Headquarters Marine Corps

Code LFL • 2 Navy Annex • Washington, D.C. 20380-1775

FINAL

Range Environmental Vulnerability Assessment

Marine Corps Base Hawaii

October 2009

Report Prepared By:

Malcolm Pirnie, Inc.

1700 West Loop South
Suite 1450
Houston, TX 77027-3005
713-840-1511

6285-024

MALCOLM PIRNIE

Executive Summary

The United States (U.S.) Marine Corps (Marine Corps) Range Environmental Vulnerability Assessment (REVA) program meets the requirements of the current Department of Defense (DoD) Directive 4715.11 *Environmental and Explosives Safety Management on Operational Ranges within the United States* and DoD Instruction 4715.14 *Operational Range Assessments*.

The purpose of the REVA program is to identify whether there is a release or substantial threat of a release of munitions constituents (MC) from the operational range or range complex areas to off-range areas. This is accomplished through a baseline assessment of operational range areas and, where applicable, the use of fate and transport modeling of the REVA indicator MC based upon site-specific environmental conditions at the operational ranges and training areas. Indicator MC selected for the REVA program include trinitrotoluene (TNT), cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), perchlorate, and lead.

This report presents the assessment results for the operational ranges and training areas at Marine Corps Base Hawaii (MCB Hawaii or MCBH), on the island of Oahu, Hawaii. This report is the first comprehensive report on MC associated with the operational ranges at MCB Hawaii and serves as the baseline of environmental conditions and potential vulnerabilities of the operational ranges. Subsequent vulnerability assessments will be conducted on operational ranges at MCB Hawaii on a five-year cycle or when significant changes are made to existing ranges that potentially affect the determinations made during this baseline assessment, as described in the *REVA Reference Manual*.

Military Munitions Training and Operations

MCB Hawaii consists of several discrete properties spread across a total of 4,718 acres on the islands of Oahu and Molokai (TECOM, 2004). Of these properties, the Marine Corps currently conducts all training exercises at three separate locations on Oahu: the Kaneohe Bay Range Training Facility (KBRTF) on MCBH Kaneohe Bay, Marine Corps Training Area Bellows (MCTAB), and Puuloa Range Training Complex. Collectively, these areas are known as the MCBH Range Complex (MCBH, 2005). The entire MCBH Range Complex provides a range of training facilities that supports the readiness and global projection of ground combat forces and aviation units of the Marine Corps (MCBH, 2005). The primary range users are the current tenants of the installation, which include the III Marine Expeditionary Force; Commander, Patrol and Reconnaissance Wing Two; and the 3rd Radio Battalion (Drigot and SRGII, 2006; NAVFACHI, 2006).

There is also significant use of these ranges by other U.S. military services and federal and local government agencies (MCBH, 2005).

Military use of the operational training areas may date to the early twentieth century. Consequently, existing operational ranges and training areas, as well as historical use areas, were reviewed to determine the locations of MC loading areas at MCB Hawaii. These areas represent the locations at which significant MC loading is occurring or suspected to have occurred as a result of training with munitions containing high explosives (HE), including TNT, RDX, and HMX, or illumination rounds/munitions containing solid propellants such as perchlorate. Four MC loading areas within the MCBH Range Complex were delineated:

- HE Impact MC loading area
- R-8 MC loading area
- Former Grenade Range MC loading area
- Former Explosive Ordnance Disposal (EOD) Range MC loading area

All four MC loading areas are located within the KBRTF on MCBH Kaneohe Bay. The HE Impact MC loading area and R-8 MC loading area represent the two current loading areas at KBRTF; both are located in the interior of Ulupau Crater, near the shoreline of Kailua Bay. Two MC loading areas—the Former Grenade Range MC loading area and the Former EOD Range MC loading area located on the western exterior side of Ulupau Crater—were established to account for loading from historical use areas within an operational range boundary. These former ranges / MC loading areas are located in a section of the KBRTF currently under consideration for establishment of a new explosive training range.

MC loading areas were not identified at MCTAB. Operations within the three training areas at this installation are restricted to non-live fire training, which does not significantly contribute to MC deposition. Historical use of former ranges located within the MCTAB training areas was also determined to contribute minimally to MC loading at this installation.

Locations with lead loading attributable to small arms ranges (SARs) were defined and evaluated for potential lead migration and exposure using the Small Arms Range Assessment Protocol (SARAP). Four ranges were identified at the KBRTF, and six ranges were identified at the Puuloa Range Training Complex. All of these current ranges use only small arms.

The REVA assessment team estimated key MC loading rates for identified current and applicable historical MC loading areas, along with rates for current SARs at KBRTF and Puuloa Range Training Complex. Conceptual site models (CSMs) were developed for these two training areas to qualitatively assess the potential for the MC loading areas and current ranges to impact identified human and ecological receptors.

CSM for MCBH Kaneohe Bay – KBRTF

MCBH Kaneohe Bay, located approximately 12 miles northeast of Honolulu, encompasses 2,951 acres at the end of Mokapu Peninsula (MCBH, 2005). KBRTF, which contains the operational ranges for this facility, is located at Ulupau Crater on the northeastern finger of Mokapu Peninsula. Ulupau Crater is surrounded by the ocean, with the exception of its southwestern boundary. Ulupau Crater is a tuff cone built on the Puu Hawaii Loa nephelinite from hydromagmatic eruptions. Marine deposits and emerged reefs are also found in and around the crater and are remnants of when the ocean level was higher than it is today (Luecker et al., 1984; NAVFACHI, 2006; USAE, 2006; SRGII, 2004; ESI, 2006).

KBRTF contains 10 ranges, four of which are designated for small arms use only. One of these ranges (R-8) is an emergency demolition range located in the crevice along the east side of the KBRTF. Two impact areas, one for inert munitions and the other for HE munitions, are defined at the north end of the KBRTF. Outside of several established metal targets, these impact areas are largely featureless and are largely covered with grassy vegetation.

There are no perennial water features at KBRTF; there is an unnamed, intermittent drainage that generally flows east from the crest, across the interior of Ulupau Crater, and down to the shoreline. Kailua Bay is located to the east, and the Pacific Ocean is found to the north and west. Runoff generated during significant precipitation events is anticipated to flow overland and through eroded drainages to the ocean. MC from loading areas at MCBH Kaneohe Bay could potentially be transported via surface water runoff through dissolution or erosion of soil and sediment. Generally, the MC loading areas are on relatively steep, compacted slopes with vegetation densities that vary seasonally. Installation personnel have found that the prevalence of invasive grasses at Ulupau Crater is not effective for controlling overland flow and subsequent erosion (SRGII, 2004). As a consequence of these conditions, the potential for surface runoff and erosion during rainstorms is high at the MC loading areas.

Limited general information is available regarding groundwater at the KBRTF. There are no groundwater level data available on Ulupau Head. On the Mokapu Peninsula, shallow groundwater levels are about 1 to 2 feet above mean sea level (amsl) (Luecker et al., 1984). Groundwater flow is generally through porous tuff and marine deposits and is toward the coastline. However, differential recharge, complex geology, and tidal influences make it difficult to define the exact path of groundwater flow and other characteristics in the area of Ulupau Head (Luecker et al., 1984). MC may be dissolved during precipitation events and infiltrate into the highly permeable lava (tuff material) generally comprising the lithology of Ulupau Crater, though infiltration is less likely around the slopes underlain by Makalapa Clay. The depth to groundwater at the MC loading areas is expected to be quite variable and dependent on the ground surface topography. Range personnel reported that they have not noticed groundwater seepage around the crater. In the absence of any streams or springs on Ulupau Head, the groundwater must be assumed to discharge offshore (EMC, 1991; Takasaki et al., 1969).

The waters surrounding the KBRTF are classified as Class A waters, which are managed for preservation of recreational and natural values (BCH, 2002; NAVFACHI, 2006). A 500-yard Naval Defense Sea Area buffer that restricts public access has been established around the entire installation. Installation personnel may not use the shoreline of the KBRTF for recreation purposes, though access by Marine Corps personnel and family may occur at areas outside of the facility for fishing, diving, swimming, or boating. As such, there are no anticipated significant human receptors of MC in surface water within the KBRTF. There are no potable water wells on MCBH Kaneohe Bay (NAVFACHI, 2006). Groundwater resources at KBRTF are brackish and unsuitable for human use; therefore, no human receptors are considered to be impacted by this pathway.

There are a variety of potential ecological receptors at the KBRTF. The red-footed booby colony located within the Ulupau Head Wildlife Management Area (WMA) at the north end of KBRTF represents the most prominent fauna within the operational range areas (BCH, 2002). Managed by the Environmental Department at MCBH Kaneohe Bay, it contains the largest breeding population of red-footed boobies in the Main Hawaiian Islands (SRGII, 2004). Laysan albatrosses have also been noted, though mostly during "rainy" low fire risk months of November through February (BCH, 2002). The red-footed booby and Laysan albatross are migratory seabirds and are protected under the Migratory Bird Act (MCBH, 1997). However, both species feed in marine waters, and active wildlife management practices—including the establishment of fuel breaks around the WMA and live capture and removal of albatrosses—minimize potential exposure to training activities. Consequently, these species are unlikely to be affected by MC potentially deposited at these locations.

MCB Hawaii is the only Marine Corps installation with coral reef ecosystems within its jurisdiction (SRGII, 2002a). Relatively high coral cover (up to 80% on ridge crests) occurs offshore of Ulupau Head in Kailua Bay and the Pacific Ocean; the greatest reef fish abundance and diversity occur in these same waters. Marine species that have been declared threatened (green sea turtles) or endangered (hawksbill turtle, monk seal, and humpback whale) have been observed in the waters offshore of MCBH Kaneohe Bay.

Screening-Level Surface Water and Groundwater Transport Analyses

The four MC loading areas identified at the KBRTF were evaluated using screening-level analyses for potential transport of MC to off-range areas via surface water and groundwater pathways. Because the Former Grenade Range and Former EOD Range MC loading areas have not been used since the late 1960s, it is unlikely that MC are currently migrating from these areas to off-range locations. However, these historical loading areas were evaluated because the installation currently is considering placing an explosives training facility on the western exterior of Ulupau Crater.

The results of the surface water transport analysis indicate that a potential exists for RDX and TNT to be transported via surface runoff from the HE Impact and R-8 MC loading areas to potential receptors outside the KBRTF, particularly ecological receptors in the intertidal/littoral zone of Kailua Bay. Modeling was performed to estimate potential transport into the Kailua Bay intertidal zone and then to determine how quickly concentrations of a conservative tracer would be reduced by mixing and dispersion in the water. Concentrations of the conservative tracer were predicted to decrease by more than 95% within approximately 10 meters from shore and along the shore of Kailua Bay.

Based on these findings, similar results would be expected for both RDX and TNT. Thus, the maximum concentration of RDX predicted to enter Kailua Bay from the HE Impact MC loading area (6.7 µg/L) would be expected to fall below the REVA trigger value at a maximum distance of approximately 15 meters from shore and 8 meters along the shore of Kailua Bay. Similarly, the maximum concentration of TNT predicted to enter Kailua Bay from the R-8 MC loading area (0.61 µg/L) would be expected to fall below the REVA trigger value at a distance of approximately 4 meters from shore and 3 meters along the shore of Kailua Bay.

Although ecological receptors might be present within the near-shore environment, the estimated concentrations of RDX and TNT released from both the HE Impact and R-8 MC loading areas are well below the draft DoD Range and Munitions Use Subcommittee (RMUS) screening values developed for ecological receptors in marine waters (5,000 µg/L for RDX; 180 µg/L for TNT). Thus, no additional actions (*e.g.*, sampling) to evaluate potential exposures due to transport of MC in surface water to off-range locations are recommended.

The results of the groundwater transport analysis support consideration of the potential for MC migration via groundwater from the R-8 and Former Grenade Range MC loading areas to offshore areas. Specifically, the modeling results showed concentrations of RDX, TNT, and perchlorate potentially reaching the saturated zone at the R-8 MC Loading Area and perchlorate reaching the saturated zone at the Former Grenade Range MC Loading Area. However, the analyses indicate that possible MC concentrations in groundwater discharging to marine environments, while above the REVA trigger values, are well below the concentrations expected to be harmful to identified receptors (i.e., based on screening values developed by the DoD RMUS). Therefore, no additional actions (*e.g.*, sampling) are warranted to address possible MC groundwater migration concerns.

CSM for Puuloa Range Training Complex

The Puuloa Range Training Complex is located on the south side of Oahu, encompassing 137.1 acres on the eastern edge of Ewa Beach, near the entrance to Pearl Harbor (MCBH, 2005; NAVFACHI, 2006). It contains six SARs, situated in a line adjacent to one another along the southern coastline of the complex. No HE munitions are currently used at the range complex.

The Puuloa Range Training Complex is located on the Ewa Plain, a flat portion of land at the south end of the Schofield Plateau, west of Pearl Harbor. The basement rock at Puuloa is Koolau basalt (Earth Tech, 2006b). A caprock layer consisting of terrestrial alluvium, marine sediments, and calcareous reef deposits overlies the basement rock. The Ewa Plain is composed of limestone reef material, marine deposits, and riverine deposits (EES, 2005). A contiguous limestone unit composed predominantly of Porites coral and Nullipores in upright growth formation underlies the Ewa Plain (Earth Tech, 2006b). Located on the leeward side of Oahu, the Puuloa Range Training Complex receives less rainfall than either the windward coast or the mountainous areas of the island; reported average rainfall is about 20 inches per year (in/yr) (Earth Tech, 2000; NAVFACHI, 2006; HIES, 2007; Oki, 1998). Precipitation varies significantly with the season, and pan evaporation is estimated at 80 in/yr, one of the highest values on the island (Oki, 1998; EMC, 1991).

With the exception of the Pacific Ocean to its south, there are no perennial surface water features located at or around the Puuloa Range Training Complex. Overland flow generated during storm events generally drains south and discharges into the Pacific Ocean, which borders the southern boundary of the Puuloa ranges. In the flatter areas of the complex, surface water runoff may collect in pools, and either evaporate or infiltrate into the subsurface before reaching the ocean (Herman, 2008). The target areas of the SARs within the complex are potentially exposed to tidal flushing from the ocean.

Limited information is available regarding groundwater at the Puuloa Range Training Complex; however, two aquifers are known to be present beneath the complex. The deeper, Koolau basaltic aquifer contains groundwater under artesian conditions and is overlain by a shallow caprock aquifer. The shallow, unconfined groundwater located immediately beneath the complex (i.e., the water table) occurs within the coralline limestone unit described previously (i.e., surficial unit), and is generally brackish as it is hydraulically connected to the Pacific Ocean. The water table is typically found at 1–3 feet amsl (Oki, 1998). Since the Puuloa Range Training Complex is close to the ocean, the low end of that range is expected, and tidal influences on hydraulic head are anticipated.

Local soil, derived from the underlying coralline bedrock, is anticipated to be porous. The USDA (2008), and Drigot and SRGII (2001), describe it as a well to excessively drained soil that consists of coral or cemented calcareous sand, with 10% to 20% red soil of a volcanic base in cracks and depressions . Based on these findings, the potential exists for the infiltration of surface water runoff within the range complex. Additionally, the gradient of the water table aquifer is expected to be toward the ocean, and transient changes in gradient due to tidal influence are expected.

Lead deposited within and around the impact berms of the SARs may be transported via surface water runoff. Overland flow that results from storm water runoff within the complex drains south and discharges into the Pacific Ocean. The overall erosion potential at the complex is low because the complex is located on flat topography where the slope throughout the range is less than 1%. The potential for soil to erode is higher at the impact berms due to their steeper slopes and sparse vegetation cover. Consequently, dissolved, particulate, and soil-adhered lead can potentially be transported to the offshore marine environment. In addition, MC in soil could potentially migrate into the shallow groundwater and potentially discharge to the ocean. Migration of MC into the deeper aquifer is unlikely due to local stratigraphy and artesian pressure within the deeper aquifer. However, previous sampling activities at the range complex and in the adjacent ocean areas indicate that lead has probably not migrated from the range into the intertidal and littoral zones to the south.

There are no anticipated significant human receptors of MC within the Puuloa Range Training Complex. By law, the general public is not allowed into this area without specific permission. Beaches adjacent to the range complex are heavily used for swimming, surfing, and fishing. Ewa Beach Park, a public park owned by the County of Honolulu, is located within 500 feet of the facility boundary. It is one of the few beaches in Hawaii that provides edible seaweed used by the native Hawaiian population. Despite this, sampling of the range soils, ocean sediments, and surface water immediately adjacent to the range complex suggest that lead has not migrated from the complex (ERDC, 2003). Neither surface water nor groundwater at the Puuloa Range Training Complex is used as a potable water source; there are no perennial surface water features at the complex, and groundwater is subject to saltwater intrusion, resulting in brackish conditions that are unsuitable as a source of drinking water (Earth Tech, 2000).

Although ecological receptors might be present at the Puuloa Range Training Complex, the entire facility is composed of anthropogenic land uses with no notable terrestrial ecological communities on the property. Several indigenous migratory shorebirds, including wandering tattler (‘ulili), ruddy turnstone (akekeke), and sanderling, (hunakai), are seen along the shoreline near the Puuloa Range Training Complex, but are generally not located within the range boundaries. These species are migratory with limited time spent on the ranges themselves. Pueo, the Hawaiian short-eared owl (*Asio flammeus sandwichensis*), which is listed as endangered by the State of Hawaii on the island of Oahu, may occasionally use the open areas of the ranges for hunting and loafing. Coral reef habitat is present in the littoral zone south of the range complex. Although no specific studies of these reef areas have been completed, the reef areas likely attract a diverse concentration of marine species. The green sea turtle (*Chelonia mydas*), a federally listed threatened species, has been observed in the waters off the installation (Drigot and SRGII, 2001). Various environmental sampling results suggest that lead has not migrated from the range where exposures to these species may occur (ERDC, 2003).

SAR Assessments

The primary REVA MC of concern at SARs is lead because it is the most prevalent (by weight) potentially hazardous constituent associated with small arms ammunition. SARs are qualitatively assessed under the REVA program to identify factors that influence the potential for lead migration. Lead loading associated with the bermed, live-fire SARs at MCB Hawaii—R-1, R-2, R-6, and R-9 at KBRTF and Range A through Range F at Puuloa Range Training Complex—were qualitatively assessed through the SARAP.

The analysis of these 10 SARs at the installation provided the following results:

- Range 1 has a Moderate surface water concern ranking and a Minimal-Moderate groundwater concern ranking.
- Ranges 2, 6, and 9 have Minimal surface water concern rankings and Minimal groundwater concern rankings.
- Ranges A through F have Moderate surface water concern rankings and Moderate groundwater concern rankings.

Generally, the Moderate scores associated with Range 1 and Ranges A through F are primarily due to the long period of range use, high rates of lead loading, and eroded condition of the impact berms. These factors are counterbalanced by the fact that there is only a limited potential for human and ecological receptors to be exposed to lead in surface water and groundwater at off-range locations. Range 2 and Range 6 received Minimal scores primarily due to the use and active maintenance of bullet traps at these ranges. Range 9 received a Minimal score due to the fact that the earthen impact berm was installed in 2004; the range previously fired into the open impact areas at KBRTF. Consequently, concentrated deposition of lead at this range addressed under the SARAP has only occurred for a short period of time.

To view the complete report, please go to
http://www.mcbh.usmc.mil/g4/environ/REVA/REVA.htm