaluation. Included at a minimum are the following parameters:

- The number of samples or measurements;
- The range of observations (i.e., minimum and maximum values);
- Mean;
- Median; and,
- Standard deviation.

Considerations as an optional aid to evaluate the data set are the coefficient of variation, measurements of relative standing, such as percentile and other statistical applications as necessary (frequency distribution, skew etc.). Finalization of the data review consists of graphically displaying the data in distributions and percentiles plots.

5.3 Evaluation of Number of Sample and Measurement Locations in Survey Units

An effective tool utilized to evaluate the number of samples collected in the sampling scheme is the Retrospective Power Curve generated by COMPASS. The Retrospective Power Curve shows how well the survey design achieved the DQOs. For reporting purposes, all Survey Unit Release Records included a Retrospective Power Curve analysis indicating that the sampling design had adequate power to pass FSS release criteria (i.e. adequate number of samples was collected).

The Sign Test was the selected statistical test for all Survey Unit Release Records covered under this FSS Final Report. This test was performed in accordance with procedure RPM 5.1-21, "Applying the Sign Test," (Reference 7.56). All the data for the survey units covered under this FSS Final Report passed the Sign Test and the null hypothesis was rejected. The FSS design has been satisfied.

During this FSS, the need to apply the Elevated Measurement Comparison (EMC) Test was not required to evaluate areas.

5.4 Comparison of Findings with Derived Concentration Guideline Levels

In conjunction with performing the Sign Test, and the generating of a Retrospective Power Curve, the data were compared to the Table 4-1 criteria and the decision rule provided in the FSS plan. Based on the comparison, and non-parametric statistical sampling (i.e., the Sign Text), the survey unit may either fail or pass.

Investigations are typically addressed in the FSS plan and may require the issue of an addendum to provide additional instruction and information. When the investigational criteria are exceeded, additional evaluation is done to understand the extent and mechanism for the apparent elevated response. Several actions may occur which include bounding the elevated area with multiple samples. Information collected from this type of plan provides additional information for statistical analysis and may stimulate further considerations to reclassify, remediate and resurvey. It should be noted that one (1) or more samples exceeding the Operational DCGL may not constitute failure of the survey unit and a viable option is to do nothing more in this area.

5.5 USNRC/Independent Verification Team Findings

The USNRC/ORISE has not performed independent verification work in the Phase V survey areas as of the submittal date of this document.

6.0 SUMMARY

The eleven (11) survey units covered under this FSS Final Report have met the criteria of the applicable FSS plans. However, the FSS results provided herein only address the dose component from soil as provided in the HNP LTP Equation 5-1. Refer to Table 2-2 and Table 5-1 for the dose component for soil in each survey unit. The second component of HNP LTP Equation 5-1, dose contribution due to existing groundwater, is bounded by either 2 mrem/yr or 8 mrem/yr per note (1) of Table 2-2.. The dose contribution from the third component of HNP LTP Equation 5-1, future groundwater, is zero (0) since there are no underground structures, systems or components containing residual radioactive material within the groundwater saturated zone in the survey areas.

7.0 REFERENCES

7.1 Haddam Neck Plant License Termination Plan

7.2 ISC 06-024, "Initial Target Operational DCGLs/Dose Targets for CY", August 2, 2006.

7.3 NUREG-1575, Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)

7.4 ISC-GQP-00001-003, "Final Status Survey Quality Assurance Plan" (FSSQAP)

7.5 GPP-GGGR-R5120-002, "Final Status Survey Program (RPM 5.1-00)"

7.6 NUREG-1757, Volume 2, Consolidated NMSS Decommissioning Guidance-Characterization, Survey, and Determination of Radiological Criteria

7.7 GPP-GGGR-R5122-001, "Preparation of Final Status Survey Reports (RPM 5.1-22)"

7.8 W. Norton (HNP) to USNRC, "Letter of Intent Concerning the Release of the East Site Grounds from the Part 50 License", dated April 29, 2004 (CY-04-069 / Docket No. 50-213)

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7.10 T. Smith (USNRC) to W. Norton (HNP), "Haddam Neck Plant – Release of East Site Grounds from Part 50 License", dated September 01, 2004

7.11 J. Bourassa (HNP) to USNRC, "Final Status Survey (FSS) Final Report Phase II", March 8, 2005 (CY-05-040/ Docket No. 50-213)

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7.13 T. Smith (USNRC) to W. Norton (HNP), "Haddam Neck Plant – Release of Phase II from Part 50 License", dated February 28, 2006

7.14 "Final Status Survey Report - Phase III", May 04, 2006

7.15 "Final Status Survey Report – Phase III", Revision 1 September 9, 2006

7.16 "Final Status Survey Report – Phase IV", November 29, 2006

7.17 GGGR-R5111-002, "Preparation of Final Status Survey Plans" (RPM 5.1-11)"

7.18 "Results of Scoping Surveys", September 1998

7.19 "Augmented Characterization Survey Report", January 1999

7.20 "Characterization Report", January 2000

7.21 "Historical Site Assessment Supplement" August 2001

7.22 GPP-GGGR-R5400-000, "Site Closure Training Program (RPM 5.4-00)"

7.23 GGGC-00001-004, "Work Plan and Inspection Record"

7.24 GGGR-R5112-001, "Determination of the Number of Surface and Subsurface Samples for FSS of Open Land Areas (RPM 5.1-12)"

7.25 GPP-GGGR-R5124-000, "Split Sample Assessment for Final Status Survey (RPM 5.1-24)"

7.26 GPP-GGGR-R51004-003, "Chain of Custody for Final Status Survey Samples (RPM 5.1-5)"

7.27 GGGR-R5123-000, "Data Quality Assessment (DQA), (RPM 5.1-23)"

7.28 "Quality Assurance Program for Haddam Nuclear Plant," (QAP HNP)

7.29 CY Quality Surveillance Report QSR 06-001-CY

7.30 Quality Surveillance Report QSR 06-007

7.31 Quality Surveillance Report QSR 06-008

7.32 CY Quality Assurance Audit CY-06-A06-01

7.33 Self Assessment 06-01 "Final Status Survey Field Activities"

7.34 CY Condition Report (CR) 05-781

7.35 Self Assessment 06-02 "Final Status Survey Field Activities"

7.36 Self Assessment 06-03 "Final Status Survey Field Activities"

7.37 Condition Report (CR) 06-223

7.38 Post Shutdown Decommissioning Activities Report (PSDAR)

7.39 Updated Final Safety Analysis Report (UFSAR)

7.40 US NRC NUREG CR-5849 "Manual for Conducting Radiological Surveys in Support of License Termination"

7.41 "NRC Historical Review Team Report – Radiological Control and Area Contamination Issues at Haddam Neck" USNRC, dated March 26, 1998

7.42 HNP Health Physics Department Technical Support Document BCY-HP-0078, "ALARA Evaluation of Soil Remediation in Support of Final Status Survey

7.43 24265-000-GPP-GGGR-R5116-002, "Area Preparation for Final Status Survey Activities (RPM 5.1-16)"

7.44 RCRA Facility Investigation Report, April 2006

7.45 Peninsula Area Investigation Report, July 2006

7.46 Health Physics Technical Support Document (TSD) BCY-HP-0063, "Background Cs-137 Concentration in Soil."

7.47 GGGR-R5114-001, "Identifying and Marking Locations for Final Status Survey (RPM 5.1-14)".

7.48 GPP-GGGR-R5110-001, "Survey Unit Classification (RPM 5.1-10)

7.49 EPRI Technical Report 1003030, "Determining Background Radiation Levels in Support of Decommissioning Nuclear Power Plants."

7.50 Health Physics Technical Support Document (TSD) BCY-HP-0079, "Use and Verification of Visual Sample Plan"

7.51 USNRC Inspection Manual, Inspection Procedure 84750, "Radioactive Waste Treatment and Effluent and Environmental Monitoring," March 1994.

7.52 Health Physics Technical Support Document BCY-HP-0081, "Scan MDC of Land Areas using a 2-inch by 2-inch Sodium Iodide Detector."

7.53 GGGR-R4206-003 RPM, "Calibration of the Eberline SPA-3 Smart Probe (RPM 4.2-14)"

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7.56 GPP-GGGR-R5121-001, "Applying the Sign Test (RPM 5.1-21)"

8.0 Appendices

A1 Survey Unit Release Record 9520-0001, Southwest Site Storage Area

A2 Survey Unit Release Record 9520-0002, Southwest Site Storage Area

A3 Survey Unit Release Record 9520-0003, Southwest Site Storage Area

A4 Survey Unit Release Record 9520-0004, Southwest Site Storage Area

A5 Survey Unit Release Record 9520-0005, Southwest Site Storage Area

A6 Survey Unit Release Record 9530-0001, Central Peninsula

A7 Survey Unit Release Record 9530-0002, Central Peninsula

A8 Survey Unit Release Record 9530-0003, Central Peninsula

A9 Survey Unit Release Record 9530-0004, Central Peninsula

A10 Survey Unit Release Record 9805-0000, Subsurface Area associated with the Peninsula

A11 Survey Unit Release Record 9807, Subsurface Area associated with the Southwest Site Storage Area