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Protecting People and the Environment

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Summary: Following documents should be added to ADAMS with a date of October 20, 2009.

Formal Comments to NRC on the Application for Possession & Handling of Depleted Uranium at Pahakuloa Training Area

License No.: SUC-1593 Docket No.: 4009083

FORMAL COMMENTARY TO THE NUCLEAR REGULATORY COMMISSION ON THE APPLICATION FOR LICENSE BY THE U.S. ARMY FOR POSSESSION AND HANDLING OF DEPLETED URANIUM AT POHAKULOA TRAINING AREA, COUNTY OF HAWAII, HAWAII

Docket No.: 4009083 License No: SUC-1593

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Table of Contents

FORMAL COMMENTARY TO THE NUCLEAR REGULATORY COMMISSION ON THE APPLICATION FOR LICENSE BY THE U.S. ARMY FOR POSSESSION AND HANDLING OF DEPLETED URANIUM AT POHAKULOA TRAINING AREA, COUNTY OF HAWAII, HAWAII

Executive Summary:

The U.S. Army has requested a license for the possession and handling of depleted uranium at the Pohakuloa Training Area (PTA), County of Hawaii, Hawaii. This license is part of a general license for multiple sites, including Schofield Barracks and Makua Firing Range, Oahu County, Hawaii.

The depleted uranium (DU) is present from the use of spotting rounds for the Davy Crockett tactical nuclear weapons system developed in the 1960s. Although hundreds of rounds were used, up to a total of 2,000, there is no record of the proportion used at any one Hawaiian range. The rounds themselves did not explode but contained a small explosive device that generated a puff of smoke on impact of the round, indicting the accuracy of firing.

It appears the primary purposes for license coverage at this time are the containment of DU and removal if any is found. This would appear to differ in some important aspects from a possession license because the quantity is not known and it is not contained in a controlled environment.

Scoping surveys indicated the presence of DU but located only a few rounds and fragments. On the Big Island, it is thought that the rounds are covered or have fallen into cracks in the surface material, basaltic lava. Although not specifically mentioned in any document, this covering could have been caused by continuing use of these ranges for live-fire and concomitant explosive shells from other munitions used in training activity.

The most probable route of migration of DU from PTA is an airborne vector. Aerosolization of the depleted uranium and its oxides can occur and these particles can travel, as measured at other sites, 25 kilometers or more.

Increased health risk from DU is still controversial although the emerging science seems to indicate there are identifiable problems from the DU and its alloys. Thus, prudence in monitoring and minimization of aerosolization and distribution is a proper means for dealing with this material and should be identified and required by the license. Those individuals most likely receiving the highest exposures are the military and civilian personnel working at PTA. Within a few kilometers of the training area are a Girl Scout Camp and a State Recreational area.

The present monitoring activity is insufficient to deal with determining a level of risk or migration of DU. Basically, the monitoring now conducted looks for uranium, not

depleted uranium. There is quite a difference in the form of these two materials. Naturally occurring uranium is probably present in a silicate matrix, reflective of the host rock from which it is derived. Depleted uranium is a metallic form of pure uranium or uranium oxide and its alloy metals. Inhalation of DU can expose tissue to up to a million times more uranium activity than inhalation of natural uranium in a silicate matrix.

It is possible to enhance the monitoring and analysis of airborne materials to determine the possible exposure to DU. These are discussed in detail in the body of the report but the major additions would include looking for other elements, such as the likely alloy components, molybdenum and titanium, looking for other radioactive isotopes such as 237-Np, 239-Pu, 236-U, and collecting larger samples over a longer period of time. Some samples should be subject to a fission-track map and scanning electron microscope imagery. An independent study conducted by an outside group would be of immense help in assuring that the current work has a framework of relevance.

Ideally, the DU should be located and removed. Realistically, this presents a logistic nightmare as it is in an area with much unexploded ordnance. All live firing operations should cease in the areas where DU is thought to have been used. This, too, will conflict with the mission of the military at PTA. However, both the cleanup and cessation of live fire activities have been implemented in other areas of the country where DU has been used.

An Environmental Impact Statement should be required as the DU is to be relocated when found and is already being displaced with live fire and when found.

The fear of many Island residents is genuine and should not be summarily dismissed with arrogant statements that they are ill-informed about radiation and its health effects.

None of the suggestions here are beyond the scope of implementation. They have been applied elsewhere; no new wheel has to be invented! I hope that NRC considers them as requirements for maintaining the license. It is sad to have as the only long-range possibility that this area will be designated a National Sacrifice Area, forever sequestered from access and use by the public.

It is hoped that the NRC will make all these suggestions part of the licensing agreement.

Scope of Commentary:

The U.S. Army has applied to Nuclear Regulatory Commission for a license (Docket No.: 4009083 License No: SUC-1593) to possess depleted uranium materials that already exist at several sites in the US. Three of these sites are in Hawaii. Commentary on the license application is provided here as it applies to the Pohakuloa Training Area (PTA), County of Hawaii, Hawaii.

The license as of the time of the preparation of this commentary appears to be a generic license covering a multitude of facilities where depleted uranium (DU) in some type of armament has been used in training and live fire exercises or storage. There are yet to be prepared specific or detailed plans for each and every site mentioned in the generic license application.

It should be understood that one plan for licensing cannot be applied to all sites. There is a wide range of site characteristics that impact the DU in different ways and there is a large variation in demographics of population that can be affected. More detail of this related to the Hawaii sites is presented later.

An NRC information panel visited the Hawaiian sites and held informal hearings the week of August 24, 2009. The panel has therefore seen the great differences and should be willing to consider specific needs of each site. The information and discussion contained in this document has some application to all sites, but, in general, is specific to PTA.

This commentary is prepared for an audience familiar with naturally occurring radiation, man-made radioactive devices, and the need for proper storage and handling. In some cases it does provide some fundamental scientific principles or background to aid the transition to specific points. Because of this familiarity by NRC, this report is not encumbered with numerous references and a reference section is not included. Only a few references are included and placed in the body of the commentary where specific examples have been used or referenced. Those sources as referenced available on the internet are taken from sources that are considered highly reliable, that is, not opinion but those having a high probability of peer review.

Appended to this commentary are two previous communications, the first in Appendix I of a letter and suggestions made by the author here to Colonel Killian who had oversight of the DU issues at PTA, and the second, Appendix II, a copy of the oral testimony presented in part at the NRC public meeting in Hilo, Hawaii, August 27, 2009.

The issue for the license request:

In the 1960s, as part of military training for a classified weapons system, the U.S. Army used a weapons system that contained depleted uranium (DU). The weapons system, known as the Davy Crockett, a tactical battlefield nuclear weapon, included a spotter round fire control device that used DU as part of its targeting operation.

Basically, an artillery round containing depleted uranium was used to realistically predetermine the trajectory of the nuclear device. According to Army records, no nuclear devices were used, just dummy rounds and the DU spotting rounds. The Army also states that no other DU munitions have been used on Hawaii, particularly at Pohakuloa Training Area (PTA) where aircraft typically fitted with DU firing cannons have participated in training.

Given the difficulty in searching records of formerly classified projects, it may be useful to conduct interviews with pilots and crews of those squadrons of aircraft that typically are armed with DU to see if any recall using DU at Pohakuloa. Similarly, if former range control officers can be located, they might be able to provide some information related to use of DU in other munitions than the Davy Crockett spotting rounds.

It is unknown how many Davy Crockett spotting rounds were used. Record searches (performed by Cabrera Services on behalf of the Army) reveal that somewhere between 700 and 2,000 rounds may have been test fired. They were probably divided between the Schofield, Makua, and Pohakuloa Training Areas, but the proportion is unknown.

At a minimum, 714 rounds or about 300 pounds of DU were used at PTA; at a maximum, 840 pounds if nearly all rounds were used at PTA. Often, an argument is presented that this amount of uranium is miniscule to that occurring in the natural environment. In Hawaii, the oceanic basalts that make up the island are generally very low in uranium, on the order of 0.1 to 1 ppm uranium, a factor of 10-30 lower than typical continental rocks as found on the mainland. Thus, a square mile to a foot depth of Hawaiian rock or soil is likely to contain a few hundred pounds of natural uranium. This can be presented in several ways. The use of DU has doubled the amount of uranium in this area, thus doubling the exposure risk; or the amount added is so little that it does not even bring the total uranium concentration up to levels of naturally occurring uranium on the mainland.

The fact that background radiation in Hawaii is so much lower because the oceanic basalts that form the bulk of the material comprising the island are lower in natural radioactive elements is not justification for bringing in and leaving radioactive waste. To imply that the people of Hawaii could receive additional radiation doses because they are under the limits deemed safe by various world agencies is absolutely corrupt reasoning.

The issue of concern to the people of Hawaii is to what extent the presence of DU contributes to increased health risk. Certainly it is consistent with the mission of NRC and their license issuing capacity to address that issue.

In large part at the current time, determination of health risk is an intractable problem. Studies of exposure to DU are based primarily from military and civilian exposures where DU munitions were extensively used (Middle-East; Balkins), and indicate that either side of the risk issue can be supported. One often hears that the most reasonable course of action is to be conservative and to err on the side of caution. That seems a reasonable approach for the Army possession license being considered by NRC.

Classical perceptions of elevated risk:

With the mention of uranium, one often thinks immediately of radiation exposure. As you well know, the very mention of radiation strikes fear in the minds of most citizens.

Recall those popular B-movies of the 1950s where mutated, giant predatory insects roam from the nuclear test sites to prey upon our frail human species. There are the real recollections of accidentally dropped nuclear weapons, the nuclear reactor meltdown at Three Mile Island and Chernobyl and the great radon scare of the 1980s.

Yet, people little recognize how much radiation they receive as natural background in their everyday lives, from eating and drinking, from solar sources, from our contact with the ground and even from their own bodies.

The U.S. EPA has taken a stance that all ionizing radiation places us at risk to develop cancer. The linear, no-threshold model gives no room for exception. We live with this concept in our daily lives. Do you question the need for x-rays every time you visit your dentist? Even marketing rises to address this fear of radiation. How many of you recall NMR being renamed MRI?* For many issues, not only radiation, people are forced to make judgment calls to determine if the benefits outweigh the risks. If you have information readily available, it is easier to make an informed decision.

* Nuclear Magnetic Resonance; Magnetic Resonance Imaging.

Uranium, the element of interest:

Uranium is a ubiquitous element in the crust of the earth. The overall crustal abundance is 2.7 parts per million. It is far from homogeneous; high grade ore deposits may contain 200,000 ppm; granites may contain 4-5 ppm; and seawater 0.003 ppm. Hawaii, made mostly of oceanic basalts has relatively low uranium in the rocks, ranging from 0.1 to 1 ppm.

Natural uranium contains three isotopes; 234-U, 235-U and 238-U, all of them radioactive and all decaying by alpha particle emission. The presence of 234-U is from the decay of 238-U. In percent, the relative natural abundances of these isotopes are 238-U 99.284; 235-U 0.711; and 234-U 0.0058%. The respective half-lives are 4.47 billion years, 704 million years, and 234-U 245.5 thousand years. Safety characteristics can be found on the material safety data sheet: http://www.ibilabs.com/U3O8-MSDS.htm

There are 249 minerals listed in the uranium database with the lowest uranium content of 0.01 percent. http://webmineral.com/chem/Chem-U.shtm. The common uranium ore, uraninite, is generally 88 percent U.

In air, pure uranium (silvery color) will oxidize to UO2 (black) and U3O8 (yellow), a mixture of different oxidation states. Because of the color of the latter, khaki to yellow, it is referred to as yellowcake in the mining industry.

Depleted uranium is uranium for which about half the 235-U isotope has been removed. This is the most fissionable isotope of natural uranium and is used in military weapons and nuclear reactors. The radiation risks from external exposure to DU are minimal.

This is due to the length of the half-life and the nature of the radiation emitted, mostly alpha particles. For the primary 238-U isotope of uranium, the half life is very long, about equal to the age of the earth at 4.5 billion years, meaning it has low specific activity. The radiation emitted in the form of an alpha particle has a range of only a few centimeters in air and can be effectively shielded against with a piece of paper. In actuality, it will not even penetrate the outer layer of the skin. There are other uranium isotopes in DU, 234-U and 235-U. They have shorter half-lives but exist at much lower quantities. It is the U-235 that is removed and reserved for reactions requiring fission, such as atomic reactors and nuclear weapons. 235-U has a shorter half life, 704 million years, so that it has a higher specific activity than 238-U, meaning that it emits more radioactive particles in a shorter period of time. For the same number of atoms, the isotope with the shorter half-life is more radioactive than the one with the longer half life.

A frequent comment about DU is that it is 60 percent less radioactive than natural uranium. This refers to the fact that the concentration (and activity) of 235-U has been reduced about half. Unfortunately, this mantra is given all too often made in a condescending manner suggesting that the audience is so uninformed that there is less risk from DU than from U. A remark made in that manner is highly offensive. When the person offering that comment is asked what is the radiation level 6 months or 3 years after the DU is processed, there is typically no response.

There are multiple means of extracting uranium isotopes. 235-U is removed as it is the most fissionable isotope and the remainder is depleted uranium. Enhanced uranium is used in nuclear weapons and for fuel rods for nuclear reactors. Depleted uranium can be derived directly from the extraction train or it can be gathered from reprocessed fuel rods where most of the fission products are removed. It would be of interest to know if the DU used in Hawaii was direct from the isotopic separation streams or extracted from fuel rods. That extracted form fuel rod processing often has trace amounts of other isotopes such as 237-Np and 239-Pu that can be indicators of the processing.

Uranium exposure and health risks:

Uranium is a radioactive heavy metal. This leads to the issue that there can be two types of health risks, one chemical from the metal and the other radiation from the ionizing particles of radioactive decay. That chemical risk is because uranium is a heavy metal and the human organism reacts to high exposures of heavy metals as toxins. It is highly unlikely that the DU at its present site at PTA will be ingested either as solid or liquid form or as transmitted to foodstuffs through growth. Radiation exposure is also highly unlikely at PTA because of the short range of the alpha particle, about 5 cm in air. A supply of potable water is being sought as a supply to PTA. Access to ground water is estimated to be found at a 3,000 foot depth. There may be shallower perched water tables but it would be the main aquifer that is the target for potable supply to PTA. Although DU could possibly migrate into the ground water table, it is likely to be a process measured in geologic time. If local ground water is contaminated, it can be purified at a cost of time and energy and water waste.

There is one vector of DU transmission that can cause potential problems. That is, the inhalation of DU aerosols. The residence time of U or DU in the lung can be for protracted periods as the solubilities are not very high. See for example, http://www.lanl.gov/BAER-Conference/BAERCon-47p-Rucker.pdf

Although it is claimed that aerosol formation was never a consideration as the rounds were not penetrating rounds that would burn, the formation of oxides can generate aerosol materials. In addition, the fact that the spotting rounds are within a live-fire area subjects them to breakup if proximal to an explosive charge.

Here it is also common belief that at PTA with minimal precipitation, oxide formation is minimal. Comparing spotter rounds found at Schofield and PTA, this certainly would seem the case. However, at PTA with active bombing, it has been proposed that the spotting rounds are no longer at the surface. This should not be a source of glee as the rounds are now exposed to moisture even at minimal depth. It is known that even desert soils can have relative humidity approaching 100 percent even at shallow depths. If a spotting round is struck with a high explosive, it is likely to fragment and create some aerosols from impact. Whether or not the temperature and shock wave are significant to cause some burning is unknown but the temperatures requires for ignition are lower than those generated by an explosion. There does not appear to be any research on whether or not a spotting round could be ignited by a nearby explosion.

As access to PTA is restricted to the general public, that is, by escorted invitation only, the group most likely to be exposed will be the military and civilian workers at the facility. There are two sites nearby designated for civilian use; the Mauna Kea State Park and the Kilohana Girl Scout Camp that should be included in the higher potential exposure group. In addition, any work on nearby projects, such as road or power line projects for example, should be included in the higher potential exposure group.

The spotting round characteristics:

The spotting round is a rocket shaped device containing an aluminum fin and a DU shell. The DU is an alloy stated to have 10 percent molybdenum. It should be noted that some sources state that often between 1 and 2 percent titanium was also used. The round contained 6.7 ounces of DU and contained a small contact explosive device that generated a puff of smoke when it struck its target. The DU spotting rounds were contained in a sleeve device that was also fired and left on the practice range, 60 to 100 yards beyond the firing point. The presence of these sleeves has helped locate the probable test areas for the DU munitions.

The DU in the spotting round does oxidize. This has been on rounds and fragments at Schofield but has not been reported at PTA. The major difference is the presence of moisture that accelerates oxidation. Both uranium metal and its common oxides UO2 and U3O8 are very insoluble in natural water (meaning neither extremely acidic nor

alkaline). The oxidized DU forms on the spotting round or fragments much as iron rust does on a car. It is friable and can be subject to mechanical release as aerosols.

It has been implied that many of the DU spotting rounds at PTA are buried because of continuing live-fire activities. As mentioned in this report previously, burying the DU even a few feet in desert soils will subject it to higher moisture concentrations than it likely encountered at the surface. See for example, (http://www.beg.utexas.edu/environqlty/vadose/pdfs/water_heat_refluxes2.pdf) Thus the oxidation process is accelerated. Continued live fire will only serve to release those oxides, possibly to an airborne environment.

Buried DU also makes it harder to locate. At one time, part of the license proposal contained a description that a specially equipped helicopter, one outfitted with extremely sensitive radiation detectors, would be used a few feet off the ground in an attempt to locate DU. The description stated that it would require about 160 grams of DU to be detected on the surface and more at depth of perhaps 20 or 30 centimeters. Of course the usefulness of this approach is clear in that only a full spotting round would be detected at the surface, there not being enough sensitivity for fragments, and that any buried rounds or fragments would not be detectable.

There is little reason to include this type of search for the DU. It is unlikely that any will be found and that then leads too quickly to the inaccurate and inappropriate interpretation, as exists with the current airborne monitoring program, that no DU is present. If this type of search is included, then during the overflights, there should be airborne collection of dust and aerosols with a full spectrum analysis, meaning both ICP-MS and alpha spectrometry. The rotor wash will provide sufficient energy to free some attached aerosols that may contain DU.

Location of DU at PTA:

Scoping surveys for DU have been performed at military facilities on Oahu and Hawaii Counties. These included looking for DU munitions and collection and analysis of samples from various media. The analytical methods used varied and Oahu (Schofield and Makua) received much greater detailed surveys than PTA. A risk analysis was performed for Oahu.

The results from Oahu should not be transferred for any interpretative basis to PTA. As the visiting panel saw, there are great differences in geologic, meteorological and demographic settings. Illustrative of this point is that found DU munitions on Oahu showed indications of fairly rapid oxidation whereas at PTA, the found munitions did not seem to indicate oxidation. This latter observation is subject to review in light of a recent final report released by the Army.

Based upon the location of the sleeves, fragments and the spotting round found at PTA, 4 probable areas of use were identified. These are within the zones of live-fire targeting

and have a significant amount of unexploded ordinance. Entrance into these areas is restricted. On Oahu, the surface area (soils) sampled adjacent to the spotting rounds revealed higher concentrations of U. At PTA, it is unclear if samples proximal to the spotting round or fragments were collected but there is the suggestion that some were and that they did not contain increased U. This result does contrast with the findings on Oahu where the proximal soil to a spotting round did contain higher uranium concentrations.

Very little soil and vegetation exist at these potential sites at PTA. There are no active surface water streams and even during the infrequent occurrence of heavy rain, moisture for the most part soaks into the highly porous basaltic rock exposed at the surface. There are some areas where sediment transport is evident and some of those areas were sampled for analysis. (Final Technical Memorandum for Pohakuloa Training Area (PTA) Aerial Surveys, The Big Island (Hawaii), Hawaii, Contract number W521J-07-D0041, Delivery Order 0003, Cabrera Project Number: 08-3040.03)

Risk determination:

It has been stated on occasion that a risk determination will not be done for Pohakuloa. One should be done. It should follow different risk determination protocols for what is known and unknown about the results of the scoping and monitoring that has taken place at PTA.

This will show some elevated risk. It should be expressed as relative risk increase. Uranium was added to the environment. Uranium has some inhalation risk; thus the addition of uranium will increase the risk for those exposed. For those not exposed, if using a population determinant, the increase will be miniscule and this properly identifies the magnitude so that people can make an informed decision of how it affects their life.

EPA suggests that uranium inhalation should follow the models for determining risk from radon and plutonium exposures. This is probably a sage approach as it deals with alpha particle exposure from an inhalation pathway. It also shows that cellular exposure influences can be orders of magnitude higher than single gamma-ray intervention. Inhalation of a DU particle significantly increases exposure to alpha radiation in a confined area compared to inhalation of the same size basaltic particle.

There are many factors that can be considered when making a risk determination from inhalation of radioactive or toxic particles. Even with the best of models, the wide range of uncertainty of various influences will create large influences. However, they can be discussed and should not prevent a risk analysis from being made.

Shortcomings of using conclusions of scoping reports:

The periodic reports submitted and released by the U.S. Army are fraught with numerous shortcomings that indicate they should have maintained a data presentation format rather

than make an attempt at interpretation. As these reports can guide future response and activity and even policy or regulation, it is important to present an example of over interpretation. NRC is staffed with very experienced and skillful individuals and they are fully capable of seeing these shortcomings. Therefore it is not necessary to dwell upon minor oversights that should have been addressed in a company internal review.

The report used for this demonstration is the July 24, 2009, FINAL Technical Memorandum for Pohakuloa Training Area (PTA) Aerial Surveys, The Big Island (Hawaii), Hawaii, Contract number W521J-07-D0041, Delivery Order 0003, Cabrera Project Number: 08-3040.03

The report makes a comment that from the soil sampling done at PTA, there is no evidence that DU is present. This is based upon isotopic analysis of uranium and that the signature is not consistent with that of DU.

Insufficient information is provided to state that conclusion and the data provided do, in fact support the alternative conclusion. The results of a 2007 soil analysis is presented in Table 2-1 and the location of the nine samples are referenced to Table 2-3. There is no table 2-3 but the locations do appear on Figure 2-2. Table 2-1 lists the activity for uranium isotopes. The soil samples were collected in areas where sediment had or may have collected from past runoff or erosion. That seems to indicate it could be a time integrated sample with several or multiple sources along the lines of flow contributing to the sediment accumulation. The text on page 2-3 states "None of the results indicate uranium depletion, where the 234-U activity concentration is significantly lower than the238-U activity concentration."

Although it might be useful to define "significantly lower," the amount as presented by the IAEA in a question and answer information sheet should suffice to indicate this magnitude. http://www.iaea.org/NewsCenter/Features/DU/du_qaa.shtml
The activity ratio of natural uranium 234/238 is 1, suggesting secular equilibrium. The activity ratio of depleted uranium 234/238 is 1:5.5, a lower value, and up to the reader to determine degree of significance.

Of the 9 samples listed in Table 4-1, three have activities of 234-U below that of 238-U. Sample 4011 is 25 percent lower. A reasonable challenge to the "no DU" statement can be made based on the analytical results and the method of sample collecting. As the sample could be integrated over time and derived from several locations, it is very likely a mixture of natural and DU contaminated soils. Thus, DU is not only present but it is mobile!

One additional point can be made. The report states (page 2-3) "The visual and scanning surveys identified no distinct surface areas with yellow, oxidized DU metal fragments." Yet the figure Photo 4-1 (page 4-7) clearly shows a partial metal DU fragment of a spotting round with yellow coloration on its surface. Later (page 4-8), the report states that only very minor oxidation is present, but again the subjective characterization is open

to interpretation. Regardless, there is oxidation present and the oxidized form is readily converted to aerosols and thus available for migration.

Finally, a conclusion is suggested in this report that is totally without merit. That conclusion is that because there is so little DU found at PTA, it has already been removed.

On page 5-2 there is the statement:

"The number of DU spotter round bodies, aluminum fin assemblies and DU fragments are much fewer than would be expected given the total number of pistons which were identified. This fact, and in comparison to the number of DU fragments and portions of the Davy Crockett spotter rounds found at Schofield Barracks, suggests that some type of range clearance may have occurred at PTA."

The distillation of this section is that conclusions contained in the technical data reports are out of place and often incomplete characterizations of the full data sets. Past information should be considered as it was originally intended, scoping surveys. The NRC license must provide direction of relevant monitoring procedures and not be based upon any erroneous or misstated conclusions of the data reports.

We have the ingrained public fear of radiation, the complexities of radiation measurement, the emerging science of DU and the health effects; and all this is complicated by the internet. For pure science, internet opinion is too often received as scientific gospel and peer review is long forgotten as a means of providing credibility. It may not take many iterations of this suggestion in the final report before it too becomes "public" fact.

Findings of current air monitoring program:

Air monitoring conducted for the Army is following strict sample collecting, analytical, and sample handling protocols. Monthly reports of three monitoring stations are being produced and are available on line. For the most part, samples are collected during periods of live-fire activity, when one might anticipate the highest amounts of DU to be released. They show a regular consistency, mostly with uranium isotopes at the minimal detection or reporting levels with concentrations of soluble uranium 4 orders of magnitude (10,000 times) below the WHO maximum recommended exposure levels. WHO does not distinguish exposure between soluble and insoluble uranium. This air monitoring program, as designed, has very little chance of finding DU. The analytical procedure is not designed to distinguish natural uranium from processed uranium. Given that the forms are quite different leaves open the question that the body reaction can be quite different to DU and its alloys and to the solubility of its form. Amplification of some points are included in Appendix I.

The Waiki'i Ranch dust analysis (July 8, 2008 Report) is an example of the difficulty in measuring these low levels of uranium. It shows by two methods (ICP-MS and Alpha Spectrometry) the slightest trace DU might be in the dust that was collected. That is in the 238-U/235-U isotopic ratio and a marginal detection of 236-U. These suggest, according to the report, that 1 percent of the U analyzed could be DU but with the caveat of being at the detection limits with errors the size of the measurements.

Recommendations for inclusion in possession license:

There are certain responsibilities that accompany the possession of a license. The license should include some requirements that enhance the security and safety of the public from potential exposure to DU.

These responsibilities are certain facts that can be stipulated to by all parties, such as the existence of DU on the Big Island, and these facts lead to requirements that shall be contained in the license agreement.

Within these recommendations are considerations of reasonableness and an evaluation on the standards "to err on the side of caution."

For example, when DU was found at Lowery Air Force Base near Denver, an acre or more of soil was removed and taken to a low level radioactive waste repository. The Denver site was to be converted to civilian use and removal was prudent to remove any concern of the public for exposure to depleted uranium. For that same reason, to remove DU at PTA may not be practical at this time. Yet, there are other situations in Hawaii that have made an effort at cleanup. There has been a clean up effort of unexploded ordinance (no reported DU usage) at the island of Kahoolawee and at Waikoloa, County of Hawaii, both consistent with transition to civilian usage and within unexploded ordinance zones.

Another safety action is to issue a cease-and-desist order for live-fire and any anthropomorphic activities that would serve to aerosolize the DU should stop at the PTA site. This is perhaps the most contentious issue as there is a direct conflict with the mission of the military and the potential increased health risks of individuals. There should be a strong recommendation to include this restriction in the suspected DU zones. Noting the probable areas in the live fire zones for DU to have fallen, the areas are not that great in size that they could not be removed from live fire activity. Alternatively, the areas are small and if the use is desired for live fire, every effort should be made to remove the DU.

Another concern on the side of reasonableness is to what degree the PTA site should be considered a low-level repository site with concomitant monitoring and security guidelines. Even if DU has been classified as a class A hazard, if it comes from reprocessed fuel rods, then technically it is classified as a material that has been subjected to neutron radiation and thus falls under the definition of material that NRC considers for

low level waste repositories. Thus, the occurrence of DU material at PTA could be considered as occupying an unlined dumping ground and would have to be monitored as such, including migration in the ground off-site and migration in surface and groundwater. While full repository monitoring may not be practical, some elements of that type of monitoring could be reasonably considered.

Those are difficult decisions that NRC must carefully consider.

The most probable risk to residents of the County is from airborne transport of DU in the form of aerosols, either the DU alloy directly or oxidized DU. The risk is much greater but undetermined for civilian or military personnel at PTA, as they are closer to the source.

There are from 300 to 700 pounds of DU introduced to the PTA on the Island of Hawaii. It appears that this material is restricted to a few areas of the training area perhaps no more than 5 square kilometers in area. These areas also contain a significant quantity of non-radioactive unexploded ordnance and are active live fire areas.

The amount of DU uranium added to these areas at PTA approximately doubles the amount of naturally occurring uranium in this area in the upper foot of rock and soil present. No statement has been issued whether or not the DU has been broken down into small fragments by the use of explosive ordnance. If it has, the supporting reason for it being described as having fallen through the cracks, then the need for additional monitoring is imperative.

The current monitoring program does not look for DU but rather U. This should be remedied. The current analysis of airborne materials for U gives a false sense of protection form increased health risks. Granted, the studies of past DU exposure of military and civilians give a very mixed picture of health risks due to exposure but the emerging science, especially the studies concerning the response to DU alloys tends to show elevated health risk is possible. The mechanism is unknown but it could be a situation in which a cancer initiator and promoter are combined.

There are several ways in which monitoring can be improved.

As currently configured, the collection of airborne particulates is submitted for uranium analysis. That is very different than submitted for DU analysis. As the form of DU may play an intrinsic part in its health risks, it should be measured. In other words, it is inadequate to state that the uranium concentration is below some standard because that standard does not distinguish between naturally occurring U and DU. Some attempt has to be made to collect sufficient sample to analyze for signatures for depleted uranium. Although this may not meet the existing sample collection protocol, sufficient sample must be collected in order to measure the low concentrations of other isotopes that could be present. Greater particulate collection can be obtained by longer running times, higher pumping speeds, and aggregating particulate filters.

The analysis of other elements should be included. Molybdenum should be added as it is part of the DU alloy. Oceanic basaltic rocks are low in Mo. Some alloys contain titanium in a concentration of 1 to 2 percent. Titanium should be added to the analysis list. For some samples, a size distribution should be provided.

Some filters should be submitted to a fission track pattern determination analysis and to electron microscope scans to obtain information on the physical nature of the particulates collected.

Greater quantities of particulate matter should be collected. As it stands, the analyses for uranium is very close to the minimum detection limit for the amount of sample supplied whether or not it is ICP-MS or alpha spectrometry. For greater quantity samples, one might be able to determine if other isotopes are present such as236-U, 237-Np, and Pu-239. The quantity taken should be such that the analysis is above the minimum detection or reporting limits.

The recovered spotter round and fragments should undergo analysis to determine the alloy composition and if any other radioactive nuclides are present. This would indicate if the DU used was from the initial purification stream or from reprocessed fuel rods. The quantity taken should be such that the analysis is above the minimum detection or reporting limit

The comment that the average total uranium concentration is 4 magnitudes below the action levels of recommended concentrations by WHO are not particularly comforting if the form of the U is unknown. Inhalation of a DU aerosol of just 40 nm diameter contains about 40,000,000 uranium atoms.

Analysis of the native rock and soil should be performed. This was done for some samples collected on Oahu and should be repeated on Hawaii.

If additional DU materials are located, they should be reported, identified, and removed. A sample of the rock or soil on which it rested should be collected for isotopic and specific alloy chemical analysis. This was done on Oahu and it was found that contamination was transferred to the rock.

The sample collection at Waiki'i Ranch had a clever objective in that the dust sample was presumed to be a history of dust over many years. If such similar samples exist at PTA, they also should be collected and analyzed. This will only provide a qualitative and subjective analysis but it could also add some interesting information.

An independent contractor should be retained to conduct independent air sampling studies. This is not a permanent contract but one to compare the findings of the initial and continuing studies conducted by the Military's prime contractor.

The location of the current samplers and the methods used are limiting but do provide some sense of the nature of the airborne particulates. If any of the enhanced monitoring

suggests the presence of DU, then the number of sampling stations should be increased, perhaps following the plume pattern, and certainly should include dedicated stations at the Girl Scout Camp and the State Park. In addition to the three stations currently in place, a roving station should be considered. There are other air monitoring stations established on the Big Island, some for general air quality, some specifically for the U.S. National Park service, and some in connection with various research programs that occasionally take place looking at other elemental contribution affecting coral growth. It may be possible to piggy back onto some of these monitoring activities. Of special note is the excellent concept by the Army's air monitor Contractor to review archived samples from a different study collected before this current program began.

A risk analysis was not performed at PTA. One should be performed but it should follow protocols different than that conducted on Oahu. It may follow the protocols for determining excess relative risk such as EPA recommends for Rn and Pu.

A training plan for DU identification should be in place and given to all persons who will be granted access to the areas of PTA where DU is likely to have been used. A detailed plan should be described in case DU munitions are located. The plan should involve the discovery, marking, identification and removal. A plan for recognition and removal is part of the existing license request and the specific training for recognition should be amplified for the license request.

The license agreement suggested the use of a helicopter with sensitive detectors mounted to survey the suspected DU areas. I do not think this has any merit. The sensitivity of the detectors stated that they might be able to locate a full spotting round of DU if it were on the surface or up to a few inches burial. Any burial (i.e., shielding) would leave the round and fragments undetected. This same discussion indicated that the DU has migrated through basalt, meaning more likely it has fallen through cracks or has been broken and covered as a result of live fire exercises.

Conclusion:

This is a very difficult issue to address because there are so many unknowns. The quantity, form, and distribution of DU at PTA are unknown. The health risks of exposure to DU are unresolved and now include the suspicion of the alloy itself having a role in increasing risk. Scoping studies and air monitoring have not provided much information on the possible presence of airborne DU.

The suggestions made in this commentary should be incorporated into the license where appropriate. By doing so, there will be better understanding and credibility from government institutions to the general public. The public concerns are real and should be addressed with consistency and respect.

APPENDIX I

Letter and perspective to Colonel Killian, March 6, 2009 from Michael Reimer, Ph.D.

Michael Reimer
75-6081 Ali`i Drive RR-103
Kailua-Kona, HI 96740
March 6, 2009

Colonel Howard Killian, Deputy Director
U.S. Army Installation Management Command
Pacific Region
132 Yamanaga Street
Fort Shafter, Hawaii 96858-5520

Dear Colonel Killian:

I have had an opportunity to review the reports released from DU studies at Schofield Barracks and Pohakuloa Training Area. I also spoke with Dr. Lorrin Pang, some members of the Community Advisory Group, and met contractor Dr. Jeff Morrow.

I agree with your statement that you mentioned in a previous communication we had, and that is to let the science speak.

In that light, I am particularly concerned that what is proposed by the U.S. Army for future studies at PTA will fall far short of providing the best information possible at this time, or for that matter, provide any information that can be used to develop a real rather than a speculative risk assessment.

DU is an issue of evolving study results and knowledge. There are some points that are immutable fact. We know that DU is present at Schofield and Pohakuloa. As I recall, the Army does not dispute the point of potential health risk. Therefore, we must take the best information we obtain today and use it to address the concerns about the level of health risks from potential exposure to DU.

The citizens of the Big Island are concerned. This is a natural, often fearful, reaction anytime the word radiation is mentioned in our society. Yet, we live in a world with ubiquitous and unavoidable natural radiation, from cosmic rays to the foodstuffs that provide our sustenance. According to the position of the U.S. EPA, any and all ionizing radiation has the potential of causing cancer. Thus, there has to be a reasoned balance between unavoidable exposure and elective exposure.

The past use of DU on the Big Island places exposure to that type of radioactive material in the "unavoidable exposure" category. This brings forth the question then of how much additional risk does it pose to the people of the Big Island including the military personnel stationed and working at Pohakuloa.

I believe that with adequate study, this question can be answered with reasonable assurance. As I mentioned, I do not believe the currently planned study has the capacity to answer that question. The reason for my belief is that the study design is to measure total uranium and to show that it is below standards set by World Agencies for regulated exposures. This may present itself as a feel-good approach, but it is unfortunately misleading even with the rudimentary information we have today about the form and occurrence of uranium in the natural environment. In other words, the study as currently planned still leaves the door wide open on determining excess health risks, if any.

The attached commentary contains suggestions on what additional information could be collected to help determine the risk. It is fair to assume that the information about the use of DU is as accurate as it can be. That is, the only use was in the Davy Crockett spotting rounds, no use of penetrating munitions occurred, that is the 20mm or 30 mm rounds from various Gatling configurations, smaller caliber rounds, or larger caliber armor penetrating munitions. It assumes that DU does not remain from any breach of containment if used as ballast or armor reinforcement, or any other possible presentation.

My comments are intended for a reasonably informed individual about DU issues; it is not overpoweringly technical but does use various standard abbreviations, chemical, isotopic, and radiological inferences and acronyms. For example, I use DU for depleted uranium and its various components, and natural uranium or NU for naturally occurring uranium. I am not suggesting that the uranium has a chemical, physical, or radiological difference. However, it is different in form and that is a significant difference for risk assessment. In addition, unless specifically mentioned, I do not separate radioactive decay into the three common particles, alpha, beta, and gamma radiation. Of special note is my use of the term "form" in describing uranium. Unlike the Hawaii Department of Health presentation (November 2007), I use form not to refer to the element uranium (and isotopes) but to describe its occurrence in a matrix – natural, alloy DU, or oxidized DU.

This is a commentary; it is not a formal, peer-reviewed technical report although it may in some instances give the appearance of a peer review for the program. I do not duplicate information that can be found elsewhere and except in unusual or compelling circumstances, I do not provide references. For detail not presented here, I am sure various contractors you have will be able to address and clarify the concepts more fully. However, I am also willing to further explain my commentary for those issues that might be seen as some in a gray area of meaning.

Sincerely,

Michael Reimer, Ph.D., geologist, retired
GeoMike5@att.net

Distribution: Sherry Davis, Corey Hardin, Hawaii County Council, Pete Hendricks, J. Morrow, Ph.D., L. Pang, M.D., LTC Richardson, S. Troute

Advisory Commentary of Michael Reimer on PTA Depleted Uranium Studies

Overview

Uranium in the natural environment occurs as an element within a mineral matrix. This is true for the oceanic basalts that comprise the bulk of the volcano building material or even uranium mineralization associated with economically recoverable uranium deposits. This is in contrast with DU used as munitions. There, uranium is in a metallic form commonly alloyed with another metal or as a component derived from that metallic form. Regardless of physical form or chemistry, uranium is radioactive. In addition, uranium is a heavy metal and can cause heavy metal toxicity if ingested in sufficient quantities.

Any analysis of airborne materials that reveals uranium does not necessarily distinguish between metallic or matrix-included uranium. DU used at Pohakuloa is reportedly 92 percent uranium alloyed with 8 percent molybdenum. Other alloy materials of DU munitions not known to have been used in Hawaii included titanium, cobalt, and nickel. Molybdenum as a heavy metal also has associated toxicity.

There is a major difference in potential cellular radiation damage if exposed to metallic uranium (or any particle with high uranium content, such as the 92 percent DU) versus exposure to oceanic basalt dust or aerosols where the uranium content may be 0.1 to 1 part per million (0.00001 to 0.0001 percent). The reason for this is quite intuitive. The more closely packed the uranium is, if embedded in tissue, the greater the likelihood that its radioactive alpha particles can provide multiple transits of the same cell during the cell's lifetime.

Chemical form is also important to consider. DU and its alloys oxidize. Oxidized uranium (commonly valence VI) is more mobile in the environment that reduced uranium (IV). DU oxidizes as seen from the photographs of yellow residues on spotting round assemblies. The rate of oxidation is highly dependent on the local environment in which the metallic alloy is deposited. One estimate from DU in soils indicated a 30 year time span before the DU would be completely oxidized. I find such a time frame incredibly quick and would need conforming evidence to reinforce its validity. From suspected

oxidized fragments found on Oahu, it does appear that the oxidization process may be rapid in a moister environment. The oxidization process of DU has been observed for spotting rounds in Hawaii and while it occurs, it seems to be at a much slower rate of progression as it has been perhaps over 40 years since the munitions were fired on the Big Island.

In effect, there is a mixed scenario regarding the transport and migration of DU, in both metallic and oxidized forms and there is a different health response from both radioactive and heavy metal exposures. Background surveys at Schofield seemed to indicate that surface U radioactivity was less than that found with samples taken from depth. This is not unusual when you consider that weather (leaching) of uranium and other metals can occur from surface materials and it can be redeposited in lower horizons. Migration of oxidized DU could follow the same path but on a more rapid time frame. I point this out so that it may be considered as a mechanism for either form of uranium.

In response to finding DU at Schofield and Pohakuloa, the military performed various scoping surveys and analyses to determine the probable extent of the distribution of the DU munitions. These surveys included soil sampling, plant sampling, controlled burn of vegetation with ash collection and analysis, ground surveys, aerial photographic surveys, and airborne fly-overs with a helicopter fitted with sophisticated radiation detectors, and walk-overs with scintillometers looking for spent rounds that have a rather unique shape.

DU, because of it purity of uranium, is difficult to find using common radioactive detectors. Its primary decay is through alpha particle emission. These alpha particles, have very limited range in air, perhaps 5 cm and even less within any matrix material or soil cover. There are limited emissions of beta and low energy gamma rays from the decay and progeny, again with limited range before all energy is transferred to the surrounding medium. That medium can be any combination of mineral matrix, soil, water, or air. The progeny of uranium decay are also radioactive until the end member is reached (Pb-206 in the case of U-238). Thus the radioactivity of purified U-238 begins to provide greater radioactivity with the in-growth of progeny than that uranium immediately after purification and the progeny can be detected just a few months after pure uranium is cast. In fact, within about 6 months after purification, the radioactivity

increases from about 50 percent that of natural uranium (depending on the extent of U-235 separation) to about 75 percent.

If the DU was obtained from reprocessed fuel rods, the possibility of other isotopes is real and they could include significant radiation emitters even in trace quantities. While one might be tempted to state factually that the radiation of DU is less than natural uranium, it is the total radiation of the spotter round that should be addressed.

The paper "Depleted Uranium, Natural Uranium and Other Naturally Occurring Radioactive Elements in Hawaiian Environments" by Dr. Kenneth Rubin, of at University of Hawaii (May 30, 2008) is an excellent overview paper covering many details of uranium in the natural environment. It is unfortunate that the copy I read did not contain references.

Analysis

Uranium can be analyzed chemically and the surveys used ICP-MS that could even provide isotopic analyses. DU typically contains the naturally occurring isotopes, U-238, U-235, and U-234. If processed from spent fuel rods, it may also contain U-232, U-233, and U-236, and nano-traces of other isotopes, as well. Typically, the presence of U-236 is an indicator of fuel rod processing. The energy of the alpha particle release is also indicative of the particular isotopes. Those energies can be resolved using alpha spectrometry.

All analytical measurements have detection limits. That is, they have a limiting number (concentration) below which the element of interest cannot be detected. The methods used in the scoping surveys probably provide the lowest possible detection limit available by analytical instrumentation today. For example, if enough of the sample is available, ICP-MS can measure one part of the element of interest in 1,000,000,000,000,000 parts of the other material; that is 1 part in a million billion. An advantage of the ICP-MS is that it can measure isotopes of some elements, if enough material of the element of interest is present.

Alpha spectrometry is another analytical means of detecting uranium isotopes and was used for some sample analysis at Schofield. It is capable of measuring the alpha decay of individual atoms and the energy released is often characteristic of the isotope! Some care must be used in selecting a calibrating isotope for this system so as to not interfere with the energy of the particle of interest.

This is, of course, high praise for the potential of the analytical capability but if not used properly in a well designed program, the analytical results can be incorrect or misleading.

For example, if the analytical results are close to the minimum detection level of the instrument, there is great uncertainty in the precision of the results. In other words, the standard deviation of the analysis can be so great that the uncertainty (often shown as a plus or minus number indicating a range of the result or expressed as standard deviation) pushes the analysis into a region less than the minimum detection level.

A note is in order here. There is another limit commonly used, identified as the reporting limit or RL. It is typically higher than the minimum detection level (MDL), often by an order of magnitude, just to avoid the great uncertainty that accompanies analyses close to the MDL. I would have to carefully check Figure 3.1 on the Final Report of the ICM-MS results for total suspended air filters to see if the RL is properly placed.

Analysis on the edge of the detection limit is particularly bothersome when attempting to use the uranium isotope ratios from ICP-MS analyses to determine if they are representative of natural or depleted uranium.

Typically, U-235 and U-234 are lower in DU than in natural uranium. U-236 does not occur in natural uranium. An isotopic analysis of uranium and comparison of ratios of isotopes can reveal whether or not it is likely to be natural or depleted uranium. In addition, the presence of U-236 is nearly confirmatory that DU is present. Thus, the analysis of uranium isotopes presents many internal controls for determining the possible existence of depleted uranium. In short, we know depleted uranium is there. The question to be resolved is if it has an airborne mobility vector.

From typical analytical results reported so far especially from the Schofield studies, the total uranium concentrations are going to be between the MDL and the RL. Isotopic analysis if performed may not present any useful (resolvable) information.

Next Sampling Phase

As I understand, the design of the continuing program to monitor airborne particulates, I believe the results are going to be inconclusive whether DU has mobility through an airborne vector. I believe only ICP-MS is going to be used for the analyses of particulates on the air filters.

Minimal modifications could enhance the monitoring to provide results that have a better chance of revealing if DU is transported in the air. I shall outline them here with a brief explanation as to why they should be incorporated into the study.

Recommendations

Alpha spectrometry. Alpha spectrometry should be applied to all the samples collected. The alpha spectrometry is an important component to the overall comprehension of the sample makeup. It should detect U-234, U-235, and U-236. It could reveal U-236 if present that would be a clear indicator of depleted uranium and the sample should be counted long enough to detect any Po and Ra, progeny of U that could help distinguish between DU and naturally occurring U. I understand from Dr. Morrow when we met on March 3, 2009, that alpha spectrometry is not part of the future studies. I believe at least some minimal number of samples should be designated for alpha spectrometry. The reason is that it might be able to detect the presence of isotopes characterizing DU. This may require extended sampling time or greater pumping speeds. Alpha spectrometry was performed at Schofield and should be continued at PTA. A total uranium analysis will not distinguish DU from NU.

ICP-MS. ICP-MS should be continued and additional elements included. In fact, there may be a suite of elements included that come as an analytical packet for a minimal fixed cost. Mo should definitely be included in the analysis. There is very little in Hawaiian basalts and larger quantities may be an indicator of DU. Additional analyses would be Ni, Co, and Ti. Ti, a later alloy of DU munitions might have a fairly high background in Hawaii as it occurs in the percent range in some Hawaiian basalts. Phosphorous may indicate the use of fertilizer in the case where high uranium values are seen. Although ideally every sample should have a full analysis, I believe for at least 25 percent of the samples, a full suite of commonly run ICP-MS analyses should be made.

The partial digestion analysis of a standing dust sample from Waiki`i ranch is interesting in that it strains the analytical detection limits and vaguely hints at the possibility of DU in airborne dust. We have no information on the quantity of the sample, counting times, particulate size distribution or calibration and standards. It is reasonable to suspect however that a rather large quantity of sample was available for this ICP-MS analysis to include U-236 detection.

Duplicate, background, standards, and blank samples. I recommend that duplicate field samples be collected at certain times, even if this means running two filters in parallel. The issue of standards, blanks, backgrounds, and replicates was poorly covered in the scoping reports. Some indication of reasonable measurement error range should be obtained and reported. The samples should be given to the laboratory unidentified as to whether they are special category samples. Typically, these samples represent 10 percent of all samples. Blanks are self explanatory; standards are those made by the lab to calibrate the equipment and those prepared by the party submitting the samples. For background, see Sampling Frequency, below.

Particle observation. I recommend that some of the filters be photographed using an electron microscope to observe the particles that have been collected. Such photographs may indicate the nature of the particulate matter, if it is amorphous or crystalline, organic (pollen) or inorganic. It would also be worthwhile to get some idea of the particle size distribution from a range of 10 nanometers to 100 micrometers. For

some samples, I recommend that an analysis be made of post-filter collections. There are multiple ways of obtaining this information, including post-filter large surface area collectors, that the contractor can recommend.

Sampling frequency. I believe the sampling of aerosols is scheduled for pumping 24 hours, once a week. I would recommend that the sampling occur every 6 days or more frequently to obtain coverage for days of the week when different scheduled activities may occur. I also would like to see sampling stations set up around the island. *I understand from Dr. Morrow that such sampling has already occurred as part of other, non-military sponsored monitoring, and some information from those collections will be included in this study. In addition, the present sampling program is following a random day, US EPA protocol.

There should be some samples that are included as background. These could be upwind samples. There are several air sampling programs in effect on the Island, from government to university studies. These monitor air quality for a number of reasons, including particulates and elements related to volcanic emissions and VOG. I would suggest exploring the feasibility of including air sampling for uranium as part of these ongoing operations and to have several stations operating for several years in the quest for airborne DU. A collection and comparison of data from these other monitoring stations and their ongoing analyses would be a good addition to discussion in a final report. This possibility of cooperation has been mentioned in various reports and I encourage it as part of this survey. For example, I highly recommend discussions and data exchange (past, present and future) with researchers at the Mauna Loa observatory. They have been measuring particulates and radioactivity as part of many different programs over the years.

Training. Personnel who traverse PTA should be given training in the appearance of spotter rounds and potential fragments. If seen, they should be noted and reported for recovery. I have seen that this training is included in the license application to the NRC.

Aerosolization. In spite of determined attempts to locate spent spotter rounds, they were largely unsuccessful. Only one round was located at PTA. There could be many reasons for this. One is the difficulty in finding DU via radiometric surveys.

The helicopter over-flights are another example of minimal detection capabilities. The helicopter flew at just feet off the ground but even that small distance is equivalent to the inches of soil cover for attenuating ionizing radiation.

There may have been several hundred to over 2,000 rounds fired. The fact that only one was recovered points out the difficulty of locating the rounds. If a suspicious material is found, that is physically located and recovered, alpha particle detection can be used to determine if it is uranium.

Speculation can present a few additional scenarios besides inadequacies of detection techniques that could provide explanation why more DU rounds are not found. The probable impact area is larger than the area being searched; upon impact (and we do not know the target material), the rounds fragment highly, including partial aerosolization; the rounds have mostly oxidized; the spotter round impact area has been highly impacted by other activities including exploding ordinance or vehicular traffic. It should be pointed out that the oxidized form is highly friable and can be dislodged easily from the host metallic form. It could be carried to deeper horizons by surface precipitation and leaching or aerosolized more readily by mechanical means. I doubt that there is only one mechanism at work making the finding of rounds difficult.

Special sampling events. Anytime there is a special event at the training area, such as road construction or a firepower demonstration, sampling should be done. It is too bad that the helicopter did not include a dust sampling device when it was searching for spotter rounds. Such activities have the capability of placing aerosols and dust into the air and DU may be a part of that release. *I understand from Dr. Morrow that this is planned.

Minimum detection level or limit (MDL). There should be a concerted effort to raise the analytical threshold above the MDL. I recognize the difficulty of this suggestion. If this

means collecting a sample for longer than 24 hours or using multiple filters to collect more sample, it should be considered.

As it currently stands, the reported concentrations of material analyzed is about the same as the MDL. This indicates that the concentrations of materials are low and a conclusion is drawn that because the uranium is low, and below the various exposure limits set by various health organizations, there is no threat from exposure. This is an inadequate approach, convenient, but inadequate.

As argued before, the form of the material is of great importance. If a 10 nanometer diameter of DU is embedded in the lung, it will present a radiation hazard even though it may only register as a small part of total uranium collected on a filter.

Aerosol characterization. These suggestions are made to enhance the characterization of the aerosol sampling program. The addition will impart increased costs but it is needed to say with certainty what any increased health risk might be if DU is present. Aerosols can be created even when a spotter round fragments. This is noted from the dust released when any brittle object is broken. Of course, it is much less than burning an object and changing the form into smoke or ash. I have no information on whether or not the spotter rounds were fired at a target and what that target might be. Simple impact and fragmentation will create aerosols. The extent of this might be seen by measuring the alloy metals (molybdenum) that would be part of the aerosol.

Health risk determination. There are several means by which health risk from exposure to DU can be determined. Various models and worse case scenarios can be used but the primary question is whether people were or are exposed to DU. For this, one hopes to have actual data for input. The difficulty of obtaining this for DU is discussed but I believe some modification to the sampling program, also discussed, can obtain data that can be useful. The selection of risk determination can take many forms; the one used recently by the US EPA for relative risk was particularly understandable by the public. For soldiers and contractors at Pohakuloa, the chance of being exposed to DU is greater than for someone more distant from the site, but the risk is not negligible and the

magnitude of that risk will not be determined until data are available from the aerosol monitoring.

For the Big Island, if you are exposed to SO_2, you have an increased health risk. It is likely that most residents in their living locations are exposed to very little SO_2, so they do have an increased risk, albeit minimal, but an increased risk nonetheless. If it can be measured, it should be reported.

I depart here from my intent of making this a commentary and include some web sites that may be of interest. I mentioned that I feel sample collection must be modified in order to determine if airborne DU is present. Dust-size particles are likely to be localized as they have a high settling velocity, meaning they drop out of the air pretty quickly when the wind that carries them decreases below a certain speed. We know of course that dust can be carried hundreds and even thousands of miles if it is elevated to high enough altitudes but local winds do not appear to have the convective action to carry the dust high to the altitudes needed for long-distance transport. Aerosols, the smaller particles, can be airborne for rather large distances. They are smaller and utilize the buoyancy effect for transport. These are also the particle sizes that are most likely to become inhaled to the deeper regions of the lung.

Noting that various statements about radiation risk are attributed to the US EPA, especially their position developed from radon that one ionizing particle intercepting a single cell increases the cancer or mutation risk, I feel it is prudent to use the EPA's risk models. They are pretty well developed and even available on line.

The reason for this approach is that DU has a different form than oxidized DU or natural uranium. It is possible that the aerosol particle is DU, 92 percent uranium (920,000 ppm) rather than basalt with 1 part per million uranium. This potentially has a very different impact from alpha particles with cells in the lung. There are analogies to plutonium risk models and radon risk models. The use of a radon risk model has been independently suggested (Albright and Barbour, 1999). http://www.isis-online.org/publications/rp1.html

The US EPA models and calculator are also available on-line. These were developed for Superfund sites and I would hope these would be considered when

developing the health risk determination of DU at PTA. The equivalent of U, Pu, and Rn can be run.

http://www.epa.gov/superfund/health/contaminants/radiation/pdfs/introglos.pdf

http://epa-prgs.ornl.gov/radionuclides

Historical input. There are uncertainties dealing with the DU use at Pohakuloa. There is still time for contact to be made with individuals who were stationed there at the time of the firing. With luck, one might find a range fire control officer. They may know if there were 200 or 2,000 rounds fired, if the testing was done in confined areas, and even if there were any hardened targets involved. In addition, perhaps a minor ecological health study could be conducted using those stationed soldiers at the time before, during and after firing, could be performed to see if there is a suggestion to conduct a case controlled epidemiological study. I include under this topic the historical data and samples collected previously and available from archives. I learned from Dr. Morrow that these samples are available and predate the recent recognition of DU use on the Big Island.

NRC license application. The license application identifies at least 12 sites in the country that potentially have depleted uranium on site. These are very diverse ecologically and it may enhance the application if each was discussed separately. I make this suggestion in lieu of suggesting that a separate application be filed for each area.

The concept of providing training is sound but training must be an ongoing program for as long or longer than there is DU at these sites. The $1.9 million sought may be insufficient to accomplish and maintain this goal. This training goes along with the commentary I provided in the brief training section above.

I believe the license application should make it perfectly clear that if DU is found, it will be removed. The license application includes a discussion of detecting depleted uranium and talks about the quantity needed to be seen on scintillometer devices. I would restructure this section as it basically states that unless a rather complete spotter round is found lying on the surface, it will not be detected. This comes from the calculation in the application of the amount of DU needed to be detected and the weight

of the DU present in a spotter round. Let me provide the example of this. In the application to the NRC for a license to handle, store and dispose of DU at various military facilities, it is stated that a sophisticated radiometric detection system will be assembled and used. It further states that it will be capable of detecting surface fragments 6 cubic centimeters of volume and those buried 2 inches deep that contain 10 cubic centers volume of DU. As the density of U is 19 g/cm3 and the weight of DU in a spotter round is 190 grams, this highly sophisticated instrument will likely detect nothing. Anything, particularly fragments buried a few inches below the surface avoids detection completely.

Summary

The present method proposed for air monitoring has very little chance of revealing depleted uranium. Several slight modifications to the sampling program are recommended. The major changes are to include alpha spectrometry (U-233, 234, 235, 236, 238, Po, Ra), and additional ICP-MS elements such as typical alloy compounds, Mo, Ti, Co, Ni, Cr, and even Pb. Quantity of samples should be sufficient to move the analysis above the RL level. An attempt to characterize size distribution from millimeter to nanometer should be made on a few samples. Sampling periods should be varied, every six days for example, and include background, duplicate, replicate, and blanks. Ideally, the air monitoring sampling at the perimeter of the training area should be monitored continuously. The sampling program should include special events at PTA such as those that may create a lot of dust and monitoring stations around the Big Island should be set up with monitoring continuing for several years.

APPENDIX II

Oral Testimony to NRC public hearing August 29, 2009 from Dr. Michael Reimer, Ph.D., geologist; presented in part August 27, 2009 by Ms. Corey Harden.

Distinguished NRC Panel Members:

Thank you for allowing my comments to be read into the record at this public forum.

As you well know, the very mention of radiation strikes fear in the minds of most citizens. It invokes images of the use of nuclear bombs in war, the 64th anniversary occurring just two weeks ago, and of those popular B-movies of the 1950s where giant predatory insects roam from the nuclear test sites to prey upon our frail human species.

Yet it is a little known fact how much radiation we receive as background in our everyday lives, from eating and drinking, from solar sources, from our contact with the ground and even from our own body.

The US EPA has taken a stance that all ionizing radiation places us at risk to develop cancer. Their linear, no-threshold model gives no room for exception. We live with this in our daily lives. In many places, regulation has been established on this position, for example, radon disclosure in real estate transactions. Do you question the need for x-rays every time you visit your dentist? We are forced to make a judgment call to determine if the benefits outweigh the risks. Sometimes, if you are knowledgeable or have information readily available, it is easier to make an informed decision. Even marketing rises to address this fear or radiation. How many of you recall NMR being renamed MRI?*

The use of radioactive munitions on Hawaii has raised the consciousness of the citizens and the naturally associated fear of increased risk of illness. I want to tell you that I and my colleagues are very concerned about the perception and problems of this issue and believe our comments and suggestions are germane to getting the best information to the public. We want the studies to have sufficient credibility so that they are accepted by the skeptical public. The credibility of the military was not helped by the rapid denial that DU munitions were not used in Hawaii and what seemed a grudging admission that they were. We must move beyond that. Now is the time for recognition of the concern and the implementation of the best and proper procedures to monitor release of radioactive materials that have been used here.

Hawaii is a unique island chain. It is a living laboratory, a climatic and ecological wonderland, and a vacation paradise. It is a fragile ecology in any sense of the word but has come under increasing pressure due to the influence of the modern world. Extraordinary efforts must be made to protect what remains. The vision of a paradise one that provides the basis for an economy based on tourism, must be sustained. You clearly

note the differences between Schofield and PTA military sites. Keep that in mind when you consider what important elements should be included in a license and if the sites deserve separate licenses.

The work at Schofield was more extensive than at PTA and it is probably not appropriate that interpretations from Schofield be extended to PTA.

At least 300 pounds of DU have been added to a few acres at PTA. The chemistry of the oceanic basalts reveals that they are very low in natural uranium, in the range of 0.1 to 1.0 part per million. A square mile of surface, up to a foot in depth would then contain about 200 pounds of naturally occurring uranium. Thus the addition of uranium from DU doubles the amount in the area, and it is not homogeneously distributed.

The scoping survey found 1 Davy Crockett projectile and fragments suggesting 2 others out of a minimum of 714 used. What happened to the rest? The current thought is that they fell through the cracks. But there should be no glee in that belief, suggesting a burial of the problem. The DU will oxidize more rapidly when buried and any activity that churns up the cover will most likely aerosolize the oxides and even some of the nearly pure DU.

There can be a big difference in health effects between respirable aerosols that contain part per million uranium in a silicon matrix and those that may be pure uranium. This is not unlike the problem with plutonium although there is a half life difference.

This leads to three issues that the license should address: 1) The quality of monitoring must be enhanced to be able to detect DU; 2) There should be independent monitoring to give assurance that the current monitoring has a place for long-term observation; 3) Any continued use of live fire at the suspected DU training area should cease immediately as it could contribute to the release of aerosols. I will provide more detail in an expanded document I will submit to NRC.

Don't sweep this issue under the rug, or in the case of PTA under the basalt. Don't contribute to dumbing down the population and with a wave of the arm substitute minimal requirements where comprehensive ones should be in place. Some very good cooperative efforts involving numerous organizations with redundant and independent monitoring have taken place. Rocky Flats Colorado is a prime example, and while perhaps never coming to closure, at least has ameliorated the immediate concerns.

Most of us are not here to be confrontational but to contribute as stakeholders to the resolution. Yes, you are going to receive some vociferous criticism, some government or military bashing, but that is part of the process. To have forum merely to meet a requirement for a public meeting but to ignore the input is the arrogance that leads to confrontation.

We know the ideal solution, that of an exhaustive search and removal of DU munitions is unrealistic here. At the former Lowery Air Base in Aurora Colorado, when DU

munitions were found, acres of surface were scraped and removed to a low level repository site. That could be applied here but we recognize the problems working in areas with unexploded ordinance. We also recognize that this area alone in this land of paradise, well beyond our lifetime, will eventually have to be declared a National Sacrifice Area, closed forever. No wilderness, not a park, not a wildlife refuge. Closed Forever. A piece of paradise lost.

Not all people of the island have equal increased risk. The people closest to the source of the toxin, those military and civilian employees who work at PTA have the most increased risk. It is no longer sufficient to ignore that by saying these individuals by the nature of accepting their job, are expendable.

*(Nuclear Magnetic Resonance – Magnetic Resonance Imaging. The differences are minimal, mostly imaging software, and NMR is today reserved more for in-vitro studies).

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