Data Summary and Evaluation Report

For Investigation Of

High Priority Sites Potentially Contaminated With Lead

Prepared for

United States Army Engineer District, Kansas City
CEMRK-ED-TP
601 East 12th Street
Kansas City, Missouri 64106-2896

Submitted by

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1819 H Street, N.W., Suite 900
Washington, D.C. 20006

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1.0 Introduction

This report summarizes the results of a site investigation of four areas at Fort Riley, Kansas that had been identified as potentially being contaminated with lead bullet fragments.

1.1 Background

As part of the Installation-Wide Site Assessment (IWSA) conducted at Fort Riley, Kansas in 1992 (LBA,7 December 1992, revised 16 February 1993), four areas were identified where soil, in areas accessible to the general public (especially children), were suspected of being contaminated with lead bullet fragments. For details of the investigation leading up to this finding, consult the IWSA. The four areas were as follows:

> Former Camp Forsyth Range (CFR) areas including the Colyer Manor housing area
>
> Former Mullins Park (FMP), which received soil from the pistol range area of the former Camp Forsyth Ranges
>
> Ware and Custer Hill Elementary Schools, which received fill material taken from near the range areas on Custer Hill

1.2 Approach

A Sampling and Analysis Plan (SAP), dated 10 May 1993 was prepared for the investigation by LBA and approved by the US EPA Region VII and the Kansas Department of Health and the Environment (KDHE). This SAP is enclosed as an appendix to this report along with two technical memoranda that were used to clarify certain aspects of the field work. The grid originally included in the SAP was modified as necessary in the field to avoid structures and take advantage of the terrain. In general, the coverage was improved over that originally planned.

The actual field work took place over a three week period from 19 May through 10 June 1993. As described in the SAP, soil samples were collected using hand augers in one-foot increments from the surface to a depth of over five feet in some cases. A representative portion of the samples from each site were taken to three foot depths in order to meet EPA risk management criteria. The original sampling grid was developed to provide adequate coverage to assess the possible contamination. It involved collecting 301 samples of soil for field screening by X-Ray Florescence. In addition, 37 samples were sent to the laboratory for comparison. A subset of the samples with total lead concentrations greater than 100 mg/kg were selected to evaluate the leachability of metals from the soils and characterize the soils with respect to the RCRA criteria for hazardous waste. Flexible criteria were built into the SAP to expand the grid to delineate any areas of contamination that were found. The sample grid was expanded around any sample point with a lead concentration of 200 ppm or greater (analyzed by XRF). The expansion consisted of additional samples collected along the gridlines, not diagonals, till the areas of contamination were defined to within plus or minus 20 to 50 feet. As a result of findings of lead by XRF, additional samples were collected and a total of 427 samples were analyzed by XRF.

The XRF is regarded as the primary analysis tool. The laboratory analyses are intended as a means of providing a level of quality control to ensure that the XRF did not overstate or underestimate contamination. It is recognized that XRF measures surface lead whereas the laboratory methods measure total lead. Thus, it is likely that lead particulates (bullet fragments) would tend to give higher results by total lead methods than by XRF. This factor was taken into consideration when setting the criteria for expanding the grid in the SAP.

The EPA criterion of 500 mg/kg was used to determine the level of concern and, in anticipation of some bias in the XRF data towards lower results than the laboratory results, 200 mg/kg by XRF was set as the trigger for delineating the area of contamination. As the field work developed, it became feasible to determine the depth of contamination as well as its areal extent. The leaching tests allow the soil to be classified with respect to its potential to leach lead into ground water and to classify it with respect to the RCRA hazardous waste criteria.

Samples were collected with a hand auger in one-foot segments. The segments of soil were homogenized in a plastic bag in the field then a one-quart zip-lock bag was collected and labeled as the sample. Splits for quality assurance laboratory analysis (MRD) and the project laboratory (Continental Analytical Services, Inc.) were made at this point. The sampling points were backfilled with clean soil in the top 6" to prevent exposure and all cuttings were returned to the hole or removed from the site. Sample preparation for XRF consisted of drying the sample by rolling a thin section between sheets of wax paper and exposing to warm air as necessary. The dried samples (only a small percentage of the samples actually needed drying) were crushed by hand and sifted through a flour sifter to obtain a consistent free-flowing powder. About a teaspoon of soil was placed in the XRF measuring cup and covered with thin plastic held in place with special snap rings. These cups were labeled on the bottom with the sample numbers and analyzed following the manufacturer's directions. The counting times for the X-ray sources were set to give the following detection limits (all these elements were determined simultaneously):

Lead (Pb)	40 mg/kg
Zinc (Zn)	200 mg/kg
Copper (Cu)	200 mg/kg
Iron (Fe)	7000 mg/kg
Barium (Ba)	200 mg/kg
Uranium (U)	50 mg/kg

These metals were selected because the X-ray source used in conducting lead analysis is the same as that used in analysis of the other metals. The additional data was collected for informational purposes. Analysis for antimony were not conducted because it would require the use of a different X-ray source. Samples representing the range of concentrations found in the XRF results were sent to the laboratory. The comparison of XRF and laboratory data is made in section 3.0 of this report. As discussed in section 4.0, there is enough information available from this work to propose remedial alternatives without further investigation.

Table 1-1 - Analytical Methods

Analysis	EPA Method Number
Antimony, Total	204.2/7041
Copper, Total	200.7/6010
Lead, Total	239.2/7421
Zinc, Total	200/7/6010
Arsenic, TCLP	206.2/7060
Barium, TCLP	200.7/6010
Cadmium, TCLP	200.7/6010
Chromium, TCLP	200.7/6010
Lead, TCLP	200.7/6010
Mercury, TCLP	200.7/6010
Selenium, TCLP	270.2/7740
Silver, TCLP	200.7/6010
TCLP Prep.	1311

1.3 Scope

This report is limited to a summary of the data obtained from the execution of the SAP. It is not a full Site Investigation report. The Site Investigation report will include additional information on the site history and geology, as well as a discussion of the regulatory impacts. The scope of the field work was intended to address primarily the question of whether or not there were levels of lead contamination in near-surface soils that would be a hazard to the community.

2.0 Observations and Findings

In this section, the principal results of the investigation are reported. This is done primarily through use of site maps on which the sampling locations are recorded with sample numbers. The sample numbering system was generally as follows:

> CFR (former Camp Forsyth Ranges), FMP (Former Mullins Park), WESS (Ware Elementary School), or CHES (Custer Hill Elementary School) were used to identify the sites. Other miscellaneous designators were used for unplanned samples added to the program as the grids were expanded.
>
> The site identifier was sometimes followed by a "B" to designate a planned "background" sample that was identified in the original grids in the SAP. For practical purposes, there is no difference in the way these samples were collected and handled as compared to that of the other samples. The background samples were expected to be low in contamination based upon the knowledge about the site before sampling began.
>
> After the site identifier, there is a sample number. These numbers are more or less in sequence, but there are gaps that were left to allow expansion in some areas and there are some sample numbers that were generated for blind duplicates that are not on the map.
>
> Some samples were taken as sediment samples. These were scooped from the surface of drainage ditches and are designated with the letter "S" before the sample number. Samples taken from playgrounds and ball fields were also scooped composites from the surface but they do not have any special identifier.
>
> After the sample number, there is an indication of the depth that the sample was taken. With the exceptions of the sediment samples and the scoop samples from playgrounds and ball fields, samples were always taken in one-foot segments. The segment taken between the surface and 1 foot depth (0-1') is designated "1", the segment taken between 1 foot and 2 foot depth (1'-2') is designated "2", and so forth. Most frequently, only 0-1' samples were taken; but a number of samples were taken to 3 feet; and a few samples were taken to over 5 feet to delineate the vertical extent of contamination.

Thus, the sample number "CFR-035-1" means the sample was taken at point "35" at the former Camp Forsyth Ranges and it was the segment between the surface and 1 foot depth. There are several elaborations and exceptions to this system that were produced as field work focused upon delineating an area of contamination found north of Building 3135, a residential building. These will be explained in the text.

A comparison of the XRF results to laboratory results in found in Section 3.1. All soil samples were analyzed for uranium using XRF. No samples collected contained detectable concentrations of uranium (greater than 50 mg/kg). For this reason, the results of the uranium analysis are not included in the data summary tables.

2.1 Camp Forsyth Ranges

The area of this study covered a large area, beginning in the west near Trooper Road and following in a strip about 400 feet wide for a distance of about a mile along the base of the bluff ending in the east just north of the water supply well field. Near the middle of this strip, it was extended in width to encompass several ball fields and recreational areas that border on McCormick Road. The general area is shown on Plate 1. The XRF results are summarized in Table 2-1. The original sampling grid was 200 feet.

2.1.1 General Survey

The majority of samples from this area were found to be below the detection limit of the XRF for lead (less than 40 mg/kg), zinc (less than 200 mg/kg), copper (less than 200 mg/kg) and uranium (less than 50 mg/kg). On the other hand, iron, and barium were found at detectable levels in every sample. Most of the iron levels were between 10,000 and 20,000 mg/kg (i.e., 1 to 2%) and most of the barium levels were between 250 and 350 mg/kg by XRF.

The samples analyzed in the laboratory, suggest that the background levels of lead in these soils are typically in the range 10 to 30 mg/kg. (See data in 3.1.)

Two samples had unexpectedly high levels of zinc. These were both sediment samples taken from the drainage ditch that runs east-west between Booth Avenue and Moore Avenue east of King avenue. CFR-S04 had 1900 mg/kg zinc and 61 mg/kg lead by XRF and CFR-S05 had 215 mg/kg zinc and less than 40 mg/kg lead by XRF. Initially galvanized corrogated culverts were suspected, but none were observed in this area. Inspection of this ditch indicated that it was used for dumping grass cuttings by the local residents and it had a dark oily appearance as though it may have also been used to dump engine oil. Analysis for hydrocarbons was conducted in order to explain the elevated zinc levels (zinc is a common motor oil additive). These samples were sent to the laboratory for confirmation of the metals and analysis for hydrocarbons. The following laboratory results are consistent with disposal of used engine oil that contains zinc anti-oxidants and residues from leaded gasoline.

Sample	**CFR-S04**	**CFR-S05**
Semivolatile Pet. hydrocarbon (motor oil)	230 mg/kg	71 mg/kg
Lead (XRF)	61 mg/kg	<40 mg/kg
Lead (total)	112 mg/kg	50 mg/kg
Zinc (XRF)	1900 mg/kg	215 mg/kg
Zinc (total)	1100 mg/kg	180 mg/kg
Copper (total)	10 mg/kg	10 mg/kg
Antimony (total)	<5 mg/kg	<5 mg/kg

The entire area in the vicinity of the old pistol range at the east end of the CFR study area appears to have XRF lead in the range of 100 to 200 mg/kg in the top one to two feet of soil. The berms that are shown on the 1985 Corps of Engineers topographic maps have been graded to produce a level area. Some soil from this area was moved to the former Mullins Park (see below) where similar load levels were found. It appears that the grading activities spread the lead more or less evenly over the area. No areas of high concentration were found.

Except as discussed below, no high lead levels were found around the Colyer Manor housing area. Specifically, lead content in the playgrounds, ball fields and near the houses were almost always below the XRF detection limit. The single area of high lead levels is discussed below.

2.1.2 Area Behind Building 3135

In the initial grid, point CFR-035-1 was found to have high lead levels. Two separate sample preparations of the same bag of soil on two different days gave the following results:

Date analyzed:	**3 June 1993**	**5 June 1993**	**12 June 1993**
Lead (XRF)	1700 mg/kg	1500 mg/kg	***********
Lead (total)	**********	***********	3000 mg/kg
Copper (XRF)	390 mg/kg	300 mg/kg	************
Copper (total)	***********	************	410 mg/kg
Antimony (total)	***********	************	less than 5 mg/kg
Zinc (total)	***********	************	95 mg/kg

It is also noted that the laboratory results subsequently confirmed the XRF data. The SAP called for expanding the grid in this area to delineate the area of contamination. Unfortunately, the area had been mowed and initial attempts to relocate sampling point "035" were unsuccessful. Using the topographic map and the indicated location, a new point "CFR-035X" was established and samples were collected at one-foot intervals to hand auger-refusal (i.e., to 5.5 feet where limestone rocks were encountered). Four points, were also set out at 25-foot intervals from "035X". These were nominally at the points of the compass (N,S,E,W) and were identified "CFR-035XN" etc. Ironically, the samples collected at "035X" proved to have no detectable lead. Similar results were found at the N, S, and W points. At the "035XE" point, high levels of lead were found and a rake was used to remove thatch from the area to find the original "035" which turned out to be about 15 feet south of the "035X" point (i.e., about 10 feet north of the 035XS point). The sampling grid was extended to the east and north from this area and other points were placed along the same general line along the ridge at 25 foot spacings and near the housing units to the south. The end result of this effort is shown in Plate 2. The XRF data for this area is summarized in Table 2-2.

Table 2-1 XRF For The Former Camp Forsyth Range Areas

Results in mg/kg		**Lead**	**Zinc**	**Copper**	**Iron**	**Barium**
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**					
CFR-001-1		110	<	<	15000	380
CFR-001-1 (B)		<	<	<	11000	300
CFR-001-1 (B)	Duplicate XRF Run	<	<	<	12000	360
CFR-001E-1		<	<	<	15000	320
CFR-001N-1		<	<	<	20000	350
CFR-001S-1		<	<	<	14000	280
CFR-001S-1		<	<	<	14000	320
CFR-001W-1		90	<	<	17000	320
CFR-002-1		<	<	<	12000	290
CFR-003-1		110	<	<	14000	270
CFR-003-2		74	<	<	15000	280
CFR-003-3		<	<	<	14000	260
CFR-003E-1		170	<	<	14000	310
CFR-003N-1		280	<	<	15000	310
CFR-003S-1		<	<	<	14000	300
CFR-003W-1		<	<	<	14000	280
CFR-004-1		<	<	<	13000	310
CFR-005-1		<	<	<	12000	270
CFR-006-1		<	<	<	13000	280
CFR-006-2		<	<	<	14000	260
CFR-006-3		<	<	<	16000	270
CFR-007-1		<	<	<	14000	290
CFR-008-1		<	<	<	13000	280
CFR-009-1		<	<	<	13000	290
CFR-010-1		<	<	<	14000	270

Table 2-1 Cont'd

		Lead	**Zinc**	**Copper**	**Iron**	**Barium**
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**					
CFR-011-1		<	<	<	14000	260
CFR-011N-1		<	<	<	15000	300
CFR-011W-1		<	<	<	16000	300
CFR-012-1		<	<	<	13000	290
CFR-012-1	Duplicate XRF Run	<	<	<	13000	270
CFR-012-2		130	<	<	14000	340
CFR-012-3		88	<	<	14000	280
CFR-012E-1		<	<	<	14000	320
CFR-012N-1		<	<	<	15000	300
CFR-012S-1		<	<	<	14000	290
CFR-012W-1		<	<	<	15000	340
CFR-013-1		<	<	<	12000	300
CFR-014-1		87	<	<	14000	310
CFR-015-1		<	<	<	16000	300
CFR-016-1		<	<	<	17000	310
CFR-018-1		<	<	<	19000	350
CFR-018-1	Duplicate XRF Run	<	<	<	19000	290
CFR-018-2		<	<	<	18000	390
CFR-019-1		<	<	<	14000	250
CFR-019-2		<	<	<	13000	310
CFR-019-3		<	<	<	15000	250
CFR-020-1		<	<	<	14000	270
CFR-021-1		<	<	<	13000	360
CFR-022-1		<	<	<	14000	280
CFR-022-2		<	<	<	15000	280
CFR-022-3		<	<	<	15000	280
CFR-023-1		<	<	<	14000	250

Table 2-1 Cont'd

		Lead	Zinc	Copper	Iron	Barium
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**					
CFR-023-1	Duplicate XRF Run	<	<	<	13000	230
CFR-024-1		<	<	<	15000	340
CFR-025-1		<	<	<	13000	360
CFR-026-1		<	<	<	12000	270
CFR-027-1		<	<	<	11000	310
CFR-027-2		<	<	<	14000	350
CFR-027-3		<	<	<	18000	300
CFR-028-1		<	<	<	14000	310
CFR-029-1		<	<	<	12000	350
CFR-030-1		<	<	<	14000	260
CFR-030-2		<	<	<	22000	350
CFR-030-3		<	<	<	23000	350
CFR-031-1		<	<	<	13000	320
CFR-032-1		<	<	<	13000	360
CFR-033-1		<	<	<	12000	330
CFR-034-1		<	<	<	14000	310
CFR-035-1		1700	<	390	15000	270
CFR-035-1	Duplicate XRF Run	1500	<	300	16000	320
CFR-036-1		<	<	<	15000	220
CFR-037-1		<	<	<	20000	360
CFR-038-1		<	<	<	15000	270
CFR-039-1		<	<	<	15000	300
CFR-039-2		<	<	<	17000	310
CFR-039-3		<	<	<	17000	320
CFR-040-1		<	<	<	14000	230
CFR-041-1		<	<	<	15000	320
CFR-042-1		<	<	<	15000	290

Table 2-1 Cont'd

		Lead	Zinc	Copper	Iron	Barium
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**					
CFR-043-1		<	<	<	16000	260
CFR-044-1		<	<	<	16000	330
CFR-045-1		<	<	<	15000	300
CFR-045-1	Duplicate XRF Run	<	<	<	14000	320
CFR-046-1		<	<	<	13000	260
CFR-047-1	Field Blank	<	<	<	14000	300
CFR-047-2	Field Blank	<	<	<	16000	320
CFR-047-3	Field Blank	<	<	<	16000	300
CFR-049-1		<	<	<	19000	360
CFR-050-1		<	<	<	14000	250
CFR-050-2		<	<	<	15000	240
CFR-050-3		<	<	<	14000	280
CFR-051-1		<	<	<	14000	290
CFR-052-1		52	<	<	14000	290
CFR-052-2		<	<	<	14000	280
CFR-052-3		<	<	<	16000	340
CFR-053-1		<	<	<	14000	250
CFR-054-1		<	<	<	14000	310
CFR-054-2		<	<	<	14000	270
CFR-054-3		<	<	<	15000	310
CFR-055-1		<	<	<	13000	240
CFR-056-1		<	<	<	12000	250
CFR-056-1	Duplicate XRF Run	<	<	<	13000	260
CFR-056-2		<	<	<	14000	290
CFR-056-3		<	<	<	12000	340
CFR-057-1		<	<	<	13000	260
CFR-057-1	Duplicate XRF Run	<	<	<	14000	290

Table 2-1 Cont'd

		Lead	**Zinc**	**Copper**	**Iron**	**Barium**
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**					
CFR-058-1		<	<	<	14000	270
CFR-059-1		<	<	<	19000	380
CFR-060-1		<	<	<	11000	300
CFR-061-1		<	<	<	12000	250
CFR-062-1		<	<	<	13000	260
CFR-063-1		<	<	<	13000	320
CFR-063-2		<	<	<	12000	360
CFR-063-3		<	<	<	12000	290
CFR-064-1		<	<	<	15000	350
CFR-065-1		<	<	<	18000	280
CFR-065-2		<	<	<	18000	320
CFR-065-3		<	<	<	17000	350
CFR-066-1		<	<	<	17000	310
CFR-067-1		<	<	<	13000	250
CFR-068-1		<	<	<	13000	270
CFR-069-1		<	<	<	13000	310
CFR-069-2		<	<	<	13000	290
CFR-069-3		<	<	<	15000	310
CFR-070-1		<	<	<	13000	260
CFR-071-1		<	<	<	13000	290
CFR-072-1		<	<	<	14000	280
CFR-072-2		<	<	<	16000	260
CFR-072-3		<	<	<	16000	270
CFR-073-1		<	<	<	14000	290
CFR-074-1		<	<	<	15000	290
CFR-074-1	Duplicate XRF Run	<	<	<	15000	240
CFR-075-1		<	<	<	14000	290

Table 2-1 Cont'd

		Lead	**Zinc**	**Copper**	**Iron**	**Barium**
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**					
CFR-076-1		<	<	<	14000	250
CFR-077-1		<	<	<	14000	300
CFR-078-1		<	<	<	14000	300
CFR-078-2		<	<	<	14000	330
CFR-078-3		<	<	<	14000	250
CFR-079-1		<	<	<	15000	310
CFR-080-1		<	<	<	16000	340
CFR-082-1		<	<	<	14000	320
CFR-083-1		<	<	<	12000	270
CFR-084-1	Surface of ball field	<	<	<	16000	250
CFR-084-0.5	Surface of ball field	<	<	<	17000	290
CFR-085-0.5	Surface of ball field	<	<	<	17000	350
CFR-085-0.5	Duplicate XRF Run	<	<	<	16000	270
CFR-086-0.5	Surface of ball field	<	<	<	17000	340
CFR-087-0.5	Surface of ball field	<	<	<	15000	260
CFR-113-1	Surface of playground	<	<	<	15000	310

Table 2-2 Samples Taken to Delineate the Area of Contamination Behind Building 3135

Results in mg/kg		**Lead**	**Zinc**	**Copper**	**Iron**	**Barium**
	Detection Limits	40	200	200	7000	200
Sample ID	**Notes**					
BLDG-3133-1	20' from building	<	<	<	15000	290
BLDG-3135-1	15' from building	<	<	<	13000	320
BLDG-3137-1	20' from building	<	<	<	15000	330
CFR-025E035XE-1		1400	<	<	15000	270
CFR-025E035XE-2		1100	<	<	15000	320
CFR-025E035EX-3		630	<	<	15000	210
CFR-025NE35XE-1		920	<	<	16000	340
CFR-025SE35XE-1		140	<	<	14000	250
CFR-035-1		1700	<	390	15000	270
CFR-035X-1		<	<	<	14000	300
CFR-035X-2		<	<	<	14000	270
CFR-035X-3		<	<	<	16000	280
CFR-035X-4		<	<	<	19000	360
CFR-035X5		<	<	<	19000	350
CFR-035X-5.5		<	<	<	19000	340
CFR-035XE-1		1200	<	220	15000	290
CFR-035XE-1	Duplicate XRF Run	1300	<	310	16000	300
CFR-035XE-2		1100	<	<	15000	300
CFR-035XE-2	Bullet Fragments	29000	910	8800	20000	<
CFR-035XE-3		120	<	<	18000	320
CFR-035XN-1		<	<	<	13000	230
CFR-035XS-1		<	<	<	16000	300
CFR-035XW-1		<	<	<	15000	290
CFR-036-1		<	<	<	15000	220
CFR-040-1	35' from building	<	<	<	14000	230
CFR-041-1	45' from building	<	<	<	15000	320

Table 2-2 Cont'd

		Lead	**Zinc**	**Copper**	**Iron**	**Barium**
	Detection Limits	40	200	200	7000	200
Sample ID	**Notes**					
CFR-101-1	In gully draining hillside	<	<	<	21000	340
CFR-102-1		<	<	<	16000	310
CFR-103-1		<	<	<	14000	270
CFR-103N-1		52	<	<	13000	270
CFR-103S-1		<	<	<	14000	340
CFR-108-1		360	<	<	14000	290
CFR-108-2		220	<	<	14000	240
CFR-108-3		<	<	<	16000	270
CFR-108N-1		790	<	<	15000	300
CFR-108S-1		95	<	<	14000	290
CFR-109-1		63	<	<	15000	320
CFR-109-2		66	<	<	15000	320
CFR-109-3		<	<	<	18000	250
CFR-109N-1		52	<	<	14000	310
CFR-109S-1		59	<	<	14000	270
CFR-120-1		46	<	<	19000	310
CFR-120-2		<	<	<	21000	280
CFR-120-3		<	<	<	19000	330
CFR-121-1		44	<	<	14000	240
CFR-122-1	No Sample					
CFR-122-2		<	<	<	15000	270
CFR-122-3		<	<	<	13000	290
CFR-123-1		41	<	<	13000	310
CFR-124-1		<	<	<	13000	260
CFR-125-1		<	<	<	13000	300
CFR-126-1		<	<	<	12000	260
CFR-127-1		<	<	<	13000	250

Table 2-2 Cont'd

		Lead	Zinc	Copper	Iron	Barium
	Detection Limits	40	200	200	7000	200
Sample ID	**Notes**					
CFR-127-2		<	<	<	13000	250
CFR-127-3		<	<	<	17000	380
CFR-127-4		<	<	<	17000	370
CFR-127-5		<	<	<	19000	310
CFR-128-1		80	<	<	14000	270
CFR-132-1	Within 2' of CFR-035	1100	<	<	16000	320
CFR-132-2	Within 2' of CFR-035	700	<	230	16000	280
CFR-132-3	Within 2' of CFR-035	210	<	<	16000	350
CFR-132-4	Within 2' of CFR-035	49	<	<	19000	370
CFR-132-5	Within 2' of CFR-035	<	<	<	17000	350
CFR-132-6	Within 2' of CFR-035	<	<	<	19000	390
CFR-133-1	Within 2' of CFR-035	1200	<	280	15000	230
CFR-133-1	Duplicate XRF Run	1200	<	240	15000	250
CFR-134-1	Within 2' of CFR-035	990	<	<	16000	300
CFR-134-2	Within 2' of CFR-035	460	<	<	16000	250
CFR-134-3	Within 2' of CFR-035	64	<	<	17000	300
CFR-134-4	Within 2' of CFR-035	<	<	<	19000	290
CFR-134-5	Within 2' of CFR-035	<	<	<	18000	330
CFR-134-6	Within 2' of CFR-035	77	<	<	19000	330

2.2 Former Mullins Park

The area of the former Mullins Park is considerably less accessible than the Colyer Manor area. The area is shown in Plate 3 and the XRF results are summarized in Table 2-3. In general, the levels of lead found in the soils here are similar to the levels found in the former pistol range area east of Colyer Manor (i.e., 100 to 200 mg/kg). This is consistent with the origin of the soils placed in the former Mullins Park area when the pistol range was removed in the mid-1980s. Soil samples were collected from a 200 foot grid.

2.3 Ware Elementary School

The Ware Elementary School area is shown in Plate 4 and the XRF data are presented in Table 2-4. There were no significant findings of lead. Soil samples were collected from a 100 foot grid.

2.4 Custer Hill Elementary School

The Custer Hill Elementary School area is shown in Plate 5 and the XRF data are presented in Table 2-5. There were no significant findings of lead. Soil samples were collected from a 75 foot grid.

2.5 Other Sites

During the course of the investigation and at the request of Fort Riley, three samples were obtained from a garden in the Burnside housing area adjacent to Building 6790. The results for these samples were as follows:

Sample	Lead	Copper	Zinc	Iron	Barium	Uranium
0-1'	<40	<200	<200	19000	220	<50
0-1'	<40	<200	<200	14000	290	<50
0-2"	<40	<200	<200	20000	290	<50

All results in mg/kg by XRF.

Table 2-3 XRF Sample Results For Former Mullins Park

Results in mg/kg		**Lead**	**Zinc**	**Copper**	**Iron**	**Barium**
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**	—	—	—	—	—
FMP-001-1		<	<	<	14000	280
FMP-001-2		<	<	<	12000	320
FMP-001-3		<	<	<	13000	270
FMP-002-1		<	<	<	12000	270
FMP-003-1		<	<	<	14000	290
FMP-003-2		<	<	<	14000	320
FMP-003-3		<	<	<	14000	300
FMP-004-1		<	<	<	13000	290
FMP-005-1		<	<	<	12000	290
FMP-005-2		<	<	<	17000	260
FMP-006-1		45	<	<	12000	280
FMP-006-2		<	<	<	17000	255
FMP-006-3		<	<	<	8900	420
FMP-007-1		<	<	<	13000	310
FMP-007-1	Duplicate XRF Run	<	<	<	13000	290
FMP-008-1		<	<	<	17000	260
FMP-009-1		<	<	<	13000	280
FMP-009-2		<	<	<	13000	340
FMP-009-3		<	<	<	13000	350
FMP-010-1		<	<	<	13000	250
FMP-011-1		<	<	<	14000	270
FMP-011-2		<	<	<	13000	230
FMP-011-3		<	<	<	13000	350
FMP-012-1		<	<	<	12000	270
FMP-013-1		<	<	<	12000	300
FMP-017-1		160	<	<	13000	290

Table 2-3 Cont'd

		Lead	Zinc	Copper	Iron	Barium
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**	—	—	—	—	—
FMP-017-2		<	<	<	8000	290
FMP-017-3		<	<	<	11000	240
FMP-017B-1	Spike	320	<	<	14000	270
FMP-018-1		51	<	<	13000	250
FMP-018-1	Duplicate XRF Run	52	<	<	13000	300
FMP-019-1		<	<	<	9100	420
FMP-020-1		<	<	<	9100	<
FMP-021-1		<	<	<	14000	240
FMP-021-2		<	<	<	12000	290
FMP-021-3		<	<	<	13000	290
FMP-B01-1	Background	<	<	<	18000	290
FMP-B02-1	Background	<	<	<	17000	270
FMP-B02-2	Background	<	<	<	15000	320
FMP-B02-3	Background	<	<	<	17000	330
FMP-B03-1	Background	<	<	<	15000	280

"Spike"- a sample to which metallic lead filings were intentionally added as a quality control check.

"Duplicate XRF Run"- same sample preparation tested a second time by XRF.

"Background" - sample from an area not suspected of lead contamination.

Table 2-4 XRF Results For Ware Elementary School

Results in mg/kg		Lead	Zinc	Copper	Iron	Barium
	Detection Limits (mg/kg)	40	200	200	700	200
Sample ID	Notes					
WESS-001-1		<	<	<	14000	<
WESS-001-2		<	<	<	15000	250
WESS-001-3		<	<	<	17000	340
WESS-002-1		<	<	<	19000	320
WESS-003-1		<	<	<	19000	350
WESS-004-1		<	<	<	17000	310
WESS-005-1		<	<	<	19000	290
WESS-005-2		<	<	<	19000	370
WESS-005-3		<	<	<	19000	340
WESS-006-1		<	<	<	18000	240
WESS-006-2		<	<	<	17000	300
WESS-006-3		<	<	<	16000	270
WESS-007-1		<	<	<	19000	280
WESS-008-1		<	<	<	18000	260
WESS-009-1		<	<	<	19000	260
WESS-010-1		<	<	<	20000	340
WESS-011-1		<	<	<	19000	250
WESS-012-1		<	<	<	18000	260
WESS-013-1		<	<	<	19000	280
WESS-014-1		<	<	<	20000	360
WESS-015-1		<	<	<	21000	290
WESS-015-2		<	<	<	20000	310
WESS-015-3		<	<	<	15000	350
WESS-016-1		<	<	<	20000	260
WESS-017-1		<	<	<	18000	280
WESS-018-1		<	<	<	19000	310

Table 2-4 Cont'd

		Lead	**Zinc**	**Copper**	**Iron**	**Barium**
	Detection Limits (mg/kg)	40	200	200	700	200
Sample ID	**Notes**					
WESS-019-1		<	<	<	18000	340
WESS-020-1		<	<	<	22000	290
WESS-021-1		<	<	<	18000	270
WESS-021-2		<	<	<	17000	230
WESS-021-3		<	<	<	19000	310
WESS-025-1		<	<	<	<	570
WESS-026-1		<	<	<	<	430
WESS-027-1		<	<	<	18000	330
WESS-027-1	Duplicate XRF Run	<	<	<	17000	290
WESS-027-2		<	<	<	19000	310
WESS-027-3		<	<	<	18000	290
WESS-028-1		<	<	<	18000	250
WESS-029-1		<	<	<	15000	250
WESS-030-1		<	<	<	16000	320
WESS-031-1		<	<	<	17000	260
WESS-032-1		<	<	<	17000	290
WESS-032-2		<	<	<	17000	330
WESS-032-3		<	<	<	16000	310
WESS-033-1		<	<	<	16000	280
WESS-034-1		<	<	<	15000	250
WESS-035-1		<	<	<	17000	270
WESS-035-2		<	<	<	18000	360
WESS-035-3		<	<	<	19000	390
WESS-037-1	Surface	<	<	<	<	1500
WESS-038-1	Surface	<	<	<	<	1500
WESS-039-1	Surface	<	<	<	<	1800
WESS-040-1	Surface	<	<	<	<	1200

Table 2-4 Cont'd

		Lead	Zinc	Copper	Iron	Barium
	Detection Limits (mg/kg)	40	200	200	700	200
Sample ID	**Notes**					
WESS-041-1	Surface	<	<	<	<	1300
WESS-042-1	Surface	<	<	<	<	1200
WESS-043-1	Surface	<	<	<	<	480
WESS-B1-1	Background	<	<	<	19000	250
WESS-B1-2	Background	<	<	<	19000	220
WESS-B1-3	Background	<	<	<	18000	250
WESS-B2-1	Background	<	<	<	14000	260
WESS-B3-1	Background	<	<	<	14000	240
WESS-B3-2	Background	<	<	<	15000	240
WESS-B3-3	Background	<	<	<	21000	240
WESS-B4-1	Background	<	<	<	17000	260
WESS-B4-2	Background	<	<	<	15000	310
WESS-B4-3	Background	<	<	<	16000	230
WESS-B5-1	Background	<	<	<	17000	220

"Spike"- a sample to which metallic lead filings were intentionally added as a quality control check.

"Duplicate XRF Run"- same sample preparation tested a second time by XRF.

"Background " - sample from an area not suspected of lead contamination.

"Surface" - samples were scooped from the surface as composites.

Table 2-5 XRF Sample Results For Custer Hill Elementary School

Results in mg/kg		**Lead**	**Zinc**	**Copper**	**Iron**	**Barium**
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**	—	—	—	—	—
CHES-001-1		<	<	<	18000	220
CHES-002-1		<	<	<	19000	270
CHES-002-1		<	<	<	20000	260
CHES-002-2		<	<	<	18000	210
CHES-002-3		<	<	<	19000	240
CHES-003-1		<	<	<	19000	200
CHES-004-1		<	<	<	20000	270
CHES-004A-1		<	<	<	21000	260
CHES-005-1		<	<	<	16000	250
CHES-006-1		<	<	<	14000	<
CHES-007-1		<	<	<	18000	280
CHES-008-1		<	<	<	20000	270
CHES-009-1		<	<	<	21000	240
CHES-009-2		<	<	<	20000	250
CHES-009-3		<	<	<	20000	230
CHES-010-1		<	<	<	18000	230
CHES-011-1		<	<	<	19000	220
CHES-011-2		<	<	<	19000	<
CHES-011-3		<	<	<	19000	210
CHES-011A-1		<	<	<	19000	240
CHES-011A-2		<	<	<	17000	220
CHES-011A-3		<	<	<	21000	300
CHES-012-1		<	<	<	14000	230
CHES-013-1		<	<	<	16000	<
CHES-014-1		<	<	<	21000	290
CHES-014-2		<	<	<	22000	230

Table 2-5 Cont'd

		Lead	Zinc	Copper	Iron	Barium
	Detection Limits (mg/kg)	40	200	200	7000	200
Sample ID	**Notes**	—	—	—	—	—
CHES-014-3		<	<	<	24000	310
CHES-015-1		<	<	<	19000	240
CHES-016-1		<	<	<	19000	270
CHES-017-1		<	<	<	20000	250
CHES-017A-1		<	<	<	18000	250
CHES-018-1		<	<	<	19000	240
CHES-018-2		<	<	<	21000	250
CHES-018-3		<	<	<	21000	220
CHES-019-1		<	<	<	20000	240
CHES-020-1		<	<	<	16000	270
CHES-021-1		<	<	<	20000	270
CHES-022-1		<	<	<	21000	240
CHES-023-1		<	<	<	20000	230
CHES-023-2		<	<	<	13000	<
CHES-023-3		<	<	<	<	<
CHES-024-1		<	<	<	20000	280
CHES-025-1		<	<	<	19000	240
CHES-B1-1	Background	<	<	<	15000	<
CHES-B2-1	Background	<	<	<	20000	240
CHES-B3-1	Background	<	<	<	23000	250
CHES-B4-1	Background	<	<	<	29000	400
CHES-B4-2	Background	<	<	<	25000	360
CHES-B5-1	Background	<	<	<	19000	280
CHES-B5-2	Background	<	<	<	16000	230
CHES-B5-3	Background	<	<	<	20000	340
CHES-B6-1	Background	<	<	<	23000	400

"Spike"- a sample to which metallic lead filings were intentionally added as a quality control check.
"Duplicate XRF Run"- same sample preparation tested a second time by XRF.
"Background " - sample from an area not suspected of lead contamination.
"Surface" - samples were scooped from the surface as composites.

3.0 Comparison of XRF Results with Other Data

The XRF technique was proposed as a method to quickly and cost effectively screen large numbers of samples for lead. It was expected that XRF would not have as favorable detection limit as laboratory methods and this was determined not to be a significant disadvantage because the XRF could detect the concentrations of concern (i.e., 200 mg/kg). It was also understood that XRF is sensitive to lead in the surface of the sample and may tend to give lower results than methods that involve dissolving the entire sample when particulate lead is involved. This is not regarded as an "error" in the XRF results but rather as an understood and explainable "bias" in the technique, this was accounted for by setting the level of concern for XRF concern at 200 mg/kg while the EPA guideline for lead in soils is 500 mg/kg. Because the bias is dependent on the specific nature of the particles being examined, it is not feasible to develop a "correction factor" to correlate the XRF results to the laboratory results. However, the comparisons that follow show the typical magnitude of the differences. In general, the laboratory results for lead were 2-2.5 times the XRF results. As far as quality control for the XRF data is concerned, it is noted that blanks, spikes, duplicates and check/reference standards were run periodically throughout the investigation.

3.1 Comparison of XRF Results with Laboratory Results

As discussed above, samples that covered the range of XRF results were analyzed in the laboratory for lead and other metals (i.e., antimony, zinc and copper). These results are compared in Table 3-1. In general there is a good correlation between XRF data and Laboratory results. This is consistent with the results that were obtained for a US EPA Standard that was used periodically as a check sample for the XRF. Typical results for these check sample runs were as follows:

Data for EPA Reference Soil Used as Check Sample
(all data in mg/kg)

Element:	Lead	Zinc	Copper	Iron	Barium
Advisory Ranges	45-146	135-369	17-52	5420-12640	173-321
XRF Date					
4 June	48	260	<200	15000	580
4 June	52	260	<200	16000	540
7 June	48	250	<200	15000	580

Table 3-1 Comparison of XRF Results With Laboratory Results

All Data in mg/kg	LEAD		COPPER		ZINC	
SAMPLE	**Lab**	**XRF**	**Lab**	**XRF**	**Lab**	**XRF**
CFR-001-1	260	110	26	<200	48	<200
CFR-003-1 (5/19/93)	360	110	27	<200	40	<200
CFR-003-1 (6/06/93)	420	—	21	—	34	—
CFR-003-3 (5/19/93)	18	<40	8	<200	36	<200
CFR-017-3 Dup of CFR-003-3 (5/19/93)	22	----	10	----	36	----
CFR-003-3 (6/06/93)	17	<40	10	<200	34	<200
CFR-012-1	44	<40	11	<200	36	<200
CFR-018-2	15	<40	16	<200	53	<200
CFR-022-1	60	<40	16	<200	40	<200
CFR-022-2	35	<40	37	<200	100	<200
CFR-022-3	60	<40	18	<200	73	<200
CFR-048-3 Dup of CFR-022-3	50	—	16	----	56	----
CFR-033-1	51	<40	11	<200	43	<200
CFR-035-1	3000	1700	410	390	95	<200
CFR-035X-1	58	<40	14	<200	59	<200
CFR-047-3	10	<40	9	<200	40	<200
CFR-127-3	17	<40	11	<200	45	<200
CFR-129-3 Dup of CFR-127-3	23	----	11	----	48	----
CFR-133-1	3700	1200	160	280	61	<200
CFR-133-1 XRF Duplicate	----	1200	----	240	----	<200
CFRB-006-1	23	<40	7	<200	34	<200
CFRB-006-2	16	<40	7	<200	32	<200
CFRB-006-3	13	<40	7	<200	30	<200

Table 3-1 Cont'd

All Data in mg/kg	LEAD		COPPER		ZINC	
SAMPLE	**Lab**	**XRF**	**Lab**	**XRF**	**Lab**	**XRF**
CFR-S04	112	61	10	<200	1100	1700
CFR-S05	50	<40	10	<200	180	215
WESS-015-1	15	<40	9	<200	45	<200
WESS-016-1	10	<40	8	<200	30	<200
WESS-022-1 Dup of WESS-016-1	11	—	9	—	34	—
WESS-035-1	14	<40	9	<200	36	<200
WESS-005-1	13	<40	9	<200	41	<200
WESS-010-1	14	<40	11	<200	44	<200
CHES-012-1	13	<40	9	<200	49	<200
CHES-014-2	10	<40	9	<200	36	<200
CHES-014-3	9	<40	9	<200	40	<200
CHES-015-1	14	<40	9	<200	39	<200
CHES-016-1	11	<40	9	<200	35	<200
CHES-025-1	14	<40	8	<200	37	<200

Listed dates are when the samples were collected. In some cases, notably CFR-003, a second sample was collected adjacent to the original sample.

3.2 TCLP Results

Leaching tests were performed on two selected samples to determine the RCRA regulatory status in the event that the soil was removed and disposed. The standard Toxicity Characteristic Leaching Procedure (TCLP) test assumes that the material would go into a sanitary landfill (if it were not managed as a hazardous waste) and in that environment the waste is exposed to organic acids, which are used in the TCLP leachate.

As was stated in the Work Plan, the purpose for the TCLP test was to determine the typical leachability of lead, and that only a subset of the samples with lead concentrations greater than 100 mg/kg would be tested. The two samples tested were selected based on their representation of the range of lead concentrations expected on Fort Riley. Table 3-2 summarizes the TCLP results for samples that are believed to present typical materials with significant levels of lead.

From these results, soils containing about 100 mg/kg lead by XRF do not produce significant amounts of leachable (soluble) lead under the TCLP conditions. However, the soils containing high levels (e.g., > 1000 mg/kg) lead by XRF fail the TCLP (buffered acetic acid leachate). This result suggests that these soils will produce substantial amounts of leachable lead if disposed in a sanitary landfill.

Table 3-2 TCLP Results

Sample	**CFR-001-1**			**CFR-035-1**		
Element	**XRF** (mg/kg)	**Total** (mg/kg)	**TCLP** (mg/l)	**XRF** (mg/kg)	**Total** (mg/kg)	**TCLP** (mg/l)
Arsenic	—	—	<1	—	—	<1
Barium	380	—	2		—	<2
Cadmium	—	—	<0.5	—	—	<0.5
Chromium	—		<0.4	—	—	<0.4
Lead	110	260	<2	1700	3000	400 &110^{a,b}
Mercury	—	—	<0.02	—	—	<0.02
Selenium	—	—	<0.5	—	—	<0.5
Silver	—	—	<0.5	—	—	<0.5
Copper	<200	26	—	390	410	—
Zinc	<200	48	—	<200	95	—
Acid	—	—	acetic	—	—	acetic
Initial pH	—	—	4.93	—	—	4.93
Final pH	—	—	6.19	—	—	4.88

a) Fails TCLP; characteristic hazardous waste. The TCLP criterion is 5.0 mg/L.

b) Sample was run twice. The theoretical maximum TCLP-Lead would be about 150 mg/L (i.e., twenty-fold dilution of total lead level).

4.0 Evaluation and Recommendations

4.1 Areas With No Contamination and Minor Contamination

Most of the areas evaluated in this study have no discernible contamination from lead. These include the Ware and Custer Hill Elementary Schools' playgrounds, the ball fields and playgrounds at Colyer Manor, and the area near the houses at Colyer Manor. Areas to the east of Colyer Manor and the former Mullins Park have levels of lead typically below 100 mg/kg, but about 10% of these samples had lead levels over 100 mg/kg with a maximum of 280 mg/kg by XRF. Allowing for any bias in the XRF results, these results are still comfortably within the EPA guidelines of 500 mg/kg total lead for unrestricted recreational use. It is noteworthy that the lead contamination in these areas seems to be only in the top 1 to 2 feet of soil.

4.2 Areas With Significant Contamination

The only area where levels of lead were found that exceeded the EPA guidelines of 500 mg/kg was north of Building 3135 adjacent to Colyer Manor. EPA has not established protective guidelines for concentrations of copper and zinc in soil. An area roughly 150' by 200' is contaminated with lead and copper in concentrations up to 1700 mg/kg lead by XRF (3000 mg/kg total) and up to 390 mg/kg copper by XRF.

Bullet fragments were found, which tested up to 29,000 mg/kg lead, 910 mg/kg zinc, and 8,800 mg/kg copper by XRF.

Plate 2 shows the area of significant contamination. Most of this is within the top two feet with concentrations generally decreasing as lower depths are reached. Soils in this area were evaluated and classified as follows:

Location CFR-127

Depth	Description
Surface	Densely vegetated with weeds and grasses.
0-1 foot	Brown, silty-sandy loam with organic root material. Some limestone pebbles. (45 Caliber bullet found at 10")
1-2 foot	Brown, silty loam, more clay. Limestone pebbles with fragments up to 1" in size. Specks noted.
2-3 foot	Tan-brown, silty-clay material. Tight lumpy with specks less evident. No limestone pebbles.

3-4 foot	Same as above. No evidence of specks material.
4-5 foot	Tan-brown, silty-sandy material, less clay. No evidence of limestone or calcareous material.

Location CFR-035X

Depth	Description
Surface	Densely vegetated with weeds and grasses.
0-1 foot	Rich in organic matter, top soil.
1-2 foot	Increasing clay with about 20% limestone fragments.
2-3 foot	Color change at 2.5 feet to yellow-brown. Dryer in nature. Stiff and moderately crumbly to weakly plastic. 2.5 to 3.0 feet darker brown with white (calcareous) micro streaks. Suspect native (undisturbed) soil.
3-4 foot	Uniform silty clay.
4-5 foot	Uniform silty clay.
5-5.5 foot	Auger refusal against limestone gravel/boulder.

4.3 Remedial Concepts

Consideration should be given to minimize exposure to soil with high lead concentrations due to the proximity to residential buildings (specifically Building 3135). The following remedial concepts are available and feasible:

1. Maintain vegetation, mark, and avoid excavation.
2. Maintain vegetation, mark, and fence to prevent trespassing.
3. Cover with new soil (e.g., 1-2 feet), reestablish vegetation, mark, and avoid excavation.
4. Excavate contaminated soil, backfill, reestablish vegetation, dispose of contaminated soil that passes the TCLP test as (non-hazardous) solid waste, and dispose of contaminated soil that fails the TCLP test as hazardous waste.

A comparative engineering analysis will be required to evaluate these and other alternatives.

References

Louis Berger & Associates, Inc. (LBA). 7 December 1992/revised 16 February 1993. Draft Final Installation-Wide Site Assessment For Fort Riley, Kansas. Prepared for US Army Engineering District, Kansas City CEMRK-ED-TP.

LBA. 10 May 1993. Work Plan For Expedited Investigation Of Sites Potentially Contaminated With Lead For Fort Riley, Kansas. Prepared for US Army Engineering District,Kansas City CEMRK-ED-TP

LBA. 25 June 1993/revisions 20 August 1993. Draft Final Quaility Assurance Project Plan for Site Investigations at Fort Riley, Kansas. Prepared for US Army Engineering District, Kansas City CEMRK-ED-TP.

RECEIVED 9/10/93

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7 September 1993

Commander
US Army Corps of Engineers
Kansas City District
ATTN: CEMRK-ED-TP/Joan Pamperien
601 East 12th Street
Kansas City Missouri 64106-2896

Dear Ms. Pamperien;

Enclosed you will find 3 pre-look copies of the Data Summary and Evaluation Report for Investigation of High Priority Sites Potentially Contaminated With Lead. The provided document contains the revisions to Plates 1 and 2. Plates 3, 4, and 5 did not have revisions from the previous 25 June 1993 edition. Therefore, these three plates have not been provided with this edition.

final revised version

Sincerely,

Louis Berger and Associates, Inc.
George Parris

cc: J. Pamperien, CEMRK
K. Watson, Fort Riley, DEH

Responses to Review Comments on: Data Summary and Evaluation Report for Investigation of High Priority Sites Potentially Contaminated With Lead
Scott Marquess, Environmental Protection Agency, Region VII (913) 551-7131

Comment	Response
1. Page 1-2, second paragraph. The sample drying procedures appear rather inconsistent. It would have been appropriate to assure that the samples were sufficiently dried to minimize any potential effects that different moisture levels may have had on the samples analysis. Were any performance standards included in the evaluation of the XRF results to verify the published detection limits?	The XRF was only used for screening; a variation in moisture content of 50% would have little affect on the conclusions drawn from the XRF. Moreover, experiments in the course of the studies showed that the technique is rather insensitive to moisture content. Moist and dry samples gave very similar results as long as they were sifted to ensure homogeneity. The XRF technique is a surface technique and is not very sensitive to changes in the bulk.
2. Page 2-2, section 2.1.1; page 2-3, Table 1. The results for the Uranium analysis should be included in the table, or the text should discuss all the Uranium detections which exceeded detection limits.	No Uranium results were found above the detection limit (50 mg/kg). Therefore, they were deleted from the table. However, the point will be made explicit in the text.
3. Page 2-14, section 2.5. Please discuss the rationale for obtaining samples from the Burnside housing area.	This supplemental study was conducted at Fort Riley's request.

4. Page 3-1, section 3.1. Your statement that "good correlation" exists between the XRF and laboratory results should be quantified (i.e., correlation coefficient). All of the "Check Sample" data should be provided to illustrate the precision and accuracy of the analytical equipment. It appears that the XRF data for Lead is biased low relative to the standard, the Iron and Barium XRF data is biased high, and no conclusions can be drawn from the Copper data.	As you indicate, there is bias in the measurements. Based on a general comparison (duplicate and XRF vs laboratory), the XRF is a reliable screening tool. In general the laboratory results for lead were 2 - 2.5 times the XRF results. This was the anticipated result at the time the SAP was developed.
5. Page 3-2, Table 6. It does not appear that a "representative" range of concentrations of XRF Lead samples were sent for laboratory confirmatory analysis. 26 of the 31 samples for comparison between the two methods used "non-detect" (less than 40 ppm) XRF Lead samples. In general, it would appear that non-detect XRF Lead data correlates with low laboratory analytical results - less than 100 ppm. This should be demonstrated more rigorously. However, insufficient comparative data is provided to assess the utility of the XRF for higher lead levels. The five data points provided suggest that the laboratory data yields Lead levels 2 - 3 times that of the XRF, but no useful statistical analysis of this correlation can be made due to the small sample size. Similar concerns are valid for the Copper and Zinc comparisons. How did you validate the Barium and Uranium XRF data?	The barium, iron, and uranium data were supplemental information that were not required by the SAP. The SAP only required XRF screening for lead. Thus, no laboratory confirmation of the other elements was planned in the SAP or executed. Most of the samples analyzed at Fort Riley were below the detection limit of the XRF for lead. Thus, it is not surprising that a preponderance of the samples sent to the laboratory were below 40 mg/kg lead. There was never an attempt to quantitatively compare XRF to laboratory total lead results. It is our impression that the XRF proved to be much more reliable than anyone expected and now interest is being shown in rigorously quantifying the technique. This was never the intent of the study. Laboratory results were generally not available at the time decisions were made to send samples to the laboratory.

6. Page 4-1, section 4.1. Since all of the XRF data for the Ware and Custer Hill Elementary Schools show non-detects for Lead, Copper, and Zinc, there appears to be no concern for potentially hazardous exposures occurring at these sites. Due to the insufficient correlation between XRF and laboratory data, as previously discussed, it is unclear where the exact areas of concern for possible Lead exposures at the Colyer Manor and Mullins Park areas would be located. It is not clear what XRF Lead level would correlate to the laboratory level of 500 ppm. It is feasible to consider that XRF Lead levels as low as 100 - 150 ppm may approach 500 ppm laboratory levels, based on the data provided in this report.	It is unlikely that XRF data as low as 150 ppm lead would approach a total lead level of 500 ppm. The most extreme ratio of lab to XRF lead observed in Table 6 is 360 vs 110 or a ratio of 3.27. The average ratio for quantified data is 2.46 which would suggest that XRF values above 203 ppm are expected to exceed 500 ppm in the laboratory analysis. However, the SAP was never intended to quantitatively determine this ratio. It was agreed at the outset that 200 ppm of the XRF would be used as the criterion for delineation (See SAP p. 2-2, 10 May 1993). This was done. The grid was expanded as described in the SAP around point CFR-003 and CFR-012 although the XRF findings were only 110 ppm and 130 ppm, respectively. As a result of expanding the grid around CFR-003 a value above 200 ppm (i.e., 280 ppm Pb by XRF at CFR-003N-1) was found. However, by this time, the data suggested that the entire area of the former pistol range (the open field east of Colyer Manor) was sporadically contaminated with lead in the 100 to 200 ppm XRF range. We did not regard the CFR-003N-1 result as needing follow up. We believe the results of this area should be taken as a whole.

7.	Page 4-3, section 4.3. The quantity of soil potentially requiring disposal which may be classified as RCRA hazardous based on TCLP data should be defined. However, it is not evident that sufficient TCLP testing was performed, as reported in section 3.2, to clearly estimate the Lead levels in soils which would fail TCLP. A schedule should be provided to indicate when Fort Riley intends to perform the removal action and associated analysis for the soils near building 3135 which are discussed in this section. Do you intend to approach this as a "time critical" or "non-time critical" removal action? Regarding remedial "concept" #4, it would be appropriate to consider disposal of the lead contaminated soil as hazardous waste, based on the levels detected and the preliminary TCLP data generated.	The quantity of soil potentially requiring disposal based on TCLP would be covered under an engineering analysis. No engineering analysis has been done yet. The cost of disposal of this soil as a hazardous waste will be substantial. Although the lead clearly leaches extensively when extracted with buffered acid (in the TCLP), its behavior in the field (higher pH) seems to indicate little or no tendency to migrate.

Responses to Review Comments on: Data Summary and Evaluation Report for Investigation of High Priority Sites Potentially Contaminated With Lead

Cpt. Kathy Krantz, CEMRK-ED-GE, (816) 426-7885

Comment	Response
1. Section 1.1, Page 1-1. "...in areas accessible to the general public (especially children)" should be enclosed by commas. The word "former" is used too many times in the second area description. Delete former from the "former pistol range." For the schools, what is meant by "near range areas?"	Concur. The text will be amended as indicated. "Near range areas" is the description of the original location of the fill materials used at the schools. When the schools were built, fill soils were taken from the areas near the firing ranges and placed in the school yard. The fill was taken from areas between the firing lines and the impact berms.

2. Section 1.2, Pages 1-1 and 1-2. Paragraph one: It would be more appropriately phrased as "A Sampling and Analysis Plan (SAP), Dated 10 May 1993, was prepared for the investigation by LBA and approved by the US EPA Region VII and the Kansas Department of Health and the Environment (KDHE)."	Concur. The text will be amended.
Paragraph two: Explain what determined when samples would be taken at depth. In the third sentence, "developed" or "designed" would be a better choice of words than "set." These two sentences should be moved to the next page.	Noted. An explanation will be provided in paragraph 2.
Include how many samples were sent to the laboratory. Delete "moreover" from the next sentence and add the criteria used in selecting samples for leachability testing.	Noted. The text will be amended an the criteria used to select samples for lechability test will be included.
Would recommend that the word flexibility be used rather than "triggers." Add a statement regarding when and how grids were expanded.	Concur. A statement will be added concerning the sampling grid expansion.
Paragraph three: Explain "a higher level of quality control." Remove "however" from the next sentence. In general, there is an over abundance of conjunctive adverbs used throughout this document.	Noted. The level of quality control provided by the laboratory analysis assured that the XRF results were not overstated or underestimated. The text will be amended to reflect this.
Paragraph four: To the first sentence, it would be appropriate to add that soil collection was done with a hand auger. Correct "flower" to flour. Teaspoon is one word and the cup is covered with a thin plastic film. Explain why metals other than lead or even lead, antimony, copper and zinc were looked for by XRF.	Noted. The text will be revised to incorporate the desired explanation.

	the number of samples that were sent for laboratory confirmation.	Thirty-seven samples were sent to the laboratory.
3	Section 1.3, Page 1-2. Please clarify why this is not considered a Site investigation Report. Paragraph two: The second sentence should read, "the level of concern." It may be more appropriate to place everything starting with the second sentence in the discussion regarding the approach. Delete "in addition to." General - It seems like the scope of the investigation should be presented prior to the discussion of the approach.	Noted. The Site Investigation Report will include additional information about the site history and geology. It will also included a more in depth analysis of the data, and a discussion of regulatory impacts. The text will be corrected and the paragraph moved as requested.
4.	Section 2.0, Page 2-1. Subparagraph two: Qualify the phrase, "...no difference between these samples ." It would be more appropriate to say that there was no difference in the way these samples were handled and/or explain why these samples were collected and what their intended use was.	Noted. The text will be amended to incorporate the suggested language.
5.	General. The QAPP should be referenced for the methods of laboratory analysis or better still, add a table depicting the analytical methods that were utilized.	Concur. A table will be added in Section 1.0 indicating the analytical methods employed.
6.	Section 2.1, Page 2-2. What was the grid size used?	Noted. A 200 foot grid size was used.
7.	Section 2.1.1, Page 2-2. Add a statement regarding whether or not these levels of iron, barium and zinc are a concern.	Noted. EPA has not established safety guidelines for these constituents in soil. Therefore, these contaminants do not present a concern.

8. General. May want to consider moving Table 2 to a location following 2.1.2.	Noted.
CFR-132, CFR-133, and CFR-134 sample locations are not depicted on the plate. I assume that this is due to their close proximity to CFR-035.	Concur.
9. Section 2.1.1, Page 2-12. Paragraph two: Suggest that words "concentration levels" be used rather than "load levels."	Concur.
10. General. Building 3135 is used throughout this document in such a way that an unfamiliar reader may not associate this with a residential dwelling.	Noted. An explanation of the type of dwelling will be included in the text.
11. Section 2.1.2, Page 2-12. Explain how the laboratory results subsequently confirmed the XRF data. Although direct correlations cannot be made, can a general statement be added regarding the difference in the order of magnitudes observed? Explain why it was decided to collect samples at depth. Delete "...and in the meantime." How were these other points spaced along the ridge? How are they designated on the Plate?	Noted. Language will be added to explain the comparison of laboratory results to XRF data. Samples were collected up to depths of 5 feet to satisfy EPAs risk assessment criteria for Superfund sites. The information will be inserted in the text.
12. Section 2.2, 2.3, and 2.4, Page 2-13. Please add the grid size utilized.	Concur.
13. Section 2.5, Page 2-14. Correct "adjacebt" to adjacent.	Noted.
14. General. May want to reiterate why some locations have samples taken at depth while others are surface samples only.	Noted.

15. Section 3.0, Page 3-1. The fourth sentence should read, "this is not regarded as an "error" in the XRF results but rather as an understood and unexplainable "bias" in the technique. This was accounted by for..." Perhaps a more appropriate phrase such as "level of concern for XRF" could be used rather than "setting the trigger." Delete "it is noted that" from the last sentence.	Concur. The text will be revised.
16. Table 6. Spaces have been left blank for sample CFR-003-1 (6/06/93). Antimony should probably be added to the tables. Although it was not analyzed for by XRF, it was an analysis required by the SAP. The analytical results for this metal have not been addressed. Likewise, uranium by XRF was not discussed. On page 2 of the table, change the <'s to < a detection limit.	Concur. A discussion of antimony will be included in Section 1.2. A discussion of uranium analysis will be presented in Section 2.1.1. The tables will be revised as appropriate.
17. Section 3.2, Page 3-4. Delete "Modified TCLP." Present the criteria used in the selection of samples for TCLP and how many were analyzed. "Present" should read "represent."	Concur. A discussion of the selection process will be added to this section. Two samples were analyzed.
18. Table 7. It was our understanding that all laboratory samples with a concentration of greater than or equal to 100 mg/kg would be analyzed for TCLP. There is only data for two samples, CFR-001-1 and CFR_035-1. CFR-011-1, CFR-133-1, and CFR-SO4 were also over 100 mg/kg total lead. The two that were analyzed for TCLP were not ones which were MRD splits, consequently we have no TCLP QA.	Noted. As was stated in the SAP, only a subset of the samples with lead concentrations grater than 100 mg/kg would be sampled. Two samples were analyzed using the TCLP method: one sample with a low concentration of lead and one with a high lead concentration. This, we believe, was sufficient to determine the typical leachability of the soil.

19. Section 4.1, Page 4-1. In comparing XRF results with analytical results, it appears that they can differ by a factor of 2 or 3. Therefore, the 280 mg/kg obtained from location 003 makes it a questionable area.	Concur. Although a laboratory samples was not collected directly from CFR-003N-1 (the sample which produced the 280 mg/kg lead), samples from the general area around 003 were analyzed for total lead. The laboratory analysis indicated that the area contained less than the EPAs 500 mg/kg concentrations for lead. Lead concentrations from this area ranged 17-420 mg/kg.
20. Section 4.2, Page 4-1. Delete "here" from the second sentence. Add a statement as to whether this copper concentration is of concern.	Noted. The text will be revised. A statement will be added explaining that EPA has not established protective guidelines for copper and zinc in soil.
21. Section 4.3, Page 4-3. First sentence needs to be reworded. Correct the type size and spacing of the remedial concepts portion. Item 4 - Not all contaminated soil will be able to be disposed of as non-hazardous waste. Sample CFR-035-1 failed TCLP which would make soil from this location a hazardous waste.	Noted. This section will be reformatted. The fourth remedial option listed will be revised to make a distinction between the disposal for soil that passes the TCLP test and those that do not.
22. References. The QAPP should also be referenced as this document provides the methods of analyses.	Concur.
23. Plate 2. Location 035xW is labeled 035xN.	Noted.
24. Plates 3. Location 06 has three depth values on the table.	Noted.

Responses to Review Comments on: Data Summary and Evaluation Report For Investigation of High Priority Sites Potentially Contaminated with Lead (25 June 1993)
Randy Brown, Kansas Department of Health and Environment (KDHE), Topeka, Kansas (913) 296-8065

Comment	Response
1. Because of the poor correlation between laboratory and XRF data, KDHE requests that any area with XRF results at 110 mg/kg or over be retained for further characterization for potential removal actions rather than the 200 mg/kg number proposed in the text. This number has been selected because in the XRF-lab comparative results chart on Page 3-2, three widely different values of lab data (namely 260, 360 and 420 mg/kg) all correspond to XRF numbers of 110 mg/kg indicating a considerable inaccuracy in correlation for the 110 mg/kg XRF lead concentration value. The total lead concentration value corresponding to the upper range of the lab data (420 mg/kg) for 110 mg/kg XRF lead concentration is near the EPA action level of 500 mg/kg (which is above the accepted soil cleanup levels in some states) and given the apparent correlative inaccuracy requires a remedial response. The lab-XRF data correlation is in general quite poor for the 110 mg/kg and over XRF results. KDHE is, however in agreement with the text for dropping all areas lower than 110 mg/kg lead XRF results from consideration of remedial actions. Soils containing over 110 mg/kg lead by XRF would also likely fail TCLP and be then characterized as a RCRA hazardous waste.	The dispersion in the data are not necessarily as broad as indicated here. Note that the 420 mg/kg sample was an entirely new sample that was not analyzed by XRF so no comparison is possible for the purpose of comparing the ratio of total-lead to XRF-lead. When all the corresponding values (6 sets) are taken together, a ratio of 2.46 for quantified data is obtained. The most extreme ratio is 110 to 360 (i.e., 3.27 one of the points noted by the commenter). It is very unlikely that the 420 mg/kg total lead value would have had an XRF value as low as 110 mg/kg. In hindsight, it would have been convenient to design this study to provide a more statistically significant correlation, but that was never the intent. The ratio 2.46 would support our original estimate that 200 mg/kg by XRF would be protective at the 500 mg/kg total lead level. However, we regard this as fortuitous; it was only a scientific guess that we made when developing the SAP. Compared to some other screening techniques and our expectations at the start, we are very pleased that these ratios are this consistent. EPA typically assumes a variability of % 100 in most trace analysis (+/- a factor of 2), thus to be calculating results to three significant figures is rather remarkable.

1. (Continued)	As far as follow up action is concerned, samples listed as f-h at Camp Forsyth are all associated with the acknowledged "hot spot" for which remediation is being considered. We believe that the areas at the east of CFR (the old pistol range) and the former Mullins Park area are best interpreted by averaging over the area. Although small areas where the total lead levels exceed 500 mg/kg may well exist, the area average is substantially below this. Because the lead contamination appears to be randomly distributed, we do not believe it is practical to try to characterize these areas more precisely nor do we believe that it would be necessary to remediate these areas based upon the findings to date. We agree that soils that have over 110 mg/kg XRF-lead may fail the TCLP, but we doubt the relevance of this test to natural conditions (i.e., pH of ground water about 8) found at Fort Riley. The TCLP finding simply indicates that placing the soil into a sanitary landfill with organic matter that would decay to produce carboxylic acids would be a bad idea. The TCLP does not indicate that lead will rapidly leach under natural conditions in the soil.
2. CFR-S04 Site. The reported levels of 230 mg/kg semi-volatile petroleum hydrocarbons is in excess of the KDHE 100 mg/kg action level for total petroleum hydrocarbons (TPH) in soils. The zinc concentrations in this sample are excessively high and elevated relative to published background soil levels for the region.	The petroleum hydrocarbon detected here is characterized as most likely engine oil. The TPH analysis was done to explain the high zinc (a common additive in engine oil) and unexpected lead findings in this sample. No odors or indications of volatile/mobile hydrocarbons were noted. The best remediation for this material is probably natural biodegradation. We do not recommend follow up or remediation.

3. KDHE requests that further work be performed at all areas screened by XRF in excess of 110 mg/kg lead. This should consist of additional soil sampling to refine boundaries of contaminated areas for better characterization and/or removal/remedial actions conducted in these areas with higher levels of lead contamination to reduce the risk of human health and environmental exposure posed by lead contaminated soils. The need for removal/remedial actions are especially warranted in the Colyer Manor base housing area behind Building 3135 where sample CFR-035-1 yielded 1700-1500 mg/kg XRF and 3000 mg/kg for total lead.	We agree that control of exposure is warranted. Removal/remedial options available to prevent exposure will need to be carefully examined. However, as stated above, it is probably best to simply acknowledge that the former pistol range area (and soil from the pistol range that was moved to the former Mullins Park) is contaminated in what appears to be a random pattern at levels that average far below the level of concern

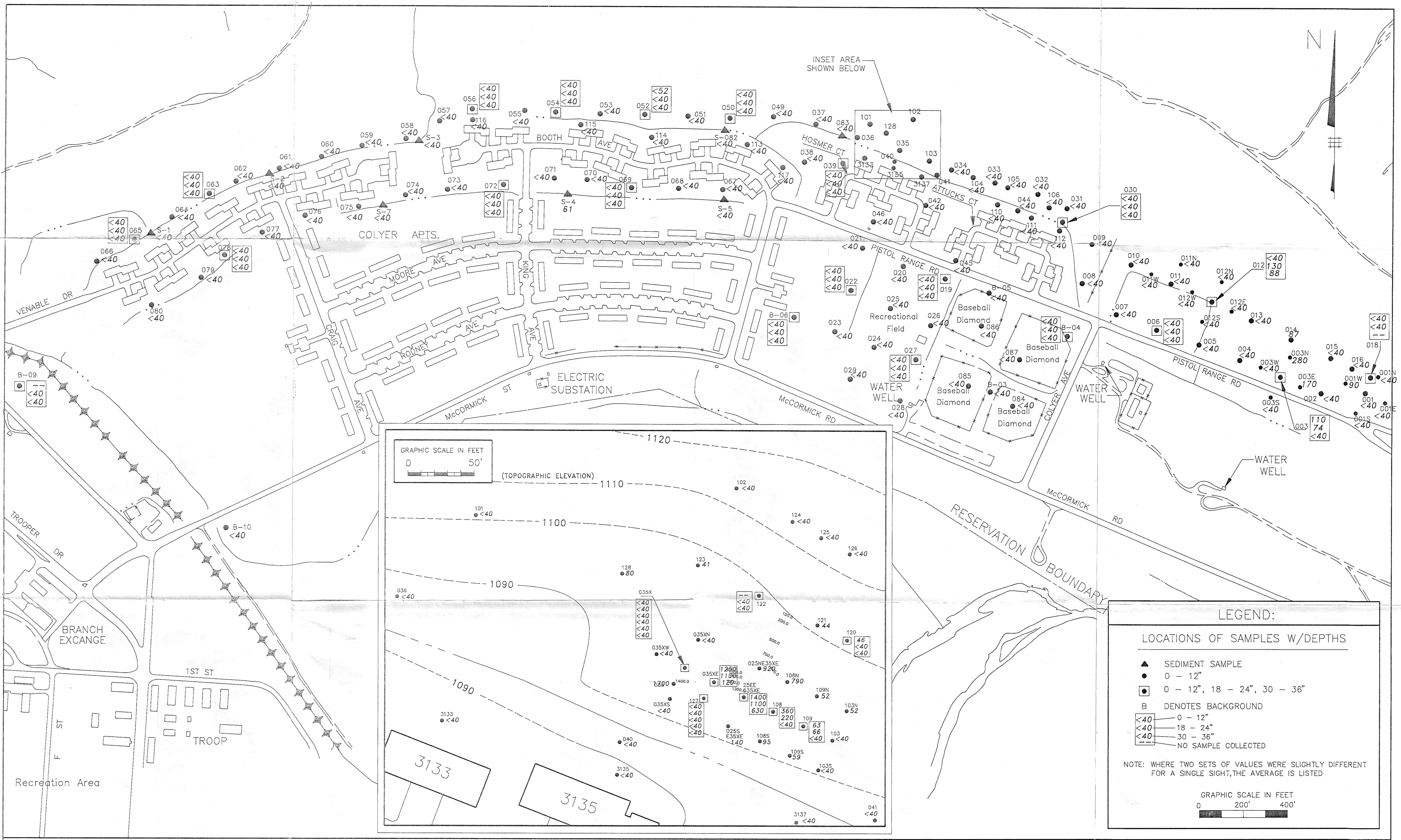

PLATE 1 – CAMP FORSYTH RANGES SOIL SAMPLING LOCATIONS

DATE: JUNE 1993

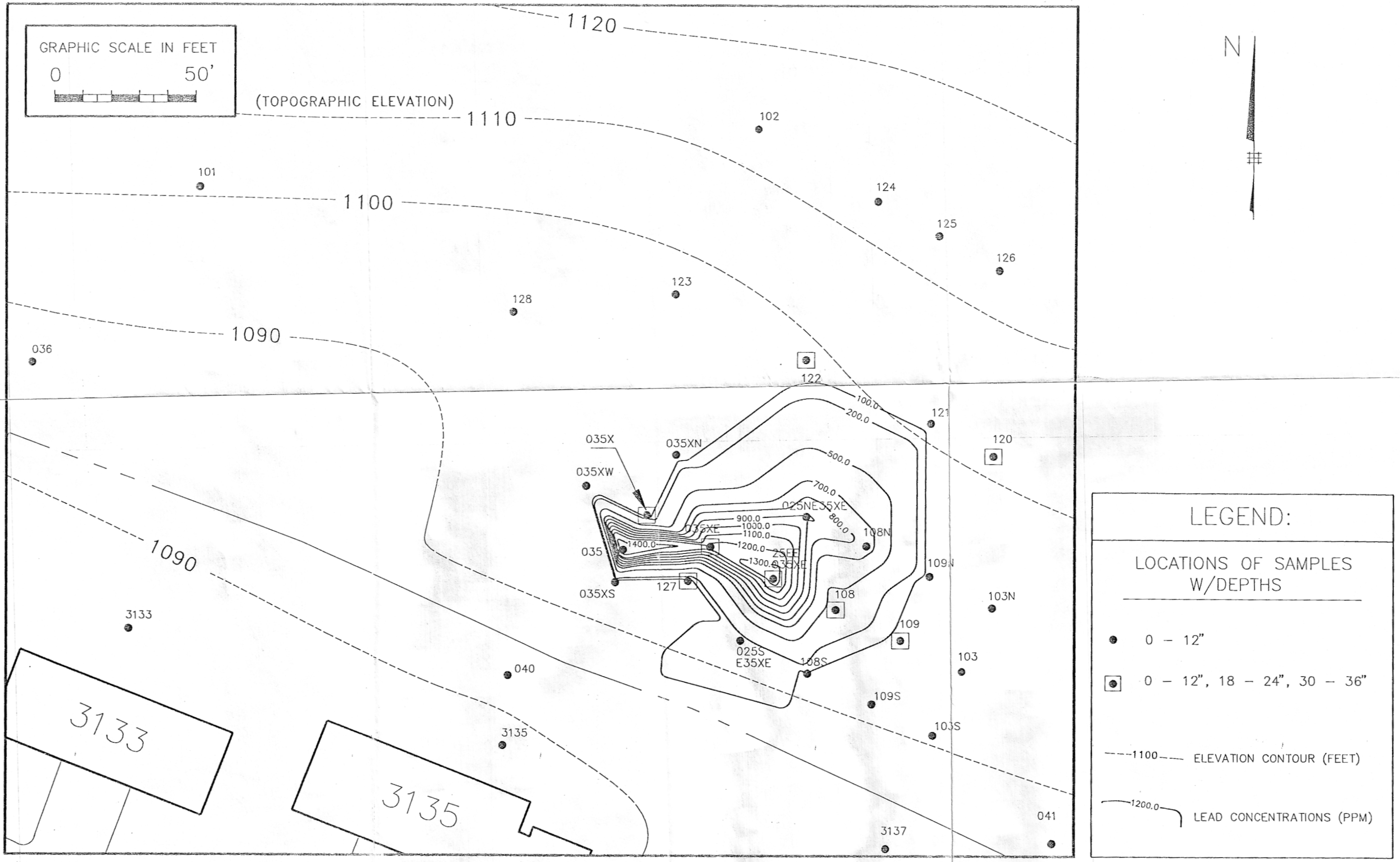

PLATE 2 – CONTOURS OF LEAD CONCENTRATIONS BEHIND
BUILDING 3135 – CAMP FORSYTH AREA

DATE: JUNE 1993