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

FINAL

Range Environmental Vulnerability Assessment

Marine Corps Air Ground Combat Center Twentynine Palms

November 2008

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Executive Summary

The United States 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 / analysis 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), and perchlorate.

This report presents the assessment results for the operational ranges and training areas at Marine Corps Air Ground Combat Center (MCAGCC) Twentynine Palms, California. This report is the first comprehensive report on MC associated with the operational ranges at MCAGCC Twentynine Palms 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 MCAGCC Twentynine Palms 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* (HQMC, 2006).

Military Munitions Training and Operations

MCAGCC Twentynine Palms is the Marine Corps' largest live-fire training facility, encompassing nearly 600,000 acres across the Mojave Desert in San Bernardino County, California. The primary mission of MCAGCC Twentynine Palms is to develop, administer, conduct, support, and evaluate the Marine Corps' training exercises and operations, while supporting the tenant commands of the Marine Expeditionary Force and the Marine Corps Communications and Electronics School. The installation conducts a full spectrum of warfighter training, from multiweapon system, multiservice field maneuvering exercises to individual small arms proficiency training by individual Marines.

The installation was first established as a full-time Marine Corps base in 1953 as the Marine Corps Training Center Twentynine Palms, although live-fire training has been conducted intermittently at the installation since 1942. Live-fire training increased greatly in the mid-1970s, following the establishment of the Combined Arms Exercise (CAX) program. The program combines the arms training program for ground (armor, artillery, and infantry units) and air fire support (fixed and rotary wing aircraft) with maneuver at the tactical level and is designed to involve all elements of the Marine Air Ground Task Forces in a live-fire, desert training environment. These exercises utilize the entire Marine Corps weapon inventory and nearly all munitions types. The Mojave Viper exercise, established in 2005, is a similar program that includes additional urban-level operations as a response to ongoing military operations in Iraq and Afghanistan. Approximately 35,000–50,000 DoD military personnel annually train during Mojave Viper, CAX, and other exercises at the installation.

The installation is administratively subdivided into 22 Range Training Areas (RTAs), a cantonment area (Mainside), and a Restricted Area. Five of the RTAs are designated for non-live-fire and maneuver training; these RTAs are located in the southwestern section of the installation, west of Mainside. Live-fire is approved within the remaining RTAs, with some exceptions (e.g., live fire is not allowed within 1,000 meters of the installation boundary). Fifty-four fixed ranges are also present across the installation, with the majority located in the Range RTA. In addition, the installation contains 12 small arms ranges (SARs), all located within the Range RTA. The RTAs are managed by the Range Operations Section / Range Control. Range Control provided military munitions expenditure data for the installation from 2001 through 2005 and noted the training areas that received the greatest level of use, for both current and historical periods.

Conceptual Site Model

MCAGCC Twentynine Palms is located in the high desert region of the Mojave Desert and is characterized by rugged terrain consisting of desert, mountains, and a few dry lakes (playas). Approximately 99% of the installation is undeveloped or unimproved grounds. The Bullion and Lava Bed mountain ranges bisect the center of the installation, trending from the northwest to the southeast. The terrain is characterized by broad alluvial plains, alluvial fans, bedrock uplands, ephemeral washes, dry lake beds, lava flows, and sand dunes. There are no perennial surface water features on the installation. Live-fire training activities are conducted throughout the alluvial deposits; weapons fire is directed at the base of the mountain ranges rather than at higher elevations.

The installation receives an average of 4 inches of precipitation per year; strong summer storms often drop the majority of this total, resulting in flash floods. During a heavy rainfall event, water flows across the bedrock surface of the mountains into drainage channels and rushes rapidly toward the basin floor. Runoff accumulates in playas found

throughout the installation and may remain for up to two months. The majority of the surface water is lost to evaporation; very little infiltration occurs due to the low-permeability soils. Although the majority of surface runoff generated within the installation boundaries is captured by on-site playas, some drainages cross the installation boundaries and discharge to playas located off installation (e.g., Dale Lake, Bristol Dry Lake).

Groundwater at MCAGCC Twentynine Palms is found in the alluvium-filled basins that flank the bedrock uplands. Primary groundwater basins include the Twentynine Palms basin on the southwestern margin of the Bullion Mountains (composed of five groundwater subbasins covering parts of MCAGCC Twentynine Palms), the Bristol Valley basin on the northeastern side of the Bullion Mountains, and several smaller intramountain subbasins (portions of the Dale Valley and Lavic Valley) that are located in the Bullion and Lava Bed mountains.

The best-characterized groundwater basin is the Twentynine Palms basin. This basin is part of a larger aquifer system known as the Morongo groundwater basin, which is characterized by small alluvial subbasins that maintain separate groundwater flow, typically terminating just beneath playas. The groundwater subbasins are divided hydrogeologically by bedrock outcrops, faults, and folds. Groundwater within the Twentynine Palms basin is generally deep, although depth to groundwater has been measured between 5 (near playas) and 400 feet below ground surface. Water supply wells at the installation are screened in the Surprise Springs subbasin and provide all potable water to the base. RTAs near the location of these wells are designated for non-live-fire training. Groundwater from basins east of the Twentynine Palms basin has been determined to be nonpotable due to high mineral content.

MC deposited on the primary MC loading areas and RTAs can migrate to potential receptors primarily via surface water transport to playas. MC potentially can accumulate within the playas over time, as the material is deposited in the playa bed following evaporation of the surface water. In addition, leaching to groundwater and subsequent groundwater flow potentially could serve as another MC transport mechanism, though such transport is likely limited by high evaporation rates and deep groundwater.

Potential receptors for MC dissolved in surface water are limited to ecological receptors with habitat within or near the playas receiving runoff. Habitat for the Mojave fringe-toed lizard (MFTL), a California species of special concern, has been identified within and surrounding playas on the installation, as well as in similar habitat off of the installation. In addition, the federally threatened desert tortoise is found throughout the region, both on- and off installation, and may be considered a receptor. However, both of these species are unlikely to consume the intermittent surface water within the playas, as they obtain most of their water requirements through consumption of plants and prey.

Potential receptors utilizing surface water in playas that are located within the installation boundaries were not considered because the REVA program is limited to the assessment of documented or potential off-range MC releases.

Because surface water within playas is not used as a potable water source, no human receptors were identified. Several salt mining operations are present in playas east (Bristol Dry Lake) and southeast (Dale Lake) of the installation. Workers operating in these areas are not exposed to surface water entering the playa, and flooding of the evaporation ponds and trenches used in the salt mining process is extremely rare.

Estimated MC loading rates on training areas were examined, along with the known migration pathways and possible receptors identified in the conceptual site model. The results of this analysis indicate that the greatest potential exists for MC to be transported via surface runoff from two RTAs on the installation boundary to receiving playas located downstream and off installation. These areas are the southern half of the Lead Mountain primary MC loading area, which drains east and empties into Bristol Dry Lake, and the Prospect primary MC loading area, which drains southeast and discharges to Dale Lake, approximately 18 miles downstream.

Screening-Level Surface Water Transport Analysis

Fate and transport analysis of potential MC migration via surface water was conducted as part of the vulnerability assessment for MCAGCC Twentynine Palms. The fate and transport analysis was conducted through screening-level transport analysis for the Lead Mountain and Prospect primary MC loading areas. This methodology was selected to provide conservative estimates of the dissolved-phase concentrations of MC reaching the exposure endpoints for these primary MC loading areas (i.e., Bristol Dry Lake and Dale Lake). MC loading from RTAs / primary MC loading areas located upstream from Lead Mountain and Prospect were also factored into the screening-level analysis. MC concentrations in surface water were estimated under three scenarios:

1. At the edge of the MC loading areas
2. At the final discharge locations (i.e., the playas), accounting for down gradient mixing
3. At the final discharge locations, applying an evaporative concentration factor analysis to account for the accumulation, redissolution, and reprecipitation of MC in the playas due to cyclical evaporation and resuspension processes (“evaporative concentration and accumulation” method)

The screening-level analysis estimated that average annual concentrations of HMX and perchlorate would be below REVA trigger values in runoff at the edges of individual MC loading areas (Tables ES-1 and ES-2). Post-mixing concentrations of RDX, HMX, and perchlorate entering Dale Lake and post-mixing concentrations of HMX and perchlorate

entering Bristol Dry Lake from all MC loading areas were also predicted to be below REVA trigger values (Tables ES-1 and ES-2). However, TNT and RDX were predicted to exceed REVA trigger values in runoff at the edges of specific MC loading areas. In addition, post-mixing concentrations of RDX and TNT entering Bristol Dry Lake and of TNT entering Dale Lake from all MC loading areas were predicted to slightly exceed their respective trigger value.

The "evaporative concentration and accumulation" method described above was used to estimate aqueous phase concentrations of MC in playas that accounted for evaporation and deposition. The predicted concentrations of HMX and perchlorate in playas were below REVA trigger values after the "evaporative concentration and accumulation" method was applied. However, the concentrations of RDX and TNT in both Bristol Dry Lake and Dale Lake were predicted to be above REVA trigger values.

Table ES-1: Estimated Concentrations of MC from Surface Water Screening-Level Analysis: Prospect Primary MC Loading Area to Dale Lake

MC	Trigger Value	Prospect Primary MC Loading Area		
		Edge of Primary MC Loading Area	Post-Mixing At Dale Lake	Accumulation in Dale Lake
RDX	0.16	**3.8**	0.15	**37**
TNT	0.08	**3.4**	**0.12**	**30**
HMX	0.08	2.4E-04	3.0E-05	7.4E-03
Perchlorate	0.98	1.1E-02	1.3E-03	0.32

Note: All concentrations are provided in µg/L – micrograms per liter.
Shading and bold indicate that the predicted concentration exceeds the REVA trigger value.

Table ES-2: Estimated Concentrations of MC from Surface Water Screening-Level Analysis: Lead Mountain Primary MC Loading Area to Bristol Dry Lake

MC	Trigger Value	Lead Mountain Primary MC Loading Area		
		Edge of Primary MC Loading Area	Post-Mixing At Bristol Dry Lake	Accumulation in Bristol Dry Lake
RDX	0.16	**4.0**	**0.19**	**47**
TNT	0.08	**4.5**	**0.25**	**63**
HMX	0.08	4.1E-05	9.6E-05	2.4E-02
Perchlorate	0.98	1.6E-03	5.4E-04	0.14

Note: All concentrations are provided in µg/L.
Shading and bold indicate that the predicted concentration exceeds the REVA trigger value.

The state-approved Colorado River Basin Plan does not include regulatory criteria for the MC associated with military munitions that might reach surface water bodies (California Regional Water Quality Control Board, 2005). There are no documented uses of the

surface water within either Bristol Dry Lake or Dale Lake. An ecotoxicity analysis conducted for ecological receptors potentially interacting with surface water in the playas (MFTL and the desert tortoise) indicates that the toxicity threshold for reptiles is several orders of magnitude above the estimated MC concentrations reaching the playas (Appendix A). Therefore, no further action is warranted for potential MC releases from the Lead Mountain and Prospect RTAs, as well as their upstream contributors.

SAR Assessments

The primary MC of concern at SARs is lead because it is the most prevalent (by weight) potentially hazardous constituent associated with small arms ammunition. Modeling parameters for lead fate and transport are contingent upon site-specific geochemical data that are generally unavailable during a baseline assessment. Therefore, SARs are qualitatively assessed under the REVA program to identify factors that influence the potential for lead migration.

There are 12 SARs located at MCAGCC Twentynine Palms. Seven of these ranges are located with the Marksmanship Training Unit (MTU) in the southeast corner of the Range RTA. The MTU conducts small arms proficiency and requalification for Marines and transiting units. The other five SARs are fixed ranges located in the central and northern sections of the Range RTA.

The analysis of the 12 SARs at the installation resulted in Minimal environmental concern rankings for all ranges, based on the results of the qualitative assessment of the ranges in the protocol and professional judgment. No ranges received a High environmental concern ranking. The low overall scores for the ranges were due primarily to the low precipitation rate, the large distance between the ranges and their intermittent receiving surface water bodies, and the deep groundwater found at the installation, all of which limit lead migration and potential impacts.

To view the complete report, please go to http://www.29palms.usmc.mil/dirs/inl/nrea/