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# 1.0 INTRODUCTION

This report documents the results of the Load Line 7 (LL7) (AOC-40) sampling effort which was completed during the activities conducted to characterize the 14 Ravenna Army Ammunition Plant (RVAAP) Area of Concern (AOCs). This document summarizes the results of the field activities conducted from October 2004 to May 2005.

## 1.1 PURPOSE AND SCOPE

Characterization activities were conducted at LL7 to collect sufficient data for all applicable media to allow efficient planning and execution of future environmental actions.

The characterization effort for the LL7 was undertaken to accomplish the following:

- Collect characterization data using multi-increment (MI) sampling to provide data for future risk assessments that may be conducted;
- Develop and/or update the Conceptual Site Model to identify the key elements that should be considered in future actions;
- Assess AOC-specific physical characteristics;
- Assess potential sources of contamination;
- Allow initial assessment of the nature and lateral extent of soil, sediment, surface and groundwater contamination (the depth of contamination was not evaluated for this characterization effort); and
- Conduct a preliminary human health and ecological screening.

The investigation approach to the LL7 involved a combination of field and laboratory activities to characterize the site. Field investigation techniques included surface soil (0-1 ft) samples (multi-increment (MI) and discrete), soil boring and sampling, surface water, monitoring well installation and development, groundwater sampling, sample and monitoring well location survey, and aquifer testing. The rationale for the AOC-specific sampling plan was biased based on historical information including past usage, past investigations, ecological settings, climatic conditions, and geological and hydrologic characteristics. The field program was conducted in general accordance with the revised (USACE, 2001a) and the Final Sampling and Analysis Plan Addendum FSAP for the characterization of 14 RVAAP AOCs (MKM, 2004).

## 1.2 BACKGROUND INFORMATION

This section briefly describes LL7 and any previous investigations that have been conducted in this AOC.

### 1.2.1 AOC Description and History

LL7 is located in the Fuze and Booster Hill area which consists of Load Lines 5, 6, 7, 8, 9, 10 and 11 collectively. Fuze and Booster Hill is located in the south central part of the RVAAP facility. LL7 is a 15 ha (37 acre) AOC that is located on Fuze and Booster Spur Road north of Load Line 6 and south of Load Line 11. Figure 1-2 Volume I shows the location of LL7 within the RVAPP facility.

LL7, also known as Booster Line No. 1, was a booster loading and assembly line for artillery projectiles. Operations began in 1941 and were discontinued at the end of WWII. The booster process equipment was removed in 1945. In 1968, the line was modified for the production of M-406 High Explosive (HE) and M-407A1 practice 40 mm rounds. Sixteen million 40 mm projectiles were assembled at LL7 between 1969 and 1970, after which the line was deactivated and the equipment removed. From 1989 through 1993, pink water associated with TNT processing was treated. The line was reactivated for the research and development of high explosive shape charges until 1993. LL7, which has been inactive for more than a decade, is not maintained, and is overgrown with young trees, bushes and weeds.

There is no evidence that bulk handling of primary explosives lead azide or lead styphnate took place within the boundaries of this load line as reported by USATHAMA. For the 1940 to 1945 production era, Load Line No. 7 was identical to Load Line # 8 in its production scheme. Detonators used in the assembly of the finished product would have been received as a sealed unit. If any spillage occurred, it would be very localized and in the vicinity of the detonator assembling area. The exact areas are available on the layout drawings. This would also hold true for the 40 mm production conducted from 1969 to 1970.

The M-42 primer and the M551 would have been received as a sealed finished sub-assembly. Dusting from the M-42 primer would have occurred in Bay B, Bldg. 1B-13 during the primer insertion process and mostly likely would have been isolated to the Centron feeder. Since the fuze is a sealed system, no spillage would be expected from the fuze assembly process. Fuze assembly would have occurred in the A Bay of Bldg. 1B-6. Again, if any spillage did occur, it would be very localized. The compositions of the M-42, M551, M-9 Propellant and A5 Boosters are included in the provided data package.

In addition to the explosive components associated with M406 and M407A1 rounds, the following solvents would have been used: isobutyl acetate (IBA), isobutyl alcohol (IBA), toluene, xylenes, and isopropyl alcohol (IPA). There were no indications of chlorinated solvent being used in this process.

The M407A1 round was a practice round and incorporated a dye (i.e. smoke pellet). The specific dye used was N,N-diethyl-4-(phenylazo)-benzenamine, CAS No. 2481-94-9.

A summary of building utilization is provided:

### 1941 – 1945 Production Era

Bldgs. 1B-1, 1B-2 and 1B-3 – Explosive Processing
Expected Secondary Explosive: Tetryl Only
Bldgs. 1B-4, 1B-17, 1B-12and 1B-13 – Pellet Mfg and Processing
Expected Secondary Explosive: Tetryl
Bldg. 1B-7 and 1B-18 – Testing
Expected Secondary Explosives: Tetryl
Bldg. 1B-5 – Detonator Storage
Expected Secondary Explosives: Mercury Fulminate and Lead Azide

The Detonator components were manufactured at Load Line 9, arrived containerized at LL7 and were stored in 1B-5 until utilization in the assembly process conducted in 1B-6. Unless spillage occurred at the storage magazine, there is no reason to expect wholesale primary explosive contamination.

Bldg. 1B-22 – Solvent Storage
Bldg. 1B-6 – Assembly and Shipping
Expected Explosives: Those specified for all the other afore-specified buildings.

**1969 – 1970 40 mm Production Era**

Bldgs. 1B-1 and 1B-18 – Booster Storage (A-5), Pellet Magazine
Expected Explosive and Other Compounds: RDX and Stearic Acid
Bldgs. 1B-2, 1B-4 and 1B-6A – Main Charge Storage, Melt Pour and Curing
Expected Explosives: RDX and TNT
Bldgs. 1B-12 and 1B-13 – M-42 Primer Storage and Case Assembly
Expected Explosive: Unknown
Bldg. 1B-17 – M551 Fuze Storage
Expected Explosive: Unknown
Bldg. 1B-22 – M-9 Propellant Storage
Expected Explosives and Other Compounds: Nitrocellulose, Nitroglycerin, Potassium Nitrate, Diphenylamine
Bldg. 1B-6 – Assembly and Shipping
Expected Explosives and Other Compounds: All of the previously specified

**1969 – 1970 40 mm Washout Era**

Bldgs. 1B-6 and Annex – Washout and Treatment
Expected Explosives: TNT

### 1.2.2 Previous Investigation

The following previous assessments and investigations have been conducted for LL7:

#### *1.2.2.1 1978 Installation Assessment of Ravenna Army Ammunition Plant (U.S. Army Toxic and Hazardous Materials Agency [USATHAMA] 1978)*

This document could not be located during the completiom of the Preliminary Draft.

#### *1.2.2.2 1989 Preliminary Review and Visual Site Inspection conducted as a part of Resource Conservation and Recovery Act (RCRA) Facility Assessment conducted by the USEPA. (Jacobs Engineering Group, Inc. 1989)*

This document could not be located during the completiom of the Preliminary Draft.

#### *1.2.2.3 1994 Preliminary Assessment Screening of the Boundary Load Line Areas (U.S. Army Environmental Hygiene Agency [USAEHA] 1994)*

This document could not be located during the completiom of the Preliminary Draft.

#### *1.2.2.4 1996 Relative Risk Site Evaluation, Ravenna Army Ammunition Plant (U.S. Army Center for Health Promotion and Preventative Medicine [USACHPPM] 1996)*

This evaluation identified only surface soil as a possible media of concern and identified a potential for contaminate migration. The evaluation also identified the potential for exposure to receptors because the site is not restricted. The final score for RRSE at LL7 is “Low.”

#### *1.2.2.5 1998 Relative Risk Site Evaluation for Newly Added Sites at the Ravenna Army Ammunition Plant (USACHPPM 1998)*

This evaluation identified groundwater and surface soil as possible media of concern and identified a potential for contaminate migration. This evaluation also identified the potential for exposure to receptors as the site has limited access. The final score for RRSE at LL7 is “Medium.”

### 1.2.3 Regulatory Authorities

Volume I, Section 1.2.3 identifies the regulatory authorities which oversee remedial activities for these AOCs.

### 1.2.4 Regulatory Status of Load Line 7

Volume I, Section 1.2.4 identifies the regulatory status for this AOC.

# 2.0 ENVIRONMENTAL SETTING AT LOAD LINE 7

This section describes the physical characteristics of LL7 and that are factors in interpreting the potential contaminant transport pathways, receptor populations, and exposure scenarios with respect to the evaluation of human health and ecological risks. The area immediately surrounding LL7 is a combination of forested and open areas of former operations. An unnamed stream is located approximately 2100 feet northeast of the AOC that flows to Sandcreek. This AOC is approximately 1000 feet north of LL 6 and 1500 feet south of the LL11 AOC. The AOC surface water flows to the east/northeast. Fuze and Booster Road is located approximately 750 to the northwest. The AOC is situated adjacent (east side) to a bedrock topographic high.

## 2.1 SURFACE FEATURES

The topography at LL7 is characterized by gently undulating contours that range in elevation between 1118 ft amsl to 1133 ft amsl. The surface topography slopes gently west to east from a topographic high in the western portion of the load line to lows in the eastern portion of the AOC (USGS Topographic Map, Windham Quadrangle 1994).

## 2.2 METEOROLOGY AND CLIMATE

Meteorology and climate are addressed in Section 2.2 of Volume I.

## 2.3 SURFACE WATER HYDROLOGY

Surface water drainage generally follows the topography of LL7 toward the east. Intermittent surface water flows in several drainage ditches located within the AOC. These ditches are fed by surface runoff from precipitation events. After leaving the AOC, the water commingles with effluent from other RVAAP drainage ways. Eventually the installation-wide drainage flows in a northeast direction and feeds the Sand Creek drainage watershed.

## 2.4 GEOLOGY

Lithologic logs from six borings, which were advanced during the characterization activities and completed as monitoring wells, were used to characterize the surface and subsurface geology at LL7. The boring logs, which detail the vertical lithologic sequences, are found in Appendix H.

### 2.4.1 Glacial Deposits

Subsurface lithology at LL7 consists mostly of sand-rich silt tills with interbedded sands. These deposits are generally firm, moderately plastic, and tend to hold water where encountered. Cross-sections of the subsurface at LL7 illustrate the lateral distribution and variation of these discontinuous glaciated sediments (Figures LL7-1 to LL7-4).

### 2.4.2 Sedimentary Rocks

Bedrock outcrops at several areas across RVAAP. Fine grained sandstone with thin interbedded shale was encountered at the range of 2 to 17 ft when installing the LL7 monitoring wells.

## 2.5 SOIL

According to the Soil Survey of Portage County, Ohio (USDASCS, 1978) RVAAP soils are described as being nearly level to gently sloping, and are poor to moderately well drained. Two soils types are found at LL7 and adjacent areas: the Mahoning Silt Loam (0 to 2 percent slopes) on the eastern portion and Mahoning Silt Loam (2 to 6 percent slopes) on the western portion of the AOC. More gently sloped land with medium to rapid runoff with severe seasonal wetness and slow permeability characterize these soils.

## 2.6 HYDROGEOLOGY

Volume 1, Section 2.6 discusses the unconsolidated sediments and bedrock characteristically found at RVAAP. When the LL7 monitoring wells were installed, fine-grained sandstone with thin interbedded shale was encountered at ranges varying from 2 to 17 ft.

## 2.7 DEMOGRAPHY AND LAND USE

Demographics and land use are discussed in Volume 1, Section 2.7.

## 2.8 ECOLOGY

Ecological information is provided in Volume I, Section 2.8.

# 3.0 CHARACTERIZATION ACTIVITIES AT LOAD LINE 7

This section describes the field and analytical methods identified during the RVAAP 14 AOC Characterization at LL7. The field and analytical programs were conducted in accordance with the RVAAP Facility Wide Sampling and Analysis Plan (FWSAP) (USACE, 2001) and the RVAAP 14 AOC FWSAP Addendum (MKM, 2004). Investigation objectives, rationale for sampling locations, and sampling methods are briefly discussed in this section.

## 3.1 FIELD ACTIVITIES

Field activities conducted from October 2004 thru May 2005 included:

- Collecting MI surface soil (0-1 ft) samples (11-08-04 – 11-18-04);
- Collecting discrete surface soil (0-1 ft) samples (11-09-04 – 11-11-04);
- Excavating of five test trenches (10-07-04);
- Installing six groundwater monitoring wells (01-10-05 – 01-14-05);
- Collecting geotechnical samples from the borings (Shelby Tubes) (11-10-04 – 01-13-05);
- Conducting well slug tests (02-02-05);
- Collecting groundwater samples from monitoring wells (01-21-05 – 02-02-05);
- Collecting surface water samples (sewers/sumps/basins) (11-10-04 – 12-07-04);
- Collecting sediment samples (sewers/sumps) (12-02-04);
- Collecting MI sediment samples (11-10-04); and
- Conducting a sampling location and monitoring well survey (12-13-04 – 01-28-05).

Sampling was conducted at this AOC to assess the impact that the LL7 operations may have had on soil, sediment, surface water and groundwater; and to evaluate where contaminants related to the former operations may have impacted the AOC. The following sections describe the rationales for, and methods of, sample collection during the characterization. Information from previous assessments, evaluations and investigations, plus institutional knowledge of the historical operations that occurred at LL7, were used to determine the sampling locations, type of media collected, analyses performed and number of samples required to adequately characterize LL7. Table LL7-1 summarizes the type and number of samples collected, rationale for collecting the samples and the analyses conducted. A photo log of investigation activities is provided in Appendix C. Figure LL7-5 shows the monitoring well locations, Figure LL7-6 shows MI soil sampling locations and Figure LL7-7 shows the sampling locations for all other media.

### 3.1.1 Trenching Activities

Before drilling operations were initiated, five test trenches were excavated in near monitoring well locations. The trenching activities provided information about the soil stratification profile, depth to groundwater and depth to bedrock.

Trenching was halted upon encountering bedrock or saturation. The LL7 did not exceed 12 ft bgs. Saturation was encountered in LL7tr-003 at 9 ft bgs. Bedrock was encountered in LL7tr-001 at 3.7 ft bgs, LL7tr-002 at 8.5 ft bgs, LL7tr-004 at 12.0 ft bgs, and LL7tr-005 at 5.0 ft bgs. No suspect soil or MEC was encountered during the trenching operation. Trenching activities were conducted as required by Section 4.4.2.1.3 of the FWSAP. Volume I, Section 3.1.5 briefly summarizes the trenching procedures that were employed during the LL7 characterization activities.

### 3.1.2 MI Surface Soil (0-1 ft) Sampling

Forty MI surface soil (0-1 ft) grids were sampled at this AOC to:

Assess the potential impact of LL7 historical operations on the soils within the AOC;
Evaluate soil surrounding process buildings, in the munition bands to the west of the AOC and dry drainage ditches within the AOC; and
Determine the nature of contamination (if present).

LL7 was divided into 31 MI grids located around process buildings and in dry drainage ditch locations within the AOC. The munition band area found, in a wooded area west of LL7, was divided into nine MI grids. The MI samples were collected as explained in Section 4.2.1.2 of the RVAAP 14 AOC FWSAP Addendum. Analysis of MI surface soils (0-1 ft) for LL7 included: Target Analyte List (TAL) Metals, Explosives, Nitrate, Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs), propellants, pesticides and polychlorinated biphenyls (PCBs).

Four split samples were collected and submitted for analysis to an independent, USACE-approved laboratory. Field sampling forms documenting the sampling activities are presented in Appendix E of this report. MI surface soil (0-1 ft) analytical results are presented in Appendix F of this report.

VOC samples were collected as discrete samples to fulfill the 10 percent full suite requirement and the FWSAP approved VOC collection methods. Section 3.1.10.3 of Volume I describes the procedure used to collect discrete surface soil (0-1 ft) samples. Discrete VOC samples were not subjected to MI sample drying or processing. Field sampling forms documenting the surface soil (0-1 ft) sampling activities are presented in Appendix E.

### 3.1.3 Discrete Surface Soil (0-1 ft) Sampling (VOC)

One discrete surface soil (0-1 ft) sample was collected at this AOC to determine whether VOC contaminants were present in the surface soil (0-1 ft). The VOC sample was collected outside the building formerly used for solvent storage. The discrete surface soil (0-1 ft) sample was collected as specified in Section 4.5.2.1.1 (bucket hand auger method) of the FWSAP or using a stainless steel push probe. Volume I, Section 3.1.10.3 describes the procedure used to collect discrete surface soil (0-1 ft) samples. The sample was prepared, packaged and shipped as explained in Section 6.0 of the RVAAP 14 AOC FWSAP Addendum.

### 3.1.4 MI Sediment Sampling (Basin)

One MI sediment sample (LL7sd-012M) was collected at this AOC to:

- Evaluate the impact of surface water runoff or sediments at LL7;
- Evaluate the migration pathway for contaminants that may have been transported via suspended sediment in surface water runoff; and

- Evaluate if contaminants have migrated beyond the AOC boundaries.

One sediment location outside Building 1B-1 (dry basin) was changed from a discrete sample location to a MI sediment sample (dry basin). This location did not have an associated surface water sample. All of the sediment from this small basin was collected for the sample. This MI sediment sample was collected from 0 to 0.15 m (0 to 0.5 ft) using a scoop as outlined in Section 4.5.2.2.1 of the FWSAP. The MI sediment sample from LL7 was collected and placed into a plastic lined 5-gallon bucket, sealed and transported to Building 1036 for processing. The sample was dry when collected and did not require air drying. The homogenized sample was immediately placed into a cooler containing ice and submitted to the laboratory under a completed chain-of-custody. This sample was analyzed for the following parameters: TAL Metals, Explosives, Nitrate, propellants, Total Organic Carbon (TOC) and grain size.

One split sample was collected and submitted for analysis to an independent USACE-approved laboratory. Samples were prepared, packaged and shipped in accordance with Section 6.0 of the RVAAP 14 AOC FWSAP Addendum. Field sampling forms are presented in Appendix Q and analytical results from the samples are presented in Appendix R.

### 3.1.5 Surface Water Sampling (Sewers/Sumps)

Surface water samples were collected at this AOC to:

Evaluate the impact of runoff or leachate from sewer, sump and/or basin water at LL7; and
Identify the migration pathways for contaminated runoff or leachate (if any) from this AOC.

Seven of the ten sewers contained enough water for a viable sample. No water was present in two sewer locations and one sewer (LL7sw-010) could not be located. If the physical structure of the sewer allowed, sewer water was collected as described in Section 4.6.2.1.1 of the FWSAP. At sewer locations, physical conditions dictated using a peristaltic pump and tubing as described in Volume I, Section 3.1. 10.6. In addition, one surface water sample was collected from the sump specified in the SOW. Water quality measurements (pH, conductivity, dissolved oxygen content, and temperature) were recorded just before collecting each sample. Analysis for surface water at LL7 included the following parameters: TAL Metals, Explosives, Nitrate, VOCs, SVOCs, propellants, pesticides and PCBs. Surface water was collected as specified in Section 4.6.2.1.1 of the FWSAP.

One split sample was collected and submitted for analysis to an independent USACE-approved laboratory. Samples were prepared, packaged and shipped as outlined in Section 6.0 of the FWSAP and Section 6.0 of the RVAAP 14 AOC FWSAP Addendum. Field sampling forms for the surface water are presented in Appendix O and analytical results are presented in Appendix P.

### 3.1.6 Sediment Sampling (Sewers/Sumps)

None of the 11 sewers/sumps specified in the SOW contained enough recoverable sediment to constitute a viable sample. Where applicable, sewer/sump water samples were collected before the collection of sewer sediment was attempted.

### 3.1.7 Groundwater Investigation Activities

The groundwater activities were conducted at this AOC to:

- Determine the potential impact of LL7 historical operations to groundwater quality;
- Evaluate the quality of groundwater upgradient of this AOC; and
- Collect data pertaining to the groundwater flow regime beneath LL7.

All six boreholes were advanced into bedrock with borehole termination depth ranging from 26.5 ft. to 31.5 ft. bgs at LL7. One round of groundwater sampling and slug testing was conducted and three rounds of water level data were collected. The monitoring wells were strategically placed to provide information about LL7 groundwater.

- LL7mw-001 is located south of the explosives handling area;
- LL7mw-002 is located downgradient of the explosives handling area and provides data for triangulation and stratigraphic correlation;
- LL7mw-003 is located downgradient of the load line and solvent building;
- LL7-mw-004 is located in the central portion of the explosives handling area;
- LL7mw-005 is located upgradient of the explosives handling area; and
- LL7mw-006 is located downgradient of the AOC.

#### *3.1.7.1 Monitoring Well Installation and Development*

An 8.25 in. outside diameter (OD), hollow-stem auger was used to advance the borehole through unconsolidated material. Upon encountering bedrock, a 6 in. OD air rotary hammer with 3.95 in core barrel was used to advance the boring. The total average borehole depth was 8.82 m (28.95 ft) bgs. Bedrock was encountered in all six boring locations at depths of 14.4 ft bgs (LL7mw-001), 1.6 ft bgs (LL7mw-002 cored 6.0 to 25.5 ft), 16.9 ft bgs (LL7mw-003 cored 20.2 to 30 ft), 9.5 ft bgs (LL7mw-004), 2.0 ft bgs (LL7mw-005) and 10.1 ft bgs (LL7mw-006 cored 12.0 to 26.5 ft).

Monitoring well installation and development at LL7 followed the procedures reported in Volume I, Section 3.1.6. Well construction diagrams and well development records are provided in Appendix H.

#### *3.1.7.2 Geotechnical Sample Collection (Shelby Tubes)*

Geotechnical analysis was conducted during groundwater monitoring well installation. Three Shelby tubes were collected at monitoring well locations LL7mw-003 (4-6 ft), LL7mw-005 (0-2 ft) and LL7mw-006 (2-4 ft), and sent to the laboratory for analysis. Geotechnical sample collection was conducted in accordance with Section 4.4.2.4.1 of the FWSAP. Geotechnical analysis for the three Shelby Tubes collected at LL7 include the following: moisture contents, Alterburg limits, specific gravity, grain size, pH and total organic content. The analytical data can be found in Appendix J.

#### *3.1.7.3 Groundwater Sampling*

Six ground water samples were collected to evaluate ground water quality at LL7. Samples were prepared, packaged and shipped per Volume I, Section 3.1.14. One split sample was collected and submitted for analysis to an independent, USACE-approved laboratory. Analysis for groundwater samples at LL7 include the following parameters TAL Metals, Explosives, Nitrate, propellants, VOCs, SVOCs, pesticides and PCBs. Well purging and sampling records are provided at Appendix H and analytical results from the samples are presented in Appendix L. No detections were observed in the PID readings for the wells at LL7. This information is provided on the field forms located in Appendix H. Specific information related to the type of PID used and calibration is included in Section 3.1.5 of Volume 1. All groundwater sampling was conducted in accordance with the procedures provided in Section 4.3.4 and 4.3.5 of the FWSAP. Section 3.1.10.11 of Volume 1 also discusses the groundwater sampling procedures used for this project.

#### *3.1.7.4 In-Situ Permeability Testing*

Slug tests were performed at each of the LL7 monitoring wells as discussed in Volume I, Section 3.1.10.12. Slug test data records are provided in Appendix K. The test results are located in Section 4.6.

#### *3.1.7.5 Water Level Measurements*

Water level measurements were performed at each of the LL7 monitoring wells as discussed in Volume I, Section 3.1.10.13. Groundwater elevation data is included in Appendix M.

### 3.1.8 Sample Location and Monitoring Well Survey

The sample location and monitoring well survey at LL7 was conducted per the specifications in Section 3.1.11, in Volume I of this characterization report. The monitoring well survey report can be found in Appendix N and sample location survey data in Appendix S.

## 3.2 DEVIATIONS FROM THE WORK PLAN

Every effort was made to complete the field activities as outlined in the FWSAP and the approved RVAAP 14 AOC FWSAP Addendum. At times, circumstances or field conditions necessitated a modification. Modifications to the FWSAP Addendum during the LL7 field activities are noted below.

- In four wells, the depth of sand placed above the screen varied from the 3 ft specified in the FWSAP. In wells LL7mw-001, LL7mw-004 and LL7mw-006, 3.5 ft of sand was placed in each well. In well LL7mw-002, 5 ft of sand was placed above the screen.
- Two of the ten scoped sewer locations did not contain water for sample collection and one sewer, LL7sw-010, could not be located during the AOC investigation.
- None of the 11 sewers/sumps specified in the SOW contained enough recoverable sediment to constitute a viable sample
- Shipping delays were encountered when Samples LL7sw-002-SW, LL7sw-006-SW and LL7sw-007-SW were sent to the laboratory, which caused the holding time for nitrate analyses to be exceeded. These samples were re-collected and re-submitted to the laboratory.
- During well development, a final well development sample was not collected for LL7MW-005.
- Based on field observations, sample LL7-ss-029-SO was changed from a dry ditch surface soil (0-1 ft) sample to a wet ditch sediment sample (sample LL7-sd-029M-SD). All the sediment

found in this shallow basin was collected. The sample was homogenized, but was not ground or sifted.

- An additional sample (LL7ss-042M) was collected to further characterize the soils around the munition bands.

Although modifications were made to the FWSAP Addendum, the objectives of the LL7 AOC characterization were achieved.

# 4.0 NATURE OF CONTAMINATION AT LOAD LINE 7

This section summarizes the analytical results from surface soil (0-1 ft), groundwater, surface water and sediment analytical results obtained from the environmental sampling conducted at the LL7. The results are organized by media: surface soil (0-1 ft), groundwater, surface water, and sediment. The number of samples collected and the number of analytical results that exceeded either the RVAAP background criteria or Region 9 residential Preliminary Remediation Goals are listed in each subsection. The evaluation completed in this section is a preliminary comparison and is not intended to be used alone for making risk management decisions. The risk screening, presented later in this report, further discusses and evaluates the contaminants detected during this AOC characterization. The following sections present a summary and initial screening of the analytical data for samples collected during the AOC characterization.

## 4.1 MI SURFACE SOIL (0-1 FT)

Forty-six MI surface soil (0-1 ft) samples (40 regular and six QC) were collected from various LL7 locations. Additionally, six discrete surface soil (0-1 ft) samples (five regular and one QC) were collected for VOC analysis. All positive detections were compared to RVAAP background and Region 9 residential PRG values as previously discussed.

Surface soil (0-1 ft) results at or above detection limits are presented in Table LL7-2. All surface soil (0-1 ft) analytical results are presented in Table LL7-6. Locations where surface soil (0-1 ft) analytes were detected at or above background levels and Region 9 residential PRGs as shown in Figures LL7-8A, LL7-8B, LL7-8C and LL7-9. Laboratory analytical reports are provided in Appendix F.

The surface soil (0-1 ft) analytical results and exceedances are summarized below:

- **Aluminum** exceeded the Region 9 residential PRG in 38 samples and exceeded background and the Region 9 residential PRG in one sample with a **maximum concentration of 18000 mg/kg.**
- **Arsenic** exceeded the Region 9 residential PRG in 45 samples and exceeded background and the Region 9 residential PRG in one sample with a **maximum concentration of 16 mg/kg.**
- **Barium** exceeded background in 15 samples with a **maximum concentration of 160 mg/kg.**
- **Beryllium** exceeded background in 11 samples with a **maximum concentration of 2.8 mg/kg.**
- **Cadmium** exceeded background in 23 samples with a **maximum concentration of 1.4 mg/kg.**
- **Calcium** exceeded background in seven samples with a **maximum concentration of 77000 mg/kg.**
- **Chromium** exceeded background in twenty-nine samples and exceeded background and the Region 9 residential PRG in one sample with a **maximum concentration of 33 mg/kg.**
- **Cobalt** exceeded background in seven samples with a **maximum concentration of 13 mg/kg.**
- **Copper** exceeded background in 12 samples with a **maximum concentration of 88 mg/kg.**
- **Iron** exceeded the Region 9 residential PRG in 39 samples, and exceeded background and the Region 9 residential PRG in seven samples with a **maximum concentration of 29000 mg/kg.**
- **Lead** exceeded background in 18 samples with a **maximum concentration of 160 mg/kg.**
- **Magnesium** exceeded background in ten samples with a **maximum concentration of 9700 mg/kg.**

- **Manganese** exceeded the Region 9 residential PRG in 43 samples, and exceeded background and the Region 9 residential PRG in three samples with a **maximum concentration of 1600 mg/kg.**
- **Nickel** exceeded background in four samples with a **maximum concentration of 25 mg/kg.**
- **Potassium** exceeded background in 22 samples with a **maximum concentration of 1800 mg/kg.**
- **Silver** exceeded background in two samples, and exceeded background and the Region 9 residential PRG in one sample with a **maximum concentration of 80 mg/kg.**
- **Sodium** exceeded background in 36 samples with a **maximum concentration of 670 mg/kg.**
- **Vanadium** exceeded the Region 9 residential PRG in 46 samples with a **maximum concentration of 28 mg/kg.**
- **Zinc** exceeded background in 26 samples with a **maximum concentration of 180 mg/kg.**
- **Mercury** exceeded background in 26 samples with a **maximum concentration of 0.4 mg/kg.**
- **Thallium** exceeded background in five samples with a **maximum concentration of 0.31 mg/kg.**
- **2-Methylnaphthalene** exceeded the laboratory detection limit in three samples with a **maximum concentration of 0.1 mg/kg.**
- **Benzo(a)anthracene** exceeded the Region 9 residential PRG in two samples with a **maximum concentration of 3.6 mg/kg.**
- **Benzo(a)pyrene** exceeded the Region 9 residential PRG in four samples with a **maximum concentration of 2.9 mg/kg.**
- **Benzo(g,h,i)perylene** exceeded the laboratory detection limit in five samples with a **maximum concentration of 1.2 mg/kg.**
- **Dibenzo(a,h)anthracene** exceeded the Region 9 residential PRG in two samples with a **maximum concentration of 0.46 mg/kg.**
- **Indeno(1,2,3-cd)pyrene** exceeded the Region 9 residential PRG in two samples with a **maximum concentration of 1.0 mg/kg.**
- **Phenanthrene** exceeded the laboratory detection limit in five samples with a **maximum concentration of 6.1 mg/kg.**
- **2-Amino-4,6-Dinitrotoluene** exceeded the laboratory detection limit in one sample with a **maximum concentration of 0.1 J mg/kg.** J value indicates an estimated result.
- **RDX** exceeded the Region 9 residential PRG in one sample with a **maximum concentration of 45 mg/kg.**
- **Nitrocellulose** exceeded the laboratory detection limit in three samples with a **maximum concentration of 156 J mg/kg.** J value indicates an estimated result.
- **VOCs, pesticides and PCBs** were below Region 9 residential PRGs and/or laboratory detection limits.

## 4.2 SEDIMENTS

Three sediment samples (two regular and one QC) were collected from one location during the LL7 AOC characterization. Analytical results from the sediment samples were compared to RVAAP facility-wide background concentrations for sediments and/or Region 9 residential PRGs for residential soil.

Sediment results at or above detection limits are presented in Table LL7-3. All sediment analytical results are presented in Table LL7-7. Locations where sediment analytes were detected at or above background levels and Region 9 residential PRGs are illustrated in Figure LL7-10. Laboratory analytical reports are provided in Appendix R.

Other details pertinent to the sediment analytical results:

- **Aluminum** exceeded the Region 9 residential PRG in two samples with a **maximum concentration of 18000 mg/kg.**
- **Arsenic** exceeded the Region 9 residential PRG in two samples with a **maximum concentration of 13 mg/kg.**
- **Barium** exceeded background in two samples with a **maximum concentration of 180 mg/kg.**
- **Beryllium** exceeded background in three samples with a **maximum concentration of 2.7 mg/kg.**
- **Cadmium** exceeded background in one sample and exceeded background and the Region 9 residential PRG in two samples with a **maximum concentration of 5.5 J mg/kg.** J value indicates an estimated result.
- **Calcium** exceeded background in three samples with a **maximum concentration of 69000 mg/kg.**
- **Chromium** exceeded background in two samples with a **maximum concentration of 27 mg/kg.**
- **Copper** exceeded background in two samples with a **maximum concentration of 51 mg/kg.**
- **Iron** exceeded the Region 9 residential PRG in two samples, and exceeded background and the Region 9 residential PRG in one sample with a **maximum concentration of 34000 J mg/kg.** J value indicates an estimated result.
- **Lead** exceeded background in two samples, and exceeded background and the Region 9 residential PRG in one sample with a **maximum concentration of 540 mg/kg.**
- **Magnesium** exceeded background in two samples with a **maximum concentration of 12000 mg/kg.**
- **Manganese** exceeded the Region 9 residential PRG in three samples with a **maximum concentration of 1900 mg/kg.**
- **Nickel** exceeded background in one sample with a **maximum concentration of 20 mg/kg.**
- **Selenium** exceeded background in one sample with a **maximum concentration of 2.5 mg/kg.**
- **Sodium** exceeded background in two samples with a **maximum concentration of 1400 J mg/kg.** J value indicates an estimated result.
- **Vanadium** exceeded the Region 9 residential PRG in three samples with a **maximum concentration of 17 mg/kg.**
- **Zinc** exceeded background in two samples with a **maximum concentration of 750 J mg/kg.** J value indicates an estimated result.
- **Nitrate** exceeded the laboratory detection limit with a **maximum concentration of 1.2 mg/kg.**

## 4.3 SURFACE WATER

Nine surface water samples (eight regular and one QC) were collected during the LL7 AOC characterization. Results from analyses were compared to RVAAP surface water background concentrations (USACE, 2000) and/or USEPA Region 9 tap water PRGs.

Surface water results at or above detection limits are presented in Table LL7-4. All surface water analytical results are presented in Table LL7-8. Locations where surface water analytes were detected at or above background levels and Region 9 tap water PRGs as shown in Figure LL7-10. Tabulated analytical results and laboratory analytical reports are provided in Appendix P.

The surface water analytical results and exceedances are summarized below:

- **Barium** exceeded background in one sample with a **maximum concentration of 140 µg/L.**
- **Beryllium** exceeded background in one sample with a **maximum concentration of 0.55 µg/L.**
- **Cadmium** exceeded background in one sample with a **maximum concentration of 1.3 µg/L.**
- **Calcium** exceeded background in two samples with a **maximum concentration of 48000 µg/L.**
- **Chromium** exceeded background in two samples with a **maximum concentration of 3.0 µg/L.**
- **Cobalt** exceeded background in one sample with a **maximum concentration of 1.2 µg/L.**
- **Copper** exceeded background in two samples with a **maximum concentration of 40 µg/L.**
- **Iron** exceeded background in two samples with a **maximum concentration of 4400 µg/L.**
- **Lead** exceeded background in five sample and exceeded background and the Region 9 tap water PRG in two samples with a **maximum concentration of 2200 µg/L.**
- **Manganese** exceeded background and the Region 9 tap water PRG in one sample with a **maximum concentration of 1400 µg/L.**
- **Nickel** exceeded background in five samples with a **maximum concentration of 30 µg/L.**
- **Potassium** exceeded background in one sample with a **maximum concentration of 9300 µg/L.**
- **Vanadium** exceeded background in one sample with a **maximum concentration of 7.9 µg/L.**
- **Zinc** exceeded background in two samples with a **maximum concentration of 230 µg/L.**
- **Antimony** exceeded background in one sample and exceeded background and the Region 9 tap water PRG in one sample with a **maximum concentration of 47 µg/L.**
- **Arsenic** exceeded the Region 9 tap water PRG in three samples with a **maximum concentration of 1.1 µg/L.**
- **Mercury** exceeded background in one sample with a **maximum concentration of 0.32 µg/L.**
- **Trichloroethene** exceeded the Region 9 tap water PRG in one sample with a **maximum concentration of 11 µg/L.**
- **1,4-Dichlorobenzene** exceeded the Region 9 tap water PRG in one sample with a **maximum concentration of 0.52 J µg/L.** J value indicates an estimated result.
- **Benzo(a)anthracene** exceeded the Region 9 tap water PRG in one sample with a **maximum concentration of 1.4 µg/L.**
- **Benzo(a)pyrene** exceeded the Region 9 tap water PRG in one sample with a **maximum concentration of 1.8 µg/L.**
- **Benzo(b)fluoranthene** exceeded the Region 9 tap water PRG in one sample with a **maximum concentration of 2.0 µg/L.**
- **Benzo(g,h,i)perylene** exceeded the laboratory detection limit in one sample with a **maximum concentration of 1.3 µg/L.**
- **Benzo(k)fluoranthene** exceeded the Region 9 tap water PRG in one sample with a **maximum concentration of 1.2 µg/L.**
- **Bis(2-ethylhexyl)phthalate** exceeded the Region 9 tap water PRG in one sample with a **maximum concentration of 12 J µg/L.** J value indicates an estimated result.

- **Dibenzo(a,h)anthracene** exceeded the Region 9 tap water PRG in one sample with a **maximum concentration of 0.42 µg/L.**
- **Indeno(1,2,3-cd)pyrene** exceeded the Region 9 tap water PRG in one sample with a **maximum concentration of 1.0 µg/L.**
- **Phenanthrene** exceeded the laboratory detection limit in one sample with a **maximum concentration of 1.7 µg/L.**
- **2-Amino-4,6-Dinitrotoluene** exceeded the laboratory detection limit in eight samples with a **maximum concentration of 7.6 µg/L.**
- **4-Amino-2,6-Dinitrotoluene** exceeded the laboratory detection limit in eight samples with a **maximum concentration of 21 µg/L.**
- **RDX** exceeded the Region 9 tap water PRG in nine samples with a **maximum concentration of 110 µg/L.**
- **Pesticides, PCBs and propellants** were below Region 9 tap water PRGs and/or laboratory detection limits.

## 4.4 GROUNDWATER

Seven groundwater samples (six regular and one QC) were collected from the six newly-installed monitoring wells (MW-001 through MW-006) during the LL7 AOC characterization. The groundwater analytical results were compared to background values and USEPA Region 9 tap water residential PRGs.

Groundwater results at or above detection limits are presented in Table LL7-5. All groundwater analytical results are presented in Table LL7-9. Locations of groundwater analytes that were detected at or above background levels and residential PRGs as shown on figure LL7-11. Laboratory analytical reports are provided in Appendix L.

The groundwater analytical results and exceedances are summarized below:

- **Cadmium** exceeded background in three samples with a **maximum concentration of 0.36 µg/L.**
- **Chromium** exceeded background in one sample with a **maximum concentration of 1.4 µg/L.**
- **Cobalt** exceeded background in seven samples with a **maximum concentration of 9.1 µg/L.**
- **Iron** exceeded background in three samples, and exceeded background and the Region 9 tap water PRG in three samples with a **maximum concentration of 20000 µg/L.**
- **Manganese** exceeded the Region 9 tap water PRG in one sample and exceeded background and the Region 9 tap water PRG in four samples with a **maximum concentration of 2000 µg/L.**
- **Silver** exceeded background in one sample with a **maximum concentration of 0.93 µg/L.**
- **Vanadium** exceeded background in one sample with a **maximum concentration of 1.4 µg/L.**
- **Arsenic** exceeded background and the Region 9 tap water PRG in two samples with a **maximum concentration of 1.1 µg/L.**
- **Mercury** exceeded background in three samples with a **maximum concentration of 0.4 µg/L.**
- **SVOCs, VOCs, pesticides, PCBs, explosives and propellants** were below Region 9 tap water PRGs and/or laboratory detection limits.

## 4.5 GEOTECHNICAL

Three Shelby tubes were collected at monitoring well locations LL7mw-003 (4-6 ft), LL7mw-005 (0-2 ft) and LL7mw-006 (2-4 ft). The results of the geotechnical analysis are summarized in the following table.

| Sample Number | Depth feet | Moisture Content % | Liquid Limit % | Plastic Limit % | Plastic Index | Agg. % | C Sand % | M Sand % | F Sand % | Silt & Clay % | Soil Description | Class Sym. | pH | Specific Gravity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LL7mw-003 (4-6 ft) | 5.8 | 12.8 | 24 | 17 | 7 | 1.7 | 2.8 | 9.3 | 25.1 | 59.3 | Brown sandy, silty clay, trace gravel | CL-ML | 7.8 | 2.742 |
| LL7mw-005 (0-2 ft) | 1.2 | 9.7 | NP | NP | NP | 64.8 | 2.4 | 15.5 | 14.0 | 3.3 | Brown poorly graded gravel with sand, trace fines | GP | 8.6 | 2.716 |
| LL7mw-006 (2-4 ft) | 3.8 | 13.9 | 25 | 18 | 7 | 15.9 | 2.4 | 8.3 | 22.3 | 51.2 | Brown sandy, silty clay with gravel | CL-ML | 7.7 | 2.729 |

## 4.6 IN SITU PERMEABILITY TESTING RESULTS

Following installation of the monitoring wells, slug tests were completed to determine the in-situ permeability of the aquifer underlying the LL7. The following table shows the results of the slug tests performed in January-February 2005.

**Hydraulic Conductivities in Load Line 7 Monitoring Wells**

| Monitoring Well ID | Screened Interval Depth (ft) | Total Borehole Depth (ft) | Geologic Material Adjacent to Screen | Hydraulic conductivity (cm/s) |
|---|---|---|---|---|
| MW-001 | 19.5-29.5 | 30 | sandstone | 1.95 E-4 |
| MW-002 | 15-25 | 26.5 | sandstone | 1.72 E-4 |
| MW-003 | 21-31 | 31.5 | sandstone | 3.82 E-4 |
| MW-004 | 19.5-29.5 | 29.5 | sandstone | 3.06 E-4 |
| MW-005 | 18-28 | 28.2 | sandstone | 6.41 E-5 |
| MW-006 | 17.5-27.5 | 28 | sandstone | 2.11 E-4 |

Based on the results of the slug tests, hydraulic conductivities arithmetic average 2.22 x $10^{-4}$ cm/s in the soil underlying LL7. The field measurements and test data are provided in Appendix K along with the calculation worksheets for the tests. Previous slug tests performed at wells located at other sites within RVAAP indicate average hydraulic conductivities range between 3.87 x $10^{-2}$ cm/s to 4.46 x $10^{-6}$ cm/s (USACE, 1999).

Data from the three rounds of well gauging were used to produce potentiometric surface maps for LL7 (Figures LL7-12 through LL7-14). The water level data suggest that groundwater flows to the southeast at a gradient of approximately 0.008 ft/ft.

# 5.0 HUMAN HEALTH AND ECOLOGICAL RISK SCREENING FOR LOAD LINE 7

This section details both the human health and ecological risk screening performed at LL7.

## 5.1 HUMAN HEALTH RISK SCREENING

Volume 1, Section 5.1 explains how the LL7 data were screened to determine human health contaminants of potential concern (COPCs). Total chromium analytical results were conservatively screened against 1/10th of the PRG value; therefore, a screening value of 21 mg/kg was used rather than 210 mg/kg.

### 5.1.1 Surface Soil (0-1 ft)

Table LL7-10 presents the human health screening table for surface soil (0-1 ft) at LL7. A total of 55 constituents were detected including metals, VOCs, and SVOCs.

- Sixteen constituents had detections greater than RVAAP background concentrations: barium, beryllium, cadmium, calcium, chromium, cobalt, copper, lead, magnesium, nickel, potassium, silver, sodium, zinc, mercury, and thallium.
- Eleven constituents had detections above the adjusted Region 9 residential PRGs: aluminum, arsenic, iron, manganese, vanadium, benzo(a)anthracene, benzo(a)pyrene, and benzo(b) -fluoranthene.
- Of these constituents, aluminum, arsenic, chromium, iron, manganese, and silver also had detected concentrations above both RVAPP background and the Region 9 residential PRG.

Based on these comparisons, 17 constituents were identified as COPCs in surface soil (0-1 ft) at LL7: aluminum, arsenic, chromium, iron, manganese, silver, 2-methylnaphthalene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, phenanthrene, 2-amino-4,6-dinitrotoluene, RDX, and nitrocellulose. Of these COPC, 2-methylnaphthalene, benzo(g,h,i)perylene, phenanthrene, 2-amino-4,6-dinitrotoluene, and nitrocellulose were identified due to the lack of screening criteria.

### 5.1.2 Sediment

Table LL7-11 presents the human health screening table for sediment at LL7. Twenty-one constituents were detected in sediment. These constituents included metals and one nutrient.

- Twelve constituents had detected concentrations greater than RVAAP background values: barium, beryllium, cadmium, calcium, chromium, copper, lead, magnesium, nickel, selenium, sodium, and zinc.
- Four constituents had detections above the adjusted Region 9 residential PRGs: arsenic, iron, manganese, and vanadium.
- Four constituents also had detected concentrations above both RVAAP background and Region 9 residential PRGs: aluminum, cadmium, iron, and lead.

Based on these comparisons, aluminum, cadmium, iron, and lead were identified as COPC.

### 5.1.3 Surface Water

Table LL7-12 presents the human health screening table for surface water at LL7. Nine surface water samples were collected resulting in a total of 47 detected constituents.

- Fifteen constituents had detections greater than RVAAP background values: barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, potassium, nickel, vanadium, zinc, antimony, lead, and mercury.
- Eleven constituents had detections above the Region 9 tap water PRGs: arsenic, trichloroethene, 1,4-dichlorobenzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and RDX.
- Three constituents also had detected concentrations greater than both RVAAP background and the Region 9 tap water PRG: lead, manganese, and antimony.

Based on these comparisons, 17 constituents were identified as COPC in surface water: lead, manganese, antimony, trichloroethene, 1,4-dichlorobenzene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, bis(2-ethylhexyl)phthalate, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, phenanthrene, 2-amino-4,6-dinitrotoluene, 4-amino-2,6-dinitrotoluene and RDX. Of these COPC, benzo(g,h,i)perylene, phenanthrene, 2-amino-4,6-dinitrotoluene, and 4-amino-2,6-dinitrotoluene were identified due to the lack of screening criteria.

### 5.1.4 Groundwater

Table LL7-13 presents the human health screening table for groundwater at LL7. A total of 22 constituents were detected including metals, SVOCs, and one nutrient.

- Seven constituents had detections greater than RVAAP background concentrations: cadmium, chromium, cobalt, iron, silver, vanadium, and mercury. Only manganese had detections above the Region 9 tap water PRG.
- Three constituents, iron, manganese, and arsenic, were detected above both RVAAP background and the Region 9 tap water PRG.

Based on these comparisons, iron, manganese, and arsenic were identified as COPC in groundwater at LL7.

## 5.2 ECOLOGICAL RISK SCREENING

See Volume I, Section 5.2 for an explanation of the procedures used to conduct this ecological risk screen.

### 5.2.1 Surface Soil (0-1 ft)

Table LL7-14 presents the ecological screening table for surface soil (0-1 ft) at LL7. A total of 55 constituents were detected.

- Twenty constituents had detections greater than RVAAP background concentrations: aluminum, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, silver, sodium, zinc, mercury, and thallium.
- Sixteen constituents had detections above ecological screening values: aluminum, arsenic, chromium, copper, iron, lead, manganese, selenium, silver, vanadium, zinc, mercury, aroclor 1254, benzo(a)pyrene, naphthalene, and 2,6-dinitrotoluene.

Based on these comparisons, 26 constituents were identified as chemicals of potential ecological concern (COPECs) in surface soil (0-1 ft) at LL7: aluminum, arsenic, chromium, copper, iron, lead, manganese, silver, zinc, mercury, aroclor 1254, 4-methylphenol, benzo(a)pyrene, carbazole, dibenzofuran, naphthalene, 2,4,6-TNT, 2,6-dinitrotoluene, 2-amino-4,6-dinitrotoluene, 2-nitrotoluene, 3-nitrotoluene, HMX, RDX, nitrocellulose, nitroglycerine, and nitrate (as N(NO3-N)). Of these COPECs, 4-ethylphenol, carbazole, dibenzofuran, 2,4,6-TNT, 2-amino-4.6-dinitrotoluene, 2-nitrotoluene, 3-nitrotoluene, HMX, RDX, nitrocellulose, nitroglycerine, and nitrate (as N(NO3-N)) were identified due to the lack of screening criteria.

### 5.2.2 Sediment

Table LL7-15 presents the ecological screening table for sediment at LL7. Twenty-one constituents were detected in sediment.

- Fourteen constituents had detected concentrations greater than RVAAP background values: aluminum, barium, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, nickel, selenium, sodium, and zinc.
- Nine constituents had detected concentrations greater than the Sediment Reference Value (SRV) (OEPA, 2003): beryllium, cadmium, calcium, copper, lead, magnesium, manganese, selenium and zinc.
- Five constituents had detections above ecological screening values: arsenic, cadmium, copper, lead, and zinc.

Based on these comparisons, seven constituents were identified as COPECs: beryllium, cadmium, copper, lead, selenium, zinc, and nitrate. Of these COPECs, beryllium, selenium and nitrate were identified due to the lack of screening criteria.

### 5.2.3 Surface Water

Table LL7-16 presents the ecological screening table for surface water at LL7. Forty-six constituents were detected in surface water.

- Sixteen constituents had detections greater than RVAAP background values: barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, manganese, nickel, potassium, vanadium, zinc, antimony, lead, and mercury.
- Five constituents (copper, zinc, lead, anthracene and HMX ) were detected above ecological screening values.

Based on these comparisons, 17 constituents were identified as COPECs in surface water at LL7: copper, iron, manganese, zinc, lead, mercury, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, HMX and nitrate (as N(NO3-N)). Of these COPECs, iron, manganese, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, and nitrate were identified due to the lack of screening criteria. Mercury was identified as a COPEC in surface water because it is considered persistent, bioaccumulative, and toxic.

# 6.0 SUMMARY AND CONCLUSION FOR THE CHARACTERIZATION OF LOAD LINE 7

This section briefly summarizes the conditions that were found during the AOC characterization at LL7 and the risk screening tasks that were completed.

## 6.1 NATURE OF CONTAMINATION

Contaminants were detected above screening criteria in four media: surface soil (0-1 ft), sediment, surface water and groundwater.

- Contaminants detected in soil above RVAAP background and/or Region 9 residential PRG screening values included 21 metals, five SVOCs and one explosive.
- In sediment 17 metals were detected at concentrations above RVAAP background and/or Region 9 residential, PRG screening values.
- In surface water, 18 metals, nine SVOCs and one explosive were detected above RVAAP background and/or Region 9 residential PRG screening values.
- In groundwater, 9 metals were detected above RVAAP background and/or Region 9 residential PRG screening values.

## 6.2 HUMAN HEALTH RISK SCREENING

A Human Health Risk Screening (HHRS) was conducted to compare the concentrations detected in the LL7 samples to RVAAP-specific background values and U.S. EPA Region 9 residential PRGs. This preliminary screening was conducted to identify potential COPCs. The following table identifies the COPCs.

**Table LL7-18**

**Chemical of Potential Concern – All Media**

| Soils | Sediment | Surface Water | Groundwater |
|---|---|---|---|
| Aluminum | Aluminum | Manganese | Iron |
| Arsenic | Cadmium | Antimony | Manganese |
| Chromium | Iron | Trichloroethene | Arsenic |
| Iron | Lead | 1,4-dichlorobenzene | |
| Manganese | | Benzo(a)anthracene | |
| Silver | | Benzo(a)pyrene | |
| 2-methylnaphthalene | | Benzo(b)flouranthene | |
| Benzo(a)anthracene | | Benzo(g,h,i)perylene | |
| Benzo(a)pyrene | | Benzo(k)flouranthene | |
| Benzo(b)flouranthene | | | |
| Benzo(g,h,i) perylene | | | |
| Dibenzo(a,h)anthracene | | | |
| Indeno(1,2,3-cd)pyrene | | | |
| Phenanthere | | | |
| 2-amino-4,6-dinitrotoluene | | | |
| RDX | | | |
| Nitrocellulose | | | |

## 6.3 ECOLOGICAL RISK SCREENING

An Ecological Risk Screening (ERS) was performed to compare contaminant concentrations detected in LL7 to RVAAP-specific background values and ecological screening values. The ERS was conducted as outlined in Volume 1, Section 5.2. The ERS identified COPECs for LL7. The following table summarizes those COPECs.

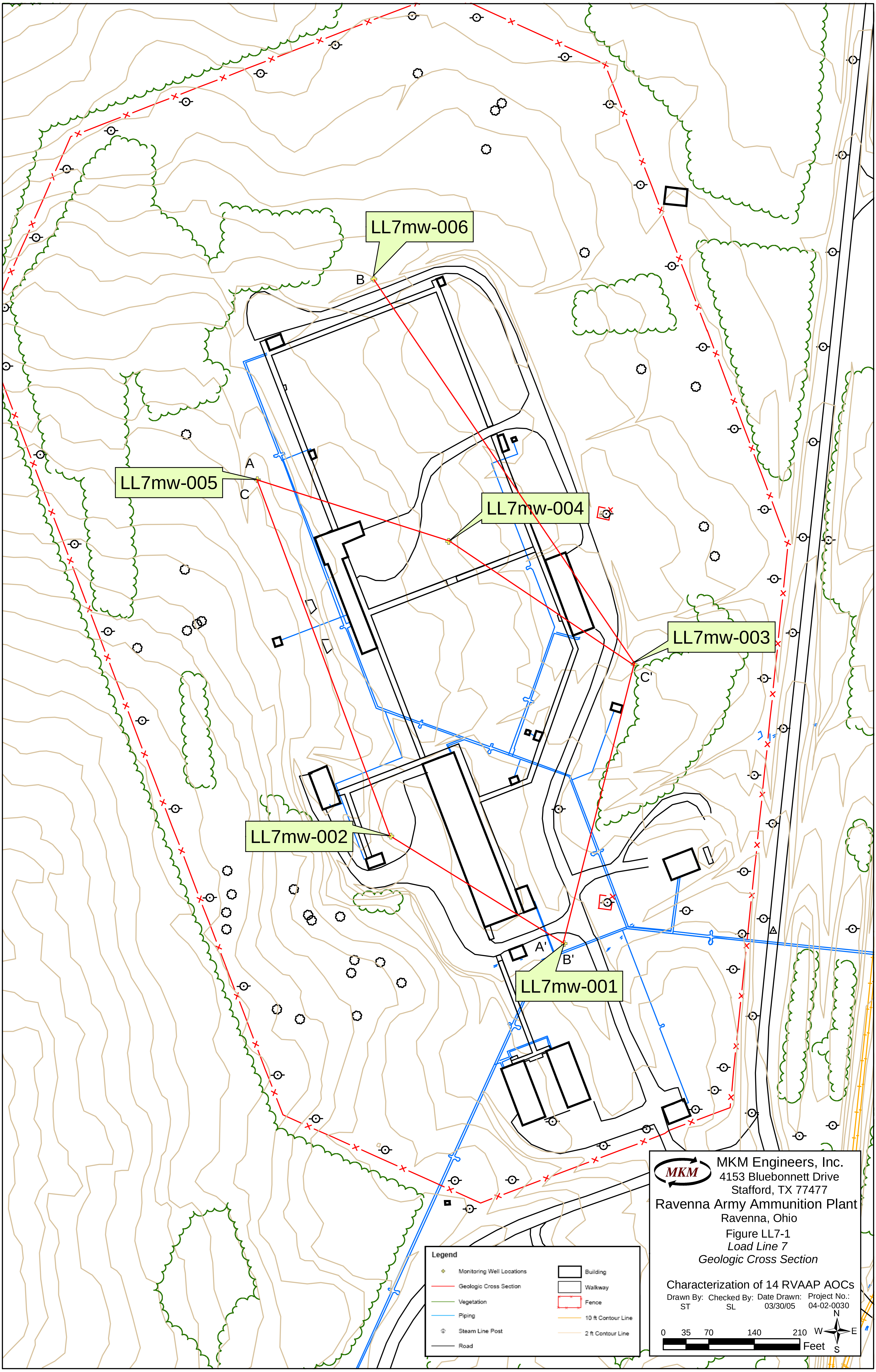
**Table LL7-19**

**Chemical of Potential Ecological Concern – All Media**

| Soils | Sediment | Surface Water | Groundwater |
|---|---|---|---|
| Aluminum<br>Arsenic<br>Chromium<br>Copper<br>Iron<br>Lead<br>Mangenese<br>Silver<br>Zinc<br>Mercury<br>Aroclor-1254<br>4-methylphenol<br>Benzo(a)pyrene<br>Carbazole<br>Dibenzofuran<br>Naphthalene<br>2,4,6-TNT<br>2,6-dinitrotoluene<br>2-amino-4,6-dinitrotoluene<br>2-nitrotoluene<br>3-nitrotoluene<br>HMX<br>RDX<br>Nitrocellulose<br>Nitroglycerine<br>Nitrate(as N(N03-N) | Beryllium<br>Cadmium<br>Copper<br>Lead<br>Selenium<br>Zinc<br>Nitrate | Copper<br>Iron<br>Manganese<br>Zinc<br>Lead<br>Mercury<br>Anthracene<br>Benzo(a)anthracene<br>Benzo(a)pyrene<br>Benzo(b)fluoranthene<br>Benzo(g,h,i)perylene<br>Benzo(k)fluoranthene<br>Chrysene<br>Dibenzo(a,h)anthracene<br>Indeno(1,2,3-cd)pyrene<br>HMX<br>Nitrate(as N(N03-N) | Groundwater not evaluated for ERS |

## 6.4 CONCLUSION

Based on COPC's identified in Section 6.2 and COPECs identified in Section 6.3 it is recommended that a full risk assessment be completed to evaluate whether the contaminants impact the AOC. The full risk assessment along with an evaluation of uncertainties should be considered in the overall risk management decisions that are made for LL7.



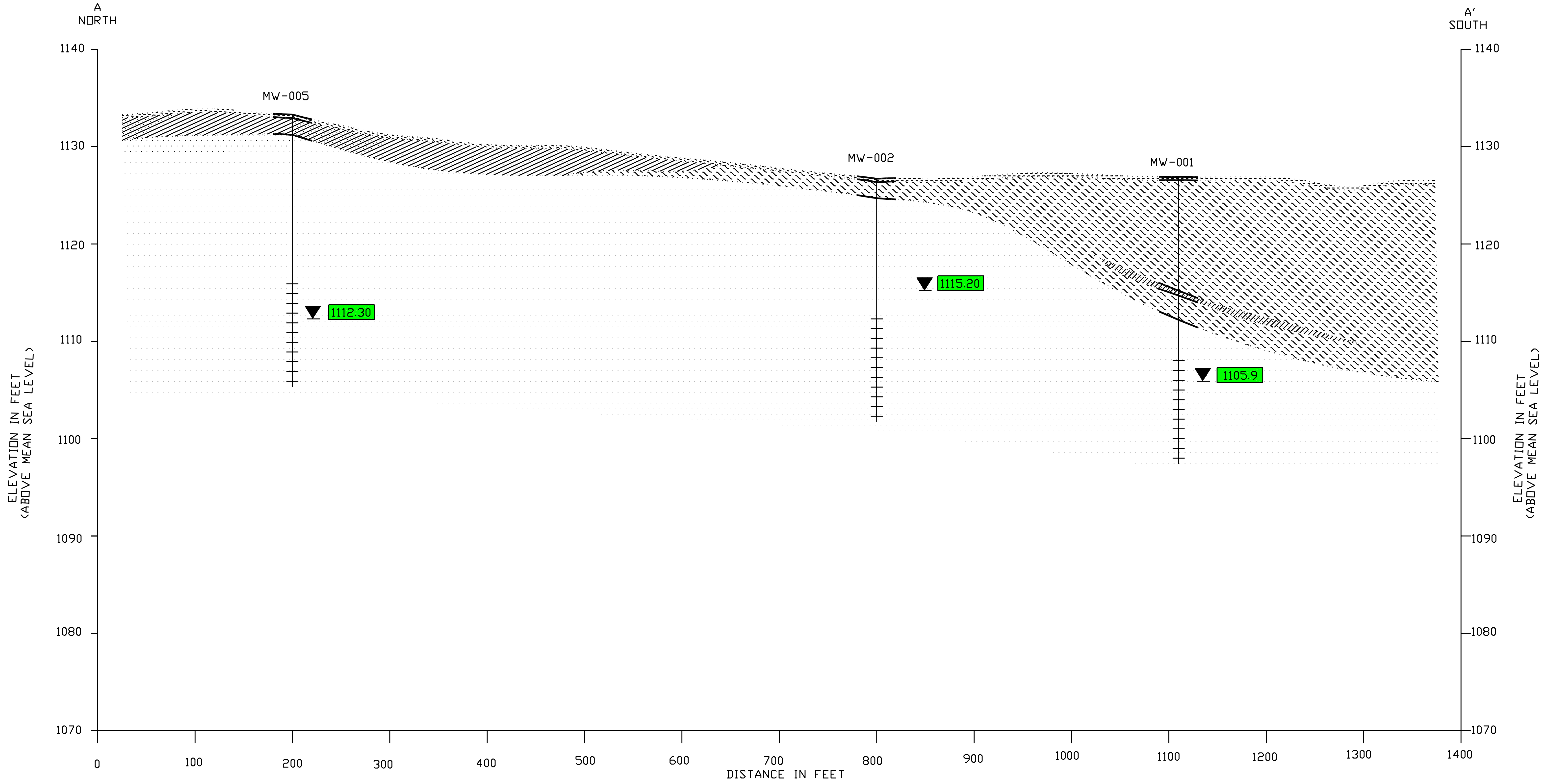
MKM
MKM Engineers, Inc.
4153 Bluebonnett Drive
Stafford, TX 77477

Ravenna Army Ammunition Plant
Ravenna, Ohio

Figure LL7-1
*Load Line 7*
*Geologic Cross Section*

Characterization of 14 RVAAP AOCs

| Drawn By: | Checked By: | Date Drawn: | Project No.: |
|---|---|---|---|
| ST | SL | 03/30/05 | 04-02-0030 |



CROSS SECTION A

HORIZONTAL 1"=100'
VERTICAL 1"=10'

VERTICAL EXAGGERATION = 10X

**LEGEND**

| | |
|---|---|
| ▦ | TOP SOIL |
| ▨ | SILTY SAND |
| ▧ | SANDY SILT |
| ⬚ | SAND STONE |
| ⌶ | SCREEN INTERVAL |
| ▼ | DEPTH GROUNDWATER ENCOUNTERED |
| 🟩 1140.64 | GROUNDWATER ELEVATION (ft) |
| — | KNOWN SUBSURFACE SOIL CONDITIONS |
| ⋯ | EXPECTED SUBSURFACE SOIL CONDITIONS |

REVISIONS

| ZONE | REV | DESCRIPTION | DATE | APPROVED |
|---|---|---|---|---|
| | | | 05/25/06 | MS |

MKM

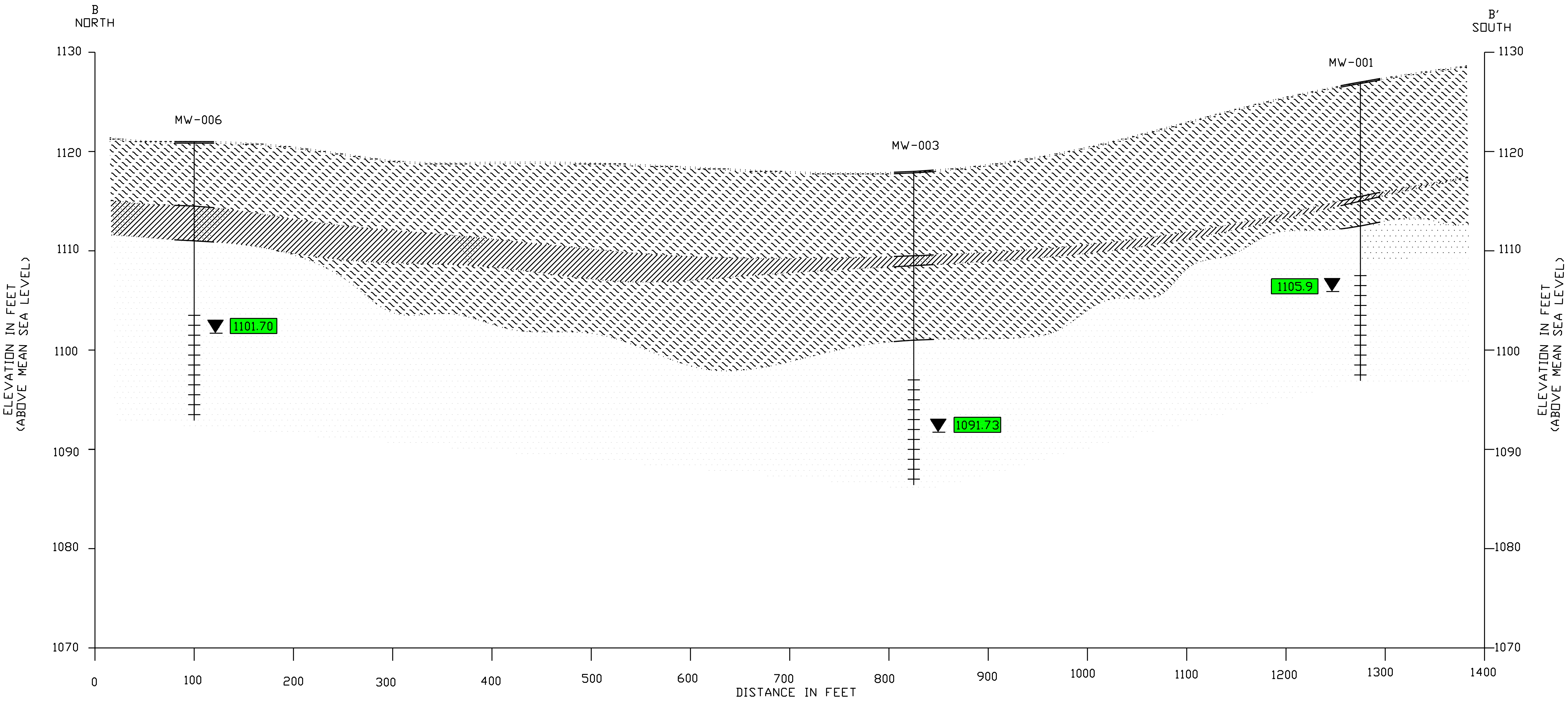
MKM ENGINEERS, INC.

DATE DRAWN 04/18/05

FIGURE LL7-2
LOAD LINE 7
GEOLOGIC CROSS SECTION A
RAVENNA ARMY AMMUNITION PLANT, RAVENNA OHIO

| SIZE | PROJECT NO. | DWG NO. | REV |
|---|---|---|---|
| D | | LL7-2 | |

| DRAWN BY | ST | APPR. BY | SRL |
|---|---|---|---|



CROSS SECTION B

HORIZONTAL 1"=100'
VERTICAL 1"=10'

VERTICAL EXAGGERATION = 10X

**LEGEND**

- ▦ TOP SOIL
- ░ SAND STONE
- ▼ DEPTH GROUNDWATER ENCOUNTERED
- — KNOWN SUBSURFACE SOIL CONDITIONS
- ▨ SILTY SAND
- Ɪ SCREEN INTERVAL
- 🟩 1140.64 GROUNDWATER ELEVATION (ft)
- ······ EXPECTED SUBSURFACE SOIL CONDITIONS
- ▧ SANDY SILT

REVISIONS

| ZONE | REV | DESCRIPTION | DATE | APPROVED |
|---|---|---|---|---|
| | | | 05/25/06 | MS |

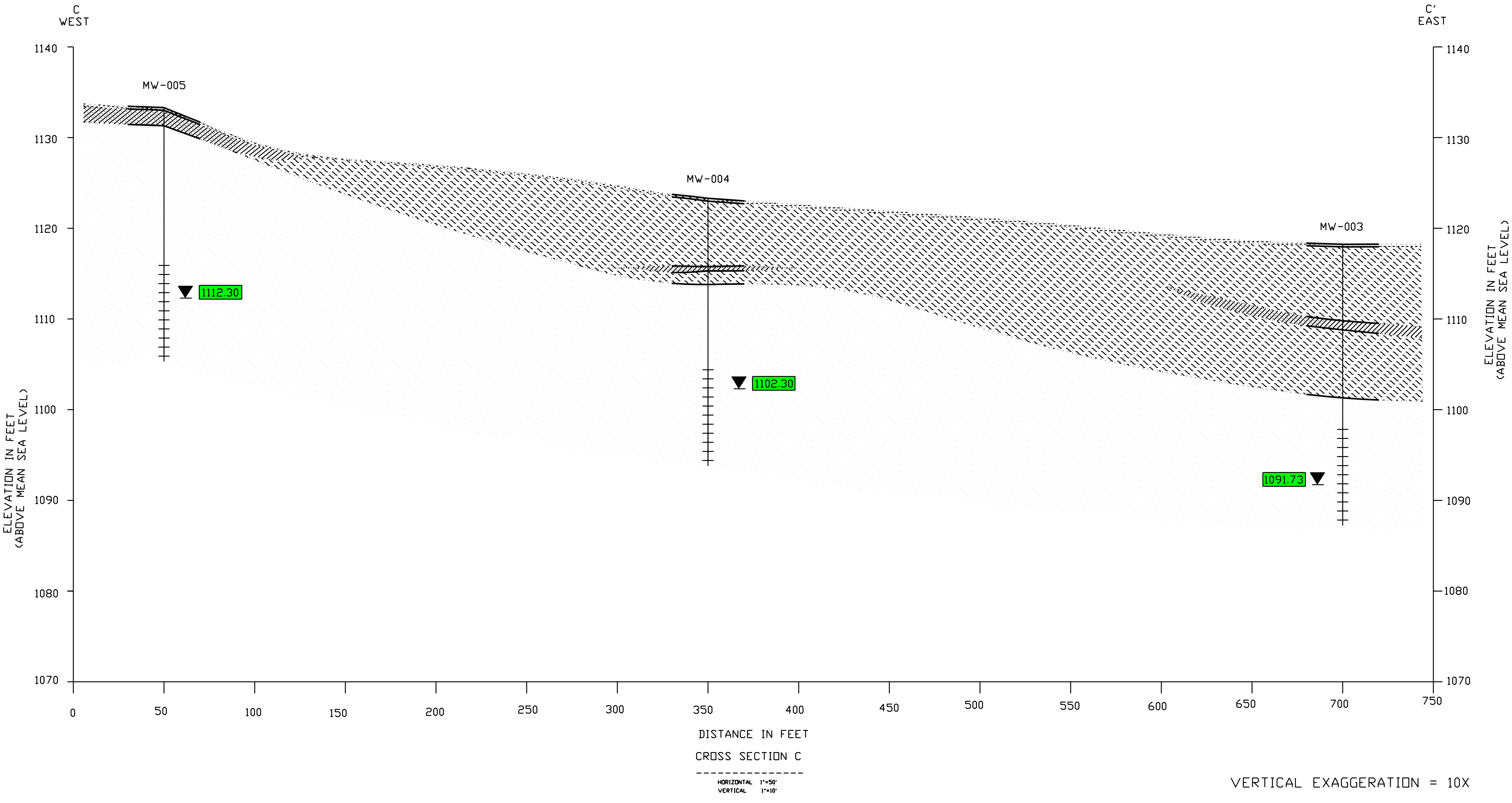
MKM ENGINEERS, INC.

DATE DRAWN 04/18/05

FIGURE LL7-3
LOAD LINE 7
GEOLOGIC CROSS SECTION B
RAVENNA ARMY AMMUNITION PLANT, RAVENNA OHIO

| SIZE | PROJECT NO. | DWG NO. | REV |
|---|---|---|---|
| D | | LL7-3 | |

| DRAWN BY | ST | APPR. BY | SRL |
|---|---|---|---|



**LEGEND**

▩ TOP SOIL

▨ SILTY SAND

▧ SANDY SILT

⋯ SAND STONE

▼ DEPTH GROUNDWATER ENCOUNTERED

⌶ SCREEN INTERVAL

🟩 1140.64 GROUNDWATER ELEVATION (ft)

— KNOWN SUBSURFACE SOIL CONDITIONS

⋯ EXPECTED SUBSURFACE SOIL CONDITIONS

REVISIONS

| ZONE | REV | DESCRIPTION | DATE | APPROVED |
|---|---|---|---|---|
| | | | 05/25/06 | MS |

MKM ENGINEERS, INC.

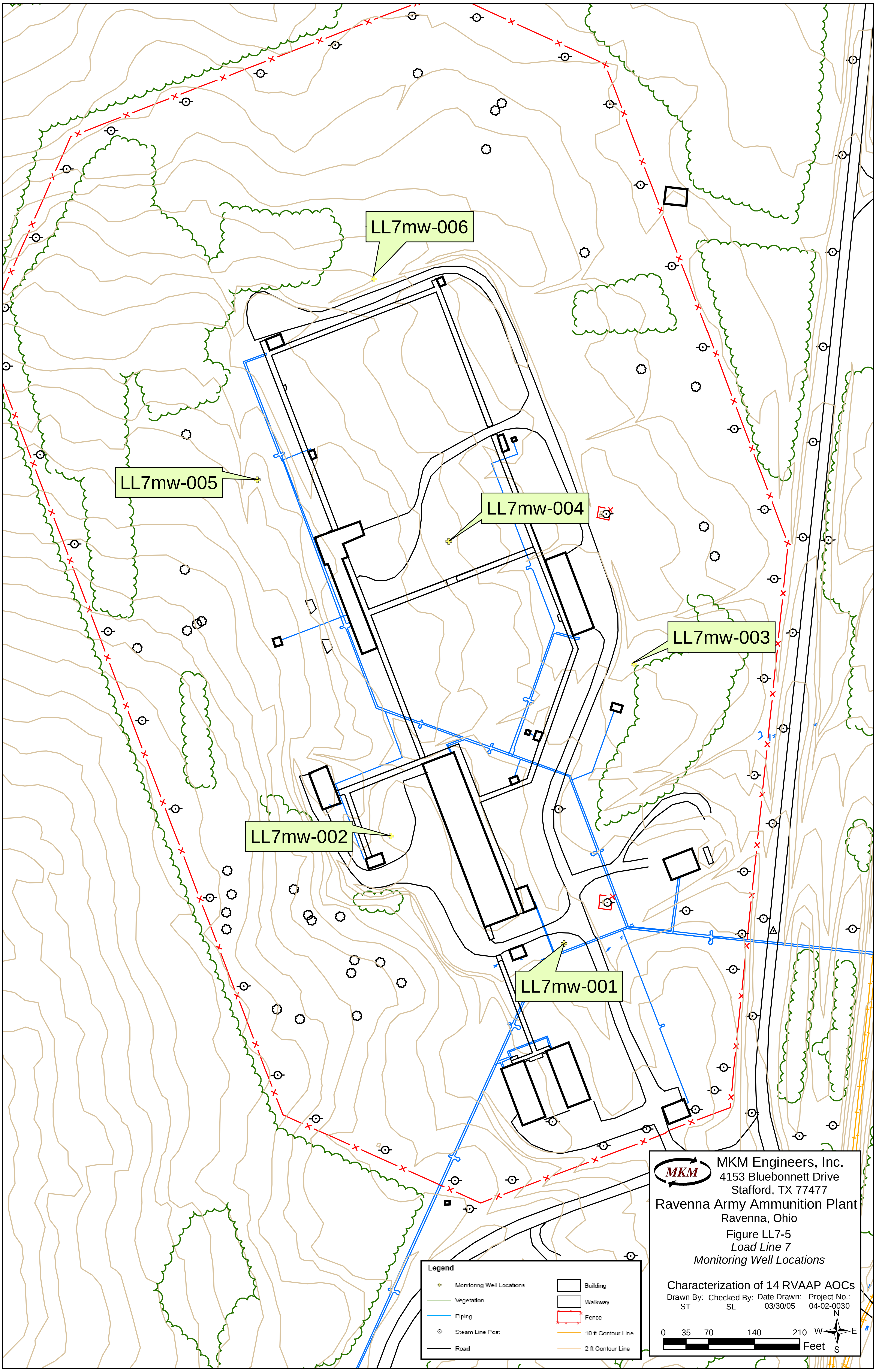
DATE DRAWN 04/18/05

FIGURE LL7-4
LOAD LINE 7
GEOLOGIC CROSS SECTION C
RAVENNA ARMY AMMUNITION PLANT, RAVENNA OHIO

| SIZE | PROJECT NO. | DWG NO. | REV |
|---|---|---|---|
| D | | LL7-4 | |

DRAWN BY ST

APPR. BY SRL



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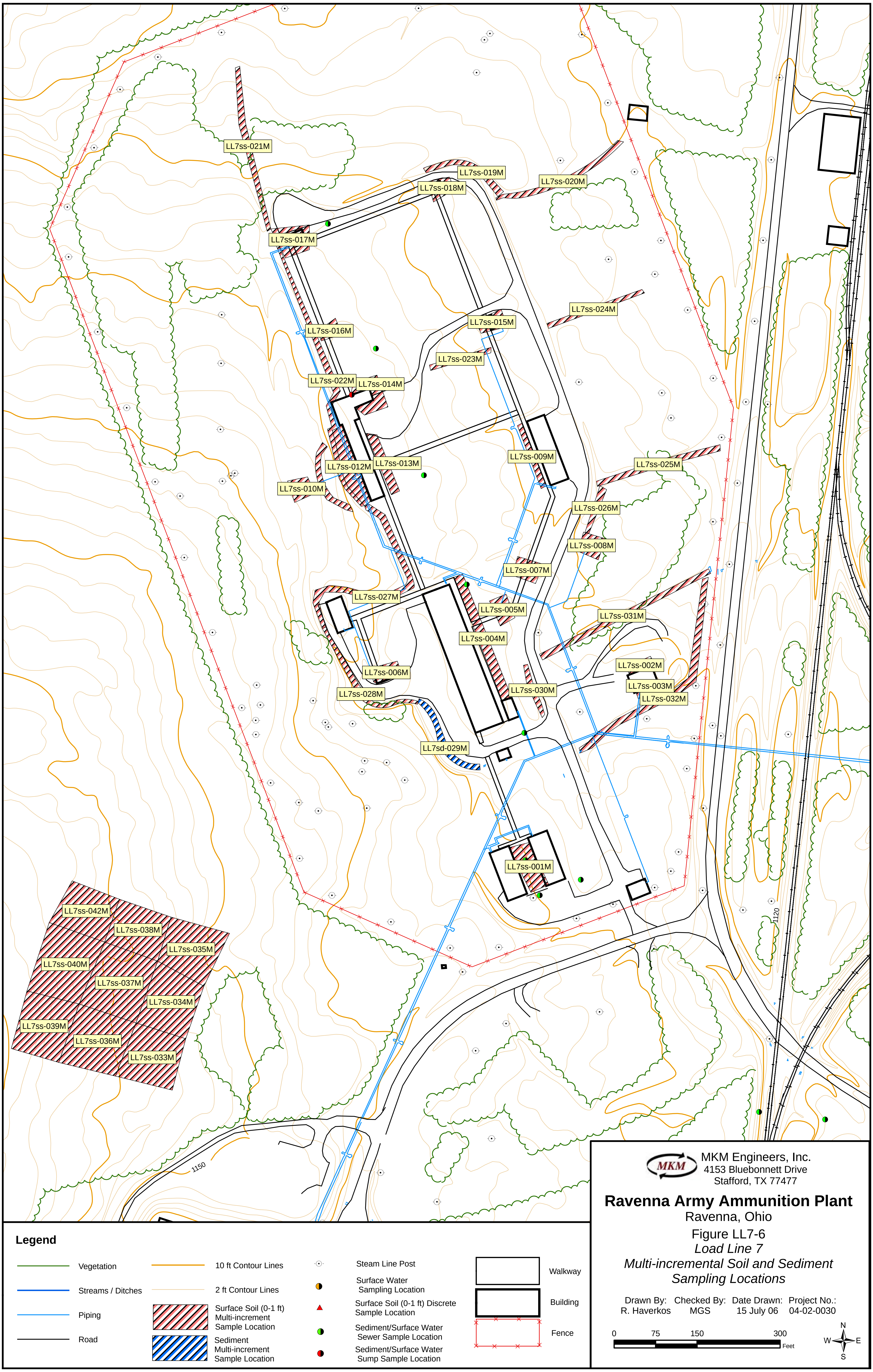
Stafford, TX 77477

Ravenna Army Ammunition Plant
Ravenna, Ohio

Figure LL7-5
*Load Line 7*
*Monitoring Well Locations*

Characterization of 14 RVAAP AOCs

| Drawn By: | Checked By: | Date Drawn: | Project No.: |
|---|---|---|---|
| ST | SL | 03/30/05 | 04-02-0030 |



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Stafford, TX 77477

## Ravenna Army Ammunition Plant

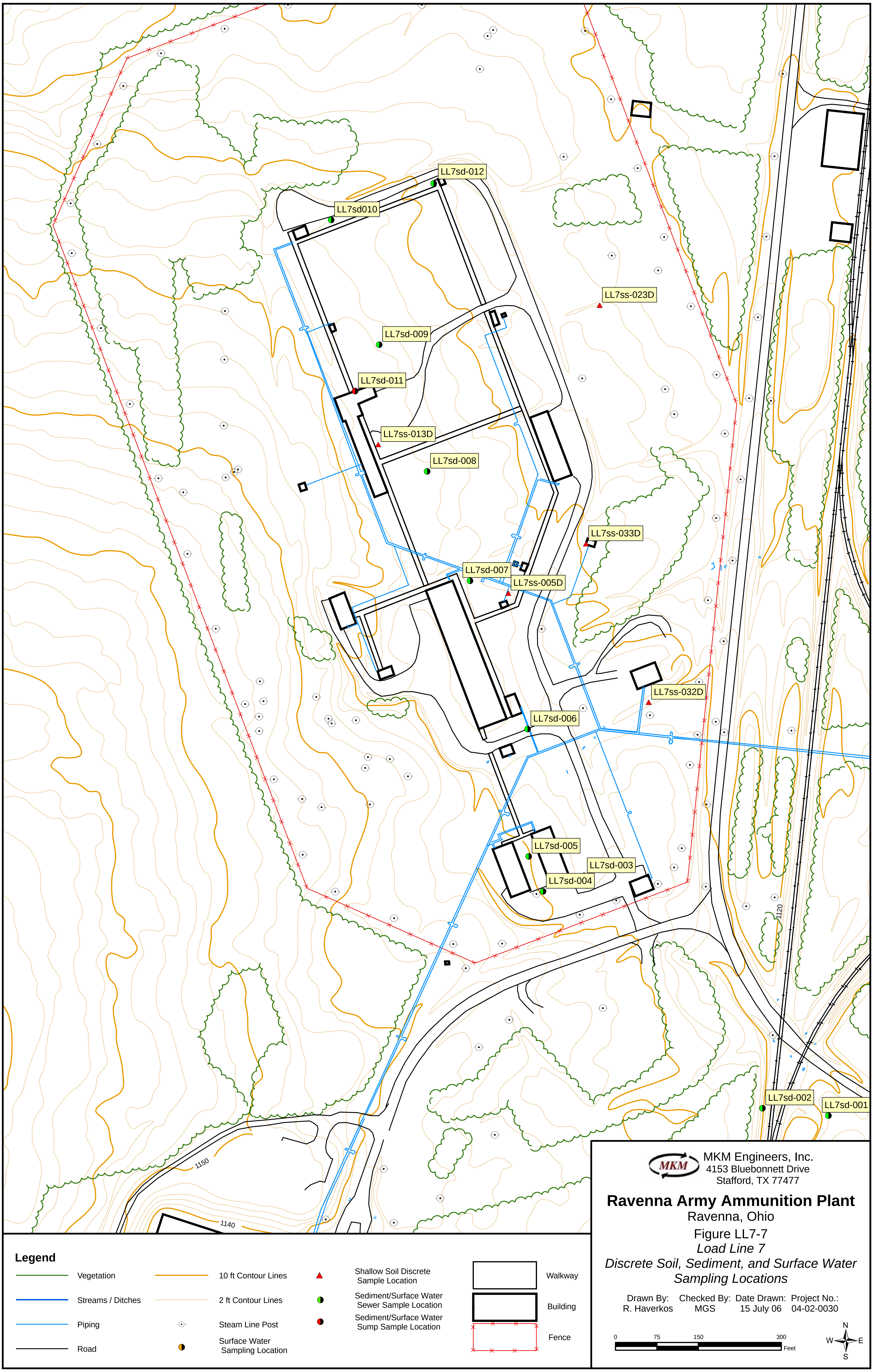
Ravenna, Ohio

Figure LL7-6

*Load Line 7*

*Multi-incremental Soil and Sediment Sampling Locations*

| Drawn By: | Checked By: | Date Drawn: | Project No.: |
|---|---|---|---|
| R. Haverkos | MGS | 15 July 06 | 04-02-0030 |



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Stafford, TX 77477

## Ravenna Army Ammunition Plant

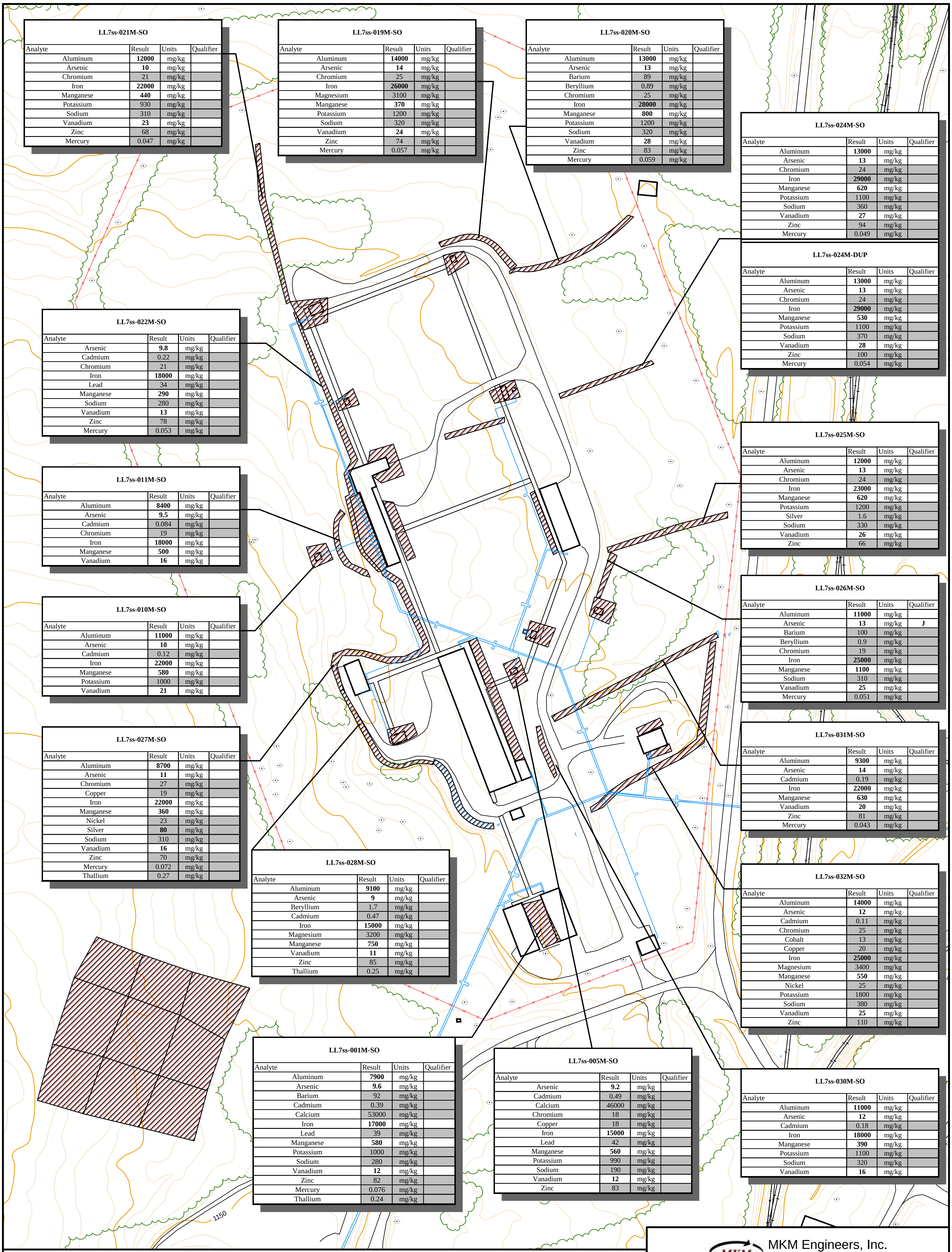
Ravenna, Ohio

Figure LL7-7

*Load Line 7*

*Discrete Soil, Sediment, and Surface Water Sampling Locations*

| Drawn By: | Checked By: | Date Drawn: | Project No.: |
|---|---|---|---|
| R. Haverkos | MGS | 15 July 06 | 04-02-0030 |



### LL7ss-021M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **12000** | mg/kg | |
| Arsenic | **10** | mg/kg | |
| Chromium | 21 | mg/kg | |
| Iron | **22000** | mg/kg | |
| Manganese | **440** | mg/kg | |
| Potassium | 930 | mg/kg | |
| Sodium | 310 | mg/kg | |
| Vanadium | **23** | mg/kg | |
| Zinc | 68 | mg/kg | |
| Mercury | 0.047 | mg/kg | |

### LL7ss-019M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **14000** | mg/kg | |
| Arsenic | **14** | mg/kg | |
| Chromium | 25 | mg/kg | |
| Iron | **26000** | mg/kg | |
| Magnesium | 3100 | mg/kg | |
| Manganese | **370** | mg/kg | |
| Potassium | 1200 | mg/kg | |
| Sodium | 320 | mg/kg | |
| Vanadium | **24** | mg/kg | |
| Zinc | 74 | mg/kg | |
| Mercury | 0.057 | mg/kg | |

### LL7ss-020M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **13000** | mg/kg | |
| Arsenic | **13** | mg/kg | |
| Barium | 89 | mg/kg | |
| Beryllium | 0.89 | mg/kg | |
| Chromium | 25 | mg/kg | |
| Iron | **28000** | mg/kg | |
| Manganese | **800** | mg/kg | |
| Potassium | 1200 | mg/kg | |
| Sodium | 320 | mg/kg | |
| Vanadium | **28** | mg/kg | |
| Zinc | 83 | mg/kg | |
| Mercury | 0.059 | mg/kg | |

### LL7ss-024M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **13000** | mg/kg | |
| Arsenic | **13** | mg/kg | |
| Chromium | 24 | mg/kg | |
| Iron | **29000** | mg/kg | |
| Manganese | **620** | mg/kg | |
| Potassium | 1100 | mg/kg | |
| Sodium | 360 | mg/kg | |
| Vanadium | **27** | mg/kg | |
| Zinc | 94 | mg/kg | |
| Mercury | 0.049 | mg/kg | |

### LL7ss-024M-DUP

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **13000** | mg/kg | |
| Arsenic | **13** | mg/kg | |
| Chromium | 24 | mg/kg | |
| Iron | **29000** | mg/kg | |
| Manganese | **530** | mg/kg | |
| Potassium | 1100 | mg/kg | |
| Sodium | 370 | mg/kg | |
| Vanadium | **28** | mg/kg | |
| Zinc | 100 | mg/kg | |
| Mercury | 0.054 | mg/kg | |

### LL7ss-022M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Arsenic | **9.8** | mg/kg | |
| Cadmium | 0.22 | mg/kg | |
| Chromium | 21 | mg/kg | |
| Iron | **18000** | mg/kg | |
| Lead | 34 | mg/kg | |
| Manganese | **290** | mg/kg | |
| Sodium | 280 | mg/kg | |
| Vanadium | **13** | mg/kg | |
| Zinc | 78 | mg/kg | |
| Mercury | 0.053 | mg/kg | |

### LL7ss-025M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **12000** | mg/kg | |
| Arsenic | **13** | mg/kg | |
| Chromium | 24 | mg/kg | |
| Iron | **23000** | mg/kg | |
| Manganese | **620** | mg/kg | |
| Potassium | 1200 | mg/kg | |
| Silver | 1.6 | mg/kg | |
| Sodium | 330 | mg/kg | |
| Vanadium | **26** | mg/kg | |
| Zinc | 66 | mg/kg | |

### LL7ss-011M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **8400** | mg/kg | |
| Arsenic | **9.5** | mg/kg | |
| Cadmium | 0.084 | mg/kg | |
| Chromium | 19 | mg/kg | |
| Iron | **18000** | mg/kg | |
| Manganese | **500** | mg/kg | |
| Vanadium | **16** | mg/kg | |

### LL7ss-026M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **11000** | mg/kg | |
| Arsenic | **13** | mg/kg | **J** |
| Barium | 100 | mg/kg | |
| Beryllium | 0.9 | mg/kg | |
| Chromium | 19 | mg/kg | |
| Iron | **25000** | mg/kg | |
| Manganese | **1100** | mg/kg | |
| Sodium | 310 | mg/kg | |
| Vanadium | **25** | mg/kg | |
| Mercury | 0.051 | mg/kg | |

### LL7ss-010M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **11000** | mg/kg | |
| Arsenic | **10** | mg/kg | |
| Cadmium | 0.12 | mg/kg | |
| Iron | **22000** | mg/kg | |
| Manganese | **580** | mg/kg | |
| Potassium | 1000 | mg/kg | |
| Vanadium | **21** | mg/kg | |

### LL7ss-031M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **9300** | mg/kg | |
| Arsenic | **14** | mg/kg | |
| Cadmium | 0.19 | mg/kg | |
| Iron | **22000** | mg/kg | |
| Manganese | **630** | mg/kg | |
| Vanadium | **20** | mg/kg | |
| Zinc | 81 | mg/kg | |
| Mercury | 0.043 | mg/kg | |

### LL7ss-027M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **8700** | mg/kg | |
| Arsenic | **11** | mg/kg | |
| Chromium | 27 | mg/kg | |
| Copper | 19 | mg/kg | |
| Iron | **22000** | mg/kg | |
| Manganese | **360** | mg/kg | |
| Nickel | 23 | mg/kg | |
| Silver | **80** | mg/kg | |
| Sodium | 310 | mg/kg | |
| Vanadium | **16** | mg/kg | |
| Zinc | 70 | mg/kg | |
| Mercury | 0.072 | mg/kg | |
| Thallium | 0.27 | mg/kg | |

### LL7ss-028M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **9100** | mg/kg | |
| Arsenic | **9** | mg/kg | |
| Beryllium | 1.7 | mg/kg | |
| Cadmium | 0.47 | mg/kg | |
| Iron | **15000** | mg/kg | |
| Magnesium | 3200 | mg/kg | |
| Manganese | **750** | mg/kg | |
| Vanadium | **11** | mg/kg | |
| Zinc | 85 | mg/kg | |
| Thallium | 0.25 | mg/kg | |

### LL7ss-032M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **14000** | mg/kg | |
| Arsenic | **12** | mg/kg | |
| Cadmium | 0.11 | mg/kg | |
| Chromium | 25 | mg/kg | |
| Cobalt | 13 | mg/kg | |
| Copper | 20 | mg/kg | |
| Iron | **25000** | mg/kg | |
| Magnesium | 3400 | mg/kg | |
| Manganese | **550** | mg/kg | |
| Nickel | 25 | mg/kg | |
| Potassium | 1800 | mg/kg | |
| Sodium | 380 | mg/kg | |
| Vanadium | **25** | mg/kg | |
| Zinc | 110 | mg/kg | |

### LL7ss-001M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **7900** | mg/kg | |
| Arsenic | **9.6** | mg/kg | |
| Barium | 92 | mg/kg | |
| Cadmium | 0.39 | mg/kg | |
| Calcium | 53000 | mg/kg | |
| Iron | **17000** | mg/kg | |
| Lead | 39 | mg/kg | |
| Manganese | **580** | mg/kg | |
| Potassium | 1000 | mg/kg | |
| Sodium | 280 | mg/kg | |
| Vanadium | **12** | mg/kg | |
| Zinc | 82 | mg/kg | |
| Mercury | 0.076 | mg/kg | |
| Thallium | 0.24 | mg/kg | |

### LL7ss-005M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Arsenic | **9.2** | mg/kg | |
| Cadmium | 0.49 | mg/kg | |
| Calcium | 46000 | mg/kg | |
| Chromium | 18 | mg/kg | |
| Copper | 18 | mg/kg | |
| Iron | **15000** | mg/kg | |
| Lead | 42 | mg/kg | |
| Manganese | **560** | mg/kg | |
| Potassium | 990 | mg/kg | |
| Sodium | 190 | mg/kg | |
| Vanadium | **12** | mg/kg | |
| Zinc | 83 | mg/kg | |

### LL7ss-030M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **11000** | mg/kg | |
| Arsenic | **12** | mg/kg | |
| Cadmium | 0.18 | mg/kg | |
| Iron | **18000** | mg/kg | |
| Manganese | **390** | mg/kg | |
| Potassium | 1100 | mg/kg | |
| Sodium | 320 | mg/kg | |
| Vanadium | **16** | mg/kg | |

## Legend

Vegetation

Streams / Diches

Piping

Road

10 ft Contour Lines

2 ft Contour Lines

Walkway

Building

Fence

Surface Soil (0-1 ft) Multi-increment Sample Location

Sediment Multi-increment Sample Location

Steam Line Post

Notes:

J - estimated value
If Result = or > Background, then the value is presented with a shaded/highlighted style
If Result = or > Background & PRG, then result is presented with a bold + shaded/highlighted style.
If Result = or > PRG, then the value is presented with a bold style.
Result < PRG & Background, then the value is presented with a normal style.
Mg/Kg - Milligrams per Kilogram (parts per million - ppm)

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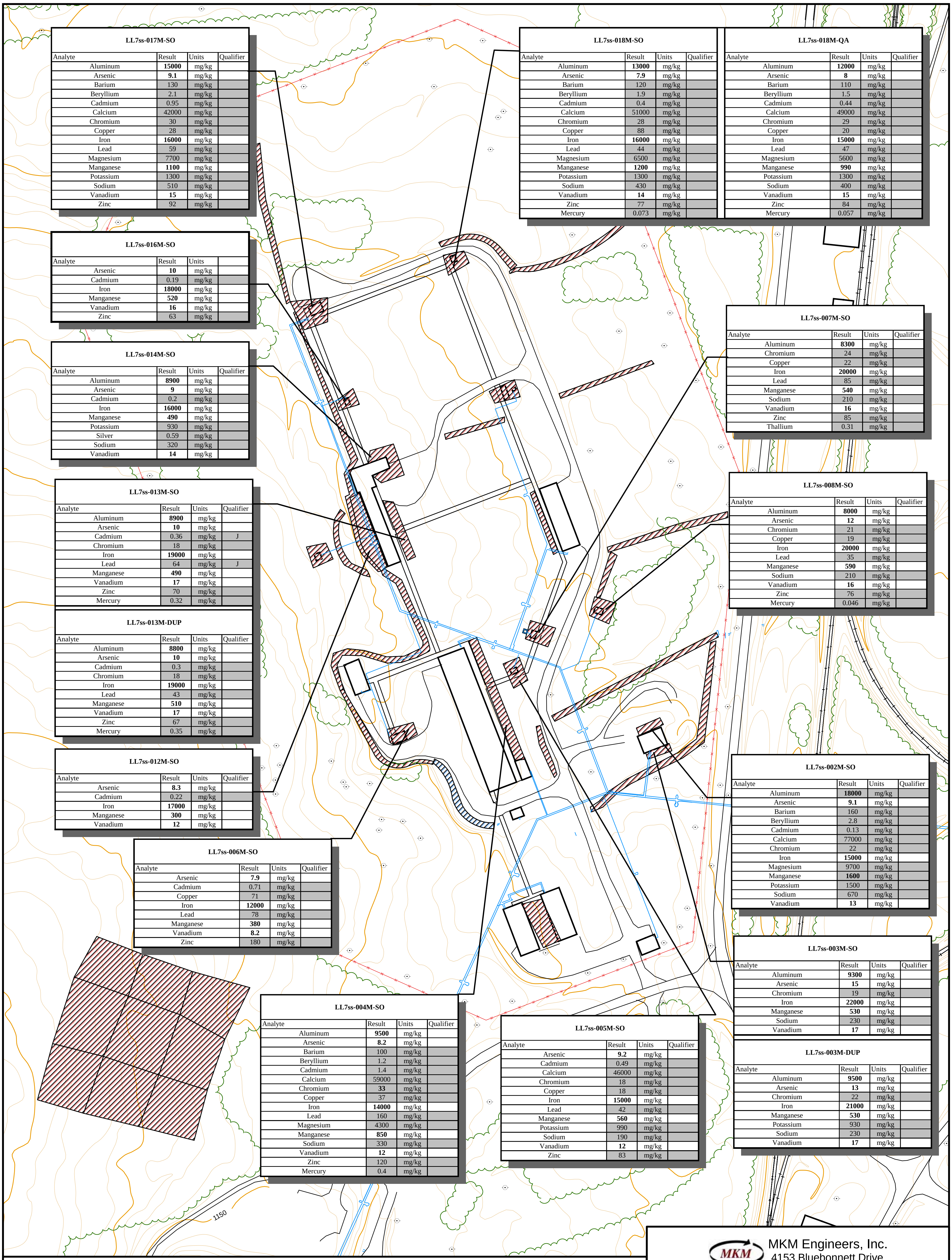
Stafford, TX 77477

## Ravenna Army Ammunition Plant
Ravenna, Ohio
Figure LL7-8A
*Load Line 7*
*Soil and Sediment Sample Locations*
*Exceedences-Inorganics*

| Drawn By: | Checked By: | Date Drawn: | Project No.: |
|---|---|---|---|
| R. Haverkos | MGS | 15 July 06 | 04-02-0030 |

0 75 150 300 Feet

N W E S



### LL7ss-017M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **15000** | mg/kg | |
| Arsenic | **9.1** | mg/kg | |
| Barium | 130 | mg/kg | |
| Beryllium | 2.1 | mg/kg | |
| Cadmium | 0.95 | mg/kg | |
| Calcium | 42000 | mg/kg | |
| Chromium | 30 | mg/kg | |
| Copper | 28 | mg/kg | |
| Iron | **16000** | mg/kg | |
| Lead | 59 | mg/kg | |
| Magnesium | 7700 | mg/kg | |
| Manganese | **1100** | mg/kg | |
| Potassium | 1300 | mg/kg | |
| Sodium | 510 | mg/kg | |
| Vanadium | **15** | mg/kg | |
| Zinc | 92 | mg/kg | |

### LL7ss-018M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **13000** | mg/kg | |
| Arsenic | **7.9** | mg/kg | |
| Barium | 120 | mg/kg | |
| Beryllium | 1.9 | mg/kg | |
| Cadmium | 0.4 | mg/kg | |
| Calcium | 51000 | mg/kg | |
| Chromium | 28 | mg/kg | |
| Copper | 88 | mg/kg | |
| Iron | **16000** | mg/kg | |
| Lead | 44 | mg/kg | |
| Magnesium | 6500 | mg/kg | |
| Manganese | **1200** | mg/kg | |
| Potassium | 1300 | mg/kg | |
| Sodium | 430 | mg/kg | |
| Vanadium | **14** | mg/kg | |
| Zinc | 77 | mg/kg | |
| Mercury | 0.073 | mg/kg | |

### LL7ss-018M-QA

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **12000** | mg/kg | |
| Arsenic | **8** | mg/kg | |
| Barium | 110 | mg/kg | |
| Beryllium | 1.5 | mg/kg | |
| Cadmium | 0.44 | mg/kg | |
| Calcium | 49000 | mg/kg | |
| Chromium | 29 | mg/kg | |
| Copper | 20 | mg/kg | |
| Iron | **15000** | mg/kg | |
| Lead | 47 | mg/kg | |
| Magnesium | 5600 | mg/kg | |
| Manganese | **990** | mg/kg | |
| Potassium | 1300 | mg/kg | |
| Sodium | 400 | mg/kg | |
| Vanadium | **15** | mg/kg | |
| Zinc | 84 | mg/kg | |
| Mercury | 0.057 | mg/kg | |

### LL7ss-016M-SO

| Analyte | Result | Units | |
|---|---|---|---|
| Arsenic | **10** | mg/kg | |
| Cadmium | 0.19 | mg/kg | |
| Iron | **18000** | mg/kg | |
| Manganese | **520** | mg/kg | |
| Vanadium | **16** | mg/kg | |
| Zinc | 63 | mg/kg | |

### LL7ss-014M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **8900** | mg/kg | |
| Arsenic | **9** | mg/kg | |
| Cadmium | 0.2 | mg/kg | |
| Iron | **16000** | mg/kg | |
| Manganese | **490** | mg/kg | |
| Potassium | 930 | mg/kg | |
| Silver | 0.59 | mg/kg | |
| Sodium | 320 | mg/kg | |
| Vanadium | **14** | mg/kg | |

### LL7ss-007M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **8300** | mg/kg | |
| Chromium | 24 | mg/kg | |
| Copper | 22 | mg/kg | |
| Iron | **20000** | mg/kg | |
| Lead | 85 | mg/kg | |
| Manganese | **540** | mg/kg | |
| Sodium | 210 | mg/kg | |
| Vanadium | **16** | mg/kg | |
| Zinc | 85 | mg/kg | |
| Thallium | 0.31 | mg/kg | |

### LL7ss-013M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **8900** | mg/kg | |
| Arsenic | **10** | mg/kg | |
| Cadmium | 0.36 | mg/kg | J |
| Chromium | 18 | mg/kg | |
| Iron | **19000** | mg/kg | |
| Lead | 64 | mg/kg | J |
| Manganese | **490** | mg/kg | |
| Vanadium | **17** | mg/kg | |
| Zinc | 70 | mg/kg | |
| Mercury | 0.32 | mg/kg | |

### LL7ss-013M-DUP

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **8800** | mg/kg | |
| Arsenic | **10** | mg/kg | |
| Cadmium | 0.3 | mg/kg | |
| Chromium | 18 | mg/kg | |
| Iron | **19000** | mg/kg | |
| Lead | 43 | mg/kg | |
| Manganese | **510** | mg/kg | |
| Vanadium | **17** | mg/kg | |
| Zinc | 67 | mg/kg | |
| Mercury | 0.35 | mg/kg | |

### LL7ss-008M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **8000** | mg/kg | |
| Arsenic | **12** | mg/kg | |
| Chromium | 21 | mg/kg | |
| Copper | 19 | mg/kg | |
| Iron | **20000** | mg/kg | |
| Lead | 35 | mg/kg | |
| Manganese | **590** | mg/kg | |
| Sodium | 210 | mg/kg | |
| Vanadium | **16** | mg/kg | |
| Zinc | 76 | mg/kg | |
| Mercury | 0.046 | mg/kg | |

### LL7ss-012M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Arsenic | **8.3** | mg/kg | |
| Cadmium | 0.22 | mg/kg | |
| Iron | **17000** | mg/kg | |
| Manganese | **300** | mg/kg | |
| Vanadium | **12** | mg/kg | |

### LL7ss-002M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **18000** | mg/kg | |
| Arsenic | **9.1** | mg/kg | |
| Barium | 160 | mg/kg | |
| Beryllium | 2.8 | mg/kg | |
| Cadmium | 0.13 | mg/kg | |
| Calcium | 77000 | mg/kg | |
| Chromium | 22 | mg/kg | |
| Iron | **15000** | mg/kg | |
| Magnesium | 9700 | mg/kg | |
| Manganese | **1600** | mg/kg | |
| Potassium | 1500 | mg/kg | |
| Sodium | 670 | mg/kg | |
| Vanadium | **13** | mg/kg | |

### LL7ss-006M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Arsenic | **7.9** | mg/kg | |
| Cadmium | 0.71 | mg/kg | |
| Copper | 71 | mg/kg | |
| Iron | **12000** | mg/kg | |
| Lead | 78 | mg/kg | |
| Manganese | **380** | mg/kg | |
| Vanadium | **8.2** | mg/kg | |
| Zinc | 180 | mg/kg | |

### LL7ss-003M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **9300** | mg/kg | |
| Arsenic | **15** | mg/kg | |
| Chromium | 19 | mg/kg | |
| Iron | **22000** | mg/kg | |
| Manganese | **530** | mg/kg | |
| Sodium | 230 | mg/kg | |
| Vanadium | **17** | mg/kg | |

### LL7ss-004M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **9500** | mg/kg | |
| Arsenic | **8.2** | mg/kg | |
| Barium | 100 | mg/kg | |
| Beryllium | 1.2 | mg/kg | |
| Cadmium | 1.4 | mg/kg | |
| Calcium | 59000 | mg/kg | |
| Chromium | **33** | mg/kg | |
| Copper | 37 | mg/kg | |
| Iron | **14000** | mg/kg | |
| Lead | 160 | mg/kg | |
| Magnesium | 4300 | mg/kg | |
| Manganese | **850** | mg/kg | |
| Sodium | 330 | mg/kg | |
| Vanadium | **12** | mg/kg | |
| Zinc | 120 | mg/kg | |
| Mercury | 0.4 | mg/kg | |

### LL7ss-005M-SO

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Arsenic | **9.2** | mg/kg | |
| Cadmium | 0.49 | mg/kg | |
| Calcium | 46000 | mg/kg | |
| Chromium | 18 | mg/kg | |
| Copper | 18 | mg/kg | |
| Iron | **15000** | mg/kg | |
| Lead | 42 | mg/kg | |
| Manganese | **560** | mg/kg | |
| Potassium | 990 | mg/kg | |
| Sodium | 190 | mg/kg | |
| Vanadium | **12** | mg/kg | |
| Zinc | 83 | mg/kg | |

### LL7ss-003M-DUP

| Analyte | Result | Units | Qualifier |
|---|---|---|---|
| Aluminum | **9500** | mg/kg | |
| Arsenic | **13** | mg/kg | |
| Chromium | 22 | mg/kg | |
| Iron | **21000** | mg/kg | |
| Manganese | **530** | mg/kg | |
| Potassium | 930 | mg/kg | |
| Sodium | 230 | mg/kg | |
| Vanadium | **17** | mg/kg | |

## Legend

| | | | |
|---|---|---|---|
| Vegetation | Road | Walkway | Surface Soil (0-1 ft) Multi-increment Sample Location |
| Streams / Ditches | 10 ft Contour Lines | Building | Sediment Multi-increment Sample Location |
| Piping | 2 ft Contour Lines | Fence | Steam Line Post |

Notes:

J - estimated value
If Result = or > Background, then the value is presented with a shaded/highlighted style
If Result = or > Background & PRG, then result is presented with a bold + shaded/highlighted style.
If Result = or > PRG, then the value is presented with a bold style.
Result < PRG & Background, then the value is presented with a normal style.
Mg/Kg - Milligrams per Kilogram (parts per million - ppm)

MKM Engineers, Inc.
4153 Bluebonnett Drive
Stafford, TX 77477

# Ravenna Army Ammunition Plant

Ravenna, Ohio

Figure LL7-8B

*Load Line 7*

*Soil and Sediment Sample Locations Exceedences-Inorganics*

| Drawn By: | Checked By: | Date Drawn: | Project No.: |
|---|---|---|---|
| R. Haverkos | MGS | 15 July 06 | 04-02-0030 |