

Letter Health Consultation

**Camp Minden
Central Proving Ground – Kick-Out Area - Munitions Response Site
Webster and Bossier Parishes, Louisiana**

Evaluation of Soil Samples

March 8, 2021

Prepared by:
Louisiana Department of Health
Office of Public Health
Section of Environmental Epidemiology and Toxicology

Letter Health Consultation: A Note of Explanation

A letter health consultation is a verbal or written response to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material.

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State of Louisiana
Louisiana Department of Health
Office of Public Health

March 8, 2021

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Dear Nancy Hanna,

The US Environmental Protection Agency (US EPA) requested that the Louisiana Department of Health/Office of Public Health/ Section of Environmental Epidemiology (LDH) perform a health consultation for the Camp Minden site. EPA asked LDH to provide independent feedback on a Remedial Investigation performed in 2020 at a portion of Camp Minden formerly used for testing, detonation, and burning of munitions. Through a cooperative agreement with the Agency for Toxic Substances and Disease Registry, LDH has provided this letter health consultation to assess the provided soil data and offered recommendations protective of human health for individuals in non-residential scenarios at the site.

Background

In 1941, The United States government contracted with the Silas Mason Company to build the Louisiana Army Ammunition Plant (LAAP) for production of ammunition, mines, grenades, and fuzes for use during World War II. Sixty-five types of ammunition were produced at the plant, and an ammonium nitrate graining plant was added to the sites near the end of the war. Ammunition production ceased at the site in August 1945, the Silas Mason Company was released from responsibility in November 1945, and the site was placed in standby status. The LAAP was reactivated by Remington Rand in February 1951 for the Korean Conflict; placed on standby in 1958; and reopened in September 1961 by Sperry Rand for the Vietnam Conflict. The Thiokol Corporation acquired the site contract in 1975. Thiokol Corporation stopped ammunition production in 1994 and the contract was acquired by Valentec, Inc. in 1997. In 2004 legislation was enacted to transfer the property to the State of Louisiana, provided the majority continued to be used for military training and the remaining property for commercial or industrial purposes. The transfer occurred in 2005 and the site was renamed Camp Minden. Environmental remediation responsibilities remained with the army until 2007 [1].

Camp Minden comprises 15,267 acres and lies approximately two miles southwest of Minden, Louisiana, on State Route 80 in Webster and Bossier Parishes (Appendix A, Figure A-1). The cities of Shreveport and Bossier City are located approximately 22 miles to the west. Houghton is located within two miles of the western boundary, the community of Doyline is located on U.S. Highway 164 at the installation's southern boundary, and the community of Goodwill is located on U.S. Highway 80 at the installation's northern boundary [2]. Table 1 provides current population estimates for the parishes associated with the site.

Table 1. Area and Population of Parishes associated with Camp Minden

Parish	Area (square miles)	Population Estimates, 2019
Bossier	840.06	127,039
Webster	593.03	38,340

Table adapted from Shaw Environmental, Inc. (Shaw). 2006. Final Five Year Review Report, Third Five-Year Review LAAP OU-1 (Area P Lagoons) and First Five-Year Review LAAP-OU-8 (Y Line Chromic Acid Etching Facility), Louisiana Army Ammunition Plant, LAD No.0213820533. July.

Demographics source: U.S. Census Bureau, accessed 2/2021

Bossier Parish's population is 71.8% White, 23.1% Black or African American, 0.6% American Indian and Alaska Native, 1.9% Asian, and 0.1% Native Hawaiian and other Pacific Islander. Two point five percent (2.5%) of residents identify as being of two or more races and 6.9% identify as Hispanic or Latino. Twenty-four point seven percent (24.7%) of the population is under 18 years of age and 89.7% of the population age 25 years+ has a high school graduate or higher [3]

Webster Parish's population is 63.2% White, 34.3% Black or African American, 0.6% American Indian and Alaska Native and 0.4% Asian. One point five percent (1.5%) of residents identify as being of two or more races and 2.1% identify as Hispanic or Latino. Twenty-two point four percent (22.4%) of the population is under 18 years of age and 83.9% of the population age 25 years+ has a high school graduate or higher [3].

Statement of Issues

The area of interest for the 2020 Remedial Investigation (RI) is the Central Proving Ground (CPG) Kick-Out Area (KOA) Munitions Response site (MRS), approximately 278.8 acres of a northeast region of Camp Minden. The objective of the RI was to collect sufficient data to fully define the nature and extent of munitions and explosives of concern, material potentially presenting an explosive hazard, and munitions constituents at the surface and subsurface within this area of interest.

The CPG KOA is located within the portion of Camp Minden designated for commercial use. This portion of Camp Minden is currently unused, heavily wooded, and undeveloped. Access to this area is restricted by a perimeter fence and security-guarded entrances, but the site is periodically open to hunters and is subject to trespassers [1].

The CPG was used from the 1950s-1990s for testing, detonation, and burning of munitions [1]. It covers approximately 17.5 acres of Camp Minden and is currently labeled as the no-Right of Entry (ROE). The CPG MRS served as a buffer zone for a former open burn/open detonation (OB/OD) area to the north of the CPG. The CPG KOA MRS is therefore defined by observed “kick-out” (ejection) of munitions debris (shrapnel and detonated ordnance) resulting from OB/OD activities at the site. The size of the CPG KOA MRS has increased as successive site investigations have resulted in better characterization of site conditions.

Following previous investigations, the selected remedy for soils at the CPG is No Further Action (NFA) with a deed restricting the State’s use of the majority of the site to military training and the remaining portion of the property to commercial/industrial activities. The detection of explosives constituents in shallow groundwater at the site resulted in site-wide groundwater controls and restrictions prohibiting the consumption and use of groundwater at the site [1]. The investigation of the Camp Minden CPG KOA MRS was performed under the Defense Environmental Restoration Program Military Munitions Response Program (MMRP), with regulatory oversight by the Louisiana Department of Environmental Quality (LDEQ) and EPA Region 6. The MMRP addresses sites that are known to contain munitions and explosives of concern in high enough concentrations to pose an explosive hazard.

Discussion

Evaluation of the CPG KOA MRS included detection of munitions debris and explosives. Assessment of these elements is outside the scope of LDH’s capacity.

LDH reviewed the results of soil sampling events during the 2020 RI and during a 2014 Site Investigation (SI) referred to in the RI. Initial screening was performed using media specific health-based comparison values (CVs) derived by the Agency for Toxic Substances and Disease Registry (ATSDR) or the EPA. The contaminants present at concentrations higher than the CVs were further evaluated as contaminants of concern (COCs).

Since deed restrictions prohibit residential use of the site, LDH estimated occupational exposures for the COCs using ATSDR’s Public Health Site Assessment Tool (PHAST). The estimated doses for accidental ingestion and skin contact were evaluated using hazard quotients, the ratio of the estimated dose to a dose at which no adverse effects are expected (the minimum risk level or reference dose). Hazard quotients of less than one indicate that adverse noncancer health effects are unlikely.

Cancer risks were estimated for COCs identified as carcinogens. The excess cancer risk estimates the 95% upper confidence limit of additional cancer risk that may occur in a large number of people with similar exposures. Estimated cancer risks greater than one excess cancer in a population of one million people ($1.0E-6$) represent additional risk of developing cancer above that expected in a population not exposed to the COC.

During the 2014 Site Investigation, ten soil sample locations were chosen based on a visual survey identifying munitions and explosives of concern. The munitions constituents detected

were N-methyl-N-2,4,6-tetranitroaniline (tetryl) and 1,2-dinitrobenzene [1]; however, subsequent review of the 2014 document's analytical reports revealed that 1,2-dinitrobenzene was the analytical surrogate for the laboratory method used and not representative of the soil samples. Figure A-2 shows the locations of these ten soil samples.

Characterization of the expanded 2017 CPG KOA included collection of a set of incremental triplicate soil samples from a demolition pit; this pit was used for four detonations of items recovered during the 2020 RI. The three samples were analyzed for munitions constituents. A single concentration of tetryl was detected at 0.242 mg/kg, which is below the EPA's Composite Worker Soil regional screening value for tetryl (2300 mg/kg). ATSDR does not have a health-based screening value available for tetryl. Figure A-3 shows the locations of these three soil samples.

The ten soil samples collected during the 2014 SI were also analyzed for perchlorate and metals. Appendix B, Table B-1 lists the complete set of contaminants the soil samples were tested for. The comparison values used to screen the detected contaminants are listed in Table B-2. Calcium, copper, magnesium, manganese and potassium are essential nutrients with low toxicity and therefore were not screened as potential COCs. Table 2 lists concentrations for the three constituents identified as COCs, arsenic, cadmium and mercury.

Table 2. Contaminants of Concern, 2014 Site Investigation soil data (concentrations in mg/kg*)

	CV [†] (mg/kg)	Sample CM-01	Sample CM-02	Sample CM-03	Sample CM-04	Sample CM-05	Sample CM-06	Sample CM-07	Sample CM-08	Sample CM-09	Sample CM-10
Arsenic	0.26 [‡]	14	9.9	5.5	3.6	3.4	9.6	2.1 J [§]	2.8 J	3	5.4
Cadmium	5.2 [¶]	7.1	30 J	2.8	5	6.7	15	2.1	1.5	1.1	1.1
Mercury	16 [#]	6.5	2 J	1.4	50	8.9	6.4	0.94	15	8.7	8.8

*mg/kg = milligrams per kilogram

[†]CV = comparison value used for screening process

[‡]Cancer screening value (Agency for Toxic Substances and Disease Registry)

[§]J = estimated value

[¶]Child chronic Environmental Media Evaluation Guide (Agency for Toxic Substances and Disease Registry)

[#]Child Reference Dose Media Evaluation Guide (Agency for Toxic Substances and Disease Registry) for inorganic mercury

Tables B-3 through B-6 summarize the results for the estimated exposure doses and the default values used to perform the dose estimations.

One soil sample contained mercury concentrations (50 mg/kg) that exceeded the ATSDR inorganic mercury screening value of 16 mg/kg. However, this concentration was significantly higher than the nine other mercury detections at the site. According to the 2014 SI, tetryl is typically mixed with mercury fulminate and potassium chlorate to ensure detonation. With that usage in mind and the fact that the samples were chosen at biased locations based on a visual survey, this elevated mercury concentration may be due more to a localized incidence of munitions constituent debris than to a site-wide cause of concern. Mercury was therefore excluded from further assessment as a COC.

Calculation of occupational exposures was determined using a work schedule of 5 days per week, 50 weeks per year. This schedule is a conservative estimation of time that would be spent in the conditions described at the CPG-KOA and is also protective of the hunters and trespassers who are reported to occasionally access the site.

Arsenic exposures estimated for occupational activities at the CPG-KOA pose low to moderate concern for increased cancer risk of 2 to 6 additional cancers in one million people (2.1E-06 to 6.4E-6) for workers engaging in outdoor soil contact through accidental ingestion and skin contact. However, it is currently unlikely that individuals would be working in this undeveloped area of Camp Minden for 5 days a week, 50 weeks per year. Exposures to arsenic that would be encountered under current site conditions would pose no harm to non-residential users of the site. Note that the state background level for arsenic naturally detected in soil is 12 mg/kg [4]. A previous remedial investigation concluded that elevated arsenic concentrations could be attributed to the legal application of pesticides at the site [5].

Cadmium exposures estimated for occupational activities at the CPG-KOA are not expected to harm the health of workers or other non-residential users of the site. No potential sources of cadmium at this location were identified by previous investigations of the CPG-KOA.

Conclusions

Extensive characterization of munitions debris and explosives at the CPG-KOA-MRS was performed as part of the 2020 RI. However, assessment of these elements is outside the scope of LDH's capacity.

Data used for assessment of soils from the CPG-KOA-MRS included ten soil samples chosen by visual survey from the 2014 CPG-KOA and incremental triplicate soil samples collected from a detonation pit in the expanded 2017 CPG-KOA. Though concentrations of tetryl detected in the pit were below levels of concern, an assessment of contaminants in the expanded 2017 KOA cannot be based on soil sampled from a single location.

Based on data available from the 2014 CPG-KOA, the concentrations of tetryl detected in soil sampled at the Camp Minden CPG KOA MRS are not expected to harm people's health. Arsenic and cadmium were identified as contaminants of concern but are not present at concentrations expected to harm the health of individuals engaged in non-residential activity at the site under current conditions. Because these conclusions are based on ten soil samples chosen by visual survey, they may not be representative of soils across the full extent of the expanded CPG-KOA-MRS.

With these data limitations, no health-based conclusion can be made about whether residual contamination from munitions constituents in soil at the expanded CPG-KOA-MRS pose potential harm to individuals working, hunting, or trespassing within this area of Camp Minden.

Recommendations

- A larger number of soil samples randomly collected from multiple locations within the full extent of the CPG-KOA-MRS would provide a more comprehensive examination of the potential risks posed by munitions constituents remaining at the site.
- If conditions at the CPG-KOA-MRS and usage of the site change in the future, additional samples should be collected and analyzed to determine if residual contaminants in the soil pose potential harm to individuals engaging in activities at the CPG-KOA-MRS.

Sincerely,



Rosalind Green, Sc.D.
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LDH/Office of Public Health/Section of Environmental Epidemiology and Toxicology

References

1. Stell Environmental Enterprises, Inc., 2014. Revised Final Site Inspection Report, CPG Kickout Area, Louisiana Army National Guard, Camp Minden, Louisiana. November.
2. Shaw Environmental, Inc. (Shaw). 2006. Final Five Year Review Report, Third Five-Year Review LAAP OU-1 (Area P Lagoons) and First Five-Year Review LAAP-OU-8 (Y Line Chromic Acid Etching Facility), Louisiana Army Ammunition Plant, LAD No.0213820533. July.
3. United States Census Bureau. QuickFacts. Accessed 23 February 2021 at: <https://www.census.gov/quickfacts/fact/table/US/PST045219>
4. Louisiana Department of Environmental Quality. Arsenic Sampling Results Explained. Accessed 23 February 2021 at: <https://thelensnola.org/wp-content/uploads/2010/02/DEQ-arsenic-explainer.pdf>
5. Shaw. 2005. Final Follow-on Remedial Investigation for Soils and the Site-Wide Ground Water Operable Unit, Louisiana Army Ammunition Plant, Doyline, LA. September.

Appendix A Maps

Figure A-1. Location of Camp Minden

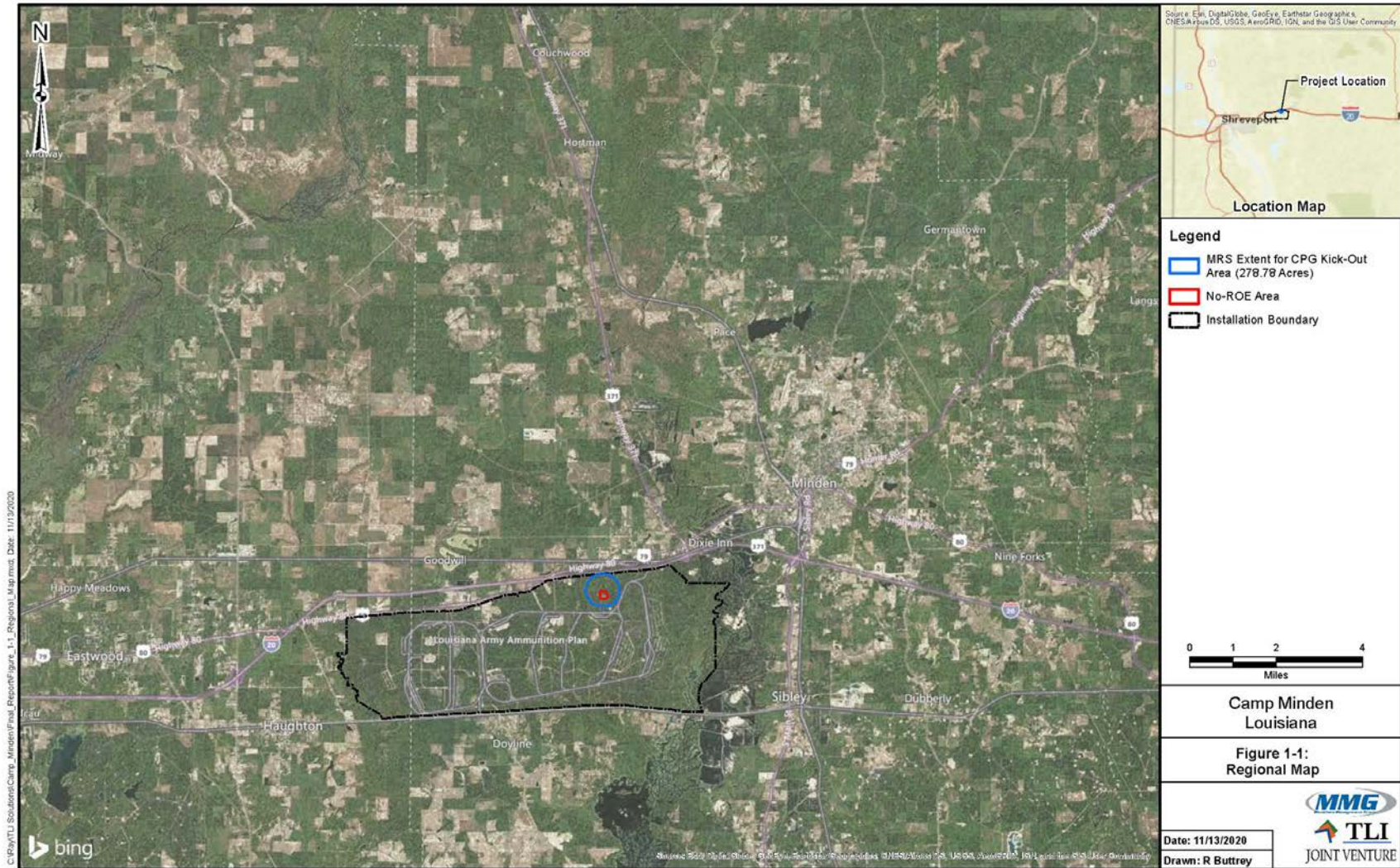
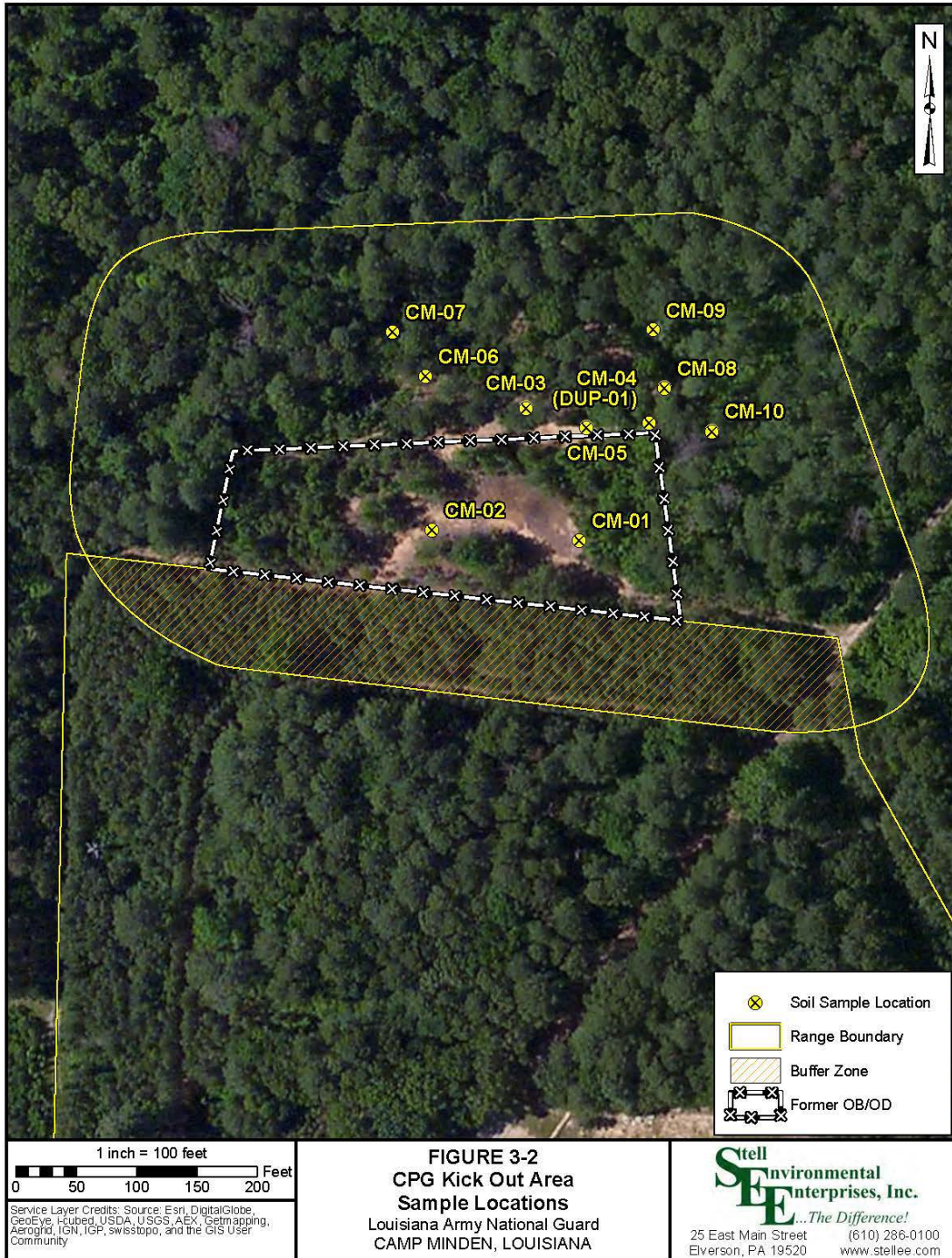
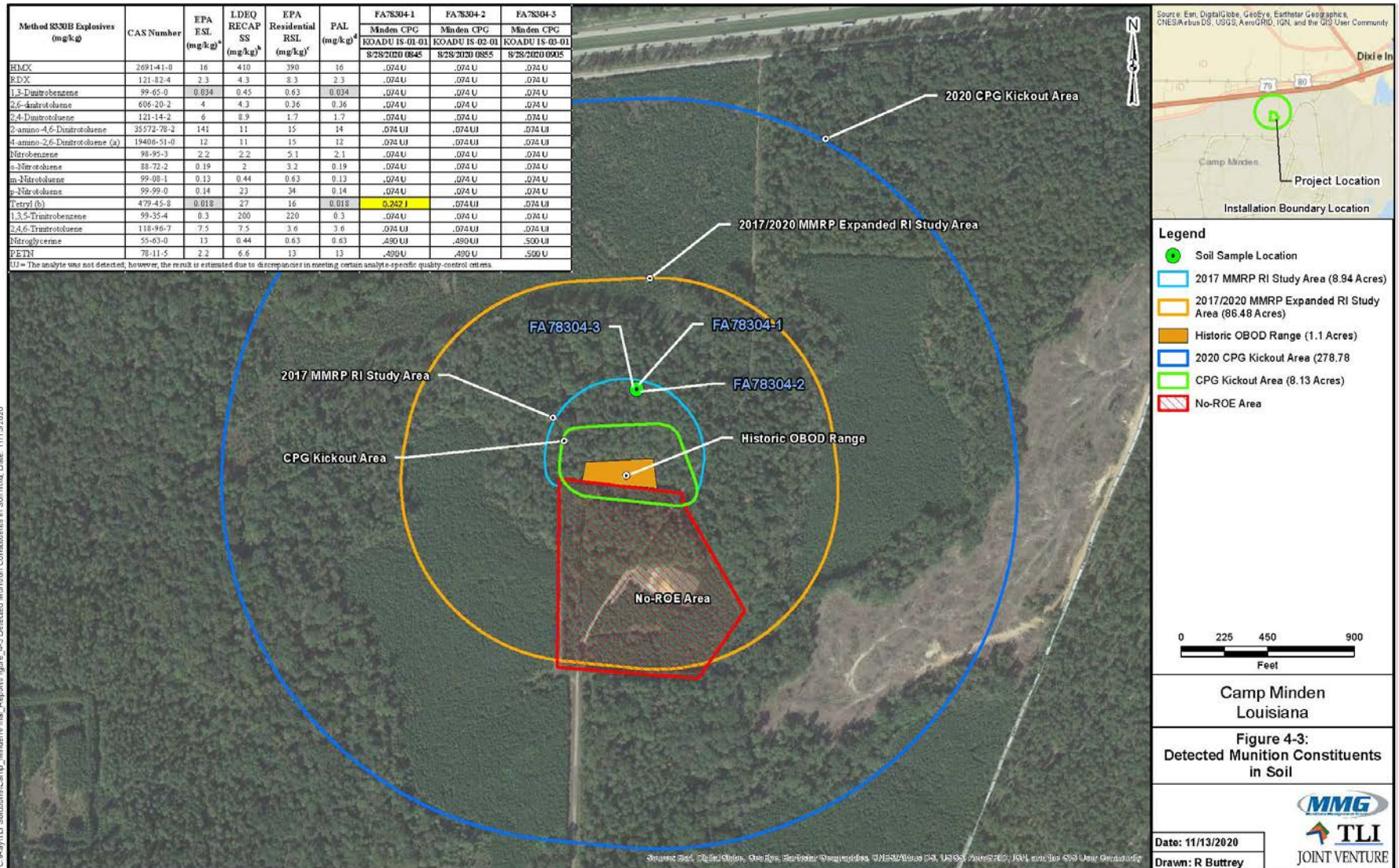


Figure A-2: Soil Sampling Locations from the 2014 Central Proving Ground Kick Out Area (CPG KOA) Site Investigation Report



Stell Environmental Enterprises, Inc., 2014. Revised Final Site Inspection Report, CPG Kickout Area, Louisiana Army National Guard, Camp Minden, Louisiana. November.

Figure A-3: Soil Sampling Locations and Results from the 2021 Remedial Investigation



Appendix B Data Evaluation

Table B-1: Surface Soil Analytical Results, 2014 Site Investigation

Client Sample ID:		CM-01	CM-02	CM-03	CM-04	CM-05	CM-06	CM-07	CM-08	CM-09	CM-10										
Explosives (discrete sampling)																					
Tetryl	mg/kg	<0.090	U	0.24	J	<0.083	U	<0.084	U	<0.084	U	<0.083	U	<0.087	U	1.7		0.079	J	<0.086	U
Perchlorate	mg/kg	<0.00029	U	<0.00030	U	<0.00028	U	<0.00031	U	0.00058	J	0.00008	B	0.00016	B	0.000091	B	0.00012	B	0.00036	U
Target Analyte List Metals																					
Aluminum	mg/kg	26,000		26,000	J	11,000		10,000		12,000		8,800		4,700		14,000		9,300		14,000	
Antimony	mg/kg	2.8		1.8	J	<0.61	U	<0.74	U	<0.66	U	<0.73	U	<0.79	U	<0.74	U	<0.71	U	<0.86	U
Arsenic	mg/kg	14		9.9		5.5		3.6		3.4		9.6		2.1	J	2.8	J	3		5.4	
Barium	mg/kg	56		340	J	68		82		88		89		94		90		130		130	
Beryllium	mg/kg	1.1		0.98		0.57		0.65		0.48	J	0.64		0.32	J	0.7		0.79		0.68	J
Cadmium	mg/kg	7.1		30	J	2.8		5		6.7		15		2.1		1.5		1.1		1.1	
Calcium	mg/kg	250		1,300		360		520		540		710		720		500		960		660	
Chromium	mg/kg	39		32		12		10		11		19		5.5		11		8.5		15	
Cobalt	mg/kg	9.1		8.8		5.1		3.4		3.7		5.4		5.3		3.6		11		3.4	
Copper	mg/kg	1,100		1,900	J	370		1,200		780		890		78		650		900		270	
Iron	mg/kg	73,000		81,000	J	18,000		13,000		11,000		18,000		4,800		11,000		8,200		15,000	
Lead	mg/kg	450		440	J	64		63		44		43		25		33		31		38	
Magnesium	mg/kg	240		540		320		440		420		370		310		470		420		630	
Manganese	mg/kg	640		890	J	300		400		650		920		1,400		430		570		280	
Mercury	mg/kg	6.5		2.0	J	1.4		50		8.9		6.4		0.94		15		8.7		8.8	
Nickel	mg/kg	77		32		17		6.8		8.1		10		5.7		11		10		6.4	
Potassium	mg/kg	310	J	380		390		420		400		310	J	230	J	420		350	J	620	
Selenium	mg/kg	<1.4	U	<1.5	U	1.4		<1.5	U	<1.3	U	<1.5	U	<1.6	U	<1.5	U	<1.4	U	<1.7	U
Silver	mg/kg	0.18	J	1.1	J	<0.20	U	<0.25	U	<0.22	U	<0.24	U	<0.26	U	<0.25	U	<0.24	U	<0.29	U
Sodium	mg/kg	<110	U	400	J	<100	U	<120	U	<110	U	<120	U	<130	U	<120	U	<120	U	<140	U
Vanadium	mg/kg	26		21		15		17		17		26		10		18		14		25	
Zinc	mg/kg	12,000		3700	J	1,600		280		330		340		130		140		170		130	

Qualifiers: U = Not detected above reported sample quantitation limit J = Estimated result B = Found in sample and associated blank
 Adapted from Stell Environmental Enterprises, Inc., 2014. Revised Final Site Inspection Report, CPG Kickout Area, Louisiana Army National Guard, Camp Minden, Louisiana. November.

Table B-2: Comparison Values (CVs) used for Screening Contaminants of Concern

Constituent	Noncancer CV in milligrams per kilogram (mg/kg)	
1,2-Dinitrobenzene	NA [*]	
Tetryl	2300	Composite Worker Soil EPA RSL [†]
Perchlorate	36	Child Chronic EMEG [‡]
Aluminum	52,000	Child Chronic EMEG
Antimony	21	Child RMEG [§]
Arsenic	16	Child Chronic EMEG (Cancer related CV = 0.26 mg/kg)
Barium	10,000	Child Chronic EMEG
Beryllium	100	Child Chronic EMEG
Cadmium	5.2	Child Chronic EMEG
Cobalt	520	Child Intermediate EMEG
Iron	820,000	Composite Worker Soil EPA RSL
Lead	1200	EPA Action Level for areas other than children's play areas
Mercury	16	Child RMEG, inorganic mercury
Nickel	1000	Child RMEG
Silver	260	Child RMEG
Vanadium	520	Child Intermediate EMEG
Zinc	16000	Child Chronic EMEG

^{*}NA = not available


[†]EPA RSL = Environmental Protection Agency Regional Screening Level

[‡]EMEG = Environmental Media Evaluation Guide (Agency for Toxic Substances and Disease Registry)

[§]RMEG = Reference Dose Media Evaluation Guide, (Agency for Toxic Substances and Disease Registry)

EPA's ProUCL statistical software was used to calculate the 95 percent upper confidence limit, (95UCL) to serve as an exposure point concentration EPC for each of the constituents identified as contaminants of concern. The 95UCL is an upper-bound estimate of the actual average concentration of each contaminant. The EPCs were then entered into ATSDR's PHAST program to assess whether the identified contaminants pose harm to public health.

Table B-3: ARSENIC - Default combined ingestion and dermal exposure doses for chronic occupational exposure to arsenic in soil at exposure point concentration 9.539 mg/kg along with non-cancer hazard quotients and cancer risk estimates*


 Exposure Group	Dose (mg/kg/day)	Non-cancer Hazard Quotient	CTE Cancer Risk 5	RME Cancer Risk 20
Workers - indoor	2.1E-06	0.0069	2.0E-7	7.9E-7
Workers - outdoor (low intensity soil contact)	5.5E-06	0.018	5.3E-7	2.1E-6 ‡
Workers - outdoor (high intensity soil contact)	1.7E-05	0.056	1.6E-6 ‡	6.4E-6 ‡

Source: Stell Environmental Enterprises, Inc., 2014. Revised Final Site Inspection Report, CPG Kickout Area, Louisiana Army National Guard, Camp Minden, Louisiana. November
 Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/kg = milligram chemical per kilogram soil; RME = reasonable maximum exposure (higher); yrs = years

* The calculations in this table were generated using ATSDR's PHAST v1.8.0.0. The non-cancer hazard quotients were calculated using the chronic (greater than 1 year) minimal risk level of 0.0003 mg/kg/day and the cancer risks were calculated using the cancer slope factor of 1.5 (mg/kg/day)⁻¹.

‡ A shaded cell indicates that the cancer risk exceeds one extra case in a million people similarly exposed, which ATSDR evaluates further.

Table B-4: CADMIUM - Default combined ingestion and dermal exposure doses for chronic occupational exposure to cadmium in soil at exposure point concentration 17.01 mg/kg along with non-cancer hazard quotients*

 Exposure Group	Dose (mg/kg/day)	Non-cancer Hazard Quotient	CTE Cancer Risk 5	RME Cancer Risk 20
Workers - indoor	5.8E-06	0.058	-	-
Workers - outdoor (low intensity soil contact)	1.6E-05	0.16	-	-
Workers - outdoor (high intensity soil contact)	4.9E-05	0.49	-	-

Source: Stell Environmental Enterprises, Inc., 2014. Revised Final Site Inspection Report, CPG Kickout Area, Louisiana Army National Guard, Camp Minden, Louisiana. November
 Abbreviations: CTE = central tendency exposure (typical); mg/kg/day = milligram chemical per kilogram body weight per day; mg/kg = milligram chemical per kilogram soil; RME = reasonable maximum exposure (higher); yrs = years

* The calculations in this table were generated using ATSDR's PHAST v1.8.0.0. The non-cancer hazard quotients were calculated using the chronic (greater than 1 year) minimal risk level of 0.0001 mg/kg/day.

Table B-5: PHAST Default Occupational Exposure Factors

Duration Category	Days per Week	Weeks per Year	Years	Exposure Group Specific EF _{noncancer}	Exposure Group Specific* EF _{cancer}
Acute	-	-	-	1	NC
Intermediate	5	50	-	0.71	NC
Chronic	5	50	See exposure group specific exposure durations	0.68	= EF _{noncancer} x Exposure Duration for Cancer _{Exposure Group (years) ÷ 78 years}

Abbreviations: EF = exposure factor; NC = not calculated

Note: The dermal absorbed dose equation includes 1 event/day EF parameter.

* Cancer Risk is averaged over a lifetime of exposure (78 years).

Table B-6: PHAST Default Occupational Exposure Parameters

Exposure Group	Body Weight (kg)	CTE Exposure Duration for Cancer (years)	RME Exposure Duration for Cancer (years)	Intake Rate (mg/day)	Adherence Factor to Skin (mg/cm ² /event)	Combined Skin Surface Area (cm ²)
Workers - indoor	80	5	20	30	0.07	3470
Workers - outdoor (low intensity soil contact)	80	5	20	100	0.07	3470
Workers - outdoor (high intensity soil contact)	80	5	20	330	0.07	3470

Equations

Soil/Sediment Ingestion Exposure Dose Equation

$$D_{\text{noncancer}} = (C \times IR \times EF_{\text{noncancer}} \times CF) \div BW$$

$D_{\text{noncancer}}$ = dose (mg/kg/day), C = contaminant concentration (mg/kg), IR = intake rate (mg/day),
 $EF_{\text{noncancer}}$ = exposure factor (unitless), CF = conversion factor (10^{-6} kg/mg), BW = body weight (kg)

Administered Dermal Dose Equation

$$ADD_{\text{noncancer}} = (C \times EF_{\text{noncancer}} \times CF \times AF \times ABS_d \times SA) \div (BW \times ABS_{GI})$$

$ADD_{\text{noncancer}}$ = administered dermal dose (mg/kg/day), C = contaminant concentration (mg/kg), $EF_{\text{noncancer}}$ =
 exposure factor (unitless), CF = conversion factor (10^{-6} kg/mg), AF = adherence factor (mg/cm²-event),
 ABS_d = dermal absorption fraction (unitless), SA = skin surface area available for contact (cm²), BW =
 body weight (kg), ABS_{GI} = gastrointestinal absorption factor (unitless)

Hazard Quotient = $D_{\text{noncancer}} \div HG$

HQ = hazard quotient, $D_{\text{noncancer}}$ = dose (mg/kg/day), HG = health guideline (e.g., oral MRL, RfD)

Cancer Risk Equations

$$CR = D_{\text{noncancer}} \times CSF \times (ED \div LY)$$

$$\text{ADAF-adjusted CR} = (D_{\text{noncancer}} \times CSF) \times (ED \div LY) \times \text{ADAF}$$

$$\text{Total CR} = \text{Sum of the CR for all exposure groups}$$

CR = cancer risk (unitless), $D_{\text{noncancer}}$ = dose, CSF = oral cancer slope factor [(mg/kg/day)⁻¹], EF (cancer) =
 exposure factor (cancer)

calculated as follows: EF (non-cancer; unitless) \times exposure group specific exposure duration (years) \div
 lifetime of 78 years,

ADAF = age-dependent adjustment factor (unitless), ED = exposure duration (years), LY = lifetime years
 (78 years)