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Field Summary Report for Technical Area - 21 Site Surveys

April 2005

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Introduction

This Field Summary Report presents the objectives, methods, and results from the September through December 2004 site-wide geophysical and radiological surveys of the mesa top areas at and around Technical Area (TA)-21.

The purpose of the surveys was to provide walkover geophysical and radiological surveys in search of buried structures and waste. This will support the development of specific plans for characterization and remediation efforts at TA-21. The areas surveyed are shown on Figure 1.

Preparation Activities

Readiness Review

In preparation for the fieldwork, a Field Implementation Plan, Site Specific Health and Safety Plan, and Integrated Work Documents were prepared. Following review and approval of these documents, a readiness review was completed in September 2004.

Aerial Photograph Review

Aerial photographs were retrieved from the Records Processing Facility archive and examined to ensure that past land uses in the study areas were reviewed to the extent possible. A total of 33 aerial photographs (Appendix A), taken from as early as 1946 and as recently as 1991, were examined. Disturbed areas that may indicate disposal sites or undocumented process areas were identified and compared to the known Solid Waste Management Units (SWMUs) at TA-21. All of the suspect areas identified in the aerial photographs were either documented SWMUs or areas of known activities. No additional disposal areas requiring investigation were identified in this review.

Field Activities

Mobilization to TA-21 was conducted in September 2004. Radiological daily response checks were performed in building 21-150. Geophysical instrument daily checks were performed in an undisturbed area north of the perimeter road near the east gate of TA-21. These areas were used throughout the duration of the surveys to ensure consistency of the data collection.

Site Walks

Following mobilization to the site, reconnaissance walks of the undeveloped areas to the east and west of TA-21 verified the findings of the aerial photograph review. Site walks east of TA-21 began at the east fence line of the Tritium System Test Assembly (TSTA) and continued to the end of DP mesa. No evidence suggesting unknown past development or waste handling/disposal activities was observed. Undocumented disposal pits are unlikely east of the TSTA facility since much of the mesa top in the area is either exposed bedrock or has very thin surface soils.

Reconnaissance walks of the areas to the west of MDA B identified remaining structures associated with the historic use of the land as a trailer park but no evidence of waste handling/disposal activities. This was expected, since the area was previously characterized by LANL and proposed for land transfer.

Additional site walks were performed to identify any safety concerns in the areas to be surveyed. Of particular interest was the access to the topographic bench along the north wall of Los Alamos canyon. These walks identified two access points for the bench surveys.

Geophysical Surveys

Geophysical surveys were performed by ARM Group, Inc. The surveys were conducted to document geophysical conditions throughout the area, investigate and accurately define the locations of structures associated with known SWMUs and AOCs at TA-21, and verify locations of underground utility corridors within TA-21. Site-wide reconnaissance surveys were conducted throughout TA-21 and the areas to the east and west using EM31 and EM61 instruments. Approximately 70 acres of the DP mesa top were surveyed. Figures 2 and 3 show the survey areas for the two methods. Specific interpretations of the data collected are presented in Appendix B.

Focused surveys were conducted using ground penetrating radar (GPR) and a pipe locator to verify the locations of former structures associated with documented SWMUs. Table 1 lists the specific SWMUs and associated structures that were targeted in the focused surveys.

EM31/EM61 Surveys

EM61 and the EM31 instruments were used for the initial site-wide reconnaissance surveys. The purpose of these surveys was to identify geophysical anomalies that might indicate past waste disposal activities that would require further investigation. The EM61 instrument is a high-sensitivity metal detector used to locate buried metallic objects such as pipes and tanks. The EM31 method uses the principle of electromagnetic induction to measure changes in terrain conductivity to identify disturbed ground, disposal areas, and buried waste. The EM31 and EM61 survey instruments were interfaced with a global positioning satellite (GPS) unit for location identification of the collected data.

GPR Surveys of SWMU Targets

ARM employed a digital SIR-2 ground penetrating radar (GPR) system to verify the locations of buried structures associated with known SWMUs and to further evaluate EM31 and EM61 anomalies. Over 300 GPR survey lines were collected and reviewed as part of the effort to locate specific buried structures. The GPR system uses the transmission and reflection of radio waves to image objects beneath the ground surface.

Pipe Locator Surveys

Sites with metal pipes with approximate locations that could be determined from EM31 or EM61 data, historical drawings, or that were exposed at the surface were investigated using the pipe locator unit. The unit was used extensively north of the TA-21 process buildings to locate the utility corridor in the area and again as part of the effort to define the location of the remaining sections of the buried former radioactive liquid waste line.

Radiological Surveys

Reconnaissance level radiological surveys were conducted over much of the same area as the EM31 and EM61 geophysical surveys. Sodium iodide (NaI) and FIDLER (field instrument for the detection of low energy radiation) detectors interfaced with GPS units were used to collect count rate data from the DP mesa top and the geologic bench along the north wall of Los Alamos canyon. The purpose of these surveys was to document general surface radiological conditions throughout the area, to identify areas of elevated count rates requiring further investigation, and to collect count rate data in the areas of specific SWMUs. A detailed write-up of the results of the radiological surveys is presented in Appendix C.

NaI Surveys

NaI detectors target high-energy radiation as emitted by Cs-137. Initial NaI survey transects were spaced 5 ft apart with a walking pace of 2.5 ft per second throughout the entire mesa top study area. Following review of the collected data, focused surveys were conducted on anomalies at a walking pace of 1 ft per second, which increased the density of the data collection.

FIDLER Surveys

The second survey used FIDLER detectors with the same configuration and deployment techniques used in NaI surveys. The FIDLER detector was chosen for its ability to detect the low energy radiation that is associated with many of the radionuclides commonly present in historic TA-21 processes.

Gamma Spectrometry Insitu Screening of Hot Spots

The third phase of radiological investigations involved a field gamma spectrometry survey of the 11 locations that produced elevated count rates compared to background during the NaI and FIDLER surveys. The energy peaks in the spectra identify the specific radionuclide(s) producing the anomaly.

Results

Geophysical Survey Results

The geophysical survey report produced by ARM (Appendix B) present graphical results of the data along with interpretive figures showing SWMU locations and identified targets such as septic tanks and pipelines. The geophysical coverage maps illustrate that the east and west ends of the study area were free of underground structures of concern with regard to site decommissioning, demolition, and remediation. The maps also highlight the fact that the south side of the industrial area and the area on the north side of TSTA contain the greatest density of structures associated with historic operations at TA-21.

In total, 74 buried structures were targeted for focused geophysical surveys. Of these, 49 of the structures were at least in part located during the focused surveys and the locations were surveyed with a GPS. Each of the buried structures that was located is plotted on the maps presented in Appendix B, which also lists survey coordinates for the structures.

Radiological Survey Results

The radiological report produced by ERG presents the site-wide survey data maps generated from the initial surveys. The overall conclusion of the initial surveys is that the TA-21 surface study area exhibits activity less than twice that of established background values. The fenced industrialized portions of TA-21, where imported fill materials and extensive paving are present, showed reduced count rates from the areas surveyed to the south where native geologic materials are present at the surface.

The radiological count rate data included the areas of all target SWMUs in the geophysical surveys. None of the radiological data identified elevated count rates associated with any specific SWMU targets. The surveys did identify eleven radiological anomalies that were found to be of very limited surface extent (point sources) and not representative of a large-scale surface release.

The eleven locations where the count rate data were elevated compared to the local conditions were investigated further with the gamma spectroscopy instrument. The spectra collected identified Am-241, U-235, Pa-234, Cs-137, and Th-232 as the principal radionuclides contributing to the anomalies. The results of the gamma spectrometer screening are presented in detail in the ERG radiological survey report (Appendix C).

Acronyms

AOC	area of concern
CMP	corrugated metal pipe
ER	Environmental Restoration
ERDB	Environmental Restoration Data Base
GPR	ground penetrating radar
LANL	Los Alamos National Laboratory
MDA	Material Disposal Area
SWMU	solid waste management unit
TA	Technical Area
TSTA	Tritium System Test Assembly

Figures

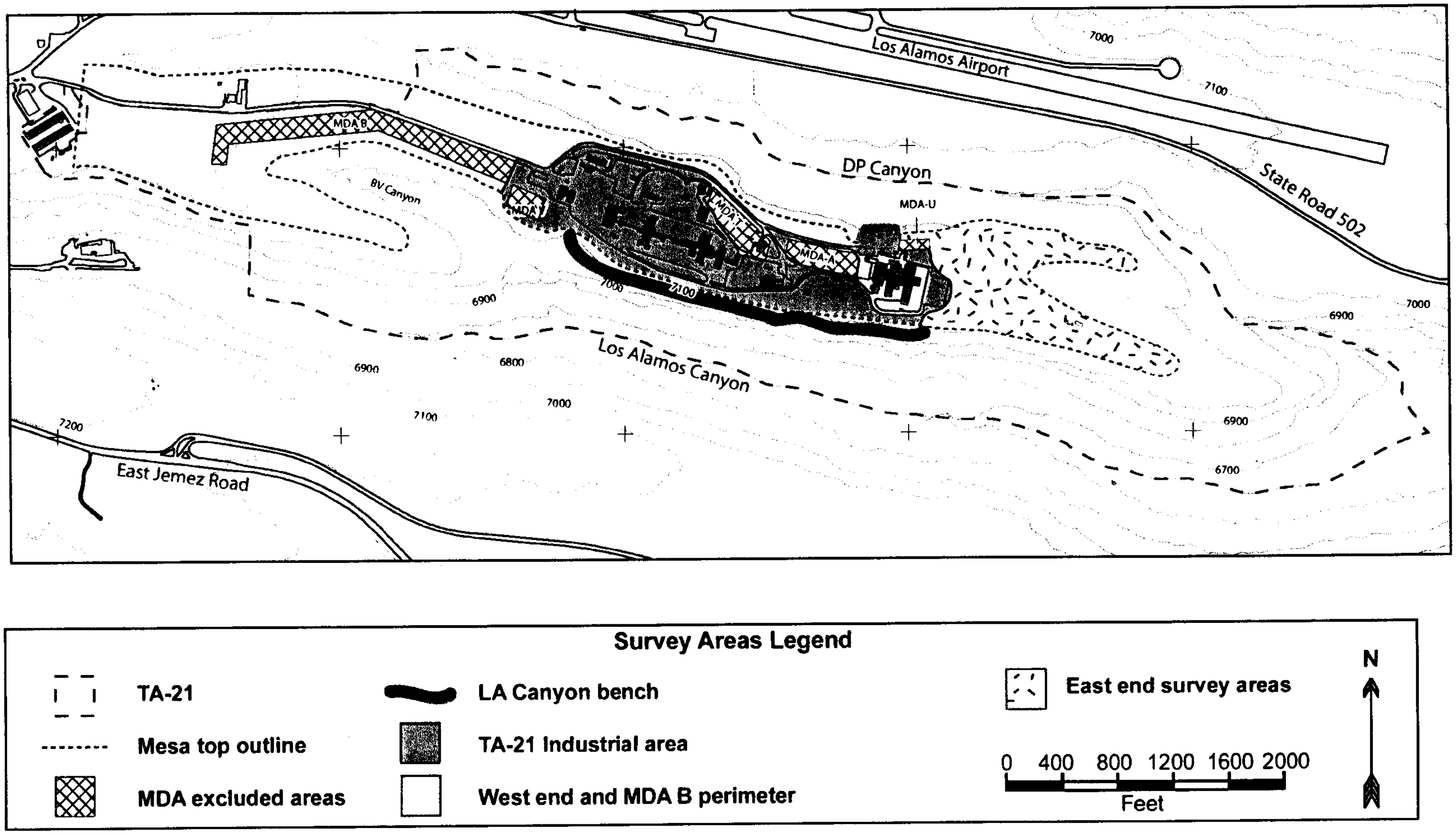


Figure 1 View of the Geophysical and Radiological Survey Areas

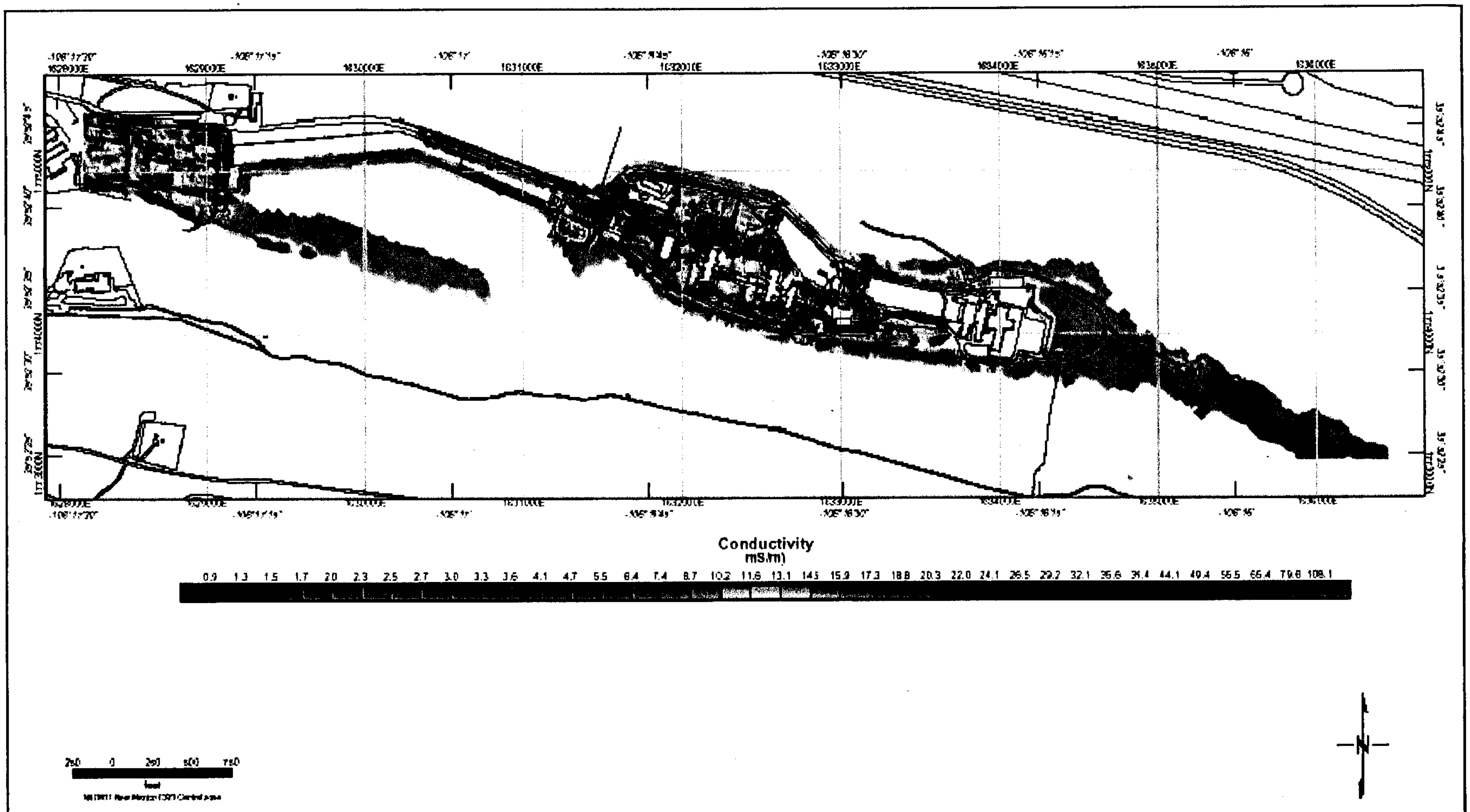


Figure 2 **Results of EM31 Geophysical Survey**

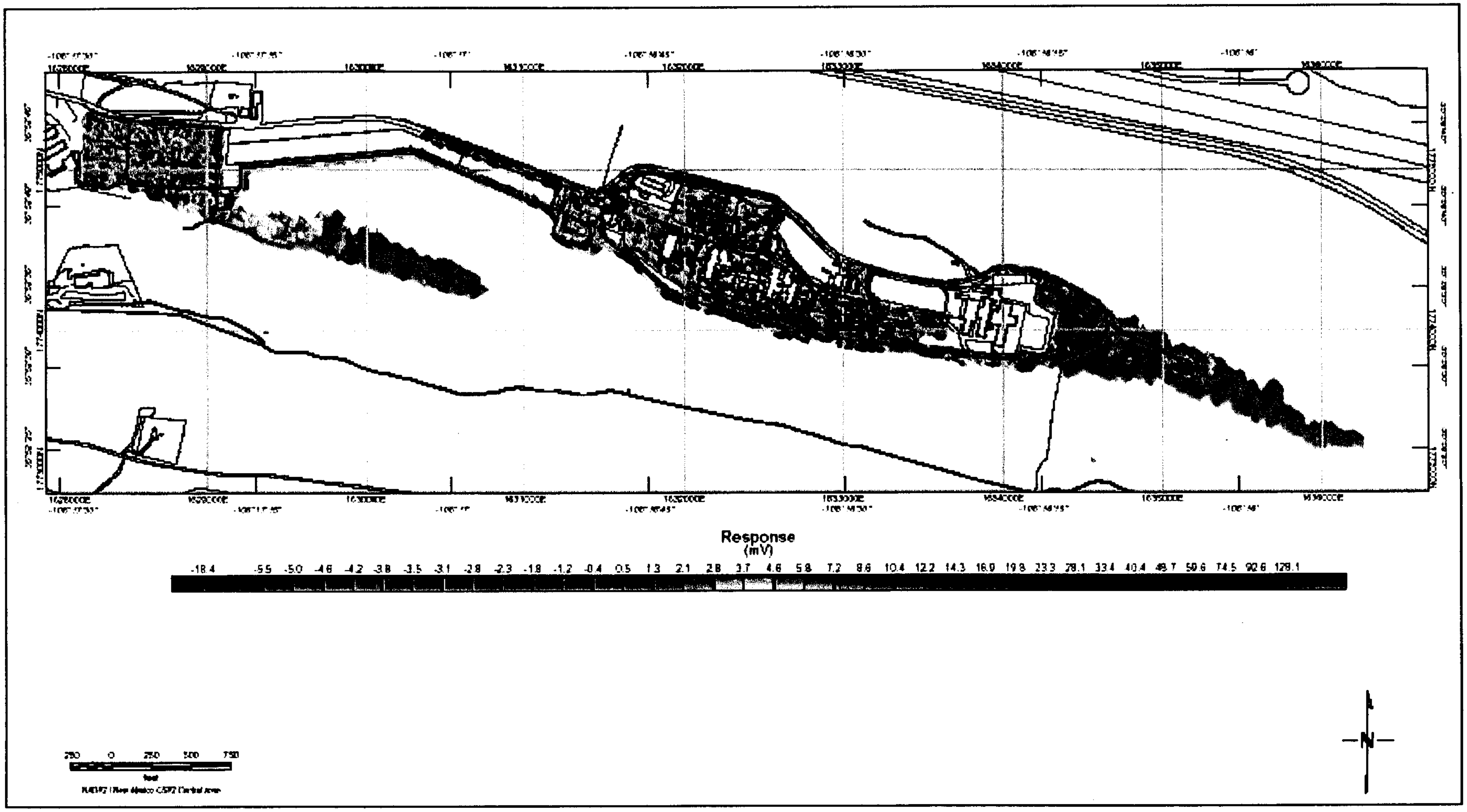


Figure 3 Results of EM61 Geophysical Surveys

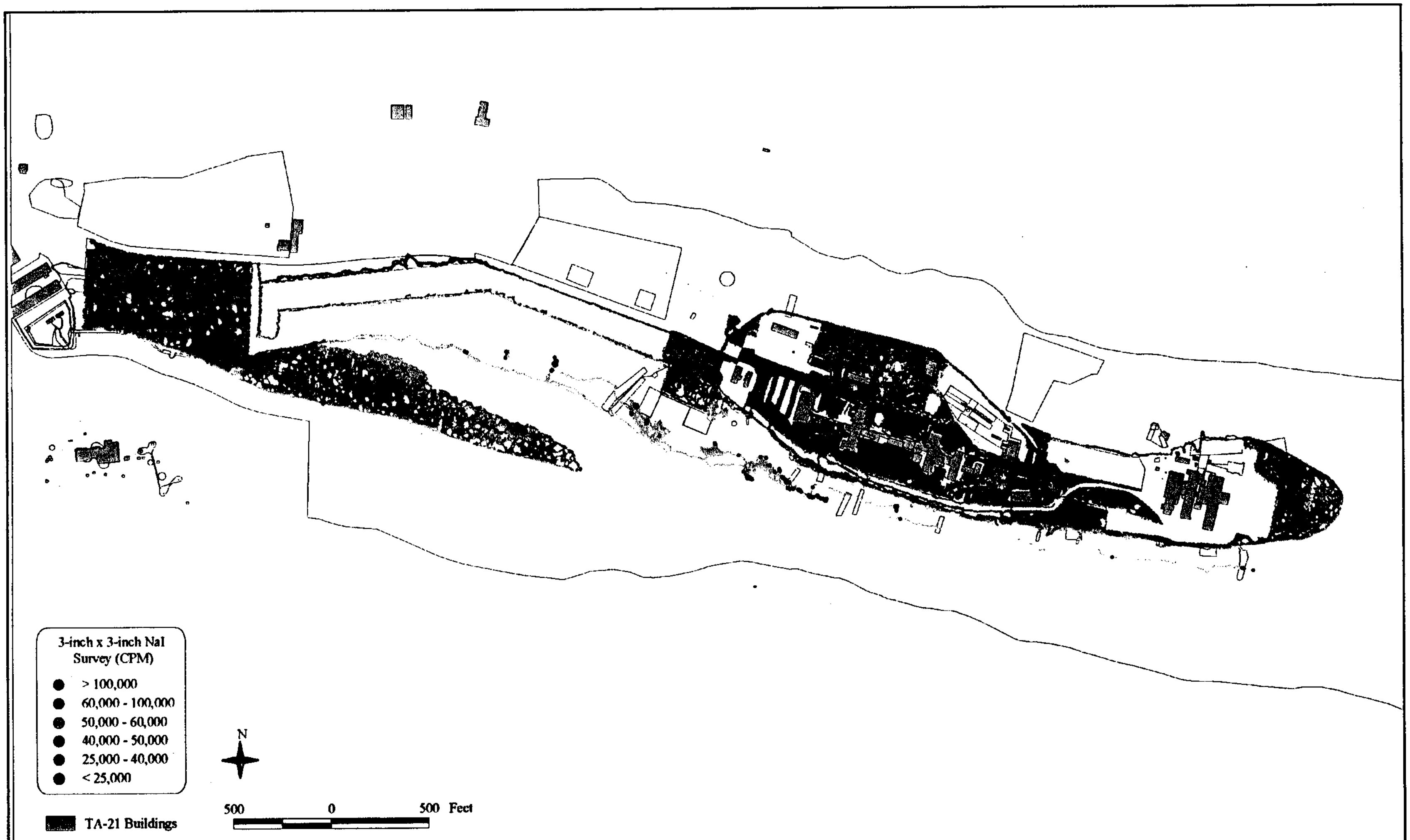


Figure 4 **3x3 NaI Map**

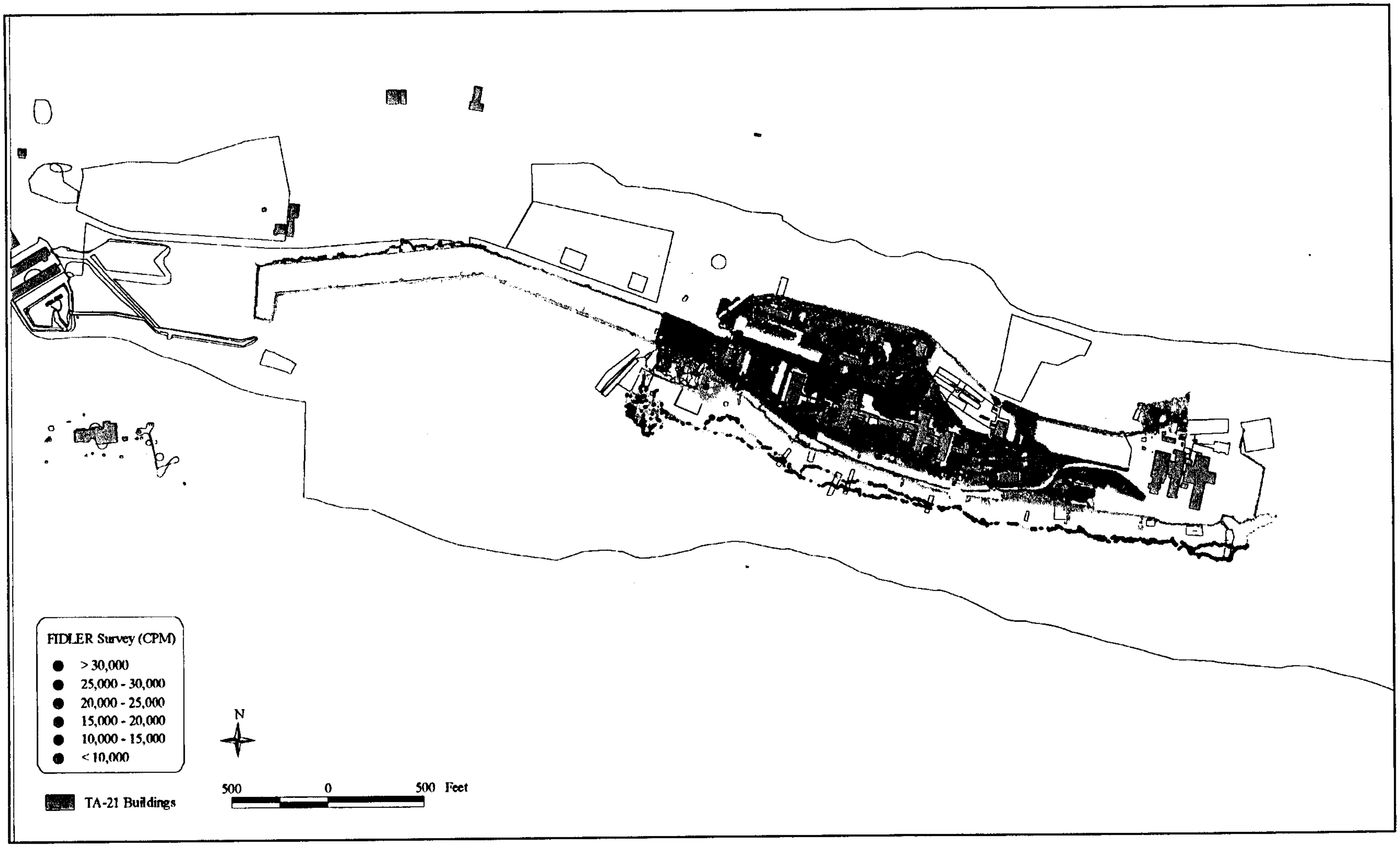


Figure 5 FIDLER Survey Map

Tables

Table 1 Information on the Focused Geophysical Survey Conducted on Selected Solid Waste Management Units (SWMUs) at TA-21

SWMU	Objectives	Results of Field Investigations
21-006 (a)	1. Locate seepage pit between bldg. 21-02 and removed bldg. 21-03	• No evidence found
21-006(b)	1. Locate seepage pit 2. Locate any associated pipelines	• Located • Located one inlet line and one outlet line
21-006 (c)	1. Locate seepage pit between bldg. 21-02 and removed bldg. 21-03	• No evidence found
21-006 (d)	1. Locate seepage pit between bldg. 2. 21-02 and removed bldg. 21-03	• No evidence found
21-009	1. Locate footprint of bldg.21-33 2. Locate any pipelines within the footprint of bldg. 21-33 3. Locate 1-in. diameter gas line that exits bldg. 21-33 and trends south	• Located • Located acid waste line • ~30 ft section of twisted 1-in. steel pipe found in trees west of MDA V
21-012 (b)	1. Locate pits 21-266 and 21-267 2. Locate inlet lines from bldg. 21-09 to pits 266 and 267, and the outlet lines to the blow down tank 3. Locate seepage pit and dry well just south of the blow down tank 4. Locate 6-in. steel and/or VCP pipe that runs south from pits 266 and 267 to the mesa edge	• No evidence found, new steam lines are located here • No evidence found • Possible anomalous evidence • Located from the mesa edge to the trench for steam lines to the new steam plant 21-357 ~20 ft to the south of bldg. 21-357
21-022 (a)	1. Locate sump 21-74 2. Locate inlet line from bldg. 21-21 to sump 21-74 3. Locate line(s) east of sump to bldg.	• Located • Located • No evidence found
21-022 (f)	1. Locate sump 21-173 2. Locate manhole 21-221 3. Locate 6-in. steel pipeline between sump 21-173 and MDA U	• Located • Located • No evidence found
21-022 (h)	1. Locate sump 2. Locate 6-in. pipeline to outfall	• Located • Located
21-022 (i)	1. Locate sump 2. Locate any pipelines from sump	• No evidence found • Possible excavation evidence
21-022 (j)	1. Locate sump 2. Locate any pipelines from sump	• Located in 4 ft x 4 ft fenced area marked "Radiation Control Area" • Possible excavation evidence, pipeline observed above ground near sump
21-024 (a)	1. Locate septic tank 21-53 2. Locate pipeline from bldg. 21-09 to tank 21-53 3. Locate pipeline from tank 21-53 to outfall	• Located • Located from tank to the trench for steam lines to the new steam plant 21-357 ~20 ft to the south of bldg. 21-09 • Located
21-024 (b)	1. Locate septic tank 21-55 2. Locate pipeline from between buildings. 21-04 and 21-05 to tank 21-55 3. Locate pipeline from tank 21-55 to outfall	• Located • Located • Located

Table 1 Information on the Focused Geophysical Survey Conducted on Selected Solid Waste Management Units (SWMUs) at TA-2 (continued)

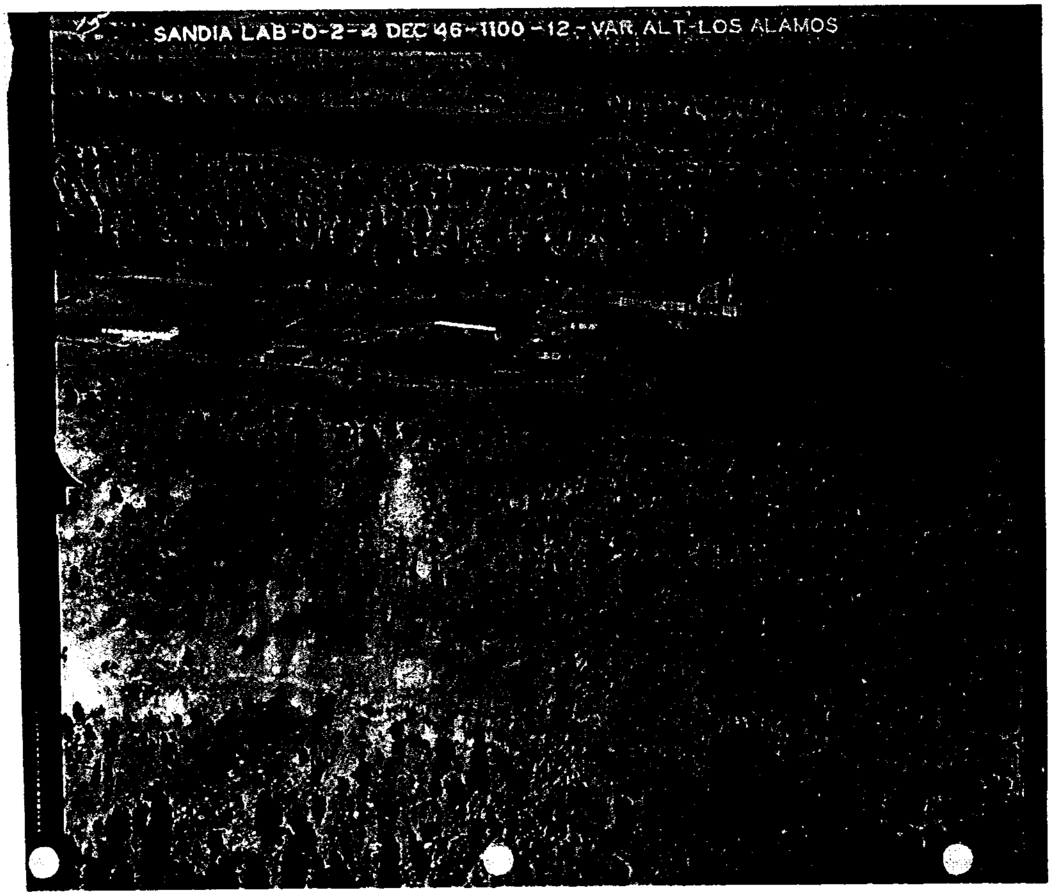
SWMU	Objectives	Results of Field Investigations
21-024 (c)	1. Locate septic tank 21-56 2. Locate pipeline from bldg. 21-54 to tank 21-56 3. Locate pipeline from tank 21-56 to outfall 4. Locate pipeline from bldg. 21-61 east to pipeline from bldg 21-54 5. Locate any pipeline extension to the east of intersection w/ bldg. 21-54 pipe	• Located • Located • Located • Located • No evidence found
21-024 (d)	1. Locate septic tank 21-106 2. Locate main pipeline from bldg. 21-01 to tank 21-106 3. Locate pipeline from tank 21-106 to outfall 4. Locate diagonal 6-in. VCP line from bldg. 21-01 to main pipeline 5. Locate any pipes that exit south from boiler room that intersect main pipeline	• Located • Possible evidence within numerous anomalies • Located • Possible evidence within numerous anomalies • Possible evidence within numerous anomalies
21-024 (e)	1. Locate septic tank 21-123 2. Locate pipeline from bldg. 21-20 to tank 21-123 3. Locate pipeline from tank 21-123 to outfall	• Located • Located between tank 21-123 up to NE corner of MDA V fence • No evidence found
21-024 (g)	1. Locate pipeline from bldg. 21-07 to 21-31 2. Locate pipeline from bldg. 21-31 to septic tank 21-125 3. Locate septic tank 21-125 4. Locate pipeline from septic tank to leach field 5. Locate pipeline from leach field to outfall	• Located • Located; truncated ~5 ft from south side of bldg. 21-31 • Located • No evidence found • No evidence found
21-024 (h)	1. Locate pipeline from bldg. 21-151 to septic tank 21-163 2. Locate pipeline from bldg. 21-152 to septic tank 21-163 3. Locate septic tank 21-163 4. Locate pipeline from septic tank to outfall	• Located • Located • Located • No evidence found
21-024 (i)	1. Locate pipeline from TSTA bldg. to chain link fence	• Located
21-024 (j)	1. Locate pipeline from bldg. 21-155 to septic tank 21-194 2. Locate septic tank 21-194 3. Locate pipeline from septic tank to outfall	• Located from southwest corner of bldg. 21-155 to south DP Road • No evidence of pipeline under road or of septic tank • Located from under the steam lines out to the south edge of mesa

Table 1 Information on the Focused Geophysical Survey Conducted on Selected Solid Waste Management Units (SWMUs) at TA-2 (continued)

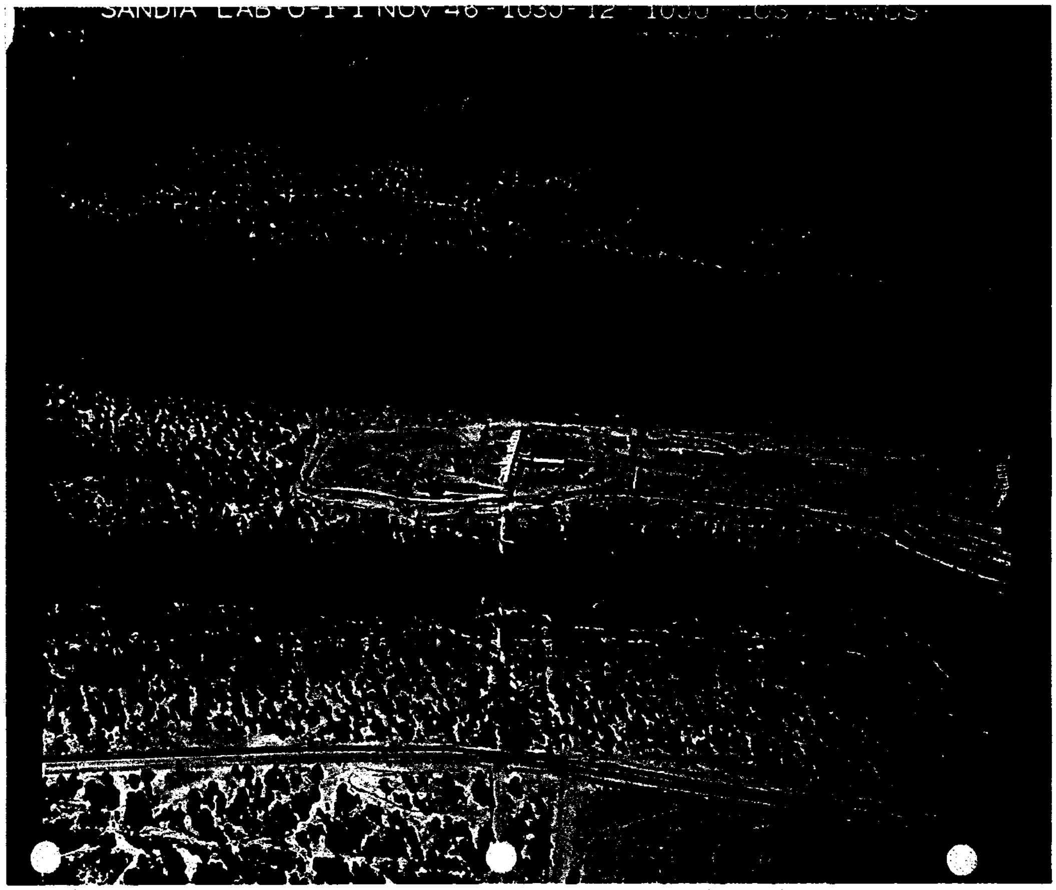
SWMU	Objectives	Results of Field Investigations
21-024 (k)	1. Locate pipeline from bldg. 21-209 to manhole 21-217 2. Locate manhole 21-217 3. Locate pipeline to manhole 21-218 4. Locate manhole 21-218 5. Locate pipeline from manhole 21-218 to septic tank 21-219 6. Locate septic tank 21-219 7. Locate pipeline from septic tank to tile field 8. Locate tile field 9. Locate both pipelines from tile field to outfall	• Located • Located • Located • Located • Located; with pieces visible at surface • Located; visible at surface • Located; with possible anomaly of distribution box • Located • East end of pipe daylights at mesa edge
21-024 (l)	1. Locate pipeline from bldg. 21-20 south to outfall	• Located
21-024 (n)	1. Locate pipeline from bldg. 21-155 to outfall	• Located; also located CS pipe from lot drain out to DP Road and steel pipe from bldg. 21-152, out along the east side of bldg. 21-213 to outfall pipe in concrete just south of North Perimeter Road
21-024 (o)	1. Locate pipeline from bldg. 21-46 south to outfall 2. Locate pipeline from bldg. 21-14 to septic tank 21-123 3. Locate pipeline from bldg. 21-14 to grease trap 4. Locate grease trap on south side of bldg. 21-14 5. Locate any pipelines that connect from above ground diesel tank to bldgs. or pipelines 6. Locate any lines from the clean oil tank next to diesel tank 7. Locate valve box between diesel tank and oil tank	• No evidence found • Only from septic tank 21-123 north to fence • No evidence found • No evidence found • No evidence found • No evidence found • No evidence found
21-027 (a)	1. Locate pipelines under paved area south of bldg. 21-03	• Located
21-027 (c)	1. Locate pipeline from bldg. 21-03 south to possible surface exposure	• Located out to south side of DP Road; no exposure

Appendix A

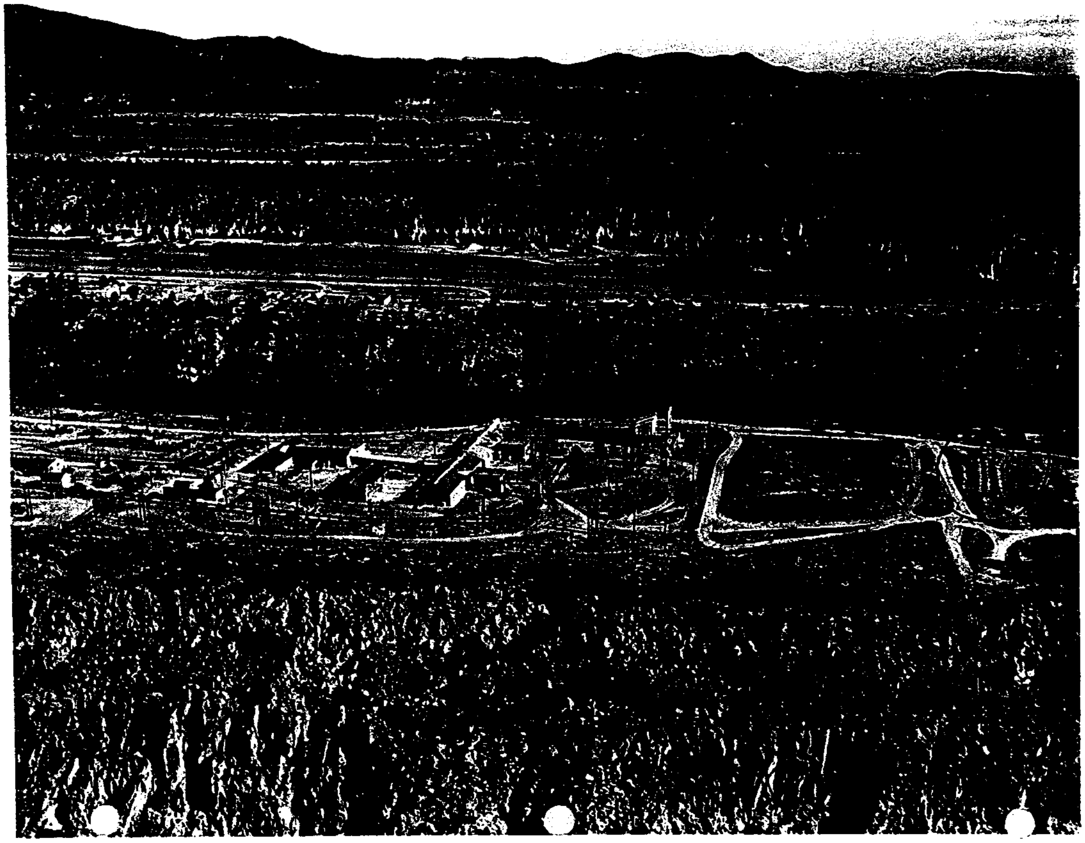
Aerial Photographs



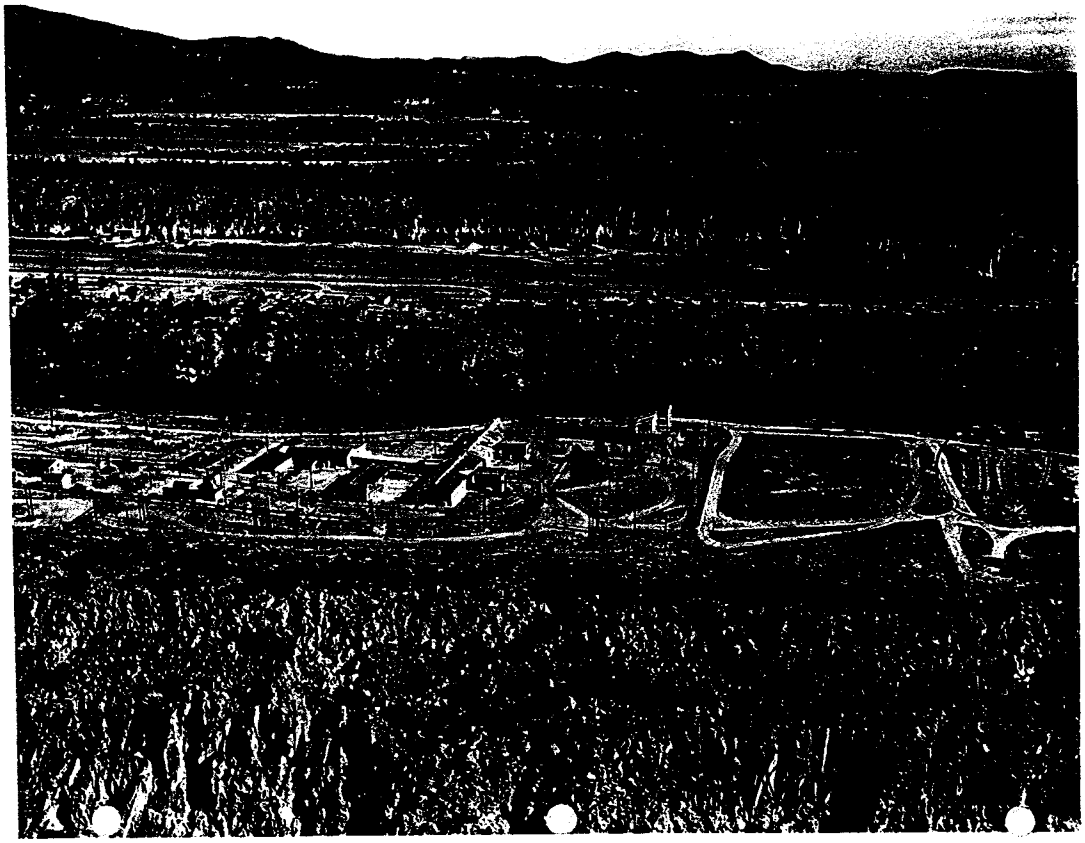
Photograph 1 View Looking North at the Eastern Portion of TA-21, December 1946 (ERID0015426)



Photograph 2 View Looking South at the East End of TA-21, November 1946 (ERID 0015427)

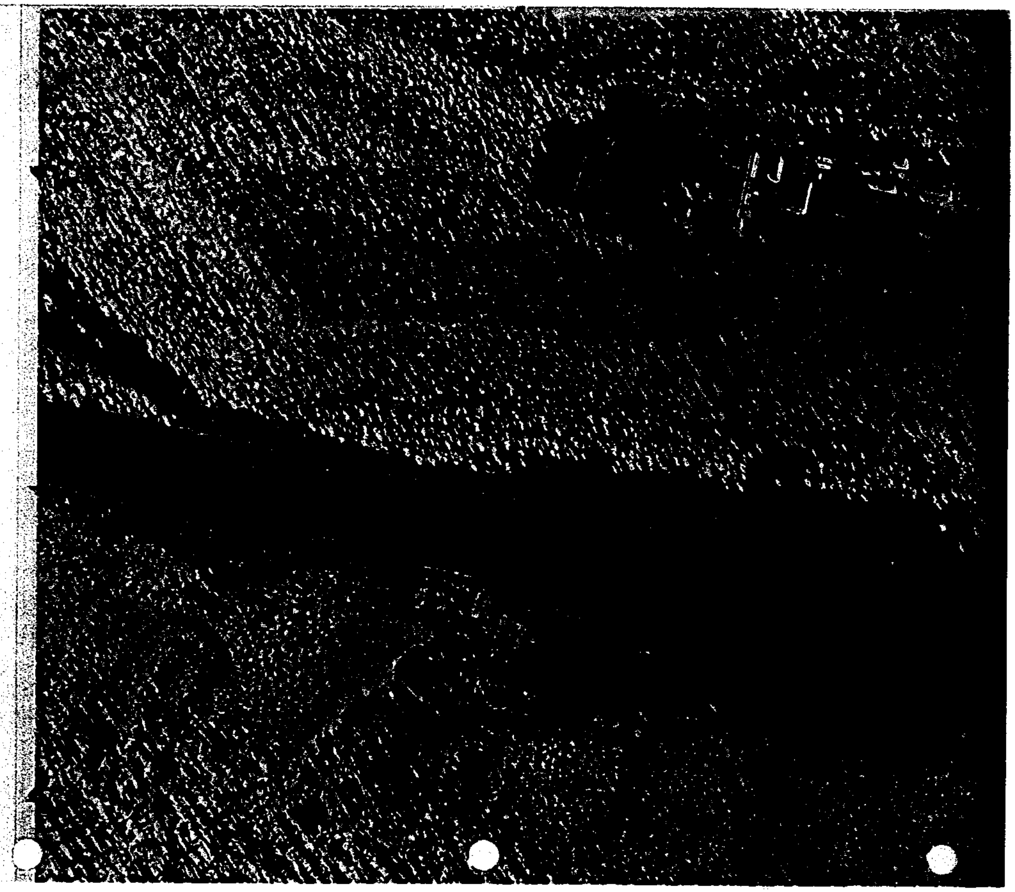


Photograph 3 View Looking North at East End of TA-21, December 1946 (ERID 0015463)



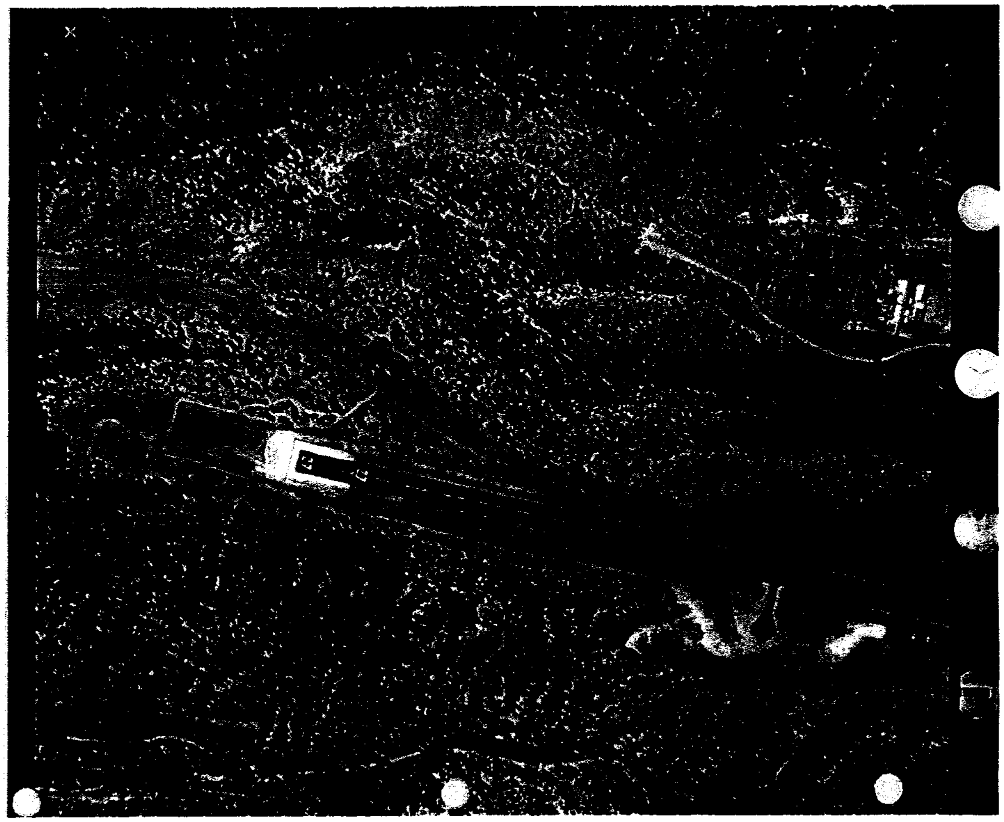
Photograph 4 View Looking North at East Portion of TA-21, September 1950 (ERID 0019083)

Photograph 5 View Looking South at the East End of TA-21, (ERID0019082)



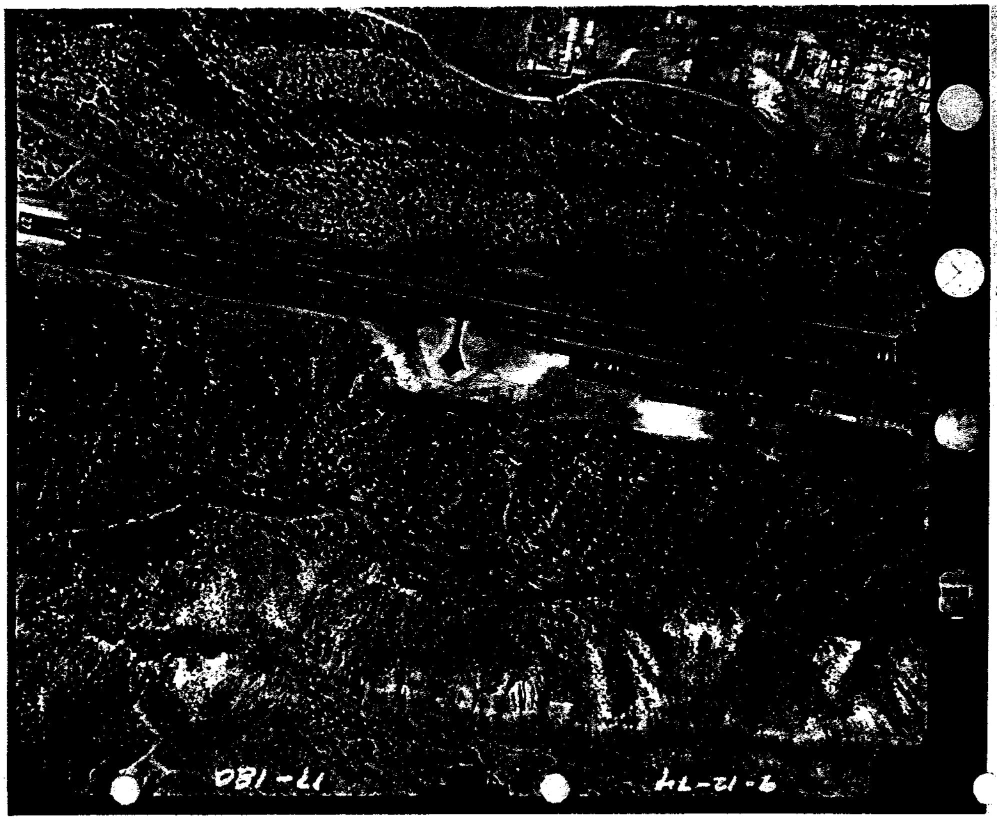
Photograph 6 View to South of the East End of TA-21, November 1958 (ERID 0015699)

Photograph 7 View to North of East End of TA-21, November 1958 (ERID 0015698)



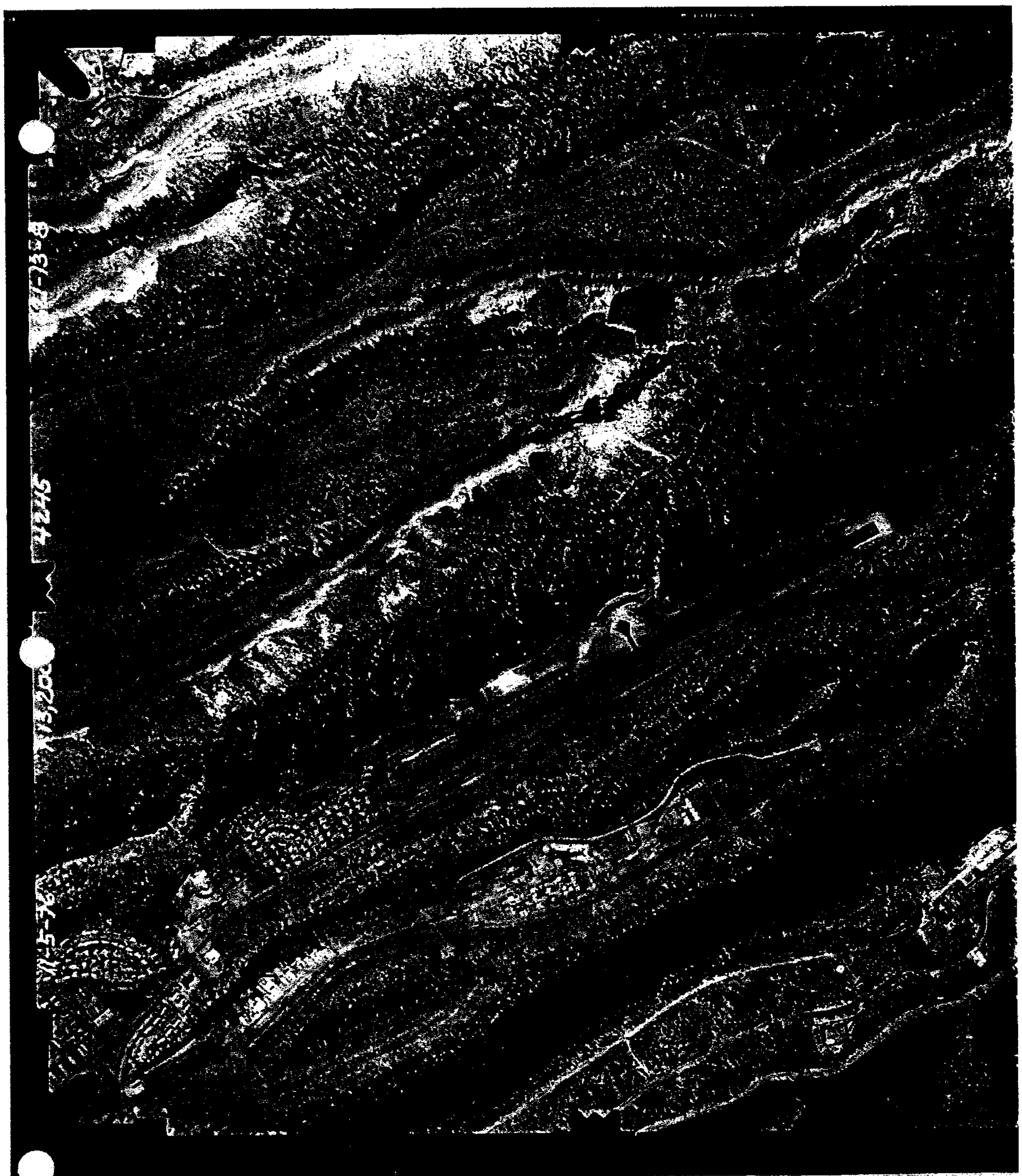
Photograph 8 View to South of East End of TA-21, September 1974 (ERID 17045)

Photograph 9 View to South of the East End of TA-21, September 1974 (ERID 0017046)

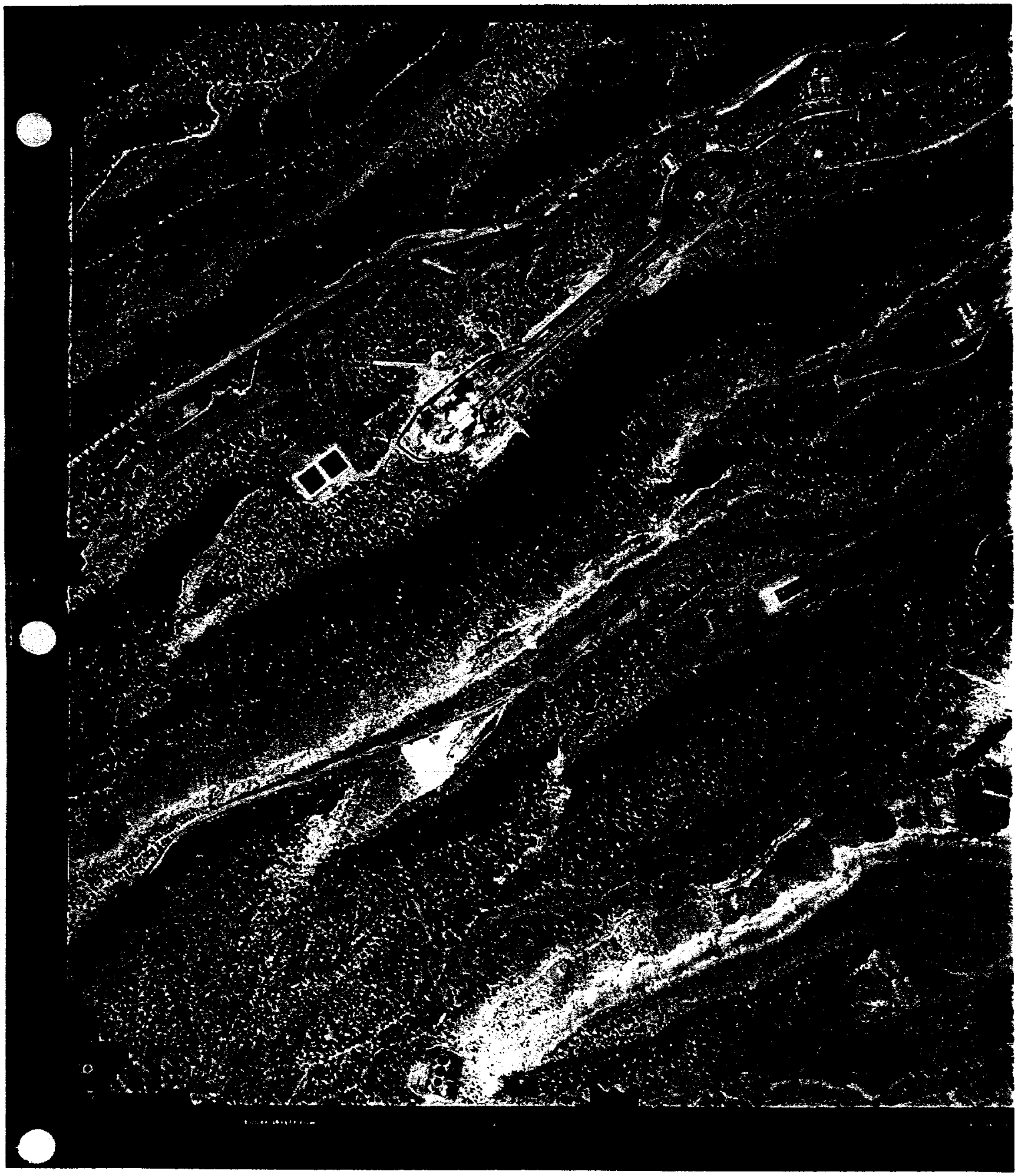


Photograph 10 View to the South of TA-21, September 1974 (ERID 0017084)

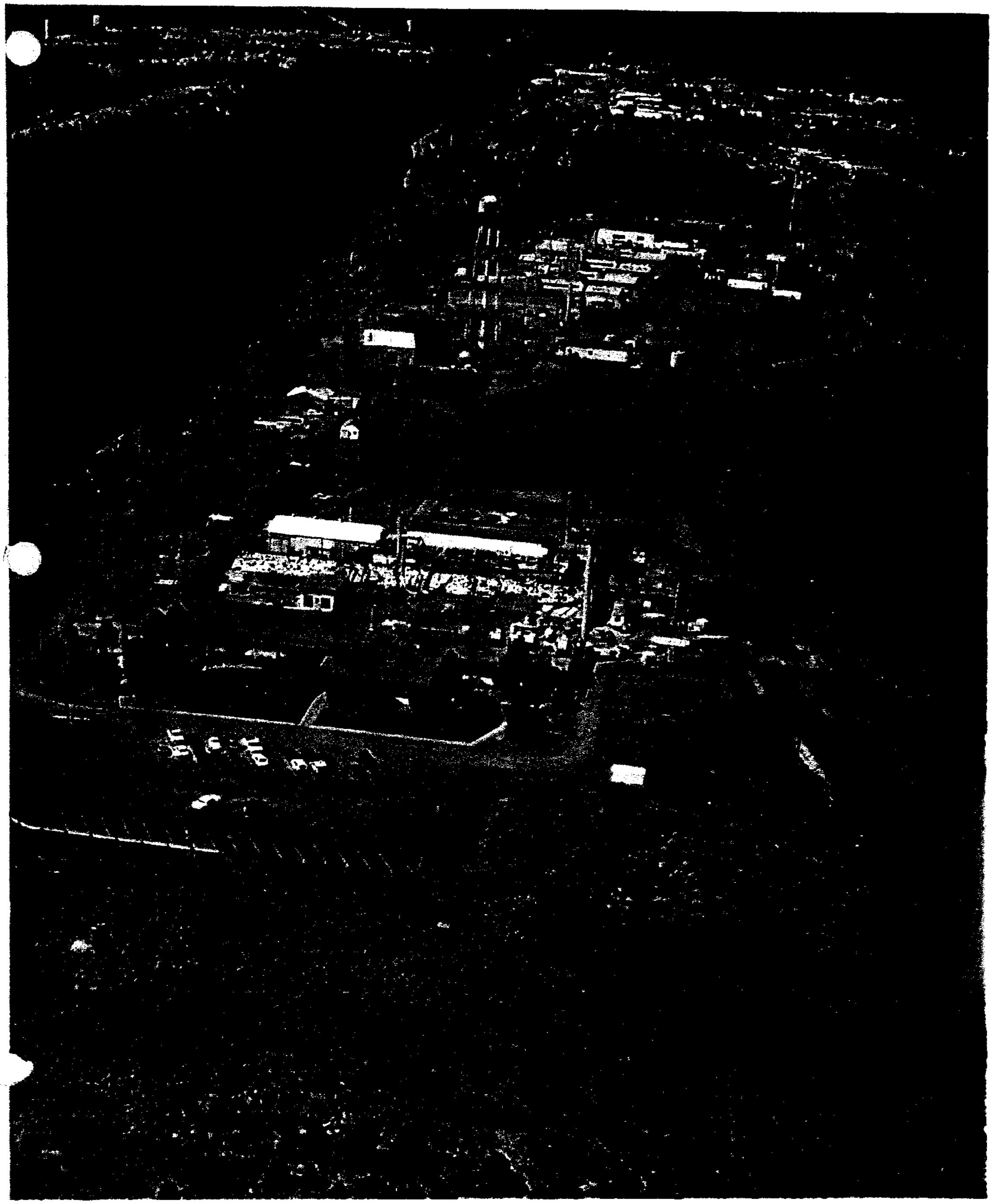
Photograph 11 View to South of TA-21, September 1974 (ERID0017085)



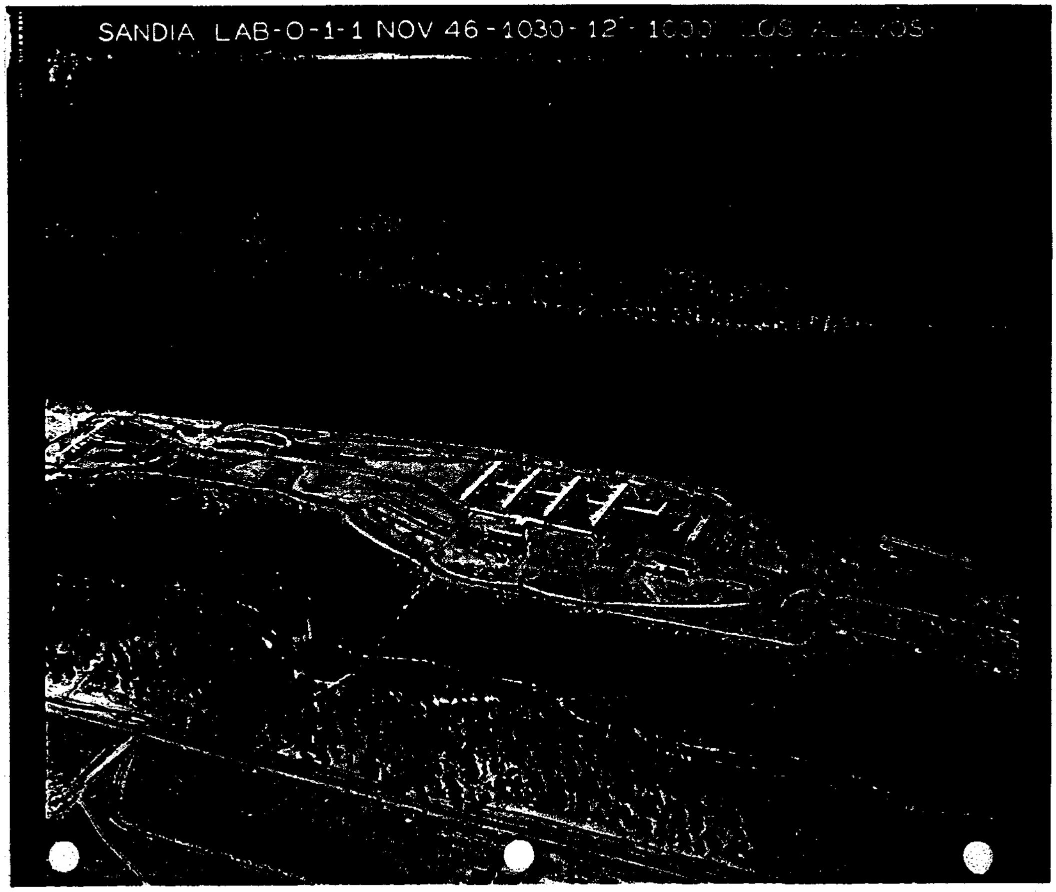
Photograph 12 View of TA-21 (DP Mesa) with the Los Alamos County Airport to the North, November 1976 (ERID0017696)



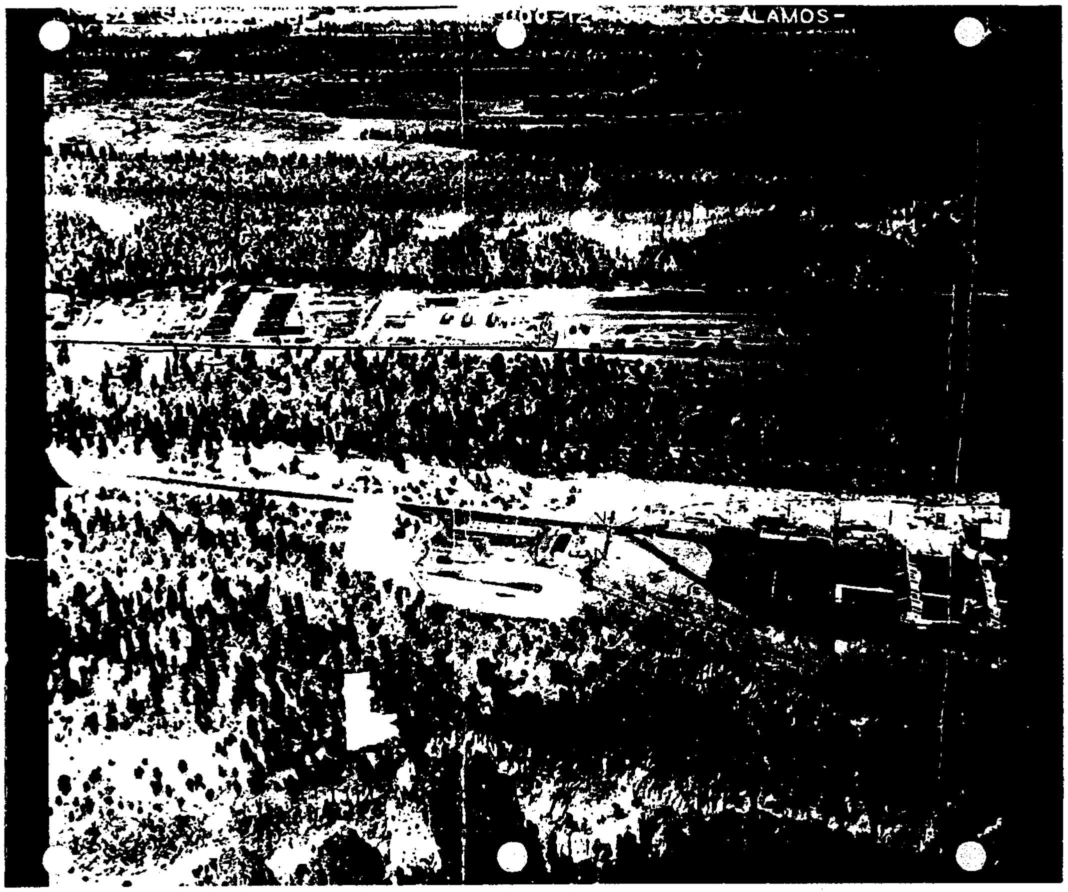
Photograph 13 View of the Eastern Flank of TA-21 and DP Mesa, November 1976 (ERID0017695)



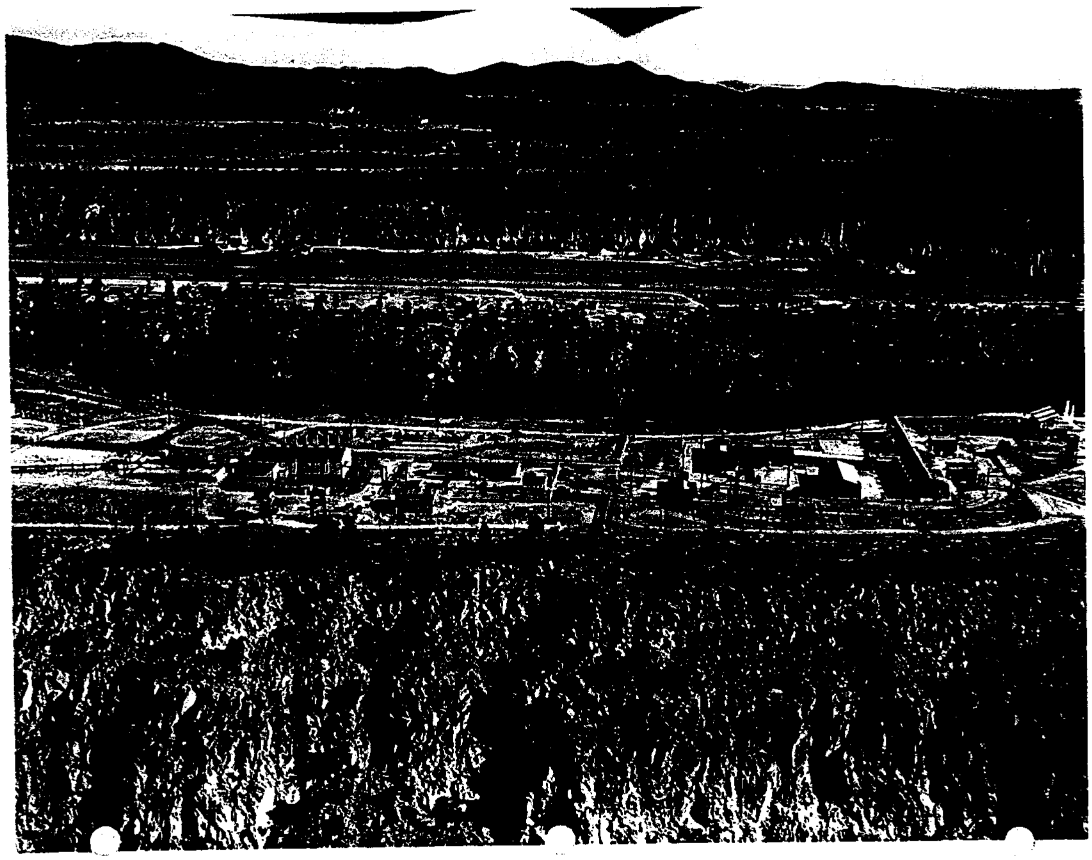
Photograph 14 View to the West of TA-21, (No date and ERID #)



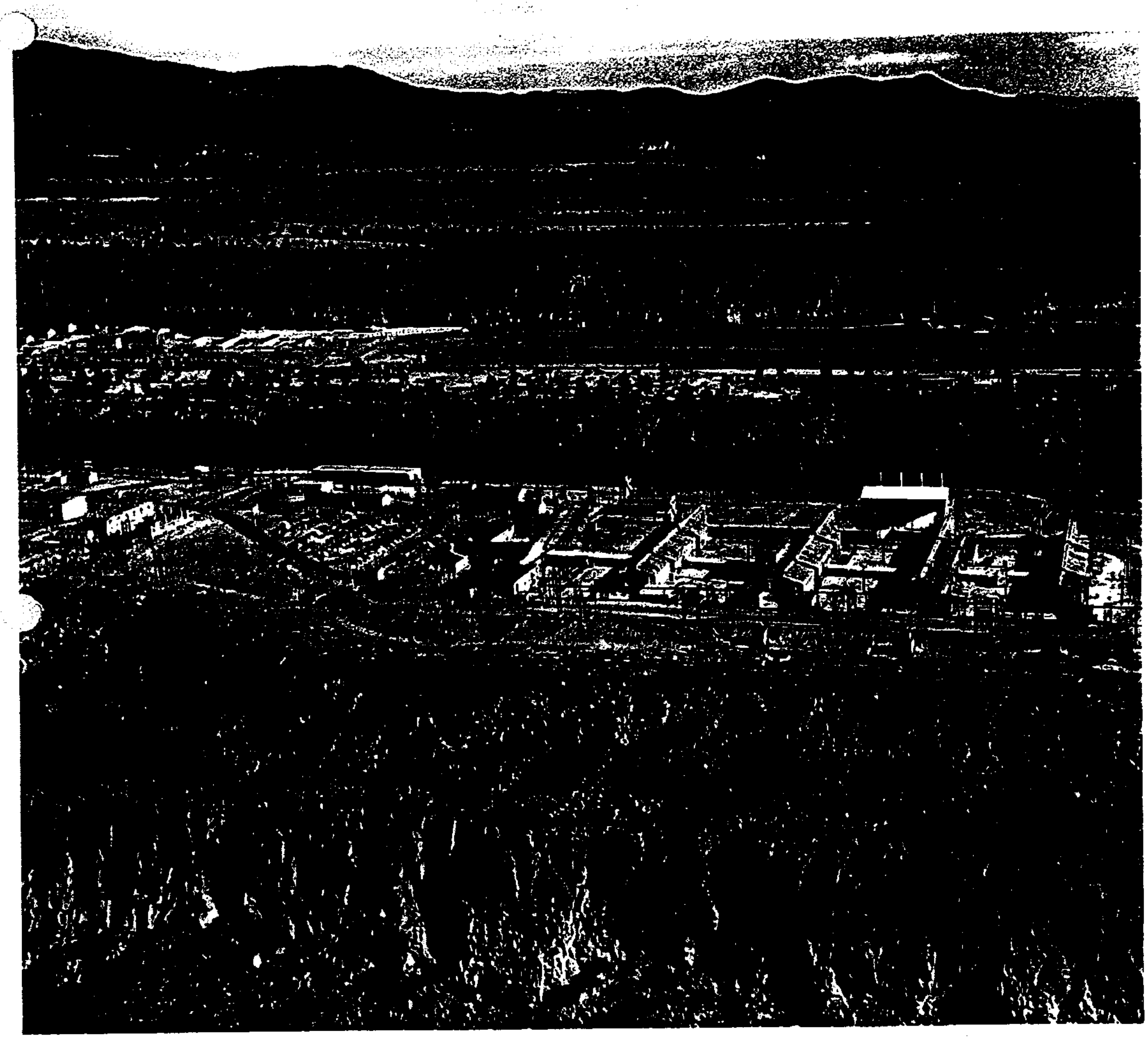
Photograph 15 View to the South of the Central Part of TA-21, November 1946 (ERID 0015423)



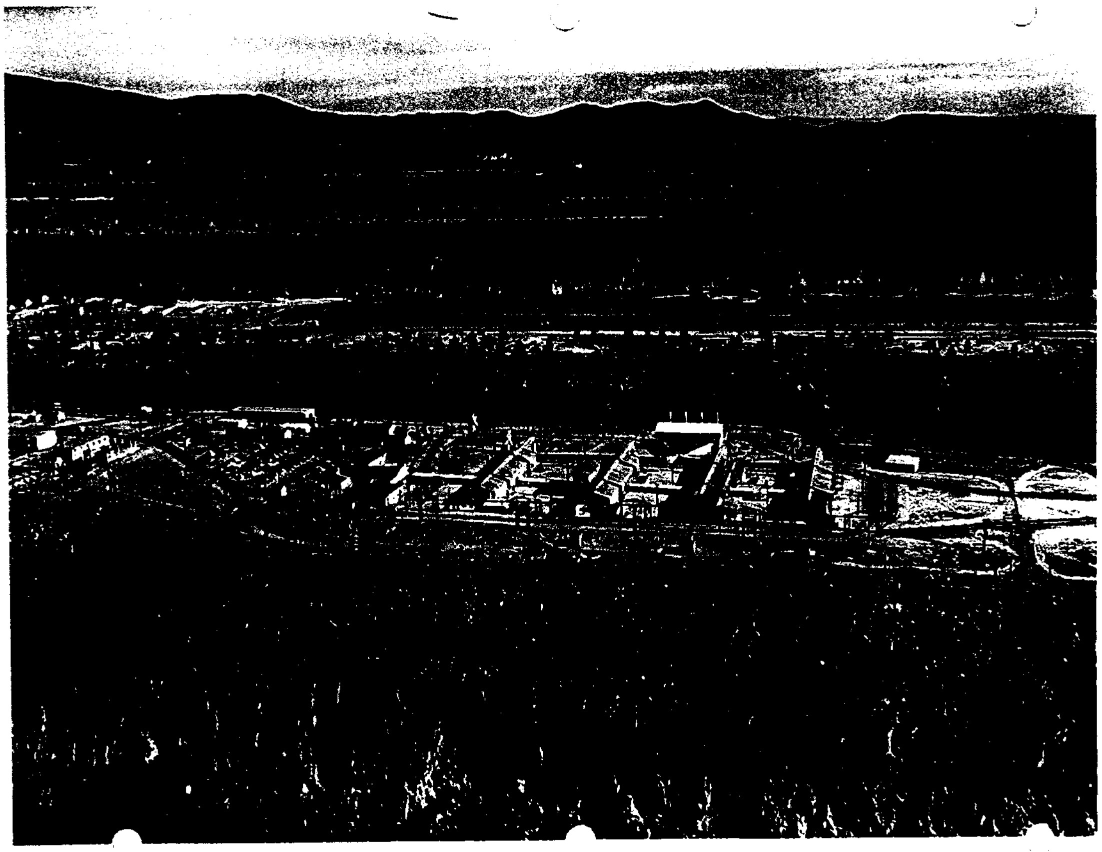
Photograph 16 View to the North of the Central Part of TA-21, January 1947 (ERID0015424)



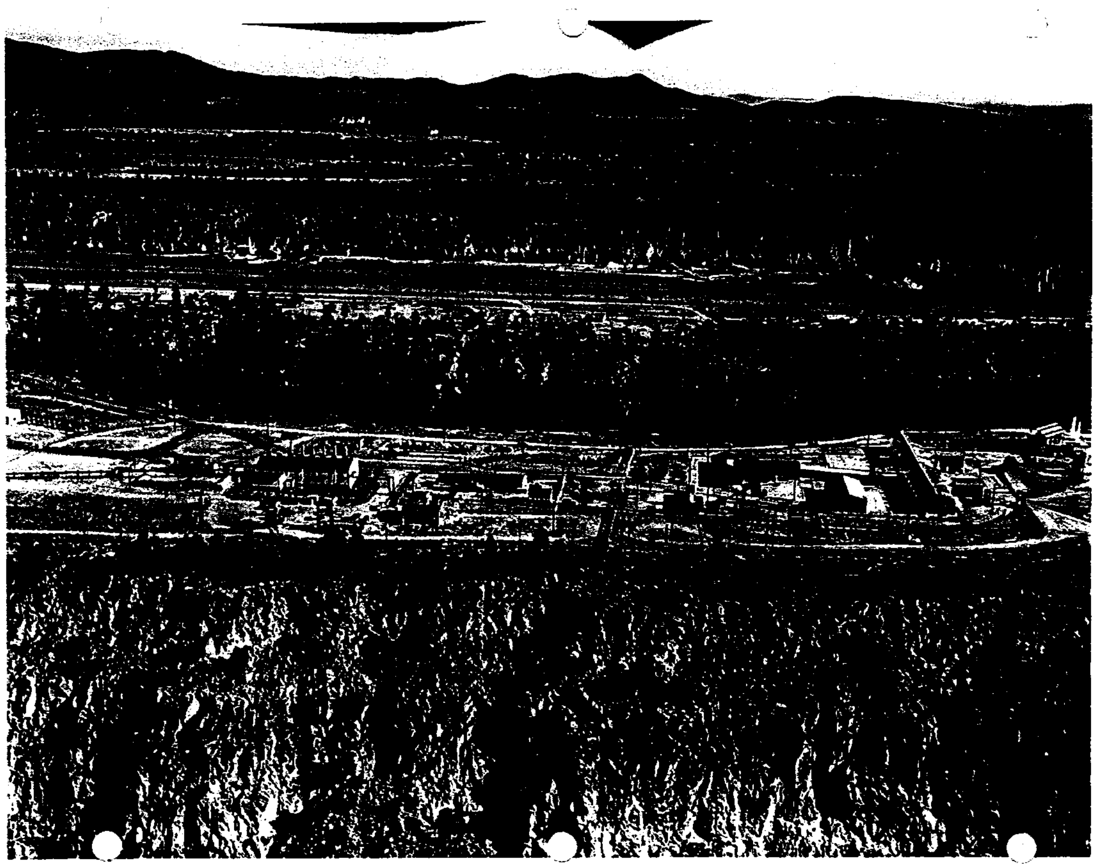
Photograph 17 View to the North of the Central Part of TA-21, September 1950 (No ERID)



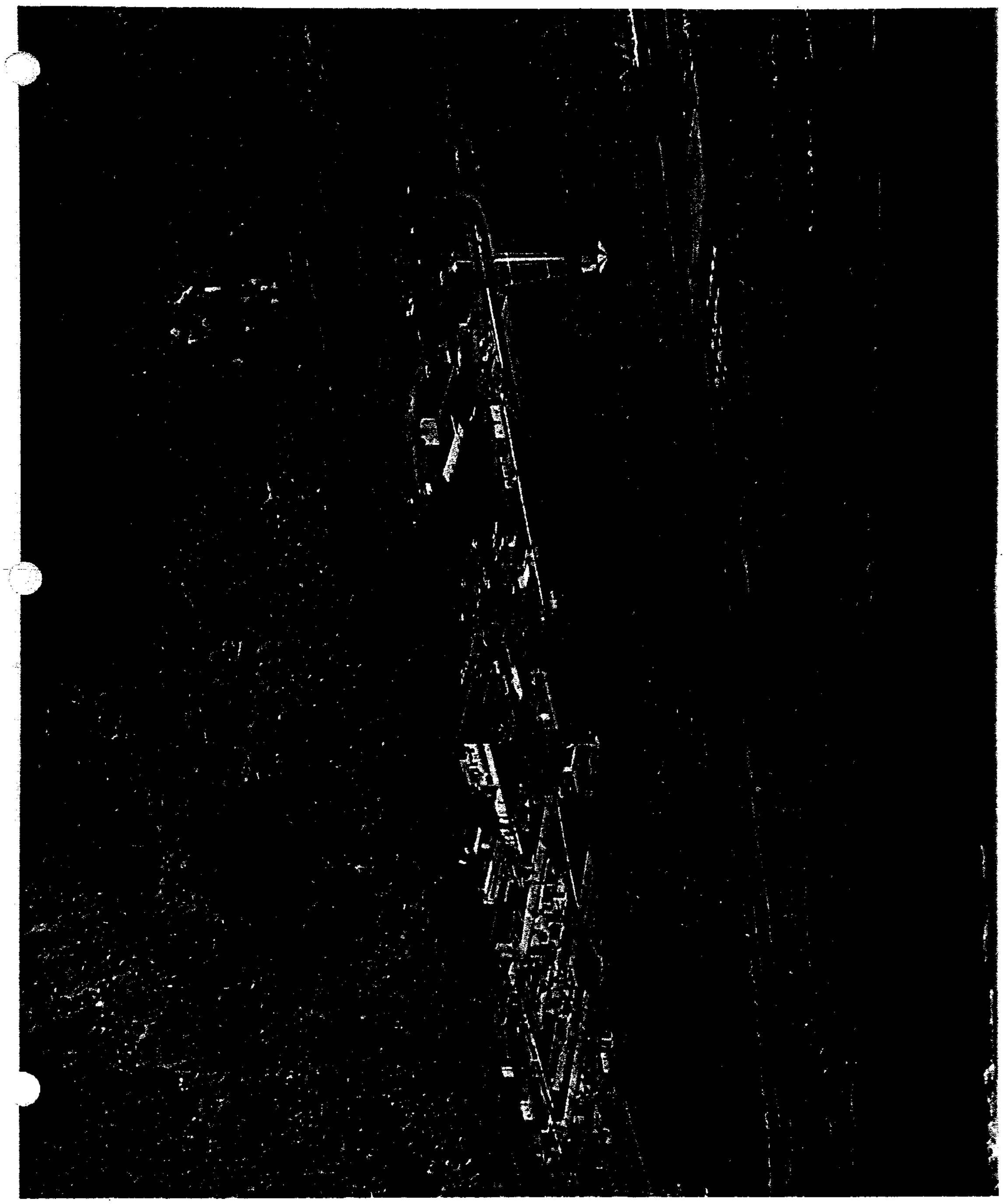
Photograph 18 View to the North of Central TA-21, July 1950 (ERID 0019084)



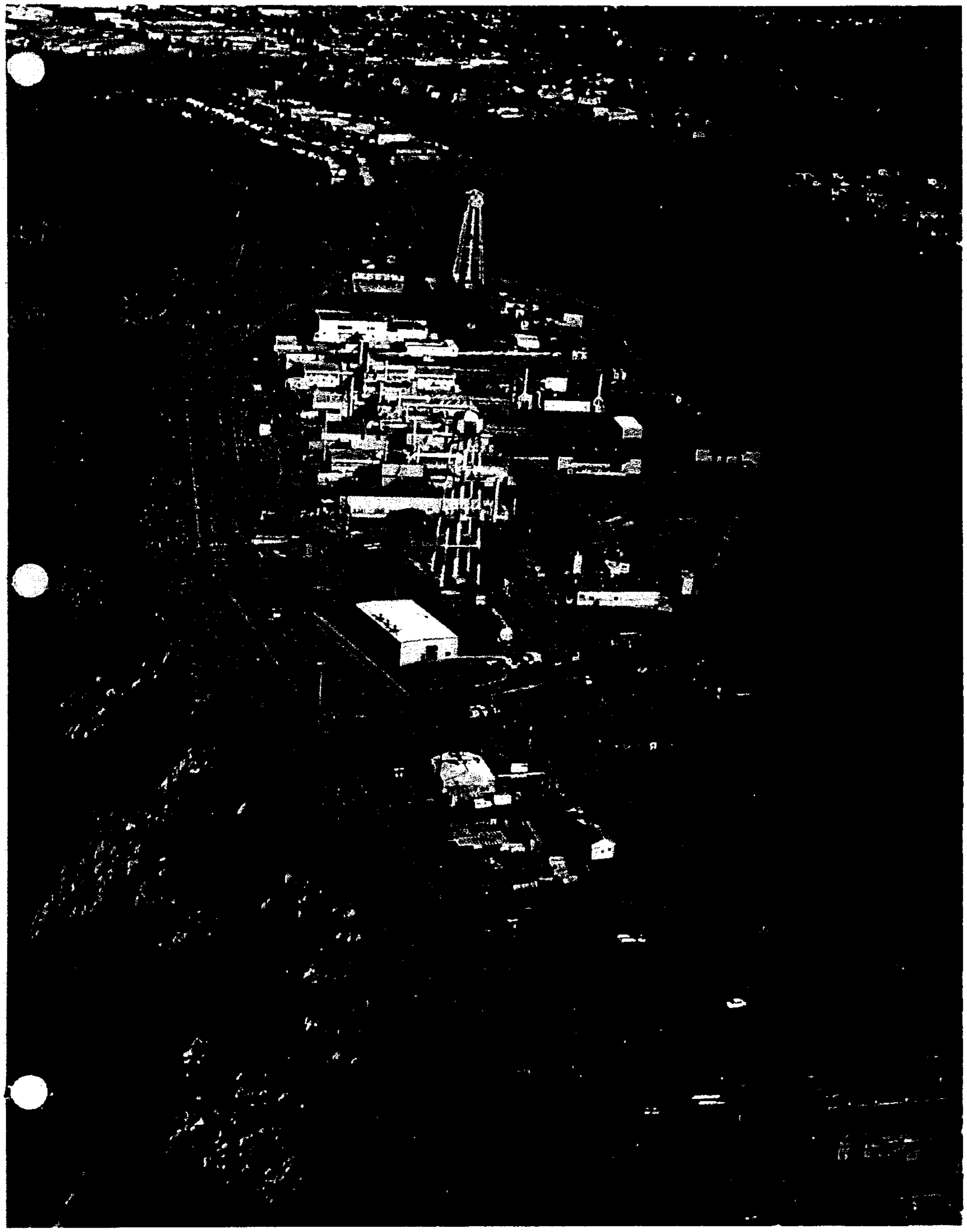
Photograph 19 View to the North of Central TA-21, (Unknown date and ERID #)



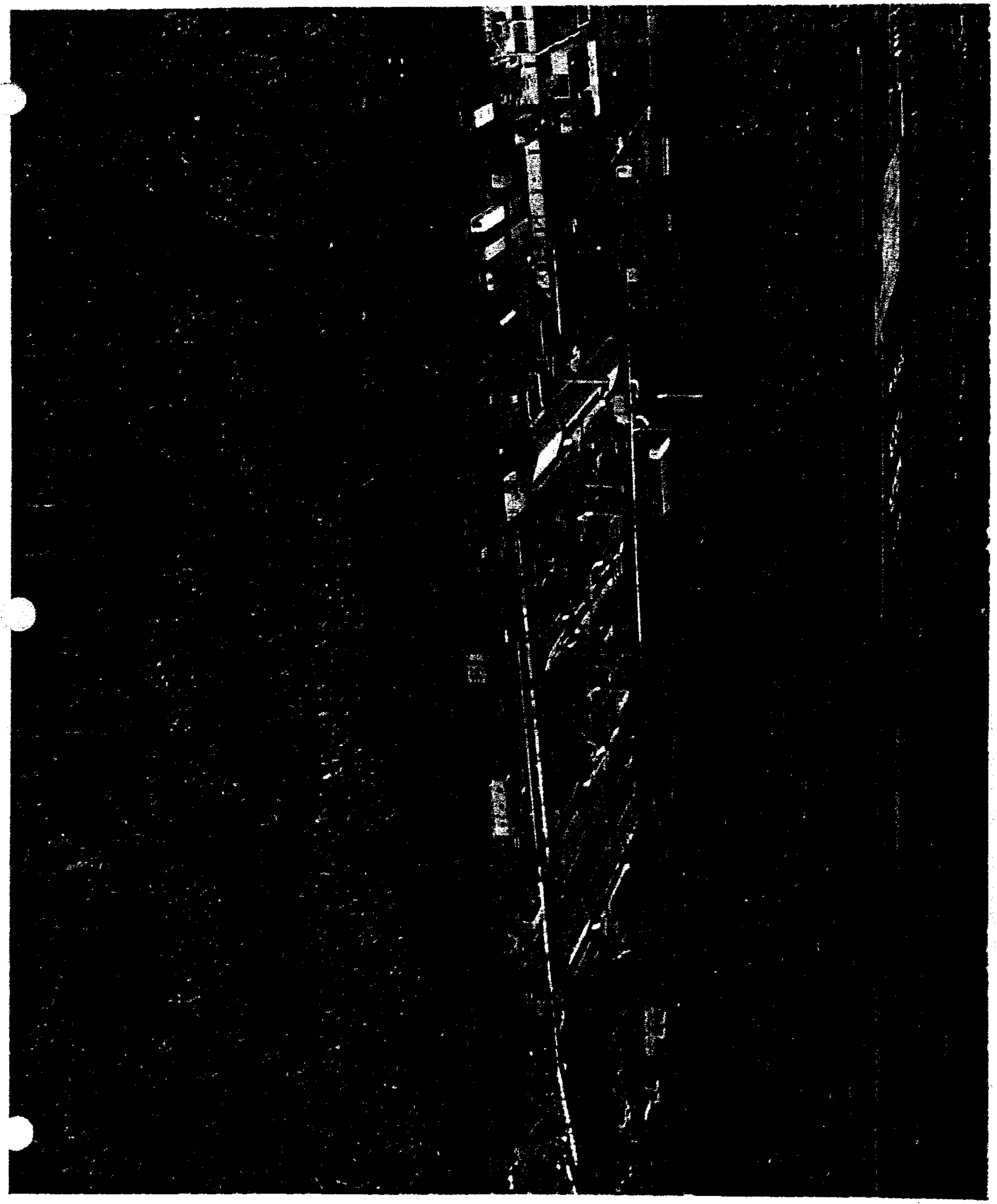
Photograph 20 View to the North of Central TA-21, (Unknown date and ERID #)



Photograph 21 View to the Northeast of Central TA-21, (Unknown date and ERID #)

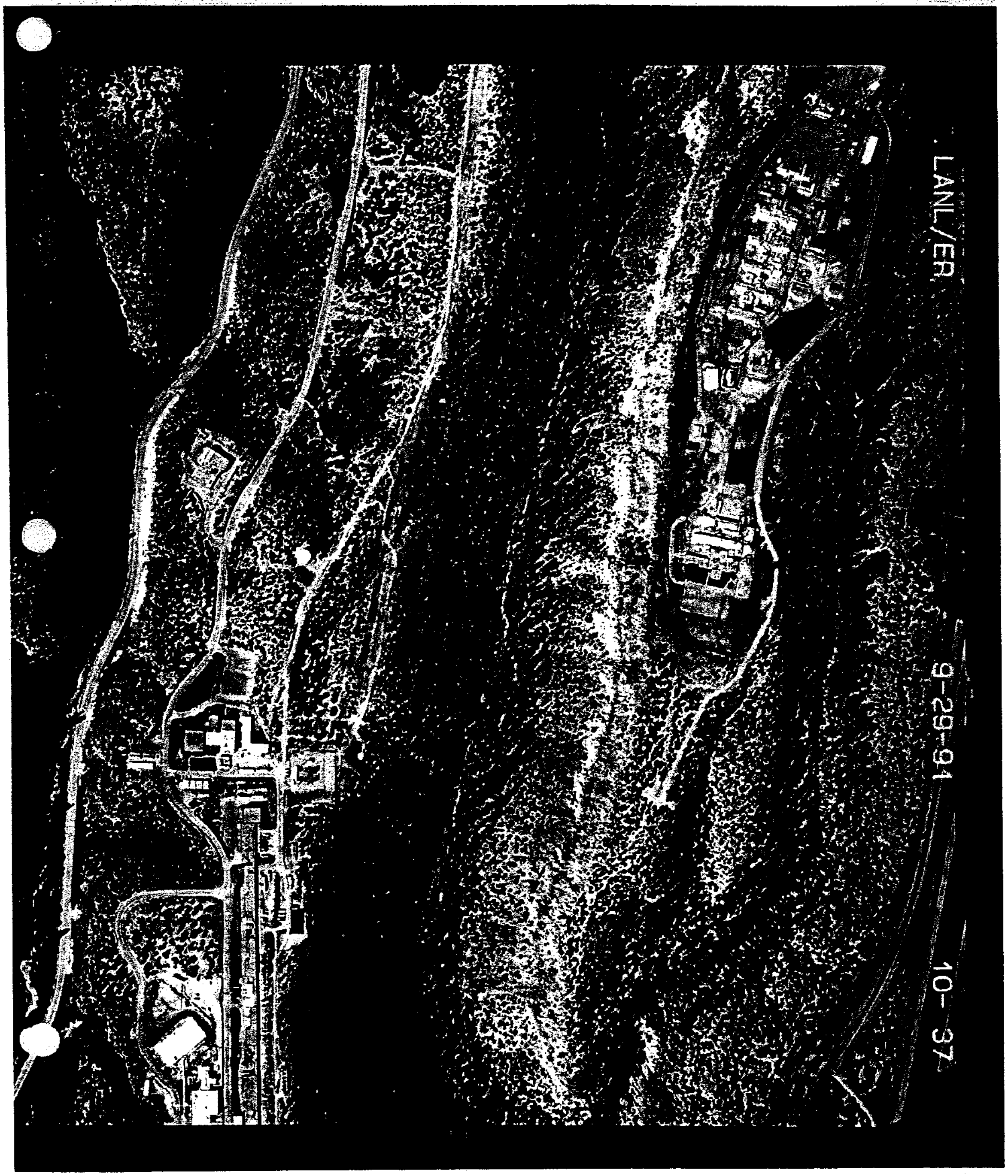


Photograph 22 View to the Northwest of Central TA-21, (Unknown Date and ERID #)

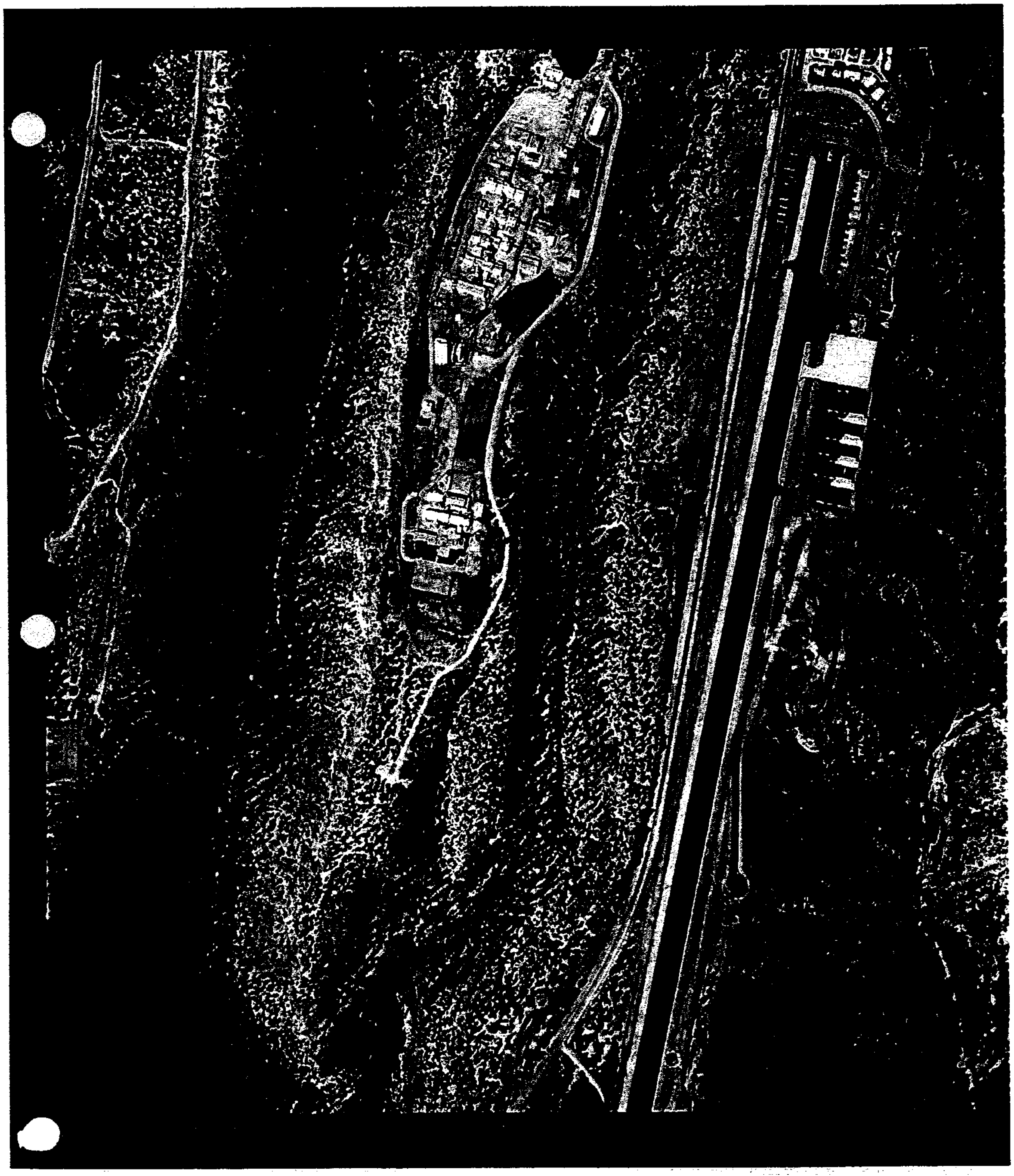


Photograph 23 View to the North of Central TA-21, Unknown date (ERID0019089)

Photograph 24 View of Central and Eastern Part of TA-21, September 1991 (No ERID #)

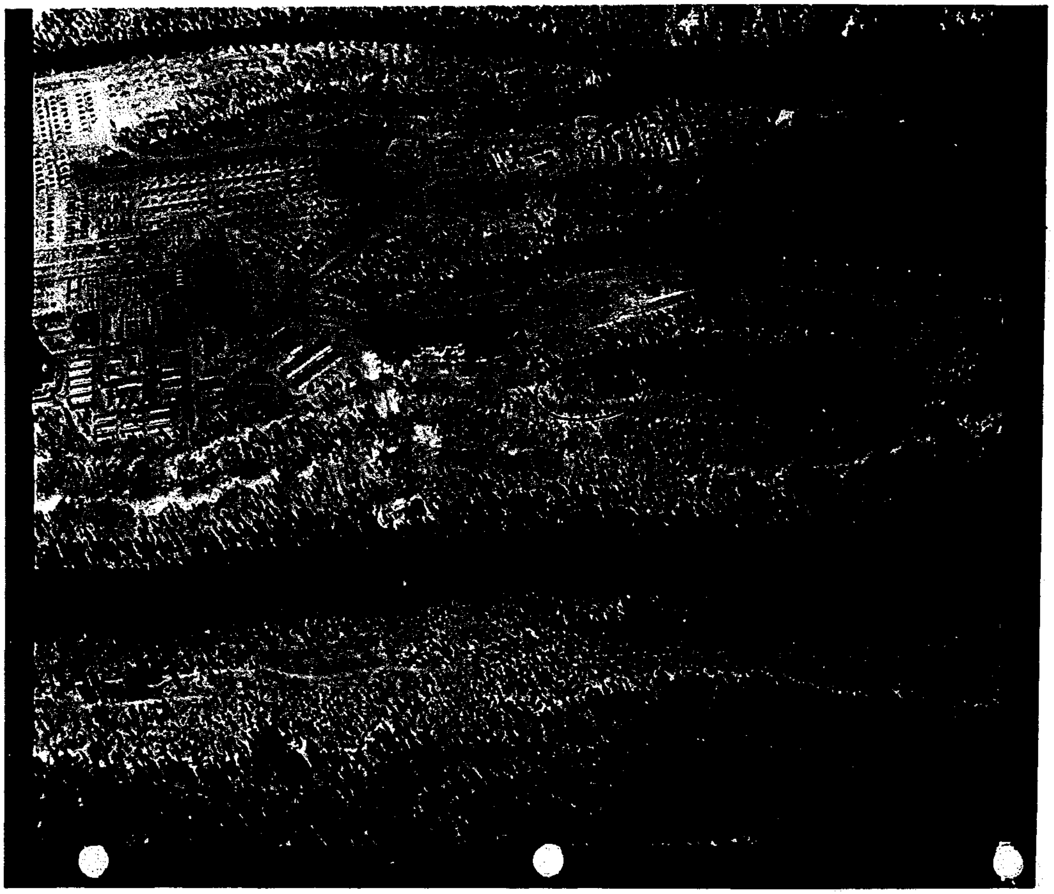


Photograph 25 View of Central and Eastern TA-21, September 1991 (ERID 0018266)

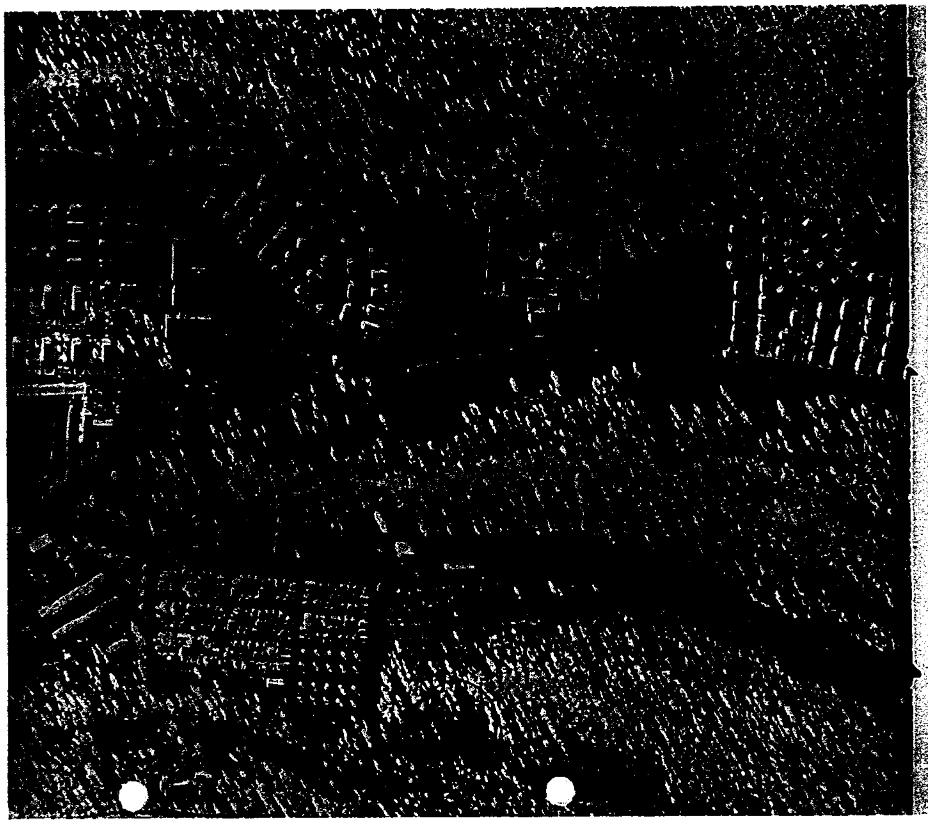


Photograph 26 View of Central and Eastern Part of TA-21, September 1991 (ERID0018267)

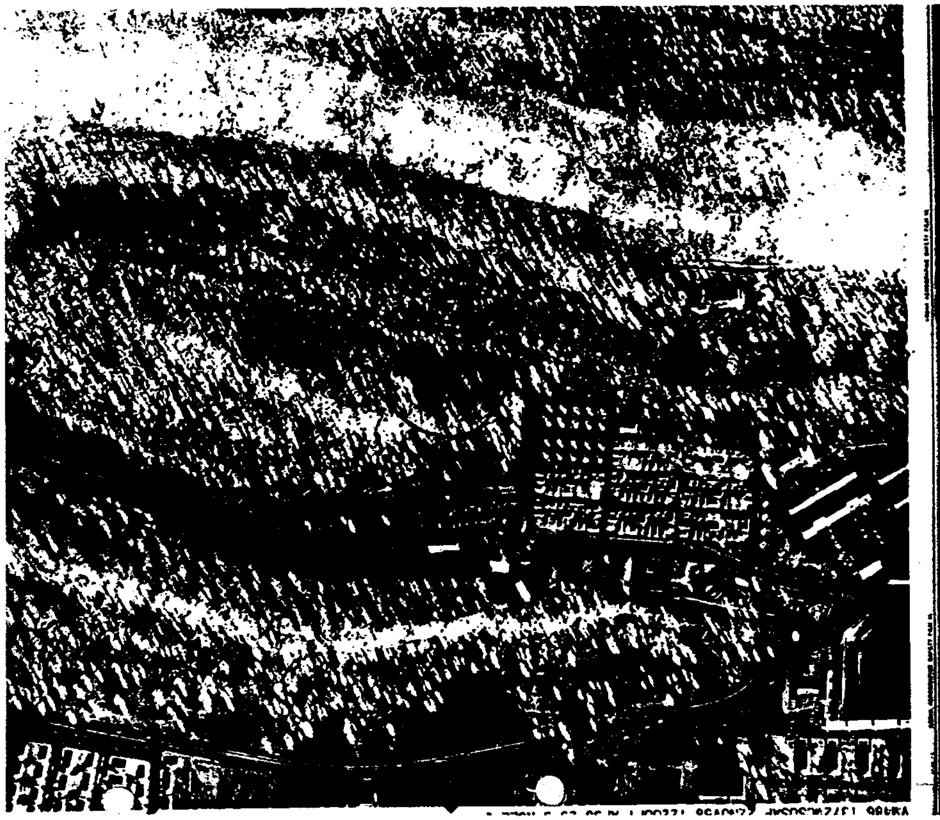
Photograph 27 View to the South of Western Part of TA-21, 1946 (ERID 0015464)



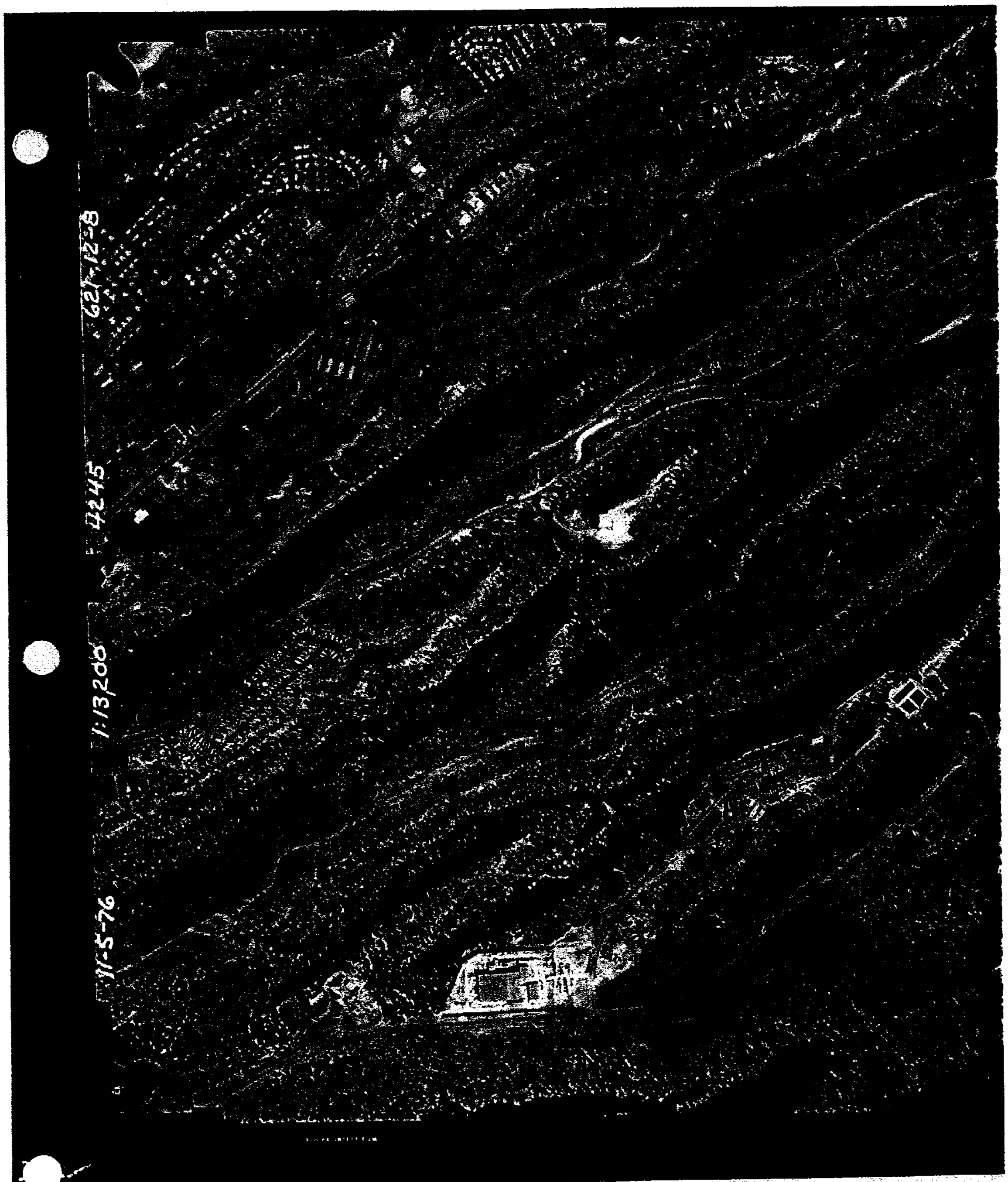
Photograph 28 View of the Western Part of TA-21, December 1946 (ERID0015418)



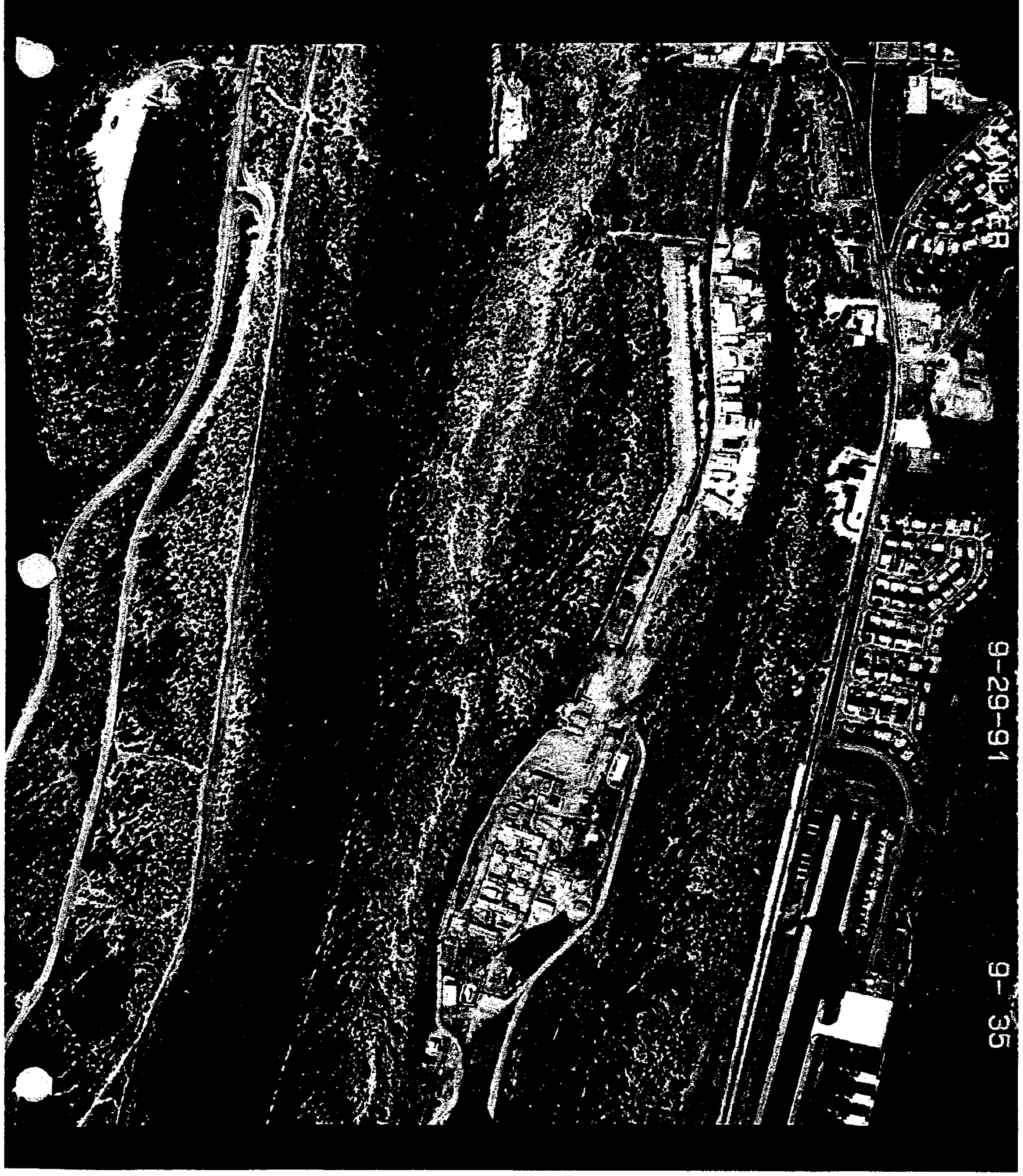
Photograph 29 View of Western Part of TA-21, November 1958 (ERID0015730)



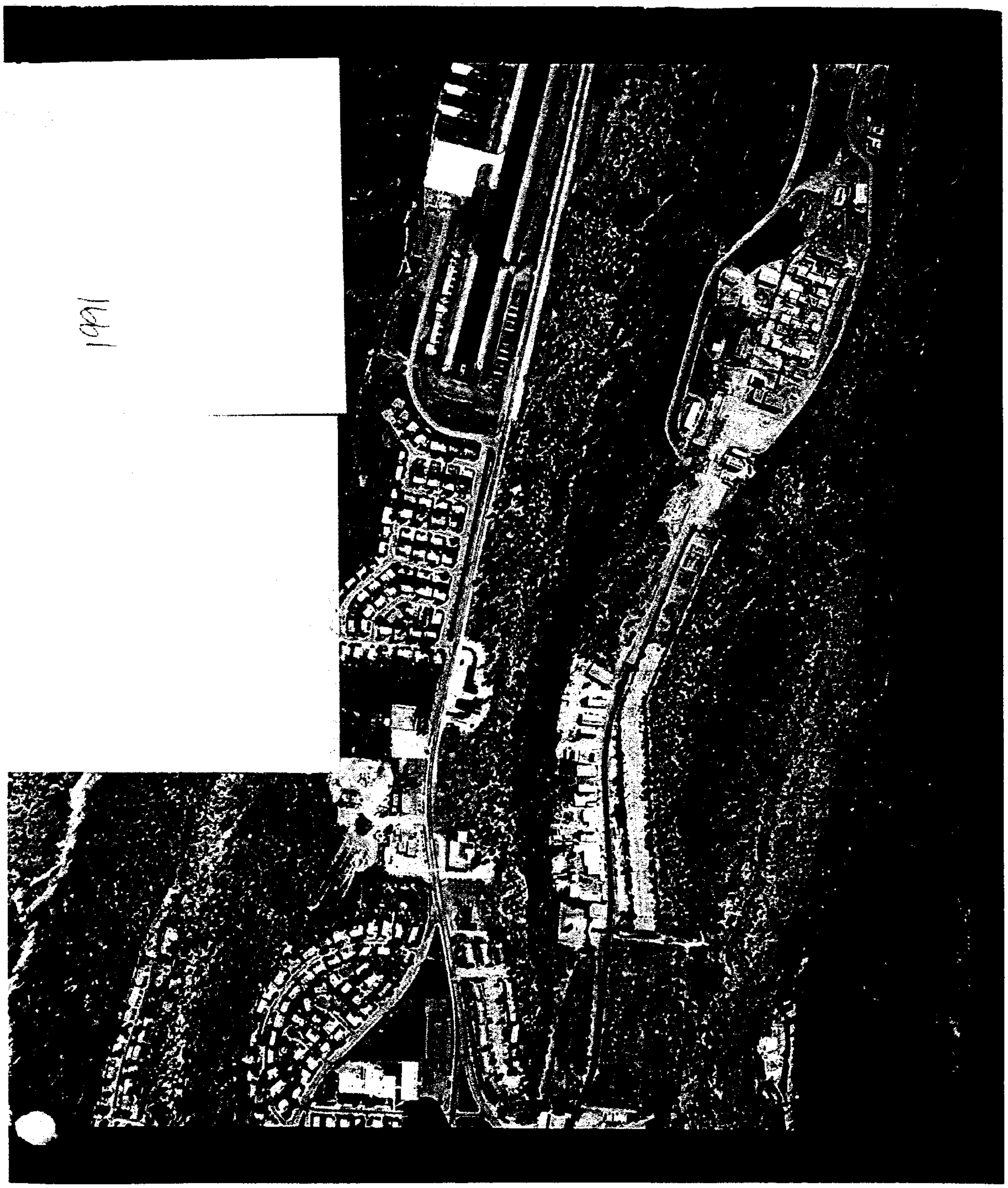
Photograph 30 View of the Western Part of TA-21, November 1958 (ERID 0015730)



Photograph 31 View of the Central and Western Part of TA-21, November 1976 (ERID0017685)



Photograph 32 View of the Western and Central Part of TA-21, September 1991
(ERID0018238)



Photograph 33 View of Western and Central Part of TA-21, September 1991 (ERID0018239)

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APPENDIX B

GEOPHYSICAL INVESTIGATION

Prepared by:

ARM Group, TerranearPMC, and Washington Group

EXECUTIVE SUMMARY

ARM Group, Inc. performed a non-intrusive geophysical investigation at and around the Los Alamos National Laboratory (LANL) Technical Area 21 (TA-21) site during September through December 2004. The geophysical investigation was performed using terrain conductivity (EM31), high-sensitivity metal detector (EM61), ground penetrating radar (GPR), and radiofrequency pipe locator techniques. The primary objectives are as follows:

1. Provide reconnaissance-level coverage of the non-industrialized areas of TA-21 to identify anomalies that could be buried structures or waste
2. Locate specific targets within selected Solid Waste Management Units (SWMU)
3. Locate the remaining segments of the Industrial Waste Line and pipelines contained within the suspected utility corridor located north of Buildings 21-2 through 21-5
4. Delineate the lateral and vertical boundaries of the former absorption beds contained within MDA V.

The reconnaissance surveys performed over the eastern non-industrialized area showed no anomalies that could be confidently attributed to buried wastes or structures. Only subtle anomalies related to potential buried bedrock channels and road-building materials were observed. The reconnaissance data from the western portion of the survey area showed numerous buried pipes presumably associated with the former trailer park.

The detailed investigations performed over 24 SWMU locations successfully located numerous buried targets including nonmetallic pipes and tanks. The located targets were geographically located using a global positioning system. The locations and geodetic coordinates of these targets are provided on the figures included with this report.

The location of the remaining segments of the industrial waste line was found using a radio-frequency pipe locator. The estimated depth to the pipe based on the locator's differential measurement system ranged from 3 to 4.5 feet.

Finally, the results from the survey performed at MDA V showed subtle linear anomalies associated with the former absorption beds. Only the central portion and the western portions of the northern and southern absorption beds were observed. Other linear anomalies observed in the EM data were attributed to buried pipes within the absorption bed and leading from the former laundry building to the absorption beds.

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Acronyms and Abbreviations

AOC	Area of Concern
EM	electromagnetic
EM31	terrain conductivity
EM61	high-sensitivity metal detector
GPR	ground penetrating radar
GPS	Global Positioning System
LANL	Los Alamos National Laboratory
MDA	Material Disposal Area
mS/m	millisiemens per meter
mV	milliVolts
SWMU	Solid Waste Management Unit
TA	Technical Area
VCP	Vitrified clay pipe
CMP	Corrugated metal pipe

1.0 INTRODUCTION

ARM Group, Inc. performed a non-intrusive geophysical investigation at and around the Los Alamos National Laboratory (LANL) Technical Area 21 (TA-21) site during September through December 2004. The objectives of the investigation were to perform reconnaissance-level, site-wide coverage to identify anomalies that may be attributed to buried structures or waste. Secondly, higher resolution investigations were performed over specific Solid Waste Management Units (SWMU) to identify buried structures such as pipes and underground storage tanks (UST). To achieve these objectives, an integrated geophysical investigation was performed using terrain conductivity (EM31), high-sensitivity metal detector (EM61), ground penetrating radar (GPR), and radiofrequency pipe locator techniques.

Both EM31 and EM61 data were acquired to provide reconnaissance coverage of the entire TA-21 mesa top. Approximately 70 acres were surveyed by these methods. The survey coverage is shown on the plan EM contour maps found at the end of this report in Figure 31 and Figure 32. Higher resolution coverage was performed using EM31 and EM61 at selected SWMUs by surveying along closer line spacings. In addition, GPR and pipe locator techniques were used at these SWMUs to identify specific targets. These techniques were also use to map the remaining segments of the industrial waste line and the utilities buried within the corridor located north of Buildings 21-02 through 21-05. The integrated use of these techniques was complementary and resulted in higher confidence levels and more complete subsurface information.

This report contains a brief description of the site in Section 2. The objectives and scope of work are outlined in Section 3. The methods, results, and conclusions are presented in Sections 4 through 6, respectively.

2.0 SITE DESCRIPTION

The survey area encompasses approximately 70 acres of DP Mesa, which contains Technical Area 21 (TA-21) and is accessible from DP Road off State Highway 502. The survey site can be divided into three main areas:

1. The fenced industrial area, located in the central part of TA-21, was the main area of interest and focus for this project.

2. The east mesa top section included the area east of the Tritium Systems Test Assembly (TSTA) out to the end of DP Mesa. The only known structures of this section are associated with the wastewater treatment plant (Building 21-230).

3. The west mesa top section was used at various times and to various degrees for surface storage and parking. Material Disposal Areas (MDAs) B and V are also located in the west section. These outer sections were surveyed to identify anomalies that would indicate structures or buried waste.

3.0 OBJECTIVE AND SCOPE

The objectives of the investigation were to perform a reconnaissance-level, site-wide survey to identify anomalies that can be attributed to buried structures or waste. Secondly, more detailed investigations were performed over specific Solid Waste Management Units (SWMU) to locate buried structures such as pipes and storage tanks. To achieve these objectives, an integrated geophysical investigation was performed using terrain conductivity (EM31), high-sensitivity metal detector (EM61), ground penetrating radar (GPR), and radiofrequency pipe locator techniques.

The primary objectives are grouped into the following main categories:

1. Provide reconnaissance-level coverage of the non-industrialized areas at the eastern and western portions of TA-21 to provide information and locations of any possible anomalies or structures of interest that may have been previously overlooked or unknown.

2. Locate specific targets within selected Solid Waste Management Units (SWMU). The specific targets associated with each SWMU are listed Table 1. The list was modified slightly from the Field Implementation Plan.

3. Locate the remaining segments of the Industrial Waste Line and pipelines contained within the suspected corridor located north of Buildings 21-2 through 21-5.

4. Delineate the lateral and vertical boundaries of the former pits contained within MDA V.

Table 1 SWMU Targets and Objectives

SWMU	OBJECTIVES
21-006 (a)	1. Locate seepage pit between Building 21-02 and removed Building 21-03
21-006 (b)	2. Locate seepage pit 3. Locate any associated pipelines
21-006 (c)	4. Locate seepage pit between Building 21-02 and removed Building 21-03
21-006 (d)	5. Locate seepage pit between Building 21-02 and removed Building 21-03
21-009	6. Locate footprint of Building21-33 7. Locate any pipelines within the footprint of Building 21-33 8. Locate 1-in. gas line that exits Building 21-33 and trends south
21-012 (b)	9. Locate pits 21-266 and 21-267 10. Locate inlet lines from Building 21-09 to pits 266 and 267, and the outlet lines to the blow down tank 11. Locate seepage pit and dry well just south of the blow down tank. 12. Locate 6-in. steel and/or VCP pipe that runs south from pits 266 and 267 to the mesa edge
21-022 (a)	13. Locate sump 21-74 14. Locate inlet line from Building 21-21 to sump 21-74 15. Locate line(s) east of sump to Building
21-022 (f)	16. Locate sump 21-173 17. Locate manhole 21-221 18. Locate 6-in. steel pipeline between sump 21-173 and MDA U
21-022 (h)	19. Locate sump 20. Locate 6-in. pipeline to outfall
21-022 (i)	21. Locate sump 22. Locate any pipelines from sump
21-022 (j)	23. Locate sump 24. Locate any pipelines from sump
21-024 (a)	25. Locate septic tank 21-53 26. Locate pipeline from Building 21-09 to tank 21-53 27. Locate pipeline from tank 21-53 to outfall
21-024 (b)	28. Locate septic tank 21-55 29. Locate pipeline from between Buildings 21-04 and 21-05 to tank 21-55 30. Locate pipeline from tank 21-55 to outfall
21-024 (c)	31. Locate septic tank 21-56 32. Locate pipeline from Building 21-54 to tank 21-56 33. Locate pipeline from tank 21-56 to outfall 34. Locate pipeline from Building 21-61 east to pipeline from bldg 21-54 35. Locate any pipeline extension to the east of intersection w/ Building 21-54 pipe
21-024 (d)	36. Locate septic tank 21-106 37. Locate main pipeline from Building 21-01 to tank 21-106 38. Locate pipeline from tank 21-106 to outfall 39. Locate diagonal 6-in. VCP line from Building 21-01 to main pipeline 40. Locate any pipes that exit south from boiler room that intersect main pipeline
21-024 (e)	41. Locate septic tank 21-123 42. Locate pipeline from Building 21-20 to tank 21-123 43. Locate pipeline from tank 21-123 to outfall

SWMU	OBJECTIVES
21-024 (g)	44. Locate pipeline from Building 21-07 to 21-31 45. Locate pipeline from Building 21-31 to septic tank 21-125 46. Locate septic tank 21-125 47. Locate pipeline from septic tank to leach field 48. Locate pipeline from leach field to outfall
21-024 (h)	49. Locate pipeline from Building 21-151 to septic tank 21-163 50. Locate pipeline from Building 21-152 to septic tank 21-163 51. Locate septic tank 21-163 52. Locate pipeline from septic tank to outfall
21-024 (i)	53. Locate pipeline from Building 21-209 to chain link fence
21-024 (j)	54. Locate pipeline from Building 21-155 to septic tank 21-194 55. Locate septic tank 21-194 56. Locate pipeline from septic tank to outfall
21-024 (k)	57. Locate pipeline from Building 21-209 to manhole 21-217 58. Locate manhole 21-217 59. Locate pipeline to manhole 21-218 60. Locate manhole 21-218 61. Locate pipeline from manhole 21-218 to septic tank 21-219 62. Locate septic tank 21-219 63. Locate pipeline from septic tank to tile field 64. Locate tile field 65. Locate both pipelines from tile field to outfall
21-024 (l)	66. Locate pipeline from Building 21-20 south to outfall
21-024 (n)	67. Locate pipeline from Building 21-155 to outfall
21-024 (o)	68. Locate pipeline from Building 21-46 south to outfall 69. Locate pipeline from Building 21-14 to septic tank 21-123 70. Locate pipeline from Building 21-14 to grease trap 71. Locate grease trap on south side of Building 21-14 72. Locate any pipelines that connect from above ground diesel tank to Buildings or pipelines 73. Locate any lines from the clean oil tank next to diesel tank 74. Locate valve box between diesel tank and oil tank
21-027 (a)	75. Locate pipelines under paved area south of Building 21-03
21-027 (c)	76. Locate pipeline from Building 21-03 south to possible surface exposure

4.0 METHODOLOGY

4.1. *GEODETIC POSITIONING*

All geophysical instruments were integrated with a differential global positioning system (GPS) to allow real-time navigation along planned survey routes, to provide accurate location of geophysical measurements, to eliminate the need to establish a local reference grid, and to allow direct data integration with LANL's geographic information system (GIS). The geographic positions of all measurement points were acquired at 1-s intervals as the geophysical data were collected. The data were acquired using a differential system, which allowed accurate positioning with real-time accuracy of less than 1 meter. All geographic data in the report are presented in New Mexico State Plane Coordinate System, North American Datum 1983, Central Zone, US survey feet.

4.2. *TERRAIN CONDUCTIVITY*

The EM31 method uses the principle of electromagnetic induction to measure the electrical conductivity of the ground. Lateral changes in terrain conductivity can indicate the presence of disturbed ground, disposal areas, buried metallic and non-metallic waste, and impacted ground water. In addition, the method is also useful in detecting linear objects such as utilities.

A Geonics EM31-MK2 was used to conduct the survey. The EM31 operates in accordance with the theory of operation at low induction numbers. An alternating current is passed through a transmitter coil to induce eddy currents into the ground below the instrument. These eddy currents generate a secondary magnetic field. The quadrature-phase component of the induced secondary magnetic field is detected by a receiver coil and measured by the instrument. The measured response is linearly related to the terrain conductivity. The instrument converts the measured signal and displays it as terrain conductivity in millisiemens per meter (mS/m)[1].

For this investigation, EM31 data were recorded approximately at 2-ft intervals along lines spaced approximately 20 ft apart. Higher resolution coverage was completed in selected target areas using a 5-ft line spacing. Line and station separation sometimes varied depending upon surface obstructions such as cultural interference (for example, above-ground metal objects and overhead power lines), buildings, and dense vegetation. Geodetic coordinates were recorded at 1-s intervals using an integrated GPS. A base station free from cultural interference was occupied at the beginning and end of each survey day to calibrate the instrument and perform system functional tests. During these tests, battery, phasing, and sensitivity checks were performed.

[1]Siemen: A unit of electrical conductivity; the reciprocal of ohm. Also called mho.

4.3. *HIGH-SENSITIVITY METAL DETECTOR*

Buried metal objects can be effectively located using a Geonics EM61-MK2 High-Sensitivity Metal Detector. The EM61 is a time domain electromagnetic (EM) system that can discriminate between conductive soils and metal objects. It has numerous advantages over other commonly used metal detection devices. For example, it is significantly less sensitive to cultural interference.

The EM61 generates rapid electromagnetic pulses and measures the response of the subsurface between pulses. Secondary EM fields are generated in the ground after each pulse. These fields dissipate rapidly in earth materials but remain for a longer time in buried metal objects. The EM61 measures the prolonged metal response only after the earth response has dissipated. This response is measured and displayed in milliVolts (mV).

The EM61 uses a portable time-domain transmitter and two receiver coils. The data received from the second receiver coil can be used to reduce the unwanted effects from interference and near-surface objects that can mask deeper and more significant objects.

Very high-resolution data are automatically recorded as the sensors are pulled along the ground surface. Survey wheels attached to the sensors facilitate data collection by allowing direct measurement of the distance traveled. The lateral position of each measurement is automatically recorded using a data logger. This method allows data to be recorded virtually as fast as the operator can walk.

For this investigation, data were collected at less than 2-ft intervals along lines spaced approximately 20 ft apart. Higher resolution coverage was completed in selected areas using a 5-ft line spacing. Line and station separation sometimes varied depending upon surface obstructions such as buildings and dense vegetation. Geodetic coordinates were recorded at 1-s intervals using an integrated GPS so each measurement point could be accurately located.

4.4. *GROUND PENETRATING RADAR*

The GPR technique uses the transmission and reflection of radio waves to image objects beneath the ground surface. The technique responds to changes in the electrical properties of the earth or buried materials. A GPR target must possess electrical characteristics that are different from the surrounding media in order to be detected. When the transmitted wave encounters an anomalous object or layer, the wave is reflected back to the surface where it is recorded and analyzed. The waves are transmitted rapidly such that a continuous subsurface image is generated as the transmitter is pulled along the ground surface.

The GPR survey was performed using a digital SIR-2 Subsurface Interface Radar System, manufactured by Geophysical Survey Systems, Inc. Following initial field tests to determine maximum penetration and sufficient resolution, a 400 MHz transducer was chosen to perform the detailed survey. A 200 MHz transducer was used in an attempt to provide greater penetration depths at MDA V. Data were digitally recorded, displayed, and analyzed during acquisition to allow real-time interpretation. Line locations were chosen based on EM anomaly location and surface obstructions.

In-field signal velocity calculations and depth calibrations were performed by recording two-way signal travel times over objects with known depths. In addition, hyperbolic fitting was performed by computer to calculate signal travel time and more accurately estimate target depths.

5.0 RESULTS AND DISCUSSION

5.1. *RECONNAISSANCE EM SURVEYS*

Plan maps of the EM31 and EM61 data are provided at the end of this report in Figure 31 and Figure 32. The eastern mesa top portion of the survey showed no significant evidence of buried structures or waste. The EM31 data show some anomalies attributed to subsurface geologic conditions. For example, these anomalies may be related to the channel exposed at the northern edge of DP Mesa. The far western portion of the reconnaissance surveys included the open area west of MDA B. This area is characterized by numerous linear anomalies that trend in both the north-south and east-west directions. The character and magnitude of these anomalies indicate that they are caused by buried utilities associated with the former trailer park. It was beyond the scope of work of this investigation to map all the utilities in this area.

5.2. *DETAILED SURVEYS AT SOLID WASTE MANAGEMENT UNITS (SWMUs)*

5.2.1. General Comments on Detectability of Targets

The detectability of a target is largely a function of the contrast in the measured physical properties between the target and surrounding materials. The vast majority of the specific targets at the SWMUs were nonmetallic items such as terra cotta, vitrified clay, and concrete pipes, as well as concrete sumps and septic tanks. These items have very similar physical properties compared to the surrounding earth or fill materials. For this reason, the targets observed in the geophysical data were mostly subtle and difficult to image. Nevertheless, other subsurface features associated with the buried targets improved the ability to map the target. For example, a specific terra-cotta pipe may occasionally appear invisible in GPR profiles. However, the excavation associated with the pipe may appear as a narrow discontinuity in otherwise horizontal layering or as a narrow zone of chaotic reflections associated with disturbed fill materials. Therefore, in some cases, the specific pipe could not be observed and a depth could not be determined, but the pipe route could be mapped.

As with the GPR method, the EM methods respond to changes in electrical properties. Therefore, similar difficulties are encountered when surveying for nonmetallic items. The sensitivity of EM techniques to cultural interference from nearby structures, fences, and power lines further reduce the detectability of nonmetallic targets in congested areas.

These difficulties notwithstanding, the integrated use of multiple techniques resulted in the successful identification and mapping of the majority of the targets listed in the objectives.

5.2.2. SWMU 21-006 (a), (c) & (d)

❖ <u>OBJECTIVE:</u>

- Locate seepage pit between Building 21-02 and removed Building 21-03

❖ <u>RESULTS:</u>

The suspected location of SWMU 21-006 is shown on the plan location map in Figure 1.[2] Historical information suggests the pit (or pits) is located on either the north or south side of the corridor connecting Buildings 21-02 and 21-03. The EM data collected over this SWMU was limited to the south side of the building corridor due to the large debris pile that remained on the north following the demolition of Building 21-3. A plan map of the EM31 data is shown in Figure 2. It indicates the presence of metal utilities and cultural interference from the existing structures, however, no anomalies were observed that would indicate the presence of a seepage pit. Similarly, GPR data were acquired over the suspected locations and revealed the presence of disturbed subsurface materials (presumably associated with the demolition of the existing buildings) but no anomalies that would suggest the presence of the seepage pit was observed.

A large buried concrete structure that appeared to be a settling tank was observed southeast of Building 21-02. Photographs of this structure are shown in Figure 3. The inlet and outlet line from this tank were mapped using GPR and the locations of these lines are shown in Figure 4.

After completion of the field effort, the possible presence of a former acid pit was uncovered while ARM was reviewing the historical drawings. The pit is shown on engineering drawing ENG-R5113 Sheet 3. It is unclear whether the acid pit shown on this drawing is the same as the seepage pit associated with SWMU 21-006.

Finally, a previous investigation to locate a seepage pit was performed by GTS Duratek in October 1999.[3] The results of their investigation indicated that the missing seepage pit is probably located beneath the posted radiological area located south of Building 21-03 that is currently posted as a contaminated area. Figure 5 presents a photograph of the posted area.

[2] Plan maps of the detected targets in each SWMU are shown along with the geodetic reference points at specific targets. The coordinates of these reference points are listed on the figures to facilitate target relocation if required in the future.

[3] *GTS Duratek*, Report on TA-21 Surveys for: SWMU 21-006, Underground Seepage Pits between Buildings 2 and 3; SWMU 21-023, Decommissioned Septic Systems in Building 3; and SWMU 21-028(b), Active Container Storage Areas in Building 150: October 1999, pg. 38.

5.2.3. SWMU 21-009

❖ *OBJECTIVES:*

- Locate footprint of Building 21-33
- Locate any pipelines within the footprint of Building 21-33
- Locate 1-inch-diameter gas line that exits Building 21-33 and trends south

❖ *RESULTS:*

The EM data shows no evidence of buried metal objects or anomalous materials that would suggest the location of former Building 21-33. GPR data were acquired at the suspected building location and revealed the presence of a thin layer of disturbed materials. This disturbance is likely associated with the construction or demolition of the former building. The interpreted location of former Building 21-33 is shown in green as SWMU 21-009 of Figure 6.

In addition to the EM and GPR techniques, the radiofrequency pipe locator was used to locate any buried utilities that may exist within the footprint of the former building. A remaining segment of the industrial waste line was located within the footprint as shown in Figure 6. Additional pipe segments were detected during the EM surveys as shown on Figure 6, however none of the geophysical methods revealed any evidence of the former 1-inch-diameter gas line thought to exit Building 21-33.

5.2.4. SWMU 21-012 (b)

❖ *OBJECTIVES:*

- Locate pits 21-266 and 21-267
- Locate inlet lines from Building 21-9 to pits 21-266 and 21-267, and the outlet lines to the blow down tank
- Locate seepage pit and dry well just south of the blow down tank
- Locate 6-inch-diameter steel and/or VCP pipe that runs south from pits 21-266 and 21-267 to the mesa edge

❖ *RESULTS:*

Figure 7 shows the location of the former steam plant (21-9) and pits 21-266 and 21-267 based on engineering drawing ENG-R5113. The former locations of these pits appear to be coincident with the existing steam lines that were installed after the former steam plant was removed. For this reason, it is likely the former pits were also removed or disturbed during the installation of the steam lines. GPR data were acquired at the former steam plant and suspected pit locations. These data showed no evidence of anomalies that could be confidently attributed to the pits. Similarly, the inlet lines were not observed between the former building, pits, and blow down tank.

GPR data acquired south of the former pits showed evidence of former excavations or disturbance and the presence of contrasting buried materials. The locations of these anomalies were coincident with the suspected locations of the former seepage pit and dry well that were located south of the former blow down tank. The locations of these anomalies are shown in Figure 7. An example radar record of the anomalies is presented in Figure 8. Figure 9 presents a photograph of the anomaly locations.

Two metal pipes (Figure 7) that run south of the former steam plant area were observed in the EM and pipe locator data, as well as from surface observations. These pipes are exposed near the fence line at the southern edge of the mesa. These exposures allowed direct connection with the pipe locator transmitter thus improving the ability to trace these lines. The configuration of these lines suggests they were associated with former pits 21-266 and 21-267 since they appear to converge near these locations.

5.2.5. SWMU 21-022 (a)

❖ *OBJECTIVE:*

- Locate Sump 21-74
- Locate inlet line from Building 21-21 to Sump 21-74
- Locate line(s) east of sump to Building

❖ *RESULTS*

Sump 21-74 was visually located on the north side of Building 21-21. The sump is covered with an aluminum or stainless steel lid. Inside the sump is a large vessel or settling tank presumably used to separate sediments from effluent. Sump 21-74 is shown in the photograph in Figure 10. A small diameter (approximately ¾-inch) copper inlet line is present on the building side of the sump. The line protrudes through a larger diameter hole that appears to have been filled in with concrete and brick fragments. The copper line was successfully traced from the sump to Building 21-21. However, the outlet line on the east side of the sump could not be traced. Ground penetrating radar showed disturbed subsurface materials, but the outlet pipe itself was not observed. Figure 11 presents a plan map of the targets located.

Two additional northeast/southwest trending pipelines were observed east of the sump area. The line closest to the sump appeared to be only a segment that could not be associated with any visible structures of the surface. This segment may be associated with SWMU 21-024 (l). The other line located near the northeast corner of the building was underground from the building to the fence line and aboveground from the fence line to Tank 21-335.

5.2.6. SWMU 21-022 (f)

❖ *OBJECTIVES:*

- Locate Sump 21-173
- Locate Manhole 21-221
- Locate 6-inch-diameter steel pipeline between Sump 21-173 and MDA U

❖ *RESULTS:*

Sump 21-173 and Manhole 21-221 were visually located near the northeast corner of Building 21-152. The area was surveyed using EM, GPR, and pipe locator techniques to locate the suspected 6-inch-diameter steel pipeline that allegedly extends between the sump and MDA U to the north. No evidence of the pipe was observed using any of the techniques. Historical information discovered after the survey was performed indicated the pipe had been removed prior to 1985. Figure 12 presents a plan map of the targets identified at SWMU 21-022(f).

5.2.7. SWMU 21-022 (h)

❖ *OBJECTIVES:*

- Locate Sump 21-202
- Locate 6-inch-diameter pipeline to outfall

❖ *RESULTS:*

Sump 21-202 was visually located near the southeast corner of Building 21-150. The pipeline was traced using GPR. An example radar record of the pipe is shown in Figure 13. The outfall was visually located at the edge of the mesa. The locations of the targets identified in this area are shown in Figure 14.

5.2.8. SWMU 21-022 (i)

❖ *OBJECTIVES:*

- Locate sump
- Locate any pipelines from sump

❖ *RESULTS:*

This area was surveyed using EM, GPR, and pipe locator techniques. No evidence of the sump or associated pipelines was observed at the locations shown on historical maps (TA-21 Operable Units RFI Work Plan for ER, May 1991). However, a buried concrete structure that appeared to be a settling pit was observed southeast of Building 21-02. Photographs of this structure are shown in Figure 3. The inlet and outlet line from this pit were mapped using GPR and the locations of these lines are shown in Figure 4.

5.2.9. SWMU 21-022 (j)

❖ *OBJECTIVES:*

- Locate sump
- Locate any pipelines from sump

❖ *RESULTS:*

This area was completely covered using EM, GPR, and pipe locator techniques. No evidence of the sump or associated pipelines was observed at the locations shown on historical maps (TA-21 Operable Units RFI Work Plan for ER, May 1991). However, the suspected location shown on the maps is very close to the posted contaminated area shown in Figure 4 and therefore may be related.

5.2.10. SWMU 21-024 (a)

❖ *OBJECTIVES:*

- Locate septic Tank 21-53
- Locate pipeline from Building 21-09 to Tank 21-53
- Locate pipeline from Tank 21-53 to outfall

❖ *RESULTS:*

The location of Tank 21-53 is marked in the field by a sign as shown in the photograph in Figure 15. A portion of the top of the tank is exposed. The remaining lateral boundaries were mapped using GPR. An example GPR record of the tank is shown in Figure 16. The tank location is shown in Figure 7. The outlet line was traced approximately 25 feet south of the tank where it was no longer observed in the radar record. Similarly, the inlet line was traced from the tank to approximately 75 feet north where the line appeared to be truncated.

5.2.11. SWMU 21-024 (b)

❖ *OBJECTIVES:*

- Locate septic Tank 21-55
- Locate pipeline from between Buildings 21-04 and 21-05 to Tank 21-55
- Locate pipeline from Tank 21-55 to outfall

❖ *RESULTS:*

Tank 21-55 was observed south of Building 21-05 and on the south side of the paved access road. The sign formerly used to mark the tank location was discovered partially buried in the debris nearby. A void was observed at the tank location that suggests that the cover of the tank is at least partially off. Figure 17 presents a photograph of the tank site. The tank boundaries were delineated using GPR. The inlet line was traced from the tank to Building 21-116. An example radar profile of the inlet pipe is shown in Figure 18. The locations of the tank and inlet line are shown in Figure 14. Neither outlet line nor outfall was observed.

5.2.12. SWMU 21-024 (c)

❖ *OBJECTIVES:*

- Locate septic Tank 21-56
- Locate pipeline from Building 21-54 to Tank 21-56
- Locate pipeline from Tank 21-56 to outfall
- Locate pipeline from Building 21-61 east to pipeline from Building 21-54
- Locate any pipeline extension to the east of intersection with Building 21-54 pipe

❖ *RESULTS:*

Tank 21-56 was located inside the perimeter fence southeast of the former Steam Plant (21-9). The sign marking the location of the structure was noted on the nearby fence as shown in Figure 19. The tank boundaries as well as the inlet and outlet lines were mapped using GPR. The outfall was visually located at the edge of the canyon. Figure 7 presents a plan map of the area.

5.2.13. SWMU 21-024 (d)

❖ *OBJECTIVES:*

- Locate septic Tank 21-106
- Locate main pipeline from Building 21-01 to Tank 21-106
- Locate pipeline from Tank 21-106 to outfall
- Locate diagonal 6-inch-diameter VCP line from Building 21-01 to main pipeline
- Locate any pipes that exit south from boiler room that intersect main pipeline

❖ *RESULTS:*

Septic Tank 21-106 was located south of former Building 21-01 and outside the perimeter fence. A corner of the concrete tank as well as the outfall were exposed and visually located. The lateral extent of the tank and the location of the inlet line were mapped using GPR. Although the inlet line was not directly observed on the radar records, the trench dug to install the line appeared as a lateral disruption or discontinuity in subsurface layering that allowed the line path to be traced. The diagonal 6-inch-diameter VCP line from Building 21-01 could not be confidently traced. Additional linear anomalies that were also attributed to buried pipes were mapped both to the east and to the west of the main inlet line as shown in Figure 4, but no pipes intersecting the main pipeline were identified.

5.2.14. SWMU 21-024 (e)

❖ *OBJECTIVES:*

- Locate septic Tank 21-123
- Locate pipeline from Building 21-20 to Tank 21-123
- Locate pipeline from Tank 21-123 to outfall

❖ *RESULTS:*

Tank 21-123 was initially located using EM61. This tank appears to be metal based on the strong EM response. This is supported by the strong radar reflections that were acquired over the tank. The GPR data were used to more accurately map the lateral extent of the tank. Figure 20 presents an example radar profile acquired over the tank. A photograph of the tank location is presented in Figure 21. GPR was also used to trace the inlet line from the tank towards the former laundry building. Although the inlet line was successfully traced to the chain-link fence bounding the west side of MDA V, it was not observed on the northern side. The outlet line and outfall from the tank were not observed. A plan map showing the location of the targets observed is presented in Figure 6.

5.2.15. SWMU 21-024 (g)

❖ *OBJECTIVES:*

- Locate pipeline from Building 21-07 to 21-31
- Locate pipeline from Building 21-31 to septic Tank 21-125
- Locate septic Tank 21-125
- Locate pipeline from septic tank to leach field
- Locate pipeline from leach field to outfall

❖ *RESULTS:*

The pipeline that extends from Building 21-31 to Building 21-07 was observed in radar profiles acquired on the south side of Building 21-31. The estimated depth to the pipe based on the GPR data is approximately 4 feet. The length of the pipe segment is approximately 80 feet.

Septic Tank 21-125 was observed north side of Building 21-31 on the opposite side of the access road. The estimated size of the tank is approximately 6 feet by 8 feet. The depth to the top of the tank appears to be approximately 4.5 feet. No anomaly was observed near the tank that could be confidently attributed to a leach field. Similarly, no inlet or outlet line to the tank was observed.

An example radar profile of both the tank and the pipeline between Building 21-31 and 21-07 is shown in Figure 22. A photograph of the interpreted tank boundaries is shown in Figure 23. Figure 24 presents a plan map of the targets located at SWMU 21-024(g).

5.2.16. SWMU 21-024 (h)

❖ *OBJECTIVES:*

- Locate pipeline from Building 21-151 to septic Tank 21-163
- Locate pipeline from Building 21-152 to septic Tank 21-163
- Locate septic Tank 21-163
- Locate pipeline from septic tank to outfall

❖ RESULTS:

A GPR anomaly attributed to septic Tank 21-163 was observed northwest of Building 21-155. The estimated size of the tank is approximately 6 feet by 14 feet. The depth of the top of the tank is estimated at approximately 3 feet. The inlet line from Building 21-152 was mapped using GPR. The line location was corroborated by cleanouts located at each bend in the line. The actual depth of the line could not be determined by radar since it was not clearly observed in the records. Instead, the pipeline route was interpreted based on disturbances associated with the excavation for the pipeline. The route of the former inlet line from Building 21-151 was mapped in a similar way. However, no outlet line or outfall was observed. Figure 12 presents a plan map of the targets identified at SWMU 21-024(h)

5.2.17. SWMU 21-024 (i)

❖ OBJECTIVES:

- Locate pipeline from Building 21-209 to chain link fence

❖ RESULTS:

The inlet line was traced approximately 125 feet from the former tank location near the TSTA perimeter fence to Building 21-209. Reflections from the actual pipe were not clearly observed in the radar data. Lateral discontinuities and chaotic reflection events associated with the former excavation were used to infer the pipe route. The interpreted location of the pipe is shown in Figure 25.

5.2.18. SWMU 21-024 (j)

❖ OBJECTIVES:

- Locate pipeline from Building 21-155 to septic Tank 21-194
- Locate septic Tank 21-194
- Locate pipeline from septic tank to outfall

❖ RESULTS:

Septic Tank 21-194 was not observed in the geophysical data. The data acquired from the suspected location indicated highly disturbed subsurface conditions. Based on these data it appears that the tank has been removed. However, the inlet and outlet line to the tank appear intact. Radar records indicate that pipes exists in the suspected locations of the former inlet and outlet lines. The approximate depths to the suspected pipes range from approximately 2 to 3 feet. The outfall was visually located at the edge of the canyon. Figure 25 presents of map showing the features identified at SWMU 21-024 (j).

5.2.19. SWMU 21-024 (k)

- *OBJECTIVES:*

- Locate pipeline from Building 21-209 to Manhole 21-217
- Locate Manhole 21-217
- Locate pipeline to Manhole 21-218
- Locate Manhole 21-218
- Locate pipeline from Manhole 21-218 to septic Tank 21-219
- Locate septic Tank 21-219
- Locate pipeline from septic tank to tile leach field
- Locate tile leach field
- Locate both pipelines from tile leach field to outfall

- *RESULTS:*

Manholes 217 to 218 were visually located. Their geodetic coordinates were measured using GPS and their position is shown in Figure 25. The pipeline was not observed in the GPR data; however, the observed disturbances associated with the former excavation were used to infer its location. A portion of the septic tank was exposed and could be visually identified. The remaining boundaries of the septic tank were mapped using GPS. The leach field was delineated using GPR by mapping the extent of the disturbed materials. The laterals or pipes within the leach field were not clearly observed in the GPR data. Only one outfall from the suspected leach field was observed as shown in Figure 25. Figure 26 presents a photograph of the interpreted location of the tank and leach field.

5.2.20. SWMU 21-024 (l)

- *OBJECTIVES:*

- Locate pipeline from Building 21-20 north to outfall

- *RESULTS:*

A pipeline was detected on the north side of Building 21-20 that may be associated with the pipe from the floor and drain in the building. Figure 11 shows the location of the detected pipe.

5.2.21. SWMU 21-024 (n)

❖ *OBJECTIVES:*

- Locate pipeline from Building 21-155 to outfall

❖ *RESULTS:*

Figure 12 shows a location of pipelines detected near SWMU 21-024 (n). One cast-iron pipe was detected at the northwest corner of Building 21-155. The outfall of the pipe was observed approximately 10 feet west of Building 21-213.

5.2.22. SWMU 21-024 (o)

❖ *OBJECTIVES:*

- Locate pipeline from Building 21-46 south to outfall
- Locate pipeline from Building 21-14 to septic Tank 21-123
- Locate pipeline from Building 21-14 to grease trap
- Locate grease trap on south side of Building 21-14
- Locate any pipelines that connect from above ground diesel tank to buildings or pipelines
- Locate any lines from the clean oil tank next to diesel tank
- Locate valve box between diesel tank and oil tank

❖ *RESULTS:*

Figure 27 presents a plan map of the SWMU 21-024(o) area. Two pipelines were observed extending from the Tank 21-123 (SWMU 21-024(e)) area towards Buildings 21-14 and 21-46. However, they appeared to be discontinuous suggesting only segments remain. The GPR data acquired near the buildings exhibited chaotic reflection events that suggested the presence of fill materials or demolition debris. No evidence of a grease trap was observed on the south side of Building 21-14. Similarly, no pipelines or valve boxes were observed that could be attributed or associated with the former above ground diesel tank.

5.2.23. SWMU 21-027 (a)

❖ <u>OBJECTIVES:</u>

- Locate pipelines under paved area south of Building 21-03 and northwest of former Cooling Tower 143

❖ <u>RESULTS:</u>

The segment of pipe remaining beneath the paved area was detected using GPR. The location of the segment is shown in Figure 4.

5.2.24. SWMU 21-027 (c)

❖ <u>OBJECTIVES:</u>

- Locate pipeline from former Building 21-06 south to possible surface exposure

❖ <u>RESULTS:</u>

A pipe segment was observed near the southeast corner of former Building 21-06. The location of the pipe segment is shown in Figure 4. Neither outfall nor surface exposure was observed.

5.3. *INDUSTRIAL WASTE LINE*

The industrial waste line was located using the radiofrequency pipe locator. The response from the pipe was strong and consistent and it was unnecessary to use a direct connection to the tracer wire or the pipe itself. The mapped location is shown in Figure 28. The estimated depth to the line varies from 3 to 4.5 feet.

5.4. *UTILITY CORRIDOR NORTH OF BUILDINGS 21-02 THROUGH 21-05*

Utilities were mapped along a corridor believed to contain numerous utilities associated with buildings 21-02 through 21-05. Surveys were performed using EM, GPR, and radio-frequency pipe locator to detect the presence of pipes. The locations of the detected utilities are shown in Figure 29. Many of the utilities detected appeared to be segments presumably associated with former structures. The type or use of the pipes could not be determined by the geophysical data. However, a fire protection (water) main was identified since features at the surface such as valves and fire hydrants could be visually located.

5.5. *MATERIAL DISPOSAL AREA (MDA) V*

Terrain conductivity (EM31) data were acquired over MDA V to map lateral changes in electrical conductivity that may be associated with the former beds. Figure 30 presents a plan map of the EM31 data. The results show several very subtle linear features that are probably associated with the former beds. The magnitude of these anomalies is small with only a difference of 2 or 3 mS/m between the anomaly and surrounding materials.

The most obvious linear anomaly is located in the center of the MDA and is coincident with central bed shown on historical drawings. A similar linear anomaly is located near the northwest corner of the area. It is parallel tó the central anomaly but only the western portion is observed. The fact that it is not observed at the eastern end may be the result of the in situ vitrification processes performed at this location. It is likely that this process homogenized the physical character of all in buried materials at this location. Similarly, the southernmost linear anomaly could only be observed in the western portion. Finally, a north-south trending linear anomaly appears to connect the remaining anomalies that run parallel to the absorption beds.

Several other linear EM anomalies attributed to buried pipes were observed north of MDA V, but are considered associated with the former absorption beds. One pipe is observed near the northern corner of the MDA V fence. Two other suspected pipes are observed between MDA V and the former laundry building. These suspected pipes are coincident with drain lines shown on historical drawings that run from the former laundry building to the former absorption beds

Ground penetrating radar data were acquired using both 200 MHz and 400 MHz antennas. The results were inconclusive since no consistent anomalies attributable to the absorption beds were observed. It is likely that the boundaries of the former absorption beds could not be observed in the radar data due to insufficient contrasts and electrical properties between the absorption bed materials and surrounding sediments. However, subtle anomalies attributed to former piping were observed near the same locations as pipes identified with EM data, as shown in Figure 30.

The interpreted locations of the former absorption bed boundaries as well as suspected pipes are shown in Figure 30. Geophysical data for the eastern portion of MDA V was not as clear as data for the western portion. There is no conclusive evidence for the differences between the eastern and western portions of the MDA, however it may be due to a combination of several factors, including the in situ vitrification process performed there. In addition to interferences from in situ vitrification discussed above, the portions of the absorption beds and boundaries located closest to the fence may be masked by interference from the surrounding chain-link fence.

6.0 CONCLUSIONS

The reconnaissance surveys performed over the eastern non-industrialized area showed no anomalies that could be confidently attributed to buried structures or waste. Only subtle anomalies related to potential buried bedrock channels and road-building materials were observed. The reconnaissance data from the western portion of the survey area showed numerous buried pipes, presumably associated with the former trailer park.

The detailed investigations performed over 24 SWMU locations successfully located numerous buried targets, including nonmetallic pipes and tanks. The targets were geographically located using a global positioning system. The coordinates of these targets are provided on the figures included with this report.

The location of the remaining segments of the industrial waste line was found using radio-frequency pipe locator. The estimated depth to the pipe based on the locators differential measurement system ranged from 3 to 4.5 feet.

Finally, the results from the survey performed at MDA V showed subtle linear anomalies associated with the former absorption beds. The central absorption bed was clearly observed in the EM data, and the western portions of the northern and southern absorption beds were also observed. Other linear anomalies observed in the EM data were attributed to buried pipes within the absorption bed and leading from the former laundry building to the absorption beds.

FIGURES

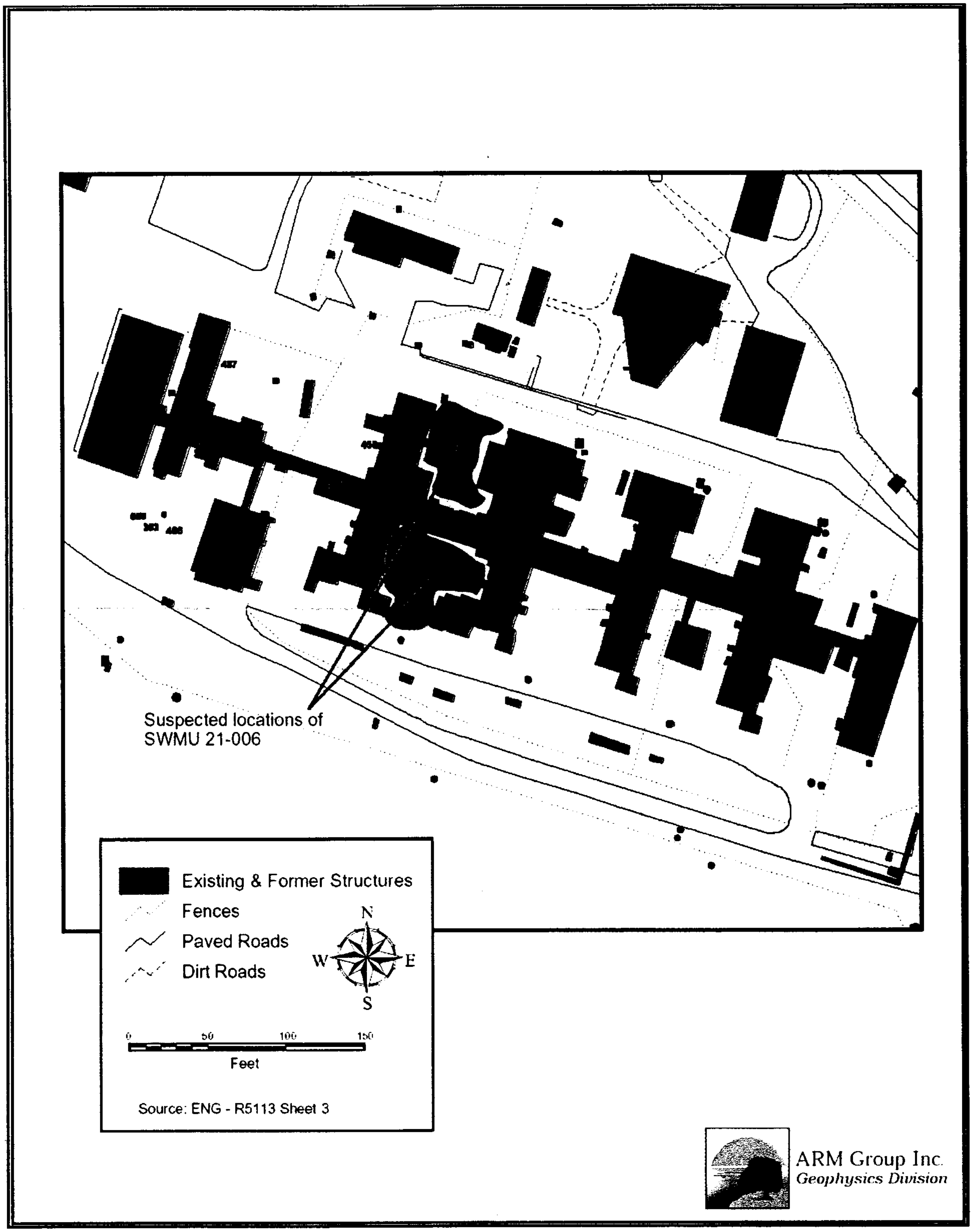


Figure 1: Suspected location of SWMU 21-006

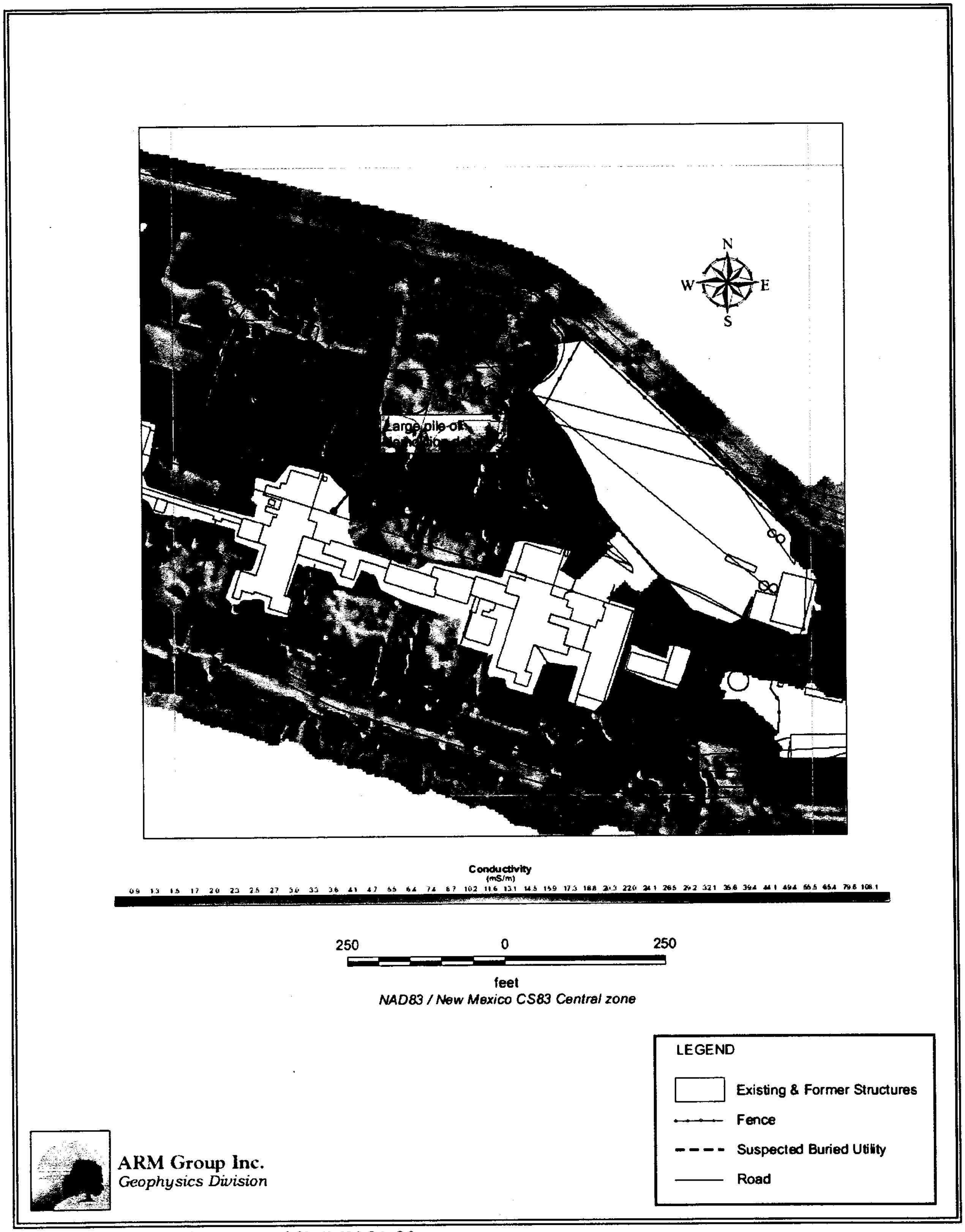
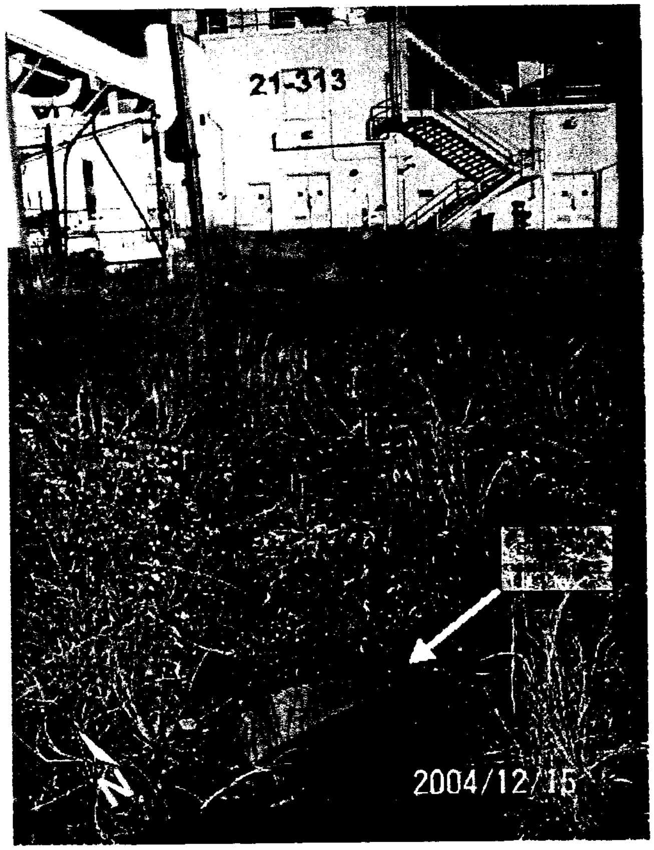


Figure 2 - EM31 plan map of SWMU 21-006 area

(A)



(B)

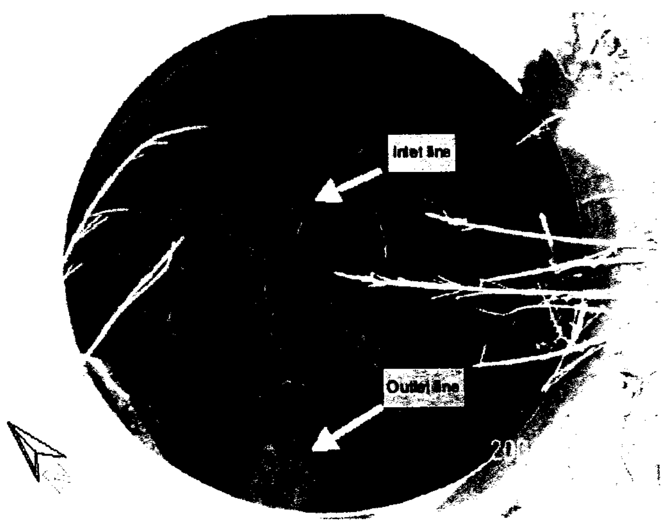


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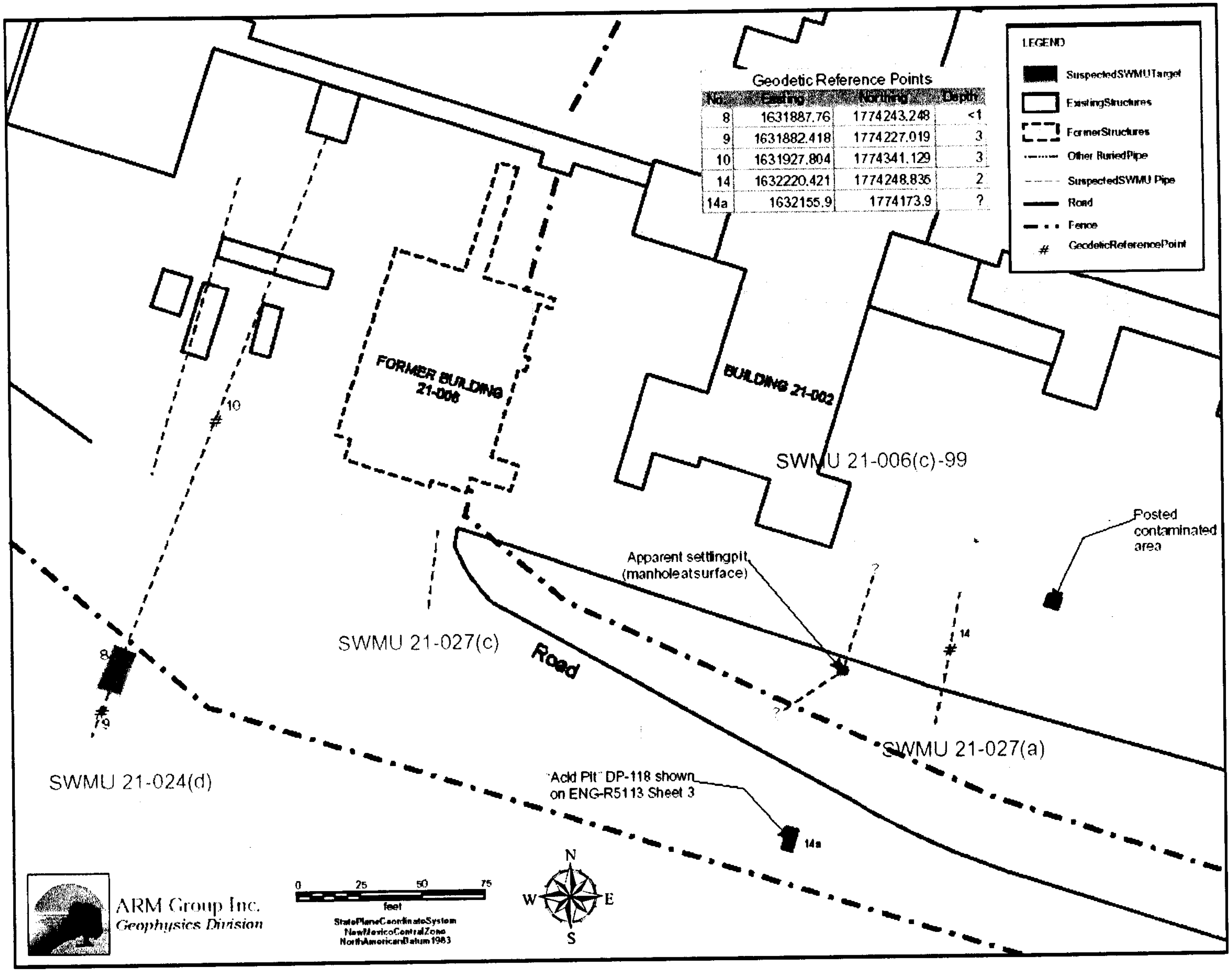
Figure 3 - Photographs of settling tank or sump observed south of Building 21-03



Geodetic Reference Points

No.	Easting	Northing	Depth
8	1631887.76	1774243.248	<1
9	1631882.418	1774227.019	3
10	1631927.804	1774341.129	3
14	1632220.421	1774248.835	2
14a	1632155.9	1774173.9	?

Figure 4: SWMU 21-024(d), 21-027(a) and 21-006 location map

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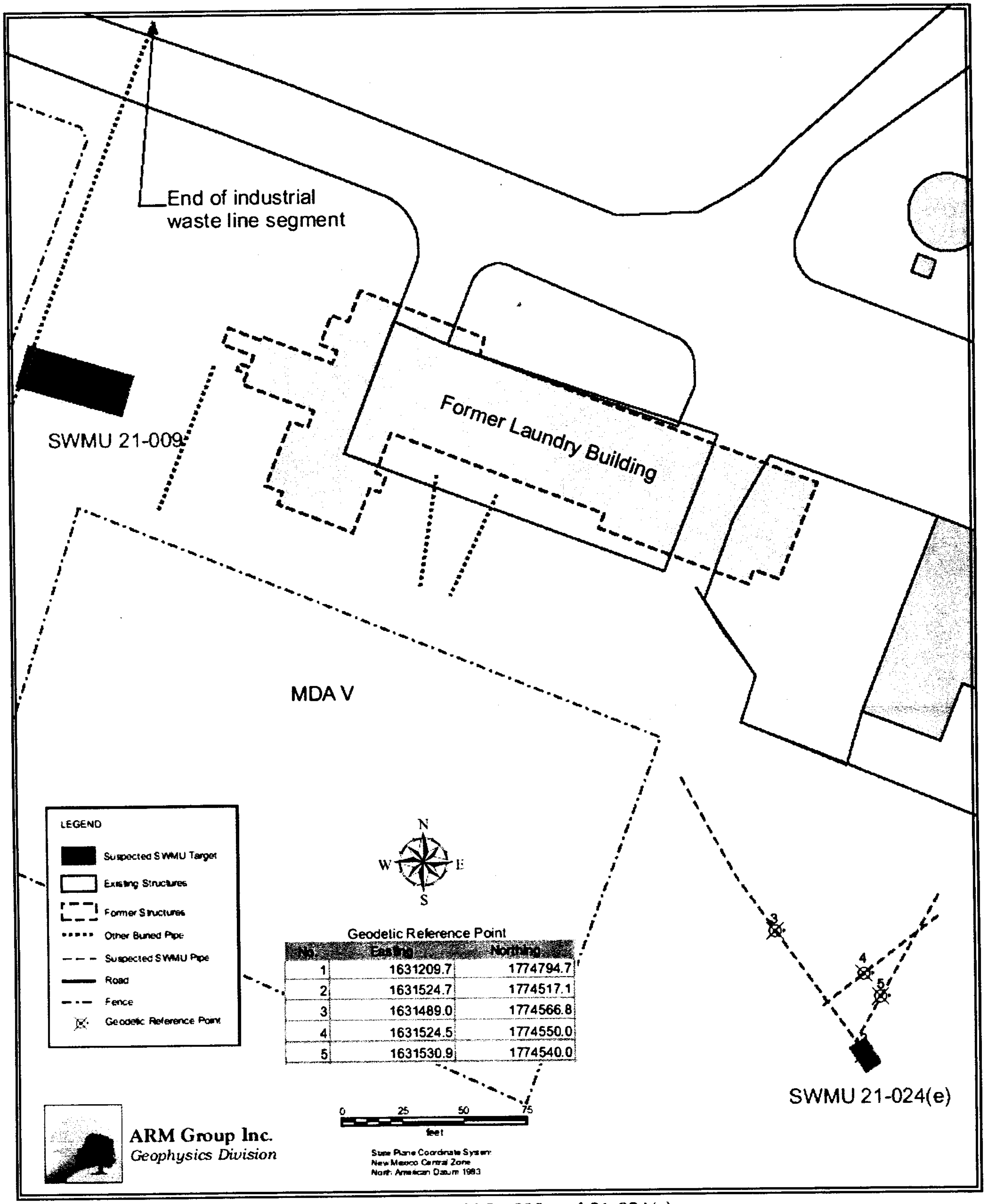
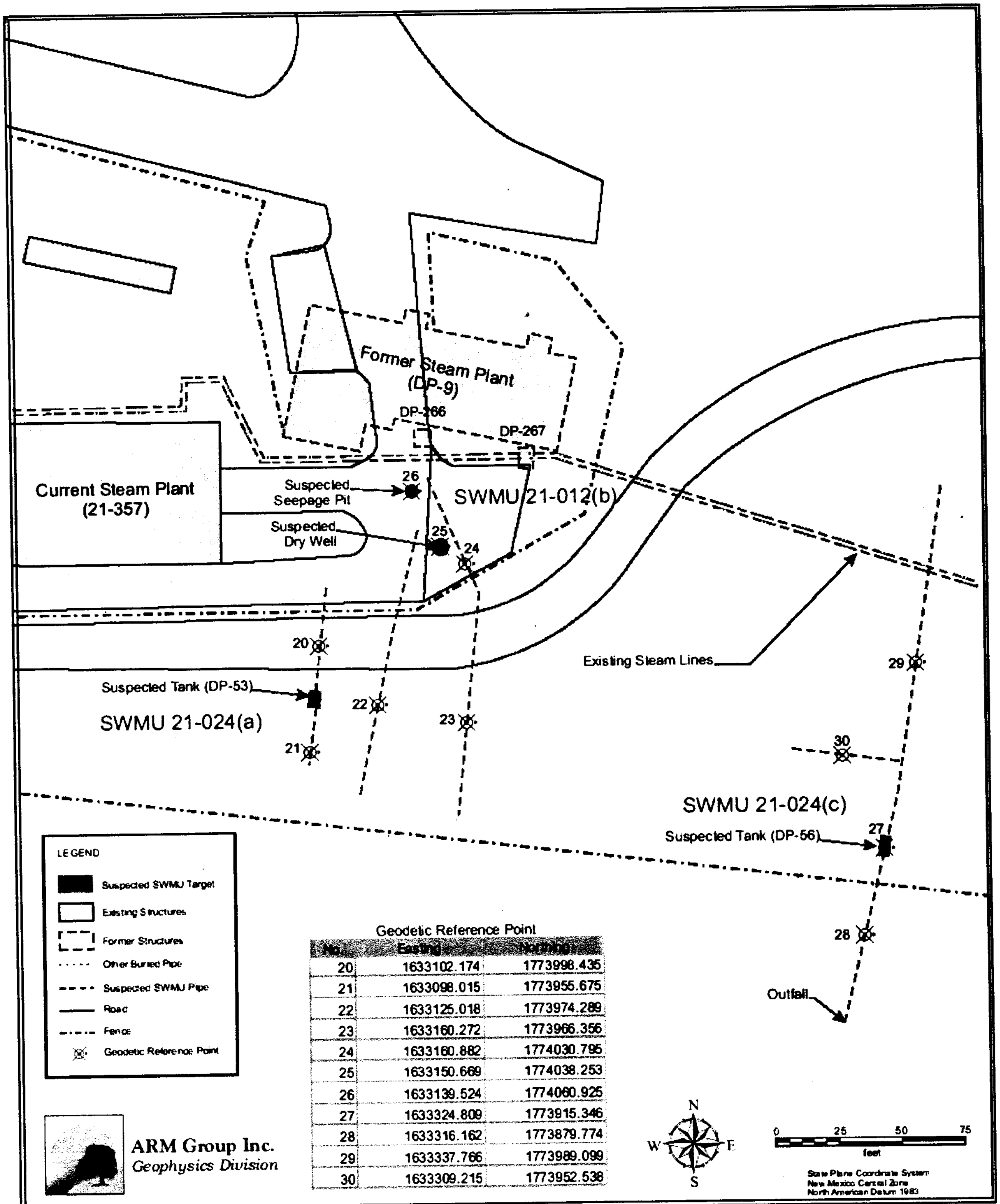
Figure 5 - Photograph of posted contaminated area south of Building 21-03



No.	Easting	Northing
1	1631209.7	1774794.7
2	1631524.7	1774517.1
3	1631489.0	1774566.8
4	1631524.5	1774550.0
5	1631530.9	1774540.0

Figure 6 - Plan map of targets identified at SWMU 21-009 and 21-024(e)

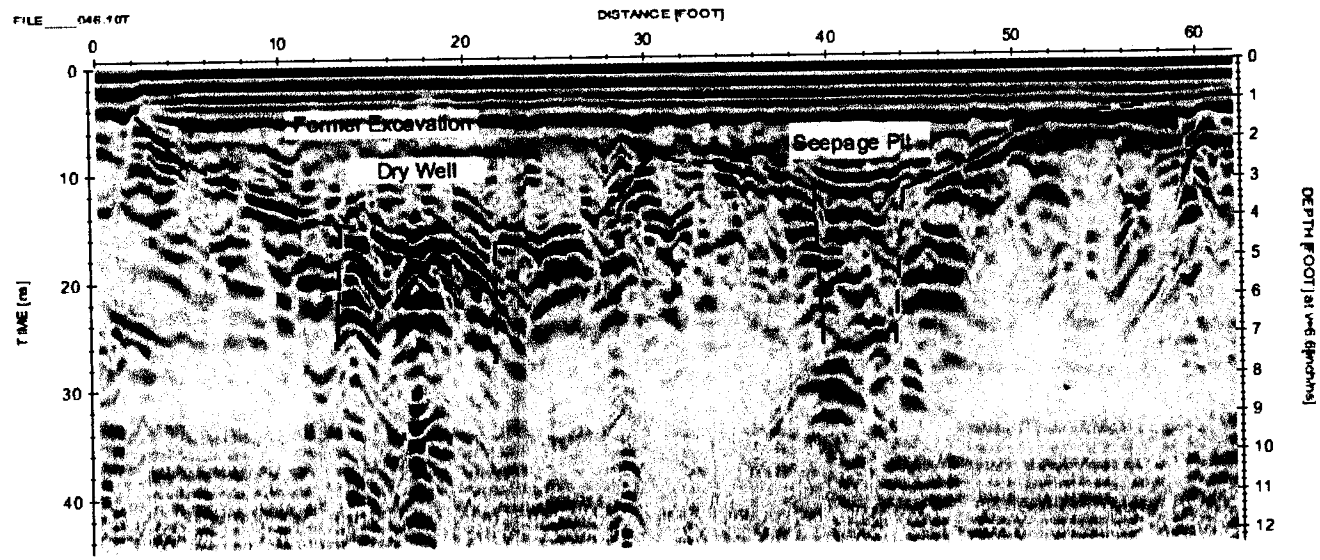


Geodetic Reference Point

No.	Easting	Northing
20	1633102.174	1773998.435
21	1633098.015	1773955.675
22	1633125.018	1773974.289
23	1633160.272	1773966.356
24	1633160.882	1774030.795
25	1633150.669	1774038.253
26	1633139.524	1774060.925
27	1633324.809	1773915.346
28	1633316.162	1773879.774
29	1633337.766	1773989.099
30	1633309.215	1773952.538

Figure 7 - Plan map of SWMU 21-012(b) area

SWMU 21-012(b)



Not to Scale

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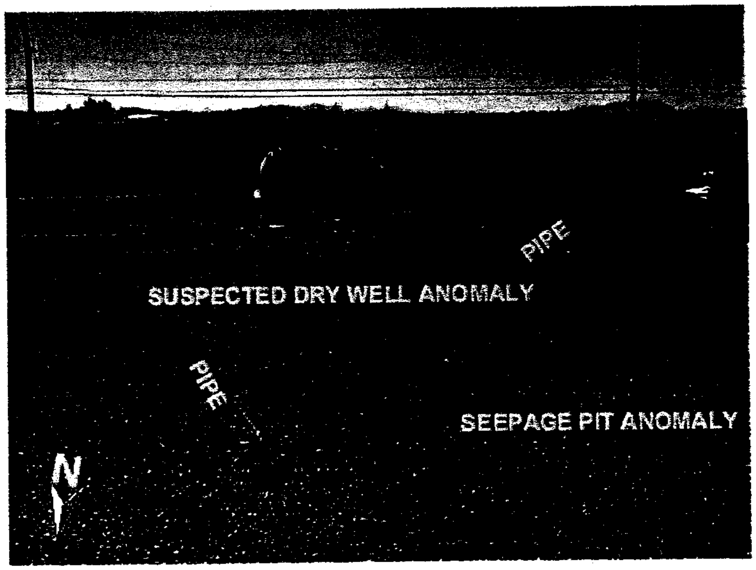
Figure 8 - Example radar record showing anomalies observed at SWMU 21-012(b)



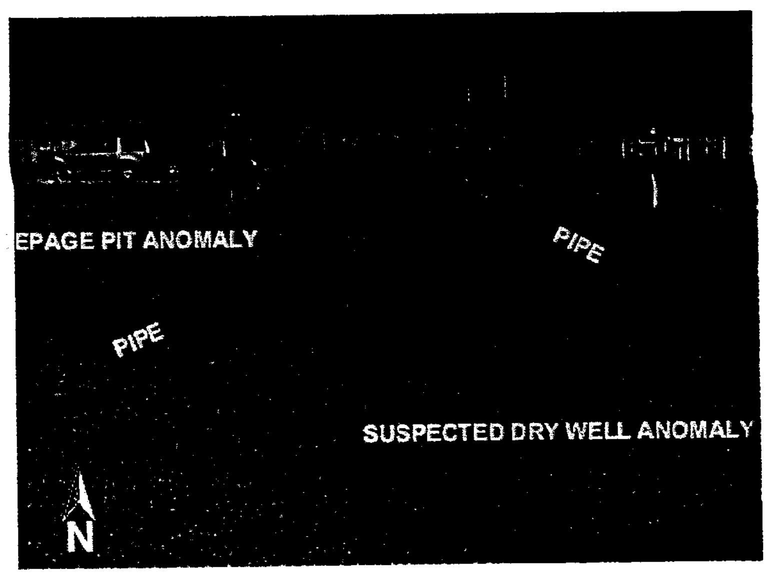


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Figure 9 - Photograph of SWMU 21-012(b) anomaly locations

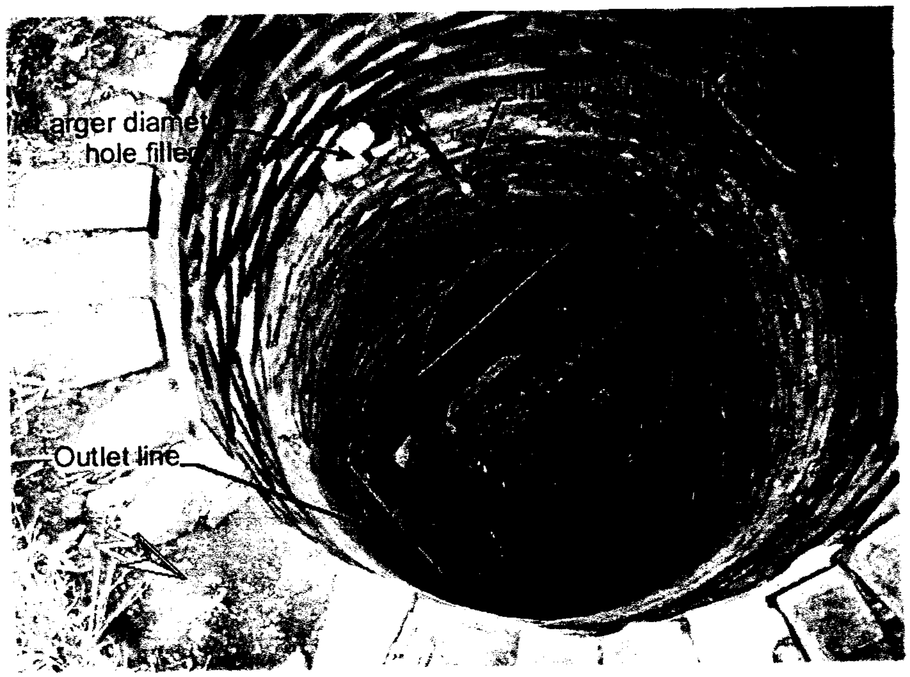

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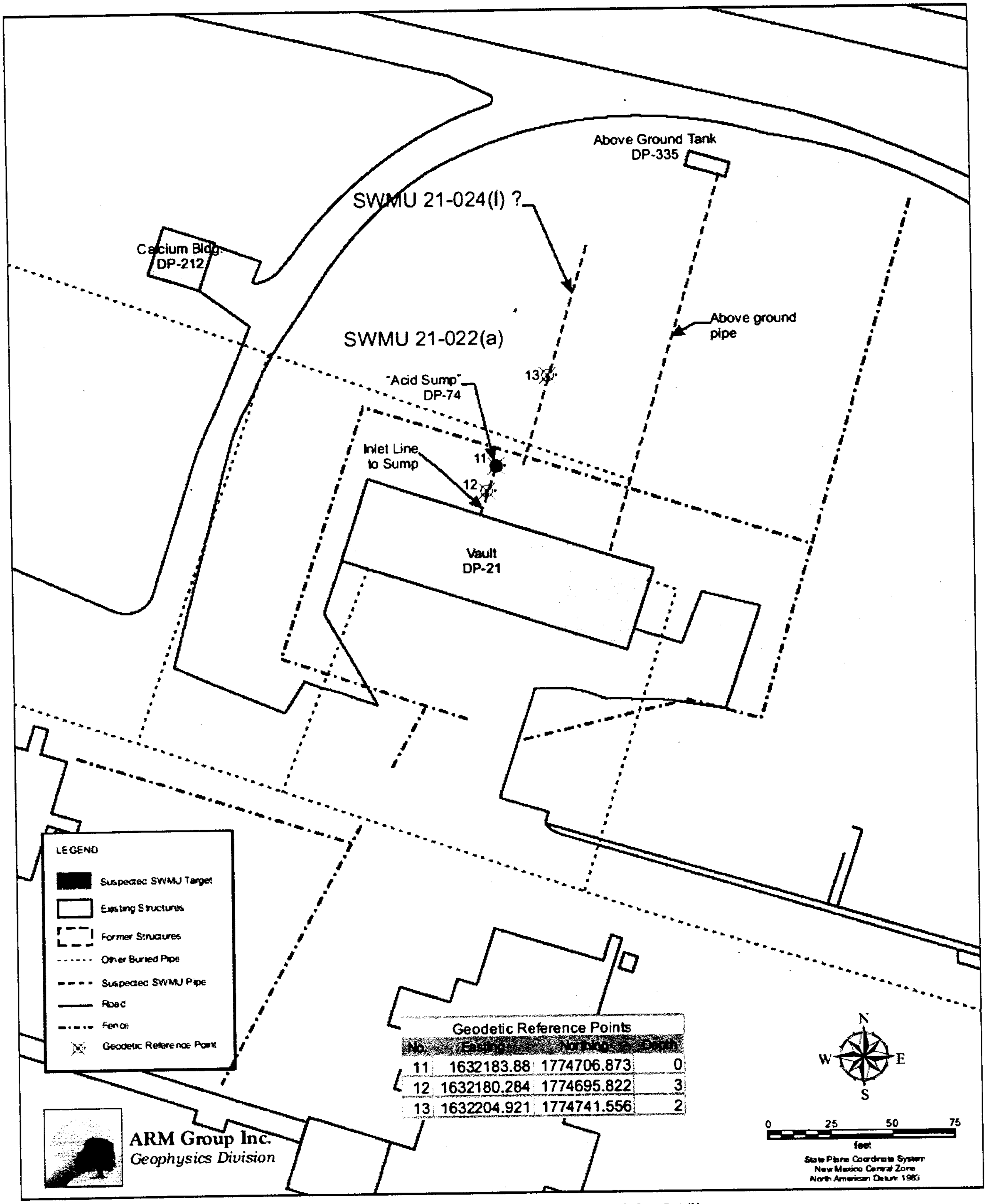
Figure 10 - Photograph of sump 21-74

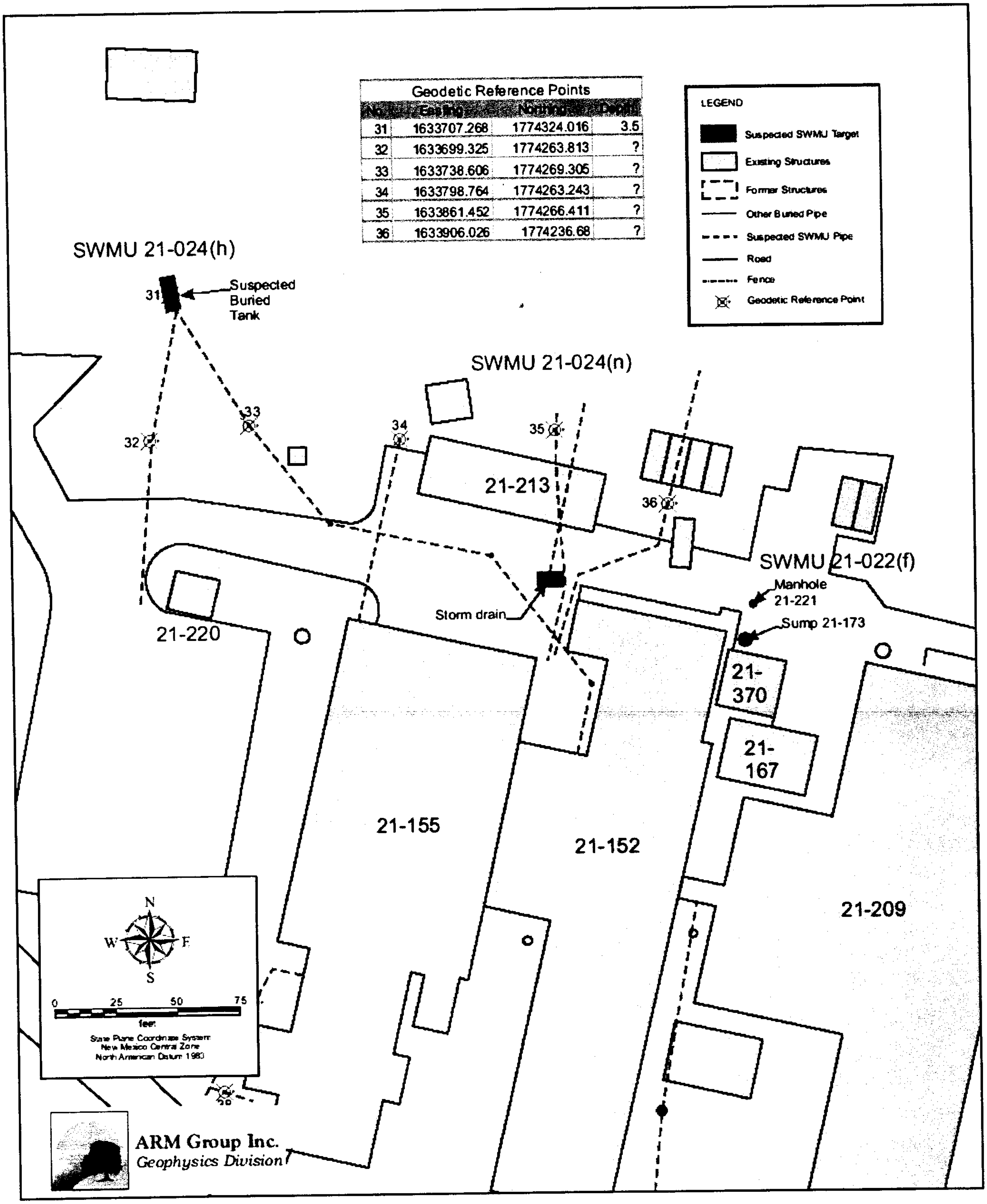


Geodetic Reference Points

No.	Easting	Northing	Depth
11	1632183.88	1774706.873	0
12	1632180.284	1774695.822	3
13	1632204.921	1774741.556	2

Figure 11 - Plan map of targets identified at SWMUs 21-022(a) and 21-24(l)

DRAFT



Geodetic Reference Points

No.	Easting	Northing	Depth
31	1633707.268	1774324.016	3.5
32	1633699.325	1774263.813	?
33	1633738.606	1774269.305	?
34	1633798.764	1774263.243	?
35	1633861.452	1774266.411	?
36	1633906.026	1774236.68	?

Figure 12 Plan map of targets identified at SWMUs 21-022(f), 21-24(h), and 21-24(n)

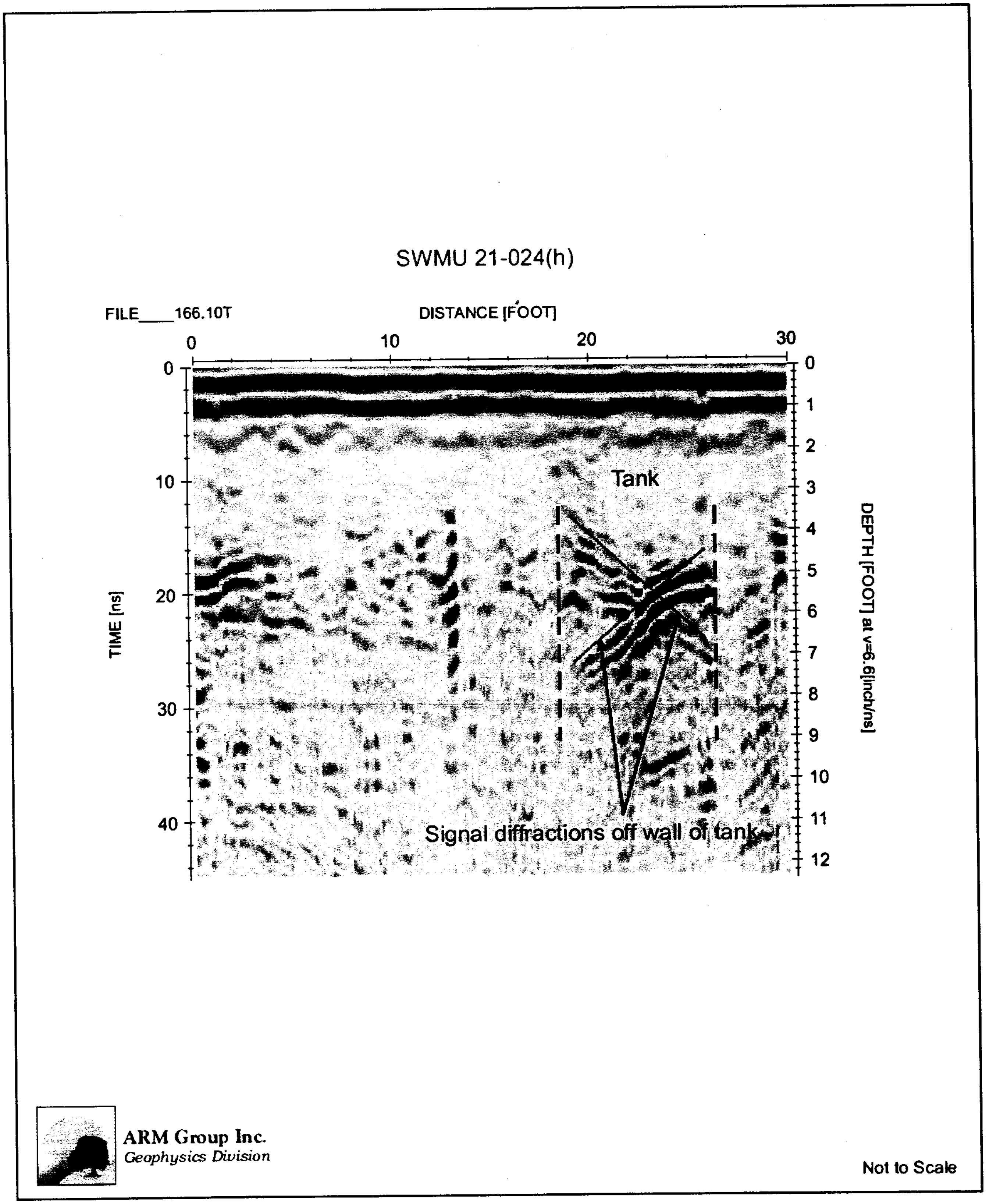
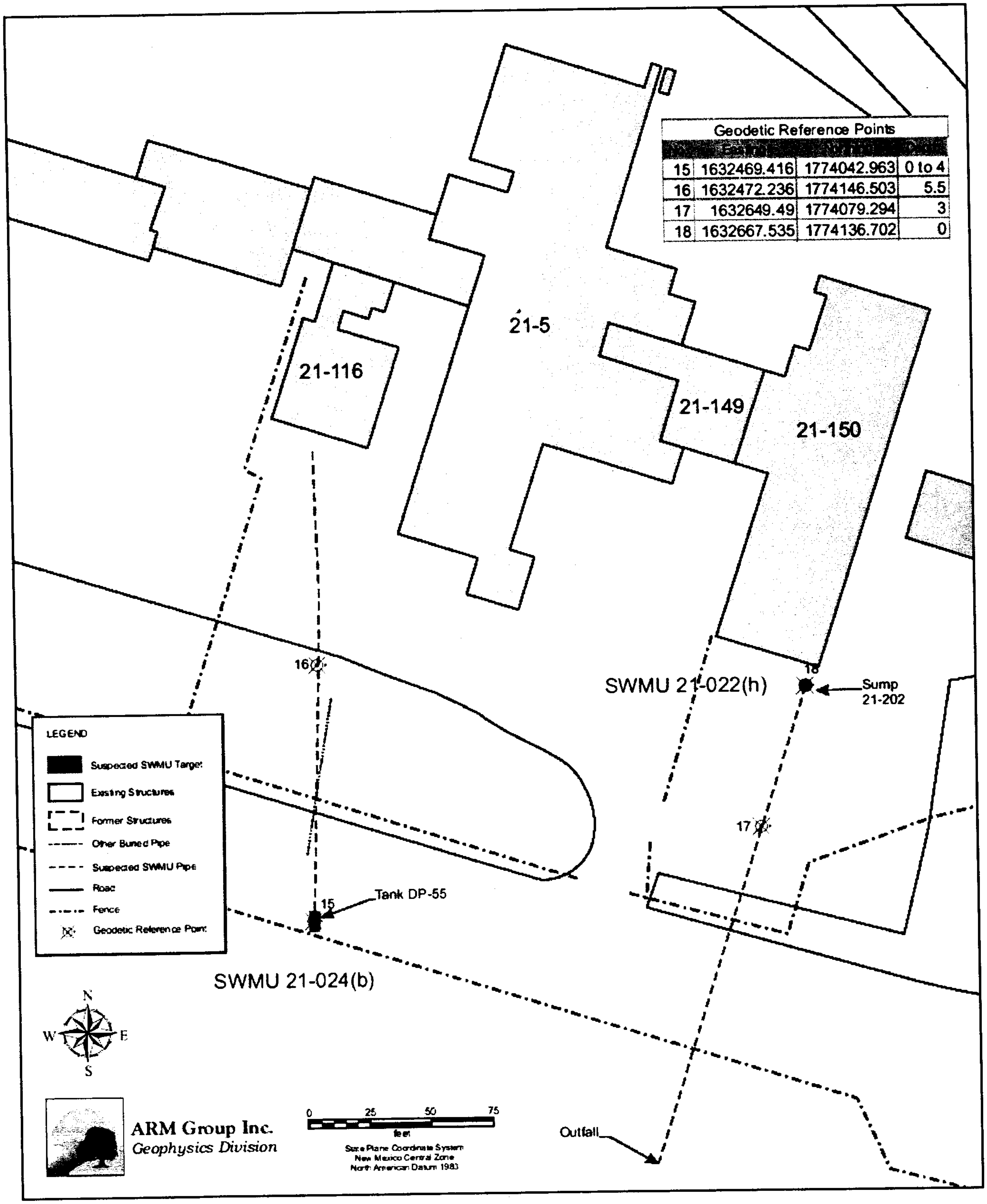


Figure 13 - Example radar record of the outlet pipe from 21-202 at SMWU 21-24(h)



Geodetic Reference Points

[illegible]	[illegible]	[illegible]	[illegible]
15	1632469.416	1774042.963	0 to 4
16	1632472.236	1774146.503	5.5
17	1632649.49	1774079.294	3
18	1632667.535	1774136.702	0

Figure 14 - Locations of the targets identified at SWMUs 21-022(h) and 21-24(b)

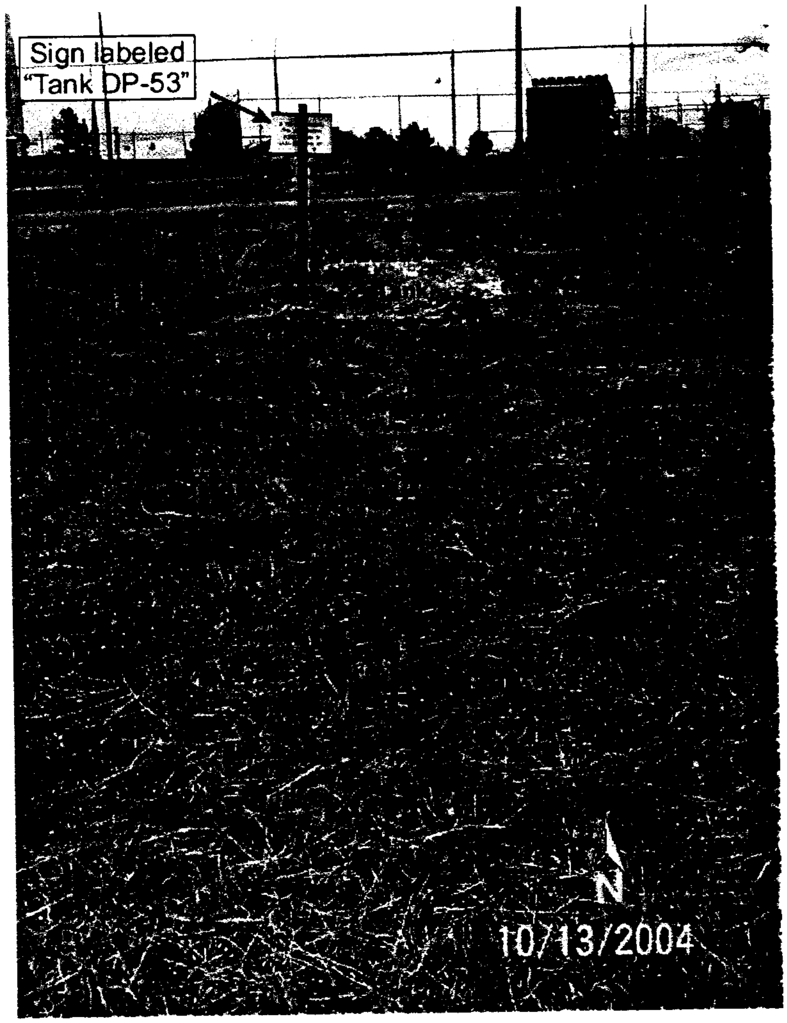


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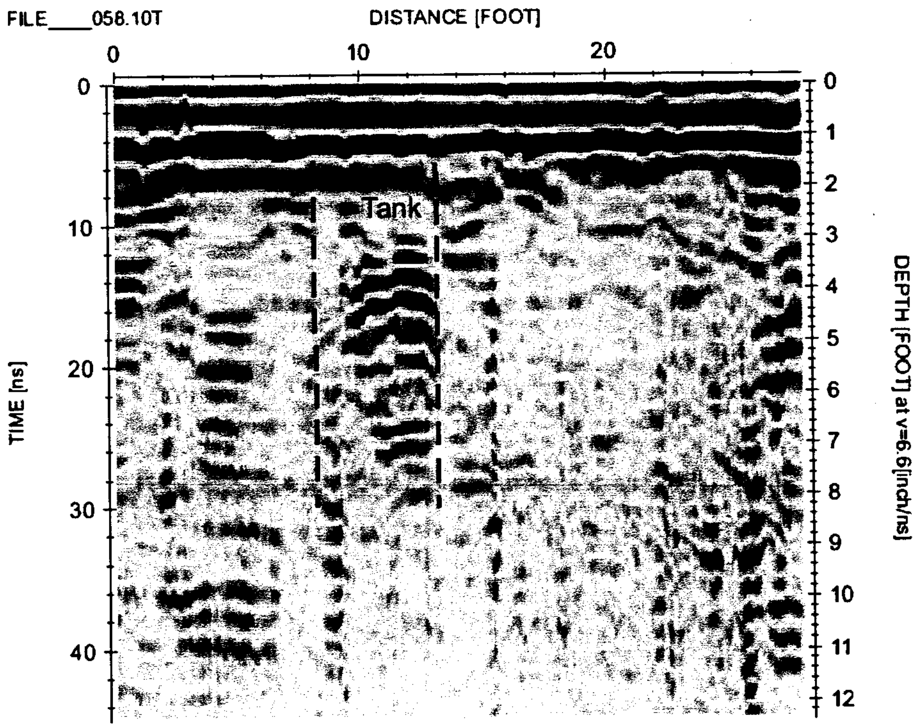
Figure 15 - Photograph of septic Tank 21-53 area at SWMU 21-24(a)

SWMU 21-024(a)



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Not to Scale

Figure 16 - Example GPR record of Tank 21-53 at SWMU 21-24(a)

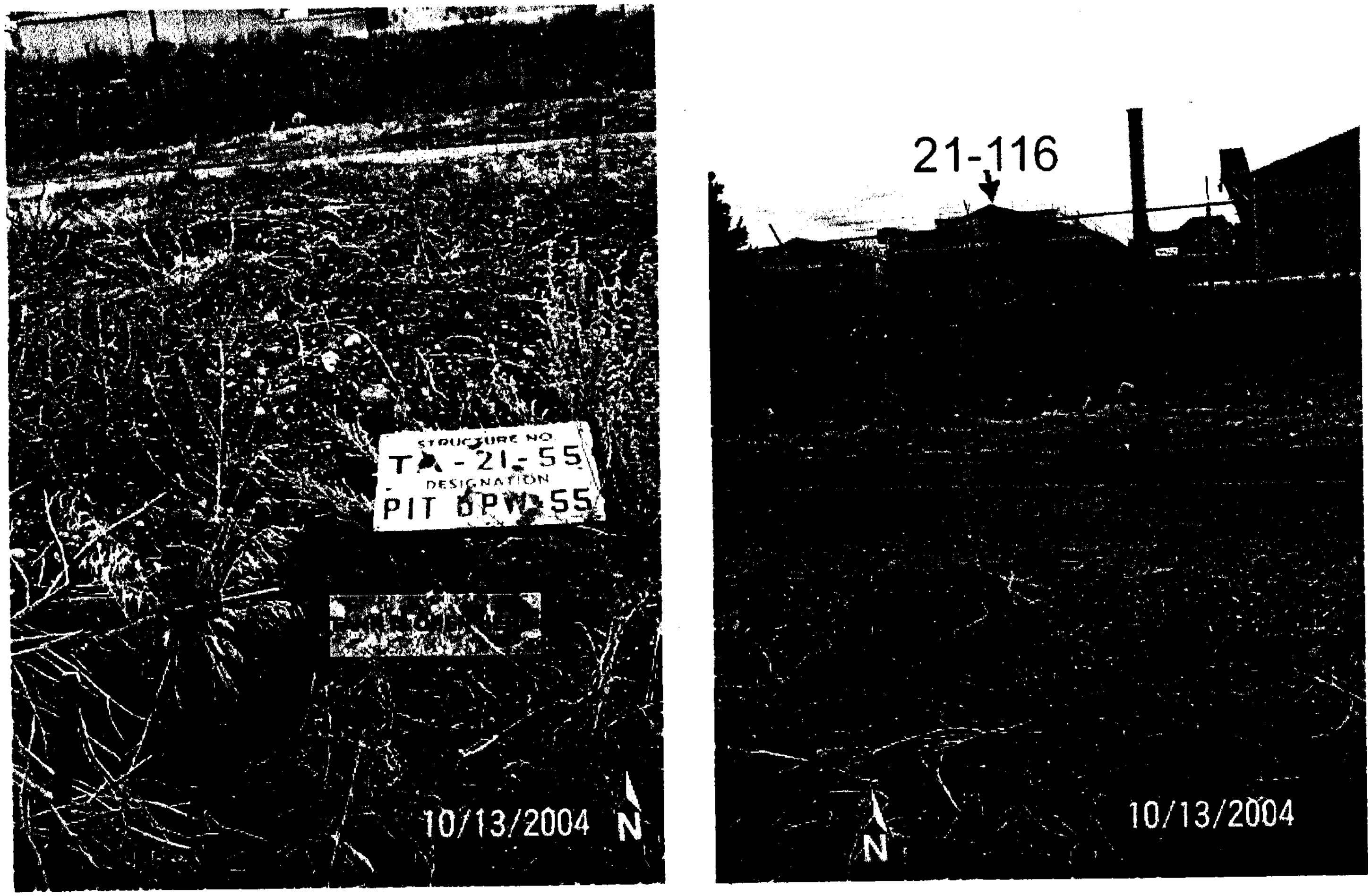

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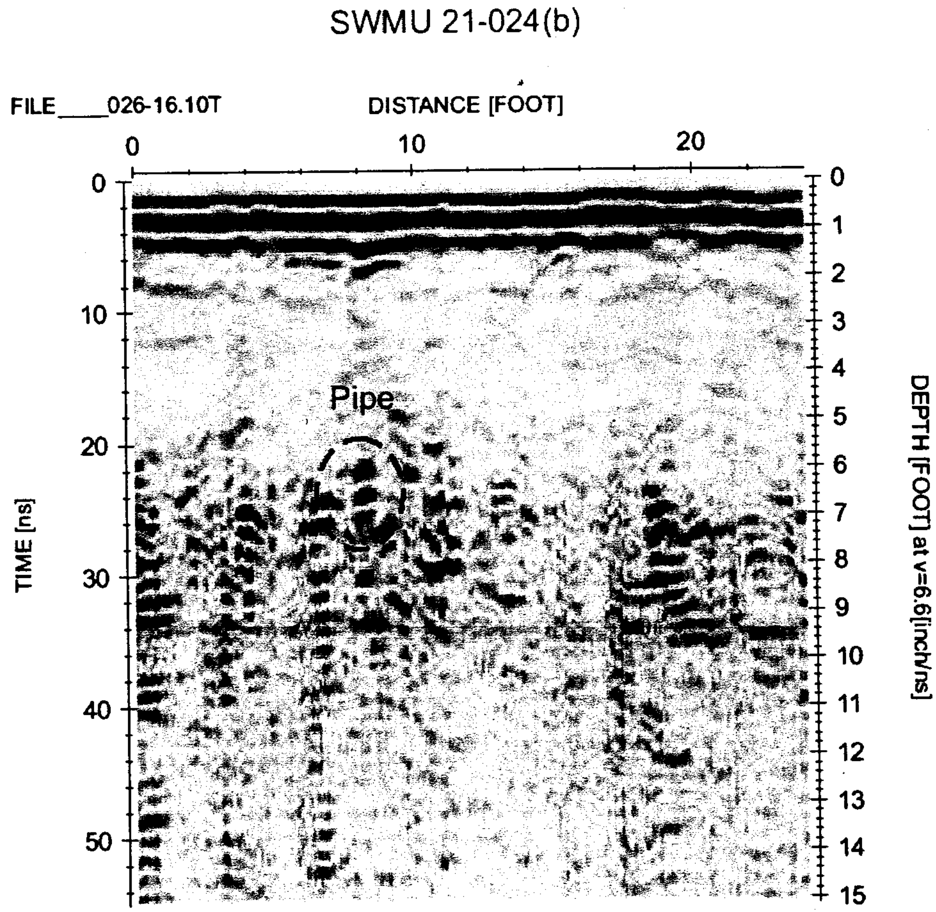
Figure 17 - Photograph of Tank 21-55 site at SWMU 21-24(b)



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Not to Scale

Figure 18 - Example GPR record of inlet line to Tank 21-55 at SWMU 21-24(b)

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Figure 19 - Photograph of Tank 21-56 location at SWMU 21-24(c)

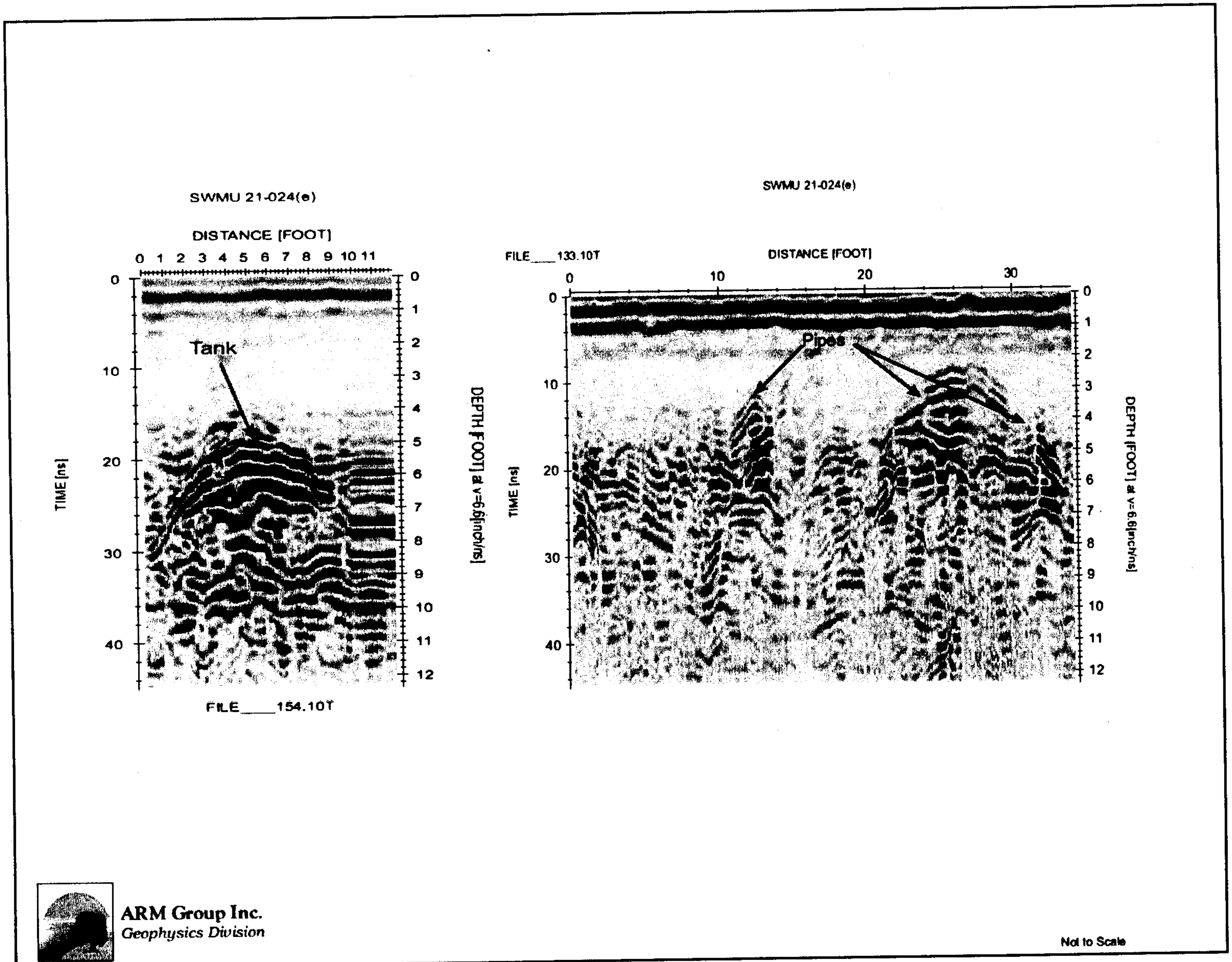

Figure 20 - GPR profile of Tank 21-123 and nearby pipes at SWMU 21-24(e)

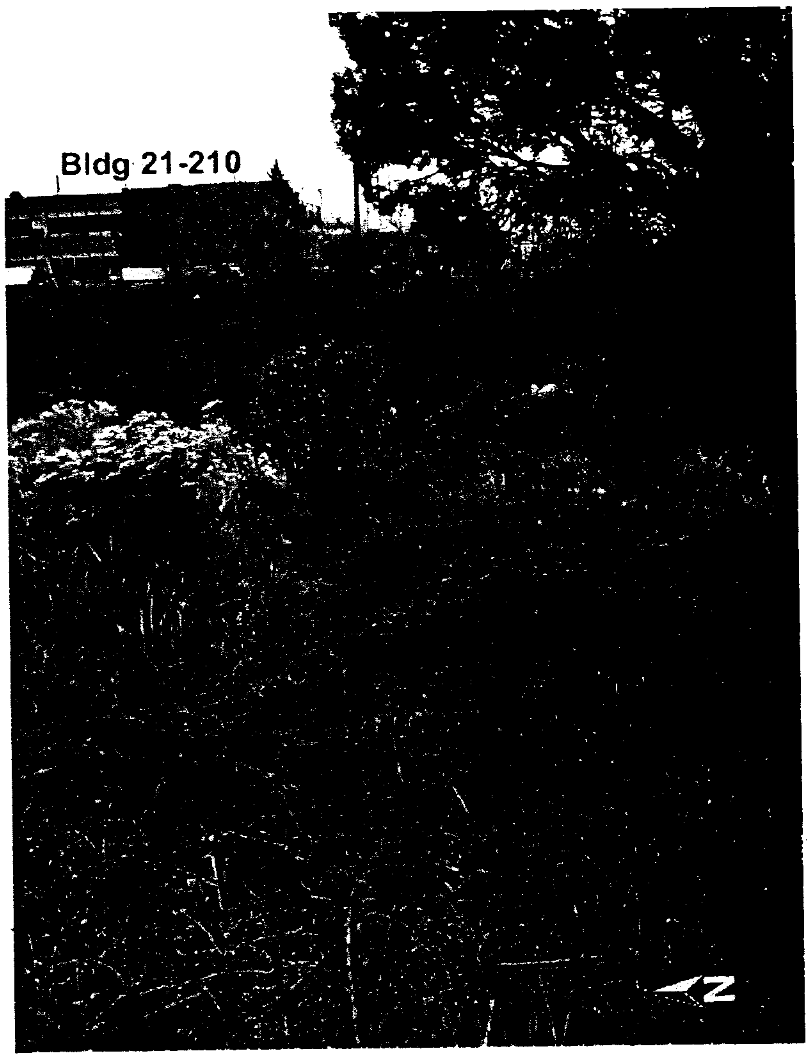

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Figure 21 - Photograph of boundaries of Tank 21-123 at SWMU 21-24(e)

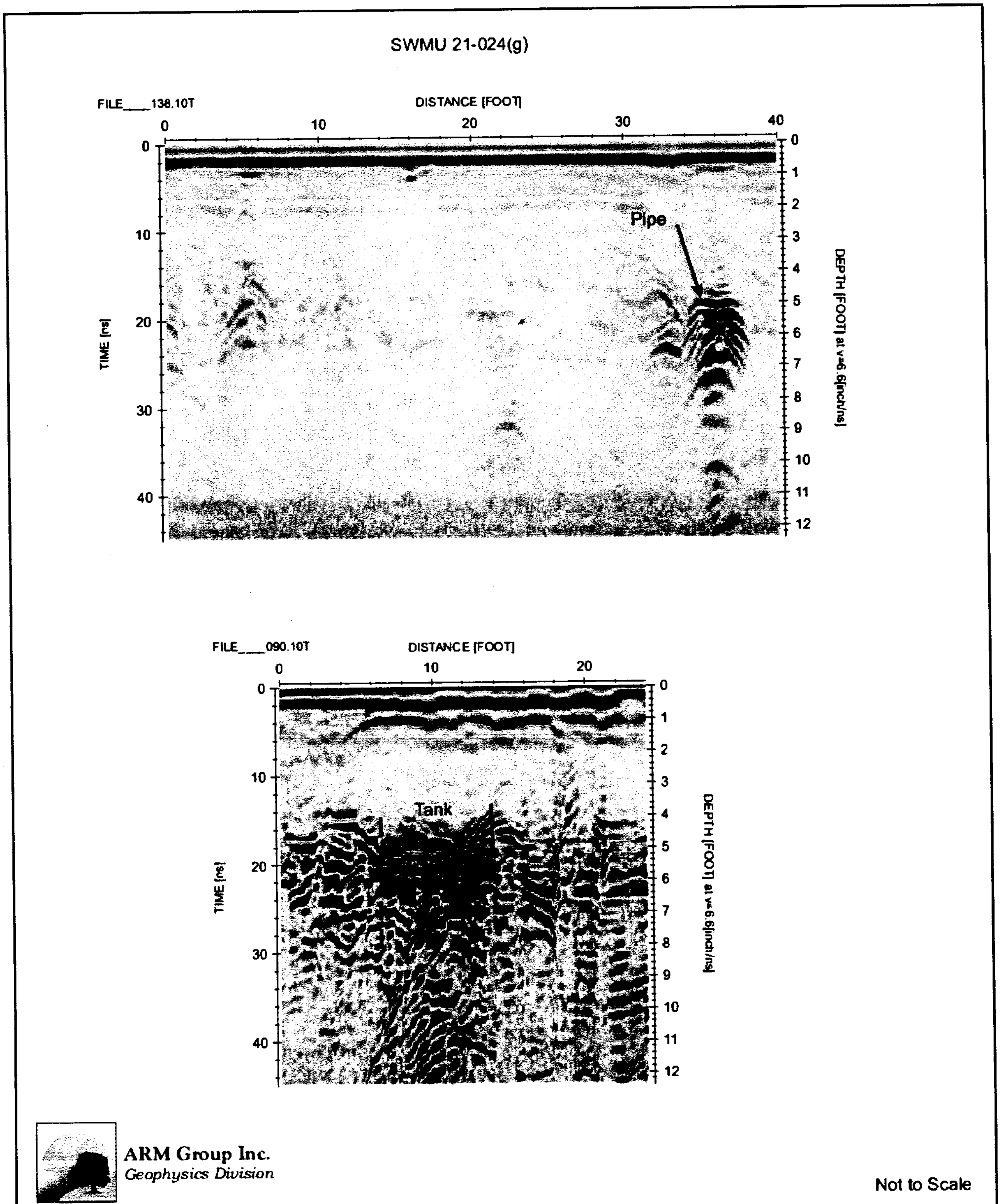

Figure 22 - Example GPR profile of Tank 21-125 and pipe from Buildings 21-07 to 21-31 at SWMU 21-24(g)

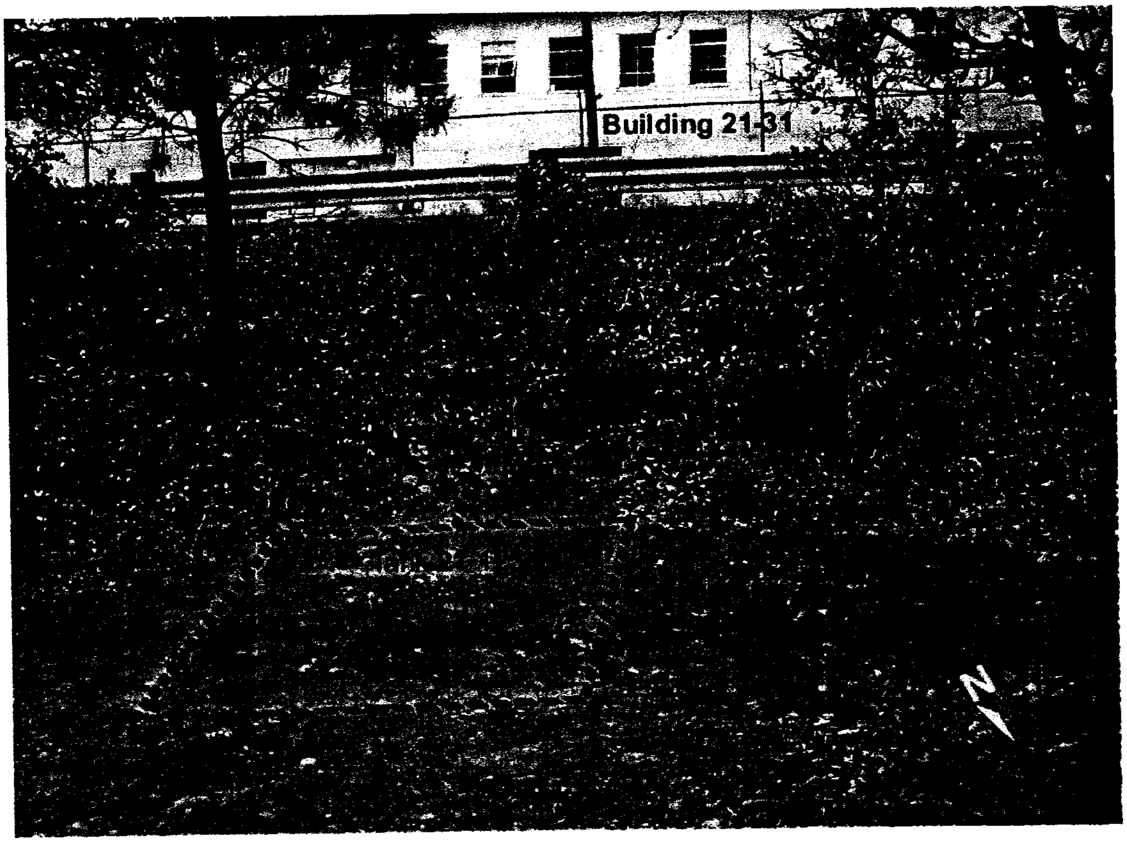

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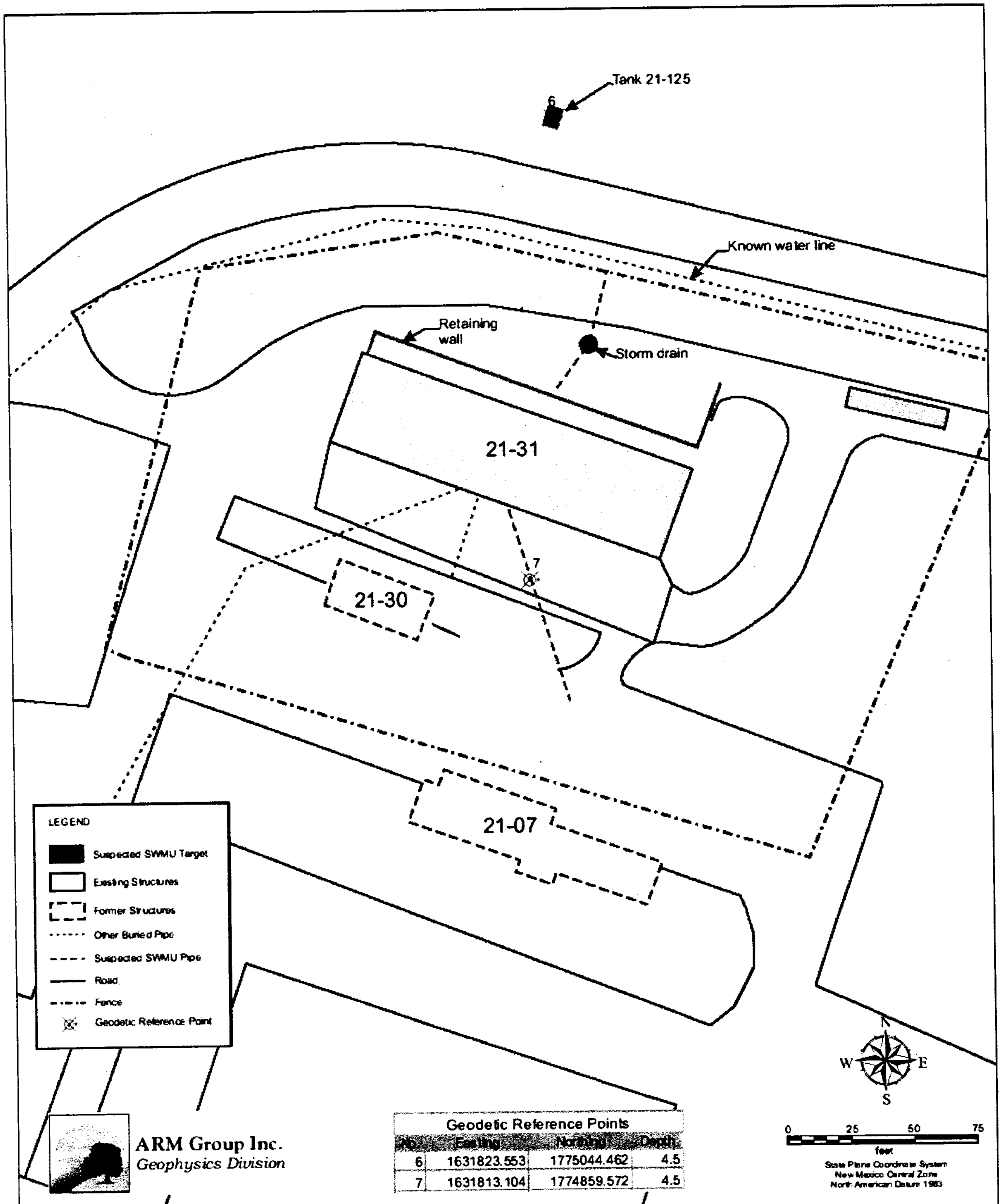
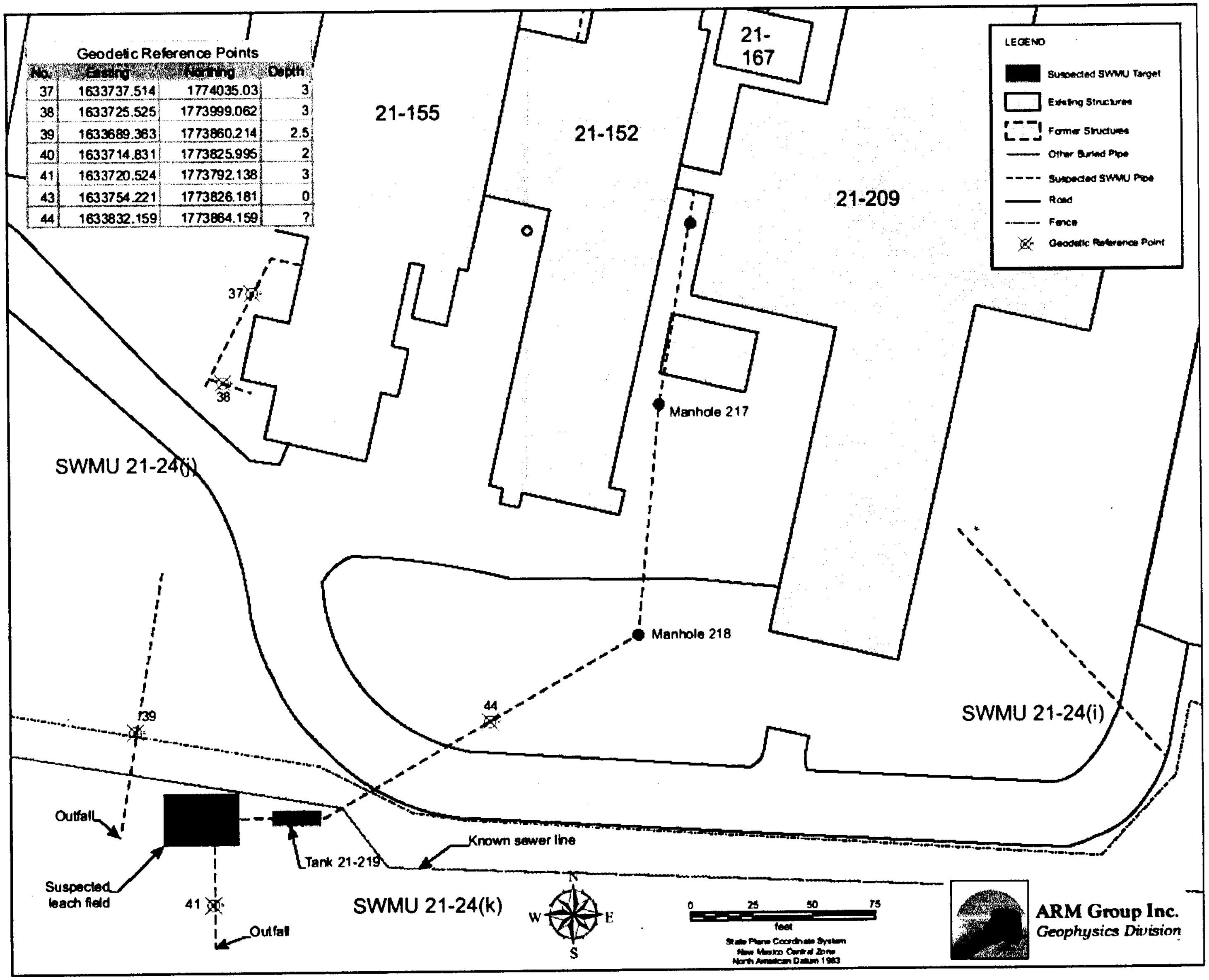
Figure 23 - Photograph of the interpreted boundaries of Tank 21-125 at SWMU 21-24(g)



Geodetic Reference Points			
No.	Easting	Northing	Depth
6	1631823.553	1775044.462	4.5
7	1631813.104	1774859.572	4.5

Figure 24 - Plan map of the targets located at SWMU 21-024(g)



No.	Easting	Northing	Depth
37	1633737.514	1774035.03	3
38	1633725.525	1773999.062	3
39	1633689.363	1773860.214	2.5
40	1633714.831	1773825.995	2
41	1633720.524	1773792.138	3
43	1633754.221	1773826.181	0
44	1633832.159	1773864.159	?

Figure 25 - Plan map of the targets located at SWMUs 21-024(i), (j), and (k)

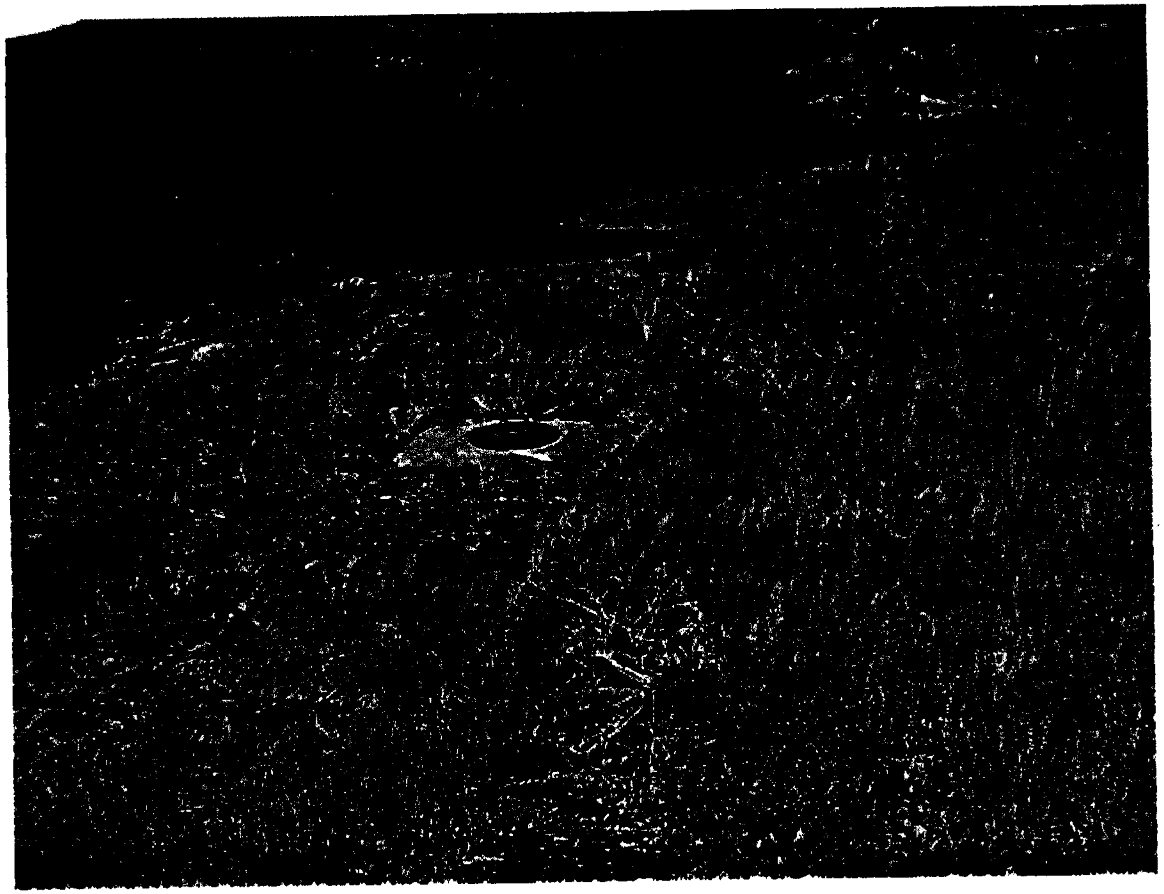


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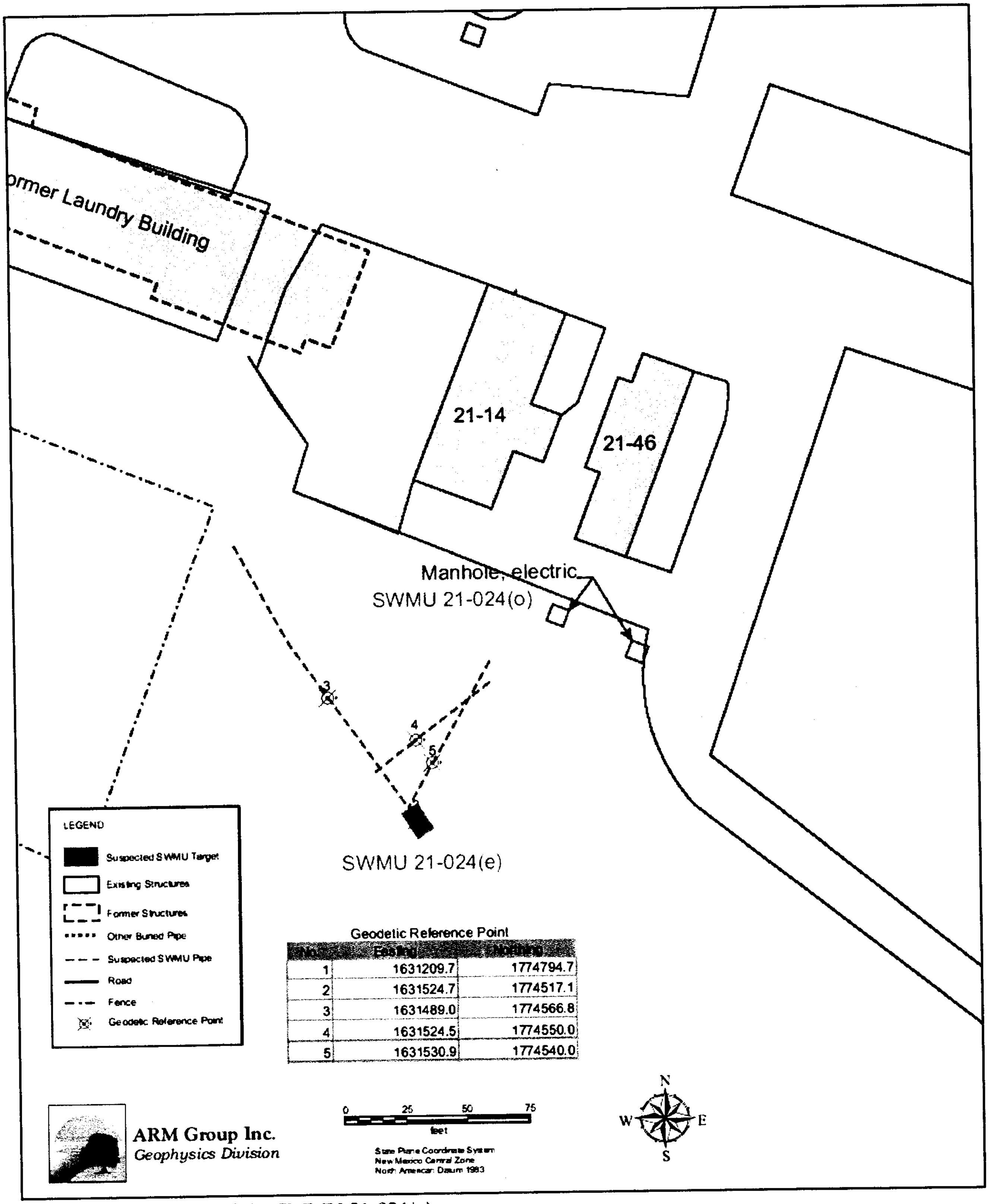
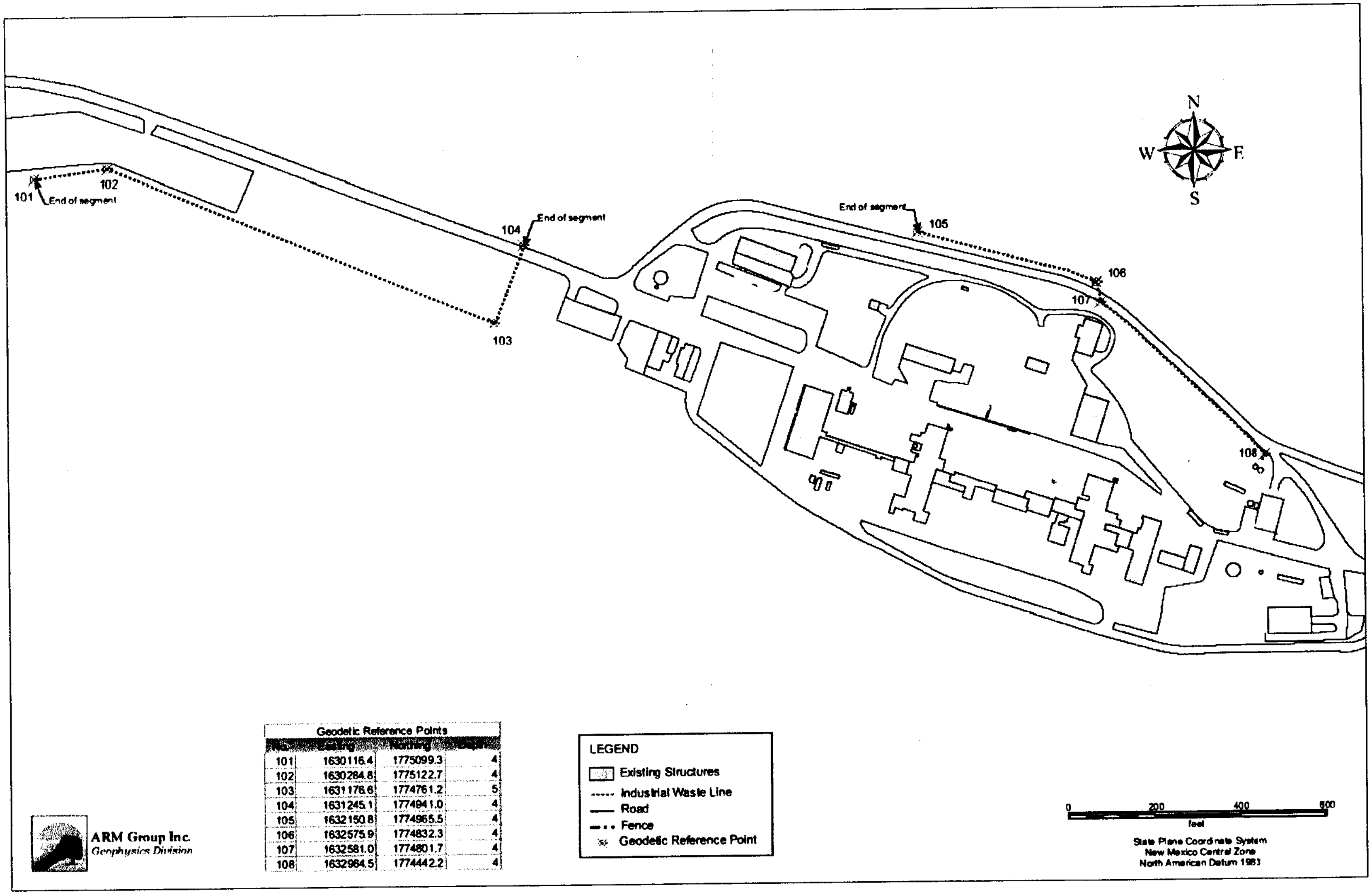
Figure 26 - Photograph of the location of SWMUs 21-024(k) targets



No.	Easting	Northing
1	1631209.7	1774794.7
2	1631524.7	1774517.1
3	1631489.0	1774566.8
4	1631524.5	1774550.0
5	1631530.9	1774540.0

Figure 27 - Plan map of the SWMU 21-024(o) area



Geodetic Reference Points

No.	Easting	Northing	Depth
101	1630116.4	1775099.3	4
102	1630284.8	1775122.7	4
103	1631176.6	1774761.2	5
104	1631245.1	1774941.0	4
105	1632150.8	1774965.5	4
106	1632575.9	1774832.3	4
107	1632581.0	1774801.7	4
108	1632984.5	1774442.2	4

Figure 28 - Plan map showing the location of the industrial waste line

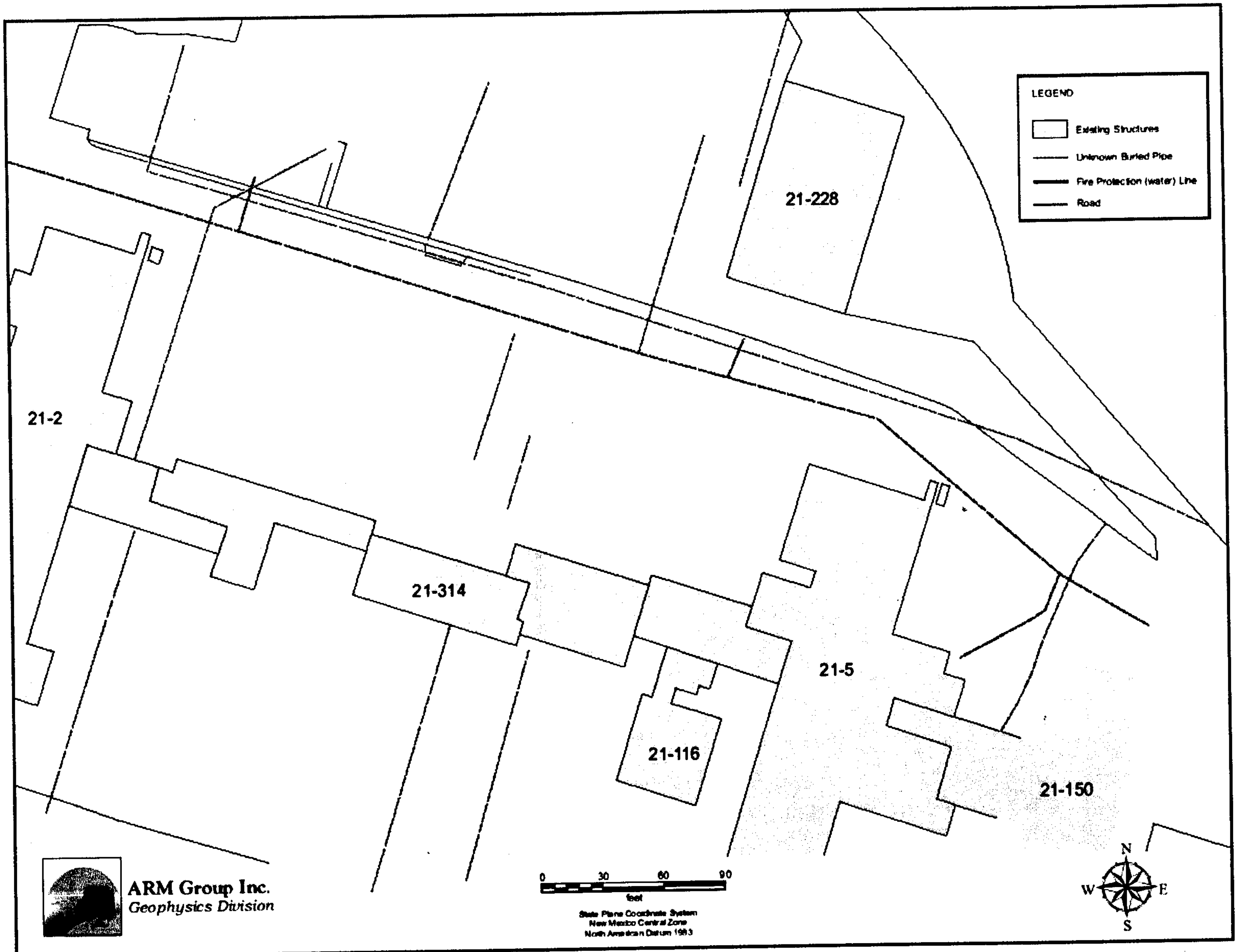


Figure 29 - Detected buried a pipes located near alleged utility corridor

Figure 30 - Plan EM31 map showing interpreted absorption bed and associated piping

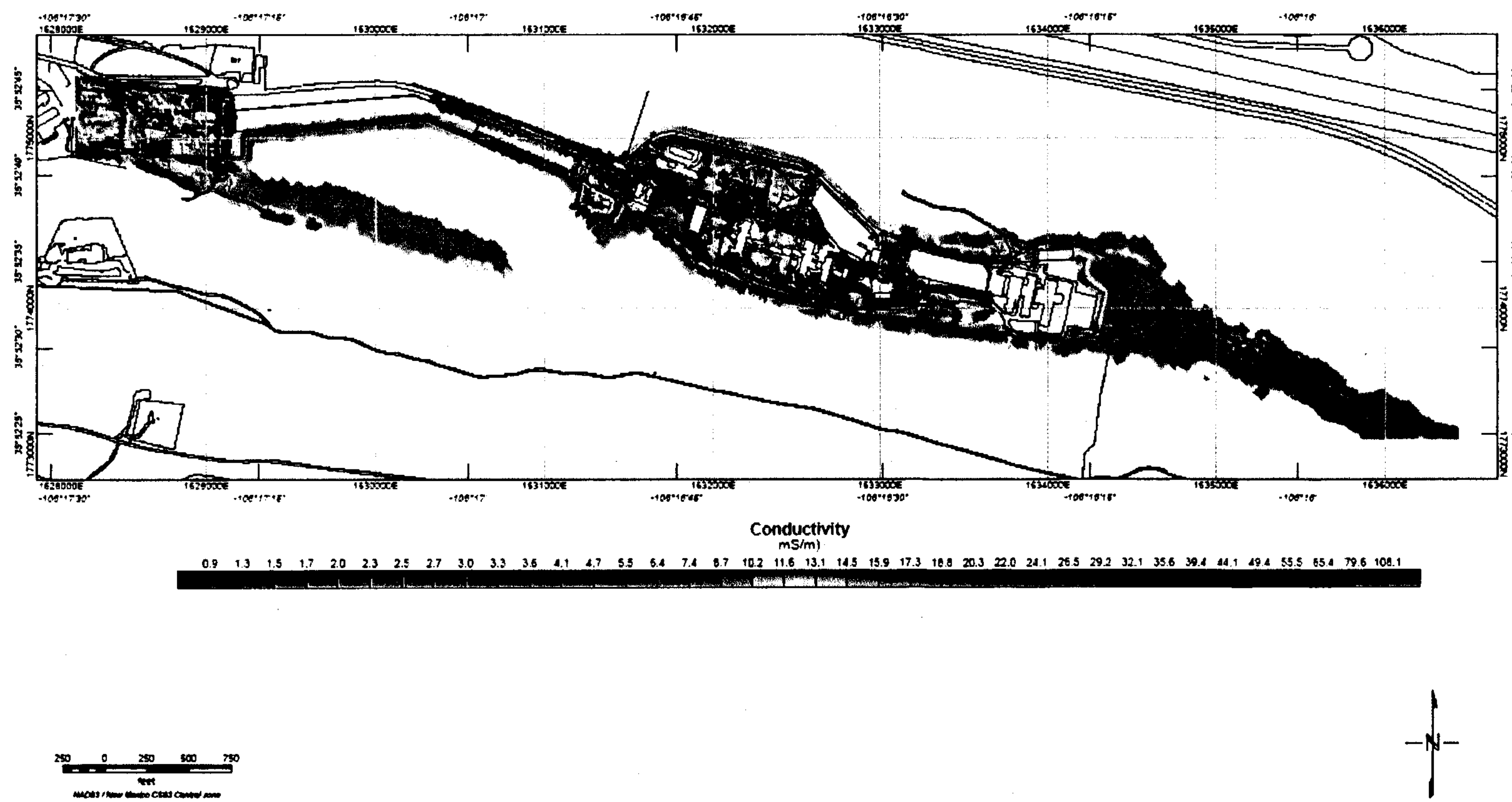


Figure 31 - EM31 Plan Map of TA-21

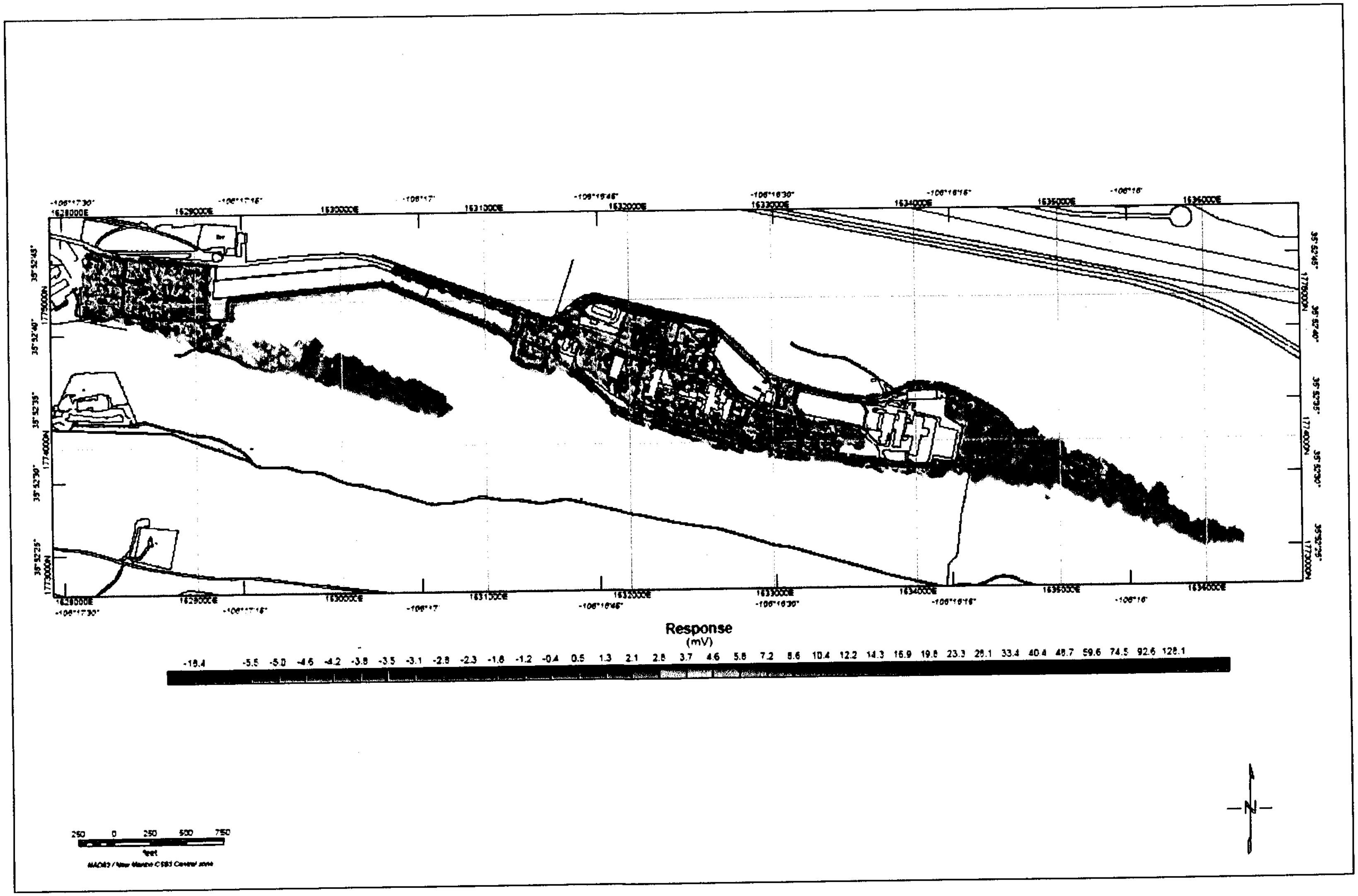


Figure 32 - EM61 Plan Map of TA-21

Appendix C

RADIOLOGICAL INVESTIGATION

Prepared by:

ERG, TerranearPMC, and Washington Group

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1.0 INTRODUCTION

Environmental Restoration Group, Inc. (ERG), with the support of Washington Group International (WGI) Team personnel (collectively, the Team), performed radiological surveys at the Los Alamos National Laboratory (LANL) Technical Area 21 (TA-21). The surveys were conducted to identify locations of elevated radiological contamination within SWMUs in support of on-going investigations and clean-up actions, and to determine if other, previously unidentified areas potentially requiring further investigation exist elsewhere across the TA. The survey area extended from the 6th street warehouse on the west to the mesa top edge on the east, and from the DP/Perimeter Road south to the mesa edge; the survey area also included the prominent geologic bench immediately south, down slope of the TA-21 mesa top. The surveys targeted multiple known SWMUs as well as open areas not known to have been directly impacted by LANL operations; nuclear facilities and established radiological control areas were specifically excluded from the surveys.

The Team scanned for high-energy gamma radiation emitting radionuclides using 3-inch by 3-inch NaI detectors, and low-energy gamma emitters using FIDLER (thin wafer NaI) detectors. The scanning radiological instrumentation was coupled to a Global Positioning System (GPS) instrument to directly correlate geodetic data with gamma radiation count rate data. Locations where elevated count rates were observed were subsequently resurveyed using gamma spectroscopy instrumentation to identify the radionuclides that are likely to be the source of the elevated count rates.

Section 2 below presents greater detail on the scanning gamma radiation survey methodologies and results. Section 3 presents an analysis of the scanning minimum detectible concentration (Scan MDC); the Scan MDC is an estimate of the lowest concentration of the various radionuclides potentially present in the study area observable with the instruments and methods used for this investigation. Radionuclide concentrations present in the study area below the Scan MDC would likely not have been detected during this investigation. Section 4 details the methods and results of the in situ gamma spectroscopy survey.

The Team conducted the radiation surveys from August 9, 2004 to October 14, 2004. The in situ gamma spectrometer survey was conducted on December 3, 2004.

2.0 GPS-RADIOLOGICAL SURVEYS

2.1 GPS Survey Method

The walk-over gamma surveys were performed at TA-21 to identify any areas with potentially elevated gamma radiation emission rates. One survey targeted high-energy gamma emitting radiaonuclides, such as cesium-137, and one survey targeted low energy gamma emitters, such as americium-241. The GPS-radiological survey system used for both surveys consisted of a Ludlum Model 2221 ratemeter/scaler with a detector coupled to a Trimble Pro XRS mapping grade global positioning system (GPS). Ludlum Model 44-20 3-inch by 3-inch NaI detectors were used for the high-energy gamma survey, Alpha Spectra FIDLER detectors were used for the low energy gamma survey. The Ludlum Model 2221's were operated in ratemeter mode allowing for a gamma count rate tagged with its corresponding coordinates to be collected at timed (2-second) intervals. The detectors were carried approximately 18 inches above the ground surface either in backpacks worn by field personnel or mounted on a "baby jogger" pushcart. The high and low energy surveys were conducted at two data collection densities. High-density surveys were performed using a detector spacing of 2.5 feet and a survey speed of 1-foot per second; low-density surveys were performed with a detector spacing of 5 feet and a survey speed of 2.5-feet per second. High density surveys in general were conducted at SWMUs and in areas of previously identified geophysical anomalies, as well as in asphalt covered areas. Low-density surveys were conducted in non-SWMU soil-covered areas.

At the end of each survey day, the field data were downloaded into a laptop computer and processed on site using a combination of Trimble Pathfinder Office and ESRI ArcView GIS computer applications. Team personnel reviewed the daily data to ensure completeness of coverage.

2.2 GPS Survey Results

Figure 1 presents the data for the high-energy survey; Figure 2 presents the low energy survey data. The data within each figure are presented with varying colors depicting the gamma count range in which each count-rate reading fell. Table 1 presents a gross statistical summary of all the high and low energy readings collected as part of this investigation.

Table 1. Survey Count Rate Data

Detector	Readings	Mean (cpm)	Standard Deviation	Maximum Reading (cpm)	Minimum Reading (cpm)
Ludlum Model 44-20	94,224	41,755	5,856	77,976	16,488
Alpha Spectra FIDLER	150,847	16,292	2,666	52,439	6,093

The survey data showed 11 locations with gamma radiation count-rates elevated above local background rates. These locations (shown in Figure 3) were selected for focused, in situ gamma spectrometer analysis and are discussed further in Section 4..

In addition, both the high and low energy gamma radiation count rates were found to be elevated above background in the geologic bench area south of the DP mesa. The elevated count rates are distinctly visible on Figures 1 and 2. The elevated count rates are believed to arise from higher natural background levels of gamma emitting radionuclides in the tuff outcrop that forms the cliff, or from increased detection efficiencies due to the physical proximity of the cliff to the survey locations.

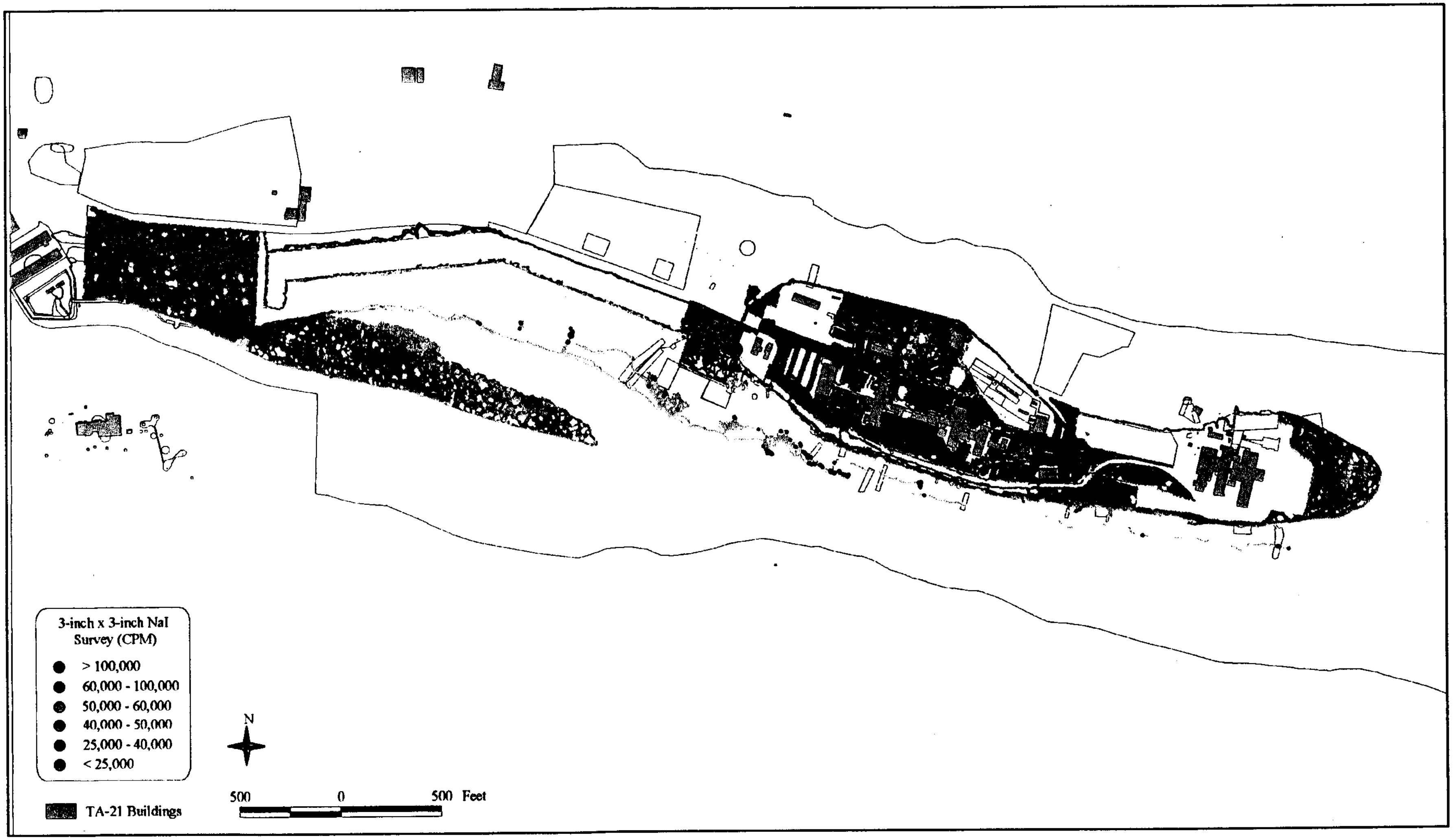

Figure 1. GPS-Radiological Survey Using FIDLER Detectors of LANL TA-21

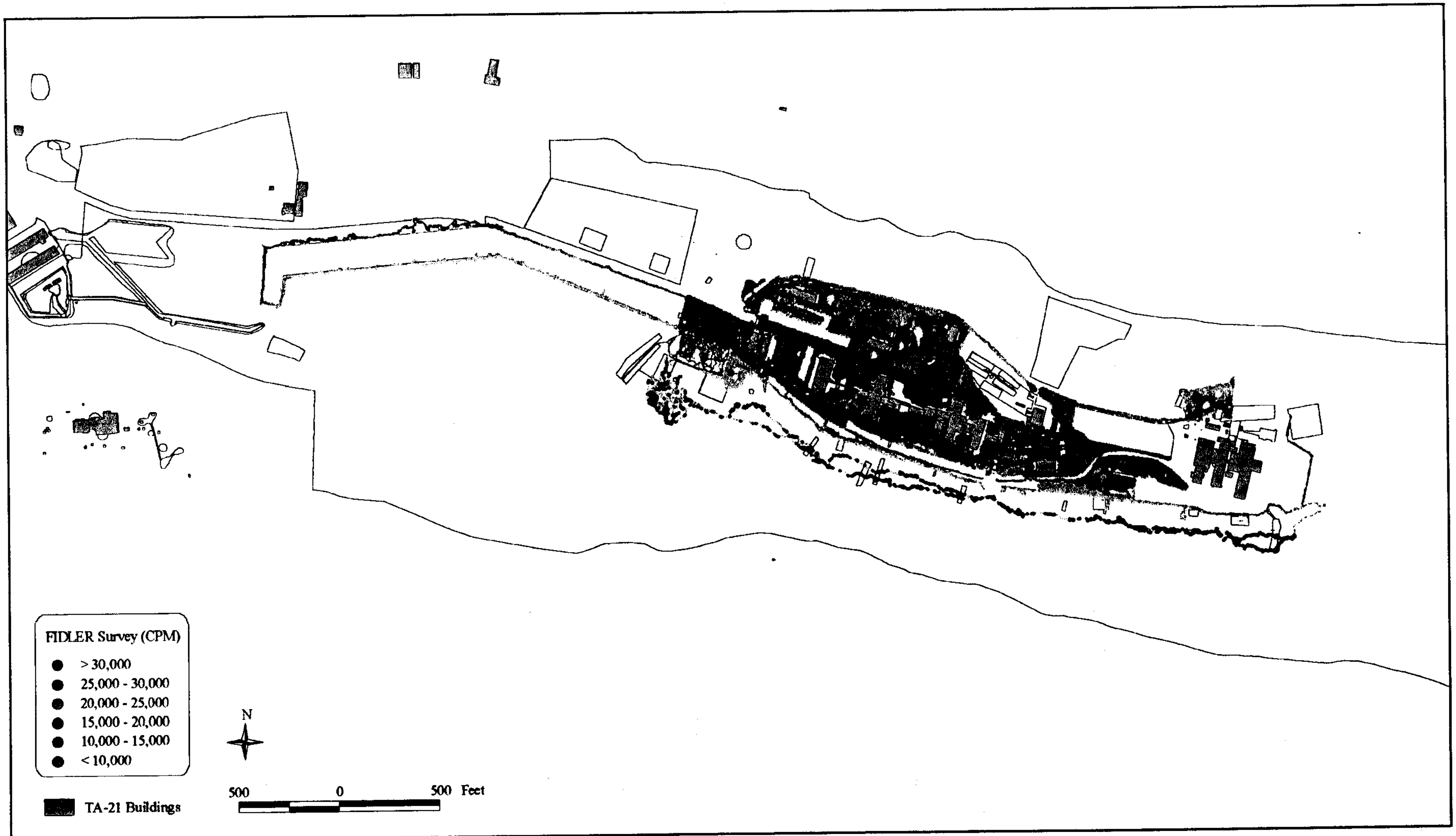

Figure 2. Gamma Spectrometer Sample Locations

A few survey data voids exist. The presence of buildings, large equipment, vehicles, vegetation, and large piles of scrap material physically prevented the collection of data in some of the planned survey locations. In addition, access to some areas was restricted to survey personnel. In a few locations survey data were not collected due to loss of signal from the GPS satellites. This can be caused by many factors such as local surroundings preventing line-of-site between the GPS survey system antenna and satellites. This was the case in some of the bench area and in a few areas close to TA-21 structures.

2.3 GPS Survey Data Quality Control

All radiological instrumentation was calibrated within a six-month period prior to use using NIST traceable sources and a pulser. The instrumentation was also function checked before and after use each day. Function check forms and calibration sheets are included in Attachment A.

3.0 SCANNING MINIMUM DETECTABLE CONCENTRATION

The scanning minimum detectable concentration is of interest for interpreting the gamma maps and associated iso-count-rate contours. The multiple federal agency guide (DOE, 2000) for radiological remediation, Multiple Agency Radiation Site Survey Manual (MARSSIM) suggests that measurements be made to empirically determine the MDC, based on actual field conditions. This requires the collection and analysis of soil samples from the survey area; this was not possible under this investigation. Therefore, estimates can only be made from published numbers and ERG's prior experience at TA-21. Several considerations are made in the following paragraphs to adjust published numbers for a 2-inch by 2-inch NaI detector to apply to the different sized detectors used in this radiation survey.

Scan MDCs published in MARSSIM are based on calculations published in NUREG-1507 (NRC, 1997), "Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions." Section 6.8.2 of that document shows calculations for various detectors and radionuclides. All assumptions and parameters are kept constant other than the detector type and radionuclide(s) so that a comparison of MDCs can be made for detector types or radionuclides. The basis of the NUREG-1507 calculations is that the contaminant is uniformly dispersed within the top 6-inch soil layer, and the contaminated area is circular in shape with a diameter of 22 inches. The detectors are assumed to be held four inches above the surface at a scanning survey speed of 1.6-feet per second. The MDC is calculated based on a 95% correct detection rate with a 60 percent false positive rate. Background count rates of 4,000 cpm and 10,000 cpm were assumed for 1.25-inch by 1.5-inch and 2-inch by 2-inch NaI detectors, respectively. The results of interest are given for a 2-inch by 2-inch NaI detector in Table 2. The calculations of the scanning MDC predicts that the MDC decreases as the detector size increases.

ERG recently completed a cleanup of a thorium-232 contaminated site at Kirtland Air Force Base, New Mexico where the Scan MDC was measured for thorium-232 using 2-inch by 2-inch NaI detectors under similar conditions as presented in Table 2 below. Three independent measured values for the Scan MDC for thorium-232 listed in the Final Status Survey Report (MWH, 2004) for that site were 0.7 pCi/g, 1.6 pCi/g, and 2.6 pCi/g. These results are similar to the thorium-232 values listed in Table 2. Therefore we believe that the numbers are reasonable for thorium-232. It should be expected that the values for the other radionuclides are reasonable as well since the only difference is in the characteristic emissions of the radioactive material, which are well understood. No empirically derived data are available on Scan MDCs for the 1.25-inch by 1.5-inch detector. The MDCs at TA-21 may be slightly higher (approximately 10 percent) than those in Table 2 since the background count rate for a 2-inch by 2-inch detector at TA-21 has been measured by ERG in a previous investigation to be approximately 12,000 cpm rather than the 10,000 cpm assumed in the calculations (MWH, 2004).

Table 2. Scan MDC for NaI Gamma Detectors (From NUREG 1507)

Radionuclide	Scan MDC for a 1.25-inch by 1.5-inch NaI Detector (pCi/g)	Scan MDC for a 2-inch by 2-inch NaI Detector (pCi/g)
Americium-241	44.6	31.5
Cesium-137	10.4	6.4
Thorium-232 in equilibrium with progeny	2.8	1.8
Depleted Uranium	80.5	56
Processed Natural Uranium	115	80
75% Enriched Uranium	188	132

For this survey, a detector height of 18 inches and speed of approximately 1-foot per second were used for conducting the high-density surveys. The speed is similar to that assumed in the NUREG-1507 calculations. For a relatively large area, the detector efficiency is independent of height above the surface. However, comparing the detector at 18 inches to that at four inches, the efficiency will be slightly lower for a contaminated area of 22 inches in diameter. This would slightly increase the relative MDC of the detector held at 18 inches relative to a detector four inches above the surface. We have, however, ignored this small difference in our calculations.

Relative background and efficiency measurements were made for the Model 44-20 3-inch by 3-inch NaI and FIDLERs detectors used in this survey. The Team also previously established relative background and efficiency measurements at the survey area for a 2-inch by 2-inch detector in order to improve the correlation of published Scan MDCs for 2-inch by 2-inch detectors to the estimated Scan MDCs for the instruments used in this investigation. Factors based on this data for all three detectors were then applied to the published Scan MDCs for the 2-inch by 2-inch detectors to obtain estimates of the Scan MDCs for the 3-inch by 3-inch and FIDLER detectors. Integrated count measurements were also made using point radioactive sources (Am-241 and Cs-137) held 18 inches from the detectors. A count time of 10 minutes was used. The data are presented in Table 3. The ratio of the background count rates of the 3-inch by 3-inch detector to the 2-inch by 2-inch detector was 2.4; the ratio of the background count rates of the FIDLER to the 2-inch by 2-inch detector was 0.93.

Table 3. Relative Detector Responses to Americium-241 and Cesium-137 Sources

Detector	Background Counts	Cs-137 Gross Counts	Cs-137 Net Counts	Relative Efficiency	Am-241 Gross Counts	Am-241 Net Counts	Relative Efficiency
3 x 3 NaI	246409	510607	264198	2.4	255916	9507	1.3
2 x 2 NaI	103425	215577	112152	1.0	110686	7261	1.0
FIDLER	96680	227005	130325	1.2	121649	24969	3.4

The Scan MDC should be proportional to the square root of the background count rate and inversely proportional to the efficiency. Therefore, the Scan MDC was calculated for the 3-inch by 3-inch detector for each source using the following equation:

$$Scan\,MDC_{3\times3} = \left(Scan\,MDC_{2\times2} \times \sqrt{\frac{C_{B3\times3}}{C_{B2\times2}}} \right) \div RE$$

Where:

Scan MDC_{2x2} = the published scan MDC of the 2-inch by 2-inch detector
C_{B3x3} = background count rate of the 3-inch by 3-inch detector
C_{B2x2} = background count rate of the 2-inch by 2-inch detector
RE = relative efficiency of the 3-inch by 3-inch detector to the 2-inch by 2-inch detector.

A similar equation was used to estimate the Scan MDC for the FIDLER detector.

The calculated Scan MDCs of the two detectors are presented in Table 4 for the americium-241 and cesium-137 sources. The published values for the 2-inch by 2-inch detector are presented in the first column for convenience. The Scan MDC for the 3-inch by 3-inch detector for americium-241 is higher than for the 2-inch by 2-inch detector. This is contrary to what we had anticipated. This may arise from differences in the detector housing materials and their relative influence on the low energy gamma rays from americium-241.

No information exists as to the enrichment of the uranium that was probably detected at TA-21 as indicated from the gamma-spectral data (discussed below in Section 4.0). We have assumed that the ratio of the Scan MDC is similar to that for americium-241 since the gamma energies are similar and very low relative to that from cesium-137. We have also assumed that the relative Scan MDC for thorium-232 is equal to that for cesium-137. Table 4 provides estimates of the Scan MDCs for the predominant radionuclides found at TA-21.

Table 4. Estimated Scan MDC for High Density Survey at TA-21

Radionuclide	Scan MDC for a 2-inch by 2-inch NaI Detector (pCi/g)	Scan MDC for a 3-inch by 3-inch NaI Detector (pCi/g)	Scan MDC for a FIDLER Detector (pCi/g)
Americium-241	31.5	37	9
Cesium-137	6.4	4	5
Thorium-232 in equilibrium with progeny	1.8	1.2	1.5
75% Enriched Uranium	132	160	37

Note that these Scan MDCs apply to the high-density surveys with the assumed circular, 22-inch diameter contaminated area.

The low density surveys were performed with the detector at 18-inches above ground surface moving at a speed of approximately 2.5-feet per second rather than the 1-foot per second that was used to produce the data listed in Table 4. In addition, the low-density surveys had a spacing of approximately five feet. It is reasonable to assume that if the contaminated area were 2.5 times larger (approximately 5 ft in diameter), the low-density surveys would have comparable Scan MDCs as given in Table 4. For even larger contaminated areas, the scan MDC for the detectors would be lower than that reported in Table 4.

4.0 IN SITU GAMMA SPECTROMETER INVESTIGATION

The in situ gamma spectrometer investigation was qualitative with the primary objective being to gain a better understanding of what radionuclides might be the cause of the observed elevated gamma count-rate readings.

4.1 Gamma Spectrometer Method

The gamma spectrometer investigation was conducted by first navigating back to the general area of an elevated gamma count-rate reading using the GPS and subsequently collecting new count-rate data using the rate meter and either the 3-inch by 3-inch NaI or the FIDLER detector to identify the exact point with the highest gamma-count rate in the area; the gamma spectra were acquired at these locations representing the highest local count-rate. The gamma spectrometer used was an ORTEC digiDART® with a 2-inch by 2-inch NaI detector. Prior to field use an energy calibration was performed on the spectrometer using both a cesium-137 and an americium-241 source. The 662 keV peak from the cesium source and the 26.3 keV and 59.5 keV peaks (and 15 keV L x-rays) of the americium source were used to adjust the spectrometer settings to match channel and corresponding photopeak energy. At each location the in-situ spectrum was collected for five minutes.

4.2 Gamma Spectrometer Results

The results for each location are shown in Table 5. A plot of each spectrum is included in Attachment B.

Table 5. Gamma Spectra Data

Location	Detector	Approximate Count on Contact (cpm)	Visible Spectrum Peak(s) (keV)	Probable Radionuclide(s)
1	FIDLER	30,000	25, 58	Am-241
			72 to 92	Pa-234
			184 to 192	U-235
2	FIDLER	45,000	25, 59	Am-241
3	FIDLER	50,000	25, 59	Am-241
4	FIDLER	50,000	26,60	Am-241
			90, 109, 145, 188	U-235
5	FIDLER	20,000	none	Background

Location	Detector	Approximate Count on Contact (cpm)	Visible Spectrum Peak(s) (keV)	Probable Radionuclide(s)
6	FIDLER	30,000	60	Am-241
			188	U-235
7	FIDLER	180,000	25, 59	Am-241
8	FIDLER	30,000	25, 59	Am-241
9	Model 44-20	100,000	662	Cesium
10	Model 44-20	50,000	240 (weak)	Th-232
11	Model 44-20	50,000	240 (weak)	Th-232

Note: Natural background on the FIDLER was approximately 15,000 cpm. Natural background on the Model 44-20 is approximately 40,000 cpm.

Location 1 is approximately 15 meters to the east of the MDA-V fenced area.. The general area of Location 1 exhibited a slightly elevated count rate of approximately 25,000 cpm with the FIDLER detector. The specific sample location selected for gamma spectrum acquisition exhibited the highest FIDLER count rate at 30,000 cpm. Review of the gamma spectrometry spectrum indicates peaks at 25 keV, 58 keV, 72 to 95 keV, and 184 to 190 keV. Based upon these peak energies it is believed the possible radionuclides present are americium-241, protactinium-234 (decay product of thorium-234), and uranium-235. The 25 keV and 58 keV energy peaks correspond to the 26.3 keV and 59.5 keV of americium-241, respectively. The 72 to 92 keV energy peak is believed to be several peaks from protactinium-234m and protactinium-234 ranging from 76.6 to 94.6 keV. Unfortunately the resolution of a 2-inch by 2-inch NaI detector is not high enough to allow verification of the individual peaks. The 184 to 192 keV peak is thought to be the 185.7 keV peak from uranium-235.

Location 2 is against an outside wall along the southwest section of Building 21-02. The selected sample location was found to be a very small point source approximately 1 inch in diameter on top of asphalt. Review of the spectrum indicates peaks at 25 keV and 59 keV strongly suggesting the presence of americium-241.

Location 3 is also along the south side of Building 21-02, in a shallow asphalt drainage next to a silver aluminum plate secured to the ground with posting signifying radioactive contamination beneath. Review of the spectrum indicates energy peaks at 25 keV and 59 keV strongly suggesting the presence of americium-241.

Location 4 is at the base of a "No Parking" sign southwest of Building 21-02. Review of the spectrum indicates energy peaks at 26 keV, 59 keV, 90 keV, 109 keV, 145 keV, and 188 keV. As in the previous three samples the first two peaks strongly suggest the presence of americium-241. The 90 keV peak is possibly the combination of the 84.2 keV peak from uranium-235 and the 91.1 keV and 96.9 keV peaks from thorium-232. The 145 keV and 188 keV peaks are possibly those of the 143.8 keV and 185.7 keV peaks, respectively, from uranium-235. The 25.6 keV, 163 keV, and 205 keV peaks typically found in uranium-235 spectra are likely present but due to the resolution of the gamma spectrometer used, are not easily distinguishable.

Location 5 is in a small area east of Location 4 outlined with radiation caution tape. There is a pipe protruding approximately one foot out of the ground at this location. The field crew made every effort to acquire a satisfactory gamma spectrum but review of the data indicate a characteristic background spectrum. The FIDLER count rate observed immediately prior to collecting the gamma spectrum data is indicative of between background and one and a half times background. The location was chosen due to initial FIDLER survey data showing twice background levels. It is possible that the spectrometer location was not optimum since the area had snow cover during the spectrometer measurements.

Location 6 is in the outfall of a culvert to the south of Building 21-314 (between buildings 21-03 and 21-04) near the perimeter fence. Review of the spectrum shows that two distinct peaks are evident. The 60 keV peak is likely to be from the americium-241 peak at 59.5 keV and the 188 keV peak is likely to be from uranium-235 at 185.7 keV. Other peaks from americium-241 and uranium-235 that should be present in the Location 4 spectrum may not be visible due to the short counting time.

Location 7 is north of Building 21-05; Location 8 is northeast of Building 21-02. There are no unusual physical features or other indicators of contamination at either location; however, Location 7 exhibited the highest FIDLER count rates observed during the gamma spectrum investigation. The spectra from both locations show energy peaks at 25 keV and 59 keV strongly suggesting the presence of americium-241.

Location 9 is located just north of tanks 21-112 and 21-113 between North DP Road and the MDA T fence line. The spectrum shows one peak at 662 keV, suggesting the presence of cesium-137. No other peaks were evident.

Location 10 is against an outside wall along the northeast section of Building 21-150. Selection of a location to collect gamma spectrum data was difficult; the general area exhibited slightly elevated readings during both the FIDLER and Model 44-20 surveys but no single hot spot could be identified. The location chosen for analysis was directly beneath a building vent. The spectrum shows a possible, very small peak at 240 keV. This peak, if present, would indicate the possibility of thorium-232 and progeny. Thorium-232 is common in building materials such as concrete.

Location 11 is located in a large debris pile southwest of MDA B's west end in an open field west of the TA-21 industrial area. The pile appears to be large chucks of concrete. The location was chosen due to elevated readings observed during the Model 44-20 survey. The gamma spectrum shows a possible peak at 240 keV. Similar to the spectrum from Location 10, this very weak peak may represent thorium-232 found in materials present in the debris pile.

Based upon review of the eleven spectra it is believed americium-241 is present in most locations where spectra were collected. There is a possibility that uranium-235 is present at Locations 1, 4, and 6. Cesium-137 is likely present at Location 9. At Locations 10 and 11, there is the possibility of thorium-232, although the spectra are not significantly different from background. No specific radionuclides were identified at Location 5.

5.0 REFERENCES

DOE, 2000. Multiple-Agency Radiation Survey and Site Investigation Manual. August 2000, DOE/EH-0624, Rev. 1. U. S. Department of Energy, Washington D.C.

USAF, 2005. Final Status Survey Report for Installation Restoration Program Site OT-10, Radiation Training Sites, 2005, HQ AFCEE/ERD Environmental Restoration Division, Brooks City Base, Texas 78253-5112.

NRC, 1997. Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. 1997, NUREG-1507. U. S. Nuclear Regulatory Agency, Washington, D.C.

Attachment A

Instrument Calibration Records

Certificate of Calibration

Voltage Plateau Form

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

Detector Mfg.: Ludlum Model: 44-20 Serial No.: PR 201774

Counter Mfg.: Ludlum Model: 2221 Serial No.: 71235

Counter Threshold Setting: 10 mV

Geometry / Distance to source: 6-inches

Source : ☐ Th230 @ 13,500 dpm sn: 4098-03 ☐ Tc99 @ 18,100 dpm sn: 4099-03

☑ Cs137 @ 6.5 µCi sn: 4097-03 ☐ Other:

Count Time: 0.5 minute(s)

High Voltage	Gross Source Counts	Background Counts
600	35501	
700	66453	
800	89601	
900	96341	
950	100240	
1000	103585	
1025	103846	
✓ 1050	104381	13339
1075	104882	
1100	104584	
1125	105418	
1150	104989	
1175	105009	
1200	105573	
1300	110244	

Recommended Operating Voltage: 1050 volts

Calibrated By: [signature]

Calibration Date: 26 JUL 04

Calibration Due: 26 JUL 05

Reviewed By: [signature]

Date: 7/26/04

Certificate of Calibration

Voltage Plateau Form

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

Detector Mfg.: Ludlum Model: 44-20 Serial No.: PR202071

Counter Mfg.: Ludlum Model: 2221 Serial No.: 86306

Counter Threshold Setting: 10 mV Geometry / Distance to source: 6-inches

Source : ☐ Th230 @ 13,500 dpm sn: 4098-03 ☐ Tc99 @ 18,100 dpm sn: 4099-03

☑ Cs137 @ 6.5 µCi sn: 4097-03 ☐ Other: ____________

Count Time: 0.5 minute(s)

High Voltage	Gross Source Counts	Background Counts
600	12759	
700	62478	
800	88391	
900	97687	
950	99943	
1000	103803	
1025	104794	
1050	105511	
1075	105625	13458
1100	106599	
1125	106840	
1150	105551	
1175	106025	
1200	107438	
1300	107238	

Recommended Operating Voltage: 1075 volts

Calibrated By: [signature] Calibration Date: 7-26-04

Calibration Due: 7-26-05

Reviewed By: [signature] Date: 7/26/04

Certificate of Calibration

Voltage Plateau Form

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

Detector Mfg.: Ludlum Model: 44-20 Serial No.: PR202073

Counter Mfg.: Ludlum Model: 2221 Serial No.: 108853

Counter Threshold Setting: 10 mV Geometry / Distance to source: 6-inches

Source: ☐ Th230 @ 13,500 dpm sn: 4098-03 ☐ Tc99 @ 18,100 dpm sn: 4099-03

☑ Cs137 @ 6.5 µCi sn: 4097-03 ☐ Other: ____

Count Time: 0.5 minute(s)

	High Voltage	Gross Source Counts	Background Counts
	600	32573	
	700	66438	
	800	90196	
	900	98538	
	950	100343	
	1000	104936	
×	1025	105683	13384
	1050	106018	
	1075	105120	
	1100	105831	
	1125	106154	
	1150	105351	
	1175	105487	
	1200	107790	
	1300	109370	

Recommended Operating Voltage: 1025 volts

Calibrated By: [signature] Calibration Date: 7-26-04

Calibration Due: 7-26-05

Reviewed By: [signature] Date: 7/26/04

Certificate of Calibration

Ratemeter / Scaler Certificate of Calibration

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

Manufacturer: Ludlum Model: 2221 Serial No.: 71235

All Ranges Calibrated Electronically; Ludlum Pulser Generator S.N. 97743

Reset ☑ Audio ☑ Mechanical ☑ Battery ☑ Window Operation ☑

High Voltage 500v ☑ 1000v ☑ 1500v ☑

Instrument found within tolerance (+/- 10%) Yes ☑ No ☐

Reference Setting	Ratemeter	Instrument "As found reading"
400 Kcpm	400 Kcpm	+/-10%
100 Kcpm	100 Kcpm	↓
40 Kcpm	40 Kcpm	↓
10 Kcpm	10 Kcpm	↓
4 Kcpm	4 Kcpm	↓
1 Kcpm	1 Kcpm	↓
400 cpm	400 cpm	↓
100 cpm	100 cpm	↓

Reference Setting	Integrated Counts (1-minute count)	Log Scale Count Rate	Instrument "As found reading"
400 Kcpm	399907	400 Kcpm	+/-10%
40 Kcpm	39935	40 Kcpm	↓
4 Kcpm	3996	4 Kcpm	↓
400 cpm	400	400 cpm	↓

Calibrated By: [signature] Calibration Date: 7-20-04

Calibration Due: 7-20-05

Reviewed By: [signature] Date: 7/26/04

DRAFT

Certificate of Calibration

Ratemeter / Scaler Certificate of Calibration

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

Manufacturer: Ludlum Model: 2221 Serial No.: 86306

All Ranges Calibrated Electronically; Ludlum Pulser Generator S.N. 97743

Reset ☑ Audio ☑ Mechanical ☑ Battery ☑ Window Operation ☑

High Voltage 500v ☑ 1000v ☑ 1500v ☑

Instrument found within tolerance (+/- 10%) Yes ☑ No ☐

Reference Setting	Ratemeter	Instrument "As found reading"
400 Kcpm	400kcpm	+/-10%
100 Kcpm	100kcpm	↓
40 Kcpm	40kcpm	↓
10 Kcpm	10kcpm	↓
4 Kcpm	4kcpm	↓
1 Kcpm	1Kcpm	↓
400 cpm	400cpm	↓
100 cpm	100cpm	

Reference Setting	Integrated Counts (1-minute count)	Log Scale Count Rate	Instrument "As found reading"
400 Kcpm	399527	400kcpm	+/-10%
40 Kcpm	39999	40kcpm	↓
4 Kcpm	3995	4kcpm	↓
400 cpm	400	400cpm	

Calibrated By: [signature] Calibration Date: 7-20-04

Calibration Due: 7-20-05

Reviewed By: [signature] Date: 7/26/04

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Certificate of Calibration

Ratemeter / Scaler Certificate of Calibration

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

Manufacturer: Ludlum Model: 2221 Serial No.: 108853

All Ranges Calibrated Electronically; Ludlum Pulser Generator S.N. 97743

Reset ☑ Audio ☑ Mechanical ☑ Battery ☑ Window Operation ☑

High Voltage 500v ☑ 1000v ☑ 1500v ☑

Instrument found within tolerance (+/- 10%) Yes ☑ No ☐

Reference Setting	Ratemeter	Instrument "As found reading"
400 Kcpm	400 Kcpm	+/- 10%
100 Kcpm	100 Kcpm	↓
40 Kcpm	40 Kcpm	↓
10 Kcpm	10 Kcpm	↓
4 Kcpm	4 Kcpm	↓
1 Kcpm	1 Kcpm	↓
400 cpm	400 cpm	↓
100 cpm	100 cpm	↓

Reference Setting	Integrated Counts (1-minute count)	Log Scale Count Rate	Instrument "As found reading"
400 Kcpm	399321	400 Kcpm	+/- 10%
40 Kcpm	39946	40 Kcpm	↓
4 Kcpm	3990	4 Kcpm	↓
400 cpm	399	400 cpm	↓

Calibrated By: [signature] Calibration Date: 7-20-04

Calibration Due: 7-20-05

Reviewed By: [signature] Date: 7/26/04

ERG Form 1.02B

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Certificate of Calibration

Ratemeter / Scaler Certificate of Calibration

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

Manufacturer: Ludlum Model: 2221 Serial No.: 117652

All Ranges Calibrated Electronically; Ludlum Pulser Generator S.N. 97743

Reset ☑ Audio ☑ Mechanical ☑ Battery ☑ Window Operation ☑

High Voltage 500v ☑ 1000v ☑ 1500v ☑

Instrument found within tolerance (+/- 10%) Yes ☑ No ☐

Reference Setting	Ratemeter	Instrument "As found reading"
400 Kcpm	400 Kcpm	+/- 10%
100 Kcpm	100 Kcpm	↓
40 Kcpm	40 Kcpm	↓
10 Kcpm	10 Kcpm	↓
4 Kcpm	4 Kcpm	↓
1 Kcpm	1 Kcpm	↓
400 cpm	400 cpm	↓
100 cpm	100 cpm	

Reference Setting	Integrated Counts (1-minute count)	Log Scale Count Rate	Instrument "As found reading"
400 Kcpm	400413	400 Kcpm	+/- 10%
40 Kcpm	40038	40 Kcpm	↓
4 Kcpm	4003	4 Kcpm	↓
400 cpm	400	400 cpm	↓

Calibrated By: [signature]

Calibration Date: 9-15-04

Calibration Due: 9-15-05

Reviewed By: [signature]

Date: 9/15/04

DRAFT

Certificate of Calibration

Voltage Plateau Form

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

Detector Mfg.: Alpha Spectra Model: FIDLER Serial No.: 1102990

Counter Mfg.: Ludlum Model: 2221 Serial No.: 108853

Counter Threshold Setting: 10 mV Geometry / Distance to source: 1/2" ~~mm~~

Source: ☑ AM-241 @ 1 mCi sn:ERGSD-1 ☐ Other:

Count Time: 0.1 minute(s)

High Voltage	Gross Source Counts	Background Counts
750	1363	
800	4125	
850	65373	
900	78875	
950	92431	
1000	113445	
1025	125093	
1050	133315	
1075	137728	
1100	140420	4912
1125	140423	
1150	140913	
1175	140316	
1200	141657	
1225	141616	
1250	142085	
1300	148125	

Recommended Operating Voltage: 1100 volts

Calibrated By: [signature] Calibration Date: 7-20-04

Calibration Due: 7-20-05

Reviewed By: [signature] Date: 7/26/04

ERG Form 1.03A

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Certificate of Calibration

Voltage Plateau Form

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

Detector Mfg.: Alpha Spectra Model: FIDLER Serial No.: 126999A

Counter Mfg.: Ludlum Model: 2221 Serial No.: 71235

Counter Threshold Setting: 10 mV Geometry / Distance to source: 1/2"

Source: ☑ AM-241 @ 1 mCi sn:ERGSD-1 ☐ Other: ______

Count Time: 0.1 minute(s)

High Voltage	Gross Source Counts	Background Counts
750	1593	
800	4290	
850	68422	
900	78751	
950	90974	
1000	109356	
1025	118641	
1050	127232	
1075	131729	
1100	135048	
1125	135590	
1150	136105	
1175	136376	
1200	136118	5027
1225	136542	
1250	136923	
1300	137304	

Recommended Operating Voltage: 1200 volts

Calibrated By: [signature] Calibration Date: 7-20-04

Calibration Due: 7-20-05

Reviewed By: [signature] Date: 7/26/04

ERG Form 1.03A

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Certificate of Calibration

Voltage Plateau Form

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

Detector Mfg.: Alpha Spectra Model: FIDLER Serial No.: 120999K

Counter Mfg.: Ludlum Model: 2221 Serial No.: 117652

Counter Threshold Setting: 10 mV Geometry / Distance to source: 1/2"

Source : ☑ AM-241 @ 1 mCi sn:ERGSD-1 ☐ Other:

Count Time: 05 minute(s)

High Voltage	Gross Source Counts	Background Counts
650	661	
700	1825	
750	6412	
800	74045	
850	82241	
900	101557	
950	123343	
975	130304	
1000	132886	
1025	134262	
→ 1050	135068	5301
1075	134968	
1100	134768	
1125	134639	
1150	135386	8
1175	135208	
1200	135384	
1250	140391	

Recommended Operating Voltage: 1050 volts

Calibrated By: [signature] Calibration Date: 9-15-04

Calibration Due: 9-15-05

Reviewed By: [signature] Date: 9/15/04

ERG Form 1.03A

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Certificate of Calibration

Voltage Plateau Form

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

Detector Mfg.: Alpha Spectra Model: FIDLER Serial No.: 120999K

Counter Mfg.: Ludlum Model: 2221 Serial No.: 86306

Counter Threshold Setting: 10 mV Geometry / Distance to source: 1/2" ~~mm~~

Source: ☑ AM-241 @ 1 mCi sn:ERGSD-1 ☐ Other: ____

Count Time: 01 minute(s)

High Voltage	Gross Source Counts	Background Counts
650	382	
700	995	
750	2753	
800	42520	
850	77988	
900	88706	
950	110806	
975	122305	
1000	130807	
1025	134744	
1050	136835	
1075	137213	4986
1100	137467	
1125	138491	
1150	138198	
1175	138539	
1200	138467	
1250	141069	

Recommended Operating Voltage: 1075 volts

Calibrated By: [signature] Calibration Date: 7-20-04

Calibration Due: 7-20-05

Reviewed By: [signature] Date: 7/21/04

ERG

Daily Function Check Form

Site: LANL

Ratemeter: 2221
Detector: 44-20
Source: CS-137
Distance to Source: 6in

Serial No. 71235
Serial No. PR201774
Activity: 5.7 uCi

Cal. Due Date 26 JUL Ø5
Cal. Due Date 26 JUL Ø5
Serial No. 5309-04

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
9-8-04	0805	5.1	1046	97	165213	36725	N/A	N/A	JM	LANL
9-8-04	1510	5.1	1040	97	166586	36872	N/A	N/A	JM	TA-21
9-9-04	0740	5.2	1046	97	166188	36735	N/A	N/A	JM	TA21
9-9-04	1515	4.9	1038	97	165664	36381	N/A	N/A	JM	TA21
9-10-04	0735	5.2	1046	97	163824	36066	N/A	N/A	JM	TA21
9-10-04	~~[illegible]~~ 1400	5.0	1042	97	166516	37265	N/A	N/A	JM	TA21
9-13-04	0730	5.2	1040	97	163374	37349	N/A	N/A	JM	TA21
9-13-04	1530	4.9	1041	97	164563	37269	N/A	N/A	JM	TA21
9-14-04	0730	5.1	1046	97	164144	37402	N/A	N/A	JM	TA21
9.14.04	1530	5.1	1040	97	164853	35898	N/A	N/A	JM	TA21
9-15-04	0740	5.1	1046	97	168986	36036	N/A	N/A	JM	TA21
9-15-04	1535	5.0	~~1044~~ 1039	97	167644	37841	N/A	N/A	JM	TA21

Reviewed By: [signature]

Date: 9-17-04

ERG Form 1.01A

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ERG

Daily Function Check Form

Site: LANL

Ratemeter: 2221
Detector: 44-20
Source: CS-137
Distance to Source:

Serial No. 86306
Serial No. PR 202071
Activity: 5.7 µCi

Cal. Due Date 7-26-05
Cal. Due Date 7-26-05
Serial No. 5309-04

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
9-8-04	0800	5.1	1077	101	165675	37097	N/A	N/A	JM	LANL
9-8-04	1520	5.1	1071	100	171431	36762	N/A	N/A	JM	TA-21
9-9-04	0730	5.3	1077	101	167968	35771	N/A	N/A	JM	TA-21
9-9-04	1510	5.1	1070	101	167487	37355	N/A	N/A	JM	TA-21
9-10-04	0730	5.2	1078	101	164590	37107	N/A	N/A	JM	TA-21
9-10-04	1405	5.1	1072	101	166226	36795	N/A	N/A	JM	TA-21
9-13-04	0735	5.3	1071	101	165486	36607	N/A	N/A	JM	TA-21

Reviewed By: Date:

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ERG

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Daily Function Check Form

Site: LANL

Ratemeter: 2221
Detector: 44-20
Source: Cs 137
Distance to Source: 6"

Serial No. 108853
Serial No. PR 202073
Activity: 5.7 uCi

Cal. Due Date 7-26-05
Cal. Due Date 7-26-05
Serial No. 530904

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
9-8-04	0810	5.0	1029	100	167805	35682	N/A	N/A	JM	TA-21
9-8-04	1515	5.1	1023	100	167776	36998	N/A	N/A	JM	TA-21
9-9-04	0735	5.1	1026	100	166171	35255	N/A	N/A	JM	TA-21
9-9-04	1520	5.1	1025	100	165426	34238	N/A	N/A	JM	TA-21
9-10-04	0740	5.1	1026	100	166286	34704	N/A	N/A	JM	TA-21
9-10-04	1410	5.1	1026	100	166126	34222	N/A	N/A	JM	TA-21
9-13-04	0851	5.2	1026	100	163429	37731	N/A	N/A	LT	TA21
9-13-04	1535	5.0	1025	100	165403	35492	N/A	N/A	JM	TA21
9-14-04	0735	5.1	1028	100	165108	36653	N/A	N/A	JM	TA21
9-14-04	1535	5.0	1023	100	165917	35256	N/A	N/A	JM	TA21
9-15-04	0735	5.1	1026	100	166258	35945	N/A	N/A	JM	TA21
9-15-04	1530	4.4	1024	104	167171	36255	N/A	N/A	JM	TA21

Reviewed By: [signature]

Date: 9-17-04

ERG Form 1.01A

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ERG

Daily Function Check Form

Site: LANL

Ratemeter: 2221
Detector: 44-20
Source: CS-137
Distance to Source: 6 in

Serial No. 71235
Serial No. PR201774
Activity: 5.7uc.

Cal. Due Date 26 JUL 05
Cal. Due Date 26 JUL 05
Serial No. 5309-04

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
9-16-04	0800	5.0	1045	97	161688	36902	N/A	N/A	JM	TA-21
9-16-04	1535	5.0	1042	97	164782	34218	N/A	N/A	JM	TA-21
9-17-04	0730	5.1	1046	97	164722	36383	N/A	N/A	JM	TA-21
9-17-04	1505	4.9	1037	97	165928	35621	N/A	N/A	JM	TA-21
9-21-04	0735	5.1	1047	97	163568	36518	N/A	N/A	JM	TA-21
9-21-04	1530	4.9	1044	97	161226	36144	N/A	N/A	JM	TA-21
9-22-04	0730	5.0	1049	97	162946	36524	N/A	N/A	JM	TA-21
9-22-04	1535	4.8	1045	97	162756	36911	N/A	N/A	JM	TA-21

Reviewed By: ________ Date: ________

ERG Form 1.01A

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Daily Function Check Form

Site: LANL

Ratemeter: 2221
Detector: 44-20
Source: Cs 137
Distance to Source: 6 in

Serial No. 108853
Serial No. PR 202075
Activity: 5.7 uCi

Cal. Due Date 7-26-05
Cal. Due Date 7-26-05
Serial No. 5309 04

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
9-16-04	0805	5.0	1027	100	164204	35397	N/A	N/A	JM	TA-21
9-16-04	1530	4.9	1024	100	165630	37897	N/A	N/A	JM	TA-21
9-17-04	0735	6.1	1026	100	166371	36355	N/A	N/A	JM	TA-21
9-17-04	1500	5.8	1022	100	166317	35800	N/A	N/A	JM	TA-21
9-20-04	0700	5.9	1029	100	164914	37776	N/A	N/A	LT	TA-21
9-20-04	1500	5.6	1027	101	165075	36966	N/A	N/A	LT	TA21
9-21-04	0730	5.8	1031	101	164745	37032	N/A	N/A	JM	TA21
9-21-04	1535	5.6	1027	101	141253	33751	N/A	N/A	JM	TA21
9-22-04	0735	5.7	1031	101	163805	36110	N/A	N/A	JM	TA21
9-22-04	1530	5.5	1029	101	162453	36788	N/A	N/A	JM	TA21
10-12-04	0735	5.3	1027	101	164473	36585	N/A	N/A	JM	TA21
10-12-04	1130	5.1	1025	101	164816	36113	N/A	N/A	JM	TA21

Reviewed By: Date:

10-14-04	0810	5.1	1026	101	164224	36556	N/A	N/A	JM	TA-21
10-18-04	1045	5.0	1022	100	164211	37135	N/A	N/A	JM	TA21

ERG Form 1.01A

#2

ERG

Daily Function Check Form

Site: TA-21

Ratemeter: 2221
Detector: FIDLER
Source:
Distance to Source:

Serial No. 108853
Serial No. 110299KU
Activity:

Cal. Due Date 7/20/05
Cal. Due Date 7/20/05
Serial No.

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
9/23/04	1200	5.5	1104	101	279278	13301	N/A	N/A	JM	TA-21
9/23/04	1530	5.4	1059	101	279330	13544	N/A	N/A	JM	TA21
9/24/04	0740	5.5	1104	102	280298	13683	N/A	N/A	LT	TA21
9/24/04	1500	5.4	1100	101	279207	13893	N/A	N/A	JM	TA 21
9/27/04	0735	5.5	1104	101	280885	13594	N/A	N/A	JM	TA-21
9/27/04	1535	5.4	1059	101	279322	13404	N/A	N/A	JM	TA 21
9/28/04	0735	5.5	1104	101	279896	13284	N/A	N/A	JM	TA 21
9/28/04	1535	5.3	1103	101	279826	13591	N/A	N/A	JM	TA 21
9/29/04	0730	5.4	1105	101	280841	13012	N/A	N/A	LT	TA-21
9/29/04	1535	5.3	1103	101	280325	13106	N/A	N/A	JM	TA-21
9/30/04	0735	5.4	1104	101	279250	13853	N/A	N/A	JM	TA 21
9/30/04	1335	5.2	1103	101	280012	13077	N/A	N/A	JM	TA 21

Reviewed By:

Date:

DRAFT

#3 3

ERG

Daily Function Check Form

Site: TA 21

Ratemeter: 2221
Detector: Fidler
Source:
Distance to Source:

Serial No. 71235
Serial No. 120999A
Activity:

Cal. Due Date 7/20/05
Cal. Due Date 7/20/05
Serial No.

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
9/23/04	1210	6.1	1205	99	274729	13477	N/A	N/A	JM	TA-21
9/23/04	1535	6.0	1200	99	276008	13404	N/A	N/A	JM	TA21
9/24/04	0745	6.0	1205	99	277347	13734	N/A	N/A	LT	TA-21
9/24/04	1510	5.8	1200	99	275590	13544	N/A	N/A	JM	TA-21
9/27/04	0740	5.9	1205	99	277309	13750	N/A	N/A	JM	TA-21
9/27/04	1540	5.7	1200	98	273044	13666	N/A	N/A	JM	TA 21
9/28/04	0740	5.8	1205	99	276185	13430	N/A	N/A	JM	TA 21
9/28/04	1540	5.6	1203	99	275521	13608	N/A	N/A	JM	TA 21
9/29/04	0725	5.7	1206	99	281861	13467	NA	N/A	LT	TA-21
9/29/04	1540	5.5	1205	99	279847	13271	N/A	N/A	JM	TA21
9/30/04	0740	5.6	1206	99	275847	13568	N/A	N/A	JM	TA-21
9/30/04	1340	5.5	1205	99	276535	13388	N/A	N/A	JM	TA-21

Reviewed By:

Date:

DRAFT

ERG Form 1.01A

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ERG

Daily Function Check Form

Site: TA-21

Ratemeter: 2221
Detector: FIDLER
Source:
Distance to Source:

Serial No. 117652
Serial No. 120999K
Activity:

Cal. Due Date 9/15/05
Cal. Due Date 9/15/05
Serial No.

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
9/23/04	1205	5.5	1053	100	270992	14355	N/A	N/A	JM	TA-21
9/23/04	1525	5.4	1049	100	273257	14444	N/A	N/A	JM	TA21
9/24/04	0740	5.5	1054	100	272994	13509	N/A	N/A	LT	TA-21
9/24/04	1505	5.3	1050	100	272105	14564	N/A	N/A	JM	TA21
9/27/04	0730	5.5	1055	100	273157	14588	N/A	N/A	JM	TA21
9/27/04	1530	5.3	1050	100	272974	14631	N/A	N/A	JM	TA21
9/28/04	0730	5.4	1056	100	277015	14269	N/A	N/A	JM	TA21
9/28/04	1530	5.3	1053	100	272001	14158	N/A	N/A	JM	TA21
9/29/04	0731	5.4	1056	100	273909	14554	N/A	N/A	LT	TA-21
9/29/04	1530	5.2	1057	100	272561	14225	N/A	N/A	JM	TA-21
9/30/04	0730	5.3	1057	100	272605	14488	N/A	N/A	JM	TA-21
9/30/04	1530	5.2	1055	100	272654	14254	N/A	N/A	JM	TA-21

Reviewed By:

Date:

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ERG Form 1.01A

#2

ERG

Daily Function Check Form

Site: TA-21

Ratemeter: 2221
Detector: FIDLER
Source:
Distance to Source:

Serial No. 108853
Serial No. 110295U
Activity:

Cal. Due Date 7/20/05
Cal. Due Date 7/20/05
Serial No.

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
10/4/04	0755	5.4	1104	100	280147	13084	N/A	N/A	JM	TA-21
10/4/04	1520	5.4	1100	100	279824	13126	N/A	N/A	JM	TA21
10/6/04	0735	5.4	1106	100	280225	13653	N/A	N/A	JM	TA21
10/6/04	1535	5.2	1103	101	279959	13658	N/A	N/A	JM	TA21
10/7/04	0725	5.4	1104	101	281015	13455	N/A	N/A	JM	TA-21
10/7/04	1535	5.2	1100	101	280621	13500	N/A	N/A	JM	TA-21
10/8/04	0725	5.3	1104	101	279575	13612	N/A	N/A	JM	TA-21
10/8/04	1338	5.2	1103	101	279825	13521	N/A	N/A	JM	TA-21
10/[illegible]/04	1230	5.2	1106	100	281700	13574	N/A	N/A	JM	TA-21
10/[illegible]/04	1530	5.1	1105	101	281354	13592	N/A	N/A	JM	TA-21
10/13/04	0740	5.2	1109	100	283318	13167	N/A	N/A	JM	TA-21
10/13/04	1705	5.1	1105	101	231245	12550	N/A	N/A	LT	TA-21
10/14/04	08:00	5.1	1115	99	267470	12747	NA	NA	LT	TA-21

Reviewed By: Date:

ERG Form 1.01A

DRAFT

#3

ERG

Daily Function Check Form

Site: TA-21

Ratemeter: 2221
Detector: FIDLER
Source:
Distance to Source:

Serial No. 71235
Serial No. 120999A
Activity:

Cal. Due Date 7/20/05
Cal. Due Date 7/20/05
Serial No.

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
10/4/04	0940	5.6	1206	99	277524	13343	N/A	N/A	JM	TA-21
10/4/04	1525	5.3	1203	99	276349	13913	N/A	N/A	JM	TA-21

Reviewed By:

Date:

DRAFT

1

ERG

Daily Function Check Form

Site: TA-21

Ratemeter: 2221
Detector: FIDLER
Source:
Distance to Source:

Serial No. 117652
Serial No. 120994K
Activity:

Cal. Due Date 9/15/05
Cal. Due Date 9/15/05
Serial No.

Notes:

Date	Time	Battery	High Voltage	Threshold (mv)	Gross Counts (CPM)	Background (CPM)	Net Counts (CPM)	Efficiency (CPM/DPM)	Initials	Location
10/4/04	0730	5.4	1057	101	270361	14478	N/A	N/A	JM	TA-21
10/4/04	1530	5.1	1053	101	271263	14149	N/A	N/A	JM	TA21
10/6/04	0730	5.3	1058	101	273773	14154	N/A	N/A	JM	TA21
10/6/04	1530	5.1	1054	101	272453	13970	N/A	N/A	JM	TA-21
10/7/04	0730	5.3	1058	101	274137	13746	N/A	N/A	JM	TA-21
10/7/04	1530	5.1	1052	101	272054	13941	N/A	N/A	JM	TA-21
10/8/04	0730	5.2	1058	101	273094	13832	N/A	N/A	JM	TA-21
10/8/04	1330	5.1	1055	101	273451	14266	N/A	N/A	JM	TA-21
10/12/04	0735	5.3	1058	101	274757	14275	N/A	N/A	JM	TA-21
10/12/04	1515	5.1	1053	101	273958	14212	N/A	N/A	JM	TA21
10/13/04	0735	5.2	1054	101	274481	13863	N/A	N/A	JM	TA21
10/13/04	1305	5.1	1052	101	274356	14114	N/A	N/A	LT	TA21
10/14/04	0800	5.1	1066	101	262274	13620	N/A	N/A	LT	TA21
10/14/04	1640	4.9	1061	101	273341	14356	N/A	N/A	LT	TA21

Reviewed By: Date:

ERG Form 1.01A

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Attachment B

Gamma Spectrometer Results

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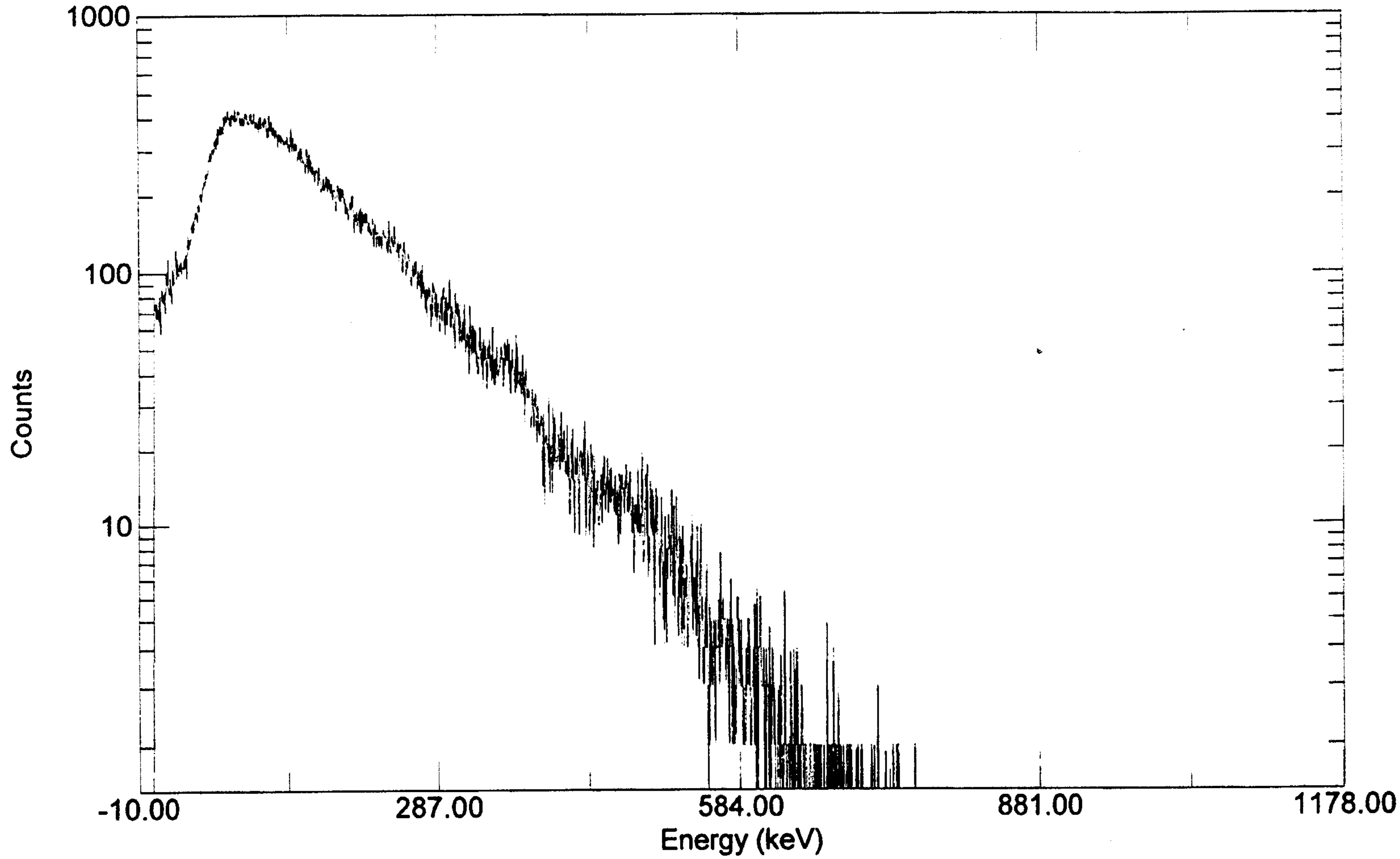
Background Check

Background Check



Acquired: 12/3/2004 9:53:41 AM
File: C:\User\TA-21\Background Check.Chn
Detector: #1 Gerry1

Real Time: 600.00 s. Live Time: 588.34 s.
Channels: 2048

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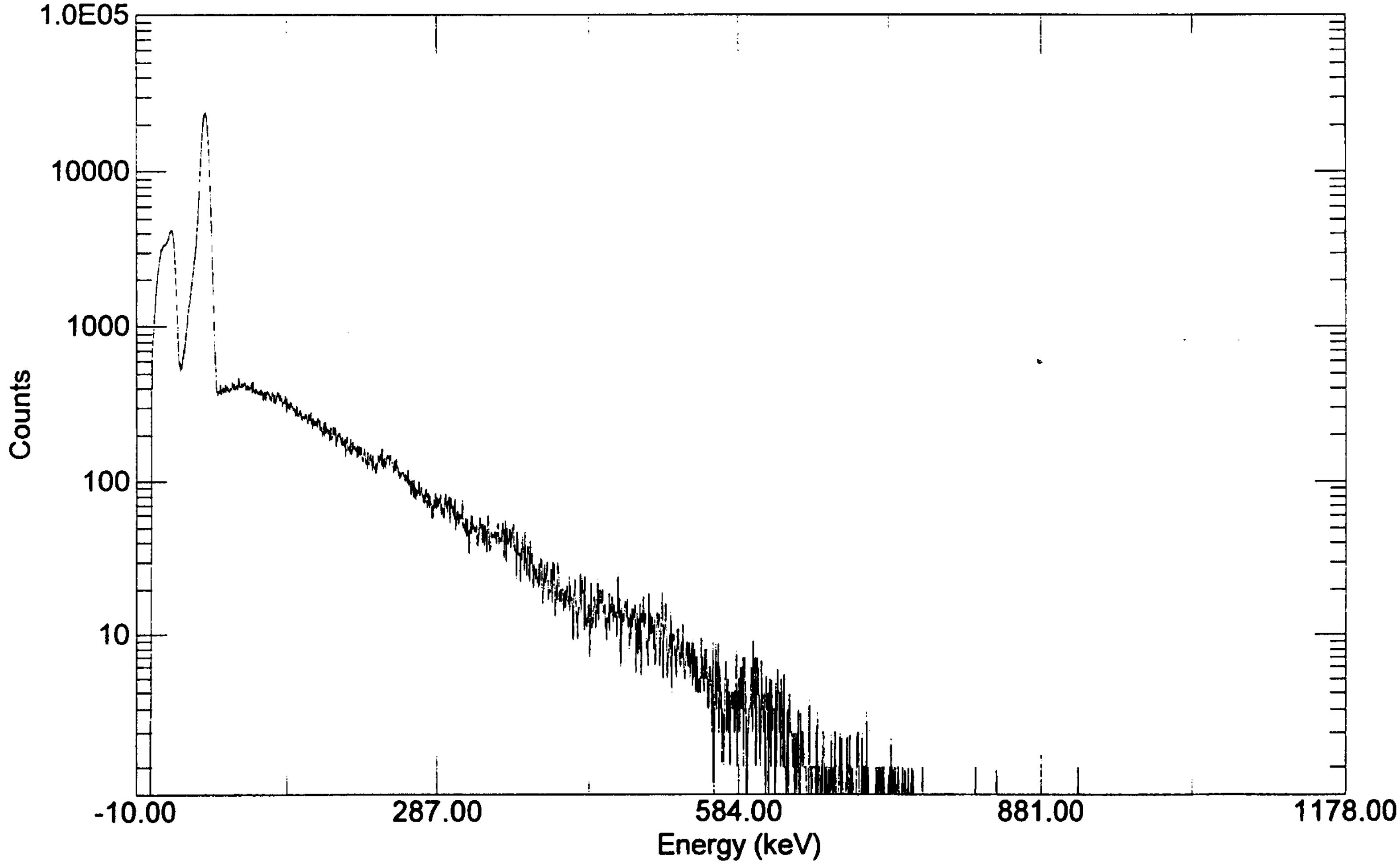
Am-241 Source Check

Am-241 Source Check



Acquired: 12/3/2004 9:40:31 AM
Real Time: 600.00 s. Live Time: 567.60 s.
File: C:\User\TA-21\Am-241 Source Check.Chn
Channels: 2048
Detector: #1 Gerry1

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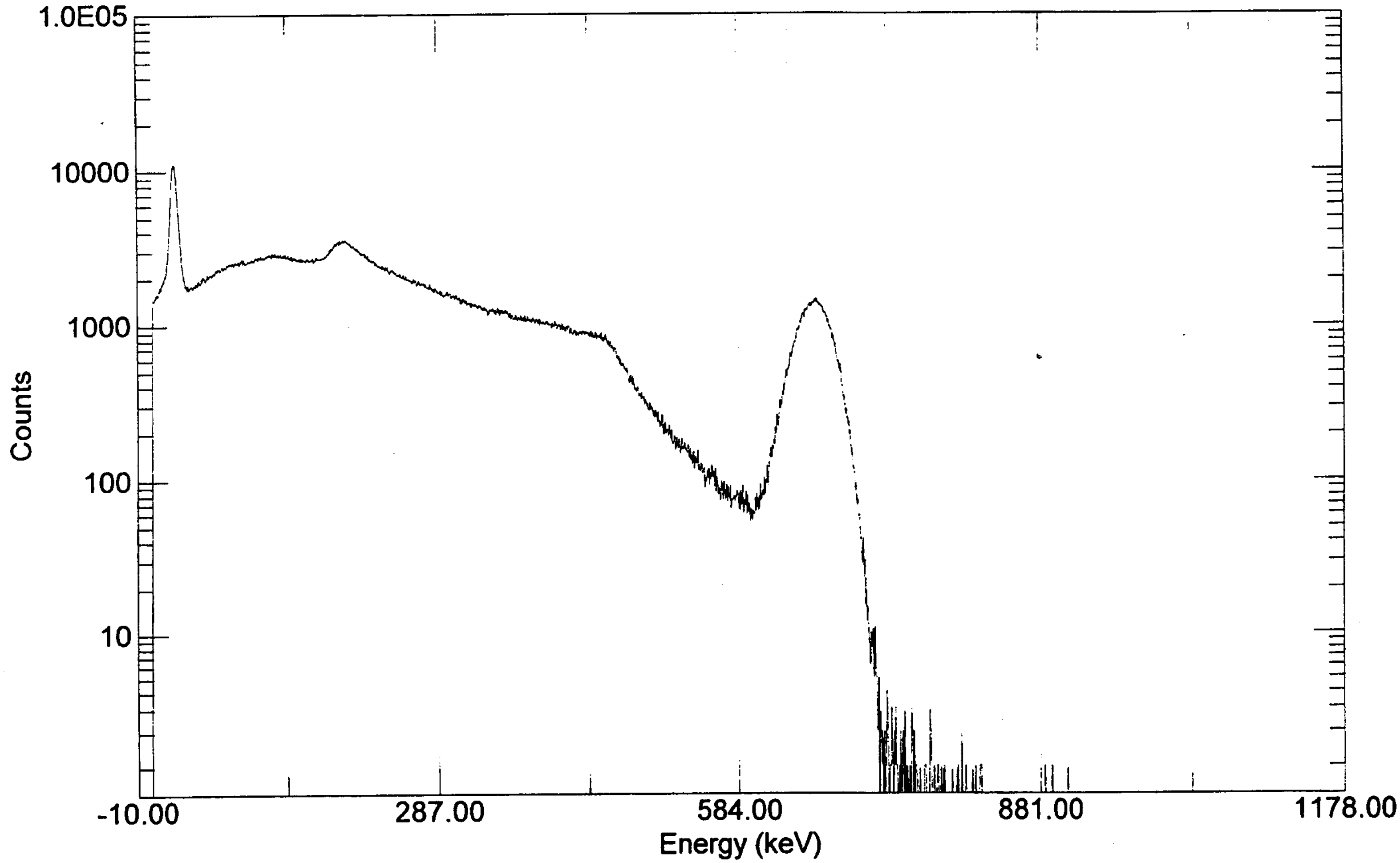
Cs-137 Source Check

Cs-137 Source Check



Acquired: 12/3/2004 9:27:46 AM
File: C:\User\TA-21\Cs-137 Source Check.Chn
Detector: #1 Gerry1

Real Time: 600.00 s. Live Time: 483.94 s.
Channels: 2048

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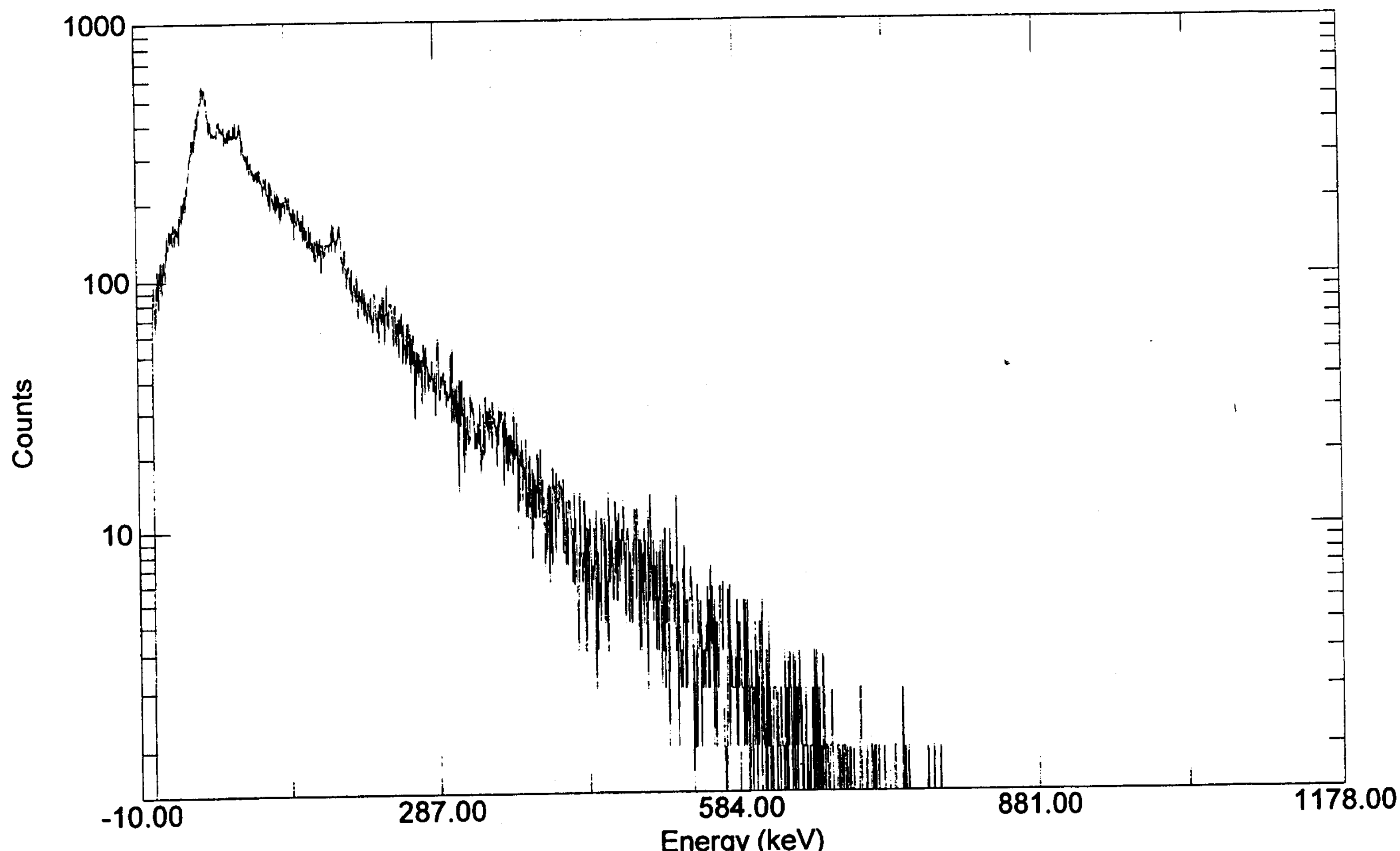
Sample Location 1

TA-21 (1)



Acquired: 12/3/2004 12:58:29 PM
File: C:\User\TA-21\Sample Location 1.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 292.10 s.
Channels: 2048

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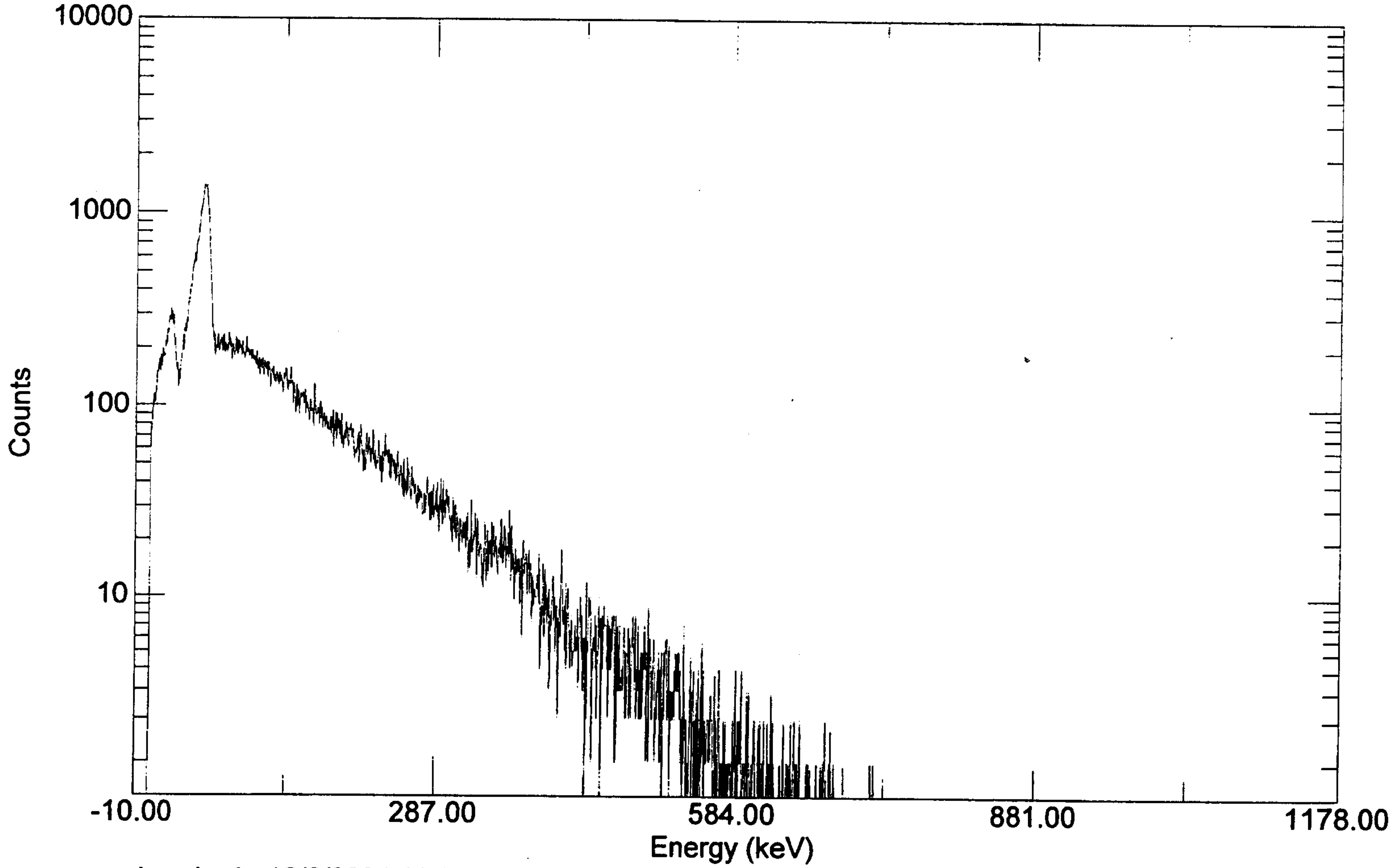
Sample Location 2

TA-21 (2)



Acquired: 12/3/2004 10:58:29 AM
File: C:\User\TA-21\Sample Location 2.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 292.88 s.
Channels: 2048

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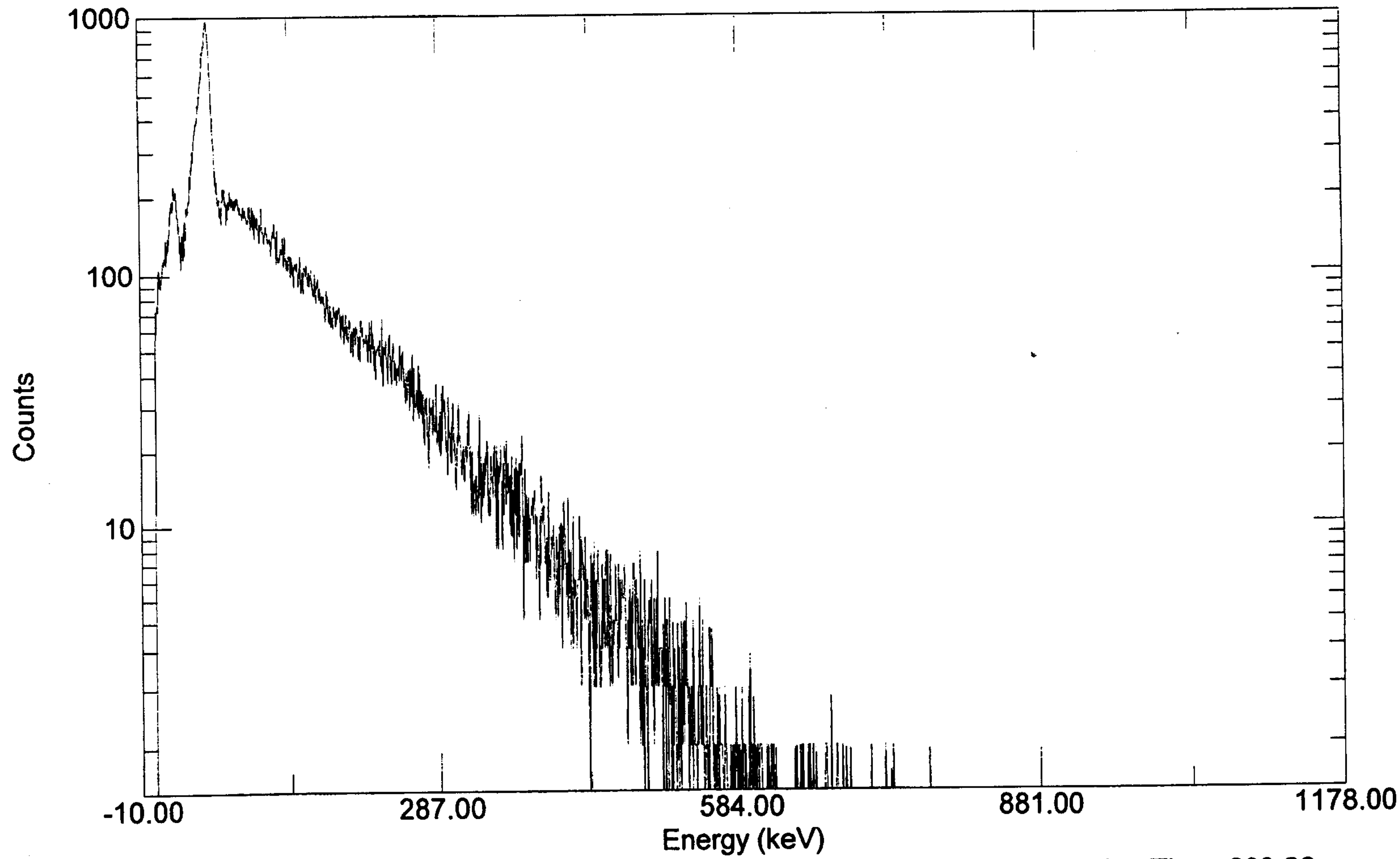
Sample Location 3

TA-21 (3)



Acquired: 12/3/2004 10:51:21 AM
File: C:\User\TA-21\Sample Location 3.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 293.22 s.
Channels: 2048

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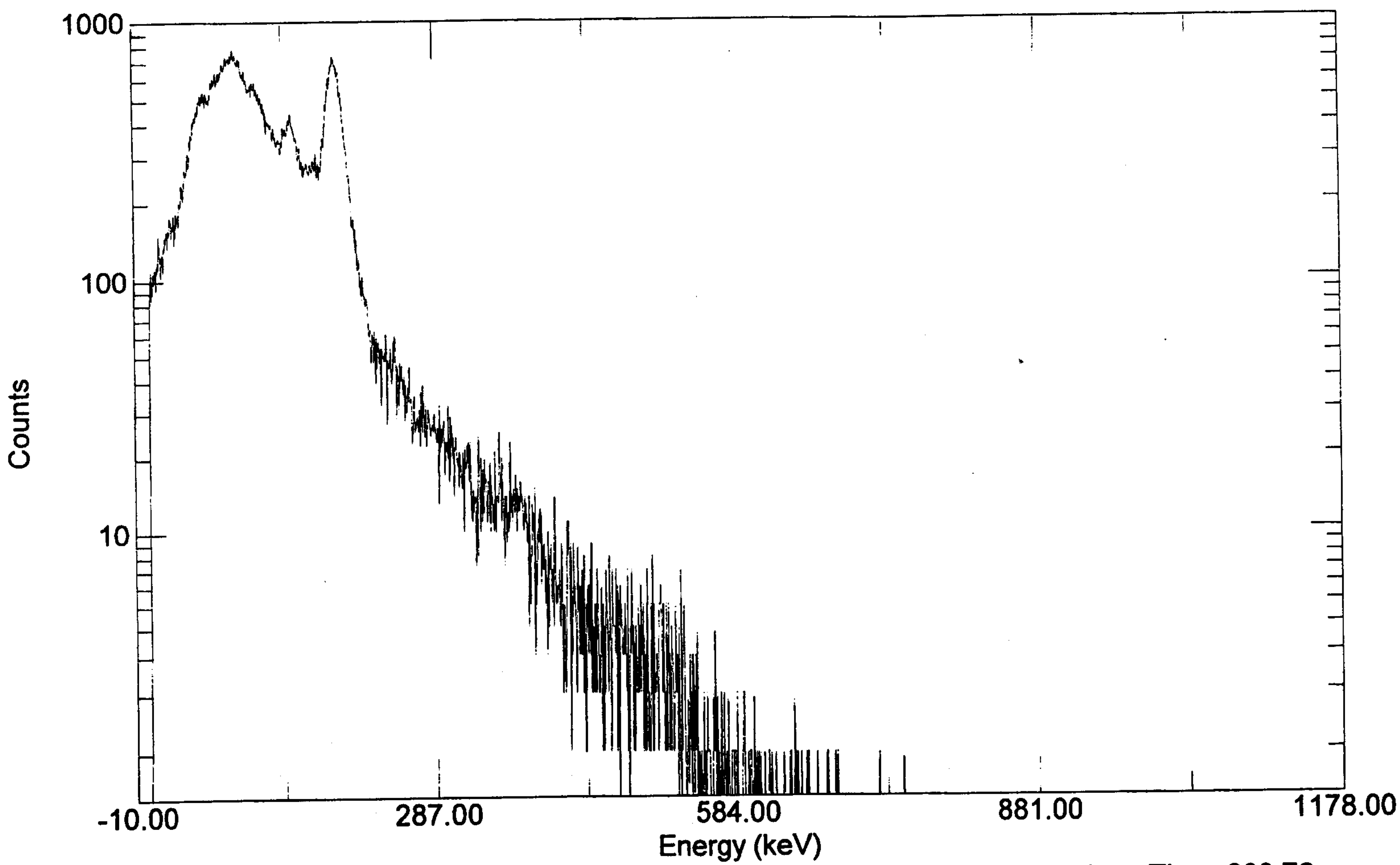
Sample Location 4

TA-21 (4)



Acquired: 12/3/2004 11:05:51 AM
File: C:\User\TA-21\Sample Location 4.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 289.76 s.
Channels: 2048

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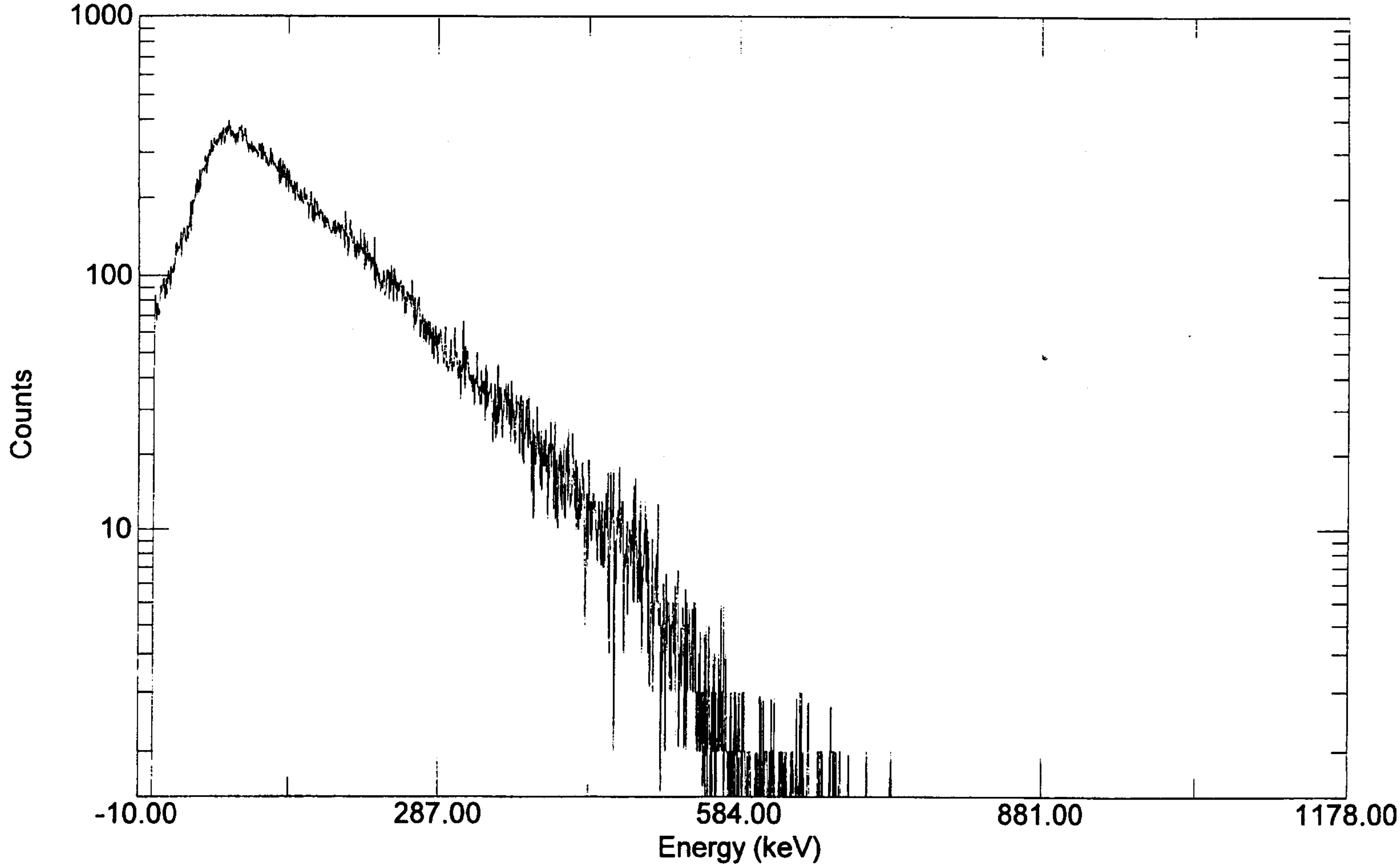
Sample Location 5

TA-21 (5)



Acquired: 12/3/2004 10:36:35 AM
File: C:\User\TA-21\Sample Location 5.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 292.04 s.
Channels: 2048

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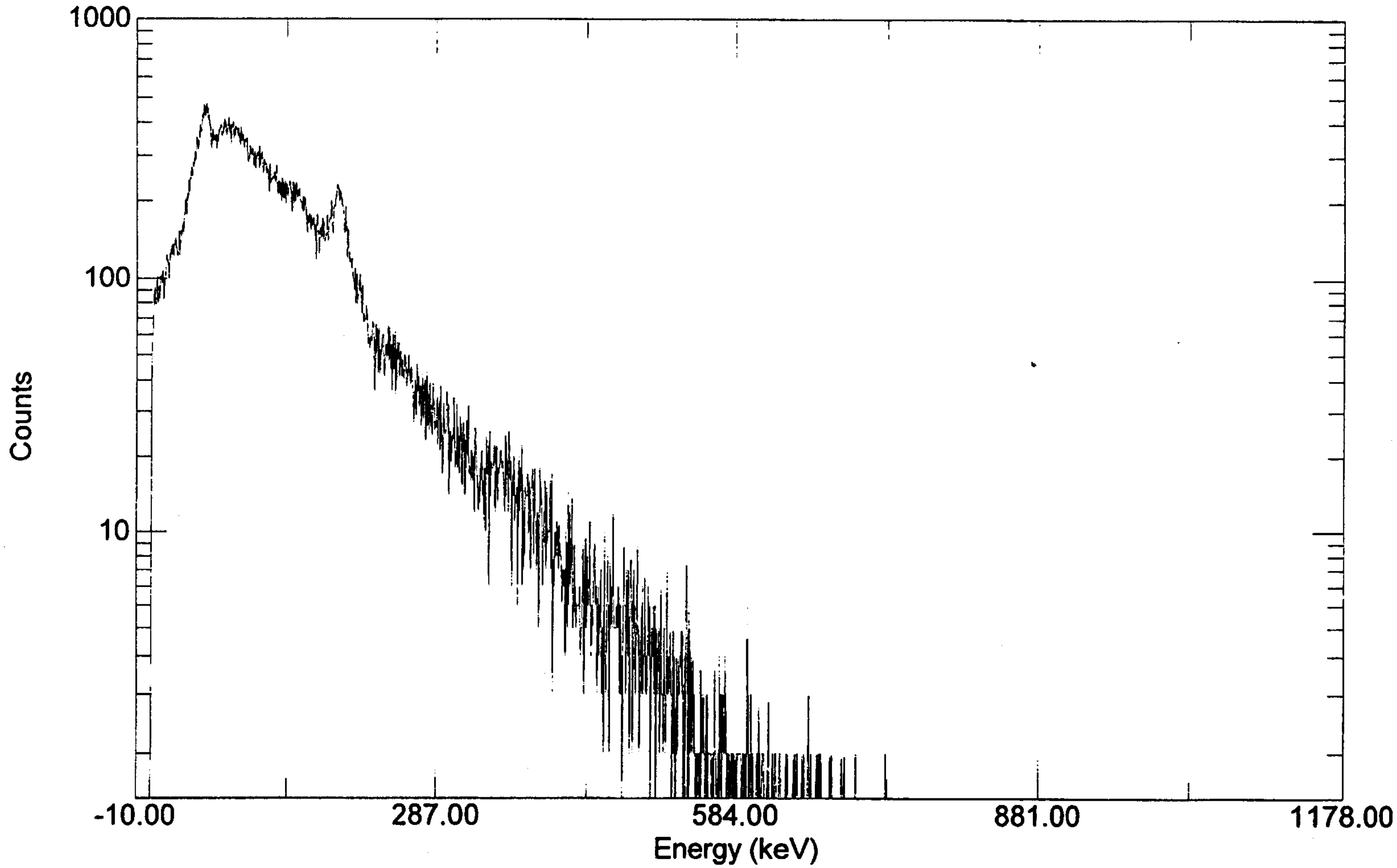
Sample Location 6

TA-21 (6)



Acquired: 12/3/2004 11:16:10 AM
File: C:\User\TA-21\Sample Location 6.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 292.28 s.
Channels: 2048

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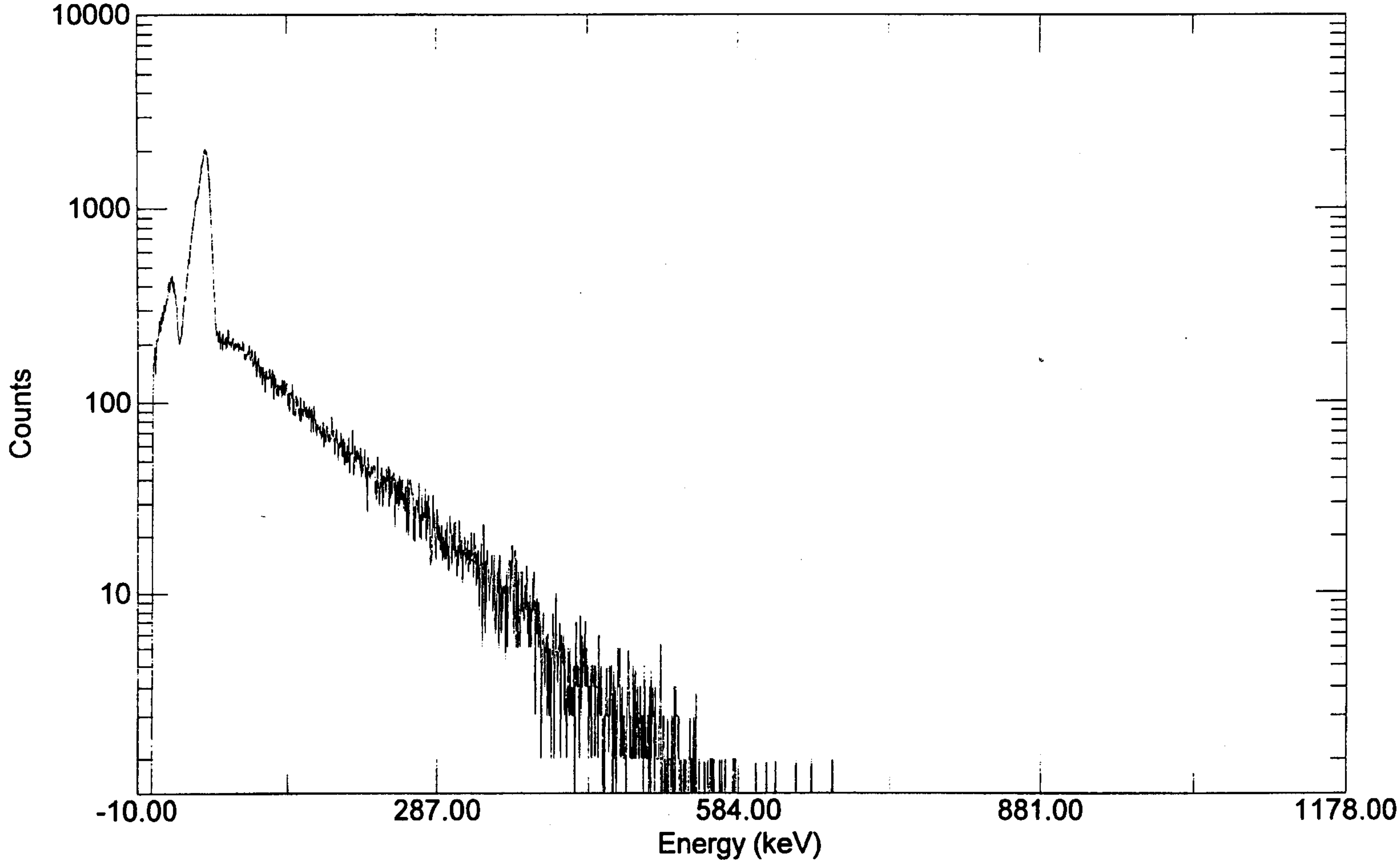
Sample Location 7

TA-21 (7)



Acquired: 12/3/2004 11:54:20 AM
Real Time: 300.00 s. Live Time: 291.78 s.
File: C:\User\TA-21\Sample Location 7.Chn
Channels: 2048
Detector: #1 Gerry1

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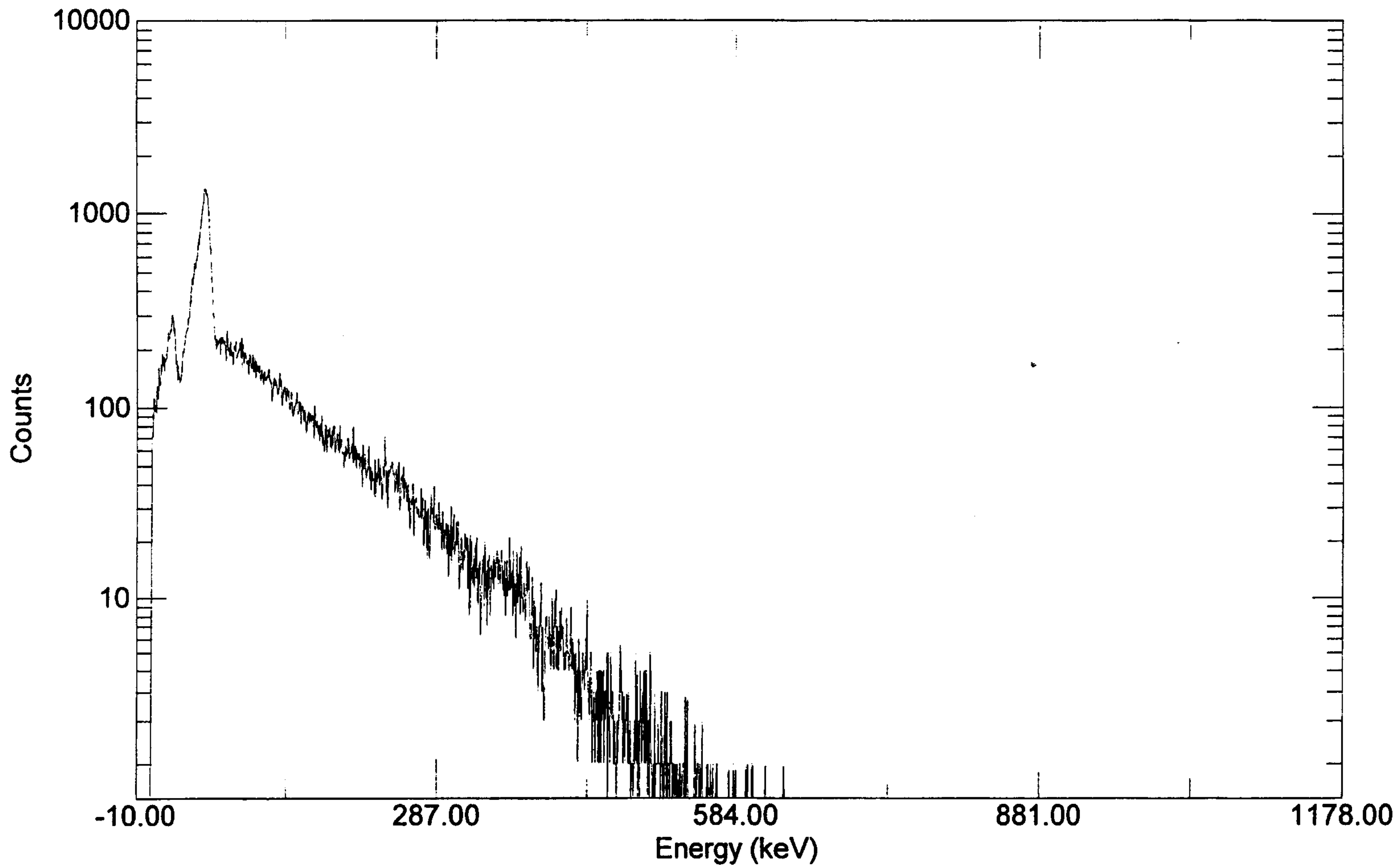
Sample Location 8

TA-21 (8)



Acquired: 12/3/2004 12:06:20 PM
File: C:\User\TA-21\Sample Location 8.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 292.84 s.
Channels: 2048

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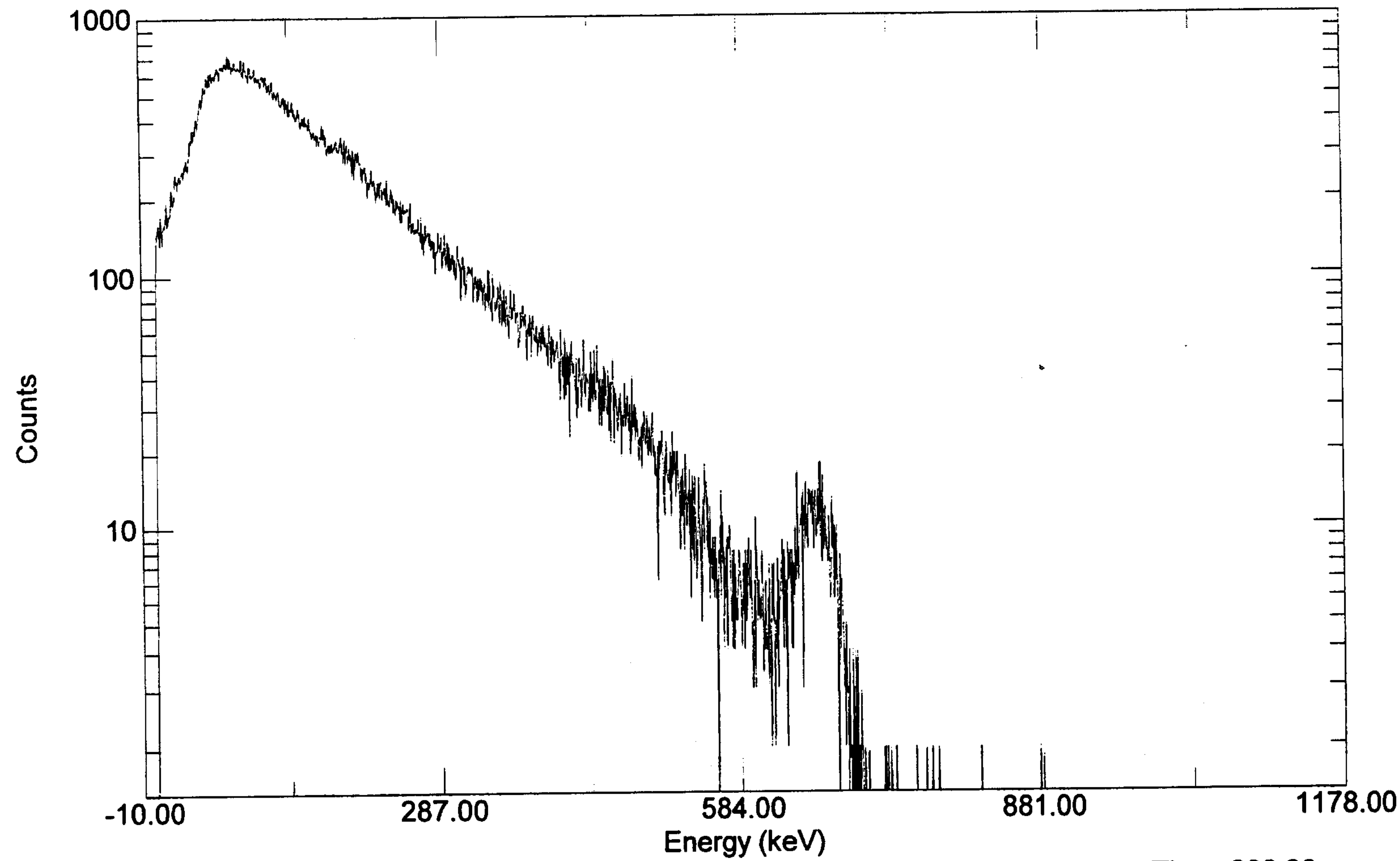
Sample Location 9

TA-21 (9)



Acquired: 12/3/2004 12:39:35 PM
File: C:\User\TA-21\Sample Location 9.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 286.98 s.
Channels: 2048

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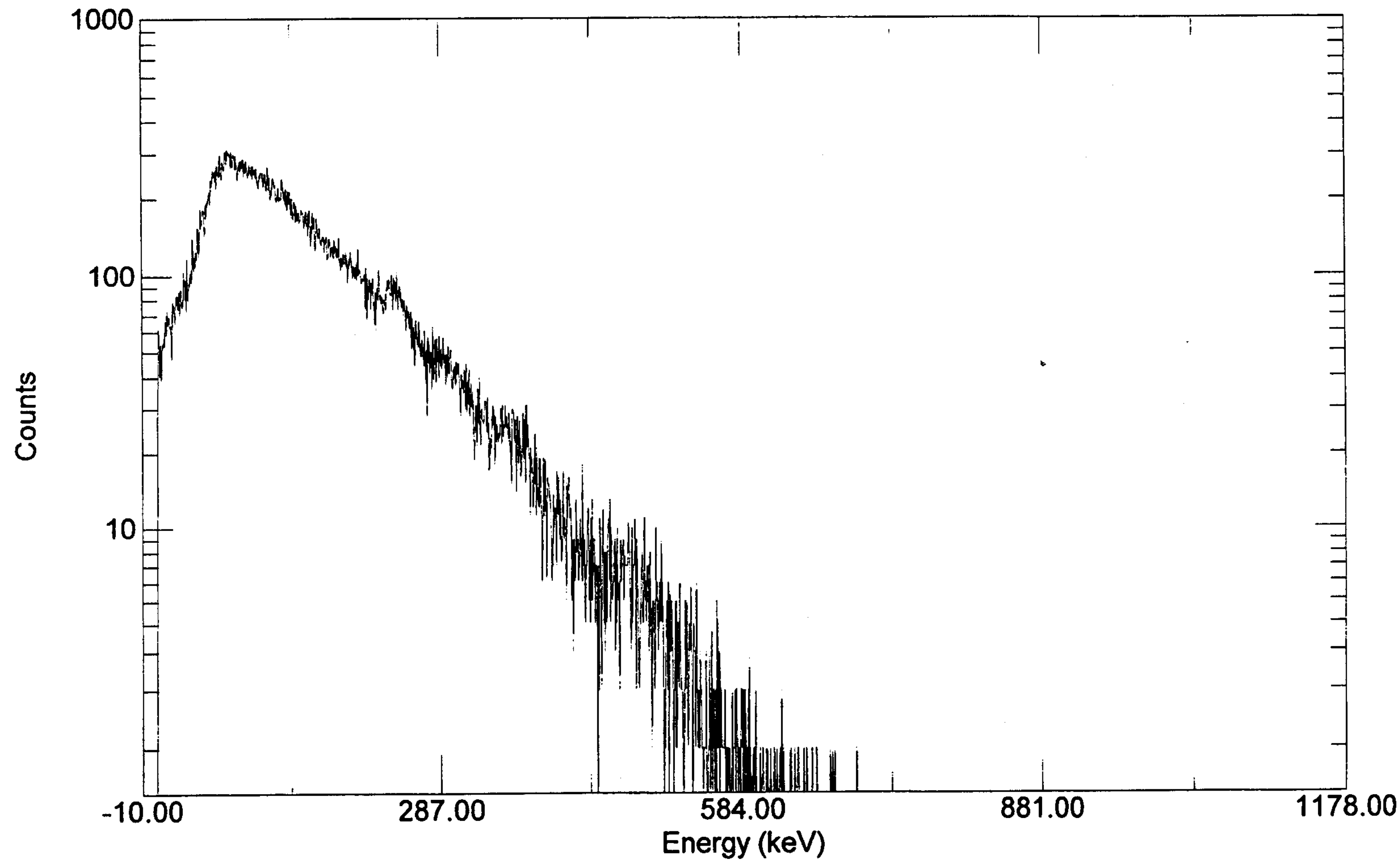
Sample Location 10

TA-21 (10)



Acquired: 12/3/2004 11:45:37 AM
File: C:\User\TA-21\Sample Location 10.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 293.48 s.
Channels: 2048

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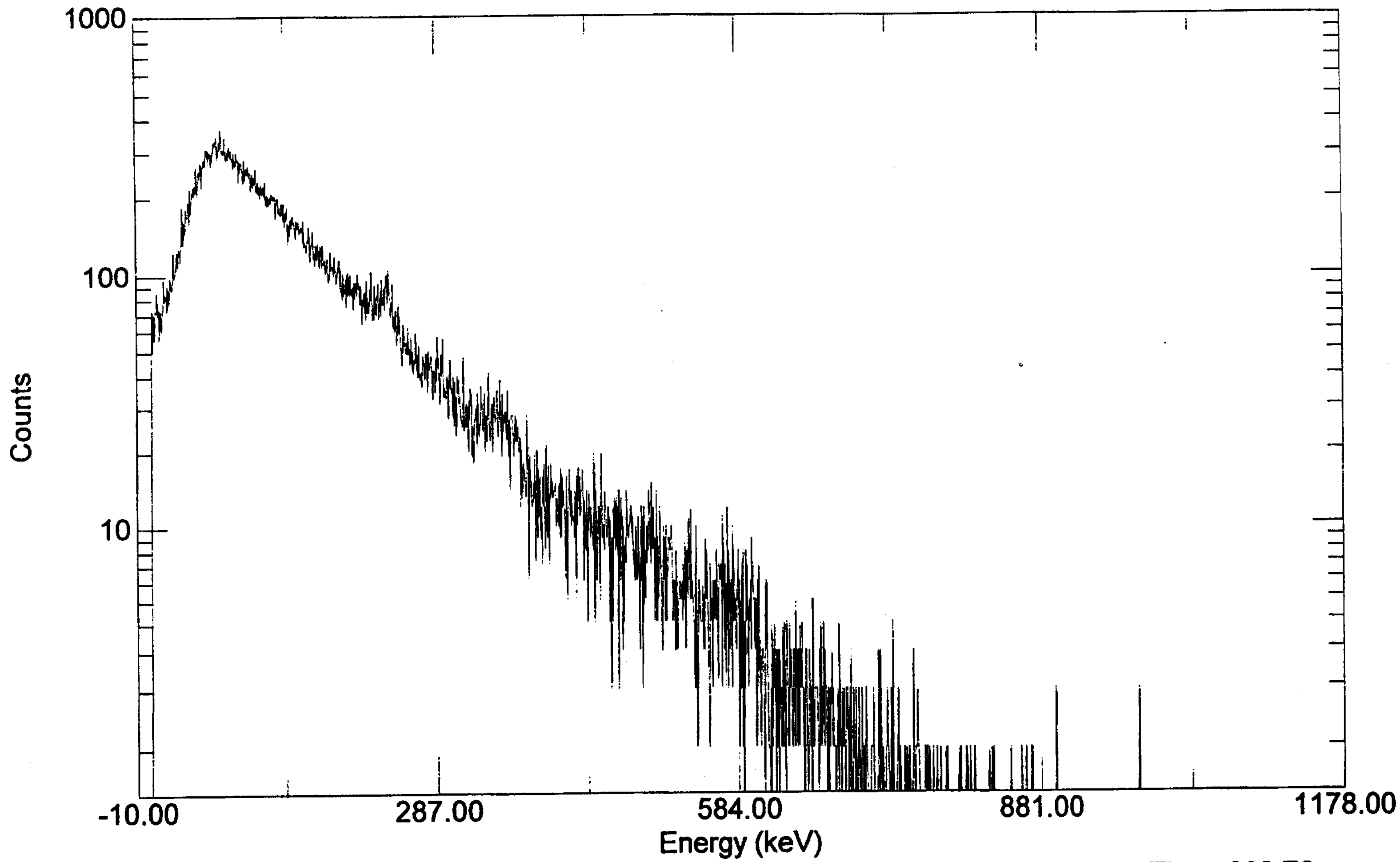
Sample Location 11

TA-21 (11)



Acquired: 12/3/2004 1:18:55 PM
File: C:\User\TA-21\Sample Location 11.Chn
Detector: #1 Gerry1

Real Time: 300.00 s. Live Time: 292.78 s.
Channels: 2048