Appendix K.10

Result of Phase I Munitions and Explosives of Concern RCRA Facility Investigation Union Carbide Corporation-Woodbine

CH2M Hill

June 2008

68 Pages

CH2M HILL
3201 Beechleaf Court
Suite 300
Raleigh, NC
27604
Tel 919.875.4311
Fax 678.579.8123

Via Federal Express

March 3, 2009

Mr. Travis Steed
Environmental Engineer
Georgia Department of Natural Resources
2 Martin Luther King Jr. Drive, SE
Suite 1154 East Tower
Atlanta, GA 30334-0900

RE: Responses to Comments on Phase I Munitions and Explosives of Concern (MEC)
RCRA Facility Investigation
Union Carbide Corporation, Woodbine, Camden County, GA
EPD ID No. GA981235294

Dear Mr. Steed:

CH2M HILL, on behalf of UCC, is hereby submitting responses to EPD's comments on the draft *Results of Phase I Munitions and Explosives of Concern (MEC) RCRA Facility Investigation*, along with the revised pages of the report.

If you have any questions, please feel free to call me at (919) 875-4311 or Tim King of UCC at (304) 747-3763.

Sincerely,

CH2M HILL

R K Ogden III

Keith Ogden, P.E.
Principal Project Manager

Enclosure – Responses to Comments
Revised pages for Results of Phase I Munitions and Explosives of Concern (MEC) RCRA Facility Investigation (3 paper copies and 1 CD)

Cc: Tim King/UCC

Response to Comments and Associated Revised Report Pages. March 3, 2009. 11 Pages

Results of Phase I Munitions and Explosives of Concern (MEC) RCRA Facility Investigation at Woodbine, Georgia Union Carbide Facility

CH2M Hill

June 2008

DOCUMENT:	Phase I Munitions and Explosives of Concern (MEC) RCRA Facility Investigation (RFI) Results (September 2008) Union Carbide Corporation Woodbine, Georgia GAD 981235294
REVIEWER:	Georgia Department of Natural Resources Environmental Protection Division Corrective Action Program (February 2, 2009)
DATE:	March 3, 2009

1. Four facts discussed in the Phase I raise questions about the boundaries of the Munitions Response Areas (MRAs):

   - Geophysical anomalies have been identified at the margins of the MRAs, as shown in Figure 3-2 and mentioned in Sections 5.1.1, 5.1.2, and 5.1.3.
   - MEG was identified far outside the test ranges (MRA-l) and over 1,500 feet from SWMU-7 (MRA-2). The 1971 explosion of the Thiokol facility may have resulted in MEG kickout.
   - Thiokol did not document their test firing or disposal practices.

   These factors indicate the importance of UCC's proposed evaluation of the adequacy of the MRAs as currently delineated. One possibility that should be evaluated is the possibility that two populations of MEG exist across the site: one population of MEG related to identified test ranges and disposal areas, and a second population of MEG generally distributed across the site. Please evaluate this possibility in the Phase II RFI.

   RESPONSE: The Phase II MEC RFI Work Plan will address the evaluation of potential MEC in areas outside of the current MRAs.

2. Page 1-15, Section 1.10.1 states: "The landfill is excluded from the investigation of MRA-l because the cap was placed after the time period during which the test ranges were active. Therefore, MEC would not be present in this area."

   This conclusion can be drawn only for surface MEC. UCC should evaluate the possibility that MEC was buried when the landfill cap was emplaced. Figure 3-2 and 3·3 show geophysical anomalies occurring at the boundary of the RCRA landfill. Sub-cap occurrences of MEC could have the potential to affect future installation of monitoring wells or corrective action.

RESPONSE: Although it is possible that MEC is buried in the landfill, non-intrusive investigation technologies do not allow for the discrimination between MEC and other metallic debris that may be present beneath the cap. Confirmation of MEC would require the removal of portions of the landfill cap. UCC instead recommends that MEC avoidance be conducted during any future intrusive activities that would penetrate the landfill cap. This recommendation has been added to the Phase I MEC RFI report.

Page 2-2, Section 2.5, states: "At MRA-2, DGM transects did not cover the entire MRA because the proposed MRA boundaries extend off of UCC property to the south and southeast , and because the northwestern boundary extended into a wetlands area." The presence of property boundaries or wetlands does not preclude the presence of MEC in these areas. Figure 3.2 shows geophysical anomalies at the margins of these two areas. Please discuss if Bayer CropScience has been approached about a MEC survey on their segment of MRA-2 and evaluate potential MEC in the wetlands area.

RESPONSE: UCC will notify Bayer CropScience that the MRA boundaries extend onto their properties and will provide the company with a copy of these EPD comments.

Although the wetland areas were not investigated in order to avoid disturbing the wetlands, the potential for MEC to be present in the wetlands will be evaluated and addressed during the Phase II MEC RFI. This evaluation will be based on the presence of MEC in the vicinity of the wetlands following the intrusive investigation of subsurface geophysical anomalies.

3. Several references to Appendix E exist between Page 1-7 and 1-12. The Phase I does not include an Appendix E. Please correct the text.

   RESPONSE: These references have been corrected.

4. Page 1-9, Section 1.8.2 references Section 3.1.1. The Phase I does not contain this section. Please correct the text.

   RESPONSE: This reference has been corrected.

5. Page 3-1, Section 3.1, states: "Twenty-one MEC items were discovered on the ground surface at MRA-1..." Figure 3-1 only shows 19 MEC items in MRA-1. Please correct this discrepancy.

   RESPONSE: Two 40mm HE grenades were found in the vicinity of the rocket test pit, but the coordinates were not recorded. Figure 3-1 has been revised to show three MEC items next to the rocket test pit, near the assumed firing point.

6. Page 3-1 and Page 3-2 refer to the anomaly concentration map as Figure 3-2. The anomaly concentration map is Figure 3-3. Please correct the text.

   RESPONSE: The text has been corrected.

TABLE 1-1
Summary of Past RFI and MEC Related Activities

Study	Date	Project Objectives	MEC Related Activities
Expanded Phase II RFI	1996 and 1997	Address GAEPD comments by resampling wells with an improved methodology, complete additional surface MEC removal at SWMU 03, complete additional soil borings at SWMUs 04 and 06.	Surface and subsurface munitions and debris removal at SWMUs 03 and 07 and UXO avoidance in support of other remediation activities.

1.8.1 Phase I RFI Report

RCRA Facility Investigation Report, Union Carbide Corporation, Woodbine, Georgia, Law Environmental Inc., February 5, 1993.

Following issuance of the RCRA Post-Closure Permit, UCC initiated RFI activities to address corrective action of the identified Solid Waste Management Units (SWMUs). Phase I RFI activities were completed by Law Environmental, Inc. (Law) in 1992 and included the installation of a groundwater monitoring well network and a combination of soil and groundwater sampling to identify the nature and extent of contamination at SWMUs 02, 03, 04, 05, 06, and 07. The presence of MEC and MD were suspected at SWMUs 03, 04, 06, and 07. MEC surface removal was included in the scope of work for pre-RFI surface debris removal conducted from September 1992 through October 1993. Appendix A, Templates 2 and 3, Figures titled, "Plot Plan Pre-RCRA Disposal Sites" and "Figure B-4, Facility Topographic Map" were developed by Law and depict the locations of the SWMUs, original monitoring wells, and other site features. EOD Technology, Inc. (EODT) of Knoxville, Tennessee, was employed to complete the MEC-related activities during the Phase I activities. Munitions-related items were found in SWMUs 03 and 07. No munitions were discovered at SWMUs 05 and 06. The aerial extent of the MEC investigation is not defined in any available report. Further details regarding the MEC clearance activities related to the Phase I RFI are provided in Section 3.4.

As a result of the Phase I RFI, Law concluded that:

- SWMU 03 did not appear to present a risk to potential receptors and recommended no further action (NFA).
- Releases to groundwater did not appear to present a risk to potential receptors at SWMU 07, but recommended additional assessment to locate and characterize buried material.

Following the submittal of the Phase I report, information was discovered regarding additional disposal areas and GA EPD requested additional investigation as part of the Phase II activities.

1.8.2 Phase II RFI Report

Report of the Phase II RCRA Facility Investigation (RFI) Conducted on the Union Carbide Corporation Woodbine, Georgia Facility, Apex Environmental, Inc., September 20, 1996.

A Phase II RFI was subsequently performed by Apex Environmental, Inc. (Apex), on behalf of Thiokol. The Phase II RFI included the collection of background soil samples for metals analysis, completion of surface geophysics at selected SWMUs, collection of subsurface soil samples; installation and sampling of monitoring wells; test pitting; and identification, removal, and deactivation of UXO.

The Phase II RFI describes SWMU 03 as being located on the east side of the asphalt road leading to the rocket test pad. During the Phase I RFI, SWMU 03 was thought to be limited to an area used for surface storage/disposal of scrap metal and munitions and a trench reportedly used for subsurface disposal of CS material, Nuchar, and other unknown waste materials. Subsequent to the submittal of the Phase I RFI, a burn area for munitions was identified in the northern section of SWMU 3 and an aldicarb disposal area was identified on the east side of the paved road across from the entrance road to the RCRA landfill (refer to Appendix A, Template 4, titled "Figure 3, SWMU 03 Site Map, Woodbine, Georgia" developed by Apex depicting significant site features of SWMU 03). Phase II activities at SWMU 03 were directed at characterizing the burn area and aldicarb disposal area. EODT was employed to provide MEC support during Phase II activities. Prior to commencing Phase II sampling at the burn area, the surface and near surface were swept for munitions due to observance of 40mm grenades in and around the area. Four 40mm grenades were located within the area under investigation and deactivated by EODT. A Ground Penetrating Radar (GPR) survey was completed to locate the burn area. The GPR survey identified four anomalous areas within the survey area that may have been associated with the burn area. Four test pits were completed and one of the four was identified as a potential burn area based on the presence of charcoal. The other three pits revealed non-munitions related debris or concrete.

The Phase II investigation of the aldicarb burial area included a geophysical survey of the mound. Prior to commencing excavation of test pits, the area was swept for munitions due to the observance of 40mm grenades and an "M301 powder train time fuze" (PTTF) in the area.

The Phase II RFI describes SWMU 7 as being located on the east and west sides of the firebreak road leading to Floyd Cemetery (refer to Appendix A, Template 5, titled "Figure 7, SWMU 07 Site Map, Woodbine, Georgia" developed by Apex depicting significant site features of SWMU 07). The area was reportedly used from 1966 to 1978 for surface disposal of off-specification energetic materials from trip flares, illuminating mortar flares, and CS pyromix and subsurface disposal of approximately 50 drums containing trip flares and concrete, approximately 40 drums containing CS gas, and an unknown number of drums containing aldicarb. The Phase II Investigation of SWMU 7 included a visual surface sweep followed by geophysical survey and shallow test pits to expose the sources of anomalous areas identified using geophysics. Further test pitting and excavation of drummed material was performed to assess the potential for a release to the environment in the final phase.

A magnetometer survey of SWMU 07 was conducted to locate munitions-related items and buried ferrous objects. Other geophysical surveys were not conducted due to the ubiquitous metal scrap present on and near the ground surface. Nineteen areas of anomalous magnetometer readings were identified during this sweep. Thirty-one exploratory test pits were excavated to identify the sources of the anomalous magnetic readings (refer to Appendix A, Template 6, titled "Figure 22, SWMU 07 Exploratory Test Pits). The test pits were intended

to identify the work that would be required to analyze the site and confirm the location and extent of disposal areas. Therefore, samples were not collected from the test pits during this initial phase.

A trench containing 408 concrete capped drums was excavated. The material inside the drums was sorted for live munitions related items. Four hundred eight 55-gallon drums of live munitions were recovered and destroyed. Also found were 3,000 warhead components of the 40mm grenades. All 3,000 grenades were destroyed by detonation. To support the destruction of the recovered munitions, a burn pit and blasting area were constructed at the rocket test pad adjacent to SWMU 03. Following the recovery of the munitions, an additional 18 test pits were excavated to investigate and characterize the area.

Test pitting at SWMU 07 indicated that CS and related degradation compounds were present in the soil. An unknown number of additional drums reportedly could not be removed during the Phase II investigation and remained buried at the site. Analysis of soil samples indicated elevated levels of chemicals of potential concern (COPCs).

Based on the information generated during Phase I and II RFI, Apex determined that:

- COPCs were present in soils beneath SWMU 07.
- An unknown quantity of drums and loose munitions (i.e., trip flares and munitions-related debris) remained buried at this site.
- CS compounds presented an important concern at this site and recommended coordination with GA EPD to determine the necessity for a Corrective Action Plan (CAP) to address SWMU 07.

During the conduct of the Phase II RFI, Apex observed additional surface areas containing MEC-related items that were outside the work zones to be cleared of MEC for the geophysical surveys and test pitting conducted as a portion of the Phase II RFI. Additional MEC clearance was, therefore performed at SWMU 3 by EODT in February 1997. The clearance efforts are described in the Addendum to the Report of the Phase II RFI summarized below.

1.8.3 Addendum to Phase II RFI Report

Addendum to the Report of the Phase II RCRA Facility Investigation (RFI) Conducted on the Union Carbide Corporation Woodbine, Georgia Facility, Apex Environmental, Inc., June 12, 1997.

Additional Phase II activities were performed to resolve GA EPD comments to the Phase II Report and to address the additional MEC noted at SWMU 03 during Phase II. The 1997 clearance was performed by EODT. EODT reportedly swept the area from fire break road to the paved Rocket Test Pad road (refer to Appendix A, Template 7, titled "Figure 1, SWMU 3 Unexploded Ordnance Location, Woodbine, Georgia" developed by Apex depicting UXO recovered at SWMU 03) and the area from the dirt road eastward approximately 75 feet. EODT did not locate munitions related items between 50 and 75 feet east of fire break and

- An explosion of the Thiokol flare manufacturing facility in 1971 on the property currently occupied by BCS may have resulted in MEC kickout. However, no documentation or details regarding the amount of munitions or explosives involved in the explosion, type or amount of munitions that may have been stored in proximity the manufacturing facility and thus subject to sympathetic detonation, or post-detonation clearance activities were uncovered during the RFA. Given the proximity of the explosion site to the UCC properties (approximately 2,500 feet), further review appears warranted.
- No documentation has been identified through historical records review that identifies the specific practices that were followed during historic test firing of munitions and disposal of waste munitions on the UCC-Woodbine property. In absence of these kinds of operational records, potential areas of interest for MEC have been identified through personnel interviews, visual site inspection, and the application of standard 40mm and 81mm mortar range surface danger zones (SDZs).

1.9 Previous MEC Clearances

Three MEC clearance activities have been previously performed at UCC-Woodbine in support of the various phases of RFIs described above. The results of these activities are summarized in Table 1-1 and described below. The focus of each of the previous removal actions was to prepare the site for media investigation (soil and groundwater sampling). No previous studies are known to have been directed at identifying the nature and extent of MEC across the site. Previous MEC clearances are summarized below. Refer to the map templates included in Appendix A for SWMU locations.

1.9.1 Surface Debris Removal Report

Report of Surface Debris Removal, Law Engineering and Environmental Services, Prepared for Union Carbide Corporation, Woodbine, Georgia, October 1993.

EODT of Knoxville, Tennessee, performed the munitions related activities for RFI implementation and the surface debris removal in August to October 1992. The areas within SWMUs 03, 04, 05, 06, and 07 were swept of visible debris including munitions. The munitions were later deactivated onsite and disposed as non-hazardous waste. Munitions-related items were found in SWMUs 03 and 07. Munitions were not discovered in SWMUs 05 and 06.

Approximately 500 munitions items consisting of M406 40mm HE grenades and XM 15 CS Canisters were removed from SWMU 03. At SWMU 07, approximately 700 live munitions related items including M301 81mm Illumination Projectiles, M301 81mm Tail Fin Assembly with M71A2 Primers, M84 PTTFs, M49 Trip Flares, and XM 15 CS canisters were recovered and removed. During sweeping operations, heavy rains reportedly exposed additional near surface munitions in the former munitions burn area and an observation was made that "a large amount of munitions is buried near the ground surface" at SWMU 7.

Demilitarization of potentially live munitions was completed by open detonation in a bermed area adjacent to the existing bunker at SWMU 03 and/or open burning on the rocket test pit concrete pad. Following the surface debris removal activities, it was

includes 40mm HE and CS grenades. Two 40mm HE grenades were recently identified and disposed of. Numerous CS grenades were visible on the soil surface at during the 2006 visual inspection.

Three previous surface and subsurface MEC clearances within the bounds of the former 40mm test range were intended to clear specific areas of MEC hazards to facilitate the investigation of the nature and extent of chemical contamination. They were not designed to characterize the nature or extent of MEC hazards.

81mm mortars were reported to have been test fired in the vicinity of the former 81mm test range. MEC in the form of mortar fuzes have on occasion been found on the property by the site caretaker. The potential for MEC within the vicinity of the area identified as the former 81mm mortar range is deemed possible, given that this area was not previously characterized.

The landfill is excluded from the investigation of MRA-1 because the cap was placed after the time period during which the test ranges were active. Although it is possible that MEC is buried in the landfill, non-intrusive investigation technologies do not allow for the discrimination between MEC and other metallic debris that may be present beneath the cap. Confirmation of MEC would require the removal of portions of the landfill cap. Therefore, the landfill is not included in the investigation of MRA-1.

No documentation has been identified through historical records review that identifies the specific practices that were followed during historic test firing of munitions and disposal of waste munitions on the UCC-Woodbine property. In absence of these kinds of operational records, potential areas of interest for MEC have been identified through personnel interviews, visual site inspection, and the application of standard 40mm and 81mm mortar range SDZs.

1.10.2 MRA-2 – Former MEC Disposal Area/SWMU 07

The history of site operations suggests that MEC ejection or kickout occurred during past waste munitions disposal activities at SWMU 07. Additionally, the limitations of historical MEC removal activities in this area suggest that residual MEC in heavily vegetated areas and mounds may be present. Due to the dense vegetation and thick ground cover and limitations of the recent visual site inspection, presence or absence of MEC could not be confirmed during the 2006 MEC RFA visual inspection.

1.10.3 MRA-3 – Former Scrap Metal Surface Disposal Area/SWMU 01

A visual site inspection conducted in 2006 for the MEC RFA confirmed that surface and subsurface MD is present in the vicinity of the hazardous waste landfill access road in the area encompassing the original SWMU 01.

SECTION 3

Investigation Results

3.1 MRA-1 – Former 40mm Test Range/SWMU 03 and Former 81mm Test Range

Twenty-one MEC items were discovered on the ground surface at MRA-1 during the surface clearance and other site investigation activities. The MEC consisted of three 40mm CS grenades and eighteen 40mm high explosive (HE) grenades. Descriptions of these items are provided in Section 4.2, below.

The surface MEC locations are shown on Figure 3-1. One 40mm grenade was found near Todd Creek, northwest of the former 40mm Test Range firing point. One 40mm grenade was found immediately west of the 40mm Test Range boundary. Two 40mm grenades were found near the former rocket test pit, which is adjacent to the former 40mm Test Range firing point. The 17 remaining 40mm grenades were found near the center of the 40mm Test Range boundary impact area.

Analysis of the DGM data at MRA-1 resulted in the selection of 597 geophysical anomalies above the targeting threshold (29 of which were quality control items placed by CH2M HILL). The locations of these anomalies are shown on Figure 3-2. The highest concentration of anomalies is found around the former rocket test pit and within the former 40mm Test Range, as represented by the anomaly concentration map provided as Figure 3-3.

3.2 MRA-2 – Former MEC Disposal Area/SWMU 07

Seven MEC items were discovered on the ground surface at MRA-2 during the surface clearance. The MEC consisted of one M71A2 primer, one M7A1 primer, and five partial M84 fuzes. Descriptions of these items are provided in Section 4.2, below.

The surface MEC locations are shown on Figure 3-4. Five of the items were found near the center of MRA-2, and the other two items were found approximately 300 yards northeast of the center of MRA-2.

Analysis of the DGM data at MRA-2 resulted in the selection of 218 geophysical anomalies above the targeting threshold (ten of which were quality control items placed by CH2M HILL). The locations of these anomalies are shown on Figure 3-2. The highest concentration of anomalies is found near the center of the site, as represented by the anomaly concentration map provided as Figure 3-3.

3.3 MRA-3 – Former Scrap Metal Surface Disposal Area/ SWMU 01

No surface MEC was discovered at MRA-3.

Analysis of the DGM data at MRA-3 resulted in the selection of 16 geophysical anomalies above the targeting threshold. The locations of these anomalies are shown on Figure 3-2. The highest concentration of anomalies is found in the northwestern corner of the site, as represented by the anomaly concentration map provided as Figure 3-3.

consists of a brass head, body assembly, and expelling charge. Safety before firing is provided by a safety wire, which must be removed just before firing.

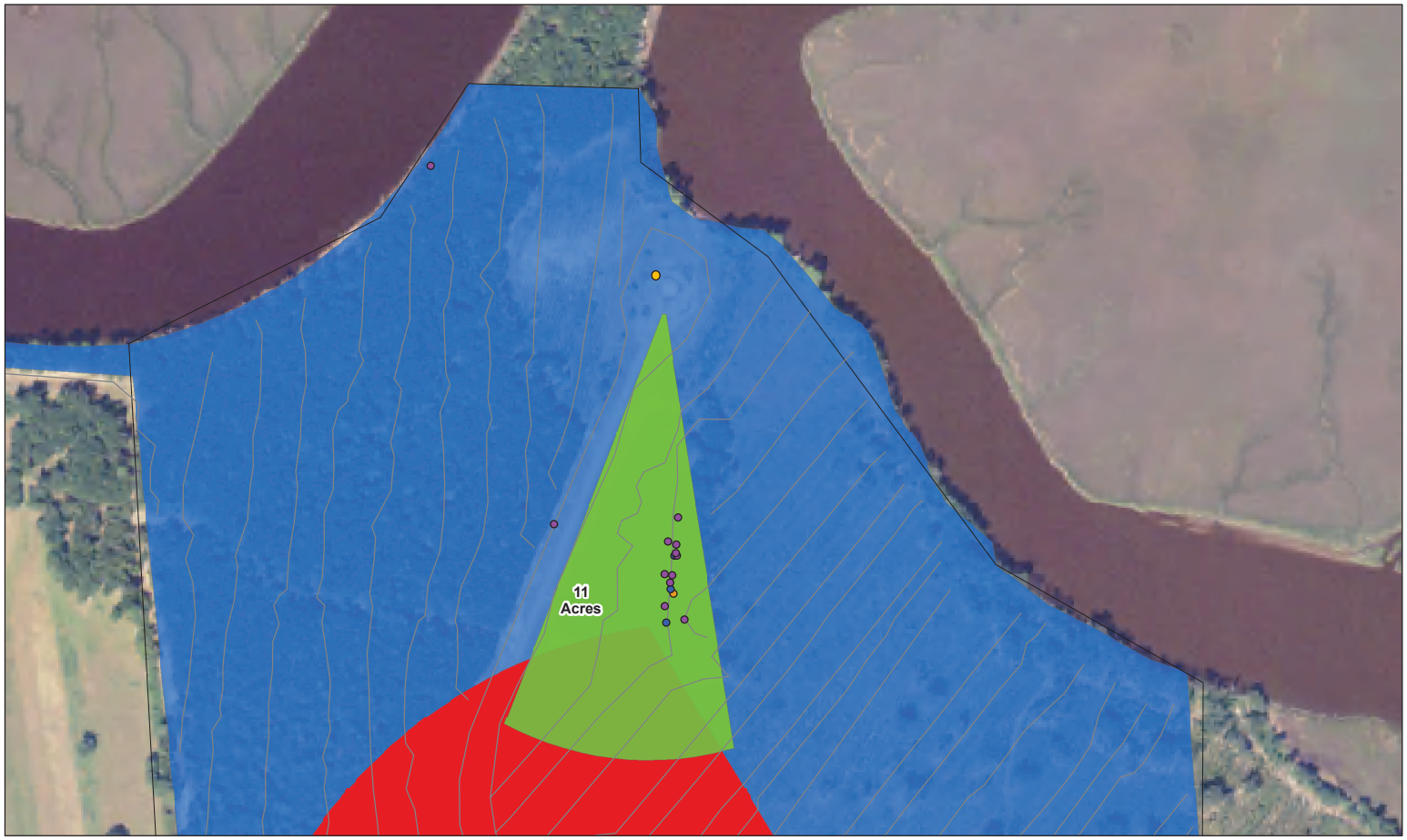
5.2.5 M49 Surface Trip Flare

The trip flare provides warning of infiltrating troops by illuminating the field when the trip wire is activated. It puts out a light intensity of 35,000 candlepower for 1 minute; it can also be activated by trigger or pull pin. A trip flare is used primarily to illuminate and to give warning of attacking or infiltrating enemy troops. The M49 Trip Flare resembles a hand grenade in size and shape, except that it is provided with a bracket for attachment to a tree or post and a trigger mechanism for firing. The flare burns with a yellowish light and illuminates an area radius of approximately 300 meters. The flare has a laminated paper body, containing one 1-ounce flare charge and is closed at both ends by metal caps. The upper cap has taped holes and a threaded central hole for the trip fuze.

5.3 Recommendations

Based on the results of the field investigation and the conclusions in Section 4.2, it is recommended that an intrusive investigation of geophysical targets be conducted at MRA-1, MRA-2, and MRA-3. To conduct this intrusive investigation, the geophysical targets would be reacquired by flagging the centers of the targets using the coordinates that were determined during the DGM effort. UXO Technicians would then use handheld metal detectors to search for geophysical anomalies a 1-meter radius around each target flag. The UXO Technicians would then dig with handheld tools to determine the source of each anomaly (MEC, MD, or cultural debris). This information would be recorded and would be used to estimate the quantities and densities of subsurface MEC, if any, that may be present within each MRA. Where the data permits, it would also be used to evaluate whether the MRA boundaries have been adequately defined and whether the boundaries need to be expanded or can be reduced. If it is determined that the MRA boundaries have been adequately defined, the data from the intrusive investigation, along with the data from the surface investigation conducted during this Phase I RFI, would be used in the evaluation of potential corrective actions that may be needed to address surface and subsurface MEC remaining at the MRAs.

Due to the possibility that MEC is buried in the landfill, it is also recommended that MEC avoidance practices be implemented during any future construction or soil boring activities that would result in disturbance of the landfill cap.



Surface MEC

Quantity & Description

- 3-Grenades, 40mm HE
- 1- Grenade, 40mm HE
- 1- Grenade, 40mm CS

- MRA1 Transects
- Former 40mm Test Range
- Former 81mm Mortar Test Range
- Munitions Response Area 1

N

0 250 500 1,000

Feet

Figure 3-1
Locations of Recovered Surface MEC at MRA-1
UCC Site
Woodbine, GA

File Path: H:\projects3\DOW Woodbine\MXDs\MEC MRA 1.mxd, Date: June 2, 2008 11:08:26 AM, User: JKELLY3

Draft

Results of Phase I Munitions and Explosives of Concern RCRA Facility Investigation

Union Carbide Corporation-Woodbine

Woodbine, Georgia

Contract No. NA-1022
Purchase Order No. 93179724

Prepared for

Union Carbide Corporation

Prepared by

CH2MHILL

June 2008

Contents

Appendices

Tables

Figures

Acronyms and Abbreviations

AAR	After Action Report
BCS	Bayer Crop Science
CAP	Corrective Action Plan
CS	orthochlorobenzalmalononitrile
°F	degrees Fahrenheit
DGM	digital geophysical mapping
DoD	Department of Defense
DQO	data quality objective
EOD	Explosive Ordnance Disposal
EPD	Environmental Protection Division
GPO	geophysical prove-out
GPOP	geophysical prove-out plan
HE	high explosive
MD	munitions debris
MEC	munitions and explosives of concern
MLI	Munitions List Items
MPPEH	Material Potentially Presenting an Explosive Hazard
MR	Munitions Response
MRA	munitions response area
MRP	munitions response program
NFA	no further action
PMSOW	Project Memorandum/Statement of Work
PMWP	Project Memorandum Work Plan
PTTF	powder train time fuze
QA	quality assurance
QC	quality control
RCRA	Recourse Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
SDZ	surface danger zone
SUXOS	Senior UXO Supervisor
SWMU	Solid Waste Management Unit
UCC	Union Carbide Corporation
USAESCH	United States Army Engineering Support Center, Huntsville
UXO	unexploded ordnance

SECTION 1

Introduction

1.1 Project Authorization

CH2M HILL submitted a Project Memorandum Work Plan (PMWP) to Union Carbide Corporation (UCC) on September 26, 2007. The PMWP provided a project description, key objectives, and scope of work for conducting a Phase I Resource Conservation and Recovery Act (RCRA) Facilities Investigation (RFI) to address munitions and explosives of concern (MEC) at UCC's facility at Woodbine, Georgia, referred to as UCC-Woodbine.

A Remediation & Environmental Services Agreement Project Memorandum/Statement of Work (PMSOW) authorizing the Phase I MEC RFI was issued by Dow on September 28, 2007. The work is being performed under Purchase Order No. 93179724 to Contract NA-1022.

A proposed *Work Plan to Conduct Phase I MEC RCRA Facility Investigation* was submitted to the Georgia Environmental Protection Division (EPD) for review and approval on November 14, 2007. GA EPD transmitted conditional approval in a January 14, 2008 letter, along with some review comments.

A final *Work Plan to Conduct Phase I MEC RCRA Facility Investigation* (CH2M HILL, 2008), including responses to regulatory agency comments, was submitted to Georgia EPD on February 13, 2008. This Work Plan identified the activities that were conducted in support of the Phase I MEC RFI, and provided detailed implementation instructions to the project team.

1.2 Purpose and Scope

The purpose of the Phase I MEC RFI was to collect data to aid in the characterization of the extent of MEC releases over three identified munitions response areas (MRAs) at UCC-Woodbine. Data collected during this first phase will be used in planning future phases of the RFI. Preliminary characterization was accomplished by conducting a munitions debris (MD) survey and digital geophysical mapping (DGM) over representative portions of the MRAs.

1.3 Report Organization

This Phase I RFI Report has been prepared to document the activities that were conducted in support of the Phase I MEC RFI at UCC-Woodbine, and to provide the results of that investigation along with recommendations for further investigation. The Phase I RFI Report is organized as follows:

- **Section 1, Introduction**—The remainder of this section provides background information on UCC-Woodbine, including project location, site description and history, current and projected land use, and summaries of previous site investigations.
- **Section 2, Field Investigation Activities,** describes the site investigation activities that were conducted during the Phase I RFI.
- **Section 3, Investigation Results,** presents the results of the field investigation activities conducted during the Phase I RFI.
- **Section 4, Summary and Recommendations** provides a summary of the data and recommendations for further investigations.
- **Section 5, References**
- **Appendix A, Geophysical Investigation Report**.

1.4 Project Location

UCC-Woodbine is a 4,012-acre parcel of a former manufacturing facility located approximately 11.5 miles due east of the town of Woodbine, in Georgia Militia District No. 31, Camden County, Georgia. The nearest major cities are Jacksonville, Florida (30 miles to the southwest) and Brunswick, Georgia (15 miles north) (Environmental, Science & Engineering, 1994). The Satilla River and Todd Creek lie to the north of the site; the Cumberland River, Floyd Creek, and the Bayer Crop Science (BCS) property are southeast of the facility; and the Sea Island Land Company owns property west of the facility. Figure 1-1 is a regional map showing the location of UCC-Woodbine within the state of Georgia. The Phase I MEC RFI addressed three munitions response areas (MRAs), shown on Figure 1-2.

1.5 Site Description

1.5.1 Topography

UCC-Woodbine is located in the Atlantic Coastal Plain Physiographic Province on flat uplands on a point known as Floyds Neck. The topography is generally flat with slight depressions and shallow drainage ways. Adjacent rivers, Todd Creek, Floyd Basin, and Cumberland River, have eroded steep banks. The facility grounds contain few natural streams. Stormwater is controlled by culverts located along the roadways. There are several depressions and seasonally flooded areas throughout the upland areas. The elevations of the MRAs range between 10 and 25 feet above mean sea level (msl).

1.5.2 Climate

Data collected from an observing station located approximately 15 miles north of UCC-Woodbine in Brunswick, GA, provide the following climate statistics for the period 1930 to 2006 (SERCC, 2007):

- The average annual maximum and minimum temperatures were 78.4ºF and 58.9ºF. Maximum temperatures equaled or exceeded 90 ºF an average of 73.7 days per year and minimum temperatures were less than or equal to 32 ºF an average of 11.9 days per year.
- The hottest month was July, with an average maximum temperature of 91.9ºF and an average of 22.4 days with temperatures above 90 ºF. The highest temperature recorded during the reporting period was 106 ºF.
- The coldest month is January with an average minimum temperature of 42.9ºF and an average of 4.9 days with temperatures below 32 ºF. The lowest temperature recorded during the reporting period was 5 ºF.
- The average annual precipitation was 52.13 inches. The maximum annual precipitation amount was 79.15 inches and the minimum annual precipitation amount was 31.92 inches. No snowfall was recorded during the reporting period.
- Summer is the wettest season, with an average season precipitation amounts of 18.96 inches, followed by: Fall (13.72 inches), Spring (10.04 inches), then Winter (9.41 inches).
- Rainfall amounts greater than or equal to 0.01 inch fell an average of 104 days per year.

1.5.3 Vegetation

The MRAs are mostly heavily forested, consisting of either hardwoods or pines. The majority of the pines are planted in rows. Undergrowth in all of the forests is thin to moderate brush.

1.5.4 Geology

UCC-Woodbine is located in the Barrier Island Sequence District of the Atlantic Coastal Plain Physiographic Province. The Barrier Island Sequence is a series of barrier islands and salt marsh deposits, deposited during Pleistocene sea level changes. The facility is situated on the Princess Anne terrace complex. The terrace deposits consist of a mantle of undifferentiated surficial sands and the underlying Satilla Formation. The Satilla Formation consists of variably fossiliferous, shelly sands and clays of offshore, inner shelf origin; bedded and non-bedded barrier island deposits; and marsh deposits. The Satilla Formation, exposed at areas of bank erosion mentioned above, consists of fine to medium, indistinctly bedded sand overlaying a layer of reddish humate-cemented sandstone (Apex, 1996).

The two dominant soil types at the facility are reported as the Mandarin fine sand and Pottsburg sand. The Mandarin fine sand is a deep, somewhat poorly drained, nearly level soil on slight ridges and broad flats. The subsurface soil is underlain by typically 15 inches of an organic hardpan layer. The permeability is rapid (6 to 20 inches per hour) except in the hardpan where the permeability is moderate (0.6 to 20 inches per hour). Mandarin soils are

found in the central, south central and western portions of the property. The Pottsburg sand has characteristics very similar to the Mandarin soils. The main difference is the depth and thickness of the hardpan layer which, in the typical soil profile, is at a depth of 63 to 80 inches. Although not listed, the permeability of the hardpan layer is probably similar to the Mandarin soils. Pottsburg soils are found in the eastern and north eastern portions of the property (Apex, 1996).

1.6 Site History

UCC-Woodbine is located within property of the historic homestead of Charles and General John Floyd. Remnants of the former plantation home, Bellevue, still stand on the UCC property and the Floyd Family Cemetery is still visited annually by family and visitors. From 1927 to 1942, the site was part of a tract known as the Sea Island Game Preserve at Cabin Bluff and used as a hunting preserve (CH2M HILL, 2005). The property offers protected habitat to a wide variety of wildlife, including a large population of boar. In the early 1940s, the land was bought by a paper company for use as a tree farm.

In 1962, Thiokol Corporation purchased the property for the production and testing of solid rocket motors for the National Aeronautics and Space Administration (NASA). The site was chosen due to low-cost shipping access to the then Kennedy Space Center in Florida. Shipment by barge was the only practical method for motors of the size anticipated (260 inches in diameter and greater than 21 feet long) later in the program and potentially for subsequent flights. To simplify processing for the demonstration phase, a large casting pit was constructed at UCC-Woodbine, which also served as the static test facility. The pit, which is still present, is 52 feet in diameter and 120 feet deep. The pit is covered and the area has been fenced. Three large load cells were located at the bottom, which could measure motor weight and thrust up to 6 million pounds. An inflatable dome was located over the casting pit to maintain an appropriate thermal and humidity environment during motor processing (McGrath, 1995).

An article in the April 19, 1963, issue of the Camden County Tribune reported that, "Thiokol Chemical Corporation was awarded Tuesday long-anticipated contracts for construction of the largest and most powerful rocket motors ever built in the United States. Thiokol received three parts of a four-part contract by the NASA acting in conjunction with the Air Force. The two contracts affecting Camden County include one for demonstration firings of 260-inch solid fuel motors and another for demonstration firings of a 156-inch motor with a 3-million-pound thrust both to be assembled and tested at the new Thiokol plant in Camden now under construction. This contract marks the first time that NASA has participated in a demonstration program looking toward the use of solid propellants for space vehicles."

On February 27, 1965, the first static test of the most powerful rocket motor ever built was a conducted at the site. The 156-inch, 3-million-pound thrust engine was constructed by Thiokol Chemical Corporation to prove the feasibility of very large (260-inch), solid-propellant boosters. The “subscale” motor tested was 100 feet long, 156 inches in diameter, packed with 800,000 pounds of ammonium perchlorate and powdered aluminum held together with synthetic rubber (McGrath, 1995). Articles report the test as a resounding success. However, on April 11, 1965, the case of the Thiokol Chemical Corporation’s

260-inch diameter SL-1 rocket motor failed during hydrotest and the program at UCC-Woodbine was subsequently terminated.

In 1966, Thiokol began toll production of silicone coatings and sealants for General Electric and TEMIK (aldicarb) for UCC. In 1967, Thiokol began to manufacture orthochlorobenzalmalononitrile (CS) for Edgewood Arsenal, Maryland. This work developed into Thiokol's production of several "deterrent containing" munitions items including, a 40mm CS round and the XM-15 (CS canister cluster). Later production included M49 trip flares, 81mm mortar illuminating cartridges and M84A1 fuzes. During the following 7 to 8 years, Thiokol continued to operate with sales from two distinct areas, custom toll processing and government contracts for specialty chemicals and munitions items (Thiokol History and Background, no date).

On February 3, 1971, an explosion occurred at the Thiokol Chemical Plant at UCC-Woodbine. A newspaper article in the Camden County Tribune (Tribune, 1971) describes the tragic event as follows: "The Thiokol Chemical Plant, a sprawling complex of 36 buildings on 7,000 acres, was working on a U. S. Army contract for trip flares (flares that are ignited by an external trigger, normally an enemy soldier approaching a camp's perimeter). Suddenly an explosion leveled one building and damaged three others. As a result of the explosion a forest fire, which would eventually destroy 200 acres of timber near the facility, was also set. Since the flares contained magnesium, many of the injured were severe burn victims, with second and third degree burns over more than 25% of their bodies." Other on-line research indicates that the explosion occurred in Building M132 located on current BCS property and places the death toll at 27 and the number injured at 34. The on-line article states that the building was "shattered" and the blast was felt 50 miles away (http://ourgeorgiahistory.com/chronpop/1685). No information regarding post-explosion evaluations or cleanup activities has been located to date.

In 1976, UCC purchased the approximately 7,193-acre property from Thiokol. A UCC subsidiary operated the facility from 1976 to 1986 as an agricultural chemical formulation and manufacturing facility. In December 1986, UCC sold the manufacturing plant and some of the adjacent land to Rhone-Poulenc, which was later renamed Aventis Cropscience and then Bayer Crop Science (BCS). UCC retained ownership of the approximately 4,012 acres referred to herein as UCC-Woodbine.

UCC continues O&M of the landfill. BCS owns and operates the adjacent manufacturing facility.

During groundwater sampling activities at UCC-Woodbine in March 2006, CH2M HILL personnel working at the site noted the presence of potential MEC in the near vicinity of the hazardous waste landfill. CH2M HILL munitions response personnel were subsequently called to the site to inspect the item and recommend an appropriate response.

On May 2, 2006, CH2M HILL's Munitions Response Segment Director Ben Redmond, a certified Master Explosives Ordnance Disposal (EOD) Technician, inspected the item in question and identified it as an expended 81-millimeter (mm) illumination mortar. The item was identified as probable munitions debris (MD), posing no explosive hazard. In accordance with Department of Defense (DoD) guidance and CH2M HILL policy, final determination requires dual inspection. On May 15, 2006, Fred Pasteris of CH2M HILL, also

a certified Master Explosive Ordnance (EOD) Technician, was mobilized to the site to verify Mr. Redmond's determination.

Mr. Pasteris confirmed that the item in question was inert MD. During the May 15, 2006, site visit, Mr. Pasteris was accompanied by Mr. Milton Lynn. Mr. Lynn is the current site caretaker and has been employed at the site since the 1960s. Mr. Lynn accounted to Mr. Pasteris a site history that involved manufacture and testing of 40mm CS and experimental (XM) 15 CS canisters, 81mm mortar illumination projectiles and M84 fuzes, and M49 trip flares, as well as onsite MEC disposal. Mr. Lynn also indicated that potential MEC items remained onsite despite past remediation efforts.

In 2006 and 2007, CH2M HILL conducted a RCRA Facility Assessment (RFA) with respect to past use of MEC at UCC-Woodbine. Findings of the RFA indicated that MEC associated with historic activity prior to UCC's acquisition of the site is currently present, but the extent has not been defined. Details of the RFA are presented in Section 1.8.4, below.

1.7 Current and Projected Land Use

The MRAs are on undeveloped private land owned by UCC. Much of the area is planted in pines. These areas have been logged in the past or are planned to be logged in the future. Future land use is undetermined. UCC is currently evaluating potential uses for the property. The results of this MEC RFI will be used in that evaluation.

1.8 Previous Site Investigations

Pertinent reports of previous site investigations are summarized below. Table 1-1 provides a snapshot of past RFI and MEC related activities.

TABLE 1-1
Summary of Past RFI and MEC Related Activities

Study	Date	Project Objectives	MEC Related Activities
Phase I RFI – SWMUs 02, 03, 04, 05, 06, and 07	1991	Complete soils and groundwater investigation to identify nature and extent of contamination. Included soils sampling at all SWMUs, groundwater wells and sampling at all SWMUs except 02 and 07.	Pre-RFI surface debris removal completed. SWMUs 03, 04, 05, 06, and 07 were swept of visible debris including munitions. Munitions related items were found in SWMUs 03 and 07. Munitions were not discovered in SWMUs 05 and 06.
Phase II RFI	1996	Collect additional information to address GAEPD comments to Phase I. Included background soils samples at all SWMUs, limited geophysical investigation at SWMUs 03, 06, and 07, collect subsurface soil samples at SWMUs 03, 04, 06 and 07, install wells at SWMU 03 and sample monitoring wells and 03, 04, 05, 06, and 07, complete test pitting at SWMUs 03, 06, and 07, and identify, remove and deactivate UXO.	Surface MEC removal only at SWMUs 03 and 07. Recommended additional surface/subsurface removal.

TABLE 1-1
Summary of Past RFI and MEC Related Activities

Study	Date	Project Objectives	MEC Related Activities
Expanded Phase II RFI	1996 and 1997	Address GAEPD comments by resampling wells with an improved methodology, complete additional surface MEC removal at SWMU 03, complete additional soil borings at SWMUs 04 and 06.	Surface and subsurface munitions and debris removal at SWMUs 03 and 07 and UXO avoidance in support of other remediation activities.

1.8.1 Phase I RFI Report

RCRA Facility Investigation Report, Union Carbide Corporation, Woodbine, Georgia, Law Environmental Inc., February 5, 1993.

Following issuance of the RCRA Post-Closure Permit, UCC initiated RFI activities to address corrective action of the identified Solid Waste Management Units (SWMUs). Phase I RFI activities were completed by Law Environmental, Inc. (Law) in 1992 and included the installation of a groundwater monitoring well network and a combination of soil and groundwater sampling to identify the nature and extent of contamination at SWMUs 02, 03, 04, 05, 06, and 07. The presence of MEC and MD were suspected at SWMUs 03, 04, 06, and 07. MEC surface removal was included in the scope of work for pre-RFI surface debris removal conducted from September 1992 through October 1993. Appendix A, Templates 2 and 3, Figures titled, "Plot Plan Pre-RCRA Disposal Sites" and "Figure B-4, Facility Topographic Map" were developed by Law and depict the locations of the SWMUs, original monitoring wells, and other site features. EOD Technology, Inc. (EODT) of Knoxville, Tennessee, was employed to complete the MEC-related activities during the Phase I activities. Munitions-related items were found in SWMUs 03 and 07. No munitions were discovered at SWMUs 05 and 06. The aerial extent of the MEC investigation is not defined in any available report. Further details regarding the MEC clearance activities related to the Phase I RFI are provided in Section 3.4.

As a result of the Phase I RFI, Law concluded that:

- SWMU 03 did not appear to present a risk to potential receptors and recommended no further action (NFA).
- Releases to groundwater did not appear to present a risk to potential receptors at SWMU 07, but recommended additional assessment to locate and characterize buried material.

Following the submittal of the Phase I report, information was discovered regarding additional disposal areas and GA EPD requested additional investigation as part of the Phase II activities.

1.8.2 Phase II RFI Report

Report of the Phase II RCRA Facility Investigation (RFI) Conducted on the Union Carbide Corporation Woodbine, Georgia Facility, Apex Environmental, Inc., September 20, 1996.

A Phase II RFI was subsequently performed by Apex Environmental, Inc. (Apex), on behalf of Thiokol. The Phase II RFI included the collection of background soil samples for metals analysis, completion of surface geophysics at selected SWMUs, collection of subsurface soil samples; installation and sampling of monitoring wells; test pitting; and identification, removal, and deactivation of UXO.

The Phase II RFI describes SWMU 03 as being located on the east side of the asphalt road leading to the rocket test pad. During the Phase I RFI, SWMU 03 was thought to be limited to an area used for surface storage/disposal of scrap metal and munitions and a trench reportedly used for subsurface disposal of CS material, Nuchar, and other unknown waste materials. Subsequent to the submittal of the Phase I RFI, a burn area for munitions was identified in the northern section of SWMU 3 and an aldicarb disposal area was identified on the east side of the paved road across from the entrance road to the RCRA landfill (refer to Appendix A, Template 4, titled "Figure 3, SWMU 03 Site Map, Woodbine, Georgia" developed by Apex depicting significant site features of SWMU 03). Phase II activities at SWMU 03 were directed at characterizing the burn area and aldicarb disposal area. EODT was employed to provide MEC support during Phase II activities. Prior to commencing Phase II sampling at the burn area, the surface and near surface were swept for munitions due to observance of 40mm grenades in and around the area. Four 40mm grenades were located within the area under investigation and deactivated by EODT. A Ground Penetrating Radar (GPR) survey was completed to locate the burn area. The GPR survey identified four anomalous areas within the survey area that may have been associated with the burn area. Four test pits were completed and one of the four was identified as a potential burn area based on the presence of charcoal. The other three pits revealed non-munitions related debris or concrete.

The Phase II investigation of the aldicarb burial area included a geophysical survey of the mound. Prior to commencing excavation of test pits, the area was swept for munitions due to the observance of 40mm grenades and an "M301 powder train time fuze" (PTTF) in the area.

The Phase II RFI describes SWMU 7 as being located on the east and west sides of the firebreak road leading to Floyd Cemetery (refer to Appendix A, Template 5, titled "Figure 7, SWMU 07 Site Map, Woodbine, Georgia" developed by Apex depicting significant site features of SWMU 07). The area was reportedly used from 1966 to 1978 for surface disposal of off-specification energetic materials from trip flares, illuminating mortar flares, and CS pyromix and subsurface disposal of approximately 50 drums containing trip flares and concrete, approximately 40 drums containing CS gas, and an unknown number of drums containing aldicarb. The Phase II Investigation of SWMU 7 included a visual surface sweep followed by geophysical survey and shallow test pits to expose the sources of anomalous areas identified using geophysics. Further test pitting and excavation of drummed material was performed to assess the potential for a release to the environment in the final phase.

A magnetometer survey of SWMU 07 was conducted to locate munitions-related items and buried ferrous objects. Other geophysical surveys were not conducted due to the ubiquitous metal scrap present on and near the ground surface. Nineteen areas of anomalous magnetometer readings were identified during this sweep. Thirty-one exploratory test pits were excavated to identify the sources of the anomalous magnetic readings (refer to Appendix A, Template 6, titled "Figure 22, SWMU 07 Exploratory Test Pits). The test pits were intended

to identify the work that would be required to analyze the site and confirm the location and extent of disposal areas. Therefore, samples were not collected from the test pits during this initial phase.

A trench containing 408 concrete capped drums was excavated. The material inside the drums was sorted for live munitions related items. Four hundred eight 55-gallon drums of live munitions were recovered and destroyed. Also found were 3,000 warhead components of the 40mm grenades. All 3,000 grenades were destroyed by detonation. To support the destruction of the recovered munitions, a burn pit and blasting area were constructed at the rocket test pad adjacent to SWMU 03. Following the recovery of the munitions, an additional 18 test pits were excavated to investigate and characterize the area.

Test pitting at SWMU 07 indicated that CS and related degradation compounds were present in the soil. An unknown number of additional drums reportedly could not be removed during the Phase II investigation and remained buried at the site. Analysis of soil samples indicated elevated levels of chemicals of potential concern (COPCs).

Based on the information generated during Phase I and II RFI, Apex determined that:

- COPCs were present in soils beneath SWMU 07.
- An unknown quantity of drums and loose munitions (i.e., trip flares and munitions-related debris) remained buried at this site.
- CS compounds presented an important concern at this site and recommended coordination with GA EPD to determine the necessity for a Corrective Action Plan (CAP) to address SWMU 07.

During the conduct of the Phase II RFI, Apex observed additional surface areas containing MEC-related items that were outside the work zones to be cleared of MEC for the geophysical surveys and test pitting conducted as a portion of the Phase II RFI. Additional MEC clearance was, therefore performed at SWMU 3 by EODT in February 1997. The clearance efforts are described in the Addendum to the Report of the Phase II RFI summarized below.

1.8.3 Addendum to Phase II RFI Report

Addendum to the Report of the Phase II RCRA Facility Investigation (RFI) Conducted on the Union Carbide Corporation Woodbine, Georgia Facility, Apex Environmental, Inc., June 12, 1997.

Additional Phase II activities were performed to resolve GA EPD comments to the Phase II Report and to address the additional MEC noted at SWMU 03 during Phase II. The 1997 clearance was performed by EODT. EODT reportedly swept the area from fire break road to the paved Rocket Test Pad road (refer to Appendix A, Template 7, titled "Figure 1, SWMU 3 Unexploded Ordnance Location, Woodbine, Georgia" developed by Apex depicting UXO recovered at SWMU 03) and the area from the dirt road eastward approximately 75 feet. EODT did not locate munitions related items between 50 and 75 feet east of fire break and

road and, therefore, did not sweep further eastward. EODT also reswept the SWMU 03 burn area and an area northwest of the rocket test pad. The clearance was accomplished using Schonstedt metal detectors and visual observation. A total of forty-six 40mm grenades were located on and near the dirt road. An additional two grenades were found in the SWMU 03 burn area, and one round was found near the Rocket Test Pad. EODT also located approximately 24 XM 15 CS cartridges near the rocket test pad and approximately twenty-six 40mm CS grenades in the vicinity of the fire break road.

Following the completion of the additional Phase II activities, Apex concurred with Law's recommendation in the Phase I RFI Report and recommended NFA for SWMU 03. However, Apex concluded that "substantial quantities of ordnance, ordnance related scrap metal, drums, and CS gas remain in the soils at the site" and recommended the development of a CAP.

On October 29, 1998, GA EPD responded to the Phase II Addendum requiring the submission of a CAP to address actions to be taken to remediate SWMUs 02, 03, 04, 05, 06 and 07, or a formal demonstration as to why remediation is not required (i.e., site-specific risk assessment) (GA EPD, 1998).

Environmental Science and Engineering, Inc. (ESE), was subsequently contracted by Apex to perform risk assessments for the SWMUs in accordance with GA EPD's *Guidance for Selecting Media Remediation Levels at RCRA Solid Waste Management Units*, 1996. A screening risk assessment for SWMUs 02, 03, and 05 resulted in a recommendation for NFA. Separate comprehensive risk assessments were prepared for SWMUs 04, 06, and 07, as these contained higher levels of residual contamination. The risk assessment at SWMU 07 was performed to assess residual risk only after removal of a large volume of waste and soils (ESE, 2000).

The ESE risk assessment report (ESE, 2000) includes a reference to the Apex Summary Report for Assessment, Remediation, and Risk Assessment for SWMUs 02, 03, 04, 05, 06 and 07 dated November 2000, which documents the soils removal at SWMU 07. The Apex document was not available for review.

1.8.4 MEC RCRA Facility Assessment

Munitions and Explosives of Concern RCRA Facility Assessment, Union-Carbide Corporation-Woodbine, CH2M HILL, October 2007 (DRAFT).

In 2006 and 2007, CH2M HILL conducted a RCRA Facility Assessment (RFA) with respect to past use of MEC at UCC-Woodbine. An RFA Report (CH2M HILL, 2007a) was prepared to meet the applicable corrective action requirements of the Hazardous and Solid Waste Amendments (HSWA) to RCRA and Georgia Hazardous Waste Act and requirements of the Georgia Rules at Chapter 391-3-11, the requirements for notifications pertaining to newly discovered releases at previously identified SWMUs as required by the facility Hazardous Waste Permit No. HW 063(D), and to evaluate the site's suitability for future land use. The RFA report was based on the results of an archival search review of records retained at UCC Charleston, West Virginia and Atlanta, Georgia combined with a site inspection and interviews with the current site caretaker.

- An explosion of the Thiokol flare manufacturing facility in 1971 on the property currently occupied by BCS may have resulted in MEC kickout. However, no documentation or details regarding the amount of munitions or explosives involved in the explosion, type or amount of munitions that may have been stored in proximity the manufacturing facility and thus subject to sympathetic detonation, or post-detonation clearance activities were uncovered during the RFA. Given the proximity of the explosion site to the UCC properties (approximately 2,500 feet), further review appears warranted.
- No documentation has been identified through historical records review that identifies the specific practices that were followed during historic test firing of munitions and disposal of waste munitions on the UCC-Woodbine property. In absence of these kinds of operational records, potential areas of interest for MEC have been identified through personnel interviews, visual site inspection, and the application of standard 40mm and 81mm mortar range surface danger zones (SDZs).

1.9 Previous MEC Clearances

Three MEC clearance activities have been previously performed at UCC-Woodbine in support of the various phases of RFIs described above. The results of these activities are summarized in Table 1-1 and described below. The focus of each of the previous removal actions was to prepare the site for media investigation (soil and groundwater sampling). No previous studies are known to have been directed at identifying the nature and extent of MEC across the site. Previous MEC clearances are summarized below. Refer to the map templates included in Appendix A for SWMU locations.

1.9.1 Surface Debris Removal Report

Report of Surface Debris Removal, Law Engineering and Environmental Services, Prepared for Union Carbide Corporation, Woodbine, Georgia, October 1993.

EODT of Knoxville, Tennessee, performed the munitions related activities for RFI implementation and the surface debris removal in August to October 1992. The areas within SWMUs 03, 04, 05, 06, and 07 were swept of visible debris including munitions. The munitions were later deactivated onsite and disposed as non-hazardous waste. Munitions-related items were found in SWMUs 03 and 07. Munitions were not discovered in SWMUs 05 and 06.

Approximately 500 munitions items consisting of M406 40mm HE grenades and XM 15 CS Canisters were removed from SWMU 03. At SWMU 07, approximately 700 live munitions related items including M301 81mm Illumination Projectiles, M301 81mm Tail Fin Assembly with M71A2 Primers, M84 PTTFs, M49 Trip Flares, and XM 15 CS canisters were recovered and removed. During sweeping operations, heavy rains reportedly exposed additional near surface munitions in the former munitions burn area and an observation was made that "a large amount of munitions is buried near the ground surface" at SWMU 7.

Demilitarization of potentially live munitions was completed by open detonation in a bermed area adjacent to the existing bunker at SWMU 03 and/or open burning on the rocket test pit concrete pad. Following the surface debris removal activities, it was

- An explosion of the Thiokol flare manufacturing facility in 1971 on the property currently occupied by BCS may have resulted in MEC kickout. However, no documentation or details regarding the amount of munitions or explosives involved in the explosion, type or amount of munitions that may have been stored in proximity the manufacturing facility and thus subject to sympathetic detonation, or post-detonation clearance activities were uncovered during the RFA. Given the proximity of the explosion site to the UCC properties (approximately 2,500 feet), further review appears warranted.
- No documentation has been identified through historical records review that identifies the specific practices that were followed during historic test firing of munitions and disposal of waste munitions on the UCC-Woodbine property. In absence of these kinds of operational records, potential areas of interest for MEC have been identified through personnel interviews, visual site inspection, and the application of standard 40mm and 81mm mortar range surface danger zones (SDZs).

1.9 Previous MEC Clearances

Three MEC clearance activities have been previously performed at UCC-Woodbine in support of the various phases of RFIs described above. The results of these activities are summarized in Table 1-1 and described below. The focus of each of the previous removal actions was to prepare the site for media investigation (soil and groundwater sampling). No previous studies are known to have been directed at identifying the nature and extent of MEC across the site. Previous MEC clearances are summarized below. Refer to the map templates included in Appendix E for SWMU locations.

1.9.1 Surface Debris Removal Report

Report of Surface Debris Removal, Law Engineering and Environmental Services, Prepared for Union Carbide Corporation, Woodbine, Georgia, October 1993.

EODT of Knoxville, Tennessee, performed the munitions related activities for RFI implementation and the surface debris removal in August to October 1992. The areas within SWMUs 03, 04, 05, 06, and 07 were swept of visible debris including munitions. The munitions were later deactivated onsite and disposed as non-hazardous waste. Munitions-related items were found in SWMUs 03 and 07. Munitions were not discovered in SWMUs 05 and 06.

Approximately 500 munitions items consisting of M406 40mm HE grenades and XM 15 CS Canisters were removed from SWMU 03. At SWMU 07, approximately 700 live munitions related items including M301 81mm Illumination Projectiles, M301 81mm Tail Fin Assembly with M71A2 Primers, M84 PTTFs, M49 Trip Flares, and XM 15 CS canisters were recovered and removed. During sweeping operations, heavy rains reportedly exposed additional near surface munitions in the former munitions burn area and an observation was made that "a large amount of munitions is buried near the ground surface" at SWMU 7.

Demilitarization of potentially live munitions was completed by open detonation in a bermed area adjacent to the existing bunker at SWMU 03 and/or open burning on the rocket test pit concrete pad. Following the surface debris removal activities, it was

recommended that a magnetometer sweep be performed at SWMU 03 and that a magnetometer and conductivity sweep be performed at SWMU 07. It was additionally recommended that excavated materials at SWMU 7 be screened to remove munitions related debris.

EODT issued an After Action Report (AAR) to document the MEC activities described above. A summary of the EODT AAR is provided below.

1.9.2 After Action Report for UXO Support Services

After Action Report for UXO Support Services, Former Union Carbide, Woodbine, Georgia, EOD Technology Inc., Prepared for Law Environmental, Inc., November 18, 1992.

Clearance activities performed during the 1992 mobilization to UCC Woodbine were limited to the surface. No subsurface clearance activities were performed. SWMU 3 is described in the AAR as consisting of approximately 2 acres located east, north, and south of UCC Production Well Number 3. A close interval sweepline utilizing six EOD technicians at 6- to 8-foot intervals was reportedly employed at SWMU 03. Due to the extremely heavy brush, sweep line integrity could not be maintained. Three complete sweeps of the area were completed, alternating sweep path and direction.

Once clearance operations began at SWMU 03, two 40mm HE launcher fired expended grenades were encountered. Interview with former UCC personnel revealed that a special lot of 40mm, M406 HE grenades were procured for the DoD and fired to establish required test velocity for the 40mm CS grenades being developed by UCC for DoD. The 40mm, M-406 grenades encountered were marked with white stenciled letters “Inert Filler/Inert Fuse” with the grenade bodies painted blue which normally indicates a practice/inert filled round. The ogives were gold in color, indicating a HE round. Normally the grenades would be considered inert filled and would present no imminent danger. Due to the combination of circumstances, all M-406s were considered as HE grenades and treated as such. A 1200 Dearmer Kit was used then used to expose and thus allow the positive identification of the fuze and/or filler associated with each grenade.

SWMU 07 is described in the AAR as consisting of two areas, 0.52 acres east of the Floyd Cemetery access road and 0.25 acres west of the access road. Clearance operations at SWMU 07 were reportedly performed using close interval sweep techniques with three to six EOD technicians. Due to the large amount of debris the most effective means to sweep and clear the areas was on hands and knees with intervals reduced to 3 feet. The sweep was conducted from south to north followed by a Quality Assurance (QA) sweep from west to east.

Munitions, cleared and disposed at SWMU 03 included M0406, 40mm grenades, 40mm CS grenades, XM 15 CS canisters, and munitions related debris. Munitions encountered, cleared and disposed at SWMU 07 included M84 PTTFs, M84 PTTF components, M49 Trip Flares, M-71A2 Primers, 40mm CS grenades, and XM-15 CS Canisters. Equipment employed by EODT during the 1992 clearances included the GA-72 CV magnetometer and GA-52B magnetometer.

Following clearance operations, a total of 1,778 munitions items were destroyed by burning (8 M301 Illumination Projectiles, 906 M84 PTTF components, 200 M49 Trip Flares, 347 M71A2 Primers, 57 XM 15 CS Canisters, and 260 40mm CS grenades). Detonation was employed to destroy 193 M406 40mm grenades.

EODT noted in its AAR that though SWMUs 03 and 07 were surface cleared of all visible MEC and MEC related debris, the area was saturated to the point that any disturbance of the ground cover could reveal additional items and recommended a complete surface/ subsurface MEC clearance of these areas.

1.9.3 After Action Report for Surface UXO/OEW and Munitions Debris Removal

After Action Report for the Surface UXO/OEW and Debris Removal at Woodbine, Georgia, EOD Technology Inc., Prepared for Apex Environmental, Inc., September 18, 1996.

The 1996 deployment to UCC-Woodbine included survey, grubbing, and remediation activities in SWMUs 03 and 07 and munitions debris monitoring during excavation of trenches in SWMU 07. In addition, EODT personnel were tasked to remove and dispose of surface/subsurface munitions and debris in SWMUs 03 and 07. EODT support services to Apex were completed November 1995 through April 1996.

A backhoe, chainsaws, and weed-eaters were reportedly used to remove select trees and vegetation to enable EODT personnel to access the trenches in SWMU 07 and subsurface UXO in SWMU 03. Vegetation reportedly was only removed if it was absolutely necessary for site activities.

A geophysical survey using a GA-72 C/V Heliflux magnetometer was employed at SWMU 03 in 5-foot lanes to identify subsurface magnetic anomalies. A similar procedure is reported to have been used at SWMU 07 to assist in the characterization of the trenches and to determine the areas to be excavated. EODT reports the area excavated at SWMU 07 as 0.52 acres on the east side of the access road to Floyd's Cemetery and 0.25 acres to the west.

Excavation activities at SWMU 07 reportedly resulted in the removal of 408 fifty-five-gallon drums containing M406 40mm grenade ball assemblies; flare/MEC mixtures; bio waste; 81mm mortars; riot control agents, such as CS and other assorted waste. The majority of the drums were partially filled with the items noted and the remainder filled with cement. UXO recovered and destroyed 38 81mm mortar illumination projectiles, 2,635 gallons of flare/MEC mixture/riot control agent and 3,001 40mm Ball Assemblies.

1.10 Identification of Munitions Response Areas

Based on the results of the MEC RFA, three MRAs were identified for investigation during the Phase I MEC RFI. These MRAs are shown on Figure 1-2. The conclusions of the MEC RFA as they pertain to these MRAs are presented below.

1.10.1 MRA-1 – Former 40mm Test Range/SWMU 03 and Former 81mm Test Range

Based on the results of a visual inspection during the MEC RFA, MEC is known to be present within the bounds of a former 40mm test range that includes SWMU 03. MEC identified in this area

includes 40mm HE and CS grenades. Two 40mm HE grenades were recently identified and disposed of. Numerous CS grenades were visible on the soil surface at during the 2006 visual inspection.

Three previous surface and subsurface MEC clearances within the bounds of the former 40mm test range were intended to clear specific areas of MEC hazards to facilitate the investigation of the nature and extent of chemical contamination. They were not designed to characterize the nature or extent of MEC hazards.

81mm mortars were reported to have been test fired in the vicinity of the former 81mm test range. MEC in the form of mortar fuzes have on occasion been found on the property by the site caretaker. The potential for MEC within the vicinity of the area identified as the former 81mm mortar range is deemed possible, given that this area was not previously characterized.

The landfill is excluded from the investigation of MRA-1 because the cap was placed after the time period during which the test ranges were active. Although it is possible that MEC is buried in the landfill, non-intrusive investigation technologies do not allow for the discrimination between MEC and other metallic debris that may be present beneath the cap. Confirmation of MEC would require the removal of portions of the landfill cap. Therefore, the landfill is not included in the investigation of MRA-1.

No documentation has been identified through historical records review that identifies the specific practices that were followed during historic test firing of munitions and disposal of waste munitions on the UCC-Woodbine property. In absence of these kinds of operational records, potential areas of interest for MEC have been identified through personnel interviews, visual site inspection, and the application of standard 40mm and 81mm mortar range SDZs.

1.10.2 MRA-2 – Former MEC Disposal Area/SWMU 07

The history of site operations suggests that MEC ejection or kickout occurred during past waste munitions disposal activities at SWMU 07. Additionally, the limitations of historical MEC removal activities in this area suggest that residual MEC in heavily vegetated areas and mounds may be present. Due to the dense vegetation and thick ground cover and limitations of the recent visual site inspection, presence or absence of MEC could not be confirmed during the 2006 MEC RFA visual inspection.

1.10.3 MRA-3 – Former Scrap Metal Surface Disposal Area/SWMU 01

A visual site inspection conducted in 2006 for the MEC RFA confirmed that surface and subsurface MD is present in the vicinity of the hazardous waste landfill access road in the area encompassing the original SWMU 01.

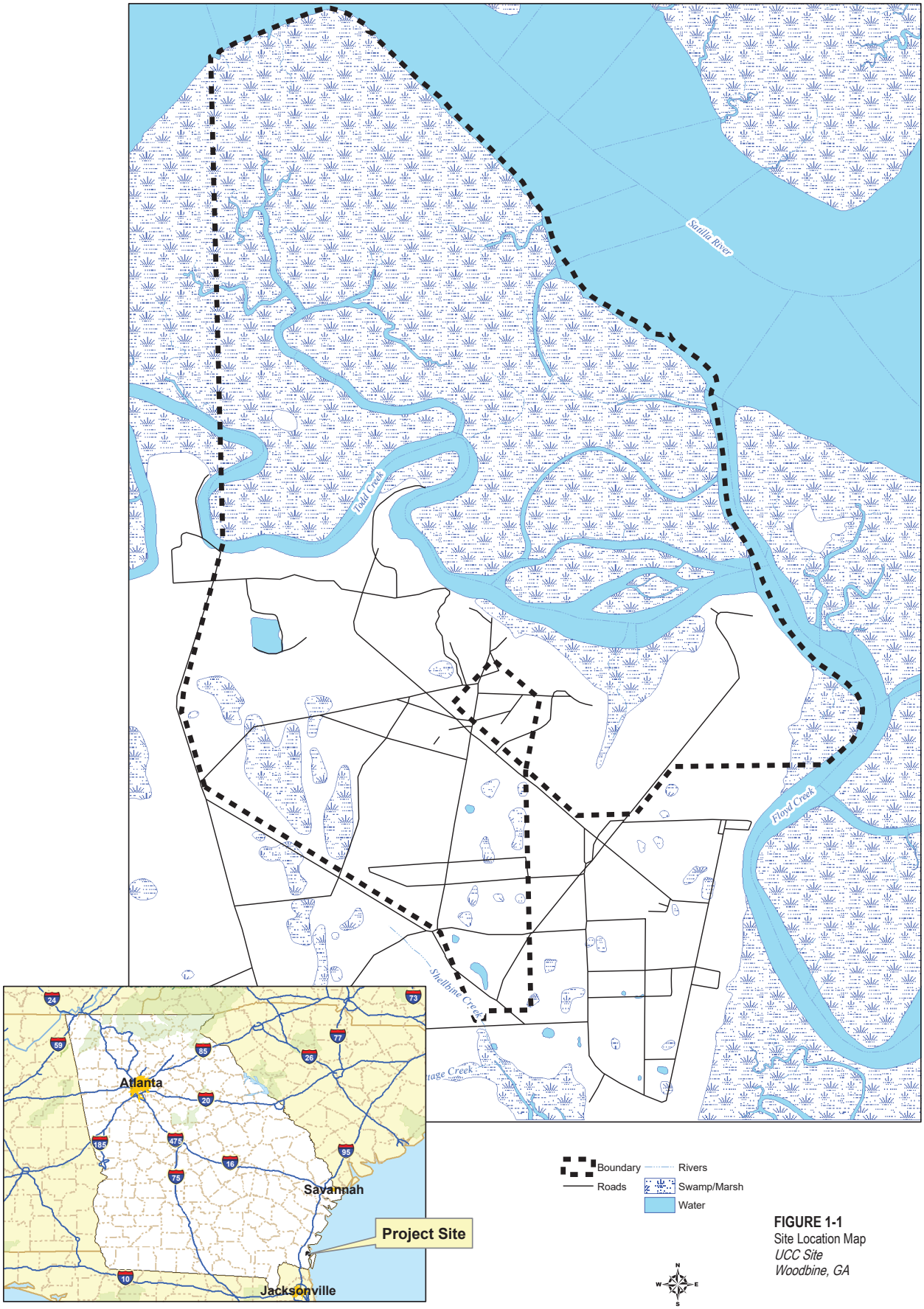


FIGURE 1-1
Site Location Map
UCC Site
Woodbine, GA

CH2MHILL

File Path: H:\projects3\DOW_Woodbine\MXDs\Basemap.mxd, Date: June 2, 2008 10:46:13 AM, User: JKELLY3

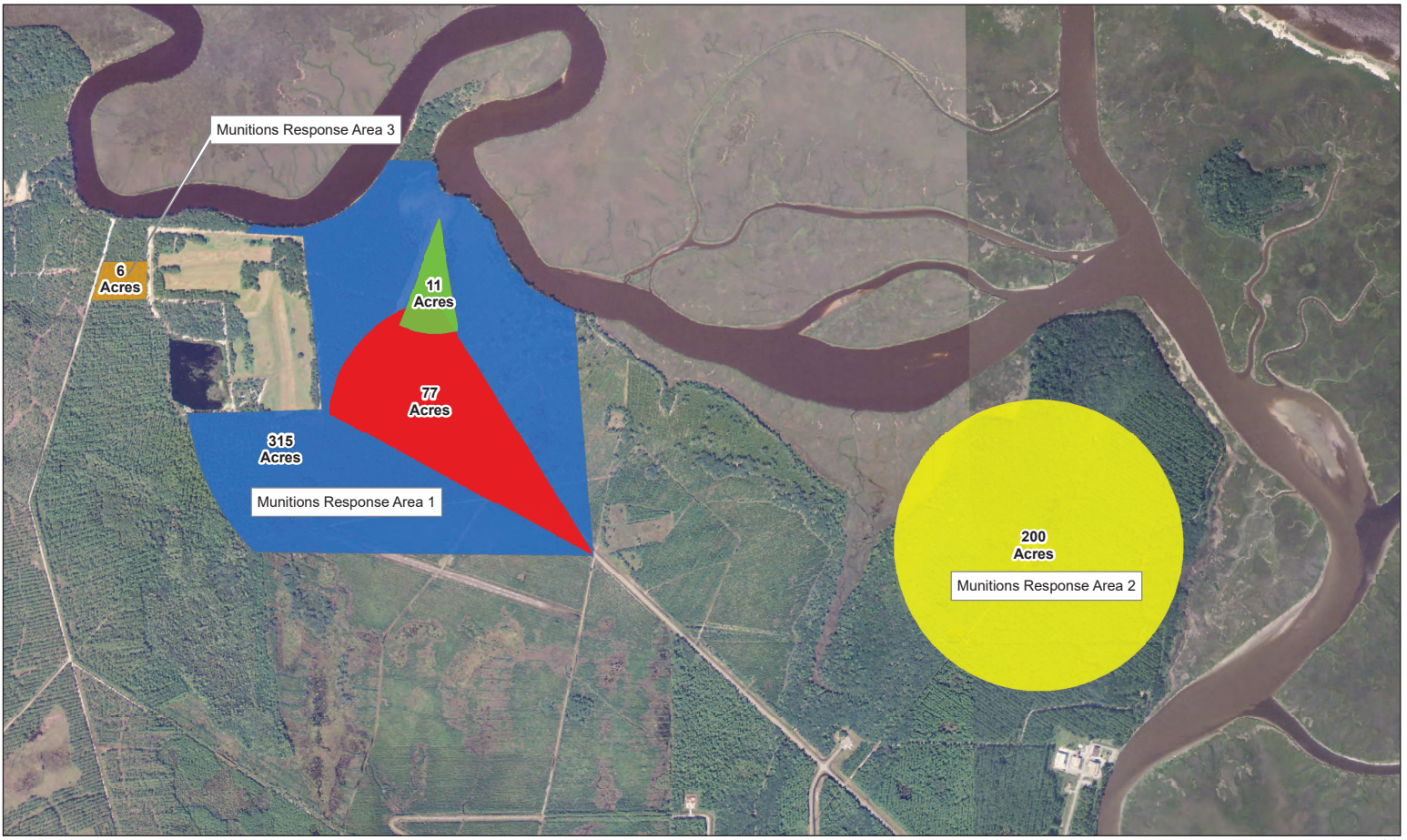


Figure 1-2
Munitions Response Areas
UCC Site
Woodbine, GA

File Path: H:\projects3\DOW Woodbine\MXDs\MEC.mxd, Date: October 29, 2007 2:57:15 PM, User: JKELLY3

SECTION 2

Field Investigation Summary

2.1 Overall Approach to Munitions Response Activities

The Phase I MEC RFI was conducted to provide a preliminary characterization of the extent of MEC over three identified munitions response areas (MRAs). The site characterization goals for this preliminary characterization were:

- Determine the scope for the Phase II RFI;
- Achieve results from the DGM survey indicating areas requiring further investigation; and
- Begin to define the extent of MEC at the site so MEC liability can be appropriately addressed and this information can be factored into decisions about appropriate future land management and property uses.

2.2 Site Preparation

Many areas at UCC-Woodbine had a dense shrub canopy that had to be removed prior to performing DGM operations. Vegetation removal consisted of clearing sufficient subgrowth and small trees (less than a 3-inch diameter) in the transects where the DGM surveys were to be performed. The transect locations are shown on Figure 2-1.

Vegetation removal was conducted by East Coast Land Improvement of Swansboro, North Carolina. Subcontractor personnel used mechanical means where possible and manual means in other areas. Vegetation removal was conducted under the supervision of a UXO technician.

2.3 Surface Clearance

After the DGM transects were cleared of vegetation and survey stakes were put in place, the MR subcontractor performed a surface MEC clearance of the transects (Figure 2-1). All metallic debris was collected and inspected by UXO Technicians to determine whether it was MEC, MPPEH, or cultural debris.

Items determined to be MEC were left in place for later demilitarization. Upon completion of surface clearance, MEC and MPPEH were demilitarized in accordance with the procedures in the Phase I RFI Work Plan (CH2M HILL, 2008). A summary of MEC discovered during the field investigation is provided in Section 3 of this report. Cultural debris was disposed of in a local landfill.

2.4 Geophysical Prove-Out

Prior to commencing the DGM survey, the selected geophysical equipment and survey methodology, which consisted of a single coil EM61-MK2 time domain metal detector in tandem mode along transects with staked turning points, were tested, evaluated, and demonstrated as meeting the data quality objectives (DQOs) in the Geophysical Prove-out (GPO) Plan (GPOP) in the Phase I RFI Work Plan (CH2M HILL, 2008). The GPO was performed on February 21 and 22, with the CH2M HILL MR Geophysicist and CH2M HILL SUXOS emplacing GPO seed items along a test transect and the DGM subcontractor, NAEVA Geophysics, Inc., performing surveys across the strip. Results of one of the GPO surveys are presented as Figure 2-2. The CH2M HILL MR Geophysicist validated results of the GPO as meeting project DQOs and approved NAEVA's "tandem" system, shown as Figure 2-3, for data collection.

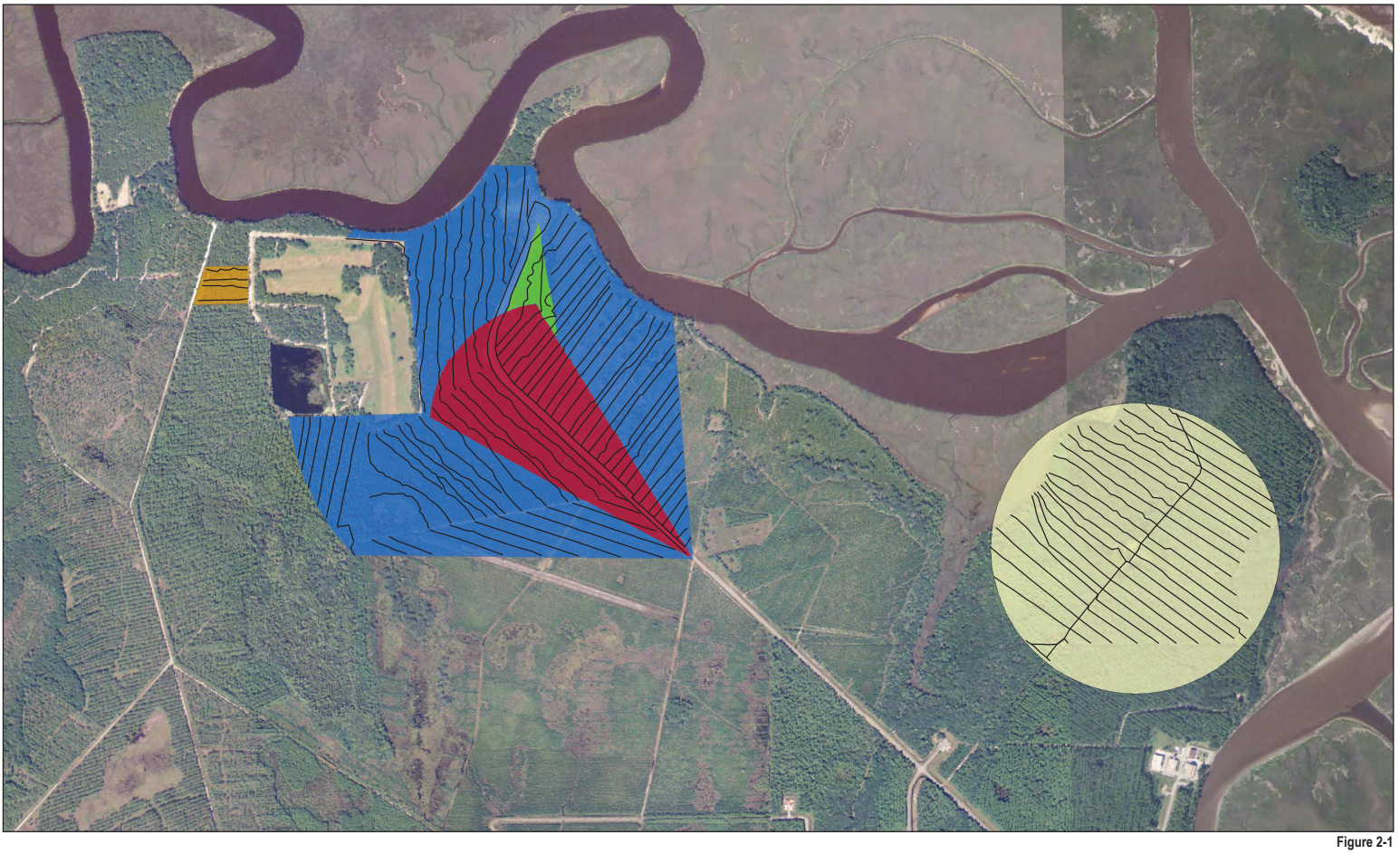
2.5 Geophysical Investigation

DGM was performed as a series of transects placed across each MRA as shown on Figure 2-1. Approximately 5 percent of the total land area of each MRA was geophysically surveyed, comprised of the following approximate total transect lengths: 32,000 linear meters at MRA-1; 16,000 linear meters at MRA-2; and 630 linear meters at MRA-3.

Each transect was 2 meters wide and was geophysically surveyed in two passes by the geophysical instrument. The transects were placed to provide the same degree of coverage across the entire area of each MRA. Because one objective of the Phase I MEC RFI was to determine the extent of MEC within each MRA, no attempt was made during this phase of work to provide varying density of coverage in different areas of the MRAs.

At MRA-2, DGM transects did not cover the entire MRA because the proposed MRA boundaries extended off of UCC property to the south and southeast, and because the northwestern boundary extended into a wetlands area.

Detailed requirements for DGM operations were provided in the Geophysical Investigation Plan, which formed Appendix B to the Phase I RFI Work Plan (CH2M HILL, 2008). The methodologies employed during DGM operations are also presented in the Geophysical Investigation Report, which comprises Appendix A to this report.



CH2MHILL

Figure 2-1
Surface Clearance and DGM Transects
UCC Site
Woodbine, GA

File Path: H:\projects3\DOW Woodbine\MXDs\MEC MRA Transects.mxd, Date: June 2, 2008 1:21:40 PM, User: JKELLY3

Figure 2-2. Example Geophysical Prove-Out Transect

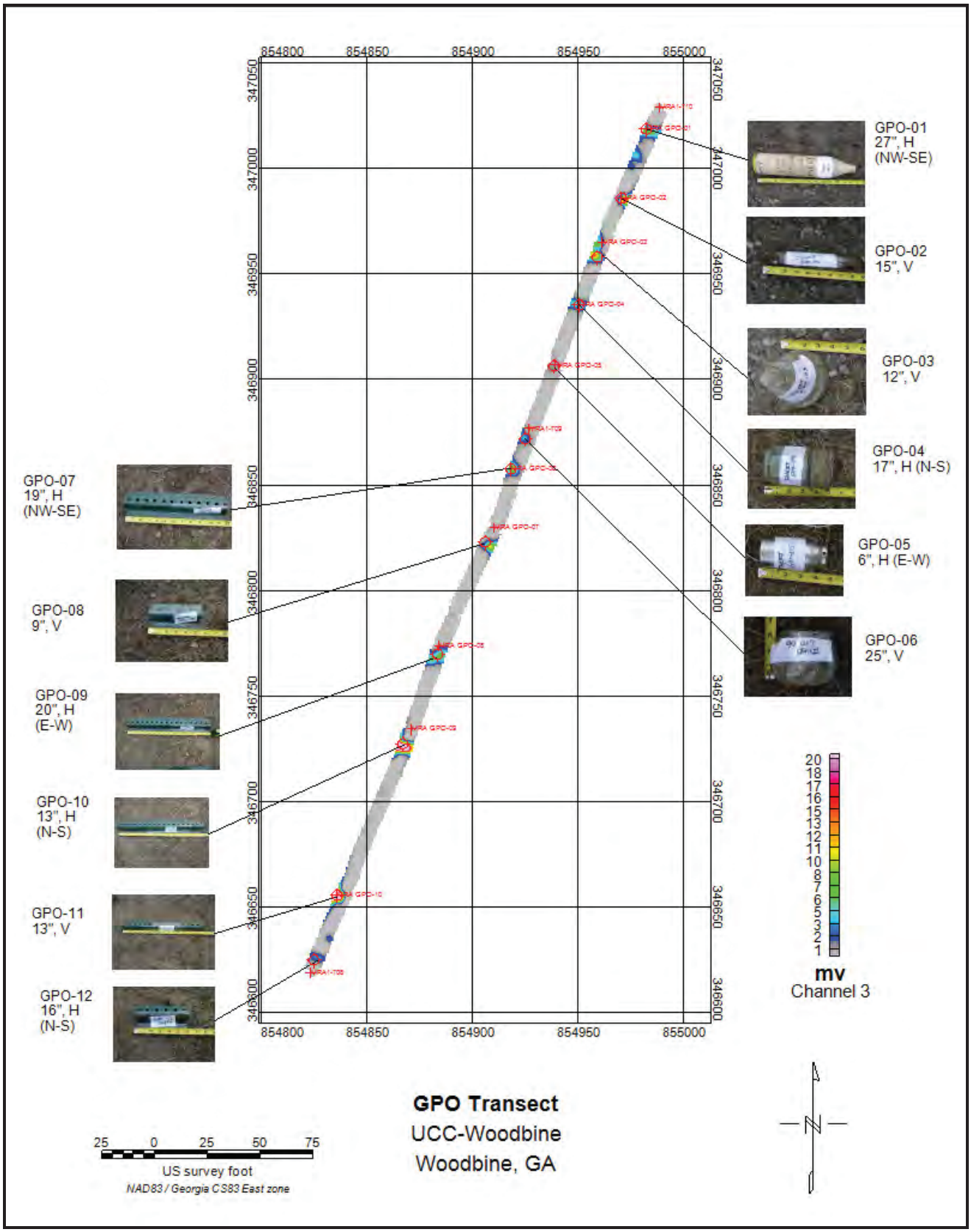


Figure 2-3. Digital Geophysical Mapping Equipment in use at UCC-Woodbine

SECTION 3

Investigation Results

3.1 MRA-1 – Former 40mm Test Range/SWMU 03 and Former 81mm Test Range

Twenty-one MEC items were discovered on the ground surface at MRA-1 during the surface clearance and other site investigation activities. The MEC consisted of three 40mm CS grenades and eighteen 40mm high explosive (HE) grenades. Descriptions of these items are provided in Section 4.2, below.

The surface MEC locations are shown on Figure 3-1. One 40mm grenade was found near Todd Creek, northwest of the former 40mm Test Range firing point. One 40mm grenade was found immediately west of the 40mm Test Range boundary. Two 40mm grenades were found near the former rocket test pit, which is adjacent to the former 40mm Test Range firing point. The 17 remaining 40mm grenades were found near the center of the 40mm Test Range boundary impact area.

Analysis of the DGM data at MRA-1 resulted in the selection of 597 geophysical anomalies above the targeting threshold (29 of which were quality control items placed by CH2M HILL). The locations of these anomalies are shown on Figure 3-2. The highest concentration of anomalies is found around the former rocket test pit and within the former 40mm Test Range, as represented by the anomaly concentration map provided as Figure 3-3.

3.2 MRA-2 – Former MEC Disposal Area/SWMU 07

Seven MEC items were discovered on the ground surface at MRA-2 during the surface clearance. The MEC consisted of one M71A2 primer, one M7A1 primer, and five partial M84 fuzes. Descriptions of these items are provided in Section 4.2, below.

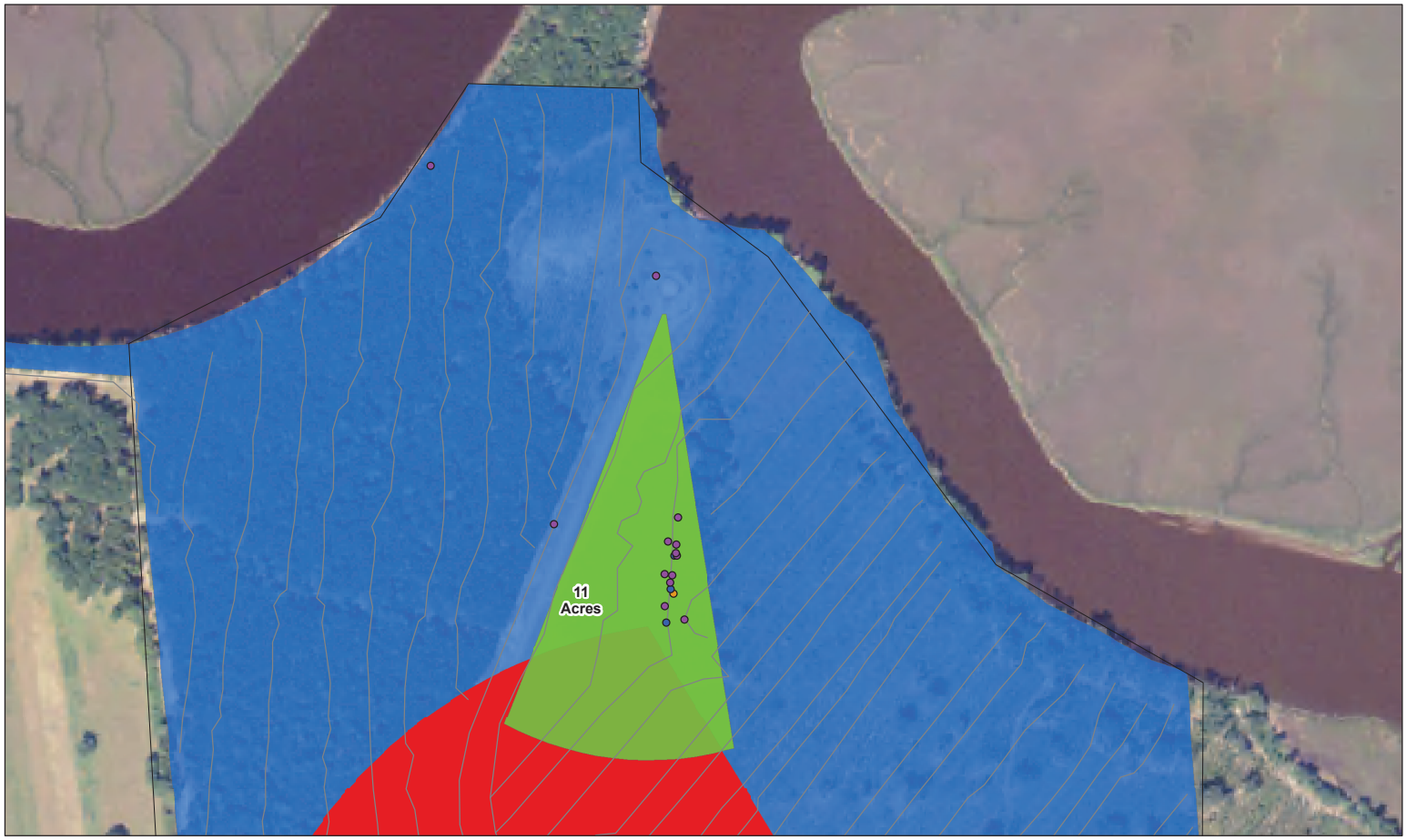
The surface MEC locations are shown on Figure 3-4. Five of the items were found near the center of MRA-2, and the other two items were found approximately 300 yards northeast of the center of MRA-2.

Analysis of the DGM data at MRA-2 resulted in the selection of 218 geophysical anomalies above the targeting threshold (ten of which were quality control items placed by CH2M HILL). The locations of these anomalies are shown on Figure 3-2. The highest concentration of anomalies is found near the center of the site, as represented by the anomaly concentration map provided as Figure 3-3.

3.3 MRA-3 – Former Scrap Metal Surface Disposal Area/ SWMU 01

No surface MEC was discovered at MRA-3.

Analysis of the DGM data at MRA-3 resulted in the selection of 16 geophysical anomalies above the targeting threshold. The locations of these anomalies are shown on Figure 3-2. The highest concentration of anomalies is found in the northwestern corner of the site, as represented by the anomaly concentration map provided as Figure 3-3.



Surface MEC

Quantity & Description

- 3-Grenades, 40mm HE
- 1- Grenade, 40mm HE
- 1- Grenade, 40mm CS

- MRA1 Transects
- Former 40mm Test Range
- Former 81mm Mortar Test Range
- Munitions Response Area 1

N

0 250 500 1,000

Feet

Figure 3-1
Locations of Recovered Surface MEC at MRA-1
UCC Site
Woodbine, GA

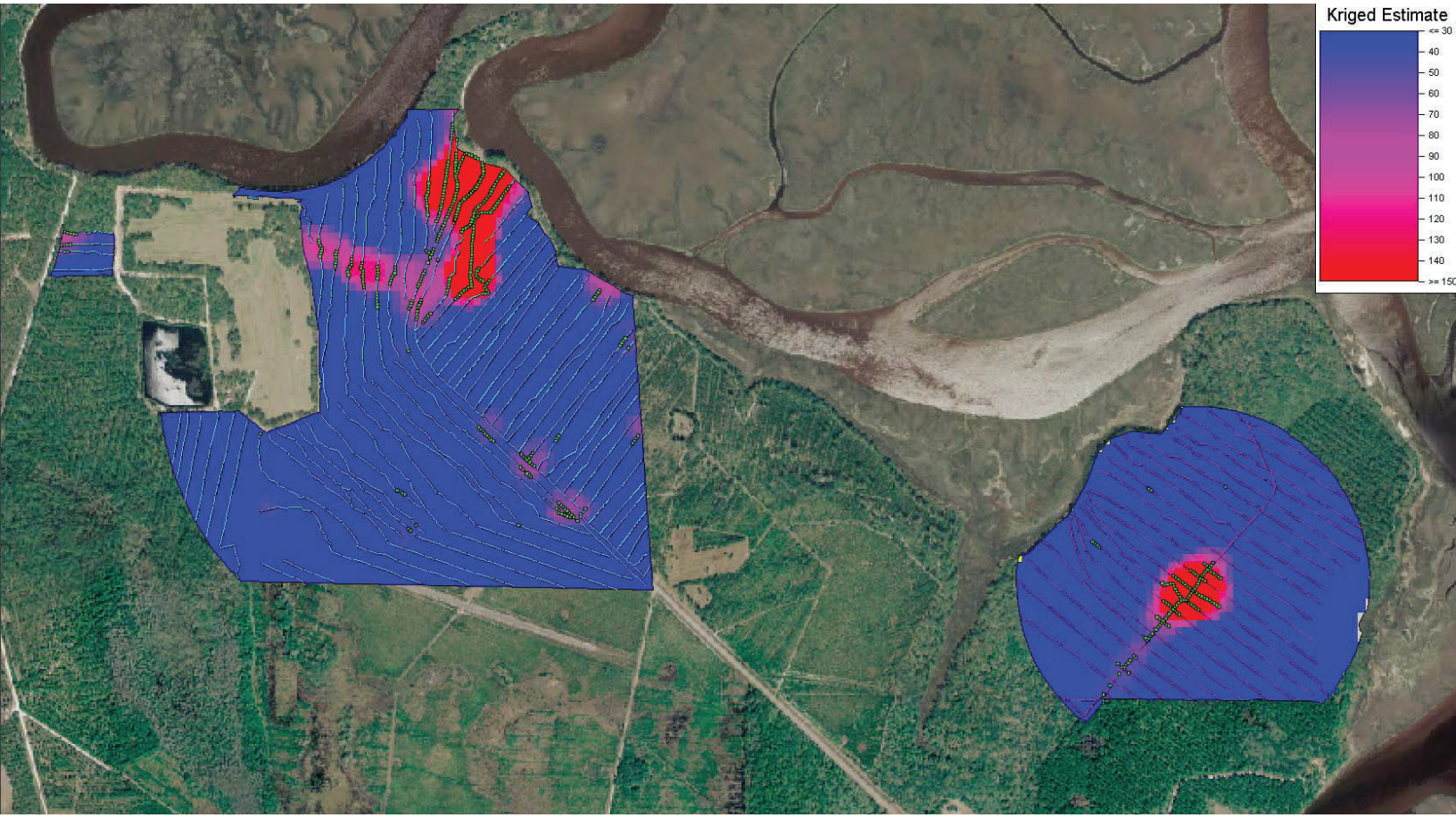
File Path: H:\projects3\DOW Woodbine\MXDs\MEC MRA 1.mxd, Date: June 2, 2008 11:08:26 AM, User: JKELLY3

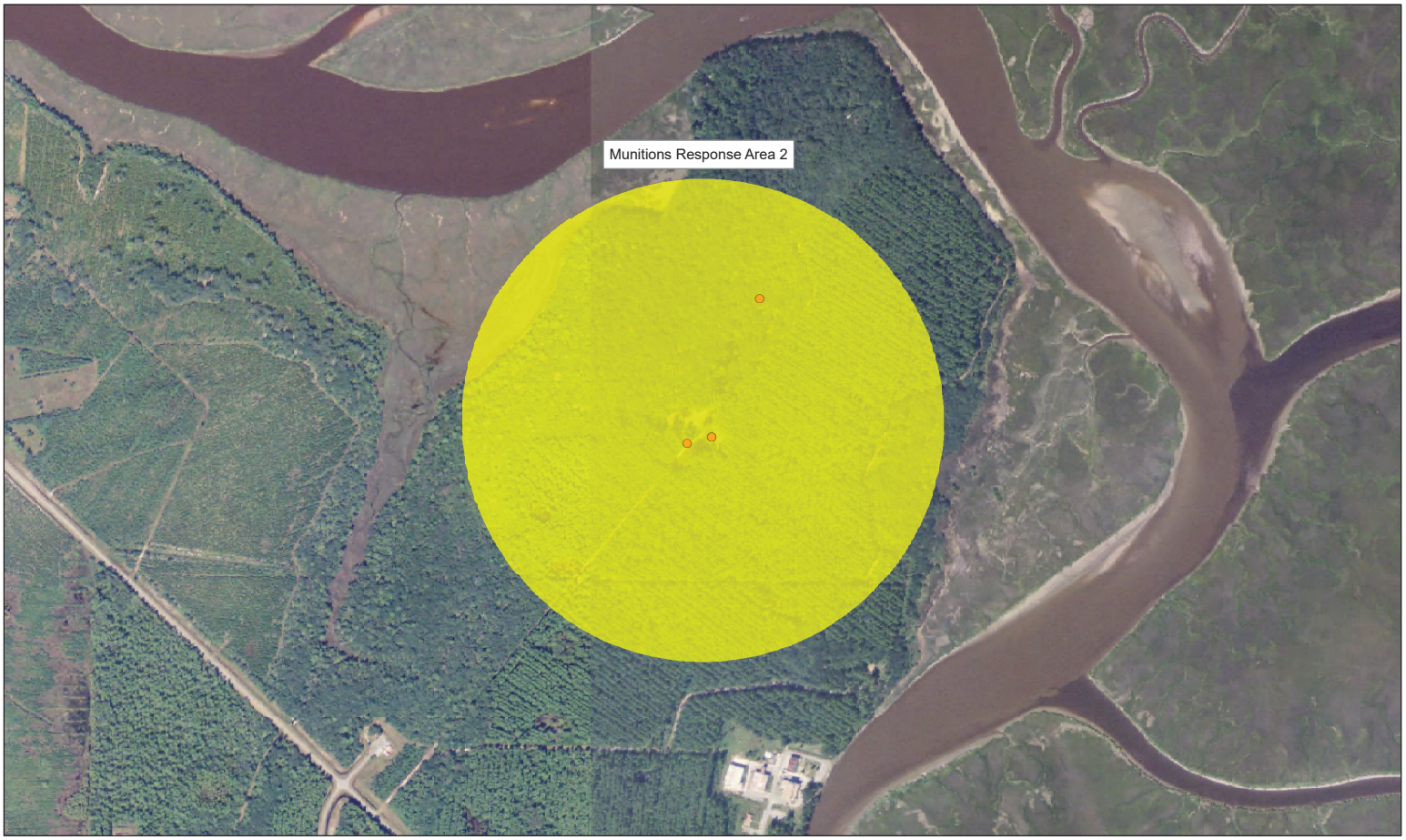
Figure 3-2
MRA Transects and Geophysical Targets
UCC Site
Woodbine, GA

CH2MHILL

File Path: H:\projects3\DOW Woodbine\MXDs\MEC MRA Targets.mxd, Date: June 2, 2008 1:17:28 PM, User: JKELLY3

Figure 3-3. Geophysical Target Density
Phase I MEC RFI, UCC-Woodbine





CH2MHILL

Surface MEC
Munitions Response Area 2

N

0 200 400 800
Feet

Figure 3-4
Locations of Recovered Surface MEC at MRA-2
UCC - Woodbine Site
Woodbine, GA

File Path: H:\projects3\DOW Woodbine\MXDs\MEC MRA 2.mxd, Date: June 2, 2008 1:24:48 PM, User: JKELLY3

SECTION 4

Quality Control

An extensive quality control (QC) program was implemented for the project work and included:

- GPO for validation of field personnel and survey system (discussed in Section 2),
- DGM system QC tests,
- Review of DGM data by the CH2M MR Geophysicist, and
- Placement of QC Seed items in the survey area and validation that the seed items were detected and positioned within project DQOs.

4.1 Quality Control Tests

The instrument QC tests outlined in the Geophysical Investigation Plan were performed on a daily basis and no quality issues were observed. Results of the tests were confirmed and validated by the CH2M HILL MR Geophysicist.

4.2 DGM Data Review

Data was collected, processed and interpreted by CH2M HILL's DGM subcontractor, NAEVA, and data and results were electronically provided to the CH2M HILL MR Geophysicist. Data provided were reviewed according to the steps shown on Figure 4-1 and approved by the CH2M HILL MR Geophysicist. All project DQOs were observed to have been met.

4.3 QC Seed Items

A total of 30 QC seeds, comprised of 6 to 18-inch pieces of steel fence posts, were emplaced by the CH2M HILL SUXOS at varying locations and depths (up to 2 feet below ground surface) along the transects to be surveyed prior to performance of the DGM surveys. An example photograph of one of the QC items is shown as Figure 4-2. All of the QC seeds were visible in the data provided to CH2M HILL by NAEVA and were selected as geophysical anomalies during NAEVA's interpretation of the data.

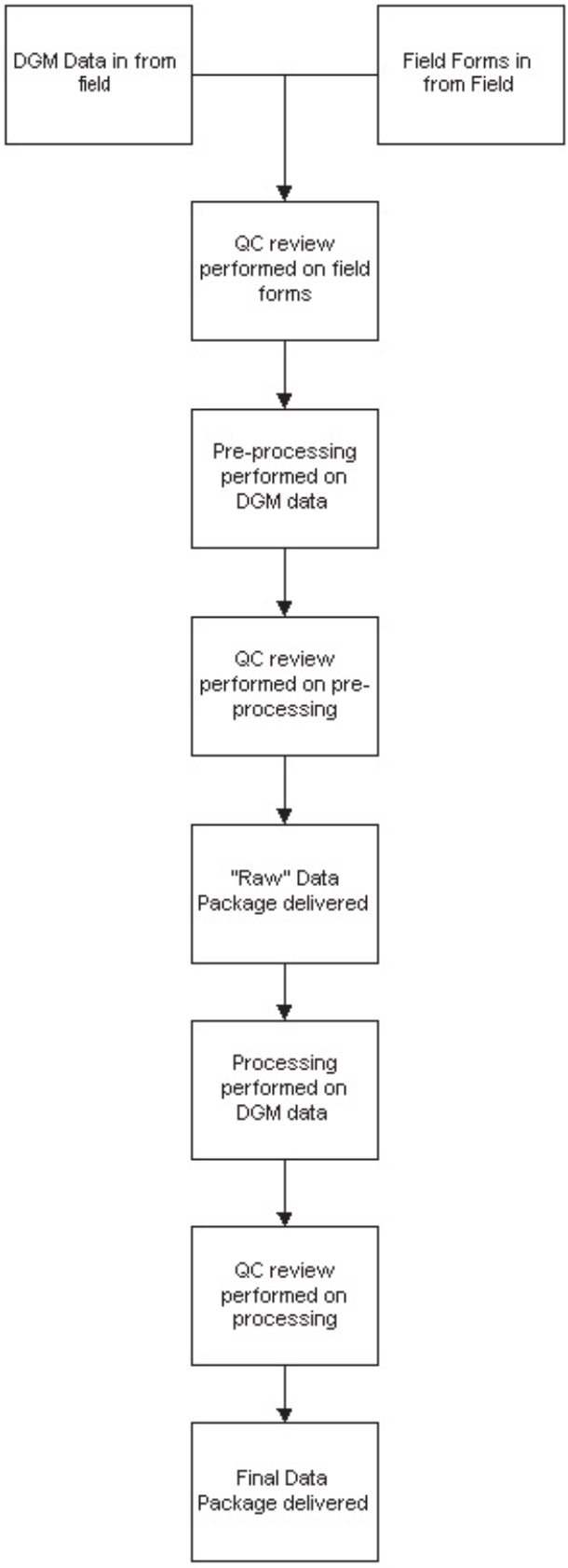


Figure 4-1. Overview of DGM Data and Deliverables QC Process

Figure 4-2. Example QC Seed Item

4.4 Surveyor Quality Control

During review of the DGM data, the NAEVA and CH2M HILL geophysicists observed that the survey coordinates provided by the land surveyor were not correlating well to the data positioning resulting from the DGM operations. It was confirmed in the field that the positioning of many of the stakes were not accurately recorded using the GPS system and the surveyor was tasked with resurveying all of the stakes again with a total station (at no cost to the project.) The DGM results were not affected except for a repositioning of the data (office operation.)

SECTION 5

Conclusions and Recommendations

5.1 Conclusions

5.1.1 MRA-1 – Former 40mm Test Range/SWMU 03 and Former 81mm Test Range

Surface MEC at MRA-1 consisted of 40mm CS and 40mm HE grenades. The locations of most surface MEC were consistent with the historical use of the 40mm Test Range, as all but one MEC item was discovered within or near the boundaries of the 40mm Test Range, or near the assumed firing point for the range.

One surface MEC item was discovered well outside the boundaries of the former 40mm Test Range, near Todd Creek. This MEC could be the result of firing 40mm grenades in a direction away from the former 40mm Test Range impact area, or could have been transported to this location by a site worker or trespasser who discovered the item elsewhere.

The densities of geophysical targets across MRA-1 are also consistent with the historical use of the former 40mm Test Range and the former 81mm Test Range, as the greatest concentration of targets was found in and adjacent to these ranges. Geophysical targets were also identified outside of these ranges, but the source of the targets cannot be determined without the completion of an intrusive investigation.

The locations and densities of surface MEC and geophysical targets appear to confirm the approximate locations of the former 40mm Test Range and the former 81mm Test Range. However, the discovery of surface MEC and the identification of geophysical targets outside of these ranges indicates the possibility of additional surface MEC and subsurface MEC both within the ranges and in other areas of MRA-1 that are outside of the range boundaries.

The results of the Phase I MEC RFI do not allow any conclusions as to whether the boundaries of MRA-1 are adequately defined. One surface MEC was discovered along the northern MRA boundary, and geophysical targets are located near the boundaries on all sides of MRA-1.

5.1.2 MRA-2 – Former MEC Disposal Area/SWMU 07

Surface MEC at MRA-2 consisted of one M71A2 primer, one M7A1 primer, and five partial M84 fuses. The locations of the surface MEC were consistent with the history of the site's use for munitions demolition in the center of the site, as most items were found in the demolition area, or within a distance that would be expected to receive kick-outs from the demolition area.

The densities of geophysical targets across MRA-2 are also consistent with the historical use of the former MEC disposal, as the greatest concentration of targets was found in the center of MRA-2 where MEC disposal was conducted.

The results of the Phase I MEC RFI do not allow any conclusions as to whether the boundaries of MRA-2 are adequately defined. Geophysical targets are located near the boundaries of MRA-2, and the source of these targets can be determined only through intrusive investigation.

5.1.3 MRA-3 – Former Scrap Metal Surface Disposal Area/SWMU 01

No surface MEC was discovered at MRA-3. The results of the Phase I MEC RFI do not allow any conclusions as to whether the boundaries of MRA-3 are adequately defined. Geophysical targets are located near the boundaries of MRA-3, and the source of these targets can be determined only through intrusive investigation.

5.2 Summary of Risk from MEC

All MEC were manufactured and/or otherwise handled during Thiokol's operations and prior to 1976. Thiokol's files were not available for review. UCC's operations were limited to the manufacture and formulation of agricultural chemicals.

Results of the archival review conducted as part of the MEC RFA revealed no specific documentation related to MEC testing or manufacturing activities. No test plans, maps identifying test locations or test ranges, or documents identifying items tested nor specific details regarding the type, amount or location of MEC manufacturing were located for review. The historical information presented previously was taken primarily from environmental reports associated with the RCRA closure and investigations related to chemical waste activities at the various identified SWMUs.

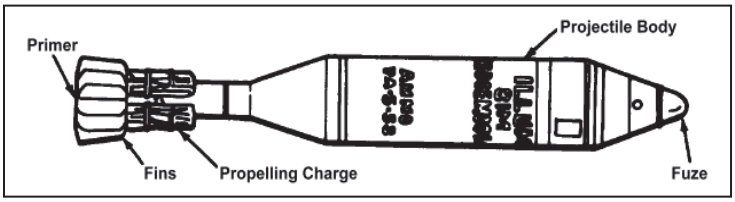
The potential for MEC to be present at the site is surmised based on reports detailing previous MEC clearance and disposal activities as summarized in Section 1.9, visual observation during previous site visits, and surface clearance activities during the Phase I RFI. Table 3-1 lists the types of MEC known or suspected to be present at UCC-Woodbine.

TABLE 3-1
Potential MEC Types at UCC-Woodbine

Item	Type	Function	Use	Fuze	Comment
1	M301 Illumination Projectile for 81mm mortar	Target Illumination	Projected High Angle Ejection	Powder Train Time Fuze (PTTF)	Reported by EODT
2	40mm grenade: M406 and M651	CS, High Explosive (HE)	Projected low velocity	Always Acting	Reported by EODT, confirmed by visual observation, and found during Phase I RFI at MRA-1
3	XM 15 CS Canisters	Pyrotechnic burn	Irritant Smoke	Percussion Cap	Reported by EODT and confirmed by visual observation
4	M84 - Fuze	Delay	81mm Illumination Projectile	PTTF	Reported by EODT and confirmed by visual observation
5	M49 Trip Flare	Illumination	Provides warning of infiltrating troops	Pressure Release	Reported by EODT

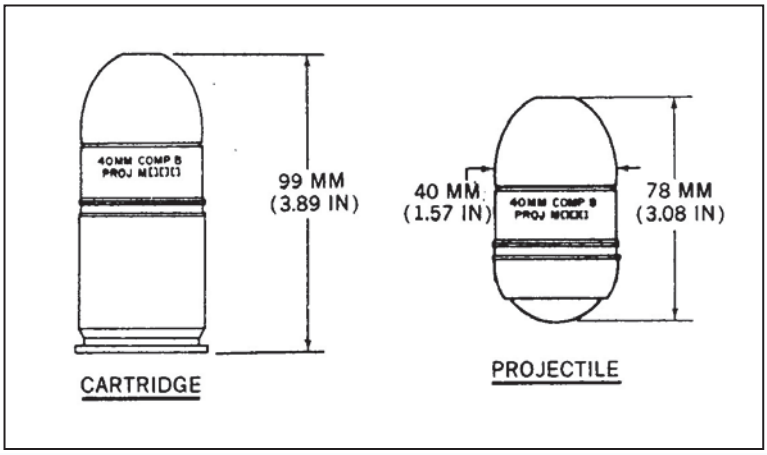
5.2.1 M301 Illumination Projectile

The 81mm mortar was designed to fire a range of munitions including high explosives (HE) and white phosphorous in addition to the illumination projectile produced by Thiokol. The M301 has a cylindrical body that contains an illuminating candle and parachute assembly. The round has a burst height of 600 meters and provides illumination for about 60 seconds. The M301 utilized the M84 time fuse, adjustable from 5 to 25 seconds before priming charge detonated, releasing the illum and chute.



5.2.2 40mm Grenades (M406 and M651)

The DoD has produced a variety of 40mm grenade cartridges including HE, anti-personnel, smoke, signal, illumination, riot control, and other unique and specialized versions. Thiokol is assumed to have produced 40mm CS grenades at UCC-Woodbine. The standard CS gas cartridge is designated M651.The round is filled with about 2 ounces of CS pyrotechnic mix containing approximately 0.75 ounces (21 grams) of CS. Maximum accuracy is obtained at ranges up to 219 yards (200 meters). Area targets may be engaged up to 437 yards (400 meters).

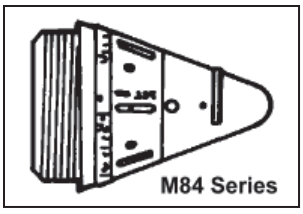


UCC-Woodbine is also known to have procured an unknown quantity of an experimental variety of M406 HE grenades as described in Section 4. Characteristics specific to this experimental variety are unknown, but a conventional M406 40mm HE round has an olive drab aluminum skirt with a steel projectile attached, gold markings, and a yellow ogive. It arms between 14 and 27 meters, and it produces a ground burst that causes casualties within a 5-meter radius.

5.2.3 XM 15 CS Canisters

In addition to standard 40mm CS grenades, archival review indicates that a portion of CS cartridges recovered at UCC-Woodbine are of an experimental variety designed to be dispensed in the XM 15 CS Cluster.

5.2.4 M84 Time Fuze



The M84 Time Fuze is a single-purpose, powder-train, mechanical-time fuze used with the 81mm M301A1 and M301A2 Illumination Projectiles. It has a time setting of up to 25 seconds. The fuze

consists of a brass head, body assembly, and expelling charge. Safety before firing is provided by a safety wire, which must be removed just before firing.

5.2.5 M49 Surface Trip Flare

The trip flare provides warning of infiltrating troops by illuminating the field when the trip wire is activated. It puts out a light intensity of 35,000 candlepower for 1 minute; it can also be activated by trigger or pull pin. A trip flare is used primarily to illuminate and to give warning of attacking or infiltrating enemy troops. The M49 Trip Flare resembles a hand grenade in size and shape, except that it is provided with a bracket for attachment to a tree or post and a trigger mechanism for firing. The flare burns with a yellowish light and illuminates an area radius of approximately 300 meters. The flare has a laminated paper body, containing one 1-ounce flare charge and is closed at both ends by metal caps. The upper cap has taped holes and a threaded central hole for the trip fuze.

5.3 Recommendations

Based on the results of the field investigation and the conclusions in Section 4.2, it is recommended that an intrusive investigation of geophysical targets be conducted at MRA-1, MRA-2, and MRA-3. To conduct this intrusive investigation, the geophysical targets would be reacquired by flagging the centers of the targets using the coordinates that were determined during the DGM effort. UXO Technicians would then use handheld metal detectors to search for geophysical anomalies a 1-meter radius around each target flag. The UXO Technicians would then dig with handheld tools to determine the source of each anomaly (MEC, MD, or cultural debris). This information would be recorded and would be used to estimate the quantities and densities of subsurface MEC, if any, that may be present within each MRA. Where the data permits, it would also be used to evaluate whether the MRA boundaries have been adequately defined and whether the boundaries need to be expanded or can be reduced. If it is determined that the MRA boundaries have been adequately defined, the data from the intrusive investigation, along with the data from the surface investigation conducted during this Phase I RFI, would be used in the evaluation of potential corrective actions that may be needed to address surface and subsurface MEC remaining at the MRAs.

Due to the possibility that MEC is buried in the landfill, it is also recommended that MEC avoidance practices be implemented during any future construction or soil boring activities that would result in disturbance of the landfill cap.

SECTION 5

References

Apex Environmental. 1996. Report of the Phase II RCRA Facility Investigation. September 20.

CH2M HILL. 2007a. *Munitions and Explosives of Concern RCRA Facility Assessment (Draft)*. Prepared for Union Carbide Corporation. October.

CH2M HILL. 2008. *Work Plan to Conduct Phase I Munitions and Explosives of Concern RCRA Facility Investigation (Final)*. Prepared for Union Carbide Corporation. February.

Environmental Science & Engineering, Inc. 1994. *Facility Investigation.* February.

McGrath, David. 1995. "Thiokol's "Big Booster Work at the Georgia Division during the 1960s." Thiokol Corp, Elkton DLV Operations, Elkton, MD, Copyright 1995 by the American Institute of Aeronautics and Astronautics, Inc.

Southeast Regional Climate Center (SERCC), University of North Carolina at Chapel Hill. http://radar.meas.ncsu.edu/. Data for Station 091340 (Brunswick) accessed October 11, 2007, at http://radar.meas.ncsu.edu/cgi-bin/sercc/cliMAIN.pl?ga1340.

This page intentionally left blank.

Appendix A

Geophysical Investigation Report

NAEVA GEOPHYSICS INC.
THE LEADER IN SUBSURFACE DETECTION
Subsurface Geophysical Surveys

GPR
MAGNETICS
ELECTROMAGNETICS
SEISMICS
RESISTIVITY
UTILITY LOCATION
UXO DETECTION
BOREHOLE CAMERA
STAFF SUPPORT

GEOPHYSICAL INVESTIGATION REPORT

Phase I Munitions and Explosives of Concern
RCRA Facility Investigation
Union Carbide Corporation – Woodbine
Woodbine, Georgia

Dates of Investigation:

February 21st – March 12th, 2008

DRAFT SUBMITTAL
May 8, 2008

PREPARED FOR

CH2MHILL

9191 South Jamaica Street
Englewood, Colorado 80112
888-242-6445

MARYLAND
4707 Benson Ave.
Suite 104
Baltimore
Maryland 21227
(410) 536-7600
(410) 536-7602 Fax

NEW YORK
50 N. Harrison Ave.
Suite 11
Congers
New York 10920
(845) 268-1800
(845) 268-1802 Fax

VIRGINIA
P.O. Box 7325
Charlottesville
Virginia 22906
(434) 978-3187
(434) 973-9791 Fax

TABLE OF CONTENTS

TABLE OF FIGURES

PLATES

APPENDICES & DVD

ACRONYMS AND ABBREVIATIONS

DGM	Digital Geophysical Mapping
DQO	Data Quality Objectives
GPO	Geophysical Prove-Out
GPS	Global Positioning System
HE	High Explosive
MEC	Munitions and Explosives of Concern
MOA	Master Ordering Agreement
MRA	Munitions Response Area
MRP	Munitions Response Program
mV	Millivolts
NAD83	North American Datum of 1983
QA/QC	Quality Assurance / Quality Control
QC	Quality Control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RTS	Robotic Total Station
SWMU	Solid Waste Management Unit
UCC	Union Carbide Corporation
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
VSP	Visual Sample Plan

1.0 INTRODUCTION

NAEVA Geophysics, Inc. (NAEVA) was contracted by CH2M HILL to conduct Digital Geophysical Mapping (DGM) of the Union Carbide Corporation (UCC) Woodbine facility near Woodbine, Georgia under the Phase I Munitions and Explosives of Concern (MEC) Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI). The area of concern encompasses over 500 acres in three separate Munitions Response Areas (MRAs). Field operations were conducted from February 21st to March 12th, 2008.

1.1 BACKGROUND AND OBJECTIVES

The goal of the Phase I RFI is to define the extent of previously discovered MEC within the UCC-Woodbine site, stemming from the manufacture and testing of ordnance in the 1960s and 1970s by the Thiokol Corporation. The purpose of this investigation is to detect and map subsurface metal associated with potential MEC in three MRAs, selected based on historical data of munitions testing and disposal. By subsequently indentifying detected geophysical anomalies as MEC or scrap metal, the scope of further remediation efforts can be estimated.

1.2 SCOPE OF WORK

Geophysical investigations were completed for all three MRAs identified in the work plan as possibly contaminated with MEC or munitions debris. In order to effectively bound the extent of MEC within these areas, a survey of transects covering approximately 5% of the entire MRA acreage was conducted. DGM efforts were accompanied by a quality control (QC) plan in order to establish confidence in the accuracy of the geophysical data.

All data were to be processed, interpreted and delivered to the CH2M HILL Project Geophysicist on the schedule and in the formats specified in the DGM Master Ordering Agreement (MOA).

1.3 SITE LOCATION AND DESCRIPTION

The UCC-Woodbine site is located near the town of Woodbine, Georgia in northeast Camden County. The 4,000-acre site is currently owned by UCC, a subsidiary of the Dow Chemical Company, adjacent to an agricultural chemical manufacturing facility owned by Bayer Crop Science. DGM was conducted only on land still owned by UCC.

Based on previous work at UCC-Woodbine identifying the presence of MEC, three MRAs were defined for further study. The largest, MRA-1, encompasses 415 acres, 309 of which were investigated, and includes former 40 mm grenade and 81 mm mortar firing positions. A known former Solid Waste Management Unit (SWMU 03) is located near the 40 mm range. Potential

MEC within this area includes inert practice, high explosive (HE), and CS gas 40 mm grenades, as well as 81 mm illumination mortars. This area also encloses a landfill operated by UCC in which no investigations were conducted. MRA-2 is a 200-acre circular area around a former MEC disposal and burn site, SWMU 07. This area had not been well investigated in the past due to thick vegetation but both buried drums and individual MEC items were found at the center disposal point. The third area of concern, MRA-3, is near former SWMU 01 and is a small 6-acre site west of the landfill identified as containing munitions debris and other scrap metal on the surface.

Vegetation on the site includes natural oak and palmetto forest as well as planted rows of pine trees for commercial logging operations. The overhead canopy, especially in the natural forest, is thick, and though ground topography is generally flat, isolated mounds and rough areas exist where vegetation is particularly dense. Data collection regions are bounded by property lines to the south and Todd Creek, a tributary of the larger Satilla River, and associated wetlands to the north.

2.0 EQUIPMENT

The instrument used for the geophysical investigation at UCC-Woodbine is the Geonics EM61-MK2 metal detector. The EM61-MK2 is a high resolution time-domain electromagnetic instrument designed to detect with high spatial resolution, shallow ferrous and non-ferrous metallic objects. In comparison with other metal detectors, especially magnetometers, it is much better suited for work in close proximity to man-made structures and in areas of dense subsurface metallic debris (i.e. impact ranges). This instrument was chosen based on the presence of non-ferrous MEC at the UCC-Woodbine site.

The EM61-MK2 system consists of two 1 meter by 0.5 meter air-cored coils, a digital data recorder, batteries and processing electronics. The EM61-MK2's transmitter generates a pulsed primary magnetic field, which then induces eddy currents in nearby metallic objects. The receivers either measure the eddy currents at three distinct time intervals in the bottom coil and one time interval in the top coil or four intervals in the bottom coil if no top coil measurements are recorded. For the work at UCC-Woodbine the latter method was chosen. Earlier time gates provide enhanced detection of smaller metallic objects. Secondary voltages induced in both coils are measured in millivolts (mV). The arrangement of coils is such that there is a vertical separation of 40 cm from the ground to the bottom coil. Assuming accurate data positioning, target resolution of approximately 0.5 meters can be expected. The data are collected using

Geonics' EM61MK2 program and temporarily stored in an Allegro CX data logger prior to downloading to a laptop computer.

3.0 METHODOLOGY

3.1 DGM SURVEY ACTIVITIES

Transect lines were established by a vegetation clearing crew and a licensed surveyor contracted by CH2M HILL. In MRA-2 these lines are approximately parallel and evenly spaced due to long rows of planted pine trees. The lines in MRA-1 are again approximately evenly spaced though are not necessarily parallel due to changing vegetation conditions. Data in MRA-1 were collected in five sections where the lines are parallel, in addition to two lines paralleling Rocket Pit Road.

Wooden stakes are generally located no more than 100 feet apart or whenever the transect line deviates due to an obstruction, such as thick brush or a large tree. Data were collected on both sides of the stakes, treating the stake line as the center line and resulting in a line spacing of about three feet. Due to the straightness of the lines in MRA-2 and MRA-3, transects have associated ID numbers written on the stakes (e.g., MRA2-15-26, where 15 is the transect ID and 26 is the stake ID); in MRA-1 IDs were assigned to aid in the ease of collection, processing, and presentation of the data, though stakes in the field just have a stake ID (e.g., MRA1-254). Refer to the MRA-1 map (Plate 1) for corresponding transect IDs.

Figure 1: EM61-MK2 in tandem mode

The method of surveying at UCC-Woodbine was the EM61-MK2 in tandem mode configuration. Wheel mode was tested in a Geophysical Prove-Out (GPO, see Section 5.1) but rough ground

conditions on the majority of the site necessitated tandem mode to achieve the best quality data. All data collected were recorded at the standard sample rate of 10 readings per second.

3.1.1 Tandem Mode

In tandem configuration, the EM61-MK2 coils are supported with 10-foot long fiberglass poles and transported by two operators. The electronics include the data logger and backpack controlled by the operator at the rear of the system. Bottom coil height is made consistent with the wheeled method of 40 cm above ground and maintained throughout DGM operations. This configuration is more suitable in areas with uneven terrain as the coil does not tip from side to side, can be lifted over tall stumps, and is less likely to be struck by sticks, roots, and other remainders of the brush clearance operation.

3.1.2 Wheel Mode

In wheel mode, the EM61-MK2 bottom coil (the receiver coil) is mounted on two manufacturer supplied 40 cm wheels and has four plastic spacers which are used to separate the top coil from the bottom coil. This configuration was tested in the GPO but was not used for the remainder of survey operations.

3.1.3 Positioning Configurations

Due to the dense canopy obstructing a clear view of the sky, using a Global Positioning System (GPS) was not possible, nor was a Robotic Total Station (RTS) feasible due to numerous obstructions to line-of-sight, changing direction of some of the transects, and narrow corridors of cleared vegetation.

Since data are recorded at a constant rate of 10 readings per second, the coil must be operated at a constant walking pace between stakes. In order to maximize control over positioning, collection was stopped at each stake and a separate line segment created in the software. This eliminated the chance of missing an essential fiducial marker if data were collected across multiple stakes. Using known UTM (Universal Transverse Mercator) coordinates for each stake, parallel offsets of 1.5 feet perpendicular to each line segment were calculated. Since the trend of a transect often changed, the distance on one side of the stakes was not necessarily equal to the distance on the other side. Using these two calculated lines on the sides of the surveyed stakes, local distances along each transect were calculated to position the raw data, which was later linearly interpolated back to NAD83 (North American Datum of 1983) UTM coordinates.

3.2 DATA PROCESSING AND INTERPRETATION

3.2.1 Data Storage and Initial Editing

EM61-MK2 data are temporarily stored in an Allegro CX data logger using Geonics EM61MK2 software version 1.09 and then downloaded into a laptop computer for further on-site processing using Geonics DAT61MK2 version 2.37 and Geosoft Oasis Montaj software version 6.4.2.

Daily logs and grid block information were input digitally into the Munitions Response Program (MRP) Enterprise field device (Trimble GeoXT). At the end of each day, this information was exported and uploaded to the project database for use in processing the geophysical data. The number of transects collected in a grid block varied, but a grid block was generally closed out before lunch and a second one begun after lunch.

Initial data processing was performed by the field team, which included reviewing data for integrity and repeatability, and positioning the data based on the local distance from the first stake on each transect.

3.2.2 Preprocessing

Converted raw data files were imported into Geosoft's Oasis Montaj to perform the following:

- Review and finalize all QC tests (cable shake, personnel, static and latency) prior to processing of the DGM data for that day
- Set projection of NAD83 UTM Zone 17 North coordinates
- Perform a 2-channel table lookup between local and UTM coordinates and linearly interpolate the data between each set of stakes
- Evaluate data density
- Apply auto leveling and instrument drift corrections
- Apply default lag correction
- Generate preliminary contour map(s) from gridded data
- Generate preliminary original vs. repeat profiles by grid block
- Generate formatted ASCII files containing preprocessed data by transect

3.2.3 Final Processing

After completion of preprocessing, the data were further evaluated and processed to generate final processed data files. Final processing steps included:

- Evaluation and refinement of auto leveling and instrument drift corrections in the channel selected for target analysis (Channel 3)
- Evaluation and refinement of lag correction in the channel selected for target analysis (Channel 3)

- Additional digital filtering and enhancement, as necessary, in the channel selected for target analysis (Channel 3)
- Targeting of data, as described in Section 3.2.4
- Generation of formatted ASCII files containing processed data by transect
- Generation of final maps for each transect showing contoured gridded data, target locations, and culture
- Generation of final original vs. repeat profiles by grid block

3.2.4 Analysis and Target Selection

The UX-Detect module within Oasis Montaj identifies peak amplitude responses associated with, but not limited to, MEC items. Initial target selections were made based on the minimum curvature gridded data. Data profiles corresponding to the anomalies selected by Geosoft were then analyzed by trained geophysicists, with the targets evaluated as to their validity and position, as single-source anomalies may generate multiple target designations depending on shape and orientation. Targets found to be invalid or incorrectly located were removed or adjusted. Additionally, anomalies that were not selected by the UX-Detect module, yet deemed to represent a potential MEC target, were manually selected. All target selection was performed on final processed data from Channel 3 of the bottom coil of the EM61-MK2.

Final processed XYZ (ASCII) files and individual geophysical maps and target lists were created for each transect (still noted as Grid ID in the project database). All anomalies occurring at or above the targeting threshold of 2.5 mV in Channel 3 were identified using a unique ID number.

Each target list provides a Target ID, Grid ID, Easting (x) and Northing (y) UTM coordinate location for each target, and the recorded peak response in millivolts. The target IDs were prioritized by designating the highest amplitude response as the number one target on each transect.

All raw and processed data have been submitted to CH2M HILL's project geophysicist and can be found on the enclosed DVD.

4.0 RESULTS

4.1 SUMMARY OF WORK PERFORMED

The digital geophysical mapping of the UCC-Woodbine site took place from February 21st to March 12th, 2008 and totaled approximately 50 kilometers of transects, with each transect surveyed in two passes. With a 2 meter swath width, this equates to approximately 24 acres of

data. MRA-2 was completed first, followed by MRA-1 and MRA-3. All data met the Data Quality Objectives (DQO) as laid out in Table 3-1 of the work plan, with one exception noted below.

Nearly all of the lines were completed as laid out on the ground. Two short sections in MRA-1 on transects 9 and 10 were not surveyed due to a substantial amount of ponded water from recent rainfall. Additionally, a line segment in MRA-2 on transect 9 between stakes 15 and 16 was deviated from around a similar collection of water. Frequent small deviations around stumps, trees, hanging vines, etc, were generally not noted. Due to the thick brush, stumps of small trees often remained on the line path. Efforts were made to avoid striking the sensor coil, as this can sometimes cause data spikes. If the coil could not be lifted over the obstruction it would be deviated around, and if a large false positive spike was observed during data collection then the line segment was recollected.

No major delays occurred during data collection. Several large thunderstorms and tornado watches prompted early termination of workdays, though this did not adversely affect the project schedule. Finally, though the project DQO state that final data packages must be submitted within five working days of collection, an issue with the survey accuracy of the stakes resulted in a delay in turning over final processed data until survey-grade geodetic stake locations were received from the surveyor.

4.2 MOBILIZATION AND SITE SETUP

NAEVA mobilized one field crew to Kingsland, Georgia on February 20th. Vegetation had been cut and survey control stakes installed prior to arrival on site. Before beginning DGM operations the transect lanes were surface-cleared of metal debris by Unexploded Ordnance (UXO) Technicians. Following two days to complete the GPO, DGM was begun in MRA-2 on February 25th.

4.3 DGM SURVEY ACTIVITIES

4.3.1 MRA-1

The southeast corner of MRA-1 is located near the historical firing point for 81 mm illumination mortars, thought to have been fired to the northwest along a main access road (Rocket Pit Road) that runs through the center of the area and turns north toward an old rocket engine test pit at the northern edge of the site. The northern boundary of MRA-1 is Todd Creek. Two transects run on either side of the road from the southeast boundary to the north, forming a loop around the test pit. Part of one of these transects includes portions of the GPO line.

MRA-1 contains approximately 32 kilometers of transect lines and 597 anomalies above the targeting threshold, a density of approximately 38 anomalies per surveyed acre, though this average is highly skewed by an uneven distribution of anomalies across the area. Some level of cultural development is present, including drainage culverts and monitoring wells. Along the main paved road are two bunkers and numerous old power poles and the remains of power line insulators and guy wires. A high concentration of anomalies exists around the rocket test pit and in the nearby former 40 mm test range and SWMU 03. During survey operations several 40 mm CS grenades, as well as frag and other pieces of munitions debris, were observed on the surface. Most of MRA-1 is free of subsurface metal, especially along the planted tree rows, which had been previously clear-cut and planted. Locations near roads have a higher concentration of anomalies.

Figure 2: Natural woods transect in MRA-1

4.3.2 MRA-2

MRA-2 is a circular area approximately one kilometer in diameter, centered on the location of former munitions disposal site SWMU 07. The southern end is bounded by Bayer Science property and the northern end by wetlands near Todd Creek. The area is split in half by an access road which runs from southwest to northeast through a clearing in the center. The southeastern portion contains planted rows of mature pine trees while the northwestern part has natural forest growth. Twenty-three approximately parallel transects and one transect along the access road were surveyed, resulting in a total of 16 linear kilometers with 218 anomalies, a target density of approximately 28 anomalies per surveyed acre, again an average raised by the high density region in the center of the area. With the exception of along the road and in the central clearing, most of the surveyed area within MRA-2 is free of anomalies. Some surface debris was visible on the sides of the road, though none appeared to be munitions related. The central clearing, however, is the focus of subsurface metal in the area, which confirms historical evidence and prior sampling.

4.3.3 MRA-3

MRA-3, located opposite the landfill from MRA-1, is 6 acres in size and contains four parallel transects running east-west, covering approximately 630 linear meters and containing 16 anomalies. The area is bounded to the east and west by dirt roads. The site was identified based on the presence of munitions-related debris on the surface and is the location of former SWMU 01. Numerous pieces of scrap metal were observed during the survey, especially on transects 1 and 2, most of which had been moved off of the lines in the surface sweep.

Figure 3: Tree row transect in MRA-2

4.4 DATA PROCESSING AND INTERPRETATION

All data were processed as described in-depth in Section 3.2. Part of the process included analyzing channel decay in order to identify possible noise or other false positive responses. Any anomalies suspected as originating from instrument strikes (e.g., channel readings out of phase) and not metallic objects are noted in the processing reports included on the DVD. These reports list down-line data density statistics, leveling, lag, and gridding parameters used in processing each grid block, and form information from the field GeoXT unit.

5.0 QUALITY CONTROL

To establish confidence in the data reliability, QC tests were conducted throughout the project. Tests were conducted prior to, during, and after all data collection sessions. All QC tests for the EM61-MK2 were conducted after a minimum 15 minute warm-up period for the electronics. Sample graphical displays of QC data are included in Appendix B.

5.1 SYSTEM VALIDATION - GEOPHYSICAL PROVE-OUT (GPO)

Prior to mapping the MRA transects, a GPO survey was completed. The purpose of surveying the GPO was to demonstrate the effectiveness of all instrumentation, methods, and personnel prior to the initiation of fieldwork and document the site-specific capabilities of a DGM system. Serial number identifications were recorded for all instrumentation (i.e. data logger, coils, EM61-MK2 electronics), and the GPO was mapped using the same personnel, equipment, and methodologies employed for the DGM survey.

The GPO consisted of a line approximately 130 meters long with two endpoints and several intermediate stakes, similar to the layout of the actual transects. A background survey was conducted to evaluate the presence of any subsurface metal on the GPO line, thereby allowing a comparison of original targeted anomalies with the seeded survey. Inert seed items were emplaced by CH2M HILL at various depths and orientations in order to test the detection capabilities of the instrument and establish a targeting threshold for geophysical anomalies.

The EM61-MK2 was used to survey the GPO in both tandem and wheel modes (see 3.1.1 and 3.1.2). Though the instrument performed well in wheel mode at the GPO site, due to uneven ground and brush on the survey transects, it was determined the instrument would be operated in tandem mode for the remainder of the survey. The EM61-MK2 was chosen based on its ability to detect small, near-surface ferrous and non-ferrous munitions.

It was determined by CH2M HILL after comparing the seeded targets to NAEVA's targeted locations, that a threshold of 2.5 mV in Channel 3 would detect the majority of the items of interest. See Appendix A for a color contour map of the GPO.

5.2 QC Test Descriptions and Acceptance Criteria

The following QC procedures were performed and documented during the data collection process and reviewed by a qualified geophysicist on a daily basis.

1. **Static Background and Static Spike:** Static tests were performed by positioning the survey equipment in an area free of metallic response and collecting data for a 3-minute period. During this time, the instrument was held in a fixed position. A static test is the primary measurement of instrument functionality and consists of one minute without a spike (known standard), one minute with a spike (a wooden board fitted to the bottom coil with a bolt secured through the center), and then one minute without a spike. The purpose of the static test is to determine whether unusual levels of instrument or ambient noise exist. An acceptance criterion of ± 20% of the spike response after background correction was used. The static background and static spike tests were conducted at the beginning and end of each grid block.

2. **Cable Shake Test:** On a daily basis, the instrument connections were checked for their response to vibrations in the cables. The response was observed in the field for immediate corrective action, transmitted back to a processor, analyzed, and checked for spikes in the data that can possibly create false anomalies. Any data spike greater than 2 mV from the mean would constitute a QC failure. The cable shake test was conducted at the beginning of the survey operation for each workday.

3. **Personnel Test:** This test checks the response of instruments to personnel and their clothing/proximity to the system. On a daily basis, the instrument was checked for its response to the personnel operating the system. The response was observed in the field for immediate corrective action and transmitted back to a processor, and analyzed and checked for spikes in the data that can possibly create false anomalies. Any data spike greater than 2 mV from the mean would constitute a QC failure. The personnel test was conducted at the beginning of the survey operation for each workday.

4. **Latency Test:** A 50-foot long single survey line was established near the GPO location with an iron railroad spike placed at the center point. A line of data was collected back and forth along the test line prior to daily collection operations to demonstrate consistency in instrument performance (both response and positioning) throughout the course of the survey, with acceptance criteria of ± 20% response amplitude and ± 20 cm positional accuracy.

5. **Repeat Data:** This test is performed to verify repeatability of the data and was performed at the end of each grid block. At least 2% of the survey lines were repeated and evaluated for consistency. Since small deviations in line path can affect the instrument response the profiles were evaluated qualitatively.

6. **Six Line Test:** This is a standard response test consisting of a pre-determined route (survey line) on or near the site in an area free of metallic contacts. The beginning, midpoint, and end of the line were marked and data were collected along the line. The line was traversed a total of six times as follows: 1) normal data collection speed without a spike at the center point (going North); 2) normal data collection speed without a spike at the center point (going South); 3) normal data collection speed with a spike at the center point (going North); 4) normal data collection speed with a spike at the center point (going South); 5) fast data collection speed with a spike at the center point (going North); 6) slow data collection speed with a spike at the center point (going South). The speed of data collection will also be evaluated as part of the GPO analysis process. The Six Line Test was conducted the first time the system was used at the site with the same acceptance criteria as for the latency test.

5.3 QC TEST RESULTS

QC data were evaluated using Geosoft's QA/QC software. Static, cable shake, and personnel test profiles were plotted with an acceptance criterion of ± 2 mV from the mean. Any readings outside this range were flagged on the profiles and an associated failure percentage was reported. The following provides a summary of the QC results:

1. **Static Background / Spike Test:** All static and spike tests were within acceptance criteria; stable, repeatable, and without spikes.
2. **Cable Shake Test:** No spikes were observed in any of the tests.
3. **Personnel Test:** No deviation from background response was observed.
4. **Latency Test:** Latency tests were plotted showing the line path and gridded response. A comparison of tests shows that response amplitudes are consistent and test item positions are accurate.
5. **Repeat Data:** Repeat lines generally showed good repeatability. Discrepancies in repeat lines were often a result of line path deviation.
6. **Six Line Test:** Latency corrected profiles were plotted to evaluate the effect of movement speed on response repeatability and positioning accuracy. Both amplitude and positioning were within tolerance.

Due to the absence of cultural noise and no observed geologic response, most QC tests were well within acceptance criteria. Some static spike tests showed slight variation, likely due to internal processing oscillations, as readings were completely stable in monitoring mode, yet when data collection was started the recorded values dropped ~1-2 mV and began long-period fluctuations. This behavior was observed on multiple occasions but did not result in any QC failures.

6.0 CONCLUSIONS

The geophysical data collected at UCC-Woodbine provide a good sample of subsurface metallic concentrations across the site. The extremely low background levels will allow quick determination as to whether the few anomalies outside of the higher density regions are MEC related and a narrowing of focus for more in-depth investigations over smaller areas.

Statistical analysis of the data reveals two concentrations of metal; one is in the center of MRA-2, the other near the former 40 mm test range in MRA-1. A free software program called Visual Sample Plan (VSP) has been developed by the Pacific Northwest National Laboratory to design

and analyze transect surveys with applications toward UXO cleanup. Transect paths and anomaly locations were imported into the software and used to mark target areas based on elevated anomaly density. A search window of 50 meters and estimated background density of 30 anomalies per acre were used with a 95% confidence interval that the computed density is above the background density. A histogram (Figure 4) illustrates that most of the site contains less than 30 anomalies per acre with isolated regions containing much higher numbers. Finally, the results

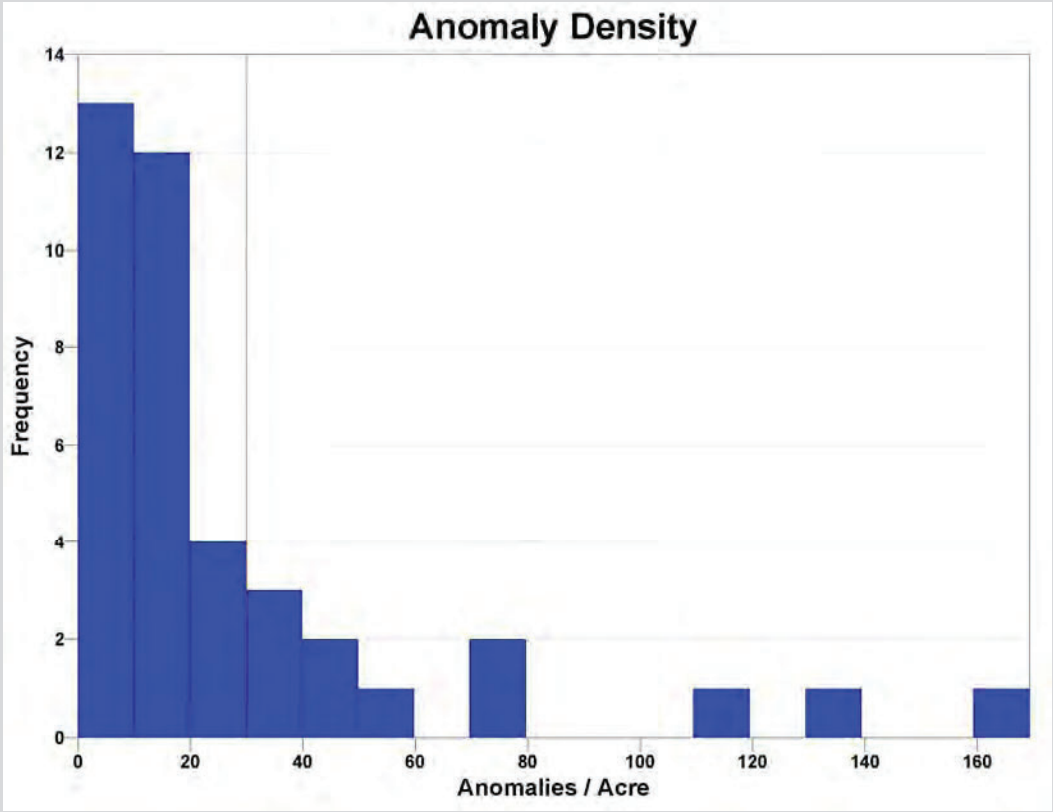


Figure 4: Histogram of anomaly density

were put through a variogram model, which describes how the variability of a set changes spatially, and kriged, which minimizes variance, to create a gridded map of anomaly density, as seen in Figure 5. The green squares are cells where the estimated anomaly density is higher than 30 anomalies per acre.

The high density area in MRA-1 is likely skewed to the west by the presence of cultural debris near the old rocket test pit, but otherwise matches the location and extent of the former 40 mm test range. Another region leading to the landfill is along the main landfill access road and is more likely scrap rather than munitions related. The bull's-eye center of MRA-2 is well-defined. What isn't obvious is a delineation of the former 81 mm mortar range, which originated in the southeast corner of MRA-1 and was pointed along the road to the northwest. This may indicate a

lower level of testing than with the 40 mm grenades, some level of cleanup at the time they were fired, or accurate enough targeting that most impacted on the road itself. It is difficult to speculate on MRA-3 given its small size, though the metal debris is more concentrated to the north of the area than to the south.

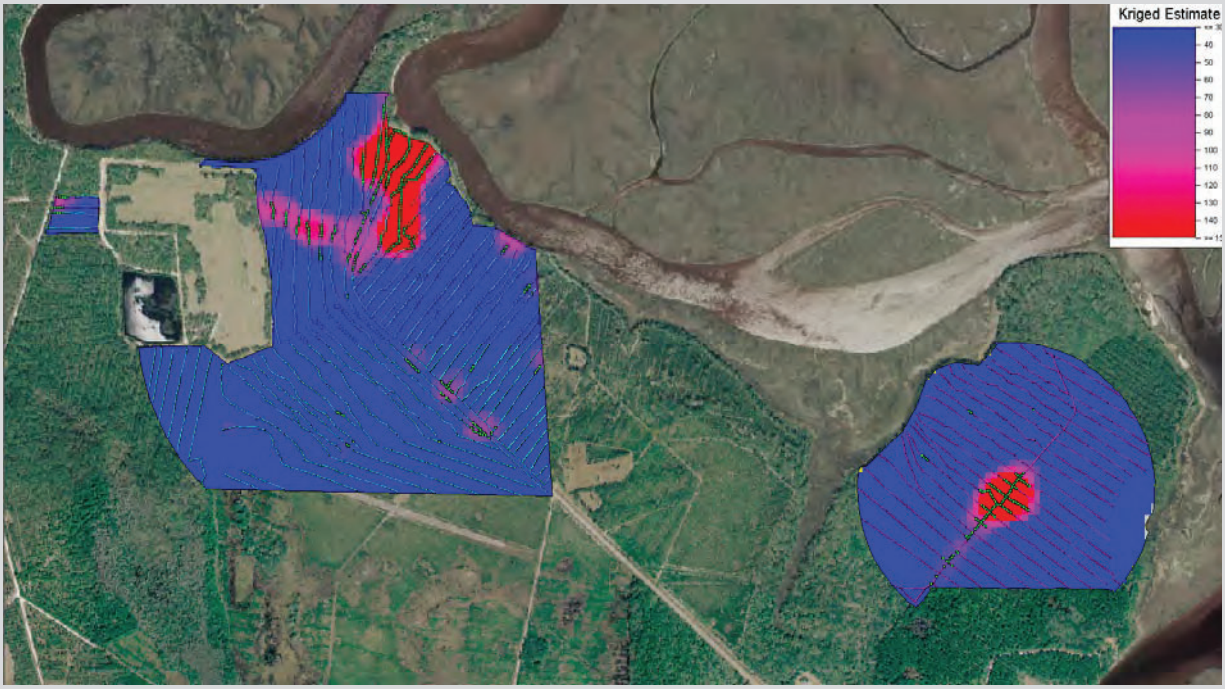


Figure 5: Anomaly density map

The enclosed DVD contains all raw, preprocessed, and processed data, including processing reports, the project database and target lists in MRP Enterprise format, QC test results, contoured data for each transect, and mosaic maps for each MRA in both colored contour and target distribution versions. A copy of this report may also be found in Adobe PDF and Microsoft Word formats.

7.0 REFERENCES

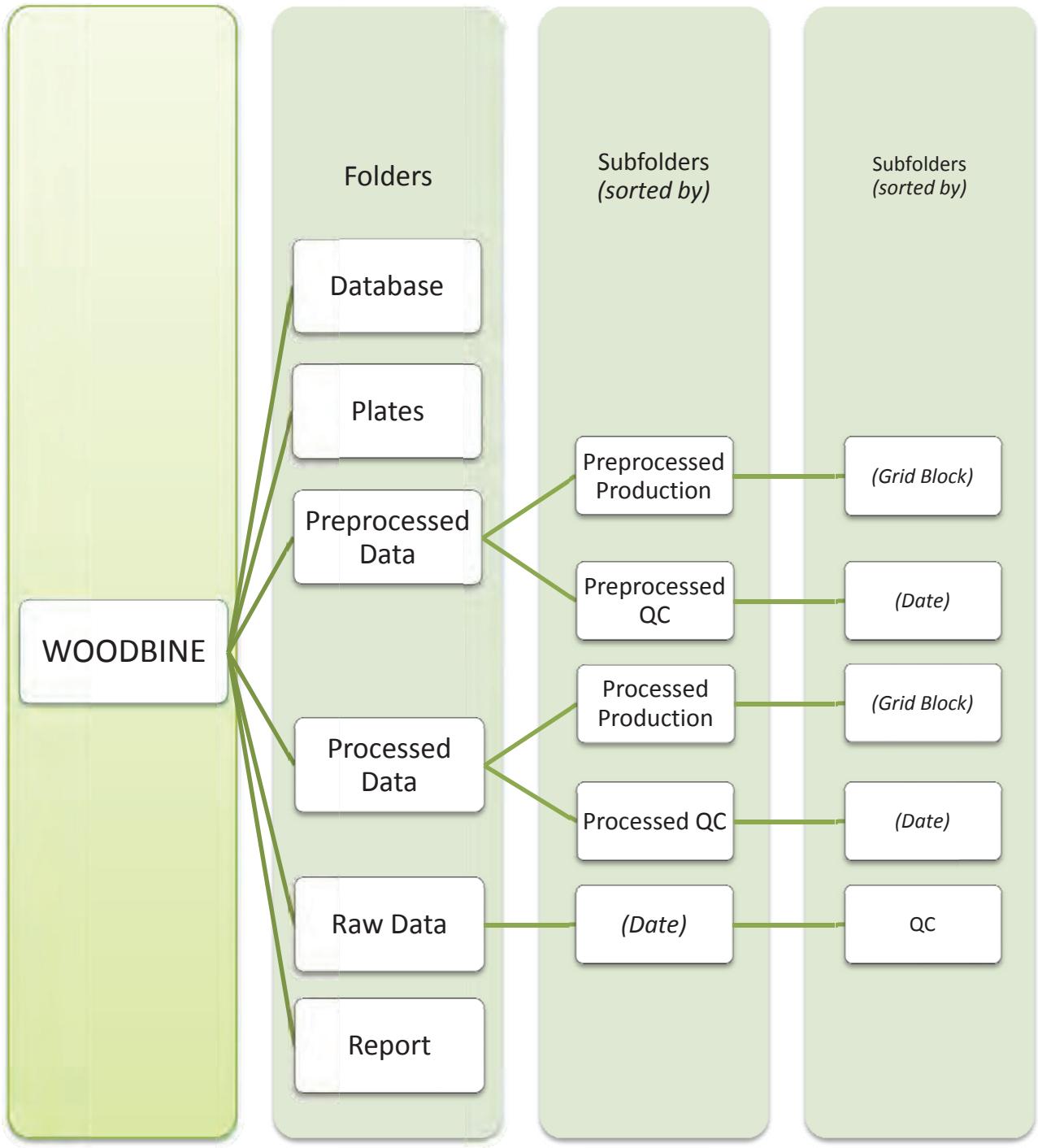
CH2M HILL. 2006. *Master Ordering Agreement.* April.

CH2M HILL. 2007. *Work Plan to Conduct Phase I Munitions and Explosives of Concern RCRA Facility Investigation (Draft).* Prepared for Union Carbide Corporation. November.

Geonics Limited. 2005. *EM61-MK2 and EM61-MK2HP 4 Channel High Sensitivity Metal Detectors Operating Manual.* July.

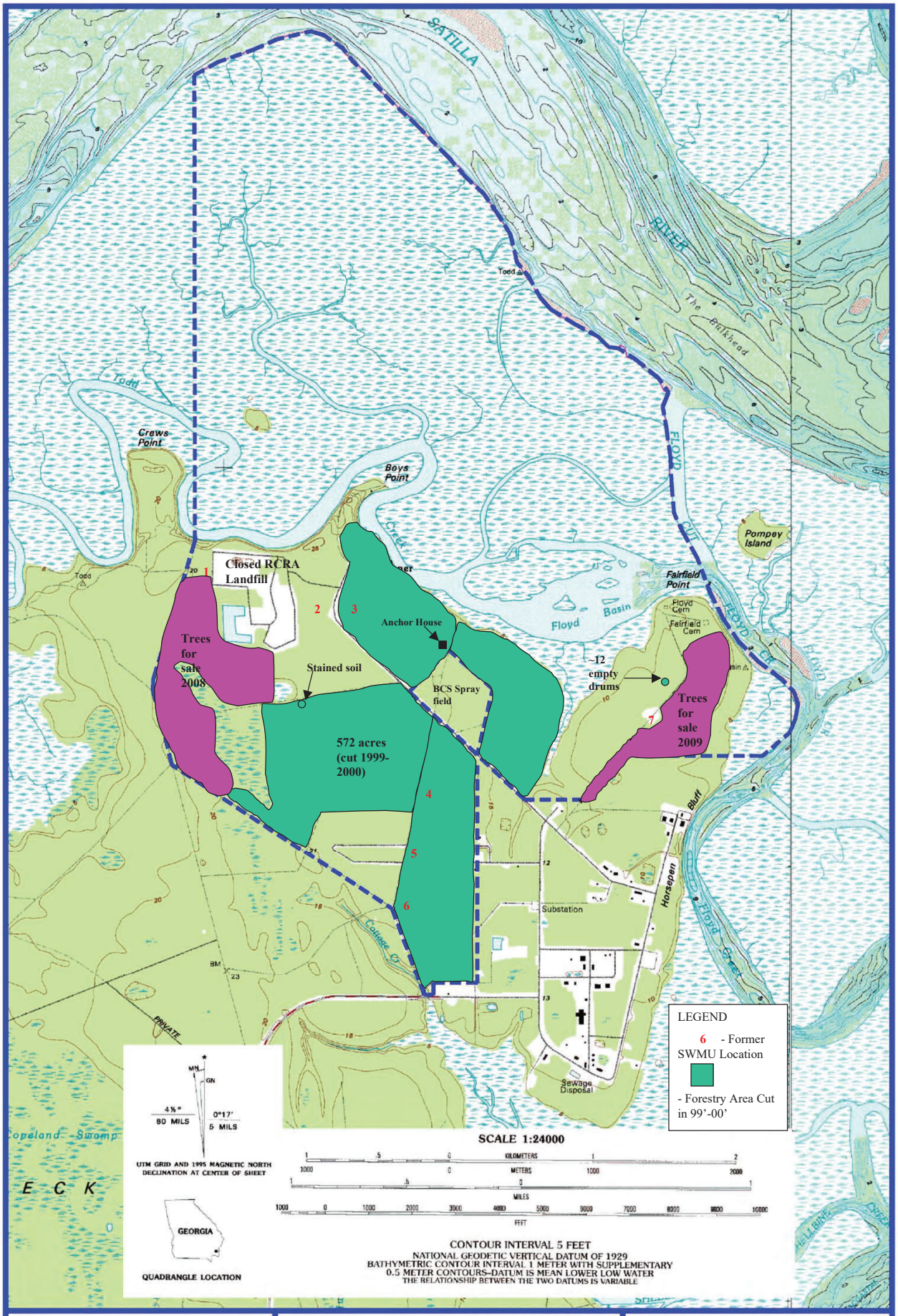
Pacific Northwest National Laboratory. 2007. *Visual Sample Plan Version 5.0 User's Guide*. September.

CONTENTS OF DVD



Appendix B

Figure Plates from Previous Studies and Reports

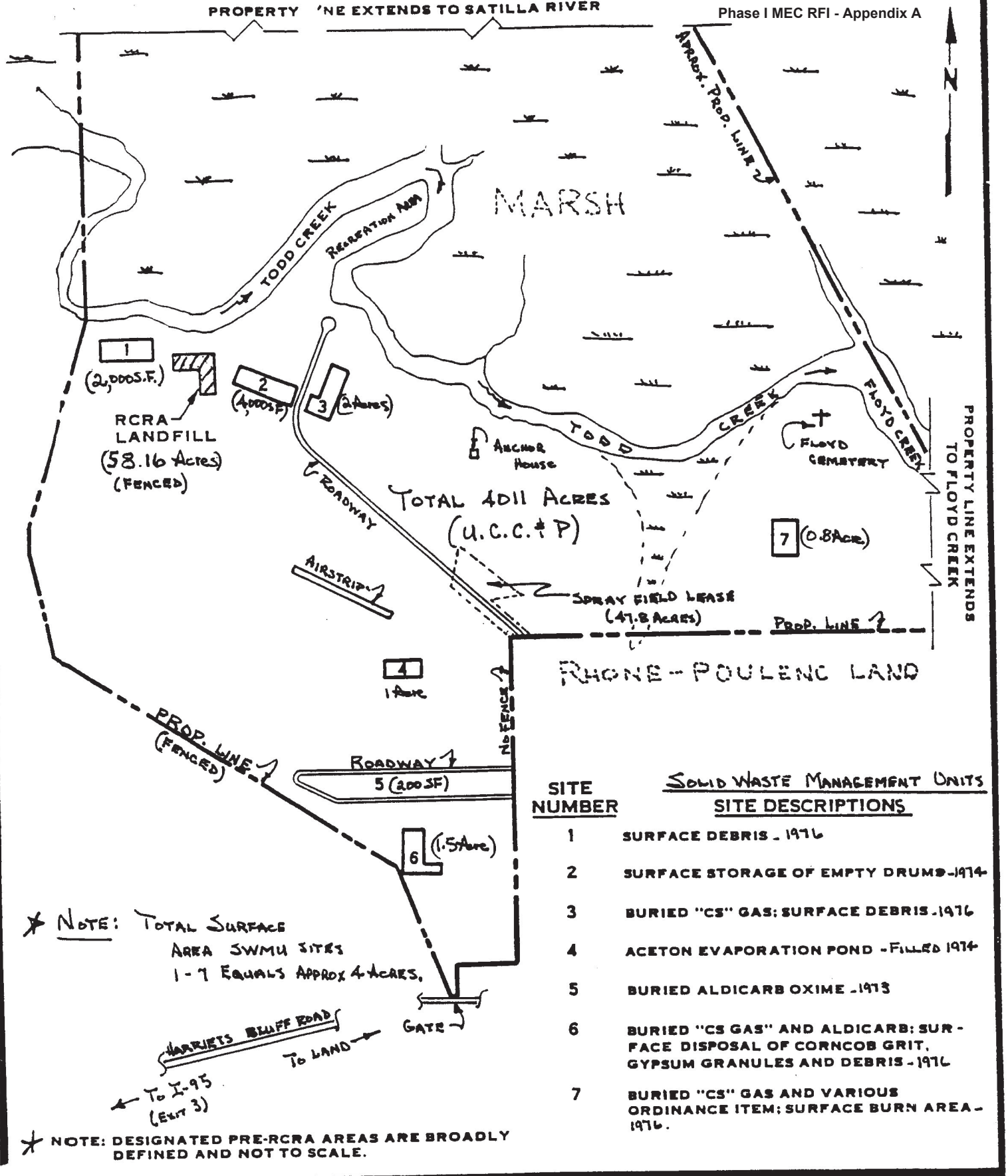


Notes:

1. Property Boundary is approximate and not based on a boundary survey.

Forestry Areas, Former SWMUs Locations & Phase I Findings
Woodbine, GA Site

CH2MHILL



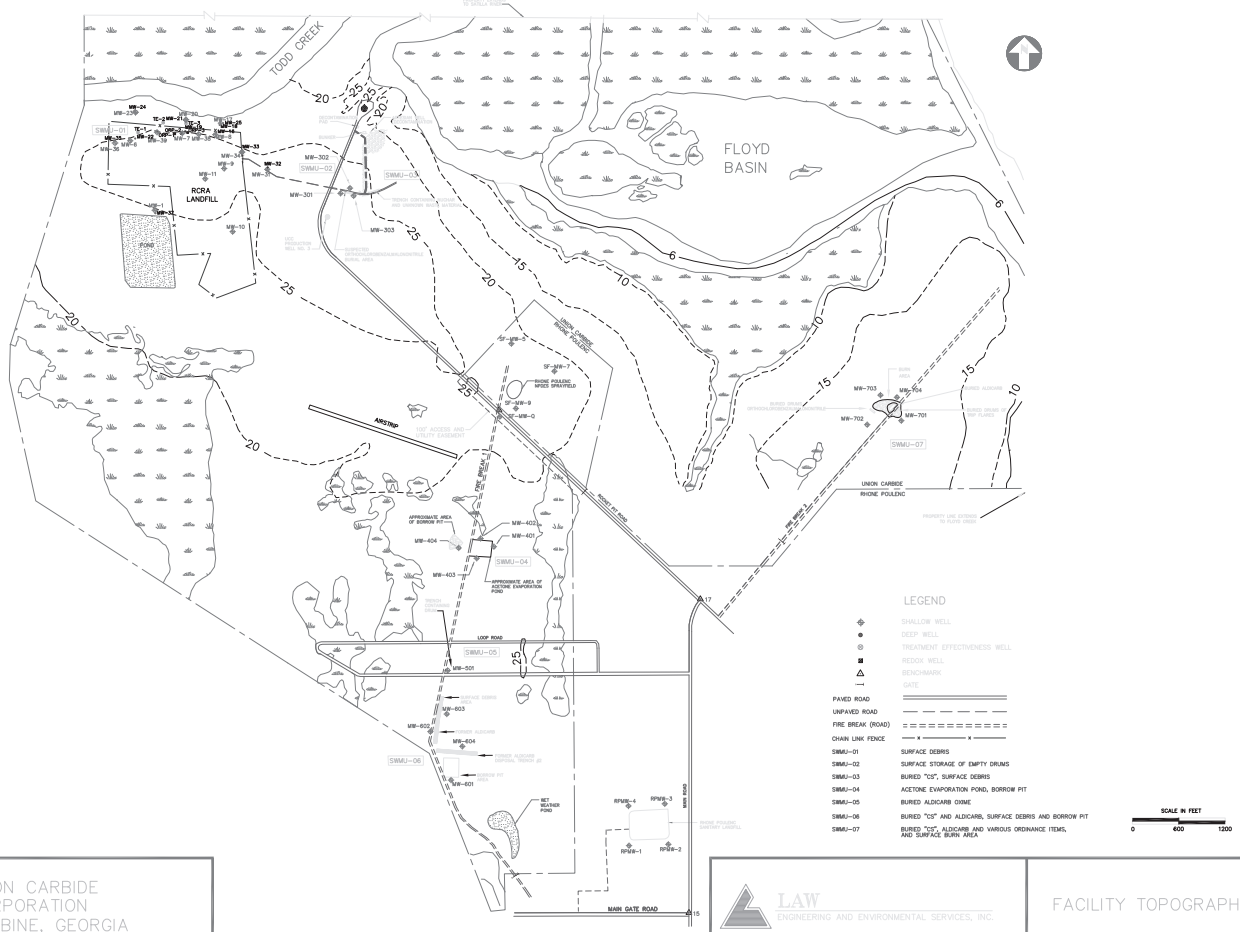
★ NOTE: TOTAL SURFACE AREA SWMU SITES 1-7 EQUALS APPROX 4 ACRES.

SOLID WASTE MANAGEMENT UNITS

SITE NUMBER	SITE DESCRIPTIONS
1	SURFACE DEBRIS - 1976
2	SURFACE STORAGE OF EMPTY DRUMS - 1974
3	BURIED "CS" GAS; SURFACE DEBRIS - 1976
4	ACETON EVAPORATION POND - FILLED 1974
5	BURIED ALDICARB OXIME - 1973
6	BURIED "CS GAS" AND ALDICARB; SURFACE DISPOSAL OF CORNCOB GRIT, GYPSUM GRANULES AND DEBRIS - 1976
7	BURIED "CS" GAS AND VARIOUS ORDINANCE ITEM; SURFACE BURN AREA - 1976.

★ NOTE: DESIGNATED PRE-RCRA AREAS ARE BROADLY DEFINED AND NOT TO SCALE.

UNION CARBIDE CORPORATION	LAW ENVIRONMENTAL INC.	PLOT PLAN PRE-RCRA DISPOSAL SITES
HB Rev. 8/8/91		NO SCALE Aug. 1988



UNION CARBIDE CORPORATION
WOODBINE, GEORGIA

LAW
ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

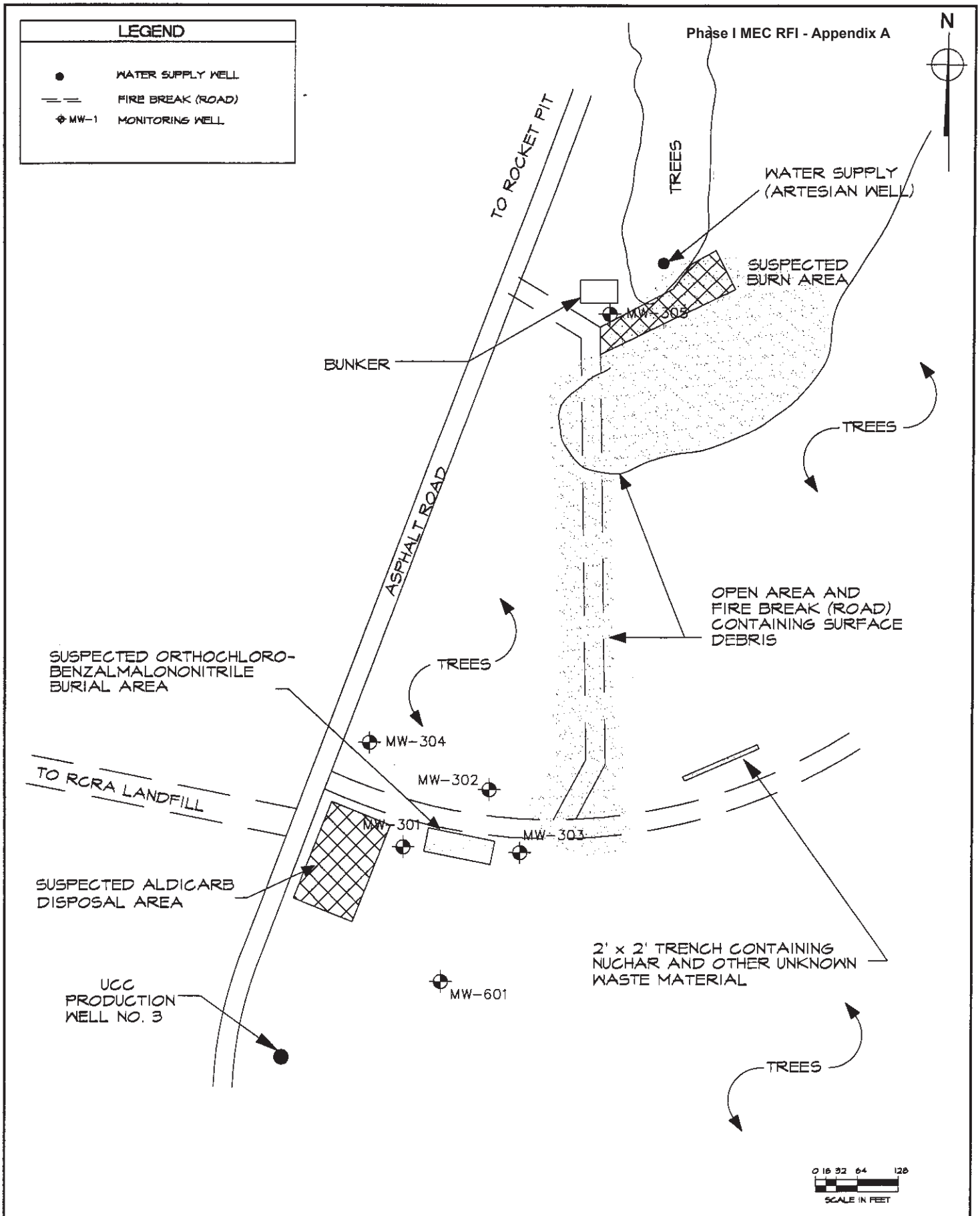
FACILITY TOPOGRAPHIC MAP

JOB NO. 55-5287

FIGURE B-4

PREPARED BY/DATE

CHECKED BY/DATE



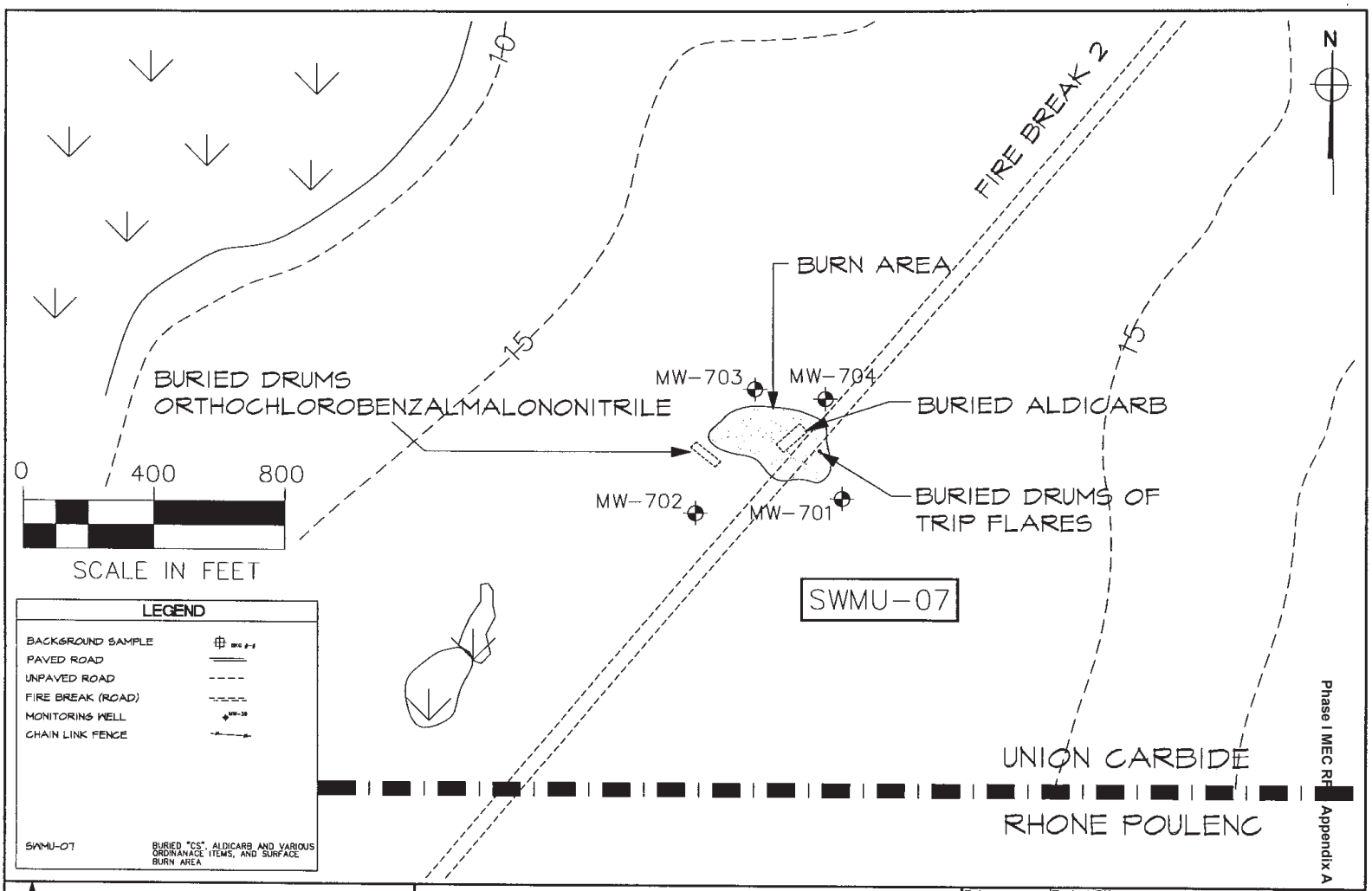
Apex environmental, inc.®
15850 CRABBS BRANCH WAY
SUITE 300
ROCKVILLE, MARYLAND 20855
TELEPHONE: (301) 417-0200

FIGURE 3
SWMU 03
SITE MAP

WOODBINE, GEORGIA

PHASE II RFI
THIOKOL CORPORATION
WOODBINE, GA

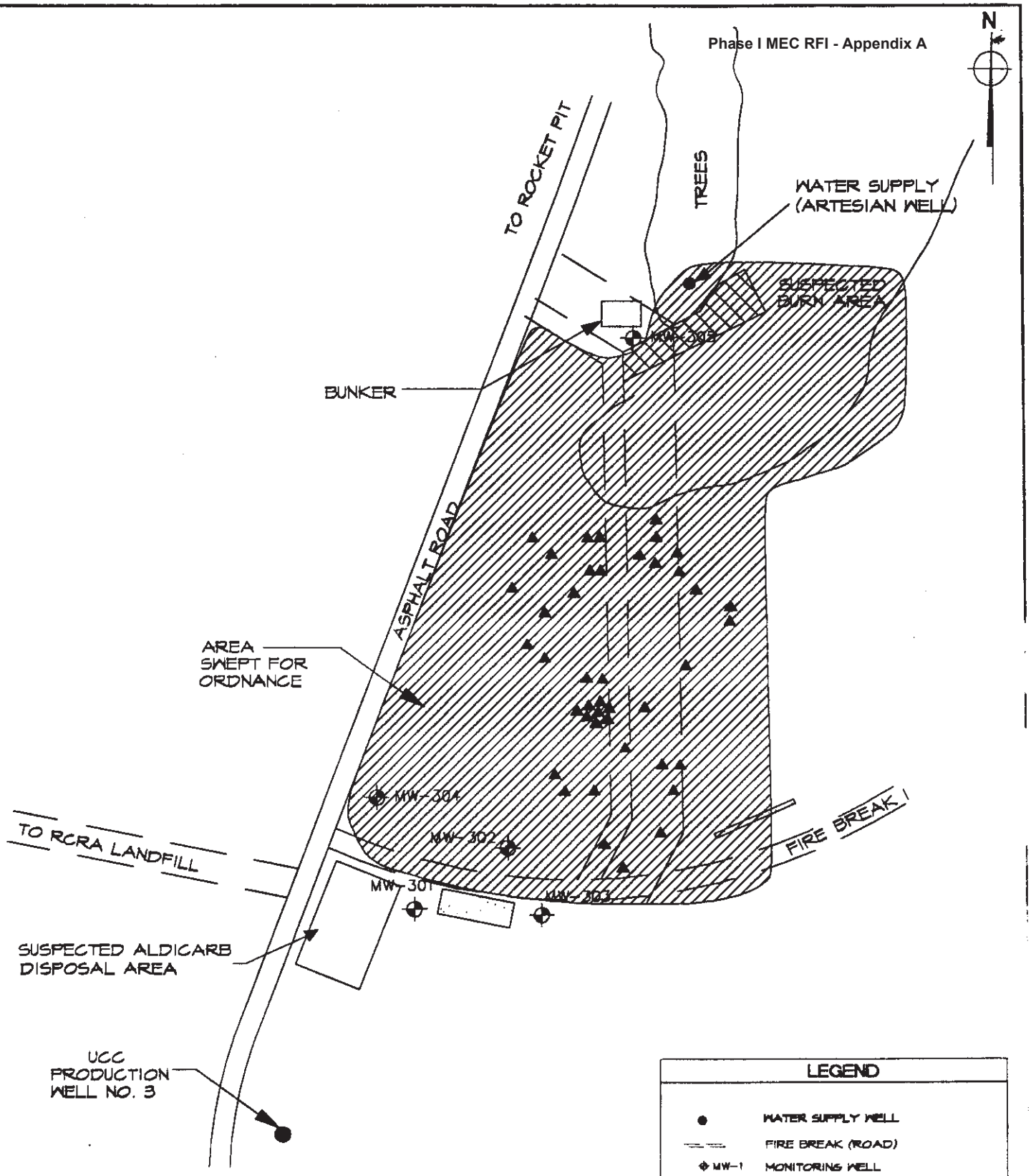
7-18-96	CDC	097.001
UNION-2	AS SHOWN	THIOKOL CORP.



Apex environmental, inc.
15850 CRABBS BRANCH WAY
SUITE 300
ROCKVILLE, MARYLAND 20855
TELEPHONE: (301) 417-0200
FACSIMILE: (301) 975-0169

FIGURE 7
SWMU 07
SITE MAP
WOODBINE, GEORGIA

Date: 7-15-96	Project Title: PHASE II RFI THIOKOL CORPORATION WOODBINE, GA		
Drawn By: SJR			
Project Number: 097.001	CAD File: BK67	Scale: AS SHOWN	Client: THIOKOL CORP



Apex environmental, inc.®
13630 CRABBS BRANCH WAY
SUITE 200
ROCKVILLE, MARYLAND 20850
TELEPHONE (301) 417-0200

FIGURE 1
SWMU 3
UNEXPLODED ORDNANCE LOCATION

WOODBINE, GEORGIA

Project Title:
PHASE II RFI ADENDUM
THIOKOL CORPORATION
WOODBINE, GA

Date:	Drawn By:	Project Number:
6-11-97	CDC	097.005
CAD File:	Scale:	Client:
UNION-A	AS SHOWN	THIOKOL CORP.