

**Old Church Rock Mine
Eastern Abandoned Uranium Mine Region**

**OCRM Removal Assessment
Appendix B
Gamma Verification and Validation Report**

**Response, Assessment, and Evaluation Services
Contract No. EP-S9-17-03
Task Order 0035**

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ATTACHMENTS

Attachment B-1: SOP No. 002 “Performing a GPS-Based Gamma Radiation Survey”

Attachment B-2: Detector and Meter Serial Numbers and Dates of Use

Attachment B-3: Raw Gamma Measurement Files (Electronic)

Attachment B-4: Gamma QA/QC Procedures

Attachment B-5: Calibration Certificates

Attachment B-6: Daily Function Check Forms

Attachment B-7: Excluded Gamma Data (Electronic)

Attachment B-8: Final Gamma Dataset (Electronic)

ACRONYMS AND ABBREVIATIONS

μCi	Microcurie
ags	Above ground surface
ANSI	American National Standards Institute
BSA	Background study area
cpm	Counts per minute
Cs-137	Cesium-137
Detectors	Gamma Radiation Detection Instrumentation
GIS	Geographic Information System
GPS	Global Positioning System
HDOP	Horizontal dilution of position
HPIC	High-pressure ionization chamber
IL	Investigation level
MARLAP	<i>Multi-Agency Radiological Laboratory Analytical Protocols Manual</i>
MARSSIM	<i>Multi-Agency Radiation Survey and Site Investigation Manual</i>
NaI	Sodium iodide
OCRM	Old Church Rock Mine
QA	Quality assurance
QC	Quality control
Ra-226	Radium-226
RPD	Relative percent difference
RSD	Relative standard deviation
SAP	Sampling and Analysis Plan
SOP	Standard operating procedure
Tetra Tech	Tetra Tech, Inc.
USEPA	U.S. Environmental Protection Agency
VDOP	Vertical dilution of position



1.0 INTRODUCTION

Appendix B to the Old Church Rock Mine (OCRM) Removal Assessment Report (hereafter referred to as the main report) presents the data validation and verification methods and results of the 2022 field investigation in-field gamma radiation surveys at OCRM in New Mexico. Tetra Tech Inc. (Tetra Tech) adhered to quality assurance (QA) and quality control (QC) procedures regarding in-field gamma measurements in accordance with the U.S. Environmental Protection Agency (USEPA) approved Removal Assessment Sampling and Analysis Plan (SAP) (Tetra Tech 2022). QA includes qualitative factors that provide confidence in results, while QC involves quantitative field evidence that supports validity of results. Tetra Tech uses data quality indicators as recommended in the *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARSSIM) (USEPA 2000) and the *Multi-Agency Radiological Laboratory Analytical Protocols Manual* (MARLAP) (USEPA 2004) to ensure acquisition of data by use of reliable gamma radiation detection instrumentation (detectors), and that those data meet quality requirements for their intended end use.

2.0 OVERVIEW OF IN FIELD GAMMA RADIATION SURVEYS

This section provides overviews data quality needs that detectors must satisfy.

2.1 GAMMA RADIATION DETECTION INSTRUMENTATION

Gamma radiation surveys proceeded by use of Ludlum Model 44-10 2- by 2-inch sodium iodide (NaI) detectors, each coupled to either a Ludlum Model 3000 or Ludlum Model 2221r ratemeter/scaler set in ratemeter mode. The ratemeter/scalers were coupled with a Juniper Mesa 2 field computer and the sub-meter accurate Geode GNS2 Global Positioning System (GPS) receiver. The NaI detector was positioned 1 meter above ground surface (ags). Gamma radiation surveys occurred at a rate of approximately 1 meter per second. Gamma count rate measurements and associated geospatial coordinates were recorded every second.

High-pressure ionization chamber (HPIC) surveys were performed by use of a Reuter-Stokes RS-S131-200-ER000 HPIC. Data collected by the HPIC are stored internally where the data can be transferred to a computer for viewing. HPIC surveys were conducted at static locations at a height of 1 meter ags for a duration of 10 minutes.

Table B-1 lists NaI detector and datalogger types for each detector setup during field work, and the corresponding serial number for each.

Table B-1. Gamma Radiation Detection Instrumentation Used during Field Investigation

Instrument Name	Description	System ID	NaI Detector		Datalogger	
			Model	Serial Number	Model	Serial Number
Orange Detector	Juniper Geode/ Mesa 2	44	Ludlum 44-10	PR355810	Ludlum 3000	25018543
Red Detector	Juniper Geode/ Mesa 2	33	Ludlum 44-10	PR406319	Ludlum 3000	25020102
Blue Detector	Juniper Geode/ Mesa 2	26	Ludlum 44-10	PR150857	Ludlum 3000	25016973
Green Detector	Juniper Geode/ Mesa 2	38	Ludlum 44-10	PR295014	Ludlum 3000	25017006
Yellow Detector	Juniper Geode/ Mesa 2	5	Ludlum 44-10	PR355771	Ludlum 3000	25018610
Black Detector	Juniper Geode/ Mesa 2	1	Ludlum 44-10	PR399729	Ludlum 2221	254783
White Detector	Juniper Geode/ Mesa 2	14	Ludlum 44-10	PR375296	Ludlum 2221	117357
Instrument Name	Description	System ID	Model		Serial Number	
-	HPIC	-	Reuter-Stokes RS-S131-200-ER000		1001321	

Notes:

HPIC High-pressure ionization chamber

NaI Sodium iodide

2.2 SURVEYS PERFORMED

The OCRM 2022 field investigation was designed to acquire scoping level data in conformance to Standard Operating Procedure (SOP) No. 002, “Performing a GPS-Based Gamma Radiation Survey” included as [Attachment B-1](#). Scoping level data aided development of assumptions pertaining to design of an upcoming characterization level data investigation. QA/QC requirements are more stringent for characterization level data; however, detectors were assessed according to both characterization level and scoping level QC Criteria as discussed in [Section 4.0](#). Areas investigated during gamma radiation survey activities were as follows:

- The fenced area
- The area adjacent to and northeast of the site
- The area adjacent to and east and southeast of the site across State Route 566
- The unnamed arroyo adjacent to the site
- Haul roads including State Route 566 and Blackrock Road
- Residential yards near the site.

Presence of windblown contamination from waste piles on the site is also possible, and therefore radial surveys originating from the center of the site were conducted in eight Cardinal directions. In areas adjacent to the fenced portion of the site where stepout investigations were necessary, gamma radiation survey investigation levels (IL) determined from the background study areas (BSA) per Section 4.1 of the main report were referenced to determine when surface contamination had been laterally delineated. [Table B-2](#) lists gamma scan surveys conducted and instrumentation used.

Table B-2. Gamma Scan Surveys Performed and Instrumentation Used

Gamma Survey	Orange Detector	Red Detector	Blue Detector	Green Detector	Yellow Detector	Black Detector	White Detector
Lateral Delineation (Includes main site, homesite, drainage, and road surveys)	X	X	X	X	X	X	
Radial Scans	X		X	X			
Background Study Areas (BSAs)		X		X			
Gamma-Radium and Exposure Rate Correlation Plots ²		X					
Static Soil Sampling							X
Static BSA Soils							X

[Attachment B-2](#) provides the detector and meter serial numbers and dates of use at the site. Also included within [Attachment B-2](#) are the file names created for each gamma scan as well as the users who performed the gamma scans. [Attachment B-3](#) includes the raw gamma survey data outputs from each device for all useable gamma survey data.

3.0 QUALITY ASSURANCE AND QUALITY CONTROL

This radiological survey project incorporated data QA/QC protocols developed to achieve guidelines established by MARSSIM (USEPA 2000). In general, QA includes qualitative factors that provide confidence in results, while QC involves quantitative field evidence that supports validity of results. Data quality indicators as recommended in MARSSIM (USEPA 2000) and MARLAP (USEPA 2004) were used to ensure reliability and sufficient quality of acquired data. [Attachment B-4](#) presents the QA/QC procedures for gamma radiation surveys. This section discusses QA/QC methods and results.

3.1 DETECTOR CALIBRATION

An important QA protocol for in-field gamma radiation surveys is detector calibration. All detectors used in the gamma radiation surveys had been calibrated in accordance with the *American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments* (American National Standards Institute [ANSI] 1997). Calibration of a detector is required (1) prior to initial use, (2) at least annually, and (3) after any scheduled or unscheduled maintenance or repair that may affect its operation. Recalibration is not necessary after general maintenance of detectors, such as cleaning, painting, and changing of buttons.

All detectors utilized during field work had been factory-calibrated within the previous 12 months and no detector underwent maintenance between the time of calibration and time of use. Copies of factory calibration documentation for all detectors used during the survey are in [Attachment B-5](#).

3.2 PRE- AND POST-SURVEY QUALITY CONTROL AND RESULTS

This subsection summarizes methods and results of QC analyses of detectors used during the gamma radiation survey. The QC protocol involved pre-survey and post-survey QC checks, and daily function QC checks. The purpose of these QC analyses is to show the comparability of the detectors and that the functionality of the instruments did not change over the course of the fieldwork. QC data measurements were recorded from all detectors used during the survey. See [Section 4.2.1](#) for a discussion of data validation.

3.2.1 Pre-Survey and Post-Survey Quality Control Methodology and Quality Control Criteria

Each detector anticipated for use during the gamma radiation survey underwent pre-survey and post-survey QC checks at an indoor location. The purpose of these measurements was to quantify consistency of readings among detectors under controlled conditions with consistent geometry and location before (pre-survey) and after (post-survey) removal assessment field activities. For both the pre-survey and post-survey, 1,000 background counts (no source) and 1,000 Cesium-137 (Cs-137) counts were collected with each detector. The exception to this was the white detector which collected 951 pre-survey background counts. Pre-survey QC checks of all seven detectors occurred during November 10 and 11, 2022. Post-survey QC checks of all seven detectors occurred on November 28, 2022. All QC checks took place in the Tetra Tech Fort Collins, Colorado office, with a setup similar to that shown on [Figure B-1](#).

The following four steps were necessary for the pre-survey QC checks, and the four associated QC Criteria must have been met to allow use of a detector for gamma surveys:

- **QC Criterion 1:** The mean of all background measurements and all Cs-137 source measurements is calculated. Then the mean of all detector-specific background measurements and Cs-137 measurements is calculated. The relative percent difference (RPD) between mean detector-specific measurements and the mean measurements from all detectors is then calculated. For each detector, this RPD must be less than 5 percent to allow use of a detector in characterization level gamma surveys, or 10 percent to allow its use in scoping level gamma surveys.
- **QC Criterion 2:** For each detector, the RPD is calculated between the mean background and the mean background of the detector that deviates the most from the detector being tested. The RPD is calculated again between the mean Cs-137 measurement. The RPD must be less than 10 percent for use of a detector for characterization level and scoping level gamma surveys.
- **QC Criteria 3:** The Relative Standard Deviation (RSD) is calculated for the mean background and Cs-137 source measurements for each detector. The RSD must be less than 5 percent for use of a detector in characterization level gamma surveys, or 10 percent for use of a detector in scoping level gamma surveys. RSD is also known as the coefficient of variation, but herein exclusively will be referred to as RSD.
- **QC Criterion 4:** Pre-survey measurements are plotted on a histogram and inspected to ensure they follow a normal distribution curve. First the normal Q-Q probability of the pre-survey and post-survey background and Cs-137 source measurements is plotted. Normal-fitted frequency histograms of the pre-survey and post-survey background and Cs-137 source measurements then are plotted. A side-by-side analysis of pre-survey and post-survey measurements on a histogram allows an inspection of the normality of the distribution. Following are the qualitative characteristics evaluated for whether a detector's measurements are normal:
 - a. Middle/highest point on histogram is the only identifiable peak.
 - b. Peak of the normal curve aligns with the peak point of the histogram.
 - c. Slopes of normal probability plots look approximately equal.

If any detectors deviate from these QC criteria, they will be re-evaluated by repetition of the 1,000 background and Cs-137 source measurements. If the deviations from QC criteria are repeatable, the detector will be sent back to the vendor for replacement. Detectors that meet the QC criteria can be used for either characterization level or scoping level gamma surveys, based upon the specific QC criteria they meet.

Upon successful completion of planned gamma surveys, a set of identical measurements in the same laboratory setting, hereafter referred to as post-survey measurements, will occur. Post-survey measurements will be completed by application of the same procedures as for the pre-survey measurements, including uses of the same location, Cs-137 (or equivalent source), and geometry. Following completion of the post-survey measurements, QC criteria 1 through 4 will

again be evaluated. In addition to the four pre-survey criteria, the following two criteria will be evaluated during post-survey QC checks:

- **QC Criterion 5:** The RPD between the mean pre-survey background gamma count rate and the mean post-survey background gamma count rate measurement should not exceed 5 percent for characterization data and 10 percent for scoping data.
- **QC Criterion 6:** The RPD between the mean pre-survey Cs-137 source gamma count rate and the mean post-survey Cs-137 source gamma count rate measurement should not exceed 5 percent for characterization data and 10 percent for scoping data.

Any detector deviating from these post-survey QC criteria will be re-evaluated by repetition of the 1,000 background and Cs-137 source measurements. If deviations from the QC criteria are repeatable, the gamma survey data collected from the detector(s) deviating from the QC criteria will be compared to data from other detectors and possibly removed from the final dataset.

Figure B-1 shows the setup for a pre-survey QC background check.



Figure B-1. Photograph of Pre-Survey QC Background Check

3.2.2 Pre-Survey Comparability Results

Table B-3 summarizes statistics of pre-survey QC measurements by each detector. The RPD between the mean of all detectors addresses QC Criterion 1, the RPD between the mean of individual detectors addresses QC Criterion 2, and the RSD addresses QC Criterion 3. All detectors passed QC Criteria 1 through 3 for scoping level data. QC Criterion 4 is addressed in Section 4.2.1.

Figure B-2 and Figure B-3 show interval plots of the mean of pre-survey background measurements and Cs-137 source measurements, respectively, for each detector. The mean of each detector is plotted as a point within plotted lines representing the mean of all detectors' measurements, a difference from the mean of 5 percent, and a difference from the mean of 10 percent.



Table B-3. Summary Statistics of Pre-Survey QC Background and Cs-137 Source Calculations

Pre-Survey Background Calculations							
Instrument Name	# of Counts	Mean (cpm)	Median (cpm)	Standard Deviation (cpm)	RSD	RPD Between Mean of Individual Instruments ¹	RPD Between Mean of All Instruments
Orange Detector	1,000	15,125	15,100	590	3.9%	9.0%	3.5%
Red Detector	1,000	15,163	15,200	581	3.8%	8.8%	3.3%
Blue Detector	1,000	16,226	16,200	589	3.6%	7.0%	3.5%
Green Detector	1,000	15,702	15,700	989	6.3%	5.3%	0.2%
Yellow Detector	1,000	15,600	15,600	581	3.7%	5.9%	0.5%
Black Detector	1,000	16,555	16,399	830	5.0%	9.0%	5.6%
White Detector	951	15,339	15,316	648	4.2%	7.6%	2.1%
Pre-Survey Cs-137 Source Calculations							
Instrument Name	# of Counts	Mean (cpm)	Median (cpm)	Standard Deviation (cpm)	RSD	RPD Between Mean of Individual Instruments ¹	Instrument RPD From Mean of All Instruments
Orange Detector	1,000	28,764	28,800	817	2.8%	3.8%	1.4%
Red Detector	1,000	29,215	29,200	774	2.6%	2.2%	0.1%
Blue Detector	1,000	29,265	29,300	742	2.5%	2.1%	0.3%
Green Detector	1,000	28,646	28,600	1,306	4.6%	4.2%	1.8%
Yellow Detector	1,000	29,091	29,100	768	2.6%	2.6%	0.3%
Black Detector	1,000	29,406	29,447	1,173	4.0%	2.6%	0.8%
White Detector	1,000	29,870	29,874	789	2.6%	4.2%	2.4%

Notes:

¹ RPD was calculated between the two instruments with the greatest difference in average cpm.

cpm Counts per minute

Cs-137 Cesium-137

QC Quality control

RPD Relative percentage deviation

RSD Relative standard deviation

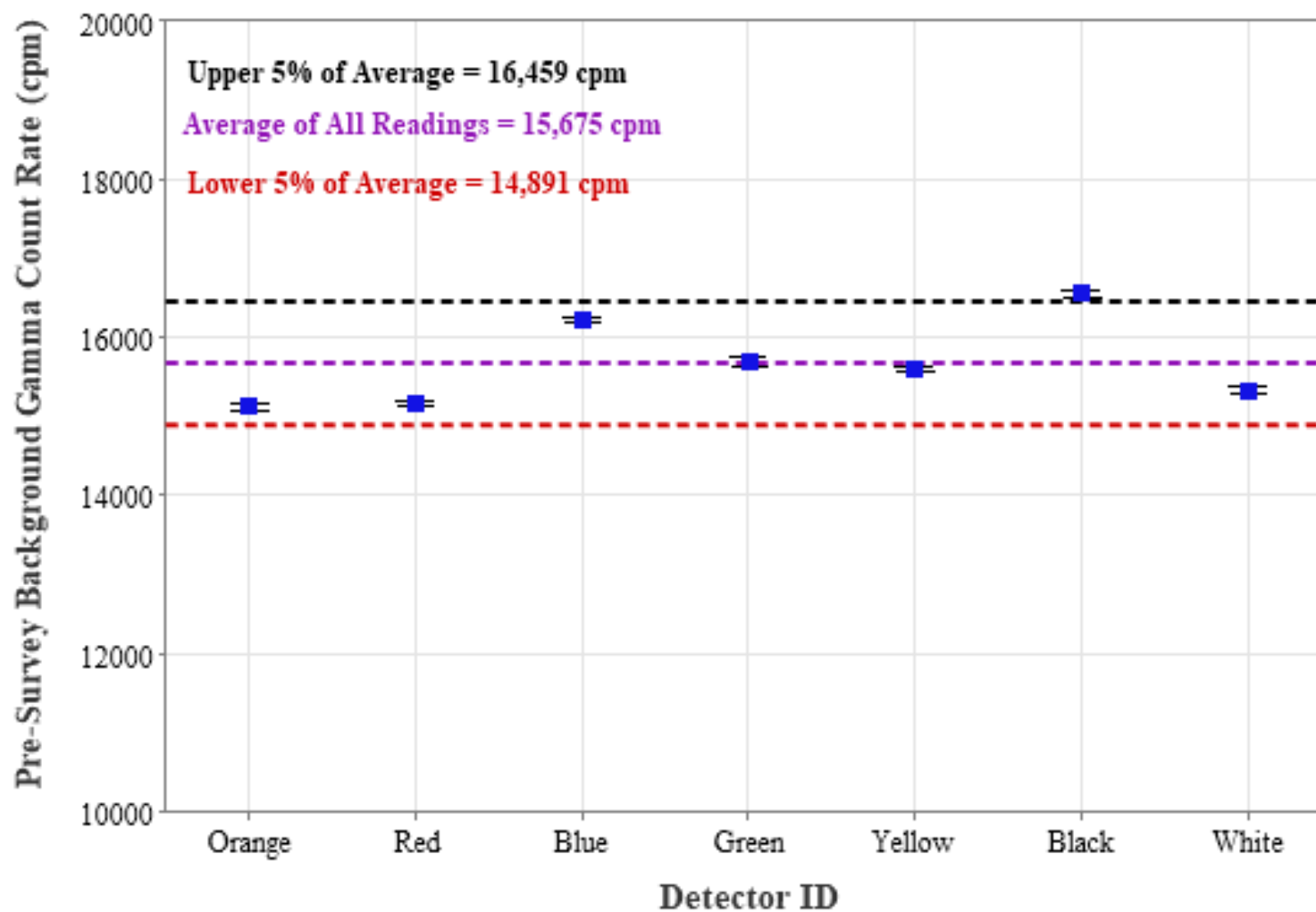


Figure B-2. Interval Plot of Pre-Survey Background Measurements by Detector

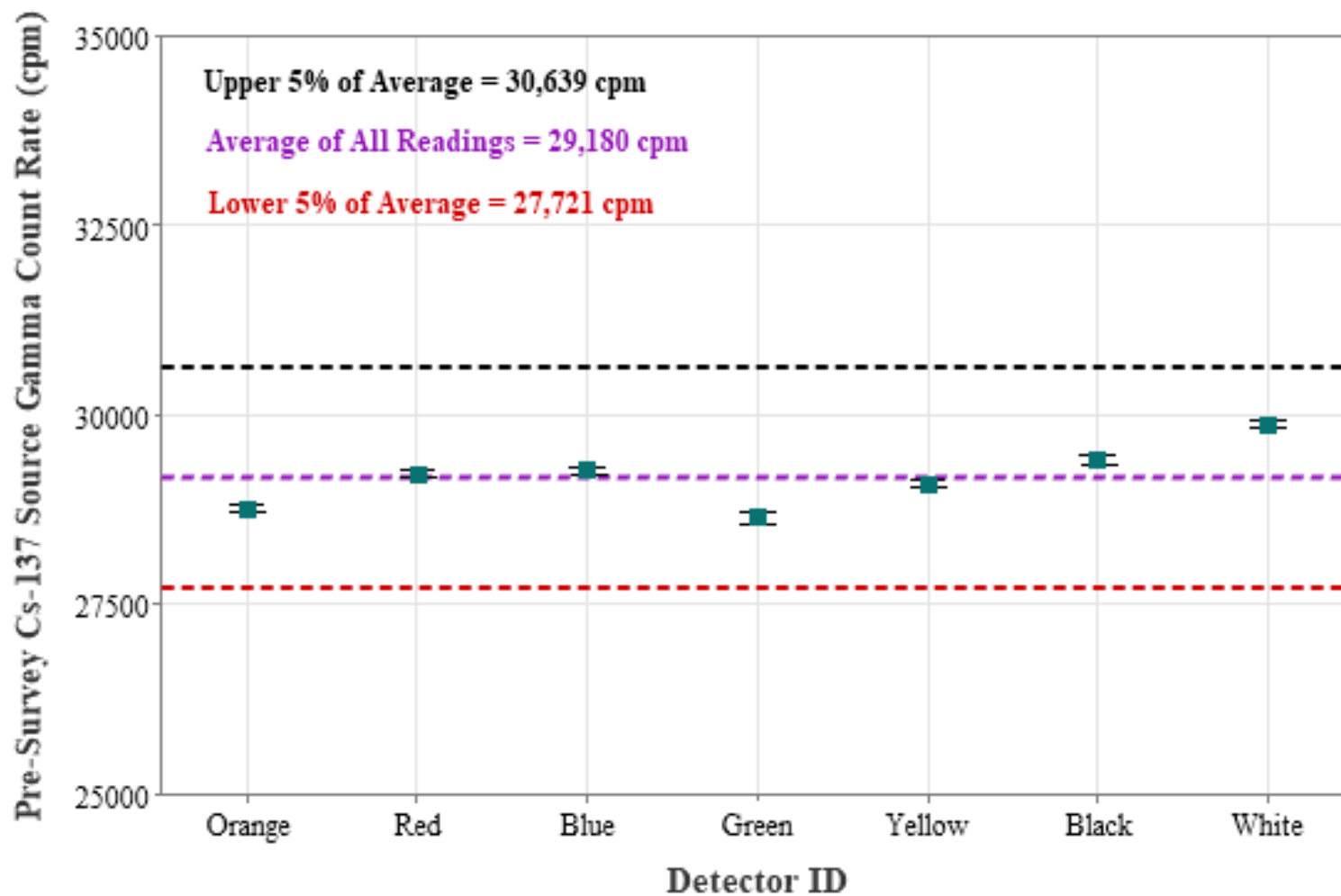


Figure B-3. Interval Plot of Pre-Survey Cs-137 Source Measurements by Detector

3.2.3 Post-Survey Comparability Results

Table B-4 summarizes statistics of post-survey QC measurements for each detector. The RPD between the mean of all detectors addresses QC Criterion 1, the RPD between the mean of individual detectors addresses QC Criterion 2, and the RSD addresses QC Criterion 3. All detectors passed QC Criteria 1 through 3 for scoping level data. QC Criterion 4 is addressed in Section 4.2.1.

Figure B-4 and Figure B-5 show interval plots of the mean of post-survey background measurements and Cs-137 source measurements, respectively, for each detector. The mean of measurements for each detector is plotted as a point within plotted lines representing the mean of all detectors measurements, a difference from the mean of 5 percent, and a difference from the mean of 10 percent.

Table B-4. Summary Statistics of Post-Survey QC Background and Cs-137 Source Calculations

Post-Survey Background Calculations							
Instrument Name	# of Counts	Mean (cpm)	Median (cpm)	Standard Deviation (cpm)	RSD	RPD Between Mean of Individual Instruments ¹	RPD Between Mean of All Instruments
Orange Detector	1,000	15,502	15,500	589	3.8%	5.3%	0.9%
Red Detector	1,000	15,797	15,800	554	3.5%	7.1%	1.0%
Blue Detector	1,000	16,219	16,200	590	3.6%	9.8%	3.7%
Green Detector	1,000	14,709	14,700	942	6.4%	9.8%	6.0%
Yellow Detector	1,000	15,659	15,700	562	3.6%	6.3%	0.1%
Black Detector	1,000	16,207	16,177	665	4.1%	9.7%	3.6%
White Detector	1,000	15,424	15,373	686	4.4%	5.0%	1.4%
Post-Survey Cs-137 Source Calculations							
Instrument Name	# of Counts	Mean (cpm)	Median (cpm)	Standard Deviation (cpm)	RSD	RPD Between Mean of Individual Instruments ¹	RPD Between Mean of All Instruments
Orange Detector	1,000	28,853	28,900	830	2.9%	5.2%	1.6%
Red Detector	1,000	28,823	28,800	755	2.6%	5.3%	1.7%
Blue Detector	1,000	29,976	29,900	776	2.6%	4.8%	2.2%
Green Detector	1,000	28,573	28,500	782	2.7%	6.1%	2.5%
Yellow Detector	1,000	29,324	29,400	1,346	4.6%	3.6%	0.0%
Black Detector	1,000	30,386	30,386	841	2.8%	6.1%	3.6%
White Detector	1,000	29,279	29,272	815	2.8%	3.7%	0.1%

Notes:

¹ RPD was calculated between the two instruments with the greatest difference in average cpm.

cpm Counts per minute

Cs-137 Cesium-137

QC Quality control

RPD Relative percentage deviation

RSD Relative standard deviation

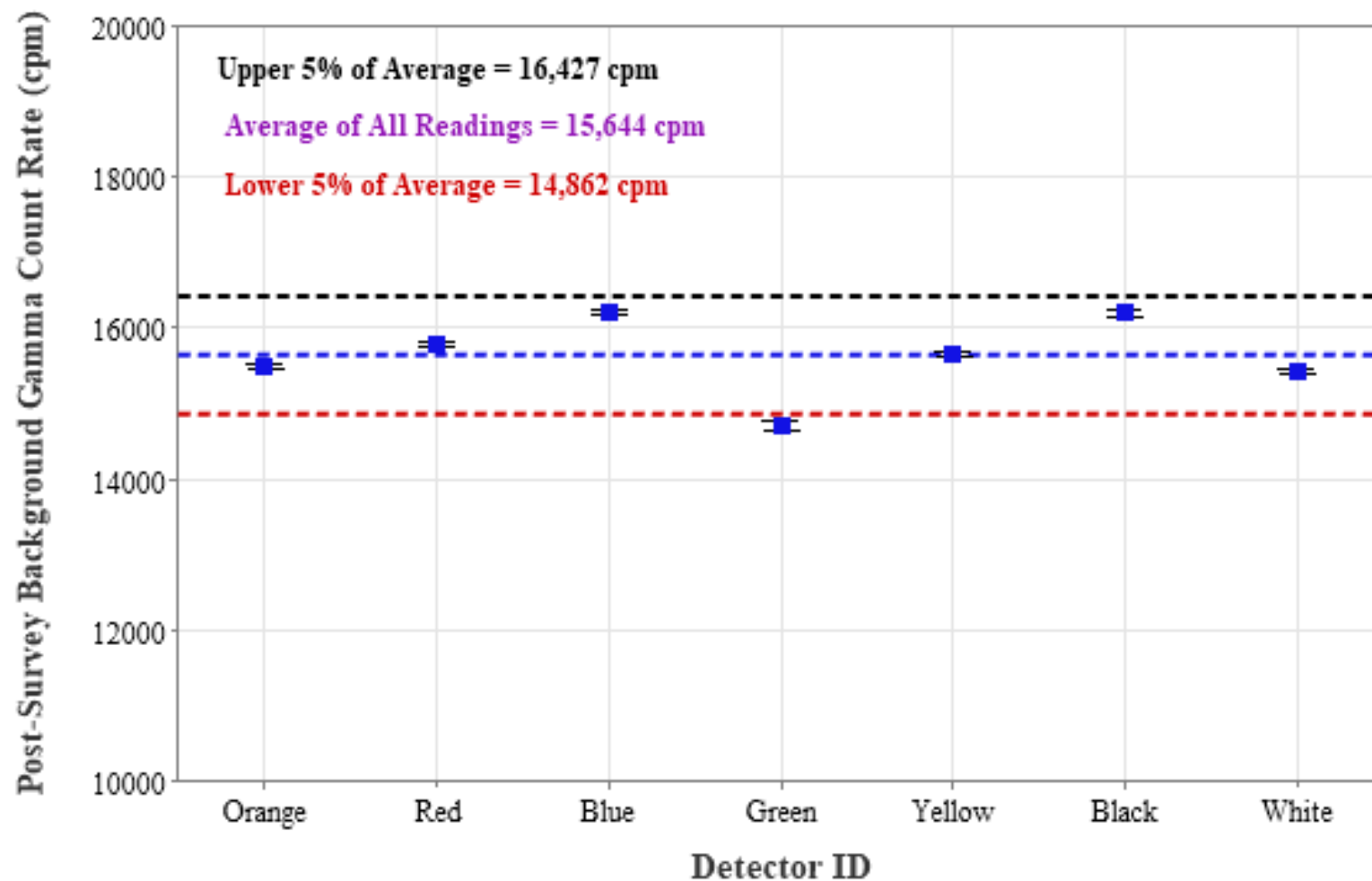


Figure B-4. Interval Plot of Post-Survey Background Measurements by Detector

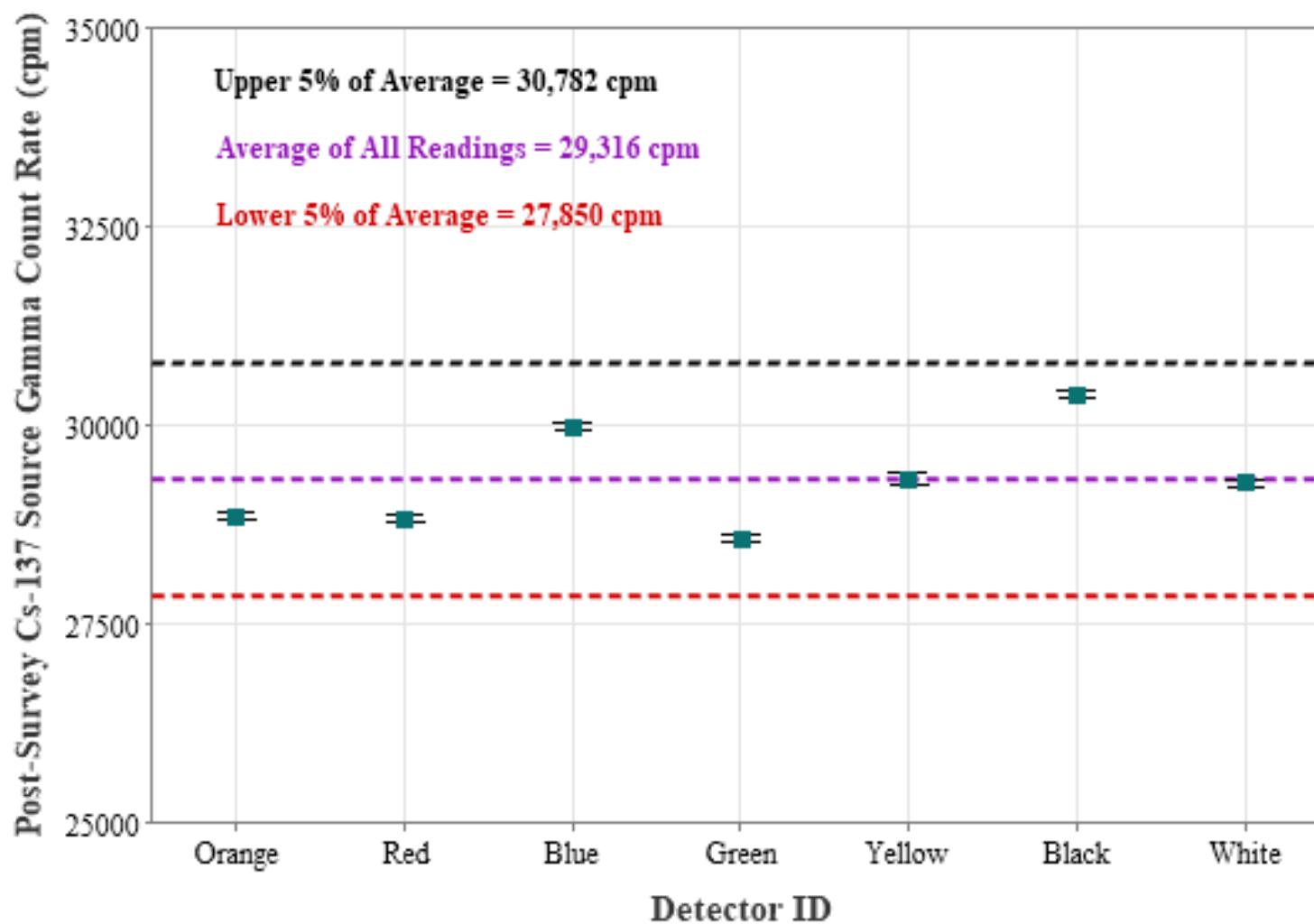


Figure B-5. Interval Plot of Post-Survey Cs-137 Source Measurements by Detector

3.2.4 Pre-Survey and Post-Survey Comparison and Distribution Analysis

Table B-5 summarizes statistics comparing pre-survey and post-survey QC measurements for each detector. The RPD of means for the background mean comparison addresses QC Criterion 5, and the RPD of means for the Cs-137 source mean comparison addresses QC Criterion 6. All detectors passed QC Criteria 5 and 6 for scoping level data.

Figure B-6 through Figure B-33 show normal probability plots, and normal-fitted frequency histograms with a normal distribution fitted curve showing pre-survey and post-survey QC measurements for each of the seven detectors. A qualitative analysis of each normal probability plot and histogram was completed.

Normal probability plots were developed displaying pre-survey and post-survey background QC measurements, and pre-survey and post-survey Cs-137 QC measurements side by side. The normal probability plots were found to contain the majority of data within the three normality prediction curves, thus demonstrating normality. Most data falling outside of the normality prediction curves can be attributed to bin sizes of the histograms. This is well within expected measurement deviation from normality for detectors, and acceptable for the use of all detectors except for the white detector. Analysis of the white detector and black detector pre-survey background measurements found that both detectors tend in frequency toward measurements below the mean; however, it was decided that each detector is acceptable for scoping level data acquisition.

Histograms were developed displaying pre-survey and post-survey background QC measurements, and pre-survey and post-survey Cs-137 QC measurements side by side. A normal distribution fitted curve was transposed over the plotted QC measurements allowing comparison of QC measurements with a normal distribution. It was found that QC measurements were substantially contained within the normal distribution fitted curve, and typically fell outside of the curve only when displays showed an exaggerated number of readings because of the size of bins used. This is well within expected measurement deviation from normality for detectors, and acceptable for use of detectors.



Table B-5. Intra-Detector Comparison of Pre-Survey and Post-Survey QC Background and Cs-137 Source Statistics

Background Mean Comparison			
Instrument Name	Pre-Survey Mean (cpm)	Post-Survey Mean (cpm)	RPD of Means (%)
Orange System	15,125	15,502	2.5%
Red System	15,163	15,797	4.1%
Blue System	16,226	16,219	0.0%
Green System	15,702	14,709	6.5%
Yellow System	15,600	15,659	0.4%
Black System	16,555	16,207	2.1%
White System	15,339	15,424	0.5%
Cs-137 Source Mean Comparison			
Instrument Name	Pre-Survey Mean (cpm)	Post-Survey Mean (cpm)	RPD of Means (%)
Orange System	28,764	28,853	0.3%
Red System	29,215	28,823	1.4%
Blue System	29,265	29,976	2.4%
Green System	28,646	28,573	0.3%
Yellow System	29,091	29,324	0.8%
Black System	29,406	30,386	3.3%
White System	29,870	29,279	2.0%

Notes:

cpm Counts per minute

RPD Relative percent difference

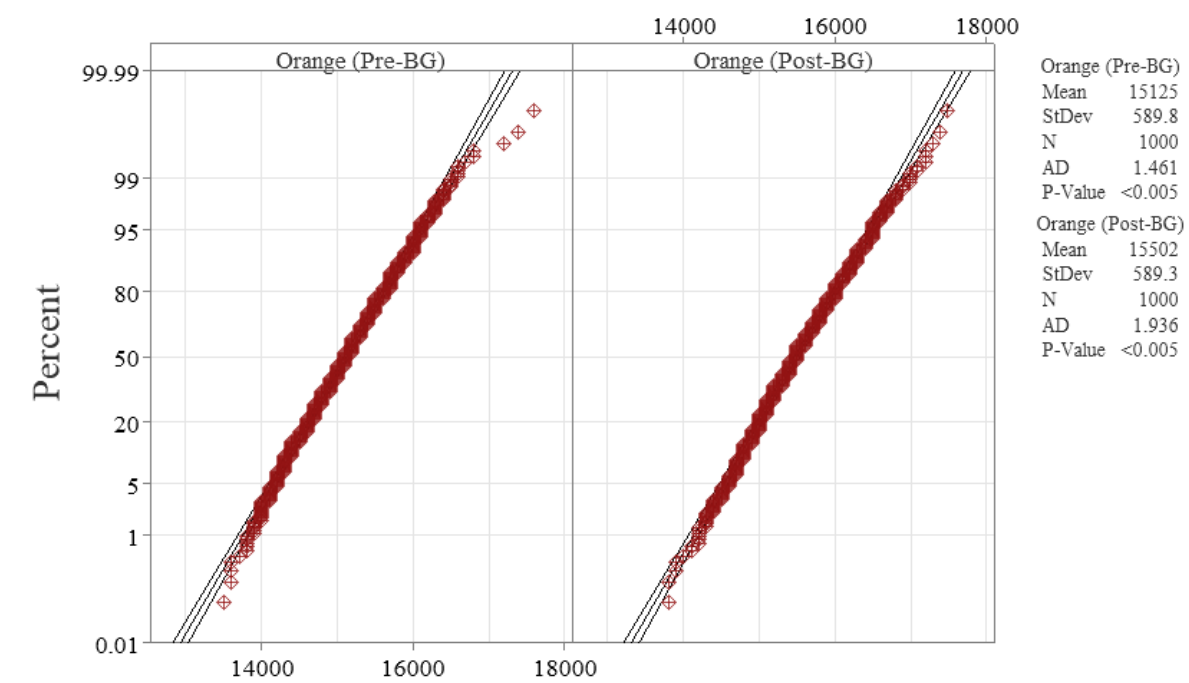


Figure B-6. Normal Probability Plot of Orange Detector Pre- and Post-Survey Background Measurements

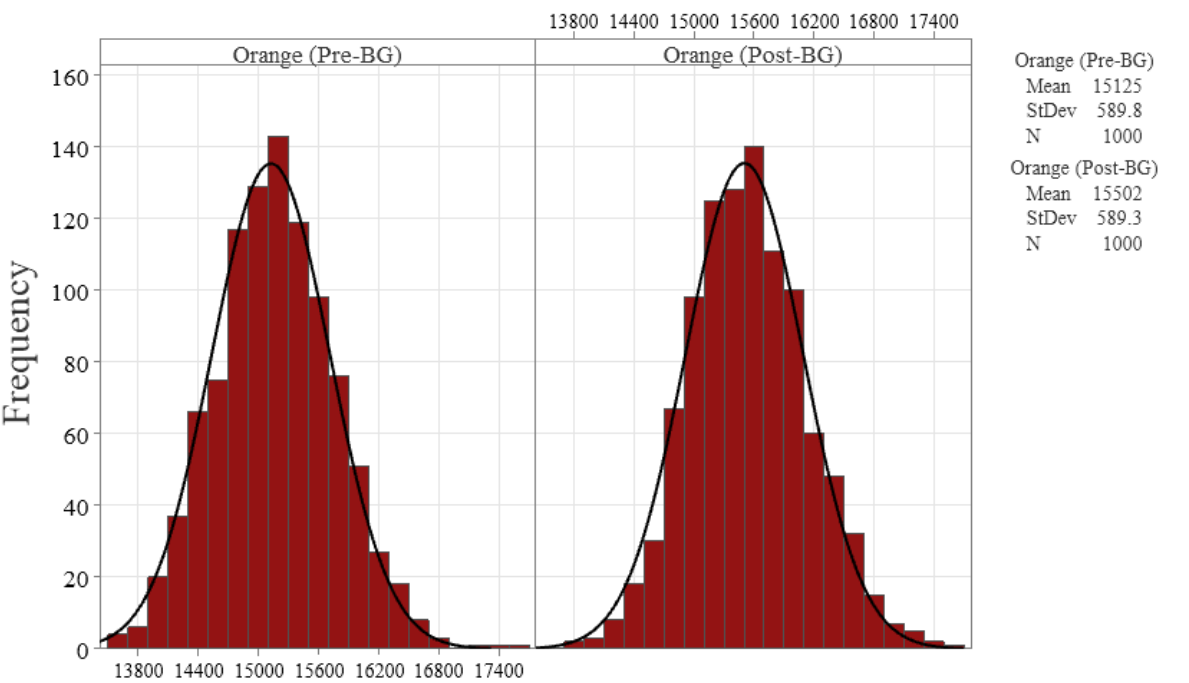


Figure B-7. Normal-Fitted Frequency Histogram of the Orange Detector Pre- and Post-Survey Background Measurements

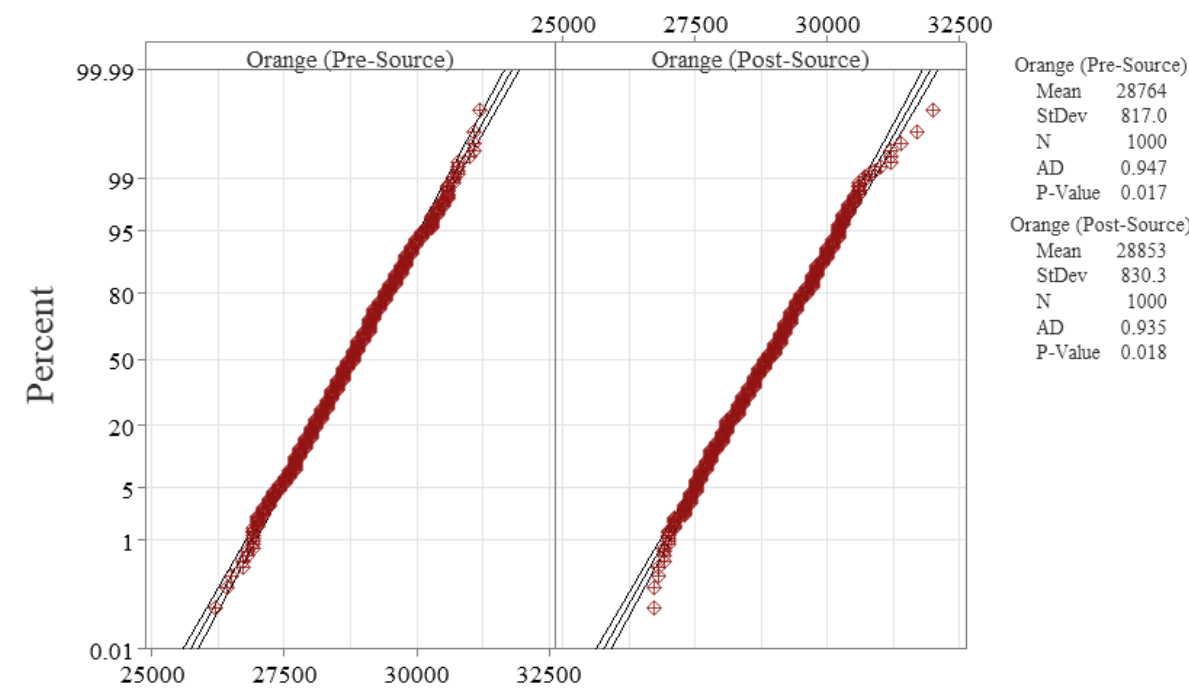


Figure B-8. Normal Probability Plot of Orange Detector Pre- and Post-Survey Cs-137 Source Measurements

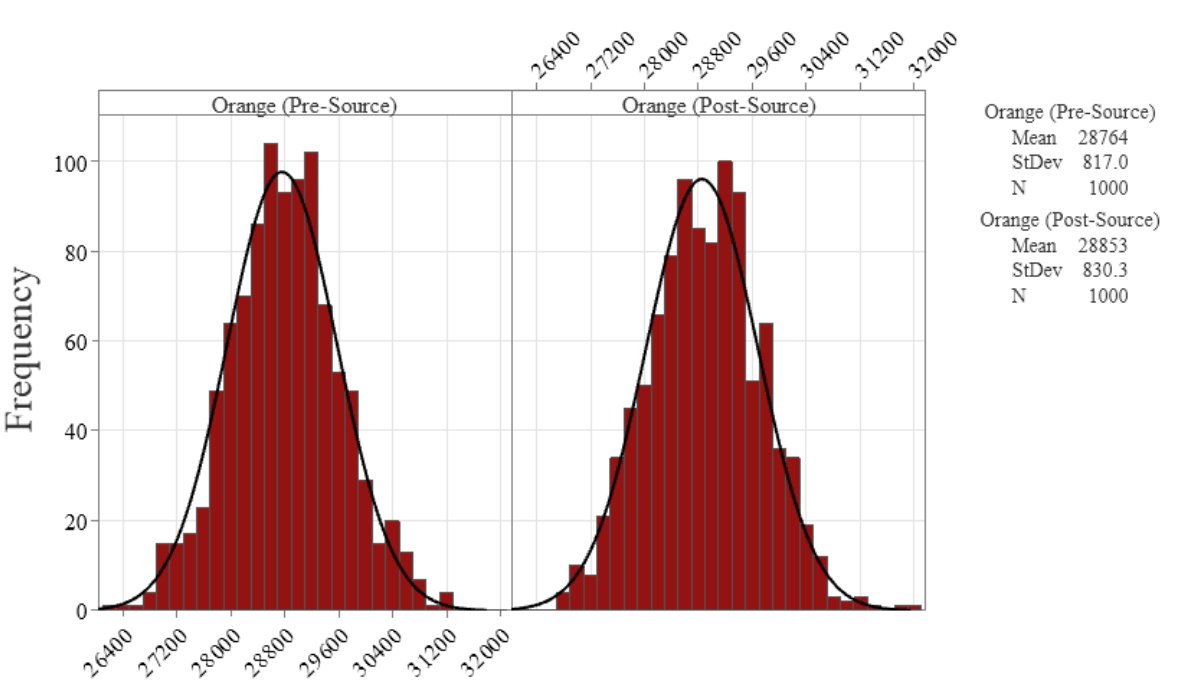


Figure B-9. Normal-Fitted Frequency Histogram of the Orange Detector Pre- and Post-Survey Cs-137 Source Measurements

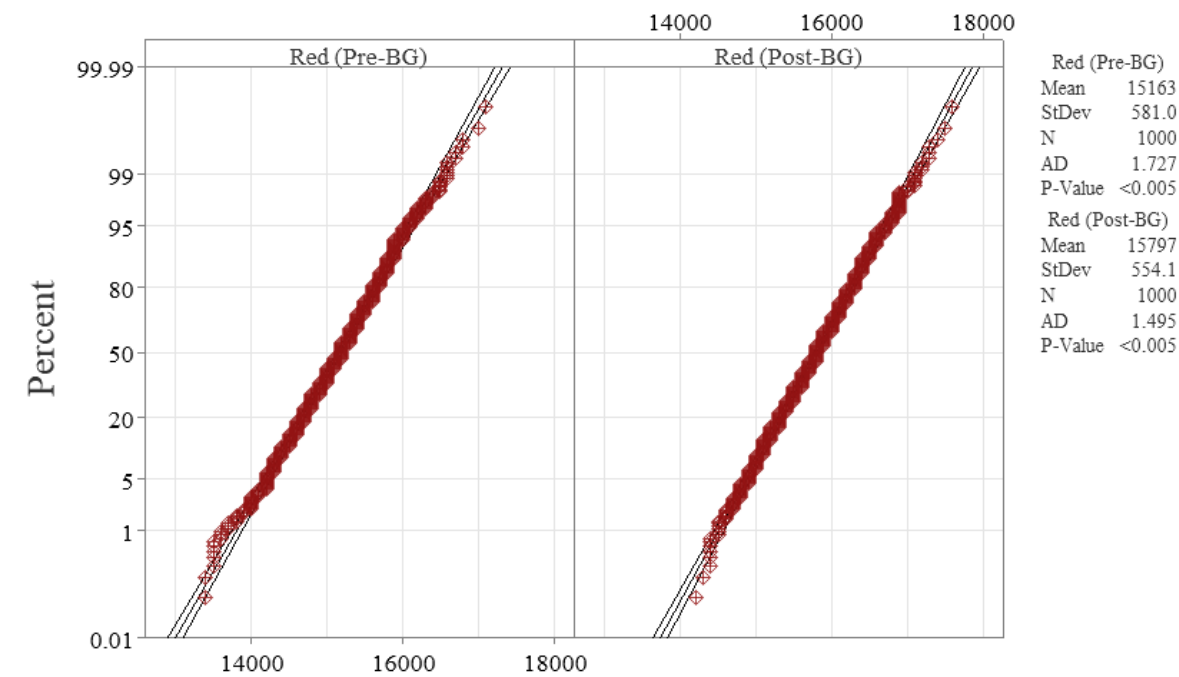


Figure B-10. Normal Probability Plot of Red Detector Pre- and Post-Survey Background Measurements

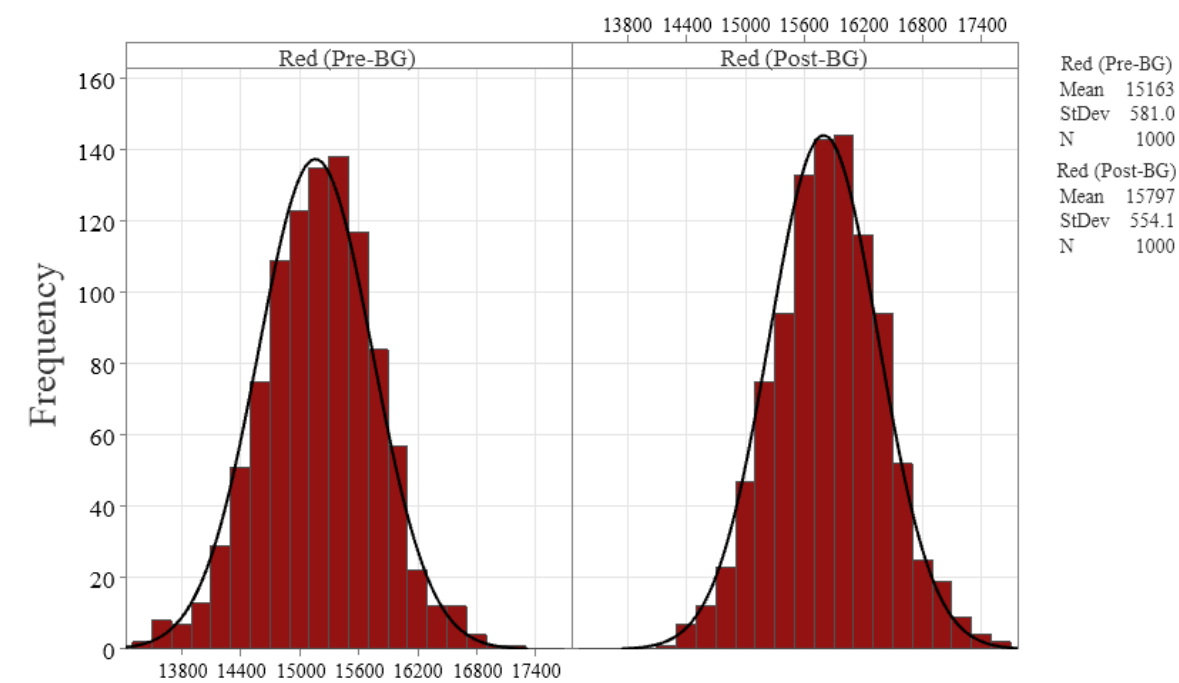


Figure B-11. Normal-Fitted Frequency Histogram of the Red Detector Pre- and Post-Survey Background Measurements

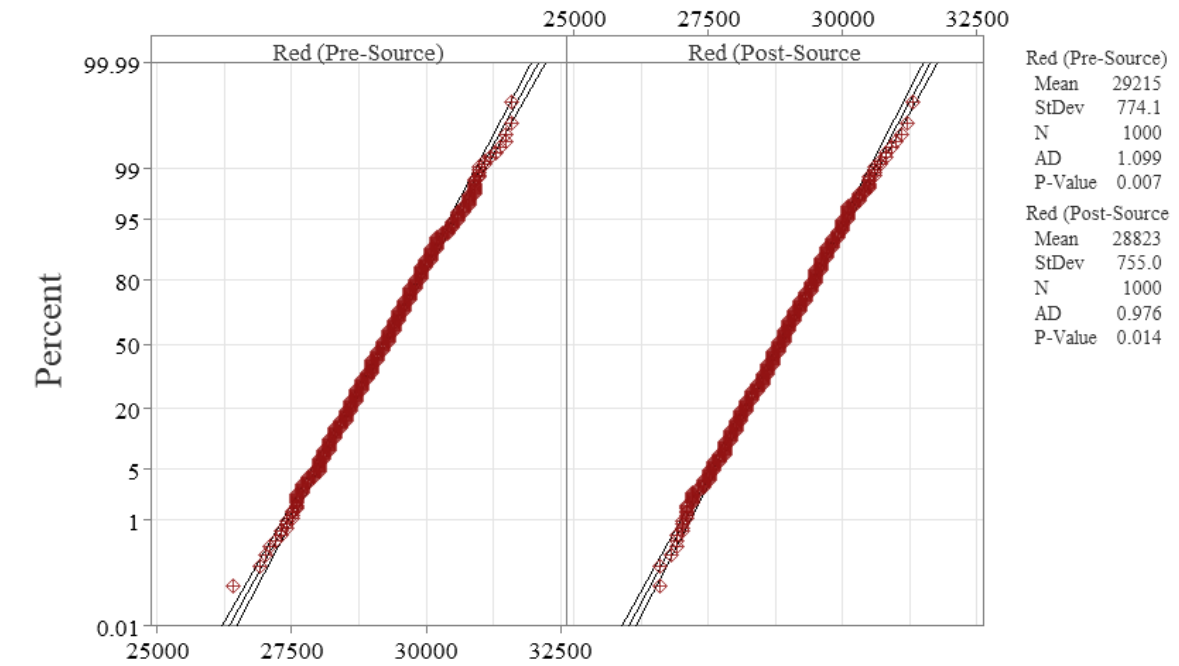


Figure B-12. Normal Probability Plot of Red Detector Pre- and Post-Survey Cs-137 Source Measurements

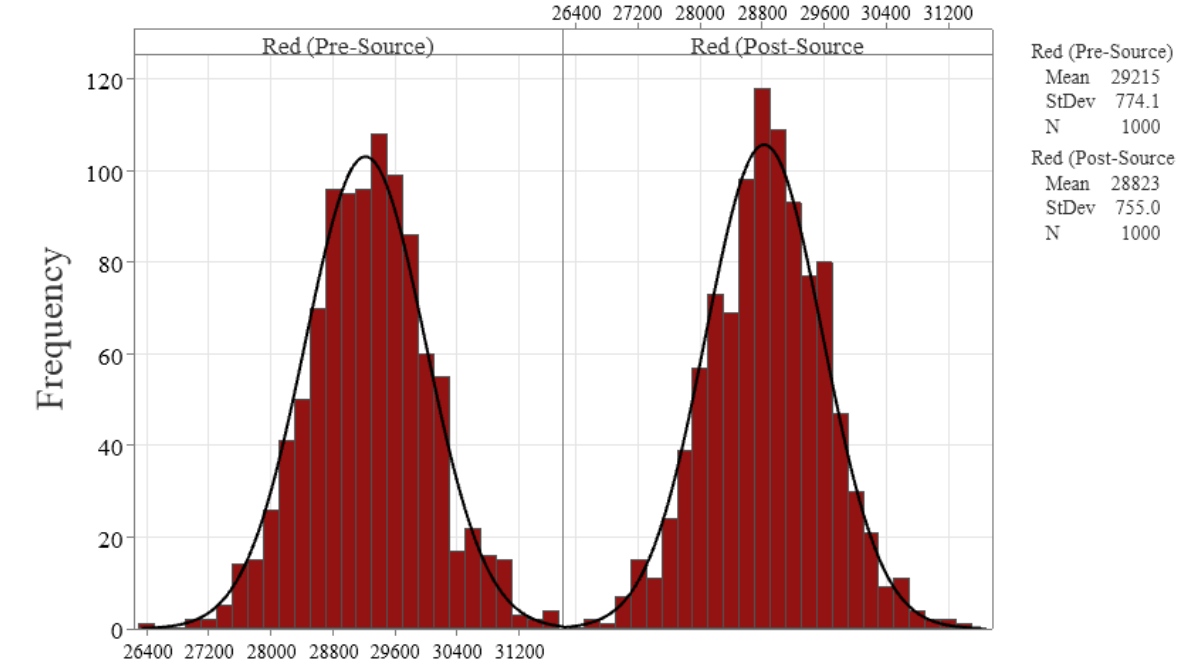


Figure B-13. Normal-Fitted Frequency Histogram of the Red Detector Pre- and Post-Survey Cs-137 Source Measurements

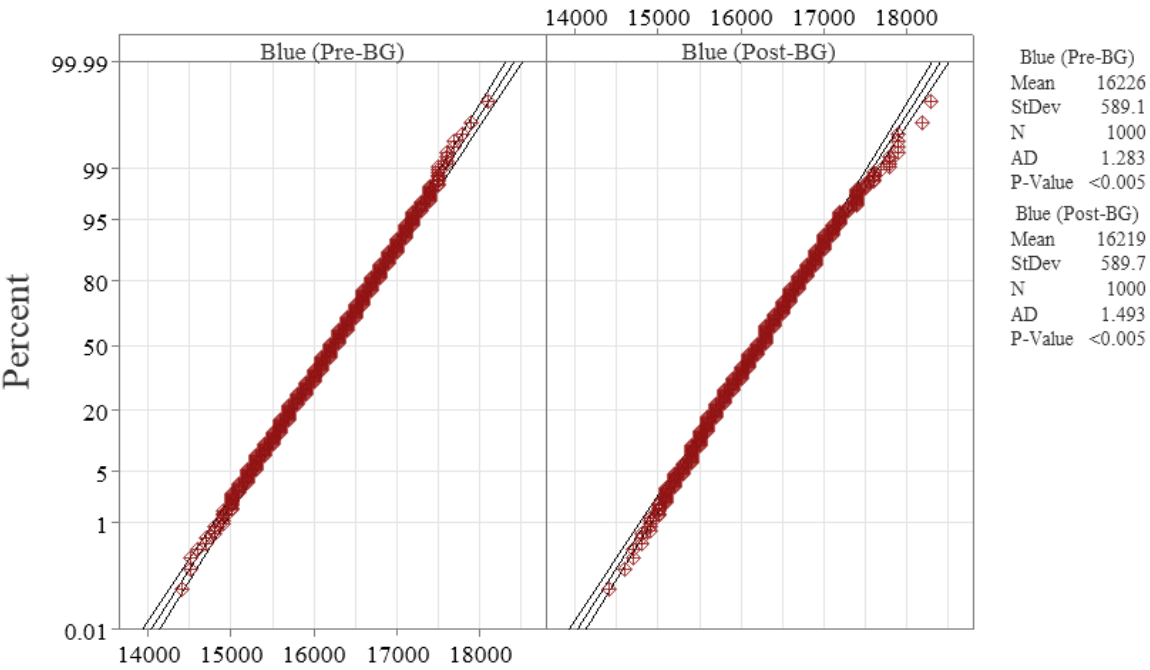


Figure B-14. Normal Probability Plot of Blue Detector Pre- and Post-Survey Background Measurements

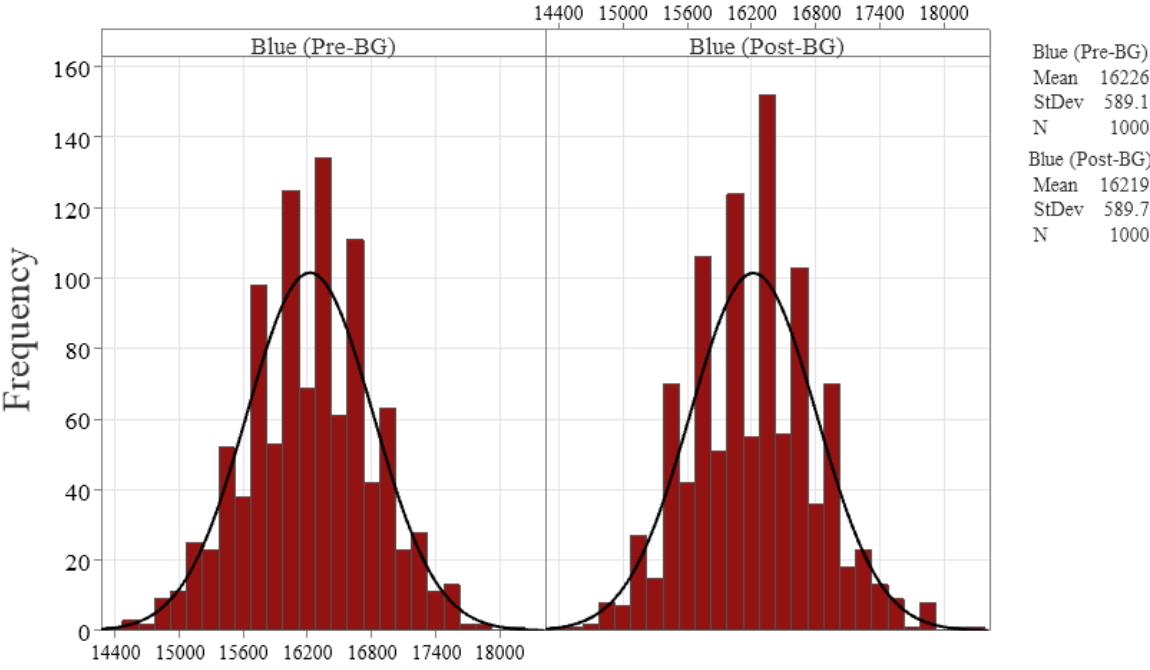


Figure B-15. Normal-Fitted Frequency Histogram of the Blue Detector Pre- and Post-Survey Background Measurements

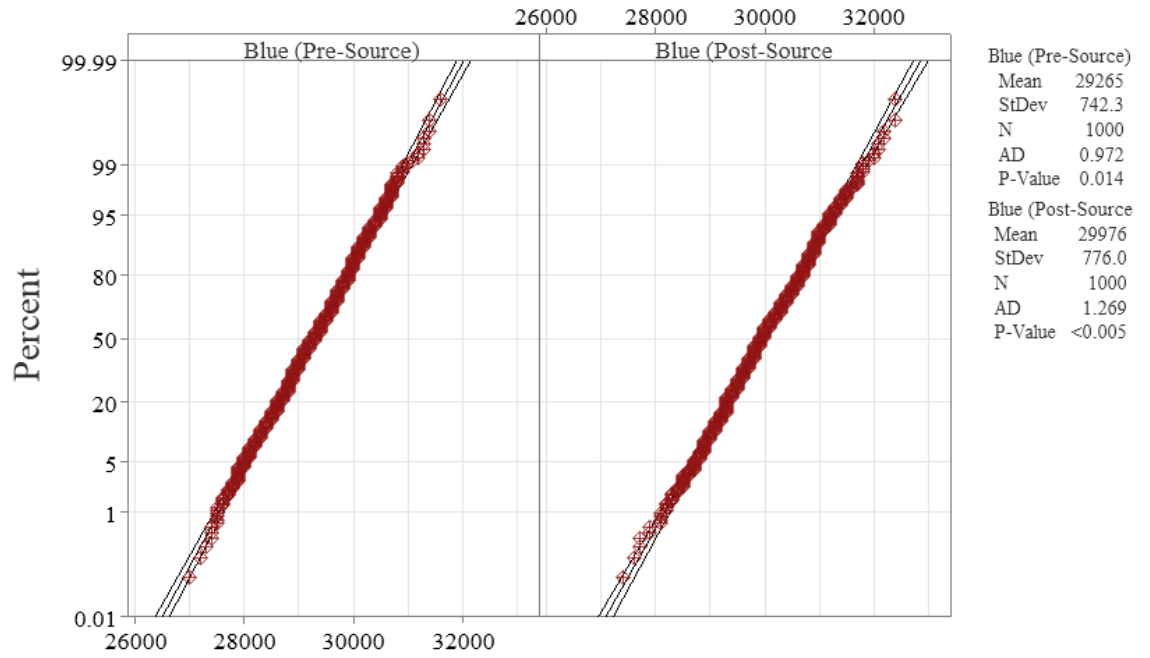


Figure B-16. Normal Probability Plot of Blue Detector Pre- and Post-Survey Cs-137 Source Measurements

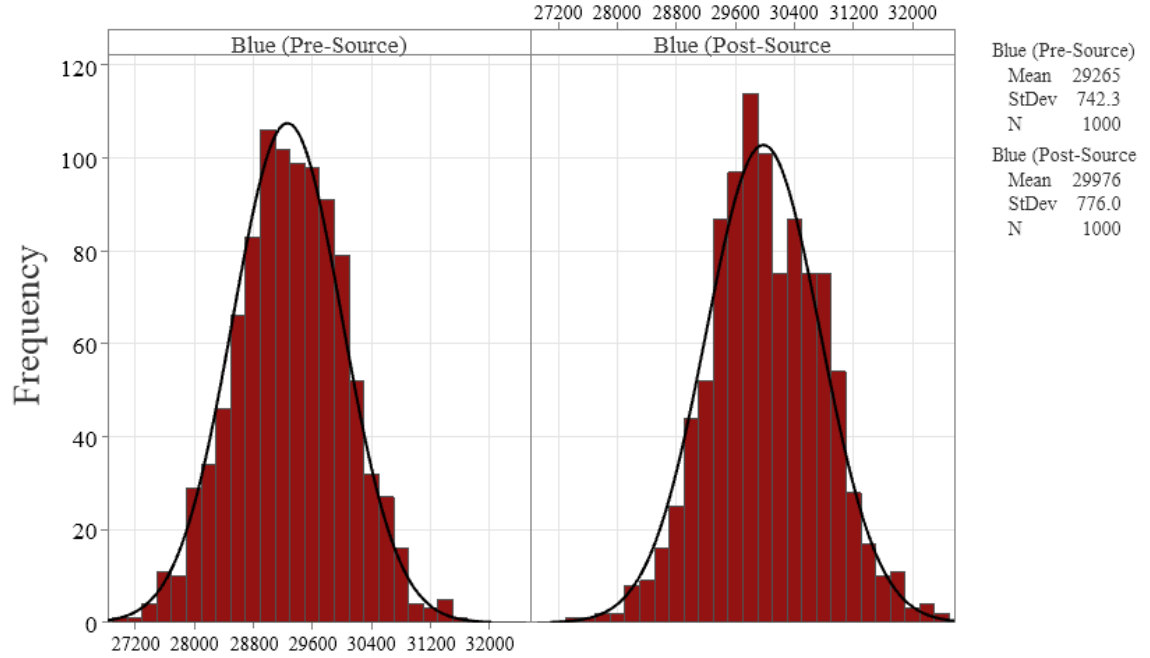


Figure B-17. Normal-Fitted Frequency Histogram of the Blue Detector Pre- and Post-Survey Cs-137 Source Measurements

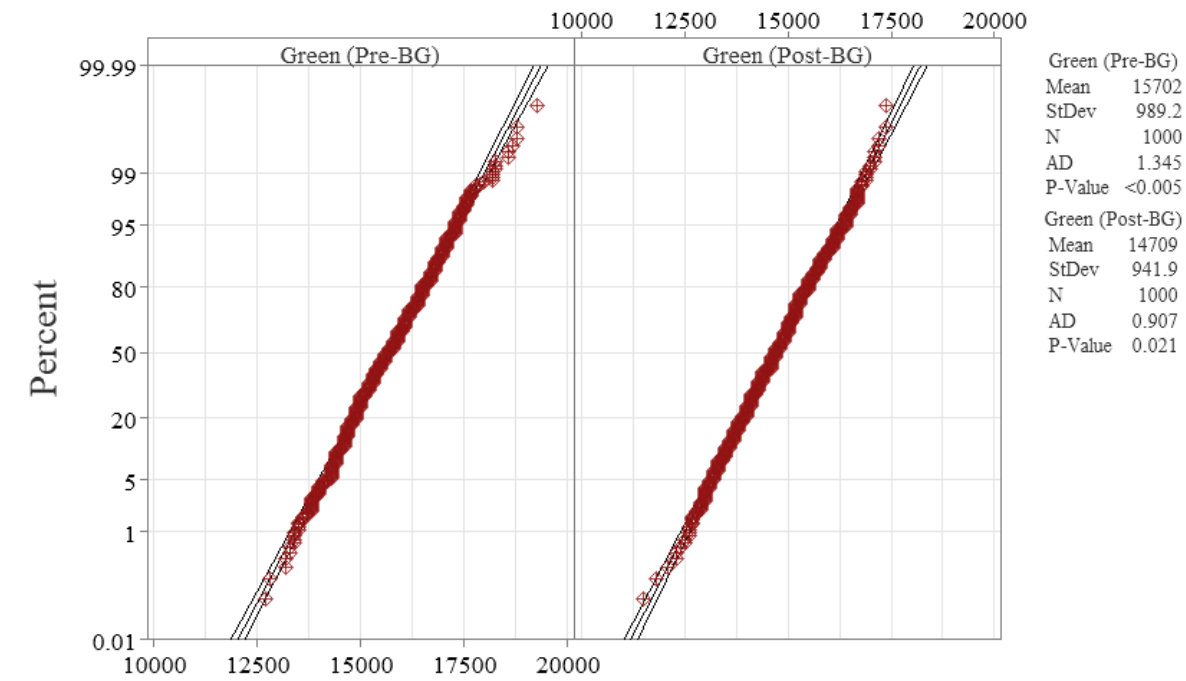


Figure B-18. Normal Probability Plot of Green Detector Pre- and Post-Survey Background Measurements

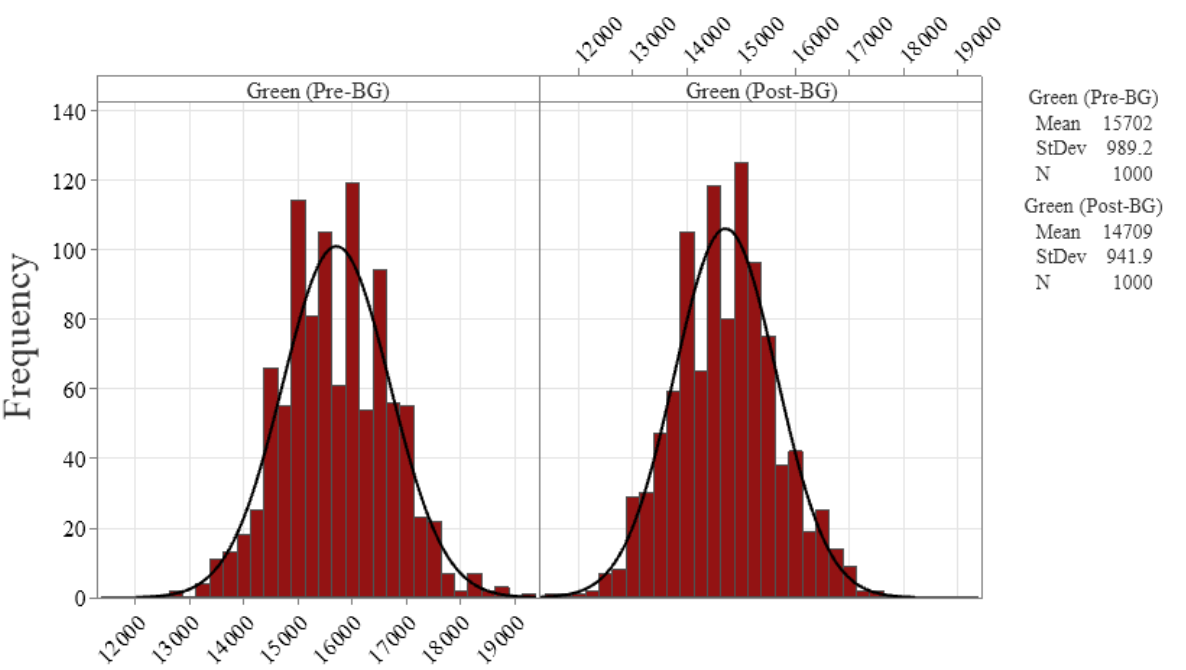


Figure B-19. Normal-Fitted Frequency Histogram of the Green Detector Pre- and Post-Survey Background Measurements

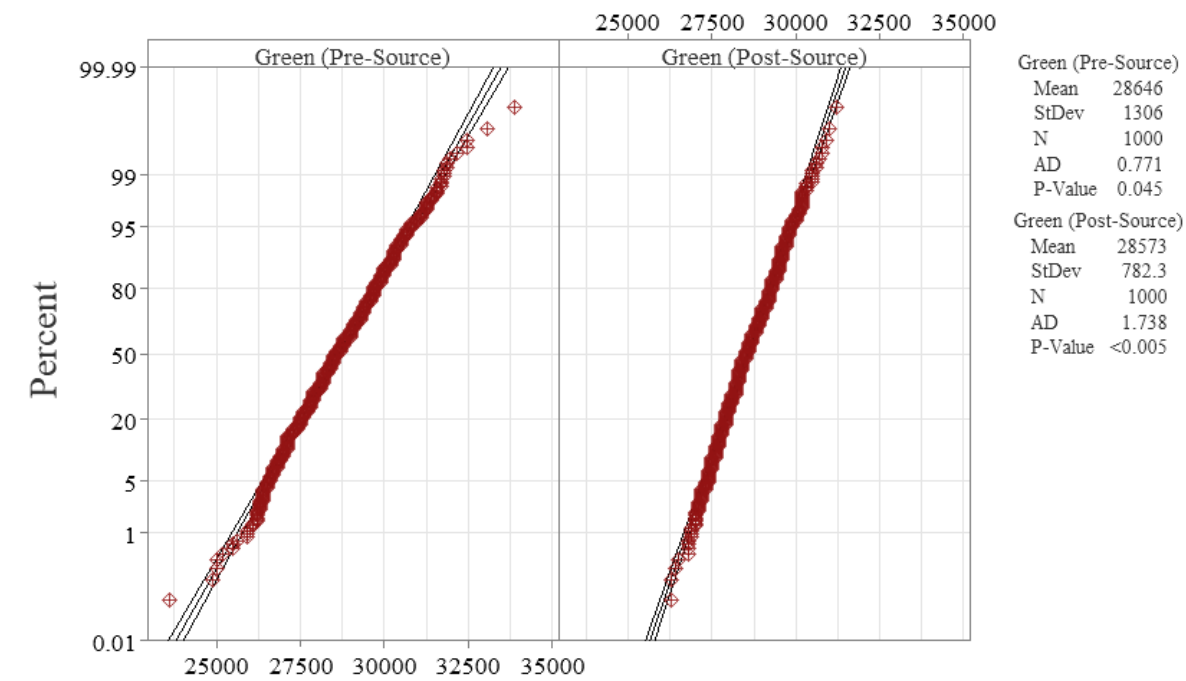


Figure B-20. Normal Probability Plot of Green Detector Pre- and Post-Survey Cs-137 Source Measurements

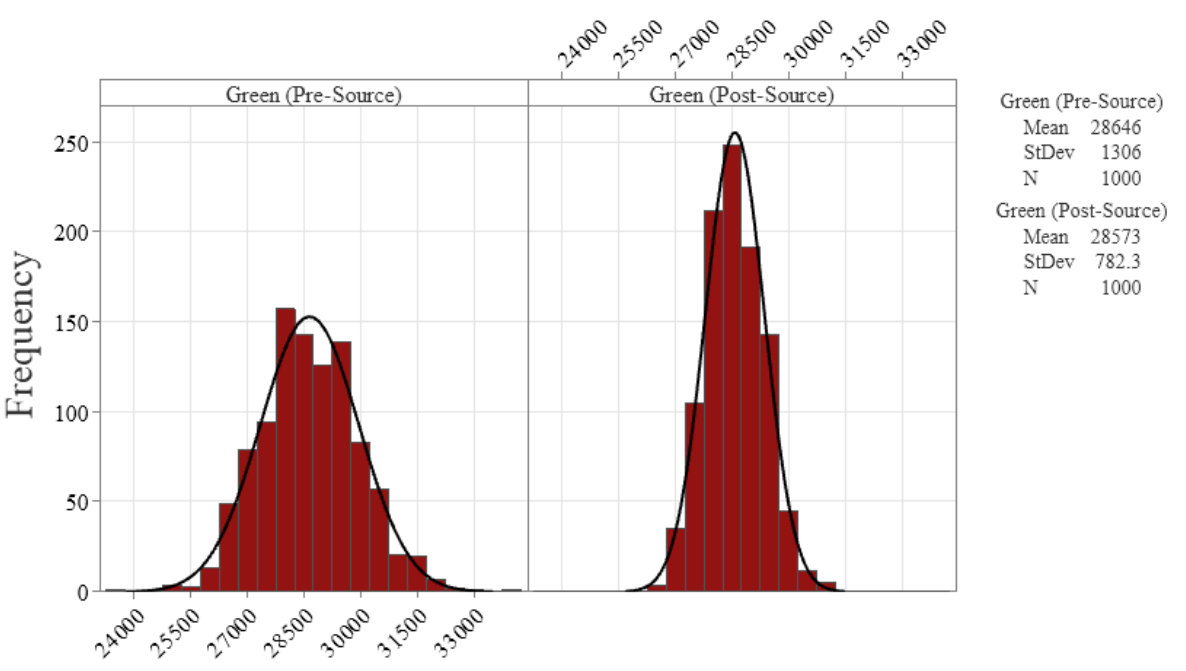


Figure B-21. Normal-Fitted Frequency Histogram of the Green Detector Pre- and Post-Survey Cs-137 Source Measurements

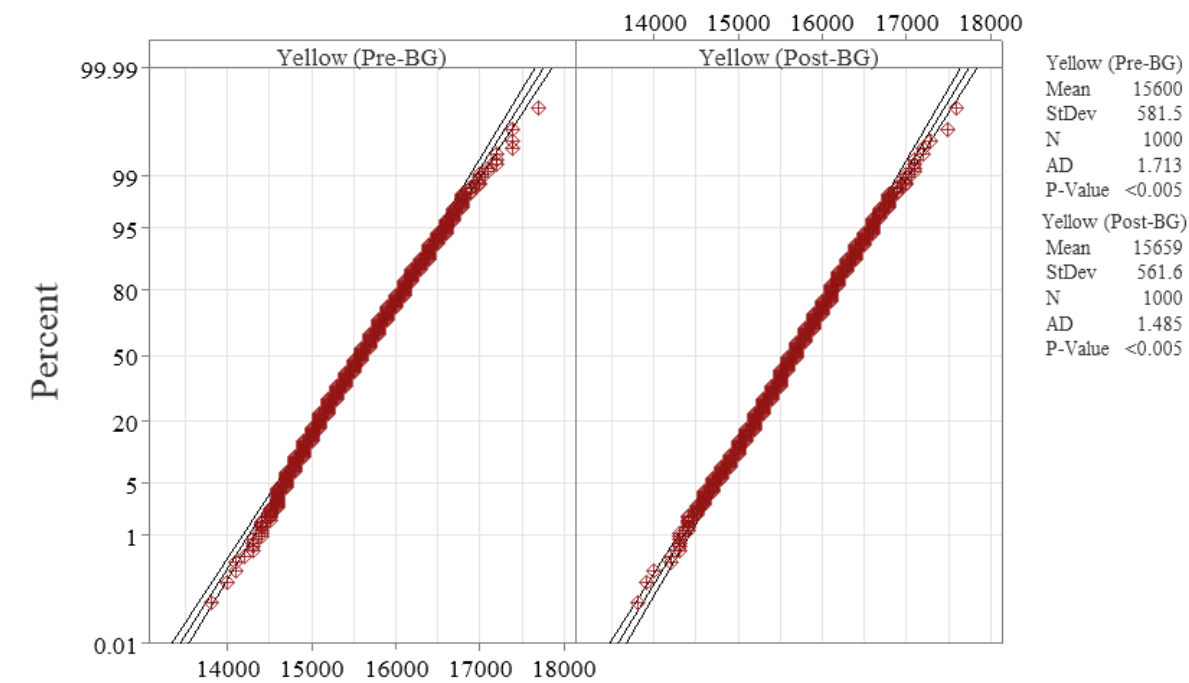


Figure B-22. Normal Probability Plot of Yellow Detector Pre- and Post-Survey Background Measurements

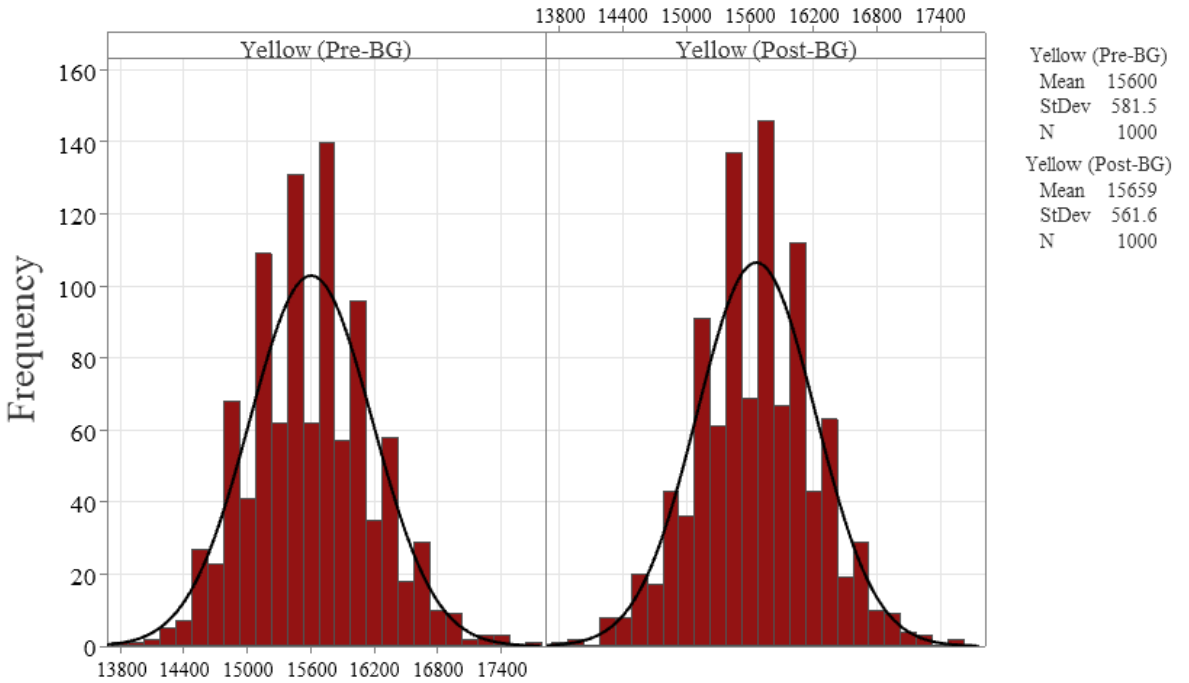


Figure B-23. Normal-Fitted Frequency Histogram of the Yellow Detector Pre- and Post-Survey Background Measurements

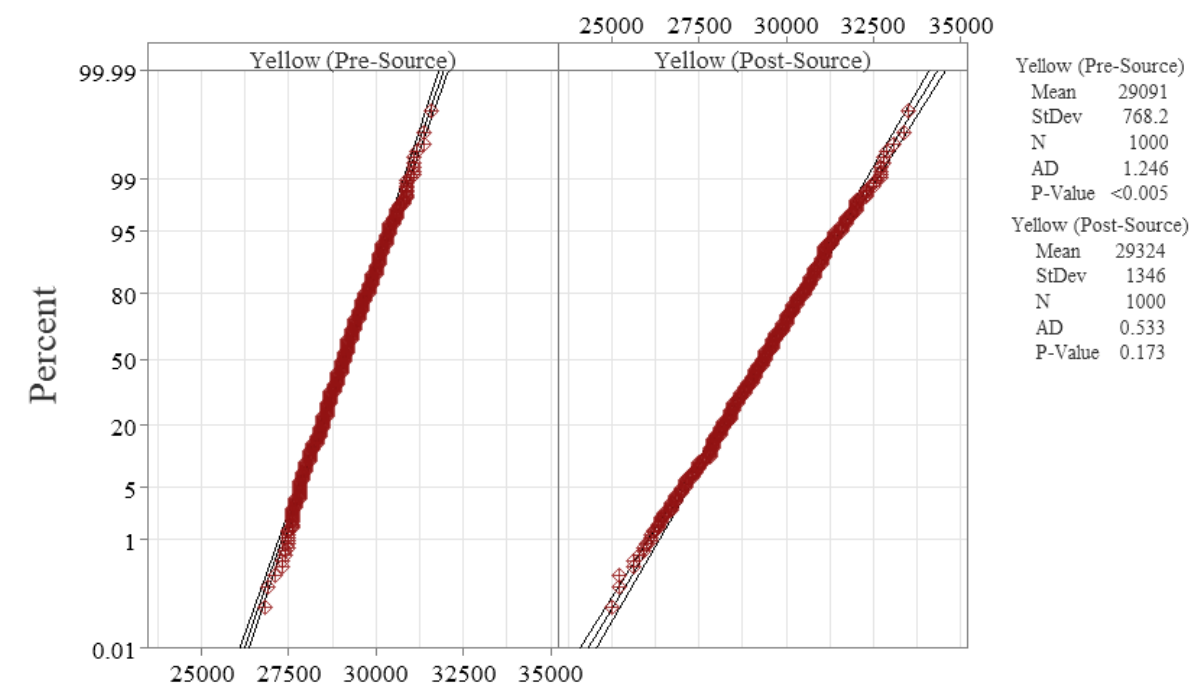


Figure B-24. Normal Probability Plot of Yellow Detector Pre- and Post-Survey Cs-137 Source Measurements

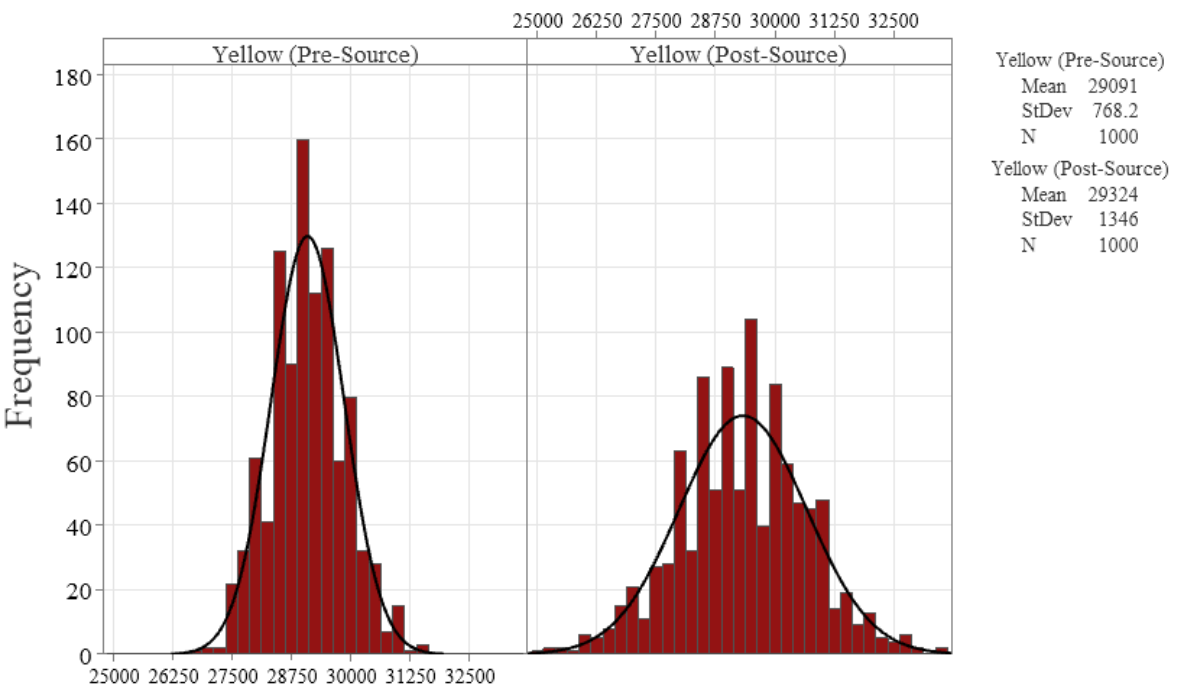


Figure B-25. Normal-Fitted Frequency Histogram of the Yellow Detector Pre- and Post-Survey Cs-137 Source Measurements

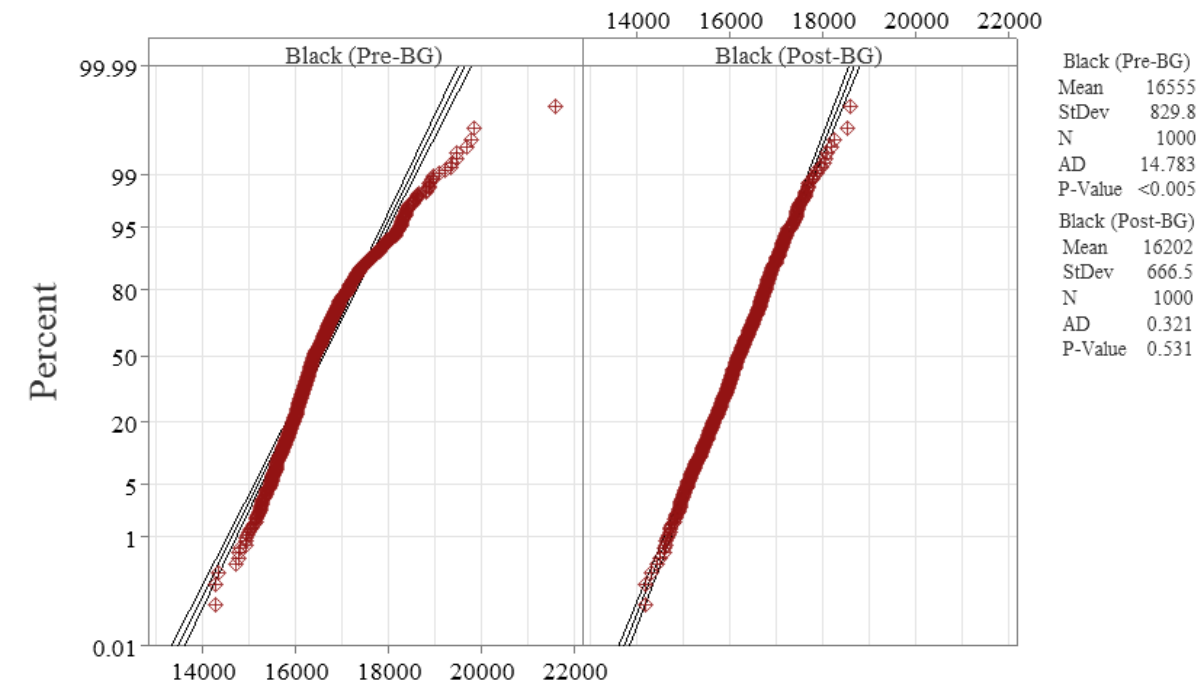


Figure B-26. Normal Probability Plot of Black Detector Pre- and Post-Survey Background Measurements

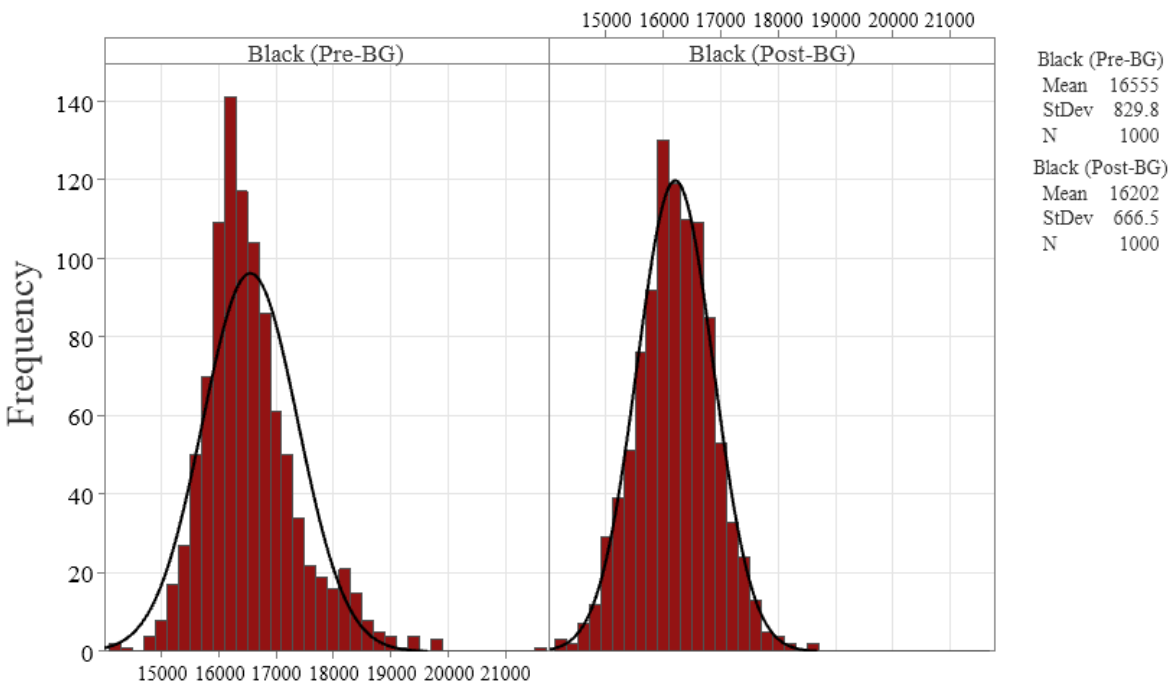


Figure B-27. Normal-Fitted Frequency Histogram of the Black Detector Pre- and Post-Survey Background Measurement

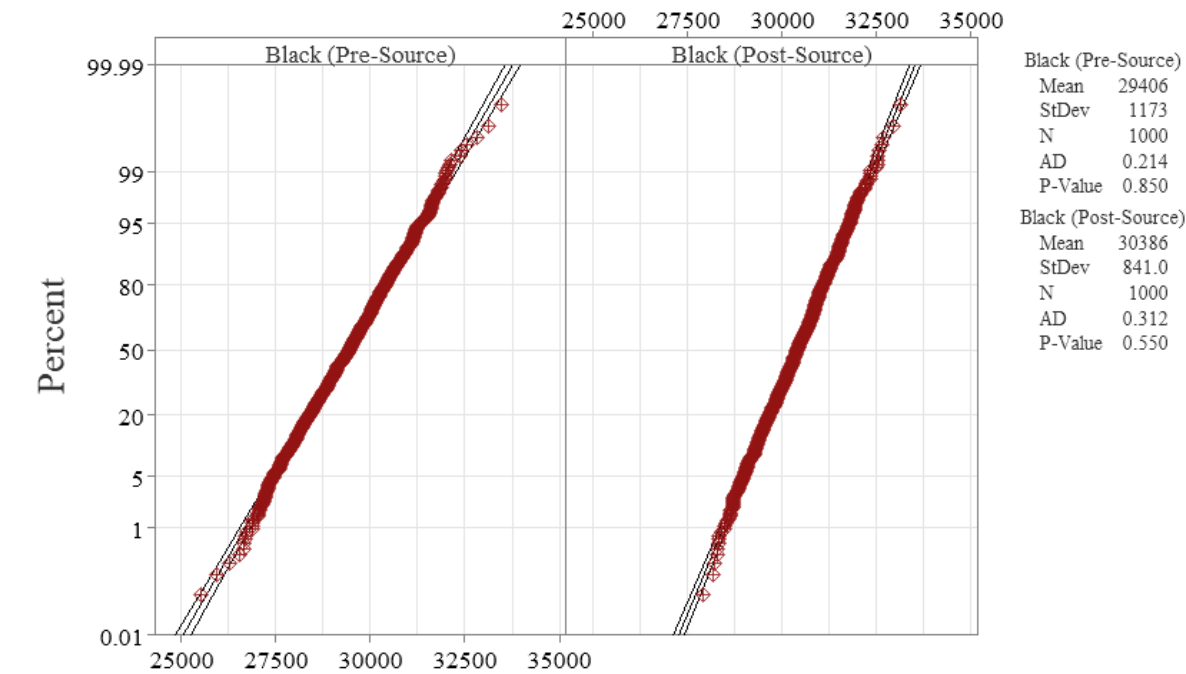


Figure B-28. Normal Probability Plot of Black Detector Pre- and Post-Survey Cs-137 Source Measurements

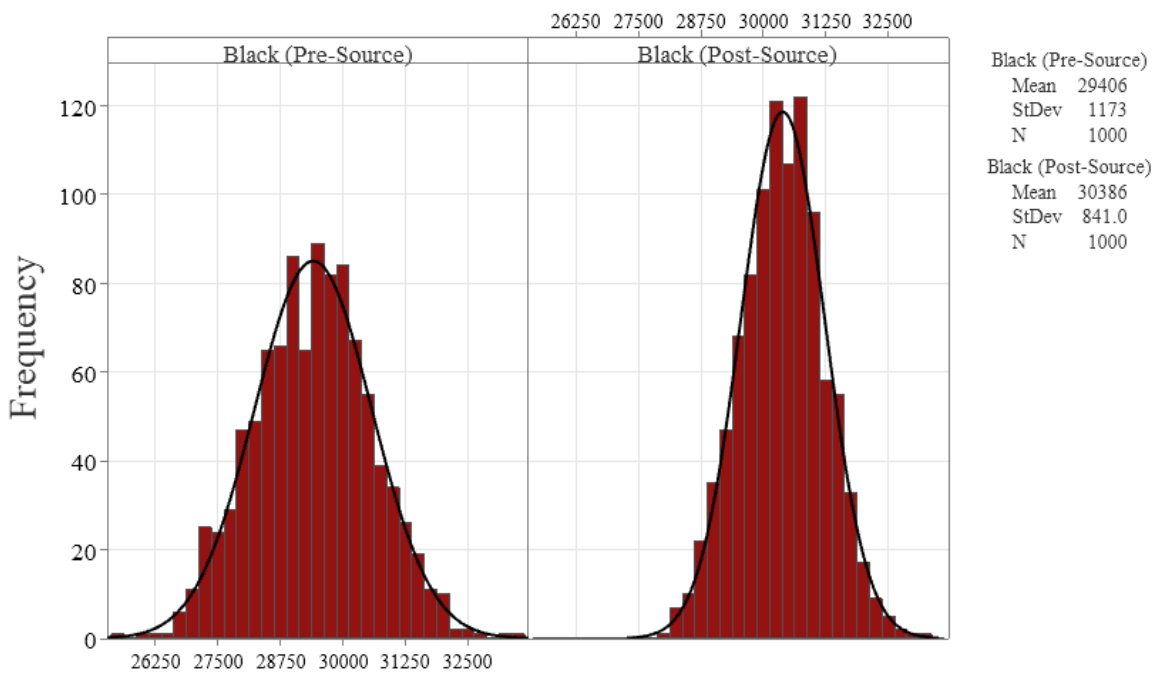


Figure B-29. Normal-Fitted Frequency Histogram of the Black Detector Pre- and Post-Survey Cs-137 Source Measurements

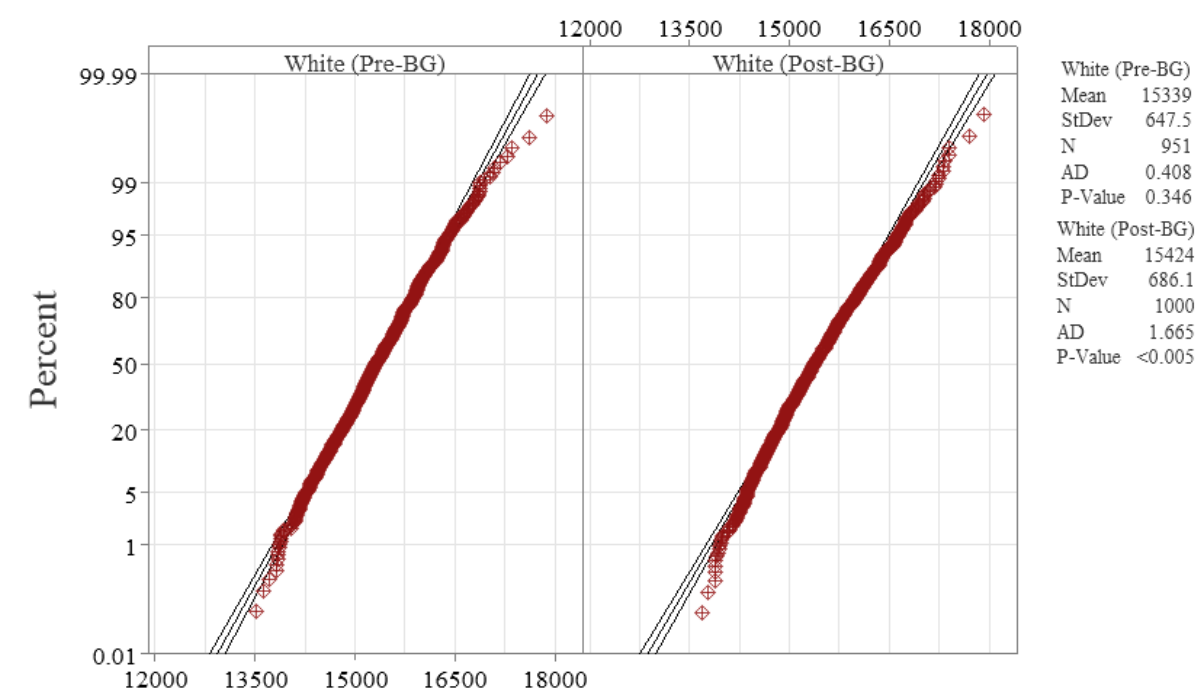


Figure B-30. Normal Probability Plot of White Detector Pre- and Post-Survey Background Measurements

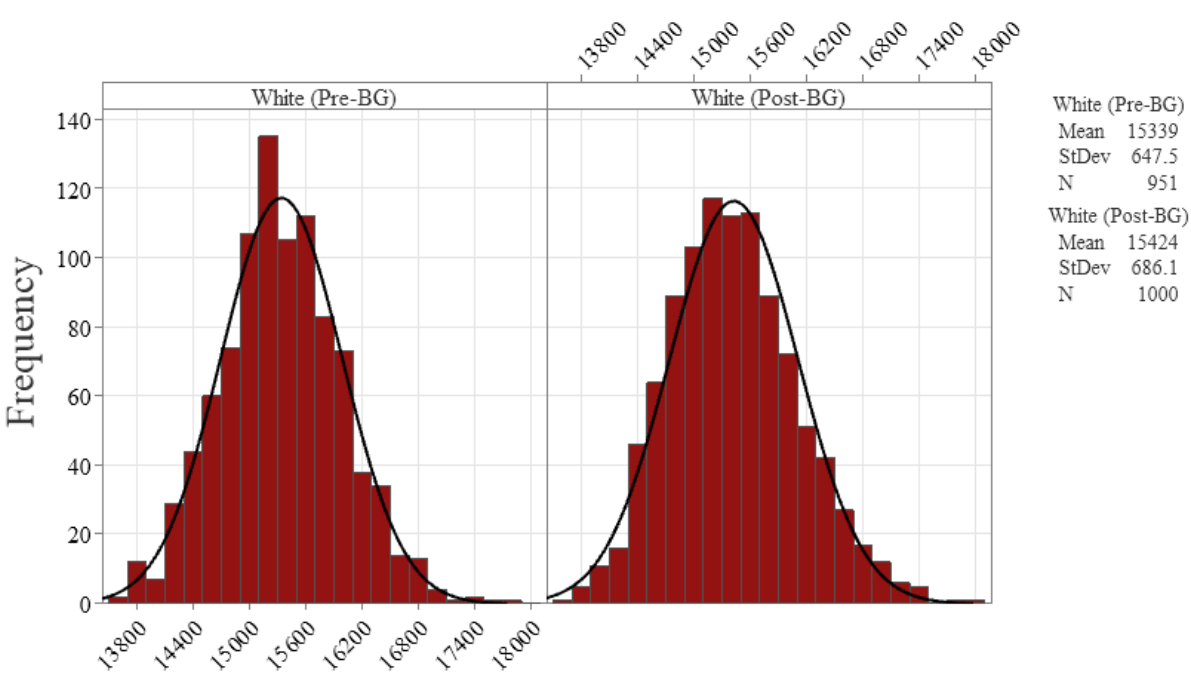


Figure B-31. Normal-Fitted Frequency Histogram of the White Detector Pre- and Post-Survey Background Measurements

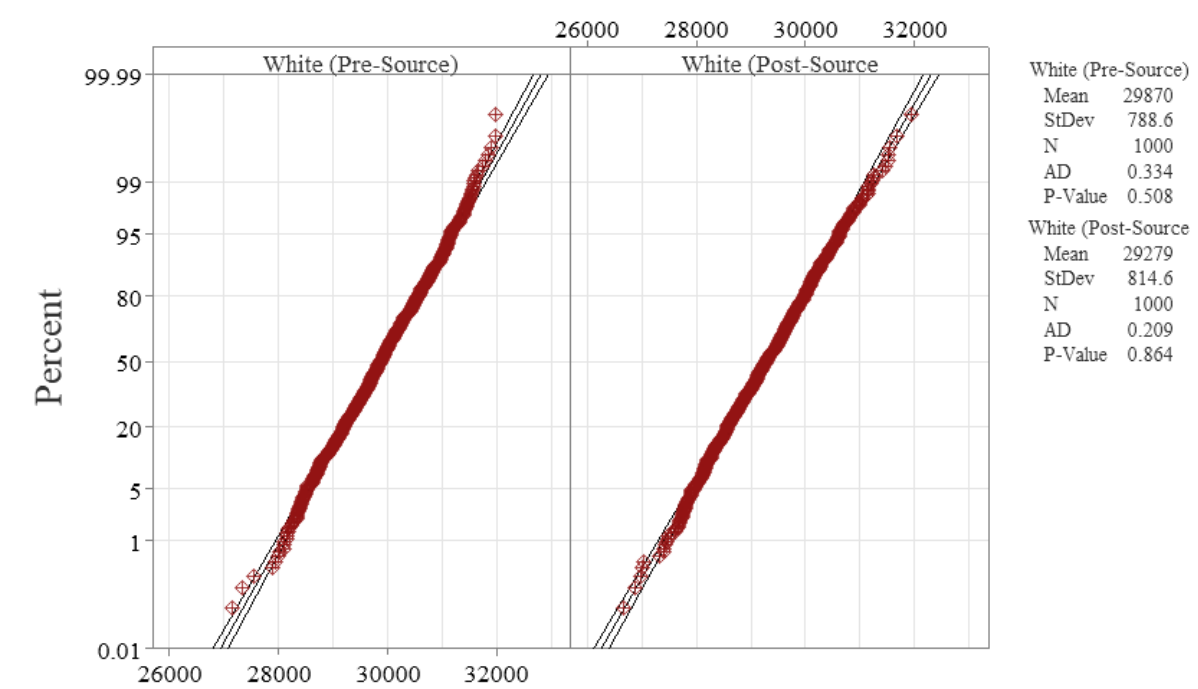


Figure B-32. Normal Probability Plot of White Detector Pre- and Post-Survey Cs-137 Source Measurements

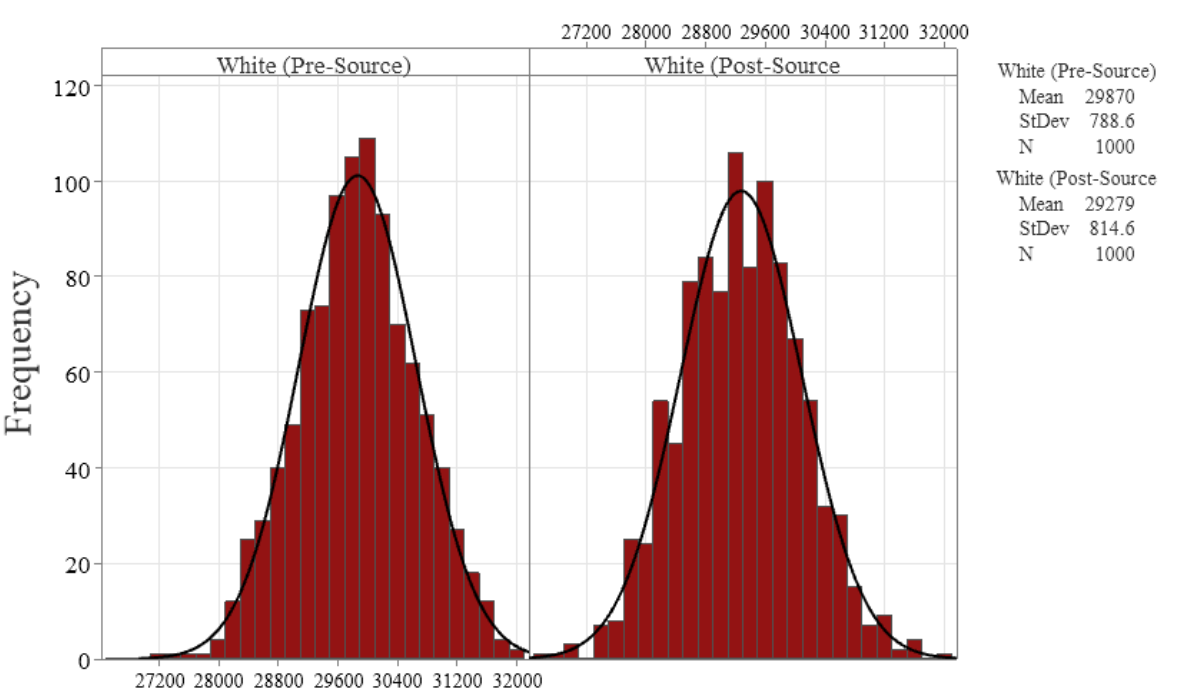


Figure B-33. Normal-Fitted Frequency Histogram of the White Detector Pre- and Post-Survey Cs-137 Source Measurements

3.3 DAILY FUNCTION QUALITY CONTROL AND RESULTS

Under the QC program, factory-calibrated detectors must also meet on-site daily function QC checks. Daily function QC checks are measurements to verify detector performance each time a detector is used (USEPA 2000). These checks occurred at a pre-determined background reference area not impacted by site activities. For this project, daily function QC checks were performed in Gallup, New Mexico, within Room 214 of the Gallup IHG Hotel. Field test strips for detectors were not used during this project. [Attachment B-6](#) includes the daily function check forms used to document daily function QC checks.

The following three steps must occur during daily function QC checks, and the three associated QC Criteria must be met each day after use of a detector to collect characterization or scoping level data:

- **Daily QC Criterion 1:** Daily function QC checks consist of collecting 60 background and 60 Cs-137 source measurements from each detector used during daily survey activities. The mean of the 60 background and the mean of the 60 Cs-137 source measurements is then calculated. These QC measurements should be performed at the same location each day, or at a location as similar as possible to the previous daily function check location if unforeseen circumstances preclude function checks at the same location as the previous day. These steps constitute Daily QC Criterion 1.
- **Daily QC Criterion 2:** For each detector, the difference between the respective means of the 60 Cs-137 source data and 60 background measurements is then calculated. This difference is called the daily net count. Daily net count for each detector then is compared to the mean of the pre-survey net counts. Any detector with a daily function QC measurement result falling outside 20 percent of the mean of pre-survey QC net measurements will require investigation. A detector exceeding control limits on any QC check may be replaced with a pre-qualified spare detector and flagged for evaluation, repair, and recalibration.
- **Daily QC Criterion 3:** For normally distributed data, 99 percent of all measurements are expected to fall within 3 standard deviations from the mean. Any detector with a QC measurement result falling outside 3 standard deviations from the mean of all daily QC measurements requires investigation. A detector exceeding control limits on any QC function check (background, field strip, or source) will be replaced with a pre-qualified spare detector and sent back to the manufacturer for evaluation, repair, and recalibration.

During the OCRM investigation, QC measurements, including a background check and Cs-137 source check, were performed once daily for each detector used for gamma surveys, satisfying daily QC Criterion 1. [Table B-6](#) lists daily function QC check results for each detector. The mean of the daily net counts was compared to the mean of the pre-survey net counts, and no mean of daily net counts was found to exceed the mean of the pre-survey net counts by more than 20 percent, satisfying Criterion 2. The daily mean counts were compared to the mean counts for all days beginning on day 3 for Cs-137 source counts, background counts, and net counts. No daily background or Cs-137 source measurement mean was found to be more than 3 standard deviations from the mean counts for all days. A data validation discussion of daily QC checks is in [Section 4.2.2](#).



Figure B-34 is a QC chart of daily QC background measurements. Average background measurements are displayed on a line accompanied on both sides by lines representing three standard deviations above and below the mean of all daily background measurements.

Figure B-35 is a QC chart for the daily QC Cs-137 source measurements. Average Cs-137 source measurements are displayed on a line accompanied on both sides by lines representing 3 standard deviations above and below the mean for all daily Cs-137 source measurements.



Date	Orange			Red			Blue			Green			Yellow			Black			White ¹		
	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)	Cs-137 Source Counts (cpm)	Background Counts (cpm)	Net Counts (cpm)
11/14/2022	17,659	5,059	12,600	17,595	5,235	12,360	18,314	5,325	12,989	17,738	5,191	12,547	17,441	5,174	12,267	18,314	5,325	12,989	18,577	5,793	12,784
11/15/2022	17,671	5,180	12,491	17,719	5,300	12,419	18,280	5,547	12,733	17,869	5,143	12,726	17,761	4,941	12,820	18,280	5,547	12,733	17,603	6,119	11,484
11/16/2022	17,241	5,019	12,222	17,970	5,088	12,882	18,051	5,455	12,596	17,926	5,132	12,794	17,585	5,285	12,300	18,051	5,455	12,596	18,299	6,025	12,274
11/17/2022	17,880	5,461	12,419	17,495	5,325	12,170	18,784	5,915	12,869	18,162	5,276	12,886	17,770	5,302	12,468	18,784	5,915	12,869	18,703	6,611	12,092
11/18/2022	18,129	5,045	13,084	17,772	5,805	11,967	18,345	5,508	12,837	17,955	6,005	11,950	17,658	5,308	12,350	18,345	5,508	12,837	18,736	6,713	12,023
11/19/2022	17,652	5,242	12,410	17,926	5,694	12,232	18,577	5,768	12,809	17,500	5,494	12,006	17,614	5,645	11,969	18,577	5,768	12,809	-	-	-
11/20/2022	18,213	5,896	12,317	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Average	17,778	5,272	12,506	17,746	5,408	12,338	18,392	5,586	12,806	17,858	5,374	12,485	17,638	5,276	12,362	18,392	5,586	12,806	18,384	6,252	12,131
Standard Deviation (cpm)	330	315	282	184	279	310	255	216	133	223	337	408	123	228	279	255	216	133	469	394	469
Counts Within 3 Standard Deviations of Mean (Yes/No)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
RSD	2%	6%	2%	1%	5%	3%	1%	4%	1%	1%	6%	3%	1%	4%	2%	1%	4%	1%	3%	6%	4%

Notes:
1 White QC attributed to 11/15/2022 actually performed the morning of 11/16/2022 prior to fieldwork
- Instrument not used
cpm Counts per minute
Cs-137 Cesium-137
QC Quality control
RSD Relative standard deviation

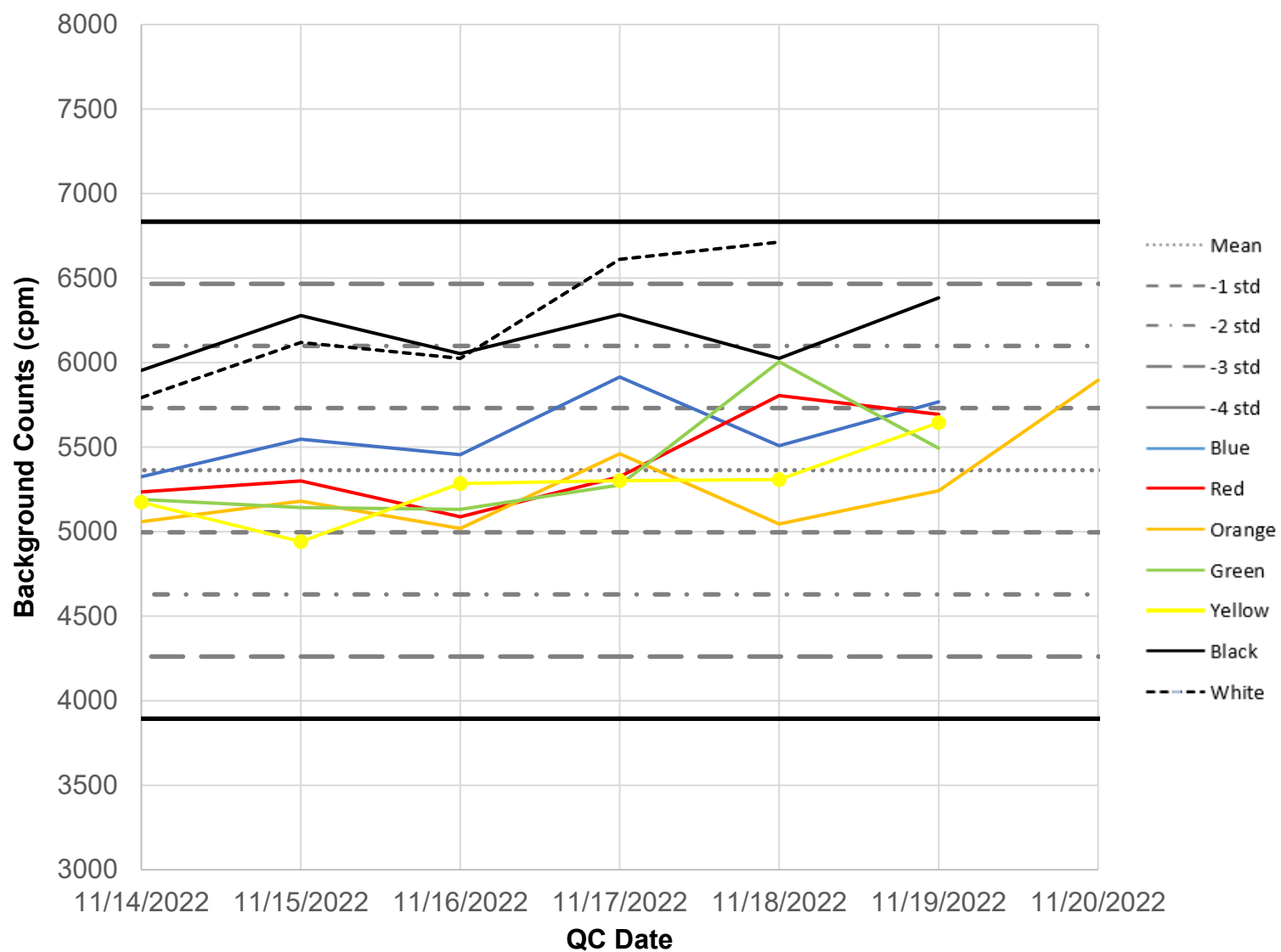
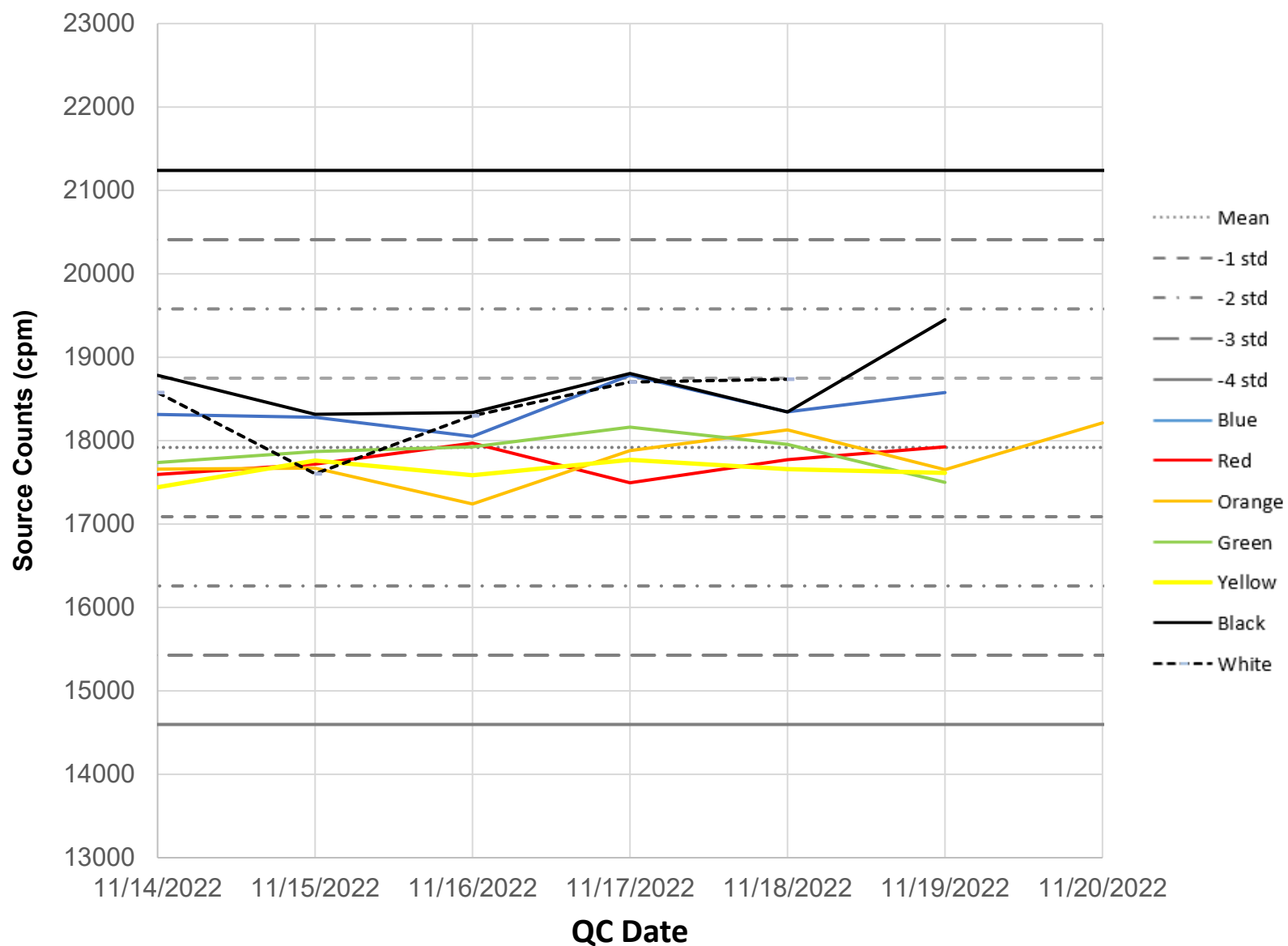


Figure B-34. Daily QC Check Control Chart – Background Measurements

**Figure B-35. Daily QC Check Control Chart – Cs-137 Source Measurements**

4.0 VALIDATION AND VERIFICATION OF INSTRUMENT OPERATION

This section discusses validation and verification of the in-field gamma radiation surveys.

4.1 CALCULATIONS

The following calculations are used to assess precision or comparability. Precision is an indicator of repeatability and reproducibility and can be assessed by evaluating primary and duplicate measurements or datasets. Comparability refers to how well detectors compare to each other so they can be interchanged in the field. The data validation methods used to evaluate the precision or comparability are RSD and RPD.

The RSD was used for evaluation of pre-survey and post-survey gamma exposure rate measurements and daily QC checks. The RSD of the sample mean is used to assess method precision. The equation for calculating RSD is:

$$RSD = \frac{\sigma}{\mu} \times 100$$

where:

RSD	=	relative standard deviation for the precision measurement of gamma radiation counts per minute (cpm)
σ	=	standard deviation of gamma radiation cpm
μ	=	mean concentration of gamma radiation cpm

The RPD was used for pre-survey and post-survey gamma exposure rate measurements. RPD was calculated for detectors with the greatest difference in mean gamma radiation cpm, giving the highest possible RPD for each detector. The equation for RPD is:

$$RPD(\%) = \frac{|S - D|}{\frac{(S + D)}{2}} \times 100$$

where:

RPD	=	relative percent difference between detectors mean gamma radiation cpm
S	=	value of the first detectors mean gamma radiation cpm
D	=	value of the detector with the greatest difference in mean gamma radiation cpm from the first detector's mean gamma radiation cpm

4.2 VALIDATION

Validation of in-field data involves a technical review comparing QC data with established quality criteria to ensure adequacy of data for intended use. The primary validation provided here involves pre-survey and post-survey QC checks in the office, and daily function QC checks in the field.

4.2.1 Pre-Survey and Post-Survey Validation

Methods and results of pre-survey and post-survey QC checks are in [Section 3.2.1](#). The OCRM investigation is a scoping level gamma survey, and detectors were compared according to these specific criteria. Data validation project quality criteria for pre-survey and post-survey are as follows:

- **QC Criterion 1:** The RPD between each detector and the detector with the greatest difference in mean background measurements must be less than 5 percent to allow use of a detector in characterization level gamma surveys, or 10 percent to allow use of a detector in scoping level gamma surveys. **This was achieved.**
- **QC Criterion 2:** The RPD between each detector and the detector with the greatest difference in mean Cs-137 measurements must be less than 5 percent to allow use of a detector in characterization level gamma surveys, or 10 percent to allow use of a detector in scoping level gamma surveys. **This was achieved.**
- **QC Criterion 3:** The RSD of an individual detector's background and Cs-137 source measurements must be less than 5 percent to allow use of a detector in characterization level gamma surveys, or 10 percent to allow use of a detector in scoping level gamma surveys. **This was achieved.**
- **QC Criterion 4:** Each individual detector's background and Cs-137 source measurements must be normally distributed. **This was achieved.**
 - a. Middle/highest point on histogram is the only identifiable peak. **This was achieved.**
 - b. Peak of the normal curve aligns with the peak point of the histogram. **This was achieved except for the white detector and black detector.** It was found that pre-survey background measurements by the white detector were skewed slightly to the left of the normal curve, and that pre-survey and post-survey background measurements by the black detector were skewed slightly to the left of the normal curve. However, neither detector's background measurements were far enough outside of the normal curve to disqualify them from scoping level gamma surveys.
 - c. Slopes of normal probability plots look approximately equal. **This was achieved.**
- **QC Criterion 5:** The RPD between each detector's mean pre-survey background gamma count rate and the mean post-survey background gamma count rate measurement must not exceed 5 percent for characterization data and 10 percent for scoping data. **This was achieved.**
- **QC Criterion 6:** The RPD between each detector's mean pre-survey Cs-137 source gamma count rate and the mean post-survey Cs-137 source gamma count rate measurement must not exceed 5 percent for characterization data and 10 percent for scoping data. **This was achieved.**

[Table B-7](#) and [Table B-8](#) summarize the Pre-Survey QC Criteria and Post-Survey QC Criteria, respectively. Each table lists specific QC criteria and whether the detectors passed those QC criteria. **All project QC requirements for scoping level data were achieved for pre-survey and post-survey measurements.**



Table B-7. Pre-Survey QC Criteria

Instrument Name	Pre-Survey QC Criteria						
	Criterion 1	Criterion 1	Criterion 2	Criterion 2	Criterion 3	Criterion 3	Criterion 4
	RPD of Detector Mean is Within 10% of Total Mean of All Detectors for Background	RPD of Detector Mean is Within 10% of Total Mean of All Detectors for Cs-137	RPD Between Detector Mean Background and Detector with Greatest Difference in Mean Background is less than 10%	RPD Between Detector Mean Cs-137 Source Measurements Compared to the Instrument with the Greatest Difference in Mean Cs-137 Source Measurements is less than 10%	RSD of Background Measurements is less than 10%	RSD of Cs-137 Source Measurements is less than 10%	Normal Distribution of Background and Cs-137 Source Measurements
Orange Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Red Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blue Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Green Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yellow Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Black Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes
White Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:
cpm Counts per minute
RPD Relative percent difference
RSD Relative standard deviation



Table B-8. Post-Survey QC Criteria

Instrument Name	Post-Survey QC Criteria								
	Criterion 1	Criterion 1	Criterion 2	Criterion 2	Criterion 3	Criterion 3	Criterion 4	Criterion 5	Criterion 6
	RPD of Detector Mean is Within 10% of Total Mean of All Detectors for Background	RPD of Detector Mean is Within 10% of Total Mean of All Detectors for Cs-137	RPD Between Detector Mean Background and Detector with Greatest Difference in Mean Background is less than 10%	RPD Between Detector Mean Cs-137 Source Measurements Compared to the Instrument with the Greatest Difference in Mean Cs-137 Source Measurements is less than 10%	RSD of Background Measurements is less than 10%	RSD of Cs-137 Source Measurements is less than 10%	Normal Distribution of Background and Cs-137 Source Measurements	RPD of Pre- and Post-Survey Background Measurements are Less Than 10%	RPD of Pre- and Post-Survey Cs-137 Source Measurements are Less Than 10%
Orange Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Red Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Blue Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Green Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Yellow Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Black Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
White Detector	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes:
cpm Counts per minute
RPD Relative percent difference
RSD Relative standard deviation

4.2.2 Daily QC Checks

The goal of the daily function QC checks is to ensure the detectors were working properly during field surveys. QC criteria and results of the daily function QC checks are presented in [Section 3.0](#). The QC charts show that data points for background and Cs-137 source checks were all within the project quality criteria limits. [Table B-9](#) lists results of daily function QC checks.

Table B-9. Daily QC Criteria

Instrument Name	Daily QC Criteria				
	Criterion 1	Criterion 2	Criterion 3	Criterion 3	Criterion 3
	Daily Function QC Checks Were Completed Daily After Survey Activities	Mean of Net Measurements Within 20% of Pre-Survey Mean	Background Measurements Within 3 Standard Deviations of Total Daily QC Mean	Cs-137 Source Measurements Within 3 Standard Deviations of Total Daily QC Mean	Net Measurements Within 3 Standard Deviations of Total Daily QC Mean
Orange Detector	Yes	Yes	Yes	Yes	Yes
Red Detector	Yes	Yes	Yes	Yes	Yes
Blue Detector	Yes	Yes	Yes	Yes	Yes
Green Detector	Yes	Yes	Yes	Yes	Yes
Yellow Detector	Yes	Yes	Yes	Yes	Yes
Black Detector	Yes	Yes	Yes	Yes	Yes
White Detector	Yes	Yes	Yes	Yes	Yes

4.3 VERIFICATION

Data verification of in-field gamma radiation survey data is the process for evaluating completeness, correctness, consistency, and compliance of a data package against the SAP. In this context, “completeness” means all required hard-copy and electronic deliverables are present. For in-field gamma radiation survey compliance verification, the primary evaluation involves completeness of gamma radiation surveys performed during the 2021 field investigation. A number of documents pertaining to the in-field gamma radiation survey compliance verification evaluation are as follows:

- A photographic log of the in-field gamma radiation surveys is in [Appendix A](#) to the main report.
- A detailed methodology regarding the gamma-radium correlation study is presented as the Gamma Correlation Report in [Appendix E](#) to the main report.



- The scanned field forms relating to in-field gamma radiation surveys are included as [Appendix F](#) to the main report.

5.0 VALIDATION AND VERIFICATION OF FIELD SURVEY DATA

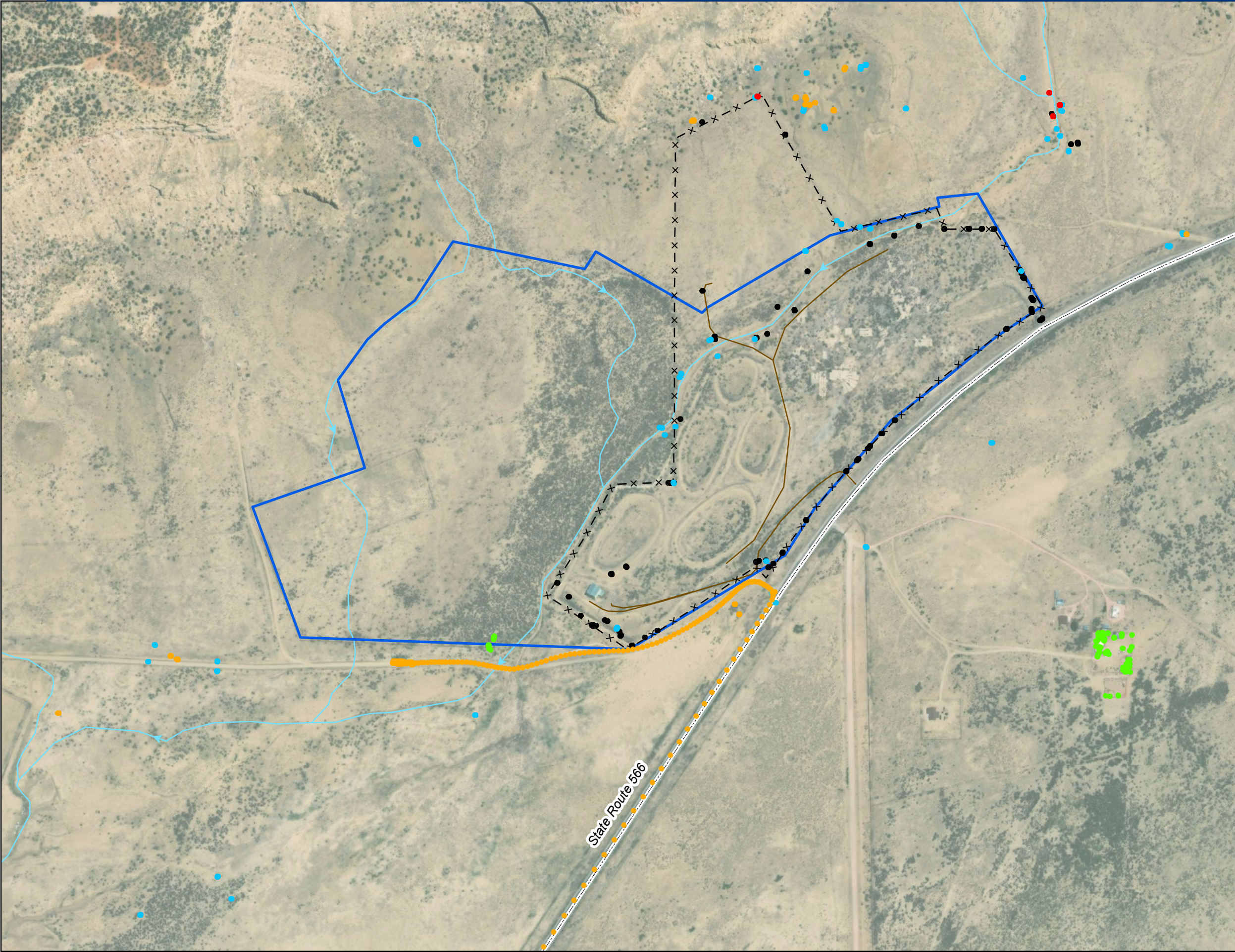
The objective of validating gamma survey data is to ensure all gamma survey data are screened for erroneous readings. Following collection of survey data, Geographic Information System (GIS) or other appropriate software shall be used to evaluate data quality associated with gamma levels, GPS accuracy, and survey indicators by:

- Screening for erroneous values including abnormally high or low gamma values, spikes in data indicating a cable issue, zeros indicating a malfunctioning detector or cable, and distribution.
- Evaluating quality of GPS data through verification of horizontal dilution of position (HDOP) and vertical dilution of position (VDOP), number of satellites, and visual inspection of the data to capture signal reflection.
- Evaluating user performance characteristics including surveyor speed and coverage through spot checking of data.

The following attachments are provided to support validation and verification of field survey data:

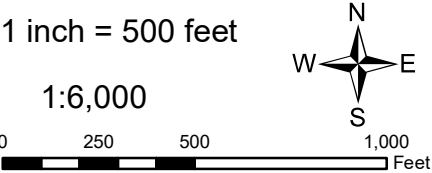
- [Attachment B-2](#) – Detector and Meter Serial Numbers and Dates of Use
- [Attachment B-3](#) – Gamma Survey MetaData (.gsf)
- [Attachment B-7](#) – Excluded Gamma Survey Data (.shp)
- [Attachment B-8](#) – Final Gamma Survey Data (.shp)

[Figure B-36](#) shows excluded gamma data. [Figure B-37](#) shows the final data set color coded to instrument identification. [Table B-10](#) summarizes data excluded from the final dataset, including date acquired, impacted data file, number of datapoints removed, justification for removal, and user. All data summarized in [Table B-10](#) are included in a SHP file as [Attachment B-7](#). The final gamma survey dataset, which comprises all data from [Attachment B-3](#) minus any excluded data, is included in a SHP file as [Attachment B-8](#). SHP files can be viewed in ESRI ArcMap, QGIS, or similar software.



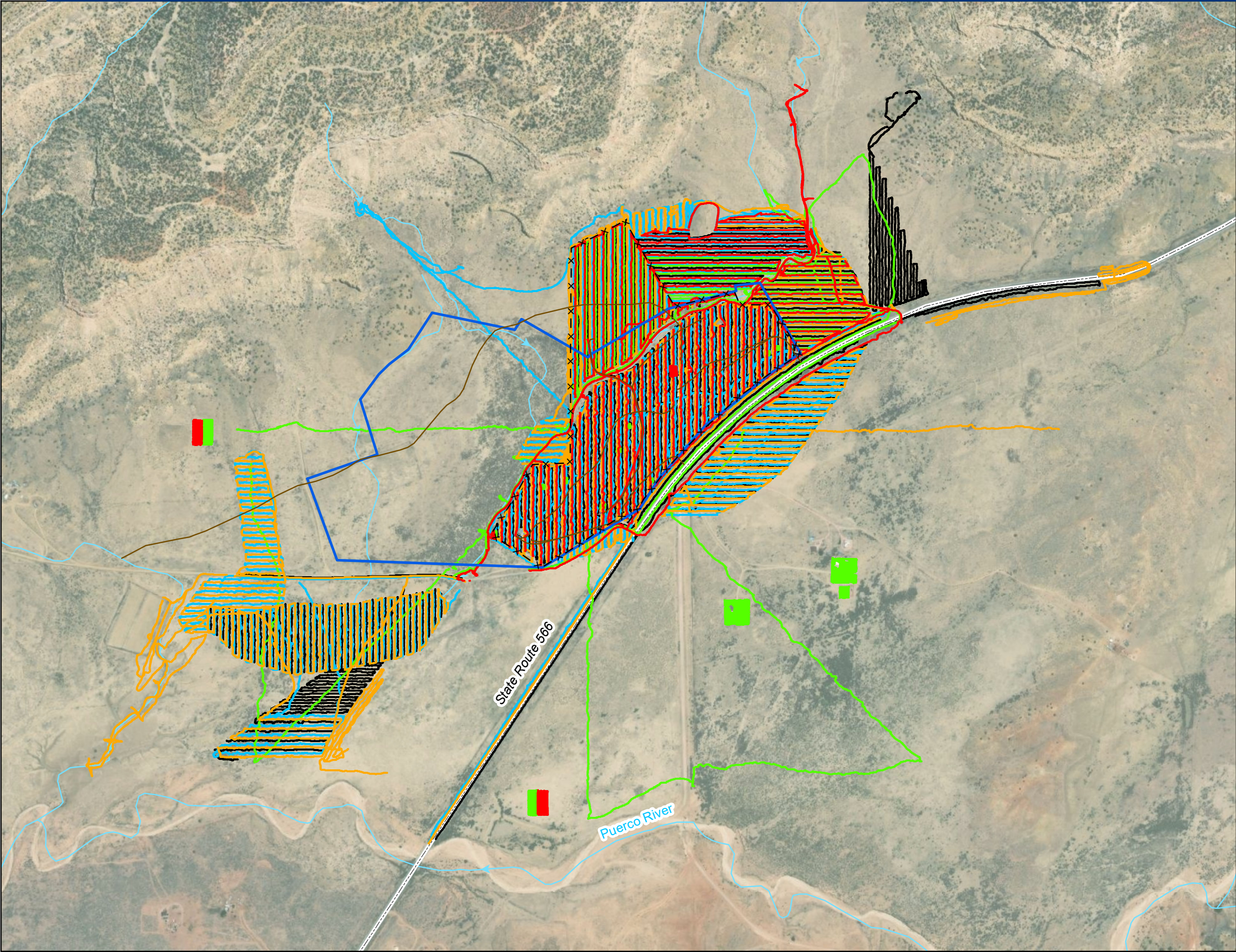
- Excluded Gamma Data¹**
- Black Detector
 - Blue Detector
 - Green Detector
 - Orange Detector
 - Red Detector
 - 2007 USEPA Navajo AUM Atlas Polygon
- Site Features**
- × — Fenced Boundary
 - Drill Road - Fall 2022
 - Community Road
 - Surface Water Pathway

Notes:
¹An additional 970 data points not shown were recorded during demobilization to nightly lodging.
AUM Abandoned uranium mine



**OLD CHURCH ROCK MINE
EXCLUDED GAMMA DATA
COLOR CODED TO INSTRUMENT ID**

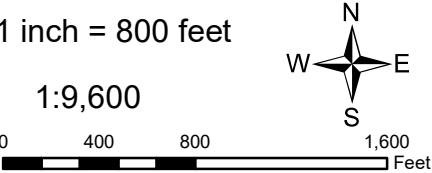
Prepared For: U.S. EPA Region 9	Prepared By:
	TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 8/21/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: B-36



- Final Gamma Dataset**
- Black Detector
 - Blue Detector
 - Green Detector
 - Orange Detector
 - Red Detector
 - AUM Site Boundary

- Site Features**
- × — Fenced Boundary
 - Facility Road
 - Community Road
 - Surface Water Pathway

Notes:
*An additional 970 data points not shown were recorded during demobilization to nightly lodging.
AUM Abandoned uranium mine



**OLD CHURCH ROCK MINE
FINAL GAMMA DATASET
COLOR CODED TO INSTRUMENT ID**

Prepared For: U.S. EPA Region 9 	Prepared By: TETRA TECH 1999 Harrison Street, Suite 500 Oakland, CA 94612
Task Order No.: 0035	Contract No.: EP-S9-17-03
Location: CHURCH ROCK CHAPTER NAVAJO NATION	Date: 4/17/2023
Coordinate System: NAD 1983 State Plane New Mexico West FIPS 3003 Feet Transverse	Figure No.: B-37

Table B-10. Data Exclusion Log

Date	Affected Dataset	Initial Records	Records Removed	Reason for Exclusion	User (Initials)
11/14/2022	111422-085300-26-blue-OCRM-MB	12982	138	Cluster of datapoints	MB
11/14/2022	111422-090424-1_black ocrm sk	15420	1991	Cluster of datapoints	SK
11/15/2022	111522-125725-33-red-ocrm-sk	11830	177	Cluster of datapoints	SK
11/16/2022	111622-101449-1-Black-OCRM-SC	9843	196	Cluster of datapoints	SC
11/16/2022	111622-103133-26-blue-OCRM-MB	13012	735	Cluster of datapoints	MB
11/18/2022	111822-094244-38-green-ocrm-mq	8058	157	GPS VDOP/HDOP	MQ
11/18/2022	111822-093922-26-blue-OCRM-MB	14775	150	Cluster of datapoints	MB
11/19/2022	111922-090705-44-Orange-OCRM-CP	19681	1803	Gamma survey meter left on during demobilization	CP
11/19/2022	111922-090705-44-Orange-OCRM-CP	19681	769	Cluster of datapoints	CP
11/19/2022	111922-093915-26-Blue-OCRM-MB	17538	586	Cluster of datapoints	MB

Notes:

GPS Global Positioning System

VDOP Vertical dilution of precision

HDOP Horizontal dilution of precision



6.0 REFERENCES

American National Standards Institute (ANSI). 1997. “American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments.”

Tetra Tech, Inc. (Tetra Tech). 2022. “OCRM Removal Assessment Sampling and Analysis Plan.” Response, Assessment, and Evaluation Services. Contract No. EP-S9-17-02. Task Order 0035.

U.S. Environmental Protection Agency (USEPA). 2000. *Multi-Agency Radiation Survey and Site Investigation Manual*. August.

USEPA. 2004. *Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP)*. July.

**ATTACHMENT B-1: SOP NO. 002 “PERFORMING A GPS-BASED
GAMMA RADIATION SURVEY”**

Environmental Standard Operating Procedure

**SOP No. 002
Performing a GPS-Based Gamma
Radiation Survey**



Tetra Tech, Inc.

Environmental Restoration Group, Inc.



February 2018



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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes a method for performing a gamma radiation survey using a survey meter and gamma radiation detector coupled to a global positioning system (GPS).

A radiation survey is often performed to provide a spatially representative radiological condition of an area. By combining the radiological survey instruments to a GPS unit the survey data and associated positions can be logged in electronic format for use in GIS. Depending upon the goals of the survey and the terrain or the survey area a GPS-based radiological survey may be performed with the system setup carried by the surveyor (backpack) or setup for use on a vehicle (push cart, utility terrain vehicle, and truck).

To perform a project related GPS-based radiological survey personnel must be recognized on their ERG Training Qualification Form as qualified to perform this procedure.

2.0 PRECAUTIONS

The following precautions will be observed during GPS-based radiation survey:

- The radiation protection plan (Attachment D-6 in Appendix D) will be followed.

3.0 EQUIPMENT AND MATERIALS

The following equipment is required for performing a GPS-based radiological survey:

- GPS survey system of mapping grade or better (sub-meter accuracy) – Juniper Systems Mesa2 and Geode, Trimble ProXRT, ProXH, or similar with data logger/controller.
- Gamma radiological survey instruments with RS-232 data output or Bluetooth output – Ludlum Model 2221 ratemeter/scaler or Ludlum Model 4612 counter matched with a Ludlum Model 44-10 (2-inch by 2-inch NaI), Model 44-20 (3-inch by 3-inch NaI), Field Instrument for Detection of Low Energy Radiation (FIDLER) detector, or similar radiation detector.
- Radiological check source – Use a cesium 137 (Cs-137) or americium 241 (Am-241) source for typical function check of a high-energy gamma detector or low-energy gamma detector such as a FIDLER, respectively. Check sources used are depend on the goal of the survey. While the sources listed above are for typical function checks, they are not required to be NIST-traceable. NOTE: Select check sources that will provide a minimum accumulation of 5,000 gross counts during the counting interval, typically one minute.
- All appropriate cables, including GPS antenna cable as necessary, RS-232 cable from meter to GPS data logger, C-cables from meter to detector, and others as necessary.
- Detector rack to hold multiple detectors at set height above ground surface, as necessary when performing a survey using a push cart, UTV, or truck.

4.0 PROCEDURE

The following procedures will be used for performing a GPS-based gamma radiation survey.

4.1 SETUP

Setup the survey system hardware by assembling the GPS backpack or detector rack (push cart, UTV, and truck), as appropriate. Connect cabling and/or Bluetooth connection(s) between GPS units, antennas, ratemeter/scaler/counters, detectors, and data loggers or controller, as necessary. Use sufficient cabling such that it will be safe and secure from damage or unintended disconnection. If performing a vehicle survey, mount rack to vehicle and attach detectors to rack. The GPS data loggers or controllers are typically setup to record the external sensor (ratemeter/scaler/counter) output with associated position every one second.

4.2 FUNCTION CHECK

Perform function check of the radiological survey instrument(s) per the safe work practices for Operational Checkout of Single-Channel Detector with Meter in the radiation protection plan or Operational Checkout of a Single-Channel Detector Array with Ludlum Model 4612 provided in the radiation protection program, whichever is applicable, before and after each day of use.

4.3 SURVEY

- **SURVEY FILE NAME** – Open a new survey file and give it a unique file name indicative of the survey. The file name could include the survey date and/or time, the surveyor initials, and/or the site name. NOTE: The default Trimble Terrasync naming format is RmmddhhA; where a file name begins with the letter R (rover), followed by the date and hour, and ends with a letter signifying the order the file was created within the hour (A: first, B: second, etc.). When multiple dataloggers are used the surveyor should add their initials and/or a description (R/L; right/left, 1: first, etc.) to the end of the file.
- **WHEN SURVEYING** –
 1. Turn the ratemeter/scaler/counter on prior to beginning a survey file. NOTE: the unit is not turned on prior to opening a survey file the initial recorded gamma count rate records will be low.
 2. Begin and end a survey data file at a point/location where it is desirable to collect data. Do not start a survey file when near the function check source.
 3. Close the survey file upon completion of the survey. If taking a break create a new survey file upon resuming the survey.
- **SURVEY DESIGN** - Perform the survey by either walking (backpack), pushing (push cart), or driving (UTV or truck) the survey equipment following the survey design, typically provided in a work plan. The survey design depends on the goal of the survey and the equipment and should take into account the radiation detector type and model, survey scan speed, detector spacing, and height of detector above ground during the survey. Some of these design parameters may be depend on the terrain of the survey area.
 1. **DETECTOR** – Choose a detector that is appropriate to meet the goals and/or requirements of the survey. For middle to high-energy gamma emitting radiation it is common to use the Model 44-10, Model 44-20, or similar detector. For low-energy emitting radiation a FIDLER detector may be more suitable. If surveying in an area where gamma shine is an issue, then

use of a detector shield may be appropriate. The project work plan will typically prescribe the type of detector to be used.

2. SURVEY SCAN SPEED – Use the designed survey scan speed or choose a range that is appropriate to meet the goals and/or requirements of the survey. A survey scan speed that is too fast may not allow for a detector to be present over a localized area of elevated gamma count rates long enough to adequately represent the conditions. For an area believed to have homogenous gamma count rates a slower survey scan speed may be unnecessary and inefficient. The project work plan will typically prescribe the survey scan speed.
3. DETECTOR SPACING – Attempt to cover the survey area adequately with an appropriate detector spacing to meet the goals and/or requirements of the survey. If surveying over an area known to have homogenous gamma count rates, then a wider/farther apart detector spacing may be appropriate. When surveying over an area where radiological conditions are unknown or known to have small localized areas of elevated readings, then a tighter/closer detector spacing may be warranted. A combination of detector spacing may also be appropriate; tighter detector spacing in areas of elevated readings and wider spacing in areas of homogenous readings. The project work plan will typically prescribe the detector spacing.
4. DETECTOR HEIGHT – The detector height above ground should be chosen to meet the goals and/or requirements of the survey. Attempt to maintain the same detector height throughout the survey. The project work plan will typically prescribe the detector height.

4.4 DATA PROCESSING AND REVIEW

Upon completion of a GPS-based radiological survey download the data from the datalogger(s) or controller and convert into usable format, typically a GIS shapefile format. Process and review the data in accordance with SOP No. 006 Validation and Verification of Gamma Survey Data. Resurvey areas where data is unexplainably missing, corrupt, or there is reason to believe the results are in error.

**ATTACHMENT B-2: DETECTOR AND METER SERIAL NUMBERS
AND DATES OF USE**

Ludlum Meter SN	Ludlum Meter Model	Ludlum Model 44-10 SN	Event	Event Color	Dates Used	User	GSF Filename / PDF Fieldform
254783	2221	PR399729	OCRM	Black	11/14/2022	SK	111422-090424-1_black ocrm sk.gsf
			Section 32/33		11/15/2022	SK	111522-095015-1-black-s32-33-sk.gsf
			OCRM		11/16/2022	SC	111622-101449-1-Black-OCRM-SC.gsf
			Section 32/33		11/17/2022	SK	111722-094631-1-black-32-33-sk.gsf 111722-014501-1-black-32-33-sk 2.gsf 111722-014834-1-black-32-33-sk 3.gsf
			OCRM		11/18/2022	BB	111822-094029-1_Black_BSB_OCRM.gsf
			OCRM		11/19/2022	BB	111922-101237-1_Black_BSB_OCRM.gsf
25016973	3000	PR150857	OCRM	Blue	11/14/2022	MB	111422-085300-26-blue-OCRM-MB.gsf
			Section 32/33		11/15/2022	MB	111522-094949-26-blue-s32-33-MB.gsf
			OCRM		11/16/2022	MB	111622-103133-26-blue-OCRM-MB.gsf
			Section 32/33		11/17/2022	MB	111722-095815-26-Blue-32-33-MB.gsf
			OCRM		11/18/2022	MB	111822-093922-26-blue-OCRM-MB.gsf
			OCRM		11/19/2022	MB	111922-093915-26-Blue-OCRM-MB.gsf
25020102	3000	PR406319	OCRM	Red	11/14/2022	SC	111222-112652-33-Red-OCRM-SC.gsf
			OCRM		11/15/2022	MQ	111522-111852-33-red-ocrm-mq.gsf
			OCRM		11/16/2022	SK	111622-125725-33-red-ocrm-sk.gsf
			Section 32/33		11/17/2022	MC	111722-122949-33_Red_MEC_3233.gsf
			Section 32/33		11/18/2022	SK	111722-011412-33corrplors.gsf
			OCRM		11/19/2022	SK	111722-115125-33-ocrmcorr.gsf 111822-042536-33-ocrm-ablation.gsf
25018543	3000	PR355810	OCRM	Orange	11/14/2022	CP	111422-085312-44-orange-OCRM-CP.gsf
			Section 32/33		11/15/2022	CP	111522-021533-44-Orange-S 32 33-CP.gsf 111522-092757-44-Orange-Section 32 33-CP.gsf
			OCRM		11/16/2022	CP	111622-094515-44-Orange-OCRM-CP.gsf
			Section 32/33		11/17/2022	CP	111722-091731-44-Orange-S 32 33-CP.gsf
			OCRM		11/18/2022	CP	111822-084955-44-Orange-OCRM-CP
			OCRM		11/19/2022	CP	111922-090705-44-Orange-OCRM-CP.gsf
			OCRM		11/20/2022	MQ	112022-084804-44-orange-ocrm-mq.gsf
25017006	3000	PR295014	OCRM	Yellow	11/14/2022	AM	111422-085423-5-yellow-OCRM-AM.gsf
			Section 32/33		11/15/2022	AM	111522-093836-5-yellow-sec3132-AM.gsf
			OCRM		11/16/2022	AM	111622-095723-5-yellow-OCRM-AM.gsf
			Section 32/33		11/17/2022	AM	111722-100303-5-yellow-3233-AM.gsf

Ludlum Meter SN	Ludlum Meter Model	Ludlum Model 44-10 SN	Event	Event Color	Dates Used	User	GSF Filename / PDF Fieldform
			OCRM		11/18/2022	AM	111822-094124-5-yellow-OCRM-AM.gsf
			OCRM		11/19/2022	AM	111922-090833-5-yellow-OCRM-AM.gsf
25018610	3000	PR355771	Section 32/33	Green	11/14/2022	BB	111422-020554-38_BSA2Test.gsf 111422-022515-38_3233_BSA2_4real.gsf 111422-031420-38_3233_CorrPlot_BSA2.gsf 111422-040819-38_3233_OCRM_corrPlot.gsf 111422-103712-38_3233BSA1.gsf 111422-103838-38_3233_BSA1.gsf 111422-115707-38_3233_BSA2.gsf
			OCRM		11/15/2022	BB	111522-085557-38_Green_BSB__OCRM.gsf
			OCRM		11/16/2022	BB	111622-101416-38_Green_BSB_OCRM.gsf
			Section 32/33		11/17/2022	BB	111722-101512-38_Green_BSB_3233.gsf
			OCRM		11/18/2022	MQ	111822-094244-38-green-ocrm-mq.gsf
			OCRM		11/19/2022	MQ	111922-093927-38-green-ocrm-mq.gsf
117357	2221	PR375296	Section 32/33	White	11/14/2022	JH/MC	2022_11_14_BSA1_BSA2_SoilSampling.pdf
			Section 32/33		11/15/2022	JH/MC	2022_11_15_BSA2_MainSite_SoilSampling.pdf
			OCRM		11/16/2022	JH/MC	2022_11_16_BSA2_Ponds_SoilSampling.pdf
			Section 32/33		11/17/2022	JH/MC	2022_11_17_MainSite_SoilSampling.pdf
			OCRM		11/18/2022	JH/MC	2022_11_17_MainSite_SoilSampling.pdf

Notes:

SK Sean Kit
SC Seth Crank
BB Braden Belliveau
MB Molly Baron
MQ Marcus Quinlan
MC Margaret Carolan
CP Christine Phillips
AM Anya Mikheicheva
OCRM Old Church Rock Mine

**ATTACHMENT B-3: RAW GAMMA MEASUREMENT FILES
(ELECTRONIC)**

ATTACHMENT B-4: GAMMA QA/QC PROCEDURES

samples to laboratories for definitive measurement of contamination. The fallible and definitive datasets will be strategically collected to allow for the statistical analysis and correlation of both datasets. This correlation of high-density fallible data with lower-density definitive data allows for the definition of a mathematical relationship between the two datasets. The fallible dataset can then be mathematically corrected to provide statistically defensible, laboratory-like results with near 100 percent coverage of the target population. This sampling approach is based on well-accepted methodology such as the double sampling approach (Gilbert 1987). Statistical approaches to correlating fallible and definitive datasets are also well-defined and accepted (Gilbert 1987; USEPA 2002a). The double sampling approach is defined as requiring strong linear correlation between the fallible and definitive datasets (Gilbert 1987). The nature of the relationship between fallible and definitive datasets that will be collected under TO 0001 is not yet known and experience indicates that relationships could be linear, logarithmic, or power-based. As a result, Tetra Tech is referring to this sampling approach as “paired sampling” in this SAP/QAPP.

Tetra Tech will use this paired sampling strategy for both gamma radiation and metals contamination investigations. The specific methods that will be used to implement the paired sampling strategy, as well as the methods used to accomplish the remaining primary Baseline Study goals are detailed in the sections below.

4.1.1.1 *Gamma Radiation Surveys*

Tetra Tech will perform GPS-based gamma radiation surveys (gamma surveys) of the land areas at each investigation area as part of the Baseline Study, including background reference areas and mine claim areas and roads and drainages that extend hydraulically (or by wind) downgradient from the mine claims, and will expand the surveys to the areal limits of contamination defined by an investigation level for Ra-226. Tetra Tech has tailored its gamma survey approach to provide near-comprehensive assessment of the target population of surface soil. Gamma survey measurements represent the fallible dataset within the paired sampling approach and will be mathematically related to both analytical results for radioactive COPCs (most notably Ra-226), and exposure rate measurements collected using a high-pressure ionization chamber (HPIC).

The purpose of performing GPS-based gamma surveys is to:

- Define the areal extent of TENORM;
- Help establish a basis from which the subsurface can be investigated;
- Establish a basis that can be used to predict Ra-226 concentrations across a site; and
- Establish a basis that can be used to predict exposure rates across a site

The use of GPS-based radiation survey systems has become a mature method for characterizing the spatial distribution of gamma radiation due to NORM in soils (Adsleya and others 2004; Johnson and others 2006; Meyer and others 2005; Vitkus and Bailey 2007; Whicker and others 2008). Furthermore, these types of systems are well-suited to outdoor gamma radiation surveys in terms of cost, portability, coverage, durability, and high sensitivity to terrestrial sources of low-level gamma radiation (Whicker and others 2015).

The gamma radiation surveys will be performed using Ludlum Model 44-10 (or equivalent) 2-inch by 2-inch NaI detectors each coupled to a Ludlum Model 2221 (or equivalent) ratemeter/scaler set in ratemeter mode. For this project, Tetra Tech plans to utilize these detectors coupled to an ERG Model 105 GPS (or equivalent). The ERG Model 105 GPS consists of a Juniper Mesa 2 field computer and geode GPS receiver (or equivalent). The surveys will be conducted on foot at approximately 3 feet per second along 2-meter transects. The detectors will be positioned at 1 meter above ground surface. The “field of view” of the sodium iodide detector in this configuration (2-meter transects and 1-meter height) provides 100 percent coverage of land areas.

Gamma count rate measurements and associated geospatial coordinates will be made and recorded every one second. The output will be converted to exposure rates in microroentgens per hour ($\mu\text{R/hr}$) using a correction factor published by Ludlum Measurements for the Ludlum Model 44-10 (or equivalent), after which the measurements will be correlated to an energy independent HPIC (see Section 4.1.1.3).

All Ludlum Model 44-10/2221 (or equivalent) instrument systems used in the gamma surveys will be calibrated in accordance with “American National Standard Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments” (ANSI, 1997), RPP SOP 002: Calibration of a Radiological Survey Meter, and RPP SOP 001: Calibration of a Radiological Survey Detector. Calibration of the detection systems is required prior to their initial use, at least annually, and after any scheduled or unscheduled maintenance or repair that may affect their operation. General maintenance of the detection systems, such as cleaning, painting, and changing buttons, does not require that they be calibrated. The instruments will be function-checked daily, before at the end of each work day in accordance with RPP SOP No. 009: Operational Checkout of Single Detector with Meter. The SOPs mentioned in this subsection are attached in Attachment C-1 to this SAP/QAPP, and a summary of instrument calibration and functional checks is provided in Table C-9.

Table C-9. Gamma Radiation Survey Equipment Summary

Equipment	Use/Calibration Summary	Relevant SOP No.
Ludlum 2221/ Ludlum 44-10 (or equivalent)	<p>Use: Ludlum 2221 ratemeter/scaler instruments will be paired with Ludlum 44-10 NaI detectors or similar to measure surface gamma radiation. This detection system will be paired with a GPS unit and data logger to record gamma survey results in real-time.</p> <p>Calibration: Each system (Ludlum 2221/44-10 pair or equivalent) will be calibrated at least annually. Calibration will also be performed following any maintenance or repair that could affect functionality.</p> <p>Functional Checks: Checks are performed on each system each day that they are used. One check is performed prior to use, and one check when all measurement activities have been completed for the day. Checks utilize a standardized source, and net results (source less background counts) must be within $\pm 20\%$ of the results established as part of ongoing control charting.</p>	RPP SOP 001 RPP SOP 002 RPP SOP 009

Table C-9. Gamma Radiation Survey Equipment Summary

Equipment	Use/Calibration Summary	Relevant SOP No.
ERG Model 105 GPS	Use: The ERG Model 105 GPS system will be used to pair radiation instruments with GPS units to simultaneously record gamma measurements with geospatial locations. The system uses a handheld tablet computer to collect and display survey results in real-time and protect the data from manipulation. Calibration: NA Functional Checks: NA	NA

Notes:

ERG	Environmental Restoration Group, Inc.
GPS	Global positioning system
NA	Not applicable
NaI	Sodium iodide
RPP	Radiological protection plan
SOP	Standard operating procedure

There will be slight variations to the data collection methodology described above during the assessments of roads and drainages.

- **Roads:** GPS-based gamma surveys will be performed on access/hauling roads to a distance of 0.25 mile from investigation areas. Gamma surveys will use the methodology described above, resulting in 100 percent survey coverage.
- **Drainages:** GPS-based gamma surveys will be performed along drainages near sites to a distance of 1 mile downstream from investigation areas, or until the first junction with another drainage channel. Gamma surveys will use the methodology described above, but may be prevented from reaching 100 percent survey coverage because of rough terrain or the presence of standing/running water in the drainages.

The measurements collected from each site will be used to:

- Estimate the areal extent of TENORM on land surfaces and identify anomalies in site conditions;
- Determine provisional areas that field personnel can use to select plots for the correlation studies described in Section 4.1.1.2;
- Predict Ra-226 concentrations and energy independent exposure rates across the sites (see Sections 4.1.1.2 and 4.1.1.3 for descriptions of these activities);
- Evaluate the scan MDC for the Ludlum Model 44-10 (or equivalent) sodium iodide detector, which is addressed in Section 3.2.1 of the SAP/QAPP.

The gamma measurements at a particular site will be processed after they have been collected by (1) overlaying 100 m² grids across the site, (2) estimating the average of the gamma measurements within each grid, (3) comparing these averages to ILs, and (4) stopping or guiding additional surveys as follows:

- If the gamma measurements made in the survey area, particularly along the perimeter of a survey area, are below the corresponding investigation level (IL), then the area will be considered accurate or defined, the survey complete, and sufficient information at that point will be available to estimate the lateral extent of TENORM. The information garnered from the XRF surveys described in Section 4.1.1.4 of this SAP/QAPP also will be considered in this decision.
- If the gamma and XRF surveys indicate clusters of point values above their ILs within drainages or other migration pathways, then the survey areas will be extended.

4.1.1.2 Gamma-Radium Correlation Study

Gamma count rates depend on a variety of conditions including the type of instruments, the configuration of the instruments (for example, height above ground surface [ags]), soil moisture, and instrument settings. If the gamma measurements are not related to a common parameter (such as concentrations of Ra-226 in soil or exposure rates), their comparison to data collected under different conditions using different equipment can be considered erroneous.

Tetra Tech will avoid this potential issue by performing two types of correlation studies to establish site-specific and regionally applicable statistical relationships between (1) gamma exposure rates as measured by the Ludlum 44-10 (or equivalent) and Ra-226 concentrations in surface soil, and (2) gamma count rates measured using a Ludlum 44-10 (or equivalent) and exposure rates measured using an HPIC. This section focuses on the gamma – Ra-226 correlation study; for additional details on the gamma – exposure rate correlation study, see Section 4.1.1.3.

The purpose of the gamma-radium correlation study is to translate the relatively high-density gamma measurements to more meaningful predicted concentrations of Ra-226. Predicted concentrations of Ra-226 are more useful for estimating volumes of TENORM that may require removal during future remediation activities.

Tetra Tech will correlate gamma count rates to concentrations of Ra-226 in surface soil and sediment according to the framework in SOP No. 001 (Attachment C-1 to this SAP/QAPP). Using the following method, Tetra Tech will:

- Select correlation study areas for a subset or individual AUM sites exhibiting gamma measurements that envelop likely future decision points, such as potential cleanup levels for Ra-226 in surface soils. Gamma measurements that represent relatively high concentrations of Ra-226 in surface soils — on the order of greater than 20 pCi/g — will be removed in a remedial action. Thus, the predicted concentrations of Ra-226 at such levels need not be known for the volume estimate.
- Establish 10-meter by 10-meter (100 m²) study plots in the areas, the number and location of which will be based on the discussion above and as determined by field personnel if the gamma measurements are relatively homogeneous. A minimum of 10 study plots will be established at AUM sites. A minimum of two study plots will be established at Target sites (primarily as a result of the smaller size of Target sites). During assessments of roads, correlation plots will be established only if there are field

ATTACHMENT B-5: CALIBRATION CERTIFICATES



Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite #150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	117357
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR375296

☒ Mechanical Check ☒ THR/WIN Operation HV Check (+/- 2.5%): ☒ 500 V ☒ 1000 V ☒ 1500 V
☒ F/S Response Check ☒ Reset Check Cable Length: ☐ 39-inch ☒ 60-inch ☐ Other:
☒ Geotropism ☒ Audio Check
☒ Meter Zeroed ☒ Battery Check

Source Distance: ☐ Contact ☒ 6 inches ☐ Other: Threshold: 10 mV Barometric Pressure: 24.43 inches Hg
 Source Geometry: ☒ Side ☐ Below ☐ Other: Window: Temperature: 72 °F
 Pulser: Ludlum 500-1 sn 201932 Multimeter: n/a Relative Humidity: 20 %
 Instrument found within tolerance: ☒ Yes ☐ No

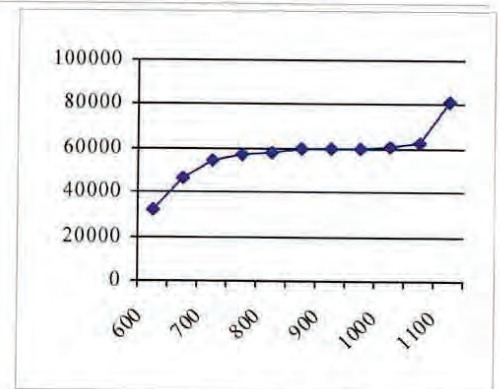
Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	400211	400
x 1000	100	100	100		100
x 100	400	400	400	40024	400
x 100	100	100	100		100
x 10	400	400	400	4003	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

Count Time (min): 1.0

High Voltage Source Counts Background Counts Net Counts

600	31976	2659	29317
650	46352	5358	40994
700	54384	7883	46501
750	56700	8686	48014
800	58342	9103	49239
850	59497	9225	50272
900	59506	9159	50347
950	59868	9268	50600
1000	60388	9494	50894
1050	62062	9977	52085
1100	80810	12312	68498

Voltage Plateau



Recommended HV (VDC) 1,000

Additional Comments:

Source 1 Cs-137 sn:4097-03 5.2μCi (1/4/12) button

Total Efficiency: n/a 4π Efficiency: n/a

Source 2

Total Efficiency: n/a 4π Efficiency: n/a

NOTE: The total efficiency provided is calculated per ISO-7503/NUREG 1575 (MARSSIM): Total Efficiency = Instrument Efficiency × Source Efficiency; where Instrument Efficiency is calculated as net counts ÷ source 2π emission rate. The 4π efficiency is calculated as net counts ÷ source 4π activity. The provided efficiencies are radionuclide specific and are calculated using source counts and background counts at the recommended operating HV. The provided efficiencies are for general information purposes only and are not intended to replace user efficiency calculation method or results.

Calibrated By:

Calibration Date: 9/21/22 Calibration Due: 9/21/23

Reviewed By:

Date: 9/22/22



Certificate of Calibration

Calibration and Voltage Plateau

Environmental Restoration Group, Inc.
8809 Washington St NE, Suite #150
Albuquerque, NM 87113
(505) 298-4224
www.ERGoffice.com

Meter:	Manufacturer:	Ludlum	Model Number:	2221r	Serial Number:	254783
Detector:	Manufacturer:	Ludlum	Model Number:	44-10	Serial Number:	PR391729

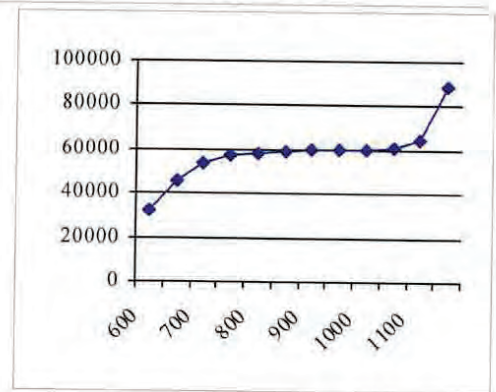
☒ Mechanical Check ☒ THR/WIN Operation HV Check (+/- 2.5%): ☒ 500 V ☒ 1000 V ☒ 1500 V
☒ F/S Response Check ☒ Reset Check Cable Length: ☐ 39-inch ☒ 60-inch ☐ Other: _____
☒ Geotropism ☒ Audio Check
☒ Meter Zeroed ☒ Battery Check
 Source Distance: ☐ Contact ☒ 6 inches ☐ Other: _____ Threshold: 10 mV
 Source Geometry: ☒ Side ☐ Below ☐ Other: _____ Window: _____
 Barometric Pressure: 24.43 inches Hg
 Temperature: 73 °F
 Relative Humidity: 20 %
 Pulser: Ludlum 500-1 sn 201932 Multimeter: n/a Instrument found within tolerance: ☒ Yes ☐ No

Range/Multiplier	Reference Setting	"As Found Reading"	Meter Reading	Integrated 1-Min. Count	Log Scale Count
x 1000	400	400	400	400176	400
x 1000	100	100	100		100
x 100	400	400	400	40020	400
x 100	100	100	100		100
x 10	400	400	400	4003	400
x 10	100	100	100		100
x 1	400	400	400	400	400
x 1	100	100	100		100

Count Time (min): 1.0

High Voltage	Source Counts	Background Counts	Net Counts
600	31799	2484	29315
650	45343	5141	40202
700	53544	7752	45792
750	56804	8512	48292
800	58443	9036	49407
850	59284	9223	50061
900	59755	9194	50561
950	60156	9415	50741
1000	60185	9485	50700
1050	60968	9683	51285
1100	63926	10483	53443
1150	88037	12858	75179

Voltage Plateau



Recommended HV (VDC) 1,000

Additional Comments:

Source 1 Cs-137 sn:4097-03 5.2μCi (1/4/12) button

Total Efficiency: n/a 4π Efficiency: n/a

Source 2

Total Efficiency: n/a 4π Efficiency: n/a

NOTE: The total efficiency provided is calculated per ISO-7503/NUREG 1575 (MARSSIM): Total Efficiency = Instrument Efficiency × Source Efficiency; where Instrument Efficiency is calculated as net counts ÷ source 2π emission rate. The 4π efficiency is calculated as net counts ÷ source 4π activity. The provided efficiencies are radionuclide specific and are calculated using source counts and background counts at the recommended operating HV. The provided efficiencies are for general information purposes only and are not intended to replace user efficiency calculation method or results.

Calibrated By: 

Calibration Date: 9/21/22 Calibration Due: 9/21/23

Reviewed By: 

Date: 9/22/22



Designer and Manufacturer
of
Scientific and Industrial
Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.

501 Oak Street
325-235-5494

Sweetwater, TX 79556, U.S.A.



CERT # 4084.01

Customer ENVIRONMENTAL RESTORATION GROUP

ORDER NO. 20415684/519368

Mfg. Ludlum Measurements, Inc. Model 3000

Serial No. 25017006

Mfg. Ludlum Measurements, Inc. Model 44-10

Serial No. PR295014

Cal. Date 26-Jan-22 Cal Due Date 26-Jan-23 Cal. Interval 1 Year Meterface 44-10 R

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. 73 °F RH 16 % Alt 712.9 mm Hg

☐ New Instrument ☐ Instrument Received ☐ Within Toler. +10% ☒ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments

☒ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity

☒ F/S Resp. ck. ☒ Reset ck. ☐ Window Operation ☐ Geotropism

☒ Audio ck. ☒ Alarm Setting ck. ☒ Batt. ck. (Min. Volt) 4.4 VDC

☒ Calibrated in accordance with LMI SOP 14.8 ☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 950 V Input Sens. 10 mV Det. Oper. 950 V at 10 mV Threshold Dial Ratio = mV

☒ HV Readout (2 points) Ref./Inst. 500 / 495 V Ref./Inst. 1500 / 1511 V

COMMENTS:

Deadtime: 6.5 µSec Overload checked but not set.

Calibration Constant: 531 e+8 Pulser calibration RATEMETER READOUT performed without deadtime.

Primary Units: R/hr Pulser calibration SCALER READOUT reflects 6 second count.

Primary Units Alarm: 5 mR/hr Calibrated using 5' C-cable.

Secondary Units: cpm

Secondary Units Alarm: 999 kcpm

Firmware: 5LC-N30.4382

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	5 mR/hr	4.15 mR/hr	4.50 mR/hr				
Digital	1 mR/hr	986 µR/hr	1.02				
	800 µR/hr	789	811 µR/hr				
	200 µR/hr	193	199				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading. Gamma uncertainty within 5.0% of reading. Neutron uncertainty within 7.0% of reading. Count rate uncertainty within 5.4% of reading

REFERENCE	INSTRUMENT	INSTRUMENT	REFERENCE	INSTRUMENT	INSTRUMENT
CAL. POINT	RECEIVED	METER READING	CAL. POINT	RECEIVED	METER READING
Digital Readout	800K cpm	799 kcpm	Scaler	800K cpm	79.9K
	200K cpm	199		200K cpm	19.9K
	80K cpm	79.9		80K cpm	7.99K
	20K cpm	19.9		20K cpm	2.00K
	8K cpm	7.99		8K cpm	799
	2K cpm	1.99		2K cpm	200
	800 cpm	800 cpm		800 cpm	80
	200 cpm	201		200 cpm	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.

All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors.

Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2.

The calibration system conforms to the requirements of ANSI/NCCL Z540-1-1994 and ANSI N323AB-2013

ISO/IEC 17025:2017(E)
State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☒ G112 ☒ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N ☐ Beta S/N ☒ Other Am241(0.66µCi)

☒ m 500 S/N 251106 ☐ Oscilloscope S/N ☒ Multimeter S/N 15060230

Calibrator James McBeth Title Calibrator Date 26JAN22

QC'd By [Signature] Title Final QC Date 26 JAN 22

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.

FORM C3000 01/22/2020

Page 1 of 2

AC Inst. ☐ Passed Dielectric (Hi-Pot) and Continuity Test
Only ☐ Failed:

Order #: 20415684/519368

Channel(s)

Customer: ENVIRONMENTAL RESTORATION
GROUP

Detector: 44-10

Serial No.: PR295014

Instrument: Model 3000

Serial No.: 25017006

BKG Time: 6

Distance: Surface

Selected HV: 950

Date: Wednesday, January 26, 2022

Notes:

Signature:

James M. Burt

Name

Threshold

Channel 1

10 mV

Source(s)

Name

ID

Activity

Time

Type

Am241

0.66 μ Ci

6

γ

High Voltage

Background

Am241

Reading

Reading

650

490

1,482

700

534

10,315

750

525

11,600

800

525

12,008

850

531

12,118

900

527

12,165

- 950

561

12,198

1000

590

12,116

1050

514

12,049

1100

529

12,197

1150

584

12,287

1200

656

12,682

1250

1,153

13,525

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25017006
1/26/2022 3:28:14 PM

Device

Device Firmware	5LC-N30.4382
Device Model	Model 3000
Device Serial Number	25017006
Device Real Time Clock Day	26
Device Real Time Clock Hour	15
Device Real Time Clock Minutes	27
Device Real Time Clock Month	1
Device Real Time Clock Seconds	56
Device Real Time Clock Year	2022
Device Real Time Clock Day of the Week	4
Device Backlight Threshold	1
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	0
Device Backlight Threshold Low Turn Off	120
Device Backlight Threshold High Turn On	0
Device Backlight Threshold High Turn Off	100
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	1
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	0
Device Button Handle RateMap 1	1
Device Button Handle RateMap 2	31
Device Button Handle RateMap 3	31
Device Button Handle CntMap 1	1
Device Button Handle CntMap 2	31
Device Button Handle CntMap 3	31
Device Battery Voltage	6.342
Device 1 Channel 1 RawCnt	4654586

Device Calibration

Device Calibration High Voltage Slope	41
Device Calibration High Voltage Offset	-58
Device Calibration Channel [1] Pulse Threshold Offset	-31

Detector 1

Detector [1] Serial Number	PR295014
Detector [1] Model	44-10
Detector [1] High Voltage	950
Detector [1] Overload	100
Detector [1] Count Time	60
Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	0
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit [1] Rate Unit Type	R/h
Detector [1] Unit [1] Rate Min Exponet	-6
Detector [1] Unit [1] Rate Max Value	0.007
Detector [1] Unit [1] Scaler Unit Type	R
Detector [1] Unit [1] Scaler Min Exponet	-6
Detector [1] Unit [1] Rate Alarm [1]	0
Detector [1] Unit [1] Rate Alarm [2]	0.005
Detector [1] Unit [1] Scaler Alarm [1]	0
Detector [1] Unit [1] Scaler Alarm [2]	0
Detector [1] Unit 1 Rate Unit Type	0
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	0
Detector [1] Unit 1 Rate Max Range	0
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	0
Detector [1] Unit 1 Rate Alarm Range	0
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	0
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	cpm
Detector [1] Unit [2] Rate Min Exponet	0
Detector [1] Unit [2] Rate Max Value	999000
Detector [1] Unit [2] Scaler Unit Type	counts
Detector [1] Unit [2] Scaler Min Exponet	0
Detector [1] Unit [2] Rate Alarm [1]	0
Detector [1] Unit [2] Rate Alarm [2]	999000
Detector [1] Unit [2] Scaler Alarm [1]	0
Detector [1] Unit [2] Scaler Alarm [2]	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	6.5
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	0
Detector [1] Channel [1] Calibration Constant	5.31E+10
Detector [1] Channel [1] Calibration Constant Exponent	0
Detector [1] Channel [1] Efficiency 4pi	15
Detector 1 Channel 1 CPSOffset	0

Customer **ENVIRONMENTAL RESTORATION GROUP**
 ORDER NO. **20421033/523055**

Mfg. **Ludlum Measurements, Inc.** Model **3000** Serial No. **25016973**
 Mfg. **Ludlum Measurements, Inc.** Model **44-10** Serial No. **PR150851**
 Cal. Date **16-Apr-22** Cal Due Date **16-Apr-23** Cal. Interval **1 Year** Meterface **44-10**

Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. **74** °F RH **33** % Alt **701.0** mm Hg
☐ New Instrument ☐ Instrument Received ☐ Within Toler. ☒ **+10%** ☐ **10-20%** ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments
☒ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity
☒ F/S Resp. ck. ☒ Reset ck. ☐ Window Operation ☐ Geotropism
☒ Audio ck. ☒ Alarm Setting ck. ☒ Batt. ck. (Min. Volt) **4.4** VDC
☒ Calibrated in accordance with LMI SOP 14.8 ☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set **1100** V Input Sens. **10** mV Det. Oper. **1100** V at **10** mV Threshold **14.9** mV
☒ HV Readout (2 points) Ref./Inst. **500** / **497** V Ref./Inst. **1500** / **1505** V

COMMENTS:

Deadtime: 9.8 µSec
 Cal Constant: 503e+8
 Primary Units Alarm: 00.00 mR/hr
 Secondary Units Alert: 00.00 kcpm
 Firmware: 5LC-N42.4885

Calibrated using 5' C-cable.
 Overload checked but not set.
 Pulser calibration "RATEMETER READOUT" performed without deadtime.
 Pulser calibration "SCALER READOUT" reflects 6 second count.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	5 mR/hr	4.38 mR/hr	5.16 mR/hr				
Digital	1 mR/hr	961 µR/hr	1.03 mR/hr				
	800 µR/hr	773	823 µR/hr				
	200 µR/hr	196	202 µR/hr				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading

REFERENCE	INSTRUMENT	INSTRUMENT	REFERENCE	INSTRUMENT	INSTRUMENT
CAL. POINT	RECEIVED	METER READING	CAL. POINT	RECEIVED	METER READING
Digital Readout	800K cpm	797 kc/m	797 kc/m	800K cpm	797 k
	200K cpm	198	198	200K cpm	199 k
	80K cpm	79.7	79.7	80K cpm	79.7 k
	20K cpm	19.9	19.9	20K cpm	1.99 k
	8K cpm	7.98	7.98	8K cpm	798
	2K cpm	1.99	1.99	2K cpm	199
	800 cpm	800 c/m	800 c/m	800 cpm	80
	200 cpm	200 c/m	200 c/m	200 cpm	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors. Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2. ISO/IEC 17025:2017(E) State of Texas Calibration License No. LO-1963 The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☒ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☐ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N ☐ Beta S/N ☐ Other ☐
☒ m 500 S/N **247891** ☐ Oscilloscope S/N ☒ Multimeter S/N **17500076**

Calibrator **Scot VanAllen** Title **Calibrator** Date **16 APR 22**
 QC'd By **Jeremy Thompson** Title **Final QC** Date **17 APR 23**

Order #: 20421033/523055

Customer: Environmental Restoration Group

Detector: 44-10

Serial No.: PR150851

Instrument: Model 3000

Serial No.: 25016973

BKG Time: 6

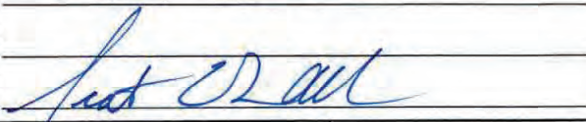
Distance: Surface

Selected HV: 1100

Date: Saturday, April 16, 2022

Notes:

Signature:



Channel(s)

Name

Threshold

Channel 1

10 mV

Source(s)

Name

ID

Activity

Time

Type

Am241

n/a

0.79 μ Ci

6

γ

High Voltage

Background

Am241: n/a

Reading

Reading

500

63

101

550

132

199

600

245

409

650

328

664

700

421

1,419

750

432

9,564

800

421

10,524

850

474

11,247

900

470

11,421

950

407

11,475

1000

463

11,626

1050

432

11,681

1100

421

11,828

1150

426

11,764

1200

468

11,714

1250

558

11,770

1300

846

12,431

1350

1,546

14,264

Dev

Mdl	Model 3000
SN	25016973
Aud Lvl	Single
Conv R To Sv	0.0106
Fw	5LC- N42.4885
LB	0
Rate Reset Btn	Off
Setup Prtct	Normal
Sleep	0
Temp	49
V Bat	6.33

AuxCom

Crypto En	Off
Enable	On
Mode	LMI Direct
Write Prtct	Off

AutoMode

Interval	1
----------	---

Pwr

Auto Off Tm	0
Mode	On At Boot

BklThr

Sensitivity	Low
-------------	-----

High

Light Turn Off	100
Light Turn On	0

Low

Light Turn Off	120
Light Turn On	0

Cnt

Audio Mode	Off
Display Mode	Timer

Ext 1

Act Det Mem	0
----------------	---

Ch 1

Cal Raw Cnt	16450
Raw Cnt	10916632

Meas

Cur	25.7992
-----	---------

RTC

Day	16
-----	----

Hr	8
Mins	42
Mo	4
Sec	9
Yr	2022

DetMem 1

Mdl	44-10
SN	PR150851
Aud Sigma	Off
Count Tm	60
HV	1100
Op Mode	Rate/Max/ Count
Over Cur	100

Ch 1

CPS Offset	0
DTC 1	9.8E-06
DTC 2	0
Eff	15
LO Cnt Tm	60
R Cal Const	5.03E+10
Thr	0.01

Response

Rate	Slow
Time	3

Unit 1**Count**

Alrm 1	0
Alrm 2	0
Min Exp	000E-6
Unit	R

Rate

Alrm 1	0
Alrm 2	0
Max Val	999000
Min Exp	000E0
Unit	cpm

Unit 2**Count**

Alrm 1	0
Alrm 2	0
Min Exp	000E0
Unit	counts

Rate

Alrm 1	0
Alrm 2	0
Max Val	999
Min Exp	000E-6
Unit	R/h

LOG

ENABLE	0
MODE	1
NOTES	
USER	

AUTO

TM	60
----	----

NUM

MAX	1000
REC	0

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.

501 Oak Street
325-235-5494

Sweetwater, TX 79556, U.S.A.



CERT # 4084.01

Customer ENVIRONMENTAL RESTORATION GROUP

ORDER NO. 20425713/526297

Mfg. Ludlum Measurements, Inc. Model 3000

Serial No. 25018543

Mfg. Ludlum Measurements, Inc. Model 44-10

Serial No. *PR 355810*

Cal. Date	28-Jun-22	Cal Due Date	28-Jun-23	Cal. Interval	1 Year	Meterface	44-10 R
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Check mark ☒ applies to applicable instr. and/or detector IAW mfg. spec. T. 71 °F RH 23 % Alt 703.8 mm Hg

☒ New Instrument Instrument Received ☒ Within Toler. $\pm 10\%$ ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☐ Other-See comments☒ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity☒ F/S Resp. ck ☒ Reset ck. ☐ Window Operation ☐ Geotropism

☒ Audio ck. ☒ Alarm Setting ck. ☒ Batt. ck. (Min. Volt) 4.4 VDC

☒ Calibrated in accordance with LMI SOP 14.8 ☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set	900	V Input Sens.	28	mV Det. Oper.	900	V at	28	mV Threshold Dial Ratio	=	mV
---------------------	-----	---------------	----	---------------	-----	------	----	-------------------------	---	----

✓ HV Readout (2 points)	Ref./Inst.	500	1	503	V	Ref./Inst.	1500	1	1498	V
-------------------------	------------	-----	---	-----	---	------------	------	---	------	---

COMMENTS:

Deadtime: 10μsec Calibrated using 5' C Cable

Cal Constant: 514 e+08 Alarms disabled

Primary Units: R/hr

Overload checked but not set

Secondary Units: CPM

Pulser Calibration RATEMETER READOUT performed without deadtime

Firmware: 4382N30

Pulser Calibration SCALER READOUT reflects 6 second count

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	4mR/hr	3.92 mR/hr	3.84 mR/hr				
Digital	1mR/hr	1.02	1.09				
Digital	800µr/hr	811 µr/hr	820 µr/hr				
Digital	200µr/hr	201	262				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading

Multimeter uncertainty within 1.3% of reading. Gamma uncertainty within 5.0% of reading. Neutron uncertainty within 7.0% of reading. Count rate uncertainty within 0.4% of reading.							
Digital Readout	REFERENCE	INSTRUMENT	INSTRUMENT	Scaler	REFERENCE	INSTRUMENT	INSTRUMENT
	CAL. POINT	RECEIVED	METER READING		CAL. POINT	RECEIVED	METER READING
	800K cpm	803 Kcpm	803 Kcpm		800K cpm	804 Kcpm	804 Kcpm
	200K cpm	200	200		200K cpm	200	200
	80K cpm	80.2	80.2		80K cpm	80.4	80.4
	20K cpm	20.0	20.0		20K cpm	20.0	20.0
	8K cpm	8.04	8.04		8K cpm	8.04	8.04
	2K cpm	1.99	1.99		2K cpm	2.00	2.00
	800 cpm	817 Cpm	817 Cpm		800 cpm	805 Cpm	805 Cpm
	200 cpm	216	216		200 cpm	201	201

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors. Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013.

ISO/IEC 17025:2017(E)

State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☒ G112 ☐ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 ☐ Neutron Am-241 Be ☐ T-304 ☐ Ra-226 ☐ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N _____ ☐ Beta S/N _____ ☒ Other Am 241 - (0.81 Nci)

☒ m 500 S/N 57883 ☐ Oscilloscope S/N ☒ Multimeter S/N 55140005

Calibrator Christopher Galindo *Christopher Galindo* Title Calibrator/ Technician Date 28 Jun 22

QC'd By Reha 11 Title Final QC Date 28 Jun 22

Order #: 20425713/526297

Customer: ENVIRONMENTAL RESTORATION
GROUP

Detector: 44-10 Serial No.: PR355810

Instrument: Model 3000 Serial No.: 25018543

BKG Count 6 seconds
Time:

Distance: SURFACE

Date: Tuesday, June 28, 2022

Notes:

Signature:

Christopher Garindo

Channel(s)

Name

Threshold

Channel: 1

10 mV

Source(s)

Name

ID

Activity

Count Time (Sec.)

Am241

E504

0.81 μ Ci

6

High Voltage	Background	Am241 (0.81 μ Ci)
700	380	11254
750	429	12795
800	437	13305
850	442	13212
900	441	13239
950	409	13284
1000	438	13347
1050	487	13577
1100	599	14159

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25018543
6/28/2022 10:55:31 AM

Device

Device Firmware	5LC-N30.4382
Device Model	Model 3000
Device Serial Number	25018543
Device Real Time Clock Day	28
Device Real Time Clock Hour	8
Device Real Time Clock Minutes	19
Device Real Time Clock Month	6
Device Real Time Clock Seconds	5
Device Real Time Clock Year	2022
Device Real Time Clock Day of the Week	6
Device Backlight Threshold	2
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	0
Device Backlight Threshold Low Turn Off	0
Device Backlight Threshold High Turn On	0
Device Backlight Threshold High Turn Off	0
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	1
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	1
Device Button Handle RateMap 1	1
Device Button Handle RateMap 2	31
Device Button Handle RateMap 3	31
Device Button Handle CntMap 1	1
Device Button Handle CntMap 2	31
Device Button Handle CntMap 3	31
Device Battery Voltage	6.23
Device 1 Channel 1 RawCnt	22536

Device Calibration

Device Calibration High Voltage Slope	45
Device Calibration High Voltage Offset	-57
Device Calibration Channel [1] Pulse Threshold Offset	6

Detector 1

Detector [1] Serial Number	PR355810
Detector [1] Model	44-10
Detector [1] High Voltage	900
Detector [1] Overload	100
Detector [1] Count Time	6
Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	0
Detector [1] Response Time	4
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit [1] Rate Unit Type	cpm
Detector [1] Unit [1] Rate Min Exponet	-2
Detector [1] Unit [1] Rate Max Value	999000
Detector [1] Unit [1] Scaler Unit Type	R
Detector [1] Unit [1] Scaler Min Exponet	-2
Detector [1] Unit [1] Rate Alarm [1]	0
Detector [1] Unit [1] Rate Alarm [2]	0
Detector [1] Unit [1] Scaler Alarm [1]	0
Detector [1] Unit [1] Scaler Alarm [2]	0
Detector [1] Unit 1 Rate Unit Type	0
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	0
Detector [1] Unit 1 Rate Max Range	0
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	0
Detector [1] Unit 1 Rate Alarm Range	0
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	0
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	R/h
Detector [1] Unit [2] Rate Min Exponet	-8
Detector [1] Unit [2] Rate Max Value	999
Detector [1] Unit [2] Scaler Unit Type	counts
Detector [1] Unit [2] Scaler Min Exponet	-6
Detector [1] Unit [2] Rate Alarm [1]	0
Detector [1] Unit [2] Rate Alarm [2]	0
Detector [1] Unit [2] Scaler Alarm [1]	0
Detector [1] Unit [2] Scaler Alarm [2]	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	10
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	60
Detector [1] Channel [1] Calibration Constant	5.14E+10
Detector [1] Channel [1] Calibration Constant Exponent	0
Detector [1] Channel [1] Efficiency 4pi	15
Detector 1 Channel 1 CPSOffset	0

	Model Number	Serial Number
Detector	44-10	PR355810
Instrument	Model 3000	25018543

	Field	Count Rate
Low	200 μ R/hr	16368 counts in 6 seconds
High	4 mR/hr	209695 counts in 6 seconds

	Constant
Calibration Constant	514e08 C/R
Dead Time Constant	10 μ Sec.
Dead Time Second Order Constant	000e00



Designer and Manufacturer
of
Scientific and Industrial
Instruments

CERTIFICATE OF CALIBRATION

LUDLUM MEASUREMENTS, INC.

501 Oak Street
325-235-5494

Sweetwater, TX 79556, U.S.A.

Customer ENVIRONMENTAL RESTORATION GROUP

ORDER NO. 20421956/523693

Mfg. Ludlum Measurements, Inc. Model 3000

Serial No. 25020102

Mfg. Ludlum Measurements, Inc. Model 44-10

Serial No. PR406319

Cal. Date 25-Apr-22 Cal Due Date 25-Apr-23 Cal. Interval 1 Year Meterface 44-10 Ra

Check mark ☒ Applies to applicable instr. and/or detector IAW mfg. spec. T. 74 °F RH 40 % Alt 707.6 mm Hg

☐ New Instrument ☐ Instrument Received ☒ Within Toler. +/-10% ☐ 10-20% ☐ Out of Tol. ☐ Requiring Repair ☒ Other-See comments

☒ Mechanical ck. ☐ Meter Zeroed ☐ Background Subtract ☐ Input Sens. Linearity

☒ F/S Resp. ck. ☒ Reset ck. ☐ Window Operation ☐ Geotropism

☒ Audio ck. ☒ Alarm Setting ck. ☒ Batt. ck. (Min. Volt) 4.4 VDC

☒ Calibrated in accordance with LMI SOP 14.8 ☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set 750 V Input Sens. 10 mV Det. Oper. 750 V at 10 mV Threshold Dial Ratio = mV

☒ HV Readout (2 points) Ref./Inst. 500 / 498 V Ref./Inst. 1500 / 1524 V

COMMENTS:
Deadtime: 8.1 µSec Unable to take as found readings with 44-10 due to first time calibration to 3000.
Calibration Constant: 570 e+8 Calibrated using 5' C-cable.
Primary Units: cpm Overload checked but not set.
Secondary Units: R/hr Pulser calibration performed without deadtime.
Firmware: 5LC-N30.4382 Pulser calibration SCALER READOUT reflects 6 second count.
Alarms disabled.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	4 mR/hr	N/A	3.99 mR/hr				
Digital	2 mR/hr		1.99				
	1 mR/hr		1.01				
	500 µR/hr		502 µR/hr				
	200 µR/hr		194				
	100 µR/hr		94				

Range(s) Calibrated Electronically

Multimeter uncertainty within 1.3% of reading, Gamma uncertainty within 5.0% of reading, Neutron uncertainty within 7.0% of reading, Count rate uncertainty within 5.4% of reading							
Digital Readout	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING	Scaler	REFERENCE CAL. POINT	INSTRUMENT RECEIVED	INSTRUMENT METER READING
	800K cpm	800 kcpm	800 kcpm		800K cpm	80.0K	80.0K
	200K cpm	200	200		200K cpm	20.0K	20.0K
	80K cpm	80.0	80.0		80K cpm	8.00K	8.00K
	20K cpm	20.0	20.0		20K cpm	2.00K	2.00K
	8K cpm	8.00	8.00		8K cpm	801	801
	2K cpm	2.00	2.00		2K cpm	200	200
	800 cpm	799 cpm	799 cpm		800 cpm	80	80
	200 cpm	201	201		200 cpm	20	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques.
All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors.
Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2.
The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013

State of Texas Calibration License No. LO-1983

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521
☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☒ Y982
☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N ☐ Beta S/N ☒ Other Am241(0.66µCi)
☒ m 500 S/N 251106 ☐ Oscilloscope S/N ☒ Multimeter S/N 15060230

Calibrator James McBeth James McBeth Title Calibrator Date 25 APR 22
QC'd By Rick H Title Final QC Date 25 Apr 22

This certificate shall not be reproduced except in full, without the written approval of Ludlum Measurements, Inc.

FORM C3000 01/22/2020

Page 1 of 2

AC Inst. ☐ Passed Dielectric (Hi-Pot) and Continuity Test
Only ☐ Failed:

Order #: 20421956/523693

Customer: ENVIRONMENTAL RESTORATION
GROUP

Detector: 44-10

Serial No.: PR406319

Instrument: Model 3000

Serial No.: 25020102

BKG Time: 6

Distance: Surface

Selected HV: 750

Date: Monday, April 25, 2022

Notes: Performed using 5' cable.

Signature: *James M. B. A.*

Channel(s)

Name

Threshold

Channel 1

10 mV

Source(s)

Name

ID

Activity

Time

Type

Am241

0.66 μ Ci

6

γ

High Voltage

Background

Am241

Reading

Reading

550

413

3,284

600

399

10,836

650

408

12,218

700

424

12,231

-750

394

12,247

800

429

12,350

850

433

12,290

900

439

12,342

950

628

12,900

1000

1,433

13,859

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25020102
4/25/2022 7:43:22 AM

Device

Device Firmware	5LC-N30.4382
Device Model	Model 3000
Device Serial Number	25020102
Device Real Time Clock Day	25
Device Real Time Clock Hour	7
Device Real Time Clock Minutes	43
Device Real Time Clock Month	4
Device Real Time Clock Seconds	13
Device Real Time Clock Year	2022
Device Real Time Clock Day of the Week	6
Device Backlight Threshold	2
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	40
Device Backlight Threshold Low Turn Off	120
Device Backlight Threshold High Turn On	17
Device Backlight Threshold High Turn Off	100
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	0
Device Auxiliary Auto Power Down	1
Device Auxiliary Write Protect	1
Device Auxiliary Encryption Enabled	1
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	0
Device Button Handle RateMap 1	1
Device Button Handle RateMap 2	31
Device Button Handle RateMap 3	31
Device Button Handle CntMap 1	1
Device Button Handle CntMap 2	31
Device Button Handle CntMap 3	31
Device Battery Voltage	6.422
Device 1 Channel 1 RawCnt	1325430

Device Calibration

Device Calibration High Voltage Slope	56
Device Calibration High Voltage Offset	-67
Device Calibration Channel [1] Pulse Threshold Offset	4

Detector 1

Detector [1] Serial Number	PR406319
Detector [1] Model	44-10
Detector [1] High Voltage	750
Detector [1] Overload	100
Detector [1] Count Time	60
Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	1
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit [1] Rate Unit Type	cpm
Detector [1] Unit [1] Rate Min Exponet	0
Detector [1] Unit [1] Rate Max Value	999000
Detector [1] Unit [1] Scaler Unit Type	counts
Detector [1] Unit [1] Scaler Min Exponet	0
Detector [1] Unit [1] Rate Alarm [1]	0
Detector [1] Unit [1] Rate Alarm [2]	0
Detector [1] Unit [1] Scaler Alarm [1]	0
Detector [1] Unit [1] Scaler Alarm [2]	0
Detector [1] Unit 1 Rate Unit Type	0
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	0
Detector [1] Unit 1 Rate Max Range	0
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	0
Detector [1] Unit 1 Rate Alarm Range	0
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	0
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	R/h
Detector [1] Unit [2] Rate Min Exponet	-6
Detector [1] Unit [2] Rate Max Value	0.007
Detector [1] Unit [2] Scaler Unit Type	R
Detector [1] Unit [2] Scaler Min Exponet	-6
Detector [1] Unit [2] Rate Alarm [1]	0
Detector [1] Unit [2] Rate Alarm [2]	0
Detector [1] Unit [2] Scaler Alarm [1]	0
Detector [1] Unit [2] Scaler Alarm [2]	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	8.1
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	60
Detector [1] Channel [1] Calibration Constant	5.7E+10
Detector [1] Channel [1] Calibration Constant Exponent	0
Detector [1] Channel [1] Efficiency 4pi	15
Detector 1 Channel 1 CPSOffset	0

Customer

ENVIRONMENTAL RESTORATION GROUP

ORDER NO.

20421242/523218

Mfg.

Ludlum Measurements, Inc.

Model

3000

Serial No.

25018610

Mfg.

Ludlum Measurements, Inc.

Model

44-10

Serial No.

PR355771

Cal. Date

14-Apr-22

Cal Due Date

14-Apr-23

Cal. Interval

1 Year

Meterface

44-10 Ra

Check mark

☒ applies to applicable instr. and/or detector IAW mfg. spec.

T.

74

°F

RH

23

%

Alt

707.9

mm Hg

☐ New Instrument

☐ Instrument Received

☐ Within Toler. +-10%

☒ 10-20%

☐ Out of Tol.

☐ Requiring Repair

☐ Other-See comments

☒ Mechanical ck.

☐ Meter Zeroed

☐ Background Subtract

☐ Input Sens. Linearity

☒ F/S Resp. ck

☒ Reset ck.

☐ Window Operation

☐ Geotropism

☒ Audio ck.

☒ Alarm Setting ck.

☒ Batt. ck. (Min. Volt)

4.4

VDC

☒ Calibrated in accordance with LMI SOP 14.8

☒ Calibrated in accordance with LMI SOP 14.9

Instrument Volt Set

850

V

Input Sens.

10

mV

Det. Oper.

850

V

at

10

mV

Threshold

Dial Ratio

=

mV

☒ HV Readout (2 points)

Ref./Inst.

500

/

496

V

Ref./Inst.

1500

/

1506

V

COMMENTS:

Deadtime: 9.1 µSec

Calibrated using 5' C-cable.

Calibration Constant: 584 e+8

Overload checked but not set.

Primary Units: cpm

Alarms disabled.

Secondary Units: R/hr

Pulser calibration performed without deadtime.

Firmware: 5LC-N30.4382

Pulser calibration SCALER READOUT reflects 6 second count.

Gamma Calibration: GM detectors positioned perpendicular to source except for M 44-9 in which the front of probe faces source.

RANGE	REFERENCE	INSTRUMENT	INSTRUMENT	RANGE	REFERENCE	INSTRUMENT	INSTRUMENT
MULTIPLIER	CAL. POINT	RECEIVED	METER READING	MULTIPLIER	CAL. POINT	RECEIVED	METER READING
Digital	4 mR/hr	4.52 mR/hr	4.00 mR/hr				
Digital	2 mR/hr	2.28	2.07				
	1 mR/hr	1.12	1.02				
	500 µR/hr	542 µR/hr	498 µR/hr				
	200 µR/hr	206	191				
	100 µR/hr	101	94				

Range(s) Calibrated Electronically

REFERENCE	INSTRUMENT	INSTRUMENT	REFERENCE	INSTRUMENT	INSTRUMENT
CAL. POINT	RECEIVED	METER READING	CAL. POINT	RECEIVED	METER READING
Digital Readout	800K cpm	800K cpm	Scaler	800K cpm	80.0K
	200K cpm	200		200K cpm	20.0K
	80K cpm	80.0		80K cpm	8.00K
	20K cpm	20.0		20K cpm	2.00K
	8K cpm	8.00		8K cpm	800
	2K cpm	1.99		2K cpm	200
	800 cpm	799 cpm		800 cpm	80
	200 cpm	201		200 cpm	20

Ludlum Measurements, Inc. certifies that the above instrument has been calibrated by standards traceable to the National Institute of Standards and Technology, or to the calibration facilities of other International Standards Organization members, or have been derived from accepted values of natural physical constants or have been derived by the ratio type of calibration techniques. All pass/fail determinations are based on the manufacturer's specifications without considering uncertainty factors. Measurement results represent expanded uncertainties expressed at approximately the 95% level of confidence, using a coverage factor of k=2. The calibration system conforms to the requirements of ANSI/NCSL Z540-1-1994 and ANSI N323AB-2013.

ISO/IEC 17025:2017(E)
State of Texas Calibration License No. LO-1963

Reference Instruments and/or Sources: Cs-137 S/N: ☐ 059 ☐ 2171CP ☐ 2261CP ☐ 720 ☐ 734 ☐ 781 ☐ 1131 ☐ 1616 ☐ 1696 ☐ 1909 ☐ 1916CP ☐ 2324/2521

☐ 5717CO ☐ 5719CO ☐ 60646 ☐ 70897 ☐ 73410 ☐ E552 ☐ G112 ☐ 2168CP ☐ S-394 ☐ S-1054 ☐ T10081 ☐ T10082 Neutron Am-241 Be ☐ T-304 Ra-226 ☒ Y982

☐ E551 ☐ 5105 ☐ CSV280

☐ Alpha S/N

☐ Beta S/N

☒ Other

Am241(0.66µCi)

☒ m 500 S/N

251106

☐ Oscilloscope S/N

☒ Multimeter S/N

15060230

Calibrator

James McBeth

Title

Calibrator

Date

14 APR 22

QC'd By

Jeremy Thompson

Title

Final QC

Date

14-Apr-22

Order #: 20421242/523218

Channel(s)

Customer: ENVIRONMENTAL RESTORATION
GROUP

Detector: 44-10

Serial No.: PR355771

Instrument: Model 3000

Serial No.: 25018610

BKG Time: 6

Distance: Surface

Selected HV: 850

Date: Thursday, April 14, 2022

Notes: Performed using 5' cable.

Signature: *James M. B. P.*

Name

Threshold

Channel 1

10 mV

Source(s)

Name

ID

Activity

Time

Type

Am241

0.66 μ Ci

6

γ

High Voltage	Background	Am241
	Reading	Reading
650	501	9,755
700	539	11,227
750	533	12,151
800	537	12,041
- 850	557	12,089
900	560	12,239
950	596	12,060
1000	650	12,098
1050	807	12,641
1100	1,561	13,894

Ludlum Device Parameters

Product: Model 3000
Serial Number: 25018610
4/14/2022 10:27:33 AM

Device

Device Firmware	5LC-N30.4382
Device Model	Model 3000
Device Serial Number	25018610
Device Real Time Clock Day	14
Device Real Time Clock Hour	10
Device Real Time Clock Minutes	27
Device Real Time Clock Month	4
Device Real Time Clock Seconds	24
Device Real Time Clock Year	2022
Device Real Time Clock Day of the Week	1
Device Backlight Threshold	2
Device Sleep	0
Device Dual Level Audio Setting	0
Device R to Sv Ratio	0.0106
Device Log Button	0
Device Backlight Threshold Low Turn On	0
Device Backlight Threshold Low Turn Off	0
Device Backlight Threshold High Turn On	0
Device Backlight Threshold High Turn Off	0
Device Backlight On	0
Device Count Display Mode	0
Device Count Audio Mode	0
Device Rate Reset Button	0
Device Setup Protect	Normal
Device Auxiliary Enabled	1
Device Auxiliary Mode	1
Device Auxiliary Auto Power Down	0
Device Auxiliary Write Protect	0
Device Auxiliary Encryption Enabled	0
Device Area Monitor enabled	0
Device Auxiliary Enabled	0
Device Auxiliary 375-Ethernet-Mode Port	0
Device Auxiliary AutoMode Interval	1
Device Button Handle RateMap 1	1
Device Button Handle RateMap 2	31
Device Button Handle RateMap 3	31
Device Button Handle CntMap 1	1
Device Button Handle CntMap 2	31
Device Button Handle CntMap 3	31
Device Battery Voltage	6.382
Device 1 Channel 1 RawCnt	2962040

Device Calibration

Device Calibration High Voltage Slope	35
Device Calibration High Voltage Offset	-55
Device Calibration Channel [1] Pulse Threshold Offset	-1

Detector 1

Detector [1] Serial Number	PR355771
Detector [1] Model	44-10
Detector [1] High Voltage	850
Detector [1] Overload	100
Detector [1] Count Time	60
Detector [1] Operation Mode	0
Detector [1] Auto Response Rate	1
Detector [1] Response Time	0
Detector [1] Audio Sigma	0
Detector [1] Enabled	0
Detector [1] Unit [1] Rate Unit Type	cpm
Detector [1] Unit [1] Rate Min Exponet	0
Detector [1] Unit [1] Rate Max Value	999000
Detector [1] Unit [1] Scaler Unit Type	counts
Detector [1] Unit [1] Scaler Min Exponet	0
Detector [1] Unit [1] Rate Alarm [1]	0
Detector [1] Unit [1] Rate Alarm [2]	0
Detector [1] Unit [1] Scaler Alarm [1]	999000
Detector [1] Unit [1] Scaler Alarm [2]	999000
Detector [1] Unit 1 Rate Unit Type	0
Detector [1] Unit 1 Rate Min Range	0
Detector [1] Unit 1 Rate Min Decimal Point	0
Detector [1] Unit 1 Rate Max Value	0
Detector [1] Unit 1 Rate Max Range	0
Detector [1] Unit 1 Rate Max Decimal Point	0
Detector [1] Unit 1 Rate Alarm Value	0
Detector [1] Unit 1 Rate Alarm Range	0
Detector [1] Unit 1 Rate Alarm Decimal Point	0
Detector [1] Unit 1 Scaler Unit Type	0
Detector [1] Unit 1 Scaler Min Range	0
Detector [1] Unit 1 Scaler Min Decimal Point	0
Detector [1] Unit 1 Scaler Alarm Value	0
Detector [1] Unit 1 Scaler Alarm Range	0
Detector [1] Unit 1 Scaler Alarm Decimal Point	0
Detector [1] Unit [2] Rate Unit Type	R/h
Detector [1] Unit [2] Rate Min Exponet	-6
Detector [1] Unit [2] Rate Max Value	999
Detector [1] Unit [2] Scaler Unit Type	R
Detector [1] Unit [2] Scaler Min Exponet	-6
Detector [1] Unit [2] Rate Alarm [1]	0
Detector [1] Unit [2] Rate Alarm [2]	0
Detector [1] Unit [2] Scaler Alarm [1]	0
Detector [1] Unit [2] Scaler Alarm [2]	0
Detector [1] Channel [1] Pulse Threshold	10
Detector [1] Channel [1] Dead Time Correction	9.1
Detector [1] Channel [1] Dead Time Correction 2	0
Detector [1] Channel [1] Loss of Count Time	60
Detector [1] Channel [1] Calibration Constant	5.84E+10
Detector [1] Channel [1] Calibration Constant Exponent	0
Detector [1] Channel [1] Efficiency 4pi	15
Detector 1 Channel 1 CPSOffset	0



Environmental Restoration Group, Inc.
8809 Washington NE, Suite #150
Albuquerque, NM 87113

office: (505) 298-4224
fax: (505) 797-1404
web: www.ERGOffice.com

Company Name: Tetra Tech

Order Number: 5233

Contact Name:

P.O. or Reference Number: 1144750 25

Contact Telephone:

Date Ordered: 11/3/2022

Shipping Method: n/a

Date Shipped: 11/10/2022

Shipping Number: ERG FedEx Number

Date of Delivery: 11/10/2022

Ship To Information:

Billing Address:

Tetra Tech

Tetra Tech - Oakland
Accounts Payable
1999 Harrison St.
Ste 500
Oakland, CA 94612

Equipment Enclosed:

Instrument

Serial Number

Tested

MSA Escort ELF Lapel Air Sampler

A2-32572



GE Energy HPIC

1001321



Special Instructions:

None

Note:

(a) By accepting and using ERG rental equipment, the Renter indemnifies and holds harmless ERG against any and all claims, actions, proceedings, costs, expenses, damages, and liabilities (including attorney's fees and costs) arising out of Renter's use of equipment.



K&S Associates, Inc.
1926 Elm Tree Drive Nashville, Tennessee 37210-3718
Voice: 615-883-9760 (800-522-2325) Fax: 615-871-0856 kslab.com

Attached are stickers for instruments

April 26, 2022	Reuter-Stokes Chamber Calibration				Test Number	M220839
Mfor: Reuter-Stokes	BEAM				DOSE RATE	CALIBRATION COEFF.
Mod: RS-S131-200-ER00	Cs-137	(11mCi)	0.22mR/h	Nx =	1.00	mR/h/rdg
Ser: 1001321	Cs-137	(11mCi)	0.08mR/h	Nx =	1.01	mR/h/rdg
AION: NA	Cs-137	(1mCi)	0.012mR/h	Nx =	1.00	mR/h/rdg
Serial number away	Cs-137	(1mCi)	0.015mR/h	Nx =	1.00	mR/h/rdg
from source	Cs-137	(20 Ci)	50mR/h	Nx =	1.01	mR/h/rdg
"True" background	Cs-137	(20 Ci)	80mR/h	Nx =	1.01	mR/h/rdg
exposure rate of 6.7						
Batt: 8.02 V; K&S	Bias:	401.3V	ERG			
Environment: Temp: 23						



K&S Associates, Inc.
1925 Elm Tree Drive
Nashville, TN 37211-2718
800-523-2325 Fax 615-875-1856



ACCREDITED COSMETOLOGY CALIBRATION LABORATORY

CALIBRATION REPORT

SUBMITTED BY: ERG
855 Washington Street Northeast
Suite 151
Albuquerque, NM 87102

INSTRUMENT: Feather Dermal PS-100-ZUL-270000 #100122

REPORT NUMBER: 21878

FEEDBACK DATE: April 14, 2022

TEST NUMBERS: 1020202

REPORT ISSUE DATE: May 12, 2022

Inventory Statement

The instrument received for calibration was a Feather Dermal PS-100-ZUL-270000 #100122, which is a cosmetic calibration instrument. The instrument was received at the time of the calibration and was used for the calibration.

Traceability Statement

1.1 The instrument was calibrated using a Feather Dermal PS-100-ZUL-270000 #100122, which is a cosmetic calibration instrument. The instrument was calibrated using a Feather Dermal PS-100-ZUL-270000 #100122, which is a cosmetic calibration instrument.

1.2 The instrument was calibrated using a Feather Dermal PS-100-ZUL-270000 #100122, which is a cosmetic calibration instrument. The instrument was calibrated using a Feather Dermal PS-100-ZUL-270000 #100122, which is a cosmetic calibration instrument.

The calibration results were used to determine the accuracy of the instrument. The instrument was calibrated using a Feather Dermal PS-100-ZUL-270000 #100122, which is a cosmetic calibration instrument.

A calibration certificate was generated for the instrument. The instrument was calibrated using a Feather Dermal PS-100-ZUL-270000 #100122, which is a cosmetic calibration instrument.

Conformance Statement and Section Rule

When a calibration certificate is generated, it is a statement of the accuracy of the instrument. The instrument was calibrated using a Feather Dermal PS-100-ZUL-270000 #100122, which is a cosmetic calibration instrument. The instrument was calibrated using a Feather Dermal PS-100-ZUL-270000 #100122, which is a cosmetic calibration instrument.



K&S Associates, Inc
Nashville, Tennessee 37210-3718



CALIBRATION CERTIFICATE

Calibration Date: 4/26/2022 Report Number: 221918 Test Number: M220839

K&S certifies that the environmental radiation monitor identified below has been calibrated for radiation measurement using collimated radiation sources whose output has been calibrated with instruments calibrated by or directly traceable to the National Institute of Standards and Technology. K&S is accredited by the American Association for Laboratory Accreditation to perform environmental level calibrations and further certifies that the calibration was performed using accredited policies and procedures (SI 25) that meet or exceed the requirements of ISO/IEC 17025:2017.

Sensor Type: 100 R/h

Serial Number: 1001321

Average Calibration Coefficient for the range of 0.012 mR/h – 0.22 mR/h*:

1.00 mR/"mR" reading
(Measured at 4 points)

Calibration Coefficient for the 50.0 mR/h point*:

1.01 mR/"mR" reading

Calibration Coefficient for the 80.0 mR/h point*:

1.01 mR/"mR" reading

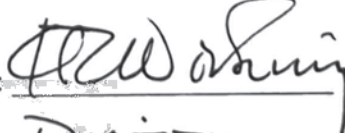
Found Sensitivity: -2.206e-8

*Multiply the reading in **mR/h** by the Calibration Coefficient to obtain true **mR/h**.

Calibrated By:


Jeremy Gossman
Title: **Calibration Technician**

Reviewed By:


Title: **DIRECTOR**

Log: M87



K&S Associates, Inc
Nashville, Tennessee 37210-3718



AS FOUND DATA
Reuter-Stokes Chamber Calibration

April 26, 2022

Test Number M220839

CHAMBER:

Mfgr: Reuter Stokes
Model: RS-S131-200-ER0000
Serial: 1001321

SUBMITTED BY:

ERG

Albuquerque, NM

ORIENTATION/CONDITIONS:

ATMOSPHERIC COMMUNICATION: SEALED

Serial number away from source

"True" background exposure rate of 6.7 uR/h, instrument reading was 7.23 uR/h

The calibration result(s) stated herein are valid under the conditions and parameters specified in this report.

POLARIZING POTENTIAL: 401.3V

LEAKAGE: Negligible

BEAM QUALITY				CALIBRATION		
BEAM		EXPOSURE RATE		COEFFICIENT	UNCERT	LOG
CsEn220	(11mCi)	0.22mR/h	$N_x =$	1.00 mR/h/rdg	11% M87	
CsEn80	(11mCi)	0.08mR/h	$N_x =$	1.01 mR/h/rdg	11%	
CsEnv12	(1mCi)	0.012mR/h	$N_x =$	1.00 mR/h/rdg	11%	
CsEnv15	(1mCi)	0.015mR/h	$N_x =$	1.00 mR/h/rdg	11%	
Cs199m	(20 Ci)	50mR/h	$N_x =$	1.01 mR/h/rdg	8%	
Cs252m	(20 Ci)	80mR/h	$N_x =$	1.01 mR/h/rdg	8%	

Comments Batt: 8.02 V; K&S Environment: Temp: 23 deg C, RH: 41%, Press: 758 mmHg

Report Number: 221918

Refer to Appendix I of this report for details on PIC ionization chamber calibrations. Procedure: SI 25

Sensitivity Found: -2.206×10^{-8}

Calibrated By Jeremy Gossman
Title: Calibration Technician

Reviewed By: [Signature]
Title: Director

Checked By: [Signature] **Prepared By:** [Signature]

Form RSS



Test Number: M220839

Report Number: 221918

Appendix I

Pressurized Ion Chambers & Reuter-Stokes Units

CALIBRATION COEFFICIENTS:

EXPOSURE CALIBRATION COEFFICIENTS_{X(N)}

R/RDG: Roentgen/reading calibration coefficients apply to the chamber-electrometer-readout system as a unit, with scales, switch settings and output mode specified. To obtain the exposure in Roentgens at the reference point*, in the absence of the chamber, the calibration coefficient is applied directly to the instrument reading corrected for temperature and pressure:

$$\text{Exposure} = \text{RDG} \cdot \text{R/RDG}$$

R/C: Roentgen/Coulomb calibration coefficients apply to the ion chamber alone. To obtain the exposure in Roentgens at the reference point*, in the absence of the chamber, an appropriately calibrated (Coulomb/reading) electrometer must be used.

$$\text{Exposure} = \text{RDG} \cdot \text{R/C} \cdot \text{C/RDG}$$

where C/RDG = calibration coefficient of electrometer

If the unit has been adjusted during the calibration, a separate data page is provided to show the calibration coefficients as found before adjustment.

* The reference point is the center of the radiation field at the appropriate distance for the dose rate shown on the calibration data page.

ENVIRONMENTAL CONDITIONS:

The background radiation level in the Environmental Laboratory is continuously monitored using a pressurized ion chamber calibrated by or directly traceable to the National Institute for Standards and Technology (NIST).

The typical background rate is between six and seven micro-Roentgen per hour. Background spectrums are periodically measured with an HP Ge detector and compared to previous spectrums. The prevailing background is reported at the time of calibration.

The room scatter at each calibration position has been evaluated and found to be negligible.



CALIBRATION CONDITIONS:

The calibration is performed using a collimated Cesium-137 source calibrated with an ion chamber calibrated by NIST. Periodically, the working ion chamber is compared to an pressurized ion chamber calibrated by the National Physical Laboratory of the United Kingdom and an Exradin ion chamber calibrated by NIST.

Biannually, K&S participates in a Proficiency Test conducted by NIST and supervised by the Health Physics Society's Laboratory Accreditation Policy Committee.

The calibration distance from the source to the instrument center, ambient conditions and other physical data are stated on each calibration page.

UNCERTAINTY:

The best combined expanded uncertainty with a coverage factor $k=2$ of the reference exposure or air kerma is 11%. This value is twice the quadratic sum of the laboratory uncertainty and the uncertainty stated by NIST for the calibration of the transfer standards used by K&S. It is believed to have the approximate significance of the 95% confidence limit.

SHADOW SHIELD CALIBRATION METHOD:

In some cases a customer may specifically request the use of the shadow shield calibration method of calibration. The shadow shield method of calibration of an instrument is an older method used to calibrate an instrument with a source that was calibrated for activity content or dose rate by NIST or a secondary laboratory in open air. It consists of an initial measurement at a distance from a calibrated source and then placing a shield between the source and the instrument that shields only the instrument in order to measure room scatter. Subtracting the room scatter component from the initial measurement provides the net reading of the instrument from the calibrated source. When this method is used, it is noted on the page with the calibration coefficient.

Present day methods with collimated sources standardized with NIST traceable instruments are equivalent to the shadow shield method and less labor intensive. They involve a replacement technique using a NIST traceable instrument to calibrate a collimated source at a specific distance and then placing the instrument at the same position to calculate the calibration coefficient. Room scatter is initially investigated to ensure that it is below an acceptable level within a specified range of operation. However, since the collimated source almost totally eliminates room scatter and since both the calibration standard and the instrument being calibrated see the same contribution from scatter, the scatter components cancel in the calculation of the calibration coefficient.

ATTACHMENT B-6: DAILY FUNCTION CHECK FORMS



Single-Channel Function Check Log

Environmental Restoration Group, Inc.
1809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	3000
Serial No.:	25618543
Cal. Due Date:	6/28/2023

DETECTOR	
Manufacturer:	Ludlum
Model:	44-80
Serial No.:	PR355810
Cal. Due Date:	6/28/2023

Comments:
Orange
Scaler Count Time:
Distance To Source:

Source: 172 Cs-137

Serial No.: 1122

Activity: 1 ^{uCi} cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery V	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1705	5.73	900	10	17,659	5,059	12,600	AM	
11/15/22	1733	5.45	900	10	17,671	5,180	12,491	AM	
11/16/22	1637	5.41	900	10	17,241	5,019	12,222	AM	
11/17/22	1717	5.17	900	10	17,880	5,461	12,419	AM	
11/18/22	1547	5.19	900	10	18,129	5,045	13,084	AM	
11/19/22	1714	5.20	900	10	17,652	5,242	12,410	AM	
11/20/22	1344	5.77	900	10	18213	5,896	12317	ma	Battery swap

Reviewed by: _____

Review Date: _____



Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	3000
Serial No.:	25020102
Cal. Due Date:	4/25/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR406319
Cal. Due Date:	4/25/23

Comments:
Red
Scaler Count Time:
Distance To Source:

Source: CS-137

Serial No.: 1122

Activity: 1 uCi
Emission Rate: 1 cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14	1740	5.52	750	10	17,959	5,235	12,724	sc	
11/15	1551	5.67	750	10	17,719	5,300	12,419	MQ	
11/16	1730	5.41	750	10	17,470	5,088	12,382	sc	
11/17/22	1737	5.52	750	10	17,495	5,325	12,170	AM	
11/18/22	1634	5.22	750	10	17,772	5,805	11,967	AM	
11/19/22	1737	5.31	750	10	17,926	5,694	12,232	AM	

Reviewed by: _____

Review Date: _____



Single-Channel Function Check Log

Environmental Restoration Group, Inc.
4809 Washington St. NE, Suite 150
Albuquerque, NM 87111
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	3000
Serial No.:	25016973
Cal. Due Date:	4/16/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 156857
Cal. Due Date:	

Comments:
Blue
Scaler Count Time:
Distance To Source:

Source: Cs-137

Serial No.: 1122

Activity: 1 uCi
Emission Rate: cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC 201 B.

Acceptable Upper Net Counts:

Acceptable Lower Net Counts:

Total Efficiency (E_t):

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1705	5.86	1,100	10	18,314	5,325	12,989	AM	
11/15/22	1647	5.71	1,100	10	18,280	5,547	12,733	AM	
11/16/22	1648	5.55	1,100	10	18,051	5,455	12,596	AM	
11/17/22	1739	5.59	1,100	10	18,784	5,915	12,869	AM	
11/18/22	1546	5.43	1,100	10	18,345	5,508	12,837	AM	
11/19/22	1715	5.30	1,100	10	18,577	5,768	12,809	AM	

Reviewed by: _____

Review Date: _____



Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	3000
Serial No.:	25017006
Cal. Due Date:	1/26/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	426422 PR 295014
Cal. Due Date:	1/26/23

Comments:
Green
Scaler Count Time:
Distance To Source:

Source: CS-137

Serial No.: 1122

Activity: ICi
Emission Rate: 1 cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B.

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1752	5.93	950	10	17738	5191	12547	BSB	
11/15/22	1553	5.89	950	10	17869	5143	12726	BSB	
11/16/22	1630	5.58	950	10	17,926	5,132	12,794	AM	
11/17/22	1731	5.63	950	10	18,162	5,276	12,886	AM	
11/18/22	1632	5.29	950	10	17,955	6,005	11,950	AM	
11/19/22	1716	5.26	950	10	17,500	5,494	12,006	AM	

Reviewed by: _____

Review Date: _____



Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	3000
Serial No.:	25018610
Cal. Due Date:	4/25/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR 355771
Cal. Due Date:	4/25/23

Comments:
Yellow
Scaler Count Time:
Distance To Source:

Source: Cs-137

Serial No.: 1122

Activity: 1 ^{uCi} cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1705	5.63	850	10	17,441	5,174	12,267	AM	
11/15/22	1730	5.72	850	10	17,761	4,941	12,820	AM	
11/16/22	1630	5.52	850	10	17,585	5,285	12,300	AM	
11/17/22	1717	5.60	850	10	17,770	5,302	12,468	AM	
11/18/22	1545	5.31	850	10	17,658	5,308	12,350	AM	
11/19/22	1713	5.24	850	10	17,614	5,645	11,969	AM	

Reviewed by: _____

Review Date: _____



Single-Channel Function Check Log

Environmental Restoration Group, Inc.
1809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	254783
Cal. Due Date:	

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR399720
Cal. Due Date:	

Comments:
Black
Scaler Count Time:
Distance To Source:

Source: C5-137

Serial No.: 1122

Activity: 1 ^{uCi}
Emission Rate: cpm/emissions

Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B.

Acceptable Upper Net Counts:

Total Efficiency (E_t):

Acceptable Lower Net Counts:

MDA (dpm/100-cm²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14/22	1723	5.7	1080	181	18,783	5,954	12,829	AM	
11/15/22	1425				18,316	6,278	12,038	AM	
11/16/22	1649	5.5	1079	180	18,337	6,053	12,284	AM	
11/17/22	1736	5.2	1079	180	18,805	6,486		AM	
11/17/22	1751	5.2	1079	180	18,805	6,284	12,521	AM	
11/18/22	1550	5.1	1017	118	18,349	6,025	12,324	AM	
11/19/22	1738	5.2	1104	205	19,450	6,383	13,067	AM	

Reviewed by: _____

Review Date: _____



Single-Channel Function Check Log

Environmental Restoration Group, Inc.
8809 Washington St. NE, Suite 150
Albuquerque, NM 87113
(505) 298-4224

METER	
Manufacturer:	Ludlum
Model:	2221
Serial No.:	117357
Cal. Due Date:	10/5/23

DETECTOR	
Manufacturer:	Ludlum
Model:	44-10
Serial No.:	PR375296
Cal. Due Date:	10/5/23

Comments:
White
Scaler Count Time:
Distance To Source:

Source: Cs-137 Serial No.: 1122 Activity: 1 uCi Emission Rate: 1 cpm/emissions Source Date: 9/19

NOTE: For use as needed. Acceptable upper/lower net counts, detector total efficiency, and detector MDA calculated on ERG Form ITC.201.B.

Acceptable Upper Net Counts:
Acceptable Lower Net Counts:

Total Efficiency (E _t):
MDA (dpm/100-cm ²):

Date	Time	Battery	High Voltage	Threshold	Source Counts	BKG Counts	Net Counts	Initials	Note(s):
11/14	2113	5.7	901	100	18,577	5793	12784	MR	
11/14	1551				17603	6119			
11/16/22	0746	5.8	901	100	17603	6119	11484	ASB	
11/16/22	1650	5.7	903	101	18,299	6,025	12,274	AM	
11/17/22	1757	5.7	905	101	18,703	6,611	12,092	AM	
11/18/22	1630	5.7	903	101	18,736	6,713	12,023	AM	

Reviewed by: _____

Review Date: _____

ATTACHMENT B-7: EXCLUDED GAMMA DATA (ELECTRONIC)

ATTACHMENT B-8: FINAL GAMMA DATASET (ELECTRONIC)