Southeast
Missouri State University

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August 25, 2011

Dr. Peter Lee
US-NRC Region III
2443 Warrenville Road
Suite 210
Lisle, Illinois 60532-4352

Dear Dr. Lee:

Attached please find the *Final Status Survey Evaluation for Soils Adjacent to Magill Hall at Southeast Missouri State University.* The report details the findings of the historical site assessment, gamma and FIDLER walkover surveys, and extensive soil sampling we have done in response to the discovery of contaminated soil in a small area near Magill Hall. Our commitment to perform these tasks was outlined in a letter to the NRC dated October 28, 2010.

The general result of the survey was that soil contamination was limited to a $7m^2$ area containing the originally discovered contamination, which was exclusively Am241. In addition, after sampling extensively here we have shown that the residual contamination in the soil poses less than a 25 mRem per year dose potential.

If there are questions regarding the report, please feel free to contact me, and I and my consultants will be happy to discuss them with you.

Sincerely,

Walt W. Lilly
Professor of Biology
Radiation Safety Officer
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FINAL STATUS SURVEY EVALUATION FOR SOILS ADJACENT TO MAGILL HALL AT SOUTHEAST MISSOURI STATE UNIVERSITY

CAPE GIRARDEAU, MISSOURI

AUGUST 25, 2011

Southeast Missouri State University
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AUGUST 25, 2011

prepared by:

Southeast Missouri State University

with assistance from:

Science Applications International Corporation

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ACRONYMS AND ABBREVIATIONS

Both English and metrics units are used in this report. The units used in a specific situation are based on common unit usage or regulatory language. For example, depths are given in feet and areas are given in square meters.

%	percent
Δ/σ	relative shift
σ_{eff}	effective standard deviation
σ	standard deviation
ALARA	as low as is reasonably achievable
Am	americium
ANSI	American National Standards Institute
bgs	below ground surface
CFR	Code of Federal Regulations
COPC	contaminant of potential concern
cpm	counts per minute
Cs	cesium
D&D	decontamination and decommissioning
DCGL	Derived Concentration Guideline Level
$DCGL_W$	Derived Concentration Guideline Level used for statistical tests (Wilcoxon Rank Sum)
$DCGL_{EMC}$	Derived Concentration Guideline Level – Elevated Measurement Comparison
DoD	Department of Defense
DOE	Department of Energy
DQA	Data Quality Assessment
DQO	Data Quality Objective
EPC	exposure point concentration
FIDLER	Field Instrument for Detection of Low Energy Radiation
FR	Federal Register
FSS	Final Status Survey
FSSE	Final Status Survey Evaluation
ft	feet/foot
FWS	FIDLER Walkover Survey
GIS	Geographic Information System
GPS	global positioning system
GWS	Gamma Walkover Survey
H_0	null hypothesis
HAZWOPER	Hazardous Waste Operations and Emergency Response
hr	hour
keV	kiloelectron volt
LBGR	lower bound of the gray region
LCS	laboratory control spike
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MDC	Minimum Detectable Concentrations
m^2	square meters
mrem/yr	millirem per year

ACRONYMS AND ABBREVIATIONS (Continued)

NAD	normalized absolute difference
NaI	sodium iodide
NIST	National Institute of Standards and Testing
NRC	Nuclear Regulatory Commission
NUREG	Nuclear Regulatory Commission Regulation
OSHA	Occupational Safety and Health Administration
pCi/g	picocurie per gram
QA	quality assurance
QC	quality control
QSM	quality systems manual
RESRAD	RESidual RADioactivity (computer model)
RPD	relative percent difference
SAIC	Science Applications International Corporation
Southeast	Southeast Missouri State University
SU	survey unit
TEDE	total effective dose equivalent
UCL_{95}	95 percent upper confidence limit of the arithmetic mean
USEPA	U.S. Environmental Protection Agency

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1.0 INTRODUCTION

1.1 INTRODUCTION

Southeast Missouri State University (Southeast) is located in the town of Cape Girardeau, Missouri, near the Mississippi River. Cape Girardeau is a community of approximately 40,000 people and is considered a hub for retailing, medicine, manufacturing, communications, and cultural activities between St. Louis, Missouri, and Memphis, Tennessee. There are approximately 11,000 students and 350 full-time faculty members at Southeast.

Magill Hall is located near the center of the campus on Greek Drive. A second-floor throughway connects Magill Hall with Rhodes Hall. Both buildings are part of the College of Science and Mathematics.

This investigation process is performed consistent with recommendations and guidance contained in the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (Nuclear Regulatory Commission [NRC] 2000). MARSSIM provides a consensus survey approach collaboratively developed by the NRC, Department of Energy (DOE), Department of Defense (DoD) and the U.S. Environmental Protection Agency (USEPA)

1.2 PURPOSE

This sampling was performed to assess the radiological status of the soils adjacent to Magill Hall.

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2.0 SITE BACKGROUND

The *Historical Site Assessment for Magill Hall at Southeast Missouri State University* (Science Applications International Corporation [SAIC] 2000a) and applicable aerial photographs were reviewed to determine changes in the landscape surrounding Magill Hall prior to the time of potential contamination and periodically through the years up to present day. Aerial photographs from 1968 (Figure 1), 1996 (Figure 2), 1998 (Figure 3) and 2005 (Figure 4) showing Magill Hall and the surrounding areas were compared to a photograph from 2009 (Figure 5). After the 1968 photo, Rhodes Hall was built to the west of Magill Hall. The two buildings are connected by a pedestrian bridge on the second level. The soil areas, walkways and buildings immediately surrounding Magill Hall appear to be in the same configuration today, as they were in 1968. As such, the existing configuration has not changed significantly since the americium-241 (Am-241) spill likely occurred.

2.1 HISTORICAL AMERICIUM-241 CONTAMINATION

- The use of Am-241 began at Southeast in 1967, when the Radiochemistry course was first available at the school.
- In 1973, a significant spill ofAm-241 occurred on a bench-top in Room 242 of Magill Hall. Other spills may have occurred but were not documented.
- Use of Am-241 at Southeast was discontinued in the 1980s and the Am-241 source was placed in a source safe in Room 242.
- Between 1980 and 1985, the source safe was moved from Room 242 to Room 017 in the basement of Magill Hall.
- In 1991, the source safe was moved from Room 017 to Room 021A and later to Room 021.
- Between 1993 and 1996, the source safe was moved within Room 021 and surrounded with lead bricks and sheeting.
- In February 2000, a routine NRC inspection of Southeast's radiation safety program identified radioactive contamination in the basement of Magill Hall (Room 021). The source of contamination was determined to be from a broken source vial contained in a source safe. It is unclear exactly when the vial was broken, however the contamination pattern and bioassay results from individuals at Southeast during this time period indicated that the spill most likely occurred in January 1997 when the safe was in Room 021. *Surplus Item Investigation Report for Southeast Missouri State University* (Southeast 2000).
- In 2000, SAIC was contracted to characterize, decontaminate, survey, and release the building. Accessible surfaces of Magill Hall were decontaminated, surveyed, and inspected by the NRC and released for unrestricted use in November 2000.
- In 2002, a study was conducted to determine the dose associated with the Magill and Rhodes Hall laboratory sink discharges to the storm water sewer system, and the findings were discussed in *Laboratory Discharge System Post-Characterization Report* (SAIC 2002). All scenarios resulted in exposures to the critical group receptors of less than 25 millirem per year (mrem/yr).

- In 2005, Southeast began classroom and laboratory renovations within Magill Hall which included decontamination, disposal and release of the portions of Magill Hall that had previously been inaccessible. This work commenced in accordance with the *Decontamination Plan for Magill Hall at Southeast Missouri State University* (SAIC 2000b), however these plan was supplanted by the *Decontamination and Survey Plan for Magill and Rhodes Halls* in 2006 (SAIC 2006a).
- In October 2010, contamination exceeding 2.1 picocuries per gram (pCi/g) was found in the soil adjacent to the radiological storage bunker outside of Magill Hall. This report addresses these soils.
- In 2010, the *Decontamination and Survey Plan for Magill and Rhodes Hall* (SAIC 2010) was revised to provide guidance in accordance with NRC approved methods to investigate soil contamination identified adjacent to Magill Hall.

3.0 SURVEY DESIGN

The methodology described in this document has been applied to all accessible areas within the project scope.

3.1 DATA REVIEW

Available information was reviewed and the site was visited during initial assessment of the area to provide insights into which areas of soil had the greatest potential for contamination.

3.2 RADIOLOGICAL SURVEYS / SAMPLING

Objectives of radiological surveys and sampling included:

- evaluation as to whether existing concentrations of site contaminants exceed screening level Derived Concentration Guideline Levels (DCGLs) developed by the NRC (see Section 3.5) (and as part of the Final Status Survey [FSS] process);
- determination as to the lateral and vertical extent of identified Contaminants of Potential Concern (COPCs) exceeding DCGLs.

Radiological investigations were conducted during various periods from May 2010 through April 2011 to investigate the presence of radiological contaminants in the soil adjacent to Magill Hall at Southeast. Radiological investigations included gamma walkover surveys to identify potentially elevated areas for further investigation and soil sampling and analysis using gamma spectroscopy to quantify residual radioactivity for comparison to screening level DCGLs.

3.2.1 Study Boundaries

The soil adjacent to Magill Hall was previously classified as non-impacted. "Non-impacted areas—identified through knowledge of site history or previous survey information—are those areas where there is no reasonable possibility for residual radioactive contamination" (NRC 2000). However, a routine survey conducted during a waste haul operation in the vicinity of the radioactive storage bunker, determined that this area was potentially contaminated. As a result, accessible soils adjacent to Magill Hall were investigated as shown of Figure 6. The results of the investigation are included in this report.

3.2.2 Gamma Walkover

All accessible soil areas were evaluated by performing walkover surveys with gamma detectors to identify and investigate areas that exhibited gamma emissions significantly above background levels. Gamma walkover surveys (GWS) were performed using Ludlum Model 44-10, 2" x 2" NaI gamma scintillation detectors and Field Instruments for Detection of Low Energy Radiation (FIDLERs) were used to perform FIDLER walkover surveys (FWS). The surveyor advanced at a speed of approximately 1.6 feet/second (0.5 meter/second) while passing the detector in a serpentine pattern approximately 10 centimeters (4 inches) above the ground surface. Audible response of the instrument was monitored by the surveyor and locations of elevated audible response, if encountered, were investigated. Elevated areas are those in which the count rate exceeds the applicable background count rate for the soil by 2,000 counts per minute (cpm) on each instrument.

Biased soil samples were collected in areas exhibiting elevated gamma activity such that results could be directly compared to the DCGLs. Results of the GWS can be found in Appendix A.

3.2.3 Soil Sampling

Soil samples were generally collected by removing soil column intervals of approximately 0.5 foot (ft) in length to a total depth of 2.0 ft below ground surface (bgs). Each 0.5 ft sample was screened with a FIDLER and a Ludlum Model 44-10, 2" x 2" NaI gamma scintillation detector. The surface sample (the top 0.0 - 0.5 ft of soil) was collected and submitted for laboratory analysis. One subsurface sample (the sample interval between 0.5 - 2.0 ft bgs with the highest field screening) was also submitted for laboratory analysis. If all subsurface intervals had similar field screening results, the deepest interval was sent to the laboratory for analysis. Soil sampling data can be found in Appendix B. Copies of the logbook entries can be found in Appendix C.

3.3 INSTRUMENT USE AND QUALITY ASSURANCE

Survey instruments used for radiological measurements were:

- selected based on the survey instrument's detection capability for the COPC (Section 3.4) present at Southeast;
- calibrated in accordance with manufacturers' recommendations and American National Standards Institute (ANSI) N323A, *Radiation Protection Instrumentation Test and Calibration – Portable Survey Instruments* (ANSI 1997); and
- operated and maintained by qualified personnel, in accordance with SAIC Health Physics Program procedures (e.g., physical inspection, background checks, response/operational checks).

Radiological field instrumentation used for this survey had been calibrated in accordance with ANSI-N323A within the past 12 months. (Instrumentation is calibrated in accordance with manufacturer's recommendations at an interval not to exceed 12 months.) Quality Control (QC) checks were performed at the beginning and end of each day consistent with SAIC Health Physics Procedures. No deviations were experienced during this sampling event. All radiation survey data obtained during these efforts used radiation measurement instrumentation that achieved all performance requirements. Field instrumentation used at Southeast is presented in Table 3-1.

Table 3-1. Survey Instrumentation Used at Southeast

Measurement Type	Detector Type	Instrument Model	Detector Model	Scan MDC for Am-241 (pCi/g)
Gamma Scan/Static	2"x 2" NaI gamma scintillator	Ludlum 2221	Ludlum 44-10	31.5*
Low-Energy Gamma Scan	Thin crystal NaI gamma scintillator	Ludlum 2221	FIDLER	Not Available+

* Value from NUREG 1507, Table 6.4.

+ No published value available.

3.3.1 Pre-Operational Checks

Pre-operational checks were performed prior to each use and whenever instrument response became questionable. Pre-operational steps included:

- Verifying instrument calibration was current.
- Visually inspecting instrument for physical damage that may affect operation.

- Performing satisfactory battery check, (manufacturer's operating instructions defined satisfactory battery check).
- Checking cable connection and cable integrity.

3.3.2 Overview of Routine Instrument Quality Evaluations

- Instrument background checks and source checks were performed at the same location in a reproducible geometry at the beginning and end of each survey day. There were no occasions that the instrument response appeared questionable; therefore, additional source checks were not required.
- The Ludlum Model 2221 scaler coupled with a Ludlum 44-10, 2" x 2" NaI Gamma Scintillation Detector was checked with a cesium-137 (Cs-137) source.
- The Ludlum Model 2221 scaler coupled with the FIDLER was checked with an Am-241 source.

3.4 RADIOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN (COPC)

Am-241 is the only radiological COPC within the soil at Southeast. Am-241 is most often produced artificially and is used for research purposes. It has a half-life of approximately 432 years. Although, the primary method of decay of Am-241 is alpha particle emission, decay is accompanied by the emission of low energy gamma particles. (The emission of the 59.5 kiloelectron volt [keV] gamma is the most important in the detection of Am-241).

Cesium-137 (Cs-137) was previously identified in a waste stream (e.g., acid dilution pit sediment) from the Southeast laboratories. During the characterization phase, the soil sample analysis was conducted that was capable of detecting both alpha and beta contamination. All results were within background specifications for Cs-137. Therefore, Cs-137 is not carried forward as a COPC for the soils at Southeast.

3.5 DERIVED CONCENTRATION GUIDELINE LEVELS

One of the first steps in the process of releasing a site (after identifying the COCs) is to determine what release criteria apply.

In 1997 and 1999 the NRC published Title 10, CFR, Part 20, Subpart E, "Radiological Criteria for License Termination," in the Federal Register (FR) (62 FR 39058) and the "Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination" (64 FR 64132). These regulations included dose-based cleanup levels, also referred to as DCGLs, for releases both with and without radiological restrictions. Section 20.1402 of Subpart E notes that, "A site will be considered acceptable for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent (TEDE) to an average member of the critical group that does not exceed 25 mrem (0.25 mSv) per year, including that from groundwater sources of drinking water, and the residual radioactivity has been reduced to levels that are ALARA."

The NRC Screening Level DCGL used for statistical tests ($DCGL_W$) for Am-241 in surface soils at Southeast is 2.1 pCi/g. This value represents the surficial soil concentration of Am-241 that would be in compliance with the 25 millirem/year (mrem/yr) unrestricted release dose limit in 10 CFR 20.1402. The NRC Screening Value is published in Table H.2 of the *Consolidated*

Decommissioning Guidance: Characterization, Survey and Determination of Radiological Criteria, Nuclear Regulatory Commission Regulation (NUREG) 1757 Volume 2, (NRC 2006).

3.5.1 Derived Concentration Guideline Level – Elevated Measurement Comparison

The Derived Concentration Guideline Level (Elevated Measurement Comparison) ($DCGL_{EMC}$) uses an area factor by which the concentration within a small area of elevated activity can exceed the $DCGL_W$ while still maintaining compliance with the release criterion. The area factors listed in Table 3-2 were developed using RESRAD (RESidual RADioactivity) default parameters and pathways (i.e., the residential scenario) with the exception of the following RESRAD non-default parameters that were changed to be consistent with assumptions used during development of screening levels using decontamination and decommissioning (D&D):

- Am-241 soil concentration was set to 2.1 pCi/g;
- Contamination zone thickness was set at 0.15 m (0.5 ft); and
- Contaminated area was set at 2,500 m^2.

Table 3-2. Outdoor Area Dose Factors*

Nuclide	Area Factor				
	0.24 m^2	2.4 m^2	24 m^2	100 m^2	2,500 m^2
Am-241	56	30	15	12	1.0

* Decontamination and Survey Plan for Magill and Rhodes Halls (Southeast 2010)

3.6 MINIMUM DETECTABLE CONCENTRATION OF THE SCAN PROCEDURE

The minimum detectable concentration (MDC) of the scan procedure that is required to detect an area of elevated activity at the limit determined by the area factor is calculated as follows:

$$Scan\ MDC_{(required)} = (DCGL_W)\ x\ (Area\ Factor)$$

The required scan MDC for an area of 24 m^2 can be calculated as follows:

$$Scan\ MDC_{(required)} = (2.1\,pCi/g)x\ (15) = 31.5\,pCi/g$$

Per Table 6.3 of NUREG-1507, the actual scan MDC of the Ludlum Model 44-10 detector coupled with a 2" x 2" NaI gamma scintillation detector is 31.5 pCi/g. The required scan MDC is equal to the actual scan MDC; this means that the available scan sensitivity is sufficient to detect small areas of elevated activity that are 24 m^2 or less.

3.7 DECISION ERRORS

There are two types of decision error: Type I (alpha) and Type II (beta). Type I error is the probability of determining that the median concentration of a particular constituent is below a criterion when it is actually not (false positive). Type II error is the probability of determining that the median is higher than criteria when it is not (false negative). The probability of making decision errors can be controlled by adopting an approach called hypothesis testing.

H_0 = the Survey Unit (SU) exceeds the release criterion.

This means the site is assumed to be contaminated above criteria until proven otherwise. The Type I error, therefore, refers to the probability of determining that the area is below the criterion when it is really above the criterion (incorrectly releasing the SU). The Type II error refers to the probability of determining that the area is above the criterion when it is really below the criterion (incorrectly failing to release the SU).

The Type I error for Southeast has been set at 0.05 and the Type II error has been set at 0.20. This means that if the contaminant concentration is near the DCGL there is a 5 percent (%) probability of erroneously releasing a SU whose true mean is greater than the DCGL and a 20% probability of not releasing a site that has attained the DCGL. This implies that if the mean is at a concentration that would produce an exposure at the criterion level, there would be a 5% probability of erroneously finding it below the criterion or a 20% probability of erroneously finding it to be greater than the criterion.

3.8 RELATIVE SHIFT

The relative shift (Δ/σ) is defined such that Δ is the $DCGL_W$ minus the lower bound of the gray region (LBGR) and standard deviation (σ) is the standard deviation of the contaminant distribution. The $DCGL_W$ for Am-241 is to 2.1 pCi/g. The σ was calculated for the soil at Southeast using results collected during the characterization sample event. These results are listed in Table 3-3 below.

Table 3-3. Characterization/Screening Sample Results

Sample ID	Am-241 Result
SEMO-100	0.22
SEMO-101	0.12
SEMO-102	0.17
SEMO-103	0.15
SEMO-104	0.37
SEMO-105	0.52
SEMO-106	0.94
SEMO-107	3.17
SEMO-108	8.79
SEMO-109	2.82
SEMO-110	3.04
σ_{eff}	2.6

The next step was to calculate the relative shift. For this calculation, the LBGR was set to 0.1.

$$\frac{\Delta}{\sigma_{eff}} = \frac{DCGL - LBGR}{\sigma_{eff}} = \frac{2.1 - 0.1}{2.6} = 0.769$$

3.9 THE NUMBER OF SAMPLES PER SURVEY UNIT

The calculated value, N, is the number of samples/measurements required to be collected from one survey unit. $Z_{1-\alpha}$ and $Z_{1-\beta}$ are critical values that can be found in MARSSIM Table 5.2, and P_r is a measure of probability available from MARSSIM Table 5.1.

The number of data points, N, for the Sign test is calculated using Equation 5-1 and Table 5.1 in MARSSIM, given 5% Type I error and 20% Type II error.

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(Sign\,p - 0.5)^2}$$

$$N = \frac{(1.645 + 0.842)^2}{4(0.758036 - 0.5)^2} = 24\,Samples$$

The uncertainty associated with the calculation, N, should be accounted for during survey planning; thus, the number of data points is increased by 20% and rounded up. This ensures there are sufficient data points to allow for any possible lost or unusable data.

$$N = 24 + 0.2(24) = 29\,Samples$$

Therefore, 29 samples/measurements were required to be collected within each SU at Southeast.

3.10 CLASSIFICATION OF SURVEY UNITS

As described in the MARSSIM, SUs are broken into three classes (Table 3-4). A Class 1 SU meets any one of the following criteria:

1. The area is or was impacted (potentially influenced by contamination);
2. The area has potential for delivering a dose above criteria;
3. There is potential for small areas of elevated activity; or
4. There is insufficient evidence to classify the area as Class 2 or Class 3.

An SU is classified as a Class 2 unit if:

1. The area has the potential to have been impacted;
2. The area has low potential for delivering a dose above criteria; or
3. There is little or no potential for small areas of elevated activity.

An SU is classified as a Class 3 unit if:

1. The area has only minimum potential for being impacted;
2. The area has little or no potential for delivering a dose above criteria; and
3. There is little or no potential for small areas of elevated activity.

Based on a review of site information and data, the soil adjacent to Magill Hall was designated as a Class 2 SU (SU-2). The soil surrounding the radioactive material storage bunker was classified as a Class 1 SU (SU-1), as shown on Figure 6. MARSSIM states that Class 1 and 2 areas are to be sampled using a random start systematic grid, and that Class 3 areas are to be sampled using random locations.

Table 3-4. MARSSIM "Suggested Survey Unit Areas" (NRC 2000)

Classification	Suggested Area
Class 1	Land Area: up to 2,000 m^2
Class 2	Land Area: 2,000 to 10,000 m^2
Class 3	Land Area: No Limit

For SU-1 and SU-2, the location of systematic sample stations were based on a triangular grid pattern, extended from a random starting point. Per MARSSIM, triangular grids are generally more efficient for locating small areas of elevated radioactivity. The random-start point for the systematic grid was designed to ensure that the sample results were representative of the SU.

Additionally, the soil under the permanent structures (i.e., buildings, walkways, driveways and parking lots) directly adjacent to Magill Hall has been evaluated. Since the walkways, driveways, parking lots and buildings immediately surrounding Magill Hall appear to be in the same configuration today as they were prior to the event that caused the soil contamination, the soil under these permanent structures has been determined to be non-impacted and no further investigation is required.

Table 3-5 contains information on area, SU, number of samples collected, the figure number that shows the sample locations and where the data summary can be found.

Table 3-5. General Sample Information

SU	Area (m^2)	Estimated Minimum Number of Systematic Samples Required[1]	Number of Systematic Radiological Samples[2]	Number of Biased Radiological Samples	Number of Subsurface Radiological Samples[3]	Sample Location Figure Number	Sample Data Summary
1	24	29 or 1 per 70 m^2	11	5	0	7	Section 6.3.1
2	3,150	29	54	0	54	8	Section 6.3.2

[1] The 29 samples calculated to be required assumes a 2,000 m^2 in SU-1; therefore, one systematic sample was required to be collected for each 70 m^2 in the SU. Because SU-1 was 24 m^2, it only required one sample to be collected. Twenty-nine samples were required in SU-2.

[2] Systematic samples were collected from the top 0.5 ft of soil or from the top 0.5 ft of accessible soils unless otherwise specified in Appendix B.

[3] Subsurface samples were collected below 0.5 ft of soil to a depth of 2.0 ft from the ground surface.

3.11 OPTIMIZATION OF DESIGN FOR OBTAINING DATA

The following actions, methods, and techniques were utilized throughout the data collection process to minimize cost, field effort, and impacts to future associated work.

- Radiological surveys and collected samples were obtained in a defensible manner. Data was collected and managed so that it will be usable in future area evaluations or investigations, if appropriate.
- Investigations utilize the graded approach for site investigations. Areas of highest potential were scrutinized the most, with less effort expended in areas less likely to contain the target contaminants.

3.12 DATA QUALITY OBJECTIVES, QUALITY ASSURANCE AND QUALITY CONTROL

- All data is of the appropriate quality to be usable after validation.
- All radiological survey instruments were operated and maintained by qualified personnel, in accordance with SAIC Health Physics Program procedures.
- Quality Assurance (QA)/QC related data and a Data Quality Assessment (DQA) are provided in Appendix D.

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4.0 SITE SAFETY AND HEALTH

Site safety and health requirements for site tasks were based on potential physical, radiological, and chemical hazards. The survey team followed the general site safety and health requirements documented in SAIC safety and health procedures. These documents/procedures were written to comply with the NRC and Occupational Safety and Health Administration (OSHA) requirements.

4.1 SAFETY AND HEALTH TRAINING

All survey team personnel had received all required training which included Hazardous Waste Operations and Emergency Response (HAZWOPER) training (40-hour [hr] and current 8-hr refresher), medical surveillance, health and safety orientation, and radiation safety training. Safety and health records were kept and maintained according to Southeast policies, procedures and NRC radioactive material license requirements.

4.2 TASK-SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

The minimum level of protection for survey activities at this site was Level D Protective Equipment.

- impermeable disposable inner gloves (i.e., nitrile, polyvinyl chloride, or equivalent)
- safety boots (ANSI Z41)
- safety glasses with side shields (ANSI Z87.1)

The designated on-site Site Safety and Health Officer/Radiation Protection Manager had the responsibility for determining if an upgrade in Personal Protective Equipment requirements was appropriate once the survey team mobilized to the site.

4.3 PERSONNEL MONITORING REQUIREMENTS

Based on the minimal potential for levels of radiological constituents that could reasonably result in survey team members receiving external or internal radiation doses exceeding 10% of regulatory dose limits (i.e., 500 mrem/yr), dosimetry was not required per 10 CFR 20.1502 (NRC 2011).

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5.0 FINAL STATUS SURVEY PROCESS

5.1 DATA QUALITY OBJECTIVES

The Data Quality Objective (DQO) process is a strategic planning approach for a data collection activity. It provides a systematic procedure for defining the criteria that a data collection design should satisfy, including where to collect samples, how many samples to collect, and the tolerable level of decision errors for the study. The DQO process includes the following seven steps from the U.S. Environmental Protection Agency's (USEPA's) *Guidance on Systematic Planning Using the Data Quality Objectives Process* (USEPA 2006a):

- State the problem. Inadvertent release of contaminants into the environment.
- Identify the decision. Determine if soils adjacent to Magill Hall can be released for unrestricted use.
- Identify inputs to the decision. Radiological sample data for soil.
- Define the study boundaries. Soil surrounding Magill Hall as shown on Figure 6.
- Develop a decision rule. If the mean concentration in the survey unit is less than the DCGL, then the survey unit is in compliance with the release criterion.
- Specify tolerable limits on decision errors. The desired tolerable limits included MDCs for soil samples equating to less than 50% of the DCGL, with the goal of 10% of the cleanup criteria. Sample error is reported with the sample result. The MARSSIM (NRC 2000) evaluation was based on decision errors of less than 5 % false negatives and less than 20 % false positives.
- Optimize the design for obtaining data. Site-specific data was used to estimate the number of required samples to be collected.

The FSS data were examined using Data Quality Assessment (DQA) guidance to ensure that the data provided the necessary basis for determining whether the soils around Magill Hall could be released for unrestricted use. The DQA involves scientific and statistical evaluations to determine if data are of the right type, quality, and quantity to support the intended use. The DQA process is based on guidance from Chapter 8 and Appendix E in MARSSIM and follows USEPA's *Data Quality Assessment: A Reviewer's Guide* (USEPA 2006b). The five steps in the DQA process are listed below and are addressed by the subsequent report sections and appendices.

- Review the FSS design, including DQOs.
- Conduct a preliminary data review.
- Select a statistical test.
- Verify the assumptions of the statistical test.
- Draw conclusions from the data.

5.2 SUMMARY OF SURVEY APPROACH

Both SU-1 and SU-2 were sampled in accordance with guidance provided in MARSSIM. The preliminary MARSSIM survey indicated that one systematic sample was required to be collected in SU-1 and 29 systematic samples were required to be collected in SU-2. The actual number of systematic samples collected were 11 samples in SU-1 and 54 samples in SU-2. Per MARSSIM a systematic grid was established for both the Class 1 and the Class 2 SUs at Southeast.

MARSSIM states that, "Scanning for alpha emitters or low-energy (<100 keV) beta emitters for land area survey units is generally not considered effective because of problems with attenuation and media interferences." To account for this, the systematic grids for both SUs were designed such that the sample density was increased greater than the number of required samples.

All impacted areas of Southeast have been evaluated to ensure compliance with MARSSIM. This includes:

- All measurements are compliant with the $DCGL_W$ and $DCGL_{EMC}$.
- Scan coverage was sufficient for each area.
- A sufficient number of measurements were collected to correctly evaluate the area.
- The area passes the Sign test. MARSSIM states that "if the largest measurement is below the $DCGL_W$, the Sign test will always show that the survey unit meets the release criterion."
- All impacted areas have been accurately classified as MARSSIM Class 1 or Class 2 SUs.

5.3 SURVEY RESULTS

The radiological FSS sample results are reported in Tables B-1 and B-3 of Appendix B.

The results of the systematic samples were included in the MARSSIM statistical analysis, used in the residual dose assessment, and compared to the NRC Screening Values found in Table H.2 of NUREG-1757, Volume 2. Data from biased samples were not included in the statistical tests per MARSSIM guidance: "judgmental measurements are not included in the statistical evaluation of the SU because they violate the assumption of randomly selected, independent measurements. Instead, these judgmental measurements are individually compared to the DCGL" (NRC 2000). Data from the biased samples were included in evaluations of residual dose. Dose assessment information can be found in Appendix E.

5.3.1 SU-1 – Soils Near the Radioactive Storage Bunker

The soil adjacent to Magill Hall in SU-1 was evaluated consistent to the methods listed in Section 3.2.2 and 3.2.3. Information pertaining to the GWS can be found in Appendix A and Figures A-1 and A-2.

A Sign Test was performed using the FSS data in SU-1 (Appendix B, Table B-1). Although the largest systematic measurement was less that the $DCGL_W$ (SEMO-238 = 0.99 pCi/g) and this will always show that the SU meets the release criterion, the Sign Test was performed anyway. The Sign Test results are in Appendix F.

During characterization several locations had results greater that the $DCGL_W$. These locations were subject to additional investigation to include; the collection of an additional sample at that location (this sample replaced the original sample as it was used to verify the results of the original sample), re-survey with the FIDLER and the Ludlum 44-10, 2" x 2" NaI gamma scintillation detector and the collection of bounding samples.

There were several biased/bounding samples (Appendix B, Table B-2) that had results greater than the $DCGL_W$ and required comparison to the $DCGL_{EMC}$. These samples are located within a relatively small area (7 m^2) within SU-1. The average Am-241 concentration in this area was found to be 3.72 pCi/g (Appendix G). The sample locations in SU-1 are shown on Figure 7.

The $DCGL_{EMC}$ is obtained by multiplying the $DCGL_W$ by the area factor that corresponds to the actual area (7 m^2) of the elevated concentration. Since an area factor for 7 m^2 was not calculated, a more conservative area factor was used; in this case it is the area factor, of 15, from Table 3-2 for an area of 24 m^2. The $DCGL_{EMC}$ is calculated to be 31.5 pCi/g, as shown in Section 3.6 Therefore, this area is deemed acceptable since it does not exceed the appropriate $DCGL_{EMC}$ (i.e., 3.72 pCi/g is less than 31.5 pCi/g).

The sample data for SU-1 was evaluated to ensure that the sample results were either less than the screening level $DCGL_W$ of 2.1 pCi/g or was compliant with the $DCGL_{EMC}$.

5.3.2 SU-2 – Soils Adjacent to Magill Hall

The soil adjacent to Magill Hall in SU-2 was evaluated consistent to the methods listed in Section 3.2.2 and 3.2.3. Information pertaining to the gamma walkover surveys can be found in Appendix A and Figures A-1 and A-2. The FSS soil sampling results can be found in Appendix B, Table B-2, the subsurface data can be found in Table B-4.

A Sign Test was performed for the FSS data in SU-2 (Appendix B, Table B-2). Although the largest systematic measurement was less that the $DCGL_W$ (SEMO-203 = 0.25 pCi/g) and this will always show that the SU meets the release criterion, the Sign Test was performed anyway. The Sign Test is in Appendix F.

The sample data for SU-2 was evaluated to ensure that the sample results were less than the screening level $DCGL_W$ of 2.1 pCi/g. The sample locations in SU-2 are shown on Figure 8.

5.3.3 Detectable Concentration for Soil Samples

Soil samples were analyzed at GEL Laboratories LLC in Charleston S.C. to determine the radionuclides present in the soil. In general, the MDC represented the lowest level that the laboratory achieved for each sample given a set of variables including detection efficiencies and conversion factors due to influences such as individual sample aliquot, sample density, and variations in analyte background radioactivity at the laboratory. The MDC was reported with each sample result in Appendix B.

In accordance with MARSSIM, analytical techniques should provide an MDC not exceeding 50% of the screening level DCGL for Am-241, with a preferred target MDC of 10% of the DCGL. These MDC limits are listed in Table 4-1.

Table 5-1. Minimum Detectable Concentration Limits

Radionuclide	Maximum MDC (pCi/g)	Preferred MDC (pCi/g)
Am-241	1.05	0.21

All MDCs were less than 50% of the screening level DCGL.

As discussed in MARSSIM, the reported radionuclide concentration from the laboratory was used in this Final Status Survey Evaluation (FSSE) even if those results were below the MDC. This data was used to complete the MARSSIM evaluation and assess the dose for the SU.

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6.0 RESIDUAL DOSE ASSESSMENT

A residual dose assessment was performed on the soils adjacent to Magill Hall. Compliance with the Screening Level DCGL confirms achievement of the 25 mrem/yr dose standard even using the conservative approach.

The dose limit prescribed in 10 CFR 20 Subpart E for license termination (unrestricted use) is 25 mrem/yr. In calculating dose, RESRAD default parameters were used to calculate the dose to the average member of the critical group (i.e., the residental receptor was the exposure scenario selected). A summary of radiological dose estimates are found in Table 7-1.

Table 6-1. Radiological Dose Estimates

Scenario	Period Assessed (years)	Maximum Dose (mrem/yr)
Onsite Resident	0 to 1,000	2

Based on the results of the dose assessment, the soils adjacent to Magill Hall are protective of public health and the environment and can be released for unrestricted use. Details on how these values were determined are provided in Appendix E.

6.1 AS LOW AS IS REASONABLE ACHIEVABLE (ALARA)

As stated in Section 3.5, the NRC Screening Level DCGL for Am-241 is 2.1 pCi/g. This value represents the surficial soil concentration of Am-241 that would be in compliance with the 25 millirem/year (mrem/yr) unrestricted release dose limit in 10 CFR 20.1402. NRC Screening Values are published in the *Consolidated Decommissioning Guidance: Characterization, Survey and Determination of Radiological Criteria,* Nuclear Regulatory Commission Regulation (NUREG) 1757 Volume 2 (NRC 2006).

"In light of the conservatism in the building surface and surface soil generic screening levels developed by NRC, NRC staff presumes, absent information to the contrary, that licensees who remediate building surfaces or soil to the generic screening levels do not need to provide analyses to demonstrate that these screening levels are ALARA. In addition, if residual radioactivity cannot be detected, it may be assumed that it has been reduced to levels that are ALARA. Therefore, the licensee may not need to conduct an explicit analysis to meet the ALARA requirement" (NRC 2006).

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7.0 CONCLUSION

Evaluation of survey and sampling data supports the conclusion that the soils adjacent to Magill Hall at Southeast contain an adequate number of samples; a sufficient percentage has been scanned; and it has been appropriately classified consistent with MARSSIM requirements. All soil sampling data were below the $DCGL_W$ in the Class 2 SU and below the $DCGL_W$ or the $DCGL_{EMC}$ in the Class 1 SU, as applicable. The Sign Test was performed for both SU-1 and SU-2 and indicated that both SUs meet release criterion. Given these results, it is clearly demonstrated that the H_0 (i.e., the SU exceeds the release criterion) is rejected for both SUs at Southeast.

Levels of radioactivity in the soils adjacent to Magill Hall achieve the requirements for unrestricted use consistent with the provisions of 10 CFR 20 Subpart E.

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8.0 REFERENCES

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FIGURES

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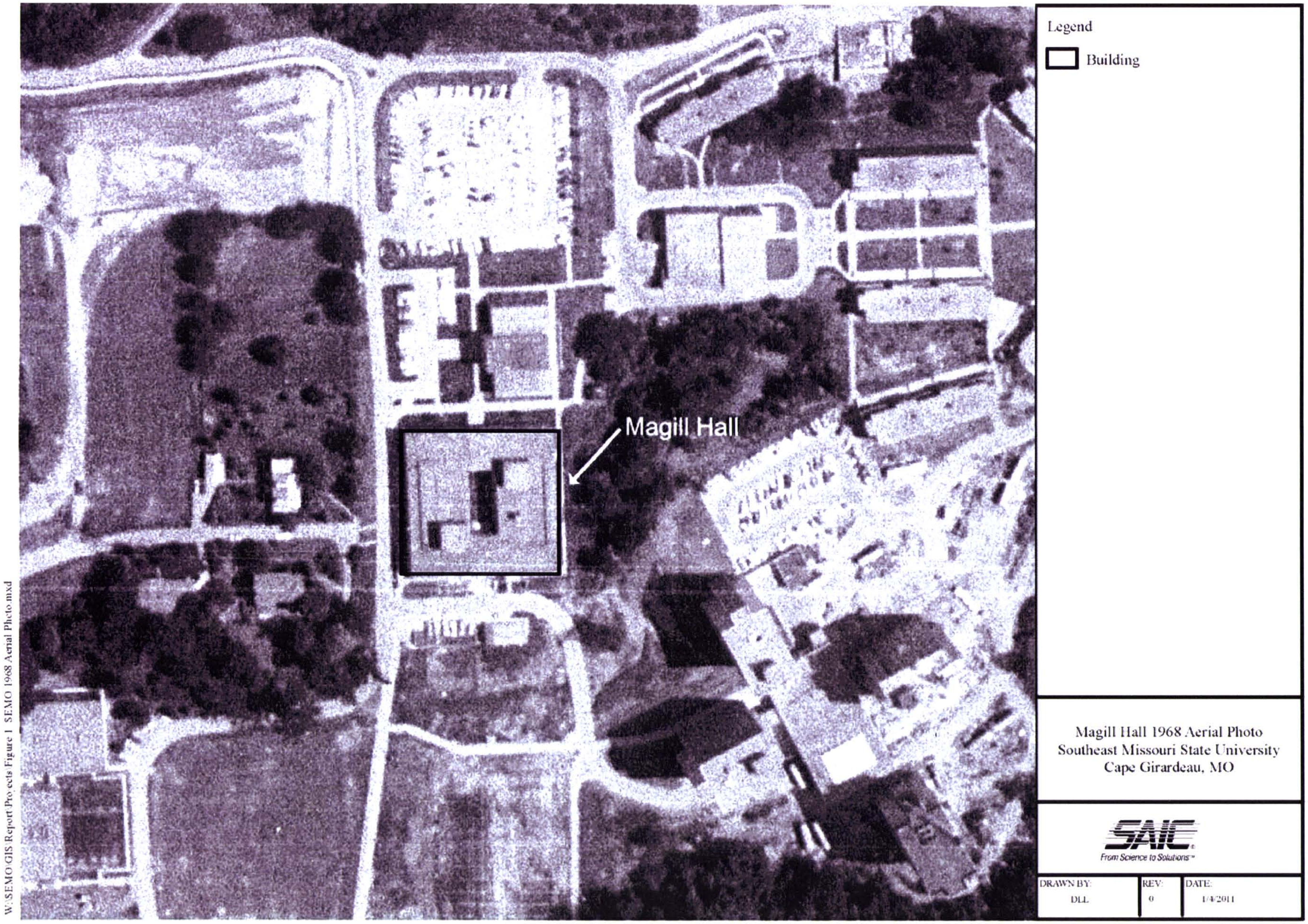

Figure 1. Magill Hall
1968 Aerial Photo

Legend

Building

Magill Hall 1996 Aerial Photo
Southeast Missouri State University
Cape Girardeau, MO

SAIC
From Science to Solutions

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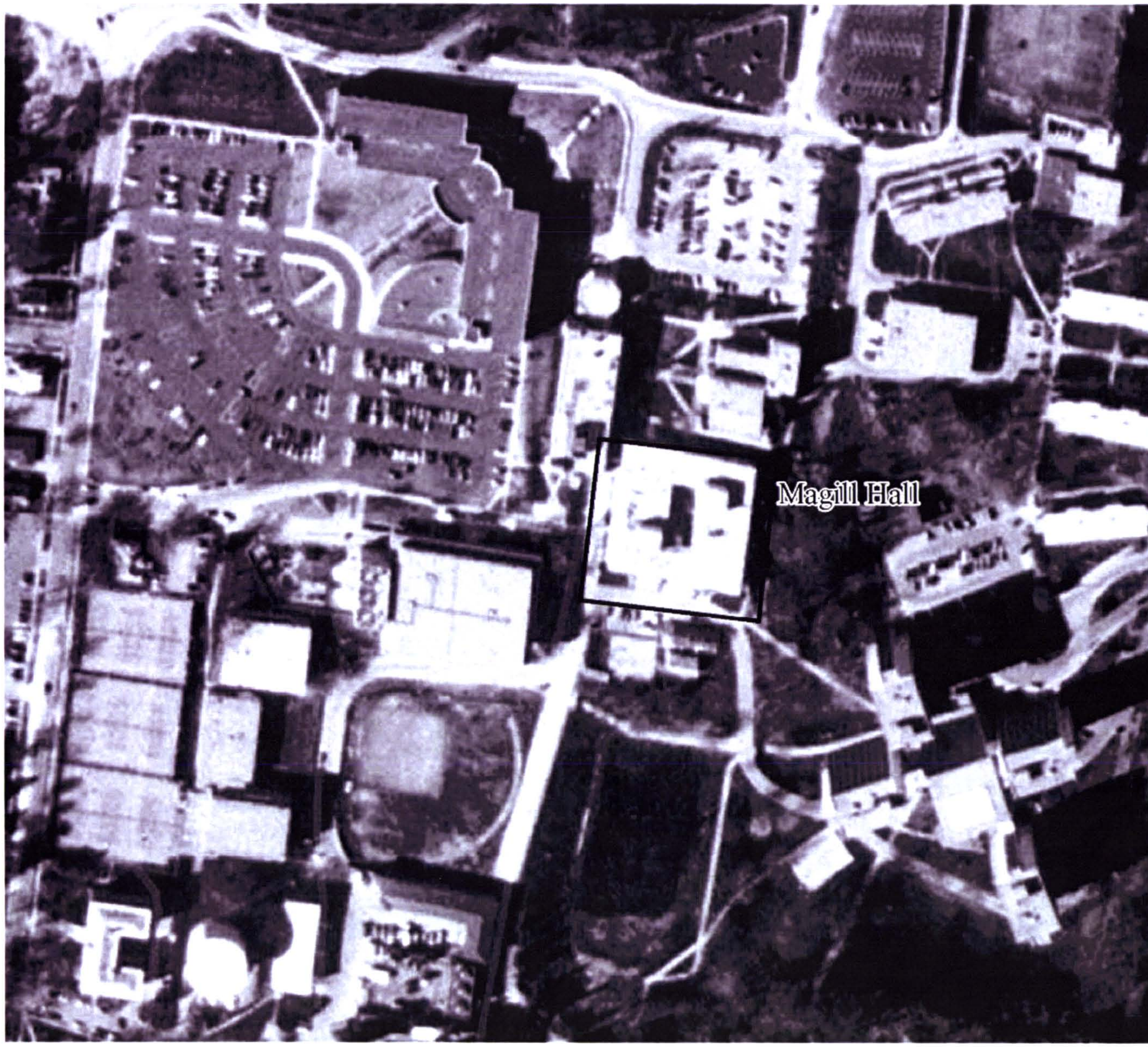
W:\SEMO\GIS\Report\Projects\Figure 2 SEMO 1996 Aerial Photo.mxd

Figure 2. Magill Hall
1996 Aerial Photo



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Building

Magill Hall 1998 Aerial Photo
Southeast Missouri State University
Cape Girardeau, MO

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Figure 3. Magill Hall
1998 Aerial Photo

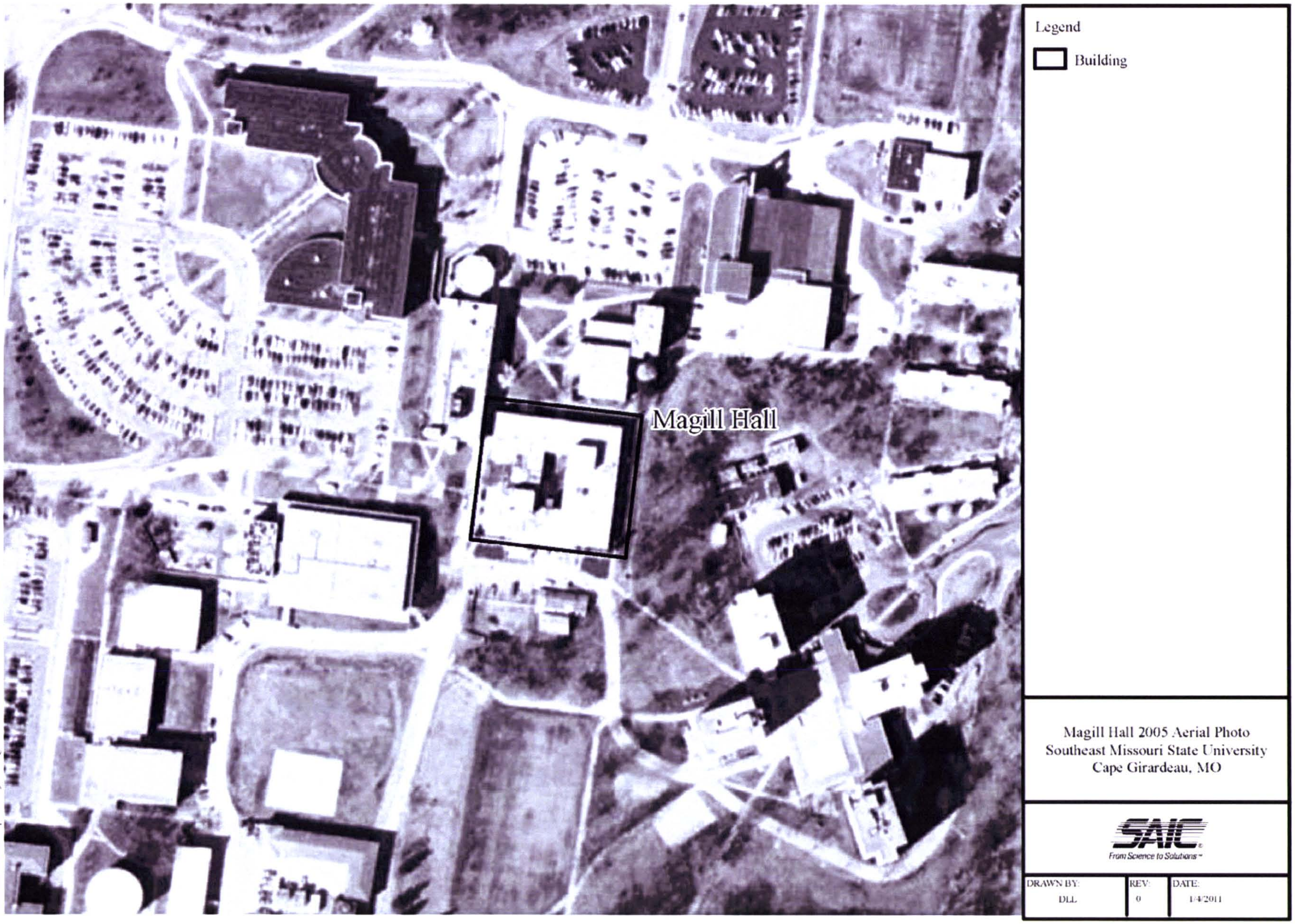

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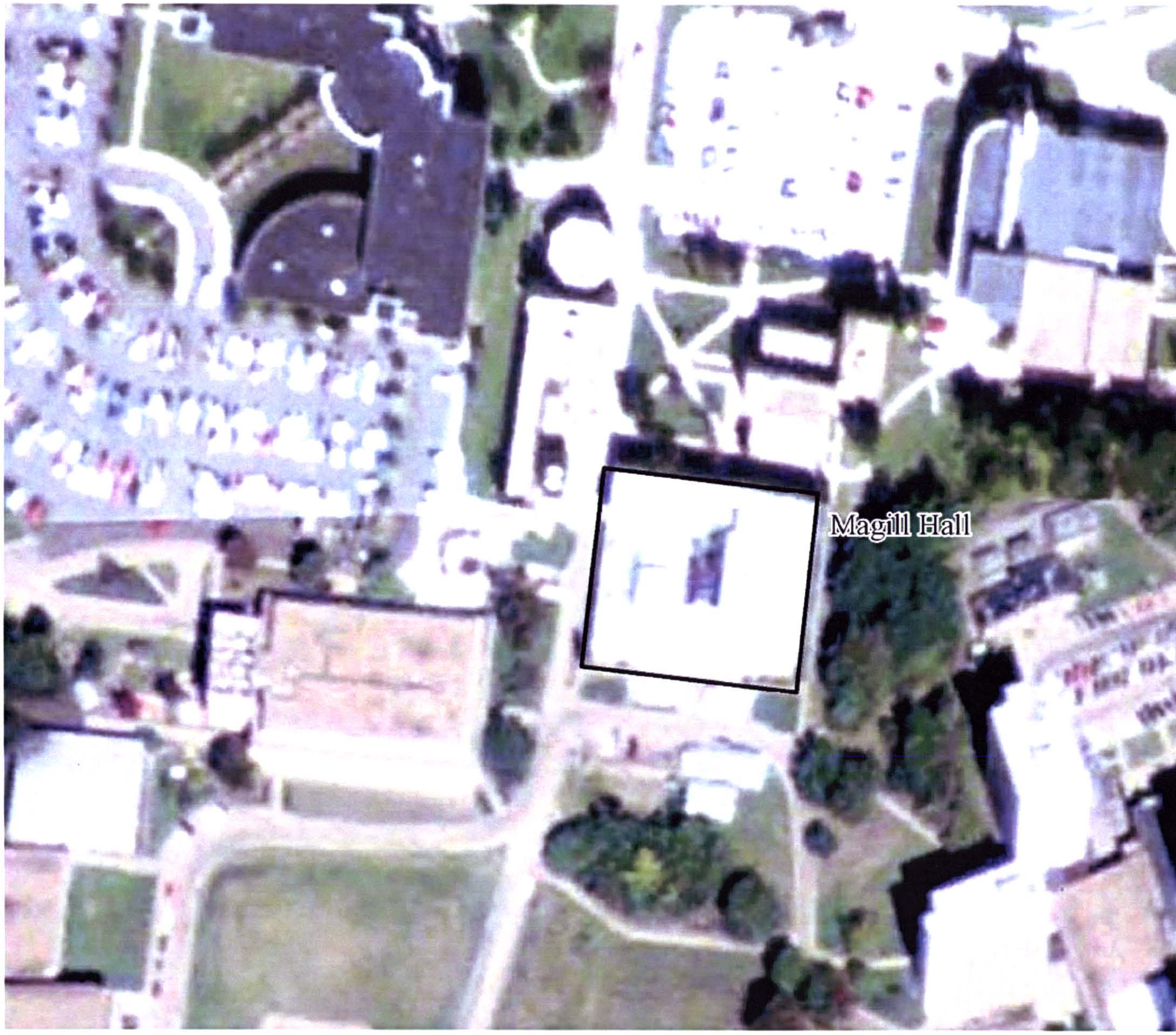
Figure 4. Magill Hall
2005 Aerial Photo



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Building

Magill Hall 2009 Aerial Photo
Southeast Missouri State University
Cape Girardeau, MO

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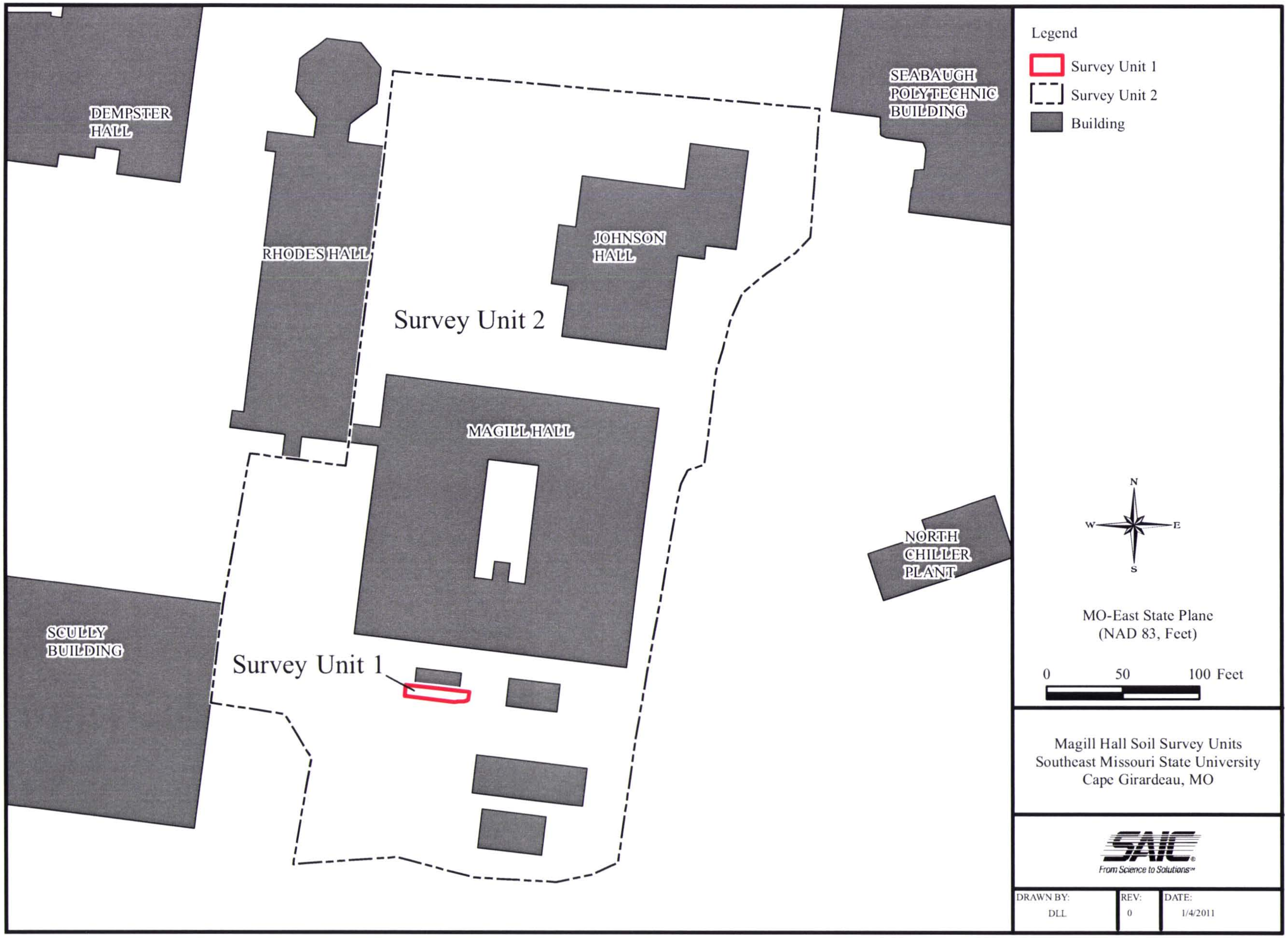
Figure 5. Magill Hall
2009 Aerial Photo



W:\SEMO\GIS\Projects\Rev\Figure 6 Magill Hall Soil Survey Units.mxd

Figure 6. Magill Hall
Soil Survey Units

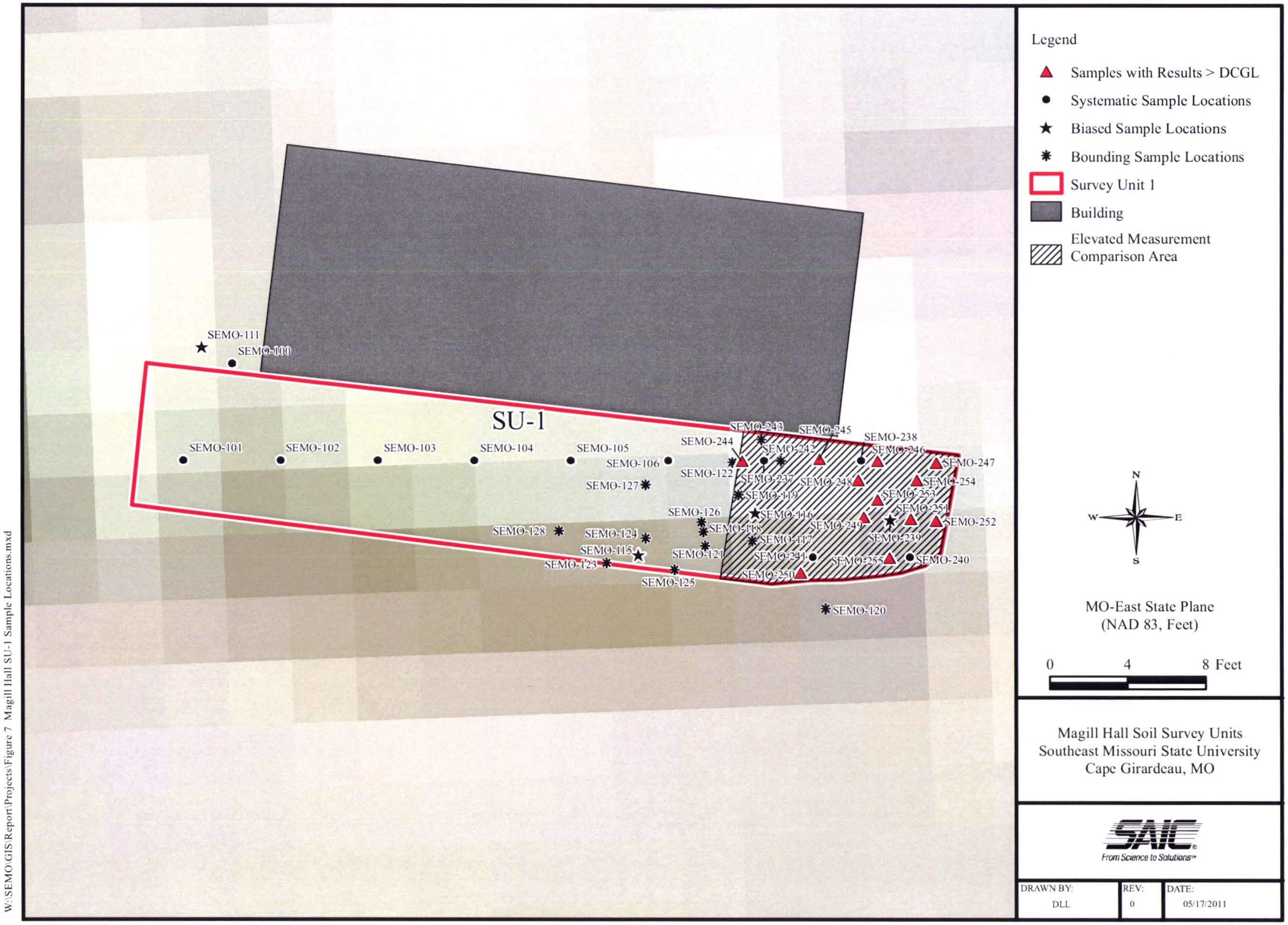


Figure 7. Magill Hall
SU-1 Sample Locations

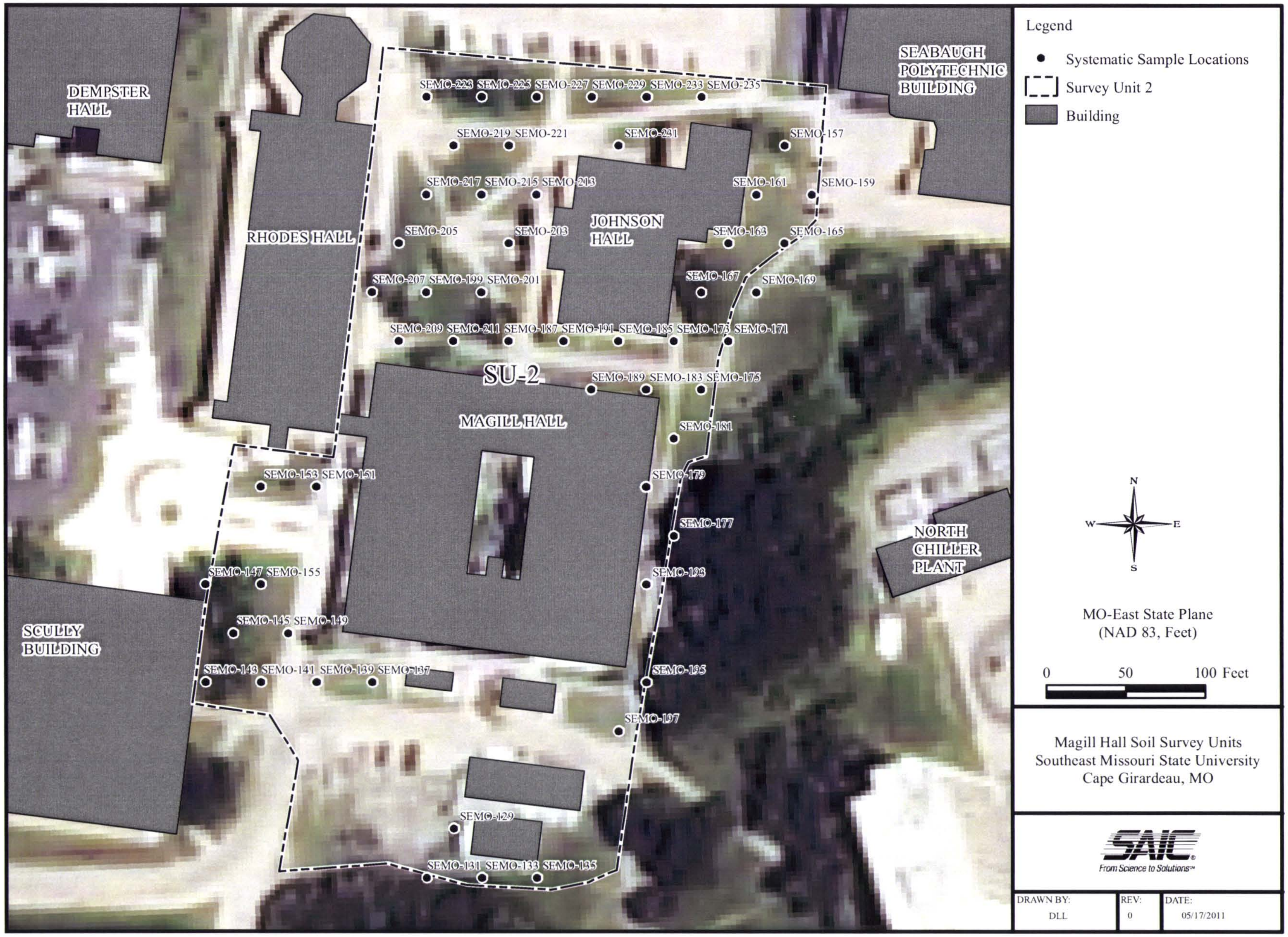


Figure 8. Magill Hall
SU-2 Sample Locations

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APPENDIX A

GAMMA WALKOVER SURVEYS

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GAMMA WALKOVER SURVEYS

Many radioactive contaminants can be identified through field detection methods such as surface gamma radiation scans. (Field detection methods are generally not available for detection of non-radioactive contaminants, which solely rely on laboratory analysis of field samples.) While radioactive contaminants that emit gamma radiation can be detected through radiation scans, the contaminants are not the only radioactivity that may be detected. The gamma scans detect radiation from both naturally-occurring sources and environmental contamination, and both are present in the GWS and FWS results. Figure A-1 presents the GWS results, and Figure A-2 presents the FWS.

Radiation walkover surveys serve as both a qualitative and quantitative tool that can help locate radioactive contamination. However, elevated readings do not, in and of themselves, provide a definitive indication that the $DCGL_W$ is exceeded. Where there are higher levels of naturally-occurring radioactivity, higher GWS or FWS readings can occur even if the $DCGL_W$ is not exceeded. Such readings can be thought of as false positive results. Representative biased samples are collected and analyzed in a radioanalytical laboratory to investigate areas identified during the walkover survey. These areas are investigated to ensure the $DCGL_W$ is met in those areas. Radio analytical laboratory samples can identify and quantify the COPC with greater sensitivity and accuracy for comparison to the $DCGL_W$.

Before starting the GWS or FWS, the professional health physics technicians established the relative background radiation level (in cpm) for the specific survey area with the survey instrument being used. During the walkover survey, the technicians assessed the count rates displayed on the instrument and the associated audible click rates to identify locations from which representative biased samples should be obtained. The identified locations had radiation readings that typically exceeded the relative background radiation levels by 2,000 cpm or higher on either instrument. Then, professional health physicists reviewed the results and defined locations from which any additional representative biased samples were collected.

This review considered count rates, mathematical analysis of the count rates, existing sample information in the area(s) of interest, increased radiation from materials with higher concentrations of naturally occurring radioactivity (such as granite, brick, some concrete, coal or coal ash, and road salt), increased radiation from soil located perpendicular to the surveyed surface (such as in an excavation or next to a hill or mound), attempts to duplicate higher count rates, and experience with variations in the radiation readings of soil.

One biased sample, as shown on Figure A-1, was collected for this FSSE based on the GWS at Southeast. Two biased samples as shown on Figure A-2, were collected for this FSSE based on the FWS.

The GWS and FWS figures were developed by using a geographic information system (GIS). The GWS and FWS results in count rates and the location coordinates were translated into maps of colored data points. The range for the colors was calculated using the mean and standard deviation of the count rate from each walkover survey, adjusted to account for detectability considerations. The MDC is calculated using equations from *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions,* NUREG-1507 (NRC 1998). Because MARSSIM identifies that environmental data may not be normally distrubuted and uses non-parametric tests, Chebyshev's Inequality was used to set the ranges of the colors for the GWS data. The 85^{th} and 95^{th} percentile of the data were chosen to focus on areas of interest with higher cpm. The 85^{th} percentile means that 85 percent of the data have values less than the 85^{th} percentile value; the 95^{th} percentile is similarly defined. To achieve the 85th percentile of the data, a 1.83 factor for the standard deviation was calculated for each GWS and FWS file using Chebyshev's Inequality. To achieve the 95th percentile of the data, a 3.15 factor for the standard deviation was calculated using Chebyshev's Inequality. A factor to account for the level of cpm that surveyors can distinguish from general levels was added to these percentile values to determine the color set points for each GWS and FWS file. An area represented by red on the GWS or FWS figure indicates an area of interest that would have been addressed through sampling and/or evaluation.

Figure A-1 presents the GWS results for the soil SU at Southeast, and Figure A-2 presents the FWS results.

There are two areas represented in red on the GWS figure (Figure A-1). One area is located near the radioactive material storage bunker to the south of Magill Hall, and the other is located to the north of Johnson Hall. A biased sample (SEMO-239) was collected near the location south of Magill Hall; this biased sample is being considered representative of both areas, because the measured radiation levels were significantly higher in this area. The results of this biased sample were below the $DCGL_W$. Sample results can be found in Appendix B, Table B-2.

There were several areas represented in red on the FWS figure (Figure A-2). These include one area near the radioactive material storage bunker to the south of Magill Hall, others to the northeast of Rhodes Hall, and to the east of Magill Hall, and several others located to the south of the greenhouse south of Magill Hall. The areas located to the south of the greenhouse south of Magill Hall were found to be the result of a faulty FIDLER cable. The cable was replaced and instrument readings returned to normal.

Biased samples (SEMO-115 and SEMO-116) were collected near the radioactive material storage bunker south of Magill Hall. These samples are considered representative of all areas represented in red, because the count rates were significantly higher in this area. The results of these samples were below the $DCGL_W$. Sample results can be found in Appendix B, Table B-2.

The global positioning system (GPS) used for the GWSs has inherent variability in identifying location coordinates. Some of the GWS and FWS samples appear to be outside the SU boundary due to structural interferences, and/or variance in the GPS and the GIS.

The GWS and FWS instruments and their detection sensitivities are listed in Table A-1 below. Detection sensitivities were determined following the guidance in NUREG 1507 and MARSSIM. The instrumentation was selected based on the potential to find Am-241.

Table A-1. Radiological Field Instrument Detection Sensitivity

Description	Application	Detection Sensitivity	
Ludlum Model 2221 with a Ludlum Model 44-10 (2" × 2" sodium iodide gamma scintillation detector)	Gamma scans of ground surface and cover material	Am-241	31.5 pCi/g*
Model G5 FIDLER Scintillation Probe	Gamma scans of ground surface and cover material		Not Available+

Note: Field instrumentation is calibrated annually.

* Value from NUREG 1507, Table 6.4.

+ No published value available.

Field instrumentation was calibrated annually and source checked at least daily during use. In addition, daily field performance checks were conducted in accordance with instrument use procedures. The performance checks were conducted prior to initiating the daily field activities, upon completion of daily field activities, and if the instrument response appeared questionable.

APPENDIX A

FIGURES

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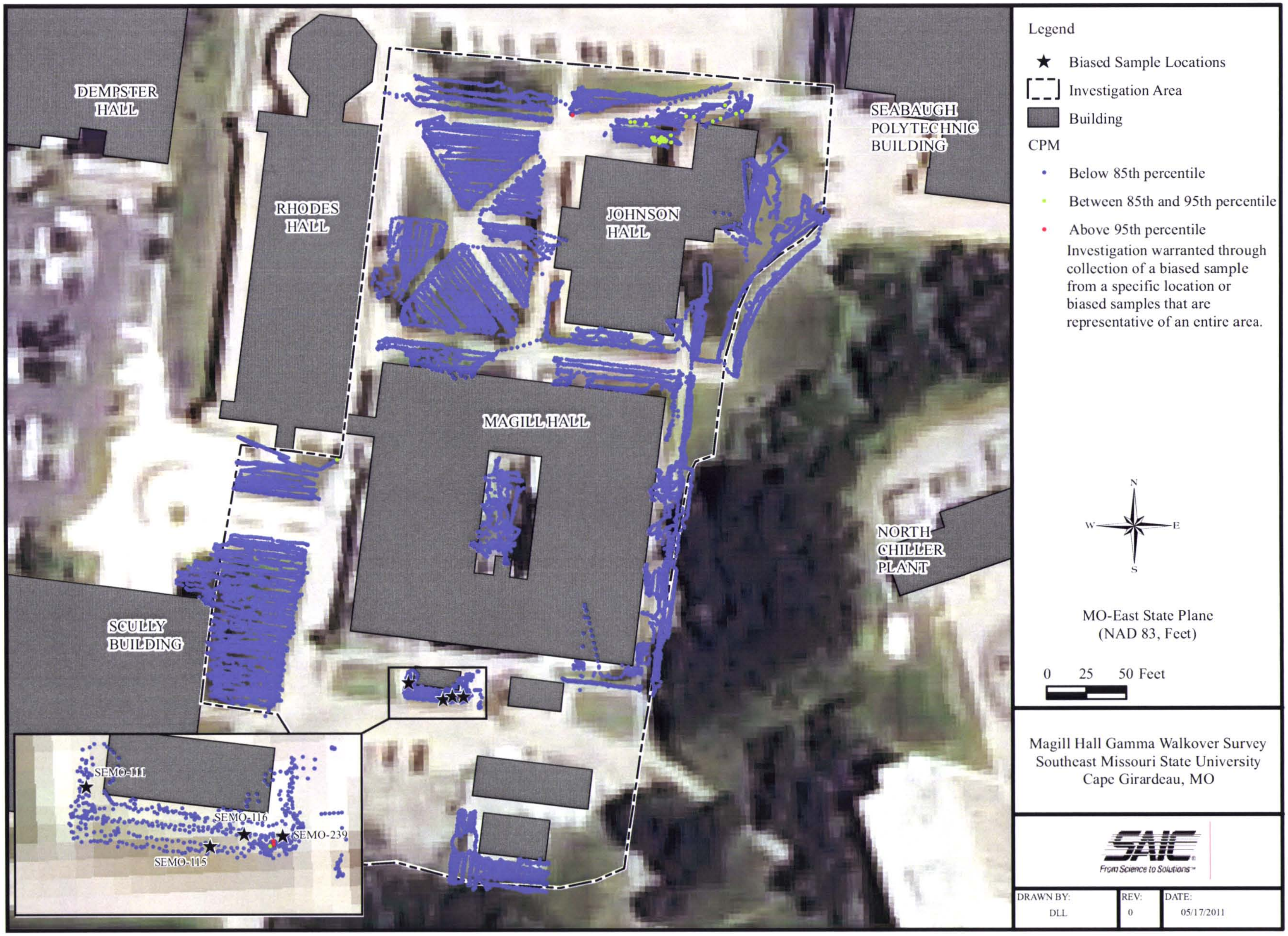

Figure A-1. Magill Hall Gamma Walkover Survey

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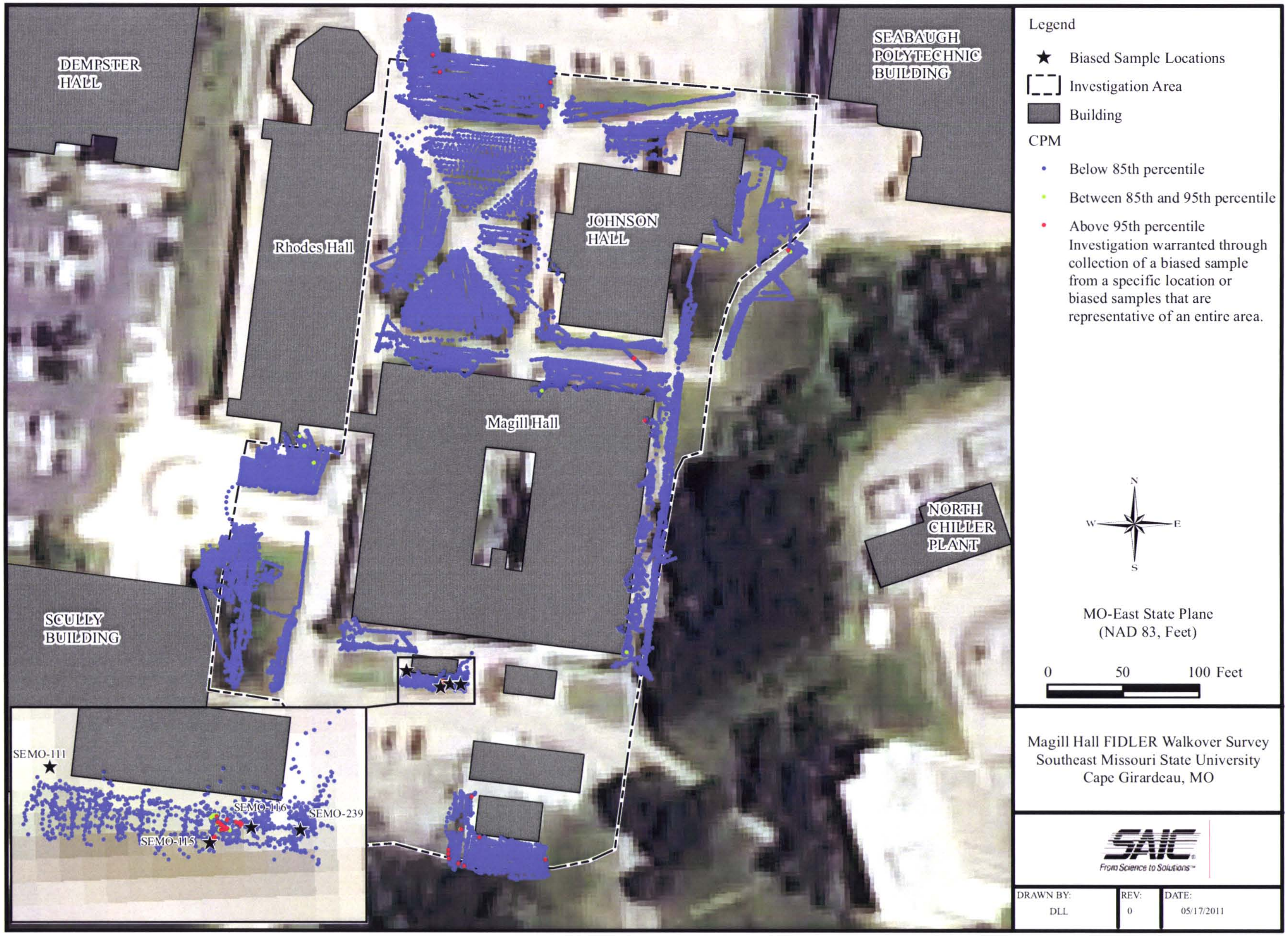

Figure A-2. Magill Hall
FIDLER Walkover Survey

APPENDIX B

FINAL STATUS SURVEY SOIL SAMPLE DATA

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Table B-1. SU-1 Final Status Survey Soil Sample Data

SU	Sample Name	Easting	Northing	Am-241				Type
				Result (pCi/g)	Error (pCi/g)	MDC (pCi/g)	Validation Qualifier	
1	SEMO-100	1102423	541051	0.22	0.16	0.14	J	Systematic
1	SEMO-101	1102420	541046	0.12	0.13	0.25	U	Systematic
1	SEMO-102	1102425	541046	0.17	0.12	0.19	U	Systematic
1	SEMO-103	1102430	541046	0.15	0.27	0.49	U	Systematic
1	SEMO-104	1102435	541046	0.37	0.22	0.19	J	Systematic
1	SEMO-105	1102440	541046	0.52	0.33	0.34	J	Systematic
1	SEMO-106	1102445	541046	0.94	0.21	0.17	=	Systematic
1	SEMO-237	1102450	541046	0.07	0.10	0.18	UJ	Systematic
1	SEMO-238	1102455	541046	0.99	0.29	0.29	=	Systematic
1	SEMO-241	1102453	541041	0.30	0.24	0.43	U	Systematic
1	SEMO-240	1102458	541041	0.00	0.06	0.11	UJ	Systematic

"=" Positive result was obtained.

"U" The material was analyzed for a COPC, but it was not detected above the level of the associated value.

"J" The associated value is an estimated quantity, indicating a decreased knowledge of the accuracy or precision of the reported value.

"UJ" The analyte was analyzed for, but it was not detected above the minimum detectable value, and the reported value is an estimate, indicating a decreased knowledge of the accuracy or precision of the reported value.

"R" The analyte value reported is unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity have raised significant question as to the reliability of the information presented.

Table B-2. SU-1 Biased and Bounding Soil Sample Data

Location ID	Sample Name	Easting	Northing	Am-241				Depth	Type
				Result (pCi/g)	Error (pCi/g)	MDC (pCi/g)	Validation Qualifier		
SEMO-111	SEMO-111	1102421	541051	1.67	0.24	0.15	=	0.0-0.5	Biased
SEMO-112	SEMO-115	1102444	541041	1.38	0.27	0.17	=	0.5-1.0	Biased
SEMO-113	SEMO-116	1102450	541043	0.00	0.08	0.15	UJ	0.5-1.0	Biased
SEMO-114	SEMO-239	1102457	541043	0.20	0.13	0.12	J	0.5-1.0	Biased
SEMO-117	SEMO-117	1102450	541041	0.28	0.17	0.19	J	0.0-0.5	Bounding
SEMO-118	SEMO-118	1102447	541042	0.19	0.12	0.20	UJ	0.0-0.5	Bounding
SEMO-119	SEMO-119	1102449	541044	0.63	0.11	0.06	=	0.0-0.5	Bounding
SEMO-120	SEMO-120	1102453	541038	1.39	0.41	0.32	=	0.0-0.5	Bounding
SEMO-121	SEMO-121	1102447	541041	0.24	0.09	0.09	=	0.0-0.5	Bounding
SEMO-122	SEMO-122	1102449	541046	0.06	0.13	0.25	UJ	0.0-0.5	Bounding
SEMO-123	SEMO-123	1102442	541040	0.13	0.09	0.16	UJ	0.0-0.5	Bounding
SEMO-124	SEMO-124	1102444	541042	0.02	0.22	0.36	UJ	0.0-0.5	Bounding
SEMO-125	SEMO-125	1102446	541040	0.14	0.15	0.24	UJ	0.0-0.5	Bounding
SEMO-126	SEMO-126	1102447	541042	0.05	0.19	0.35	UJ	0.0-0.5	Bounding
SEMO-127	SEMO-127	1102444	541044	0.57	0.15	0.16	=	0.0-0.5	Bounding
SEMO-128	SEMO-128	1102440	541042	0.62	0.28	0.25	=	0.0-0.5	Bounding
SEMO-242	SEMO-242	1102451	541046	0.59	0.10	0.07	=	0.0-0.5	Bounding
SEMO-243	SEMO-243	1102450	541047	0.39	0.11	0.11	=	0.0-0.5	Bounding
SEMO-244	SEMO-244	1102449	541046	6.87	0.65	0.26	=	0.0-0.5	Bounding
SEMO-245	SEMO-245	1102453	541046	7.13	0.65	0.17	=	0.0-0.5	Bounding
SEMO-246	SEMO-246	1102456	541046	14.50	1.64	0.49	=	0.0-0.5	Bounding
SEMO-247	SEMO-247	1102459	541046	2.84	0.35	0.08	=	0.0-0.5	Bounding
SEMO-248	SEMO-248	1102455	541045	4.55	0.46	0.12	=	0.0-0.5	Bounding
SEMO-249	SEMO-249	1102455	541043	3.54	0.36	0.12	=	0.0-0.5	Bounding
SEMO-250	SEMO-250	1102452	541040	3.14	0.47	0.28	J	0.0-0.5	Bounding
SEMO-251	SEMO-251	1102458	541043	7.96	0.77	0.25	=	0.0-0.5	Bounding
SEMO-252	SEMO-252	1102459	541043	5.91	0.55	0.17	=	0.0-0.5	Bounding
SEMO-253	SEMO-253	1102456	541044	3.73	0.71	0.41	=	0.0-0.5	Bounding
SEMO-254	SEMO-254	1102458	541045	11.30	1.00	0.30	=	0.0-0.5	Bounding
SEMO-255	SEMO-255	1102457	541041	2.93	0.34	0.19	=	0.0-0.5	Bounding
SEMO-256	SEMO-256	1102457	541042	5.22	0.48	0.19	=	0.0-0.5	Bounding
SEMO-257	SEMO-257	1102453	541041	1.08	0.21	0.16	=	0.0-0.5	Bounding
SEMO-258	SEMO-258	1102451	541041	1.62	0.28	0.17	=	0.0-0.5	Bounding
SEMO-259	SEMO-259	1102452	541042	6.52	0.78	0.35	J	0.0-0.5	Bounding
SEMO-260	SEMO-260	1102454	541046	12.60	1.25	0.31	=	0.0-0.5	Bounding
SEMO-261	SEMO-261	1102449	541042	1.66	0.23	0.08	=	0.0-0.5	Bounding

* Negative results occur when the measured value is less that of than the laboratory blank or background due to random effects or measurement limitations. Negative radioactivity is physically impossible but the inclusions of these results allows for better statistical analysis.

"=" Positive result was obtained.

"U" The material was analyzed for a COPC, but it was not detected above the level of the associated value.

"J" The associated value is an estimated quantity, indicating a decreased knowledge of the accuracy or precision of the reported value.

"UJ" The analyte was analyzed for, but it was not detected above the minimum detectable value, and the reported value is an estimate, indicating a decreased knowledge of the accuracy or precision of the reported value.

"R" The analyte value reported is unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity have raised significant question as to the reliability of the information presented.

Table B-3. SU-2 Final Status Survey Soil Sample Data

SU	Sample Name	Easting	Northing	Am-241				Type
				Result (pCi/g)*	Error (pCi/g)	MDC (pCi/g)	Validation Qualifier	
2	SEMO-129	1102455	540959	0.04	0.22	0.35	UJ	Systematic
2	SEMO-131	1102438	540928	0.24	0.16	0.27	UJ	Systematic
2	SEMO-133	1102473	540928	0.03	0.06	0.10	UJ	Systematic
2	SEMO-135	1102508	540928	0.07	0.14	0.23	UJ	Systematic
2	SEMO-137	1102403	541052	-0.01	0.04	0.06	UJ	Systematic
2	SEMO-139	1102368	541052	0.05	0.19	0.31	UJ	Systematic
2	SEMO-141	1102333	541052	0.09	0.16	0.26	UJ	Systematic
2	SEMO-143	1102298	541052	0.08	0.11	0.17	UJ	Systematic
2	SEMO-145	1102315	541083	-0.03	0.05	0.07	UJ	Systematic
2	SEMO-147	1102298	541114	0.05	0.17	0.29	UJ	Systematic
2	SEMO-149	1102350	541083	0.06	0.09	0.15	UJ	Systematic
2	SEMO-151	1102368	541176	-0.07	0.18	0.32	UJ	Systematic
2	SEMO-153	1102333	541176	0.08	0.16	0.26	UJ	Systematic
2	SEMO-155	1102333	541114	0.01	0.05	0.08	UJ	Systematic
2	SEMO-157	1102665	541393	-0.13	0.14	0.24	UJ	Systematic
2	SEMO-159	1102683	541362	0.04	0.05	0.09	UJ	Systematic
2	SEMO-161	1102648	541362	0.04	0.05	0.09	UJ	Systematic
2	SEMO-163	1102630	541331	0.00	0.12	0.19	UJ	Systematic
2	SEMO-165	1102665	541331	0.03	0.09	0.14	UJ	Systematic
2	SEMO-167	1102613	541300	-0.03	0.17	0.26	UJ	Systematic
2	SEMO-169	1102648	541300	0.01	0.17	0.30	UJ	Systematic
2	SEMO-171	1102630	541269	0.02	0.10	0.15	UJ	Systematic
2	SEMO-173	1102595	541269	0.06	0.16	0.27	UJ	Systematic
2	SEMO-175	1102613	541238	0.02	0.09	0.15	UJ	Systematic
2	SEMO-177	1102595	541145	0.13	0.15	0.24	UJ	Systematic
2	SEMO-179	1102578	541176	-0.03	0.18	0.31	UJ	Systematic
2	SEMO-181	1102595	541207	0.19	0.12	0.19	UJ	Systematic
2	SEMO-183	1102578	541238	0.13	0.13	0.23	UJ	Systematic
2	SEMO-185	1102560	541269	0.09	0.18	0.34	UJ	Systematic
2	SEMO-187	1102490	541269	0.00	0.31	0.25	UJ	Systematic
2	SEMO-189	1102543	541238	0.04	0.19	0.31	UJ	Systematic
2	SEMO-191	1102525	541269	0.06	0.06	0.09	UJ	Systematic
2	SEMO-193	1102578	541114	0.02	0.11	0.17	U	Systematic
2	SEMO-195	1102578	541052	0.15	0.14	0.24	U	Systematic
2	SEMO-197	1102560	541021	-0.13	0.14	0.24	U	Systematic
2	SEMO-199	1102438	541300	0.03	0.14	0.23	U	Systematic
2	SEMO-201	1102473	541300	0.00	0.08	0.07	UJ	Systematic
2	SEMO-203	1102490	541331	0.25	0.17	0.29	U	Systematic
2	SEMO-205	1102420	541331	0.17	0.18	0.29	U	Systematic
2	SEMO-207	1102403	541300	0.00	0.05	0.09	U	Systematic
2	SEMO-209	1102420	541269	0.00	0.18	0.30	UJ	Systematic
2	SEMO-211	1102455	541269	0.11	0.09	0.16	UJ	Systematic
2	SEMO-213	1102508	541362	0.15	0.15	0.15	UJ	Systematic
2	SEMO-215	1102473	541362	0.10	0.16	0.28	UJ	Systematic
2	SEMO-217	1102438	541362	0.04	0.10	0.16	UJ	Systematic
2	SEMO-219	1102455	541393	0.04	0.04	0.07	UJ	Systematic
2	SEMO-221	1102490	541393	0.13	0.13	0.21	UJ	Systematic
2	SEMO-223	1102438	541424	-0.17	0.14	0.25	UJ	Systematic

Table B-3. SU-2 Final Status Survey Soil Sample Data

SU	Sample Name	Easting	Northing	Am-241 Result (pCi/g)*	Am-241 Error (pCi/g)	Am-241 MDC (pCi/g)	Am-241 Validation Qualifier	Type
2	SEMO-225	1102473	541424	-0.04	0.10	0.15	UJ	Systematic
2	SEMO-227	1102508	541424	0.08	0.14	0.26	UJ	Systematic
2	SEMO-229	1102543	541424	0.08	0.19	0.29	UJ	Systematic
2	SEMO-231	1102560	541393	0.10	0.17	0.28	U	Systematic
2	SEMO-233	1102578	541424	-0.03	0.05	0.07	U	Systematic
2	SEMO-235	1102613	541424	0.08	0.15	0.25	UJ	Systematic

* Negative results occur when the measured value is less that of than the laboratory blank or background due to random effects or measurement limitations. Negative radioactivity is physically impossible but the inclusions of these results allows for better statistical analysis.

"=" Positive result was obtained.

"U" The material was analyzed for a COPC, but it was not detected above the level of the associated value.

"J" The associated value is an estimated quantity, indicating a decreased knowledge of the accuracy or precision of the reported value.

"UJ" The analyte was analyzed for, but it was not detected above the minimum detectable value, and the reported value is an estimate, indicating a decreased knowledge of the accuracy or precision of the reported value.

"R" The analyte value reported is unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity have raised significant question as to the reliability of the information presented.

Table B-4. SU-2 Subsurface Soil Sample Data

Station ID	Sample Name	Easting	Northing	Am-241				Depth	Type
				Result (pCi/g)*	Error (pCi/g)	MDC (pCi/g)	Validation Qualifier		
SEMO-129	SEMO-130	1102455	540959	0.04	0.13	0.20	UJ	1.5-2.0	Subsurface
SEMO-131	SEMO-132	1102438	540928	0.02	0.15	0.23	UJ	1.5-2.0	Subsurface
SEMO-133	SEMO-134	1102473	540928	0.08	0.14	0.26	UJ	1.5-2.0	Subsurface
SEMO-135	SEMO-136	1102508	540928	0.12	0.10	0.17	UJ	1.5-2.0	Subsurface
SEMO-137	SEMO-138	1102403	541052	0.02	0.06	0.09	UJ	1.5-2.0	Subsurface
SEMO-139	SEMO-140	1102368	541052	0.09	0.13	0.21	UJ	1.5-2.0	Subsurface
SEMO-141	SEMO-142	1102333	541052	0.08	0.10	0.16	UJ	1.5-2.0	Subsurface
SEMO-143	SEMO-144	1102298	541052	-0.15	0.19	0.33	UJ	1.5-2.0	Subsurface
SEMO-145	SEMO-146	1102315	541083	-0.17	0.18	0.28	UJ	0.5-1.0	Subsurface
SEMO-147	SEMO-148	1102298	541114	0.06	0.15	0.27	UJ	1.5-2.0	Subsurface
SEMO-149	SEMO-150	1102350	541083	-0.13	0.17	0.29	UJ	0.5-1.0	Subsurface
SEMO-151	SEMO-152	1102368	541176	-0.02	0.10	0.15	UJ	0.5-1.0	Subsurface
SEMO-153	SEMO-154	1102333	541176	-0.04	0.11	0.18	UJ	1.5-2.0	Subsurface
SEMO-155	SEMO-156	1102333	541114	0.09	0.09	0.14	UJ	1.0-1.5	Subsurface
SEMO-157	SEMO-158	1102665	541393	0.03	0.18	0.31	UJ	1.5-2.0	Subsurface
SEMO-159	SEMO-160	1102683	541362	0.15	0.18	0.29	UJ	1.5-2.0	Subsurface
SEMO-161	SEMO-162	1102648	541362	0.06	0.13	0.22	UJ	1.5-2.0	Subsurface
SEMO-163	SEMO-164	1102630	541331	-0.03	0.11	0.17	UJ	0.5-1.0	Subsurface
SEMO-165	SEMO-166	1102665	541331	0.02	0.05	0.08	UJ	1.0-1.5	Subsurface
SEMO-167	SEMO-168	1102613	541300	0.02	0.04	0.07	UJ	0.5-1.0	Subsurface
SEMO-169	SEMO-170	1102648	541300	0.08	0.06	0.10	UJ	0.5-1.0	Subsurface
SEMO-171	SEMO-172	1102630	541269	-0.01	0.13	0.20	UJ	1.5-2.0	Subsurface
SEMO-173	SEMO-174	1102595	541269	-0.10	0.15	0.27	UJ	1.0-1.5	Subsurface
SEMO-175	SEMO-176	1102613	541238	0.06	0.12	0.18	UJ	1.0-1.5	Subsurface
SEMO-177	SEMO-178	1102595	541145	0.06	0.10	0.16	UJ	1.5-2.0	Subsurface
SEMO-179	SEMO-180	1102578	541176	-0.01	0.10	0.16	UJ	0.5-1.0	Subsurface
SEMO-181	SEMO-182	1102595	541207	-0.06	0.20	0.33	UJ	1.0-1.5	Subsurface
SEMO-183	SEMO-184	1102578	541238	0.00	0.04	0.07	UJ	1.0-1.5	Subsurface
SEMO-185	SEMO-186	1102560	541269	-0.08	0.15	0.21	UJ	1.5-2.0	Subsurface
SEMO-187	SEMO-188	1102490	541269	0.01	0.13	0.21	UJ	0.5-1.0	Subsurface
SEMO-189	SEMO-190	1102543	541238	0.03	0.06	0.10	UJ	1.5-2.0	Subsurface
SEMO-191	SEMO-192	1102525	541269	-0.05	0.19	0.30	U	1.5-2.0	Subsurface
SEMO-193	SEMO-194	1102578	541114	0.03	0.11	0.18	U	1.5-2.0	Subsurface
SEMO-195	SEMO-196	1102578	541052	0.05	0.09	0.15	U	1.0-1.5	Subsurface

Table B-4. SU-2 Subsurface Soil Sample Data

Station ID	Sample Name	Easting	Northing	Am-241				Depth	Type
				Result (pCi/g)*	Error (pCi/g)	MDC (pCi/g)	Validation Qualifier		
SEMO-197	SEMO-198	1102560	541021	0.22	0.14	0.16	=	1.0-1.5	Subsurface
SEMO-199	SEMO-200	1102438	541300	0.03	0.08	0.14	U	1.5-2.0	Subsurface
SEMO-201	SEMO-202	1102473	541300	0.03	0.13	0.20	U	1.0-1.5	Subsurface
SEMO-203	SEMO-204	1102490	541331	0.02	0.12	0.19	U	1.5-2.0	Subsurface
SEMO-205	SEMO-206	1102420	541331	0.03	0.05	0.09	U	0.5-1.0	Subsurface
SEMO-207	SEMO-208	1102403	541300	0.01	0.04	0.07	U	0.5-1.0	Subsurface
SEMO-209	SEMO-210	1102420	541269	-0.12	0.15	0.26	UJ	1.0-1.5	Subsurface
SEMO-211	SEMO-212	1102455	541269	0.05	0.04	0.07	UJ	1.5-2.0	Subsurface
SEMO-213	SEMO-214	1102508	541362	-0.04	0.17	0.29	UJ	1.5-2.0	Subsurface
SEMO-215	SEMO-216	1102473	541362	0.08	0.12	0.19	UJ	1.5-2.0	Subsurface
SEMO-217	SEMO-218	1102438	541362	0.09	0.12	0.21	UJ	1.5-2.0	Subsurface
SEMO-219	SEMO-220	1102455	541393	0.00	0.18	0.29	UJ	0.5-1.0	Subsurface
SEMO-221	SEMO-222	1102490	541393	-0.06	0.18	0.30	UJ	0.5-1.0	Subsurface
SEMO-223	SEMO-224	1102438	541424	0.00	0.06	0.09	UJ	0.5-1.0	Subsurface
SEMO-225	SEMO-226	1102473	541424	0.13	0.20	0.33	UJ	1.0-1.5	Subsurface
SEMO-227	SEMO-228	1102508	541424	0.11	0.09	0.15	UJ	1.0-1.5	Subsurface
SEMO-229	SEMO-230	1102543	541424	-0.03	0.11	0.17	U	0.5-1.0	Subsurface
SEMO-231	SEMO-231	1102560	541393	0.10	0.08	0.28	UJ	0.0-0.5	Subsurface
SEMO-233	SEMO-234	1102578	541424	0.01	0.11	0.18	UJ	1.5-2.0	Subsurface
SEMO-235	SEMO-236	1102613	541424	0.12	0.09	0.15	UJ	1.0-1.5	Subsurface

* Negative results occur when the measured value is less that of than the laboratory blank or background due to random effects or measurement limitations. Negative radioactivity is physically impossible but the inclusions of these results allows for better statistical analysis.

"=" Positive result was obtained.

"U" The material was analyzed for a COPC, but it was not detected above the level of the associated value.

"J" The associated value is an estimated quantity, indicating a decreased knowledge of the accuracy or precision of the reported value.

"UJ" The analyte was analyzed for, but it was not detected above the minimum detectable value, and the reported value is an estimate, indicating a decreased knowledge of the accuracy or precision of the reported value.

"R" The analyte value reported is unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity have raised significant question as to the reliability of the information presented.

APPENDIX C

COPIES OF LOGBOOK PAGES

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APPENDIX D

DATA QUALITY ASSESSMENT

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INTRODUCTION

PROJECT DESCRIPTION

This Data Quality Assessment was performed on the soil samples taken for the Final Status Survey Evaluation for soils adjacent to Magill Hall at Southeast Missouri State University.

PROJECT OBJECTIVES

The intent of the Data Quality Assessment is to document the usability of the data based on precision, accuracy, representativeness, comparability, completeness, and sensitivity.

PROJECT IMPLEMENTATION

The sampling was conducted between November 2010 and April 2011. Laboratory radiological analysis was performed by GEL Laboratories LLC.

PROJECT PURPOSE

The primary intent of this assessment is to evaluate whether data generated from these samples can withstand scientific scrutiny, are appropriate for their intended purpose, are technically defensible, and are of known and acceptable sensitivity, precision, and accuracy.

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QUALITY ASSURANCE PROGRAM

The Department of Defense Quality Systems Manual (DoD QSM) establishes requirements for both field and laboratory quality control procedures. The DoD Quality System Standard contains all of the requirements that environmental testing laboratories have to meet if they wish to demonstrate that they operate a quality system, are technically competent, and are able to generate technically valid results. The standard is applicable to all organizations performing environmental tests. These include, for example, first-, second- and third-party laboratories, and laboratories where environmental testing forms part of inspection and product certification. This Standard is for use by laboratories in developing their quality, administrative and technical systems that govern their operations. Laboratory clients, regulatory authorities and accreditation authorities may also use it in confirming or recognizing the competence of laboratories. Therefore, this standard was utilized to verify, validate and assess the analytical data results for the samples at Southeast. An analytical laboratory QC duplicate sample, laboratory control sample, and a method blank were performed for each matrix and analytical batch.

A primary goal of the Data Quality Assessment is to ensure that the quality of measurements is appropriate for the intended use of the results. Through the process of readiness review, training, equipment calibration, QC implementation, and detailed documentation, the project has successfully accomplished the goals required by the DoD QSM.

The resulting "definitive" data, as defined by EPA, has been reported including the following basic information:

- Laboratory case narratives
- Sample results
- Laboratory method blank results
- Laboratory control standard results
- Laboratory duplicate sample results
- Sample extraction dates
- Sample analysis dates

This information provides the basis for an independent data evaluation relative to accuracy, precision, sensitivity, representativeness, comparability, and completeness, as discussed in the following sections.

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DATA VALIDATION

This project implemented the use of data validation checklists to facilitate technical review of data. These checklists were completed by the project designated validation staff and were reviewed by the project laboratory coordinator. Data validation checklists or verification summaries for each laboratory sample delivery group have been retained with laboratory data deliverables by SAIC.

LABORATORY DATA VALIDATION

Analytical data generated for this project have been subjected to a process of 100% data verification, 10% validation, and review. The following documents establish the criteria against which the data are compared and from which a judgment is rendered regarding the acceptance and qualification of the data:

- *Department of Defense Quality Systems Manual for Environmental Laboratories* (DoD 2006).
- *Multi-Agency Radiological Laboratory Analytical Protocols Manual (USEPA 2004).*
- *Data Validation* (SAIC 2006b).

Upon receipt of field and analytical data, verification/validation staff performed a systematic examination of the reports to ensure the content, presentation, and administrative validity of the data. In conjunction with data package verification, laboratory electronic data deliverables were obtained. These data deliverables were subjected to review and verification against the hardcopy deliverable. Both a contractual and technical assessment of the laboratory-delivered electronic and hardcopy reports were performed. The contractual evaluation verified that required data had been reported and contract specified requirements were met (i.e., analytical holding times, contractual turnaround times, etc.).

During the validation process, data were subjected to a systematic technical review by examining the field results, analytical QC results, and laboratory documentation following appropriate guidelines provided in the above referenced documents. These data validation guidelines define the technical review criteria, methods for evaluation of the criteria, and actions to be taken resulting from the review of these criteria. The primary objective of this process was to assess and summarize the quality and reliability of the data for the intended use and to document factors that may affect the usability of the data. Data verification/validation included but was not necessarily limited to the following parameters for radiological methods, as appropriate:

— Holding time information and methods requested
— Discussion of laboratory analysis, including any laboratory problems
— Sample results
— Initial calibration
— Efficiency check
— Background determinations
— Duplicate sample results
— Laboratory control samples
— Run log

As an end result of this process the data were qualified based on the technical assessment of the validation criteria. Qualifiers were applied to each analytical result to indicate the usability of the data for its intended purpose with a reason code to explain the retention or the qualifier.

DEFINITIONS OF DATA QUALIFIERS

During the data validation process, all laboratory data were assigned appropriate data validation qualifiers and reason codes, as follows:

"=" Positive result was obtained.

"U" The material was analyzed for a COPC, but it was not detected above the level of the associated value.

"J" The associated value is an estimated quantity, indicating a decreased knowledge of the accuracy or precision of the reported value.

"UJ" The analyte was analyzed for, but it was not detected above the minimum detectable value, and the reported value is an estimate, indicating a decreased knowledge of the accuracy or precision of the reported value.

"R" The analyte value reported is unusable. The integrity of the analyte's identification, accuracy, precision, or sensitivity have raised significant question as to the reliability of the information presented.

Note:

A positive result is flagged with a "J" qualifier and a non-detect result is flagged "UJ" when data quality is suspect due to quality control issues, either blank contamination or analytical interference. None of the laboratory data were assigned an "R" code. validation qualifiers, reason codes, copies of validation checklists and qualified data forms are filed with the analytical hard copy deliverable.

DATA EVALUATION

The data validation process considers precision, accuracy, representativeness, completeness, comparability, and sensitivity. The following sub sections will provide detail to the particular parameters and how the data were evaluated for each with discussion and tables to present the associated data.

ACCURACY

Accuracy provides a gauge or measure of the agreement between an observed result and the true value for an analysis. For this report, accuracy is measured through the use Laboratory Control Spike Samples (LCS) through a comparison of a known amount of radionuclide versus the results of the measured amount of radionuclide. The DoD QSM requires LCS samples to be analyzed once per analytical batch consisting of no more than 20 samples, or 5% frequency. Accuracy for the LCS sample can be measured by calculating the percent recovery using the following equation:

$$Percent\,\mathrm{Re}cov ery = \left(\frac{Measured\,Radionuclide\,Activity}{Known\,Radionuclide\,Activity} \right) * 100$$

The acceptable range for LCS percent recovery is 75%-125%. There were no LCS sample percent recoveries that exceeded the acceptance criteria, as demonstrated in Table D-1, resulting in 100% acceptance.

Table D-1. LCS Sample Percent Recovery

Sample Name	Americium-241 LCS Percent Recovery
LCS-253228	87.6%
LCS-262130	114%
LCS-266633	106%
LCS-266634	106%
LCS-266637	103%
LCS-266639	115%
LCS-266640	106%
LCS-266641	111%
LCS-266642	115%
LCS-266643	107%
LCS-266777	110%
LCS-274850	116%
LCS-274851	119%

PRECISION

Analytical/Field Precision

Precision is a measure of mutual agreement among individual measurements performed under the same laboratory controls. To evaluate field precision, a field duplicate sample is submitted to the laboratory along with the original parent sample. Both samples are analyzed under the same laboratory conditions. If any bias was introduced at the laboratory, that bias would affect both samples equally.

Precision can be measured by the relative percent difference (RPD) for radiological analyses or the normalized absolute difference (NAD) for radiological analyses using the following equations:

$$RPD = \left(\frac{|S - D|}{\frac{S + D}{2}} \right) * 100$$

$$NAD = \frac{|S - D|}{\sqrt{U_S^2 + U_D^2}}$$

Where:
- S = Parent Sample Result
- D = Field Split/Duplicate Parent Sample Result
- U_S = Parent Sample Uncertainty
- U_D = Field Split/Duplicate Parent Sample Uncertainty

The RPD is calculated for all radiological field duplicate and laboratory duplicate pairs. For radiological samples, when the RPD is greater than 50 percent, the NAD is used to determine the precision of the method. NAD accounts for uncertainty in the results, RPD does not. The NAD should be equal to or less than a value of 1.96. Neither equation is used when the analyte in one or both of the samples is not detected. In cases where neither equation can be used, the comparison is counted as acceptable in the overall number of comparisons.

Field duplicate samples were collected at a frequency of approximately one duplicate sample per 20 samples. As a measure of analytical precision, the RPDs for these field duplicate sample pairs were calculated at the time of verification/validation. RPD (and/or NAD) values for all analytes were within the 50 percent window (or less than or equal to 1.96) of acceptance for the samples, except where noted.

System Precision

Field duplicate samples were collected to ascertain the contribution to variability (i.e., precision) due to the combination of environmental media, sampling consistency, and analytical precision that contribute to the precision for the entire system of collecting and analyzing samples. The field duplicate samples were collected from the same spatial and temporal conditions as the primary environmental sample. Soil samples were collected from the same sampling device, after homogenization for all analytes.

Field duplicate samples were analyzed at a frequency of one duplicate per analytical batch of no more than 20 samples, or 5% frequency. There were 10 field duplicate samples analyzed from a total of 155 samples taken, meeting the five percent frequency requirement (6.45%).

For the 10 field duplicate samples taken for the soil activities, the NAD and RPD values indicated acceptable precision for the data. For radiological analyses, Americium-241 was compared for 10 field duplicate pairs for a total of 10 comparisons. All comparisons were within the criteria, as demonstrated in Table D-2. The data are acceptable.

Table D-2. Field Duplicate Precision for Americium-241

Sample Name	Americium-241	
	RPD	NAD
SEMO-140 / SEMO-140-1	NA	NA
SEMO-147 / SEMO-147-1	NA	NA
SEMO-161 / SEMO-161-1	NA	NA
SEMO-170 / SEMO-170-1	NA	NA
SEMO-180 / SEMO-180-1	NA	NA
SEMO-198 / SEMO-198-1	NA	NA
SEMO-201 / SEMO-201-1	NA	NA
SEMO-206 / SEMO-206-1	NA	NA
SEMO-211 / SEMO-211-1	NA	NA
SEMO-237 / SEMO-237-1	NA	NA

NAD — Calculated for additional information when RPD greater than 50 percent.

Boldface — Values for RPD/NAD pairs exceed the control limits. Values not in boldface – pair meets the acceptance criteria.

NA — Value cannot be calculated since the radionuclide was not detected in one or both of the samples, or precision requirement was met with other calculated value.

Laboratory duplicate samples were analyzed at a frequency of one duplicate per analytical batch of no more than 20 samples, or 5% frequency. There were 12 laboratory duplicate samples analyzed from a total of 155 samples taken, meeting the five percent frequency requirement (7.74%).

For the 12 laboratory duplicate samples analyzed for the soil activities, the NAD and RPD values indicated acceptable precision for the data. For radiological analyses, Americium-241 was compared for 12 field duplicate pairs for a total of 12 comparisons. All comparisons were within the criteria, as demonstrated in Table D-3. The data are acceptable.

Table D-3. Laboratory Duplicate Precision for Americium-241

Sample Name	Americium-241	
	RPD	NAD
SEMO-100 / SEMO-100D	NA	NA
SEMO-115 / SEMO-115D	2.86	NA
SEMO-117 / SEMO-117D	NA	NA
SEMO-137 / SEMO-137D	NA	NA
SEMO-155 / SEMO-155D	NA	NA
SEMO-173 / SEMO-173D	NA	NA
SEMO-192 / SEMO-192D	NA	NA
SEMO-209 / SEMO-209D	NA	NA
SEMO-228 / SEMO-228D	NA	NA
SEMO-R1 / SEMO-R1D	NA	NA
SEMO-237 / SEMO-237D	NA	NA
SEMO-256 / SEMO-256D	0.57	NA

NAD — Calculated for additional information when RPD greater than 50 percent.

Boldface — Values for RPD/NAD pairs exceed the control limits. Values not in boldface – pair meets the acceptance criteria.

NA — Value cannot be calculated since the radionuclide was not detected in one or both of the samples, or precision requirement was met with other calculated value.

SENSITIVITY

Determination of MDC values allows the investigation to assess the relative confidence that can be placed in a value in comparison to the magnitude or level of analyte concentration observed. The closer a measured value comes to the MDC, the less confidence and more variation the measurement will have. These levels were achieved or exceeded throughout the analytical process.

The MDC is reported for each result obtained by laboratory analysis. These very low MDCs are achieved through the use of gamma spectroscopy for all radionuclides of concern,. Variations in MDCs for the same radiological analyte reflects variability in the detection efficiencies and conversion factors due to factors such as individual sample aliquot, sample density, and variations in analyte background radioactivity for gamma spec, at the laboratory.

ACCURACY/BIAS

Method blanks were analyzed to verify the absence of any laboratory instrument contamination. Method blanks were analyzed at a frequency once per every analytical batch of no more than 20 samples, or 5% frequency. Equipment rinsate blanks were analyzed to verify the absence of any contamination of field equipment. Tables D-4 and D-5 present the results for all method blanks and equipment rinsate blanks, respectively. There were no blank samples with Americium-241 results greater than the Minimum Detectable Activity, resulting in 100% blank result acceptance, as demonstrated in Tables D-4 and D-5.

Table D-4. Americium-241 Results for Method Blank Samples

Sample Name	Americium-241			
	Result (pCi/g)	**Error (pCi/g)**	**Detection Limit (pCi/g)**	**Validation Qualifier**
MB-253228	-0.0102	0.03	0.04	U
MB-262130	0.00481	0.07	0.12	U
MB-266633	-0.00838	0.06	0.10	UJ
MB-266634	0.0323	0.08	0.15	UJ
MB-266637	0.0109	0.02	0.04	UJ
MB-266639	0.00831	0.04	0.07	UJ
MB-266640	-0.00895	0.03	0.04	U
MB-266641	-0.00729	0.07	0.11	UJ
MB-266642	0.0176	0.04	0.07	U
MB-266643	-9.97	22.8	37.3	U
MB-266777	0.0332	0.10	0.18	U
MB-274850	-0.0616	0.04	0.07	U
MB-274851	0.0211	0.09	0.15	U

Table D-5. Americium-241 Results for Equipment Blank Samples

Sample Name	Americium-241			
	Result (pCi/g)	**Error (pCi/g)**	**Detection Limit (pCi/g)**	**Validation Qualifier**
SEMO-R1	-3.69	7.89	11.5	UJ
SEMO-R2	-9.93	29.3	42.6	UJ

REPRESENTATIVENESS AND COMPARABILITY

Representativeness expresses the degree to which data accurately reflect the isotope of interest for an environmental site and is the qualitative term most concerned with the proper design of a sampling program. Factors that affect the representativeness of analytical data include proper preservation, holding times, use of standard sampling and analytical methods, and determination of matrix or isotope interferences. Sample preservation, analytical methodologies, and soil sampling methodologies were documented to be adequate and consistently applied.

Comparability, like representativeness, is a qualitative term relative to a project data set as an individual. These investigations employed appropriate sampling methodologies, site surveillance, use of standard sampling devices, uniform training, documentation of sampling, standard analytical protocols/procedures, QC checks with standard control limits, and universally accepted data reporting units to ensure comparability to other data sets. Through the proper implementation and documentation of these standard practices, the project has established the confidence that the data will be comparable to other project and programmatic information.

Tables D-6 and D-7 present field duplicate and laboratory duplicate results used in comparison with associated parent sample results for Americium-241, respectively.

Table D-6. Americium-241 Results for Parent Samples and Associated Field Duplicate Samples

Sample Name	Americium-241			
	Result (pCi/g)	Error (pCi/g)	Detection Limit (pCi/g)	Validation Qualifier
SEMO-140	0.085	0.13	0.20	UJ
SEMO-140-1	0.0946	0.09	0.15	UJ
SEMO-147	0.0545	0.17	0.29	UJ
SEMO-147-1	0.1178	0.06	0.09	UJ
SEMO-161	0.0432	0.05	0.09	UJ
SEMO-161-1	-0.0214	0.10	0.17	UJ
SEMO-170	0.0753	0.06	0.10	UJ
SEMO-170-1	-0.0206	0.16	0.29	UJ
SEMO-180	-0.0136	0.10	0.16	UJ
SEMO-180-1	0.04	0.17	0.27	UJ
SEMO-198	0.22	0.13	0.16	=
SEMO-198-1	0.212	0.17	0.31	U
SEMO-201	0.07196	0.08	0.07	UJ
SEMO-201-1	-0.0949	0.19	0.32	U
SEMO-206	0.032	0.05	0.09	U
SEMO-206-1	0.0172	0.17	0.31	U
SEMO-211	0.114	0.09	0.16	UJ
SEMO-211-1	0.3063	0.21	0.17	UJ
SEMO-237	0.0693	0.10	0.18	UJ
SEMO-237-1	0.0414	0.04	0.07	UJ

Table D-7. Americium-241 Results for Parent Samples and Associated Laboratory Duplicate Samples

Sample Name	Americium-241			
	Result (pCi/g)	Error (pCi/g)	Detection Limit (pCi/g)	Validation Qualifier
SEMO-100	0.216	0.16	0.14	J
SEMO-100D	0.0885	0.16	0.28	U
SEMO-115	1.38	0.27	0.17	=
SEMO-115D	1.42	0.19	0.14	=
SEMO-117	0.277	0.17	0.19	J
SEMO-117D	0.358	0.20	0.37	UJ
SEMO-137	-0.0134	0.04	0.06	UJ
SEMO-137D	0.0733	0.10	0.17	U
SEMO-155	0.0101	0.05	0.08	UJ
SEMO-155D	0.0655	0.13	0.22	UJ
SEMO-173	0.0645	0.16	0.27	UJ
SEMO-173D	-0.181	0.21	0.33	UJ
SEMO-192	-0.0515	0.19	0.30	U
SEMO-192D	-0.0784	0.15	0.26	U
SEMO-209	-0.00324	0.18	0.30	UJ
SEMO-209D	0.117	0.23	0.38	U
SEMO-228	0.105	0.09	0.16	UJ
SEMO-228D	-0.0226	0.15	0.26	U
SEMO-R1	-3.69	7.89	11.5	UJ
SEMO-R1D	3.43	10.4	15.6	U
SEMO-237	0.0693	0.10	0.18	UJ
SEMO-237D	0.0899	0.06	0.09	U
SEMO-256	5.22	0.45	0.19	=
SEMO-256D	5.25	0.53	0.18	=

COMPLETENESS

Acceptable results are defined as those data, which pass individual scrutiny during the verification and validation process and are accepted for unrestricted use. The data quality objective of achieving 90 percent completeness was satisfied with the project producing valid results for 100 percent of the sample analyses performed and successfully collected.

A total of 155 soil samples, were collected with approximately 155 discrete analyses being obtained, reviewed, and integrated into the assessment. The project produced acceptable results for 100 percent of the sample analyses performed.

DATA QUALITY ASSESSMENT SUMMARY

The overall quality of this data meets or exceeds the established project objectives. Through proper implementation of the project data verification, validation, and assessment process, project information has been determined to be acceptable for use.

Sample data, as presented, have been qualified as usable, but estimated when necessary. Data that have been estimated have concentrations/activities that are below the quantitation limit or are indicative of accuracy, precision, or sensitivity being less than desired but adequate for interpretation. Comparisons that have exceeded the requirements have bolded type in associated tables. There are numerous possibilities for these anomalies:

- Dilution of a sample due to high analyte concentration(s) that exceed analytical calibration(s);
- Excessive dilution for sample turbidity or other matrix issues that was deemed necessary for a laboratory analysis;
- Incomplete sample homogenization, either at the laboratory or during the field sampling;
- Matrix interferences within the sample itself that caused inadequate analytical quantitation;
- Different preparation methods for associated split samples at different laboratories;
- Different analytical methods for associated split samples at different laboratories; and
- Concentration of an analyte being below the calibration range, or near the method detection limit for that analyte; etc.

Further analysis of the data can display trends or even randomness within the data set that could be explained with one or more of the above mentioned contributors to anomalies. For instance, a single duplicate pair for which the RPD was not met for americium-241, could be an indicator of incomplete homogenization in the field, matrix effects in the sample, concentration, or analyte concentrations approaching the method detection limit. Precision and/or accuracy anomalies occurring for some analytes, but not for others, could be the results of a simple matrix effect causing poor quantitation of a sample, or perhaps low concentrations of those analytes.

The *Department of Defense Quality Systems Manual for Environmental Laboratories* defines allowable marginal exceedances as 10 percent of the total analysis for random anomalies that occur during regular laboratory analysis. As presented in this report, there are 24 total comparisons with no exceedances, resulting in a marginal exceedance rate of zero percent. This is well within the *Department of Defense Quality Systems Manual for Environmental Laboratories* 10 percent allowance for marginal exceedances. The allowable marginal exceedance requirements for the project have been met, with over 90 percent of the data being within acceptance limits.

Data evaluated by this assessment demonstrates that it can withstand scientific scrutiny, are appropriate for its intended purpose, are technically defensible, and are of known and acceptable sensitivity, precision, and accuracy. Data integrity has been documented through proper implementation of QA/QC measures. The environmental information presented has an established confidence, which allows utilization for the project objectives and provides data for future needs.

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APPENDIX E

RESIDUAL DOSE ASSESSMENT

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RESIDUAL DOSE ASSESSMENT FOR SOUTHEAST

INTRODUCTION

The dose assessment in this appendix was conducted solely for the purpose of providing a conservative dose value for potential on site receptors.

DOSE ASSESSMENT MODEL

RESRAD Version 6.5 was used for the dose assessment for Southeast to calculate dose to the average member of the critical group potentially exposed to soil surrounding Magill Hall at Southeast. RESRAD is a computer code developed by Argonne National Laboratory under contract to Department of Energy (DOE) and NRC. RESRAD calculates site-specific dose to various future hypothetical on-site receptors at sites that are contaminated with residual radioactive materials. Dose was assessed for a 1,000-year period.

RADIOLOGICAL RECEPTOR SCENARIO

The industrial worker (i.e., university maintenance or academic employee) is the average member of the critical group at Southeast. However, for this assessment, a more conservative residential scenario is selected to account for potential future change of the university to a residential setting. Per NUREG/CR-6697 Section 2.1, "The default land use scenario in RESRAD assumes the presence of an on-site subsistence farmer with all exposure pathways active." Therefore, the dose assessment was performed for the site based on a residential exposure scenario using RESRAD default parameters.

RADIOLOGICAL EXPOSURE SCENARIO

The exposure pathways applicable to the radiological dose assessment for the receptor scenario are external gamma, soil ingestion, plant ingestion, and inhalation of particulates. Because groundwater is not a potential source of drinking water at Southeast, the drinking water pathway was not considered as a potential pathway for the site.

DETERMINATION OF RADIOLOGICAL SOURCE TERM

Radionuclide COC: Am-241 was the potential contaminant for the property assessed.

Determination of Exposure Point Concentration (EPC): Dose for Southeast was determined by developing a source term and applying that source term to the receptor scenario using RESRAD. The source term is based upon an EPC. To obtain the EPC for Am-241, the sample results for Am-241 were inserted into the EPA-designed software ProUCL (Version 4.0) to calculate the 95 percent upper confidence limit of the arithmetic mean (UCL_{95}). As the background concentration for Am-241 is zero, the UCL_{95} value calculated by ProUCL was used as the EPC. The EPC is listed in Table E-1.

Table E-1. Exposure Point Concentration for Am-241

Statistic	Am-241 (pCi/g)
Background	0.00
Maximum	1.39

Table E-1. Exposure Point Concentration for Am-241 (Continued)

Statistic	Am-241 (pCi/g)
Distribution	X
UCL-95	0.16
EPC	**0.16**

X = Non-Parametric

RADIOLOGICAL DOSE ASSESSMENT RESULTS

Table E-2 summarizes radiological dose in a 1,000-year period to a resident receptor from exposure to the residual radionuclide present at the assessed property.

Table E-2. Results of Dose Assessment for Entire Site to Resident Receptor

	Dose (mrem/yr)
Onsite Resident	2

The RESRAD results indicate that the residential receptor at Southeast received a dose of 2 mrem/yr. The dose for the receptor is below 25 mrem/yr.

SUMMARY

In summary, for Southeast, the site is deemed to be in compliance with the 25-mrem/yr unrestricted release dose limit to the average member of the critical group as established by Title 10, CFR Part 20 Section 1402, *Radiological Criteria for License Termination,* because all FSS sample results were less than the NRC Screening Values found in Table H.2 of NUREG 1757. Additionally, a dose assessment for an average member of the critical group resulting in a dose of 2 mrem/yr validates the screening value comparison. Based on the results of this dose assessment, it can be concluded that dose from residual contamination in soil surrounding Magill Hall at Southeast is protective for all current and future potential receptor scenarios is ALARA, and the site can be released for use without any land use restrictions.

EPC calculations (including ProUCL output files) and RESRAD output files for the modeled scenario are attached (Attachment E-1 and Attachment E-2).

ATTACHMENT E-1

EPC CALCULATIONS (PRO-UCL OUTPUT FILES)

(On CD-ROM on the Back Cover of this Report)

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ATTACHMENT E-2

RESRAD OUTPUT SUMMARY REPORTS

(On CD-ROM on the Back Cover of this Report)

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APPENDIX F

SIGN TESTS

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Table F.1 Sign Test: SU-1

Data (pCi/g)	$DCGL_W$-Data (pCi/g)	Sign
0.216	1.884	1
0.122	1.978	1
0.174	1.926	1
0.146	1.954	1
0.37	1.73	1
0.521	1.579	1
0.936	1.164	1
0.0693	2.0307	1
0.986	1.114	1
0.299	1.801	1
0	2.1	1
Number of + differences S+		11

Null Hypothesis

H_0 = Survey Unit exceeds the release criterion

n= 11

Critical Value (NUREG-1505, Table I.3) = *5*

α = 0.05

Number of + differences S+ = 11

Null hypotheses accepted or rejected? **Rejected**

Does survey unit meet release criterion? ***Yes***

Table F.2 Sign Test: SU-2

Data (pCi/g)*	$DCGL_W$-Data (pCi/g)	Sign
0.04	2.1	1
0.24	1.9	1
0.03	2.1	1
0.07	2.0	1
-0.01	2.1	1
0.05	2.1	1
0.09	2.0	1
0.08	2.0	1
-0.03	2.1	1
0.05	2.0	1
0.06	2.0	1
-0.07	2.2	1
0.08	2.0	1
0.01	2.1	1
-0.13	2.2	1
0.04	2.1	1
0.04	2.1	1
0.00	2.1	1
0.03	2.1	1
-0.03	2.1	1
0.01	2.1	1
0.02	2.1	1
0.06	2.0	1
0.02	2.1	1
0.13	2.0	1
-0.03	2.1	1
0.19	1.9	1
0.13	2.0	1
0.09	2.0	1
0.00	2.1	1
0.04	2.1	1
0.06	2.0	1

Null Hypothesis

H_0 = Survey Unit exceeds the release criterion

n= 54

Critical Value (NUREG-1505, Table I.3) = *33*

α = 0.05

Number of + differences S+ = 54

Null hypotheses accepted or rejected? **Rejected**

Does survey unit meet release criterion? ***Yes***

Table F.2 Sign Test: SU-2

Data (pCi/g)*	$DCGL_W$-Data (pCi/g)	Sign
0.02	2.1	1
0.15	2.0	1
-0.13	2.2	1
0.03	2.1	1
0.00	2.1	1
0.25	1.8	1
0.17	1.9	1
0.00	2.1	1
0.00	2.1	1
0.11	2.0	1
0.15	1.9	1
0.10	2.0	1
0.04	2.1	1
0.04	2.1	1
0.13	2.0	1
-0.17	2.3	1
-0.04	2.1	1
0.08	2.0	1
0.08	2.0	1
0.10	2.0	1
-0.03	2.1	1
0.08	2.0	1
Number of + differences S+		54

* Negative results occur when the measured value is less that of than the laboratory blank or background due to random effects or measurement limitations. Negative radioactivity is physically impossible but the inclusions of these results allows for better statistical analysis.

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APPENDIX G

ELEVATED MEASUREMENT COMPARISON

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Table G-1. Data for the Elevated Measurement Comparison

Sample Name	Easting	Northing	Result	MDC	Depth	Type
SEMO-237	1102450.15	541045.63	0.07	0.18	0.5-1.0	Systematic
SEMO-238	1102455.15	541045.63	0.99	0.29	0.5-1.0	Systematic
SEMO-241	1102452.65	541040.63	0.30	0.43	0.5-1.0	Systematic
SEMO-240	1102457.65	541040.63	0.00	0.11	0.5-1.0	Systematic
SEMO-116	1102449.68	541042.90	0.00	0.15	0.5-1.0	Biased
SEMO-239	1102456.66	541042.56	0.20	0.12	0.5-1.0	Biased
SEMO-117	1102449.52	541041.46	0.28	0.19	0.0-0.5	Bounding
SEMO-119	1102448.81	541043.84	0.63	0.06	0.0-0.5	Bounding
SEMO-120	1102453.30	541037.97	1.39	0.32	0.0-0.5	Bounding
SEMO-242	1102451	541045.6	0.59	0.07	0.0-0.5	Bounding
SEMO-243	1102450	541046.7	0.39	0.11	0.0-0.5	Bounding
SEMO-244	1102449	541045.6	6.87	0.26	0.0-0.5	Bounding
SEMO-245	1102453	541045.7	7.13	0.17	0.0-0.5	Bounding
SEMO-246	1102456	541045.6	14.50	0.49	0.0-0.5	Bounding
SEMO-247	1102459	541045.5	2.84	0.08	0.0-0.5	Bounding
SEMO-248	1102455	541044.6	4.55	0.12	0.0-0.5	Bounding
SEMO-249	1102455.3	541042.7	3.54	0.12	0.0-0.5	Bounding
SEMO-250	1102452	541039.8	3.14	0.28	0.0-0.5	Bounding
SEMO-251	1102457.7	541042.6	7.96	0.25	0.0-0.5	Bounding
SEMO-252	1102459	541042.5	5.91	0.17	0.0-0.5	Bounding
SEMO-253	1102456	541043.6	3.73	0.41	0.0-0.5	Bounding
SEMO-254	1102458	541044.6	11.30	0.30	0.0-0.5	Bounding
SEMO-255	1102456.6	541040.6	2.93	0.19	0.0-0.5	Bounding
SEMO-256	1102457	541041.6	5.22	0.19	0.0-0.5	Bounding
SEMO-257	1102453	541040.6	1.08	0.16	0.0-0.5	Bounding
SEMO-258	1102451	541040.9	1.62	0.17	0.0-0.5	Bounding
SEMO-259	1102452	541021.5	6.52	0.35	0.0-0.5	Bounding
SEMO-260	1102454	541045.7	12.60	0.31	0.0-0.5	Bounding
SEMO-261	1102449	541042.1	1.66	0.08	0.0-0.5	Bounding

Average	3.72
Average of Elevated Samples	6.58

The area for evaluation by Elevated Measurement Comparison (EMC) is $7m^2$.

Since we have no area factor for $7m^2$ we have to use the next most conservative area factor ($24\ m^2$, area factor of 15).

The $DCGL_{EMC}$ for this area is 2.1 x 15 = 31.5 pCi/g

The average Am-241 result in the $7m^2$ area is 3.72 pCi/g.

This area meets the $DCGL_{EMC}$.

In addition to evaluating all the data within the area of elevated activity (the $7\ m^2$ area), just the data with a result greater that the $DCGL_w$ were evaluated as a conservative measure. In this case the average Am-241 is 6.58, which also meets the $DCGL_{EMC}$.

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