

# Health Consultation

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DEPLETED URANIUM AT HAWAIIAN MILITARY SITES

SCHOFIELD BARRACKS IMPACT AREA

MAKUA MILITARY RESERVATION

POHAKULOA TRAINING AREA

ON

ISLANDS OF OAHU AND HAWAII

AUGUST 25, 2008

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

Public Health Service

Agency for Toxic Substances and Disease Registry

Division of Health Assessment and Consultation

Atlanta, Georgia 30333

## **Health Consultation: A Note of Explanation**

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared By:

The U.S. Department of Health and Human Services  
Agency for Toxic Substances and Disease Registry

## Summary and Statement of Issues

The Agency for Toxic Substances and Disease Registry (ATSDR) prepared this health consultation in response to a request by the United States Army to assess the public health risks from the presence of M101 spotting rounds containing depleted uranium at Army firing ranges in the Hawaiian Islands and to review related documents. This depleted uranium, a Cold War legacy, was used in spotting rounds for the Davy Crockett recoilless guns that were produced from 1956 until 1963 and were used in soldier training exercises in Hawaii from 1962 through 1968. The Davy Crockett launched a large projectile from either a 120-millimeter or 155-millimeter recoilless rifle with maximum ranges of 1.24 miles or 2.49 miles, respectively. Before firing the large projectile from the 120-millimeter recoilless rifle, a smaller 20-millimeter spotting M101 cartridge was fired mirroring the trajectory of the larger projectile to identify where the weapon system was aimed and to identify the need for adjustments to obtain correct positioning of the rifle. The cartridge consisted of several components which included a nosecone, a body, and a tailfin. The body of this spotting round was made of a depleted uranium alloy. (For more detail, refer to the *Brief History and Description of Weapon System* section of this report.) After the cartridge was fired and upon impact of the spotting round, a small cloud of smoke identified the impact point. The use of these spotting cartridges is significantly different from the use of depleted uranium armor penetrating rounds in the Persian Gulf where depleted uranium partially aerosolized when the penetrator hit a hardened target such as steel or concrete.

ATSDR staff consulted, reviewed, and discussed with Army representatives and their consultants environmental sampling and analysis procedures and identified data gaps in environmental sampling, analyses, and methodologies for three sites (Schofield Barracks, Makua Military Reservation, and Pohakuloa Training Area). ATSDR staff also reviewed and provided comments on reports and documents prepared by or for the Army on the presence of depleted uranium at Schofield Barracks on the Island of Oahu, which included the *Schofield Barracks Impact Range Baseline Human Health Risk Assessment for Residual Depleted Uranium*, dated April 2008.

ATSDR staff also reviewed the following documents prepared by Cabrera Services for the Department of the Army: *Characterization Report Schofield Barracks Davy Crockett Impact Area*, *Schofield Barracks Firing Range Monitoring of Air Quality During Burning of Vegetation*, and *Technical Memorandum Depleted Uranium Scoping Investigations: Makua Military Reservation, Pohakuloa Training Area, Schofield Barracks Impact Area Islands of Oahu and Hawaii*. Other reviewed documents included *Depleted Uranium, Natural Uranium and Other Naturally Occurring Radioactive Elements in Hawaiian Environments* and *Natural and Depleted Uranium in Hawaii Fact Sheet*, both prepared by Kenneth H. Rubin, Ph.D. from the University of Hawaii.

As requested by the Army, ATSDR focused on depleted uranium rather than addressing other potential contaminants at these sites. The ATSDR health consultation and public health assessment (sometimes referred to as an exposure assessment) differ significantly from the classical risk assessment in purpose and methodology. ATSDR staff evaluate if exposures to one or more toxicants are or have occurred at a site, at what level of

exposure, and if potential adverse health effects have occurred or could occur as a result of these exposures. As a public health agency, and not an environmental regulatory or clean up authority, ATSDR staff act as advisors to citizens, groups, and agencies regarding the body of scientific knowledge of human exposures to chemicals and radioactive materials in the environment and whether such exposures would likely result in adverse health effects. ATSDR makes recommendations to stop, reduce, or prevent exposures and for additional public health actions, if needed.

## Findings

### *Public Health Impact*

ATSDR representatives reviewed several reports and visited three sites to determine the public health implications of the presence of depleted uranium spotting rounds at firing ranges at Schofield Barracks, Pohakuloa Training Area, and potentially Makua Military Reservation. ATSDR also reviewed and advised the US Army on environmental monitoring programs for the Hawaiian Islands firing ranges. While in Hawaii, ATSDR representatives attended technical discussion meetings with Army and contractor representatives and the press conference at Fort Shafter in Honolulu on April 22, 2008, for the release of the *Schofield Barracks Impact Range Baseline Human Health Risk Assessment for Residual Depleted Uranium*.

- Although ATSDR provided detailed comments and recommendations for this report, ATSDR agrees with the conclusion, based on the information reviewed and current knowledge about the site and past use of M101 spotting rounds containing depleted uranium at Schofield Barracks, that no adverse human health effects would be expected as a result of potential exposure to the depleted uranium in its current location.
- Based on information about the condition of the spotting rounds, the site's environment, the limited environmental sampling results, the distance to populated areas, and restricted access at Pohakuloa Training Area's impact areas, ATSDR also concludes that no adverse human health effects would be expected as a result of potential exposure to depleted uranium at Pohakuloa Training Area if the depleted uranium rounds were left at their current locations.
- The Makua Military Reservation has easier accessibility, has cultural significance, and has a different history and use of the impact areas than the other sites. Since use of the depleted uranium spotting rounds at the Makua Military Reservation has not been determined and insufficient environmental survey data are available at this time, ATSDR did not make a determination for this site.

Additional information that led to ATSDR conclusions for each site is included in this report.

## **Background and History**

### ***Brief History and Description of Weapon System***

The Davy Crockett (M28 and M29 series) recoilless guns that used spotting rounds containing depleted uranium were produced from 1956 until 1963 and were used in soldier training exercises in Hawaii from 1962 through 1968 (Brookings 2008; USACE 2007). Records indicate that 714 rounds of the Spotting M101 Cartridges were shipped to Oahu in 1962 (USACE 2007). These rounds were used at the Schofield Barracks and the Pohakuloa firing ranges and possibly at the Makua Military Reservation.

The Davy Crockett launched a large projectile from either a 120-millimeter (-mm) or 155-mm recoilless rifle with maximum ranges of 1.24 miles or 2.49 miles, respectively. The 155-mm recoilless rifle fired a 37 mm spotting round that did not contain depleted uranium. Before firing the 120-mm projectile, a 20-mm cartridge (Spotting M101 Cartridge) was fired to identify the impact point and to identify the need for adjustments to obtain correct positioning of the rifle (USACE 2007). The 20-mm cartridge (similar to a large bullet) consisted of several components: a projectile, a primer (small detonator), a propellant (an explosive charge to propel the projectile), and a casing. The projectile consisted of a nosecone, a body, and a tailfin. The nosecone fuze was screwed onto a hollow body made of depleted uranium alloy (92% depleted uranium and 8% molybdenum) into which a red phosphorus charge was placed. An aluminum tailfin was epoxied into the rear of the body for in-flight stability. When used, the cartridge was chambered into a large bore rifle attached below the larger recoilless rifle. When the cartridge was fired and the projectile impacted its target, the fuze ignited the red phosphorus charge. The pressure ruptured the sidewall of the projectile's body releasing a cloud of smoke approximately two to three meters in diameter, two to five meters in height, and visible for several seconds. This is similar to setting off a firecracker in a metal can where the side is ruptured ejecting large metal fragments but leaving a large part of the can intact. The use of the Spotting M101 Cartridges containing depleted uranium is significantly different from the use of depleted uranium armor penetrating rounds in the Persian Gulf where the depleted uranium partially aerosolized when the penetrator hit a hardened target such as steel or concrete (USAEPI 1994).

### ***Site Descriptions***

The Hawaiian sites where spotting rounds containing depleted uranium were used or potentially used include firing ranges and impact areas at three locations: Schofield Barracks, Makua Military Reservation, and Pohakuloa Training Area. Schofield Barracks and Makua Military Reservation are located on the Island of Oahu (Figure 1). Pohakuloa Training Area is located on the Island of Hawaii (Figure 2). ATSDR representatives visited these sites on April 23 and 24, 2008.

Figure 1. Schofield Barracks and Makua Military Reservation on the Island of Oahu



Figure2. Pohakuloa Training Area on the Island of Hawaii



### *Schofield Barracks*

Schofield Barracks is the largest Army post in the State of Hawaii, located on 17,725 acres (72 km<sup>2</sup>) on the north central plateau of the Island of Oahu approximately 22 miles northwest of the city of Honolulu. The post is divided into two sections: the East Range and the Main Post (also referred to as Schofield Barracks Military Reservation). The Main Post, which has controlled access, includes an active training area and a cantonment area. The cantonment area is east-southeast of the training area (Figure 3). The training area is in a large valley facing east with ridgelines to the north, west and southwest. The training area can be reached by several roads through the cantonment area or by the Kolikole Pass Road that crosses over the Waianae ridgeline to the west (globalsecurity 2008a).

The training area has maneuver training areas, firing ranges and impact areas. The impact area is on the eastern slope of the Waianae Mountain Range and extends eastward toward Highway 801 (Figure 3). The steep slopes to the west and southwest are unsuitable for maneuvers but provide a safety zone for the impact area. The firing ranges are primarily along the eastern and southern boundary of the impact area (globalsecurity 2008a).

Figure 3. Schofield Barracks, Center of the Island of Oahu





Vegetation varies from heavily wooded on the steeper slopes to open grassland in the impact and firing range area. Several thickly wooded gullies cut through the impact area. The impact areas have a high fire hazard rating due to the tall grasses and dry conditions from April through October (US Army 2008a). To reduce the risk of uncontrolled fires, the Army performs regular controlled burns in the impact areas. Since these clearing operations of the training area began in 2005, unexploded ordnance has been discovered. Several legacy (from WWI and WWII) chemical munitions recovered during range clearance activities were detonated in place or in a specially designed detonation chamber (Honolulu Advertiser 2008).

The prevailing winds are northeasterly trade winds from 4 to 12 mph in the warmer summer months and lighter southeasterly winds in the winter months (US Army 2008a). The soils on the training site are silty clay originally created from basalt flow and alluvial sediments from the Wai'anae Volcano to the west and the Ko'olau Volcano to the east (US Army 2008b, 2008c). Soils that appear grey or black are rich in magnesium oxide. Soils that appear reddish are richer in iron oxide (Figures 4 and 5).

Figure 4. Schofield Barracks Impact Area toward the Wai'anae Mountain Range (west)



Figure 5. Schofield Barracks Impact Area down the valley toward the east-northeast



Currently, the 25<sup>th</sup> Light Infantry Division and the 45<sup>th</sup> Support Group are headquartered at Schofield Barracks. As of the 2000 census, the base population in the cantonment area was 14,428 military personnel and family members (Census 2000a).

Wheeler Army Airfield (formerly Wheeler Air Force Base) is between and south of Schofield Barracks' Main Post and East Range. It is approximately four miles from the training area (globalsecurity 2008a). As of the 2000 census, this base had a total population of 2,829 military personnel and family members (Census 2000b).

The closest municipality is Wahiawa. It is adjacent to and immediately north of the East Range but is separated from most of Schofield Barracks by Lake Wilson (also known as Wahiawa Reservoir). It is approximately four miles from the training area (globalsecurity 2008a). As of the 2000 census, the population of Wahiawa was 16,151 (Census 2000c).

The Schofield Forest Reserve (a conservation district) and the Oahu Agricultural District are north and northwest of the Schofield Barracks training area (globalsecurity 2008a).

#### *Makua Military Reservation*

Makua Military Reservation is on the west coast of the Island of Oahu, 38 miles northwest of Honolulu and approximately three miles north of Makaha (population of 7,753) (Census 2000d). Highway 93 (Farrington Highway) runs through the site along the shoreline terminating at the northern boundary of the site (globalsecurity 2008b). South of the reservation numerous beach dwellers live in temporary housing and tents between

Highway 93 and the shoreline. It is not clear whether these people are permanent or transient residents.

Figure 6. Makua Military Reservation, Northeast Corner of the Island of Oahu



The reservation covers 4,856 acres (globalsecurity 2008b). It has a beautiful shoreline and two valleys, the Makua and the Kahanahaiki that drain to the Wai'anae Coast (Lucking 2001). The Makua Valley has been used by the Army and other United States military forces as a training area since before World War II. Steep cliffs partially surround the impact area from the southwest to the north. The cliffs are too steep to be used for maneuvers. Several thickly wooded gullies cut through the impact area and the cliffs (Figure 7). The soils in this valley are similar to those found at Schofield Barracks. A forest reserve is to the north and to the south with the Waianae Mountain Range to the east (globalsecurity 2008b).

Temperatures range across the site with the warmest temperatures near the coast and the coolest temperatures at the ridge line. The wind directions and speed can change quickly and dramatically from easterly to westerly (Onyx 2001). A dramatic wind change caused a planned “controlled” burn of 900 acres to turn into an “uncontrolled” burn scorching 2,500 acres in July 2003 (Honolulu Advertiser 2003).

Figure 7. Looking to the east in Makua Valley on the Makua Military Reservation



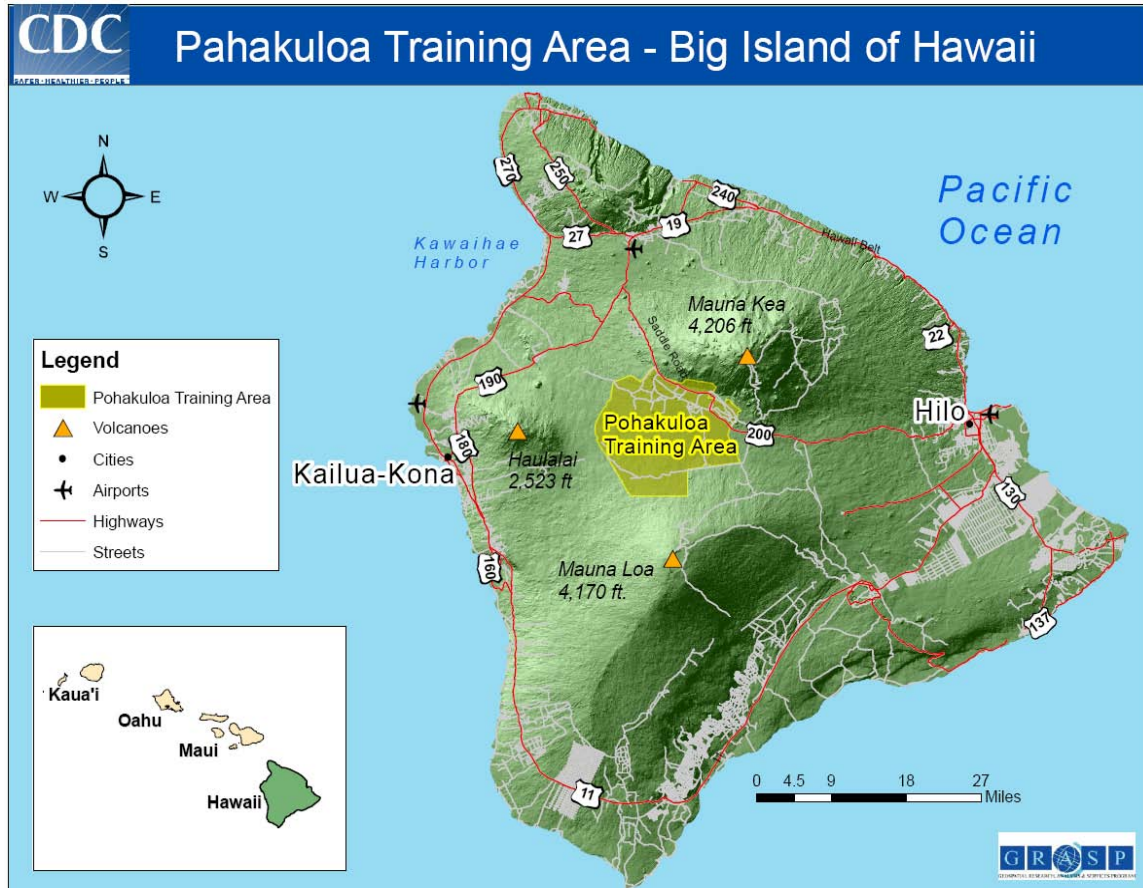
The Army has been responsible for the site since 1943; however, the training area has also been used by the Marine Corps, Coast Guard, Air Force, the Army Reserve, and the Hawaii Army National Guard (Onyx 2001). Currently, for legal reasons, this site is not being used as an active training area. In the past, the Makua Valley has been subjected to air bombing, ship to shore firing, amphibious operations and live firing of infantry and artillery weapons leaving the reservation dotted with unexploded ordnance. Since 1950, there have been several clearing operations that included controlled burning of undergrowth and detonating unexploded ordnance, but the site is still known to have a variety of unexploded ordnance. In August 1998, five World War II-era bombs were discovered while surveying and mapping the site. These bombs were safely detonated. Later, 81 smaller pieces of unexploded ordnance were located and detonated (Lucking 2001). Although the use of the M101 spotting rounds has not been confirmed at Makua, it is possible that training on the Davy Crockett recoilless guns could have taken place at this site due to the size of the firing range.

No personnel or families reside at this reservation. Portions of these lands have been designated as cultural places or sacred sites important to native Hawaiian populations as traditional religious, hunting, gathering, and fishing areas (Lucking 2001); however, native Hawaiians are not currently being allowed to enter the site (AP 2007). (Note: This may have recently changed. If escorted, cultural monitors may now be allowed to access portions of this site.)

### *Pohakuloa Training Area*

The Pohakuloa Training Area (PTA) located near the center of the Island of Hawaii in the central saddle area between Mauna Loa, Mauna Kea and the Hualalai Volcanic Mountains covers 108,863 acres (Figure 8). The mountains and the central saddle area are designated as a conservation district. Hilo on the east coast and Kailua-Kona and Kawaihae Harbor on the west coast are approximately 40 miles from the training area by way of Saddle Road which crosses the center of the island (globalsecurity 2008c).

Figure 8. Map of the Island of Hawaii



The terrain is mostly level or gently sloping and mostly uninhabited with few trees or gullies. Even so, ten plants and nine animals listed on the endangered species list are within the site borders (more than on any other Army installation). Approximately 32,000 acres can be used for large maneuver exercises; however, few large exercises are conducted since troops, vehicles and equipment have to be transported by ship from Oahu. Most of the 108,863 acres are unusable for maneuvers (globalsecurity 2008c). A large percentage of the surface area is covered with two types of lava flow: pahoehoe and 'a'a. Pahoehoe is a Hawaiian term for basaltic lava that has smooth undulating surfaces and can be traversed on foot for short distances. Aa (or 'a'a) is a Hawaiian term for basaltic lava that has a surface covered with thick, jumbled piles of loose, sharp blocks

(SDSU 2008). The rough 'a'a are jagged, slag-like piles of very sharp material which are very difficult to traverse on foot (Figure 9).

Figure 9. 'A'a (type of lava) on artillery range at Pohakuloa Training Area



The eastern portion of the training area is sparsely vegetated. The northern and western portions have the deepest soils and slightly more vegetation (Beavers 2000). Pohakuloa's 51,000-acre impact area located in the eastern portion is over ten times the size of the impact area at Schofield Barracks. It is surrounded on the north by several ranges and designated firing points for artillery (globalsecurity 2008c). Cinder cone hills (or puu's) dot the landscape and can be used for artillery practice (Figures 10 & 11).

Trade winds blow through the saddle from the east in the mornings and from the west in the early afternoon. During this transition, wind speeds and directions are unpredictable. At Bradshaw Army Airfield (adjacent to Pohakuloa), the average annual wind speed in the late 1990s was 10.7 mph with little variation. Precipitation supplemented by fog drip is sparse. Temperatures show little variation throughout the year. The average annual temperature for the late 1990s was 17.7 C (63.8 F) (Beavers 2000).

The Kilohana Girl Scout Camp is within five miles to the west of the training area. The Army has agreed to install an air monitoring system at this location. The State of Hawaii Department of Health (DOH) did some preliminary air monitoring downwind from Pohakuloa Training Area in the summer or late spring of 2007 and reported that all results were "normal" (Honolulu Advertiser 2007). The Army has purchased four additional air monitoring systems which will be placed at locations agreed upon by the Army and the State of Hawaii Department of Health.

Figure 10. Artillery range at Pohakuloa Training Area (puu and mountains to the north)



Figure 11. Firing/impact range at Pohakuloa Training Area (view to the south from one puu toward another puu)



## Chronology of Current Events

In August 2005, during range clearance activities to allow the installation of new range targets at Schofield Barracks Impact Area, 15 projectile bodies and tailfins from Davy Crockett Spotting M101 Cartridges containing depleted uranium were found at the Schofield Barracks munitions impact range (Cabrera 2007). After a controlled grass burn in the summer of 2006, Schofield personnel surveyed the eastern edge of the impact range and discovered several additional depleted uranium fragments (Cabrera 2008a). Between November 27 and 30, 2006, a scoping survey of accessible portions of the Schofield impact range was performed to determine whether additional depleted uranium was present and to gather information for the follow-up characterization survey. (Cabrera 2007).

On November 1, 2006, the U.S. Army Joint Munitions Command notified the U.S. Nuclear Regulatory Commission of the situation and of their plans to perform a scoping survey and historical archive search for relevant information by the U.S. Army Corps of Engineers, St. Louis District (US Army 2008b). On May 15, 2007, the U.S. Army Corps of Engineers released their report, *Archives Search Report (ASR) On the Use of Cartridge, 20mm Spotting M101 For Davy Crockett Light Weapon M28, Schofield Barracks and Associated Training Areas, Islands of Oahu and Hawaii*. According to the researched records, 714 spotting rounds were shipped to Hawaii in the 1960s, but the records did not indicate how many rounds were fired and where they were used (USACE 2007).

Five surface water samples were collected during March of 2007 from outfalls that drain the impact area at Schofield Barracks. Although only two samples had detectable activity of naturally-occurring uranium well below EPA's drinking water standards, the Army has agreed to continue the water sampling program (Cabrera 2008a). Precipitation at Schofield Barracks is low, and the sampling of surface water runoff is feasible only when significant rainfall occurs.

During the summer of 2007, the Army found more depleted uranium fragments in the northern and eastern portions of the firing range at Schofield Barracks, confirmed that depleted uranium was also used at Pohakuloa Training Area (PTA) on the Island of Hawaii, and said that spotting rounds also may have been fired in Makua Valley (Cabrera 2008b, US Army 2007b). Between July 30 and August 2, 2007, prescribed burns (reference area, test, and range burns) were performed at the Schofield Barracks firing range. Downwind and upwind air monitoring samples were collected to measure concentrations of uranium isotopes in air during the burns. Soil, vegetation, and ash samples were also collected and analyzed. (Cabrera 2008c, 2008a).

On July 1, 2007, the State of Hawaii Legislature enacted House Bill Number 1452 that requires the State of Hawaii Department of Health to take soil samples at least every three months within 500 meters of Schofield Barracks but not beyond ten meters from the impact sites. The Department of Health was directed to develop a sampling plan and to submit summaries of their findings to the legislature no later than twenty days prior to



each regular session beginning in 2008. The bill also provided for depleted uranium urinalysis screening of personnel (civilian or Hawaii National Guard) reporting symptoms compatible with Gulf War Syndrome, or those exposed to military ranges or other suspected depleted uranium sites (Hawaii 2007). However, it appears that funding for these projects was never approved.

In August 2007, field scoping survey investigations were conducted at all three sites to assess the presence of depleted uranium fragments (Cabrera 2008a). The investigations included review of the archived records search, site reconnaissance, and additional surface soil sampling. The site reconnaissance included aerial surveillance of the firing ranges and ground investigations of accessible areas. Sampling results are discussed in the next section, Review of Environmental Data.

- The document search did not reveal any documentation that the Davy Crockett weapon system had been used at the Makua Military Reservation. Due to dense vegetation, the aerial survey was limited to ravines and dry stream beds. No depleted uranium fragments were located. Physical entry to the impact areas was not allowed due to safety concerns. Soil samples were collected where sediment had accumulated from past runoff/erosion events.
- The document search and map analyses identified twelve possible locations at Pohakuloa Training Area where the spotting rounds could have been used. After further review, it was narrowed down to four potential ranges. An aerial survey confirmed that the Davy Crockett weapon system had been used at the four ranges. It was estimated that approximately 30 to 100 spotting rounds could have been used at each location. Rough terrain limited accessibility to the ranges. One spotting round resting on top of lava rock was recovered intact. Soil samples could not be taken in this area so soil samples were collected around the perimeter of the impact areas and sediment samples were collected from areas of past runoff/erosion.
- During the site reconnaissance at Schofield Barracks, an area with bright yellow soil, small yellow fragments, and elevated gross gamma activity was observed in the northeast portion of the training area. This yellow color is consistent with highly oxidized uranium or uranium octaoxide ( $U_3O_8$ ). Only a single soil sample was collected during this investigation. It was positive for depleted uranium. New boundaries for the site characterization survey were established.

From August to October 2007, additional soil samples were collected from the Schofield Barracks impact area and a reference area (Cabrera 2008b). There were 1,226 soil samples collected from 646 sample locations in the accessible portions of the impact areas (biased and systematic sampling), reference area (random sampling), and in the deep gullies of the impact area (biased sampling). Soil samples were collected at 0 to 6 inches below ground surface (surface soils) or 6 to 12 inches below ground surface (shallow subsurface).

During the week of April 20, 2008, ATSDR representatives participated in site visits of these three locations and attended a media briefing for the final release of the document,

*Schofield Barracks Impact Range Baseline Human Health Risk Assessment for Residual Depleted Uranium*, dated April 2008. The media briefing on April 22, 2008, conducted by Colonel Howard Killian, the Army's Deputy Director for IMCOM-Pacific, was attended by six media outlets. Questions from the media representatives were addressed by Colonel Killian, Greg Komp (U.S. Army Radiation Safety Officer), and Russell Takata (State of Hawaii Department of Health). Various branches of the Army hosted or participated in the site visits and the media briefing. Other participants included representatives from the Department of Defense, the U.S. Nuclear Regulatory Commission (both headquarters and Region IV), the State of Hawaii's Department of Health, Cabrera Services (contractor) and Mississippi State University (contractor).

## **Review of Environmental Data**

ATSDR reviewed drafts and final copies of five environmental investigation documents covering the three military sites in Hawaii where depleted uranium was either used or potentially used in the past. These documents were prepared by Cabrera Services for the U.S. Department of the Army. The final copies were all dated April 2008. Below are discussions of information from each report relevant to our review:

- *Technical Memorandum – Schofield Barracks Firing Range Phase I Depleted Uranium Investigation, Wahiawa, Hawaii (Cabrera 2007)* – This scoping survey of the western portion of Schofield Barracks impact area was conducted on November 27 and 30, 2006. Visual inspections of the area along with low energy gamma scans were conducted. Soil samples were collected if spotting rounds, yellow fragments, or elevated readings were encountered. One background and five other soil samples were collected. Three metallic fragments were retrieved. One soil sample contained depleted uranium ( $^{238}\text{U}$  concentration of  $209 \pm 36$  pCi/g). Two samples were consistent with naturally-occurring uranium. The metallic fragments were identified as depleted uranium. This survey indicated that more spotting round fragments could possibly be located on this training area.
- *Final Technical Memorandum – Depleted Uranium Scoping Investigations – Makua Military Reservation, Pohakuloa Training Area, Schofield Barracks Impact Area, Islands of Oahu and Hawaii (Cabrera 2008a)* – This document covers scoping surveys performed at all three sites in August 2007.
  - o For Makua Military Reservation, aerial surveillance and ground investigations were limited due to thick vegetation and areas where unexploded ordnance prevented safe access. No surface water samples were collected; however, ten soil/sediment samples were collected from outfalls for suspected impact areas. The samples contained low levels of naturally occurring uranium (less than 1 pCi/g). None of the samples revealed any evidence of the presence of depleted uranium, and no depleted uranium spotting round fragments have been found at this site.
  - o The Pohakuloa Training Area aerial surveys confirmed that the Davy Crockett weapon systems had been used on at least four ranges. There was

- limited access to the suspected impact areas due to the rough terrain. One spotting round was recovered intact resting on top of the lava rock. No soil samples were collected at this location. Nine soil samples were collected from around the perimeter of the suspected impact areas where sediment had accumulated from past runoff or erosion. All nine samples had low levels of naturally occurring uranium (less than 1 pCi/g) but no indication of depleted uranium.
- The focus for the scoping survey at Schofield Barracks included the mostly flat northern and eastern portions of the impact area. Visual reconnaissance identified the additional eastern area training range which was confirmed with a field survey and surface soil sample. The soil sample contained depleted uranium (2,180 pCi/g  $^{238}\text{U}$  and 360 pCi/g  $^{233/234}\text{U}$ ). No surface water samples were collected during this investigation; however, the Army monitors surface water runoff from Schofield Barracks under another program. Five of the surface water samples collected in March of 2007 were analyzed for isotopic uranium. Three of the samples had no detectable uranium activity. Two of the samples had detectable activity for naturally occurring uranium (both less than 1 pCi/L  $^{238}\text{U}$  and less than 1 pCi/L  $^{233/234}\text{U}$ ), well below EPA's drinking water standard of 30 pCi/L. There was no evidence of depleted uranium in the runoff.
- *Final Technical Memorandum – Schofield Barracks Firing Range Monitoring Air Quality During Burning of Vegetation, Wahiawa, Hawaii (Cabrera 2008d)* – This document evaluated the potential release of depleted uranium during prescribed burns at Schofield Barracks in July and August 2007. A reference area burn (in an area known not to contain depleted uranium) and a test burn (in a small area where depleted uranium was known to be present) were performed prior to burning the full firing range. Soil and vegetation samples were collected prior to the burns to confirm the presence or non-presence of depleted uranium in the area. Air samples were collected to demonstrate whether particles of uranium were airborne during the burns. Concentrations of uranium in these air filters and ash samples collected after the burn indicated that uranium did not get airborne during the burn.
- The *reference* burn was performed on one acre of land in an area with no depleted uranium. Two air samplers were placed upwind and six air samplers were placed about 200 feet apart downwind. Of sixteen air samples collected during the reference burn, only one sample result for  $^{233/234}\text{U}$  was slightly above the minimum detectable air concentration but well below an action level set in the sampling plan. This sample was downwind from the burn but had no detectable  $^{238}\text{U}$  concentration. Five vegetation samples were collected prior to the burn and five vegetation ash samples were collected after the burn. The ash samples after the burn had a higher concentration of uranium than the vegetation samples prior to the burn; however, the ash samples were not collected from the same location

- as the vegetation samples. The vegetation and ash samples contained very low concentrations of naturally occurring uranium.
- Visual identification and field surveys confirmed the presence of depleted uranium in the *test* burn area. Prior to the burn two soil samples and three vegetation samples were analyzed to confirm the presence of depleted uranium. Two air samplers were placed upwind and six samplers were placed downwind. Sixteen air samples were collected during the test burn; however, one of the samplers had shut down during the burn. No airborne depleted uranium particulates were observed in the air monitoring results. Five ash samples were collected after the test burn, but their location did not correspond with the location of the vegetation and soil samples prior to the burn. Although depleted uranium was present in at least one of the vegetation samples (180 pCi/g  $^{238}\text{U}$ ) and one soil sample (470 pCi/g  $^{238}\text{U}$ ) prior to the burn, none of the ash samples contained significant concentrations of depleted uranium after the burn.
  - For the range burn, two air samplers were placed upwind and six air samplers were placed downwind. The range burn continued for several days, but since the burn was less intense and outside the area of known depleted uranium after the second day, air monitoring did not continue. On the second day the downwind monitors had to be moved due to a different area of the range being burned. The wind direction (from the east-northeast) did not change. Twenty-four air samples were collected with only three considered to be above the minimum detectable activity. All three samples appeared to be naturally occurring uranium and not depleted uranium. The maximum concentrations were below the action levels designated in the sampling plan.

In this study, no evidence of depleted uranium was found in the airborne particulates generated by the controlled burns at the Schofield Barracks training range. If the range and conditions remain unchanged from the current situation, no additional air monitoring is suggested.

- *Final Characterization Report, Schofield Barracks Davy Crockett Impact Area (Cabrera 2008b)* – This document covers the results of a more comprehensive survey of the 428-acre Schofield Barracks Impact Area. The survey included a gamma walkover survey, exposure rate measurements, and the collection of 1,225 soil and sediment samples.
  - The gamma walkover survey covered approximately 25% of the accessible land area, defined the boundaries of the areas of concern, and revealed areas of elevated gamma activity. Soil samples were collected in these areas with elevated gamma activity.
  - Exposure rate measurements were made in 582 locations on the Schofield Barracks Impact Area and 12 reference area locations in order to evaluate potential external radiation exposures to individuals who may enter or may have entered the site. The readings were taken at three feet from the ground surface (midline of the body). The maximum exposure rate on the

impact area was 0.07 milliroentgen per hour (mR/hr), and the mean exposure rate was 0.01 mR/hr. Both the maximum and mean exposure rates are the same or slightly above the exposure rate at the reference location (0.01 mR/hr). The median exposure rates for both areas are the same (0.01 mR/hr); therefore, most of the exposure rates for the impact area are consistent with natural background. An individual would have to be at the maximum exposure location for eight hours per day for over 200 days per year to exceed ATSDR's Minimal Risk Level (MRL) for chronic exposure of 100 mrem/year above background levels. Even if an individual were exposed to the mean exposure rate 24 hours per day, they would not exceed the MRL based on external exposure. Therefore, on-site external exposure to the depleted uranium would not cause any adverse health effects.

- Surface (0" to 6" below ground surface) and shallow subsurface (6" to 12" below ground surface) soil samples were collected at 416 locations (approximately one location per acre) for a total of 832 samples. These samples were mainly collected from the flatter areas including the areas between the ravines (fingers). Also, 318 soil samples were collected at 166 locations where elevated gamma activity was indicated during the gamma walkover survey, 52 sediment samples were collected from ravines where depleted uranium may have washed down and collected during rain storms, and 12 surface and 11 shallow subsurface soil samples were collected from a reference area at Wheeler Army Airfield.
  - For the reference *surface* soil samples, the maximum, average, and minimum  $^{238}\text{U}$  concentrations were 1.9 pCi/g, 1.48 pCi/g, and 1.11 pCi/g, respectively. For the reference *shallow subsurface* soil samples, the maximum, average, and minimum  $^{238}\text{U}$  concentrations were 2.92 pCi/g, 1.82 pCi/g, and 1.22 pCi/g, respectively.
  - Only two out of 52 ravine samples had concentrations above background (148 pCi/g  $^{238}\text{U}$  with 22.6 pCi/g  $^{234}\text{U}$ ; and 5.69 pCi/g  $^{238}\text{U}$  with 1.2 pCi/g  $^{234}\text{U}$ ). Both of these samples obviously contained depleted uranium and were located near Finger 5 in the far west central portion of the impact area. Although samples were collected from various portions of the impact area, sampling was limited to sediments where the depleted uranium may have washed down during rain storms and did not include ravines in the entire impact area. The only conclusion that could be reached at this time is that depleted uranium is present in at least one of the ravines and runoff should be monitored for a sufficient period of time to understand migration potential.
  - Of the 1,150 systematic and biased soil samples, 29 samples (16 surface and 13 shallow subsurface) contained depleted uranium with  $^{238}\text{U}$  concentrations ranging from 5.48 pCi/g to 7,030 pCi/g. Not all locations that had surface soil contamination had shallow subsurface contamination. Generally, for locations that did have some shallow subsurface contamination, the  $^{238}\text{U}$  concentration

was significantly lower than the concentration of  $^{238}\text{U}$  at the surface. Only one sample had higher shallow subsurface contamination than the surface which could have been caused by the impact of the spotting round. Since the survey of 166 locations indicated elevated gamma activity, the corresponding 318 soil samples were biased. Still, approximately 2.5% of the results indicated elevated levels of uranium assumed to be depleted uranium; thus, the contamination is not uniformly spread across the impact area nor does it appear to be spreading significantly from the original impact locations.

- *Final Schofield Barracks Impact Range Baseline Human Health Risk Assessment for Residual Depleted Uranium* (Cabrera 2008e) – This document evaluates the potential for adverse human health effects from exposure to depleted uranium present at Schofield Barracks Impact Area. Results from investigations discussed in the previously listed documents were used to identify the nature and extent of depleted uranium contamination, identify contaminated media, and identify potential pathways to human exposure. Pathways considered were external radiation exposure, dermal (skin) exposure, incidental ingestion of soil, inhalation of airborne particulates, and ingestion of food crops grown in contaminated soil. Health risks were estimated based on both the radiological properties and the chemical toxicity of uranium. For this risk assessment, four on-site exposure scenarios were evaluated: current and future maintenance workers, future construction/remediation workers, future adult cultural monitors/trespassers/visitors, and future site workers. One off-site exposure scenario (a subsistence farmer living 1500 meters from the impact area) was also evaluated. The potential exposures and the related risk were estimated using computer codes: The Argonne National Laboratory's RESidual RADioactivity (RESRAD) code, Version 6.3 (ANL 2005) for effects from radiological exposures and the U.S. Environmental Protection Agency's Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual for effects from chemical exposures. This document concludes that no adverse health effects are expected from either the radiological or chemical exposures on-site or off-site.

## Conclusions and Recommendations

ATSDR agrees with the conclusions of the *Final Schofield Barracks Impact Range Baseline Human Health Risk Assessment for Residual Depleted Uranium* based on the following additional factors that would indicate any significant changes to the current situation:

- The Army has agreed to continue sampling surface water outfalls for uranium at Schofield Barracks Impact Area. (Depleted uranium is present in the impact area including at least one of the ravines; therefore, runoff should be monitored for a sufficient period of time to understand migration potential.)
- Air sampling indicated that depleted uranium does not appear to become airborne under either normal conditions or during range burns, and would not pose any adverse health impact to persons offsite.
- Due to the nature of the soil sample results, it appears that the depleted uranium is not uniformly distributed on the site and has not significantly spread from the point of original impact; therefore, it does not appear that other weapons fired on this range, range burns, or weather conditions have spread the contamination.

ATSDR recommends that anyone (military or civilian) entering the Schofield Barracks impact area should have a pre-briefing so they can identify depleted uranium from the spotting rounds and, if located, to take appropriate action (not to touch it, but mark and report the location).

ATSDR has not reviewed a characterization report for Pohakuloa Training Area; however, ATSDR can make some conclusions for this site. Currently, based on the condition of the intact spotting round located at the site, the results from perimeter monitoring, the terrain, the current use of the site, and distance to populated areas, ATSDR does not anticipate any completed pathways of exposure for the general population. Military personnel and contractors should be instructed as mentioned above.

ATSDR has not seen any evidence that depleted uranium was used at Makua Military Reservation. Although there has been limited monitoring and sampling, none of the data indicate that depleted uranium is present at this site. However, due to the uncertainty of the use of the Davy Crockett weapon system at this location, the close proximity to communities, drainage of the site to the ocean, and cultural interest in this property, further investigations appear to be warranted. Until additional information is available, ATSDR finds the potential health concerns for this site to be indeterminate.

## **Public Health Action Plan**

The following action items are planned for these sites:

- When surface water runoff is present, the Army will continue to sample and analyze surface water for depleted uranium at the outfalls for the Schofield Barracks Impact Area.
- The Army will continue to investigate the Pohakuloa Training Area and the Makua Military Reservation for the presence of depleted uranium.
- The Army has agreed to work with the State of Hawaii Department of Health to monitor for potential airborne particulates of depleted uranium at locations adjacent to the Pohakuloa Training Area, such as the Kilohana Girl Scout Camp on the Island of Hawaii.



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