

QUANTIFYING LEAD EXPOSURE TO PERSONNEL ON FORT RILEY RANGES

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B.S. Life Science, Kansas State University, 2011

A FIELD EXPERIENCE REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF PUBLIC HEALTH

Master of Public Health Program
Department of Diagnostic Medicine/Pathobiology
College of Veterinary Medicine

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2013

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Abstract

Fort Riley Kansas is a U.S. Army military installation. In 2012 over five and a half million rounds of ammunition were fired on the training ranges (2). Most of these munitions contain lead and over time lead will accumulate on the ranges. Inhaled or ingested lead can have detrimental effects on human health. This study was conducted to determine if soldiers and range personnel are being exposed to lead particulates and if so, what are the levels of lead at the different locations. Soil, air and dust samples were collected from the ranges where personnel spend their work day and tested for the presence of lead.

Many of the samples collected tested positive for lead in the areas one would expect to find lead particulates to be present on a shooting range. Soil samples collected from outside the range area showed that lead particulates are not being carried off the ranges into the surrounding training areas. However, there was a sample collected from a small arms range ammunition shed that tested positive for lead when it shouldn't have considering the low number of ammunition fired on that range compared to other ranges ammunition sheds that tested negative for lead. This positive test resulted in multiple follow ups with different departments on Fort Riley to determine the cause of the contamination and what changes were needed.

It was determined that the ammunition shed on the small arms range most likely contained lead particles because of a misunderstanding of policy by the soldiers using the range; soldiers being briefed on the proper turn-in procedures for spent ammunition casings could alleviate the lead contamination issue on this range. Reviewing current procedures in place to protect range maintenance personnel from lead exposure only raised more questions in the

effectiveness of these procedures; the Fort Riley Public Health/Industrial Hygiene department will be conducting further studies to determine these risks.

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Acknowledgements

Thank you, Colonel Paul Benne, for your assistance with my Research Project and for allowing your staff to make time to accommodate Graduate Students so that they are able to complete their internships. I would also like to thank the entire Fort Riley Public Health Staff for all their help. Lastly, thank you Eric Coates, Gary Hicks and Heather Chance, of the Fort Riley Industrial Hygiene Department for all your guidance and help with this research.

Chapter 1 - Introduction

Fort Riley Kansas is home to the Army's 1st Infantry Division, various other Army units, and their supporting staff; in total Fort Riley employs 25,520 personnel, (7) and covers an area of 100,656 acres. (6) The impact area of Fort Riley covers about 22,000 acres of land that roughly resembles a rectangle. The vast majority of the impact area is off limits to all personnel for safety reasons; mortars, artillery, and tank rounds are all fired into the impact area and this gives the high probability that the impact area contains Unexploded Ordnance (UXO). The border of the impact area is marked by warning signs to keep out. **Figure 1**

Figure 1



Warning Sign (2013)

Outlying the warning signs is a “hard-ball” (paved) road that encircles the impact area and outlying the hard-ball road is the “tank trail”. As the name suggests this is a gravel road that is used by tanks and other heavy military vehicles that could damage the hard-ball road. The weapons ranges for Fort Riley are on the outlying border of the impact area with all the weapons being fired towards the center. Weapon calibers such as: 9mm, 5.56, .50, and 7.62, greatly vary

in their sizes and the amount of lead they contain. The typical round is a copper jacketed lead bullet, which makes the round relatively safe to handle (in terms of lead exposure) before the round has been fired. Upon impact the lead bullet will deform depending on the type of round and the type of surface it strikes. A standard “green tip” 5.56 round used by American forces and the North Atlantic Treaty Organization (NATO) Forces contains a steel core for add strength to penetrate through body armor or hardened targets; while a hollow point round is designed to expand on impact (typically called a “mushroom”) so that it passes on its kinetic energy to the target, making it less likely that the round will penetrate though, and at the same time it will inflict more damage (this is important for use in aircraft). Upon expanding these rounds can fragment and leave pieces of lead in the target even if the round itself passes through. These fragments increase the likelihood of causing a fatal injury or they increase the amount of time it will take a surgeon to remove the fragments, and this increases the wait times at a surgical ward, making it more likely that the target will die. **Figure 2.** These lead rounds or their particles can accumulate on the ranges, and possibly pose a risk for personnel using the ranges. The focus of this research is to determine if soldiers and range personnel are at risk of lead exposure from working on or around the Fort Riley ranges.

Figure 2



From left to right: .50, 12 Gauge, 7.62, 5.56 (green tip), .45 (hollow point), and 9 mm. 2013

Literature Review

The Williams-Steiger Occupational Safety and Health Act of 1970, requires that employers furnish to their employees a place of employment that is free from recognized hazards that are likely to cause death to or cause physical harm to their employees. (1) The Occupational Health and Safety Administration (OSHA) is a part of the Department of Labor that is responsible for setting the regulations that employers are required to follow. (1) OSHA produces

the manual: Standards for General Industry; in this manual under “Subpart Z- Toxic and Hazardous Substances, §1910.1025” it deals with lead safety in the work environment.

The most common forms of lead absorption into the body are by ingestion and inhalation; lead may also be absorbed through the dermis but this form of absorption is less common since tetraethyl lead is no longer a fuel additive. Inhalation of lead particles can be absorbed through the lungs and upper respiratory tract and are the most common means of lead absorption in the work place. Ingested lead particles are readily absorbed through the Gastrointestinal Tract (GI) when swallowed. Inhaled or ingested lead can enter the blood stream where it is circulated throughout the body and can become stored in various organs or tissues. (1)

The range of health effects caused by lead are broken down into 5 developmental stages by OSHA; normal, physiological changes of uncertain significance, pathophysiological changes, overt symptoms, and mortality. One of the first clinical signs of lead toxicity is the disruption of 2 enzymes that are used in the Heme Synthesis Pathway; the enzymes delta aminolevulinic acid dehydrase (ALA-D) and ferrochelatase become inhibited in blood lead levels below 20 microgram/100 grams (20µg/100g) of whole blood. Disruption of these enzymes leads to decreased hemoglobin production, resulting in anemia. (1)

Lead has been found to have an effect on both the Central Nervous System (CNS) and the Peripheral Nervous System (PNS). There are disputes about what exposure levels are needed to produce the earliest disruption of the CNS but it is agreed that symptoms will definitely be seen at blood lead levels of 60µg/100g whole blood. The earliest clinical signs in the form of behavioral disturbances are: irritability, restlessness, insomnia, fatigue, vertigo, headache, poor memory, tremors, depression, and apathy. Peripheral neuropathy from lead exposure typically

effects motor function; most commonly the extensor muscles of the most active extremity are affected first. After the source of lead exposure has been removed the detrimental effects from the exposure are typically not reversible or recovery is only partial. (1)

Blood lead levels above 80µg/100g of whole blood affect the gastrointestinal system by causing abdominal colic, diarrhea, constipation and abdominal pain. Renal toxicity in the early stages of lead poisoning are difficult to detect because blood urea nitrogen and serum creatinine only increase when 2/3 of kidney function is lost; continued exposure will eventually lead to uremia. (1)

Lead exposure can have detrimental effects on the reproductive systems of both men and women. Men exposed to lead may have a decreased sex drive, teratospermia (malformed sperm), and sterility. Teratospermia has been documented at mean blood lead levels of 53µg/100g. (1) Lead exposure in women can damage germ cells causing genetic damage to their eggs; this damage results in a higher than normal rate for stillbirths, miscarriages and sterility. Lead is capable of being passed from the mother to the fetus through the placental barrier allowing the fetus's blood lead level to be the same as the mothers. A fetus exposed to lead from their mother typically have higher mortality rates during their first year, lower birth weights, nervous system disorders, and decreased growth weight. Significant neurobehavioral impairments can occur in young children with blood lead levels of 50µg/100g. OSHA recommends that the maximum permissible blood lead levels in both men and women who are planning on procreating to be below 30µg/100g. (1)

Based on the aforementioned findings OHSA set their lead exposure in the work place limits. If lead is present in the workplace regardless of the amount, employers are required to

make a determination of whether the action level is being exceeded. The action level for lead is set at 30 micrograms per cubic meter of air ($30\mu\text{g}/\text{m}^3$), weighed on the average 8 hour work day. The action level requires the employer to monitor lead levels, conduct medical surveillance, lead safety training and educate its employees on lead exposures. Permissible Exposure Limit (PEL) for lead particulates in the air is set at $50\mu\text{g}/\text{m}^3$ air averaged over an 8 hour period. (1) This is the highest level of air to lead ratio that employees may be exposed to without additional safety equipment. Lead levels in excess of the PEL requires employers to provide their employees with respirators, at no cost to the employee. (1)

Certain types of lead compounds can cause eye and skin irritation, in such case the employer is required to provide protective work clothing and appropriate equipment for the hazard. For airborne lead levels above $200\mu\text{g}/\text{m}^3$, full body clothing, gloves, hats and disposable shoes must be provided to the employee; along with changing rooms and closed containers for contaminated clothing. The employer must also insure employees are not wearing their safety equipment outside of the work area, or on their breaks. (1)

Fort Riley Ordnance Standard Operating Procedures (SOP)

All the ammunition used on Fort Riley is first delivered to the Ammunition Supply Point (ASP), where it is stored in bunkers. The ASP is a secure location within Fort Riley and is operated by both Military and Civilian staff. When a military unit wants to use the ranges for training they put in a request for the type and quantity of ammunition they need for their training. On the day of training the unit sends a military vehicle to the ASP to pick up the requested ammunition, and to transport it to the range. Once at the range, the ammunition is unloaded and

moved into the ammunition (ammo) shed that is located on the range. The ammo sheds have a floor area of 89 square feet, one door, and a window with a platform that is used for the distributing of ammunition. Typically, specific soldiers will be designated to handle the ammunition and they will remain in the ammo shed for the duration of the training. With the qualification ranges the soldiers in the ammo shed are responsible for the loading of all the magazines to be fired, this ensures that qualifying soldiers all receive exactly the required amount of bullets. Once the training is completed, the brass casings (and belt links for the chain fed weapons) are picked up from the firing line to be returned to the ASP for recycling. The ASP has a 100% accountability policy for ammunition. This means that some form of the ammunition must be returned to the ASP as proof that the ammunition was used for training and not kept for personal use or sold illegally. For bullets, this is done by weighing all of the returned brass shells at the ASP; a given numbers of brass shells will have a predetermined weight. Any unused or damaged ammunition is returned to the ASP. (9)

Fort Riley Range SOP

The training to be conducted determines what range will be used because different ranges are set up for different types of weapons and different types of training. **Table 1** lists the ranges by their designated numbers, the type of weapons fired at each range and the number of rounds that were expended in 2012.

Table 1

RANGE #	RANGE TYPE	# OF ROUNDS EXPENDED
Range 1	M-4	1,128,000
Shoot House 1	M-4, M-9	32,000
Range 2	M-9, Shot Gun	464,000

Range 3	M-4	850,000
Range 4	Grenadier Gunnery, Public Range	278,000
Range 5	Shoot House 5	84,710
Range 6	M-4, M-9, M-2	267,000
Range 7	Machine Gun	2,140,000
Range 8	Not in Use	Not in Use
Range 9/10	Live Convoy	250,000
Range 25	Fragmentation	
Range 27	M-9	25,000
TLC 1	M-9, M-4, M-249	50,000
TLC 2	M-9, M-4, M-249	42,000
TOTAL ROUNDS 2012		5,610,710

Rounds Fired Per Range in 2012.

Fort Riley Range Support (2013)

TLC = Troop Leader Course

M-4 = 5.56 Rifle

M-9 = 9mm Hand Gun

Grenadier = 40 mm grenade

M-240 = 7.62 mm Machine Gun

M-249 = .223 mm Machine Gun

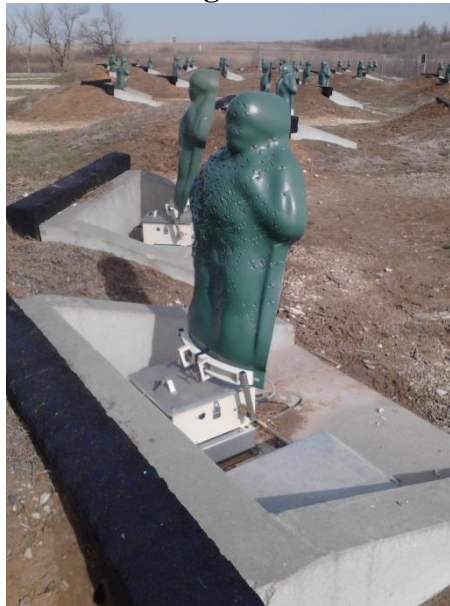
M-2 = .50 caliber Machine Gun

Machine Gun = M-249, M-240, M-2

Each range has a latrine (bathroom), ammo shed, instruction bleachers, classroom, control tower, maintenance shed and a firing line. On a typical range soldiers do not go past the firing line, the exception is the zero range. Before the soldiers go to the qualifying range they must first zero the sights on their weapons. This is done on a short range where the soldiers fire 3 rounds into a paper target at 25 meters; after firing the 3 rounds they walk to the target to check their shot grouping and adjust their sights accordingly until the weapon is zeroed. The qualifying ranges have plastic pop-up targets that are raised and lowered by a machine; this machine sits behind a dirt berm to protect it from bullets that fall short of their target. These targets are at different distances ranging from 50 meters to 1,000 meters, and are programmed to pop-up at different times for a few seconds or until they are hit with a bullet, then lie back down. The pop-

up targets are made from a plastic that allows the bullet to pass through them and close the hole afterward. (**Figure 3**) The life span of the targets will vary greatly from range to range, depending on the type and caliber of weapons being used. (2)

Figure 3



Pop-up targets (2013)

Some ranges have simpler targets called “Iron Maiden”; this target is a silhouette of a human that has been cut out of steel and suspended off the ground (**Figure 4**). When a soldier fires a bullet and it hits the target it produces a ‘ping’ sound letting the soldier know he scored a hit.

Figure 4



Iron Maiden (2013)

Range control personnel are responsible for the maintenance and the up keep of the ranges on Fort Riley; they are the individuals who go down range (past the firing line) to replace worn out targets, work on the pop-up machines, mow the grass, clear snow, keep the range clean, and maintain the protective berms. When the ranges are in use the range personal operate the targets from the control tower.

Fort Riley Shoot Houses

There are two shoot houses on Fort Riley, shoot house 1 and shoot house 5. These houses are used by soldiers to practice Close Quarters Battle (CQB), part of urban warfare training. During training in these facilities soldiers can fire their weapons using: blanks, paint rounds or live rounds. Blanks are bullets without the lead projectile; the brass shell has been crimped at the open end to hold in the gun powder. When firing blanks the weapon must be fitted with a brightly colored blank adapter over the end of the barrel for functional reasons and for additional safety. The paint rounds are non-lethal rounds that can be fired from the soldiers M-4 rifle when a special bolt and magazine are replaced in the weapon. When using blanks or paint rounds, live individuals can serve as an enemy that is waiting inside the rooms of the shoot house that can respond to the attacking soldier's tactics while being able to return fire; they are more commonly known as Opposing Force (OP4). The shoot houses are also used for live fire training. The rooms can be fitted with dummy OP4 targets that when shot fall down. All of the training conducted in both shoot houses is recorded on cameras that are located in every room of the building. The camera footage can be reviewed after the training as part of the soldiers After Action Review (AAR), where the soldiers critique their training.

The walls of shoot house 5 are made of cement, while the walls of shoot house 1 are made from plywood and boards; something that would resemble a wall in a house, only here instead of insulation filling the space in the walls they are filled with gravel. This is done to stop the bullets during live fire training and to prevent ricochets. (2) The live fire targets for both shoot houses sit in front of an additional bullet catcher that is free standing and designed to collect the bullets in a trap at its base; these bullet traps make cleanup faster and extend the life of the gravel filled walls. **(Figure 5)**

Figure 5



Bullet Stop (2013)

Both shoot house buildings are an open air design that allows the wind to blow freely through them; this is supposed to negate the need for a mechanical venting system. (2)

Shoot house 1 is a two story complex that is made up of 7 rooms on the ground floor and one room on the second floor. Shoot house 5 is the largest and more modern of the two complexes. Shoot house 5 has 8 rooms all located on the ground floor. The second floor is made up of catwalks that allow observers to view firsthand the training going on below. Shoot house 5 is co-located with the Fort Riley Range Support buildings that house the administrative office, maintenance area, and employee break room.

Due to government budget cuts the amount of training being conducted in the two shoot houses has decreased. During the two months of my internship/research on Fort Riley the shoot houses were not in use. On 3 different occasions in 2012, personnel from the Fort Riley Public

Health/Industrial Hygiene office conducted lead sampling from shoot houses 1 and 2; their analytical results have been incorporated with this report.

Chapter 2 - Methods

Fort Riley Public Health/Industrial Hygiene has several different tools/methods to test for the presence of lead; these are: “Ghost Wipes”, air sampling pumps, and a metal agar for soil collection. All of the collected samples are sent to the United States Army Public Health Command, located at Aberdeen Proving Grounds, Maryland for analysis.

When testing solid surfaces for the presence of lead “Ghost Wipes” are typically used. Ghost wipes are 15cm x 15cm, pre-moistened wipes (deionized water) that are individually packaged; these wipes meet all of the American Society for Testing and Materials (ASTM) Designation E 1792 specifications for sampling materials for the presences of lead particulates.

(3) Sampling for the presence of lead was done in accordance with the National Institute of Occupational Health and Safety (NIOSH) Manual of Analytical Methods (NMAM) standards. Wearing a clean pair of plastic gloves for each sample collected, a pre-cut square template with an opening of 6inches-by-6inches was placed over the area to be sampled. A wipe would be removed from its individual packaging and unfolded. Using the 2nd & 3rd digits of the hand and applying light pressure, the surface would be wiped in an ‘S’ pattern over the whole surface area, top to bottom. Folding the exposed side of the wipe in, then wiping in the same ‘S’ pattern from left to right. Folding the wipe for a 3rd time with the exposed side in, one final wipe of the area is done. Folding the wipe for a 4th time with the exposed side in, the wipe was placed in its own individual plastic bag and sealed. One wipe was removed from its packaging and placed in an

individually sealed bag at the beginning, middle and end of the sampling process to serve as the controls. (4)

Air samples were collected using the GilAir Plus, a universal air sampling pump. These pumps can be set to sample air for a general area or they can be clipped onto a belt and a hose can be clipped to the shirt collar to test the air that an individual would be breathing (breathing zone sample). Before and after being used for testing the pumps are calibrated. The air being pulled in through the hose by the pump is forced through a Cellulose Ester Membrane Filter, .8-micron pore size. These filters are assembled by the Fort Riley Public Health staff in their lab. An unused, assembled filter is submitted with the filters that were used to collect the air samples; this serves as a control blank to insure there was no contamination during assembly.

Soil Samples were collected using a stainless steel 1 inch diameter sampling tube that was driven 6 inches into the soil. The soil was removed from the tube and placed into a clean sealable bottle to be submitted for analysis. The instrument was cleaned between each sampling to insure there was no cross contamination between samplings.

Doctor Ganga M. Hettiarachchi from the Department of Agronomy at Kansas State University was contacted to determine a base line for what the average lead levels for this area of Kansas are. Per the KSU agronomy lab, soils tested in this area normally have a lead concentration at or below 20 mg/kg; as long as the soil is uncontaminated by mining, leaded gasoline, lead paint, or batteries. (5)

Chapter 3 - Sampling / Analytical Results

Ranges

Collecting samples to test for lead was conducted on February 13th, 2013; the results are charted on **Table 2**.

Table 2

RANGE #	SAMPLE TYPE / TIME COLLECTED	SAMPLE #	AREA COLLECTED	ADDITIONAL INFO	DATA RESULTS
1	AIR / 0754	1	FIELD BLANK	AMMO SHED	0.50 µg U
1	AIR / ON: 0756 / OFF: 1010	2	PUMP 268L	AMMO SHED	0.50 µg U
1	WIPE / 0756	3	WINDOW	AMMO SHED	20µg/wipe U
1	WIPE / 0756	4	BACK SHELF	AMMO SHED	20µg/wipe U
1	WIPE / 0806	5	TABLE	CLASSROOM	20µg/wipe U
1	WIPE / 0806	6	BRM STOOL	CLASSROOM	20µg/wipe U
2	WIPE / 0816	7	DESK	TOWER	20µg/wipe U
2	WIPE / 0820	8	WINDOW	AMMO SHED	25µg/wipe
4	WIPE / 0830	9	DESK	TOWER	20µg/wipe U
4	WIPE / 0835	10	TABLE	FIRING LINE	20µg/wipe U
4	WIPE / 0838	11	WINDOW	AMMO SHED	20µg/wipe U
4	WIPE / 0840	12	TABLE	CLASSROOM	20µg/wipe U
7	WIPE / 0848	13	TABLE	TOWER	20µg/wipe U
7	WIPE / 0856	14	TABLE	CLASSROOM	20µg/wipe U
7	WIPE / 0854	15	WINDOW	AMMO SHED	20µg/wipe U
7	WIPE / 0905	16	MACHINE	TARGET	90ug/wipe
7	SOIL / 0911	17	BERM	TARGET	400mg/kg
9 / 10	WIPE / 0919	18	WINDOW	AMMO SHED	20µg/wipe U
9 / 10	WIPE / 0923	19	PLATFORM	FIRING LINE	20µg/wipe U
9 / 10	SOIL / 0930	20	BERM	TARGET	72 mg/kg
9 / 10	WIPE / 0931	21	MACHINE	TARGET	20µg/wipe U
6	WIPE / 0942	22	IRON MAIDEN	TARGET	1,100µg/wipe
6	SOIL / 0945	23	BERM	TARGET	2,500 mg/kg
5	WIPE / 0955	24	TABLE	BREAKROOM	20µg/wipe U
5	WIPE / 0955	25	TRASH CAN LID	BREAKROOM	20µg/wipe U

Lead Data from Range 2013

U = the analyte/element was not detected at or above the limit of quantitation (LOQ).

µg = microgram

mg = milligram

Range 1: the GilAir pump was set up in the ammo shed and allowed to run for 2 hours and 16 minutes; pumping a total of 268 liters of air while soldiers were actively loading M-4 rifle magazines to be fired on the range. The back shelf and window of the ammo shed were sampled with ghost wipes; in the range classroom a table and stool were sampled by using ghost wipes. The air sampling for lead particulates in the ammo shed was below the limit of quantitation (LOQ), .50µg. The results for lead sampling with the ghost wipes at range 1 were all below the LOQ, 20 µg/wipe.

Range 2: ghost wipe samples were collected from the desk in the control tower and the ammo shed window. The sample collected in the control tower tested below the LOQ, 20µg/wipe for lead. The ghost wipe taken from the window of the ammo shed tested positive for the presence of lead at 25µg/wipe. At the time of sampling the range was in use by soldiers.

Range 4: ghost wipe samples were collected from the desk in the control tower, a table on the firing line, a table in the classroom, and from the window of the ammo shed; at the time the range was in use by soldiers. All of the wipe samples collected from range 4 detected below the LOQ, 20µg/wipe for lead.

Range 5: ghost wipe samples were collected from the range support break area, to see if lead particulates were being carried over from the ranges by personnel; wipe samples were collected from the eating table and trash can lid. Both of these samples tested below the LOQ, 20µg/wipe for lead. The break room was not in use when samples were collected.

Range 6: a sample for lead was taken using a ghost wipe on one of the iron maidens located down range from the firing line. The wipe sample tested positive for the presence of lead, 1100µg/wipe. A soil sample was collected from below the iron maiden; this sample also tested positive for the presence of lead, 2,500 milligram/kilogram (mg/kg). Range 6 was not in use when the samples were collected.

Range 7: lead was sampled for by using ghost wipes on a table in the control tower, a table in the classroom, and the window of the ammo shed; all three of these samples tested below the LOQ, 20µg/wipe for lead. 150 meters down range from the firing line a pop-up target machine was sampled with a ghost wipe and a soil sample was collected from the machines protective berm; both samples tested positive for the presence of lead. The ghost wipe sample from the pop-up target machine tested 90µg/wipe and the soil sample tested 400 mg/kg. Range 7 was not in use when the samples were collected.

Range 9 and 10 are collocated. Ghost wipe samples were collected from the window of the ammo shed and from a platform on the firing line; both of these samples tested below the LOQ, 20µg/wipe for lead. 50 meters down range from the firing line a ghost wipe sample was collected from a pop-up target machine and a soil sample collected from the protective berm in front. The ghost wipe of the pop-up machine tested below the LOQ, 20µg/wipe for lead. The soil sample tested positive for lead, 72 mg/kg. Ranges 9/10 were not in use when the samples were collected.

Peri-Impact Area

At the request of Colonel Benne (Chief of the Fort Riley Public Health Department), soil samples were collected on March 1st, from the roadside of the tank trail that surrounds the impact area; Samples were collected from the: North, Northeast, East, Southeast, South, Southwest, West, and Northwest. The intent for this sampling was to assess if lead particulates are being carried off the impact area into the surrounding training areas. **Table 3** shows the collection sites and their analytical results.

Table 3

Sample #	Location	Area	Time	Results
1	91	N	1000	12 mg/kg U
2	33	NE	1011	12 mg/kg U
3	25	E	1024	13 mg/kg U
4	7	SE	0900	10 mg/kg U
5	9	S	0913	11 mg/kg U
6	15	SW	0924	11 mg/kg U
7	41	W	0935	8.8 mg/kg U
8	90	NW	0950	12 mg/kg U

Soil Samples Peri-Impact Area (2013)

U = the analyte/element was not detected at or above the limit of quantitation (LOQ).

All of the soil samples collected from around the impact area tested below the LOQ for the presence of lead. The data shows different limits of quantitation for different samples because different soil samples required different dilutions for testing the at the lab.

Shoot houses 1 & 5, General Area Air Sampling

Personal from the Fort Riley Public Health/Industrial Hygiene office conducted air sampling in both the shoot houses over the course of 10 days, May 1st to May 10th. The air pumps were placed on tripods to capture any lead particulates in general areas located within the

shoot houses; samples were collected on days when the shoot houses were in use and on days when not in use; the results are shown in **Table 4.** (8)

Table 4

Field Sample #	DATE	COLLECTION SITE / STATUS	TOTAL RUN TIME (MIN)	AIR VOLUME	DATA RESULTS	AIR PER OSHA STANDARDS
1756	5/1/12	SH1 / NOT IN USE	427	1060 L	.50 µg U	<.50 µg/sample
1757	5/1/12	SH1 / NOT IN USE	424	1060 L	.50 µg U	<.50 µg/sample
1758	5/1/12	SH1 / NOT IN USE	419	1050 L	.50 µg U	<.50 µg/sample
1759	5/1/12	SH1 / NOT IN USE	423	1050 L	.50 µg U	<.50 µg/sample
1762	5/4/12	SH5 / NOT IN USE	414	998 L	.50 µg U	<.50 µg/sample
1763	5/4/12	SH5 / NOT IN USE	415	1010 L	.50 µg U	<.50 µg/sample
1764	5/4/12	SH5 / NOT IN USE	413	1010 L	.50 µg U	<.50 µg/sample
1765	5/4/12	SH5 / NOT IN USE	413	1000 L	.50 µg U	<.50 µg/sample
1768	5/8/12	SH5/ LIVE FIRE	441	1100 L	.79 µg	.72 µg/m ³
1769	5/8/12	SH5 / LIVE FIRE	434	1090 L	.35 µg	32 µg/m ³
1770	5/8/12	SH5 / LIVE FIRE	436	1090 L	14 µg	13 µg/m ³
1771	5/8/12	SH5 / LIVE FIRE	428	1080 L	2.1 µg	2 µg/m ³
1774	5/10/12	SH1 / LIVE FIRE	489	1230 L	30 µg	24 µg/m ³
1775	5/10/12	SH1 / LIVE FIRE	487	1220 L	10 µg	8.2 µg/m ³
1776	5/10/12	SH1 / LIVE FIRE	485	1220 L	7.8 µg	6.4 µg/m ³
1777	5/10/12	SH1 / LIVE FIRE	484	1190 L	12 µg	10 µg/m ³

Department of Public Health, Irwin Army Community Hospital, Fort Riley. (2012)

SH = Shoot House

µg = Microgram

U = The analyte/element was not detected at or above the limit of quantitation (LOQ)

m³ = Meter Cubed

L= Liter

Shoot house 5

Personal from the Fort Riley Public Health/Industrial Hygiene Department collected ghost wipe samples in shoot house 5 on June13, 2012 to test the different areas for lead particulate build up. For obvious Safety reasons, the shoot house was not in use at the time the samples were collected. The results are shown in **Table 5**. (8)

Table 5

Description	Sample #	DATE / TIME	DATA RESULTS
Wall Room 9 A	SH59A	13JUN12 / 1318	20 µg/wipe U
Wall Room 12 B	SH512B	13JUN12 / 1323	20 µg/wipe U
Wall Room 11 C	SH511C	13JUN12 / 1327	20 µg/wipe U
Wall Room 10 D	SH510D	13JUN12 / 1330	20 µg/wipe U
Wall Room 6 E	SH56E	13JUN12 / 1334	20 µg/wipe U
Wall Room 6 F	SH56F	13JUN12 / 1345	160 µg/wipe
Catwalk 1 A	SH5CAT 1A	13JUN12 / 1350	20 µg/wipe U
Catwalk 2 A	SH5CAT2A	13JUN12 / 1352	20 µg/wipe U
Camera 1	SH5CAM1	13JUN12 / 1400	20 µg/wipe U
Bullet Trap / Room 6	SH56BLT	13JUN12 / 1335	29 µg/wipe
Bullet Trap / Room 12	SH512BLT	13JUN12 / 1342	110 µg/wipe
TGT 1	SH5TGT1	13JUN12 / 1340	20 µg/wipe U
TGT 25	SH5TGT25	13JUN12 / 1338	27 µg/wipe

Department of Public Health, Irwin Army Community Hospital, Fort Riley. (2012)

U = The analyte/element was not detected at or above the limit of Quantitation (LOQ).

µg = Microgram

SH = Shoot House

TGT = Target

BLT = Bullet Trap

Shoot House 1

In November, 2012 shoot house 1 underwent repairs by the Range Support Personal. Industrial Hygiene was present to take air samples during the cleanup to monitor the repair process and insure OSHA guidelines for lead cleanup were being followed. The results of the air sampling are shown in **Table 6.** (8)

Table 6

FIELD SAMPLE #	DATE	SITE	TOTAL RUN TIME (MIN)	AIR VOLUME	DATA RESULTS	AIR PER OSHA STANDARDS
12-EC-001	4/11/2012	GE	68	139 L	95 µg	680 µg/m ³
12-EC-002	4/11/2012	BZ	81	164 L	140 µg	850/µg/m ³
12-EC-003	4/11/2012	NONE	BLANK	Blank	Blank	Blank

Department of Public Health, Irwin Army Community Hospital, Fort Riley. (2012)

µg = Microgram
m³ = Meter Cubed
mg = Milligram
BZ = Breathing Zone
GE = General Area

Chapter 4 - Discussion

Ranges

The majority of the Ghost wipe samples collected from the ranges tested negative for the presence of lead where it was expected (before the firing line), with one exception. On range 2 the Ghost wipe taken from the window of the ammo shed showed lead present at 25µg in a six inch square area. The presence of lead in this location was a surprise because range 2 is only used for hand guns and shot guns; this means relatively few rounds are fired from this range compared to the machine gun ranges, which tested negative for the presence of lead in the areas

before the firing line. Speaking with the Range Support Personnel I found out that all of the spent shell casings for range 2 are returned to the ammo shed where they are individually placed back into the box they came out of. **Figure 6** shows the range 2 ammo shed window with loaded magazines waiting to be fired and an open box of rounds that the 9 mm bullets come in. Normally on the ranges the last thing soldiers do on the range is “Police up the brass” (collect all the spent shell casings), and dump the casings back into the ammunition cans they came in. I asked the range personnel why the spent shell casing collection was different for the 9 mm shell casings and I was told it is because there is 100% accountability for the 9mm and the casings have to go back into the box they came in.

This led me to speak with Mr. Jackson from the Ammunition Supply Point (ASP) to find out why the policy for 9 mm rounds was different from other munitions. From Mr. Jackson I learned about how ASP personnel weigh the spent shell casings as a means for accountability. I found that it is in fact not the policy for soldiers to place the spent shell casings individually back into the box they came from and in fact soldiers are told not to do so by the ASP personnel when they pick up their ammo; the reason being that when the casings are placed back into the box in which they came from, the ASP personnel can tell if a single shell is missing and there is no need to weigh the shells. However, when the shells are weighed it is for within two pounds of the designated weight and this gives the soldiers some leeway if they don't find 100% of the spent casings.

Figure 6



Range 2 Ammo Shed. (2013)

Testing areas down range demonstrated that as assumed there is lead contamination in these areas and personnel are exposed to it. Lead levels of 1,100 μ g were detected on the Iron maiden at range 6. The machine responsible for raising/lowering pop-up targets on range 7 tested positive at 90 μ g, but the pop-up target machine at range 9/10 tested negative for the presence of lead. It was expected to find high levels of lead on the iron maiden since it is struck by bullets and they do not always pass through the steel plate. As for why the pop-up target machine at range 7 tested positive for lead while range 9/10 did not, I can only speculate; range 7 had over 2 million rounds fired in 2012, while range 9/10 only had only a half million fired. The sheer difference in numbers can account for this difference or it is because range 7 has been in use for years, while range 9/10 is only a couple years old.

The soil sample results were what was expected. Range 7's berm tested at 400mg/kg for lead, while range 9/10 berm tested at 72 mg/kg of lead; range 7 simply has more rounds fired and

this could account for why the lead levels are higher. The soils sample collected from range 6 tested positive for lead at 2,500 mg/kg. This sample was collected from directly under the iron maiden where the lead bullets fall after striking the steel plate.

Once it was verified that there is a risk of lead exposure to the personnel working down range I spoke with Mr. Bomia, the supervisor for the ranges to determine what protocol was in place to reduce the risk to his employees. When employees go down range they wear leather gloves, this is because majority of the items down range have been shot and have jagged edges that can cut the skin. During the summer months when the ranges require the grass to be cut, only closed cab mowers are used down range; this helps prevent the operator from inhaling any lead dust that might be kicked up. The protective dirt berms around the targets do erode and they are fixed using a closed cab bobcat with a bucket scoop; again, the closed cab is intended to prevent the operator from inhaling any lead particles that may be disturbed when digging.

As was hoped for, the employee/soldier work areas (control tower, break room, class room) tested negative for the presence of lead. For the purpose of this study it was important to be sure lead was not being tracked from down range back into the working areas where the soldiers and personnel are; for the most part this was confirmed, the exception being range 2's ammo shed.

Peri-Impact Area

The intent of this sampling was to determine if lead particulates are being carried off the impact area into the surrounding training areas. All 8 of the soil samples collected tested below the LOQ for the presence of lead. This finding is important because the samples were taken from the sides of the tank trail; military vehicle typically travel in convoys that create clouds of

dust for the next vehicle behind them. This is not to say that lead has not leached out from the impact area and into the local streams or water table; there is definitely a potential environmental hazard from the impact area, but that is out of the scope of this paper.

Shoot Houses

General area air samples were collected over a 10 day period from both shoot houses while they were in use and not in use during May 2012, to test for lead particulates in the air. When not in use both shoot houses tested below the LOQ for the presence of lead, .50 μ g. When the shoot houses were in use and air samples were collected both shoot house 1 and shoot house 5 tested positive for lead particulates; the average mean being 12.15 μ g/m³ and 11.43 μ g/m³, respectively. Shoot house 1's highest test sample for lead was 24 μ g/m³ over an 8 hour period and shoot house 5's highest sample tested at 32 μ g/m³ over a 7 hour period. The Action Level set by OSHA for lead exposure is 30 μ g/m³ over an 8 hour period; at first glance it would seem shoot house 5 surpasses the Action limit. However, the pumps were left running non-stop collecting air throughout the day, while in reality soldiers in the shoot houses are rarely in the building for longer than 15 minutes and most likely were not in the room where the 30 μ g/m³ sample was collected for longer than 1 to 2 minutes. When the time frame is taken into account, these seemingly high exposure risks are actually very low and do not come close to the Action Levels set for lead exposure.

In June 2012, one month after the air samples were collected from both shoot houses, shoot house 5 was tested for the presence of lead using ghost wipes. Since air samples taken

while the shoot house was in use tested positive for the presence of lead particulates in the air, one would expect those particulates to settle out of the air and accumulate within the building.

However, only 4 of the 13 the ghost samples tested positive for the presence of lead. The outdoor range targets and pop-up machines tested positive for the presence of lead with ghost wipes, so it was of no surprise that the bullet traps in the shoot houses tested positive, as well as one of the targets.

During the repairs to shoot house 1, the sampled lead/air levels were extremely high: $680\mu\text{g}/\text{m}^3$ and $850\mu\text{g}/\text{m}^3$. High lead levels were anticipated and the workers performing the repair task were in full compliance with OSHA standards by wearing protective clothing, gloves, shoe covers, hats and filtered masks. The work itself was done in less than 1.5 hours and according to the range personnel these repairs are only done once a year. Mr. Coates from Industrial Hygiene said as a precaution after the repairs were finished several of the range workers has their blood tested for the presence of lead and all came back negative; because of HIPAA (Health Insurance Portability and Accountability Act) regulations he was not able to give me any more specific information.

Chapter 5 – Recommendations

Reviewing the data from the collected samples for lead on the Fort Riley Ranges shows that there is a potential risk of lead exposure. Having tested for the presence of lead and now knowing the specific quantitative levels of lead in the different locations; recommendations can be made to protect soldiers and range personnel from exposure. However, as happens in most research topics, the findings in this research just raises more questions and requires more testing to be done.

Ranges

From the data collected it appears that most of the lead particulates are staying down range where the majority of soldiers never go, the one exception being the ammo shed on range

2. Having tracked down the suspected cause of the lead getting into the ammo shed (the spent casings that are being returned to the shed and placed back into their box) and finding that this is not the proper SOP for the handling of casings; a simple enforcement of a policy to keep spent casing out of the buildings should correct this issue and the ammo shed should be cleaned of the lead accumulation currently there as per OSHA standards: “employer must establish a housekeeping program sufficient to maintain all surfaces as free as practicable of accumulations of lead dust.” (1) At a later date the ammo shed should be tested again to insure that the ammo shed is still free of lead particulates.

Per Dr. Hettiarachchi of Kansas State University’s Agronomy Department, the average soil for the Fort Riley area should contain no more than 20µg/kg of lead. (5) Soil samples collected from down range contained lead in concentrations that at one measurement was 125 times higher than what should have been typical for that area without contamination. As a protective measure the range personnel supervisor only allows closed cab mowers and Bobcats to be used down range; however Mr. Coates of the Industrial Hygiene Department said they will be collecting breathing zone air samples from workers both inside and outside of the cabs of the vehicles while range personnel work down range to insure these protective measures are adequate. Range personnel also operate down range in civilian trucks that can create dust clouds that engulf the range vehicle once it stops. Air sampling needs to be conducted to test for the

level of lead in these dust clouds; a reduction in speed can help reduce the amount of dust suspended into the air by moving vehicles.

Hand washing facilities are in place at all of the ranges and it is important that they are stocked with degreaser hand soap. Ft. Riley Personnel should be washing their hands with soap after returning from down range or after handling items that have come from down range and always before eating. Soldiers should be washing their hands after handling ammo or after firing their weapons.

Peri-Impact Area

All of the soil samples collected from around the impact area tested below the LOQ. The LOQ varied from sample to sample but none surpassed the 20µg/kg of lead to soil concentration; these findings are in line with what Dr. Hettiarachchi of Kansas State said the soil sample concentrations for that area should be if they have not been contaminated with lead.

This is not to say that lead from the ranges is not leaching down into the water table, washing away in the streams or bio accumulating in the wildlife that moves in and out of the impact area at free will. These scenarios are possible but they were outside of the parameters of this study. The Fort Riley Public Health Department will continue monitoring and testing the environment for the presence of lead.

Shoot Houses

The major threat found for lead exposure in the shoot houses on Fort Riley was during the repair work in shoot house one; the high level of lead exposure had already been identified

and the range personnel followed full OSHA safety guidelines during repairs to minimize their exposures.

During active shooting in the houses, one air sample collected showed lead levels as high as $32\mu\text{g}/\text{m}^3$, over a 7 hour period. As discussed before, soldiers using the Fort Riley shoot houses are only in the buildings for very brief periods; this means the actual exposure risk is very low. This cannot be said for all shoot houses on other military installations. Fort Riley does not house any Special Operations units. Special Operations units train for considerably longer periods of time and expend thousands of rounds while in shoot houses; their exposure is considerably higher than the average soldiers. Research into a Special Operations soldiers risk for lead exposure in shoot houses needs to be conducted.

Knowing that lead particulates are present in the shoot houses it is recommended that after training is finished samples be collected for the presence of lead on the soldier's uniforms. Unless soldiers are in the field for training they typically go home after the day's training in the same uniform they wore while shooting. If lead particulates are found to be present on their uniforms, this could pose a significant risk for soldiers who have young children at home.

Chapter 6 - Field Experience

During my internship on Fort Riley I was rotated through the different departments at Irwin Army Community Hospital that fall under the Public Health Department. This rotation gave me an idea of how all the different departments work together to maintain and improve health on the base. I was rotated through the departments of: Environmental Health, Public Health Nursing, Industrial Hygiene, Veterinary Services, Occupational Health, and Army Hearing Conservation.

Environmental Health

During this rotation I shadowed the Environmental Health staff as they conducted a food service inspection of the food court located at the main Post Exchange (PX). The food court restaurants that were inspected are: Charley's Grilled Subs, Burger King, Anthony's Pizza 2, Starbucks, Manchu Wok, and Popeye's Chicken. The food court restaurants were inspected for: cleanliness, chemicals were being stored separate from the food, food was being kept at the appropriate temperatures, and that all opened food packages were labeled with the date they were opened. During the lunch rush (11:00 to 1:00) we monitored all the employees as they worked to ensure the food was handled correctly and that employees were washing their hands when regulations required them to. The main violation observed that day was employees not washing their hands.

Working with the same staff members who conducted the food service inspections we conducted inspections at one of Fort Riley's Child Development Centers (CDC). The inspection of this facility began in the kitchen, checking for cleanliness, expiration dates, food temperature and that any open food was labeled and stored properly. Then we inspected every child care room for: all cabinets were locked, refrigerators were at the correct temperatures, food or bottles in the fridge had the time & dates they were prepared, changing areas were clean, hand washing areas had soap & paper towels, checked to make sure spray bottles of cleaning solutions were made daily, and checked that the bleach bottle solution had at least 20 parts per million of chlorine.

For the most part the CDC inspection was uneventful except for an unlocked cabinet every few rooms. However, all of the cleaning bleach solutions checked were showing chlorine levels so low that they were below detectible levels for the test strips. When we asked the staff members who prepared the solutions they told us they had followed the mixing instructions that they always had but noted that the bleach bottles looked different from what they usually used. We checked the laundry room where the bleach solutions are prepared and found that instead of the regular bleach solution they had “Clorox Green Works Chlorine- Free Bleach”. After speaking with the facility manager we found out that the company that delivers supplies to the CDC was out of regular bleach so they substituted it with the chlorine free bleach. The inspector informed the facility manager that this bleach did not meet the federal standards and they were also in violation by not having the new chemical in the Material Safety Data Sheet (MSDS) book. The facility manager agreed to immediately replace all the cleaning solution with the correct bleach solution (after digging around they found a couple bottles of the old bleach) and to send back all of the chlorine free bleach they had received. Upon returning the Environmental Health office, the office of Public Health Nursing was made aware of the chlorine bleach problem since both offices do inspections at the Post CDC’s.

Working with the Water Quality Surveillance supervisor we went to different locations on Post to collect water samples for culturing and to test the levels of chlorine & PH. Chlorine and PH levels are tested on location where they are collected, this is done with a water quality tester. Before we headed out to Post we ran calibration tests and preformed them again when we returned. Using a “Colier 18”, (Idexx Company) the water is tested for the presence of Coliform and Escherichia Coli. Water sampling is conducted every week to ensure the base water supply stays within the State of Kansas regulations.

Fort Riley covers a large area and not all areas consume water at the same rate; this creates a problem for residual chlorine levels in the less used areas. Camp Funston is located on the East side of the base and is the farthest part of the Post that receives water from the water treatment facility. Camp Funston once housed the Combat Advisor School for soldiers before they deployed to Iraq or Afghanistan as advisors. With the drawdown of military actions, the school was closed and the buildings turned over to the Kansas National Guard who mainly uses them during the summers for training. Because Camp Funston is so far separated from the rest of main Post and is now used very little, the residual chlorine levels drop below the acceptable State levels. Also, after long periods of non-use there is a considerable amount of rust in the water. The current solution has been to let the fire hydrants on Camp Funston run a couple times a month to insure proper chlorine levels and to flush out rust from the pipes. This is of course is a waste of water and environmental health is still looking for a better solution to the problem. Currently, Fort Riley is having a new water main put in to replace the old corroded cast iron water main. We looked at samples that had been removed from the old water main in 2007 that help lead to the decision to replace it. **Figure 7**

Figure 7



Samples of the Cast Iron Pipes taken from Fort Riley's Water Main.

2013

The Environmental Health Department is also responsible for conducting quarterly inspections of Irwin Army Community Hospitals different departments to insure proper waste management is being followed; we conducted an inspection of the hospital pharmacy. We insured the proper waist bins (sharps, biowaste, medication, and cytotoxic) were in their proper locations and not full. This was the first time I have learned about the special handling required for cytotoxic (cancer) drugs. The handling of cytotoxic drugs is generally only done by the male staff, since there is a high risk involved to females who may be pregnant.

Public Health Nursing

Public Health Nursing is also responsible for inspecting the day care facilities on Fort Riley. The inspections we performed were very similar to the inspections that the Environmental Health Department performs. The key difference is that after the facility has been inspected, Public Health Nursing reviews at random 20% of the files kept on employees and the children who attend the day care. The employee's files are reviewed to insure all of their required training is up to date and they have had the required immunizations. The children's files are reviewed to make sure all prescriptions are up to date, they have had the required shots for their age, and to insure their picture ID is no older than 1 year.

Part of the department's duty is to investigate any reportable disease on Fort Riley and to insure they are entered into the military wide computer reporting system. During my rotation a soldier tested positive for Hepatitis C and I was able to participate with the investigation. Due to HIPAA I cannot go into detail about the investigation other than to say that we were able to track the cause and others who were infected.

Industrial Hygiene

I spent most of my time working with the Industrial Hygiene Department because they assisted me in collecting my lead data. Prior to my field experience I knew next to nothing about what Industrial Hygiene does and I found they have a very broad and important job. I accompanied the Industrial Hygiene Department on an inspection of a building looking for asbestos and took part in FIT testing. FIT testing is a required yearly procedure where all of the

medical staff working on Fort Riley have their N 95 Class face mask tested to insure it still fits and is functional. The N 95 Class face mask is worn for protection when the staff may come into contact with an individual who has or may have tuberculosis.

I accompanied a staff member who specialized in ergonomics while she spoke with some of the hospital office workers who had been complaining lower back and wrist pain while working. After listening to their complaints we installed new mouse's at their computers that places the wrist into a more ergonomic friendly position and installed lumbar support on their chairs.

Veterinary Services

Fort Riley has horses that are used in ceremonies to pay homage to the original horseback Calvary Soldiers who once served on Fort Riley. It is the Veterinary's Services responsibility to oversee the animals health and to perform health inspections of the facility where they are kept. Soldiers and their family members can bring their pets to Veterinary Services at a discounted price when compared to off post.

During my rotation the Military Police (MP) came in seeking advice on how to handle a dog bite situation. A woman had checked into the Emergency Room on base because her puppy had bitten her hand. All animal bites are required to be reported to the MP's and the MP's are required to report animal bites to the Veterinary Services. The women had been playing with the puppy when it accidentally bit her hand; the MP's said the injury "looked like nothing more than a scratch". The problem was that because of the puppy's age it was too young to have had its rabies vaccination. The MP's were not sure what the protocol was in this situation. The on duty

veterinarian looked up the policy; it was determined that the puppy would have to be brought in to the Veterinary Services and kept for observations for 7 days.

Veterinary Services is also responsible for inspecting the base commissary (grocery store) to insure they are in compliance with health and safety codes. I accompanied one of the soldiers as he did his daily inspection. The inspection included checking the produce to insure it was fresh, checking the temperatures on the fridges/freezers, insuring the meat department is following proper handling procedures, insuring the food on the salad bar was at the appropriate temperatures, and insuring that all the floors were dry and free of obstructions.

Occupational Health

The Department of Occupational Health does all the pre-employment health screenings for personnel being hired to work as government workers on Fort Riley, and perform assessments if an employee is injured while on the job. Certain jobs on Fort Riley require yearly health assessments to insure that the job is not having detrimental effects on the employees. I sat in on one of the yearly health assessments for an employee who worked in the Industrial Hygiene Department. Because Industrial Hygiene performs safety testing in all areas of Fort Riley, they are potentially being exposed to numerous hazardous substances; it is the Department of Occupational Health to monitor the employee's health and look for any changes.

Army Hearing Conservation

The Army requires all soldiers to take a hearing loss prevention class once a year and the class is given by the Army Hearing Program. The class involves watching a video and giving the soldiers instructions to insure they are using their hearing prevention device properly. For soldiers who have already lost hearing, the Army Hearing Program runs tests and fits the individual for a hearing aid.

It was working with the audiologist that she asked me what was wrong with my hearing. I told her I had hearing loss in my right ear from my second combat deployment and that I receive 10% disability from the Veterans Affairs (VA) for it. After looking at my medical records the audiologist gave me a temporary hearing aid that was adjusted for my hearing loss to wear for a week. The hearing aid was set up to compensate for my hearing loss and I was shocked when I realized how bad my hearing had become. After the test trial the audiologist put me in touch with the VA audiology department and I now have a custom hearing aid.

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