Rockwell International
Energy Systems Group

SUPPORTING DOCUMENT

GO NO.	S/A NO.	PAGE 1 OF	TOTAL PAGES	REV LTR/CHG NO SEE SUMMARY OF CHG	NUMBER
07704	42000				N704TI990057

PROGRAM TITLE

Decontamination and Disposition of Facilities Program

DOCUMENT TITLE

Final Radiological Inspection of the Below-Grade Areas in the SRE Prior to Release for Unrestricted Use

DOCUMENT TYPE

Radiological Inspection

KEY NOUNS

SRE, Environmental Inspection

ORIGINAL ISSUE DATE

REL. DATE

8-26-81

PREPARED BY/DATE | DEPT | MAIL ADDR

John C. Blake | 755-520 | KB45

IR&D PROGRAM? YES ☐ NO ☒
IF YES, ENTER TPA NO.

APPROVALS | DATE

R. J. Tuttle 8/25/81
C. C. Conners
J. H. Walter
D. C. Empey

DISTRIBUTION

* NAME	MAIL ADDR
*R. J. Tuttle	NB13
*W. D. Kittinger	NB02
*A. P. Lichtman	KB45
*R. Aguilera	KB45
*T. D. Hunnicutt (3)	T011
*W. McCurnin	T020
*J. Marzec	T143
*J. M. Harris	T055
*J. H. Walter	T006
*B. Ureda	NB02
*J. Carroll	NB02
*C. C. Conners	NB02
*R. K. Owen	T143
*D. Phillips	T143
*F. Seward	T143

755-C.51/sjd/feh

* COMPLETE DOCUMENT
NO ASTERISK, TITLE PAGE/SUMMARY OF CHANGE PAGE ONLY

ABSTRACT

This document defines and discusses the activities which will be performed at the SRE to demonstrate compliance with the established cleanness criteria. It includes the monitoring techniques which will be employed, the data to be collected, and the analysis activities to be performed. Controls over the back filling operation are also discussed.

RESERVED FOR PROPRIETARY/LEGAL NOTICES

FORM 734-C REV. 12-79

CONTENTS

TABLES

1.0 INTRODUCTION

The Energy Systems Group of Rockwell International has been in the process of decommissioning the Sodium Reactor Experiment (SRE) Building 143 at the Santa Susana Field Laboratory. With this effort nearing completion, it is necessary that a comprehensive radiological survey be conducted of the areas to be backfilled within and adjacent to this building. This is an important step in the release of the building for unrestricted use. It is necessary to provide reasonable assurance that residual radioactivity is below acceptable limits. These limits have been established and are presented in the cleanness criteria contained in Table 1 (see Section 3.0).

Quality Assurance has developed this document to describe the activities which will be performed at the SRE to provide an independent assessment of effectiveness of the decontamination operations which have been conducted. This effectiveness will be established by extensive meter surveys, smear sample examination, and a material sampling program conducted within the SRE for the purpose of defining the existing levels of the natural and induced radioactivity. These will be compared to the criteria established as necessary to release the site for unrestricted use.

Three specific approaches using radiation measuring instruments will be utilized. First, a complete sweep of the area will be made to identify any areas of "high" activity that are detectable with field survey instruments. Second, very thorough surveys of areas which the records show as having had high levels of contamination and were cleaned up will be performed concentrating on the boundaries with assumed clean areas. Third, a 1-meter square (1-m^2) grid will be developed on a drawing of the SRE and samples of material will be taken from the SRE surfaces for a preestablished number of both random and selected location samples. Specific analytical data on the average and maximum radiation levels will be determined and statistically evaluated. This data will be compared to the criteria to establish whether the backfilling can commence.

Three methods for obtaining material samples of soil and rock will be employed. Surface soil samples will be obtained in areas where there is sufficient loose material to make this approach more feasible. In hard-surfaced areas (sandstone or rock), material will be chipped away. Second, surface smears will be obtained from existing original concrete surfaces. Third, ground water samples will be obtained from points in and/or around the SRE for analysis. Each of these samples will be carefully identified and of sufficient quantity to provide for analysis and material archiving.

The material samples obtained for Quality Assurance will be submitted to Health, Safety and Radiation Services (HS&RS) for determination of the level of radioactivity and to an independent outside laboratory for analysis and determination of the radionuclides present. The results of both analysis activities will be accumulated into a final report of the survey prepared by Quality Assurance and Operations covering all activities at the SRE.

Comprehensive records of all activities supporting this plan will be maintained to provide a clear presentation of the survey and results. The data developed from the various examinations will be analyzed and a final report on the activities prepared.

755-C.51/sjd

2.0 SCOPE OF ACTIVITIES

This program has been developed to evaluate that portion of the SRE building and immediately adjacent areas which have been excavated during the decontamination operations. It is specifically limited to those below-grade areas which are to be backfilled. In some areas, it was necessary to excavate extensively to remove various items of equipment and piping. These areas have already been backfilled for safety purposes. This plan will address the existing conditions in the SRE.

Since no releases of alpha-emitting radionuclides occurred at the SRE, the meter surveys and measurements made at the SRE will be specifically to detect beta-gamma and gamma radiation. Alpha measurements will be obtained from the material samples obtained and submitted for analysis.

755-C.51/sjd

3.0 ACCEPTANCE CRITERIA

The criteria which have been established to release the SRE for unrestricted use are presented in Table 1 below.

TABLE 1
CONTAMINATION LIMITS FOR RELEASE TO UNRESTRICTED USE

A. Surfaces:

Beta Gamma Emitters:	Total	= 0.1 mrad/h at 1 cm, with 7 mg/cm^2 absorber
	Removable	= 100 dpm/100 cm^2
Alpha Emitters:	Total	= 100 dpm/100 cm^2
	Removable	= 20 dpm/100 cm^2

B. Soil:

Near Surface:	100 pCi/g gross detectable beta activity
Below 3 m (average):	1000 pCi/g gross detactable beta activity
*(maximum):	3000 pCi/g gross detectable beta activity

*The maximum value may be average over a volume of 1 m^3 to meet the limit for the average value.

In order to be able to present the facility for unrestricted use, clearly all of these criteria must be met. A series of surveys and sample collection and analyses will be performed to fully establish the extent to which the criteria have been met. The evaluation of each of the criteria is dependent on the method utilized in its measurement.

755-C.51/sjd

4.0 EXAMINATION METHODS

In this section the methods to be employed in the evaluation of each of the acceptance criteria will be discussed. At the outset, it is important to recognize that the evaluation is dependent on two major factors: appropriate, calibrated equipment, and the knowledge and skill of the person doing the survey.

4.1 SURFACE DOSE RATE

The first of the criteria from Table 1 is for beta-gamma emitters. Total radiation dose will be measured with a CP-7 (ion chamber) with a 7 mg/cm^2 window at 1 cm from the chamber front. The CP-7 is a large, high-sensitivity ion chamber for measuring true dose rate in air. Other measurements of beta activity are generally considered to be more sensitive contamination indicators and, therefore, the dose rate survey will be conducted in the manner of discovery. This means that the entire area will be surveyed in an attempt to locate and identify areas of increased radioactivity. As these are located, they will be evaluated against the acceptance criteria of 0.1 mrad/h. Any area which exceeds this limit will be identified for additional cleanup.

4.2 REMOVABLE BETA

The second of the acceptance criteria is the removable beta activity, which will be measured by a smear and reported in units of dpm/100 cm^2 with a limit of 100 dpm/100 cm^2. A 2.4-cm diameter Whatman No. 540 filter paper disc will be passed over a representative portion of a section of a surface using moderate pressure with the tip of the thumb. (The judgement of "moderate pressure" is a matter of experience.) Normally, the area of the portion smeared should approximate 100 cm^2. Since the pressure-bearing portion of the filter paper disc is approximateley 2 cm wide, the length of the smear should be about 50 cm (18 in.) long. This should be achieved by a Z or S pattern with legs that are each about 6 in. long. The original SRE concrete surfaces that are to be buried are to be sampled by this method. The smear paper will be protected against loss of activity prior to counting by use of a "smear book" composed of file cards. To prevent transfer of contamination, these books will not be reused. Approximately 10% of the 1-m^2 containing original concrete will be sampled with this technique.

4.3 ALPHA EMITTERS

Alpha emitters will be measured by the scanning scaler technique using an alpha detector, averaged over 1 m^2, and using the most sensitive range practical reported in dpm/100 cm^2. The acceptance criteria is 100 dpm/100 cm^2 maximum.

The scanning scaler method for alpha measurements uses the integrating function of a scaler in providing a direct measurement of the average surface activity. The measurement of surface radioactivity will use portable scalers (Ludlum Model 2200 or the Technical Associates Model FS-8) and alpha-sensitive detectors (Ludlum Model 43-5 alpha scintillator or the Technical Associates PAS-9 alpha scintillator). The detector probe will be slowly traversed across the surface to provide complete coverage during the counting time period set on the scaler. This time period will be 10 min for either of the alpha scintillator detectors. The average gross and net countrates will be calculated by dividing the gross count by the counting time and subtracting the background countrate. The net countrate will be converted to surface activity (dpm/100 cm^2) by correcting for detection efficiency and the area ratio (relative to 100 cm^2). The resulting value is the surface activity averaged over 1 square meter (the area scanned during the counting time period). If the area is scanned uniformly, this result is essentially independent of scan speed, so if the scan of the area is completed before completion of the count time, the probe should be moved in a random pattern over the area for the remainder of the counting time.

This method is not generally effective with soils, and so it will be limited to specific preselected areas which will be designated by Quality Assurance. The purpose will be to obtain a sufficient number of 1-m squares identified, documented, and measured so that positive conclusions can be made about the alpha activity at the SRE. Approximately 1% of the 1-m^2 grid will be sampled with this technique.

4.4 REMOVABLE ALPHA

The removable alpha will be determined from the beta smears and is limited to 20 dpm/100 cm^2. The only additional precaution to be observed is to avoid the excessive loading of the filter paper with surface dirt since this could cause incorrectly low measurements of the alpha activity.

The filter paper disc will be placed on a counting planchet flat in order to avoid source geometry errors. The activity for alpha and beta radioactivity will be recorded on the data sheet with any other related information.

4.5 SOIL CONTAMINATION LIMITS

The acceptance criteria for soils is based solely on beta activity and is established as 100 pCi/g at the surface, and 1000 pCi/g average at 3 m (10 ft) below the surface with a maximum of 3000 pCi/g. This criteria will be evaluated by three methods: instrument surveys, surface measurement, and laboratory analysis of soil samples.

Surveys for beta activity will be conducted by use of a Ludlum Model 12 or Technical Associates PUG-1 countrate meter and a thin-window, pancake G-M detector (Ludlum 44-9, Eberline HP-210, or Technical Associates P-11 or P-11A). The background countrate will be determined locally by placing a clean hand over the face of the probe or by placing the probe face against a known clean surface, preferrably with a low effective atomic number, such as a plastic slab, and estimating the mean meter indication, using the slow time response. During the survey, the probe may be in contact with the surface or up to 1/2 in. away. The survey traverse rate should not exceed 2 in./sec. The surveys will be conducted throughout the entire area in a manner of discovery, attempting to locate and identify areas of increased radioactivity. Surveys will be conducted with the audio on, the fast time response selected, and using the most sensitive range practical.

The surface soil samples will be obtained using a clean shovel to remove the soil and place it in a 2-quart waterpoof cardboard container. The shovel must be wiped clean after each sample is obtained. Each soil sample should be approximately 1 kg and should be free of rocks and debris. The identification for each sample will be clearly marked on both the cardboard container and lid. The lid will then be taped on in a manner that will not obscure the labeling nor result in damaging it when the tape and lid are removed.

Subsurface soil samples may also be required by Quality Assurance, and these will come from auger holes drilled in the surface. Core drilling will be used to obtain these samples, and care must be exercised to avoid cross contamination. In addition, it will be necessary to drill through a plastic sheet spread on the surface in the event radioactive material is picked up during the drilling. The material being removed from the hole will be continuously monitored for beta and gamma radiation as it is being withdrawn.

Samples of rock and concrete will also be obtained, identified, and submitted for analysis. These samples will be chipped from their surfaces and placed in the 2-quart waterproof cardboard containers, identified, and taped closed as discussed above.

4.6 SPECIAL EXAMINATIONS

The preceding section discussed the methods and activities necessary to demonstrate compliance to the established acceptance criteria. This section will describe certain additional tests and activities which will be performed to provide further confidence that the decontamination program has been effective and comprehensive.

4.6.1 Gamma Emitters

A comprehensive survey of the area will be conducted to locate and define any areas of increased gamma activity. While it should be recognized that there was a gamma component accounted for in the "surface dose rate," a specific evaluation of the gamma activity in the area has not been performed. A Ludlum Model 12S Micro R meter (which uses a 1-in. x 1-in. NaI (Tℓ) scintillator calibrated for Cs-137 gamma rays) will be used for the surveys of gamma radiation. The survey will be conducted with the audio on, and the fast (F) time response and most sensitive range selected. In performing the survey, the operator should move at a slow pace while monitoring the gamma radiation reading from approximately 1 m above the ground (waist level for most people). Areas of increased activity will be identified and defined and records maintained of the measurements obtained. These will be cross correlated with the results of the examinations performed to demonstrate compliance to the acceptance criteria. No limit has been established for gamma radiation.

4.6.2 Migration Control Activities

A clear demonstration that there is no migration of residual radioactive contamination from the SRE to the surrounding environment is also necessary to assure a continuing acceptable condition. Two transport methods are available for the dispersion of the radioactive materials into the environment: water and air. Each of these will require monitoring to assure that the decommissioning task has been properly completed.

4.6.2.1 Water

Water samples will be obtained from the water sampling locations in and around the SRE on a weekly basis. Several wells exist in the area for this purpose, and there are low points in the SRE into which water seeps from time to time. If these prove to be insufficient, additional sampling locations within the SRE may be drilled for the purpose of water sampling.

Samples will be obtained in clean jars and properly identified with date and location. These will be submitted for a determination of the level of radioactivity which exists in each sample. Charts of the individual measurements and a ten measurement running average will be prepared for each location to identify significant changes in the levels identified.

4.6.2.2 Air Monitoring

The second transport method of radioactivity is through air movement, and the extent of contamination transfer from this method will be monitored. Air samples will be taken by passing air through filter paper by use of air sampling pumps (Gast 0211) with Type AE glass fiber filters, or high-volume air samplers (Hi-Q Filter Products CF-12B with 4-in. fiberglass Type E filters). The sampler used, its flow rate, and the sampling time will be noted on the data sheet. The filter paper will be placed in an envelope with the serial number marked on the envelope. These air samples are generally ready for counting as received, however, the high-volume air samplers use a 4-in.-diameter filter paper from which a 1-in.-diameter sample must be cut for counting. In this case, only 1/16 of the surface gets counted, and the results must be adjusted accordingly. The airborne sample information will be reported and this data will be plotted on a chart with a ten measurement running average to identify any unusual conditions.

The air monitoring system will be operational during the shifts when soil is being disturbed in the SRE. A suitable representative location for the instrument will be identified, and comprehensive records of its operation and the resulting data will be maintained.

4.6.3 Alpha Emitters

Approximately five additional soil samples will be taken for the specific purpose of providing material for analysis for plutonium. These samples will consist of at least 2 quarts of soil and each will be well mixed and split into an archive sample and a sample to be sent to an outside laboratory for analysis. No limit has been established for plutonium.

5.0 CALIBRATION AND QUALIFICATION

5.1 CALIBRATION

Maintenance and calibration of all battery-powered (field instrument) systems will be performed with 13-week service periods, and laboratory instruments (ac-powered) will be serviced and calibrated within 6-month service periods by QA Instrumentation and Technical Support at ESG/De Soto (or more frequently if required by the manufacturer). Prior to use of an instrument, the calibration label shall be checked to assure that the instrument is in current calibration. No instrument shall be used for a documented measurement or for radiation safety purposes if the calibration has expired.

Instrument calibration shall determine the correct operating parameters and will indicate both the background countrate and the efficiency factor. The efficiency factor is defined as:

$$E = \frac{A}{C - B} \text{ (dpm/cpm)}$$

where A is the total source activity rate (dpm) for the selected radiation corrected for backscatter, C is the gross countrate (cpm) with the source in place, and B is the background countrate (cpm) with the source removed. Calibration sources prepared as a thin deposit on a relatively high-Z metal backing, such as steel, copper, or nickel, may exhibit a strong back-scatter effect. This effect is negligible for smear and filter papers, and very small for soil and water samples in aluminum planchets. Therefore, when using calibration sources of this sort, the efficiency factor is defined as:

$$E = \frac{2\ (2\pi \text{ emission rate})}{C - B} \text{ (dpm/cpm)}$$

For the Tc-99 calibration sources, this effect will cause a difference of 25% in the efficiency factor. For the Th-230 alpha calibration sources, this is only 1.4%. Use of these efficiency factors will result in a small, but variable and uncertain, systematic error. This error will not be adjusted. For calibration sources and for samples near the acceptance levels, no correction is required for dead-time losses.

5.2 QUALIFICATION

In order to assure continued calibration of an instrument and detect malfunction or drift at an early time, repeated qualification measurements must be made and recorded. For each of the instruments described above, a measurement of the background (in a stable environment with low background) and the response to identified sources will be made and plotted on control charts prior to the first use of the instrument each day. For measurements with a small number of counts (alpha detector background), the action and limit lines will be established as closely as possible at the 68%, 95%, and 99% bounds as determined from the Poisson distribution (see Appendix A), while for measurements with 20 or more events, the Gaussian (normal) distribution will be assumed with the lines set at $\pm\sqrt{N}$, $\pm 1.960\sqrt{N}$, and $\pm 2.576\sqrt{N}$, where N is the number of counts recorded. The gross values are to be plotted; no corrections nor unjustified rejections are to be made. Redetermination of the average countrate and action and limit lines will be necessary following repair or servicing of an instrument.

Qualification data for each instrument shall be kept on instrument record sheets of the type shown in Appendix B. Sample control charts are also shown in this appendix. The records sheets and control charts are part of the permanent documentation to be developed in this program.

755-C.51/sjd

6.0 GRID SURVEYS

The entire area to be surveyed at the SRE is approximately 140 ft long (east to west) and 65 ft wide (north to south) with the floor approximately 20 ft below grade. This represents about 18,500-ft^2 surface or 1700-m^2 area to be surveyed. Clearly, surveying each square foot or square meter of the area would represent an unreasonable task. Accordingly, alternative approachs of sampling the total population will be utilized.

The area to be surveyed will be defined on a drawing of the SRE. On this drawing will be overlayed 1-m^2 grid pattern covering the inside and outside below-grade areas including all of the walls, columns, and the post and plank retaining wall on the south edge of the excavation. Each of the resulting 1-m squares, representing the total population, will be given a number, and 54 of these numbers will be selected using a table of random numbers. These will form the unbiased or control sample.

A second independent group of 54 samples will be identified on the meter squares. These will be from specific locations selected because the history of operations or the previously run sweep surveys suggest that they are areas of higher activity. Every attempt will be made to make these 54 samples truly represent the worst case.

All 108 samples locations will be initially identified on the drawing or map of the SRE. Using the southwest corner, where the retaining wall meets the existing concrete wall, as the starting point, the sample locations on the SRE surfaces will be established. Material samples (soil, rock, or concrete from the original structure; there is nothing to be gained from chipping away the new column supports) will be obtained and identified, as discussed in Paragraph 4.5. In addition, the measurements used to establish the sample location will be recorded with the rest of the sample information. A 1-m^2 perimeter will be placed on the surface at the sample location. Material samples for the 54 unbiased samples will be obtained from any random location within the parameter. For 54 selected samples, however, it will be necessary to measure the surface gamma radiation within the perimeter and obtain the sample from the area showing the highest reading. This reading is to be recorded with the other sample data.

The samples will be carefully inventoried and submitted to HS&RS to establish the amount of radioactivity present in each sample, as discussed in the Sample Analysis section.

755-C.51/sjd

7.0 SAMPLE ANALYSIS

The material obtained from the grid survey activity will be submitted to HS&RS for the determination of the amount of radioactivity present in the sample. This will be determined using standard, documented procedures and will yield a result in pCi/g. This information will be recorded and reported for each of the 108 samples submitted.

A second group of 27 samples will be drawn from the original 108 samples and submitted to HS&RS for a second determination of the amount of radioactivity present. These samples will be numbered only permitting tracibility to the original sample. The data from the reevaluated samples will permit an evaluation of the repeatability of the analysis system and provide for increased confidence in the resulting data.

A third group of samples will be drawn from the original 108 and submitted to an outside laboratory for a complete breakdown to provide an inventory of the natural and induced radionuclides present in the contribution each makes to the total radioactivity present in the sample. These samples will be selected from those with the highest measured radioactivity, original SRE material, or which in some manner seem to be unusual. The number of these samples cannot be predetermined, but it is expected that there will be more than ten.

755-C.51/sjd/feh

8.0 SAMPLE PLAN DESIGN

The grid sampling plan for the SRE has been designed to provide statistically supportable information about the radiological condition of the total below-grade area prior to backfilling. The approach taken is to establish an adequate, random, unbiased sample of the SRE surfaces and statistically compare it to an equal sample which the history of the building and surveys of the area indicate to be the worst condition. The sample size for the random sample has been established from accepted statistical tables and will represent the population of the entire area. This unbiased sample will represent the expected baseline or general condition of the total area. A second sample from the same population will be selected and will represent the worst case which can be defined for the area. The closer these two samples are, based on statistical tests, the more uniform will be the area and thus, the greater the assurance that the total area can be represented by the samples and be declared as acceptable.

In establishing the sample plan, MIL-STD-414 was consulted to determine the number of samples which would be required. This document indicated that 40 or 50 samples would be necessary for a total population of 1,700 where the variability is unknown and the standard deviation method is employed with a single specification limit.

In the case of the SRE, however, it is necessary to establish more than just a simple accept or reject condition. Certain statistical tests are necessary to adequately support the judgments made. Accordingly, the MIL-STD-414 sample sizes were used as a point of departure in establishing a more suitable sample size. In order to perform a single-sided "t" test of the mean where $\alpha = 0.025$ and β is selected at 0.05 and δ/σ is chosen as 0.5, then 54 samples would be required. This sample size offers a very satisfactory trade off between the cost of sampling and analysis versus the adequate and sufficient accumulation of data for statistical purposes. Therefore, a random sample of 54 will be drawn from the total population of approximately 1,700 m squares. A second sample of 54 will be drawn from the same population but at selected locations. These two samples will then be compared using a number of tests including the "difference of means" and others.

755-C.51/sjd

9.0 BACKFILLING

The volume to be backfilled in and immediately adjacent to the SRE has been estimated at approximately 6,500 yd^3. This equates to approximately 1,300, 5 yd^3 truckfulls of material, although the actual number will be higher since the loose material from the truck will have to be compacted when it is dumped in the SRE. Some of this material was removed from the SRE during the decontamination activities and has been determined to be safely below the cleanness limits for the SRE. Additional material will be required to complete the backfill operation, and this will be obtained from other areas at SSFL.

In order to be confident that the backfilling material which is used is substantially less than the cleanness criteria for soils established in Table 1, a monitoring program will be established. This program will required the radiolotical survey of the areas from which the material will be obtained, the sampling of soil which is used to establish the levels of radioactivity, the monitoring of water from the wells in the SRE area for changes in radioactivity levels, and the monitoring of the air. These are the controls necessary to assure that the materials and methods used in the backfilling operation do not result in creating a condition which exceeds the established criteria.

9.1 MATERIAL SITES

The meter surveys discussed in Paragraph 4.5 for beta and Paragraph 4.6.1 for gamma activity will be used at each site from which backfill material is drawn. These surveys will be performed approximately every other day while the material is being drawn from the site. The purpose of the survey will be to assure that the sites are essentially homogeneous with activity levels well below those established for soils. Records of each survey will be accumulated for incorporation into the final report.

9.2 SOIL SAMPLES

Samples of the backfill material will be obtained from approximately 10% of the truckloads each day. Material will be taken from several locations in the load (before or after it is dumped) and placed in a 2-quart waterproof cardboard container and identified as described in Paragraph 4.5. This material will be submitted to HS&RS for analysis to establish the activity in pCi/g. This data will be used to establish the "as left" condition of the SRE.

Obtaining samples from 10% of the truckloads is substantially more than would be required if a standard sampling program based on MIL-STD-414 were used. Had this standard been used, only 40 or 50 samples (approximately 3% to 5%) would have been required. The larger number of samples is justified when the cost of locating and removing material with excessive radioactivity is compared to the cost of sampling and the resulting data base which will be developed. A control chart will be used to provide substantiation that the backfill material is consistently within acceptable limits.

9.3 WATER SAMPLES

Water will be drawn from all available locations in and around the SRE each day and submitted to HS&RS for analysis. Water will be used in compacting the backfill material. By monitoring the well water, assurance can be gained that there is no migration of any residual high-level radioactivity from the SRE into the water table. Both the absolute levels of activity and the longer term trend will be tracked. This data will be accumulated, analyzed, and incorporated into the final report.

9.4 AIR SAMPLES

Air samples will be obtained and analyzed as described in Paragraph 9.4.

755-C.51/sjd/feh

APPENDIX A
THE POISSON DISTRIBUTION

Radioactive disintegration belongs to a class of phenomena that are represented by a statistical (or probability) distribution known as the binomial distribution. When the probability of a specific event (the radioactive transition of a specified nucleus) within the measurement time interval is small, the binomial distribution is well approximated by the Poisson distribution:

$$P(n) = \frac{m^n e^{-m}}{n!}$$

where P(n) is the probability of n events (counts, for example) occurring if the mean (or true) value is m. The standard deviation of this distribution is $\sqrt{m}$.

For values of m of 20 or more, the Poisson distribution is well represented by the discrete Gaussian distribution which, for the sake of generality, is represented by the continuous Gaussian distribution. The standard deviation (σ) is equal to $\sqrt{m}$.

Values of the percentage of occurrence of a specified number of counts (n) for distribution with true means (m) are shown in Table A-1.

The precise 95% bounds are shown for comparison below.

Mean Count	Lower Bound (-2.5%)	Upper Bound (+2.5%)
3	0.6	8.8
4	1.1	10.2
5	1.6	11.7
6	2.2	13.1
7	2.8	14.4
8	3.5	15.8
9	4.1	17.1
10	4.8	18.4
11	5.5	19.7
12	6.2	21.0
13	6.9	22.2
14	7.7	23.5
15	8.4	24.7
16	9.1	26.0
17	9.9	27.2
18	10.7	28.4
19	11.4	29.7
20	12.2	30.9

It may be noted that these differ somewhat from the bounds that would be selected from Table A-1. This may be due to representation of the discrete Poisson distribution in this calculation of bounds, as a continuous distribution.

TABLE A-1

PERCENTAGE OF MEASUREMENTS EXPECTED TO PRODUCE A CERTAIN NUMBER OF COUNTS FOR ACTIVITY WITH THE SPECIFIED MEAN COUNT (POISSON STATISTICS)

Number of Counts	Mean Count 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	Number of Counts
0	90.48	81.87	74.08	67.03	60.65	54.88	49.66	44.93	40.66	0
1	9.05	16.37	22.22	26.81	30.33	32.93	34.76	35.95	36.59	1
2	0.45	1.64	3.33	5.36	7.58	9.88	12.17	14.38	16.47	2
3	0.02	0.11	0.33	0.72	1.26	1.98	2.84	3.83	4.94	3
4	-	0.01	0.03	0.07	0.16	0.30	0.50	0.77	1.11	4
5		-	-	0.01	0.02	0.04	0.07	0.12	0.20	5
6				-	-	-	0.01	0.02	0.03	6
7							-	-	-	7

Number of Counts	Mean Count 1	2	3	4	5	6	7	8	9	10	
0	36.79	13.53	4.98	1.83	0.67	0.25	0.09	0.03	0.01	-	0
1	36.79	27.07	14.94	7.33	3.37	1.49	0.64	0.27	0.11	0.05	1
2	18.39	27.07	22.40	14.65	8.42	4.46	2.23	1.07	0.50	0.23	2
3	6.13	18.04	22.40	19.54	14.04	8.92	5.21	2.86	1.50	0.76	3
4	1.53	9.02	16.80	19.54	17.55	13.39	9.12	5.73	3.37	1.89	4
5	0.31	3.61	10.08	15.63	17.55	16.06	12.77	9.16	6.07	3.78	5
6	0.05	1.20	5.04	10.42	14.62	16.06	14.90	12.21	9.11	6.31	6
7	0.01	0.34	2.16	5.95	10.44	13.77	14.90	13.96	11.71	9.01	7
8	-	0.09	0.81	2.98	6.53	10.33	13.04	13.96	13.18	11.26	8
9		0.02	0.27	1.32	3.63	6.88	10.14	12.41	13.18	12.51	9
10		-	0.08	0.53	1.81	4.13	7.10	9.93	11.86	12.51	10
11			0.02	0.19	0.82	2.25	4.52	7.22	9.70	11.37	11
12			0.01	0.06	0.34	1.13	2.63	4.81	7.28	9.48	12
13			-	0.02	0.13	0.52	1.42	2.96	5.04	7.29	13
14				0.01	0.05	0.22	0.71	1.69	3.24	5.21	14
15				-	0.02	0.09	0.33	0.90	1.94	3.47	15
16					-	0.03	0.14	0.45	1.09	2.17	16
17						0.01	0.06	0.21	0.58	1.28	17
18						-	0.02	0.09	0.29	0.71	18
19							0.01	0.04	0.14	0.37	19
20							-	0.02	0.06	0.19	20
21								0.01	0.03	0.09	21
22								-	0.01	0.04	22
23									-	0.02	23
24										0.01	24
25										-	25

PERCENTAGE OF MEASUREMENTS EXPECTED TO PRODUCE A CERTAIN NUMBER OF COUNTS FOR ACTIVITY WITH THE SPECIFIED MEAN COUNT (POISSON STATISTICS)

Number of Counts	Mean Count 11	12	13	14	15	16	17	18	19	Number of Counts
0	-	-								0
1	0.02	0.01	-	-						1
2	0.10	0.04	0.02	0.01	-	-				2
3	0.37	0.18	0.08	0.04	0.02	0.01	-	-		3
4	1.02	0.53	0.27	0.13	0.06	0.03	0.01	0.01	-	4
5	2.24	1.27	0.70	0.37	0.19	0.10	0.05	0.02	0.01	5
6	4.11	2.55	1.52	0.87	0.48	0.26	0.14	0.07	0.04	6
7	6.46	4.37	2.81	1.74	1.04	0.60	0.34	0.19	0.10	7
8	8.88	6.55	4.57	3.04	1.94	1.20	0.72	0.42	0.24	8
9	10.85	8.74	6.61	4.73	3.24	2.13	1.35	0.83	0.50	9
10	11.94	10.48	8.59	6.63	4.86	3.41	2.30	1.50	0.95	10
11	11.94	11.44	10.15	8.44	6.63	4.96	3.55	2.45	1.64	11
12	10.94	11.44	10.99	9.84	8.29	6.61	5.04	3.68	2.59	12
13	9.26	10.56	10.99	10.60	9.56	8.14	6.58	5.09	3.78	13
14	7.28	9.05	10.21	10.60	10.24	9.30	8.00	6.55	5.14	14
15	5.34	7.24	8.85	9.89	10.24	9.92	9.06	7.86	6.50	15
16	3.67	5.43	7.19	8.66	9.60	9.92	9.63	8.84	7.72	16
17	2.37	3.83	5.50	7.13	8.47	9.34	9.63	9.36	8.63	17
18	1.45	2.55	3.97	5.54	7.06	8.30	9.09	9.36	9.11	18
19	0.84	1.61	2.72	4.09	5.57	6.99	8.14	8.87	9.11	19
20	0.46	0.97	1.77	2.86	4.18	5.59	6.92	7.98	8.60	20
21	0.24	0.55	1.09	1.91	2.99	4.26	5.60	6.84	7.83	21
22	0.12	0.30	0.65	1.21	2.04	3.10	4.33	5.60	6.76	22
23	0.06	0.16	0.37	0.74	1.33	2.16	3.20	4.38	5.59	23
24	0.03	0.08	0.20	0.43	0.83	1.44	2.26	3.28	4.42	24
25	0.01	0.04	0.10	0.24	0.50	0.92	1.54	2.37	3.36	25
26	-	0.02	0.05	0.13	0.29	0.57	1.01	1.64	2.46	26
27		0.01	0.02	0.07	0.16	0.34	0.63	1.09	1.73	27
28		-	0.01	0.03	0.09	0.19	0.38	0.70	1.17	28
29			0.01	0.02	0.04	0.11	0.23	0.44	0.77	29
30			-	0.01	0.02	0.06	0.13	0.26	0.49	30
31				-	0.01	0.03	0.07	0.15	0.30	31
32					0.01	0.01	0.04	0.09	0.18	32
33					-	0.01	0.02	0.05	0.10	33
34						-	0.01	0.02	0.06	34
35							-	0.01	0.03	35
36								0.01	0.02	36
37								-	0.01	37

APPENDIX B

INSTRUMENT QUALIFICATION RECORD SHEETS AND CONTROL CHARTS

Each instrument (counting system, scaler and detector, or countrate meter and probe) used in the inspection surveys will be assigned a disinct code consisting of two alphanumeric characters to identify it and its results. As long as an instrument is in use, a Qualification Record Sheet will be maintained, documenting the calibration and quality control measurements. For instruments consisting of two components, such as the portable scaler and its detectors or countrate meters and probes, the first character will be assigned to the major component and the second to the minor. Each unit will have a label showing its identifying code.

Information on the Qualification Record Sheet will fully describe each instrument. A master sheet is included in this Appendix. These sheets provide for a dated record of response to background and to calibration sources. This record will also be shown on control charts to provide indication and early warning of deviation of the instrument from proper behavior.

The use of control charts is demonstrated by a fictitious example in Figures B-1 and B-2, for a scaler and alpha probe. The first figure shows the background count (not count rate) while the second shows the count (not count rate) for a standard alpha source. The first chart involves Poisson statistics, while the second involves Gaussian statistics. Normal background counts are shown initially, for a true count of 4. An abrupt change in April suggests a small light leak, while the slow upward drift in June could result from a drift in the discriminator. The control chart for the standard source shows normal behavior initially, then some erratic behavior in April, perhaps due to electrical supply noise. The slow decline in response after June could result from many causes: degradation of the scintillator screen, reduced amplification in the photomultiplier tube, declining high voltage. In any event, unacceptable

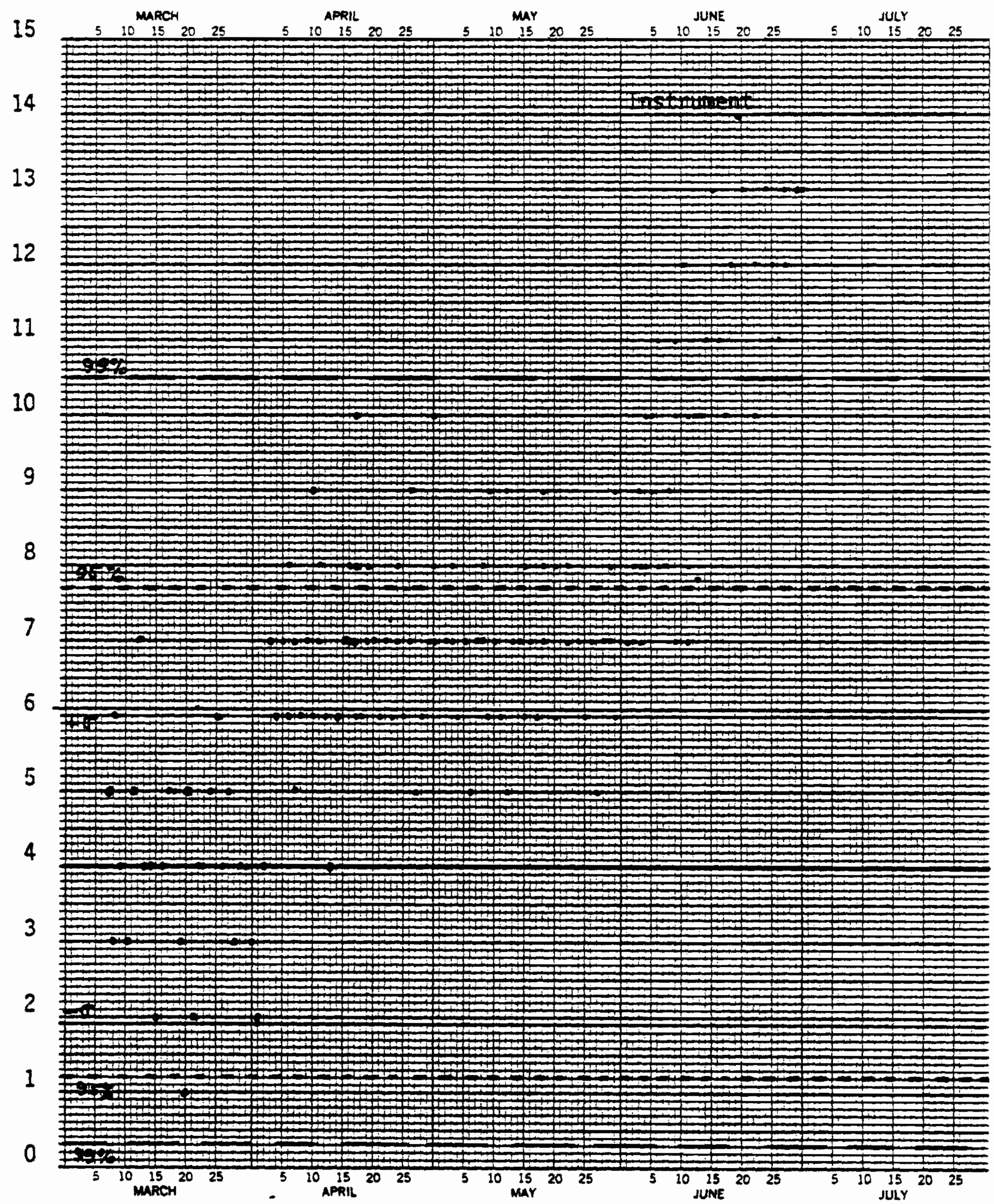

Figure B-1
Background Control Chart

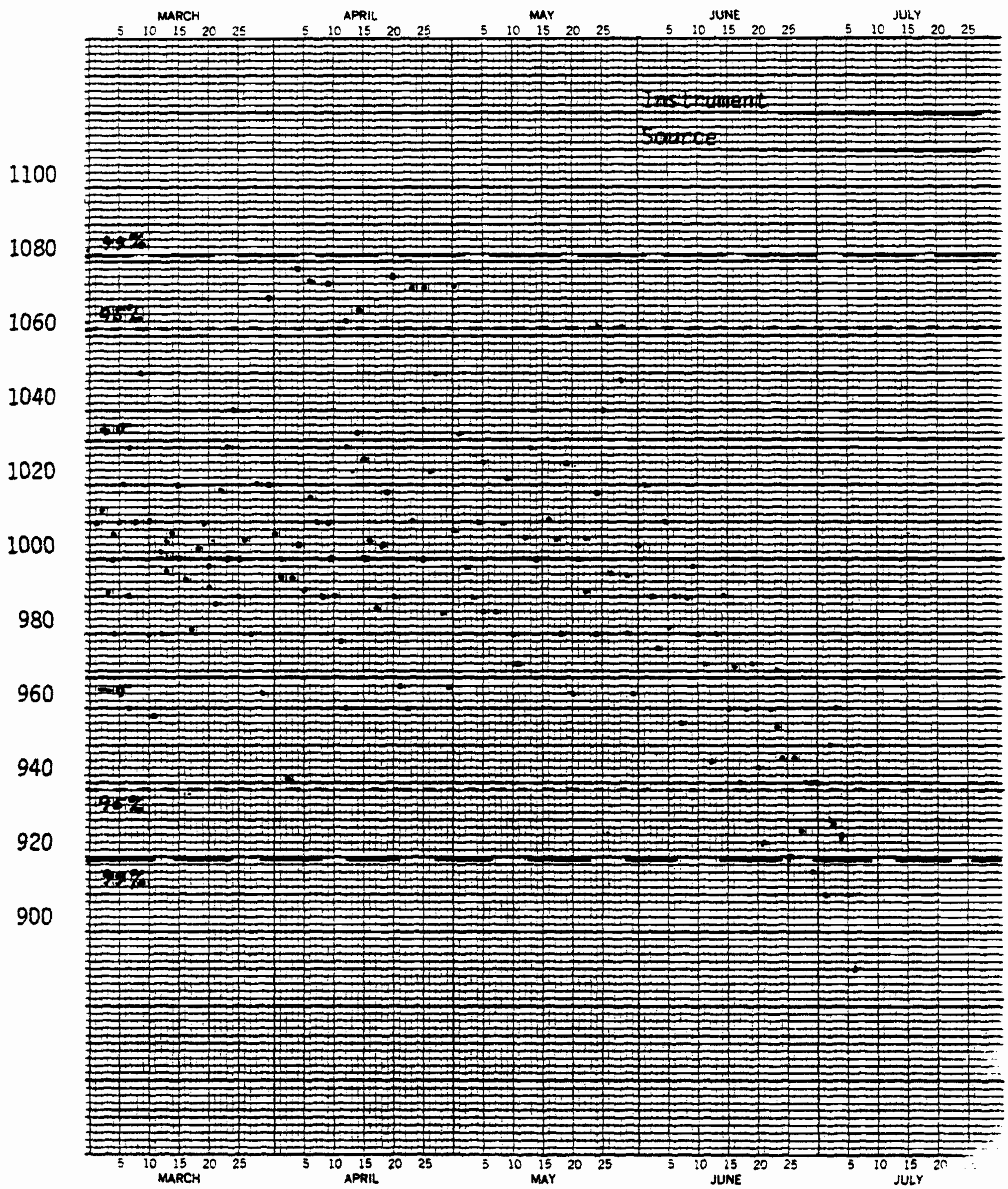

Figure B-2
Source Response Control Chart

performance is clearly forecast. (Note that indication of similar poor performance by several instruments checked with the same source suggests the need for checking the source itself.)

The scale and guidelines on a control chart should be selected and drawn with care. The scale should provide reasonable separation of the guidelines and good resolution for various count values, but should not spread them so widely that trends are hard to discern. For the Poisson distribution, the guidelines are chosen as symmetrically about the mean as possible to provide 68%, 95%, and 99% limits. For the Gaussian distribution, these correspond to $\pm 1\sigma$, $\pm 1.96\sigma$, and $\pm 2.576\sigma$. The standard deviation, σ, shall be taken as equal to $\sqrt{N}$ where N is the expected (true) number of counts in the counting interval, determined from a set of 100 counts (or alternatively, 100 times the counting time interval). This provides an uncertainty on the mean value of one-tenth the standard deviation of the data distribution for the basic counting interval, thus limiting the bias introduced by departure of this value from the true value. Mechanical and electronic adjustments to the instrument may affect both the background and source-response results, so these values must be redetermined after servicing of an instrument.

The Qualification Record Sheets and the Control Charts are part of the permanent documentation.

INSTRUMENT QUALIFICATION RECORD SHEET

Instrument Code ____ ____

Type: ____________________ ____________________

Mfr: ____________________ ____________________

Model: ____________________ ____________________

Serial: ____________________ ____________________

Prop. No.: ____________________ ____________________

Source Identification: ____________

Date	Calib. Due Date	Background		Source Response			Efficiency Factor
		Count	Time	Rate	Count	Time	