UNITED STATES AIR FORCE
JOINT BASE ELMENDORF-RICHARDSON, ALASKA

ENVIRONMENTAL RESTORATION PROGRAM

SS22 RADIOLOGICAL CHARACTERIZATION SURVEY

FINAL

October 2011

REPORT STATUS

This report documents the radiological characterization effort conducted at Spill Site 22 (SS22), the current and former Defense Reutilization and Marketing Office Storage Yard, at Joint Base Elmendorf-Richardson, Alaska. SS22 East contains the 15 geophysical anomalies (Anomaly Areas #1 through #15). SS22 West contains 13 geophysical anomalies (Anomaly Areas #16 through #28). Radiological investigations were conducted in each of these geophysical anomalies. This work was conducted in conjunction with other remedial investigation (RI) activities at SS22 under the installation's Comprehensive Environmental Response, Compensation, and Liability Act Federal Facility Agreement. The findings of this study are intended to be used in the RI/Feasibility Study for SS22. Subsequent reports will be submitted based on comments received from stakeholders.

EXECUTIVE SUMMARY

The purpose of the project was to perform a radiological characterization survey to define the nature and extent of radiological contamination discovered within distinct areas of Spill Site 22 (SS22). SS22 comprises the current and former Defense Reutilization and Marketing Office (DRMO) Storage Yard, at Joint Base Elmendorf-Richardson, Alaska. The spill site has been divided into two areas, SS22 East and SS22 West. SS22 East contains 15 geophysical anomalies which were identified during a 2002 geophysical survey. SS22 West contains an additional 13 geophysical anomalies that were identified in 2010.

The 2007 radiological scoping surveys, which consisted of gamma radiation walkover surveys of the SS22 East geophysical anomalies, identified three of the anomaly areas (Anomaly Areas #2, #3, and #11) as containing radiological anomalies. In 2008, a characterization effort was conducted in these three areas to determine the nature and extent of the radiological impact. This characterization included additional gamma walkover surveys, systematic surface soil sampling, and exploratory trenching and subsurface soil sampling.

The SS22 East characterization was performed in accordance with the Characterization Survey Work Plan (WP) (Earth Tech 2008a), which identified radium-226 (Ra-226) as the radiological contaminant of concern. The field work was performed from 4–18 September 2008. The characterization effort for SS22 East included gamma walkover surveys that covered 100 percent (%) of the three geophysical anomaly areas, systematic surface soil sampling using a random-start triangular grid, hot spot surface soil sampling at locations of elevated gamma count rates, and a subsurface investigation. The radiological assessment applied a 2 picocurie per gram (pCi/g) Ra-226 screening criterion that was established by the Department of the Air Force.

A background reference area was established in the northeast corner of SS22 East. This area was selected based on review of historical photographs showing limited use of this area and the absence of geophysical anomalies. Weighted average background surface soil concentrations for Ra-226 at the background reference area were calculated to be 0.96 ± 0.07 pCi/g. The results of the SS22 East characterization are summarized below.

- Ra-226 is the only radioactive contaminant of potential concern.
- In Anomaly Area #2, the walkover survey identified four areas of elevated surface radioactivity where Ra-226 soil concentrations were likely greater than the established screening level of 2 pCi/g. A hot spot surface soil sample from Anomaly Area #2 recorded Ra-226 concentrations approximately 10 times the site screening level. The Anomaly

Area #2 trench investigation also identified concentrations above the screening level in the subsurface soil.

- In Anomaly Area #3, the walkover survey identified one area of elevated surface radioactivity. However, surface soil samples recorded Ra-226 concentrations less than the screening level. It was also noted that one compass dial and one gauge dial containing Ra-226 were recovered from the Anomaly Area #3 test trench.
- In Anomaly Area #11, the walkover survey identified one area of elevated surface radioactivity where Ra-226 soil concentrations likely exceeded the screening level. The highest concentration of Ra-226 at SS22, 166 ± 6 pCi/g, was observed in a subsurface soil sample collected from the Anomaly Area #11 test trench.
- Direct push subsurface soil samples and monitoring well samples were collected in May and June 2009 in conjunction with a previously scheduled chemical investigation of SS22 and are included in this radiological characterization report. With the exception of one direct push subsurface soil sample collected in close proximity to a previously identified area of elevated radioactivity, the results of these samples were consistent with background radionuclide concentrations.

A scoping/characterization survey of SS22 West was conducted in July 2010 in accordance with a WP Addendum (AECOM 2010). This effort included 100% gamma walkover surveys of 13 geophysical anomalies areas identified inside the DRMO fence and inside the RV Lot and background surveys in three reference areas. These walkover surveys were followed up by surface soil sampling at several locations that demonstrated elevated gamma counts and also exploratory trenching. The soil/debris from the trenches was also scanned for radioactive materials and soil samples were taken when radioactive materials were identified. The results of the SS22 West characterization are summarized below.

- Gamma walkover surveys identified only 2 locations of surface or near surface radioactive materials, both in Anomaly Area #19.
- Ra-226-containing items were identified in and recovered from eight of the 13 exploratory trenches excavated in the geophysical anomalies. Most of these eight trenches yielded more than one source.
- Residual Ra-226 soil contamination was identified at levels greater than the 2 pCi/g screening level in five of the eight trenches. Samples were only collected if a radioactive item was located.

Results from groundwater sampling indicate that groundwater has not been impacted. Based on the nature of the contaminant, groundwater is not expected to become impacted in the future.

Residual Ra-226 contamination will be addressed in the SS22 risk assessment and remedial investigation/feasibility study report. The greatest imminent risk posed by the presence of radioactive materials and/or contamination in these areas would be an event in which an individual unknowingly handled a radioactive item from the site. This could result in low level contamination of the individual’s hands and small potential uptake of radioactive material. For this reason, restrictive land use controls should be implemented to prevent intrusive activities on site except when appropriate health physics monitoring is conducted.

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ACRONYMS AND ABBREVIATIONS

%	percent
μCi	microCurie
μR/hr	microroentgen per hour
3×3	three-inch by three-inch
AFB	Air Force Base
ARS	ARS International, Inc.
ASL	ASL Laboratory Group
bgs	below ground surface
COC	chain-of-custody
COPC	contaminant of potential concern
cpm	count per minute
Cs-137	cesium-137
DQO	data quality objective
DRMO	Defense Reutilization and Marketing Office
EPA	Environmental Protection Agency, United States
FS	feasibility study
GM	Geiger-Muller
GPS	global positioning system
ID	identification
IL	investigation level
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	minimum detectable concentration
NaI(Tl)	sodium iodide (thallium activated)
pCi/g	picocurie per gram
pCi/L	picocurie per liter
Ra-226	radium-226
RI	remedial investigation
RIC	U.S. Air Force Radioisotope Committee
SS22	Spill Site 22
WP	work plan

1. INTRODUCTION

In accordance with the statement of work dated 15 November 2006 (AFCEE 2006), a remedial investigation (RI) and feasibility study (FS) for Spill Site 22 (SS22), the current and former Defense Reutilization and Marketing Office (DRMO) Storage Yard, at Elmendorf Air Force Base (AFB) within Joint Base Elmendorf-Richardson (JBER), Alaska, is being completed. For the RI/FS, SS22 has been divided into two areas, SS22 East and SS22 West. SS22 East lies adjacent to the eastern boundary of the current DRMO yard. SS22 West includes portions of the current DRMO and the "RV Lot" adjacent to the southern border of the current DRMO.

As part of the RI/FS, the following radiological investigations were conducted:

- August 2007: Radiological scoping surveys in SS22 East
- September 2008: Radiological characterization survey/sampling of three geophysical anomalies in SS22 East
- May/June 2009: Additional subsurface soil and groundwater samples collected and analyzed to support the SS22 East radiological characterization effort
- July 2010: Radiological characterization of geophysical anomalies in SS22 West

1.1 Objective

The primary objective of this project was to characterize the nature and extent of radioactive contamination associated with historical disposal/burial of radioactive instruments/articles (e.g., gauges, toggle switches) at SS22. Based on site knowledge, the contaminant of primary concern is radium-226 (Ra-226). Impact can be in the form of buried discrete objects containing Ra-226 or soil contamination from the degradation of objects containing Ra-226.

The Air Force maintains Radioactive Materials Permit number AK-00492-00/00AFP for SS22. The permit, issued by the United States Nuclear Regulatory Commission under the Air Force's Master Materials License 42-32539-XXAF, authorizes the storage of radioactive materials containing up to 1 curie of Ra-226 within the approximate 20-acre area of SS22, pending disposal. The permit is set to expire on February 28, 2015. As described later in this report, a surface soil sample from SS22 East was collected by JBER Bioenvironmental Engineering personnel on 14 August 2007 and submitted to the Air Force Institute for Operational Health for gamma spectroscopy analysis. The results of this analysis identified Ra-226 with a concentration of 4.7 ± 0.5 picocuries per gram (pCi/g), which is greater than the background Ra-226 concentration determined in this survey to be 0.96 ± 0.07 pCi/g. All other radionuclides identified were within background concentrations.

1.2 Site History

The Defense Logistics Agency has operated the former JBER DRMO facility as a collection point and storage yard for excess government materials awaiting resale or salvage from approximately the late 1950s to 2003. This is the area referred to as SS22 East. The current DRMO facility is located immediately west of SS22 East and is referred to as SS22 West. Based on historical aerial photographs available at JBER, the site is believed to have been used solely for these purposes with no indications of land use either prior to or since the closure of the DRMO facility (Earth Tech 2008a). Figure 1-1 provides the layout of SS22 East and SS22 West.

All available historical aerial photographs for SS22 were reviewed at the 673 Civil Engineer Squadron Environmental Restoration Office, JBER. The photographic record starts with a 1950 aerial photograph showing the site was heavily vegetated with timber. The next photograph in the historical record is dated 1962 and indicates a cleared site consistent with storage operations. Two old maps from 1957 show part of the area as a “Post Engineer Yard” or Utility Yard” and the rest of the area as “Open Storage”.

Aerial photographs from 1962 through 2003 indicate the site was used for various vehicle and material storage operations. The terrain currently consists of bare, unpaved ground, interspersed with small saplings and other low vegetation.

1.3 Geophysical Surveys

1.3.1 October 2002 Geophysical Survey

A geophysical survey of SS22 East, completed in October 2002, identified 15 geophysical anomalies where buried metal debris was suspected (USAF 2002). Buried drums and other scrap metallic debris were confirmed in the subsurface soil by excavating test trenches across 14 of the geophysical anomalies. Buried debris was identified in each of the trenches excavated in the anomaly areas. Soil testing was not conducted during the 2002 geophysical survey and trenching activities. Subsequent radiological surveys performed in 2007 were limited to areas delineated as geophysical anomalies.

1.3.2 July 2010 Geophysical Survey

A geophysical survey of SS22 West, completed in July 2010, identified 13 geophysical anomalies in the DRMO and the RV Lot where buried metal debris was suspected. Buried drums, vehicles, and other scrap metallic debris were confirmed in the subsurface soil by excavating test trenches across each of the geophysical anomalies. Buried debris was identified in each of the trenches excavated in

the anomaly areas. Radiological surveys performed the same week were limited to areas delineated as geophysical anomalies.

1.4 Radiological Surveys

In August 2007, a limited radiological scoping survey was performed within the 15 identified geophysical anomalies at SS22 East (noted as Anomaly Area #1 through Anomaly Area #15). It was determined that these areas potentially contained residual radioactive items from former scrap storage operations at the former DRMO facility. The scoping survey identified elevated gamma radiation in 2 of the 15 geophysical anomaly areas (Anomaly Areas #2 and #11), which are discussed below. No elevated gamma radiation was identified in Anomaly Area #3. However, due to its proximity to Anomaly Area #2, it was later included in the 2008 characterization effort.

In 2008, a characterization effort conducted in areas of SS22 East was limited to the three geophysical anomalies that indicated the presence of radioactive materials in SS22 East. This characterization included gamma walkover surveys and soil sampling as described in Appendix E, *Radiation Characterization Survey Work Plan,* herein referred to as the SS22 East Work Plan, of the *Management Plan for the Remedial Investigation/Feasibility Study, SS22 (Former DRMO Storage Yard)* (Earth Tech 2008a), herein referred to as the SS22 East Management Plan.

The 2010 characterization effort was limited to the geophysical anomalies identified in SS22 West in accordance with Appendix B.1, *Radiological Work Plan Addendum,* herein referred to as the SS22 West Work Plan, of the *Management Plan Addendum for the Remedial Investigation/Feasibility Study* (AECOM 2010), herein referred to as the SS22 West Management Plan. This effort included radiological surveys and soil sampling.

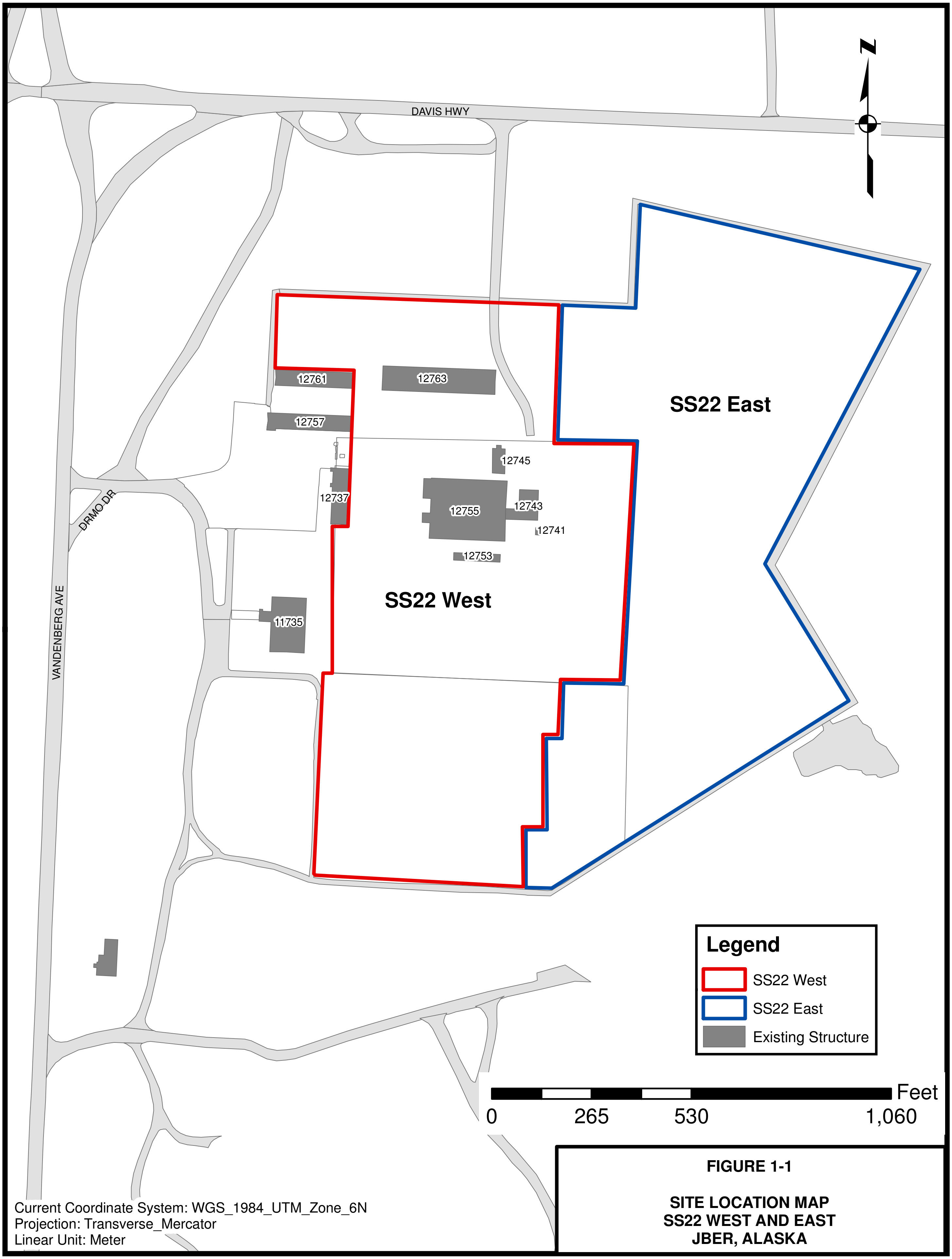


FIGURE 1-1

SITE LOCATION MAP
SS22 WEST AND EAST
JBER, ALASKA

2. BASIS FOR CHARACTERIZATION METHODS

2.1 Activity Limits for Contamination in Surface Soil

As described in Section 2.5 of the SS22 East Work Plan (WP) (Earth Tech 2008a, Appendix E), discussions with Air Force personnel during the preparation of this plan led to a screening value for the concentration of Ra-226 in soil of 2 pCi/g. As discussed in the WP, the screening value was used to derive the number of samples required and the selection of radiation scanning instruments for the characterization survey. The same screening value was applied to SS22 West (AECOM 2010). Screening values were not established for any other potential radioactive contaminants.

2.2 SS22 East Scoping Surveys

In August 2007, a limited radiological scoping survey was performed within the 15 identified geophysical anomalies at SS22 East (noted as Anomaly Area #1 through Anomaly Area #15). It was determined that these areas potentially contained residual radioactive items from former scrap storage operations at the former DRMO facility. The limited scoping survey was targeted within the geophysical anomalies to detect surface or near surface Ra-226 sources. The survey results were then used to design the SS22 East characterization effort.

2.3 SS22 East Characterization

Following the 2002 geophysical survey and the 2007 scoping surveys, the 2008 SS22 East characterization was initially designed in accordance with the methods described in *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC, DOE, EPA, and DoD 2000) as described in the SS22 East WP. These methods included additional surface walkover surveys and random soil sampling in Anomaly Areas #2, #3, and #11. The random soil sampling locations were determined using a random-start triangular grid pattern. MARSSIM methods were also used to determine the number of samples needed from each anomaly area.

MARSSIM also describes the data quality objective (DQO) process used to determine appropriate survey and collection protocols as well as radiological analysis requirements. DQOs include the minimum detectable activities for walkover surveys as soil sample analysis. The site-specific survey methods and DQOs are provided in the Management Plan for SS22 (Earth Tech 2008a). Adherence to these methods ensures that the conclusions reached from the characterization survey are statistically defensible within the established confidence limits.

Additional subsurface and groundwater characterization data were collected in 2008 that were outside the MARSSIM scope. These included surveys of trench stockpiles and analysis of subsurface soil samples collected from the stockpiles. These samples were collected for radiological

analysis either randomly or at locations of elevated gamma measurements. Groundwater samples were collected from monitoring wells installed around the site as part of the chemical investigation.

2.4 SS22 West Characterization

Based on the observations and analytical data from the SS22 East characterization effort, the 2010 characterization for SS22 West deviated from the MARSSIM methods described in Section 2.3 above. Scoping surveys were replaced with more sensitive characterization surface walkover surveys of all SS22 West geophysical anomalies, but there was no systematic soil sampling determined by a MARSSIM method.

The SS22 East characterization effort demonstrated that the MARSSIM methodology of selecting soil sample locations using a random-start grid pattern does not provide a useful method for locating near-surface or buried point sources or very small areas of disperse contamination. Therefore, the SS22 West characterization method differed from the SS22 East characterization method by increasing the sensitivity of the gamma walkover survey for all geophysical anomalies (noted as Anomaly Area #16 through Anomaly Area #28) and eliminating systematic soil sampling. Sensitivity was increased by adding a lead shield to the detector (lowering background radiation levels), moving the detector closer to the ground, and slowing the scan speed (walking pace). The lead shield was a cylindrical shield about 1 inch thick with an open bottom. The bottom had two aluminum bars across it to hold the 3” × 3” detector. Daily background measurements and source checks were made without the shield. Background reference area surveys were performed with the shield.

The instrumentation setup was tested prior to completing the SS22 West walkover surveys using a known 0.8997 microCurie (μCi) Ra-226 source. Figure 2-1 displays a field-of-view assessment of the shielded detector placed 3 inches above the ground surface in the paved area just northwest of Building 12745 inside the DRMO fence. The width of the test area shown on the figure is about 54 inches with each pass about 3 inches apart. It should be noted that the position of the data points are sub-meter accurate but not accurate enough to delineate straight transects spaced 3 inches apart. Therefore, data is a bit intermixed; however, the general swath of measurements greater than 6,000 counts per minute (cpm) demonstrates that the field of view is about 24 inches wide.

A second test using static 12-second measurements is shown on Figure 2-2. The 12-second duration of these measurements was selected because it provided a reasonable response time to provide a noticeable difference in background. The 0.8997 μCi Ra-226 source provided sufficient activity that a short count time was acceptable. This figure demonstrates that the source is detectable with the detector more than 12 lateral inches from the source with the detector 3 inches above the ground surface (within the 24-inch field of view predicted in the first test)). In fact, the

ground-level source may be detectable beyond 12 inches as the measurements are still above the expected 12-second background count of less than 800 to 1,000 counts at a distance of 21 inches. However, because the detector survey transects were spaced 22 inches apart, detectability beyond 12 inches is inconsequential.

Therefore, using the information provided by both tests, a spacing for the walkover survey transects of about 22 inches, the distance between the back wheels of the buggy containing the detector, provides an acceptable spacing to provide nearly 100 percent (%) coverage of an area.

A third test evaluated the detectability of the 0.8997 μCi Ra-226 source below a layer of asphalt and buried at various depths below the ground surface. The test involved collecting 12-second static measurements with the shielded detector positioned 3 inches directly above the ground or asphalt surface. The asphalt used in the test was 3.5 inches thick and was believed to approximate the thickness of the asphalt in the DRMO. Table 2-1 provides the results of the analysis to determine the source detectability at depth with and without an asphalt cover. The data demonstrate that the test source is detectable below the ground surface and below a layer of asphalt during static measurements.

Table 2-1: Source Detectability at Depth

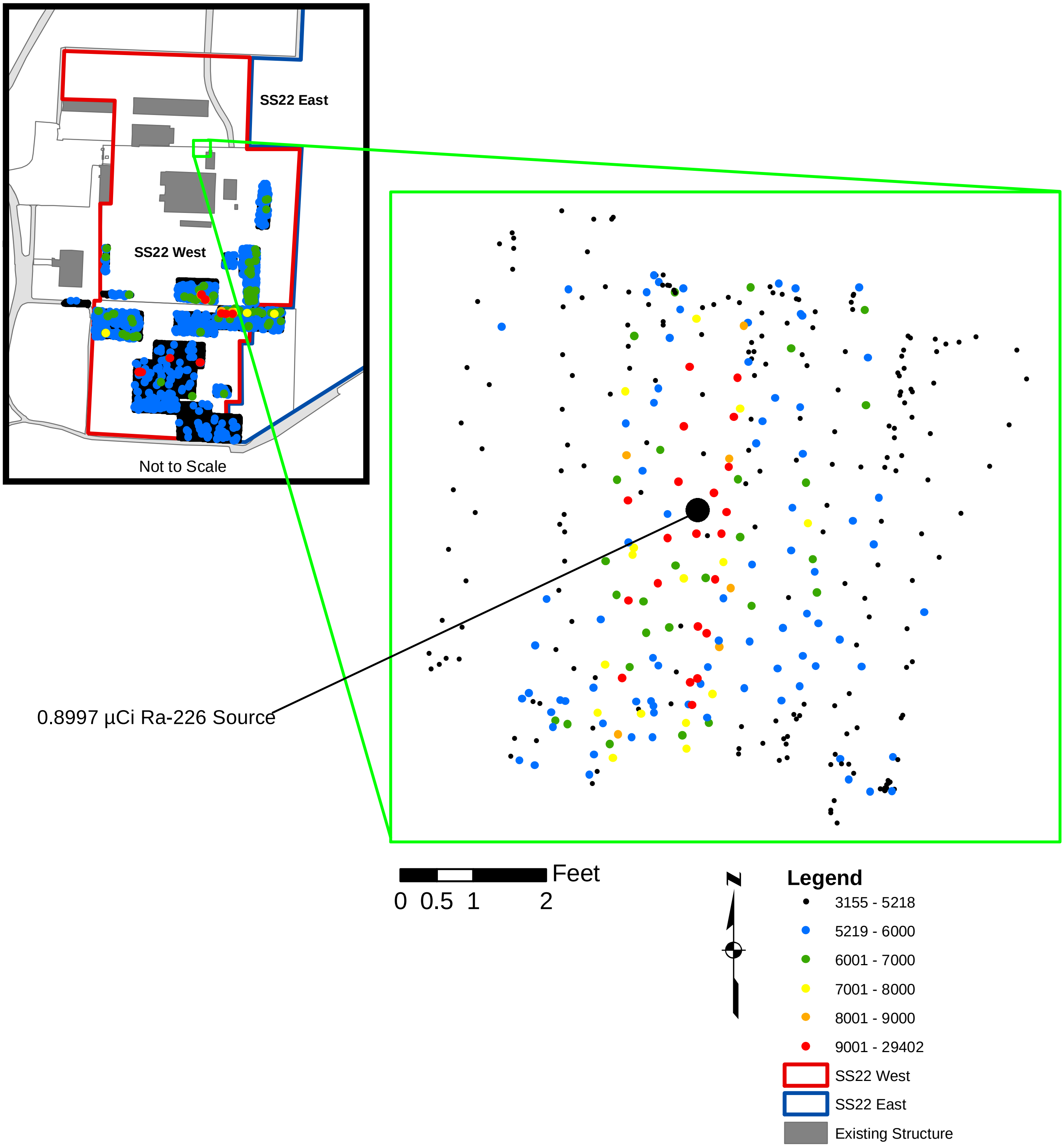
Depth of Buried Source (inches)	Without Ashpalt (gross counts in 12-seconds) [a]	With Ashpalt (gross counts in 12-seconds) [a]
2	8773	2244
4	5552	1944
6	2594	1226
8	1733	1012
10	1331	939

[a] 12-second background = 805 counts

In accordance with MARSSIM guidance, because Ra-226 is present in natural soils, a background reference area was identified and characterized as part of the 2008 SS22 East investigation. MARSSIM requires establishing a background reference area for recording background measurements and collecting background soil samples for radiological analysis (NRC, DOE, EPA, and DoD 2000).

The background reference area is a geographical area from which representative reference measurements are performed for comparison with measurements performed in specific survey units. The background reference area is defined as an area that has similar physical, chemical, radiological, and biological characteristics as the survey unit(s) being investigated but has not been contaminated by site activities (i.e., non-impacted).

The SS22 East characterization survey background reference area was located in an unpaved area in the northeast corner of SS22 in a location where geophysical anomalies were absent. This area was used to provide background gamma measurements for the Anomaly Area #2, #3, and #11 surveys and background soil samples (see Figure 3-6). Two of the three SS22 West characterization survey background reference areas were located in the southwestern part of the DRMO fenced in area; one between the paved area and the corner of the southwestern fenced area extending approximately 100 feet (ft) to the east and one on the paved surface near the western fence. A third background area was selected to represent the gravel-covered RV Lot. This background area was located just west (outside) of the RV Lot gate These SS22 West background reference areas, shown on Figure 4-1, were used for background gamma measurements only. No additional background soil samples were collected from these areas.



Notes

1. Units in Counts Per Minute (CPM)
2. Instrument:
   Ludlum Model 44-20 with lead shield

Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 2-1

DETECTOR FIELD-OF-VIEW TEST
SHIELDED 3x3 NAI DETECTOR
SS22 WEST
JBER, ALASKA

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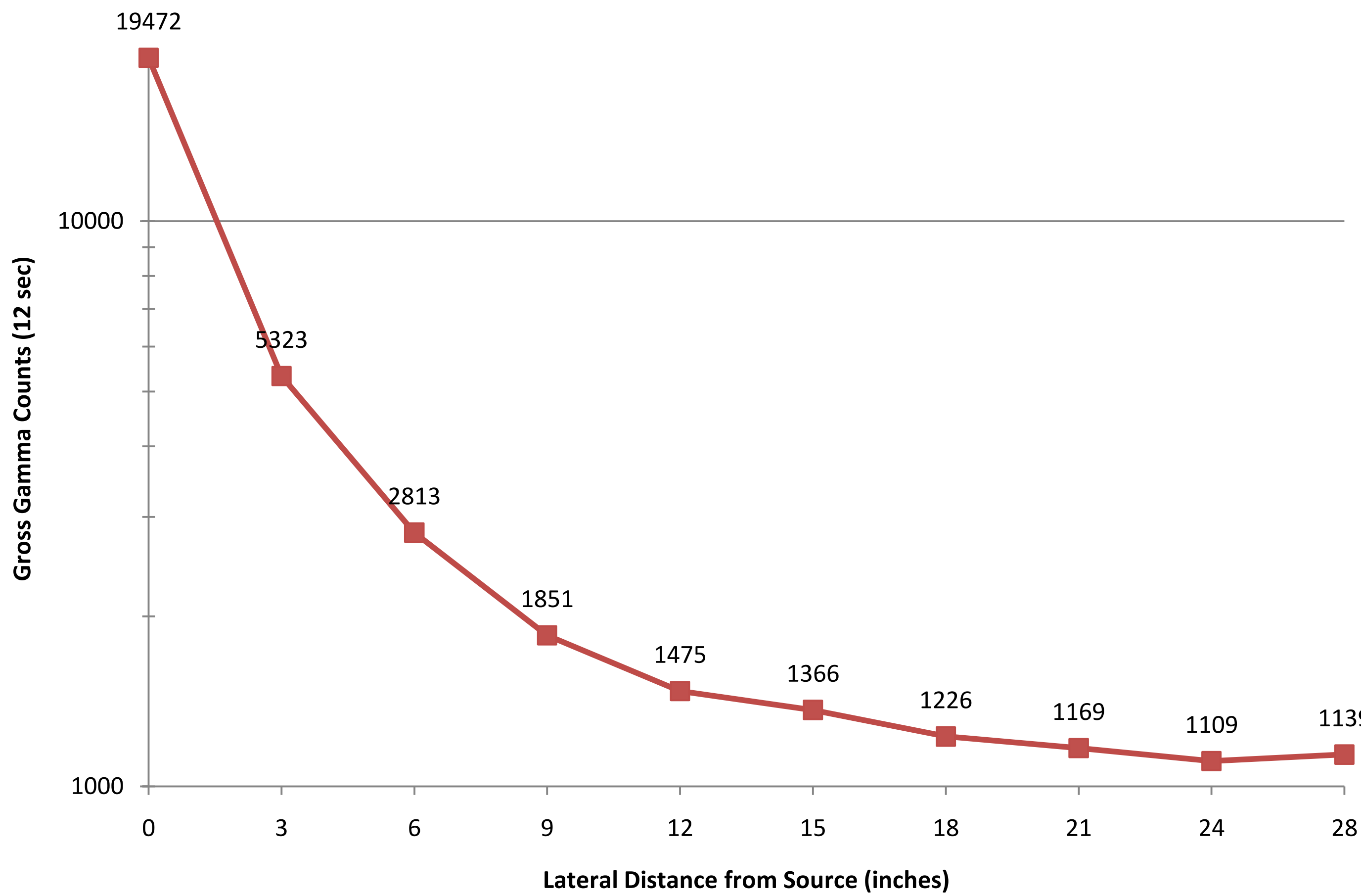


FIGURE 2-2

FIELD OF VIEW ANALYSIS FOR SHIELDED 3 X 3 NaI DETECTOR, 3 INCHES ABOVE THE GROUND SURFACE, SS22, JBER ALASKA

3. SURVEY AND SAMPLING METHODS

This section provides the technical basis for instrument performance requirements and demonstrates that the instruments selected for this investigation meet or exceed the expectations of the DQOs expressed in the *SS22 East and SS22 West* Management Plans for SS22 (Earth Tech 2008a, AECOM 2010).

This section also includes a discussion on walkover survey, sampling, and analytical methods. Walkover surveys and sample collection were conducted in both the background reference area and the geophysical anomaly areas.

3.1 Radiological Instrumentation

The instruments used during the site investigation are listed in Table 3-1 and are described in the following paragraphs. Calibration certificates for all instruments appear in Appendix A.

Table 3-1: Instrumentation

Ludlum Instrument Model	Serial Numbers	Survey Area Year	Radiation Detected	Survey Method
Model 2221 w/ Model 44-20 3×3 NaI(Tl)	81308 w/ PR201774	SS22 East 2007	Gamma	GPS walkover survey; direct measurements
	108859 w/ PR269985	SS22 East 2007	Gamma	GPS walkover survey; direct measurements
	117636 w/ PR269983	SS22 East 2007	Gamma	GPS walkover survey; direct measurements
	268647 w/ PR201774	SS22 West 2010	Gamma	GPS walkover survey; direct measurements
	254764 w/ PR269985	SS22 West 2010	Gamma	GPS walkover survey; direct measurements
Model 2221 w/ Model 44-10 2×2 NaI(Tl)	94955 w/ PR153990	SS22 West 2010	Gamma	Trench surveys
Model 19A MicroR meter	114790	SS22 East 2007	Gamma	Exposure rate measurements
	111333	SS22 West 2010	Gamma	Exposure rate measurements
Model 12/2221 w/ Model 44-9	125264 w/ PR125462	SS22 East 2007	Beta/gamma	Contamination surveys
	117328 w/ PR251713	SS22 West 2010	Beta/gamma	Contamination surveys
Model 2929	196226 w/ PR215943	SS22 East 2007	Alpha and beta	Removable contamination surveys
	121870 w/ PR126405	SS22 West 2010	Alpha and beta	Removable contamination surveys

GPS global positioning system
NaI(Tl) sodium iodide (thallium activated)

Alpha/beta scintillation detectors and Geiger-Muller (GM) detectors were used for contamination control and release of materials and equipment. Gamma scintillation detectors were used for characterization surveys.

The types of detectors used in this project for monitoring contamination were the following:

- Hand-held Ludlum Model 44-9 GM detector for conducting beta/gamma surface contamination measurements on equipment and materials. This instrument was coupled to a Ludlum Model 12 survey meter.
- Desk-top Ludlum Model 2929 Sample Counter with a Model 43-10-1 ZnS(Ag)-plastic scintillator combination alpha/beta probe for measuring removable alpha and beta contamination on surface swipes.

The Ludlum Model 2929 and Ludlum Model 44-9 were not used for the purpose of characterizing the site or collecting data to determine the presence or extent of Ra-226 contamination in the soil. These instruments were used to monitor potential contamination of equipment and materials. Daily instrument source checks (see Appendix B) were performed to check for instrument performance by using a sealed low-activity technetium-99 (Tc-99) beta radiation check source, and a sealed low-activity thorium-230 (Th-230) alpha radiation check source, and a sealed Ra-226 check source.

The Ludlum Model 44-20 three-inch by three-inch (3×3) NaI(Tl) scintillation detectors deployed during this investigation measured gamma radiation levels in cpm during walkover surveys and ground-level static measurements at sampling locations and hot spots. Daily instrument source checks (Appendix B) were performed to check instrument performance by using a sealed low-activity cesium-137 (Cs-137) gamma radiation check source or the sealed Ra-226 check source (the Ra-226 check source was not available for the SS22 East characterization effort in 2008). For the 2010 SS22 West surveys, the 3×3 detectors were calibrated by the manufacturer using Ra-226.

3.2 Gamma Walkover Surveys

3.2.1 SS22 East

3.2.1.1 Classification of Areas

The survey methodology described in MARSSIM assigns classifications to survey units (Class 1 through 3) based on the likelihood of a sample collected from that survey unit having contaminant concentrations in excess of the site release criteria (NRC, DOE, EPA, and DoD 2000). The site release criteria used at this stage of the investigation process is a conservative value that often changes during the later stages of the investigation and risk assessment process as site-specific information becomes available. Areas designated as Class 1 areas have the highest probability of

having residual radioactive contamination above a release limit while Class 3 areas have the lowest probability.

The SS22 East WP (Earth Tech 2008a, Appendix E) designated each of the geophysical anomaly areas as Class 2 survey units in accordance with MARSSIM methodology; however, the areas were surveyed and sampled as Class 1 survey units and were subject to a 100% gamma walkover survey. Class 2 survey units typically receive only 10% to 100% coverage during walkover surveys. Sampling efforts in Class 1 and Class 2 areas use the same systematic sample density and random-start triangular grid pattern.

3.2.1.2 Scanning Measurements

The 2007 scoping surveys and 2008 characterization surveys were performed utilizing a Ludlum Model 44-20 3 inch by 3 inch (3×3) NaI(Tl) crystal detector, coupled with a Ludlum 2221 survey meter. The system was calibrated from the vendor and response checks with a National Institute of Standards and Technology traceable source (Cs-137) were performed daily. The system passed all daily statistical response checks.

The auxiliary output of the system was coupled to a Trimble Power/TSCe global positioning system (GPS) with sub-meter accuracy and data logger to create positionally correlated data during the survey. The output was configured to capture integrated count rates (cpm) with the corresponding GPS location at one second intervals. The operator was also able to observe the count rate of the meter during the survey from the digital display, as well as listen for changes in the audible output.

The system was placed in a three wheeled cart, and the detector was mounted 12 inches above the ground surface to maintain a consistent scanning geometry. The survey was performed by scanning or “rolling” over each anomaly in one meter passes at a scanning speed not exceeding one meter per second. When a significant count rate above the observed background (approximately twice background) was encountered, the detector was placed on the location exhibiting the highest count rate and a ground-level static 1-minute reading was recorded. The scan was adjusted for accessibility and obstacles, and professional judgment was utilized in collecting the scan data.

3.2.1.3 Minimum Detectable Concentrations

The minimum detectable concentrations (MDC) of radionuclides in soils are determined for static and scanning instruments to verify that instrument sensitivities are sufficient to demonstrate compliance with screening criteria and/or to satisfy the site investigation DQOs. The MDC calculations are presented in Appendix C. The MDC analysis demonstrated that the walkover survey methodology provided an acceptable MDC and meets the investigation DQOs.

The relationship between the instrument count rate and the Ra-226 soil concentration was established using the information provided in Appendix C and the instrument manufacturer's published data. This analysis showed that a Ra-226 concentration of 2 pCi/g above background corresponds to about 2,100 cpm above the mean background. This demonstrates the gamma walkover survey provides sufficient sensitivity to determine surface or very near surface concentrations of Ra-226 at the screening level and can be used for risk assessment and remedial actions.

3.2.2 SS22 West

3.2.2.1 Classification of Areas

The survey methodology described in MARSSIM was not used to classify the SS22 West geophysical anomaly areas (survey areas). However, all but one of the survey areas received a 100% gamma walk over survey. To meet the project schedule, the survey area containing Anomaly Areas #27 and #28, which were within the RV Lot, approximately 30% of the area was surveyed. The project health physicist felt that this was an adequate approach considering no walk over surveys within the geophysical anomaly area in the RV Lot had identified any radiological anomalies.

As discussed previously, a systematic sampling effort was considered unnecessary for these areas as it would unlikely to produce any meaningful results. However, a few biased soil samples were collected in SS22 West.

3.2.2.2 Scanning Measurements

The potential for the presence of radioactive sources or radioactive contamination in surface soil was evaluated by moving the shielded Ludlum Model 44-20 3×3 NaI(Tl) scintillation detectors close to ground surfaces and logging the instrument response and position. As with the SS22 East surveys, the auxiliary output of the detector was coupled to a Trimble Power/TSCe GPS system and data logger to create positionally correlated data during the survey with sub-meter accuracy. The output was configured to capture integrated count rates (cpm) with the corresponding GPS location at one second intervals.

The detector was mounted on a cart and positioned 3 inches above the ground surface and the cart was pushed along at a rate of about 0.5 meters per second. The purpose of this monitoring was to log gamma count rates and identify and flag any areas exhibiting elevated gamma activity for further investigation. Walkover surveys were conducted in the background reference areas and Anomaly Areas #16 through #28.

3.2.2.3 Minimum Detectable Concentrations

The MDC of radionuclides in soils are determined for static and scanning instruments to verify that instrument sensitivities are sufficient to demonstrate compliance with screening criteria and/or to satisfy the site investigation DQOs. The MDC calculations are presented in Appendix C. The MDC analysis demonstrated that the walkover survey methodology provided an acceptable MDC and meets the investigation DQOs.

The SS22 West WP established a procedure for determining the investigation level (IL). After collecting background measurements, the IL was calculated as 5,218 cpm. However, once in the field, it was determined that this IL was far too low and time would not allow for the additional characterization steps to be taken at all locations with gamma count rates greater than the IL. Therefore, the project health physicist analyzed the field count rate data and selected a more reasonable IL of 6,000 cpm, which was determined using the mean background count rate (4,312 cpm) plus approximately 3 times the standard deviation (535 cpm) of the complete data set of 53,252 data points which were recorded once every second.

Application of the IL resulted in 86 survey locations that were further characterized with direct gamma measurements. Each of these 86 locations is representative of one or more consecutive measurements. The point with the highest count rate in a set of consecutive measurements greater than 6,000 cpm was assigned as the single location for additional characterization. Measurements that the survey technician noted as electronic noise were deleted from this data set. Electronic noise was indicated by a sudden burst of counts that could not be replicated when the surveyor paused over the area where the burst occurred.

Walkover survey data is presented on maps at the end of Section 4 that plot the data point and assign a color coding to the data point on the map. The color-coded data are grouped as follows: data points below the original IL of 5,218 cpm, data points between the original IL and the revised IL of 6,000 cpm, increments of 1,000 cpm above 6,000 cpm to 9,000 cpm, and from 9,000 cpm (approximately twice background) to the maximum count rate detected.

3.3 Systematic Soil Sampling for Radiological Contaminants

3.3.1 Number of Soil Samples

3.3.1.1 SS22 East

It was determined in the SS22 East WP that a minimum of 12 surface soil samples were required for collection in the background reference area and in each of the survey units to meet the DQOs presented in the Management Plan for SS22 (Earth Tech 2008a). Table 3-2 provides a summary of

the number of samples taken in the background reference area and the three geophysical anomaly areas in SS22 East.

Table 3-2: SS22 East Soil Sample Analysis Summary

Site	Location	Number of Samples	Number of Field Replicates	Total Number of Samples
Background Reference Area	Surface soil	12	2	14
Anomaly Area #2	Systematic surface soil	12	2	32
	Surface hot spot	3	0	
	Trench hot spot	6	0	
	Soil borings	9	0	
Anomaly Area #3	Systematic surface soil	12	2	26
	Surface hot spot	0	0	
	Trench hot spot	8	0	
	Soil borings	4	0	
Anomaly Area #11	Systematic surface soil	12	2	27
	Surface hot spot	1	0	
	Trench hot spot	10	0	
	Soil borings	2	0	
Total		**91**	**8**	**99**

Note: A “hot spot” is defined as a location where the gamma count rate exceeded twice the average background count rate.

As described in Section 3.2.1.3, the scan MDC is less than the screening value. In accordance with MARSSIM (NRC, DOE, EPA, and DoD 2000) and the SS22 East WP, the number of samples identified is therefore sufficient. In the event the scan MDC had been greater than the screening level, additional samples would have been required to meet the confidence limits defined in the DQOs.

The results of the soil samples collected in SS22 East were available during the planning phase for the SS22 West characterization. The systematic surface soil sampling approach (MARSSIM approach) presented in the SS22 East WP did not yield data of any significance for demonstrating that the survey areas are free of radioactive materials in excess of the screening criteria. Such a systematic approach is best suited for larger areas of disperse contamination, not very small areas of contamination or point sources. Therefore, the SS22 West WP did not propose any systematic surface soil sampling.

3.3.1.2 SS22 West

In accordance with the SS22 West WP, surface soil sampling in SS22 West consisted only of sampling at biased locations. Biased locations include those where there was a greater potential for contamination based on the walkover gamma survey results – walkover gamma count rates were greater than the IL. Table 3-3 provides a summary of the seven surface soil samples collected in SS22 West. The basis for the selection of these seven locations is provided below in Section 3.3.2.4.

Table 3-3: SS22 West Soil Sample Analysis Summary

Site	Location	Number of Samples	Number of Field Replicates	Total Number of Samples
Background Reference Area	See Table 3-2			
Anomaly Areas #16 – #28	Surface hot spot (> IL)	7	3	
	Trench hot spot	27	0	
	Soil borings	0	0	
Total		**34**	**3**	**37**

3.3.2 Location of SS22 Surface Soil Samples

3.3.2.1 SS22 East Background Reference Areas

The SS22 East background reference area received a walkover survey and systematic soil sampling in 2008. Background reference area soil sample points were located within a 100-foot by 200-foot area in the northeast corner of SS22 East as shown on Figure 3-1. Sampling locations were determined using a random-start triangular grid pattern. Following this pattern, only 11 sampling points fit within the background reference area so a 12th sampling location was randomly selected. The background sample points and their locations are provided in Table 3-4 and Figure 3-1. The origin of the north/east sample grid system was located in the southwestern corner of the grid.

3.3.2.2 SS22 West Background Reference Areas

Soil samples collected in the SS22 East background reference area are considered to be representative of SS22 West soils as well. Therefore, soil samples were not collected in the background reference area located in SS22 West. Only walkover gamma rate data was collected in the background reference area.

3.3.2.3 SS22 East Anomaly Areas

A total of 12 sample points were located within each of the three anomaly areas using a random-start triangular grid pattern as shown on Figure 3-2, Figure 3-3, and Figure 3-4. The sample point locations are provided in Table 3-4. The origin of each sample grid system was located in the southwestern corner of the survey area.

During the walkover survey, stakes were used to indicate the location of the survey hot spots. Surface soil samples were later collected at these locations.

Table 3-4: SS22 East Surface Soil Sampling Locations

	Background (SS22ANBK-SS)		Anomaly Area #2 (SS22AN02-SS)		Anomaly Area #3 (SS22AN03-SS)		Anomaly Area #11 (SS22AN11-SS)	
Sample Number	Feet North	Feet East	Feet North	Feet East	Feet North	Feet East	Feet North	Feet East
Systematic Grid Samples								
-001 *	74.8	78.4	80.4	109.9	215.2	114.0	48.5	32.9
-002	122.1	78.4	22.0	109.9	281.5	114.0	84.6	32.9
-003	169.4	78.4	138.8	109.9	148.9	114.0	66.6	64.2
-004	216.6	78.4	197.2	109.9	82.6	114.0	102.7	64.2
-005	27.6	78.4	51.2	59.4	16.3	114.0	138.8	64.2
-006	51.2	119.3	109.6	59.4	314.7	56.6	48.5	95.4
-007	98.5	119.3	168.0	59.4	182.1	56.6	84.6	95.4
-008	193.0	37.4	226.4	59.4	115.8	56.6	120.7	95.4
-009	145.7	37.4	255.6	8.8	49.5	56.6	156.8	95.4
-010	98.5	37.4	168.0	160.5	49.5	171.5	102.7	126.7
-011	51.2	37.4	109.6	160.5	115.8	171.5	138.8	126.7
-012	149.3	91.6	51.2	160.5	182.1	171.5	30.5	64.2
Replicate Samples								
-013	51.2	37.4	109.6	160.5	115.8	171.5	138.8	126.7
-014	149.3	91.6	51.2	160.5	182.1	171.5	30.5	64.2

* Random start point

3.3.2.4 SS22 West Anomaly Areas

Following the gamma walkover surveys in SS22 West, there were 86 locations with gamma scan count rates greater than the IL of 6,000 cpm. Of these locations, only one location had a direct gamma measurement greater than 6,000 cpm. A surface soil sample was taken at this single location and five other surface soil samples were taken at randomly selected locations where the scan count rate was greater than 6,000 cpm. The surface soil sampling locations are provided on Figure 3-5 and in Table 3-5.

Table 3-5: SS22 West Surface Soil Sampling Locations

Sample Number	GPS Coordinates [a]		Gamma Measurements (cpm)	
	Northing	Easting	Walkover (Scan)	Direct (1-minute)
17RAD29-310810 17RAD01-010810	6793683.8452	351337.3058	6108	4437
19RAD30-240810	6793687.5481	351280.2239	13108	4714 [b]
19RAD31-240810	6793681.2151	351284.5415	10199	10650
20RAD33-310810	6793663.8238	351317.8880	11814	4154
20RAD34-010910	6793667.6044	351304.0112	8554	4091
22RAD37-010910	673636.9458	351200.7459	6310	3895

[a] Coordinate System: WGS 1984 UTM Zone 6N.
[b] Near surface Ra-226 source removed prior to taking direct measurement.

3.3.3 Surface Soil Sample Collection Methods

A total of 67 background and geophysical anomaly area surface soil samples were collected at SS22 (60 surface soil samples from SS22 East and 7 surface soil samples from SS22 West). Surface soil samples were collected from the first 6 inches of soil at the sampling location. Organic material and rocks were avoided while collecting the sample. The samples were collected in 0.5-liter glass/plastic containers. Replicate samples were collected immediately adjacent to their corresponding primary sample.

3.4 SS22 Trenching Methodology

Trenching was conducted during both the SS22 East and the SS22 West characterization efforts as an investigational tool to inspect a small cross section of each geophysical anomaly to determine the types of materials buried in the subsurface. Sections 3.4.1 and 3.4.2 below describe the two methodologies used for determining trench locations, length and width, collection of subsurface soil samples, and detection of radioactive materials.

3.4.1 SS22 East Trenching

An investigational trench was excavated in each of the three geophysical anomaly areas to visually inspect materials buried below the ground surface. The location, depth, and extent of the trenches were determined based on the specifications established during the Triad Meeting held between the Air Force, United States Environmental Protection Agency (EPA), and Alaska Department of Environmental Conservation on 13 March 2008.

The objective set forth by the EPA was to determine the extent of buried debris in the anomaly area (Earth Tech 2008b). The direction of trench construction was selected based on the orientation that

offered the greatest length across the respective anomaly. Table 3-6 provides the direction of each of the SS22 East geophysical anomaly trenches.

In the case of Anomaly Areas #2 and #11, elevated areas of radioactivity were found during previous surveys. Trench orientation was placed to deliberately intersect the approximate area of elevated radioactivity. Anomaly Area #3 was designated for trenching based on the concurrent non-radiological characterization work being conducted on the site.

The length and depth of the final trenches were determined by the extent of the buried debris found during the trenching activities. Following the excavation, health physics personnel surveyed the excavated material but, due to safety concerns, did not enter the trenches to survey the trench bottom or side walls. Samples were collected from the soil excavated from the trenches indicating the highest gamma count rates. Samples were also collected for analysis at random locations. The samples were collected in 0.5-liter containers. Table 3-6 lists the number of samples collected at the trenches.

Table 3-6: SS22 East Trenching

Geophysical Anomaly Number	Orientation	Length (ft)	Depth (ft)	Radioactive Materials Identified	Number of Samples Collected
2	North-South	99	10	None	6
3	East-West	193	6.5	1 dial and 1 gauge	8
11	Southeast-Northwest	102	4.5	Localized contaminated soil; no source	10

3.4.2 SS22 West Trenching

An investigational trench was excavated in each of the 13 geophysical anomaly areas located in SS22 West to visually inspect materials buried below the ground surface. The location and extent of the trenches were based on the findings of the SS22 West geophysical survey conducted at the site just prior to trenching operations.

The direction of trench construction was based on covering a minimum of 50% of the long axis of the anomaly such that the trench intersected the highest conductivity readings found during the geophysical survey. Table 3-7 provides the direction of each of the SS22 West geophysical anomaly trenches.

Table 3-7: SS22 West Trenching

Geophysical Anomaly Number	Orientation	Length (ft)	Depth (ft)	Radioactive Materials Identified	Number of Samples Collected
16 (DRMO)	North-South	80	6	None	0
17 (DRMO)	East-West	120	8	None	3
18 (DRMO)	East-West	25	6	None	0
19 (DRMO)	East-West	80	12	Gauge and lamp assembly with radium switch	4
20 (RV Lot)	East-West	30	16	Gauge, 3 rocks, a speedometer hand, and some contaminated soil	6
21(RV Lot)	East-West	90	20	Speedometer hand	1
22(RV Lot)	East-West	80	14	None	0
23 (Trench A) (RV Lot)	East-West	50	22	Gauge and partial speedometer hand	1
23 (Trench B) (RV Lot)	East-West	40	20	None	0
24 (RV Lot)	North-South	70	16	7 toggle switches and a complete dash board with radium gauges	8
25 (RV Lot)	North-South	70	25	Partial gauge, dash board with two sources	3
26 (RV Lot)	North-South	20	10	None	0
27 (RV Lot)	North-South	70	10	Gauge and switch	3
28 (RV Lot)	North-South	50	12	Dual dials, radio transmitter/receiver with power supply	2

The length of each trench was a minimum of 50% of the actual anomaly length. Each trench was excavated until native material was encountered in the bottom of the trench. The maximum depth of the trenches was 25 ft. The width of each trench was initially marked off as 10 ft. Due to the wet and unstable soil in and around the trench area, as well as the sometimes large debris being removed from the trenches, 10 ft was the minimum trench width. Trench width ranged from a minimum of 10 ft to nearly 20 ft.

Following the excavation, health physics personnel surveyed the excavated material but, due to safety concerns, did not enter the trenches to survey the trench bottom or side walls. Samples were collected from the soil located under and adjacent to the radioactive items excavated from the trenches. Subsurface soil samples were collected in 0.5-liter glass/plastic containers. Table 3-7 lists the number of samples collected in the trenches. No random subsurface soil samples were collected from SS22 West.

3.5 Subsurface Soil Borings

As an adjunct to the May 2009 non-radiological investigation at SS22 East, soil samples were collected from subsurface borings for radiological analysis. The selection of the boring interval sent for analysis was a function of the non-radiological sampling requirements. The boring interval that showed the highest chemical field screening value was selected for radiological analysis. If no elevated chemical field screening readings were found, the bottom interval was selected for radiological analysis. The soil boring locations are indicated on Figure 3-6.

At SS22 West, ten 5-foot deep soil gas monitoring boreholes and one 25-foot monitoring well were monitored using a 2×2 NaI detector. No radioactive contamination was found at the soil borings. Soil samples were not collected for radiological analysis from any of the soil borings.

3.6 Groundwater Samples

To determine whether any migration of Ra-226 above background levels from SS22 was occurring, groundwater samples were collected from monitoring wells installed around SS22, including both upgradient and downgradient wells. The location of the monitoring wells is shown on Figure 3-7. In 2008, groundwater samples were collected from monitoring wells MW1 through MW17. The 2009 groundwater samples were submitted to ARS International, Inc. (ARS) in Port Allen, Louisiana, for analysis using ARS-008/EPA 903.0, *Alpha-Emitting Radium Isotopes In Drinking Water*. The groundwater samples collected in 2010 were analyzed by ASL Laboratory Group (ASL) in Ft. Collins Colorado. ASL used EPA Method 903.1(m), *Radium-226 in Drinking Water, Radon Emanation Technique*.

3.7 SS22 East Composite Samples

The Air Force Radioisotope Committee (RIC) Secretariat requested in its 11 September 2008 letter (USAF 2008) that composite samples be assembled to determine whether radioisotopes other than Ra-226 are present in site soils above background levels. Thus, for each anomaly area (i.e., Anomaly Areas #2, #3, and #11) and the background reference area, a composite sample was assembled. The composite samples combined both surface and subsurface soils from the respective anomaly areas. Table 3-8 describes the composite samples.

Table 3-8: SS22 Composite Samples

Site	Composite Sample Number	Sample Make Up
Background	1	Surface soil
	2	Groundwater (Wells MW12 and MW13)
Anomaly #2	3	Surface soil & hot spot soil
	4	Trench & subsurface soil
Anomaly #3	5	Surface soil & hot spot soil
	6	Trench & subsurface soil
Anomaly #11	7	Surface soil & hot spot soil
	8	Trench & subsurface soil
Water Wells	9	Groundwater (Wells MW1 – MW11 and MW14 – MW17)

The composites were analyzed for gross alpha/beta activity and isotopic activity by gamma spectroscopy. During the 18 May 2009 telephone conference between the Air Force and the Air Force Prime Contractor, the RIC further requested that groundwater samples from monitoring wells installed at the site be composited and analyzed for gross alpha/beta activity and isotopic activity by gamma spectroscopy.

The Air Force Prime Contractor’s implementation differed slightly from the RIC’s request. The sample mixing used was a superset of the RIC’s requested approach. The composite samples were further subdivided by surface and subsurface classifications. This was done with two objectives:

- Segregating surface and subsurface data from the anomalies allows more refined data to be used in the follow on Comprehensive Environmental Response, Compensation, and Liability Act Human Health Risk Assessment process. The computer codes used in the assessment allow for data collected from the surface soil to be considered as a separate component.
- The larger number of composite samples offers a better probability of capturing discrete radioactive particles that have been shown to exist at the site.

During the two mobilizations in July and October 2010, no composite soil samples were collected for analysis.

3.8 Packing and Shipment of Soil Samples to Offsite Laboratory

Soil samples collected for offsite gamma spectroscopy were shipped under chain-of-custody (COC) protocol to an offsite laboratory. Shipping containers were sealed with a custody seal and labeled with a unique number that was recorded on the COC form along with the bill of lading or the transporter tracking number. Soil samples for radiological analysis did not require preservation or

cooling. Sample containers were monitored with a GM pancake probe to ensure radiological contamination was not present on the soil sample containers.

3.9 Offsite Laboratory Radiological Analysis of Soils

Soil samples collected from SS22 East during 2008 and 2009 were sent to ARS in Port Allen, Louisiana, for laboratory analysis using gamma spectroscopy. The analysis was performed on high-purity germanium detectors using ARS procedure ARS-007/EPA 901.1M, *Modified Gamma Emitting Radionuclides in Water, Soil, Air and Biota Matrixes*. ARS quality control methods used at the laboratory included control sample evaluation, laboratory blank evaluation, and duplicate evaluation.

The soil samples collected from SS22 West in 2010 were analyzed by ASL in Ft. Collins Colorado. These samples were prepared according to ASL procedure SOP739R10. Samples were sealed in steel cans on 9 September 2010 and stored for at least 25 days to allow radon-222 to approach secular equilibrium with its parent, Ra-226. The degree of ingrowth achieved prior to analysis on 4 October 2010 was at least 98.92%. The samples were analyzed for the presence of gamma emitting radionuclides on high-purity germanium detectors according to ASL procedure SOP713R11.

Soil samples submitted to ARS and ASL were analyzed by gamma spectroscopy. The gamma spectroscopy algorithm used by ARS included a library of isotopes including the naturally occurring uranium and thorium series isotopes (including Ra-226 and its decay daughters), potassium-40 (K-40), and other non-naturally occurring isotopes. The extensive ARS library resulted in multiple false positives; therefore, the library used by ASL was limited to only naturally occurring isotopes to eliminate some of the false positives.

3.10 Offsite Laboratory Radiological Analysis of Groundwater

Groundwater samples were collected from monitoring wells MW1 through MW17 in May 2009 and submitted to ARS for analysis using ARS-008/EPA 903.0, *Alpha-Emitting Radium Isotopes In Drinking Water*. The groundwater samples collected in 2010 were analyzed by ASL. ASL used EPA Method 903.1(m), *Radium-226 in Drinking Water, Radon Emanation Technique* and analyzed for Ra-226 by EPA Method 903.0.

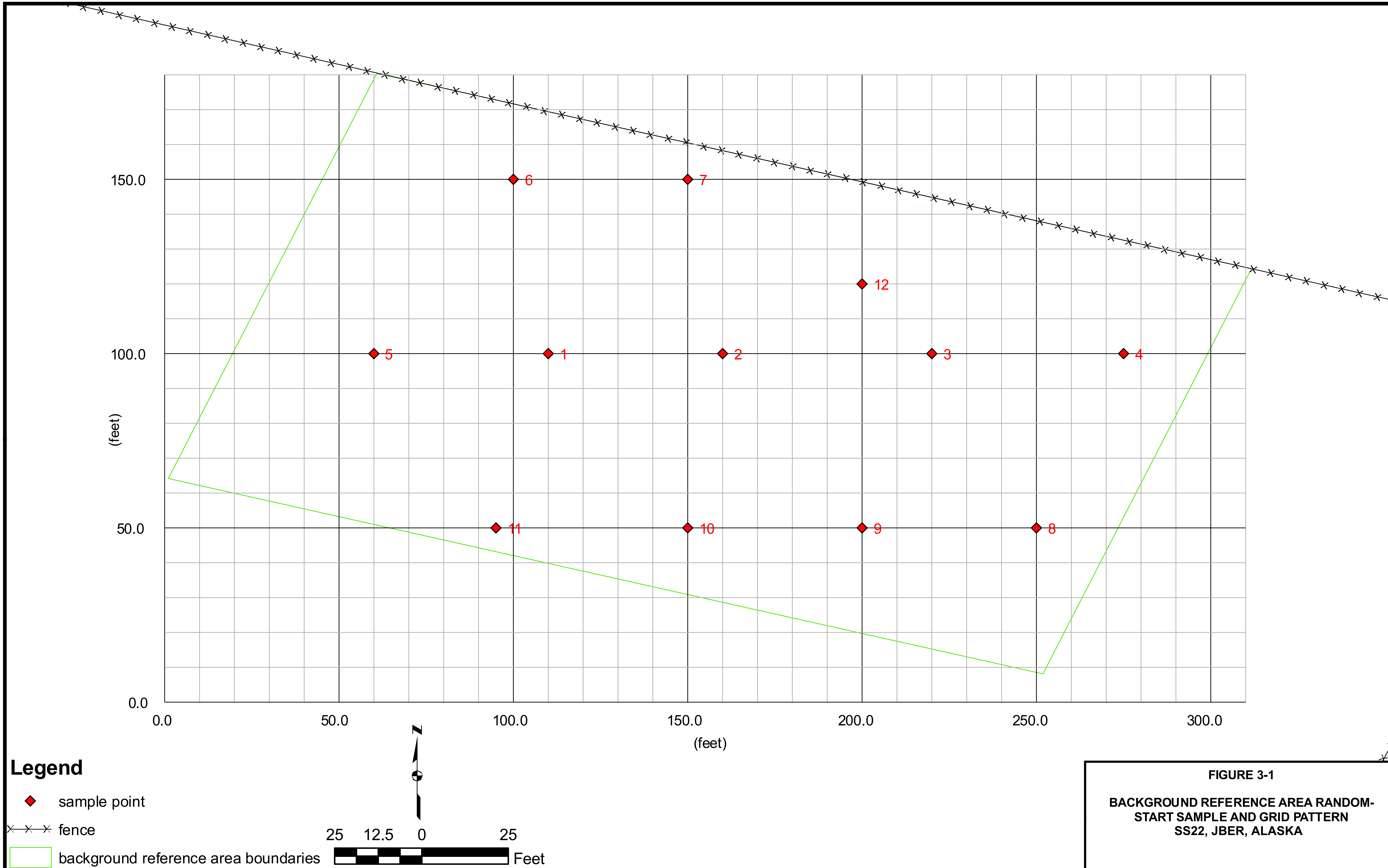


FIGURE 3-1

BACKGROUND REFERENCE AREA RANDOM-START SAMPLE AND GRID PATTERN SS22, JBER, ALASKA

(Denver) L:\GROUP\CAD\ELMENDORF AFB\JULY09\GRID999.MXD DATE: 7/20/2009

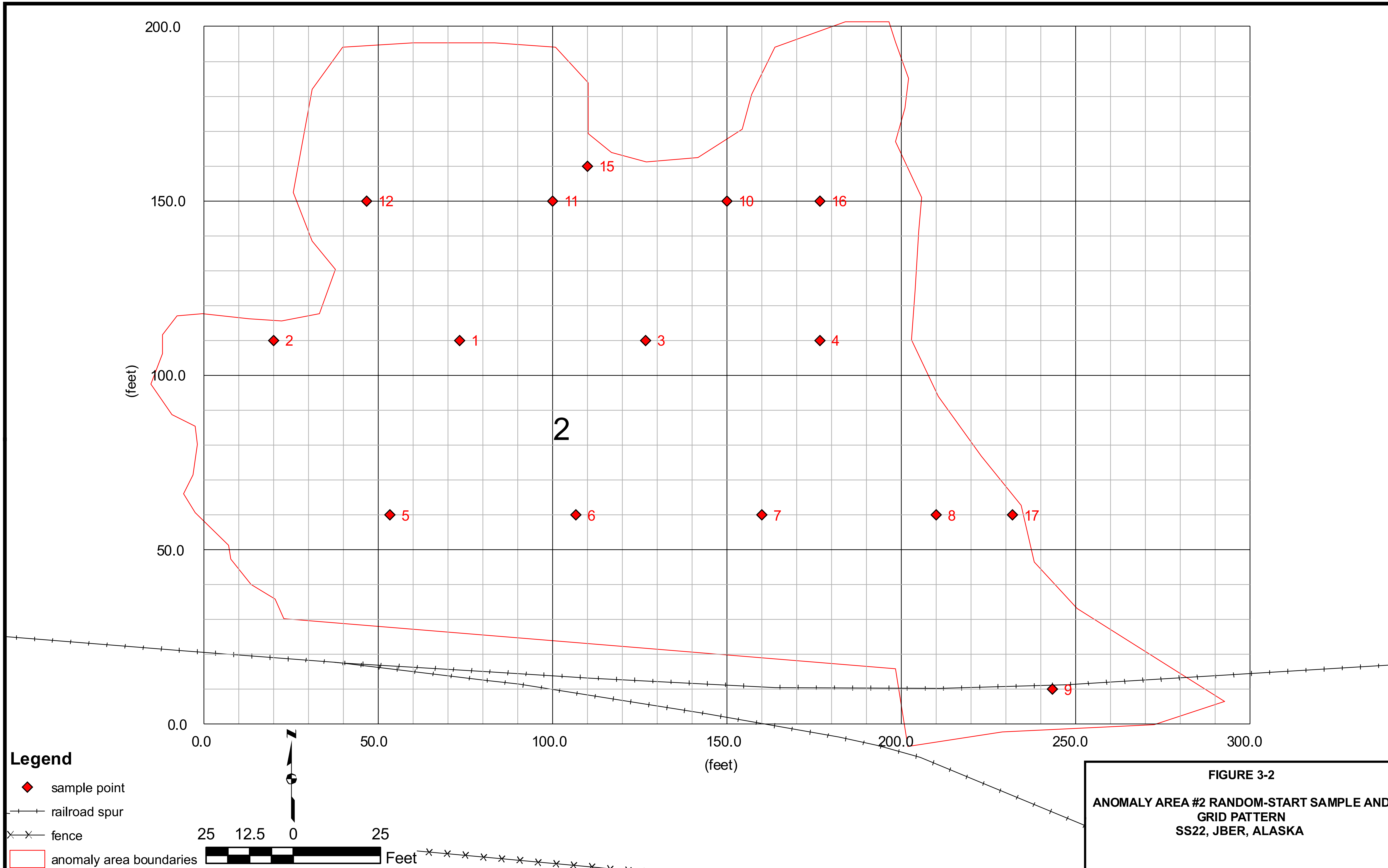


FIGURE 3-2

ANOMALY AREA #2 RANDOM-START SAMPLE AND GRID PATTERN
SS22, JBER, ALASKA

(Denver) L:\GROUP\CAD\ELMENDORF AFB\JULY09\GRID2.MXD DATE: 7/20/2009

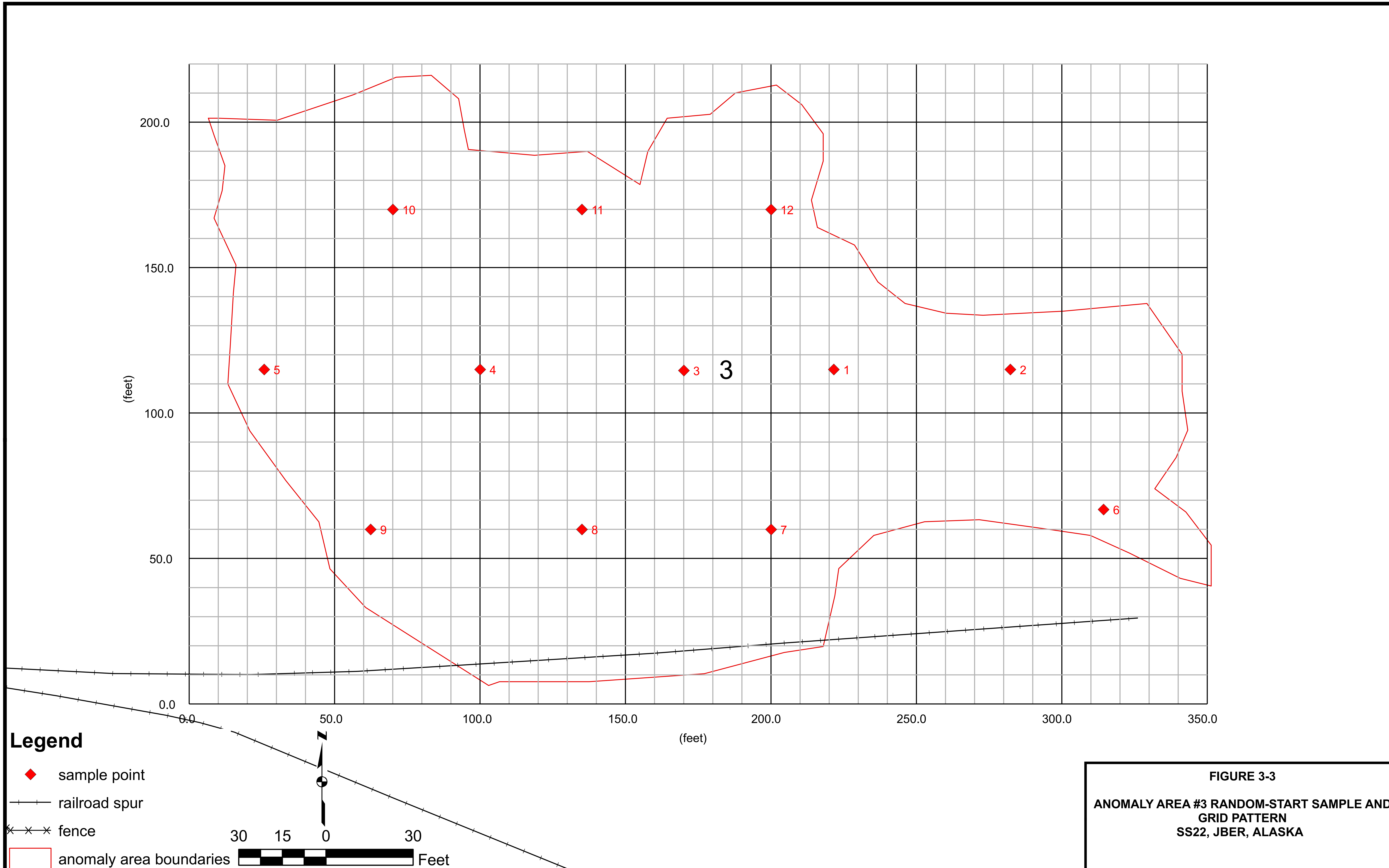


FIGURE 3-3

ANOMALY AREA #3 RANDOM-START SAMPLE AND GRID PATTERN
SS22, JBER, ALASKA

(Denver) L:\GROUP\CAD\ELMENDORF AFB\JULY09\GRID3.MXD DATE: 7/20/2009

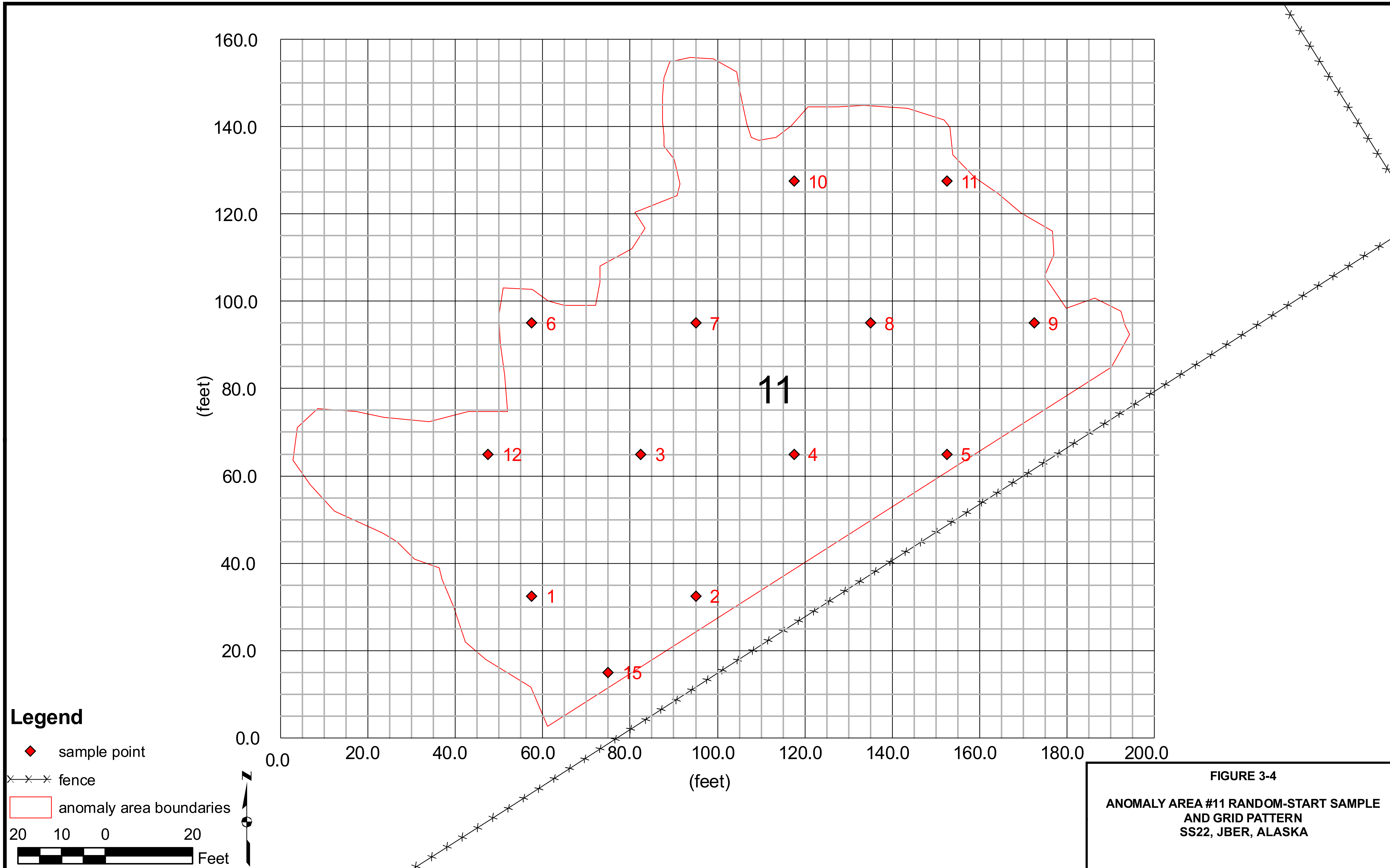


FIGURE 3-4

ANOMALY AREA #11 RANDOM-START SAMPLE AND GRID PATTERN
SS22, JBER, ALASKA

(Denver) L:\GROUP\CAD\ELMENDORF AFB\JULY09\GRID11.MXD DATE: 7/20/2009

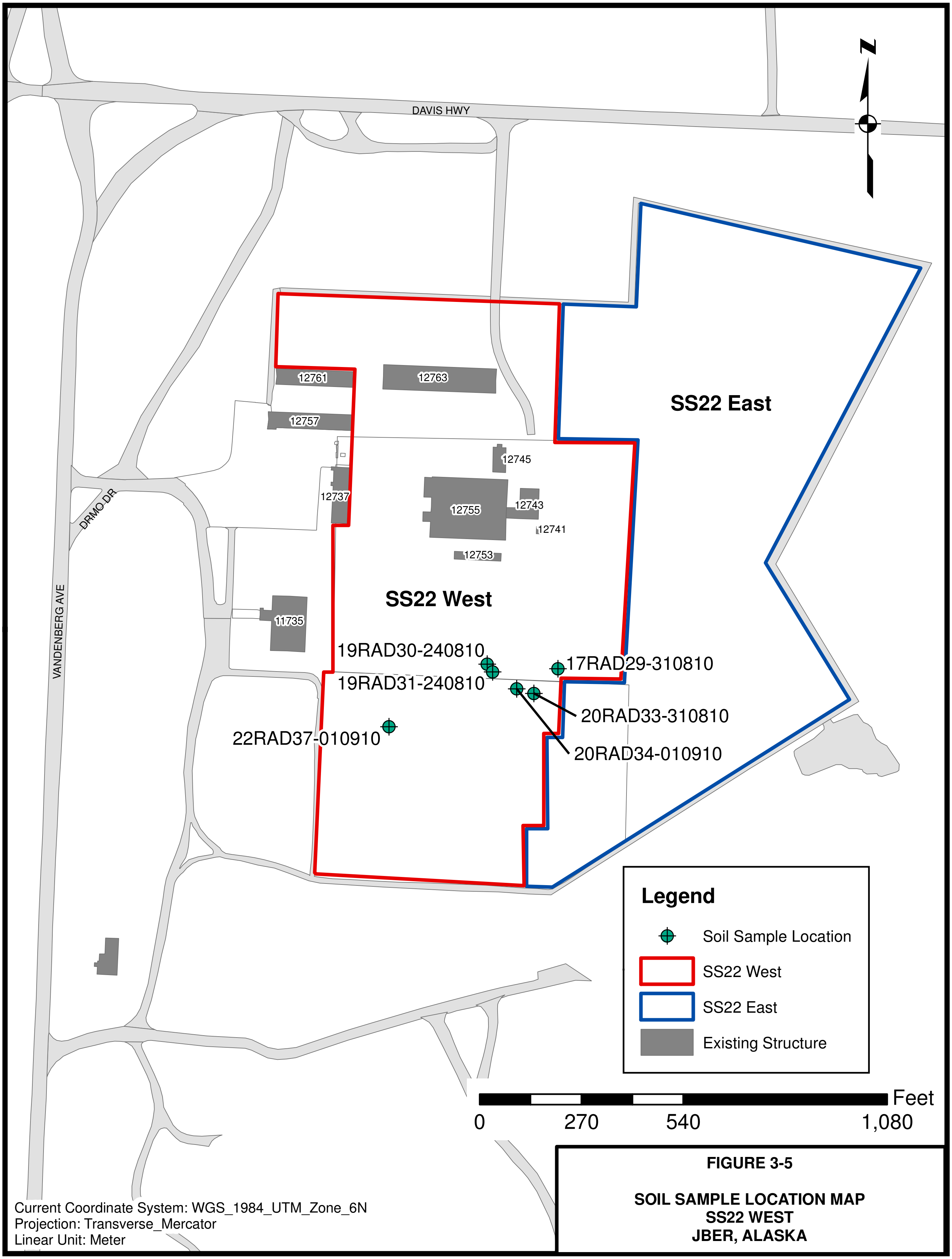


FIGURE 3-5

SOIL SAMPLE LOCATION MAP
SS22 WEST
JBER, ALASKA

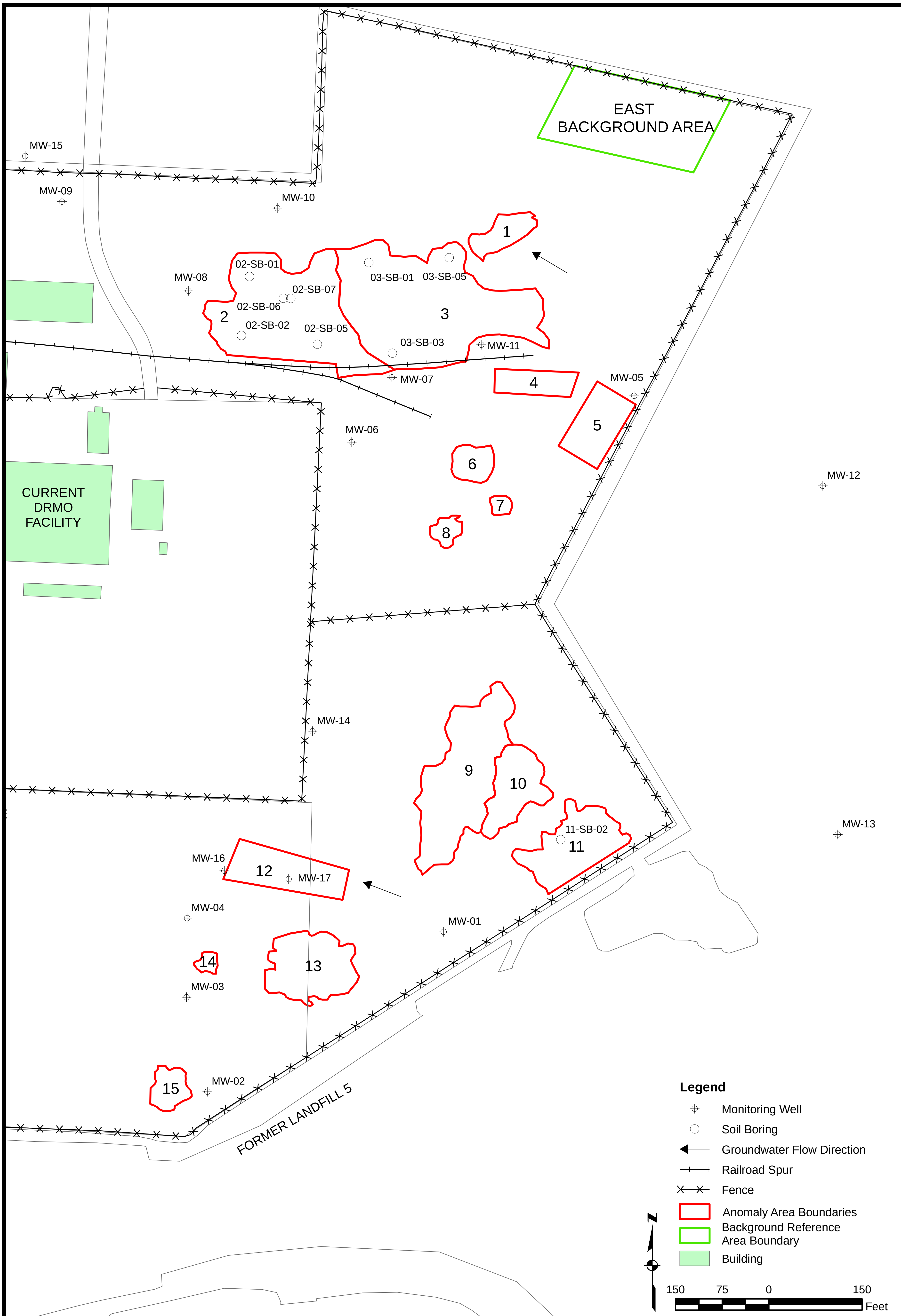
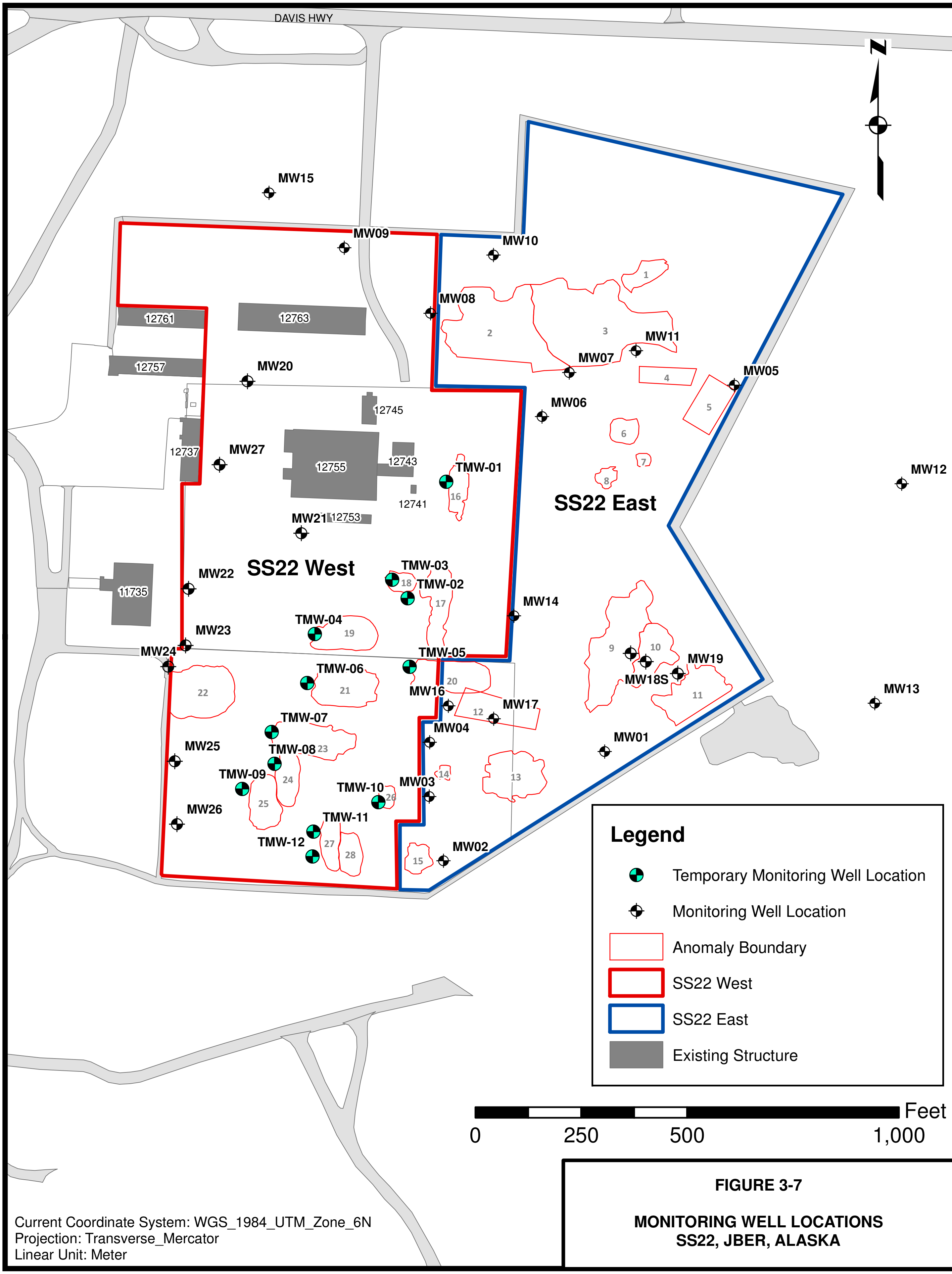


FIGURE 3-6

SOIL BORING AND MONITORING WELL LOCATIONS
SS22, JBER, ALASKA

Path: \\ushnl1fp002\data\work\AFCEE\Alaska\TO 0208 Elemendorf (FFP)\7.0 Deliverables\Rad Charac. Rpt\3 Working Final\Draft Figures\Native Files\Figure 3-6 Ver9_SD.mxd



Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 3-7

MONITORING WELL LOCATIONS
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\Maps\Monitoring Well Location Map_R1.mxd

4. RESULTS

4.1 Background Surveys and Sampling

4.1.1 SS22 East Background

The objective of the background reference area survey was to establish instrument response to naturally occurring radioisotopes in the area. As stated in Section 2.3, the background survey area was chosen because it had been identified as an area not containing geophysical anomalies and appeared to have remained undisturbed based on a review of historical aerial photographs.

The average gamma count rate for the background walkover survey was 14,191 cpm using the unshielded 3×3 NaI detector. Count rates ranged from 12,313 to 16,448 cpm with a standard deviation of 553 cpm. The survey consisted of 9,624 data points. The gamma walkover survey was conducted with the detector mounted in a rolling cart approximately 4 to 6 inches above the ground surface. Background gamma exposure rates were between 5 to 7 micro Roentgen per hour (μR/hr).

The one-minute static direct gamma count rate measurements provided in Table 4-1 were made at the ground surface or as close as possible to the ground surface if objects intervened (generally 1 to 2 inches). These static measurements are within the range of the gamma walkover survey results.

Analysis of the 14 background surface soil samples (including the two replicate samples) indicated that the mean background concentration for Ra-226 is about 1 pCi/g (0.96 ± 0.07 pCi/g). This background concentration is consistent with natural concentrations in various soil types and geographic regions in North America. Other naturally occurring isotopes such as uranuium-238 (U-238), thorium-232 (Th-232), their respective decay daughters, and K-40 are also within expected background levels. However, because they are not considered contaminants of potential concern (COPCs), the data is not presented here.

Table 4-1 provides a summary of the Ra-226 concentrations, which ranged from 0.7 ± 0.2 pCi/g to 1.4 ± 0.5 pCi/g, along with a statistical summary to aid the reader in evaluating the data set. Statistical data is provided in Table 4-1. Figure 4-1 shows the location of each background sample along with its respective soil concentration and gamma count rate. Figure 4-2 provides the distribution of the walkover survey data from the background reference area (unshielded 3×3 NaI detector). The purpose of the histogram plot is to display the natural distribution of the data for comparison against the distribution of the data from the Anomaly Area surveys.

Table 4-1: SS22 East Background Surface Soil Concentrations

Sample ID Number	Ra-226 (pCi/g)	Direct Gamma Count Rate (cpm) [a]
SS22ANBK-SS-001	0.9 ± 0.3	13,984
SS22ANBK-SS-002	1.4 ± 0.5	14,066
SS22ANBK-SS-003	0.8 ± 0.2	14,169
SS22ANBK-SS-004	0.9 ± 0.3	13,970
SS22ANBK-SS-005	1.3 ± 0.3	13,777
SS22ANBK-SS-006	1.1 ± 0.3	13,729
SS22ANBK-SS-007	0.9 ± 0.2	13,981
SS22ANBK-SS-008	1.0 ± 0.3	13,873
SS22ANBK-SS-009	1.1 ± 0.3	14,245
SS22ANBK-SS-010	1.1 ± 0.3	14,238
SS22ANBK-SS-011	0.7 ± 0.2	14,510
SS22ANBK-SS-012	1.1 ± 0.2	14,480
SS22ANBK-SS-013 [b]	0.9 ± 0.3	14,238
SS22ANBK-SS-014 [c]	1.0 ± 0.3	14,480
Statistics		
Weighted Average	0.96 ± 0.07	—
Mean	1.0 ± 0.08	14,000 ± 500
Maximum	1.4 ± 0.5	14,510
Minimum	0.7 ± 0.2	13,729

ID identification
[a] Taken at ground level or close as possible to the ground level if objects interfered (generally 1 to 2 inches above ground level).
[b] Co-located sample with SS22ANBK-SS-010.
[c] Co-located sample with SS22ANBK-SS-012.

4.1.2 SS22 West Background

The objective of the background reference area surveys in SS22 West was to establish instrument response to naturally occurring radioisotopes considering various ground cover materials. As stated in Section 2.4 for SS22 East, the background survey areas for SS22 West (Figure 4-3) were chosen because they had been identified as an area not containing geophysical anomalies. The background reference areas included:

1. Paved area west of Anomaly Area #19 inside the DRMO fence (northern survey area in Figure 4-3)
2. Unpaved area west of Anomaly Area #19 between the asphalt pad and the southern DRMO fence (southeastern survey area in Figure 4-3)
3. Gravel covered drive just outside the western gate to the RV Lot (southwestern survey area in Figure 4-3)

The gamma walkover surveys of the three background areas were conducted with the detector mounted in a rolling cart approximately three inches above the ground surface. There was no noticeable difference in gamma count rate distribution in each of these areas. Therefore, they are grouped into a single background data set. The average gamma count rate for the background walkover surveys was 4,440 cpm using a shielded 3×3 NaI detector. Count rates ranged from 3,318 to 6,280 cpm with a standard deviation of 448 cpm. The surveys consisted of a total of 746 data points. The data distribution for the SS22 West background survey (shielded 3×3 NaI detector) is shown on Figure 4-4. Background gamma exposure rates were between 5 to 7 μR/hr.

No surface soil samples were collected in the background reference areas of SS22 West. Soil samples were not necessary since it had already been determined that Ra-226 concentrations existed in the natural soils of Site SS22 and it had been determined that no anomalies existed in the background reference area chosen for SS22 West.

4.2 Gamma Walkover Surveys

4.2.1 SS22 East Scoping Surveys

The results of the 2007 scanning survey of each of the 15 geophysical anomaly areas are provided in Table 4-2. Gamma count rates are provided in gross cpm. Background count rates were established prior to entering each of the anomalies. When a count rate approximately twice the observed background was encountered, the detector was placed on the location exhibiting the highest count rate and a contact reading was recorded. The SS22 East 2007 scoping survey results are shown on Figure 4-5.

Table 4-2: SS22 East 2007 Scoping Survey Summary

Geophysical Anomaly Number	Average Background (cpm)	Area Coverage (%)	Summary	Direct Contact Measurements (cpm)
1	10K – 12K	100	No readings above background	—
2	11K – 13K	100	Several readings above background ranges were encountered as well as a general area of slightly elevated activity	#1 – 102K #2 – 186K #3 – 282K
3	10K – 12K	100	No readings above background	—
4	11K – 13K	100	No readings above background	—
5	10K – 13K	100	No readings above background	—
6	10K – 13K	100	No readings above background	—
7	10K – 14K	100	Readings were slightly above background in some areas; it was concluded the slightly elevated areas coincided with tar/asphalt materials	—
8	11K – 13K	100	No readings above background	—

Geophysical Anomaly Number	Average Background (cpm)	Area Coverage (%)	Summary	Direct Contact Measurements (cpm)
9	10K – 12K	80	No readings above background	—
10	10K – 12K	70	No readings above background	—
11	10K – 13K	50	One location exhibited a reading in excess of 20K cpm at one foot	42K
12	11K – 13K	100	No readings above background	—
13	11K – 15K	100	While some readings were slightly above background, no readings were significantly above background	—
14	10K – 12K	60	No readings above background	—
15	10K – 12K	70	No readings above background	—

4.2.2 SS22 East Characterization Surveys

Anomaly Area #2 and #3 received a 100% walkover survey. For Anomaly Area #11, standing vegetation partially obscured the anomaly area during the 2007 survey resulting in only about 50% of the area receiving survey coverage. Anomaly Area #11 was cleared of vegetation prior to the 2008 survey to allow a 100% survey. Figure 4-6 shows the results of the 2008 SS22 East walkover characterization surveys. Table 4-3 provides a statistical summary of the 2008 gamma walkover survey data and the type of ground cover in the area. Gamma count rates are provided in gross cpm.

Table 4-3 provides the number of walkover survey data points that correlate to a surface soil Ra-226 activity of about 2 pCi/g or more above background. Appendix C derives a ratio of Ra-226 soil concentration to the resulting exposure rate measured in pCi/g per µR/hr of 2.15 (or 0.47 µR/hr per pCi/g) and an estimated efficiency of 2,300 cpm per µR/hr for the 3x3 NaI(Tl) detector. Therefore, the 2 pCi/g Ra-226 screening level corresponds to about 2,100 cpm above the mean background, or 16,291 gross cpm. While the derivations provided in Appendix C do not necessarily have a linear correlation to field measurements, this method provides an overall evaluation of the potential for contamination above the screening level.

All of the walkover surveys were conducted using the same instrumentation. Daily instrument checks (see Appendix B) ensured consistent detector response despite changing weather conditions during the survey effort. Consequently, gamma walkover survey data are comparable regardless of when it was collected. The walkover survey data are shown in frequency charts at the end of this section for comparison against the natural background distribution and for identification of outliers or “hot spots.” The chart is shown on a logarithmic scale so that outliers are more easily identified.

Table 4-3: SS22 East 2008 Characterization Survey Summary Statistics

Parameter	Background	Anomaly Area #2	Anomaly Area #3	Anomaly Area #11
Ground Cover	Natural	Natural	Natural	Natural
Number of Measurements	9,624	15,156	15,338	10,563
Mean Count Rate (cpm)	14,191	15,027	13,665	14,104
Median Count Rate (cpm)	14,178	14,871	13,652	13,944
Maximum Count Rate (cpm)	16,448	132,451	22,906	214,773
Number of Measurements > Background + 2 pCi/g [a]	N/A	2,260	37	77
Number of Measurements > 2 × Mean Background [b]	N/A	6	0	20

N/A not applicable
[a] 16,291 cpm
[b] 28,382 cpm

4.2.3 SS22 West Characterization Surveys

SS22 West anomaly areas each received a 100% walkover survey with a transect spacing of 22 inches except for Anomaly Areas #27 and #28. The walkover survey in Anomaly Areas #27 and #28 covered about 30% of the area. In these areas, the spacing between transects was increased to a width of about 65 to 70 inches to meet the project schedule. The decision to increase the spacing was made by the project health physicist based on observations made during the previous surveys in the RV Lot.

All walkover surveys were conducted using the same shielded 3×3 NaI detector. Daily instrument checks (see Appendix B) ensured consistent detector response despite changing weather conditions during the survey effort. Consequently, gamma walkover survey data are comparable regardless of when they were collected. The SS22 West gamma walkover survey results are summarized in Table 4-4. Figure 4-7 shows the results of all SS22 West walkover surveys.

Table 4-4 provides the number of walkover survey data points that may correlate to a surface soil Ra-226 activity of about 2 pCi/g or more above background. Appendix C describes the use of a known Ra-226 source to approximate the shielded 3x3 NaI detector efficiency as 1,890 cpm to µR/hr. Additionally, Appendix C describes the use of the MicroShield dose modeling software to derive a relationship between exposure rate and Ra-226 activity in soil (0.853 µR/hr per pCi/g). Therefore, the 2 pCi/g Ra-226 screening level corresponds to about 3,224 cpm above the mean background, or 7,664 gross cpm. While the derivations provided in Appendix C do not necessarily have a linear correlation to field measurements, this method provides an overall evaluation of the potential for contamination above the screening level. The values in Table 4-4 include all data points,

including points that were later eliminated because they could not be reproduced with additional surveys.

The walkover survey data are shown in frequency charts at the end of this section for comparison against the natural background distribution shown in previous figures and for identification of outliers or “hot spots.” The chart is shown on a logarithmic scale so that outliers are more easily identified.

Survey maps presented in the following section show all the data that was collected (including electronic noise and multiple measurements at the same location).

Table 4-4: SS22 West Walkover Survey Summary Statistics

Parameter	Background (3 areas)	DRMO			
		Anomaly Area #16	Anomaly Area #17	Anomaly Area #18	Anomaly Area #19
Ground Cover	Natural, Gravel, & Asphalt	Asphalt	Asphalt	Asphalt	80%/20% Natural/ Asphalt
Number of Measurements	746	2,570	1,027	5,624	4,408
Mean Count Rate (cpm)	4,440	4,408	4,335	4,559	4,512
Median Count Rate (cpm)	4,412	4,369	4,332	4,517	4,441
Maximum Count Rate (cpm)	6,280	6,656	5,472	6,646	13,108
Number of Measurements > Background + 2 pCi/g [a]	N/A	0	0	0	16
Number of Measurements > 2 × Mean Background [b]	N/A	0	0	0	10

Parameter	RV Lot					
	Anomaly Area #20	Anomaly Area #21	Anomaly Area #22	Anomaly Area #23, #24, #25	Anomaly Area #26	Anomaly Areas #27, 28
Ground Cover	30%/70% Natural/ Gravel	Gravel	Gravel	Gravel	Gravel	Gravel
Number of Measurements	6,277	3,761	6,162	17,778	585	4,664
Mean Count Rate (cpm)	4,432	4,304	4,329	4,151	4,383	4,176
Median Count Rate (cpm)	4,364	4,269	4,293	4,110	4,350	4,152
Maximum Count Rate (cpm)	19,624	6,620	7,192	28,864	6,273	5,832
Number of Measurements > Background + 2 pCi/g [a]	15	0	0	20	0	0
Number of Measurements > 2 × Mean Background [b]	7	0	0	16	0	0

N/A not applicable
[a] 7,664 cpm
[b] 8,880 cpm

4.3 SS22 Anomaly Area Surface Soil Surveys and Sampling

The criteria for collecting surface soil samples in SS22 West differed from the criteria used for surface soil samples collected in SS22 East. In SS22 East, surface soil samples were collected using MARSSIM protocols which recommended determining the number of sample point locations based on a triangular grid pattern. Using MARSSIM protocols a total of 12 surface soil samples were collected in each of the 3 anomalies as well as 12 surface soil samples in the established background area.

In SS22 West, surface soil samples were taken only at locations where the walkover survey IL of 6,000 gross cpm was exceeded. During the walkover gamma survey 84 locations were determined to be above 6,000 gross cpm. These 84 locations did not include measurements that were determined by the survey technician to be detector "noise." Electronic noise was identified as a sudden burst of counts that could not be replicated when the surveyor paused over the area where the burst occurred. A measurement location may also consist of more than one data point greater than 6,000 cpm. The survey technician would often pause or back up over a location if it was thought to be elevated, resulting in multiple data points collected in the same general area.

A scaler measurement was collected at each of the 84 measurement locations. The scaler measurements were collected with a 3×3 NaI detector located 3 inches above the ground surface the same height as the 3×3 detector used in the buggy during the walkover gamma survey. All 84 one-minute scaler measurements were less than 6,000 cpm except for the two hot spots located in Anomaly Area #19 in the DRMO fenced area. Surface soil samples were collected at these two hot spots located in Anomaly Area #19 and at four other randomly selected points from the 82 remaining locations.

Subsurface soil samples from SS22 West were also collected from locations directly under the radioactive items found during the trenching operations in each anomaly. The required three quality assurance (replicate) soil samples were collected from the six surface soil samples.

Only the Ra-226 soil concentrations are reported in the following sections. While other naturally occurring isotopes were reported by the laboratories, the data indicate that concentrations are within the range of natural background levels. All data and field observations indicate that Ra-226 and its decay daughters are the only COPCs. When carried forward for risk assessment purposes, it is assumed that Ra-226 is in equilibrium with its decay daughters and the decay chain can be represented by the notation "Ra-226+D." Ra-226 concentrations can then be used to represent the entire Ra-226 decay chain. The complete results, which includes reported concentrations of other naturally occurring isotopes, is available in Appendix D.

4.3.1 Anomaly Area #2

Anomaly Area #2 contained the only area in which a significant portion of gamma walkover survey measurements indicated residual activity above the screening value (see Table 4-3). The plot of the survey data on Figure 4-8 shows that the distribution of count rates in Anomaly Area #2 is skewed slightly to the right when compared to the background distribution (Figure 4-8). This data distribution and the greater number of data points greater than 16,400 cpm on Figure 4-8, indicate that the storage or disposal of Ra-226-containing materials has impacted the surface soil of this area more than other areas at the site.

Table 4-5 provides the soil sample concentrations and the ground level direct gamma count rates and exposure rates at 3 ft above the ground surface at each sample location. Most samples and measurements were within the range of background. However, sample SS22AN02-SS-015 had a Ra-226 concentration of 19.151 pCi/g. This high soil concentration corresponds with one of the highest direct gamma measurements, 72,553 cpm. This indicates that the soil sample contained at least a portion of the activity measured during the direct survey. However, as seen with the data corresponding to sample location SS22AN02-SS-016, a grab sample does not always capture the activity that is measured by the direct reading. Even at ground level, the direct gamma measurement has a much larger field of view than the volume of soil captured in a grab sample. This is not an atypical phenomenon for a site containing discrete radioactive sources in the near-surface and subsurface soils. According to MARSSIM protocols, the soil sample locations of the random-start grid are not to be biased based on the direct measurement and, therefore, there was no attempt to pinpoint the source of the activity prior to collecting the sample.

Table 4-5: Soil Sample Concentrations and the Ground Level Direct Gamma Count Rates and Exposure Rates

Sample ID Number	Ra-226 (pCi/g)	1σ Error (pCi/g)	Exposure Rate (μR/hr)	Direct Gamma Count Rate (cpm)
SS22AN02-SS-001	0.773	0.113	5	10,842
SS22AN02-SS-002	0.929	0.105	6	10,942
SS22AN02-SS-003	1.094	0.126	6	11,405
SS22AN02-SS-004	1.003	0.138	5	10,408
SS22AN02-SS-005	0.812	0.128	5	10,603
SS22AN02-SS-006	1.058	0.151	6	10,901
SS22AN02-SS-007	1.878	0.189	6	11,072
SS22AN02-SS-008	2.5 [a]	—	6	10,904
SS22AN02-SS-009	1.058	0.152	5	11,530
SS22AN02-SS-010	1.055	0.165	6	13,203
SS22AN02-SS-011	0.816	0.105	6	14,012
SS22AN02-SS-012	1.088	0.149	6	11,640

Sample ID Number	Ra-226 (pCi/g)	1σ Error (pCi/g)	Exposure Rate (μR/hr)	Direct Gamma Count Rate (cpm)
SS22AN02-SS-013 [b]	1.109	0.156	—	—
SS22AN02-SS-014 [c]	0.987	0.123	—	—
SS22AN02-SS-015 [d]	19.151	0.851	7	72,553
SS22AN02-SS-016 [d]	1.075	0.143	10	75,556
SS22AN02-SS-017 [d]	1.701	0.199	11	35,378
Mean (12 grid samples)	1.174	—	5.5	11,455
Mean	2.281	0.063	—	—
Standard Deviation	4.368	—	—	—
Maximum	19.151	0.851	11	75,556
Minimum	0.773	0.113	5	10,408

[a] The laboratory reported value was rejected due to a high level of uncertainty. The Ra-226 activity is estimated based on laboratory-reported Pb-214 and Bi-214 values and the expected Pb-214/Bi-214-to-Ra-226 ratio (about 38%).
[b] Co-located sample with SS22AN02-SS-010.
[c] Co-located sample with SS22AN02-SS-012.
[d] “Hot spot” sample.

4.3.2 Anomaly Area #3

The gamma walkover survey data did not identify locations for Anomaly Area #3 that suggest the presence of surface or near surface dispersed Ra-226 contamination or discrete Ra-226 sources. The data distribution, which shows no radiological anomalies greater than twice the mean background, is shown on Figure 4-9.

Table 4-6 provides the soil sample concentrations and the ground level direct gamma count rates and exposure rates at 3 ft above the ground surface at each sample location. There are no locations in the Anomaly Area #3 where the walkover survey data or soil sample data suggest disperse Ra-226 contamination or discrete Ra-226 sources.

Table 4-6: Anomaly Area #3 Surface Soil Concentrations

Sample ID Number	Ra-226 (pCi/g)	1σ Error (pCi/g)	Exposure Rate (μR/hr)	Direct Gamma Count Rate (cpm)
SS22AN03-SS-001	1.507	0.205	5	10,396
SS22AN03-SS-002	0.691	0.201	6	10,466
SS22AN03-SS-003	1.293	0.173	5	10,661
SS22AN03-SS-004	1.158	0.139	6	10,569
SS22AN03-SS-005	0.661	0.143	6	10,025
SS22AN03-SS-006	0.792	0.127	6	11,004
SS22AN03-SS-007	1.302	0.158	5	10,938
SS22AN03-SS-008	1.050	0.130	6	11,233
SS22AN03-SS-009	1.618	0.223	5	11,672

Sample ID Number	Ra-226 (pCi/g)	1σ Error (pCi/g)	Exposure Rate (µR/hr)	Direct Gamma Count Rate (cpm)
SS22AN03-SS-010	1.095	0.135	5	11,249
SS22AN03-SS-011	0.995	0.150	6	10,723
SS22AN03-SS-012	1.012	0.135	5	10,925
SS22AN03-SS-013 [a]	1.294	0.187	—	—
SS22AN03-SS-014 [b]	0.789	0.152	—	—
Mean (12 grid samples)	1.098	—	5.5	10,821
Mean	1.113	0.027	—	—
Standard Deviation	0.294	—	—	—
Maximum	1.618	0.223	6	11,672
Minimum	0.789	0.152	5	10,025

[a] Co-located sample with SS22AN02-SS-010.
[b] Co-located sample with SS22AN02-SS-012.

4.3.3 Anomaly Area #11

The 2008 survey results do not indicate a hot spot in the southwest corner of Anomaly Area #11 that was observed during the 2007 survey. This is likely due to a change in overburden resulting from site clearing operations or possibly from natural weathering that moved or diluted the contamination. Small changes in overburden can significantly affect the ability to detect the low mass particles containing Ra-226.

The hot spot identified in the 2008 survey in the northeast corner of Anomaly Area #11 was not identified during the 2007 survey because the area was inaccessible and not surveyed in 2007. The data distribution is shown on Figure 4-10.

Table 4-7 provides the soil sample concentrations and the ground level direct gamma count rates and exposure rates at 3 ft above the ground surface at each sample location. All samples and measurements were within the range of background.

Table 4-7: Anomaly Area #11 Surface Soil Concentrations

Sample ID Number	Ra-226 (pCi/g)	1σ Error (pCi/g)	Exposure Rate (µR/hr)	Direct Gamma Count Rate (cpm)
SS22AN11-SS-001	1.468	0.188	6	11,421
SS22AN11-SS-002	1.045	0.131	6	11,075
SS22AN11-SS-003	0.789	0.148	6	11,600
SS22AN11-SS-004	0.780	0.201	5	11,077
SS22AN11-SS-005	1.153	0.196	6	11,887
SS22AN11-SS-006	0.976	0.127	6	11,765
SS22AN11-SS-007	0.741	0.198	6	11,109

Sample ID Number	Ra-226 (pCi/g)	1σ Error (pCi/g)	Exposure Rate (μR/hr)	Direct Gamma Count Rate (cpm)
SS22AN11-SS-008	1.026	0.133	6	11,739
SS22AN11-SS-009	1.406	0.159	6	10,977
SS22AN11-SS-010	1.217	0.181	6	10,995
SS22AN11-SS-011	0.995	0.199	6	11,242
SS22AN11-SS-012	0.980	0.138	6	11,419
SS22AN11-SS-013 [a]	1.413	0.191	—	—
SS22AN11-SS-014 [b]	0.836	0.151	—	—
SS22AN11-SS-015 [c]	1.007	0.143	6	26,027
Mean (12 grid samples)	1.048	—	6	11,359
Mean	1.055	0.028	—	—
Standard Deviation	0.243	—	—	—
Maximum	1.468	0.188	6	26,027
Minimum	0.780	0.201	5	10,977

[a] Co-located sample with SS22AN02-SS-010.
[b] Co-located sample with SS22AN02-SS-012.
[c] "Hot spot" sample.

4.3.4 Anomaly Area #16

There were only two survey points in Anomaly Area #16 that exceeded the IL of 6,000 cpm during the gamma walkover survey. Direct 1-minute measurements at these locations were 4,650 and 5,620 cpm. The gamma radiation exposure rate at 3 ft above the ground surface at each location was 5 μR/hr. The survey results indicated that there were no detectable surface or near surface radioactive sources in the area. No surface soil samples were collected from this area. Figure 4-11 shows the distribution of the survey data after removing the erroneous measurements (detector noise) greater than 6,000 cpm, while Figure 4-12 displays all of the walkover survey results (including measurements greater than 6,000 cpm). A walkover survey data point was considered to be detector noise if the elevated measurement could not be replicated during a re-scan and direct measurement in the area.

4.3.5 Anomaly Area #17

There were 25 survey points in Anomaly Area #17 that exceeded the IL of 6,000 cpm during the gamma walkover survey. In some instances, multiple data points greater than 6,000 cpm are grouped together to represent a single location. Direct 1-minute measurements at these 25 locations ranged from 4,170 to 4,574 cpm. The gamma radiation exposure rate at 3 ft above the ground surface at each location was 5 μR/hr. The survey results indicated that there were no detectable surface or near surface radioactive sources in the area. Figure 4-13 shows the distribution of the

survey data after removing detector noise, while Figure 4-14 displays all of the walkover survey results (including measurements greater than 6,000 cpm).

Two soil samples were collected in Anomaly Area #17 trench with a Ra-226 concentrations of 0.46 +/- 0.25 pCi/g (17RAD01-010810) and 0.59 +/- 0.25 pCi/g (17RAD02-010810). A confirmatory soil sample was also collected at location 17RAD01-010810 and demonstrated a concentration of 0.55 +/- 0.25 pCi/g (17RAD29-310810). The Ra-226 soil concentrations in these samples were less than the Ra-226 background concentration of 0.96 ± 0.07 pCi/g.

4.3.6 Anomaly Area #18

There were no survey points in Anomaly Area #18 that exceeded the IL of 6,000 cpm during the gamma walkover survey. Direct 1-minute and gamma radiation exposure rate measurements were not performed at these locations because they were covered by trench spoils prior to returning to the locations for the measurements. The survey results indicated that there were no detectable surface or near surface radioactive sources in the area. No surface soil samples were collected from this area. Figure 4-15 shows the distribution of the survey data after removing detector noise, while Figure 4-16 displays all of the walkover survey results (including measurements greater than 6,000 cpm).

4.3.7 Anomaly Area #19

There were 12 locations in Anomaly Area #19 that exceeded the IL of 6,000 cpm during the gamma walkover survey with two locations demonstrating levels greater than 10,000 cpm. In some instances, multiple data points greater than 6,000 cpm were grouped together to represent a single location. Direct 1-minute measurements at these 12 locations ranged from 4,202 to 10,650 cpm. The gamma radiation exposure rate at 3 ft above the ground surface at each location was 5 to 8 μR/hr. Figure 4-17 shows the distribution of the survey data after removing detector noise, while Figure 4-18 displays all of the walkover survey results (including measurements greater than 6,000 cpm).

Two surface soil samples and one duplicate soil sample were collected in Anomaly Area #19 with Ra-226 concentrations of 1.35 +/- 0.29 pCi/g (19RAD30-240810) and 1.40 +/- 0.31 pCi/g (19RAD31-240810). The duplicate soil sample Ra-226 concentration was 18.5 +/- 02.3 pCi/g (19RAD32-270810).

A Ra-226 gauge was found at soil sampling location 19RAD30-240810 at approximately 8 inches below ground surface (bgs). No radioactive source was found at sample location 19RAD32-270810. The soil at this location had a very high gamma rate measurement (greater than 14,000 cpm). The

radioactive contamination is likely to be the result of a broken or degraded source which has disintegrated and become dispersed in the soil.

4.3.8 Anomaly Area #20

There were 30 locations in Anomaly Area #20 that exceeded the IL of 6,000 cpm during the gamma walkover survey. In some instances, multiple data points greater than 6,000 cpm were grouped together to represent a single location. Direct 1-minute measurements at these 30 locations ranged from 3,813 to 4,427 cpm. The gamma radiation exposure rate at 3 ft above the ground surface at each location was 4 to 6 µR/hr. The survey results indicated that there were no detectable surface or near surface radioactive sources in the area. Figure 4-19 shows the distribution of the survey data after removing detector noise, while Figure 4-20 displays all of the walkover survey results (including measurements greater than 6,000 cpm).

Two surface soil samples were collected in Anomaly Area #20 with Ra-226 concentrations of 0.53 +/- 0.23 pCi/g (20RAD34-010910) and 0.50 +/- 0.19 pCi/g (20RAD33-310810). A duplicate soil sample was also collected at location 20RAD34-010910 with a Ra-226 concentration of 0.35 +/- 0.31 pCi/g (20RAD35-010910). The Ra-226 soil concentrations in these samples were less than the Ra-226 background concentration of 0.96 ± 0.07 pCi/g.

4.3.9 Anomaly Area #21

There was one survey point in Anomaly Area #21 that exceeded the IL of 6,000 cpm during the gamma walkover survey. The direct 1-minute measurements at this location was 4,253 cpm. The gamma radiation exposure rate at 3 ft above the ground surface at this location was 5 µR/hr. The survey results indicated that there were no detectable surface or near surface radioactive sources in the area. No surface soil samples were collected from this area. Figure 4-21 shows the distribution of the survey data after removing detector noise, while Figure 4-22 displays all of the walkover survey results (including measurements greater than 6,000 cpm).

4.3.10 Anomaly Area #22

There were 12 locations in Anomaly Area #19 that exceeded the IL of 6000 cpm during the gamma walkover survey with two locations demonstrating levels greater than 10,000 cpm. In some instances, multiple data points greater than 6,000 cpm are grouped together to represent a single location. Direct 1-minute measurements at these 12 locations ranged from 3,776 to 4,040 cpm. The gamma radiation exposure rate at 3 ft above the ground surface at each location was 5 µR/hr. The survey results indicated that there were no detectable surface or near surface radioactive sources in the area. Figure 4-23 shows the distribution of the survey data after removing detector noise, while

Figure 4-24 displays all of the walkover survey results (including measurements greater than 6,000 cpm).

Only one surface soil sample was collected in Anomaly Area #22 with a Ra-226 concentration of 0.47 +/- 0.23 pCi/g (22RAD36-010910). A duplicate soil sample was also collected with a Ra-226 concentration of 0.38 +/- 0.20 pCi/g (22RAD37-010910). The Ra-226 soil concentrations in these samples were less than the Ra-226 background concentration of 0.96 ± 0.07 pCi/g.

4.3.11 Anomaly Area #23/24/25

There were two survey points in Anomaly Areas #23, #24, or #25 that exceeded the IL of 6,000 cpm during the gamma walkover survey. The survey results indicated that there were no detectable surface or near surface radioactive sources in the area. Direct 1-minute measurements at these locations were 4,961 cpm and 4,215 cpm. The gamma radiation exposure rate at 3 ft above the ground surface at each location was 5 µR/hr. The survey results indicated that there were no detectable surface or near surface radioactive sources in the area. No surface soil samples were collected from these areas. Figure 4-25 shows the distribution of the survey data after removing detector noise, while Figure 4-26 displays all of the walkover survey results (including measurements greater than 6,000 cpm).

4.3.12 Anomaly Area #26

There was only one survey point in Anomaly Area #26 that exceeded the IL of 6,000 cpm during the gamma walkover survey. The direct 1-minute measurement at this location was 4,390 cpm. The gamma radiation exposure rate at 3 ft above the ground surface at this location was 5 µR/hr. The survey results indicated that there was no detectable surface or near surface radioactive source in the area. No surface soil samples were collected from this area. Figure 4-27 shows the distribution of the survey data after removing detector noise, while Figure 4-28 displays all of the walkover survey results (including measurements greater than 6,000 cpm).

4.3.13 Anomaly Area #27/28

There were no survey points in Anomaly Areas #27 and #28 that exceeded the IL of 6,000 cpm during the gamma walkover survey. Therefore, no direct 1-minute measurements were made in these Anomaly Areas. The survey results indicated that there were no detectable surface or near surface radioactive sources in the area. No surface soil samples were collected from this area. Figure 4-29 shows the distribution of the survey data after removing detector noise, while Figure 4-30 displays all of the walkover survey results (including measurements greater than 6,000 cpm).

4.3.14 Surface Soil Summary

The gamma walkover survey and surface soil data indicate that the geophysical anomaly areas in SS22 East and SS22 West are not impacted by widely spread Ra-226 contamination. However, there are a few localized areas that are associated with the presence of discrete Ra-226-containing sources that have impacted the immediately surrounding soil.

4.4 SS22 Trench Surveys and Sampling

Due to safety considerations, technicians did not enter trenches; therefore, soil samples and direct gamma measurements were not collected directly from within any of the trenches excavated in SS22 East or SS22 West. Samples were collected from and direct measurements were made on the soil/debris piles next to the trench. For the trenches in SS22 East Anomaly Areas (#2, #3, and #11) soil samples were collected at “hot spots” and at random locations. In the SS22 West trenches, soil samples were collected at 8 of the 14 trenches but only when associated with the finding of radioactive items such as gauges, dials, and switches, etc., within a trench. As discussed previously, only Ra-226 concentrations are provided in the following sections. Radioactive items removed from the trenches were transferred to Base Bioenvironmental Engineering. Items recovered from SS22 East were subsequently shipped to Environmental Management Division, 88 ABW/CEV, at Wright-Patterson AFB, Ohio. Items recoved in SS22 West have not yet been shipped to Wright-Patterson.

4.4.1 Anomaly Area #2

No radioactive items or contaminated soil was discovered in the Anomaly Area #2 trench. Table 4-8 summarizes the Ra-226 concentrations in soil samples collected from the trench spoils.

Table 4-8: Anomaly Area #2 Trench Soil Concentrations

Sample ID Number	Ra-226 (pCi/g)	1σ Error	Exposure Rate (μR/hr)	Sample Depth (ft)	Direct Gamma Count Rate (cpm)
SS22AN02-ST-001	1.198	0.148	6	1	11,731
SS22AN02-ST-002	0.879	0.126	6	4	11,526
SS22AN02-ST-003	2.326	0.319	6	1	11,796
SS22AN02-ST-004	0.829	0.118	5	1	11,874
SS22AN02-ST-005	1.540	0.167	6	1	11,743
SS22AN02-ST-006	3.205	0.232	6	5	11,927

4.4.2 Anomaly Area #3

Two items, one dial and one gauge, were recovered from the trench in Anomaly Area #3. The total activity of these two items was estimated at 0.03 millicurie. These items were transferred to Base Bioenvironmental Engineering and then shipped to the Environmental Management Division,

88 ABW/CEV, at Wright-Patterson AFB, Ohio. Table 4-9 summarizes the Ra-226 concentrations in soil samples collected from the trench spoils.

Table 4-9: Anomaly Area #3 Trench Soil Concentrations

Sample ID Number	Ra-226 (pCi/g)	1σ Error	Exposure Rate (μR/hr)	Sample Depth (ft)	Direct Gamma Count Rate (cpm)
SS22AN03-ST-001	1.087	0.148	6	1	12,085
SS22AN03-ST-002	0.954	0.156	6	4	11,090
SS22AN03-ST-003	1.019	0.138	6	1	10,710
SS22AN03-ST-004	1.669	0.178	5	4	10,710
SS22AN03-ST-005	36.16	1.378	6	1	11,731
SS22AN03-ST-006	1.013	0.140	6	4	11,526
SS22AN03-ST-007	0.662	0.103	140	4	3,162,031
SS22AN03-ST-008	129.9	4.341	10	6	43,620

4.4.3 Anomaly Area #11

The Anomaly Area #11 trench provided the subsurface soil sample, SS22AN11-ST-008, with the highest Ra-226 concentration of approximately 165 pCi/g. This high soil concentration corresponds with one of the highest direct gamma measurements, 149,876 cpm. No discrete Ra-226 source was found. Table 4-10 summarizes the Ra-226 concentrations in soil samples collected from the trench spoils.

Table 4-10: Anomaly Area #11 Trench Soil Concentrations

Sample ID Number	Ra-226 (pCi/g)	1σ Error	Exposure Rate (μR/hr)	Sample Depth (ft)	Direct Gamma Count Rate (cpm)
SS22AN11-ST-001	0.815	0.024	6	1	11,704
SS22AN11-ST-002	0.758	0.125	6	4	11,230
SS22AN11-ST-003	0.910	0.131	6	1	11,290
SS22AN11-ST-004	0.668	0.100	5	4	11,334
SS22AN11-ST-005	0.510	0.181	6	1	11,155
SS22AN11-ST-006	0.858	0.124	6	4	11,862
SS22AN11-ST-007	16.48	0.779	6	5	13,363
SS22AN11-ST-008	165.6	6.296	6	6	149,876
SS22AN11-ST-009	0.999	0.138	6	1	11,976
SS22AN11-ST-010	0.695	0.145	6	4	11,222

4.4.4 Anomaly Area #16

No radioactive items were discovered in the Anomaly Area #16 trench. Therefore no subsurface soil samples were collected. Soil samples were only collected from trenches in which radioactive items

were found. No direct exposure rate or gamma measurements were collected on soil removed from this trench.

Only scrap metal, 55 gallon drums (mostly empty), and other miscellaneous debris were found in this trench. If the trench's contents are representative of the rest of Anomaly Area #16, no Ra-226 containing items are expected to be found in this area.

4.4.5 Anomaly Area #17

No radioactive items were discovered in the Anomaly Area #17 trench. Therefore, no subsurface soil samples were collected. Soil samples were only collected from trenches in which radioactive items were found. No direct exposure rate or gamma measurements were collected on soil removed from this trench.

Only scrap metal, pieces of 55 gallon drums, bomb storage brackets, metal rods, etc. were found in this trench. If the trench's contents are representative of the rest of Anomaly Area #17, no Ra-226 containing items are expected to be found in this area. Photo 4-1 provides a representative picture of the materials found in Anomaly Area #17's trench.

4.4.6 Anomaly Area #18

No radioactive items were discovered in the Anomaly Area #19 trench. Therefore, no subsurface soil samples were collected. Soil samples were only collected from trenches in which radioactive items were found. No direct exposure rate or gamma measurements were collected on soil removed from this trench.

Only scrap metal and metal pipe was found in this trench. If the trench's contents are representative of the rest of Anomaly Area #18, no Ra-226 containing items are expected to be found in this area.

4.4.7 Anomaly Area #19

A radioactive gauge and a lamp array with a radioactive toggle switch were located and removed from material excavated from the Anomaly Area #19 trench (Photo 4-2 and Photo 4-3). Two soil samples were collected from the excavated soil that was around these items. After the items and samples were removed, no radioactive contamination or other radioactive items were identified and gamma count rate scan measurements were within the range of background.

Sample 19RAD03-090810 was collected beneath the lamp array 10 ft from the east end of the trench at a depth of about 6 ft. This sample had a Ra-226 concentration of 1.44 +/- 0.35 pCi/g. A second sample, 19RAD04-100810, was collected beneath the gauge about 78 ft from the east end of the trench at a depth of about 11 ft. This sample had a Ra-226 concentration of 0.64 +/- 0.40 pCi/g.

In additional to the radioactive items recovered from the Anomaly Area #20 trench, the trench contained scrap metal, pieces of 55 gallon drums, wooden spools, sheet aluminum, metal rods, and part of a jet engine. If the trench's contents are representative of the rest of Anomaly Area #19, other Ra-226 containing items would be expected to be found in this area.

4.4.8 Anomaly Area #20

A radioactive gauge, three radioactive rocks ranging in size from 1/4-inch to approximately 1/2-inch in diameter, and a speedometer hand, were located and removed from the material excavated from the Anomaly Area #20 trench (Photo 4-4 and Photo 4-5). Five soil samples were collected from the excavated soil that was around these items. After the items and samples were removed, one area of elevated radioactivity was identified but no source could be found and an additional soil sample was collected in this area.

No other radioactive contamination or other radioactive items were identified and gamma count rate scan measurements were within the range of background.

The soil samples collected in the Anomaly Area #20 trench are summarized in Table 4-11.

In additional to the radioactive items recovered from the Anomaly Area #20 trench, the trench contained various truck and tank parts, steel beams, and other scrap metal. If the trench's contents are representative of the rest of Anomaly Area #20, other Ra-226 containing items would be expected to be found in this area.

Table 4-11: Anomaly Area #20 Trench Samples

Sample ID Number	Ra-226 (pCi/g)	Location
20RAD05-140810	7.8 +/- 1.1	Beneath gauge discovered near the surface at the west end of the trench
20RAD06-140810	10.6 +/- 1.4	Near radioactive rock about 22 ft from the west end of the trench at a depth of about 8 ft
20RAD07-140810	4.38 +/- 0.67	Near radioactive rock about 25 ft from the west end of the trench at a depth of about 10 ft
20RAD08-160810	17.6 +/- 2.2	Contaminated soil (no source found) located about 28 ft from the west end of the trench at a depth of about 8 ft
20RAD09-160810	4.46 +/- 0.65	Near radioactive rock about 25 ft from the west end of the trench at a depth of about 9 ft
20RAD10-160810	0.91 +/- 0.25	Near speedometer hand about 30 ft from the west end of the trench at a depth of about 8 ft

4.4.9 Anomaly Area #21

A radioactive speedometer hand was located and removed from material excavated from the Anomaly Area #21 trench. One soil samples was collected from the excavated soil that was around this item. After the item and sample were removed, no radioactive contamination or other radioactive items were identified, and gamma count rate scan measurements were within the range of background.

Sample 21RAD11-170810 was collected beneath the speedometer hand 25 ft from west end of trench at a depth on about 16 ft. This sample had a Ra-226 concentration of 1.37 +/- 0.31 pCi/g.

In addition to the radioactive item recovered from the Anomaly Area #21 trench, the trench contained various scrap metal and practice bombs. If the trench's contents are representative of the rest of Anomaly Area #21, additional Ra-226 containing items may be present in this area.

4.4.10 Anomaly Area #22

No radioactive items were discovered in the Anomaly Area #22 trenches (2A, 22B, and 22C). Therefore, no subsurface soil samples were collected. Soil samples were only collected from trenches in which radioactive items were found. No direct exposure rate or gamma measurements were collected on soil removed from this trench.

Scrap metal, drums, a bus, and two cars were found in the #22A trench. No debris was observed in the 22B and 22C trenches.

4.4.11 Anomaly Area #23

A radioactive gauge and a partial speedometer hand were located and removed from material excavated from the Anomaly Area #23 trench (specified as #23A) (Photo 4-6). A soil sample was collected from the excavated soil that was around the gauge. After the items and sample were removed, no radioactive contamination or other radioactive items were identified, and gamma count rate scan measurements were within the range of background.

Sample 23ARAD12-180810 was collected beneath the gauge 5 ft from the north end of the trench at a depth of about 6 ft. This sample had a Ra-226 concentration of 8.6 +/- 1.1 pCi/g.

No soil samples were collected from soil removed from Anomaly Area #23B trench. Soil samples were only collected from trenches in which radioactive items were found. No exposure rate measurements or gamma rate measurements were collected from soil removed from these trenches.

Miscellaneous scrap metal and two large boilers were found in the #23A trench, and the material recovered from the 23B trench was mostly scrap metal. If the trenches' contents are representative of the rest of Anomaly Area #23, additional Ra-226 containing items may be present in this area.

4.4.12 Anomaly Area #24

A vehicle dash board containing Ra-226 gauges and 7 identical switches with Ra-226 toggle switches were located and removed from material excavated from the Anomaly Area #24 trench (Photo 4-7). Eight soil samples were collected from the excavated soil that was around these items. After the item and sample was removed, no radioactive contamination or other radioactive items were identified, and gamma count rate scan measurements were within the range of background.

The soil samples collected in the Anomaly Area #24 trench are summarized in Table 4-12.

This trench contained 55 gallon drums, heat exchangers, pipes, bomb brackets, trash cans, rebar, and other scrap metal. Since multiple Ra-226 switches were found throughout the trench it can be expected that the remainder of the anomaly has radioactive materials distributed throughout the area.

Table 4-12: Anomaly Area #24 Trench Samples

Sample ID Number	Ra-226 (pCi/g)	Location
24RAD13-190810	1.49 +/- 0.34	Near toggle switch about 5 ft from the north end of the trench at a depth of about 6 ft
24RAD14-190810	0.76 +/- 0.25	Near toggle switch about 17 ft from the north end of the trench at a depth of about 6 ft
24RAD15-190810	1.03 +/- 0.28	Near toggle switch about 19 ft from the north end of the trench at a depth of about 7 ft
24RAD16-190810	0.85 +/- 0.43	Near toggle switch about 30 ft from the north end of the trench at a depth of about 12 ft
24RAD17-200810	0.74 +/- 0.27	Near toggle switch about 45 ft from the north end of the trench at a depth of about 13 to 15 ft
24RAD18-200810	0.55 +/- 0.24	Near toggle switch about 45 ft from the north end of the trench at a depth of about 16 ft
24RAD19-200810	0.61 +/- 0.27	Near toggle switch about 53 ft from the north end of the trench at a depth of about 16 ft
24RAD20-200810	0.81 +/- 0.27	Near dial in dashboard; no location; discovered as trench was being backfilled

4.4.13 Anomaly Area #25

A partial radioactive gauge and 2 vehicle dash boards containing Ra-226 gauges were located and removed from material excavated from the Anomaly Area #25 trench (Photo 4-8 and Photo 4-9).

Three soil samples were collected from the excavated soil that was around these items. After the items and samples were removed, no radioactive contamination or other radioactive items were identified, and gamma count rate scan measurements were within the range of background.

The soil samples collected in the Anomaly Area #25 trench are summarized in Table 4-13.

This trench contained 55 gallon drums, multiple vehicles, and other scrap metal. Since multiple Ra-226 items were found in the trench it can be expected that the remainder of the anomaly may contain radioactive materials.

Table 4-13: Anomaly Area #25 Trench Samples

Sample ID Number	Ra-226 (pCi/g)	Location
25RAD21-200810	7.9 +/- 1.1	Near partial gauge about 15 ft from the north end of the trench at a depth of about 10 ft
25RAD22-210810	0.47 +/- 0.22	Near dashboard containing gauges about 25 to 30 ft from the north end of the trench at a depth of about 12 ft
25RAD23-210810	0.53 +/- 0.32	Near dashboard containing gauges about 40 ft from the north end of the trench at a depth of about 12 to 14 ft

4.4.14 Anomaly Area #26

No radioactive items were discovered in the Anomaly Area #26 trench. Therefore, no subsurface soil samples were collected. Soil samples were only collected from trenches in which radioactive items were found. No direct exposure rate or gamma measurements were collected on soil removed from this trench.

Metal drums, pipes, and cables were found in this trench. If the trench's contents are representative of the rest of Anomaly Area #26, no Ra-226 containing items are expected to be found in this area.

4.4.15 Anomaly Area #27

A radioactive gauge and a switch with a Ra-226 toggle switch were located and removed from material excavated from the Anomaly Area #27 trench (Photo 4-10 and Photo 4-11). Two soil samples were collected from the excavated soil that was around these items. An additional soil sample was collected in a location where elevated gamma rate measurements were detected but no gauge or other radioactive items could be found. After the items and samples were removed, no radioactive contamination or other radioactive items were identified, and gamma count rate scan measurements were within the range of background.

The soil samples collected in the Anomaly Area #27 trench are summarized in Table 4-14.

This trench contained miscellaneous debris including aircraft parts, lockers, beds, and electrical parts. Since multiple Ra-226 items were found in the trench it can be expected that the remainder of the anomaly may contain radioactive materials.

Table 4-14: Anomaly Area #27 Trench Samples

Sample ID Number	Ra-226 (pCi/g)	Location
27RAD24-230810	13.7 +/- 1.8	Near gauge about 5 ft from the north end of the trench at a depth of about 6 ft
27RAD25-230810	3.41 +/- 0.60	Contaminated soil (no source found) about 8 ft from the north end of the trench at a depth of about 6 to 8 ft
27RAD26-230810	1.30 +/- 0.32	Near toggle switch containing gauges about 10 ft from the north end of the trench at a depth of about 8 ft

4.4.16 Anomaly Area #28

A unit containing two radioactive dials and a radio transmitter/receiver were located and removed from material excavated from the Anomaly Area #19 trench (Photo 4-12 and Photo 4-13). Two soil samples were collected from the excavated soil that was around these items. After the items and samples were removed, no radioactive contamination or other radioactive items were identified, and gamma count rate scan measurements were within the range of background.

Sample 28RAD27-250810 was collected near a dual gauge 8 to 10 ft from south end of trench at a depth of about 12 ft. This sample had a Ra-226 concentration of 13.4 +/- 1.7 pCi/g. A second sample, 28RAD28-250810, was collected near a radio/transmitter about 15 ft from the south end of the trench at a depth of about 10 ft. This sample had a Ra-226 concentration of 4.91 +/- 0.73 pCi/g.

This trench contained miscellaneous debris including pipes, file boxes, lockers, beds, and empty drums. Since multiple Ra-226 items were found in the trench, it can be expected that the remainder of the anomaly may contain radioactive materials.

4.4.17 Trench Soil Summary

Multiple radioactive items were recovered from the trenches excavated in the geophysical anomalies in SS22 East and West. Analysis of the soil samples from the trenches indicated the presence of residual Ra-226 contamination in the subsurface soil in each of the three geophysical anomaly areas from SS22 East and 8 of the 14 anomaly areas from SS22 West. A summary of the trench investigations is provided in Table 4-15.

The greatest soil sample activity of 166 +/- 13 pCi/g Ra-226 was measured in trench sample SS22AN11-ST-008 (SS22 East Anomaly Area #11). This high soil concentration corresponds with

one of the highest direct gamma measurements, 149,876 cpm (unshielded detector). This indicates that the soil sample contained at least a portion of the activity measured during the direct survey. However, a direct measurement does not always reflect solely the measurement collected in the soil sample. One possibility is that the sample contained a small flake of radium paint or other piece of radium-containing debris that was collected from a depth of approximately 6 inches. The 3×3 sodium iodide (thallium activated) (NaI[Tl]) detector may not have detected the activity because the soil above the source may have shielded the gamma radiation activity measurement. This is not an uncommon phenomenon for a site containing discrete radioactive sources in the near-surface and subsurface soils.

The highest Ra-226 concentration measured in SS22 West, 17.6 +/- 2.2 pCi/g, was in sample 20RAD08-160810. This sample was collected from the trench in Anomaly Area #20.

The trenching approach did demonstrate that discrete Ra-226-containing materials are present in SS22 East and West that cannot be detected from walkover gamma radiation surveys. Radioactive items were removed from the trenches and placed in 55-gallon drums. The drums were transferred to Base Bioenvironmental Engineering. Items recovered from Trench 3 were subsequently shipped to Environmental Management Division, 88 ABW/CEV, at Wright-Patterson AFB, Ohio. Items recovered in SS22 West have not yet been shipped to Wright-Patterson.

Table 4-15: Summary of Trench Investigations

Trench	Number of Soil Sample Collected	Number of Soil Samples > 2 pCi/g	Number of Radioactive Items Recovered
2	6	2	0
3	8	2	2
11	10	2	0
16	0	0	0
17	0	0	0
18	0	0	0
19	2	0	2
20	6	5	6
21	1	0	1
22A	0	0	0
22B	0	0	0
22C	0	0	0
23A	1	1	1
23B	0	0	0
24	8	0	8
25	3	1	3
26	0	0	0

Trench	Number of Soil Sample Collected	Number of Soil Samples > 2 pCi/g	Number of Radioactive Items Recovered
27	3	2	2
28	2	2	2

4.5 SS 22 East Subsurface Soil Boring Samples

As an adjunct to the May 2009 non-radiological investigation of SS22, soil samples were collected from subsurface borings and analyzed for Ra-226. The results of the sample analyses are provided in the following sections.

4.5.1 Anomaly Area #2

Table 4-16 lists the subsurface soil boring results for Anomaly Area #2. The results for all samples are consistent with the Ra-226 background concentration of 0.96 ± 0.07 pCi/g. Figure 4-31 shows the location of each sample along with its respective soil concentration.

Table 4-16: Anomaly Area #2 Subsurface Soil Boring Sample Concentrations

Field Sample ID Number (COC ID) [a]	Ra-226 (pCi/g)	Depth (ft bgs)
AN02-SS-025B07-N-01-0002 (AN02SB-07-0002)	2.5 ± 1.7	0 – 2
AN02-SB-02SB06-N-01-0304 (AN02SB06-0304)	1.0 ± 0.8	3 – 4
AN02-SB-02SB07-N-01-0305 (AN02SB07-0305)	1.0 ± 0.9	3 – 5
AN02-SB-02SB06-N-01-0911 (AN02SB06-0911)	0.8 ± 0.8	9 – 11
AN02-SB-02SB01-N-01-1012 (AN02SB01-1012)	0.1 ± 0.6	10 – 12
AN02-SB-02SB02-N-1-1012 (AN02SB02-1012)	0.6 ± 0.5	10 – 12
AN02-SB-02SB07-N-01-1012 (AN02SB07-1012)	0.5 ± 0.6	10 – 12
AN02-SB-02SB01-N-01-1214 [b] (AN02-SB01-1214)	0.8 ± 0.8	10 – 12
AN02-SB-02SB05-N-01-1214 (AN02SB05-1214)	0.7 ± 0.8	12 – 14

[a] COC ID is used on all figures.
[b] Co-located with AN02-SB-02SB01-N-01-1012.

4.5.2 Anomaly Area #3

Table 4-17 lists the subsurface soil boring results for Anomaly Area #3. The results for all samples are consistent with the Ra-226 background concentration of 0.96 ± 0.07 pCi/g. Figure 4-32 shows the location of each sample along with its respective soil concentration.

Table 4-17: Anomaly Area #3 Subsurface Soil Boring Sample Concentrations

Field Sample ID Number (COC ID) [a]	Ra-226 (pCi/g)	Depth (ft bgs)
AN03-SB-03SB01-N-01-0810 (AN03SB01-0810)	1.0 ± 0.9	8 – 10
AN03-SB-03SB03-N-01-1012 (AN03SB03-1012)	1.1 ± 0.8	10 – 12
AN03-SB-03SB05-N-01-1012 (AN03SB05-1012)	1.2 ± 0.7	10 – 12
AN03-SB-03SB05-N-01-1214 [b] (AN03SB05-1214)	0.8 ± 0.8	10 – 12

[a] COC ID is used on all figures.
[b] Co-located with AN03-SB-03SB05-N-01-1012.

4.5.3 Anomaly Area #11

Table 4-18 lists the subsurface soil boring results for Anomaly Area #11. The results for all samples are consistent with the Ra-226 background concentration of 0.96 ± 0.07 pCi/g. Figure 4-33 shows the location of each sample along with its respective soil concentration.

Table 4-18: Anomaly Area #11 Subsurface Soil Boring Sample Concentrations

Field Sample ID Number (COC ID) [a]	Ra-226 (pCi/g)	Depth Interval (ft bgs)
AN11-SB-11SB02-N-01-0305 (AN11SB02-0305)	1.0 ± 0.7	3 – 5
AN11-SB-11SB02-N-01-0507 [b] (AN11SB02-0507)	0.8 ± 0.7	3 – 5

[a] COC ID is used on all figures.
[b] Co-located with AN11-SB-11SB02-N-01-0305.

4.5.4 Subsurface Soil Boring Summary

The results for all samples are consistent with the Ra-226 background concentration of 0.96 ± 0.07 pCi/g. Figure 4-31 through Figure 4-33 provide the location and results of the soil boring samples.

4.6 SS22 East Composite Soil Samples

The samples composited were collected over the 2008 and 2009 field seasons. Of the results in Table 4-19, the surface soil, hot spot, and trench samples were collected during the September 2008 field work. The subsurface soil samples were collected during the May–June 2009 fieldwork period.

A “cone and quartering” technique was used to composite the soil samples. This technique consisted of placing an entire sample on a clean surface, blending, and splitting the sample in halves and quarters using a clean spatula/straight edge. The sample was further sectioned based on the number of samples that comprise the composite. This fraction (approximately 1 gram) was added to the respective composite for analysis. Soils were analyzed for gross alpha/beta activity using EPA Method 900M and isotopic activity by EPA Method 901.1M.

Composites 4, 6, and 8 contain Ra-226 above background concentrations and have indications of alpha, beta, and gamma activities above Composite 1 (background). Composites 3, 5, and 7 do not show these indications. Although these data are not definitive, they are consistent with the implication that the only contaminant of concern is Ra-226.

Composites were derived from the trench and subsurface soils of Anomaly Areas #2, #3, and #11, respectively. While quantitative comparison of total gamma with gross alpha and gross beta values is problematic due to the lack of isotopic specificity, the results imply that radioisotopes not easily detected by gamma spectroscopy do not occur in elevated concentrations in the composites. For purposes of risk assessment for the SS22 site, gamma spectroscopy analysis meets the required DQOs.

Table 4-19: SS22 East Soil Composite Concentrations

Composite [a]	Ra-226 (pCi/g)	Total Gamma (pCi/g) [b]	Gross Alpha (pCi/g)	Gross Beta (pCi/g)
1 (background)	1.1 ± 0.3	14	–1 ± 2 [c]	8 ± 2
3 (Anomaly Area #2 surface and hot spot)	1.1 ± 0.3	15	8 ± 2	11 ± 3
4 (Anomaly Area #2 trench and subsurface)	1.8 ± 0.3	13	11 ± 3	11 ± 3
5 (Anomaly Area #3 surface and hot spot)	1.0 ± 0.3	12	5 ± 2	12 ± 3
6 (Anomaly Area #3 trench and subsurface)	13.6 ±1.2	52	50 ± 12	24 ± 6
7 (Anomaly Area #11 surface and hot spot)	0.9 ± 0.3	12	5 ± 2	10 ± 3
8 (Anomaly Area #11 trench and subsurface)	4.0 ± 0.5	19	31 ± 8	17 ± 4

[a] Each composite sample combines either surface or subsurface soil from the SS22 East anomaly areas.
[b] The laboratory did not provide uncertainties for total gamma concentrations. Laboratory results are given with two significant digits.
[c] The laboratory subtracted instrument background radiation counts from the gross sample counts. When the concentration of the analyte is close to zero, this can result in reported net counts less than zero.

4.7 SS22 Groundwater Samples

Groundwater samples were collected from monitoring wells MW1 through MW17 in May 2009 and submitted to ARS for analysis using ARS-008/EPA 903.0, *Alpha-Emitting Radium Isotopes In Drinking Water.* Table 4-20 displays the results of the analysis. Figure 3-7 shows the location of the groundwater monitoring wells at the site.

Table 4-20: 2009 Groundwater Data

Sample ID Number	Ra-226 (pCi/L)	Sample ID Number	Ra-226 (pCi/L)
MW01	0.1 ± 0.2	MW10	0.2 ± 0.2
MW02	0.10 ± 0.10	MW11	0.2 ± 0.3
MW03	0.1 ± 0.2	MW12 [a]	0.0 ± 0.2
MW04	0.05 ± 0.17	MW13 [a]	0.1 ± 0.2

Sample ID Number	Ra-226 (pCi/L)	Sample ID Number	Ra-226 (pCi/L)
MW05	0.04 ± 0.14	MW14	0.03 ± 0.19
MW06	-0.03 ± 0.13 [b]	MW15	0.2 ± 0.2
MW07	0.07 ± 0.20	MW16	0.11 ± 0.18
MW08	-0.10 ± 0.16 [b]	MW17	0.4 ± 0.3
MW09	0.1 ± 0.3	—	—

pCi/L picocurie per liter
[a] Background well.
[b] The laboratory subtracted instrument background radiation counts from the gross sample counts. When the concentration of the analyte is close to zero, this can result in reported net counts less than zero.

Based on the groundwater flow patterns at the site, monitoring wells MW12 and MW13 were considered upgradient and represent background Ra-226 groundwater concentrations. Including the error, the range of Ra-226 concentration for wells MW12 and MW13 was 0.0 to 0.3 picocurie per liter (pCi/L). The results from the downgradient wells are all within the range of background.

The composite water samples comprised groundwater collected downgradient of SS22 (Wells MW1 through MW11 and MW14 through MW17) into a single composite, and groundwater collected upgradient of SS22 (Wells MW12 and MW13) into a separate composite. The composites were analyzed by gamma spectroscopy and gross alpha/beta counting. The results are shown in Table 4-21.

The laboratory results for the groundwater composites reported for gamma spectroscopy are difficult to evaluate and draw conclusions from due to high MDCs that are inherent to gamma spectroscopy for this type of low radioactivity sample. Conversely, the gross alpha/beta results for the composites correlate well and are indicative of background values for both upgradient and downgradient groundwater sampling points relative to the investigation area.

Table 4-21: Water Composite Concentrations

Composite	Ra-226	Total Gamma (pCi/L) [a]	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
2 (wells MW12 and MW13) [b]	–10 ± 50 [c]	23	0.9 ± 0.7	2.4 ± 1.0
9 (wells MW1–MW11 and MW14–MW17)	20 ± 50	140	1.2 ± 0.6	1.6 ± 1.0

[a] The laboratory did not provide an uncertainty for the gross gamma concentration. Laboratory result is given with two significant digits.
[b] Background composite.
[c] The laboratory subtracted instrument background radiation counts from the gross sample counts. When the concentration of the analyte is close to zero, this can result in reported net counts less than zero.

The groundwater samples collected in 2010 were analyzed by ASL. ASL used EPA Method 903.1(m), *Radium-226 in Drinking Water, Radon Emanation Technique,* and analyzed for Ra-226 by

EPA Method 903.0. Nineteen groundwater samples collected from monitoring wells MW20 through MW26 and temporary monitoring wells TMW01 through TMW12 and analyzed by ALS on 8 September 2010. These samples were prepared and analyzed according to ALS procedure SOP783R8. An additional six blanks and duplicates were also analyzed. Table 4-22 displays the results of the analysis. Figure 3-7 provides the location of the groundwater wells.

The results demonstrate that the groundwater at SS22 does not appear to have been impacted by residual Ra-226 contamination. Background (upgradient) Ra-226 concentrations in MW12 and MW13 are 0.0 to 0.3 pCi/L. The highest on-site Ra-226 concentration in groundwater, 0.45 +/- 0.29 pCi/L (TMW05-090810D), was collected from TMW05 at the north end of the RV Lot near Anomaly Area #20. This was a duplicate sample. The other sample from the sample location (TMW05-090810D) was reported as 0.08 +/- 0.29 pCi/L. These, and all other downgradient samples, are within the range of background.

Table 4-22: 2010 Groundwater Data

Laboratory ID	Field Sample ID	Ra-226 (pCi/L)
1008269-17	MW20-170810	-0.02 +/- 0.22 [a]
1008269-15	MW21-160810	0.02 +/- 0.19
1008269-21	MW22-160810	0.04 +/- 0.23
1008269-23	MW23-160810	0.03 +/- 0.21
1008269-4	MW24-170810	0 +/- 0.33
1008269-3	MW24-170810D (duplicate)	0.04 +/- 0.32
1008269-18	MW25-160810	0.08 +/- 0.19
1008269-12	MW26-120810	0.08 +/- 0.19
1008269-9	TMW01-110810	0.13 +/- 0.22
1008269-16	TMW02-130810	0.13 +/- 0.17
1008269-10	TMW03-060810	0.14 +/- 0.16
1008269-13	TMW04-060810	0.07 +/- 0.25
1008269-25	TMW05-090810	0.08 +/- 0.29
1008269-5	TMW05-090810D (duplicate)	0.45 +/- 0.29
1008269-6	TMW06-090810	0.03 +/- 0.17
1008269-8	TMW07-090810	0.11 +/- 0.14
1008269-24	TMW08-090810	0.06 +/- 0.18
1008269-22	TMW09-090810	0 +/- 0.19
1008269-20	TMW10-100810	0.03 +/- 0.16
1008269-14	TMW10-100810D (duplicate)	0.03 +/- 0.18
1008269-7	TMW11-100810	0 +/- 0.25
1008269-11	TMW12-110810	0.34 +/- 0.33

[a] The laboratory subtracted instrument background radiation counts from the gross sample counts. When the concentration of the analyte is close to zero, this can result in reported net counts less than zero.

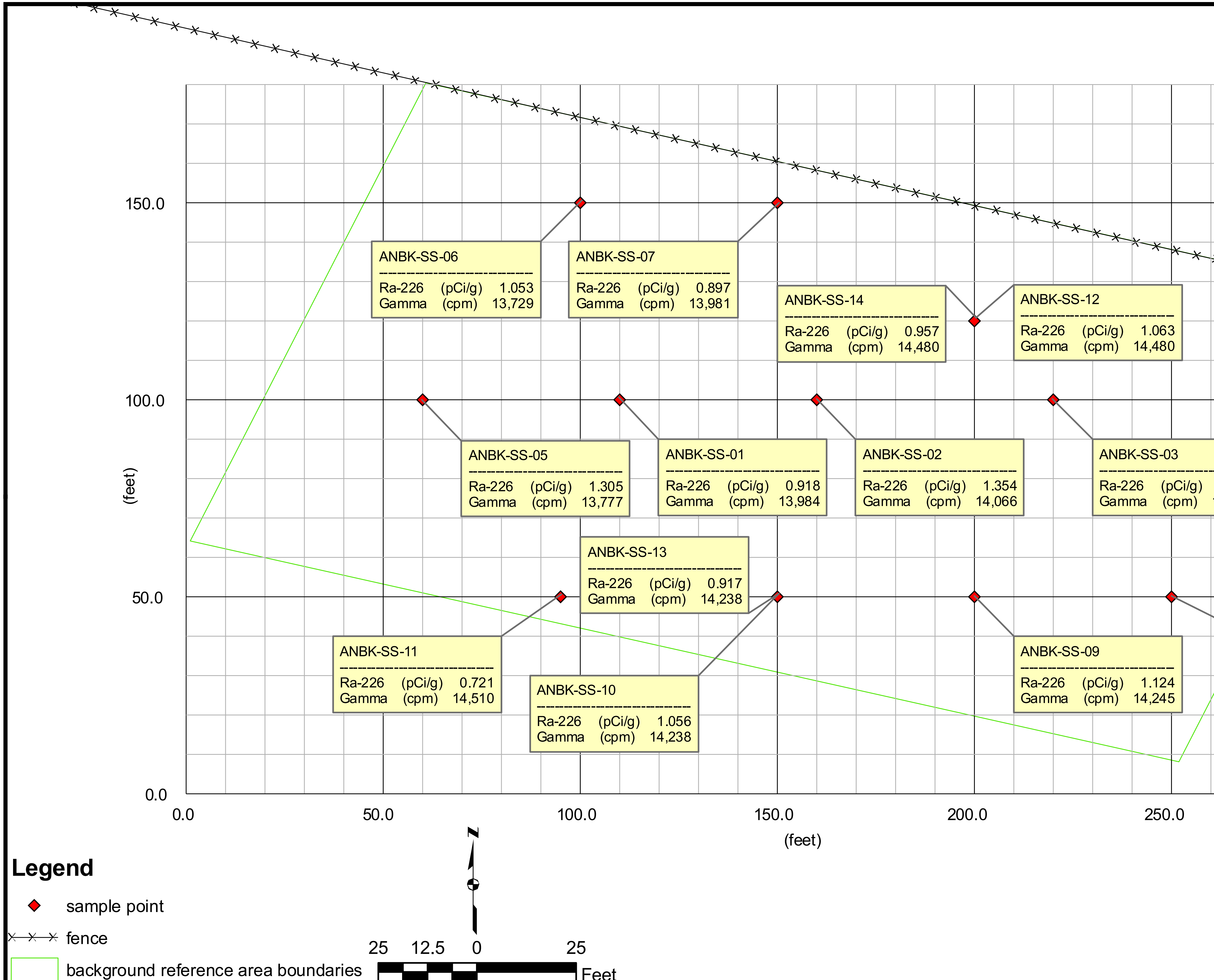


FIGURE 4-1

BACKGROUND REFERENCE AREA SURFACE SOIL RESULTS SS22, JBER, ALASKA

(Denver) L:\GROUP\CAD\ELMENDORF AFB\JULY09\ANA_ANOMOLY999.MXD DATE: 7/20/2009

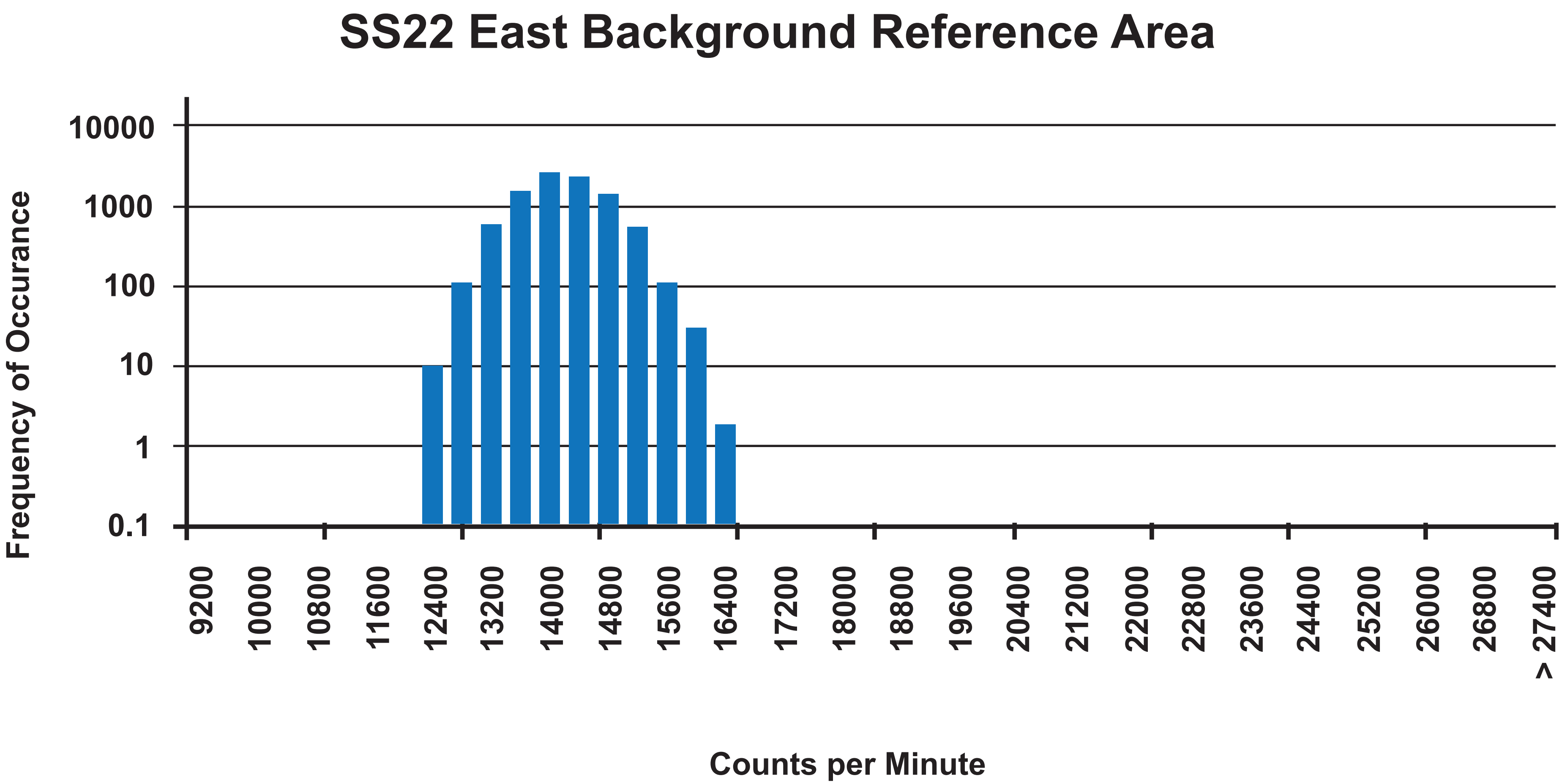
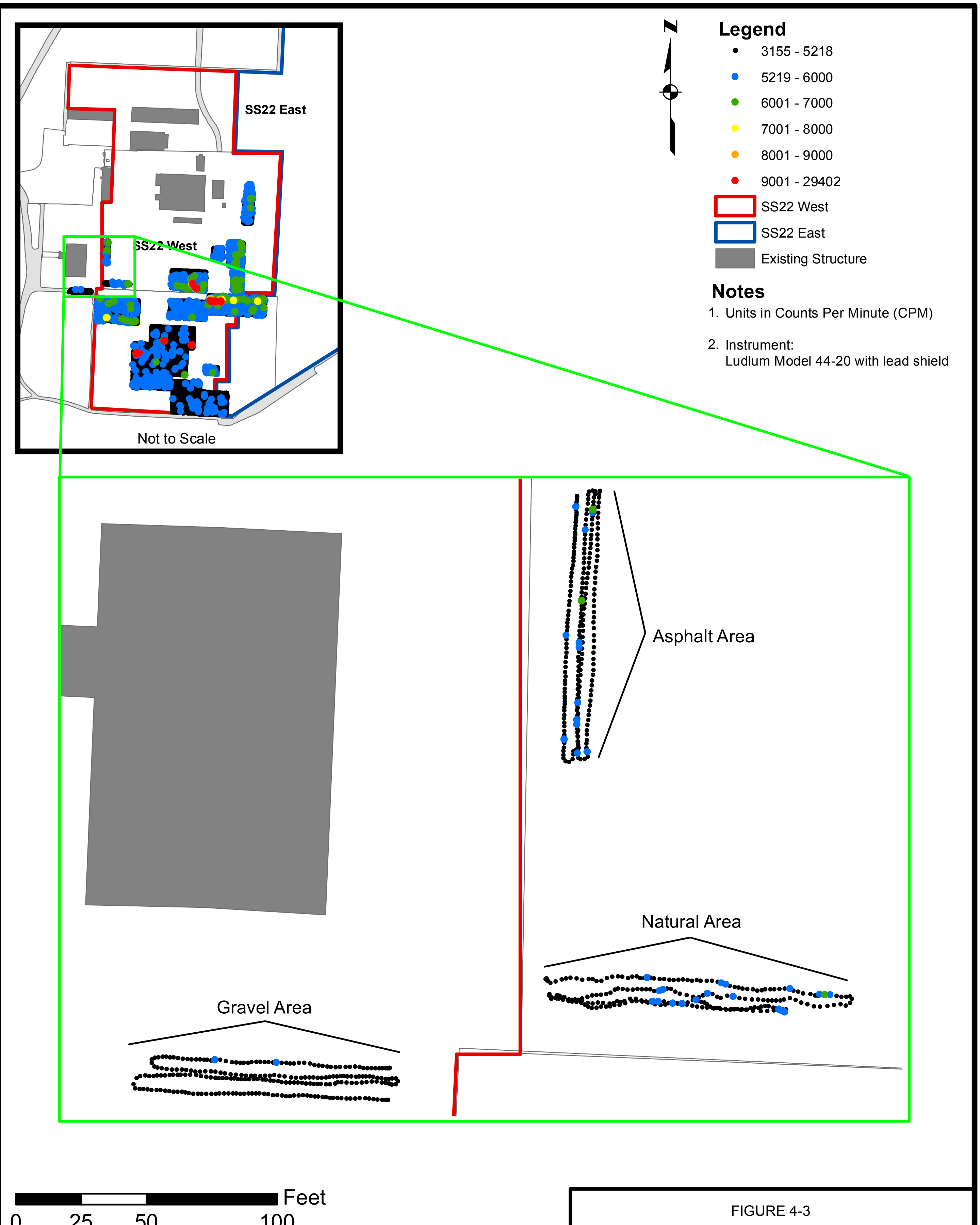


FIGURE 4-2

**SS22 EAST BACKGROUND REFERENCE AREA
GAMMA WALKOVER SURVEY DATA DISTRIBUTION
(UNSHIELDED 3X3 NAL DETECTOR)
SS22, JBER, ALASKA**



Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-3

GAMMA WALKOVER SURVEY
BACKGROUND STUDY AREAS, SS22 WEST
JBER, ALASKA

L:\work\60134053\ENG\Maps\Figure_4-3.mxd August 12, 2011

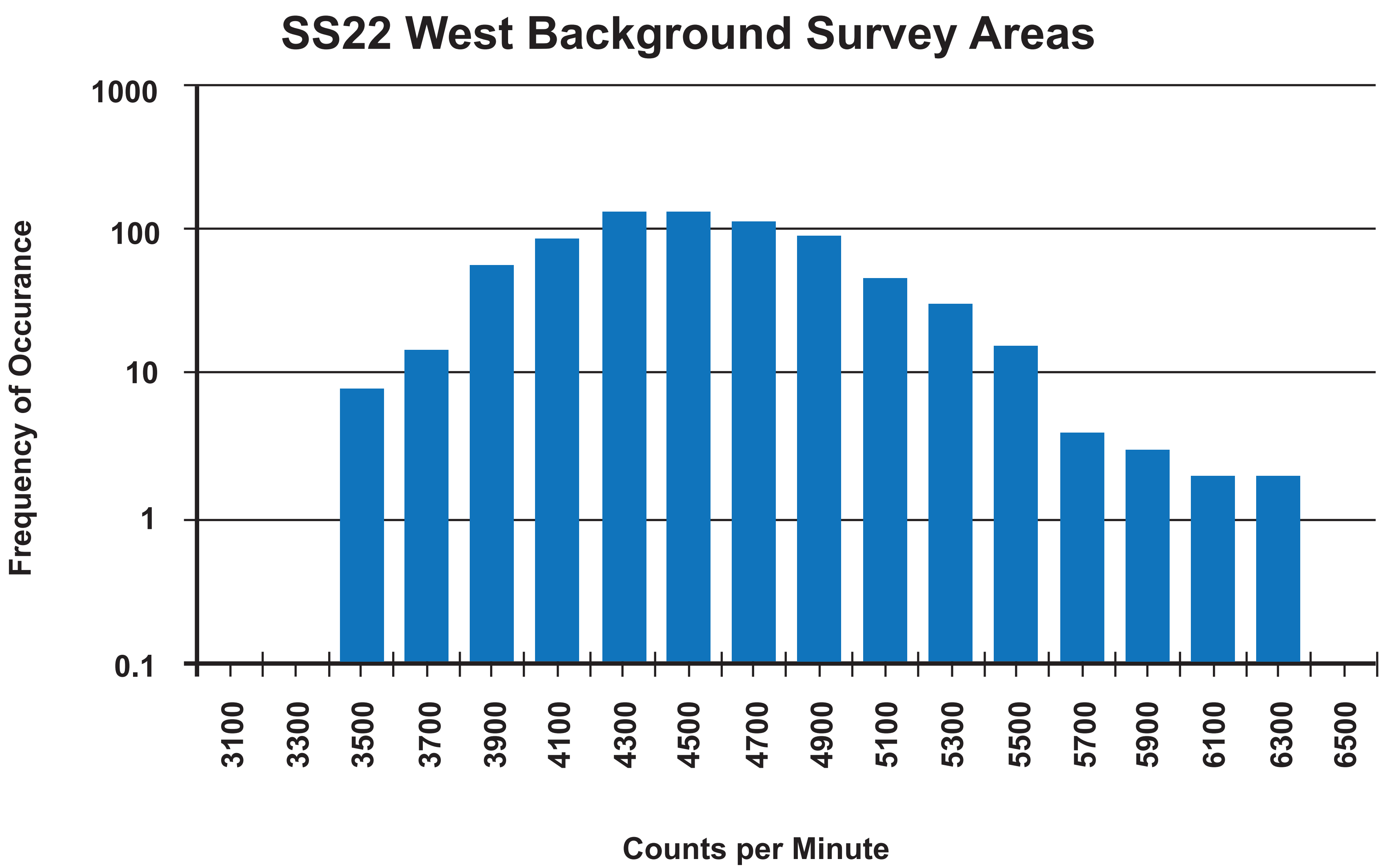


FIGURE 4-4

SS22 WEST BACKGROUND AREA
GAMMA WALKOVER SURVEY DATA DISTRIBUTION
(SHIELDED 3X3 NAL DETECTOR)
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-4.ai 1/13/2011

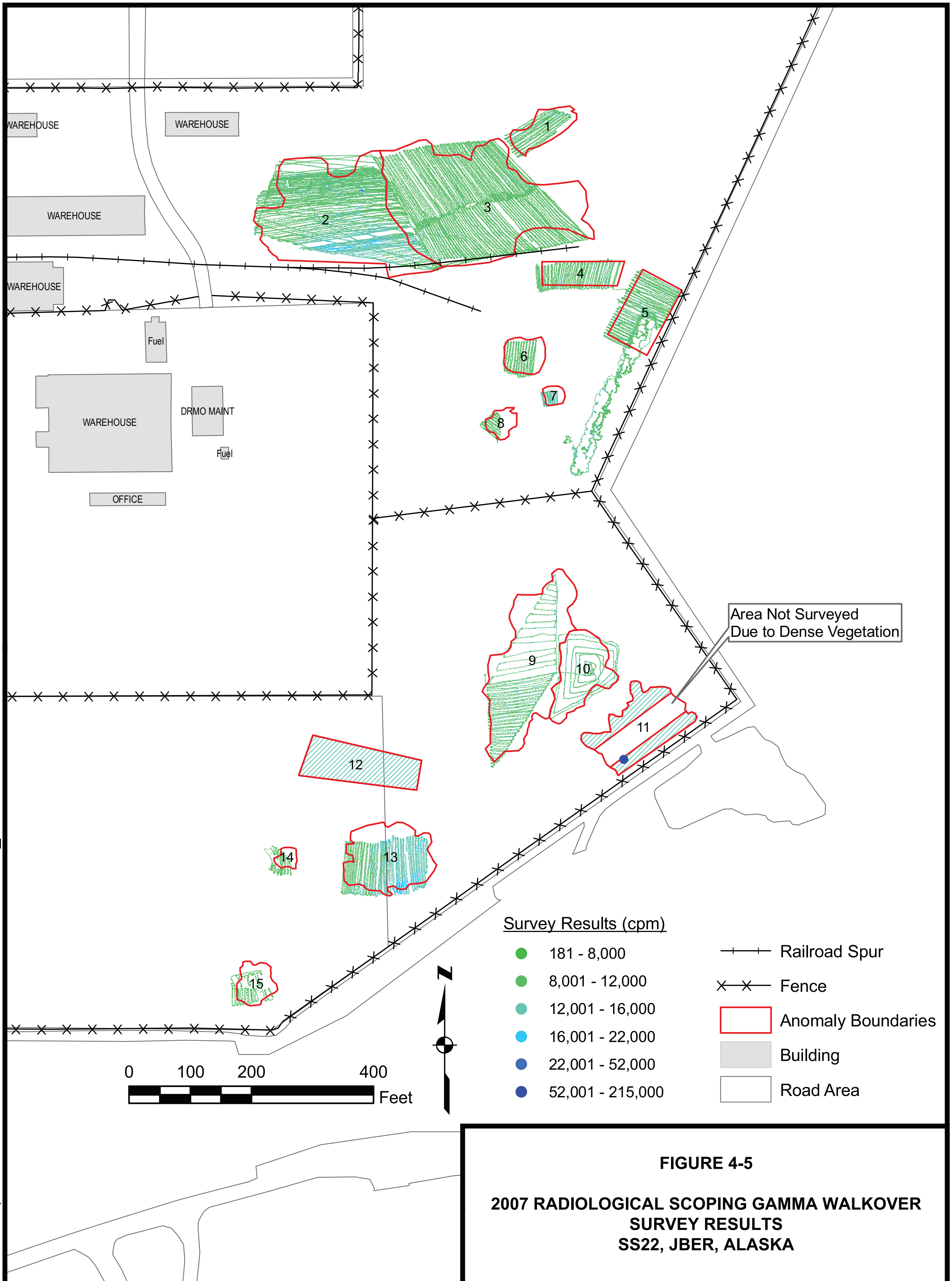


FIGURE 4-5

2007 RADIOLOGICAL SCOPING GAMMA WALKOVER SURVEY RESULTS
SS22, JBER, ALASKA

(Bloomfield) H:\basket\Elmendorf\GPSRad\ElmendorfJul09_3.mxd DATE: 7/31/2009

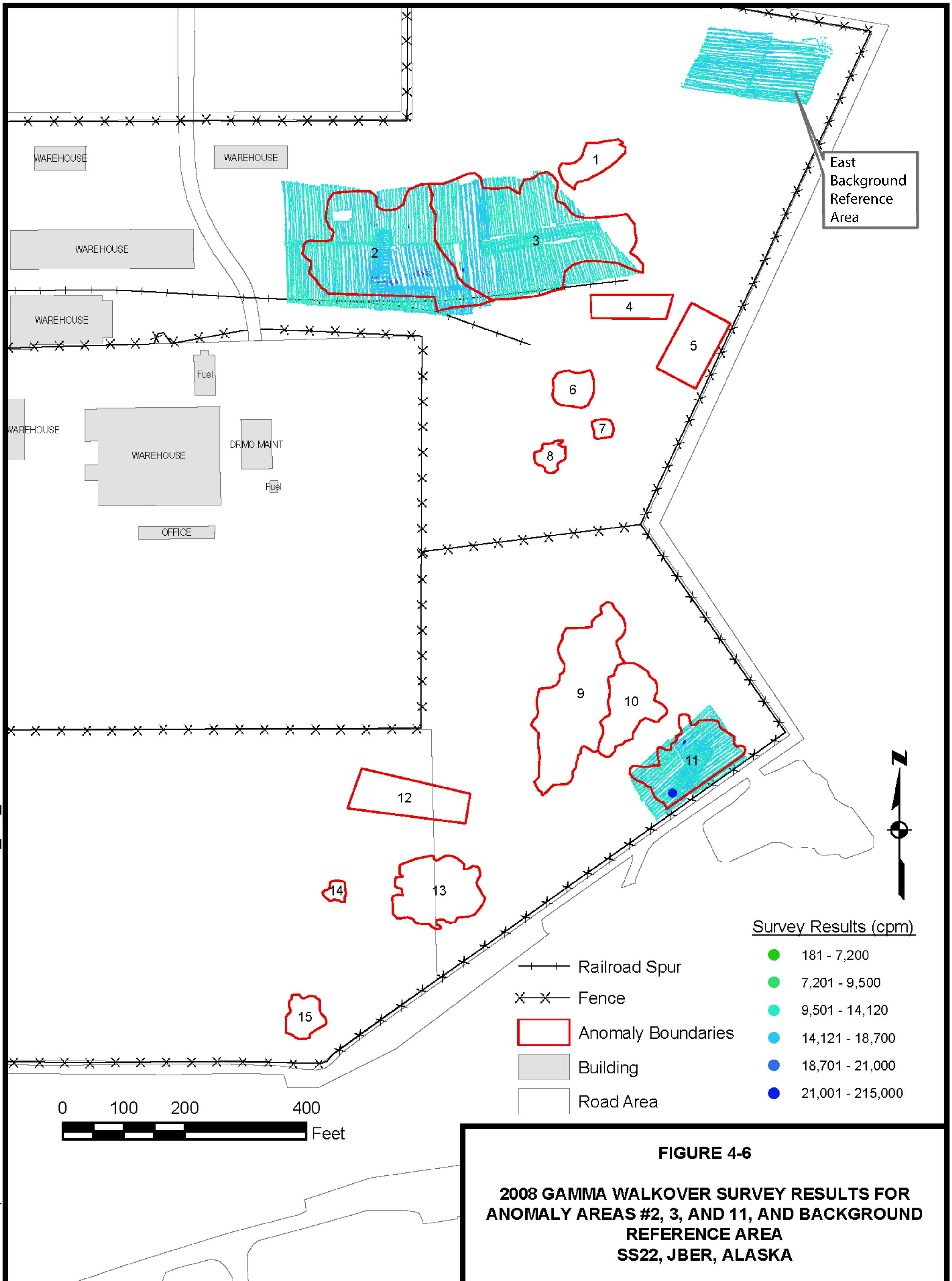


FIGURE 4-6

2008 GAMMA WALKOVER SURVEY RESULTS FOR ANOMALY AREAS #2, 3, AND 11, AND BACKGROUND REFERENCE AREA SS22, JBER, ALASKA

(Bloomfield) H:\basket\Elmendorf\GPSRad\ElmendorfJul09_4-1_1.mxd DATE: 7/31/2009

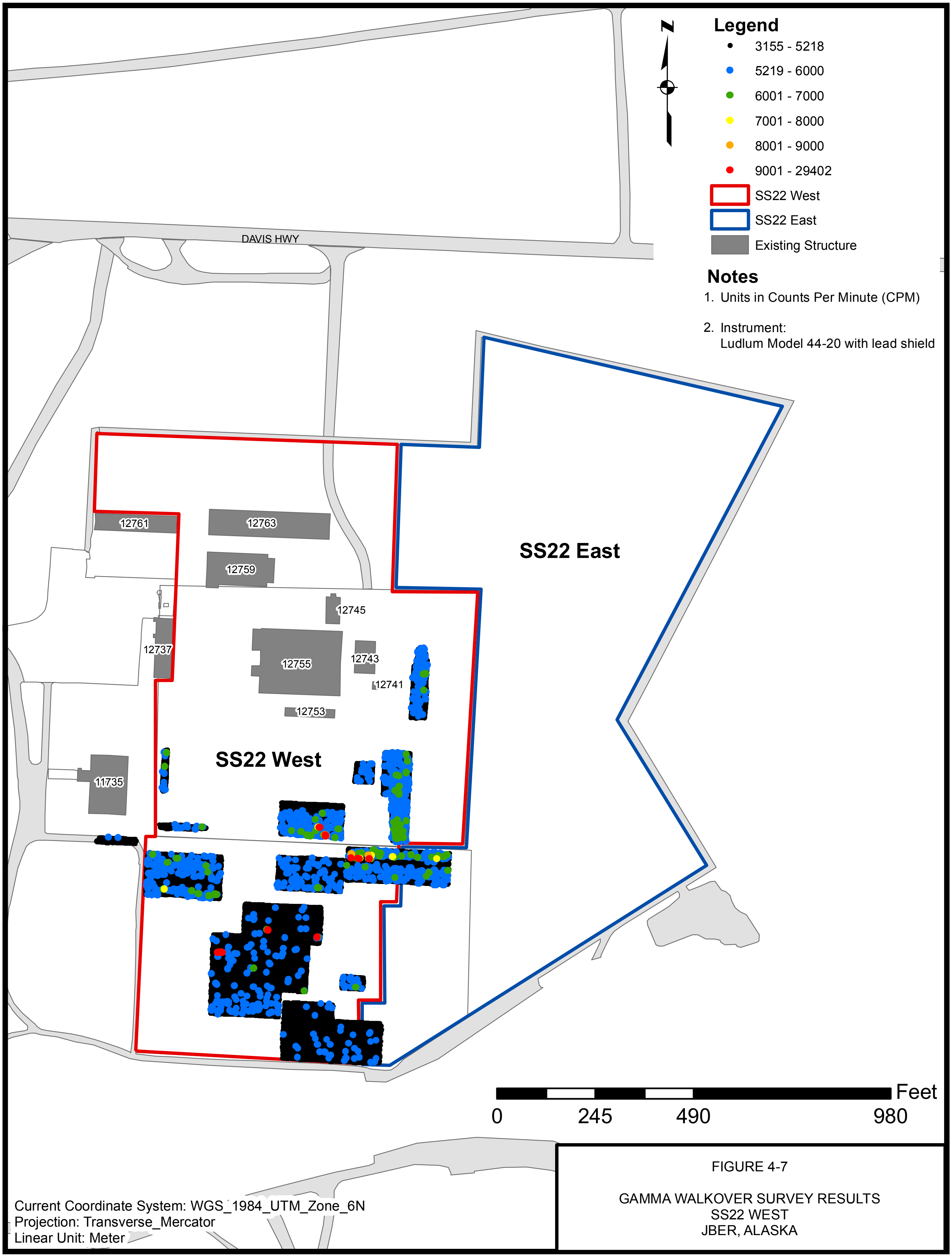


FIGURE 4-7

GAMMA WALKOVER SURVEY RESULTS
SS22 WEST
JBER, ALASKA

L:\work\60134053\ENG\Maps\Figure_4-7.mxd August 12, 2011

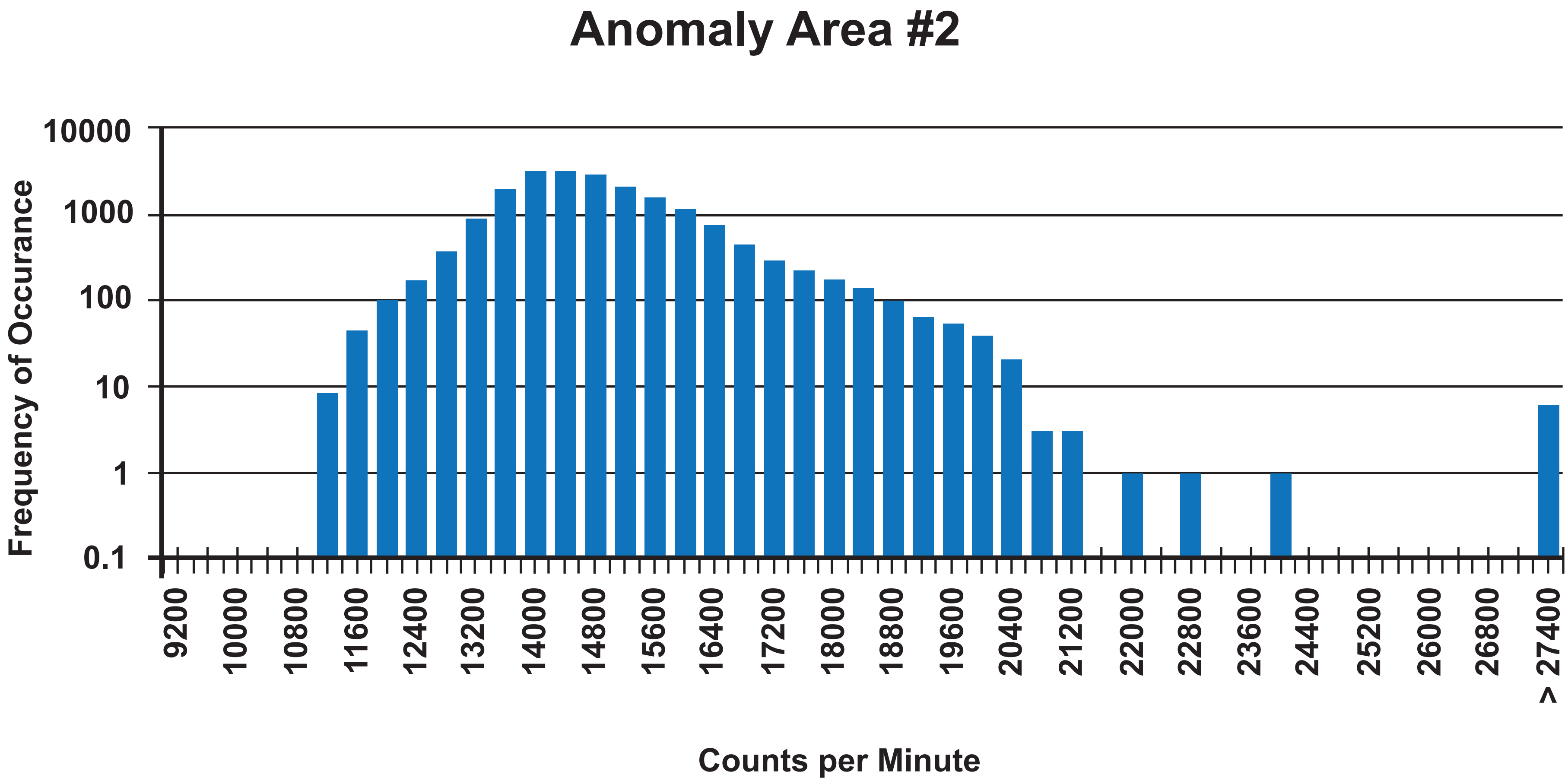


FIGURE 4-8

ANOMALY AREA #2
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-8.ai 1/13/2011

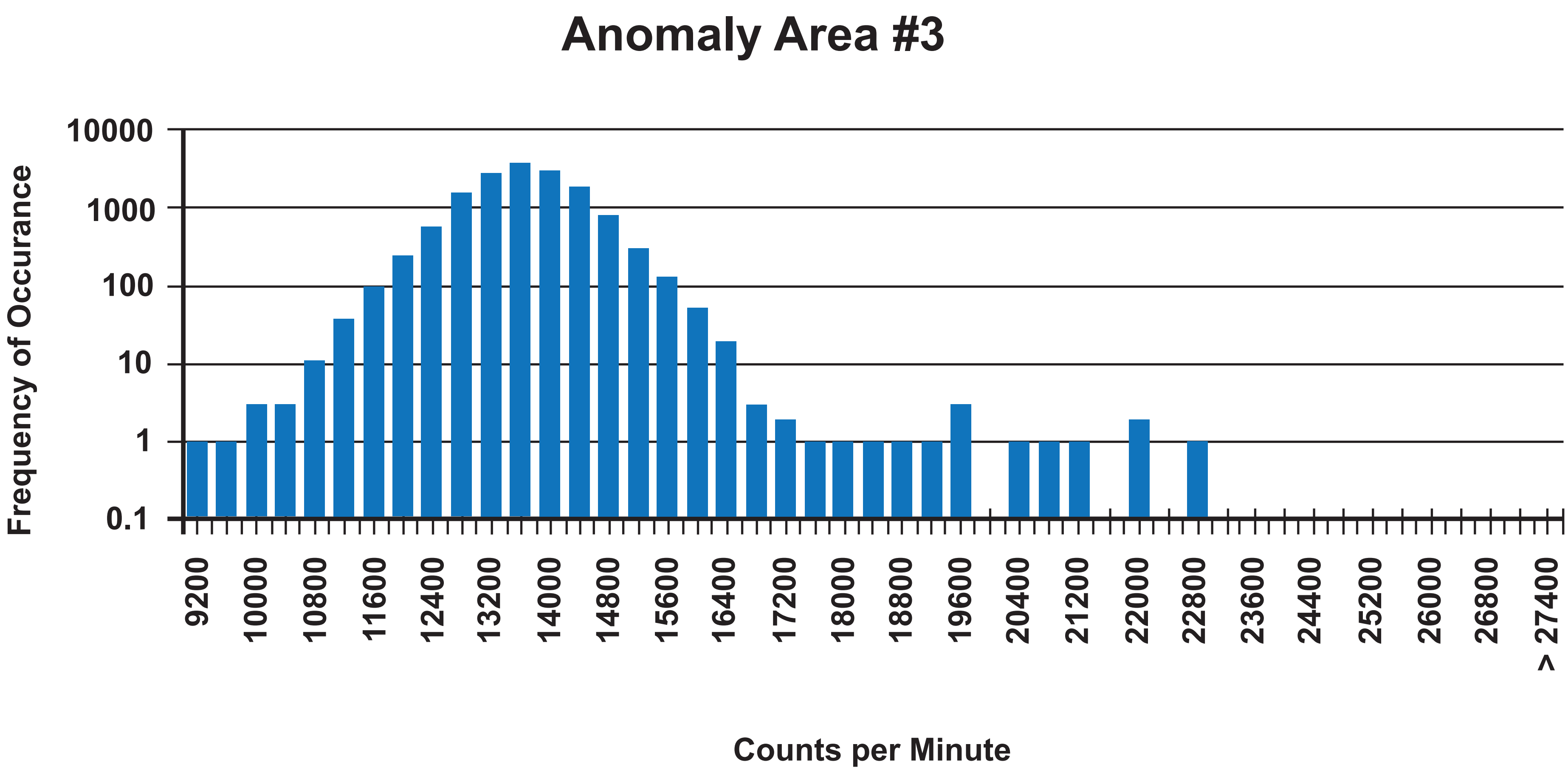


FIGURE 4-9

ANOMALY AREA #3
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-9.ai 1/13/2011

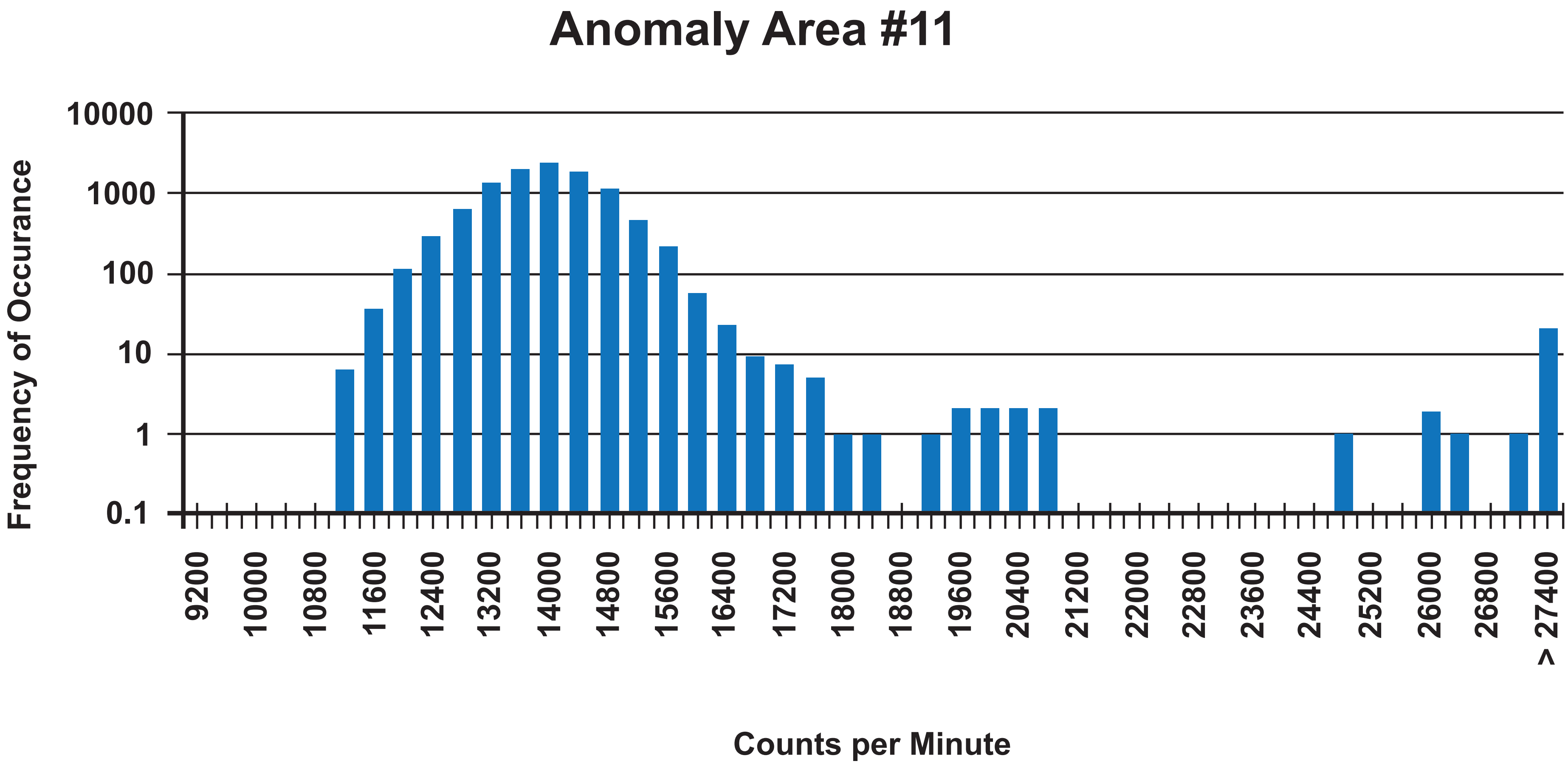


FIGURE 4-10

ANOMALY AREA #11
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-10.ai 1/13/2011

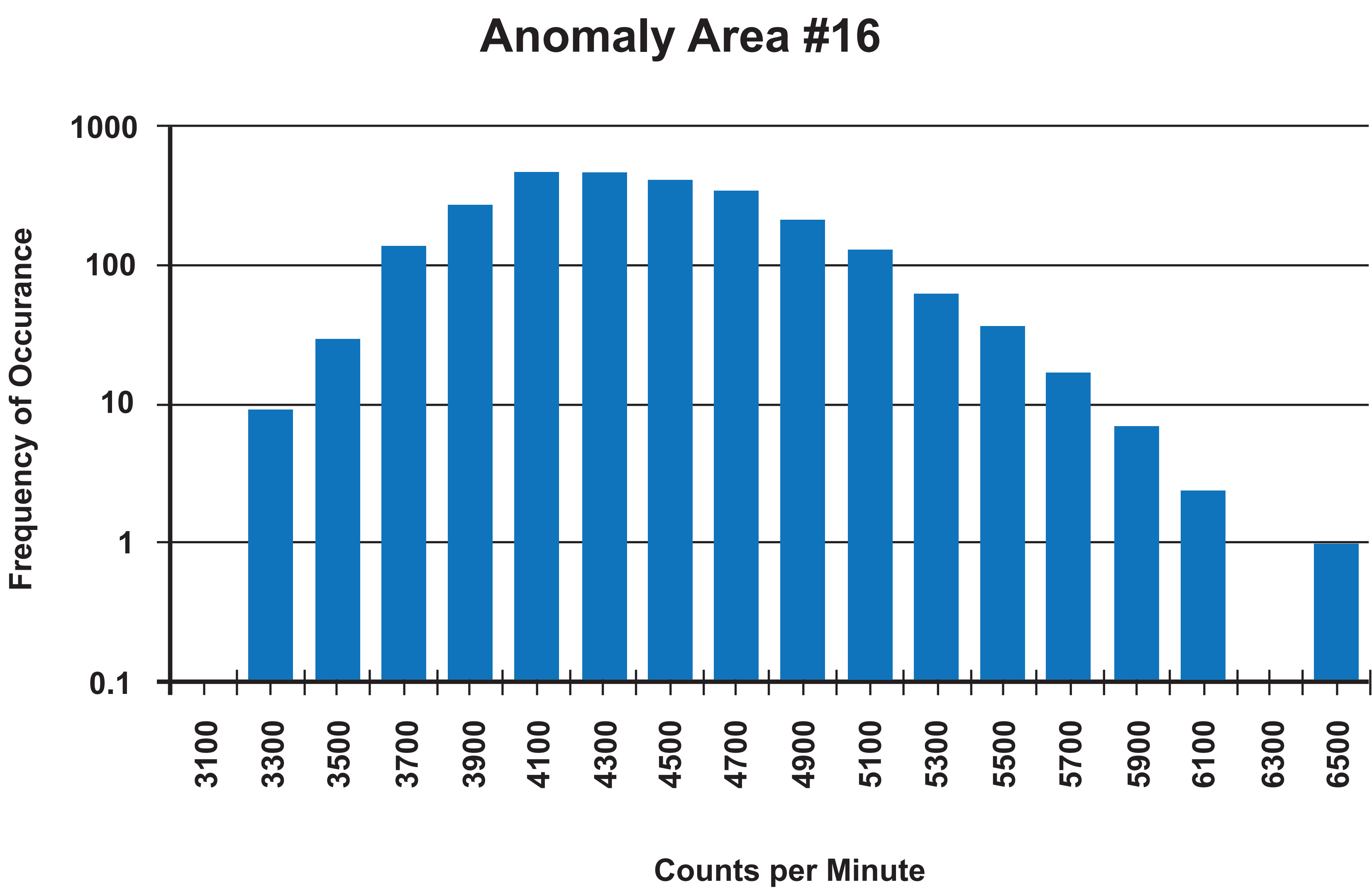
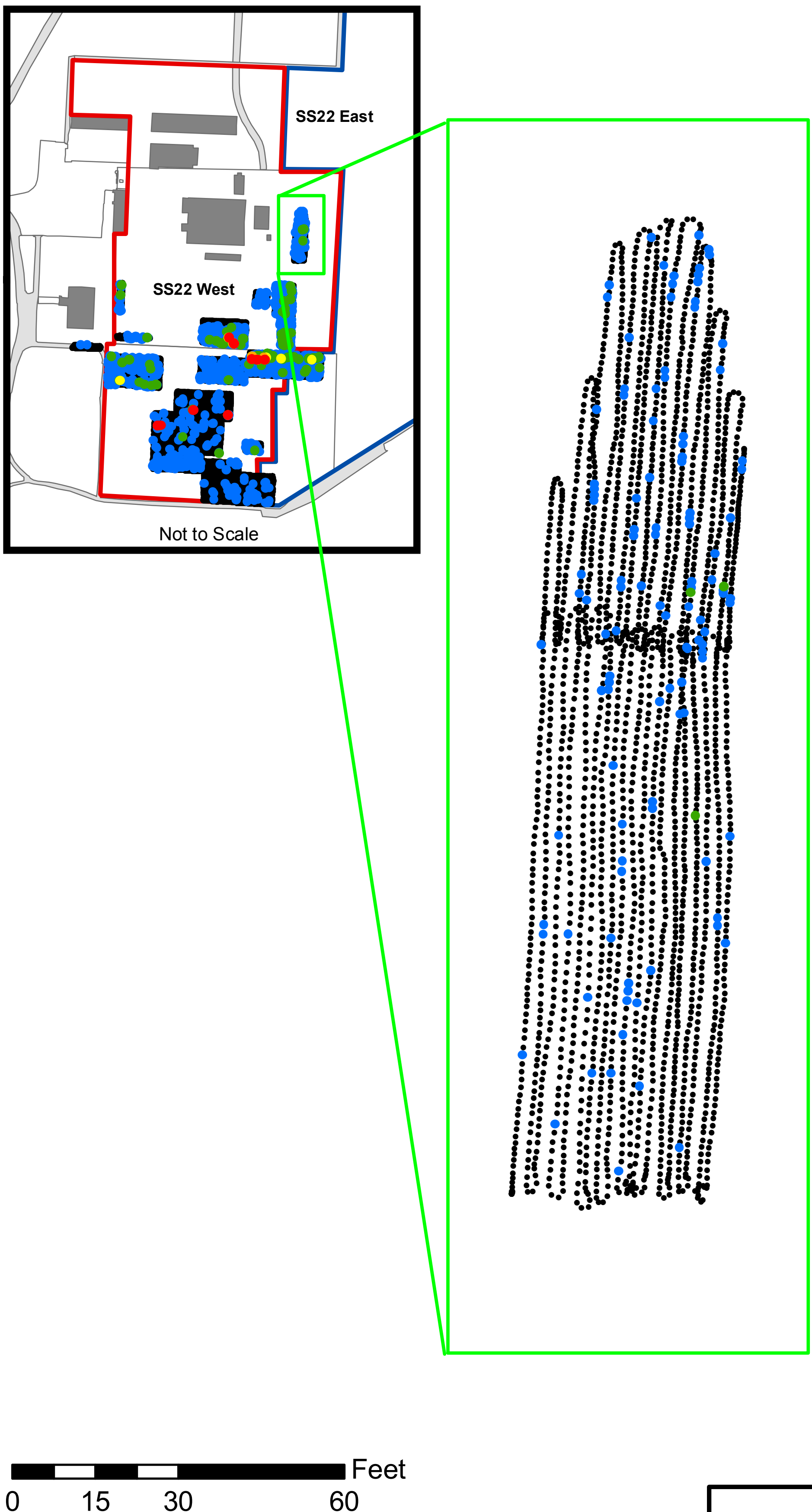


FIGURE 4-11

ANOMALY AREA #16
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-11.ai 1/13/2011



N

Legend

- 3155 - 5218
- 5219 - 6000
- 6001 - 7000
- 7001 - 8000
- 8001 - 9000
- 9001 - 29402
- SS22 West
- SS22 East
- Existing Structure

Notes

1. Units in Counts Per Minute (CPM)
2. Instrument:
   Ludlum Model 44-20 with lead shield

Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-12

GAMMA WALKOVER SURVEY
ANOMALY AREA #16, SS22 WEST
JBER, ALASKA

L:\work\60134053\ENG\Maps\Figure_4-12.mxd

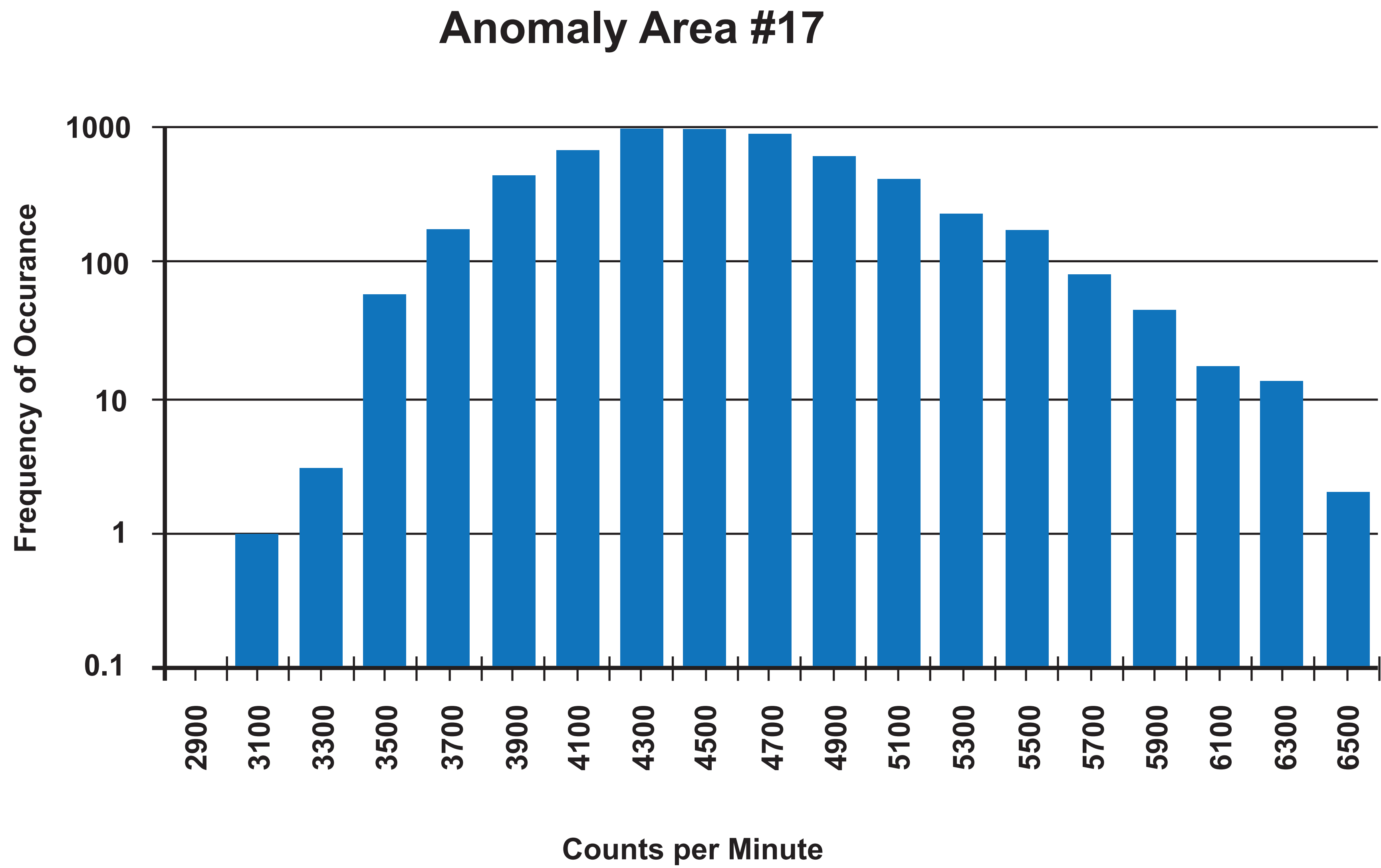
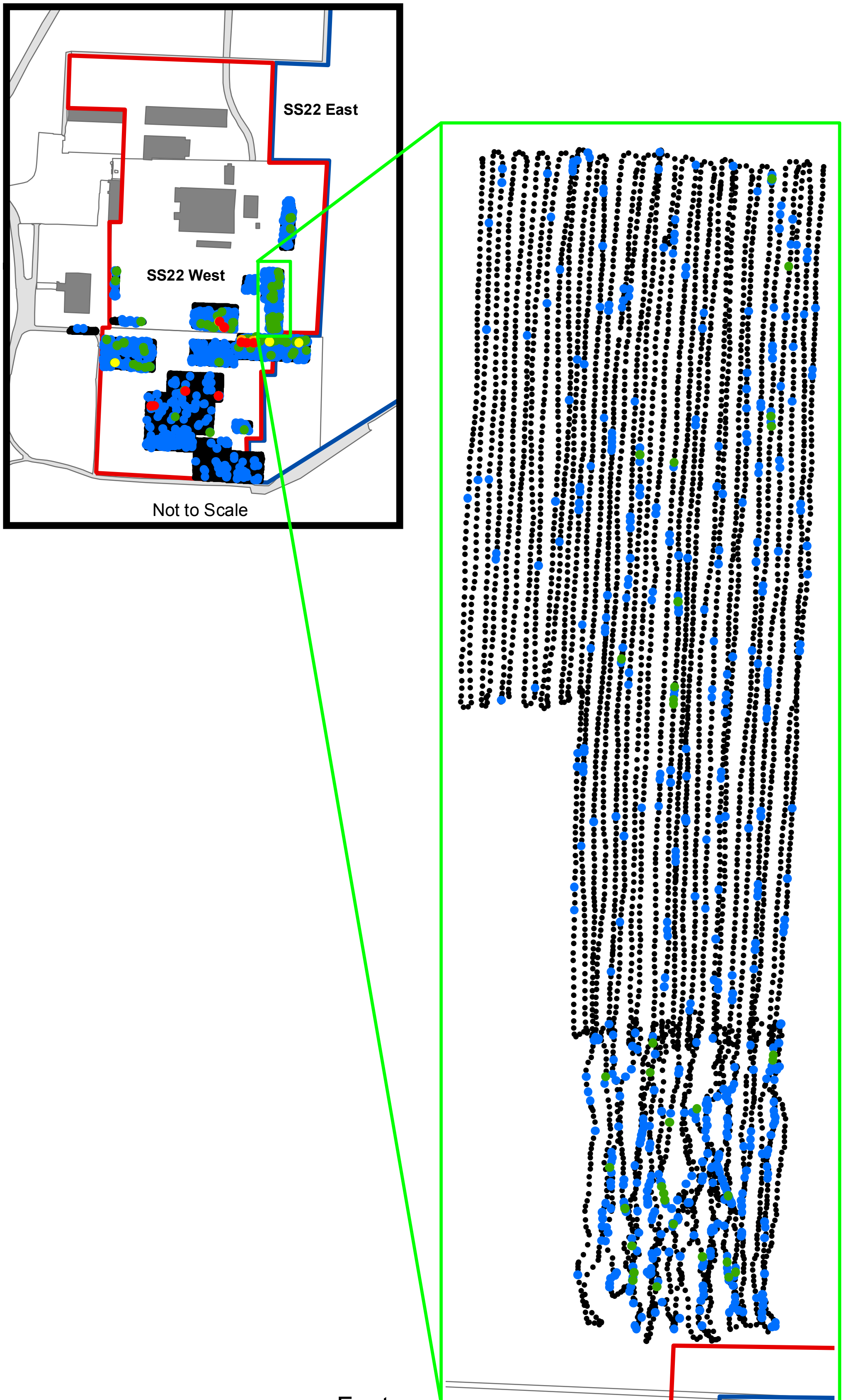


FIGURE 4-13

ANOMALY AREA #17
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-11.ai 1/13/2011



N

Legend

- 3155 - 5218
- 5219 - 6000
- 6001 - 7000
- 7001 - 8000
- 8001 - 9000
- 9001 - 29402
- SS22 West
- SS22 East
- Existing Structure

Notes

1. Units in Counts Per Minute (CPM)
2. Instrument:
   Ludlum Model 44-20 with lead shield

Feet
0 15 30 60

Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-14

GAMMA WALKOVER SURVEY
ANOMALY AREA #17, SS22 WEST
JBER, ALASKA

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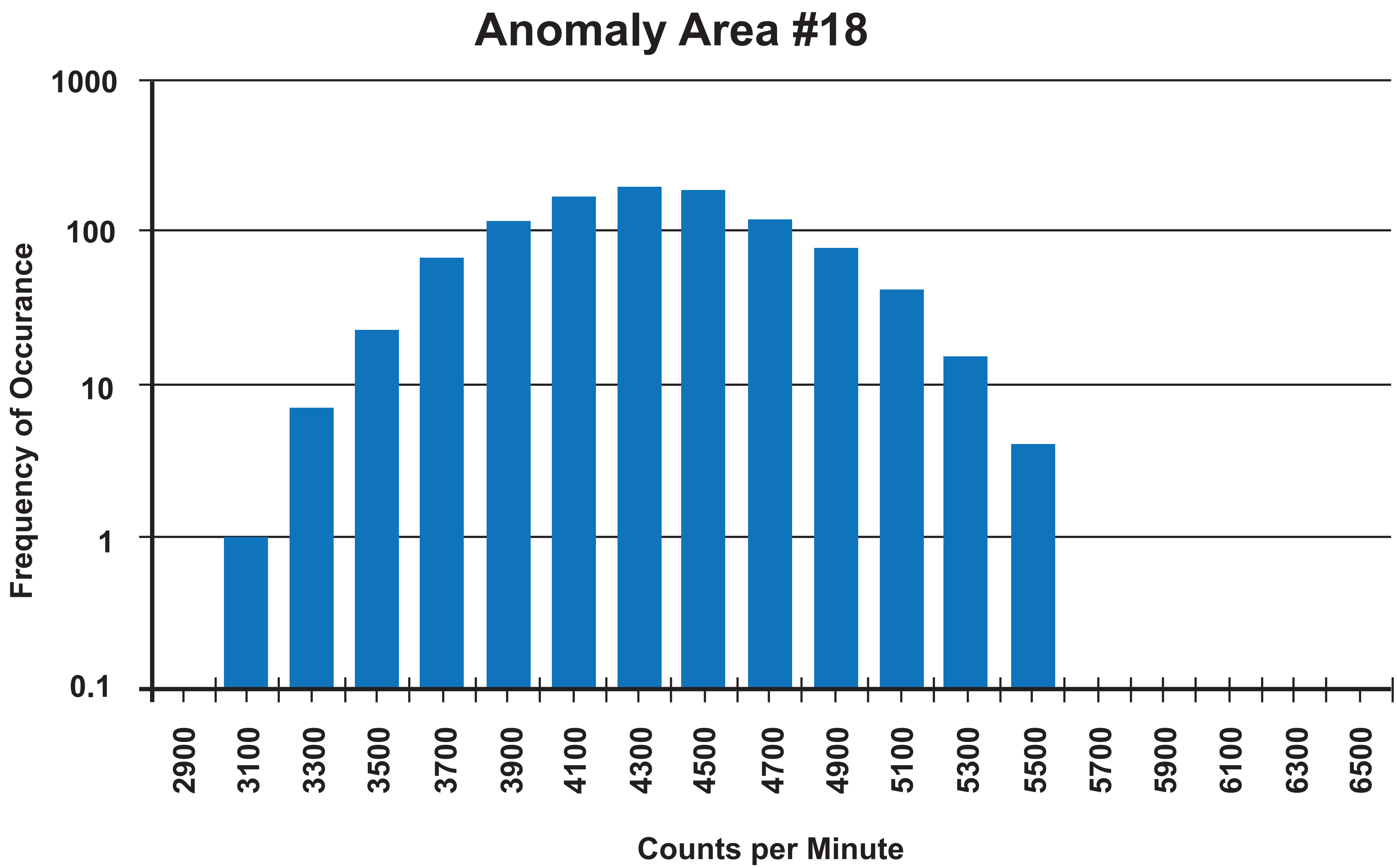
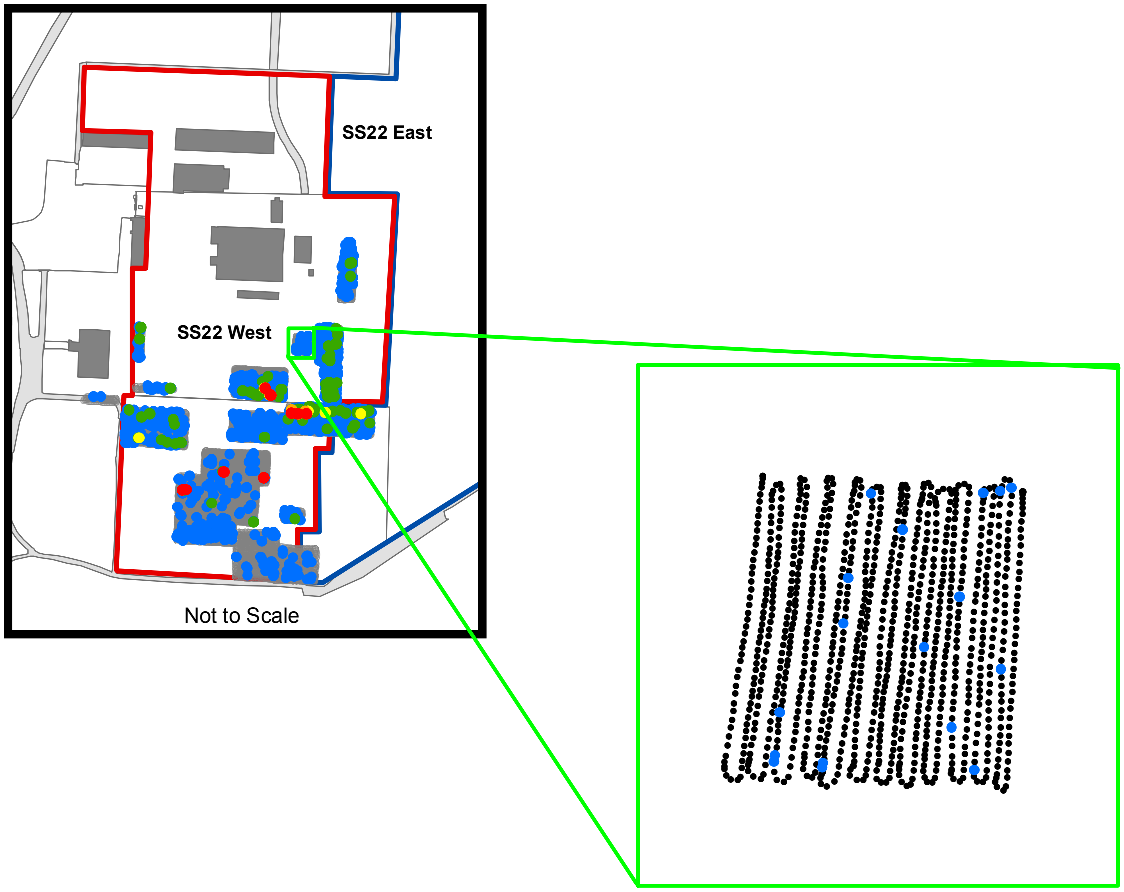


FIGURE 4-15

ANOMALY AREA #18
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-15.ai 1/13/2011



N

Legend

- 3155 - 5218
- 5219 - 6000
- 6001 - 7000
- 7001 - 8000
- 8001 - 9000
- 9001 - 29402
- SS22 West
- SS22 East
- Existing Structure

Notes

1. Units in Counts Per Minute (CPM)
2. Instrument: Ludlum Model 44-20 with lead shield

Feet
0 15 30 60

Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-16

GAMMA WALKOVER SURVEY
ANOMALY AREA #18, SS22 WEST
JBER, ALASKA

L:\work\60134053\ENG\Maps\Figure_4-16.mxd

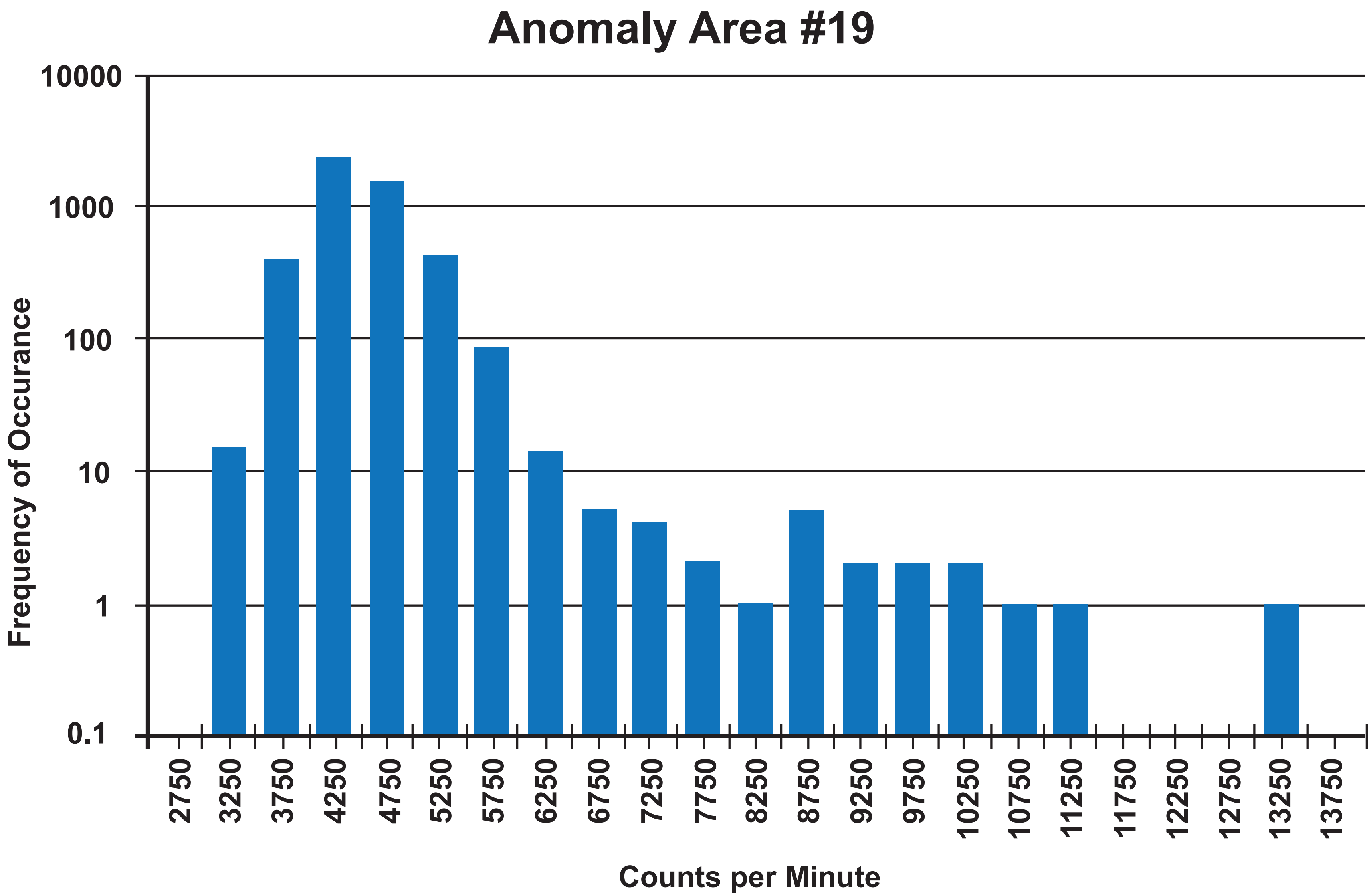
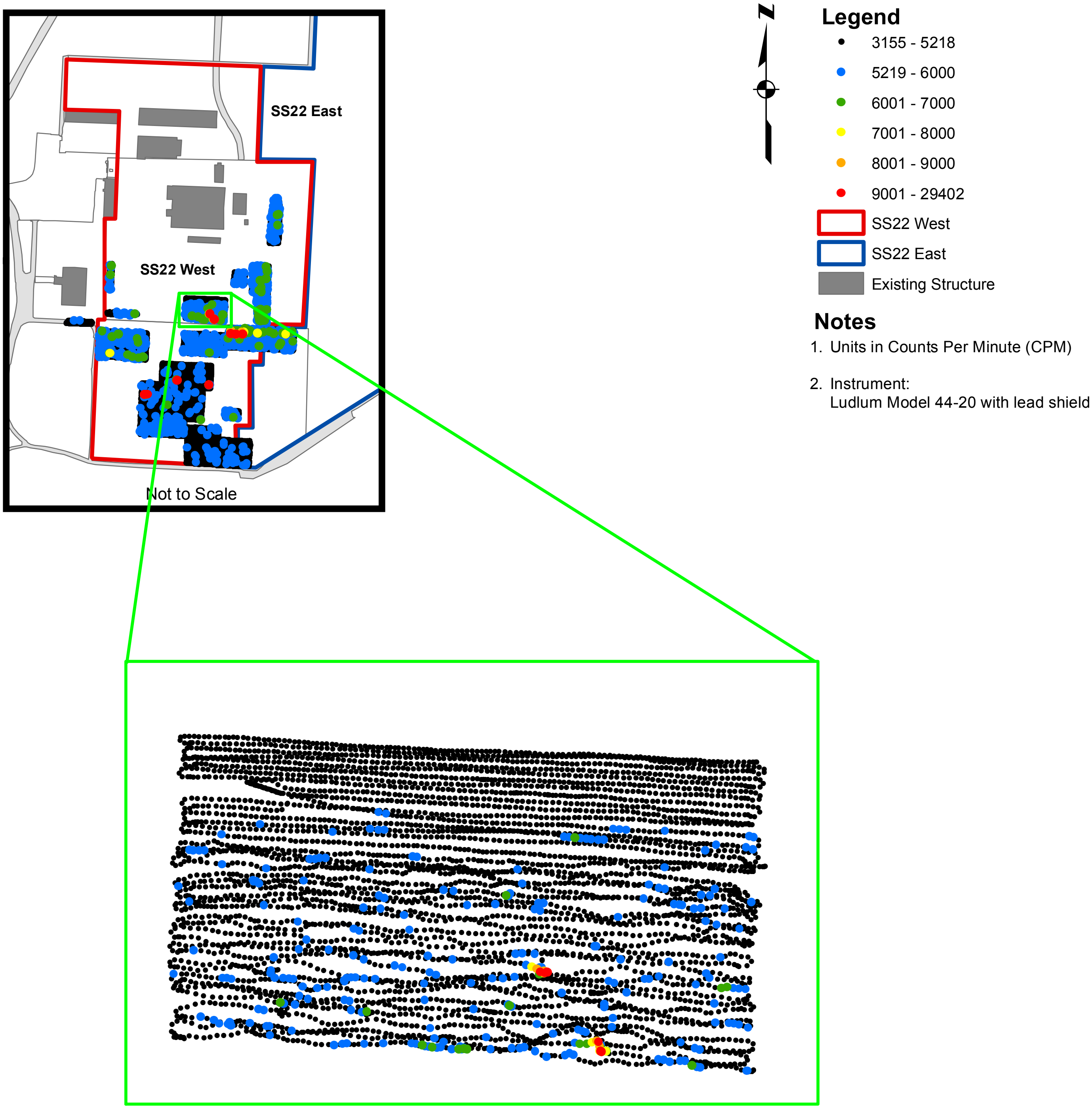


FIGURE 4-17

ANOMALY AREA #19
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-17.ai 1/13/2011



Feet
0 20 40 80

Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-18

GAMMA WALKOVER SURVEY
ANOMALY AREA #19, SS22 WEST
JBER, ALASKA

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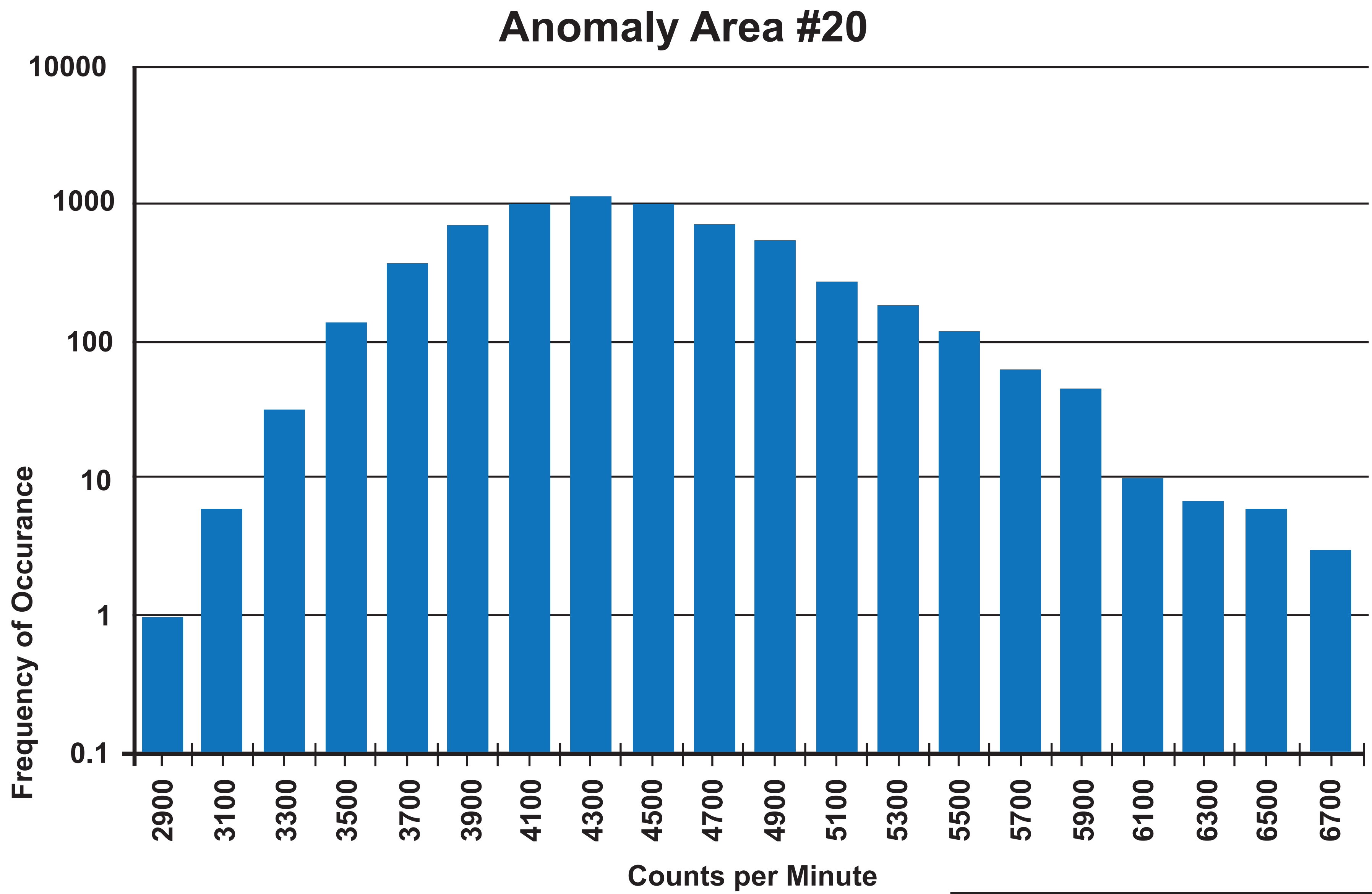
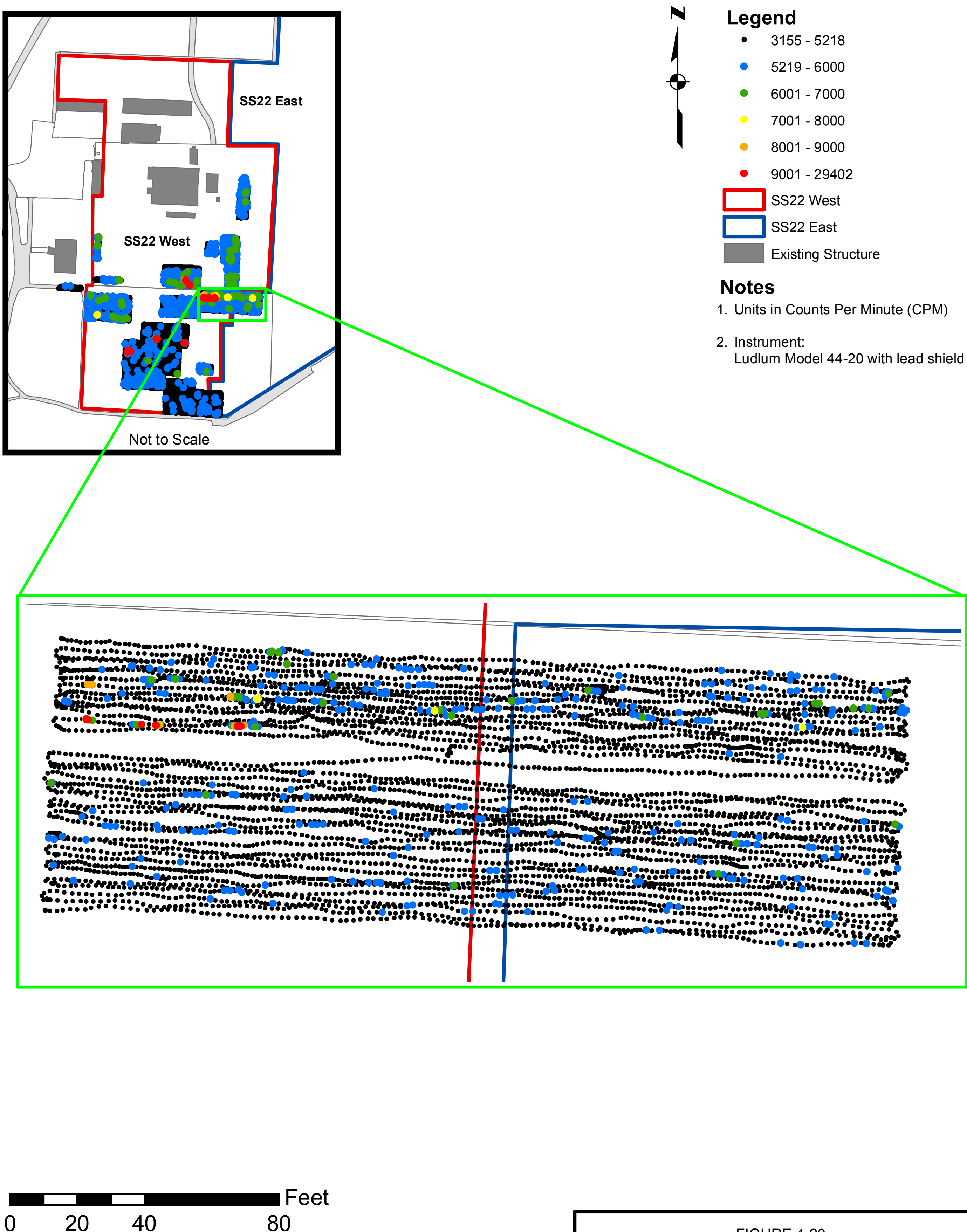


FIGURE 4-19

ANOMALY AREA #20
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-19.ai 1/13/2011



Notes

1. Units in Counts Per Minute (CPM)
2. Instrument:
   Ludlum Model 44-20 with lead shield

Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-20

GAMMA WALKOVER SURVEY
ANOMALY AREA #20, SS22 WEST
JBER, ALASKA

L:\work\60134053\ENG\Maps\Figure_4-20.mxd

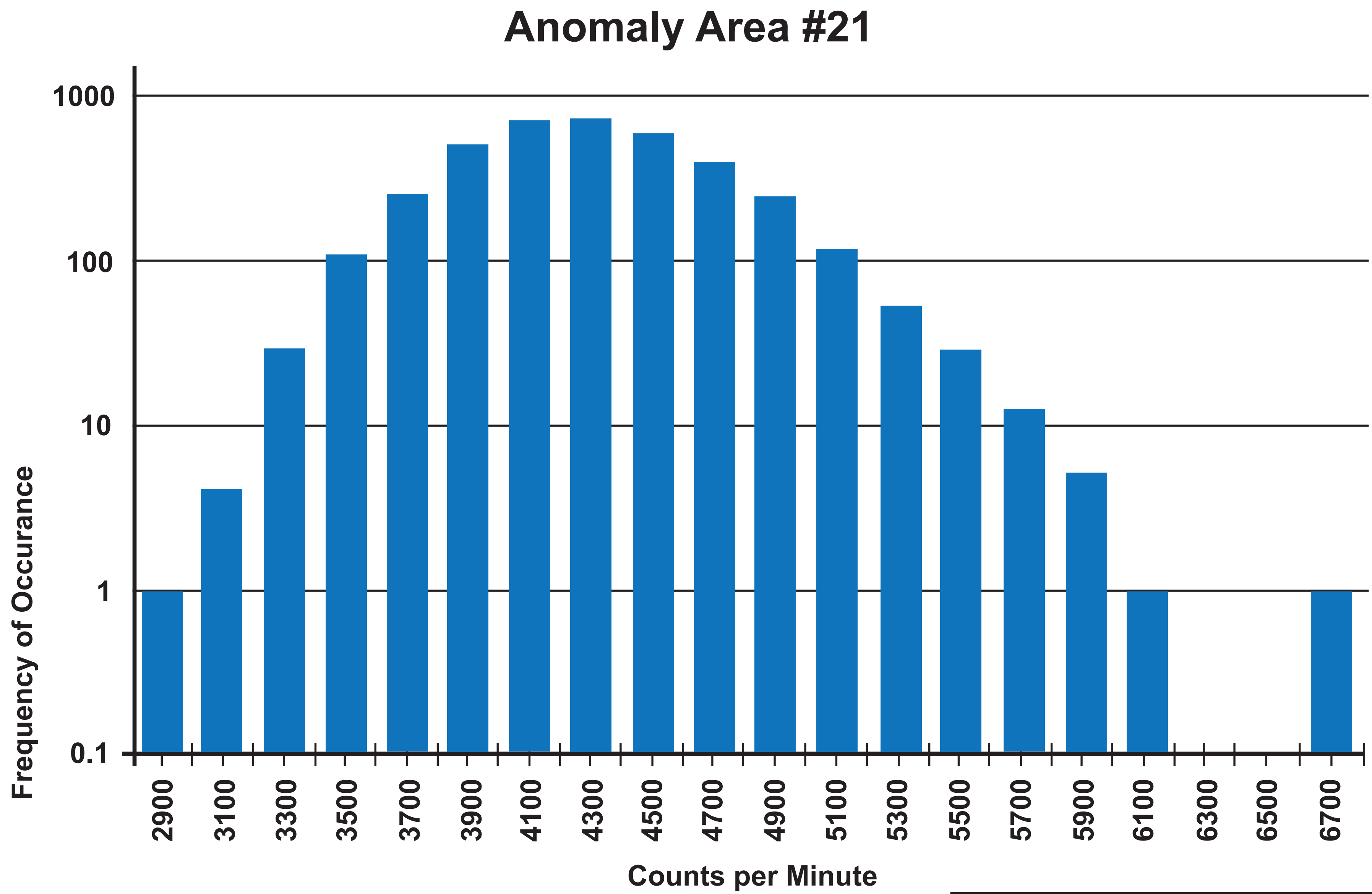


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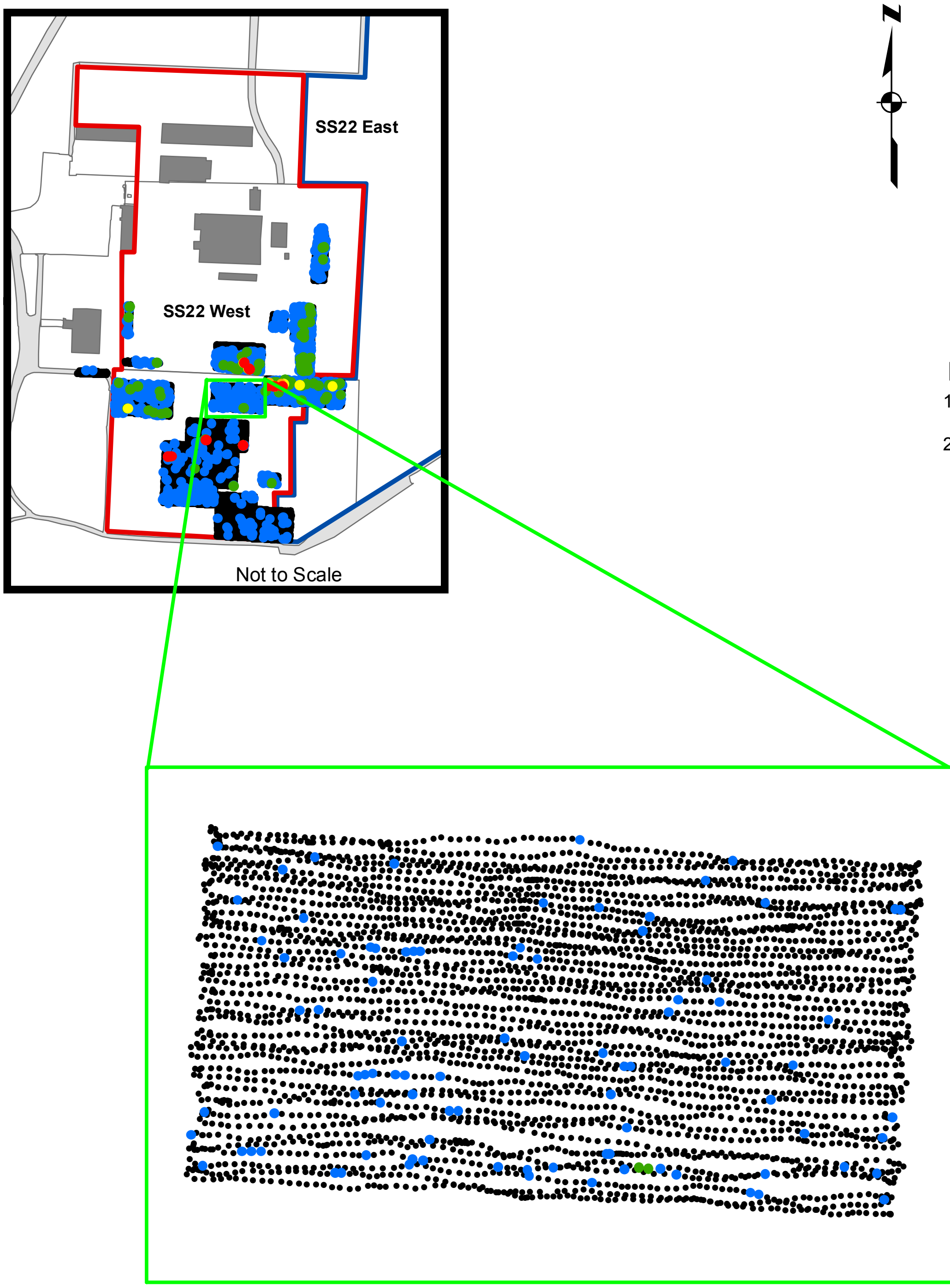
FIGURE 4-21

ANOMALY AREA #21
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA



N

Legend

- 3155 - 5218
- 5219 - 6000
- 6001 - 7000
- 7001 - 8000
- 8001 - 9000
- 9001 - 29402
- SS22 West
- SS22 East
- Existing Structure

Notes

1. Units in Counts Per Minute (CPM)
2. Instrument:
   Ludlum Model 44-20 with lead shield

Feet
0 20 40 80

Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-22

GAMMA WALKOVER SURVEY
ANOMALY AREA #21, SS22 WEST
JBER, ALASKA

L:\work\60134053\ENG\Maps\Figure_4-22.mxd

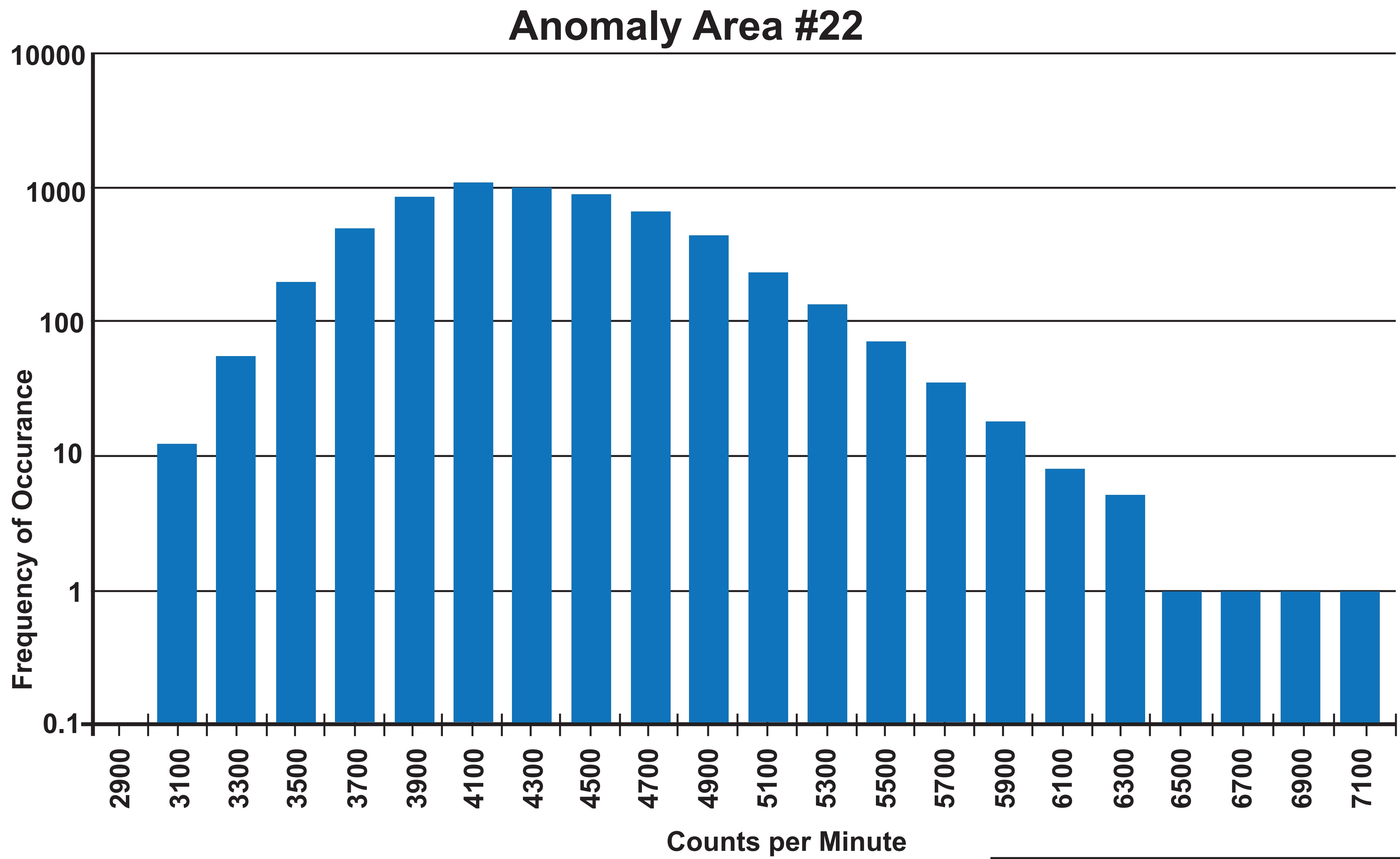
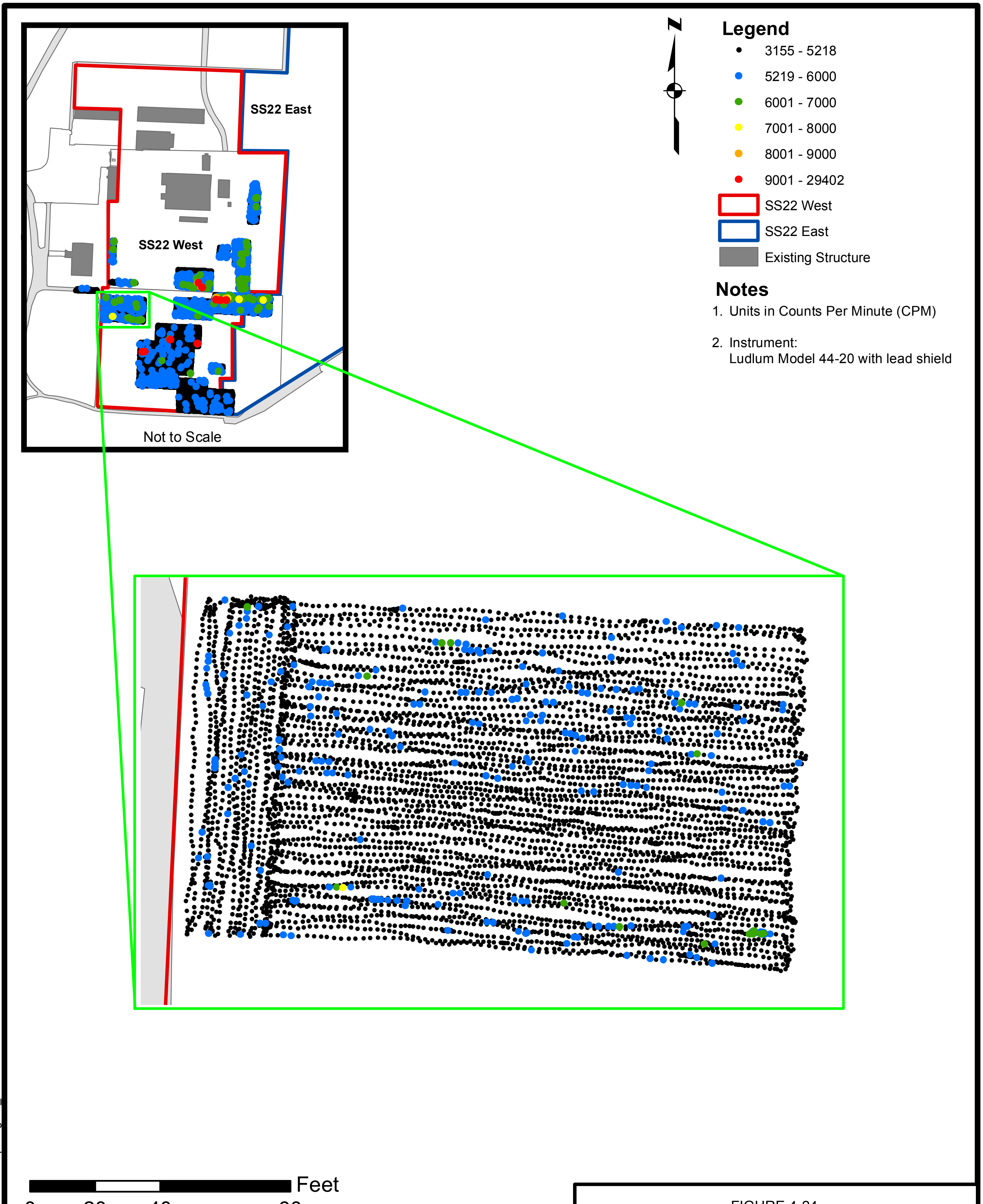


FIGURE 4-23

ANOMALY AREA #22
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-23.ai 1/13/2011



Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

L:\work\60134053\ENG\Maps\Figure_4-24.mxd

FIGURE 4-24

GAMMA WALKOVER SURVEY
ANOMALY AREA #22, SS22 WEST
JBER, ALASKA

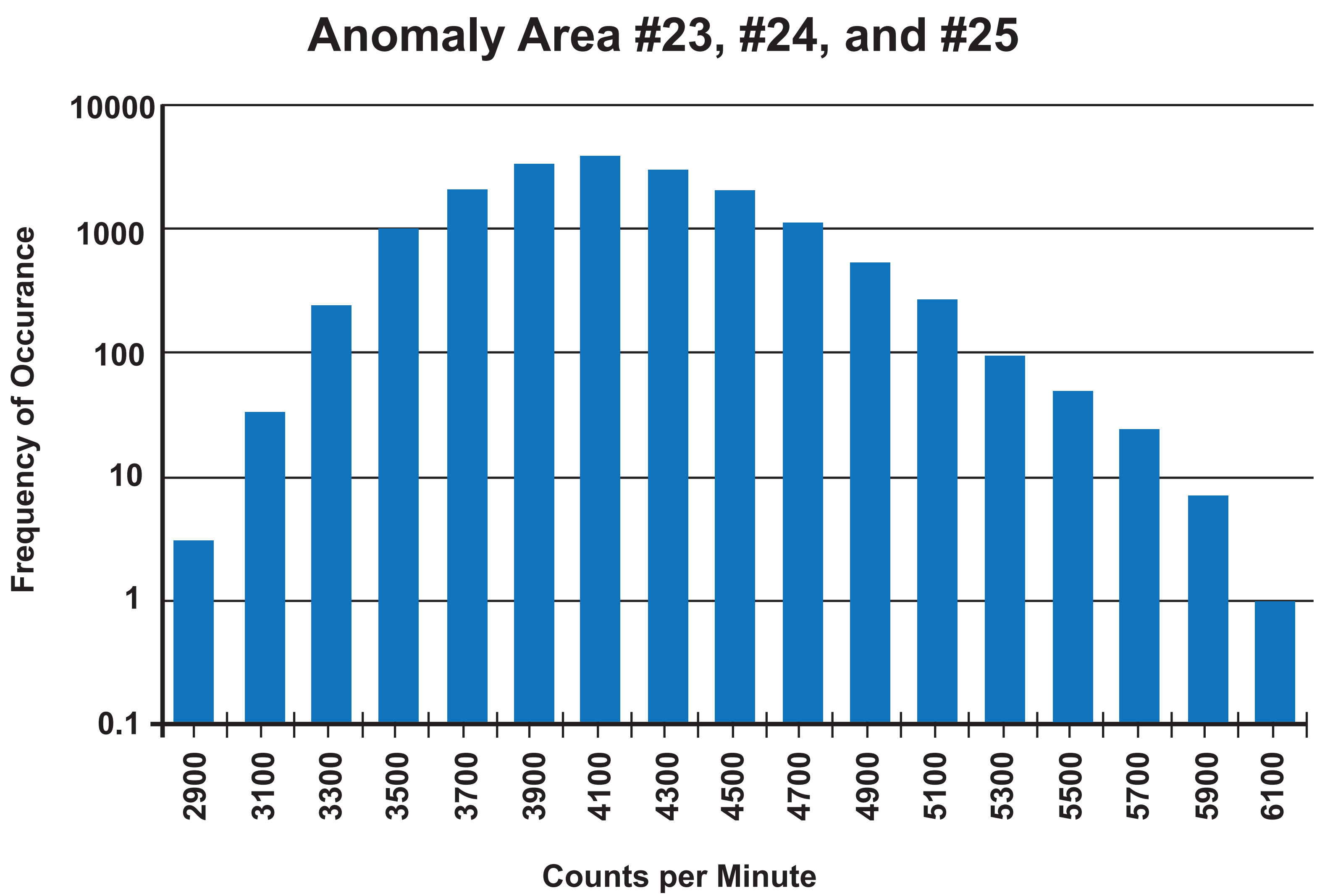
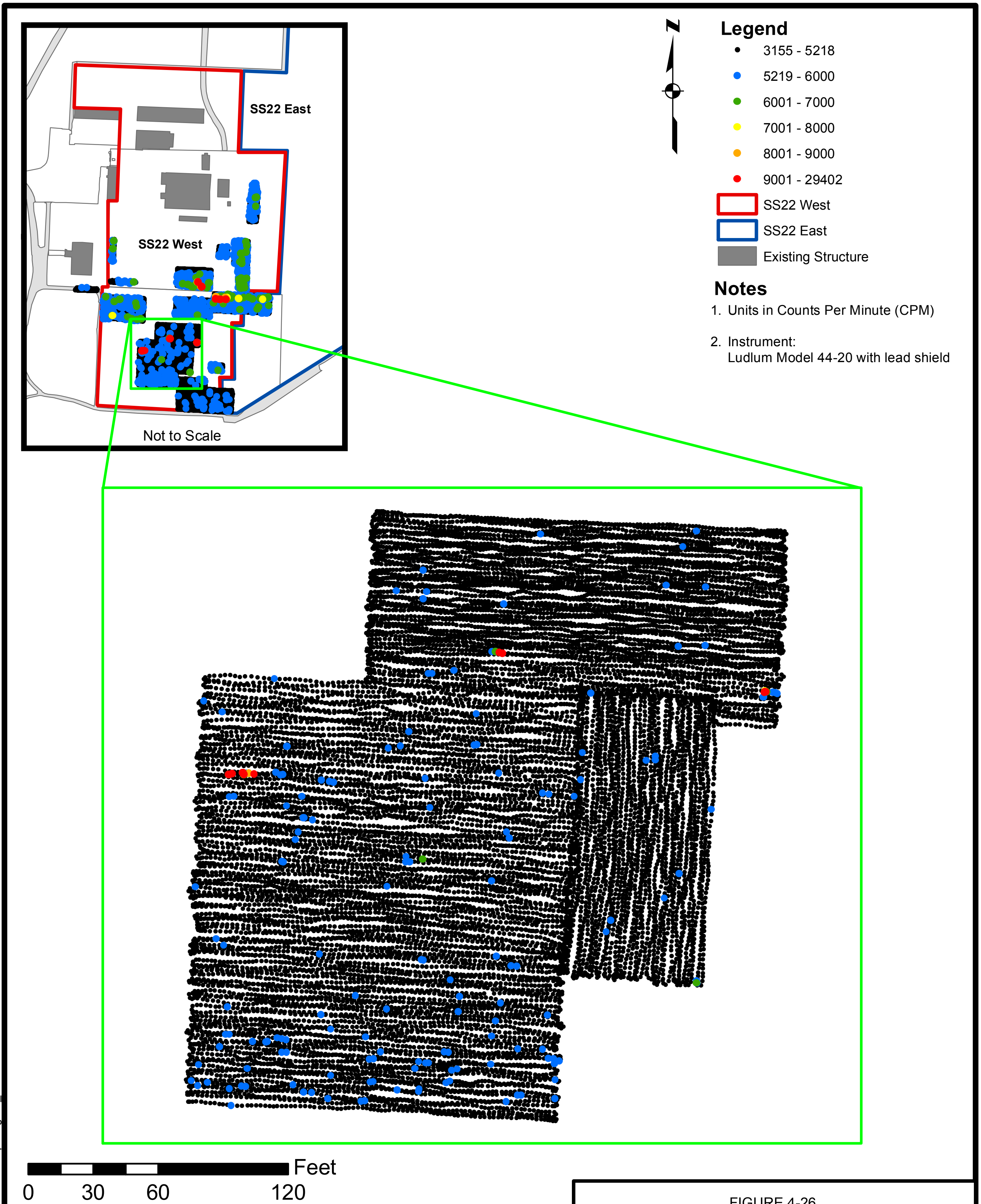


FIGURE 4-25

ANOMALY AREAS #23, #24, AND #25
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA



Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-26

GAMMA WALKOVER SURVEY
ANOMALY AREA #23, #24 and #25, SS22 WEST
JBER, ALASKA

L:\work\60134053\ENG\Maps\Figure_4-26.mxd

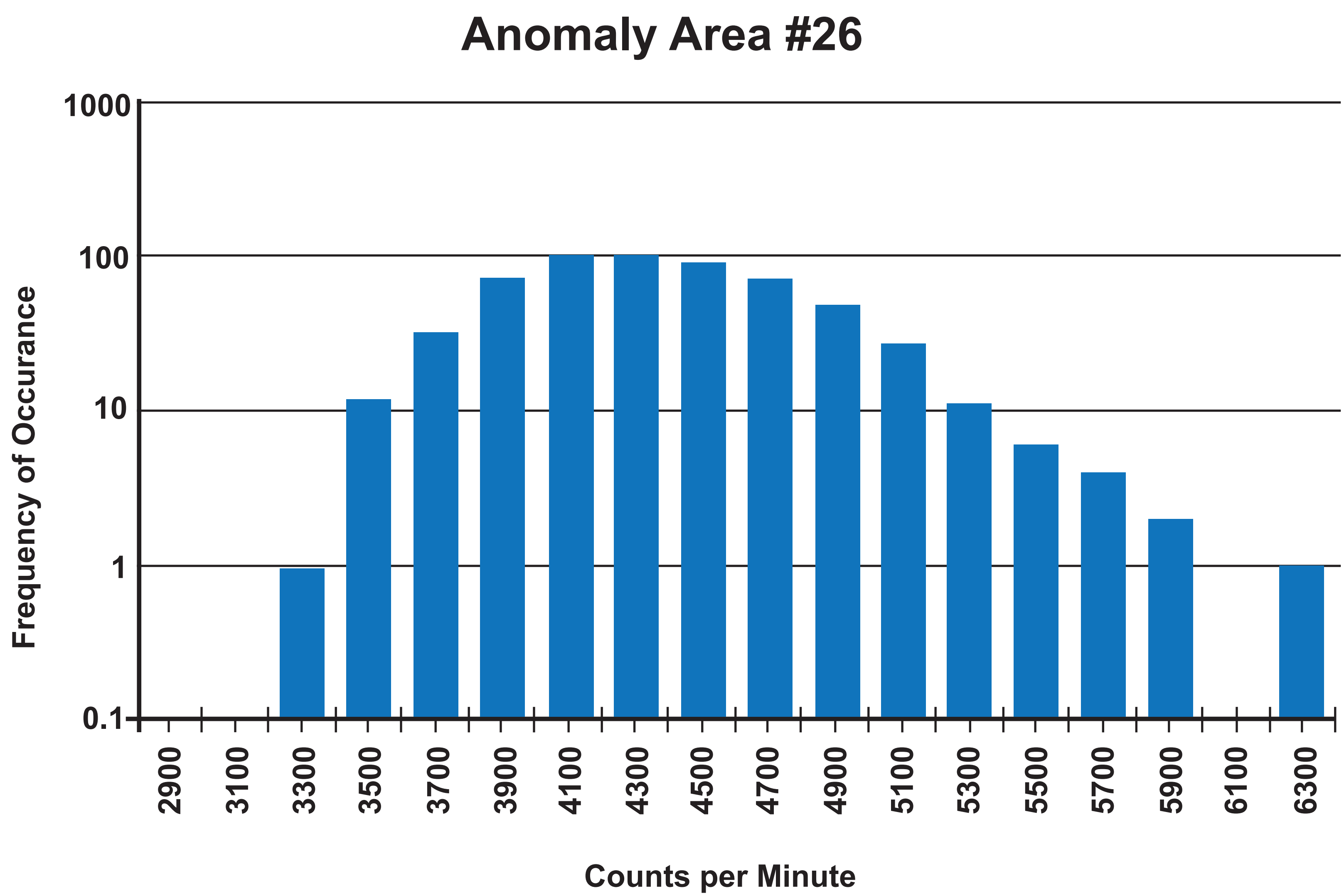


FIGURE 4-27

ANOMALY AREA #26
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-27.ai 1/14/2011

Legend

- 3155 - 5218
- 5219 - 6000
- 6001 - 7000
- 7001 - 8000
- 8001 - 9000
- 9001 - 29402
- SS22 West
- SS22 East
- Existing Structure

Notes

1. Units in Counts Per Minute (CPM)
2. Instrument:
   Ludlum Model 44-20 with lead shield

Feet
0 10 20 40

Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-28

GAMMA WALKOVER SURVEY
ANOMALY AREA #26, SS22 WEST
JBER, ALASKA

L:\work\60134053\ENG\Maps\Figure_4-28.mxd

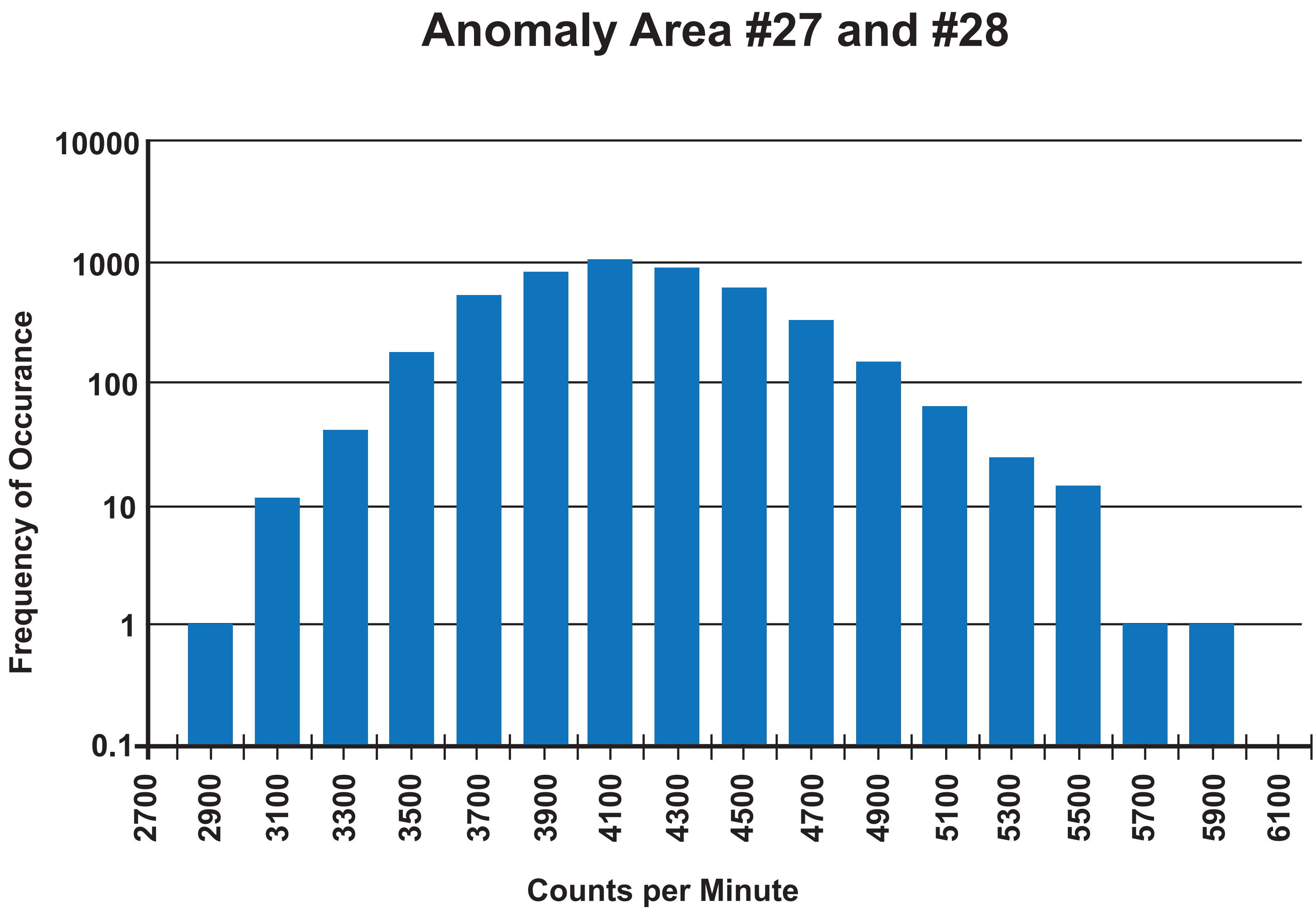
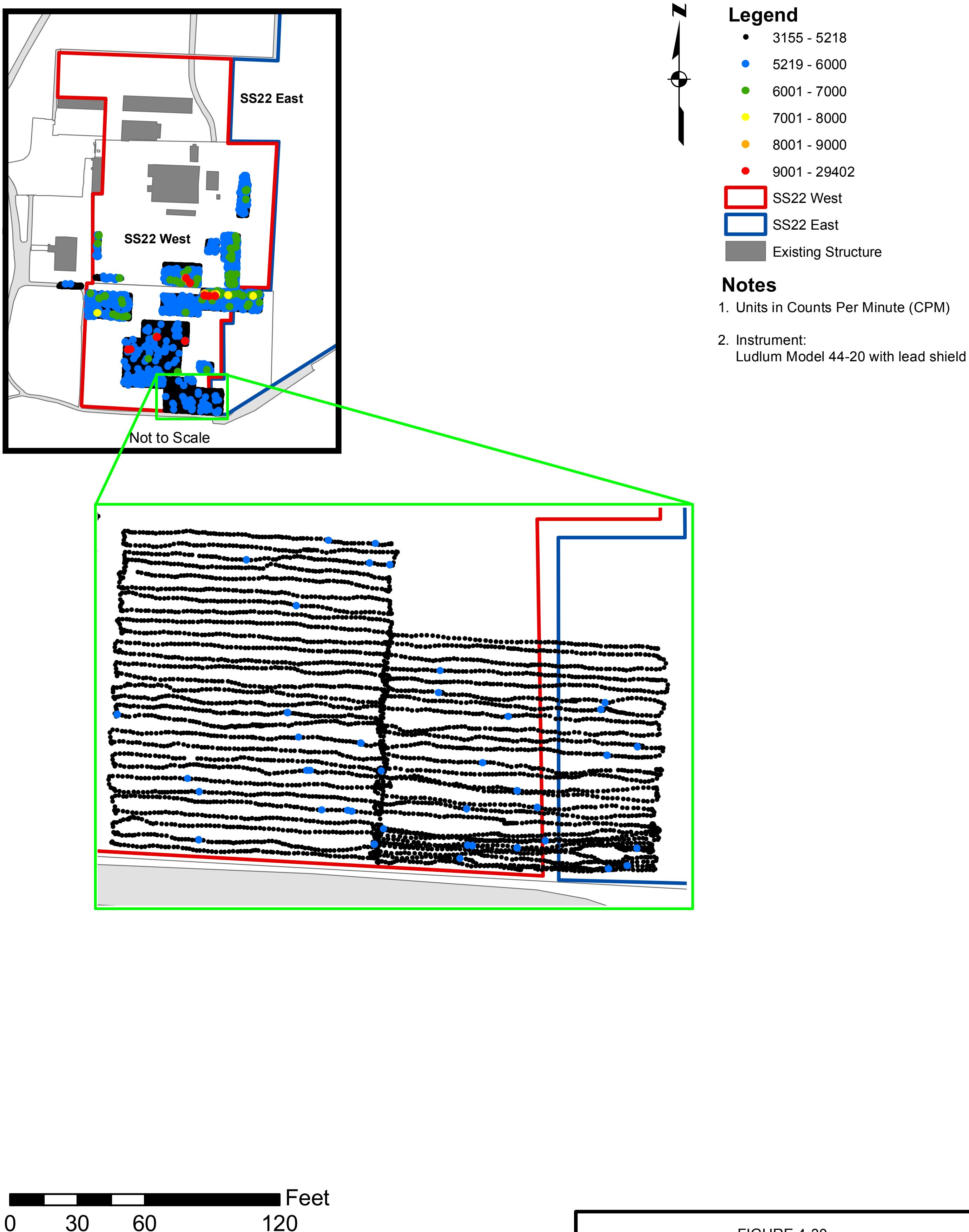


FIGURE 4-29

ANOMALY AREAS #27 AND #28
GAMMA WALKOVER SURVEY
DATA DISTRIBUTION
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Fig 4-29.ai 1/14/2011



Current Coordinate System: WGS_1984_UTM_Zone_6N
Projection: Transverse_Mercator
Linear Unit: Meter

FIGURE 4-30

GAMMA WALKOVER SURVEY
ANOMALY AREA #27 and #28, SS22 WEST
JBER, ALASKA

L:\work\60134053\ENG\Maps\Figure_4-30.mxd

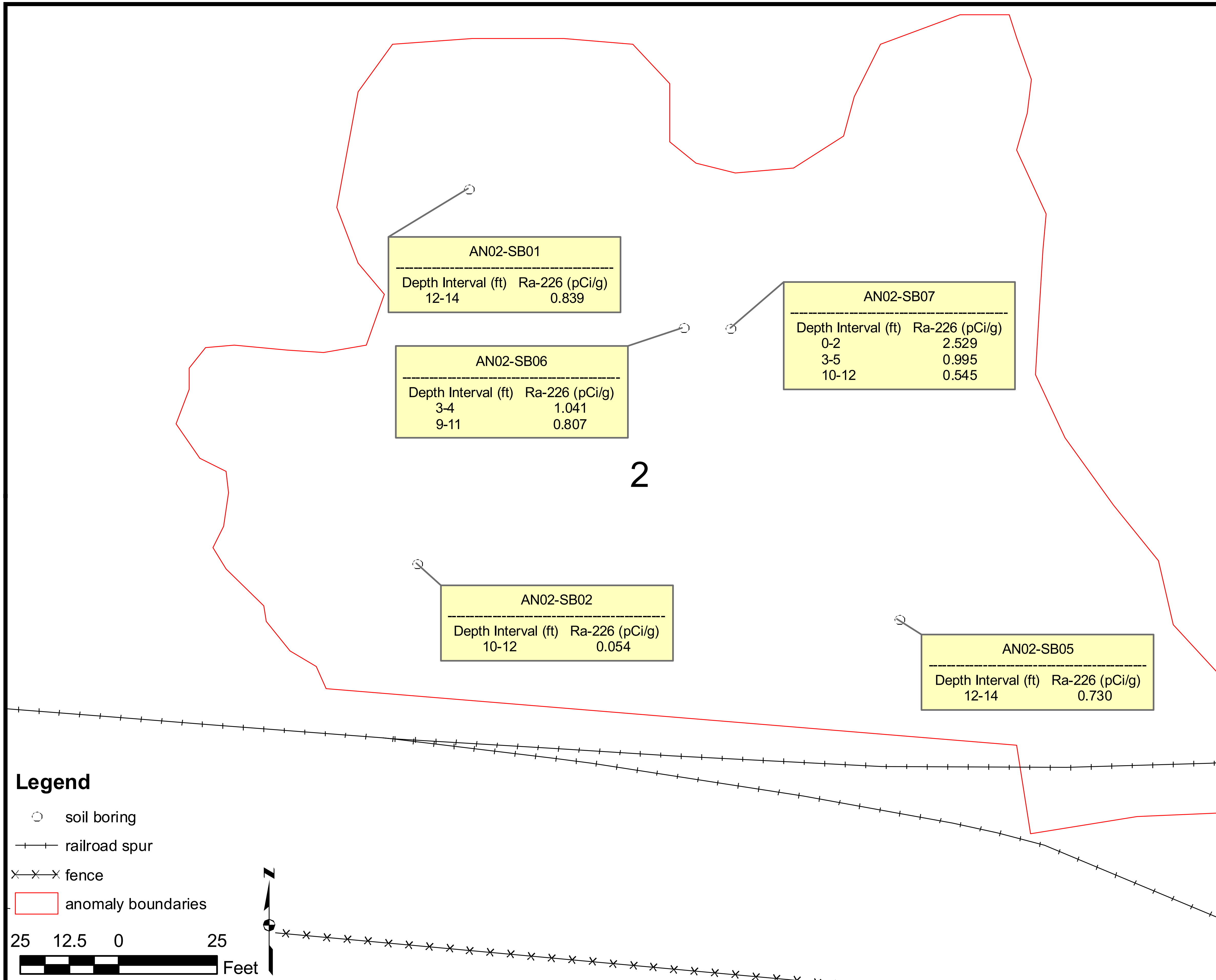


FIGURE 4-31

ANOMALY 2 SOIL BORING RESULTS
SS22, JBER, ALASKA

(Denver) L:\GROUP\CAD\ELMENDORF AFB\JULY09\ANA_SB02.MXD DATE: 7/20/2009

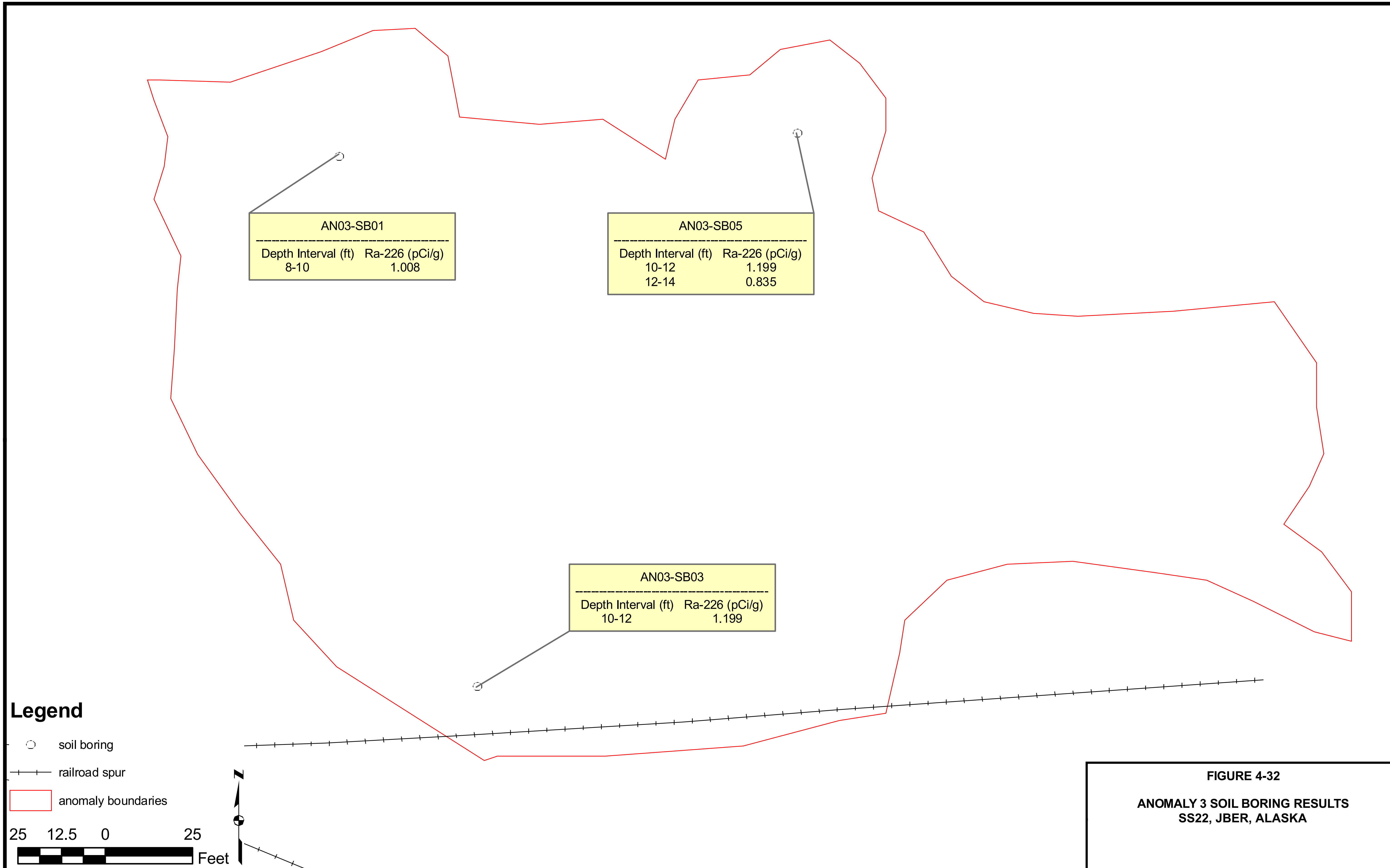


FIGURE 4-32

ANOMALY 3 SOIL BORING RESULTS
SS22, JBER, ALASKA

(Denver) L:\GROUP\CAD\ELMENDORF AFB\JULY09\ANA_SB03.MXD DATE: 7/20/2009

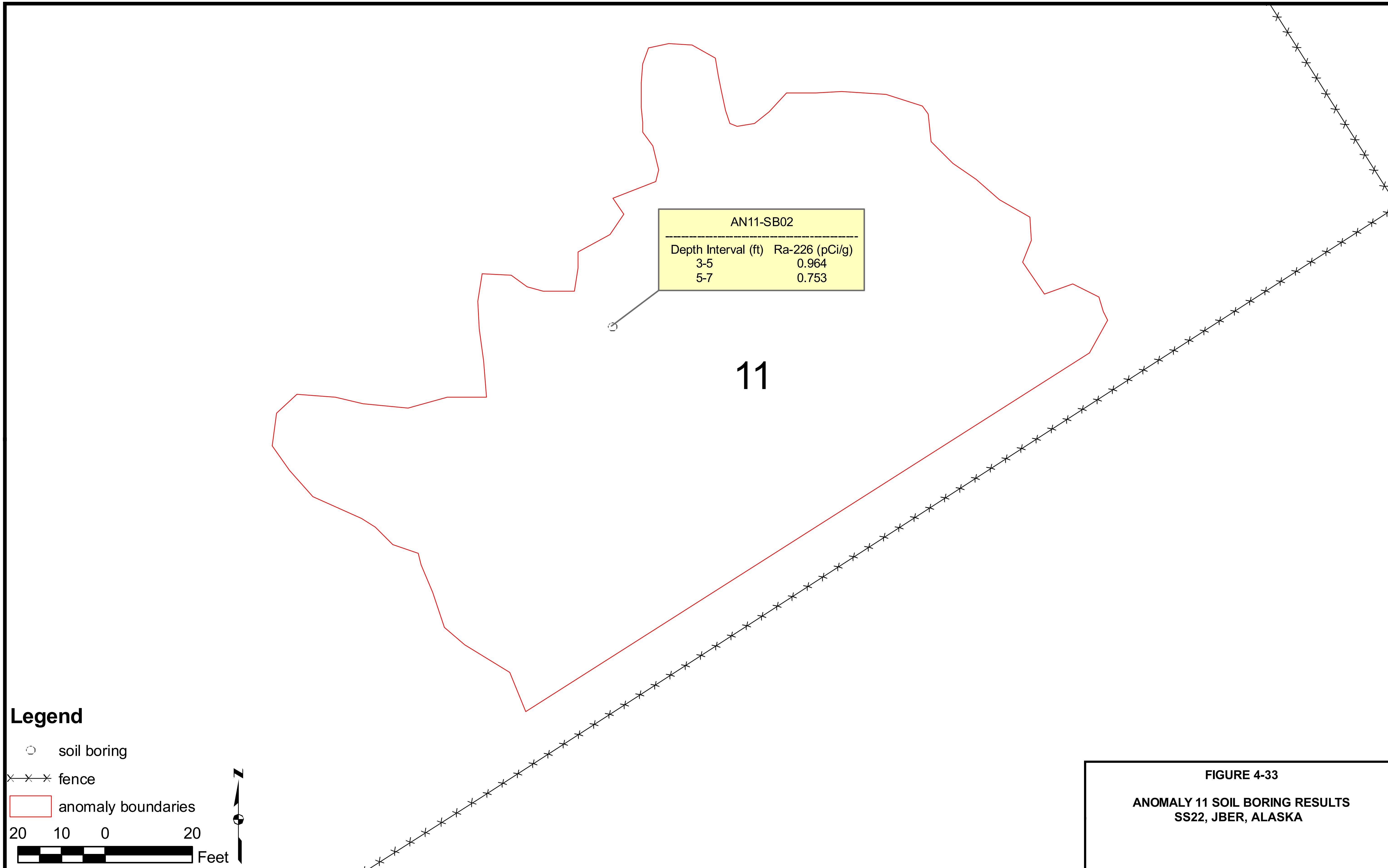


FIGURE 4-33

ANOMALY 11 SOIL BORING RESULTS
SS22, JBER, ALASKA

(Denver) L:\GROUP\CAD\ELMENDORF AFB\JULY09\ANA_SB11.MXD DATE: 7/20/2009

PHOTO 4-1

MATERIALS FOUND IN ANOMALY AREA #17'S TRENCH SS22, JBER, ALASKA

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PHOTO 4-2

**RA-226-CONTAINING LAMP SWITCH
FROM ANOMALY AREA #19 TRENCH
SS22, JBER, ALASKA**

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Photo 4-2.ai 1/17/2011

PHOTO 4-3

RA-226-CONTAINING GAUGE
FROM ANOMALY AREA #19 TRENCH
SS22, JBER, ALASKA

S:\work\AFCEE\Elmendorf_AFB\GIS\ENG\PDFs\JPEGS\Figures\Photo 4-3.ai 1/14/2011

PHOTO 4-4

RA-226-CONTAINING GAUGE FROM ANOMALY AREA #20 TRENCH SS22, JBER, ALASKA

PHOTO 4-5

RA-226-CONTAINING ROCKS
FROM ANOMALY AREA #20 TRENCH
SS22, JBER, ALASKA

PHOTO 4-6

RA-226-CONTAINING SPEEDOMETER FACE FROM ANOMALY AREA #23A TRENCH SS22, JBER, ALASKA

PHOTO 4-7

DASHBOARD WITH RA-226-CONTAINING GAUGES FROM ANOMALY AREA #24 TRENCH SS22, JBER, ALASKA

PHOTO 4-8

RA-226-CONTAINING GAUGE FROM ANOMALY AREA #25 TRENCH SS22, JBER, ALASKA

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PHOTO 4-9

DASHBOARD WITH RA-226-CONTAINING GAUGES FROM ANOMALY AREA #25 TRENCH SS22, JBER, ALASKA

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PHOTO 4-10

**RA-226-CONTAINING GAUGE
FROM ANOMALY AREA #27 TRENCH
SS22, JBER, ALASKA**

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PHOTO 4-11

RA-226-CONTAINING GAUGE
FROM ANOMALY AREA #27 TRENCH
SS22, JBER, ALASKA

PHOTO 4-12

RA-226-CONTAINING GAUGES
FROM ANOMALY AREA #28 TRENCH
SS22, JBER, ALASKA

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PHOTO 4-13

RADIO/TRANSMITTER WITH RA-226-CONTAINING PARTS FROM ANOMALY AREA #28 TRENCH SS22, JBER, ALASKA

5. CONCLUSIONS

5.1 Nature of Contamination

Based on the results of the characterization surveys, SS22 East and SS22 West are impacted by radioactive materials. Review of the gamma spectroscopy data for all samples and the gross alpha and beta data for the composite samples indicates that only Ra-226 and its decay daughters are present at concentrations that exceed background levels and Ra-226+D is conceded to be the only radiological COPC. Ra-226 is present in the form of intact items containing radioluminescent paint and contamination in the soil. The soil contamination is non-homogeneous and likely consists of dispersed Ra-226 paint chips or flakes from damaged or degraded items. Ra-226 concentrations in eight soil samples collected from the anomaly areas exceeded 10 pCi/g and two samples exceeded 100 pCi/g.

The site characterization also indicates that residual contamination is not limited to the surface soils, and is more prevalent and in higher concentrations in the subsurface soils. The confirmed presence of subsurface contamination in areas where no radiological surface anomalies were identified during the walkover surveys indicates that ground-level gamma surveys alone will not reveal the presence of subsurface radiological sources or residual radiological contamination. Test trenches demonstrate that materials are buried to a depth of more than 20 ft at some of the anomalies.

5.2 Extent of Contamination

The radiological characterization survey confirmed the presence of Ra-226-items in Anomaly Areas #3, #19, #20, #23, #25, #27, and #28. Only a few of these items were detected during walkover surveys, demonstrating that radioactive sources contained in the debris buried at SS22 are rarely detectable from the ground surface. Consequently, it is possible that other radioactive sources and/or subsurface soil contamination is present at SS22.

As provided in Table 5-1, Ra-226 contamination was confirmed in soils in Anomaly Areas #2, #3, #11, #20, #23, #25, #27, and #28 at concentrations above the site screening level of 2 pCi/g. The characterization efforts further demonstrated that residual contamination above the site screening level is localized in small areas and is more prevalent in the subsurface soils. However, the extent of the subsurface impact is not quantifiable using surface walkover surveys, surface soil sampling, or systematic subsurface borehole sampling. Only excavation of the material provides an accurate method of determining the extent of the contamination or the distribution of Ra-226 sources.

Groundwater samples from monitoring wells installed around the site are consistent with background radionuclide concentrations. No observations indicated that migration of radionuclides from buried

radioactive sources or surface hot spots is impacting groundwater conditions in detectable concentrations.

Table 5-1: Summary of Soil with Ra-226 Concentrations Greater than 2 pCi/g

Anomaly Area	Number of Soil Samples Collected	Number of Soil Samples > 2 pCi/g Ra-226	Maximum Ra-226 Concentration (pCi/g)
2	6	2	3.2
3	8	2	129.9
11	10	2	165.6
20	6	5	17.6
23	1	1	8.6
25	3	1	7.9
27	3	2	13.7
28	2	2	13.4

5.3 Applicability of Characterization Data

The results of the radiological characterization efforts indicate that distributed sources of Ra-226 exist on the site, primarily intermixed with the subsurface debris. The subsurface radioactivity appears to be confined to discrete locations of contaminated soil and discrete Ra-226-containing items.

The gamma walkover survey and radiological analysis of soil samples collected at SS22 demonstrate that the surface residual radioactivity is confined to discrete low activity particles at several locations on site. Under current site use, the exposure risk from the residual radioactivity is small.

Characterization data can be used in a radiological risk assessment, but care should be taken when assigning an exposure point concentration to a defined area. In many cases, soil samples were collected only at locations associated with the discovery of a Ra-226 source and could represent the worst observed case.

The greatest risk posed would be an event in which an individual unknowingly handled a radioactive item from the site. This could result in low level contamination of the individual's hands and small potential uptake of radioactive material. For this reason, restrictive land use controls should be implemented to prevent intrusive activities on site except when appropriate health physics monitoring is conducted.

Based on the findings of this survey, residual Ra-226 contamination will be addressed in the SS22 Conceptual Site Model, Risk Assessment, and RI/FS Report.

6. REFERENCES

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