Westinghouse Electric Corporation

Bloomfield Lamp Plant Site Final Survey Plan Buildings 7, 8, 9 and 10A

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SCIENTIFIC ECOLOGY GROUP, INC.

Radiological Engineering & Decommissioning Services

SCIENTIFIC ECOLOGY GROUP, INC.

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BLOOMFIELD LAMP PLANT
SITE FINAL SURVEY PLAN
BUILDINGS 7, 8, 9 AND 10A

WESTINGHOUSE ELECTRIC CORPORATION

BLOOMFIELD, NEW JERSEY

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PREFACE

This document describes the methods used by the Westinghouse Electric Corporation to demonstrate that radioactive contamination levels within the documented survey areas of Buildings 7, 8, 9 and 10A at the Bloomfield Lamp Plant have been reduced to levels below criteria established for release for unrestricted use. This plan has been developed in accordance with the Draft NUREG/CR-5849, *Manual for Conducting Radiological Surveys in Support of License Termination*; the NRC's 1987 *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct Source or Special Nuclear Material*; and the NRC's 1981 Branch Technical Position *Disposal or On-site Storage of Thorium or Uranium from Past Operations*. It supplements and updates the Westinghouse Electric Corporation, August 1992, *Radiological Decontamination Confirmatory Survey, Westinghouse Bloomfield Lamp Plant, Buildings 7, 8 and 9.*

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1.0 HISTORICAL BACKGROUND

The Bloomfield Lamp Plant is located approximately 7.5 miles north of the Newark International Airport in Bloomfield, New Jersey. The plant consists of 11 buildings on Macarthur and Arlington Avenues. The primary purpose of the facility was the manufacturing and development of electric lamps. Studies involving various types of materials, including radioactive materials, were also performed at the facility throughout its history.

Several of the processes utilized at the plant involved the use and study of radioactive material in the form of natural uranium and thorium. Natural thorium was used in the production of thoriated tungsten wire and in the study of emission mixtures. In the 1940s and early 1950s, natural uranium was used in various metallurgical studies related to the Manhattan Engineering District.

In 1986, decontamination and decommissioning activities were initiated to remediate the residual radioactivity remaining in the facility resulting from past operations. Decontamination and survey activities were completed in April 1991 for Buildings 1 through 6 located west of Arlington Avenue. The unrestricted release of these buildings was authorized by the NRC in 1993. Decontamination activities continued in Buildings 7, 8, 9 and 10A, (east of Arlington Avenue) into early 1992. The unrestricted release of these facilities was requested in an application to the NRC dated August 24, 1992. At the request of the NRC Region I office, the Oak Ridge Institute of Science and Education (ORISE) performed confirmatory surveys of Buildings 7, 8, 9 and 10A in May 1993. The results of the confirmatory surveys identified several locations throughout these buildings where residual radioactivity above the unrestricted release limits was still present.

SEG was contracted in November 1993 to characterize, remediate and perform the final release surveys for all areas identified as contaminated in the ORISE confirmatory survey. At this time, the characterization surveys and remediation work is in progress for Buildings 7, 8 and 10A. Due to safety concerns, Building 9 must be partially demolished before the characterization and remediation can continue. This issue is addressed in a separate letter to the NRC. Upon completion of the remediation work in each building, a final release survey will be performed in accordance with this Final Survey Plan.

2.0 SITE INFORMATION

2.1 Site Description

Building 7 is a five-story building containing office and laboratory space. The building is constructed of steel and concrete. The concrete floors are covered with 3 to 4 inches of asbestos nail-crete and further covered with wood and floor tile. Some of the offices have carpet flooring.

Building 8 is a five-story building constructed of steel and concrete. The building floors are also covered with 3 to 4 inches of asbestos nail-crete, wood and floor tile. The building consists of large open areas that housed manufacturing equipment.

Building 9 and 10A is a single story manufacturing facility constructed of steel and concrete. This building housed furnaces, plating equipment and presses used in the manufacture of thoriated lamp filaments.

2.2 Site Conditions for Final Survey

In preparation for the final survey, areas identified as potentially contaminated in the ORISE Confirmatory Survey of Buildings 7, 8, 9 and 10A are being characterized and remediated. The characterization surveys are being performed at each location identified as potentially contaminated by ORISE and in the general area around each location. The size of the survey areas is based on an objective to survey within a 10 meter radius surrounding each location identified by ORISE. If the physical dimensions of the area or room are less than the 10 meters, the survey is only performed up to the walls of the area. In most cases, this criteria results in the performance of a full survey for each room where ORISE identified potential contamination. The characterization surveys are being performed following the guidance contained in NUREG-5849, *Manuals for Conducting Radiological Surveys in Support of License Termination*, for the type of survey being performed. Using this guidance, the final survey can be limited to only those grids where contamination was found during the characterization survey.

Samples were taken in each survey area to determine if the radioactive contaminant was natural thorium, natural uranium or both and to determine the appropriate survey guidelines. Samples were analyzed using gamma spectroscopy by Scientific Ecology Group, Inc., in Oak Ridge, Tennessee.

A remediation work plan is being developed and implemented for each survey area based upon the results of the characterization surveys and sample analyses. All areas within the scope of the characterization survey will be remediated to levels below the NRC acceptance criteria.

The final survey of the areas will be performed in accordance with this plan and supporting procedures to verify that each survey area meets the NRCs acceptance criteria for unrestricted use and license termination.

2.3 Site Areas Covered - Scope of Survey

Characterization surveys are being performed in the following areas to determine the quantity and extent of radioactive contamination. Highlighted maps illustrating the locations being surveyed are included in Appendix C. All areas identified as containing residual radioactivity above the limits specified in Table 3-1 will be remediated and final surveys performed in accordance with the site final survey plan. Final release surveys will only be performed in areas where remediation was performed. This data will then be combined with the characterization data obtained in accordance with NUREG-5849, *Manuals for Conducting Radiological Surveys in Support of License Termination*, for all other areas where contamination was not identified.

Building 7

First Floor	Room 128
	Room 129
	South Hall and Stairwell
Second Floor	Elevator Shaft and Carriage
	SE Pipe Chase
	South Hall and Stairwell
	North Hall and Stairwell
Third Floor	Room 310
	Hallway (outside 310)
	SE Pipe Chase
	Central Pipe Chase
	Room 314
	Room 316/317
Fourth Floor	Room 424
	Central Stairwell
Fifth Floor	Central Stairwell

Building 8

Basement	East Half of Basement
First Floor	Center of Floor (approx. 500 m^2)
Third Floor	West Wing (approx. 600 m^2)
	Room in West Wing
Fourth Floor	South Wing (approx. 250 m^2)

Building 9

All areas

Building 10A

All areas

Outside of Buildings

Facility grounds outside Building 7, Freight elevator
Soil and concrete pad, South side, Building 9/10A

3.0 FINAL SURVEY OVERVIEW

3.1 Survey Objective

The Final Survey is designed to demonstrate that licensed radioactive materials have been removed from the Bloomfield Lamp Plant in the documented survey areas of Buildings of 7, 8, 9 and 10A to levels below regulatory limits (Table 3-1) and that Westinghouse has met all necessary requirements for termination of the current license.

Table 3-1
Acceptable Surface and Soil Contamination Levels[1, 2]

Thorium	1,000 dpm/100 cm^2, total, averaged over a 1 m^2 area 3,000 dpm/100 cm^2, total, maximum in a 100 cm^2 area 200 dpm/100 cm^2, removable activity 10 pCi/g in soil
Uranium	5,000 α dpm/100 cm^2, total, averaged over a 1 m^2 area 15,000 α dpm/100 cm^2, total, maximum in a 100 cm^2 area 1,000 α dpm/100 cm^2, removable activity 35 pCi/g in soil

[1] *Guidelines for Decontamination of Facilities and Equipment Prior to the Release for Unrestricted Use or Termination of Licenses for Byproduct Source or Special Nuclear Material* (NRC August 1987).

[2] *Disposal or On-site Storage of Thorium or Uranium Wastes from Past Operations* (NRC 1981).

3.2 Identity of Contaminants

The radioactive contaminants present in each survey area were identified through sampling and gamma spectroscopy analysis. The results of these analyses showed natural uranium and thorium to be present in the following areas.

Building 7

First Floor	Room 128	Natural uranium/natural thorium
	Room 129	Natural uranium
	South Hall and Stairwell	Natural uranium
Second Floor	All	Natural uranium
Third Floor	Room 310	Natural uranium/natural thorium
	Room 314	Natural thorium
	Room 316/317	Natural uranium
	Hallway	Natural uranium
Fourth Floor	Room 424	Natural thorium
	Center Stairwell	Natural uranium
Fifth Floor	Stairwell	Natural uranium

Building 8

Basement	East End	Natural uranium/natural thorium
First Floor	West and South Wings	Natural uranium/natural thorium
Third Floor	West Wing	Natural uranium
Fourth Floor	South Wing	Natural uranium/natural thorium

Building 9		Natural thorium
Building 10A		Natural thorium
Facility Grounds		
Buildings 9/10A	South Side	Natural thorium
Building 7	Outside Freight elevator	Natural uranium
Building 7	North Wing, East Side	Natural thorium

Additional sampling and analysis will be conducted throughout the characterization and remediation process to verify the above findings.

3.3 Determination of Site-Specific Guidelines

3.3.1 Gamma Exposure Rate Guidelines (External Effective Dose)

The gamma exposure rate for all radionuclides was evaluated by ORISE during the confirmatory survey and found to be acceptable. Additional gamma measurements are not planned for the Final Survey.

3.3.2 Alpha and Beta-Gamma Removable Surface Contamination Guidelines

The levels of removable alpha and beta-gamma surface contamination will be limited to the values provided in Table 3-1. Samples will be counted such that the MDA will be, as a minimum, 75% of these guidelines.

3.3.3 Alpha and Beta-Gamma Total Surface Contamination Guidelines

The levels of alpha and beta-gamma total (fixed) surface contamination will be limited to the values provided in Table 3-1. Count times for direct activity measurement will be established such that the MDA will be, as a minimum, 75% of these guidelines.

3.3.4 Soil Contamination Guidelines

The levels of total uranium and total thorium soil contamination will be limited to the values provided in Table 3-1. Samples will be analyzed by gamma spectroscopy analysis such that the minimum MDA will be, as a minimum, 10% of these guidelines

3.4 Organization and Responsibilities

Final Survey Plan development and implementation of the Final Survey Program will be performed by qualified members of the Westinghouse/SEG Project Team. An organization chart is included in Figure 3-1.

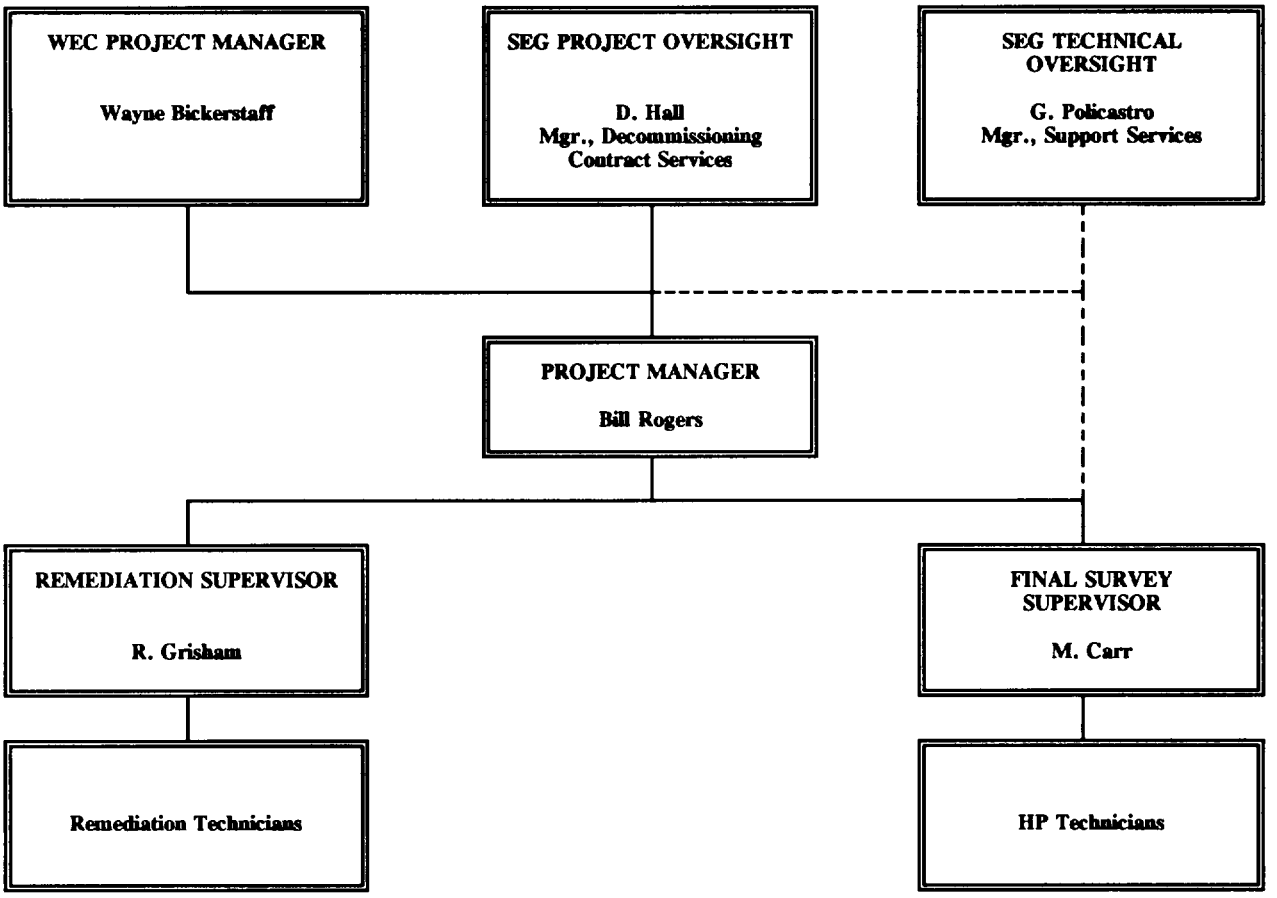

Figure 3-1

Final Survey Organization Chart

4.0 FINAL SURVEY INSTRUMENTATION

Radiation detection and measurement instrumentation for final surveys has been selected to provide reliable operation and adequate sensitivity to demonstrate that the measurements taken are sufficient to conclusively demonstrate that the release criteria have been met. An evaluation has been conducted of commercially available portable and laboratory instruments and detectors produced by several manufacturers. Instrumentation has been selected based upon detection sensitivity, operating characteristics and expected performance in the field. The detectors selected and their detection characteristics are summarized in Table 4-1.

4.1 Instrument Detector Description

The principal detector selected for final survey measurements are illustrated in Table 4-1, *Final Survey Instrumentation*. The detectors used for total surface contamination monitoring will, for the most part, be operated with data logging survey meters.

Table 4-1
Final Survey Instrumentation

Instrument	Detector	Radiation Detected	Source	Use
Ludlum Model 2350/43-68	gas proportional	alpha	Th-230	Surface contamination and scanning
Ludlum Model 2350/43-68		beta	Tc-99	
Ludlum Model 2350/44-2	NaI(Tl) scintillator	gamma	Cs-137	Exposure rate
Ludlum Model 2350/44-40	GM	beta-gamma	Tc-99	Surface contamination (restricted access)
Gamma Spectrometer	HPGe	gamma	Mixed Gamma, Am-241	Concrete and soil isotopic
Tennelec LB-5100/W or BC-4	gas proportional or scintillator	alpha	Po-210	Removable surface contamination
Tennelec LB-5100/W or SAC-4		beta	Tc-99	

4.2 Detection Sensitivity

The detection sensitivity of the detectors selected for field surface contamination measurements have been evaluated and determined to satisfy the detection requirements outlined in Table 3-1. The minimum detectable activities for field equipment have been calculated by using the SEG proprietary spreadsheet program, CNTTIME© (Reference 13), and MDA and limit value software.

Laboratory fixed based equipment minimum detectable activities are calculated using the equation from section 4.3. The minimum detectable activity, (MDA), is dependent upon several factors: Sample count time, background count time, background count rate and detector efficiency. Smear counters for measurement of removable surface contamination are of current design (anti-coincidence low-background) and will be used to determine the activities to meet the guideline value MDA for both alpha and beta radiation.

4.3 Minimum Detectable Activity Calculation

MDA values for smear counting instrumentation will be calculated as shown below:

$$MDA = \frac{\frac{2.71}{t_s} + 3.29\sqrt{\frac{R_b}{t_s} + \frac{R_b}{t_b}}}{E}$$

where:

MDA	=	the minimum amount of activity that can be statistically detected above background with a 95% probability and with a maximum of 5% probability of falsely interpreting background activity as activity due to contamination (dpm/100 cm²),
t_s	=	Sample counting time (minutes)
R_b	=	The background count rate in counts per minute (cpm)
t_b	=	Background counting time (minutes) and
E	=	The counting efficiency (cpm/dpm).

4.4 Calibration and Maintenance

Instruments and detectors used to conduct final surveys will be calibrated and maintained in accordance with instrumentation procedures. Radioactive sources used for the purpose of calibration will be traceable to the National Institute of Standards and Technology (NIST).

5.0 FINAL SURVEY PROCESS

The final survey of the Bloomfield site will be planned, performed and controlled in accordance with the final survey procedures listed below and related project procedures listed in Appendix A.

REDS-FSP-100, *Preparation of a Final Survey Plan*
REDS-FSP-101, *Final Survey of Structures*
REDS-FSP-103, *Final Survey of Environs*
REDS-FSP-104, *Final Survey Data Handling and Analysis*

The finals survey procedures are included as Appendix B to this document.

The final survey process consists of six general tasks for each survey area:

- Area Classification
- Area Walkdown and Survey Design
- Survey Package Preparation
- Survey Area Preparation
- Area Surveys
- Data Processing and Analysis

Each of these tasks are discussed briefly in the following sections. Applicable SEG procedures are also referenced which provide guidance for each survey task.

5.1 Area Classification (REDS-FSP-100)

Each survey area and unit are classified into "affected" and "unaffected" areas based upon the historical use of radioactive materials and processes in the areas, past surveys and other area records. Affected and unaffected areas are defined as follows:

- Affected Areas

  Areas that have potential radioactive contamination (based on plant operating history) or known radioactive contamination (based on past or preliminary radiological surveys). Affected areas are further subdivided, according to survey effort, into suspect and non-suspect areas.

- Unaffected Area

  All areas not classified as affected. These areas are not expected to contain residual radioactivity, based on a knowledge of site history and previous survey information.

This classification provides a basis for the final survey design and methodology. All of the areas covered by the final survey at the Bloomfield Lamp Plant are designated as "affected" areas.

5.2 Area Walkdown and Survey Design (REDS-FSP-100)

Each survey area is inspected prior to performing final release surveys. This inspection, or "walkdown," is intended to identify all survey and safety concerns that would impact the final release survey and to identify any additional suspect areas that would require survey. Typical items identified in the walkdown include area housekeeping, power supplies, confined spaces, surface penetrations, drains, materials of construction, painted surfaces, needs for special equipment, and the overall condition of the facility and survey area.

Upon completion of the walkdown, the methods of survey are determined and a survey package is prepared to track the completion status of the final release survey. All systems and areas requiring survey are identified and grid sizes are established.

5.3 Survey Package Preparation (REDS-FSP-100)

A portfolio, referred to as a final survey package, will be prepared for each survey area. Within this package will be a Final Survey Package Worksheet identifying grid size, types of measurements required, description of the area, any special sample requirements, historical information (if available), survey data location code(s), and other information pertinent to the survey area. Also provided in the package will be survey drawings that will include the survey grids. As each package is prepared, it will be reviewed by supervisory personnel for both completeness and suitability to achieve the acceptance criteria. Survey packages will be referenced during the performance of final surveys. Reports of survey data, smear data and the results of required sample analyses will be placed into the packages.

5.4 Survey Area Preparation (REDS-FSP-100)

Preparation of the survey area generally consists of laying out the grid markings in accordance with the survey package specifications. All survey surfaces will be cleaned to ensure accurate detection of residual radioactivity. In some instances, additional preparation such as scaffolding may be required to permit access to survey areas.

5.5 Area Surveys (REDS-FSP-100, REDS-FSP-101, REDS-FSP-103)

Area surveys will be performed using instrumentation capable of detecting radioactive contaminants to the limits specified in Table 3-1 in accordance with the survey package for the area. The final surveys for Bloomfield will consist of surface scans and direct measurements for contamination and smear surveys for removable contamination for surfaces inside of the buildings. Soil samples will be analyzed to verify that contamination is below NRC guidelines in outdoor areas. The process for performing surface surveys is described below.

5.5.1 Building Surface Scanning

The first step in conducting the final survey measurements within a grid will consist of scanning the entire grid. The purpose of scanning is to identify the presence of elevated alpha or beta-gamma readings. The detector used to perform the scanning will be the same detector used to make the direct surface measurements. The detector will be maintained as close as possible to the surface (approximately 1/2 inch) and moved across the surface at a slow speed (no more than 1/3 detector width per second). The distance between the detector and the surface scanned will not exceed 2 cm for beta scanning and 1 cm for alpha scanning. To provide optimum sensitivity to changes in the instrument response, audible output will be monitored using the instruments audible speaker or headphones. Earphones will be available for use in higher noise areas. If elevated readings are found, the suspect area will be investigated to determine if further decontamination is needed.

5.5.2 Building Surface Measurements - Direct

A direct measurement for beta surface activity will be performed near each corner of the grid and at any location of elevated activity detected by scanning using the 100 cm^2 gas-flow proportional detector calibrated to a Tc-99 standard. The datalogger will be used in the scaler mode with a count time of 3 seconds or greater. Using daily calculated efficiencies and local background measurements, an MDA value will be determined. The beta counts will be corrected for the local background.

A direct measurement for alpha surface activity will be performed at the center of each grid and at any location of elevated activity detected by scanning using the 100 cm^2 gas-flow proportional detector system calibrated to a Th-230 standard. The datalogger will be used in the scaler mode with a count time of 20 seconds or greater. Using daily calculated efficiencies and local background measurements, an MDA value will be determined. The gross alpha counts will be corrected for the alpha background.

A few survey areas and penetrations on the walls and floors may offer restrictions to a contact measurement with the 100 cm^2 gas-flow proportional detector. In such situations, smaller detectors such as a 15.5 cm^2 thin-window pancake GM detector will be used. Count times will be adjusted to provide alarm set points capable of responding to the guideline value at a high confidence level.

5.5.3 Building Surface Measurements - Removable

A smear will be taken at the center of each remediated grid by wiping a 100 cm^2 area of the surface with a dry cloth smear. Smears will be counted for alpha and beta activity on a SAC-4 and BC-4 calibrated with Th-230 and Tc-99 sources, respectively.

5.5.4 Background Measurements

Before a beta survey of each survey unit is performed, the background count rate will be measured for the survey unit. The same instrument will be used for both the survey and background measurements. Three or more 5-minute (scaler) background measurements will be made with the detector face shielded to determine the gamma component of the local area background. Three additional background measurements will be made at the end of the survey of each survey unit. The average of all six measurements will be used as the background count rate in the data conversion calculation.

Local alpha background values will be determined in the same way as the beta background measurements. A 5-minute scaler count will be used for these alpha background measurements. These values will be used for alpha background in the data conversion calculation.

These alpha background measurements will be performed before and after each alpha survey period, not necessarily by individual survey units. The alpha survey period is determined by the 250 data point memory capacity of the data logger.

5.6 Data Processing and Analysis (REDS-FSP-104)

5.6.1 Data Processing

Records of final surveys will be maintained in the separate survey package for each area in accordance with project procedures. The specific records that will be compiled in a survey package are:

- Final Survey Package Worksheet giving the package identification, survey location information, historical information of area surveyed, general survey instructions and any specific survey instructions.
- Final Survey Comment Addendum is provided for comments from the survey technician regarding any unusual situation that may encounter while surveying.
- The Survey Unit Diagram provides a drawing of the area to be surveyed. Survey grids are represented on the drawing.
- Photographs of the survey area will be provided, as necessary, to show special or unique conditions.
- Printout of smear survey analyses.
- Printout of gamma spectroscopy results (if performed).
- Ludlum Model 2350 data files and Paradox® converted values for all direct alpha, direct beta, and exposure rate measurements.

Direct survey measurements are taken using the Ludlum Model 2350 Datalogger system. Upon completion of the survey of an individual survey unit or combination of units, the contents of the datalogger's memory will be downloaded to a database. The download process utilizes a proprietary program, developed by Ludlum Measurements, Inc., and revised by SEG to fit specific needs of a final survey.

During each datalogger download, two data files are automatically generated. These files are sequentially assigned an identical index (file) number by the software. These files are automatically combined and translated into a Paradox® database table. In conjunction with the download process, a second Paradox® table is manually updated. This file will contain the following information: the computer generated (assigned) file number, the survey description, data logger and detector serial numbers, detector efficiency in cpm/dpm and the local background level in cpm.

A printed report, referred to as Survey Report, will then be generated for review. All raw data, converted data and information by survey location code will be presented in the report. This report will be reviewed by the survey technician and supervisor for completeness, accuracy and any suspect entries that had been noted.

Any changes to the database tables such as detector efficiency, background, etc., that could affect survey results will require supervisor approval. In addition, changes to data in the primary table will require a written explanation on a hardcopy printout of the Survey Report. The marked-up hardcopy will be maintained as a permanent record.

Data and document control will include maintaining raw data files, translated data files (Paradox® data files) and corrected data files showing documentation of all corrections. Paradox® program scripts and related data and information, including modifications, used for the development of the report will be identified and controlled to ensure accurate identification. The databases will be backed-up and archived on a weekly basis.

5.6.2 Data Analysis

All measurements will be converted to the appropriate units for comparison with release criteria limit values. Surface activity measurements and removable contamination will be converted to units of dpm per 100 cm^2.

The upper boundaries of the average values for each survey unit and/or subunit will be compared with the release criteria values. Confidence intervals will be estimated for mean values of each survey unit (and/or subunit) at the 95% confidence level.

a. Direct Measurements - Total Surface Activity

Measurements of total surface activity will be converted from observed gross counts per minute to net dpm/100cm^2. By subcontracting the background counting rate for the instrument and correcting the net count rate for geometry and efficiency, the results in dpm/100 cm^2 units are obtained. Total surface activity measurement results will be reviewed to ensure that the applied background values are appropriate.

The statistical evaluation of the resulting set of measurements is examined. When the results statistically exceed the administrative action levels, the findings will be investigated. The SEG spreadsheet program, CNTTIME© is used to establish the statistical limits based on instrument type, detector efficiency, background and counting duration. The program provides counting time, scaler alarm settings, point and MDA settings in dpm and dpm/100 cm^2. The confidence level for false positive values may be varied to reflect confidence intervals from the 95 to the 99.9 percentile. CNTTIME© in conjunction with applicable Regulatory Guide 1.86 guidelines, provides the values and flag conditions for critical and action levels.

b. Removable Contamination Measurements

Measurements of removable surface activity will be converted from gross count rate to units of net dpm/100 cm^2 by subcontracting the background count rate of the smear counting detector and correcting the net count rate for detector geometry and efficiency.

5.6.3 Attainment of Release Criteria for Surface Contamination

The methods outlined below will be used to demonstrate attainment of the release criteria limits.

a. Total Surface Activity (fixed plus removable contamination):

Individual measurements: Do not exceed 15,000 dpm/100 cm^2 for uranium or 3000 dpm/100 cm^2 for thorium.

Sample: Upper limit of confidence interval for the mean value is below 5000 dpm/100 cm^2 for uranium and 1000 dpm/100 cm^2 for thorium.

b. Removable Surface Contamination:

Individual measurements: Do not exceed 1000 dpm/100 cm^2 for uranium and 200 dpm/100 cm^2 for thorium.

c. Calculation of Upper Limit of Confidence Interval of the mean:

$$U_a = \overline{X} + t_{1-a,\,df} \frac{s_x}{\sqrt{n}}$$

where:

U_a	=	upper confidence limit of population mean, and
x	=	sample mean value
$t_{1-a,\,df}$	=	Student T statistic for the degree of confidence and degrees of freedom; df (degrees of freedom) is equal to n - 1 and "a" is 0.05 for this test.
s_x	=	sample standard deviation
n	=	number of measurements in the population

5.6.4 Evaluation of Soil Sample Results

All soil samples will be evaluated for total uranium and total thorium activity by gamma spectroscopy analysis at Scientific Ecology Group, Inc., in Oak Ridge, Tennessee, or by another approved licensed facility. The samples will be analyzed such that the MDA value for total thorium and uranium is 10% of the guideline values of 10 pCi/g and total thorium and 35 pCi/g total uranium activity. All samples will be collected according to SEG procedure, packaged and shipped for analysis. Duplicate samples will also be submitted for Quality Assurance and Quality Control according to procedure.

6.0 QUALITY ASSURANCE AND QUALITY CONTROL

The Quality Assurance program is constructed to ensure that all quality and regulatory requirements are satisfied. All activities affecting quality are suitably controlled by SEG procedures. A list of the applicable procedures to be implemented and used during the final release survey are presented in Appendix A. These procedures ensure that the appropriate equipment, environmental conditions, quality controls and prerequisites for any given activity are met. These procedures include the following Quality Control measures as an integral part of the final release survey process.

6.1 General Provisions

6.1.1 Selection of Personnel

The selection of supervisory personnel directing the final survey is based upon their experience and familiarity with Final Survey procedures and processes. Health Physics technicians performing the surveys are selected based upon their experience and ability to meet ANSI-3.1 qualifications. All of the personnel have previously performed final surveys on other projects. Training and qualification records will be maintained for all personnel selected to perform the final survey.

6.1.2 Written Procedures

All final survey tasks which are essential to survey data quality will be controlled by procedures. Appendix A is a list of SEG procedures utilized for the Bloomfield project. Appendix B contains procedures which control the Final Survey process.

6.1.3 Instrumentation Selection, Calibration and Operation

Instrumentation has been selected which has been proven to reliably detect the contaminants present at the Bloomfield site. Instrumentation will be operated and counting times established such that the minimum MDA values for the various measurements will be at least 75% of the specified values provided in Table 3-1. Table 4-1 lists the instruments to be used.

Instrumentation calibrations are performed either under approved procedures using calibration sources traceable to the National Institute of Standards and Technology (NIST) or by qualified vendors with the results traceable to NIST (National Institute of Standards and Technology). Measurements are performed using approved written procedures for each instrument. Issue, control and accountability of all survey instrumentation has been established by an instrumentation control procedure. Procedures for calibration, maintenance, accountability, operation and quality control of radiation detection instruments are written to implement the guidelines established in American National Standard Institute (ANSI) standard ANSI N323-1978 and ANSI N42.17A-1989. All detectors used during surveys for direct measurement are subject to the following quality control checks:

- All 100 cm^2 detectors will be subjected to a linearity check. This involves counting a NIST traceable source of known activity at each end of the detector and ensuring that both counts fall within $\pm 20\%$ of the mean of the counts. If an acceptable linearity check is obtained, an efficiency is calculated.

- An efficiency in cpm/dpm is determined for each detector to be used for direct beta-gamma and alpha measurements. The efficiency is determined daily before and after use. The pre-use efficiency will be used to determine surface activity for all surveys done that day in dpm/100 cm^2.

- The post-use efficiency is used to check detector operability at the end of the day. An acceptability range of $\pm 20\%$ will be used to determine detector operability. If the post-use efficiency was not within the data quality objective of $\pm 20\%$ of the pre-use efficiency, the lower efficiency of the two will be used.

- The above checks will also be carried out following any repairs or modifications to the Ludlum Model 2350/detector set-up (e.g., mylar window change, change in high voltage cable, etc.)

6.1.4 Survey Documentation

The survey packages will be the primary method of controlling and tracking the hardcopy records of final survey results. Records of final surveys will be documented and maintained in the survey package for each area according to SEG procedures. Each Final Survey measurement will be identified by the date, technician, instrument type and serial number, detector type and serial number, location code, type of measurement, mode of instrument operation, and QC (Quality Control) sample number, if applicable.

6.1.5 Quality Control - Verification

Replicate field and laboratory measurements will be performed independently on a selected sample of survey measurements. Instruction regarding the type and number of Quality Control measurements are contained within the applicable procedures.

6.1.6 Chain of Custody

Procedures establish responsibility for custody of samples and survey data from the time of measurement or collection until final results are obtained. All samples shipped off-site for analysis will be accompanied by a chain-of-custody record to track each sample.

6.1.7 Records Management

Generation, handling and storage of final survey design and data packages is controlled by an approved procedure.

6.1.8 Independent Review of Survey Results

The survey package from each survey unit will be given independent review to verify all documentation is complete and accurate and that release criteria have been met prior to input into the Final Survey Database.

6.2 Training

Prior to implementation of the Final Survey Plan, applicable project personnel shall receive additional training, including an overview of the Final Survey Plan, the objectives of the final survey and on procedures governing the final survey.

6.3 Laboratory Services

Gamma spectrometry analyses are provided by the Scientific Ecology Group, Inc., at their laboratory in Oak Ridge, Tennessee. The analyses are performed in accordance with SEG procedures and subject to the SEG Quality Assurance Program. During the final survey, quality control duplicate samples will be analyzed in accordance with project procedures.

7.0 FINAL REPORT

Upon completion of the final survey, a final report will be prepared for submission to the Nuclear Regulatory Commission. The report will follow the guidance of Draft NUREG-CR/5849 regarding content.

7.1 Topical Outline

The Final Report will address the following topics. The report will provide adequate data and discussion of each topic to meet the intent of Draft NUREG/CR-5849. The following describes the format for the Final Report with regards to document volumes, topical outline and content:

List of Figures
List of Tables
1.0 Introduction and Scope
- 1.1 Introduction
- 1.2 Project Scope

2.0 Background Information
- 2.1 Facility Description
- 2.2 Operating History
- 2.3 Decommissioning Purpose and Objectives
- 2.4 Management Approach
- 2.5 Radiological Characterization

3.0 Decommissioning Activities
- 3.1 Decommissioning Approach and Procedures
- 3.2 Summary of Decommissioning Activities
- 3.3 Waste Generation

4.0 Final Survey
- 4.1 Introduction
- 4.2 Final Survey Guideline Values
  - 4.2.1 Regulatory Agencies
  - 4.2.2 Nuclides of Concern
  - 4.2.3 Minimum Detectable Activity
- 4.3 Instrumentation
  - 4.3.1 Instrument Types
  - 4.3.2 Instrument Calibration
  - 4.3.3 Quality Control

8.0 REFERENCES

8.1 USNRC NUREG/CR-5849, *Manuals for Conducting Radiological Surveys in Support of License Termination*, Draft, June, 1992

8.2 USNRC *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of License Byproduct, Source or Special Nuclear Materials*, May, 1987.

8.3 USNRC Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*, June, 1984

8.4 ORISE, *Radiological Decontamination Confirmatory Survey, Westinghouse Bloomfield Lamp Plant, Buildings 7, 8, and 9*, August, 1992.

8.5 SEG, *Bloomfield Lamp Plant, Site Characterization Survey Plan, Building 7, 8, 9, and 10A, Westinghouse Electric Corporation, Bloomfield, New Jersey*, December, 1993.

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APPENDIX A

List of Procedures

List of Procedures

REDS-CHM-101	Sample Identification and Chain-Of-Custody
REDS-CHR-100	Site Characterization Plan
REDS-CHR-101	Characterization of Structures
REDS-CHR-102	Characterization of Systems
REDS-CHR-106	Surface Soil Sampling
REDS-CHR-107	Subsurface Soil Sampling
REDS-DEC-201	Operation of Wall and Floor Scabblers
REDS-DEC-203	HEPA Vacuum Operation
REDS-DEC-204	Operation and Maintenance of the PENTEK CORNER CUTTER
REDS-DEC-205	Operation and Maintenance of the PENTEK SQUIRREL-III Scabbler
REDS-DEC-206	Operation and Maintenance of the PENTEK VAC-PAC Models 6A and 9A
REDS-DEC-301	Decontamination of Tools, Equipment and Area
REDS-DEC-302	Control and Use of Radiological Containments
REDS-DEC-303	Decontamination Techniques - Selection and Precautions
REDS-FSP-100	Preparation of a Final Survey Plan
REDS-FSP-101	Final Surveys of Structures
REDS-FSP-103	Final Surveys of Environs
REDS-FSP-104	Final Survey Data Handling and Analysis
REDS-HS-101	Confined Space Entry
REDS-INST-100	Radiation Protection Instrumentation Program
REDS-INST-101	Issue, Control and Accountability of Radiation Protection Instrumentation
REDS-INST-102	Quality Control of Counting Systems and Portable Counters
REDS-INST-201	Operation of the Ludlum Model 2350 Data Logger
REDS-INST-203	Operation of NE Technology CM7A Contamination Monitor
REDS-INST-205	Operation of Ludlum Model 3 Survey Meter with Model 44-9 Beta Gamma Probe or Model 43-5 Alpha Scintillation Probe

List of Procedures
(continued)

REDS-INST-206	Operation of the Ludlum Model 19 Micro-R Meter
REDS-INST-207	Operation of Eberline Ion Chamber Model RO-2/RO-2A
REDS-INST-209	Operation of Ludlum Model 177 Portable Frisker
REDS-INST-211	Operation of Eberline BC-4 Portable Beta Counter
REDS-INST-212	Operation of Eberline SAC-4 Portable Alpha Counter
REDS-INST-216	Operation of F&J Lv-1 and Hv-1 air samplers
REDS-OPS-201	Radiation Work Permits
REDS-OPS-202	Selection and Use of Protective Clothing
REDS-OPS-301	Performance of Surveys
REDS-OPS-302	Survey Documentation and Review
REDS-OPS-303	Posting of Radiologically Controlled Areas
REDS-OPS-304	Analysis and Evaluation of Air Samples
REDS-RAM-103	Unconditional Release of Tools, Equipment and Waste Materials
REDS-RSP-101	Selection and Issue of Respiratory Protection Equipment
REDS-RSP-104	Respirator Fit Test
REDS-RSP-105	Respirator Cleaning and Drying
REDS-RSP-107	Use of Respiratory Protection Equipment

APPENDIX B

Final Survey Procedures

SCIENTIFIC ECOLOGY GROUP, INC.

RADIOLOGICAL ENGINEERING AND DECOMMISSIONING SERVICES

REDS-FSP-100

REVISION 0

PREPARATION OF A FINAL SURVEY PLAN

PREPARED BY: John P. Andrews — 1-31-94
Author — **Date**

REVIEWED BY: [signature] — 2/4/94
Reviewer — **Date**

APPROVED BY: [signature] — 2-7-94
Donald R. Neely — **Date**
Vice President
Radiological Engineering and
Decommissioning Services

1.0 PURPOSE

This procedure describes the administration, policies and requirements for the preparation and implementation of a *Site Final Survey Plan* for reactors and facilities licensed for byproduct, source or special nuclear material or unlicensed facilities that have experienced an incident.

2.0 APPLICABILITY

This procedure applies to all project personnel involved in the supervision of or preparation of the plan for the final survey for termination of the license for a facility.

3.0 REFERENCES & COMMITMENTS

3.1 References

3.1.1 USNRC. NUREG/CR-5849. *Manual for Conducting Radiological Surveys in Support of License Termination*. Draft. June 1992.

3.1.2 USNRC. Regulatory Guide 1.86. *Termination of Operating Licenses for Nuclear Reactors*. June 1984.

3.1.3 USNRC. *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material*. May 1987.

3.1.4 REDS-FSP-101. *Final Survey of Structures*.

3.1.5 REDS-FSP-102. *Final Survey of Systems*.

3.1.6 REDS-FSP-103. *Final Survey of Environs*.

3.1.7 REDS-FSP-104. *Final Survey Data Handling and Analysis*.

3.1.8 *Site Final Survey Plan*.

3.1.9 *Health and Safety Plan*.

3.2 Commitments

None

4.0 GENERAL

4.1 Discussion

This procedure provides guidance on the planning for final surveys. It describes the essential contents of the *Site Final Survey Plan* for all facilities. The plan must contain all the necessary administrative decisions that affect the performance of the final survey.

Final surveys are designed and performed in such a manner that the requirements of decommissioning plans and procedures are met, allowing for license termination. The survey design is based on the assumption that the entire building is below guideline values and that the remaining activity is essentially normally distributed. If the results of the surveys demonstrate that this assumption is not true, then the surveys defined in this procedure should be modified to accommodate the changed conditions.

In addition to the administrative, policy and technical requirements specified by this procedure, implementing procedures provide more detailed instructions. These procedures are REDS-SFSP-101, *Final Survey of Structures*, REDS-SFSP-102, *Final Survey of Systems*, REDS-SFSP-103, *Final Survey of Environs* and REDS-SFSP-104, *Final Survey Data Handling and Analysis*.

4.2 Definitions

4.2.1 Affected Area

Areas that have potential radioactive contamination (based on plant operating history) or known radioactive contamination (based on past or preliminary radiological surveillance). This would normally include areas where radioactive materials were used and stored, where records indicate spills or other unusual occurrences that could have resulted in spread of contamination, and where radioactive materials were buried. Areas immediately surrounding or adjacent to locations where radioactive materials were used, stored, spilled, or buried are included in this classification because of the potential for inadvertent spread of contamination. The *Site Final Survey Plan* must identify all affected areas.

4.2.2 Biased Survey

A survey based on measurement or sample locations selected in a non-random manner, considering the expected distribution of radioactivity. Biased surveys are usually performed in an affected area. Biased surveys are taken using the best judgement of the person doing the survey. In general biased surveys cannot be treated as a statistical sample of the population; the use of these surveys is limited in the final survey program. All surveys in the final survey program should be unbiased random or systematic surveys.

4.2.3 Final Survey

A survey of the area demonstrating that it meets the acceptance criteria for termination of the license.

4.2.4 Guideline Values

A set of numerical guidelines that enable the licensee to demonstrate compliance with release criteria for unrestricted use of a facility or site. The *Site Final Survey Plan* must specify the guideline values for the final survey program.

4.2.5 Location Code

A unique code designating a survey location or unit.

4.2.6 Random Survey

A survey in which the points are selected by a random process, not a technician. Random processes include the use of a random sheet produced by a computer code. Random surveys are unbiased and are usually used for indoor areas.

4.2.7 Stratum

Division of a site into two or more groupings by: geography; survey blocks; homogeneity of beta or gamma variance; homogeneity of soil nuclides variance; operational or processing areas; areas of decreasing hazard potential; or a combination of the same, for convenience of the surveyor or of the statistician, or both.

4.2.8 Survey Area

An easily identifiable area selected for radiological evaluation that may be divided into smaller, more manageable units as necessary (e.g., a building elevation or portion thereof, a room). Survey areas must exist within only one stratum. The *Site Final Survey Plan* must identify all survey areas.

4.2.9 Survey Location

The survey data point within a grid square or in an ungridded area.

4.2.10 Survey Package

The portfolio for a specific area being surveyed. Each survey package contains the details for surveillance including sample locations, types of measurements, sample point selection criteria, background determinations, maps, diagrams, photographs and the results and analyses of all data collected. The *Site Final Survey Plan* should contain a list of all survey packages.

4.2.11 Survey Unit

A division of a Survey Area that is expected to have similar contamination deposition patterns (e.g., floors, walls, horizontal surfaces).

4.2.12 Systematic Survey

A survey in which sample and measurement points are selected based upon an organized method, such as grid line intersections. If all points or a regular interval set of points are measured, this type of survey is unbiased. If grid points are selected randomly, the survey is a random unbiased survey.

4.2.13 Unaffected Area

All areas not classified as affected. These areas are not expected to contain residual radioactivity, based on a knowledge of site history and previous survey information. The *Site Final Survey Plan* should identify all unaffected areas.

4.2.14 Unbiased Survey

A survey based on measurement or sample locations selected in a random manner usually in an unaffected area that has been marked off in a uniform grid pattern. In an unbiased survey, all points are equally likely to be surveyed. All final surveys should be unbiased.

4.3 Responsibilities

4.3.1 The Project Manager or designee is responsible for the preparation, administration and implementation of the *Site Final Survey Plan* and supporting procedures.

4.4 Prerequisites

4.4.1 A characterization survey should have been completed to determine the radionuclides present. If any characterization work remains, it should be defined in the *Site Final Survey Plan.*

4.5 Precautions & Limitations

4.5.1 The *Site Final Survey Plan* may be modified during implementation based on the data obtained and/or the licensee's requirements. Requirements for modifications will be listed in the plan.

4.6 Apparatus

None

4.7 Records

All records must be retained for the duration of licensed activities. The plan should provide for archiving records to meet regulatory and client requirements.

4.7.1 Survey Packages

4.7.2 Site Historical Records

4.7.3 Site Drawings

4.7.4 Supporting Lists and Databases

5.0 PROCEDURE

5.1 Introduction

Prepare an introduction to the *Site Final Survey Plan* that describes for the reader what the plan contains and describes for whom the plan was written.

5.2 Site History and Description

5.2.1 Prepare a section of the plan discussing the history of the site, the processes used in each of the buildings, radionuclides used on site, and the duration of processing.

5.2.2 Describe each of the buildings on the site.

5.2.3 Describe the general site and the local environment within several miles of the site. Include a description of surface water flow in the vicinity of the site.

5.2.4 Describe all available information on the ground water in the vicinity of the site including the location of wells and a summary of results of recent ground water surveys.

5.2.5 Describe the current site conditions at the time of the final survey and identify all contaminants that exist in the survey areas.

5.3 Scope of the *Site Final Survey Plan*

5.3.1 Establish the survey objectives, i.e., to demonstrate that the radiological conditions at the site satisfy the NRC or state or other government agency guidelines for release from licensing.

5.3.2 Describe the organization and responsibilities of the survey team. An organizational chart may be provided to show lines of authority and responsibility for key adminstrative and radiological management positions.

5.3.3 Provide a general schedule which will be followed to complete survey activities.

5.3.4 Unrestricted Release Acceptance Criteria

1. Establish the legal limits or guideline values for the surveys based upon the radionuclides present at the site. Select these values from tables developed by the NRC and included in Regulatory Guide 1.86, *Termination of Operating Licenses for Nuclear Reactors*, for decommissioning of reactor facilities and in *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source or Special Nuclear Material*, for decommissioning of source material or byproduct material licensed facilities.

2. Establish all the administrative limits for the site. Base these values on the statistical confidence parameters for the license termination survey approved by the client. A statistical basis should be provided for administrative limits if they differ from the legal limits.

3. Establish the MDA (Minimum Detectable Activity) probabilities for failure to detect (alpha) and false detection (1-beta) in the plan. Avoid using the usual MDA probabilities because they provide much too large probability of false detection. Instead, set the probabilities to be used for the MDA calculation.

5.3.5 Clearly establish the physical boundaries for the site and the designated areas to be surveyed.

5.4 Survey Design

Survey design in the *Site Final Survey Plan* should be based on the requirements of NUREG/CR-5849, *Manual for Conducting Radiological Surveys in Support of License Termination.*

5.4.1 Area Walkdowns

1. Perform walkdowns of the facility, supporting systems and structures and the associated outdoor areas. Observations made during walkdowns provide additional information concerning the history of the site, processes used and nuclides present.

2. Note the following in the walkdown:

   a. Housekeeping status reflecting past practices;

   b. Difficult access to an area or component;

   c. Inoperable equipment;

   d. Availability of access points;

   e. Penetrations, blind flanges, drain valves, etc.

   f. Special equipment or protective equipment needed;

   g. General materials of construction for floors, walls, and overhead, dropped ceilings, carpeting, evidence of painting to cover contamination, etc.

   h. Interferences in the purposed survey area

3. Take photographic, video and/or audio records of the walkdown. Make written records of the walkdown using Attachment 6.1, *Walkdown Record Sheet* or equivalent. Each walkdown participant should record his or her own observations.

5.4.2 Classify Areas and Establish Strata

1. Do a document search to identify those sections of the site which will be surveyed. Consult site drawings, licenses, former employees, correspondence and other related site documents to obtain site history, information on processes used at the site and radionuclides used, stored or processed in each area.

2. Divide the buildings or structures, systems and outdoor areas at the site into survey areas and units. Show all survey areas or units on drawings. Provide a list (or database) of all survey areas and survey units.

3. Classify survey areas into the two major subdivisions based upon potential for residual contamination, as affected or unaffected. Base this classification on the history of radioactive materials use or storage or potential for contamination of the overall survey area.

4. Classify areas as affected when the following conditions apply:

   a. A potential for contamination exists based on operating history;

   b. Contamination does exist based on radiological surveys;

   c. Radioactive materials were used or stored in the area;

   d. Records indicate spills or incidents which resulted in contamination occurring in the area; and

   e. Radioactive materials were circulated, stored or processed in systems.

5. Classify areas as unaffected if they are not expected to contain residual activity and do not meet the criteria for classification as affected.

6. Use additional unique strata to define other areas such as distinct geologic formations. All strata must be independent and must be inclusive of the entire site.

7. Survey areas may be reclassified from unaffected to affected whenever new information is obtained concerning the radiological status of the area.

8. Specify in the plan that survey areas may **NOT** be reclassified from affected to unaffected.

5.4.3 Establish Information Databases

1. Organize all information collected in the document search and walkdowns in a database to provide easy access to it for survey package development and future reports. The types of information in the database include but are not limited to the following:

   a. Site descriptions and maps;

   b. Site history documents;

   c. Copies of licenses;

   d. Previous surveys performed in survey areas;

   e. Survey area maps;

   f. Walkdown record sheets; and

   g. Photographic, video or audio records of the survey areas.

2. Provide in the plan for the following databases. These may be made up of a number of files and independent tables and programs to do various reports and calculations.

   a. Package database to hold the details of the surveys and the survey progress information.

   b. Raw survey information database to hold all raw data before computer processing. This database becomes the basis for all derived values. Raw files are never edited. Raw files include such things as direct survey results downloaded from computerized survey meters, analytical measurement raw data files from spectrometers, and the original records from data recorded on forms and in notebooks.

   c. Survey database containing details of all direct and indirect (sampling) measurement surveys, and the basis for all computations and editing of survey data.

   d. Location database containing the descriptions of all codes used to define survey location points.

e. Instrument database containing all survey instrument information including makes, models, serial numbers, use dates, calibration information and quality control information.

5.4.4 Survey Packages

Prepare survey packages for each survey area. Each package must contain survey worksheets which identify specific instructions for the area survey and other information which may be pertinent to the area. Include scaled drawings in the packages. If the preparation of survey packages is part of the final survey activity, then the plan must contain instructions for defining the surveys to be performed and sufficient detail to permit evaluation of the adequacy of the surveys.

5.4.5 Area Preparation

1. Specify cleanliness criteria for surveys. Dirty or wet surfaces cannot be surveyed for direct radiation. If necessary, survey areas should be cleaned and inspected before surveys are started.

2. Establish the requirements for gridding to provide a mechanism for referencing sample or measurement locations for systematic and random surveys. Systematic and random surveys are used for determining the statistical values for packages.

   a. Normally interior floors and the lower (<2 meters high) walls of an affected area are gridded into grids no smaller than one square meter. If there is a potential for upper wall and ceiling contamination, provide for grids on these surfaces also. Otherwise grids of larger spacing can be used, or surveys can be referenced to the floor or lower wall grids.

   b. Normally outdoor areas and grounds that are affected are gridded at 10 meter intervals. Unaffected areas do not require gridding; however, grid systems of larger spacing (5-15 meters for interior surfaces and 20-50 meters for outdoor areas) should be used to reference survey locations.

5.5 Instrumentation and Equipment

5.5.1 Select instrumentation to detect the type of radiation of interest and to meet or exceed the legal and administrative limit requirements. Specify that operation and calibration of instrumentation must be in accordance with approved procedures.

5.5.2 Provide a list of field instrumentation showing manufacturer, model and detectors to be used in the *Site Final Survey Plan.*

5.5.3 Provide a list of laboratory instrumentation showing manufacturer, model and detectors to be used in the *Site Final Survey Plan.*

5.5.4 If calibration will be performed off site, provide a list of calibration vendors, showing the types of instruments to be calibrated and traceability to NIST.

5.5.5 If calibration will be performed on site, describe the calibration methods to be used for each instrument.

5.5.6 Provide a list of sources, showing the nuclide, radiation emitted, approximate intensity in units comparable to the units for the limits which will be used for the final survey.

5.5.7 Minimum Detectable Activity (MDA) Criteria

Use an appropriate equation for the type of instrument used to establish the MDA criteria for surveys to meet the established confidence levels.

5.5.8 Selection of Counting Time

1. The selection of the counting time for different types of surveys will be based on the normal range of backgrounds and the predetermined range of acceptable efficiencies for the detectors in use at the site.

2. Require that counting times for background and samples be determined before doing surveys.

3. The counting times should be long enough so that when activity is detected at the administrative limits, the detection decision is based on Normal statistical criteria.

5.6 Final Survey Techniques

Descriptions of the final survey techniques are detailed in the *Site Final Survey Plan.*

5.6.1 Surface Scanning

Provide that surfaces in affected areas be scanned to identify the presence of elevated direct radiation. When scans are required, specify that these be performed prior to any fixed measurements. Surface scanning done as part of the decontamination program to release an area for final survey will meet the scan requirement and need not be repeated.

5.6.2 Surface Measurements - Direct

Provide that large area (100 to 500 cm^2) detectors be used for direct measurements. Choice of detector size may depend on accessibility and cost factors.

5.6.3 Surface Measurements - Removable

1. Provide for measuring removable contamination at each direct measurement location. However, removable contamination is rarely found following decontamination; so if experience dictates, provide for a smaller number of smears than direct measurements.

2. Provide that smears be collected randomly or systematically, not using biased locations.

3. Provide that the analysis protocol is appropriate for the nuclide being measured.

5.6.4 Exposure Rate Measurements

1. Reactor Facilities

   a. Provide for measurements of gamma radiation one meter from affected surfaces. Design this so as not to make duplicate measurements.

   b. Provide for gamma measurements above the floor only if there is significant probability of neutron activation and potential occupancy of the area.

2. Other Facilities

   For facilities where no activation is possible, provide for gamma measurements if there is a potential for significant buried or covered contamination that can be measured only with penetrating gamma radiation.

3. Activity Verification

   If gamma measurements are to be made, provide for the appropriate field gamma spectroscopy equipment to verify that the measured activity is from licensed material.

5.6.5 Accessibility Restrictions

1. If areas are inaccessible and may be contaminated, provide in the plan the actions to take to evaluate the area and establish the absence of radioactive contamination.

2. Provide for special survey instrumentation and techniques to be used when normal instruments cannot be used.

3. Provide for control of penetrations. Penetrations are monitored using either removable contamination techniques or direct measurement techniques. Measurements must be made before any decontamination of the penetration.

5.6.6 Background Measurements

Describe in the plan the purpose of the background survey if it is required. Provide for each type of measurement to be made and the specific use of the information determined. Perform a background survey only if it is necessary to show the absence of radioactive materials at the site. This would be necessary if one of the radioactive contaminants was naturally occurring in the general environment.

1. Alpha and Beta Backgrounds

   Alpha and beta backgrounds are measured locally as part of the survey. Alpha and beta backgrounds are taken in each area using a shield so that the response of the detector is measured in net counts per time.

2. Gamma Backgrounds

   Gamma backgrounds are measured locally as part of the survey. The mean value of the gross gamma reading is taken as the background for the local area for comparison against the 5 μR/hr value. As an additional test, the positive readings for gamma radiation must exceed the 99th percentile for the area AND the 5 μR/hr value above the mean for the local area.

5.6.7 Sample Collection

1. Collection

   a. Provide for sample collection depending on the specific conditions found at the facility. Samples of soil collected following decontamination or soil in unaffected areas should be obtained to demonstrate that the mean residual activity is less than the applicable limit. Provide that sampling procedures adhere to ASTM procedures.

   b. Other types of samples may be useful to demonstrate the absence of contamination under surface coatings, wall junctions, in concrete, etc.

2. Custody

   Provide in the plan for control of custody and security of samples from the time the sample is collected.

5.6.8 Sample Analysis

Sample analysis methods should be described in the plan. Include in this discussion the laboratory instruments to be used for analysis and the MDA capabilities of the instruments.

5.6.9 Exceeding Limits

The plan should discuss actions in the event that survey results exceed site limits.

1. **IF** administrative limits are exceeded in two or more adjacent survey points, **THEN** an investigation should be initiated and documented per REDS-FSP-104, *Final Survey Data Handling and Analysis*.

2. **IF** guideline values (regulatory limits) are exceeded, **THEN** an investigation should be initiated and documented per REDS-FSP-104, *Final Survey Data Handling and Analysis*.

5.7 Documentation

5.7.1 Provide that all original survey documents and calculations be kept as evidence of the surveys performed. These documents may not be altered or changed except under controlled conditions.

5.7.2 Final survey records are original records and should be maintained in survey packages prepared for each survey area. The specific records compiled in a survey package should include the following:

1. Survey package identification, survey location information, historical information of area surveyed, general survey instructions and any specific survey instructions.

2. Comments from the survey technician regarding any unusual situation that he may have encountered while surveying.

3. Physical Data Sheet, documenting physical characteristics pertinent to a cost analysis.

4. The survey diagram of the area surveyed. Survey grids must be represented on the drawing, if applicable.

5. Photographs of the survey area showing the physical features and grid markings.

6. Printout of smear survey analyses (if performed).

7. Printout of gamma spectroscopy results (if performed).

8. Raw data files and software converted values for all direct alpha, direct beta, and exposure rate measurements (if performed).

5.8 Quality Assurance/Quality Control

5.8.1 Quality Assurance

The Quality Assurance program is constructed to ensure that, when implemented effectively, quality and regulatory requirements are satisfied. Activities affecting quality shall have suitably controlled conditions established to ensure that the appropriate equipment, environmental conditions and prerequisites for the given activity have been met. Project quality assurance criteria will be identified in a Quality Assurance Plan. This plan may be part of the *Site Final Survey Plan* if a specific plan does not exist. Quality assurance criteria will be developed for the following:

1. Management commitment and organization
2. Personnel training and qualification
3. Management assessment
4. Procurement of items and services
5. Use of computer hardware and software
6. Implementation of planned operations
7. Assessment of data usability
8. Design, construction, assembly, operation and maintenance of engineered systems
9. Inspection and acceptance testing of equipment
10. Quality audits and assessments

5.8.2 Quality Control

The Quality Control (QC) program for final surveys may also be described in the *Site Final Survey Plan* if a specific plan does not exist. Quality control will be implemented through procedures. This is a multi-faceted program to ensure the quality and accuracy of the survey data.

1. Instrumentation

   The QC program for field and laboratory instrumentation must be implemented through instrument calibration and operating procedures. Provide that the program contains the following QC elements:

   a. All instrumentation must be controlled to ensure its proper use.

   b. All instrumentation must be operated in accordance with procedures that describe precautions and limitations of the equipment used.

   c. All instrumentation must be calibrated to within the accuracy necessary for the required levels of detection.

d. Maintenance, calibration and testing schedules must be established to ensure the validity of survey data.

e. Calibration of instrumentation must be based on sources traceable NIST standards.

f. All equipment and instrumentation must be calibrated and response tested at the minimum frequencies required, before initial use, and after maintenance or modifications that could effect the instruments performance and calibration.

g. Instruments must be response tested daily before use and compared to predetermined ranges of acceptable performance.

h. All calibration and maintenance records must be maintained for each instrument.

i. Contracted calibration facilities must be on an approved vendors list.

2. Samples

The QC program for the control of samples will be implemented through the sample collection procedures. Provide that the program contains the following QC elements:

a. All samples must be labeled and identified with unique sample identification numbers to ensure sample accountability and for archiving samples.

b. Sample chain of custody must be established to prevent lost or misplaced samples.

c. Samples must be retained throughout the survey for follow-up analysis and analysis reproducibility.

d. Samples must be packaged as appropriate to prevent the loss of integrity or volume of the sample.

e. Samples must be controlled by chain-of-custody procedures and stored in designated locations.

3. Sample Analysis

The QC program for sample analysis must be implemented through laboratory analysis procedures or documented in laboratory notebooks. Provide that the following elements are included in the program:

a. Samples will be analyzed using instrumentation designed for the appropriate analysis desired.

b. Duplicate samples will be submitted to a qualified laboratory to ensure the accuracy and precision of analysis results.

c. Measurement results and analyses will be maintained and filed for record.

d. Contracted laboratories must be qualified and listed on the most current QC approved vendors list.

4. Radioactive Sources

Radioactive sources used for final survey activities must be controlled in accordance with the radioactive source control procedures. Provide that the program contains the following QC elements:

a. Sources must be stored in a locked cabinet located in the instrument facility and must be issued to survey technicians when needed in the field.

b. A source sign-out sheet must be used to track location of sources used in the field.

c. Survey technicians must be required to sign all sources in and out of the instrument facility.

d. Source inventory must be performed on a quarterly basis.

e. All sources must be leak tested using the smear method upon arrival at the site and on an annual basis.

5. Data Processing, Management and Control

Data processing, management and control will be implemented through final survey procedures. Provide that the following elements are included in the QC program:

a. Methods of data generation, handling, computations, evaluation and reporting will be documented.

b. A system of data review and validation will be used to ensure consistency, thoroughness and acceptability of survey data.

c. Methods for interpreting, evaluating and managing final survey data are detailed in REDS-SFSP-104, *Final Survey Data Handling and Analysis* and the *Site Final Survey Plan.*

5.9 Final Survey Report Preparation

Following completion of the final survey, a Final Survey Report will be prepared for the site. The report will provide all information needed for the NRC to make a decision concerning termination of the site's license. Describe briefly in the *Site Final Survey Plan* the contents of the report. The contents should include the following:

5.9.1 Decommissioning/survey background

5.9.2 Site and facilities descriptions

5.9.3 Operating history

5.9.4 Decommissioning/decontamination activities

5.9.5 Final survey procedures/protocol

5.9.6 Survey results

5.9.7 Comparisons of results with guideline values

5.9.8 Conclusion that the site meets requirements for license termination

6.0 ATTACHMENTS

6.1 *Walkdown Record Sheet* (example)

ATTACHMENT 6.1
WALKDOWN RECORD SHEET
Sheet _ of _

Participant:	Date:	
Facility:		
Purpose:		
Observation No.	Finding	Comment

Participant Signature_____

SCIENTIFIC ECOLOGY GROUP, INC.

RADIOLOGICAL ENGINEERING AND DECOMMISSIONING SERVICES

REDS-FSP-101

REVISION 0

FINAL SURVEYS OF STRUCTURES

PREPARED BY: _____ 2/9/94
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REVIEWED BY: _____ 2/11/94
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APPROVED BY: _____ 2/17/94
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1.0 PURPOSE

This procedure provides methods for defining and controlling final surveys to assure that all required surveys are performed and the data are acceptable.

2.0 APPLICABILITY

This procedure applies to all project personnel preparing final survey packages and performing final surveys.

3.0 REFERENCES & COMMITMENTS

3.1 References

3.1.1 REDS-FSP-100. *Preparation of a Final Survey Plan.*

3.1.2 REDS-FSP-104. *Final Survey Data Handling and Analysis* .

3.1.3 REDS-OPS-301. *Performance of Surveys.*

3.1.4 *Site Final Survey Plan.*

3.1.5 *Site Health and Safety Plan.*

3.2 Commitments

None

4.0 GENERAL

4.1 Discussion

The objective of this procedure is to provide guidance for the collection of sufficient and accurate radiological data from representative locations such that a statistically sound conclusion about the radiological status of the structure can be developed. This procedure implements the survey requirements stated in the site final survey plan for structures.

This procedure provides guidance on the preparation and performance of final surveys of site structures. Final surveys are designed and performed in such a manner that the requirements of decommissioning plans and procedures are complied with, allowing for license termination. The final surveys will be deemed to have complied with plans and procedures if all survey results are less than the limits specified and the surveys are of sufficient sensitivity, accurate, reproducibility, and detail and are well documented. Final surveys will be considered complete upon review and closure of final survey packages.

This procedure assumes that the cleanup efforts have removed essentially all the contamination from the building and that the cleanup efforts have been effective. The survey design is based on the assumption that the structure is below the guideline values and that the remaining activity is essentially normally distributed. If the results of the surveys demonstrate that this assumption is not true, then the surveys defined in this procedure should be modified to accommodate the changed conditions.

4.2 Definitions

4.2.1 Affected Area

Areas that have potential radioactive contamination (based on plant operating history) (or preliminary radiological surveillance). This would normally include areas where radioactive materials were used and stored, where records indicate spills or other unusual occurrences that could have resulted in spread of contamination, or where radioactive materials were buried. Areas immediately surrounding or adjacent to locations where radioactive materials were used, stored, spilled, or buried are included in this classification.

4.2.2 Biased Survey

A survey based on measurement or sample locations selected in a non-random manner, considering the expected distribution of radioactivity. Biased surveys are usually performed in an affected area. Biased surveys are taken using the best judgement of the person doing the survey. In general biased surveys cannot be treated as a statistical sample of the population.

4.2.3 Final Survey

A survey of the area demonstrating that it meets the acceptance criteria for termination of the license.

4.2.4 Interference

An object in a survey area which cannot be removed, and thus obstructs the survey of surfaces adjacent to the interfering object.

4.2.5 Location Code

A unique code designating a survey location or unit.

4.2.6 Random Survey

A survey in which the points are selected by a random process, not a technician. Random processes include the use of a random sheet produced by a computer code. Random surveys are unbiased and are usually used for indoor areas.

4.2.7 Stratum

Division of a site into two or more groupings by: geography; survey blocks; homogeneity of beta or gamma variance; homogeneity of soil nuclides variance; operational or processing areas; areas of decreasing hazard potential; or a combination of the same, for convenience of the surveyor or of the statistician, or both.

4.2.8 Structure

A building or similar large object located on the survey site.

4.2.9 Survey Area

An easily identifiable area selected for radiological evaluation that may be divided into smaller, more manageable units as necessary (e.g., a building elevation or portion thereof, a room). Survey areas must exist within only one stratum.

4.2.10 Survey Location

The survey data point within a grid square or in an ungridded area.

4.2.11 Survey Package

The portfolio for a specific area being surveyed. Each survey package contains the details for surveillance including sample locations, types of measurements, sample point selection criteria, background determinations, maps, diagrams, photographs and the results and analyses of all data collected.

4.2.12 Survey Unit

A division of a Survey Area that is expected to have similar modes of contamination and deposition patterns (e.g., floors, walls, horizontal surfaces).

4.2.13 Systematic Survey

A survey in which sample and measurement points are selected based upon an organized method, such as grid line intersections. If all points or a regular interval set of points are measured, this type of survey is unbiased. If grid points are selected randomly, the survey is unbiased.

4.2.14 Unaffected Area

All areas not classified as affected. These areas are not expected to contain residual radioactivity, based on a knowledge of site history and previous survey information.

4.2.15 Unbiased Survey

A survey based on measurement or sample locations selected in a random manner usually in an unaffected area that has been marked off in a uniform grid pattern. In an unbiased survey, all points are equally likely to be surveyed.

4.3 Responsibilities

4.3.1 The Project Manager is responsible for administering this procedure. The Project Manager may change requirements of the final survey dependent upon the type and amount of contamination originally found on site, the size of the facilities decontaminated, and the client's request.

4.3.2 Project engineers are responsible for implementing this procedure.

4.3.3 Health Physics technicians are responsible for performing final surveys.

4.4 Prerequisites

4.4.1 The Project Manager shall determine if work activities require a safety work permit and the radiological protection requirements needed to perform survey activities.

4.4.2 A characterization survey of the survey area should have been completed to determine the radionuclides that may be present.

4.4.3 Any required decontamination of the survey area shall have been completed.

4.4.4 The appropriate final survey limits have been established authoritatively.

4.5 Precautions and Limitations

4.5.1 All personnel performing radiological measurements shall be qualified in the use of the instruments and laboratory analysis equipment.

4.5.2 Survey technicians and supervisors must be trained and qualified to this procedure.

4.5.3 Prior to surveying any area ensure all safety requirements are met in accordance with OSHA industry (29 CFR 1910), contractor (29 CFR 1926) safety requirements and the *Site Health and Safety Plan.*

4.5.4 The Project Manager may determine that some portions of this procedure need not be performed due to the limited scope of a project.

4.6 Apparatus

4.6.1 Survey instrumentation

4.6.2 Smears

4.6.3 Grid marking materials

4.6.4 Camera and film

4.6.5 Computers necessary to produce drawings, maintain databases, perform calculations and control scheduling of work

4.7 Records

4.7.1 Survey Packages

5.0 PROCEDURE

5.1 Background Determinations for Structures

5.1.1 Establish background response for each type of instrument to be used for surface contamination and gamma exposure rate measurements. Gamma exposure rate measurements require determination of the gamma background response of detectors at one meter from surfaces. The relative background responses of the pressurized ion chamber and micro-R instruments will be determined. In addition, backgrounds will be determined for specialized detectors and detector systems. These include: large area detectors and detectors for insitu monitoring (GM, Gas-flow Proportional, and NaI(T1) scintillator).

5.1.2 Determine background by measuring and sampling at locations on the site, or in the vicinity of the site, which are unaffected by site operations. Selection of the site structures to be surveyed for background determination will be based upon the results of the characterization survey and the structure's similarity in construction materials with the site structures which are known or suspected of being contaminated. It may be necessary to group the background readings to match the structural differences of the site. For example, a site composed of concrete buildings and lightweight steel buildings should have a background developed for each type of structure.

5.1.3 Identify locations as needed, to acquire background measurement data for each type of measurement. Collect background data in accordance with approved procedures appropriate for the instrument used. Perform background determinations for each type of final survey measurement as described below.

1. Direct Surface Beta-Gamma Measurements

   To determine background for direct surface beta-gamma measurement data will be collected at the time of survey for each survey unit. The number of background locations is dependent upon the survey unit size and complexity. The counts will be accumulated by a scaler in the preset time accumulation mode.

2. Direct Surface Alpha Measurements

   The same protocols used to determine the direct surface beta-gamma background are used to determine the direct surface alpha background. Special counting techniques may be required to assess the influence of naturally occurring radionuclides.

3. Removable Surface Measurements

Background determinations of beta-gamma smear counters will be made by taking a series of measurements of a blank smear or, a series of smears collected from an area verified free of licensed material. Mean values, standard deviation and standard errors of the mean will be determined from the data obtained using an approved procedure.

4. Gamma Exposure Rate

Measurement data will be collected at the time of survey for each survey unit. For purposes of demonstrating that residual contamination levels are below 5 μR/hr above background (measured at one meter), a Reuter-Stokes pressurized ion chamber (PIC) may be used to establish gamma exposure rate background characteristics at the survey locations. The PIC will be used as the reference instrument for establishing the gamma response of portable micro-R meters. The latter are typically used for the bulk of the final survey gamma exposure rate measurements.

Each set of measurements in each survey area will be used to define the background for that area. The median (or, if unattainable, mean) value of the set of measurements is the best value to use for gamma backgrounds.

5. Specialized Measurements

It has been observed that detector background maybe affected when detectors are inserted inside massive components or within piping embedded in concrete. This is particularly noticeable when NaI detectors are used. Thus it may be necessary either to provide a mockup of an embedded pipe, for example, or to develop empirical correction factors for backgrounds when surveying such equipment. To this end, a series of background measurements may be performed in embedded piping and in large components which can be ascertained to be free of radioactive contamination.

6. Verification of Background Measurement Population

Each population of background measurement described above will be analyzed using calculation found in REDS-FSP-104, *Final Survey Data Handling and Analysis* number of measurements in the data set is adequate to support the population statistics.

5.1.4 Documentation And Control of Background Measurements

Collect and record background measurements in a survey package in accordance with The Final Site Survey Plan.

5.2 Survey Preparation

5.2.1 Define the Survey Requirements

1. Floors and lower walls (up to two meters above the floor) of affected areas shall receive 100% survey coverage. Upper walls, ceilings and equipment not suspected of being contaminated they will not require 100% survey coverage but will require a minimum of 30 measurements each on horizontal and vertical surfaces. Adjacent grids or surfaces within 1 meter of affected areas will be surveyed as though they were also classified as affected.

2. Areas not suspected of being radioactively contaminated should have a random systematic survey of 25% of all grids in the survey area.

5.2.2 Determine the survey counting times.

1. Determine the minimum counting time for direct measurement of contamination which provides a minimum detectable activity (MDA) that is less than or equal to the established guideline values.

2. Use an appropriate software program or the following equation to determine the minimum counting times based on MDA.

3. **IF** the MDA exceeds the guideline value, **THEN** increase the counting time and recalculate the MDA until the MDA is less than 75% (preferably at or below 10%) of the guideline value.

5.2.3 Turnover for Final Survey

Prior to acceptance of a survey area for the final survey, a number of conditions will be satisfied. These include:

- Decommissioning activities having the potential to contaminate the survey unit must be completed.
- All tools and equipment not required to perform the survey should be removed.

- Housekeeping and area cleanup must be completed.
- Decontamination of affected structural areas and system components must be completed.
- Operational radiological surveys have been performed.

A physical walkdown prior to turnover will be performed to ensure the above conditions have been met. Scaffolding needed to be left in place for performance of the final survey should be identified during turnover preparation. Results of the operational radiological survey verifying the status of the area will be included in the final survey package.

5.3 Survey Design

The collection of survey measurement data by utilizing a grid basis is an option which provides for easily reproducible data. Grids are methods that can assist in the systematic selection of measuring and sampling locations while providing a mechanism for referencing a measurement to specific locations. Grids are also convenient means to determine average activity levels.

An alternative approach to a final survey is to minimize (limit) establishing area grids without compromising the quality of survey measurements while maintaining representative and appropriate grid location areas. It is further intended that if those methods are used, they will provide the same sound statistical conclusions for determination of the final survey status. Depending on cost considerations and site preference surveys will be performed using grid techniques or non-grid techniques. To this end, the required measurement location representation will be location traceable, systematic and provide for appropriate averaging of the findings.

5.3.1 Define the Survey Instructions.

The final survey instructions will be contained within the survey package per the *Site Final Survey Plan*. These instructions will specify the number and type of radiological measurements to be taken at each location or component identified in the survey design. The instructions will also identify smear samples and other samples to be collected. The survey instructions will identify those survey locations (specific components or survey points) where verification surveys are required.

5.3.2 Define the Survey Measurements.

Final survey measurements will be conducted in accordance with procedure and specific survey instructions for the survey unit provided in the survey package. A sufficient number of measurements incorporating the appropriate guidance of the *Site Final Survey Plan* will be taken to conclusively demonstrate that the release criteria have been met. The measurements will be obtained by conducting surveys using approved methods and techniques such as surface scans, direct measurements of surface contamination, smear samples for removable surface contamination and gamma exposure rate measurements.

5.3.3 Identify Reference Locations

Reference locations will be clearly identified using the general guidance contained in the *Site Final Survey Plan* with regards to reproducible survey measurement locations. The physical grid layout may be substituted with the use of physical and logical facility markers that will remain identifiable at the facility after decommissioning is completed.

Sound engineering judgement will be used to divide a survey area into survey units (or subunits) to support reproducible QC and NRC Confirmatory Survey applications. This will be accomplished through selecting reference locations that identify the survey area bounds such as; horizontal and vertical structural support beams, systems, components, piping runs, physical sheet steel weld seams and concrete pour seams. Actual lengths, widths and distances will be included to support reproducibility.

In addition, the use of photographs, structural and actual system drawings or maps will be included to support survey area and survey unit (or subunit) configurations. This method of area designation will also serve to assist survey personnel to define areas of elevated activity requiring additional investigational surveys and/or remediation. Areas where gridding may not be feasible include, but are not limited to, interior structural surfaces, portions of interior walls within the and where interferences exist and they are not expected to be removed. Whenever gridding is appropriate and deemed cost effective, it will be considered for use.

5.3.4 Prepare Survey Maps.

Survey maps will be used to document the measurement locations. Maps may be prepared for specific survey areas to identify facility structures, systems or equipment which define boundaries of other survey areas, units or subunits where grid layout cannot be performed and gridding is not practical or cost effective.

5.3.5 Survey Point Identification

Survey areas will be uniquely identified by a reference location ID code or number. The numbering convention will be to start at the reference location, usually the extreme southwest corner, and proceed sequentially west to east labelling each survey point on the floor or wall from south to north in a continuing sequence. Survey points are numbered in sequence for each subunit similarly as described above. An individual reference location will have a unique identification code as determined by its survey unit (or subunit) ID and the number of the survey points within that unit.

5.3.6 Define the Final Survey Techniques.

1. Scanning

Perform scanning surveys to screen large areas, efficiently searching for areas above the average release criteria and to detect localized areas above the maximum release criteria. The scanning methods used (instrument and survey technique) will be capable of detecting 75% of the average total surface contamination release criteria, (e.g., 3750 dpm/100 cm^2 for beta gamma).

2. Surface Activity Measurements

Take surface activity measurements at locations and frequencies based upon the classification of affected or unaffected. Specific guidance regarding the location and number of measurements will be provided in the survey package. The general set of measurements will consist of direct (total) beta-gamma and removable beta-gamma at each measurement location. In areas and systems identified as alpha affected, direct (total) surface and removable surface alpha measurements will also be taken.

When surveys indicate that contamination levels above the average contamination release criteria may be present, appropriate follow-up investigation and/or measurements will be performed. Areas of elevated activity will be tested to assure that the average surface activity level within a contiguous square meter is less than the guideline value.

3. Exposure Rate Measurements

Take gamma exposure rate measurements taken at one meter from accessible surfaces at all measurement locations in structures and outdoor areas. In locations where it is not physically possible to locate an instrument one meter from the surface, gamma exposure rate measurements will not be taken.

4. Soil Sampling

Collect soil samples in accordance with the *Site final Survey Plan.* Specific guidance regarding the location and number of soil samples will be provided in the survey packages. Additional soil samples will be collected if a contamination event or spill occurs, or in the event that survey measurements indicate areas of elevated activity.

5. Sampling of Sediment and Loose Material

Collect samples of loose paint, dust or other sediment for laboratory analysis as part of biased sampling and measurements. Such samples may be collected in drain receptacles, sumps, and other catchments in affected areas. As necessary, selected accessible storm drain catchments will be sampled and surveyed. Analyze these samples will be analyzed by gamma spectroscopy.

5.4 Final Survey

5.4.1 Surveys should be performed in accordance with REDS-OPS-301, *Performance of Surveys.*

5.4.2 If required, grid the survey unit.

1. Affected areas should be gridded at 1 meter intervals. For unaffected areas it is suggested that larger spaced grids (2 to 5 meters) be used.

2. Grids for survey units may be laid out using any means that provides a reference point. The method of marking the grids is flexible and depends upon the size and shape of the survey area. For small areas there may be no need to grid the area at all. Some of the methods which may be used are as follows:

   a. Stickers, chalk lines, tape or paint to identify the intersection point of grid lines. (Painted cross-hairs preferred)

   b. Removable overlays.

   c. Lighting overlays.

3. Grids should be identified with an alphanumeric designator (numbers for rows, letters for columns). Refer to Attachment 6.1 for an example. A small area, such as a storage space, may be identified with a single grid coordinate.

4. Ensure that cover plates, access panels or other interferences to systems (drain lines, ventilation ducts, piping, sumps, etc.) have been removed to allow access for the survey.

5. Ensure the necessary equipment is staged for access to the survey unit (ladders, scaffolding, etc.).

6. Verify that the area and grid layout matches the survey diagram. Make any corrections necessary and record the grid identification letters and numbers on the survey diagram.

7. Take photographs of the survey unit. Label the photos with the survey package identification number and survey unit I.D.

8. Label the survey diagram with the grid coordinates.

9. For gridded survey units where less than 100% of the grids are to be surveyed, obtain using random selection software, a listing of random sample locations. Identify the grids to be surveyed on the survey diagram.

10. For ungridded survey units, identify the points to be surveyed on the survey diagram. Refer to the survey package for required survey points required by the package. Record the position of structural features (lights, beams, piping, etc.) for reference points.

5.4.3 Proceed to the survey unit and record background readings as follows. (Background readings are not required for direct gamma radiation surveys.)

1. Background readings for the gas proportional detector shall be taken with a 300 mg/cm^2 cover over the detector face.

2. Take background counts prior to the survey in accordance with the *Site Final Survey Plan*. The background counts shall be repeated after the survey has been completed

3. Collect final survey measurements from sequential grid blocks within a survey unit as follows:

4. Scan survey area for elevated readings working all survey points that exceed 75% of guideline values.

5. IF 100% of the grid blocks within a survey unit are to be surveyed, THEN begin with the grid block located in the lower left corner for walls, or the southwest corner for floors and ceilings. Surveys move left-to-right for walls or west-to-east for floors and ceilings.

   a. After a row of grid blocks has been completed, move back to the left or west and repeat the survey for the next row of grid blocks.

   b. The measurements will be taken in the same manner in each grid: bottom left corner, bottom right corner, center, top left corner, top right corner.

   c. If this convention cannot be followed, indicate by labeling the survey data with the appropriate grid block numbers on the Final Survey Review Report

6. Take five direct surface measurements in each selected grid. Additional direct measurements should be taken at any location found during the scan to have elevated counts.

7. A gamma exposure rate measurement will be taken at one meter from the most elevated readings and during the scan or at the center of each selected grid with a Ludlum Model 2350 equipped with a sodium iodide probe.

8. One smear for removable contamination will be taken at the center of each selected grid, and at the location of any elevated reading found during the scan.

9. Biased surveys are surveys where the locations and types of measurements will be chosen by the technician that will perform the survey or by he supervisor that performed the pre-survey walkdown. Biased surveys include the following:

   - Surveys of overhead areas above six feet - The number and type of measurements will be specified during the initial supervisory walkdown of the area. Actual survey locations will be chosen by the technicians performing the surveys.

   - Surveys of vents - During the pre-survey supervisory walkdown, all vents will be identified and specific instructions given on type and quantity of measurement in the survey package. A minimum of one direct surface contamination measurement and one smear for removable contamination will be required in each vent in the survey area.

10. **IF** less than 100% of the grid blocks within a survey unit are to be surveyed, **THEN** indicate by labeling the survey data with the appropriate grid block numbers on the *Final Survey Review Report.*

11. **IF** the survey unit is not gridded, **THEN** record the number of survey measurements collected within the survey unit and identify the survey location on a area survey map.

5.4.4 Unaffected Survey Areas

NOTE

The number of measurement locations shall be at least 30, and when averaged over the entire survey unit, shall be equal to or greater than 1 measurement per 50 m^2.

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1. Perform a scan survey over 10% of the survey unit concentrating on main passageways and horizontal surfaces. Unaffected area scanning is a bias survey.
2. Collect a minimum of 30 fixed measurements of the total surface contamination per survey unit.

3. Collect a minimum of 30 gamma exposure rate measurements one meter from each surface location of the fixed measurements.

4. Collect a smear of removable contamination from each location of the fixed measurements.

5. Upper Walls, Ceilings and other surfaces

    a. Collect at least 30 random measurements from horizontal surfaces consisting of fixed measurements, and smears.

    b. Collect at least 30 random measurements from vertical surfaces consisting of fixed measurements, and smears.

5.4.5 Affected Survey Areas

1. Floors and Lower Walls (up to 2 meters)

   a. Perform a scan survey over 100% of the survey unit.

   b. Collect at least five fixed measurements of the surface contamination in every grid block.

   c. Collect a gamma exposure rate measurement at one meter at the location of the most elevated fixed measurement in every grid.

   d. Collect a smear of removable contamination from the location of the most elevated fixed measurement in every grid.

2. Upper Walls (above 2 meters), Ceilings and other surfaces

   Survey protocol are identical to the survey requirements for floors and lower walls.

6.0 ATTACHMENTS

6.1 *Example of Grid Numbering*

ATTACHMENT 6.1
EXAMPLE OF GRID NUMBERING

D1	D2	D3	D4	D5
C1	C2	C3	C4	C5
B1	B2	B3	B4	B5
A1	A2	A3	A4	A5

SCIENTIFIC ECOLOGY GROUP, INC.

RADIOLOGICAL ENGINEERING AND DECOMMISSIONING SERVICES

REDS-FSP-103

REVISION 0

FINAL SURVEYS OF ENVIRONS

PREPARED BY: _____ Date: 2/8/94
Author

REVIEWED BY: _____ Date: 2/8/94
Reviewer

APPROVED BY: _____ Date: 2/9/94
for **Donald R. Neely**
Vice President
Radiological Engineering and
Decommissioning Services

1.0 PURPOSE

This procedure provides methods for defining and controlling environmental surveys to assure that all required surveys are performed and the data are acceptable.

2.0 APPLICABILITY

This procedure applies to all project personnel preparing survey packages and performing final surveys in outdoor areas.

3.0 REFERENCES & COMMITMENTS

3.1 References

3.1.1 REDS-FSP-100. *Preparation of a Final Survey Plan.*

3.1.2 REDS-FSP-104. *Final Survey Data Handling and Analysis.*

3.1.3 REDS-OPS-301. *Performance of Surveys.*

3.1.4 *Site Final Survey Plan.*

3.1.5 *Site Health and Safety Plan.*

3.2 Commitments

None

4.0 GENERAL

4.1 Discussion

This procedure provides for the collection of high quality radiological data from sufficient representative locations such that a statistically sound conclusion about the status of the environs can be developed.

This procedure provides guidance for the preparation and performance of termination surveys for the outdoor areas on site. Final surveys are designed and performed in such a manner that the requirements of decommissioning plans and procedures are complied with, allowing for license termination. The final surveys will be deemed to have complied with plans and procedures if all survey results are less than the limits specified and the surveys are of sufficient sensitivity, accurateness, reproducibility, and detail and are well documented. Final surveys will be considered complete upon review and closure of final survey packages.

This procedure assumes that the cleanup efforts have removed essentially all the contamination from the outdoor areas and that the cleanup efforts have been effective. The survey design is based on the assumption that the outdoor areas are below the guideline values and that the remaining activity is essentially normally distributed. If the results of the surveys demonstrate that this assumption is not true, then the surveys defined in this procedure should be modified to accommodate the changed conditions.

4.2 Definitions

4.2.1 Biased Survey

A survey based on measurement of sample locations selected in a non-random manner, considering the expected distribution of radioactivity. Biased surveys are usually performed in an affected area. Biased surveys are taken using the best judgement of the person doing the survey. In general biased surveys cannot be treated as a statistical sample of the population.

4.2.2 Final Survey

A survey of the area demonstrating that it meets the acceptance criteria for termination of the license.

4.2.3 Location Code

A unique code designating a survey location or unit.

4.2.4 Random Survey

A survey in which the points are selected by a random process, not a technician. Random processes include the use of the random sheet produced by a computer code.

4.2.5 Survey Area

An easily identifiable area selected for radiological evaluation that may be divided into smaller, more manageable units as necessary (e.g., a building elevation or portion thereof, a room). Survey areas must exist within only one stratum.

4.2.6 Survey Location

The survey data point within a grid square or in an ungridded area.

4.2.7 Survey Package

The portfolio for a specific area being surveyed. Each survey package contains the details for surveillance including sample locations, types of measurements, sample point selection criteria, background determinations, maps, diagrams, photographs, and results and analyses of all data collected.

4.2.8 Survey Unit

A division of a Survey Area that is expected to have similar modes of contamination and deposition patterns (e.g., floors, walls, horizontal surfaces).

4.2.9 Systematic Survey

A survey in which sample and measurement points are selected based upon an organized method, such as grids. If all points or a regular interval set of points are measured, this type of survey is unbiased. If grid points are selected randomly, the survey is a random unbiased survey.

4.3 Responsibilities

4.3.1 The Project Manager is responsible for administering this procedure. The Project Manager may change requirements of the final survey dependent upon the type and amount of contamination originally found on site, the size of the facilities decontaminated, and the client's request.

4.3.2 Project engineers are responsible for implementing this procedure.

4.3.3 Health Physics technicians are responsible for performing final surveys.

4.4 Prerequisites

4.4.1 The Project Manager shall determine if work activities require a safety work permit and the radiological protection requirements needed to perform survey activities.

4.4.2 A characterization survey of the survey area should have been completed to determine the radionuclides that may be present.

4.4.3 Any required decontamination of the survey area shall have been completed.

4.4.4 The appropriate final survey limits have been established authoritatively.

4.5 Precautions and Limitations

4.5.1 Ensure personnel performing radiological measurements are qualified in the use of the instruments and laboratory analysis equipment.

4.5.2 Survey technicians and supervisors must be trained and qualified to this procedure.

4.5.3 Prior to surveying any area ensure all safety requirements are met in accordance with OSHA industry (29 CFR 1910), contractor (29 CFR 1926) safety requirements and the *Site Health and Safety Plan.*

4.5.4 The Project Manager may determine that some portions of this procedure need not be performed due to the limited scope of a project.

4.6 Apparatus

4.6.1 Survey instrumentation

4.6.2 Smears

4.6.3 Grid marking materials

4.6.4 Camera and film

4.6.5 Computers necessary to produce drawings, maintain databases, do calculations and control scheduling of work

4.7 Records

4.7.1 Survey Packages

5.0 PROCEDURE

5.1 Background Determination for Environs

5.1.1 Determine the site background by measuring and sampling locations around or off the site not affected by site operations or effluent releases.

1. Select the points to be surveyed. A minimum of 30 is recommended.

2. Avoid choosing the following areas for obtaining background samples as they will affect the background:

   a. Locations of potential runoff from areas of surface contamination;

   b. Waste management areas and their drainage pathways;

   c. Roads, parking lots and other large paved surfaces;

   d. Storm drains and ditches receiving industrial or agricultural runoff;

   e. Railroad tracks;

   f. Material handling areas such as truck and rail loading facilities; and

   g. Fill areas.

3. Take the following samples and measurements at each sample location.

   a. More than one liter surface soil sample (top 15 cm of soil).

   b. Direct beta-gamma and alpha contamination on paved surfaces.

   c. Direct gamma radiation at 1 meter above the ground.

4. Prepare the soil sample for analysis (sift and dry) and analyze the sample using gamma spectroscopy.

5. Record the sample and measurement locations and results.

5.1.2 Statistically test the background measurements in accordance with REDS-FSP-104, *Final Survey Data Handling and Analysis* for direct beta-gamma contamination and direct radiation.

5.1.3 Record the background measurements and the statistical test. This information will be used in preparing the survey packages for the site environs.

5.1.4 Review the background values with the client and obtain their approval for the use of the data for final surveys.

5.2 Survey Preparation

5.2.1 Define those areas to be surveyed. Survey areas should include but are not limited to the following:

1. Open land areas on-site;
2. Areas immediately adjacent to facilities where radioactive materials were handled;
3. Outdoor equipment, product, waste and raw material storage areas;
4. Liquid waste collection lagoons;
5. Areas downwind of stack release points;
6. Surface drainage pathways;
7. Roadways used for transport of radioactive materials;
8. Spill sites;
9. Septic leach fields which may have received contaminated liquid; and
10. Areas where there is buried piping, underground tanks, etc.

5.2.2 Define the percent of open land area to be surveyed.

1. Affected outdoor areas shall be gamma scanned to identify the presence of elevated direct radiation. Paved areas shall also be scanned for alpha and beta radiation. The scans shall cover 100% of the survey area.
2. A minimum of 10% of the surface area shall be gamma scanned in unaffected outdoor areas. Paved areas shall also be scanned for alpha and beta radiation.
3. A minimum of 30 soil samples should be systematically taken from each survey area that contains soil. At least 30 locations should be sampled from each paved area. If the survey area is too small ($< 300\ m^2$) to obtain 30 samples, combine the survey area with another area having the same or similar radiological characteristics to collect the samples.

5.2.3 Determine the survey counting times.

1. Determine the minimum counting time for direct measurement of contamination which provides a minimum detectable activity (MDA) that is less than or equal to the established guideline values.

2. Use an appropriate software program or equation to determine the minimum counting times based on the desired MDA.

3. **IF** the MDA exceeds the guideline value, **THEN** increase the counting time and recalculate the MDA until the MDA is less than 75% (preferably at or below 10%) of the guideline value.

5.3 Final Surveys

5.3.1 If required by the *Site Final Survey Plan*, grid the survey unit.

1. Affected open land areas should be gridded at 10 meter intervals. Unaffected areas do not require gridding; however, larger spaced grids (20 to 50 meters) are suggested to reference survey locations.

2. Grids should be marked in such a way to ensure the grid coordinates are clearly identifiable during the survey such as surveyor markers or flags, wooden or metal stakes or paint marks at the intersections, depending on the surface. The grids may be marked individually, in groups, or by marking the rows and columns of the survey unit.

3. Grids should be identified with an alphanumeric designator (numbers on one axis, letters on the other).

4. Verify that the area and grid layout matches the survey diagram. Make any corrections necessary and record the grid identification letters and numbers on the survey diagram.

5. Take photographs of the survey unit. Label the photos with the survey package identification number and survey unit I.D.

6. Label the survey diagram with the grid coordinates.

NOTE

Surveys using the Model 2350 Data Logger should be designed to keep the number of measurements reasonable. This may require subdividing a large area. Ensure each section of the survey unit has been identified with a unique location code.

7. For gridded survey units where less than 100% of the grids are to be surveyed, obtain a listing of random sample locations. Random sample locations can be identified using a software program. Identify the grids to be surveyed on the survey diagram.

8. For ungridded survey units, identify the points to be surveyed on the survey diagram. Refer to the survey package for required survey points required by the package. Record the position of structural features (lights, beams, piping, etc.) for reference points.

5.3.2 Proceed to the survey unit and record background readings as follows. (Background readings are not required for direct gamma radiation surveys.)

1. Background readings for the gas proportional detector shall be taken with a 300 mg/cm^2 cover over the detector face.

2. Take background counts prior to the survey in accordance with the *Site Final Survey Plan*. The background counts shall be repeated after the survey has been completed.

5.3.3 Perform the survey on the survey unit as follows. (Surveys are performed in accordance with REDS-OPS-301, *Performance of Surveys*.)

1. Surfaces shall be gamma scanned to identify the presence of elevated direct radiation.

2. Paved areas should be scanned for alpha and beta radiations as well.

3. Direct measurements are taken in those areas where elevated activity is found from the scans.

4. It is unlikely that surfaces will have significant levels of removable surface activity. If removable activity is suspected, smears may be obtained from those suspect areas.

5. When the direct measurements have been completed, then take another series of background readings equal to the ones performed at the start of the survey.

5.3.4 Obtain environmental samples as follows.

1. Collect a surface sample of soil or other material from the chosen locations. These locations should be equidistant between the center and each of the grid corners. Additional locations can be sampled along the perimeter of the grid and from the center to provide close-spaced triangular grid patterns.

2. Ensure that more than 1 liter of sample is collected for analysis unless otherwise directed in the *Site Final Survey Plan.*

3. Quality control samples should be obtained in the same manner as other samples, in accordance with the *Site Final Survey Plan.*

4. Perform a gamma spectroscopic analysis of the environmental samples.

5.3.5 Obtain special samples as follows.

For those areas which are inaccessible to surveys due to size or location (such as piping interiors, drains, sewers, etc.) the following can be done.

1. Calibrated detectors of small enough size to extend into piping, drains, etc. in a controlled manner can be used to survey interiors of these areas.

2. Samples of material inside or around inaccessible areas can be collected. These samples include paint, dust, sediment and shall be analyzed by gamma spectroscopy.

6.0 ATTACHMENTS

None

SCIENTIFIC ECOLOGY GROUP, INC.

RADIOLOGICAL ENGINEERING AND DECOMMISSIONING SERVICES

REDS-FSP-104

REVISION 0

FINAL SURVEY DATA HANDLING AND ANALYSIS

PREPARED BY: _____ 1/31/94
Author **Date**

REVIEWED BY: _____ 2/7/94
Reviewer **Date**

APPROVED BY: _____ 2/7/94
Donald R. Neely **Date**
Vice President
Radiological Engineering and
Decommissioning Services

1.0 PURPOSE

This procedure describes the survey data handling and analysis methods used to show the absence of radioactivity in a survey unit.

2.0 APPLICABILITY

This procedure applies to all project personnel processing final survey packages.

3.0 REFERENCES & COMMITMENTS

3.1 References

3.1.1 REDS-FSP-100. *Preparation of a Final Survey Plan.*

3.1.2 *Site Final Survey Plan.*

3.2 Commitments

None

4.0 GENERAL

4.1 Discussion

This procedure provides guidance on the handling and analysis of data associated with final surveys.

The testing of means is done using normal statistics even though lognormal statistics may be more appropriate for some sample types. The use of normal statistics allows for simpler handling of negative numbers and provides a conservative test of a lognormal variable.

4.2 Definitions

4.2.1 Administrative Limit

The value which will be flagged in a survey review report for further investigation.

4.2.2 Confidence Interval

A range of values derived from a sample such that there is a probability that a population parameter being estimated, e.g., a mean value, lies within range.

4.2.3 Confidence Level

The probability associated with a confidence interval which expresses the probability that the confidence interval contains the population parameter value being estimated.

4.2.4 Survey Review Report

A computer generated report for the Ludlum 2350 Data Logger.

4.2.5 Survey Package

The portfolio for a specific area being surveyed. Each survey package contains the details for surveillance including sample locations, types of measurements, sample point selection criteria, background determinations, maps, diagrams and the result and analyses of all data collected. Each package must have a unique number.

4.3 Responsibilities

4.3.1 The Project Manager is responsible for administering this procedure.

4.3.2 Project engineers are responsible for implementing this procedure.

4.3.3 Health Physics technicians are responsible for performing portions of this procedure.

4.4 Prerequisites

4.4.1 Final surveys have been performed in accordance with appropriate procedures.

4.5 Precautions & Limitations

4.5.1 **WHEN** calculating sample means for data testing, use the calculated net data value even if it is a negative value. **DO NOT** use the Minimum Detectable Activity (MDA) value for calculation of means.

4.5.2 The Project Manager may determine that some sections of this procedure need not be performed due to the limited scope of a project.

4.6 Apparatus

4.6.1 Computer

4.6.2 Printer

4.6.3 Floppy disks

4.6.4 Backup software

4.6.5 Computer Aided Design (CAD) software

4.6.6 Spreadsheet software

4.6.7 MDA and limit value calculation software

4.6.8 Random selection software

4.6.9 Database software

4.6.10 Download software

4.6.11 Calculation on graphics software, LocIndex Application

4.7 Records

Records described here are considered to be original and shall be maintained as directed by the Project Manager.

4.7.1 Survey Packages

4.7.2 Raw data files

4.7.3 Survey Databases

4.7.4 Survey Review Reports

4.7.5 Survey Data Investigation Forms

4.7.6 Revisions to survey records

5.0 PROCEDURE

5.1 Survey Packages

The project engineer supervising the final survey shall ensure survey packages contain the following data.

5.1.1 Description of location codes. Define the codes used for each surface including the following:

1. Ceiling

2. Dropped Ceilings

3. Drain

4. Floor

5. Hole

6. Irregularity

7. Crack

8. Penetration

9. Pipe

10. Conduit

11. Interferences

12. Wall

13. Horizontal surfaces above the floor

14. Others (define)

5.1.2 Counting parameters used to meet Minimum Detectable Activity;

5.1.3 Instrumentation used and detector calibration parameters;

5.1.4 Sketches, drawings of the survey area; and

5.1.5 Random sheets used to determine survey/sample location.

5.2 Survey Data Review

5.2.1 The Health Physics technician shall perform the following for survey data taken with the Ludlum 2350 Data Logger:

1. Download the data from the Data Logger to the database. Include the following in the database.

   a. Description of survey.

   b. Location or location code.

c. Instrument make, model and serial number.

d. Detector type and serial number.

e. Date and time of survey.

f. Person(s) performing survey.

g. Counting duration.

h. Instrument background and efficiency.

2. Complete the survey data form for the downloaded data.

3. Print the Survey Review Report.

4. Return the documentation to the Health Physics technician who performed the survey for review and signature.

5. **WHEN** the Survey Review Report has been reviewed and signed, **THEN** the project engineer shall review the report for any corrections. Revise the survey data file as necessary for the corrections on the survey. **IF** the data files are revised, **THEN** reprint the applicable reports, sign and date the reports and attach them to the original Survey Review Report.

6. Forward the Survey Review Report to the project engineer for review.

7. **WHEN** the survey has been reviewed, **THEN** forward the Survey Review Report for filing in the survey package.

5.2.2 The Health Physics technician shall perform the following for smear survey analysis performed using a scaler counter:

1. Transfer the data file or raw data to the survey database. Include the following database.

a. Description of survey.

b. Location or location code.

c. Instrument make, model and serial number.

d. Detector type and serial number.

e. Date and time of survey.

f. Person(s) performing survey.

g. Counting duration.

h. Instrument background and efficiency.

i. Minimum detectable activity.

j. Radiation detected.

k. Reason for smear survey.

l. Smear data.

2. Print out the Survey Review Report and review for correctness.

3. Forward the Survey Review Report to the project engineer for review.

4. **WHEN** the survey has been reviewed, **THEN** forward the Survey Review Report for filing in the survey package.

5.2.3 The Health Physics technician shall perform the following for samples collected and analyzed by laboratory instrumentation:

1. Review analysis results.

2. Transfer results including the description of the samples, location of the samples, date and time samples were collected, person(s) that collected the samples and all pertinent laboratory instrument information to the survey database.

3. Forward the sample report to the project engineer for review.

4. **WHEN** the survey has been reviewed, **THEN** forward the Survey Review Report for filing in the survey package.

5.2.4 Minimum Detectable Activity (MDA) values shall be based on the degree of confidence specified in the *Site Final Survey Plan.* Instrument counting time should be selected to meet MDA stated in the Final Survey Plan.

NOTE

Section 5.2.4 may be omitted if counting times for the survey are based on actual (not estimated) background readings from the survey area, or if maximum background rates are defined so as to ensure an acceptable MDA.

5.3 Survey Unit Data Analysis

5.3.1 The project engineer shall test survey data from each survey unit to verify the beta and alpha measurements satisfy the guideline values at the 95% confidence level. This is accomplished by setting the flag value on the Survey Review Report to the Administrative Limit that may exceed the guideline value at the 95% confidence level. Those results greater than the flag value are identified by an asterisk (*) or other special mark on the Survey Review Report.

1. **IF** two or more adjacent survey points exceed the administrative limits **THEN** investigate the location and, if necessary, decontaminate. Document the investigation of the survey points in accordance with Section 5.4 on a *Survey Data Investigation Form*, Attachment 6.1.

2. Generally, the investigation of survey point(s) exceeding the administrative limit involves the following tasks:

   a. Do a follow-up survey to quantify the extent of the contamination.

      1) Perform follow-up surveys on the smallest area (survey unit or survey zone) surrounding the contaminated area which has an assigned location code. **IF** it is desired to survey less than the entire survey unit or zone, **THEN** identify the contaminated area as a separate survey zone with a unique location code prior to performing follow-up surveys. This will facilitate data handling for the final report.

      2) **IF** contamination is found in an ungridded survey unit, **THEN** after decontamination is complete grid the survey unit or zone before doing the follow-up final survey.

      3) Do follow-up surveys on 100% of the grids in the survey unit or zone.

b. Collect samples for analysis or do direct analysis in the field using portable gamma spectroscopy (for qualitative analysis) if natural radioactivity is suspected to be the cause of the elevated readings.

c. Decontaminate the affected area.

d. Do a follow-up survey after any decontamination.

e. Revise the data from the database for those areas which were decontaminated. Transfer the old data from the final survey database to the characterization database.

5.3.2 Calculate the mean and standard deviation for the measurements taken of the survey unit as shown below. The calculations should **ONLY** include survey measurements that are considered acceptable for final release and **NOT** preliminary surveys which initiated decontamination activities.

$$\bar{x} = \frac{1}{n} \sum x_i$$

Where: $\bar{x}$ = the mean of the measurements

x_i = the individual measurement

n = the number of sample measurements

$$s = \sqrt{\frac{\sum (\bar{x} - x_i)^2}{n-1}}$$

Where: s = the standard deviation of the population

$\bar{x}$ = the mean of the measurements

x_i = the individual measurement

n = the number of sample measurements

5.3.3 Calculate and test the 95% confidence level upper bound for the samples as follows. The Project Manager shall ensure that the calculations are performed and shall review the results.

$$95\%\ CL\ Upper\ Bound = \bar{x} + t_{0.95,\ n-1}\frac{s}{\sqrt{n}}$$

Where:

	$\bar{x}$	=	the mean of the measurements
	t	=	the "student 't' statistic" values at the 95% confidence level dependent on the degrees of freedom, n-1 (see Attachment 6.2, *Student 't' Values*)
	s	=	the standard deviation of the population
	n	=	the number of sample measurements

NOTE

For n=2, $t._{95,1} = 6.3$ and for n=3, $t._{95,2} = 2.9$. These t values are quite large and generally indicate that for 2 or 3 measurements, the mean is not very well known. For this reason, 3 or more measurements of any unique surface shall be taken when a mean is calculated.

a. This test is acceptable if the 95% confidence level upper bound of the sample mean is less than the guideline value for the sample type.

b. **IF** the 95% confidence level upper bound of the sample mean is greater than the guideline value, **THEN** complete a *Survey Data Investigation Form*, Attachment 6.1, in accordance with Section An unacceptable means test may require additional sampling AND/OR decontamination activities.

5.3.4 Calculate the mean and standard deviation for each subset of the survey unit measurements that may exceed the mean limit. Verify that the mean value for local areas (approximately 1 square meter) is less than the mean limit at the 95% confidence level by testing the maximum subset using the equations in 5.3.2 and 5.3.3. If the test passes for the maximum set, all lesser sets will also pass. The Project Manager shall ensure that this calculation is performed and shall review the results.

5.3.5 For direct gamma radiation (μR/hr) measurements, samples exceeding the 99.9% confidence level upper bound for the background and exceeding 5 μR/hr above the mean will be investigated. This assumes normal distribution for the set of measurements. If the data results are skewed or exhibit log-normal distribution, the values exceeding the 99.9 percentile for the measurement set and exceeding 5 μR/hr above the geometric mean or median, will be investigated. Ensure the background mean used is appropriate for the survey unit being tested.

1. **IF** the individual sample is less than both of the following, **THEN** it is acceptable.

$$x_i < [(t_{1-\alpha,n-1})s] + \bar{x}$$

and

$$x_i < \bar{x} + 5\ \mu R/hr$$

Where:

x_i	=	the individual gamma readings in the area being tested
t	=	the "student 't' statistic" values dependent on the degrees of freedom, n-1 (Attachment 6.2, *Student 't' Values*)
$1 - \alpha$	=	the degree of confidence required (α is usually taken to be 0.001 for gamma surveys)
n	=	the number of measurements used to determine the background mean
s	=	the estimated standard deviation of the survey unit sample
$\bar{x}$	=	the average of the measurements for the survey unit sample

2. If the survey unit has more than 30 random or systematic measurements in the sample, then the background set for the survey unit is the sample set itself.

3. If there is a potential for significant neutron irradiation of a large fraction but less than half of the survey unit, then the median value rather than the mean shall be used for $\bar{x}$.

4. If there is a potential for more than half of the survey unit to be irradiated or to have contamination deep within the surface, then the background must be determined from a similar surface without the same neutron irradiation or contamination potential.

5. **IF** the sample mean is **NOT** acceptable, **THEN** complete a *Survey Data Investigation Form*, Attachment 6.1, in accordance with Section 5.4. An unacceptable test may require additional samples and/or decontamination activities on these areas with the highest gamma measurements.

5.3.6 Forward the survey package for the review and approval to the Project Manager when all the survey units in the survey area pass the tests specified in Section 5.3.

5.3.7 After the data has been reviewed and compared to release criteria, the Project Manager will initial and date the survey package work sheet.

5.4 Survey Data Investigation

5.4.1 The purpose of the *Survey Data Investigation Form*, Attachment 6.1 or equivalent, is to provide a record of the investigation, analysis and disposition for survey measurements exceeding termination criteria or for any other situation where there is a need to document the evaluation of survey data. *Survey Data Investigation Forms* provide a history and the technical basis for decisions and shall be retained as part of the survey package.

5.4.2 The project engineer shall complete the following information on the *Survey Data Investigation Form* and attach any pertinent information.

1. Location code.

2. Description of the problem.

3. Follow-up actions (detailed biased survey, decontamination and resurvey, analysis for natural radioactivity, etc.).

5.4.3 **WHEN** the follow-up actions have been satisfactorily completed, **THEN** close out the *Survey Data Investigation Form* by completing the disposition section and obtaining the review and approval of the Project Manager.

5.5 Quality Control of Data

Quality control criteria for data handling and analysis is described in the *Site Final Survey Plan.*

6.0 ATTACHMENTS

6.1 *Survey Data Investigation Form*

6.2 *Student 't' Values*

ATTACHMENT 6.1
SURVEY DATA INVESTIGATION
(example)

Location Code:	Date:
Description Of Problem	
Follow-up Actions:	
Disposition:	
Reviewed By:	**Date:**

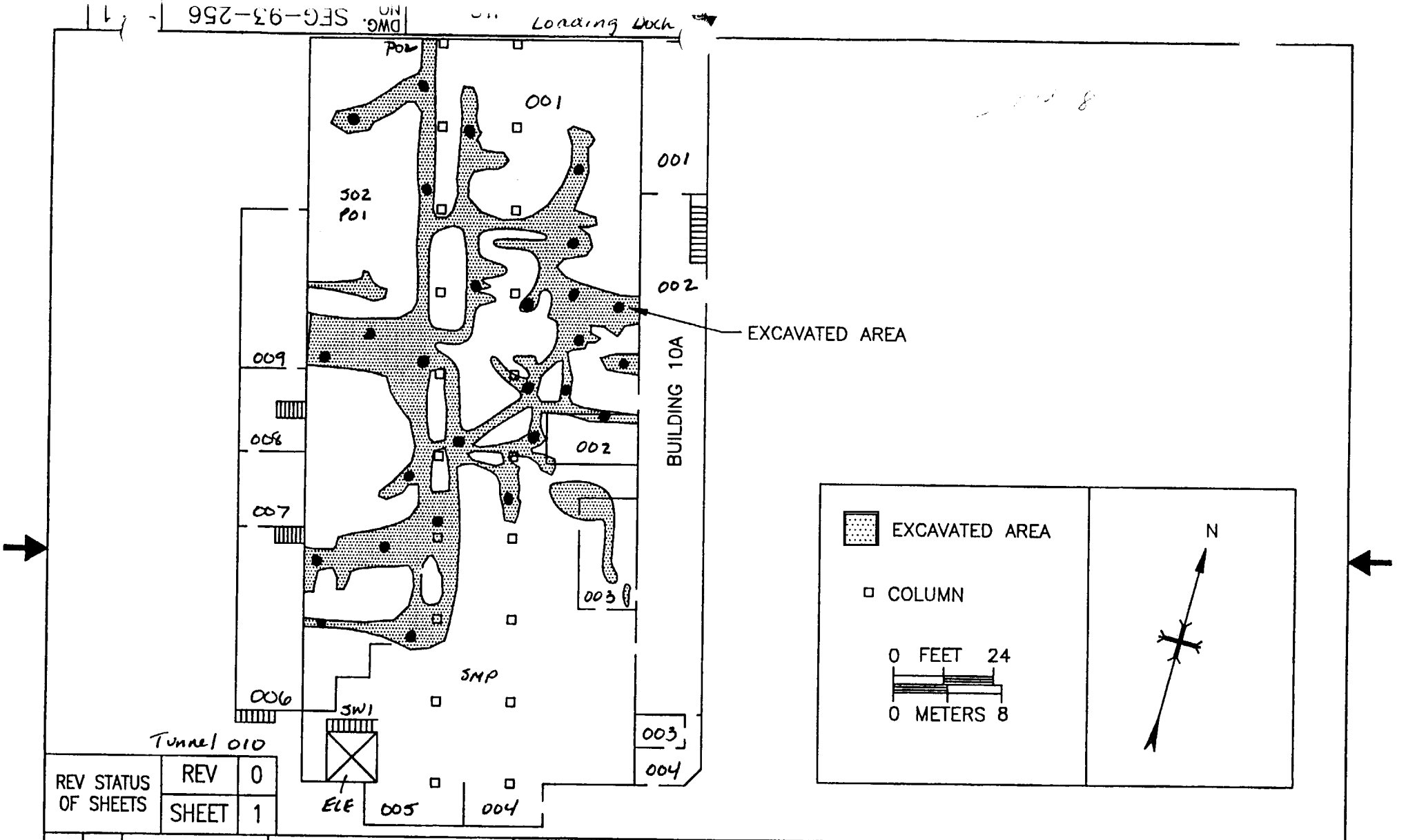
ATTACHMENT 6.2
STUDENT 't' VALUES

Degrees of Freedom*	$t_{95\%}$	$t_{99\%}$	$t_{99.9\%}$
1	6.314	31.821	318.31
2	2.920	6.965	22.326
3	2.353	4.541	10.213
4	2.132	3.747	7.173
5	2.015	3.365	5.893
6	1.943	3.143	5.208
7	1.895	2.998	4.785
8	1.860	2.896	4.501
9	1.833	2.821	4.297
10	1.812	2.764	4.144
15	1.753	2.602	3.733
20	1.725	2.528	3.552
30	1.697	2.457	3.385

*Degrees of freedom is the number of samples minus 1.

APPENDIX C (continued)

Buildings 9 & 10A



Tunnel 010

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CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SCIENTIFIC ECOLOGY GROUP, INC.

Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDINGS 9 AND 10A

SIZE	DWG NO	REV
A	SEG-93-256	0

SCALE NONE SHEET 1 OF 1

11065

DWG. SEG-93-253 | 1

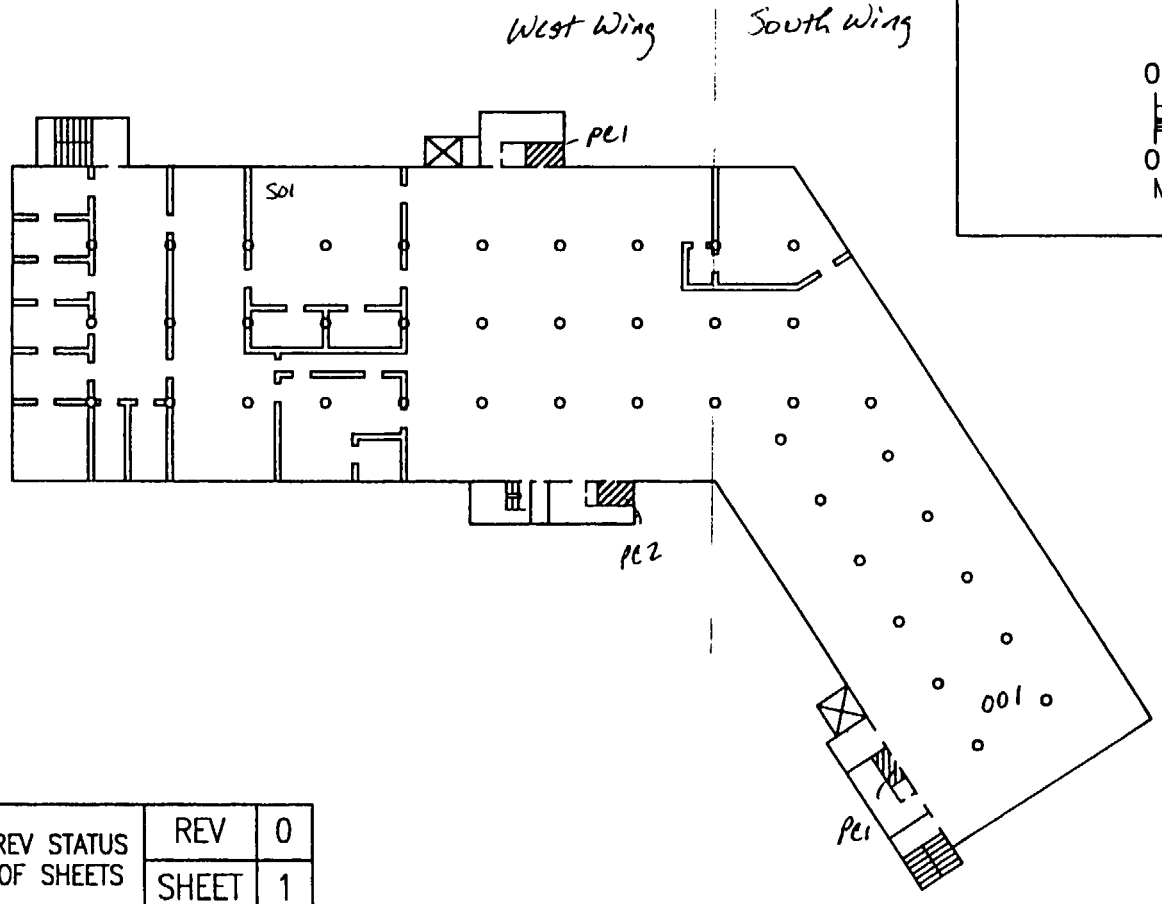
PIPE CHASE

COLUMN

20' BETWEEN COLUMNS

FEET
0 24
0 8
METERS

N



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CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SCIENTIFIC ECOLOGY GROUP, INC.

Oak Ridge Engineering
Oak Ridge, Tennessee

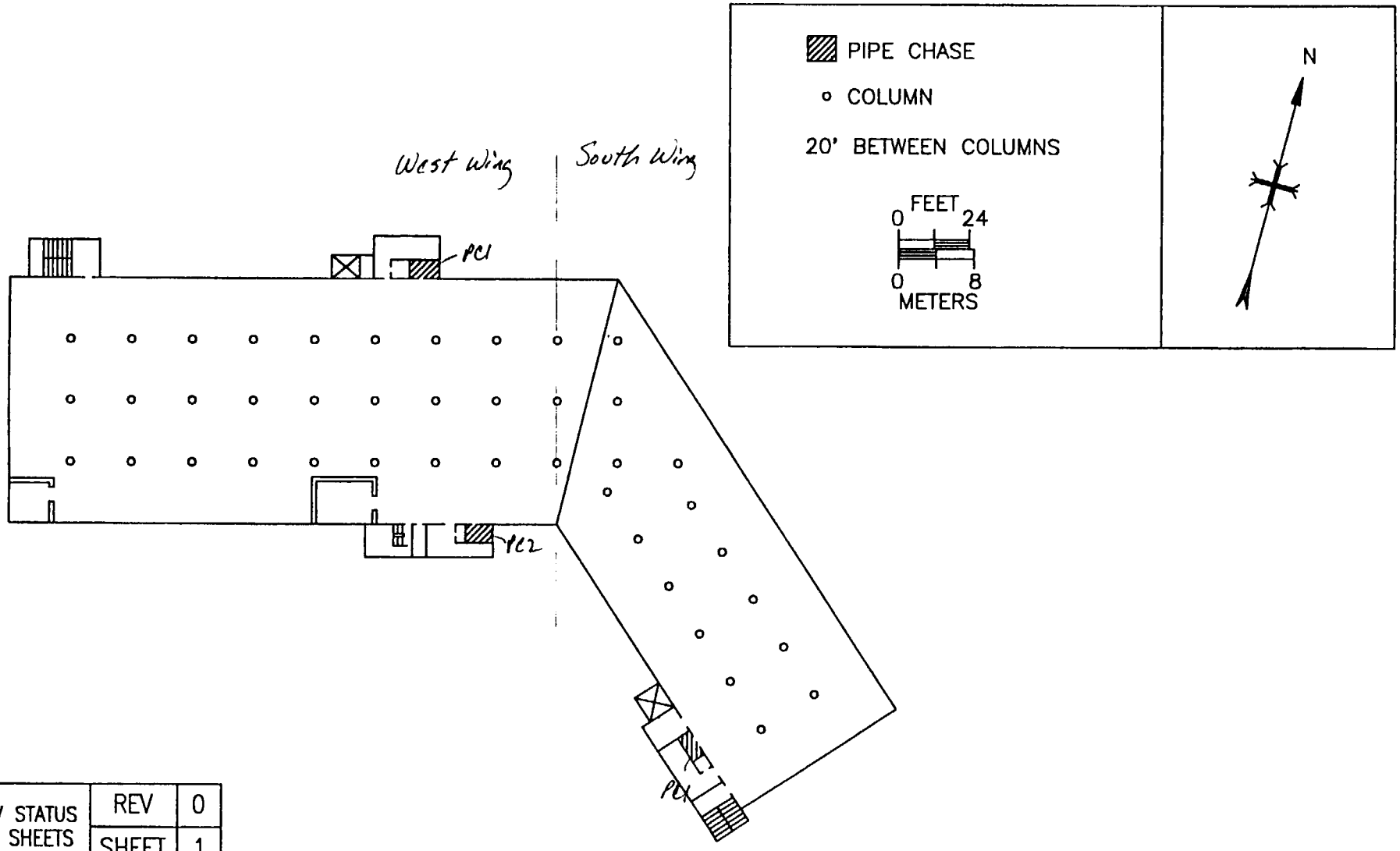
BUILDING 8
FOURTH FLOOR

SIZE	DWG NO	REV
A	SEG-93-253	0

SCALE NONE

SHEET 1 OF 1

DWG NO. SEG-93-254 Rev. 1



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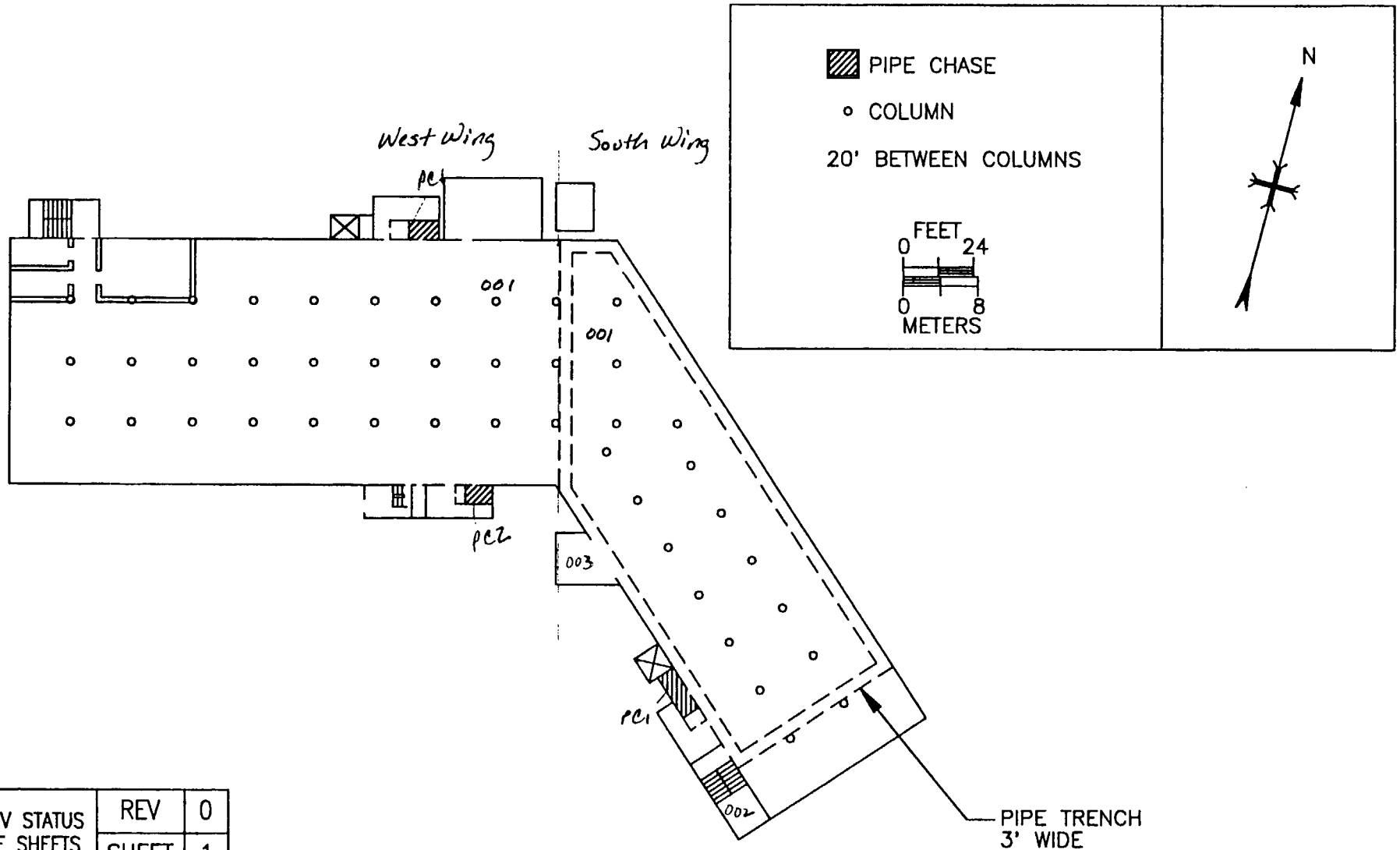
CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SCIENTIFIC ECOLOGY GROUP, INC.
Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 8
FIFTH FLOOR

SIZE	DWG NO	REV
A	SEG-93-254	0

SCALE NONE SHEET 1 OF 1



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CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SEG SCIENTIFIC ECOLOGY GROUP, INC.
Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 8
FIRST FLOOR

SIZE	DWG NO	REV
A	SEG-93-250	0

SCALE NONE | SHEET 1 OF 1

DWG. NO. SEG-93-251 REV. 1

PIPE CHASE

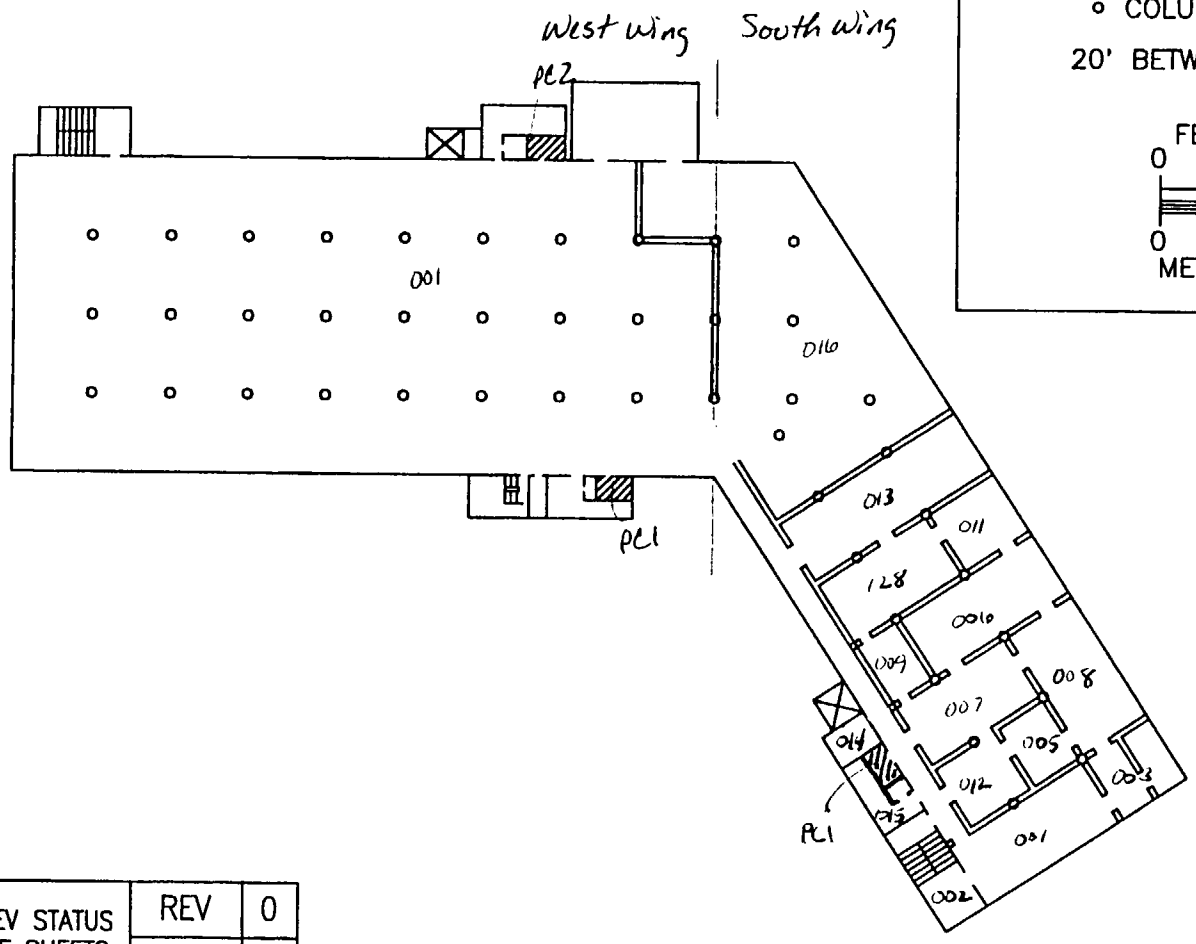
COLUMN

20' BETWEEN COLUMNS

FEET 0 24

0 8 METERS

N



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REVISIONS

ZONE	DESCRIPTION

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DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SEG SCIENTIFIC ECOLOGY GROUP, INC.

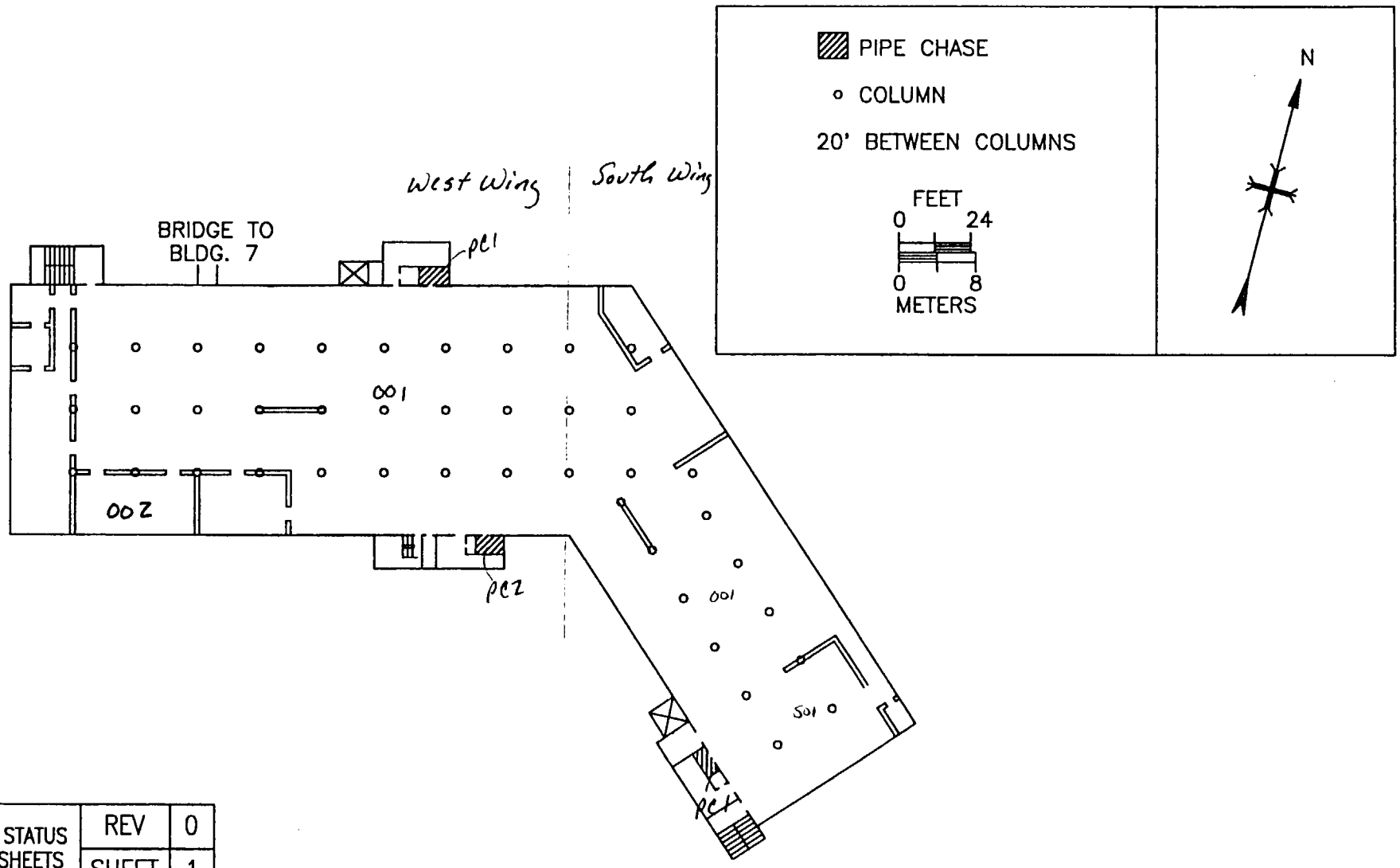
Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 8 SECOND FLOOR

SIZE	DWG NO	REV
A	SEG-93-251	0

SCALE NONE SHEET 1 OF 1

DWG. NO. SEG-93-252 1



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DSGN MGR	DATE
MFG	DATE
QA	DATE
APPRVD	DATE

SCIENTIFIC ECOLOGY GROUP, INC.

Oak Ridge Engineering
Oak Ridge, Tennessee

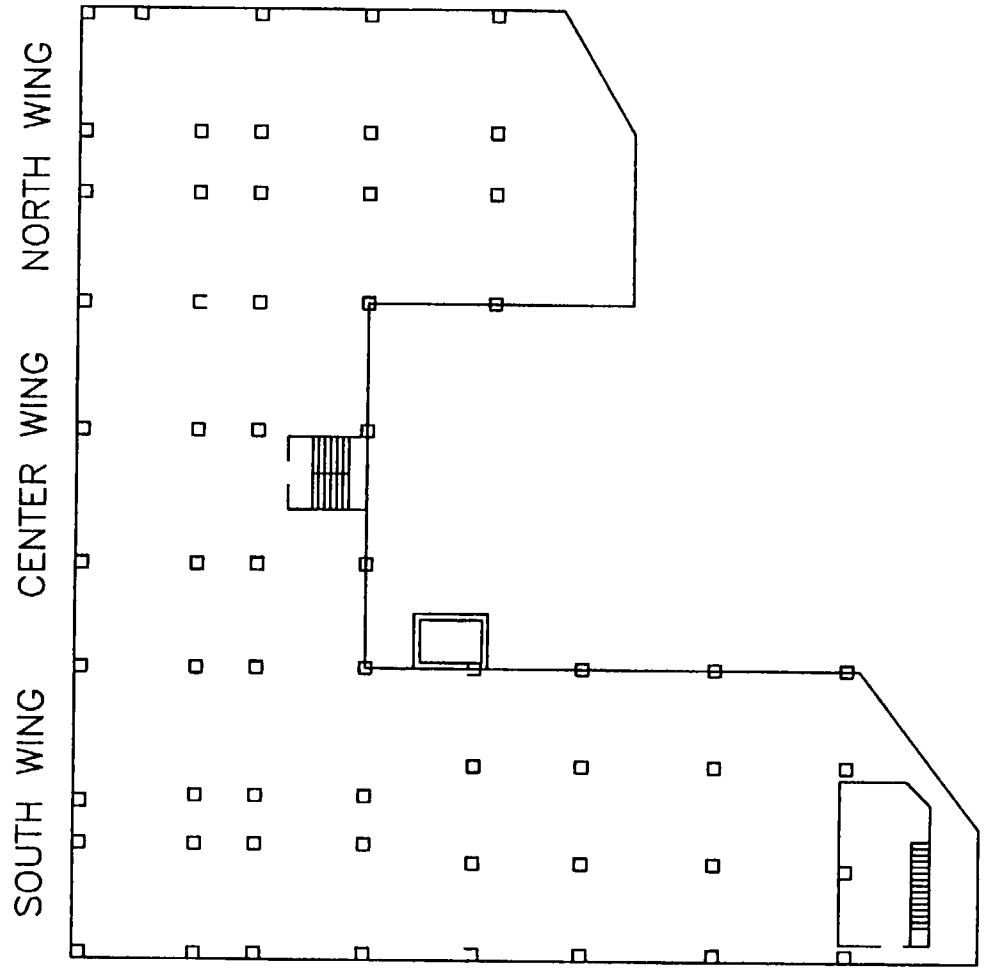
BUILDING 8
THIRD FLOOR

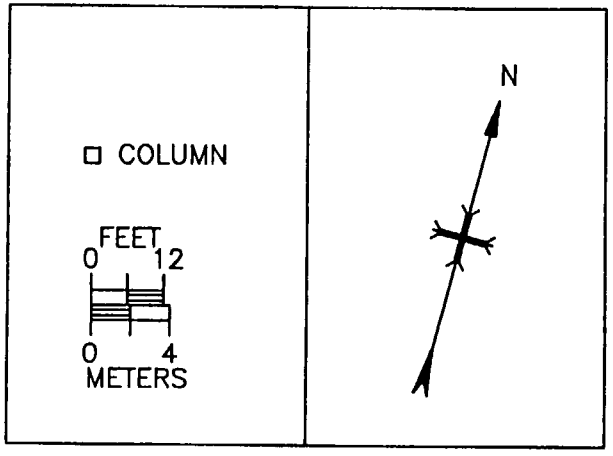
SIZE	DWG NO	REV
A	SEG-93-252	0

SCALE NONE

SHEET 1 OF 1

DWG NO. SEG-93-249





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ZONE	DESCRIPTION

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DSGN MGR	DATE
MFG	DATE
QA	DATE
APPRVD	DATE

SEG SCIENTIFIC ECOLOGY GROUP, INC.

Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 7
ROOF

SIZE	DWG NO	REV
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SCALE NONE SHEET 1 OF 1

APPENDIX C (continued)

Building 8

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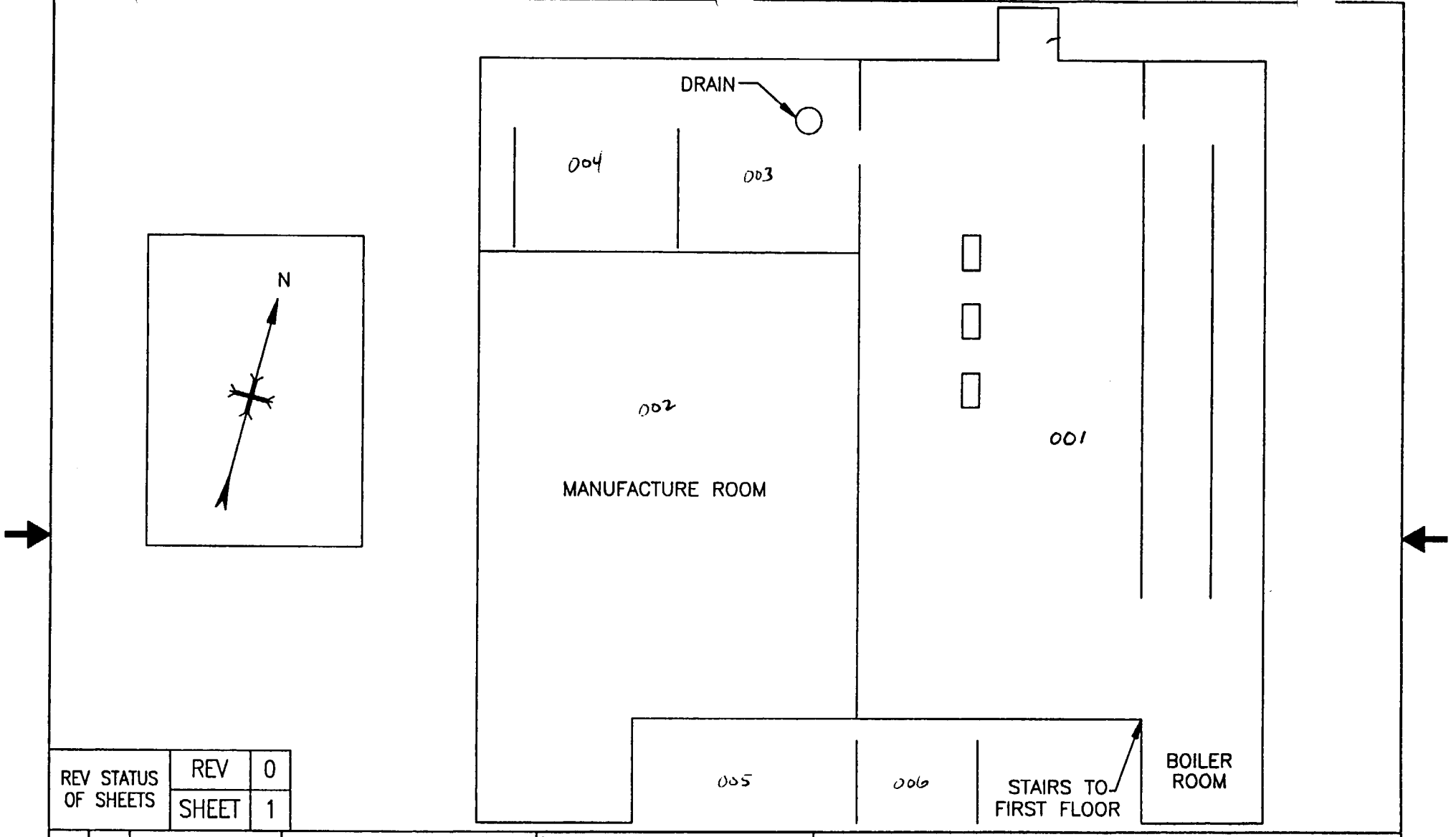

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REVISIONS	ZONE	DESCRIPTION

PROPRIETARY INFORMATION

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		DATE
DFTR	MES	11-19-93
CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SCIENTIFIC ECOLOGY GROUP, INC.

Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 8 BASEMENT

SIZE	DWG NO	REV
A	SEG-93-255	0

SCALE NONE

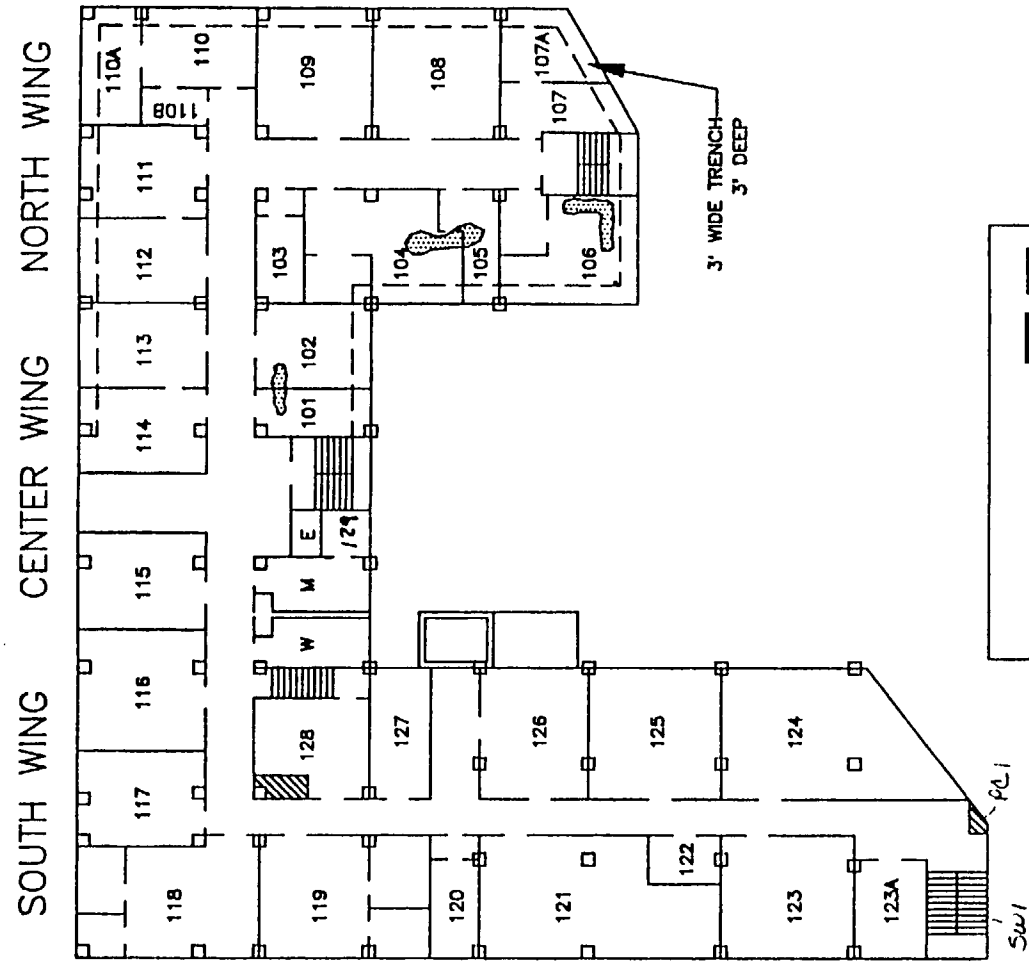
SHEET 1 OF 1

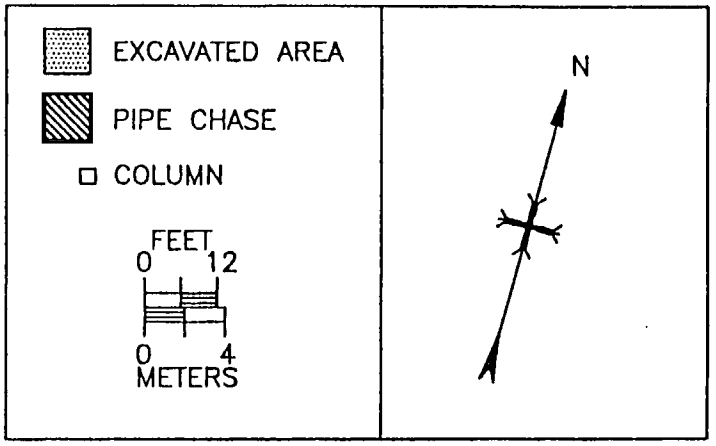
APPENDIX C

Final Survey Area Maps

APPENDIX C (continued)

Facility Grounds
(Soil)





REV STATUS OF SHEETS		
	REV	0
	SHEET	1

REVISIONS		
ZONE	DESCRIPTION	

		DATE
DFTR	MES	11-19-93
CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SCIENTIFIC ECOLOGY GROUP, INC.

Oak Ridge Engineering
Oak Ridge, Tennessee

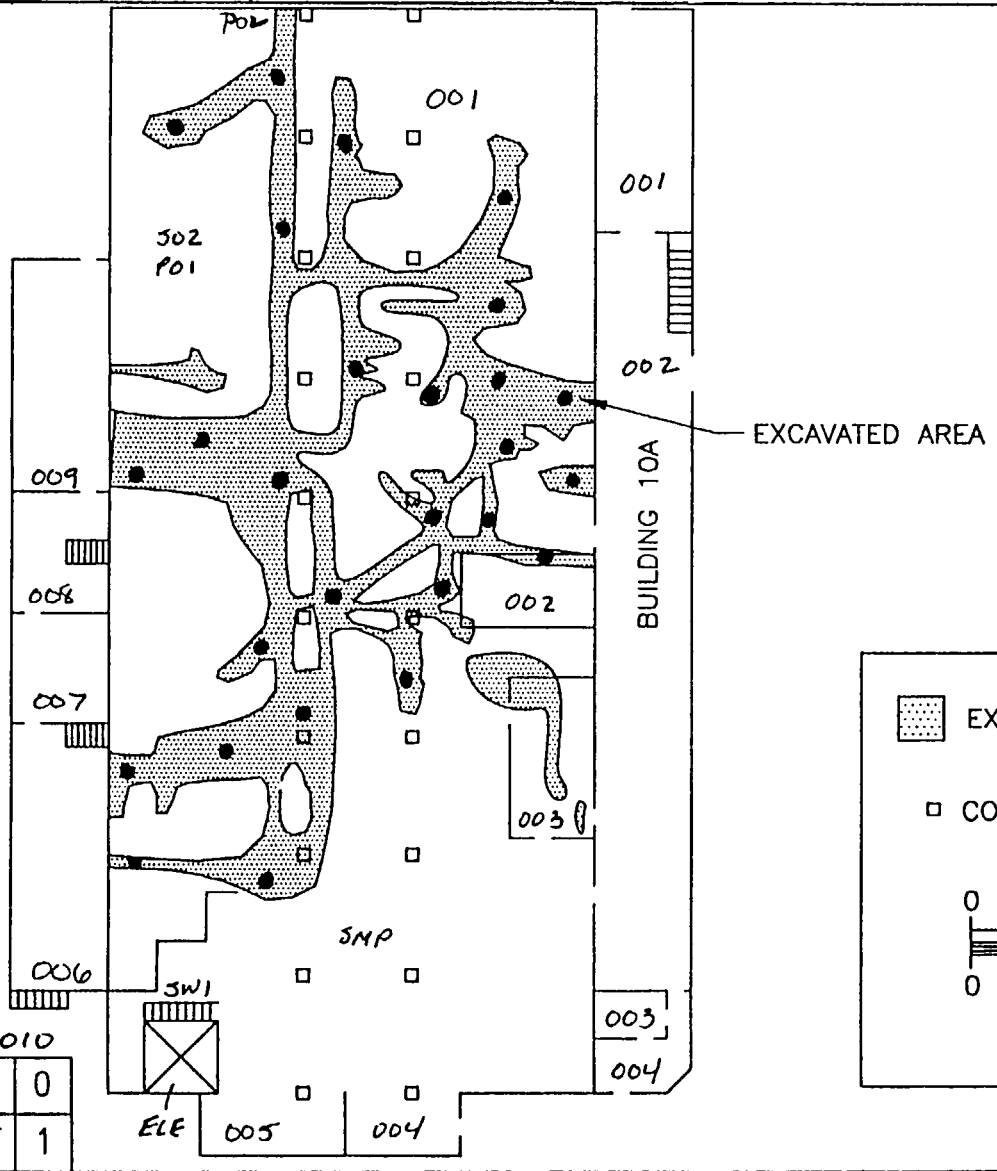
BUILDING 7
FIRST FLOOR

SIZE	DWG NO	REV
A	SEG-93-244	0

SCALE NONE

SHEET 1 OF 1

Loading Dock



EXCAVATED AREA

COLUMN

0 FEET 24

0 METERS 8

N

REV STATUS OF SHEETS		
	REV	0
	SHEET	1

REVISIONS		
ZONE	DESCRIPTION	

		DATE
DFTR	MES	11-19-93
CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SCIENTIFIC ECOLOGY GROUP, INC.

Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDINGS 9 AND 10A

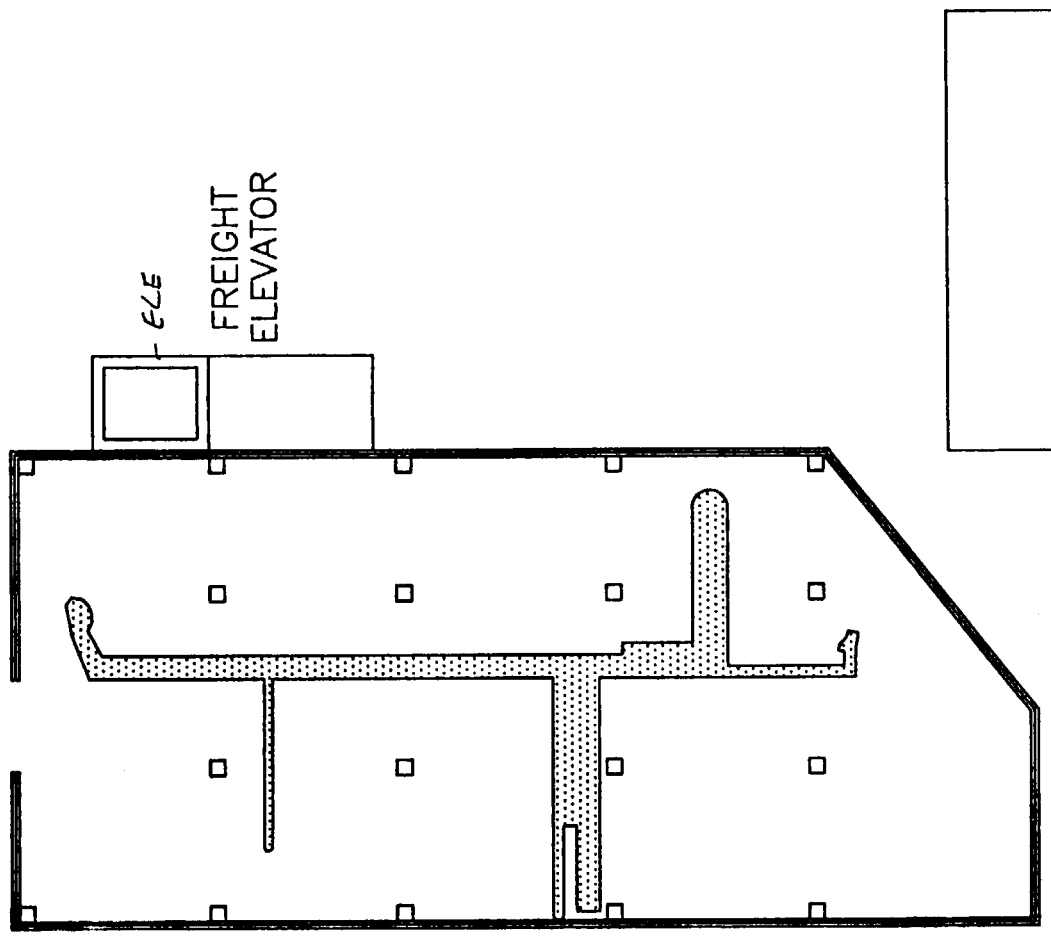
SIZE	DWG NO	REV
A	SEG-93-256	0

SCALE NONE

SHEET 1 OF 1

APPENDIX C (continued)

Building 7



COLUMN

EXCAVATED AREA

0 FEET 12

0 METERS 4

N

REV STATUS OF SHEETS	REV	0
	SHEET	1

REVISIONS

ZONE	DESCRIPTION

	DATE
DFTR MES	11-19-93
CHKR	DATE
DSGN ENGR	DATE
DSGN MGR	DATE
MFG	DATE
QA	DATE
APPRVD	DATE

SCIENTIFIC ECOLOGY GROUP, INC.

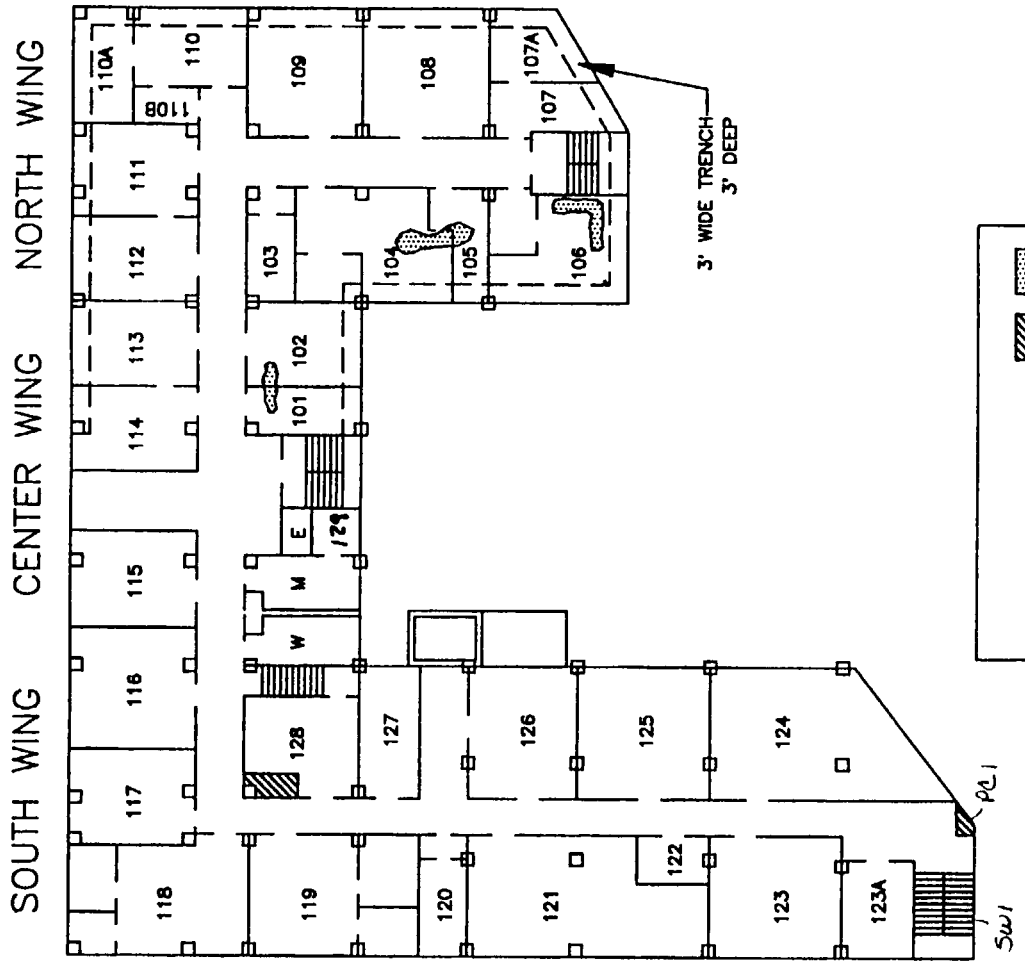
Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 7 BASEMENT

SIZE	DWG NO	REV
A	SEG-93-243	0

SCALE NONE

SHEET 1 OF 1



REV STATUS OF SHEETS	REV	0
	SHEET	1

REVISIONS	ZONE	DESCRIPTION

		DATE
DFTR	MES	11-19-93
CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SCIENTIFIC ECOLOGY GROUP, INC.

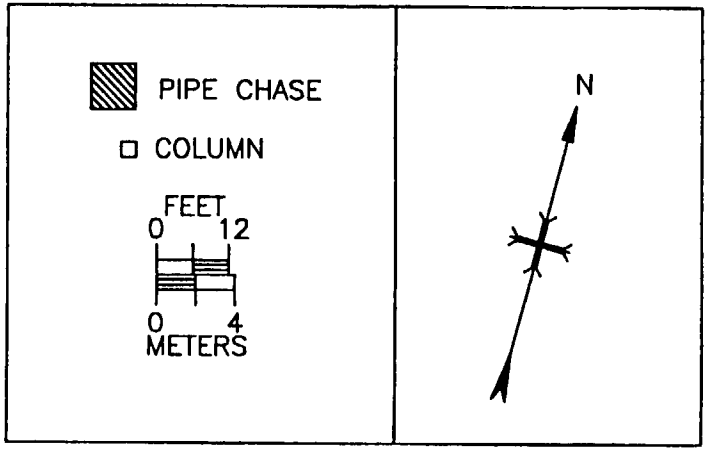
Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 7
FIRST FLOOR

SIZE	DWG NO	REV
A	SEG-93-244	0

SCALE NONE SHEET 1 OF 1

DWG. SEG-93-245 | SHT. 1



REV STATUS OF SHEETS	REV	0
	SHEET	1

REVISIONS	DESCRIPTION	
	ZONE	

	DATE
DFTR MES	11-19-93
CHKR	DATE
DSGN ENGR	DATE
DSGN MGR	DATE
MFG	DATE
QA	DATE
APPRVD	DATE

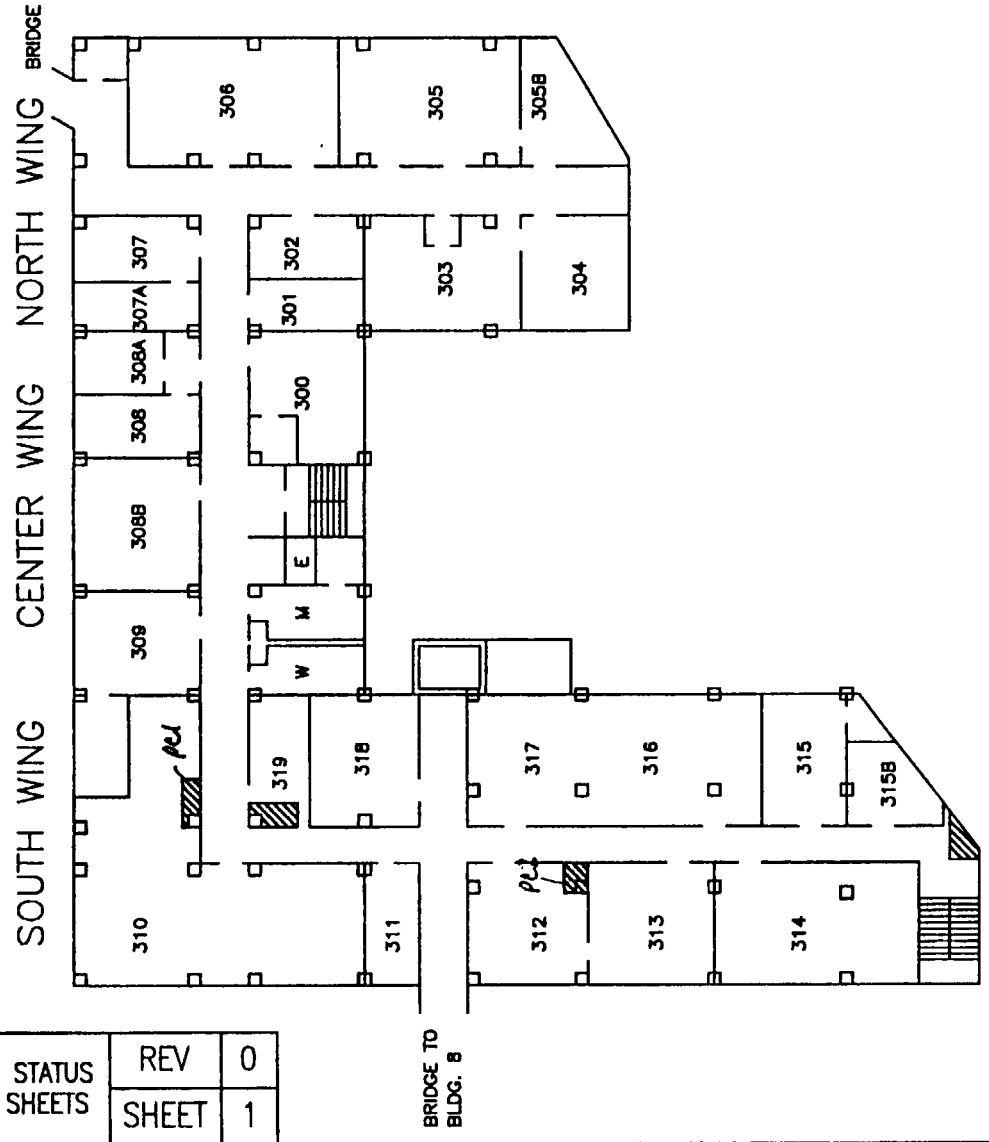
SEG SCIENTIFIC ECOLOGY GROUP, INC.

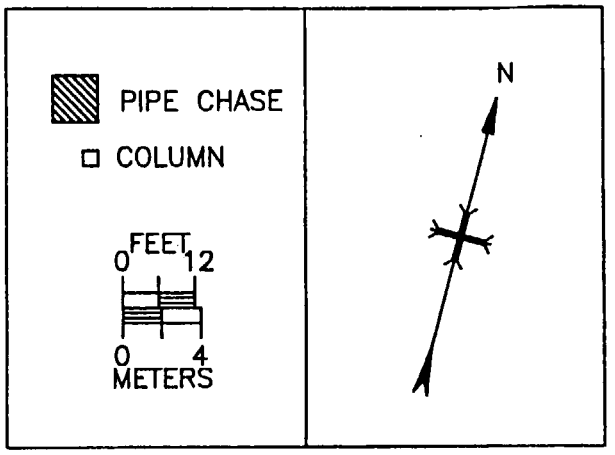
Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 7
SECOND FLOOR

SIZE	DWG NO	REV
A	SEG-93-245	0

SCALE NONE | SHEET OF 1





REV STATUS OF SHEETS		
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	SHEET	1

REVISIONS			
ZONE	DESCRIPTION		

		DATE
DFTR	MES	11-19-93
CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

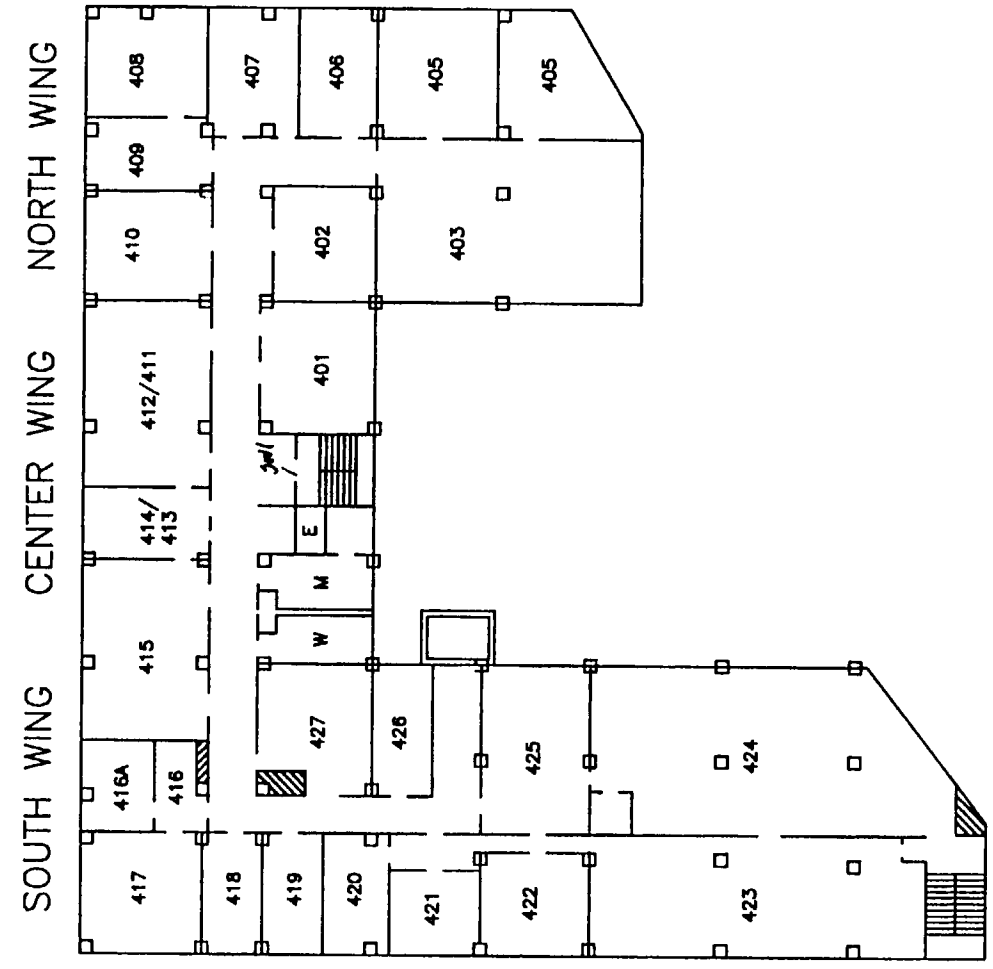
SEG SCIENTIFIC ECOLOGY GROUP, INC.

Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 7
THIRD FLOOR

SIZE	DWG NO	REV
A	SEG-93-246	0
	SCALE NONE	SHEET 1 OF 1

DWG. NO. SEG-93-247



PIPE CHASE

COLUMN

FEET 0 12

0 4 METERS

N

REV STATUS OF SHEETS	REV	0
	SHEET	1

REVISIONS	ZONE	DESCRIPTION

	DATE
DFTR MES	11-19-93
CHKR	DATE
DSGN ENGR	DATE
DSGN MGR	DATE
MFG	DATE
QA	DATE
APPRVD	DATE

SCIENTIFIC ECOLOGY GROUP, INC.

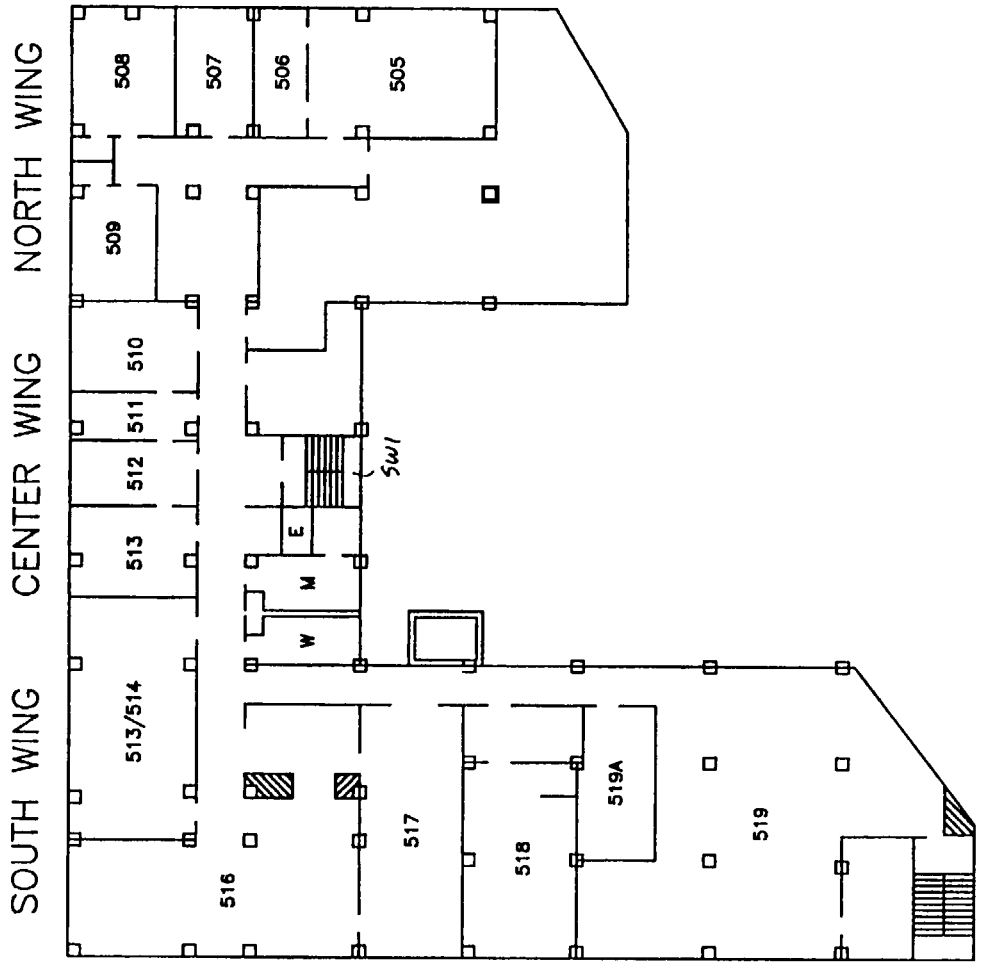
Oak Ridge Engineering
Oak Ridge, Tennessee

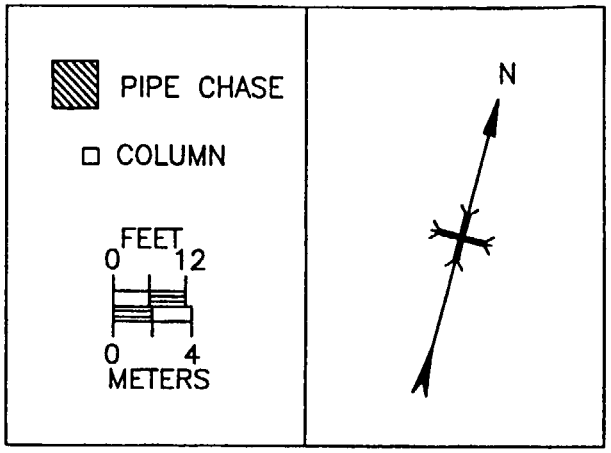
BUILDING 7
FOURTH FLOOR

SIZE	DWG NO	REV
A	SEG-93-247	0

SCALE NONE

SHEET 1 OF 1





REV STATUS OF SHEETS		
	REV	0
	SHEET	1

REVISIONS	DESCRIPTION	
	ZONE	

		DATE
DFTR	MES	11-19-93
CHKR		DATE
DSGN ENGR		DATE
DSGN MGR		DATE
MFG		DATE
QA		DATE
APPRVD		DATE

SEG SCIENTIFIC ECOLOGY GROUP, INC.
Oak Ridge Engineering
Oak Ridge, Tennessee

BUILDING 7
FIFTH FLOOR

SIZE	DWG NO	REV
A	SEG-93-248	0

SCALE NONE SHEET 1 OF 1