



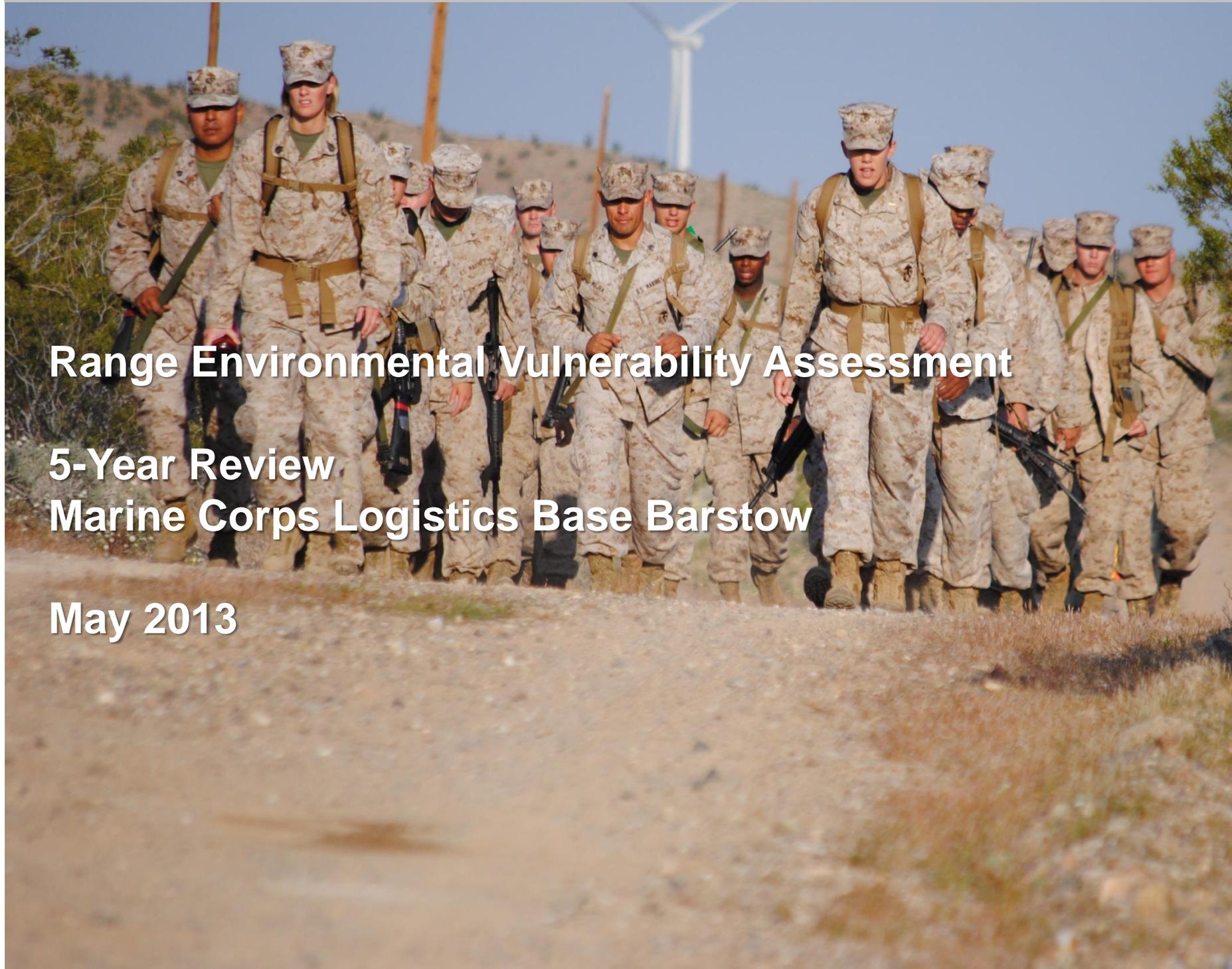
FINAL

Range Environmental Vulnerability Assessment  
5-Year Review  
Marine Corps Logistics Base Barstow  
May 2013



Marine Corps Installations Command

FINAL



Range Environmental Vulnerability Assessment  
5-Year Review  
Marine Corps Logistics Base Barstow  
May 2013



## **Marine Corps Installations Command**

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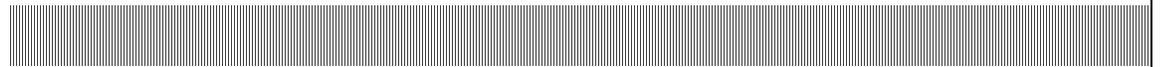
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# **Range Environmental Vulnerability Assessment**

## **5-Year Review**

### **Marine Corps Logistics Base Barstow Barstow, California**

May 2013



Report Prepared By:

701 Town Center Drive

Suite 600

Newport News, VA 23606



06285037.0000



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## Acronym List

Acronym	Definition
amsl	Above Mean Sea Level
bgs	Below Ground Surface
BLM	Bureau of Land Management
CA	California
cal	caliber
CSM	Conceptual Site Model
DoD	Department of Defense
DoDI	Department of Defense Instruction
DoDIC	Department of Defense Identification Code
DWMA	Desert Wildlife Management Area
ft/d	Feet per day
FY	Fiscal Year
GIS	Geographic Information System
HMX	Cyclotetramethylene Tetranitramine
INRMP	Integrated Natural Resources Management Plan
lb/yr	pound per year
Marine Corps	United States Marine Corps
MC	Munitions Constituents
MCI COM	Marine Corps Installations Command
MCLB	Marine Corps Logistics Base
mg/kg	Milligram per Kilogram



Acronym	Definition
MIDAS	Munitions Items Disposition Action System
MMRP	Military Munitions Response Program
MOA	Memorandum of Agreement
mph	Miles per hour
PRA	Preliminary Range Assessment
RDX	Cyclotrimethylene Trinitramine
REVA	Range Environmental Vulnerability Assessment
RFMSS	Range Facility Management Support System
SAR	Small Arms Range
SARAP	Small Arms Range Assessment Protocol
SDZ	Surface Danger Zone
T/E	Threatened and Endangered
TECOM	Training and Education Command
TNT	Trinitrotoluene
U.S.	United States
USGS	United States Geological Survey

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# Executive Summary

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The United States (U.S.) Marine Corps (Marine Corps) Range Environmental Vulnerability Assessment (REVA) program meets the requirements of the 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 REVA program is a proactive and comprehensive program designed to support the Marine Corps' Range Sustainment Program. Operational ranges across the Marine Corps are being assessed through the REVA program to identify areas and activities that are subject to possible impacts from external influences, as well as to determine whether a release or substantial threat of a release of munitions constituents (MC) from operational ranges to off-range areas creates an unacceptable risk to human health and/or the environment. This is accomplished through a baseline assessment of operational range areas, periodic five-year review assessments, 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.

This report presents the five-year review assessment results for the operational ranges at Marine Corps Logistics Base (MCLB) Barstow, California (CA). This report serves as the first five-year review assessment and documents the period of munitions loading from 2007 through 2012. The baseline assessment completed in 2008 documented all munitions use through 2006.

## **Military Munitions Training and Operations**

MCLB Barstow is located in San Bernardino County in south-central California, approximately 3.5 miles east of the city of Barstow, CA. The installation was transferred to the Marine Corps from the U.S. Navy on December 28, 1942, and consisted of the Nebo Area, which at that time was called the Marine Corps Depot of Supplies. The Commanding General of the Marine Corps Depot of Supplies transferred operations from San Francisco to Barstow in 1955 to establish several small arms ranges (SARs) for Marine marksmanship training. The base was designated as MCLB Barstow in November 1978.

The installation comprises approximately 5,405 acres, and it is still divided into the three original areas: the Nebo Area (1,286 acres), the Yermo Annex (1,681 acres), and the Rifle Range Complex (2,438 acres). The dry bed of the Mojave River forms the northern boundary of the Nebo Area. The Yermo Annex is four miles east of the Nebo Area, north of the Mojave River bed, and between Interstates 15 and 40. The Rifle Range Complex is located south of Interstate 40 and directly south of the Nebo Area.



The primary mission of MCLB Barstow is to procure, maintain, store, and issue supplies and equipment for Marine Corps facilities worldwide, as well as to repair and rebuild DoD equipment. The Nebo Area contains base headquarters and administration, storage, recreational activities, shopping, and housing functions. The Yermo Annex is used for storage and industrial activities. The Rifle Range Complex contains three SARs and is the only area on the installation where military training occurs.

REVA assesses all operational ranges and training areas at the Marine Corps installation, including those where training activities use high explosives ammunition. However, only small arms training activities are conducted at MCLB Barstow; therefore, estimation of deposition and modeling of the fate and transport of other MC (trinitrotoluene (TNT), cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), and perchlorate) were not considered in this evaluation. Should information in the future indicate the use of high explosive ammunition, the REVA assessment will evaluate the data available.

The primary MC 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. The tool used to evaluate SARs is called the Small Arms Range Assessment Protocol (SARAP). The SARAP incorporates information such as lead loading, surface water and groundwater characteristics, and potential receptors to determine if there is a possible threat of a release of lead from the sites.

The baseline REVA assessment, completed in May 2008, evaluated the three SARs within the Rifle Range Complex: the Rifle Range, the Pistol Range, and the Shotgun Range. Prior to assessing the current data for this five-year review, the results of the baseline assessment were considered. **Table ES-1** provides a summary of the results of the baseline assessment.

**Table ES-1: Summary of Baseline Assessment Results for MCLB Barstow**

SAR	Surface Water Ranking	Groundwater Ranking	Assessing in 5-Year Review
Rifle Range	Minimal	Minimal	Yes
Pistol Range	Minimal	Minimal	Yes
Shotgun Range <sup>a</sup>	Minimal	Minimal	Yes

a. The Shotgun Range was referred to as the Close Combat Pistol Range in the baseline report. Shotgun Range is be used in the five-year review for consistency with the current installation naming convention.

The SARs received minimal rankings for surface water and groundwater in the baseline assessment. These minimal rankings indicate little potential for off-range migration of lead to human or ecological receptors. Based on these rankings, it was determined no further action was



required for these SARs. The five-year review effort reevaluates the ranges to ensure any changes that might affect lead transport from the SARs are captured.

### **Five-Year Review Pathway and Receptor Analysis for MCLB Barstow**

The following exposure pathways were evaluated to determine the potential for lead to migrate off of the operational range area.

- Surface water runoff, including sediment transport
- Leaching to groundwater and subsequent groundwater flow

Potential exposure points for receptors used in the evaluation include the following:

- The water supply wells located within the boundaries of MCLB Barstow in Yermo Annex
- Potential off-installation wells located down gradient of the Yermo Annex
- Surface water bodies, including ephemeral streams and wetlands, that are used for groundwater recharge and potentially support special status species

Several physical parameters were used to evaluate the SARs. The relevant information is provided here to summarize the full suite of information provided in the REVA 5-Year Review Report.

MCLB Barstow is located in the Mojave Desert within the Mojave River valley. The climate is characterized by low precipitation (averaging 4.4 inches per year), high temperatures, and low humidity. Localized flooding may occur with high intensity summer storms.

#### Surface Water and Sediment Pathway

The primary pathway assessed was the transport of lead via surface water runoff from MCLB Barstow operational ranges to off-range areas. Surface runoff follows natural topographic gradients from the ranges through incised ephemeral washes northward toward the Mojave River, approximately 0.8 miles from the ranges. Such drainage patterns can transport lead downstream through dissolution in runoff water or erosion of soil with lead (particularly on the berms). However, because site soils and storm water measurements indicate neutral or slightly alkaline conditions (soil pH between 7.4 and 8.4; an average storm water pH of 8.1), lead migration via dissolution in surface water is likely to be limited. The soil erosion potential at the Rifle Range Complex can be significant because of the sparse vegetation cover, moderately steep topography, and the occurrence of flash floods capable of moving large loads of sediment during high-intensity rainfall. Therefore, soil erosion is a potential pathway for MC mobilization into surface water runoff and, ultimately, into streams. Wind erosion also can be significant at MCLB

Barstow. Although wind might not be a significant mechanism for lead transport off range, it can increase erosion of the bullet pockets and surrounding soils that help keep the lead in place.

Engineering controls that limit run-on from entering the Shotgun and Pistol Ranges combined with periodic maintenance conducted as needed at all three ranges (addition of soil to bullet pockets) minimize the potential for erosion and surface water transport of lead.

Surface water is only present in the Mojave River and associated drainages after infrequent rain events. Therefore there are no known uses of surface water (e.g., potable water source, irrigation, recreation) by human receptors. Exposure to ecological receptors (the desert tortoise) via surface water is limited because the water either evaporates or infiltrates into surficial soils quickly.

#### Groundwater Pathway

The groundwater pathway was evaluated because of the highly permeable gravelly sandy soil present at the Rifle Range Complex. High temperatures and low humidity in the region contribute to high rates of evaporation. Additionally the depth to groundwater is great. Based on these factors, the potential for infiltration to groundwater is very limited.

Site conditions suggest the pH of the soil is neutral or slightly alkaline, indicating that the lead deposited on site likely will remain absorbed to the soil instead of migrating down with the limited infiltration that occurs. Furthermore, the depth to groundwater at the ranges limits the potential for lead to migrate downward to the groundwater. Studies have indicated that the depth to groundwater approximately 1.5 miles northwest of the Rifle Range ranges from 160 to 210 feet below ground surface (bgs). Groundwater depth on the alluvial fan south of Interstate 40 near the Rifle Range Complex has been documented to be 175 feet bgs (Jacobs Engineering, 1997; Tetra Tech, 2003).

The closest groundwater extraction wells for potable use are located at the Yermo Annex, northeast of the Rifle Ranges. It is unlikely for lead in groundwater at the Rifle Ranges to be transported to these wells due to the water chemistry, the significant distance to the wells, and the presence of the Harper Lake-Camp fault that traverses the Rifle Range complex. It could be possible for lead transported in the ephemeral washes and the Mojave River to recharge the Mojave River aquifer within the Yermo Annex where the supply wells are screened. However, this pathway likely is limited due to storm water pH of 8 that favors a condition for lead to precipitate out of solution or remain bound to soil instead of dissolving in water. The pathway is further limited by the control side berm structures, which reduce the surface water runoff rate at the Rifle Ranges and the travel distance that will lead to dilution.

## **Results and Conclusions of the REVA Five-Year Review**



A summary of the results and conclusions for the SARs assessed at MCLB Barstow in the REVA five-year review are presented in **Table ES-2**.

**Table ES-2: Summary of Five-Year Review Assessment Results for MCLB Barstow**

SAR	Surface Water Ranking	Groundwater Ranking
Rifle Range	Minimal	Minimal
Pistol Range	Minimal	Minimal
Shotgun Range	Minimal	Minimal

The minimal rankings for surface water and groundwater indicate a low potential for migration of lead to receptor points. The rankings are based on the low use of the ranges and site characteristics, such as very low precipitation, high evaporation rates, neutral pH of surface water and soils, and the deep groundwater table. These elements indicate the limited potential for lead to migrate via surface water, sediment, or groundwater transport. No further action is recommended at this time. If conditions change at the ranges prior to the next five-year review, such as an increase in training, the ranges may be reevaluated to assess how the changes impact the potential migration of lead.

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# 1. Introduction

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## 1.1. Purpose

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

The REVA program is a proactive and comprehensive program designed to support the Marine Corps' Range Sustainment Program. Operational ranges across the Marine Corps are being assessed to identify areas and activities that are subject to possible impacts from external influences, as well as to determine whether a release or substantial threat of a release of munitions constituents (MC) from operational ranges to off-range areas creates an unacceptable risk to human health and/or the environment. This is accomplished through periodic five-year review assessments of operational range areas.

This report presents the five-year review results for the operational ranges and training areas at the Marine Corps Logistics Base (MCLB) Barstow, California (CA). This report serves as the first five-year review assessment documenting the period of munitions use from 2007 through 2012. The baseline assessment conducted in 2007 documented munitions use at MCLB Barstow from the initial use of the ranges in 1955 through 2006.

MCLB Barstow is located in San Bernardino County in south-central California, approximately 3.5 miles east of the city of Barstow, CA (**Figure 1-1**). Its primary mission is to procure, maintain, store, and issue supplies and equipment for Marine Corps facilities worldwide, as well as to repair and rebuild DoD equipment. MCLB Barstow comprises approximately 5,405 acres. The installation is divided into three areas: the Nebo Area (1,286 acres), the Yermo Annex (1,681 acres), and the Rifle Range Complex (2,438 acres) (**Figure 1-2**) (Tierra Data, 2011).

The Nebo Area contains base headquarters and administration, storage, recreational activities, shopping, and housing functions. The Yermo Annex is used for storage and industrial activities, and the Rifle Range Complex is where the three small arms ranges (SARs) are located. The dry bed of the Mojave River forms the northern boundary of the Nebo Area. The Yermo Annex is four miles east of the Nebo Area, north of the Mojave River bed, and between Interstates 15 and 40. The Rifle Range Complex is located south of Interstate 40 and directly south of the Nebo Area (**Figure 1-2**).

## 1.2. The Scope and Applicability

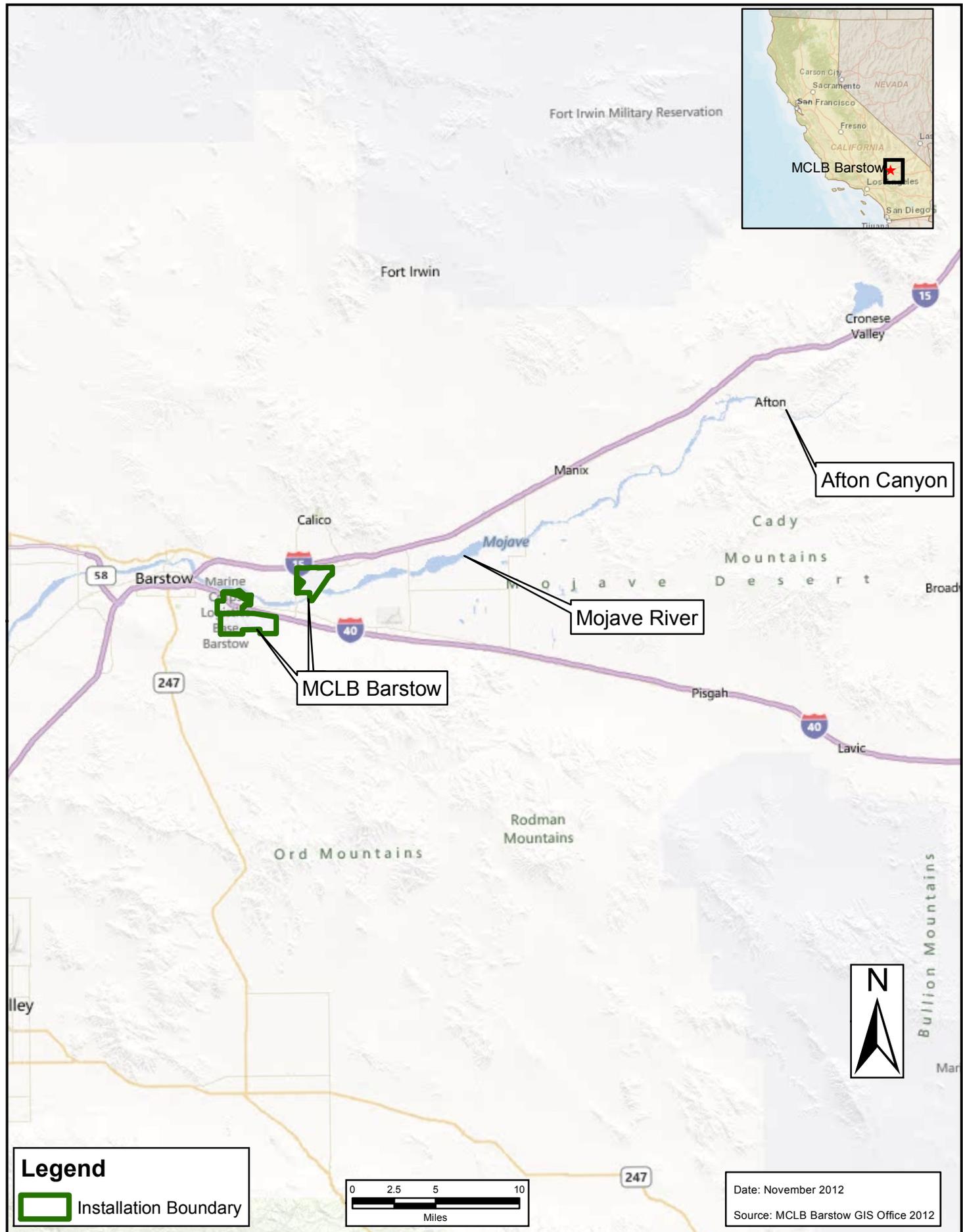
The scope of the REVA program includes Marine Corps operational ranges located within the United States and overseas. Operational ranges (as defined in 10 United States Code 101(e)(3)) include, but are not limited to, fixed ranges, live-fire maneuver areas, SARs, buffer areas, and training areas where military munitions are known or suspected to have been used currently or historically. Operational ranges used exclusively for small arms training are evaluated qualitatively under REVA. Although the Marine Corps (specifically the Training and Education Command [TECOM]) purposely separates operational ranges and training areas, the term “operational range” includes both operational ranges and training areas in this document.

A number of range types are excluded specifically from DoDI 4715.14 and are not assessed as part of the REVA program. Operational ranges that have a Resource Conservation and Recovery Act Subpart X permit are excluded since they are monitored under a specific regulatory program. Military Munitions Response Program (MMRP) sites are excluded because they are nonoperational ranges and no longer are used for their intended purpose. Additionally, the management and funding of MMRP sites are conducted under a separate DoD program. Any ranges located wholly indoors also are not included, as any MC associated with these ranges are assumed to be contained and not available to the environment.

The MCLB Barstow operational ranges assessed in the baseline report and this five-year review are SARs. MC associated with small arms ammunition commonly used at operational ranges include lead, antimony, copper, and zinc. REVA focuses on lead as the MC indicator for SARs because lead is the most prevalent (by weight) potentially hazardous constituent associated with small arms ammunition. Lead is geochemically specific regarding its mobility in the environment. Site-specific conditions must be known (i.e., geochemical properties) in order to quantitatively assess lead migration. These site-specific geochemical properties are identified by sampling and analysis and cannot be observed physically. Without site-specific physical and chemical characterization, lead cannot be modeled effectively using fate and transport modeling. As such, the potential for lead migration is evaluated using a qualitative approach, as discussed in Section 1.3.

REVA assesses all operational ranges and training areas at the Marine Corps installation, including those where training activities use high explosives ammunition. However, only small arms training activities are conducted at MCLB Barstow; therefore, estimation of deposition and modeling of the fate and transport of other MC (TNT, HMX, RDX, and perchlorate) were not considered in this evaluation. Should information in the future indicate the use of high explosive ammunition the REVA assessment would evaluate the data available.





**Legend**

 Installation Boundary



Date: November 2012  
Source: MCLB Barstow GIS Office 2012



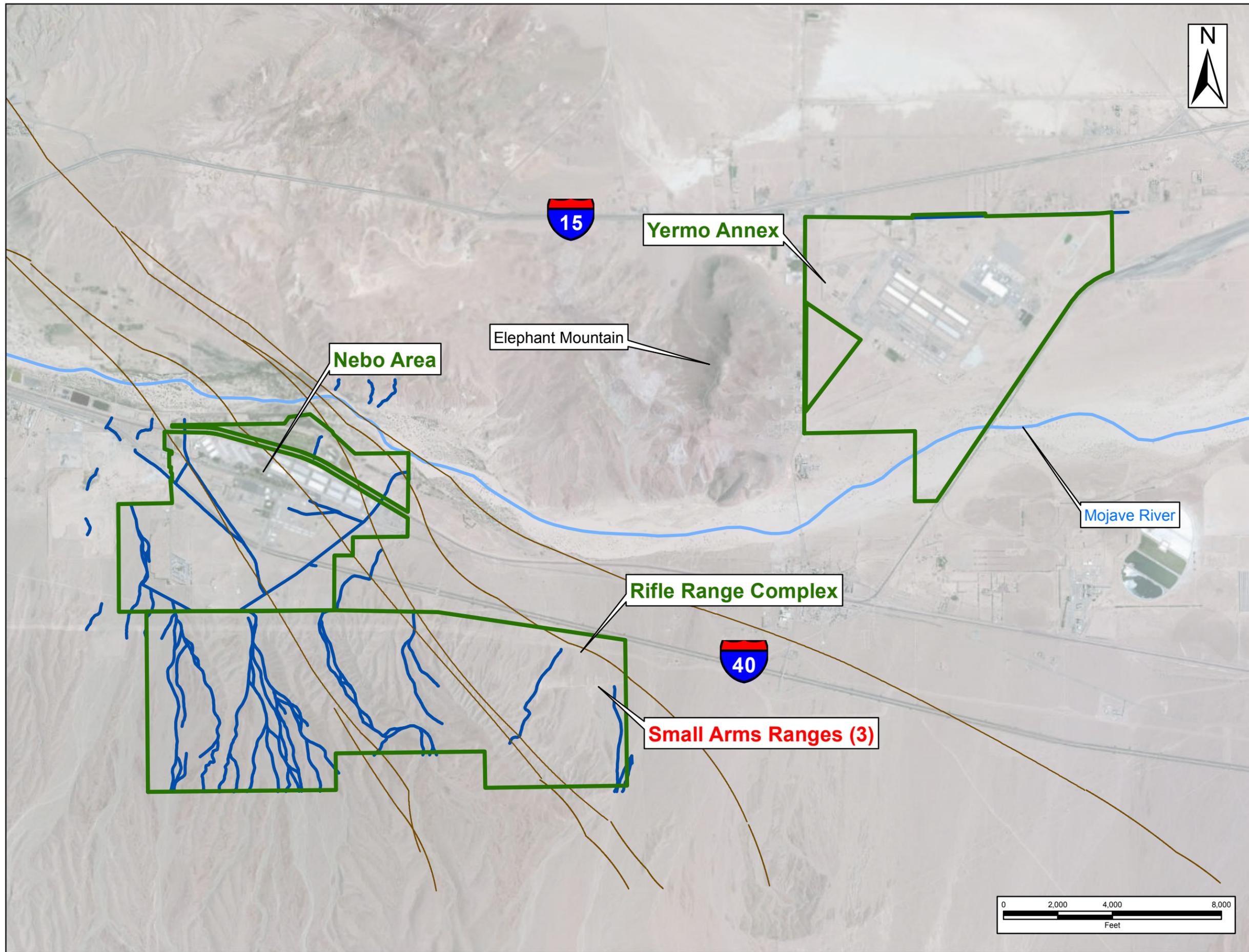
Range Environmental  
Vulnerability Assessment  
5-Year Review  
MCLB Barstow  
Barstow, CA

**FIGURE 1-1**  
**Site Location Map**

**NOVEMBER 2012**

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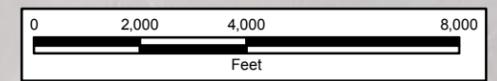


**FIGURE 1-2  
Installation Map**

Range Environmental  
Vulnerability Assessment  
5-Year Review  
MCLB Barstow  
Barstow, CA

**Legend**

-  Installation Boundary
-  Harper Lake - Camp Rock Fault System
- Surface Water Course**
-  Dry
-  Intermittent



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### 1.3. REVA Assessment of Lead

Metallic lead (such as recently fired, unweathered bullets and shot) generally has low chemical reactivity and low solubility in water and is relatively inactive in the environment under most ambient or everyday conditions. However, a portion of lead deposited on a range may become environmentally active if the right combination of conditions exists.

Site-specific environmental conditions and MC (lead) loading totals are used in the qualitative evaluation of SARs to assess whether the potential exists for a release or substantial threat of a release of MC from an operational range or range complex area to an off-range area. The evaluation, referred to as the Small Arms Range Assessment Protocol (SARAP), is conducted for each SAR at the installation. The amount of lead deposited on the range is estimated using expenditure reporting or other documentation provided by the installation.

Other considerations for the qualitative evaluation for SARs include the range design and layout, the physical and environmental conditions of the area (as documented through the conceptual site model [CSM]), current and past operation and maintenance practices, and potential receptor groups. Receptor groups considered in the REVA process include human and ecological receptors (defined in the REVA analysis as any threatened or endangered [T/E] species or species of concern). Human exposure pathways considered include consumption of surface water and groundwater for off-range human receptors, as described in the REVA Five-Year Review Manual (HQMC, 2010). Exposure pathways for off-range ecological receptors include direct consumption of surface water and direct exposure to surface water and sediment. Other off-range exposure scenarios (e.g., soil ingestion, incidental dermal contact, bioaccumulation, food chain exposure) currently are not considered in the REVA process unless site-specific considerations warrant an evaluation.

Environmental sampling and analysis (i.e., field data collection) is conducted if the results of the SARAP evaluation suggest an off-range release of MC where receptors may be present. Field data collection activities are conducted to determine whether an off-range release has occurred and whether such a release constitutes an unacceptable risk to human health and the environment.

The process and assumptions used to estimate the amount of MC (lead) deposited onto the SARs, defined in REVA as MC loading, are discussed in Section 3. The SARAP qualitative assessment process and the results of the SAR assessments are presented in Section 5. A detailed description of the REVA MC Loading Rate Calculator tool used to estimate MC deposition on operational ranges is provided in the *REVA Reference Manual* (HQMC, 2009).

This five-year review REVA report presents the conditions of the operational ranges at the time the assessment was conducted. The assessment was performed using available data and

personnel interviews and is supplemented with information from external sources, including reports and documentation.

#### **1.4. Data Collection Effort**

A thorough review of data collected during the baseline assessment was conducted prior to collecting data from the installation for the five-year review. Data required for the operational range assessments were obtained from the installation during a site visit by the REVA assessment team, from the Marine Corps Installation Command (MCI COM) GF, and from external data sources. Data collected include documents and reports prepared for the installation, such as expenditure data, range operating procedures, natural and cultural resource surveys, weather records, and geographic information systems (GIS) files.

The REVA team conducted a site visit to MCLB Barstow on 22 and 23 March 2012. MCI COM and TECOM personnel accompanied the team during the site visit. The installation site visit involved reviewing data repositories and conducting interviews with installation personnel from the following offices:

- Environmental Division, including the Natural Resource/Cultural Resources Office
- Base Operations
- Facilities Management Division
- GIS

Subject matter experts within each of these offices were interviewed to identify areas of interest and specific concerns pertaining to each office. Specific issues relating to operational range use and potential impacts to training were the focus of these discussions.

During the five-year review installation visit, the REVA team observed all of the operational ranges to survey the physical condition of each range and note firing points, impact areas, engineered controls, and other environmental factors (e.g., areas of erosion, potential migration routes).

#### **1.5. Report Organization**

This REVA five-year review environmental range assessment report for MCLB Barstow is organized into the following sections:

Section 1 – Introduction

Section 2 – Baseline Results and Installation Changes

Section 3 – Munitions Constituents Loading Rate and Assumptions

Section 4 – Conceptual Site Model



Section 5 – Small Arms Range Assessments

Section 6 – References



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## 2. Baseline Results and Installation Changes

### 2.1. Baseline Results

The baseline assessment for MCLB Barstow was completed in May 2008 and evaluated all information from the range inception (1955) through 2006. Three operational SARs were identified in the baseline assessment; these same ranges remain operational and are the basis of this five-year review. The results of the baseline assessment are documented in the *Range Environmental Vulnerability Assessment Marine Corps Logistics Base Barstow* (Malcolm Pirnie, 2008). **Table 2-1** lists the areas that were evaluated using the SARAP in the baseline assessment and a summary of the results.

**Table 2-1: Summary of SARs Evaluated in the Baseline Assessment**

SAR	Surface Water Ranking	Groundwater Ranking	Assessing in 5-Year Review
Rifle Range	Minimal	Minimal	Yes
Pistol Range	Minimal	Minimal	Yes
Shotgun Range <sup>a</sup>	Minimal	Minimal	Yes

a. The Shotgun Range was referred to as the Close Combat Pistol Range in the baseline report. Shotgun Range is used in the five-year review for consistency with the current installation naming convention.

As the three SARs are adjacent to one another, the physical setting and environmental characteristics were the same for all three ranges in the baseline assessments. Characteristic differences between the ranges that factored into the assessments included operational attributes, such as ammunition used, expenditure rates, directions of fire, and engineered controls.

The minimal ratings assigned for surface water and groundwater pathways/receptor interactions were primarily a result of the limited range use, low precipitation, and neutral soil, storm water, and groundwater pH. These factors limit migration of lead off range. Additionally, human receptors were not identified near the ranges, and limited potential exists for ecological receptor exposure.

## 2.2. Installation Changes

Some changes have occurred at the MCLB Barstow range complex since the baseline assessment was completed in 2008. From October 2010 to March 2011, range improvements were completed on the SARs. The installation upgraded targets, cleaned target carriages, filled bullet pockets with sand, cleaned buildings at the ranges, and surveyed all firing points.

The training tempo on the ranges has increased since the baseline assessment. Nonmilitary use of the ranges had occurred on a regular but infrequent basis until 2006, when nonmilitary use ceased. From 2006 through 2010, only Marines and the Military Police force used the ranges. In May 2010, the Commanding Officer at MCLB Barstow made the ranges again available for nonmilitary use; the training frequency increased at that time.

The Shotgun Range was referred to as the Close Combat Pistol Range in the baseline assessment, as named in the Preliminary Range Assessment (PRA; USACE, 2001b). Base Operations personnel confirmed that this range always has been a shotgun range and use has not changed; therefore, it is referred to as the Shotgun Range in the five-year review in order to remain consistent with the current installation naming convention.

MCLB Barstow Base Operations now manages SAR expenditure data in the Range Facility Management Support System (RFMSS). RFMSS was not used prior to 2010, and very limited munitions use tracking data were available during the baseline assessment. The baseline assessment evaluated lead loading from 1955 through 1998 using data identified in the Preliminary Range Assessment for MCLB Barstow. Lead loading estimates between 1998 and 2007 were based on the amount of small arms ammunition allocated in one year and assumptions based on training iterations and range use provided by installation personnel. Additional details on the assumptions used to generate the lead loading estimates are provided in the MCLB Barstow REVA Report (Malcolm Pirnie, 2008).

Use of RFMSS was initiated in October 2010, and it provides actual expenditure data that can be used to more accurately estimate MC loading at the ranges. The values for the five-year review based on RFMSS data are slightly higher than those estimated for the 1998 to 2007 time period; however, the lead loading values are relatively low when compared to other ranges across the Marine Corps. Details on the lead loading process are described in Section 3. **Table 2-2** shows the estimated lead loading for the three ranges for each time period.

**Table 2-2: Lead Loading from 1955 to 2012 at the SARs**

SAR	1955-1998	1998-2007	2008-2012
Rifle Range	1,425	130	279



Pistol Range	1,544	101	359
Shotgun Range	250	101	92

Notes: Values are shown in pounds per year (lb/yr)



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## 3. Munitions Constituents Loading Rates and Assumptions

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SARs are the only type of operational range present at the installation. This section describes the process used to estimate the amount of lead deposition in these areas.

The qualitative analysis conducted under REVA requires estimation of the amount of indicator MC deposited on operational ranges in order to determine if there is a release or substantial threat of a release of MC off range and to potential off-range receptors. The deposition of indicator MC that is estimated under the REVA program is referred to as MC loading.

Operational range usage, boundaries, and other characteristics typically change over time. The objective of the five-year review is to determine the impact of MC loading since the baseline assessment. For this five-year review of training at MCLB Barstow, MC loading estimates include the period from 2007 to 2012. The general locations of SARs are depicted in **Figure 3-1**.

The MC loading process is outlined in the *REVA Reference Manual* (HQMC, 2009), while specifics pertaining to MCLB Barstow are discussed in its baseline REVA Report (Malcolm Pirnie, 2008). This five-year review utilizes and builds upon this process, developing MC loading estimates expressed as the average loading rate (pounds per year [lb/yr]) deposited annually in the defined area(s) of interest for the most recent time period (from baseline assessment to five-year review). Assumptions were made throughout this MC loading analysis process pertaining to the spatial distribution of the MC on the SARs, as summarized in Section 3.1 through Section 3.4. Section 3.5 provides a description of the SARs at MCLB Barstow.

### 3.1. Munitions Constituents Loading Process

The MC loading was estimated based on mass-loading principles. One key consideration for MC loading estimates is the MC content of each type or specific item(s) used at a given SAR. Information on the types and amounts of fillers associated with military munitions was developed primarily through the use of Internet-based sources, such as the Defense Ammunition Center's Munitions Items Disposition Action System (MIDAS) Web site and the ORDATA database (2012), which is hosted on the Mine Action Information Center Web site of the James Madison University. Based on the known history and current training activities, the REVA team did not identify any MC loading areas at MCLB Barstow where high explosive- or perchlorate-containing munitions are used. All of the live-fire ranges at MCLB Barstow use small arms ammunition. The design and use of a SAR typically concentrates (via an impact berm) or limits

affected areas to a relatively small, restricted area (typically the range fan), and the SARAP may be used to qualitatively assess it, as covered in Section 5. Lead loading was based on the total number of rounds used at the range, as reported in / estimated from the expenditure data, and the approximate lead content of each type of munition / DoD Identification Code (DoDIC). Details on this process are included in the MCLB Barstow baseline report and the *REVA Reference Manual* (Malcolm Pirnie, 2008; HQMC, 2009).

Deposition rates can provide a measure of potential impact from lead on training ranges; however, it is important to note that the lead loading rates differ from other MC loading rates. Given the nature of metals, lead deposition estimates assume no consumption from impact (i.e., no loss due to detonation of the munition) and that all of the lead contained within the munition is deposited on the range. However, the amount of lead that is deposited in a form that is exposed to the environment and available for transport (i.e., small particles and dust separated from the munition body upon impact) cannot be estimated without site-specific measurements. Fate and transport parameters for lead are dependent on site-specific geochemical properties, which may vary across small areas in a designated MC loading area and cannot be determined solely by physical observation. For these reasons, the lead loading estimates developed for this assessment are intended to serve as a general indicator of the total lead deposited rather than an estimate of the fraction of lead that is environmentally available for transport and exposure to receptors. Because of these limitations, SARs are qualitatively assessed using the SARAP. Results of the SARAP analysis are summarized in Section 6.

### 3.1. Expenditure Data for MCLB Barstow

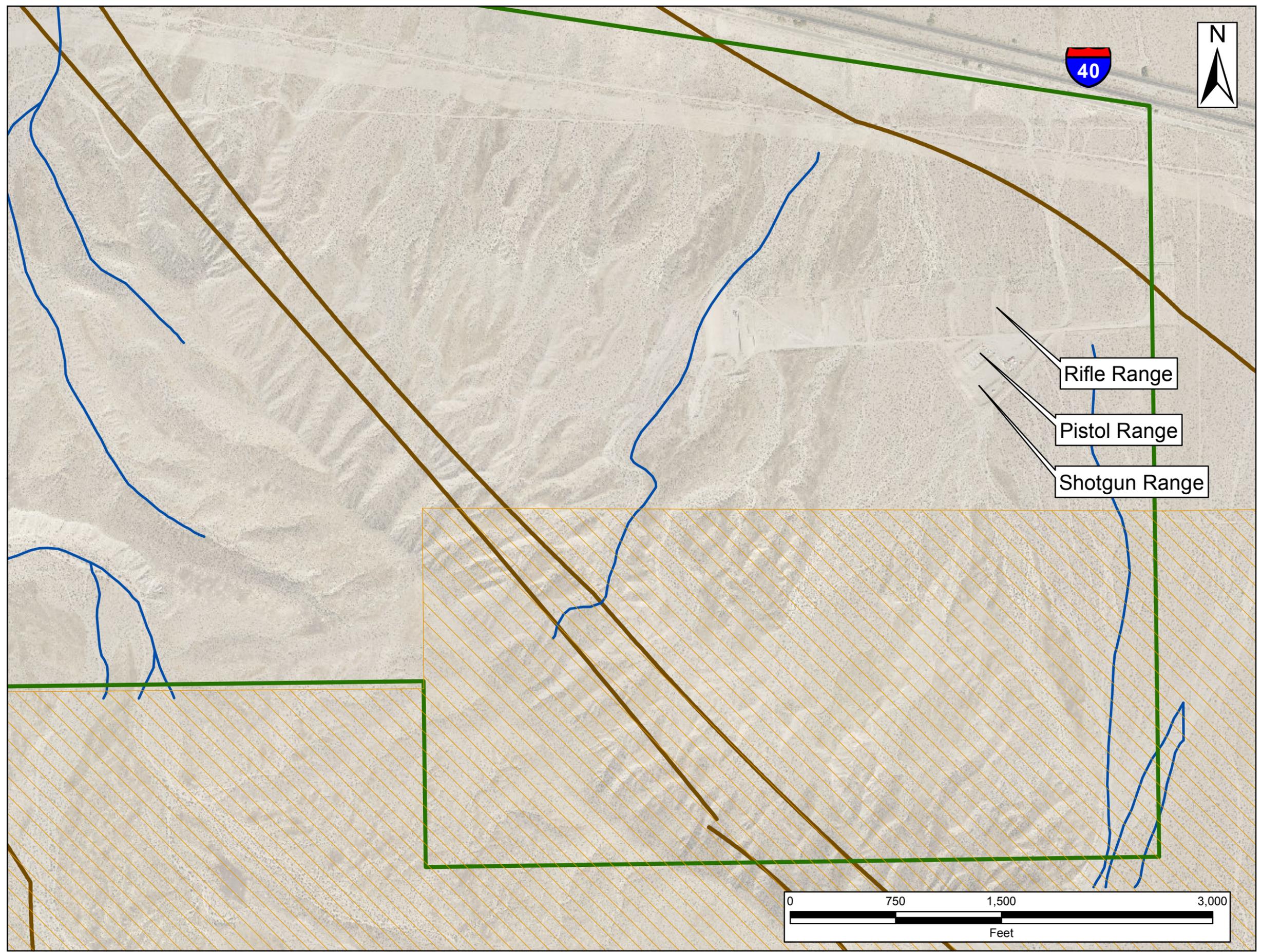
MC loading for the five-year review at MCLB Barstow was estimated using RFMSS expenditure data obtained from Base Operations covering the period from October 2010 through March 2012. The use of documented expenditure data is preferred in the REVA program.

A quality review of the expenditure data provided by the installation resulted in a series of assumptions applicable across operational SARs at MCLB Barstow.

- Expenditure data were not available for fiscal years (FYs) 2007–2010. It was assumed that the average yearly expenditure counts generated from the available data (October 2010 through March 2012) were suitable for extrapolation across the entire five-year review period. While Range Operations and Control indicated that the training tempo increased at the installation in May 2010, the extrapolation approach reflects higher range use and provides a conservative estimate of munition quantities used in training operations for the entire five-year review period. The REVA team used the available



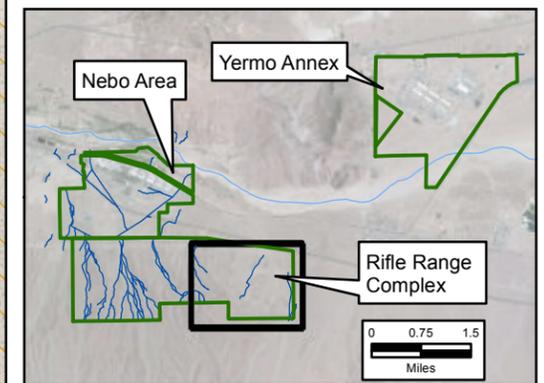
**Figure 3-1  
Operational Ranges**  
Range Environmental  
Vulnerability Assessment  
5-Year Review  
MCLB Barstow  
Barstow, CA



**Legend**

- ORD - Rodman Desert Wildlife Management Area
- Installation Boundary
- Surface Water Course**
- Dry
- Intermittent
- Harper Lake - Camp Rock Fault System

Rifle Range  
Pistol Range  
Shotgun Range



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expenditure data to generate yearly expenditure averages, which then were applied to the MC loading calculations to generate conservative MC loading estimates.

According to Range Operations personnel, all rifle rounds are expended at the Rifle Range; all pistol rounds are expended at the Pistol Range; and all shotgun rounds are expended at the Shotgun Range. As such, the total rounds of each type were divided among the three SARs and totaled for the lead loading estimate.

- FY 2012 data only account for 5.5 months of expenditures (10/1/2011–3/15/2012). Base operations confirmed training tempo was consistent throughout the year. Therefore, the REVA team assumed the 5.5 months of FY 2012 expenditure data are a representative sample of a full 12-month training total. As such, expenditure counts were increased proportionately to account for the entire 12-month period of FY 2012.
- The expenditure summaries contained one DoDIC for which data regarding MC content were not available in MIDAS or other inventories. In this instance, a general description of the munitions associated with the DoDIC was identified as part of the installation data. This was reviewed along with available information regarding the associated range, its design, and its regulations. A surrogate MC loading factor was selected from a similar munition for use in the MC/lead loading calculations.

### 3.2. REVA Munitions Constituents Loading Rate Calculator

The REVA MC Loading Rate Calculator provides an automated method to calculate the overall loading of SARs in pounds per year. It uses information about the MC and information from the military munitions expenditure data obtained from the installation to provide lead loading estimates. As previously stated, expenditure data from RFMSS dating from October 2010 through March 2012 were used to estimate lead loading values for the five-year period between 2007 and 2012. The results of the lead loading for the three SARs are reported in Table 3-1. Lead loading estimates are quantified in pounds (lbs) of lead loaded to the SAR surface per year (yr) (lbs/yr). Further details regarding the REVA MC Loading Rate Calculator are provided in the *REVA Reference Manual* (HQMC, 2009).

### 3.3. Small Arms Ranges

The three SARs are located within MCLB Barstow's Rifle Range Complex, which is immediately south of the Nebo Area and 3.5 miles southwest of the Yermo Annex. Military training on these ranges consists solely of small arms training for weapon proficiency and requalification. A summary of the SARs, including the average annual lead loading, is provided in **Table 3-1**, and general locations of the ranges is shown in **Figure 3-1**.

**Table 3-1: SARS at MCLB Barstow**

Name	Range Size (acres)	Range and SDZ Size (acres)	Primary Use	Lead (lb/yr)
Rifle Range	20.8	816.2	Marksmanship training for rifle	279
Pistol Range	0.29	243.6	Marksmanship training for pistol	359
Shotgun Range	0.90	44.5	Marksmanship training for shotgun	92

Note:

mm – millimeters

SDZ – surface danger zone

Base Operations personnel indicated that shooters at each SAR include military personnel and civilians.

Lead mining of the impact berms at all three ranges was completed in August 2012. The final total lead weight for the projectiles recovered at MCLB Barstow is 12,110 pounds (lb). It is estimated approximately 50% of the material is from the Pistol Range, 35% from the Rifle Range, and 15% from the Shotgun Range (Sherer, pers comm). At the time of this report, a formal report had not been generated documenting the activity.

Information from the baseline report indicates two previous mining events were completed on the Rifle Range between 1990 and 2005 and one mining event each occurred on the Pistol and Shotgun Ranges in the early 2000s (Stormo, pers comm.). The exact dates of berm mining were not known, and no additional information on these mining events was identified in the five-year review data collection. According to installation personnel, future lead mining activities will be conducted as needed and as funding becomes available rather than on a regular schedule.

The three SARs were qualitatively evaluated using the SARAP. The results for each SAR evaluation are provided in Section 5; the SARAP tables used in the evaluation are included as Appendix A.

### 3.3.1. Rifle Range

The Rifle Range is used for marksmanship training and (re)qualification of Marines at MCLB Barstow. The direction of fire is westerly into an impact berm. Several ephemeral creek beds are located inside the SDZ. Currently, the 25-, 200-, 300-, and 500-yard firing lines are used, and the 600- and 1000-yard firing lines are not. Base Operations personnel are exploring the possibility of reopening these two firing lines for sniper training, although no schedule has been established. Bullet capture technology has never been used at the range.



Based on the expenditure data recorded in RFMSS and discussions with MCLB Barstow Base Operations personnel, only one type of small arms ammunition is currently used at the Rifle Range.

### **3.3.2. Pistol Range**

The Pistol Range is used for marksmanship training and (re)qualification of Marines at MCLB Barstow. Based on the expenditure data recorded in RFMSS and discussions with MCLB Barstow Base Operations personnel, two types of small arms ammunition are currently used at the Pistol Range.

The direction of fire is southwest into an impact berm; however, bullet fragments were observed beyond the impact berm. There are 12 firing points with a maximum firing distance of 50 yards. Bullet capture technology has never been used at the range.

The Pistol Range SDZ extends slightly outside the installation boundary because of the addition of the closer firing lines within the last 10 years. A Right of Way Grant was approved on February 13, 2007, for use of the property extending beyond the installation boundary. The parties involved in this agreement are MCLB Barstow (Public Works) and the Bureau of Land Management (BLM), who owns the surrounding area.

### **3.3.3. Shotgun Range**

The Shotgun Range is used for marksmanship training and (re)qualification of Marines at MCLB Barstow. This range was called the Close Combat Pistol Range during the baseline assessment but currently is called the Shotgun Range at the installation. Military training use has not changed since the baseline assessment. Based on the expenditure data recorded in RFMSS and discussions with MCLB Barstow Base Operations personnel, only one type of small arms ammunition is currently used at the Shotgun Range.

The direction of fire is southwest into an impact berm; however, bullet fragments were observed beyond the impact berm. There are 20 firing points with a maximum firing distance of 100 yards. Bullet capture technology has never been used at the range.

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## 4. Conceptual Site Model

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Predicting off-range migration of MC requires the evaluation of potential exposure pathways, such as surface water and groundwater flow characteristics, and possible receptors (human and ecological) that might be affected. To this end, the REVA assessment team developed a CSM of MCLB Barstow and the Rifle Range Complex. The primary components of this CSM include identification of lead deposition locations at the SARs and a synthesis and interpretation of various environmental data to identify potential lead migration pathways and receptors.

The CSM was developed using information obtained during the site visit, environmental reports obtained from MCLB Barstow, and local geologic field studies. Where information on site-specific characteristics was limited, regional information was used to estimate site-specific characteristics. Documents obtained from the MCLB Barstow Environmental Division and the installation facilities include information on site geology and hydrology, the water supply system, and natural resources studies. In addition, the REVA team used various types of spatial data provided by the Environmental Division to map site characteristics. The REVA team used the CSM in conjunction with range-specific environmental data to complete the SARAPs for the SAR assessments. The SARAP summary is presented in Section 5.

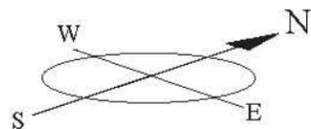
A schematic diagram depicting the site conditions addressed in the CSM is presented in **Figure 4-1**. This figure shows the topography and geologic structures of the installation relative to the operational ranges, the range boundary, and surface water and groundwater pathways.

### 4.1. Installation Profile

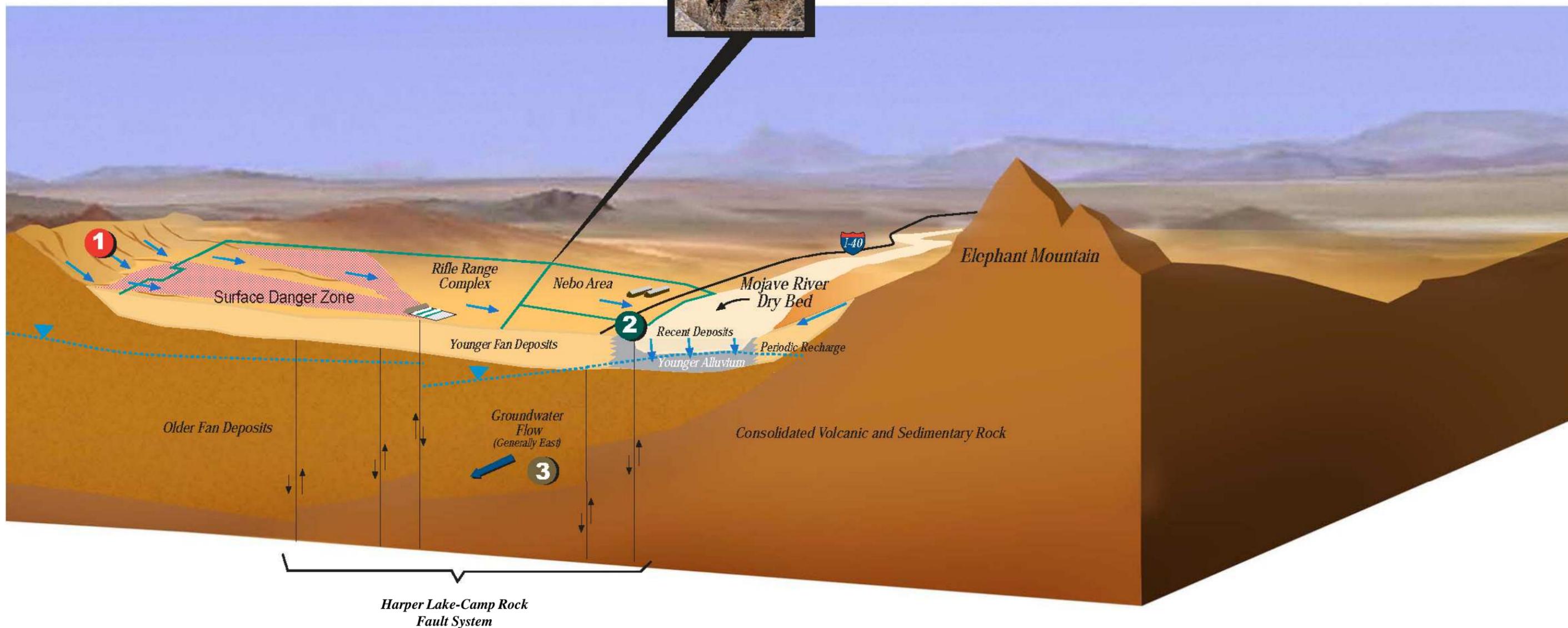
CSM Information Profiles – Installation Profile	
Information Needs	Information
<b>Installation location</b>	MCLB Barstow is located in western San Bernardino County, CA, approximately 3.5 miles east of the city of Barstow, CA.
<b>Date of Installation establishment</b>	The installation was transferred to the Marine Corps from the U.S. Navy on December 28, 1942, and consisted of the Nebo Area, which at that time was called the Marine Corps Depot of Supplies. It served as a storage facility annex to the San Francisco Marine Corps Supply Depot. The installation was expanded to include the Yermo Annex in 1946, and it

CSM Information Profiles – Installation Profile	
Information Needs	Information
	<p>operated as a surplus Army installation. The Commanding General of the Marine Corps Depot of Supplies transferred operations from San Francisco to Barstow in 1955 to establish SARs for Marine marksmanship training. The land added in 1955 to create the Rifle Range Complex was an unclaimed and undeveloped tract of public land. The base was designated as MCLB Barstow in November 1978 (USACE, 2001a).</p>
<b>Installation area and layout</b>	<p>As reported in the 2011 Integrated Natural Resources Management Plan (INRMP) (Tierra Data, 2011), the installation covers a total of approximately 5,405 acres and consists of three different areas:</p> <ul style="list-style-type: none"> <li>• Nebo Area: 1,286 acres (base headquarters and administration, storage, recreational activities, shopping, housing)</li> <li>• Yermo Annex: 1,681 acres (storage and industrial complex)</li> <li>• Rifle Range Complex: 2,438 acres (marksmanship and requalification)</li> </ul> <p>The baseline assessment reported a discrepancy between the acreages reported in the 2005 INRMP (Tierra Data, 2005) and those estimated by the REVA team using spatial data. The 2011 INRMP provides the most current data in use by the installation (Tierra Data, 2011).</p> <p>The dry bed of the Mojave River forms the northern boundary of the Nebo Area. The Rifle Range Complex is located south of Interstate 40, directly south of the Nebo Area. The Yermo Annex is located 4 miles east of the Nebo Area, north of the Mojave River bed, and between Interstates 15 and 40.</p> <p>With the addition of firing lines in the last 10 years, the Pistol Range SDZ now extends slightly beyond the installation boundary. MCLB Barstow has a Right of Way Grant with the BLM for this arrangement.</p>
<b>Installation mission</b>	<p>The primary mission of MCLB Barstow is to procure, maintain, store, and issue supplies and equipment for Marine Corps facilities worldwide, as well as to repair and rebuild DoD equipment.</p>





Desert Tortoise



Not to Scale

**Legend**

- |  |                            |
|--|----------------------------|
| Consolidated Volcanic and Sedimentary Rock | MC Loading Area            |
| <b>REGIONAL AQUIFER</b>                    | Water Table                |
| Older Fan Deposits                         | Faults                     |
| Younger Fan Deposits                       | Groundwater Flow Direction |
| <b>MOJAVE RIVER AQUIFER</b>                | Surface Danger Zone (SDZ)  |
| Younger Alluvium                           | Surface Water              |
| Recent Alluvium Deposits                   | Installation Boundary      |

This cross-section is based on a basic distribution of geologic units and features and represents the general conceptual model for the surface and groundwater flow at the installation. Although it is based on information from reports by Densmore et. al. (1997) and Mojave Water Agency (2004), this figure is not intended as a geologic cross-section with accurate subsurface contacts and bedrock outcrops.

Possible lead transport mechanisms

1. Surface runoff toward Mojave River Bed through the Rifle Range Complex
2. Recharge of runoff into the Mojave River Bed sediments
3. Subsurface groundwater flow generally parallel to the Mojave River Bed

**Figure 4-1**  
**Graphical Conceptual Site Model**  
 MCLB Barstow  
 Barstow, CA

Date: November 2012



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## 4.2. Operational Range Profile

CSM Information Profiles – Operational Range Profile	
Information Needs	Information
<b>SARs</b>	Three operational SARs are at MCLB Barstow: the Rifle Range, Pistol Range, and Shotgun Range. All are located in the Rifle Range Complex.
<b>Date of range establishment</b>	The Marine Corps acquired the land for ranges in 1955, and the ranges became operational that same year. The Pistol Range and Shotgun Range were separated from each other by construction of a central berm in the 1960s (USACE, 2001b).
<b>Range design and use</b>	<p>The three SARs are adjacent to one another in the Rifle Range Complex, occupying 2,438 acres.</p> <p>The Rifle Range, including range footprint and its associated SDZ, occupies approximately 816 acres. The range footprint is 3,000 feet by 600 feet and is oriented to fire to the west.</p> <p>The Pistol Range and Shotgun Range are parallel and separated by an earthen berm. They both fire to the southwest. The combined footprint of the ranges is 300 feet by 350 feet. The Pistol and Shotgun ranges also are bound on the left and right sides by earthen berms.</p> <p>The Rifle Range has 30 firing points and currently uses firing lines at 25, 200, 300, and 500 yards. The 600- and 1000-yard firing lines currently are not used. The Pistol Range has 12 firing points and firing lines at 15, 25, and 50 yards. The Shotgun Range has up to 20 firing points and a firing line at 50 yards.</p> <p>Projectiles are directed toward impact berms at the back of each range. The majority of rounds fired are captured by the berm; however, fragments were observed on the back sides of the Pistol and Shotgun Range berms during the REVA site visit in March 2012.</p> <p>According to Base Operations, primarily active duty Marines (including personnel from Marine Corps Base Camp Pendleton) and Marine Corps police, use the ranges. Other users include civilians and the Riverside</p>

CSM Information Profiles – Operational Range Profile	
Information Needs	Information
	County District Attorney Office.
<b>Range security</b>	Two portions of the Rifle Range Complex, including the southern boundary of the Nebo Area and along Interstate 40, are bordered by chain-link fence (DON, 2004). The remaining 36,000 ft of fence enclosing the complex are four-strand barbed wire not lower than 12 inches above the ground to allow the desert tortoise to move throughout the fenced area (Tierra Data, 2005). Installation security does not actively patrol the Rifle Range Complex.
<b>Military munitions usage</b>	Munitions are restricted to small arms ammunition. .
<b>MC</b>	<p>MC evaluated under the REVA program for SARs are limited to lead (HQMC, 2009).</p> <p>A soil sampling study was completed in 2005 at the Pistol Range. The concentrations detected in sampling points behind the berm were 41.7 and 33.7 milligrams per kilogram (mg/kg) in the 6-inch profile. These values were below screening values and significantly below detections at the berm and target line (Panacea, 2005; DON, 1995). Although the range is generally flat, it does gently slope toward the firing line. The low concentrations detected at the firing line (less than the average concentration established at MCLB Barstow [7.5 mg/kg]) show the limited migration of lead off range. Additional information is provided in Section 5.</p>
<b>Maintenance</b>	The impact berms at all three ranges were reconstructed in August 2012. The existing soil was removed and sieved to remove lead shot. The final total lead weight for the projectiles recovered at MCLB Barstow is 12,110 lb. It is estimated approximately 50% of the material is from the Pistol Range, 35% from the Rifle Range, and 15% from the Shotgun Range (Sherer, pers comm). Prior to replacing the soil on the berms, erosion control matting (Envirogrid) was put in place. The soil was replaced on



CSM Information Profiles – Operational Range Profile	
Information Needs	Information
	<p>the berms to a 2/1 rise. At the time of this report, a formal report had not been generated documenting the activity.</p> <p>Information from the baseline report indicates two previous mining events were completed on the Rifle Range between 1990 and 2005 years and one mining event each occurred on the Pistol and Shotgun Ranges in the early 2000s (Stormo, pers comm.). The exact dates of berm mining were not known, and no additional information on these mining events was identified in the five-year review data collection. Per information gathered in the five-year review, no known prior removal of bullets has been completed.</p> <p>Berm material occasionally is replenished to fill bullet pockets to reduce erosion and potential lead transport. Routine maintenance at the complex includes repairing firing berm erosion and trimming vegetation in the live-fire areas. Road grading is conducted semiannually and after severe storms as needed. The areas graded may include the access roads, including the road that runs behind the berm, and parking lots (semiannually). The grading can redistribute lead fragments. On the March 2012 site visit, lead fragments were observed behind the Shotgun and Pistol Ranges in the roadbed and on the back side of the impact berms, as if moved by grading activities.</p>
<b>Engineered controls</b>	<p>Sandbags are placed across the top of the Rifle Range berm to help prevent erosion caused by high-energy runoff. The tops of all the berms are sloped slightly away from the berm face to minimize drainage flow across the impact area. Sandbags or wooden beams are present at the foot of the berms at the Pistol and Shotgun Ranges to help capture any erosion down the face of the berms. In addition, during berm reconstruction in August 2012 erosion control matting was installed on the face of the berms at all three ranges to limit soil erosion on the berm faces. The back sides of the Pistol and Shotgun ranges are terraced down to a flat road bed. Side berms at the Pistol and Shotgun Ranges divert</p>

CSM Information Profiles – Operational Range Profile	
Information Needs	Information
	storm water run-on to the ranges.

### 4.3. Physical Profile

CSM Information Profiles – Physical Profile	
Information Needs	Information
<b>Climate</b>	<p>MCLB Barstow is in the north-central Mojave Desert; thus, the climate is very arid. The facility receives approximately 4.4 inches of precipitation per year, with an annual minimum of 1.08 inches and an annual maximum of 10.62 inches. The majority of the precipitation falls between November and March. Localized flooding may occur in the summer during occasional torrential thunderstorms. Snow is rare but may occur because the temperature falls below the freezing point approximately 58 days per year.</p> <p>Winds primarily originate from the west at monthly average speeds approaching 8 to 9 miles per hour (mph); gusts exceeding 40 to 50 mph are not uncommon (Tierra Data, 2005).</p> <p>Pan evaporation rates for the Mojave weather station, recorded between 1948 and 2005, average 111 inches per year (Western Region Climate Center, 2012).</p>



CSM Information Profiles – Physical Profile	
Information Needs	Information
<b>Elevation</b>	<p>The installation lies between approximately 1,940 and 2,650 feet above mean sea level (amsl) (Tierra Data, 2005). The low elevation of 1,940 feet amsl is at the Yermo Annex, and the high elevation point of 2,650 feet amsl is at the Rifle Range (MCLB Barstow, 2011). Based on U.S. Geologic Survey (USGS) topographic maps, the Rifle Range Complex ranges in elevation from 2,500 feet amsl in the southwestern corner to 2,100 feet in the northeastern corner near Interstate 40.</p>
<b>Topography</b>	<p>MCLB Barstow is located in the lower Mojave River Valley Basin. It is characterized by low ridges and terraces that surround and slope downward to an alluvial valley that generally trends west to east.</p> <p>The Rifle Range Complex contains plateaus and ephemeral washes that drain toward the Mojave River. The Nebo Area and Yermo Annex are flatter, with fewer topographic features. Elephant Mountain, located between the Nebo Area and the Yermo Annex, is the dominant topographic feature in the area (Densmore et al., 1997).</p>
<b>Stratigraphy</b>	<p>MCLB Barstow is situated in the Mojave River valley, where Holocene alluvial fan and stream channel deposits constitute the upper 600 feet of unconsolidated sediments, which are underlain in places by Pleistocene and late Miocene alluvium, fanglomerate, and playa deposits. A number of northwest-trending, right-lateral, strike-slip faults are present throughout the area (Jacobs Engineering, 1997). Notably, the Harper Lake-Camp Rock fault zone traverses the eastern portion of the Nebo Area and Rifle Range Complex. This fault zone displaces sediments as recent as the Holocene and Pleistocene eras, while many of the other fault zones in the area displace only older units.</p> <p>The Rifle Range Complex is set south of the dry riverbed where Pleistocene- and Holocene-aged alluvium is exposed at the surface. Consolidated volcanic and metavolcanic bedrock is between 100 and 1,000 feet below ground surface (bgs) beneath the base. Tertiary</p>

CSM Information Profiles – Physical Profile	
Information Needs	Information
	<p>volcanics and sedimentary rocks up to 6,000 feet thick underlie the entire basin. The greatest depth to bedrock in the Barstow area is approximately 8,300 feet (Jacobs Engineering, 1997; Densmore et al., 1997).</p>
<p><b>Hydrostratigraphic units</b></p>	<p>Water-bearing deposits in the Mojave River Valley basin are predominantly unconfined. MCLB Barstow has two primary water bearing units: the Mojave River aquifer and the underlying regional aquifer. The Mojave River aquifer consists of alluvial deposits of Pleistocene and younger age and is restricted to within approximately 1 mile of the Mojave River channel. The regional aquifer consists of alluvial fan deposits of Pliocene and younger age and is more extensive than the Mojave River aquifer. Additional data regarding these units are provided in the groundwater profile (DWR, 2004; Densmore et al., 1997; Tierra Data, 2005).</p>
<p><b>Soil and vadose zone characteristics</b></p>	<p>Soils across the installation typically consist of alluvial deposits, characterized as generally unconsolidated to partially consolidated sediments consisting of sand and gravel with some fine-grained material. The three operational ranges are located primarily in Cajon gravelly sand and have 2%–15% slopes. The Cajon series is described as very deep, somewhat excessively drained soils with generally neutral pH to moderate alkalinity (pH of 8.0) and formed in sandy alluvium from granitic rocks (NRCS, 2002). Bedrock formations crop out in the higher elevations of MCLB Barstow and at the southern end of the installation, near the Rifle Range Complex.</p> <p>In 1993, a background metals in soil study was conducted on the southern portion of the Nebo Area and northern portion of the Rifle Range Complex, as well as part of the Yermo Annex. The arithmetic mean lead concentrations from 15 soil sample locations resulted in the following background levels:</p> <ul style="list-style-type: none"> <li>• Surface (0–3 feet bgs): 6.5 mg/kg</li> <li>• Mid-depth (3.1–10 feet bgs): 4.4 mg/kg</li> </ul>



CSM Information Profiles – Physical Profile	
Information Needs	Information
	<ul style="list-style-type: none"> <li>• Deep (10.1 feet bgs and deeper): 3.6 mg/kg</li> </ul> <p>The maximum detected lead concentration in soil for the southern Nebo Area was 14.3 mg/kg.</p> <p>Background lead concentrations at the Yermo Annex were 7.5 mg/kg at the surface, 4.4 mg/kg at mid-depth, and 3.6 mg/kg at the deep interval (DON, 1995).</p> <p>Installation personnel indicated that studies associated with the landfill cap at the Nebo Area reported surface soil pH to range from 7.4 to 7.5 (Joia, pers. comm.).</p>
<b>Erosion potential</b>	<p>The Nebo Area and the Rifle Range Complex are subject to flash floods capable of moving large loads of sediment during high-intensity rainfall. The arid, hot climate and sparse vegetation of the Mojave Desert, combined with the availability of loose surface material, allows wind to act as an erosion agent (EDAW, 2006). Wind can be a persistent erosional force for smaller particles in the Mojave Desert (Tierra Data, 2005). Base Operations personnel indicated that wind does cause problems with keeping targets in place. Even though it is not anticipated that wind is a significant mechanism for lead transport off range, it can increase erosion of the bullet pockets and surrounding soils that help keep the lead in place. Additional information related to the air transport mechanism for MC is provided in the <i>REVA Reference Manual</i> (HQMC, 2009).</p>
<b>Potential lead release mechanisms</b>	<p>Potential lead release mechanisms include erosion of the source material and subsequent mobilization in surface water runoff. Annual precipitation is minimal and generally limited to the winter months, but intense summer storms can create flash floods. Surface runoff follows natural topographic gradients from the ranges through incised washes northward toward the Mojave River. Such drainage patterns can transport lead downstream through dissolution in runoff water or erosion of soil from the berm. The potential for dissolution into surface water is likely limited given the near-neutral soil and surface water pH recorded at MCLB Barstow. It is unlikely that lead infiltrates</p>

CSM Information Profiles – Physical Profile	
Information Needs	Information
	and reaches the groundwater due to the low precipitation, high evaporation, and the depth of groundwater.

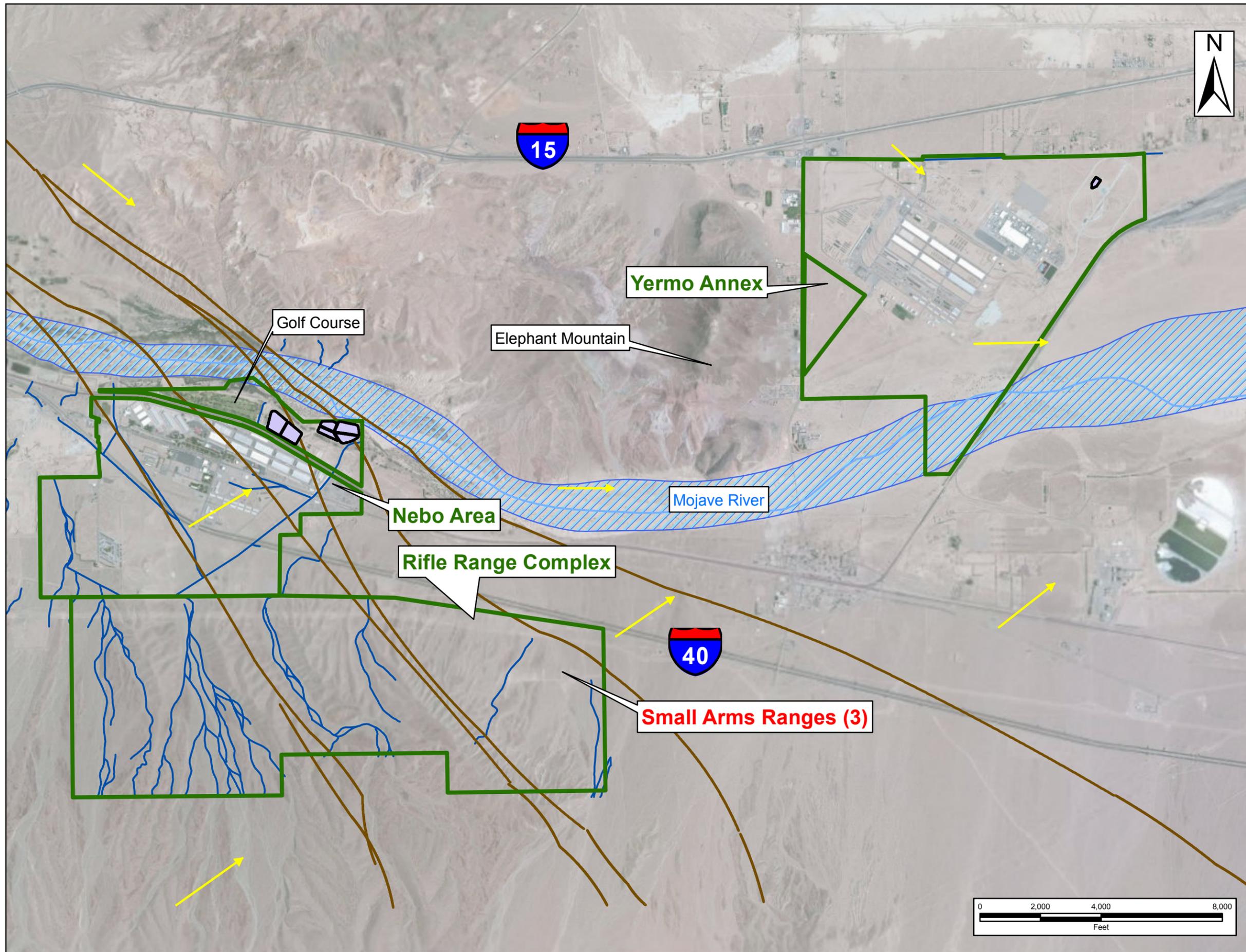
#### 4.4. Surface Water Profile

CSM Information Profiles – Surface Water Profile	
Information Needs	Information
<b>Surface water and drainage</b>	<p>Natural drainages carry runoff from plateaus and mountainous areas toward the Mojave River in ephemeral drainages and dry washes (Tierra Data, 2005). The general flow of surface water in the Rifle Range Complex is from the southwest to northeast, toward the Mojave River. Drainage channels around the improved areas at the Nebo Area and the Yermo Annex are concrete-lined. Surface water in the Mojave River channel in the Barstow area only occurs during periods of intense rainfall.</p> <p>The Mojave River is the dominant surface water feature in the area; although, for the majority of the year, it is a dry riverbed (<b>Figure 4-2</b>). The Mojave River begins in the San Bernardino Mountains, located to the west, and terminates at the Soda and Cronese Lakes, located to the east (Tierra Data, 2005). The river advances in a series of surface and subsurface flows. It generally flows with groundwater and reappears periodically where impermeable clays or bedrock prevent down gradient migration. The river is ephemeral for an approximately 40-mile stretch upstream of MCLB Barstow near Victorville. The riverbed remains ephemeral approximately 35 miles downstream of MCLB Barstow until the Afton Canyon.</p> <p>Wastewater treatment ponds operated by MCLB Barstow and the City of Barstow for treatment of industrial and domestic waste (oxidation and</p>



**FIGURE 4-2  
Surface Water Features**

Range Environmental  
Vulnerability Assessment  
5-Year Review  
MCLB Barstow  
Barstow, CA



**Legend**

- Installation Boundary
- MOJAVE RIVER (DRY)
- Harper Lake - Camp Rock Fault System
- Surface Impoundments
- Surface Water Course**
- Dry
- Intermittent
- Approximate Groundwater Flow



Date: November 2012  
Source: MCLB Barstow GIS Office 2012  
Aerial - ESRI/Bing Maps



**ARCADIS MALCOLM PIRNIE**  
Infrastructure · Water · Environment · Buildings

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CSM Information Profiles – Surface Water Profile	
Information Needs	Information
	<p>effluent ponds) are located along the banks of the Mojave River (Tetra Tech, 2003). Water in these ponds evaporates or seeps into the Mojave River aquifer by discharge to river channel deposits. . Storm water sampling has not been conducted in recent years, though installation personnel stated that the pH of storm water is generally above 6.5. Water quality data collected from USGS stream gages in the Mojave hydrologic unit near MCLB Barstow for years ranging from 2009 through 2012 have an average field measured pH value of 8.1 and most frequently measured value of 8 (USGS, 2012).</p>
<p><b>Hydrological unit &amp; watershed areas</b></p>	<p>The installation is located completely within the South Lahontan Hydrological Region, Mojave Unit, Lower Mojave Area (State of California Regional Water Quality Control Board, Lahontan Region, 2005).</p> <p>A small portion of the northern Nebo Area is located within the 100-year floodplain of the Mojave River (Tierra Data, 2005).</p>
<p><b>Designated beneficial uses</b></p>	<p>The beneficial uses of surface water in the Lower Mojave Hydrologic Area, as designated in the State of California Regional Water Quality Control Board’s Lahontan Regional Basin Plan Amendment (2005), include:</p> <ul style="list-style-type: none"> <li>• municipal and domestic supply,</li> <li>• agricultural supply,</li> <li>• industrial service supply,</li> <li>• groundwater recharge and freshwater replenishment,</li> <li>• flood peak attenuation / flood water storage,</li> <li>• contact and noncontact water recreation,</li> <li>• navigation,</li> <li>• hydropower generation,</li> <li>• fishing,</li> <li>• water quality enhancement,</li> <li>• cold and warm freshwater habitat, and</li> </ul>

CSM Information Profiles – Surface Water Profile	
Information Needs	Information
	<ul style="list-style-type: none"> <li>wildlife habitat.</li> </ul> <p>Because the Mojave River is typically dry most of the year at MCLB Barstow, the principal beneficial uses of surface water at the installation and in downstream areas are groundwater recharge to the Mojave River aquifer and wildlife habitat. Surface water bodies are ephemeral and are insufficient for agricultural supply and recreation.</p> <p>Wetlands in the area are designated for the same uses as above, as well as for freshwater replenishment; rare, threatened, or endangered species habitat; water quality enhancement; and flood peak attenuation and storage. A wetland delineation was conducted in 2006 and determined that there are approximately 18 acres of jurisdictional wetlands on base, all located within the Nebo Area. This includes areas north of the golf course, areas along an old water diversion canal, and portions of old percolation ponds located in the Nebo Area (MCLB Barstow, 2011). There are no wetlands in the range area; however, surface water flow, if present, is toward the Nebo Area to the Mojave River bed. Little or no surface water flow in the Mojave River bed is common due to low precipitation and high evapotranspiration.</p>
<b>Supported habitats/ ecosystems</b>	No notable aquatic surface water habitats are present in the installation because the Mojave River and surrounding intermittent dry washes are typically dry year-round. All jurisdictional wetlands are located on base within the Nebo Area.
<b>Gaining or losing streams</b>	When present, water in the Mojave River and surrounding washes generally recharges groundwater aquifers by infiltration into the subsurface. Therefore, the streams at MCLB Barstow are losing. Groundwater occasionally does discharge into the Mojave River. However, it is unlikely groundwater flowing from the Range Complex discharges to the river due to the faults, which act as a groundwater barrier.
<b>Surface water</b>	There are no active potable water storage reservoirs at MCLB Barstow.



CSM Information Profiles – Surface Water Profile	
Information Needs	Information
collection points	

#### 4.5. Groundwater Profile

CSM Information Profiles – Groundwater Profile	
Information Needs	Information
<b>Groundwater aquifers</b>	<p>The two primary water-bearing units are the Mojave River aquifer and the regional aquifer. The Mojave River aquifer typically is made up of recent and younger alluvial and fan deposits and is restricted to within approximately 1 mile of the Mojave River channel. The Mojave River aquifer has a hydraulic conductivity of 150 feet per day (ft/d). Beneath the Yermo Annex, this aquifer extends from the surface to approximately 200 feet bgs. Beneath the Nebo Area, the aquifer extends from approximately 50 to 200 feet bgs (Stamos et al., 2001).</p> <p>The regional aquifer underlies and surrounds the Mojave River aquifer. It generally consists of alluvial fan deposits of Pliocene and younger age and covers more area than the Mojave River aquifer (Densmore et al., 1997). The regional aquifer has a hydraulic conductivity of 1.5 ft/d. Beneath the Yermo Annex, the regional aquifer is located from approximately 200 feet bgs to bedrock at about 600 feet bgs (Densmore et al., 1997).</p>
<b>Designated beneficial uses</b>	<p>Designated beneficial uses for all groundwater basins within the Mojave Basin include municipal supply, agricultural supply, industrial service supply, freshwater replenishment, and aquaculture (State of California Regional Water Quality Control Board Lahontan Region, 2005). Groundwater in the Yermo Annex is used for municipal supply at MCLB Barstow, and groundwater in the Nebo Area is used for limited irrigation (Tierra Data, 2005).</p>

CSM Information Profiles – Groundwater Profile	
Information Needs	Information
<b>Groundwater supply wells</b>	<p>The Yermo Annex, located on the north side of the Mojave River channel, draws its potable water supply from on-site groundwater supply wells. The wells are located within the Mojave River aquifer. Three private water supply wells that also tap water from the Mojave River aquifer are located down gradient of the Yermo Annex (ATSDR, 2007).</p> <p>Two water wells on private property are present east of the Nebo Area, but they are no longer used. Due to migration of industrial contaminants from the Nebo Area, the private residences now are supplied with water from the city of Barstow and the wells have been inactivated. Prior to 1977, the Nebo Area main base obtained potable water from six on-base production wells for drinking and operations. In 1977, MCLB Barstow stopped using the wells for drinking water and production water because of high levels of total dissolved solids. The Nebo Area now obtains potable water from the City of Barstow. One of the six wells was abandoned in the 1950s for unknown reasons; another well was abandoned in 1993; the other wells are used for golf course irrigation (ATSDR, 2007).</p>
<b>Recharge source(s)</b>	<p>Primary groundwater recharge sources include stream runoff, ephemeral stream flow, infrequent surface flow of the Mojave River, and underflow of the Mojave River from the west subbasin of the aquifers (Stamos et al., 2001). Other sources of groundwater recharge include seepage of sewage effluent and irrigation return flow (Densmore et al., 1997). The historical recharge rate at the city of Barstow is estimated at approximately 9,000 acre-feet per year (Tierra Data, 2005; Jacobs Engineering, 1997). Recharge near MCLB Barstow includes anthropogenic or artificial recharge sources, such as irrigation return flow, fish hatchery return flow, sewage return flow, septic system effluent, and golf course irrigation (Stamos et al., 2001). Because precipitation is low and the potential for evaporation is high, little, if any, recharge occurs on the installation from direct infiltration of precipitation (Densmore et al., 1997). However, precipitation and runoff from the San Bernardino Mountains play a significant role in recharging the Mojave</p>



CSM Information Profiles – Groundwater Profile	
Information Needs	Information
	River Basin (ASTDR, 2007).
<b>Porous or fracture flow</b>	MCLB Barstow is underlain by several hundred feet of unconfined alluvial fan deposits, which allow for significant porous flow.
<b>Depth to groundwater</b>	<p>Depth to groundwater at MCLB Barstow is highly variable and likely controlled by the faults that bisect the installation, with groundwater levels generally deeper east of the Harper Lake–Camp Rock fault zone, which extends within approximately 40 feet of the surface at the Nebo Area. Observations at the Nebo Area indicate that the depth to the water table ranges from 10 to 138 feet bgs. Studies conducted at an Installation Restoration Program site located approximately 1.5 miles northwest of the Rifle Range documented depth to water between 160 and 210 feet bgs. Depths up to 175 feet bgs have been noted on the alluvial fan south of Interstate 40 near the Rifle Range Complex (Jacobs Engineering, 1997; Tetra Tech, 2003).</p> <p>Groundwater depths are relatively shallow within the Mojave River bed, typically 4 to 5 feet bgs. The depth to groundwater at the drinking water supply wells within the Yermo Annex ranges from 174 to 400 feet bgs (ATSDR, 2007).</p>
<b>Gradient and flow velocity</b>	<p>Historical monitoring has revealed groundwater gradients at the Nebo Area ranging from 0.002 to 0.03. Reported gradients east of the fault zone range from 0.005 to 0.008 (Jacobs Engineering, 1995; Tetra Tech, 2003). Combining these gradient values with the hydraulic conductivity values presented above yields a flow velocity of 0.3 to 4.5 ft/d in the Mojave River aquifer and a flow velocity of 0.002 to 0.045 ft/d in the regional aquifer.</p> <p>Groundwater studies indicate that the Harper Lake–Camp Rock fault zone acts as a partial barrier to groundwater flow. Groundwater west of the fault zone tends to be relatively shallow, whereas groundwater east of the fault zone resides at greater depths; however, groundwater</p>

CSM Information Profiles – Groundwater Profile	
Information Needs	Information
	<p>chemistry is fairly similar on both sides of the fault zone (Tetra Tech, 2003).</p> <p>West of the Harper Lake–Camp Rock fault zone groundwater generally flows northeast and east; east of the fault zone, it flows southeast to northeast. There is significant communication between the Mojave River aquifer and the regional aquifer. Currently, groundwater flow from the Mojave River floodplain is a primary recharge component for the regional aquifer. However, before development of the area, groundwater flow was in the opposite direction, from the regional aquifer to the river aquifer (Mojave Water Agency, 2004). The reversal was due to increased pumping from the regional aquifer in the surrounding communities.</p> <p>The Mojave Water Agency (2004) cites a chemical tracer study near Victorville, which indicated that it could take up to 200 years for the natural recharge from an ephemeral streambed to infiltrate to the water table, about 430 feet bgs. Water depths are much shallower near MCLB Barstow; however, based on the recharge data, infiltration occurs very slowly.</p>
<b>Known water quality characteristics</b>	<p>Groundwater quality in the area is characterized as a sodium bicarbonate type (DWR, 2004). High concentrations of dissolved solids have been noted in the Barstow area (Mojave Water Agency, 2004), likely the result of release of industrial and domestic effluent, irrigation return flow, and naturally occurring high dissolved solids water from underlying and surrounding older fan deposits (Densmore et al., 1997). The Harper Lake earthquake fault between the Nebo Area and Yermo Annex has created a difference in the water table at each location, and the water quality in the Yermo Annex is of higher quality (MCLB Barstow, 2011). A 2002 groundwater study and Yermo Annex drinking water reports referenced by installation personnel indicate that the pH typically ranges between 7 and 8 (Tetra Tech, 2003; Cox, pers. comm.). Early 1993 sampling at the Nebo Area revealed low background concentrations of lead in groundwater across the base, ranging to a maximum of 5 micrograms per</p>



CSM Information Profiles – Groundwater Profile	
Information Needs	Information
	liter (Jacobs Engineering, 1995). There is known contamination of the unconfined groundwater in the area, including solvent plumes associated with the Nebo Area and the Yermo Annex. Lead is not a contaminant associated with these plumes.
<b>Discharge location(s)</b>	The supply wells located within the Yermo Annex, and the wells within the Nebo area that are used for golf course irrigation are groundwater discharge locations. There are no playas, springs, or seeps in the MCLB Barstow area where groundwater discharges, but groundwater occasionally does discharge to the Mojave River. However it is unlikely groundwater flowing from the Range Complex discharges to the river due to the faults, which act as a groundwater barrier.

#### 4.6. Human Land Use and Exposure Profile

CSM Information Profiles – Human Land Use and Exposure Profile	
Information Needs	Information
<b>Land use</b>	<p>The Nebo Area is used for base headquarters, administration, storage, recreational activities, shopping, and housing. The Yermo Annex is primarily for storage, equipment repair, and loading/unloading. The Rifle Range Complex contains three operational ranges. There are no active uses of the Rifle Range Complex beyond training and qualification, and the majority of the complex serves as a buffer zone. A small area containing cultural resources is located just north of the Rifle Range (EDAW, 2006). A utility corridor runs along the northern portion of the Rifle Range Complex (USMC, 2006).</p> <p>Much of the land immediately surrounding MCLB Barstow is undeveloped BLM lands. The Ord-Rodman Desert Wildlife Management Area (DWMA) is located south of the range complex and is used for sheep grazing and recreation (off-road vehicles) (BLM, 2007). A few</p>

CSM Information Profiles – Human Land Use and Exposure Profile	
Information Needs	Information
	<p>commercial buildings and private residences are located east of the Rifle Range Complex on the north side of Interstate 40. Quarry operations are located to the west of the installation and are operated by Service Rock Products for concrete and aggregate production (Service Rock Products, 2007). The city of Barstow is located west of the installation boundaries.</p>
<b>Current human receptors</b>	<p>Potential human receptors are limited due to the lack of significant development and use of the area. The closest existing drinking water wells are located at the Yermo Annex, several miles from the Rifle Range Complex. Potential receptors include installation personnel and users of privately owned groundwater wells farther down gradient of the installation. There are no surface water users near MCLB Barstow because the Mojave River is dry throughout most of the year. Potable water for use at the Rifle Range Complex is trucked in and stored (Tierra Data, 2005); thus, there is no direct exposure from consumption of water at the Rifle Range Complex.</p> <p>Drinking water for the installation is pumped from Marine Corps–owned production wells at the Yermo Annex or purchased from the Golden State Water Company. Production wells at the Nebo Area have been inactive since approximately 1975 (MCLB Barstow, 2011).</p>
<b>Land use restrictions</b>	<p>In general, the public is not allowed on MCLB Barstow; however, in the past, California Highway Patrol and other public groups have been granted access to the Rifle Range Complex (Tierra Data, 2005). Warning signs are posted around the range complex to warn the public of the training exercises conducted at the Rifle Range Complex (DON, 2004). Operation and maintenance activities at the range complex have required Section 7 consultation with the U.S. Fish and Wildlife Service due to the presence of the federally listed threatened desert tortoise and its designated critical habitat (see Section 4.7). The presence of cultural resources at the range complex also has necessitated occasional consultation with the State Historic Preservation Office.</p>



## 4.7. Natural Resources Profile

CSM Information Profiles – Natural Resources Profile	
Information Needs	Information
<b>Ecosystems</b>	MCLB Barstow is located within the north-central Mojave Desert (Tierra Data, 2005). Ecosystems are consistent with high desert ecosystems in the region.
<b>Vegetation</b>	Five plant communities have been identified at MCLB Barstow, with creosote bush scrub covering an overwhelming majority of the base. Sensitive plant communities include the desert wash scrub and cottonwood-willow desert riparian communities (Tierra Data, 2011).
<b>Fauna</b>	Fauna at MCLB Barstow primarily consists of small mammals (such as mice, squirrels, and rabbits) and small reptiles. Snakes, bobcats, and coyotes also are known to be present in the area. A number of bird species use available vegetated areas, and migratory birds that pass through the region commonly are associated with the limited wetlands present in the Nebo Area. Although not surveyed at the base, bats are known to be present in urban areas of the region (Tierra Data, 2005).
<b>Special status species</b>	<p>The desert tortoise is a federally and state-listed threatened species whose presence on MCLB Barstow has been documented at the Rifle Range Complex (MCLB Barstow, 2011). There are a number of other special concern or T/E plant and animal species that have the potential to occur on the base; however, very few have been observed at the base:</p> <ul style="list-style-type: none"> <li>• A 2006 bird survey indicates sightings of the southwestern willow flycatcher (federally and state-listed endangered), but no nests were observed (Lovio, 2006).</li> <li>• The golden eagle (California Species of Concern, Federal Bald and Golden Eagle Protection Act) and vermilion flycatcher (California Species of Concern) were observed at the installation during an older survey (Tierra Data, 1996).</li> <li>• The 2005 INRMP indicates the burrowing owl has been observed at</li> </ul>

CSM Information Profiles – Natural Resources Profile	
Information Needs	Information
	<p>the installation, though installation personnel could not confirm that sightings of these species have ever been made (Joia, pers. comm.).</p> <p>The desert tortoise represents the primary species of concern due to its consistently observed presence and habitat at the Rifle Range Complex. Approximately 540 acres of the Rifle Range Complex are designated as critical desert tortoise habitat, the Ord-Rodman DWMA (MCLB Barstow, 2011).</p> <p>The three operational ranges are estimated to be 800 feet north of the Ord-Rodman DWMA boundary. Surface water runoff from the ranges flows north toward the Mojave River, away from the Ord-Rodman DWMA. The SDZs for the Shotgun Range and Pistol Range extend over the DWMA, while the SDZ for the Rifle Range slightly overlaps the DWMA boundary. In 2009, approximately 14 kilometers of the Rifle Range Complex was surveyed for desert tortoises. Only two countable tortoises were encountered; the encounter rate is extremely low. It was recommended that future efforts by MCLB Barstow in reading/surveying the established area in the Rifle Range Complex be suspended (Tierra Data, 2009).</p>

#### 4.8. Potential Pathways and Receptors

- The following exposure pathways were evaluated to determine if lead has the potential to migrate off of the operational range area. Surface water runoff including sediment transport
- Leaching to groundwater and subsequent groundwater flow

Exposure pathways considered in the REVA process include consumption of surface water and groundwater by off-range human receptors, as described in the *REVA Reference Manual* (HQMC, 2009). For groundwater, water supply wells located within or just beyond the installation boundaries are considered an exposure source because the water is distributed to a public drinking water system. Exposure pathways for off-range ecological receptors (defined in the REVA analysis as any T/E species or species of concern) also are considered, including direct consumption of or exposure to surface water and exposure to sediment. Other off-range exposure



scenarios (e.g., soil ingestion, incidental dermal contact, bioaccumulation and food chain exposure) are not considered in the REVA process. Potential exposure points for receptors of MC at MCLB Barstow include the following:

- The water supply wells located within the boundaries of MCLB Barstow in Yermo Annex
- Potential off-installation wells located down gradient of the Yermo Annex
- Surface water bodies, including ephemeral streams and wetlands, that are used for groundwater recharge and potentially support special status species

#### **4.8.1. Surface Water and Sediment Pathway**

Transport of lead via surface water runoff is the primary transport mechanism at the MCLB Barstow operational ranges. Annual precipitation is low and generally limited to the winter months; however, brief and intense thunderstorms during the summer can create flash floods, which may move relatively significant amounts of soil on the ground surface. Surface runoff follows natural topographic gradients from the ranges through incised ephemeral washes northward toward the Mojave River, approximately 0.8 miles from the ranges. Such drainage patterns can transport lead downstream through dissolution in runoff water or erosion of soil with lead (particularly on the berms). However, because site soils and storm water measurements indicate neutral or slightly alkaline conditions (soil pH between 7.4 and 8.4; an average storm water pH of 8.1), lead migration via dissolution in surface water is likely to be limited. The soil erosion potential at the Rifle Range Complex can be significant because of the sparse vegetation cover, moderately steep topography, and the occurrence of flash floods capable of moving large loads of sediment during high-intensity rainfall. Therefore, soil erosion is an important mechanism for MC mobilization into surface water runoff and, ultimately, into streams. Wind erosion also can be significant at MCLB Barstow. Although wind might not be a significant mechanism for lead transport off range, it can increase erosion of the bullet pockets and surrounding soils that help keep the lead in place. .

The Shotgun and Pistol Ranges are bounded by the rear impact berm and side berms. In August 2012, the impact berms were excavated and resurfaced. The bases of the impact berms are supported by ballistic block, and erosion matting was installed on the berm faces to minimize erosion of the berms. The back sides of the berms are sloped away from the berm faces to minimize surface water run-on to the berm face and range... These structures reduce the erosion of the berms and minimized surface water run onthereby reducing its sediment carrying capacity and leading to a reduction in erosion and sediment transport of lead off of the range. The berms also reduce the surface water running off the range which promotes on-range infiltration. Periodic maintenance of the berms, including regrading after major storm events to rework soil that has been moved /shifted during major storms, also is conducted.

Although rounds can be fired over the berm, its occurrence is very infrequent. The lead concentrations detected in sampling points behind the berm were 41.7 and 33.7 mg/kg in the top 6 inches of ground surface. These values were below screening criteria and significantly below detections at the berm and target line (maximum concentration detected 1200 mg/kg) (Panacea, 2005; DON, 1995). The lower concentrations detected off range suggest the target berm is containing a majority of the ammunition fired on range.

There are no known uses of surface water (e.g., potable water source, irrigation, recreation) by human receptors because surface water is not present within the Mojave River and its associated drainages contain water only during infrequent storm events. The desert tortoise, which is present on the Rifle Range Complex, potentially may interact with surface water in drainages running north toward the Mojave River. However, given the velocity of runoff moving through the drainages during the torrential storms in the region and limited contact time of runoff with underlying soil (thus limiting contact time for dissolution of lead), it is unlikely that the desert tortoise would be exposed to lead dissolved in surface water draining from the operational ranges. Desert tortoises have been noted to create depressions in their territories to collect rainwater and occasionally sit in the depressions in anticipation of storms (Malcolm Pirnie, 2007). During the storms, the water is fast moving and typically does not remain collected in one area for a large period of time. Therefore, the desert tortoise exposure to lead contained in surface water is limited.

Sediment in the drainages could present potential exposure pathway to the desert tortoise through dermal contact; however, lead transport in sediment from the ranges is likely limited due to the existing control berm structures that reduce erosion. Therefore, this minimizes this exposure pathway.

#### **4.8.2. Groundwater Pathway**

The groundwater pathway was evaluated because of the highly permeable gravelly sandy soil present at the Rifle Range Complex. High temperatures and low humidity in the region contribute to high rates of evaporation. Additionally the depth to groundwater is great. Based on these factors, the potential for infiltration to groundwater is very limited.

Site conditions suggest the pH of the soil is neutral or slightly alkaline, indicating that the lead deposited on site likely will remain absorbed to the soil instead of migrating downward in the limited infiltration that occurs. Furthermore, the depth to groundwater at the ranges limits the potential for lead to migrate downward to the groundwater. Studies have indicated that the depth to groundwater approximately 1.5 miles northwest of the Rifle Range ranges from 160 to 210 feet bgs. Groundwater depth on the alluvial fan south of Interstate 40 near the Rifle Range Complex has been documented to be 175 feet bgs (Jacobs Engineering, 1997; Tetra Tech, 2003).



If lead deposited on the ranges reaches the deep groundwater, pH measurements of groundwater (pH between 7.79 and 7.81) indicate that it is unlikely to desorb and migrate with subsurface flow. The closest groundwater extraction wells for potable use are located at the Yermo Annex. It is unlikely for lead in groundwater at the Rifle Ranges to be transported to these wells due to the water chemistry, the significant distance to the wells, and the presence of the Harper Lake-Camp fault, which traverses the Rifle Range complex. It could be possible for lead transported in the ephemeral washes and the Mojave River to recharge the Mojave River aquifer within the Yermo Annex where the supply wells are screened. However, this pathway is likely limited due to the average storm water pH of 8 that favors a condition for lead to precipitate out of solution or remain bound to soil instead of dissolving in water. The pathway is further limited by the control side berm structures that reduce the surface water runoff rate at the Rifle Ranges and the travel distance that will lead to dilution.

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## 5. Small Arms Range Assessments

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The REVA indicator MC for SARs is lead because it is the most prevalent (by weight) potentially hazardous constituent associated with small arms ammunition. Training areas and ranges that use only small arms ammunition (defined solely for the purposes of REVA as nonexplosive ammunition, .50 cal or smaller) are qualitatively assessed. The SARs at MCLB Barstow are used for the mandatory weapons qualifications by Marines on their assigned individual small arms including rifle, pistol and/or shotgun. Ranges that perform joint small arms and live-fire training with high explosive munitions are not assessed through this process and are not applicable to MCLB Barstow. Only operational SARs are addressed in this protocol.

The SARAP was developed as a qualitative approach to identify and assess factors that influence the potential for lead to migrate from an operational range. These factors include the following:

- Range design and layout, including any best management practices
- Physical and chemical characteristics of the area
- Past and present operation and maintenance practices.

In addition, potential receptors and pathways are identified relative to the SAR. The assessment includes an evaluation of the potential for an identified receptor to be impacted by MC migration through an identified pathway.

### 5.1. Summary of the Small Arms Range Assessment Protocol

The SARAP produces two ratings: the sum of surface water elements and the sum of groundwater elements. These determine the overall rankings for surface water and groundwater conditions. The scoring system assigns minimal, moderate, and high values for each category:

- Minimal (0 to 29 points) – SAR has minimal or no potential for lead to migrate to a receptor, but actions may be necessary to ensure that continuing training activity at the range does not pose a future threat to human health and the environment.
- Moderate (30 to 49 points) – The SAR may have the potential for lead to migrate to a receptor, most likely indicating no immediate threat to human health and the environment, but actions may be necessary to mitigate future concerns.
- High (50 to 65 points) – The SAR has high potential for lead to migrate to an identified receptor and requires additional action(s).

The completed SARAPs for MCLB Barstow are provided in Appendix A and include information used in performing the assessments. Where warranted, key range-specific considerations not captured by the SARAP were taken into account during the assessments, and rankings were modified accordingly.

The general locations of the ranges are shown in **Figure 3-1**. **Table 5-1** provides a summary of SAR assessments. Given the similarity in site conditions among the three SARs, the final SARAP results are discussed together in Section 5.2.4.

**Table 5-1: SAR Qualitative Ranking**

SAR	Surface Water Ranking	Groundwater Ranking
Rifle Range	Minimal	Minimal
Pistol Range	Minimal	Minimal
Shotgun Range	Minimal	Minimal

## 5.2. Small Arms Ranges

Three SARs are located at MCLB Barstow, as seen in **Figure 3-1**, **Figure 5-1** and **Figure 5-2**. The general information used to document soil characteristics, groundwater characteristics, fate and transport pathways, potential receptors, and T/E species is the same for all three ranges. Site-specific information, if available, was used to complete the SARAPs for each SAR and is provided in Appendix A.

The impact berms at all three ranges were reconstructed in August 2012. The existing soil was removed and sieved to remove lead shot. The final total lead weight for the projectiles recovered at MCLB Barstow is 12,110 lb. It is estimated approximately 50% of the material is from the Pistol Range, 35% from the Rifle Range, and 15% from the Shotgun Range (Sherer, pers comm). Prior to replacing the soil on the berms, erosion control matting (Envirogrid) was put in place. The soil was replaced on the berms to a 2/1 rise. Ballistic block walls were constructed at the base of the impact berms. Photographs of the construction are provided in **Appendix B**. The removal of the source material significantly reduces the potential for lead transport.

Information from the baseline report indicates two previous mining events were completed on the Rifle Range between 1990 and 2005 and one mining event each occurred on the Pistol and Shotgun Ranges in the early 2000s (Stormo, pers comm.). The exact dates of berm mining were

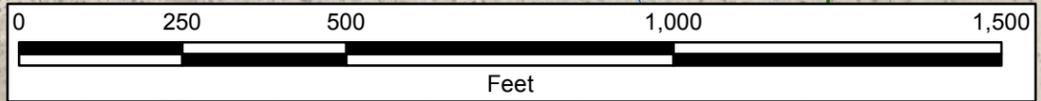
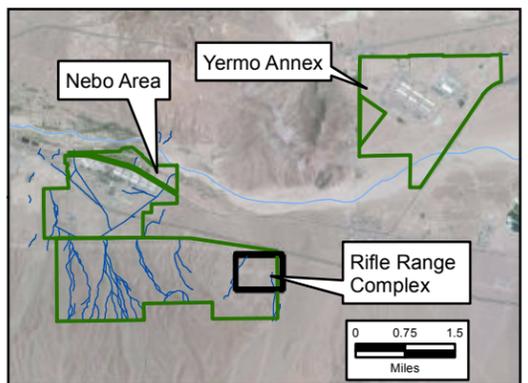




**Figure 5-1  
Rifle Range**  
**Range Environmental  
Vulnerability Assessment  
5-Year Review  
MCLB Barstow  
Barstow, CA**

**Legend**

- Installation Boundary
- Surface Water Course**
- ~~~~~ Dry
- ~~~~~ Intermittent



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**Figure 5-2**  
**Pistol and Shotgun Ranges**  
 Range Environmental  
 Vulnerability Assessment  
 5-Year Review  
 MCLB Barstow  
 Barstow, CA

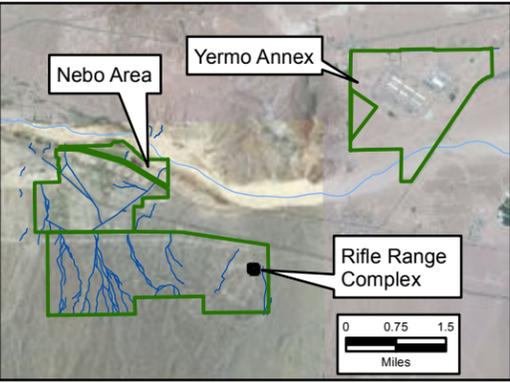
**Legend**

- Installation Boundary
- Soil Sample Location

**Surface Water Course**

- ~ Dry
- ~ Intermittent

Soil Sample ID  
Lead Concentration (mg/kg)



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not known, and no additional information on these mining events was identified in the five-year review data collection.

Berm material occasionally is replenished to fill bullet pockets to reduce erosion and potential lead transport. Routine maintenance at the complex includes repairing firing berm erosion and trimming vegetation in the live-fire areas. Road grading activity redistributes sediment displaced over time due to erosion. The grading is conducted semiannually and after severe storms as needed. The areas graded may include the access roads, including the road that runs behind the impact berm at the Pistol and Shotgun Ranges, and parking lots (semiannually). This activity also potentially can redistribute lead material. During the March 2012 site visit, lead fragments were observed in the roadbed behind the Shotgun and Pistol Range berms and on the back sides of the berms, as if moved by grading activities.

Minimal scrub vegetation was observed during the site visit in the area between the firing lines and the backstop berm at the Rifle Range and surrounding the firing lines and the berms of all ranges. An environmental assessment of the range area conducted in 2006 describes the area as relatively open with 10% to 20% vegetative cover provided by creosote bush scrub (USMC, 2006). This is the predominant vegetative community in the Rifle Range Complex (Tierra Data, 2005).

The soils at MCLB Barstow include a mixture of sands, gravelly sands, and loamy sands with low organic content (Tierra Data, 2005). The range floors of the Pistol and Shotgun Ranges are gravel. These sandy soil types are permeable, and the slopes within the Rifle Range footprint are relatively flat, suggesting infiltration is the predominant water transport mechanism. However, precipitation can occur at MCLB Barstow in intense rainfall events. This can generate flash flood conditions and increase the potential for erosion and surface runoff rather than infiltration. High evaporation rates in the region (111 inches) also limit infiltration (Western Region Climate Center, 2007).

Surface water and groundwater receptors for the installation are identified in Section 4. No drinking water wells are present at the Rifle Range Complex; potable water is trucked in from an off-site source. The closest wells used for potable water sources are located 2.5 miles to the northeast at the Yermo Annex. The Ord-Rodman DWMA is considered critical habitat for the desert tortoise and is located south of the Rifle Range SDZ. The desert tortoise has been observed within and around the Rifle Range Complex (**Figure 3-1**). As REVA only assesses ecological receptors in off-range locations and surface water runoff travels from the source area (e.g., the impact berm) to the north, only desert tortoises located north of the Rifle Range have the potential to come into contact with lead in surface water. Desert tortoises have been noted to create depressions in their territories to collect rainwater and occasionally sit in the depressions in anticipation of storms (Malcolm Pirnie, 2007). During the storms, the water is fast moving and typically does not remain collected in one area for a large period of time. Therefore, the desert

tortoise exposure to lead contained in surface water is limited. The sediment in the ephemeral washes could present potential exposure pathway to the desert tortoises; however, lead transport in sediment from the ranges is likely limited due to the existing control structures at the ranges that minimize erosion.

### 5.2.1. Rifle Range

The Rifle Range is used for marksmanship training and (re)qualification of Marines at MCLB Barstow. Based on the expenditure data recorded in RFMSS and discussions with MCLB Barstow Base Operations personnel, one type of small arms ammunition currently is used at the Rifle Range. The direction of fire is westerly into an impact berm. Currently, the 25-, 200-, 300- and 500-yard firing lines are used, and the 600- and 1000-yard firing lines are not. A general location of the range is depicted in **Figure 5-1**.

RFMSS recorded that 914 personnel trained at the Rifle Range from October 2010 through September 2011. During the five-year review period, the Rifle Range had an estimated lead loading rate of 279 lb/yr.

Sandbags are piled on top of the impact berm in order to minimize erosion of the berm. Scattered scrub vegetation is present on the range; however, very limited vegetation is present on the berm, likely because of the difficulty of establishing vegetation in the arid environment and the sandy soil matrix on the steep angle of the berm (> 22.5-degree angle). In August 2012, the impact berm at the pistol range was reconstructed. The soil was removed and sieved for lead shot. Erosion control matting was installed on the berm face and soil was replaced on the berms to a 22.5 degree angle. Photographs of the berm reconstruction are provided in Appendix B.

The area that extends out from the berm is graded, which would reduce runoff velocity from the face of the berm. The Rifle Range itself, including the rear impact berm in which most lead accumulates, is primarily composed of Cajon gravelly sands with 2% to 15% slope. The slope of the Rifle Range is flat, with dry washes bisecting the range between firing lines, running south to north toward the Mojave River. Erosion issues at the base of the impact berm, which were noted in the baseline assessment, did not appear to be a concern during the 2012 site visit.

### 5.2.2. Pistol Range

The Pistol Range is used for marksmanship training and (re)qualification of Marines at MCLB Barstow. Based on the expenditure data recorded in RFMSS and discussions with MCLB Barstow Base Operations personnel, two types of small arms ammunition are currently used at the Pistol Range. The direction of fire is southwest into an impact berm. There are 12 firing points and a maximum firing distance of 50 yards. A general location of the range is depicted in **Figure 5-2**.



RFMSS recorded that 441 personnel trained at the Pistol Range from October 2010 through September 2011. During the five-year review period, the Pistol Range had an estimated lead loading rate of 359 lb/yr.

Surface water is prevented from running onto the range by a separate earthen berm constructed on the south side of the adjacent Shotgun Range, as well as the backstop berm at the back of the Pistol Range. Sandbags are piled on top of the impact berm in order to minimize erosion on the berm. Virtually no vegetation is present on the range or the berm. In August 2012, the impact berm at the pistol range was reconstructed. The soil was removed and sieved for lead shot. Erosion control matting was installed on the berm face and soil was replaced on the berms to a 22.5 degree angle. A block wall was constructed at the base of the impact berm. In addition, ballistic panels and blocks were installed on the Pistol Range to reduce ricochets and protect the block wall behind the targets. Photographs of the remodeled impact berm are provided in Appendix B. The top of the berm is sloped slightly away from the berm face to minimize drainage flow across the impact area. The back of the berm is terraced, and wooden beams are located on the back side of the berm to help minimize erosion. Side berms minimize the amount of surface water run-on to the range. Areas southwest of the Shotgun Range drain toward the range and then are diverted either north or northeast, around the range. Runoff then generally runs north, toward the Mojave River. Due to the limited surface water run-on and runoff at the Pistol Range, the majority of rainfall that falls directly on the Pistol Range likely remains on site and evaporates with little infiltration potential.

Soil sampling and analysis at the Pistol Range was completed in 2005. Soil samples were collected from 34 locations on the range, and two background samples were collected behind the berms. As expected, peak lead concentrations were detected on the surface of the main target berm and in front of the target line, with a maximum concentration of 1220 mg/kg at a depth of 6 inches bgs. The lead concentrations detected in soil at the 50-yard firing line (5.40 and 7.0 mg/kg) were below the average lead concentrations established at MCLB Barstow (7.5 mg/kg), as documented in a previous study (DoN, 1995). Lead concentrations generally decrease with increasing distance from the impact berm. The concentrations detected in sampling points behind the berm were 41.7 and 33.7 mg/kg in the 6-inch profile. These values were below screening values and significantly below detections at the berm and target line (Panacea, 2005; DON, 1995). The lower concentrations detected off-range suggest the target berm is containing a majority of the ammunition fired into the impact berm. Although the range is generally flat, it does gently slope toward the firing line. The low concentrations detected at the firing line suggest limited migration of lead off range.

### 5.2.3. Shotgun Range

The Shotgun Range is used for marksmanship training and (re)qualification of Marines at MCLB Barstow. This range was called the Close Combat Pistol Range during the baseline assessment

but currently is called the Shotgun Range at the installation. Based on the expenditure data recorded in RFMSS and discussions with MCLB Barstow Base Operations personnel, one type of small arms ammunition is currently primarily used at the Shotgun Range. There are 20 firing points and a maximum firing distance of 50 yards. A general location of the range is depicted in **Figure 5-2**.

RFMSS recorded that 89 personnel trained at the Shotgun Range from October 2010 through September 2011. It is the least used of the three ranges at MCLB Barstow, with an estimated lead loading rate of 92 lb/yr during the five-year review period.

The control structures on site are similar to the Pistol Range as described in Section 5.2.2. In addition, the impact berm was also reconstructed at the Shotgun Range and photographs are provided in Appendix B. Due to the limited surface water run-on and runoff at the Shotgun Range, the majority of rainfall that falls directly on the range likely remains on site and evaporates with little infiltration potential.

#### **5.2.4. SARAP Assessment Results**

##### Surface Water

The result of the surface water evaluation for all three SARs resulted in minimal scores (27 for the Shotgun Range and 29 for the Rifle and Pistol Ranges).

The minimal scores were determined based on several factors. Lead loading is low across all three SARs and has been mitigated further by the lead mining performed in August 2012. Low precipitation (less than 5 inches per year) is a major contributing factor to limiting the potential for transport. The occasional flush flood storm events that occur have the potential to promote the movement of lead via surface water or sediment pathways. However, the side berm control structures at the Pistol and Shotgun Ranges help reduce surface water runoff rate and minimize soil erosion and sediment transport from these ranges.

Some evidence of erosion was noted at the base of the Rifle Range berms during the baseline assessment, but the berms appeared in good condition with minimal evidence of erosion during the 2012 site visit. Control measures (sandbags) in place appear to limit the amount of erosion on the berm faces minimizing sediment and surface water transport from this range.

The neutral or slightly alkaline condition of the soil and surface water runoff on site limits lead migration via dissolution in surface water. Also, the high rate of evaporation at MCLB Barstow limits the volume of down gradient flow. Lastly, no known human use of surface water was noted during the evaluation. Exposure to ecological receptors (the desert tortoise) via surface water is limited because the water either evaporates or infiltrates into surficial soils quickly.



A minimal score indicates a minimal potential for lead migration to reach off-range receptors. A minimal score also indicates that no further action is required at the site based on the results of the REVA 5-Year Review; however, the sites will be reevaluated in future REVA efforts.

#### Groundwater

The results of the groundwater evaluation for the Pistol and Rifle Ranges resulted in moderate scores (a score of 31 for each range). The Shotgun Range resulted in a minimal score (29). The scores for the Pistol and Rifle Ranges were adjusted from moderate to minimal. The moderate score was driven by the sandy soil conditions on site, which promotes transport through the vadose zone to reach groundwater. The SARAP system does not account for extreme site characteristics, such as desert conditions (low rainfall) as in the case of MCLB Barstow. So, while the SARAP ranking resulted in the moderate range, the following paragraphs describe the qualitative groundwater evaluation and provide the supporting information required to adjust the score to minimal.

The minimal ranking for the Pistol and Rifle Ranges was determined based on several factors. Lead loading is low across all three SARs and has been mitigated further by the lead mining performed in August 2012.

Physical parameters do not promote the movement of lead via groundwater pathways, and it is not expected that lead would reach the water table. Neutral soil pH lowers the rate of dissolution of lead, thereby limiting the migration of lead with infiltrating water. The high temperatures and low humidity promote evaporation and, therefore, limit the amount of water infiltrating down to the groundwater that is estimated to be at a depth of over 160 feet bgs. Due to the depth to groundwater, direct infiltration from rain events is likely not a major contributing source to groundwater. The pH of groundwater is neutral; therefore, even if lead does migrate down to groundwater, it likely will precipitate out of solution and not transport to potential receptor points.

Groundwater wells used for potable water sources at the Yermo Annex are far from the Rifle Range Complex, and the Harper Lake–Camp Rock fault restricts groundwater flow from the range to the Yermo Annex. Therefore, there are no identified human pathway / receptor interactions for lead in groundwater for the Rifle Range Complex. It could be possible for lead transported in the ephemeral washes and the Mojave River to recharge the Mojave River aquifer within the Yermo Annex where the supply wells are screened. However, this pathway is likely limited due the average storm water pH of 8 (which favors a condition for lead to precipitate out of solution or remain bound to soil instead of dissolving in water), the presence of the control side berm structures that reduce the surface water runoff rate at the Pistol and Shotgun Ranges, and the travel distance that will lead to dilution.

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A minimal score indicates a minimal potential for lead migration to reach off-range receptors. A minimal score also indicates that no further action is required at the site based on the results of the REVA 5-Year Review; however, the sites will be reevaluated in future REVA efforts.



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# Appendix A

## Small Arms Range Assessment Protocol Tables



## SMALL ARMS RANGE ASSESSMENT

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### Introduction

The purpose of the Range Environmental Vulnerability Assessment (REVA) is to identify whether there has been a release or there is a substantial threat of a release of munitions constituents (MC) of concern from the operational range or range complex areas to off-range areas. This is accomplished through the use of fate and transport modeling and analysis of the REVA indicator MC based upon site-specific environmental conditions at the operational ranges and training areas at an installation.

Lead is the primary REVA indicator MC for small arms ranges. The fate and transport parameters for lead are based entirely on site-specific geochemical properties, which cannot be determined solely by physical observation. Therefore, small arms ranges associated with the installation are qualitatively reviewed and assessed to identify factors that influence the potential for lead migration at the operational range, including:

- design and layout, including any best management practices in place,
- the physical and chemical characteristics of the area, and
- current and past operation and maintenance practices.

In addition, potential receptors and pathways must be identified relative to the small arms range being assessed. The potential for an identified receptor to be impacted by MC migration through an identified pathway will be evaluated.

MC associated with small arms ammunition commonly used at operational ranges include lead, antimony, copper, and zinc. REVA focuses on lead as the MC indicator for small arms ranges because lead is the most prevalent (by weight) potentially hazardous constituent associated with small arms ammunition. No specific quantitative conclusions can be made regarding the fate and transport of lead since it is unlike any other MC. Lead is geochemically specific regarding its mobility in the environment. Site-specific conditions must be known (i.e., geochemical properties) in order to quantitatively assess lead migration. Site-specific geochemical properties are only identified via sampling and cannot be observed physically. Without site-specific physical and chemical characterization, lead cannot effectively be modeled using fate and transport modeling like the other indicator MC in REVA. The scientific community has established that metallic lead (such as recently fired, unweathered bullets and shot) generally has low chemical reactivity and low solubility in water and is relatively inactive in the environment under most ambient or everyday conditions. However, a portion of lead deposited on a range may become environmentally active if the right combination of conditions exists.

This Small Arms Range Assessment Protocol was developed in lieu of collecting site-specific information for every small arms range. The protocol will help to determine which ranges necessitate data collection of site-specific geochemical properties or further assessment based the range's overall prioritization regarding the potential for an identified receptor to be impacted by potential lead migration through an identified pathway.

## **Purpose**

This protocol is to be used for:

- 1) Identifying the small arms ranges within the Marine Corps that have the greatest potential for lead migration and impact to identified receptors, and
- 2) Assessing the need for implementing further actions. Recommended further actions may include, but are not limited to, the following:
  - Sampling surface water, groundwater, and/or soil
  - Conducting additional studies
  - Implementing best management practices (BMPs)

## **Data Collection and Documentation**

The qualitative assessment process for a small arms range involves first defining and documenting its physical and environmental conditions, as well as how the range is utilized and maintained (including dates of use and types and amounts of small arms ammunition expended). The small arms range data collection form within Section 3 of the REVA Reference Manual is a guide to collecting and documenting the necessary information in order to complete the evaluation forms presented later in this protocol (Tables 1 through 6). It includes a comprehensive list of data elements that are useful in establishing the historical and current physical and environmental conditions, as well as capturing the types of information on conditions that influence lead's potential to migrate from the range. The data collection form is organized by major topics or information areas associated with the operational range, including the following:

- Basic range information
- Current range layout
- Current range operations
- Historical range operations
- Amount of lead potentially deposited
- Environmental characteristics
- Potential receptors
- Surrounding land use

- Environmental activities conducted on the range
- Summary

The data collection form in the REVA Reference Manual can be modified, where needed, to fully capture the major factors that can potentially influence lead's ability to migrate from each specific small arms range.

### **Qualitative Assessment**

The small arms range can be qualitatively assessed once the conditions of the range have been fully understood and documented. The assessment process involves a discussion of possible factors that can influence the potential for lead to migrate off range. Several of these factors are listed below, followed by a detailed discussion:

- Range use and range management (source)
- Surface water conditions
- Groundwater and soil conditions
- Pathways
- Receptors

#### ***Range Use and Range Management (Source)***

The amount of lead and other MC deposited on a range is a combination of the following factors:

- Duration of use
- Current and historical frequency of range usage
- Amount and types of small arms ammunition expended on the range
- Scope and frequency of any range maintenance activities involving the removal of lead from the range
- Presence and duration of bullet-capturing technologies

#### ***Surface Water Conditions***

Under specific pH conditions, lead from shot or bullets can slowly dissolve in water. Runoff and groundwater recharge could transport this dissolved lead off range. In

addition, lead adsorbed onto sediment can be transported off range in surface runoff. The primary factors influencing the potential for lead to migrate via surface water include, but are not limited to, the following:

- pH of the water
- Duration of water contact with the lead
- Intensity and frequency of rainfall
- Steepness of the slope containing lead
- Amount and type of vegetation on the slope
- Infiltration rate of surface soils
- Presence of engineering controls or BMPs to modify or control surface water runoff

### ***Groundwater and Soil Conditions***

The amount of lead that dissolves in water is primarily influenced by the pH of the water and the duration of water contact with the lead. Once lead is dissolved in water, the amount of lead that attaches to the soil and/or enters the groundwater is determined by several factors, including the following:

- Organic carbon content of the soil
- pH of the soil
- Properties of the soil, including porosity, irreducible water content, and hydraulic conductivity
- Amount of recharge percolating through the vadose zone
- Clay content of the soil (lead attaches to clay minerals more than other soil fractions)
- Depth to groundwater

### ***Pathways***

The REVA Small Arms Range Assessment Protocol involves developing a conceptual site model (CSM) for the range to identify the range's physical and environmental conditions. The CSM's purpose is to identify if a potential for source-receptor-pathway interaction may exist. Factors that influence the potential for a source-receptor-pathway

interaction (e.g., heavy range use, potable water supply wells in proximity to the range), as well as factors that decrease the potential for such interactions, should be discussed in the assessment.

Potential pathways include:

- groundwater used as a source of potable or agricultural water,
- the use of surface water downstream of a range as a source of potable or agricultural water, and
- the use of the soil, surface water, or groundwater by sensitive species.

### ***Receptors***

Receptors in REVA can include on-range and off-range personnel and sensitive species and ecosystem areas. Factors considered when assessing the potentially complete exposure pathways for receptors include, but are not limited to, the following:

- The number and proximity of water supply wells relative to the range
- The characteristics of nearby water supply wells (e.g., depth to groundwater, well construction details)
- The uses of the surface water or groundwater (e.g., agriculture, drinking water)
- The locations of nearby sensitive species areas, such as endangered species habitats (i.e., within proximity to the range)

### **Small Arms Range Assessment Protocol**

This Small Arms Range Assessment Protocol is based on evaluating the potential for exposure to receptors by MC. Evaluation rankings for surface water and groundwater conditions are established for each small arms range. The rankings range between high (indicating the highest potential for lead to migrate toward identified receptors) and minimal (indicating the lowest potential for lead to migrate toward identified receptors). Possible recommended actions are based on the evaluation rankings assigned by the protocol. High rankings necessitate further actions. Further actions may include sampling, additional site-specific studies, and/or BMPs. These actions will be evaluated based on site conditions for each range.

### ***Protocol Instructions***

1. For Tables 1 through 5:
  - a. Enter the appropriate score for each criteria in the site score column. Use the highest (i.e., most conservative) value if no information is known to complete the score. A designated score may be overridden if it is determined that the value does not adequately represent the site based on site characteristics and constituent loading estimates, mark the score column appropriately (\*) and fill in the notes section at the bottom of the table with text detailing why the score was adjusted. Sum the site scores in the last row.
2. Transfer the scores from Tables 1 through 5 onto Table 6 in the appropriate rows.
3. Use the scores in Table 6 to determine the surface water and groundwater evaluation rankings.

### ***Evaluation Ranking Designation***

Once Table 6 is complete, the protocol finishes with two scores: the sum of surface water elements and the sum of groundwater elements. These scores are used to identify the appropriate evaluation ranking (High, Moderate, Minimal) for surface water and groundwater (as mentioned in step 3 of the protocol instructions).

The surface water evaluation ranking and the groundwater evaluation ranking identify the potential impact for lead migration for each of those pathways at the small arms range.

The ranking designations and their descriptions follow:

- High = Small arms range most likely has the potential for lead migration to an identified receptor and requires additional action(s).
- Moderate = Small arms range may have the potential for lead migration to a receptor, most likely indicating that there is no immediate threat to human health and the environment, but actions may be necessary to mitigate future concerns.
- Minimal = Small arms range has minimal or no potential for lead migration, but actions may be necessary to ensure that continuing training activity at the range does not pose a future threat to human health and the environment.

These rankings are used to determine whether additional actions are appropriate. The evaluation ranking (surface water or groundwater), as determined in Table 6, is used to

evaluate if further actions are suggested, based on the guidelines for recommended actions (Table 7, provided on Page A-9).

The overall range evaluation rankings are compared to each range within the installation and to the overall rankings of all ranges across the Marine Corps. These rankings assist in determining how funding should best be allocated across the Marine Corps to address SARs with the highest potential for off-range migration of lead.

### **Assessment Report**

Once the Small Arms Range Assessment Protocol has been completed and appropriate actions have been designated and implemented, the assessment should be written into a report that describes the process taken, details the information used to score Tables 1 through 5, outlines the scores and evaluation rankings, and identifies the additional actions taken. The report should detail whether an identified receptor is or is not impacted by lead migration through the identified pathway(s). The completed protocol tables should be included as an appendix to the report.

### **Best Management Practices for Small Arms Ranges**

BMPs are important for all ranges and should be used appropriately to maintain the sustainability of operational ranges. However, this protocol prioritizes which small arms ranges may need BMPs to address specific possibilities of lead migration.

Following the Small Arms Range Assessment Protocol, BMPs may be recommended based on the evaluation ranking. Prior to selecting and implementing BMPs, the management objectives must be established. Depending on the range-specific site conditions and the management objectives, the following BMPs should be considered:

- Bullet and shot containment techniques (e.g., berms, backstops, traps)
- Prevention of soil erosion from berms, aprons, and other range areas
- Soil amendments
- Recovery and/or recycling of lead

Negative impacts of implementation should also be considered when selecting a BMP. For example, using soil amendments may affect water quality of nearby water bodies or modifying surface water runoff may impact nearby habitats.

The prevention of soil erosion can be achieved by implementing one or several of the following practices:

- Maintaining vegetation on berms and drainageways
- Reducing runoff rates by adjusting site drainage patterns
- Providing sediment traps such as a vegetated detention basin or infiltration area
- Preventing the creation of a “point source”

Soil amendments may be an effective BMP by implementing one or both of the following practices:

- Increasing the retentive capacity of soil by adding organic matter, fertilizer, and/or lime
- Maintaining a pH range between 6 and 8 by adding triple superphosphate, bone meal, or other applicable additives

The recovery and recycling of lead from operational ranges should be considered as a way to control the migration of lead. The following should be considered when implementing recovery and recycling practices:

- Focus on safety as the primary concern of the proposed activities
- Avoid practices that appear as treatment activities (e.g. acid leaching, fixation, etc.)
- Dispose lead by using a lead recycler or smelter
- Use residual soil for the original purpose (e.g. berm/target area soil) following lead recovery practices.

<b>Table A-1: Guidelines for Recommended Actions</b>	
<b>Evaluation Ranking</b>	<b>Recommended Action</b>
<b>High</b>	Action required. 1) Consider sampling appropriate media (groundwater, surface water, and/or soil). 2) Identify and implement BMPs, if necessary.
<b>Moderate</b>	1) Consider identifying and implementing BMPs, if necessary. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
<b>Minimal</b>	1) No further action is needed at this time. 2) Consider identifying and implementing BMPs, if necessary.

**SARAP Tables**

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Rifle Range  
MARINE CORPS LOGISTICS BASE BARSTOW  
BARSTOW, CALIFORNIA

The Rifle Range is used for marksmanship training and (re)qualification of Marines at MCLB Barstow. This is a small arms range that primarily uses one type of small arms ammunition. The direction of fire is towards the west into an impact berm. Currently, the 25-, 200-, 300-, and 500-yard firing lines are used, and the 600- and 1000-yard firing lines are not.

FIVE-YEAR REVIEW ASSESSMENT RESULTS:

The surface water evaluation resulted in a minimal ranking (29 points). Range conditions presented in the following tables were evaluated using public databases, historical documentation, information gathered from interviews with installation personnel, and field observations made during the site visit. Lead loading is low, and the range is used only two to three times per month. Site conditions (low precipitation and high evaporation; neutral surface water and soil pH) and engineered controls minimize the potential for lead migration, and there is limited or no presence of receptors (no human receptors; limited potential exposure to ecological receptors).

The groundwater evaluation resulted in a moderate ranking (31). This score was adjusted from moderate to minimal based on several factors. The moderate score is driven by the sandy soil conditions which promotes transport through the vadose zone to reach groundwater. The SARAP system does not account for extreme site characteristics such as desert conditions (low rainfall) as in the case of MCLB Barstow. Low range use and site conditions (low precipitation, high evaporation rate, neutral soil pH, depth to groundwater) minimize potential for lead to reach groundwater. In addition, there are limited receptor exposure points (groundwater wells).

**MARINE CORPS LOGISTICS BASE BARSTOW  
RIFLE RANGE**

<b>Table 1: Range Use and Range Management (Source) Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Duration of Range Use</b>	<i>Range used from 1955 to present.</i>	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
<b>Bullet-Capturing Technology</b>	<i>There is an impact berm at the range, but no bullet-capturing technology has ever been in place at the range.</i>	-3 if range usage duration = bullet capture duration -1 if range usage duration – bullet capture duration = 10 to 30 years 0 if range usage duration – bullet capture duration > 30 years, or no bullet capture technology present.	0
<b>MC Loading Rates</b>	<i>Approximately 279 pounds of lead per year are used at the rifle range.</i>	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	3
<b>Range Maintenance</b>	<i>Lead removal was completed in August 2012. Lead removal is conducted on an as needed basis.</i>	5 if lead is removed less than every three years 3 if lead is removed more than every three years but less than annually 1 if lead is removed at least annually	5
<b>Source Element Score</b>			13
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
RIFLE RANGE**

<b>Table 2: Surface Water Pathways Characteristics Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>pH of Water</b>	Gaging stations in the Mojave hydrologic unit near MCLB Barstow for years ranging from 2009 through 2012 have an average field measured pH value of 8.1 and most frequently measured value of 8 (USGS, 2012).	5 if pH < 6.5 3 if pH > 8.5 1 if pH 6.5 ≤ pH ≤ 8.5	1
<b>Precipitation</b>	<i>Annual average precipitation is approximately 4.4 inches per year.</i>	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
<b>Slope of Range and Berm</b>	<i>Based on a visual survey, the slope of the berm is greater than 50%. The area in front of the berm is largely flat.</i>	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
<b>Vegetation</b>	<i>There is very sparse scrub vegetation on the range.</i>	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	5
<b>Soil Type/Runoff Conditions</b>	<i>Soils are typically low in organic material and a mixture of sands: coarse sand, gravelly sand, and loamy sand.</i>	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1
<b>Runoff/Erosion Engineering Controls</b>	<i>Sandbags were placed on top of the berm to minimize erosion, and backside of the berm was sloped to reduce run-on down the face of the berm. The front of the berm is graded to help reduce run-off velocity. Side berms help retain some of the run-off north of the range.</i>	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	-5
<b>Surface Water Pathway Score</b>			<b>8</b>
<b>Notes:</b> Water quality data collected from United States Geological Survey (USGS) stream gages at Barstow (USGS stream gage 10262500) have field measured pH concentrations above 6.5. One water quality sample at Barstow had a pH of 7.8 (USGS, 2007).			

**MARINE CORPS LOGISTICS BASE BARSTOW  
RIFLE RANGE**

<b>Table 3: Groundwater Pathways Characteristics Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Depth to Groundwater</b>	Studies conducted at an Installation Restoration Program site located approximately 1.5 miles northwest of the Rifle Range documented depth to water between 160 and 210 feet bgs. Depths up to 175 feet bgs have been noted on the alluvial fan south of Interstate 40 near the Rifle Range Complex (Jacobs Engineering, 1997; Tetra Tech, 2003).	5 if depth to groundwater < 20 feet 3 if depth to groundwater = 20-99 feet 1 if depth to groundwater = 100-300 feet 0 if depth to groundwater >300 feet	1
<b>Precipitation</b>	<i>Annual average precipitation is approximately 4.4 inches per year.</i>	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
<b>pH of Water</b>	<i>pH measurements averaged approximately 7.5 during 2011 groundwater sampling conducted at the installation.</i>	5 if pH < 6.5 3 if pH > 8.5 1 if pH 6.5 ≤ pH ≤ 8.5	1
<b>pH of Soil</b>	<i>NCRS soil data suggest a pH between 7.4-8.4</i>	5 if pH < 6.5 3 if pH > 8.5 1 if pH 6.5 ≤ pH ≤ 8.5	1
<b>Soil Type/Infiltration Conditions</b>	<i>Soil type is sand.</i>	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
<b>Clay Content in Soil</b>	<i>Little to no clay is present.</i>	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
<b>Groundwater Pathway Score</b>			<b>14</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
RIFLE RANGE**

<b>Table 4: Surface Water Receptors Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Drinking Water Usage</b>	<i>The Mojave River is the primary surface water body in the area, and it is not used for drinking water; however, the Mojave River is connected with the Mojave River aquifer and the Regional aquifer.</i>	<p>10 if analytical data or observable evidence indicates that contamination in the media is present at, is moving toward, or has a reasonable potential to move toward a surface water body used as a potable water supply or if a designation as a potable water source is unknown</p> <p>5 if contamination in the media has moved or is expected to move only slightly beyond the source (tens of feet) or could move, but is not moving appreciably, toward surface water body used as a potable water supply or if a designation as a potable water source is unknown</p> <p>2 if low possibility for contamination in the media to be present at or migrate to a point of exposure</p>	2
<b>Agricultural or Other Beneficial Usage</b>	<i>Because of the climate, minimal agriculture is conducted in the area. The closest known agricultural farms are approximately 10 miles east of the installation.</i>	<p>5 if analytical data or observable evidence indicates that contamination in the media is present at, is moving toward, or has moved to a point of exposure or if a designation as agricultural or other beneficial usage is unknown</p> <p>3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably.</p> <p>1 if low possibility for contamination in the media to be present at or migrate to a point of exposure</p>	1
<b>Sensitive Species Habitat and Threatened or Endangered Species</b>	<i>The desert tortoise is present in the range complex and could potentially access surface water (when flowing) and sediment. However, the infrequent rainfall is expected to limit the access to potentially contaminated media.</i>	<p>10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary</p> <p>5 if potential for receptors to have access to possibly contaminated media</p> <p>1 if little or no potential for receptors to have access to possible contaminated media</p>	5
<b>Surface Water Receptor Score</b>			<b>8</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
RIFLE RANGE**

<b>Table 5: Groundwater Receptors Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Wells Identified as Potable Water Sources</b>	<i>The closest potable water supply wells are located at the Yermo Annex . A fault prevents groundwater from the Rifle Range complex from reaching groundwater serving the potable wells.</i>	<p>10 if analytical data or observable evidence or site conditions indicate that MC may be within or moving toward a reasonable radius of influence of a well or other point of exposure or if a designation as a potable water source is unknown</p> <p>5 if analytical data or observable evidence or site conditions indicate that MC have moved only slightly beyond the source (tens of feet) or could move toward a reasonable radius of influence of a well or other point of exposure, but are not moving appreciably</p> <p>2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure</p>	2
<b>Wells Identified for Agricultural or Other Beneficial Usage</b>	<i>Groundwater supply wells for the MCLB golf course are located cross-gradient from the rifle range. The closest non-potable well is over one mile from the pistol range.</i>	<p>5 if analytical data or observable evidence or site conditions indicate that MC may be within or moving toward a reasonable radius of influence of a well or other point of exposure or if a designation as agricultural or other beneficial usage is unknown</p> <p>3 if analytical data or observable evidence or site conditions indicate that MC have moved only slightly beyond the source (tens of feet) or could move toward a reasonable radius of influence of a well or other point of exposure, but are not moving appreciably</p> <p>1 if low possibility for MC to be present at or migrate to within a reasonable radius of influence of a well or point of exposure</p>	1
<b>Sensitive Species Habitat and Threatened and Endangered Species</b>	<i>The desert tortoise is present in the area, but there are no known points where it could access groundwater.</i>	<p>5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources</p> <p>3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources</p> <p>1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources</p>	1
<b>Groundwater Receptor Score</b>			<b>4</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
RIFLE RANGE**

<b>Table 6: Evaluation Results</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)										
<b>Surface Water</b>										
Element	Table	Score								
Range Use and Range Management (Source)	1	13								
Surface Water Pathways	2	8								
Surface Water Receptors	4	8								
<b>Sum of Surface Water Element Scores</b>		<b>29</b>								
<b>Groundwater</b>										
Element	Table	Score								
Range Use and Range Management (Source)	1	13								
Groundwater Pathways	3	14								
Groundwater Receptors	5	4								
<b>Sum of Groundwater Element Scores</b>		<b>31</b>								
<p>The evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:</p> <table border="0" style="width: 100%;"> <thead> <tr> <th style="text-align: left;"><u>Evaluation Ranking*</u></th> <th style="text-align: left;"><u>Score Range</u></th> </tr> </thead> <tbody> <tr> <td>High</td> <td>50-65</td> </tr> <tr> <td>Moderate</td> <td>30-49</td> </tr> <tr> <td>Minimal</td> <td>0-29</td> </tr> </tbody> </table> <p>*Use the Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table A-1.</p>		<u>Evaluation Ranking*</u>	<u>Score Range</u>	High	50-65	Moderate	30-49	Minimal	0-29	
<u>Evaluation Ranking*</u>	<u>Score Range</u>									
High	50-65									
Moderate	30-49									
Minimal	0-29									
<b>Surface Water Evaluation Ranking</b>		<b>Minimal</b>								
<b>Groundwater Evaluation Ranking</b>		<b>Moderate*</b>								
<p>Notes:</p> <ul style="list-style-type: none"> <li>The Groundwater Evaluation Ranking has been modified from Moderate to Minimal. The moderate score is driven by the sandy soil conditions on site which promote transport through the vadose zone to reach groundwater. The low range use and site conditions (low precipitation, high evaporation rate, neutral soil pH, depth to groundwater) minimize potential for lead to reach groundwater. In addition, there are limited receptor exposure points (groundwater wells).</li> </ul>										

Pistol Range  
MARINE CORPS LOGISTICS BASE BARSTOW  
BARSTOW, CALIFORNIA

The Pistol Range is used for marksmanship training and (re)qualification of Marines at MCLB Barstow. This range uses five types of small arms ammunition. There are 12 firing points and a maximum firing distance of 50 yards.

FIVE-YEAR REVIEW ASSESSMENT RESULTS:

The Surface Water Ranking is Minimal. Range conditions presented in the following tables were evaluated using sampling data from the 2005 sampling event, public databases, historical documentation, installation personnel interviews, and field observations made during the site visit. Lead loading is low, and the range is used only two to three times per month. Site conditions (low precipitation and high evaporation; neutral surface water and soil pH) minimize the potential for lead migration, and there is limited or no presence of receptors (no human receptors; limited potential exposure to ecological receptors).

The groundwater evaluation resulted in a moderate ranking (31). This score was adjusted from moderate to minimal based on several factors. The moderate score is driven by the sandy soil conditions which promotes transport through the vadose zone to reach groundwater. The SARAP system does not account for extreme site characteristics such as desert conditions (low rainfall) as in the case of MCLB Barstow. Low range use and site conditions (low precipitation, high evaporation rate, neutral soil pH, depth to groundwater) minimize potential for lead to reach groundwater. In addition, there are limited receptor exposure points (groundwater wells).

**MARINE CORPS LOGISTICS BASE BARSTOW  
PISTOL RANGE**

<b>Table 1: Range Use and Range Management (Source) Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Duration of Range Use</b>	<i>Range used from 1955 to present.</i>	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
<b>Bullet-Capturing Technology</b>	<i>There is an impact berm at the range, but no bullet-capturing technology has ever been in place at the range.</i>	-3 if range usage duration = bullet capture duration -1 if range usage duration – bullet capture duration = 10 to 30 years 0 if range usage duration – bullet capture duration > 30 years, or no bullet capture technology present.	0
<b>MC Loading Rates</b>	<i>Approximately 359 pounds of lead per year are used at the pistol range.</i>	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	3
<b>Range Maintenance</b>	<i>Lead removal was completed in August 2012. Lead removal is conducted on an as needed basis.</i>	5 if lead is removed less than every three years 3 if lead is removed more than every three years but less than annually 1 if lead is removed at least annually	5
<b>Source Element Score</b>			13
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
PISTOL RANGE**

<b>Table 2: Surface Water Pathways Characteristics Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>pH of Water</b>	Gaging stations in the Mojave hydrologic unit near MCLB Barstow for years ranging from 2009 through 2012 have an average field measured pH value of 8.1 and most frequently measured value of 8 (USGS, 2012).	5 if pH < 6.5 3 if pH > 8.5 1 if pH 6.5 ≤ pH ≤ 8.5	1
<b>Precipitation</b>	<i>Annual average precipitation is approximately 4.4 inches per year.</i>	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
<b>Slope of Range and Berm</b>	<i>Based on a visual survey, the slope of the berm is approximately 22.5 degrees. The range is largely flat.</i>	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
<b>Vegetation</b>	<i>There is virtually no vegetation on the range. A few scrub bushes are present on side berms but are very sparse.</i>	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	5
<b>Soil Type/Runoff Conditions</b>	<i>Soils are typically low in organic material and a mixture of sands: coarse sand, gravelly sand, and loamy sand.</i>	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1
<b>Runoff/ Erosion Engineering Controls</b>	<i>A wall of sandbags is present at the foot of the berm in an effort to control sand that could potentially erode down the berm. The top of the berm is slightly sloped towards the back to prevent run on down the face of the berm. The back and side berms are present at the range which minimize run-on to the range.</i>	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	-5
<b>Surface Water Pathway Score</b>			<b>8</b>
<b>Notes:</b> Water quality data collected from United States Geological Survey (USGS) stream gages at Barstow (USGS stream gage 10262500) have field measured pH concentrations above 6.5. One water quality sample at Barstow had a pH of 7.8 (USGS, 2007).			

**MARINE CORPS LOGISTICS BASE BARSTOW  
PISTOL RANGE**

<b>Table 3: Groundwater Pathways Characteristics Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Depth to Groundwater</b>	Studies conducted at an Installation Restoration Program site located approximately 1.5 miles northwest of the Rifle Range documented depth to water between 160 and 210 feet bgs. Depths up to 175 feet bgs have been noted on the alluvial fan south of Interstate 40 near the Rifle Range Complex (Jacobs Engineering, 1997; Tetra Tech, 2003).	5 if depth to groundwater < 20 feet 3 if depth to groundwater = 20-99 feet 1 if depth to groundwater = 100-300 feet 0 if depth to groundwater >300 feet	1
<b>Precipitation</b>	<i>Annual average precipitation is approximately 4.4 inches per year.</i>	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
<b>pH of Water</b>	<i>pH measurements averaged approximately 7.5 during 2011 groundwater sampling conducted at the installation.</i>	5 if pH < 6.5 3 if pH > 8.5 1 if pH 6.5 ≤ pH ≤ 8.5	1
<b>pH of Soil</b>	<i>NCRS soil data suggest a pH between 7.4-8.4</i>	5 if pH < 6.5 3 if pH > 8.5 1 if pH 6.5 ≤ pH ≤ 8.5	1
<b>Soil Type/Infiltration Conditions</b>	<i>Soil type is sand.</i>	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
<b>Clay Content in Soil</b>	<i>Little to no clay is present.</i>	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
<b>Groundwater Pathway Score</b>			<b>14</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
PISTOL RANGE**

<b>Table 4: Surface Water Receptors Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Drinking Water Usage</b>	<i>The Mojave River is the primary surface water body in the area, and it is not used for drinking water; however, the Mojave River is connected with the Mojave River aquifer and the Regional aquifer.</i>	<p>10 if analytical data or observable evidence indicates that contamination in the media is present at, is moving toward, or has a reasonable potential to move toward a surface water body used as a potable water supply or if a designation as a potable water source is unknown</p> <p>5 if contamination in the media has moved or is expected to move only slightly beyond the source (tens of feet) or could move, but is not moving appreciably, toward surface water body used as a potable water supply or if a designation as a potable water source is unknown</p> <p>2 if low possibility for contamination in the media to be present at or migrate to a point of exposure</p>	2
<b>Agricultural or Other Beneficial Usage</b>	<i>Because of the climate, minimal agriculture is conducted in the area. The closest known agricultural farms are approximately 10 miles east of the installation.</i>	<p>5 if analytical data or observable evidence indicates that contamination in the media is present at, is moving toward, or has moved to a point of exposure or if a designation as agricultural or other beneficial usage is unknown</p> <p>3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably.</p> <p>1 if low possibility for contamination in the media to be present at or migrate to a point of exposure</p>	1
<b>Sensitive Species Habitat and Threatened or Endangered Species</b>	<i>The desert tortoise is present in the range complex and could potentially access surface water (when flowing) and sediment. However, the infrequent rainfall is expected to limit the access to potentially contaminated media.</i>	<p>10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary</p> <p>5 if potential for receptors to have access to possibly contaminated media</p> <p>1 if little or no potential for receptors to have access to possible contaminated media</p>	5
<b>Surface Water Receptor Score</b>			<b>8</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
PISTOL RANGE**

<b>Table 5: Groundwater Receptors Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Wells Identified as Potable Water Sources</b>	<i>The closest potable water supply wells are located at the Yermo Annex which . A fault prevents groundwater from the Rifle Range complex from reaching groundwater serving the potable wells.</i>	<p>10 if analytical data or observable evidence or site conditions indicate that MC may be within or moving toward a reasonable radius of influence of a well or other point of exposure or if a designation as a potable water source is unknown</p> <p>5 if analytical data or observable evidence or site conditions indicate that MC have moved only slightly beyond the source (tens of feet) or could move toward a reasonable radius of influence of a well or other point of exposure, but are not moving appreciably</p> <p>2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure</p>	2
<b>Wells Identified for Agricultural or Other Beneficial Usage</b>	<i>Groundwater supply wells for the MCLB golf course are located cross-gradient from the pistol range. The closest non-potable well is over one mile from the pistol range.</i>	<p>5 if analytical data or observable evidence or site conditions indicate that MC may be within or moving toward a reasonable radius of influence of a well or other point of exposure or if a designation as agricultural or other beneficial usage is unknown</p> <p>3 if analytical data or observable evidence or site conditions indicate that MC have moved only slightly beyond the source (tens of feet) or could move toward a reasonable radius of influence of a well or other point of exposure, but are not moving appreciably</p> <p>1 if low possibility for MC to be present at or migrate to within a reasonable radius of influence of a well or point of exposure</p>	1
<b>Sensitive Species Habitat and Threatened and Endangered Species</b>	<i>The desert tortoise is present in the area, but there are no known points where it could access groundwater.</i>	<p>5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources</p> <p>3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources</p> <p>1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources</p>	1
<b>Groundwater Receptor Score</b>			<b>4</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
PISTOL RANGE**

<b>Table 6: Evaluation Results</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)										
<b>Surface Water</b>										
Element	Table	Score								
Range Use and Range Management (Source)	1	13								
Surface Water Pathways	2	8								
Surface Water Receptors	4	8								
<b>Sum of Surface Water Element Scores</b>		<b>29</b>								
<b>Groundwater</b>										
Element	Table	Score								
Range Use and Range Management (Source)	1	13								
Groundwater Pathways	3	14								
Groundwater Receptors	5	4								
<b>Sum of Groundwater Element Scores</b>		<b>31</b>								
<p>The evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:</p> <table border="0" style="width: 100%;"> <thead> <tr> <th style="text-align: left;"><u>Evaluation Ranking*</u></th> <th style="text-align: left;"><u>Score Range</u></th> </tr> </thead> <tbody> <tr> <td>High</td> <td>50-65</td> </tr> <tr> <td>Moderate</td> <td>30-49</td> </tr> <tr> <td>Minimal</td> <td>0-29</td> </tr> </tbody> </table> <p>*Use the Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table A-1.</p>		<u>Evaluation Ranking*</u>	<u>Score Range</u>	High	50-65	Moderate	30-49	Minimal	0-29	
<u>Evaluation Ranking*</u>	<u>Score Range</u>									
High	50-65									
Moderate	30-49									
Minimal	0-29									
<b>Surface Water Evaluation Ranking</b>		<b>Minimal</b>								
<b>Groundwater Evaluation Ranking</b>		<b>Moderate*</b>								
<p>Notes:</p> <p>* The Groundwater Evaluation Ranking has been modified from Moderate to Minimal. The moderate score is driven by the sandy soil conditions on site which promote transport through the vadose zone to reach groundwater. The low range use and site conditions (low precipitation, high evaporation rate, neutral soil pH, depth to groundwater) minimize potential for lead to reach groundwater. In addition, there are limited receptor exposure points (groundwater wells).</p>										

Shotgun Range  
MARINE CORPS LOGISTICS BASE BARSTOW  
BARSTOW, CALIFORNIA

The Shotgun Range is used for marksmanship training and (re)qualification of Marines at MCLB Barstow. The range uses four types of small arms ammunition. There are 20 firing points and a maximum firing distance of 100 yards.

FIVE-YEAR REVIEW ASSESSMENT RESULTS:

The Surface Water Ranking is Minimal. Range conditions presented in the following tables were evaluated using public databases, historical documentation, installation personnel interviews, and field observations made during the site visit. Lead loading is low. Site conditions (low precipitation and high evaporation; neutral surface water and soil pH) minimize the potential for lead migration, and there is limited or no presence of receptors (no human receptors; limited potential exposure to ecological receptors).

The groundwater evaluation resulted in a minimal ranking. Low range use and site conditions (low precipitation, high evaporation rate, neutral soil pH) minimize potential for lead to reach groundwater. In addition, there are limited receptor exposure points (groundwater wells).

**MARINE CORPS LOGISTICS BASE BARSTOW  
SHOTGUN RANGE**

<b>Table 1: Range Use and Range Management (Source) Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Duration of Range Use</b>	<i>Range used from 1955 to present.</i>	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
<b>Bullet-Capturing Technology</b>	<i>There is an impact berm at the range, but no bullet-capturing technology has ever been in place at the range.</i>	-3 if range usage duration = bullet capture duration -1 if range usage duration – bullet capture duration = 10 to 30 years 0 if range usage duration – bullet capture duration > 30 years, or no bullet capture technology present.	0
<b>MC Loading Rates</b>	<i>Approximately 92 pounds of lead per year are used at the shotgun range.</i>	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	1
<b>Range Maintenance</b>	<i>Lead removal was completed in August 2012. Lead removal is conducted on an as needed basis..</i>	5 if lead is removed less than every three years 3 if lead is removed more than every three years but less than annually 1 if lead is removed at least annually	5
<b>Source Element Score</b>			<b>11</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
SHOTGUN RANGE**

<b>Table 2: Surface Water Pathways Characteristics Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>pH of Water</b>	Gaging stations in the Mojave hydrologic unit near MCLB Barstow for years ranging from 2009 through 2012 have an average field measured pH value of 8.1 and most frequently measured value of 8 (USGS, 2012).	5 if pH < 6.5 3 if pH > 8.5 1 if pH 6.5 ≤ pH ≤ 8.5	1
<b>Precipitation</b>	<i>Annual average precipitation is approximately 4.4 inches per year.</i>	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
<b>Slope of Range and Berm</b>	<i>Based on a visual survey, the slope of the berm is approximately 22.5 degrees. The range is largely flat.</i>	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
<b>Vegetation</b>	<i>There is very sparse scrub vegetation on the range.</i>	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	5
<b>Soil Type/Runoff Conditions</b>	<i>Soils are typically low in organic material and a mixture of sands: coarse sand, gravelly sand, and loamy sand.</i>	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1
<b>Runoff/ Erosion Engineering Controls</b>	<i>A wall of sandbags is present at the foot of the berm in an effort to control sand that could potentially erode down the berm. The top of the berm is slightly sloped towards the back to prevent run on down the face of the berm. The back and side berms are present at the range which minimize run-on to the range.</i>	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	-5
<b>Surface Water Pathway Score</b>			<b>8</b>
<b>Notes:</b> Water quality data collected from United States Geological Survey (USGS) stream gages at Barstow (USGS stream gage 10262500) have field measured pH concentrations above 6.5. One water quality sample at Barstow had a pH of 7.8 (USGS, 2007).			

**MARINE CORPS LOGISTICS BASE BARSTOW  
SHOTGUN RANGE**

<b>Table 3: Groundwater Pathways Characteristics Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Depth to Groundwater</b>	Studies conducted at an Installation Restoration Program site located approximately 1.5 miles northwest of the Rifle Range documented depth to water between 160 and 210 feet bgs. Depths up to 175 feet bgs have been noted on the alluvial fan south of Interstate 40 near the Rifle Range Complex (Jacobs Engineering, 1997; Tetra Tech, 2003).	5 if depth to groundwater < 20 feet 3 if depth to groundwater = 20-99 feet 1 if depth to groundwater = 100-300 feet 0 if depth to groundwater >300 feet	1
<b>Precipitation</b>	<i>Annual average precipitation is approximately 4.4 inches per year.</i>	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
<b>pH of Water</b>	<i>pH measurements averaged approximately 7.5 during 2011 groundwater sampling conducted at the installation.</i>	5 if pH < 6.5 3 if pH > 8.5 1 if pH 6.5 ≤ pH ≤ 8.5	1
<b>pH of Soil</b>	<i>NCRS soil data suggest a pH between 7.4-8.4</i>	5 if pH < 6.5 3 if pH > 8.5 1 if pH 6.5 ≤ pH ≤ 8.5	1
<b>Soil Type/Infiltration Conditions</b>	<i>Soil type is sand.</i>	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
<b>Clay Content in Soil</b>	<i>Little to no clay is present.</i>	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
<b>Groundwater Pathway Score</b>			<b>14</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
SHOTGUN RANGE**

<b>Table 4: Surface Water Receptors Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Drinking Water Usage</b>	<i>The Mojave River is the primary surface water body in the area, and it is not used for drinking water; however, the Mojave River is connected with the Mojave River aquifer and the Regional aquifer.</i>	<p>10 if analytical data or observable evidence indicates that contamination in the media is present at, is moving toward, or has a reasonable potential to move toward a surface water body used as a potable water supply or if a designation as a potable water source is unknown</p> <p>5 if contamination in the media has moved or is expected to move only slightly beyond the source (tens of feet) or could move, but is not moving appreciably, toward surface water body used as a potable water supply or if a designation as a potable water source is unknown</p> <p>2 if low possibility for contamination in the media to be present at or migrate to a point of exposure</p>	2
<b>Agricultural or Other Beneficial Usage</b>	<i>Because of the climate, minimal agriculture is conducted in the area. The closest known agricultural farms are approximately 10 miles east of the installation.</i>	<p>5 if analytical data or observable evidence indicates that contamination in the media is present at, is moving toward, or has moved to a point of exposure or if a designation as agricultural or other beneficial usage is unknown</p> <p>3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably.</p> <p>1 if low possibility for contamination in the media to be present at or migrate to a point of exposure</p>	1
<b>Sensitive Species Habitat and Threatened or Endangered Species</b>	<i>The desert tortoise is present in the range complex and could potentially access surface water, when flowing. However, the infrequent rainfall is expected to limit the access to potentially contaminated range use.</i>	<p>10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary</p> <p>5 if potential for receptors to have access to possibly contaminated media</p> <p>1 if little or no potential for receptors to have access to possible contaminated media</p>	5
<b>Surface Water Receptor Score</b>			<b>8</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
SHOTGUN RANGE**

<b>Table 5: Groundwater Receptors Element</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
<b>Criteria</b>	<b>Evaluation Characteristics</b>	<b>Score Criteria</b>	<b>Site Score</b>
<b>Wells Identified as Potable Water Sources</b>	<i>The closest potable water supply wells are located at the Yermo Annex . A fault prevents groundwater from the Rifle Range complex from reaching groundwater serving the potable wells..</i>	<p>10 if analytical data or observable evidence or site conditions indicate that MC may be within or moving toward a reasonable radius of influence of a well or other point of exposure or if a designation as a potable water source is unknown</p> <p>5 if analytical data or observable evidence or site conditions indicate that MC have moved only slightly beyond the source (tens of feet) or could move toward a reasonable radius of influence of a well or other point of exposure, but are not moving appreciably</p> <p>2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure</p>	2
<b>Wells Identified for Agricultural or Other Beneficial Usage</b>	<i>Groundwater supply wells for the MCLB golf course are located cross-gradient from the shotgun range. The closest non-potable well is over one mile from the shotgun range.</i>	<p>5 if analytical data or observable evidence or site conditions indicate that MC may be within or moving toward a reasonable radius of influence of a well or other point of exposure or if a designation as agricultural or other beneficial usage is unknown</p> <p>3 if analytical data or observable evidence or site conditions indicate that MC have moved only slightly beyond the source (tens of feet) or could move toward a reasonable radius of influence of a well or other point of exposure, but are not moving appreciably</p> <p>1 if low possibility for MC to be present at or migrate to within a reasonable radius of influence of a well or point of exposure</p>	1
<b>Sensitive Species Habitat and Threatened and Endangered Species</b>	<i>The desert tortoise is present in the area, but there are no known points where it could access groundwater.</i>	<p>5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources</p> <p>3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources</p> <p>1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources</p>	1
<b>Groundwater Receptor Score</b>			<b>4</b>
<u>Notes:</u>			

**MARINE CORPS LOGISTICS BASE BARSTOW  
SHOTGUN RANGE**

<b>Table 6: Evaluation Results</b> (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)										
<b>Surface Water</b>										
<b>Element</b>	<b>Table</b>	<b>Score</b>								
Range Use and Range Management (Source)	1	11								
Surface Water Pathways	2	8								
Surface Water Receptors	4	8								
<b>Sum of Surface Water Element Scores</b>		<b>27</b>								
<b>Groundwater</b>										
<b>Element</b>	<b>Table</b>	<b>Score</b>								
Range Use and Range Management (Source)	1	11								
Groundwater Pathways	3	14								
Groundwater Receptors	5	4								
<b>Sum of Groundwater Element Scores</b>		<b>29</b>								
<p>The evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:</p> <table border="0" style="width: 100%;"> <thead> <tr> <th style="text-align: left;"><u>Evaluation Ranking*</u></th> <th style="text-align: left;"><u>Score Range</u></th> </tr> </thead> <tbody> <tr> <td>High</td> <td>50-65</td> </tr> <tr> <td>Moderate</td> <td>30-49</td> </tr> <tr> <td>Minimal</td> <td>0-29</td> </tr> </tbody> </table> <p>*Use the Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table A-1.</p>		<u>Evaluation Ranking*</u>	<u>Score Range</u>	High	50-65	Moderate	30-49	Minimal	0-29	
<u>Evaluation Ranking*</u>	<u>Score Range</u>									
High	50-65									
Moderate	30-49									
Minimal	0-29									
<b>Surface Water Evaluation Ranking</b>		<b>Minimal</b>								
<b>Groundwater Evaluation Ranking</b>		<b>Minimal</b>								
Notes:										

# Appendix B

## Photographic Log



# PISTOL RANGE

		<b>Photographic Log</b>	
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	
		<b>Project No.</b> 06285037.0000	
<b>Photo No.</b> 1	<b>Date:</b> 3-22-2012		
<b>Description:</b> Pistol Range; View downrange during March 2012 site visit.			

		<b>Photographic Log</b>	
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	
		<b>Project No.</b> 06285037.0000	
<b>Photo No.</b> 2	<b>Date:</b> 3-22-2012		
<b>Description:</b> Pistol Range; View downrange during March 2012 site visit.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 4	<b>Date:</b> 3-22-2012		
<b>Description:</b> Pistol Range: target carriages and berm during March 2012 site visit.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 5	<b>Date:</b> 3-22-2012		
<b>Description:</b> Pistol Range: berm face during March 2012 site visit.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 6	<b>Date:</b> 3-22-2012		
<b>Description:</b> Pistol Range: Top of berm, note slope away from the face of the berm, and flat terrace. March 2012 site visit.			

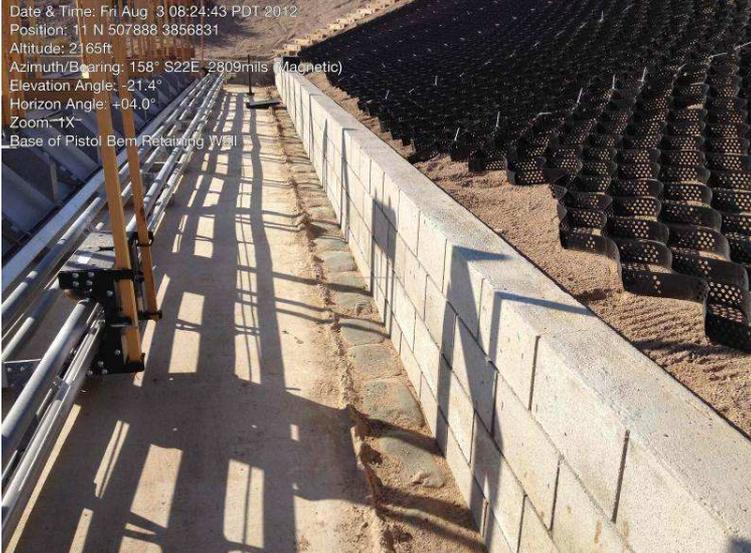
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 7	<b>Date:</b> 3-22-2012		
<b>Description:</b> Pistol Range, behind berm during March 2012 site visit.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 8	<b>Date:</b> 3-22-2012		
<b>Description:</b> Pistol Range: View from top of berm towards firing positions during March 2012 site visit.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 9	<b>Date:</b> August 2012		
<b>Description:</b> Pistol Range: View downrange after lead mining and berm resurfacing action in August 2012.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 10	<b>Date:</b> August 2012	<p>Date &amp; Time: Fri Aug 17 11:44:58 PDT 2012                  Position: 11 N 507803 3856823                  Altitude: 2173ft                  Azimuth/Bearing: 209° S25W 3716mils (Magnetic)                  Elevation Angle: -10.3°                  Horizon Angle: +03.5°                  Zoom: 1X</p> 	
<p><b>Description:</b> Pistol Range after lead mining and berm reshaping. Note ballistic block retaining walls to reduce ricochet.</p>			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 11	<b>Date:</b> August 2012	<p>Date &amp; Time: Fri Aug 17 11:58:51 PDT 2012                  Position: 11 N 507883 3856832                  Altitude: 2169ft                  Azimuth/Bearing: 168° S12E 2367mils (Magnetic)                  Elevation Angle: -10.3°                  Horizon Angle: +03.1°                  Zoom: 1X</p> 	
<p><b>Description:</b> Pistol Range after lead mining and berm reshaping. Ballistic block used at the berm retaining wall.</p>			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 12	<b>Date:</b> August 2012	<p>Date &amp; Time: Fri Aug 3 08:24:43 PDT 2012                  Position: 11 N 507888 3856831                  Altitude: 2165ft                  Azimuth/Bearing: 158° S22E 2809mils (Magnetic)                  Elevation Angle: -21.4°                  Horizon Angle: +04.0°                  Zoom: 1X                  Base of Pistol Bem Retaining Wall</p> 	
<p><b>Description:</b>                  Pistol Range: Base of retaining wall. Note the erosion matting (Envirogrid) used to minimize erosion.</p>			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 13	<b>Date:</b> August 2012	<p>Date &amp; Time: Wed Aug 8 08:50:15 PDT 2012                  Position: 11 N 507887 3856836                  Altitude: 2162ft                  Azimuth/Bearing: 176° S04E 3129mils (Magnetic)                  Elevation Angle: -20.6°                  Horizon Angle: +03.9°                  Zoom: 1X                  Ballistic Panel being placed, Pistol Range, MCLB Barstow</p> 	
<p><b>Description:</b> First set of Ballistic Panel Clamed and Curing at Pistol Range</p>			

## Shotgun Range

		<b>Photographic Log</b>	
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	
<b>Project No.</b> 06285037.0000			
<b>Photo No.</b> 14	<b>Date:</b> 3-22-2012		
<b>Description:</b> Shotgun Range: view from on top of pistol range berm looking at shotgun range targets and berm during March 2012 site visit.			

		<b>Photographic Log</b>	
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	
<b>Project No.</b> 06285037.0000			
<b>Photo No.</b> 15	<b>Date:</b> 3-22-2012		
<b>Description:</b> Shotgun Range: view from Pistol Range berm looking uprange toward firing locations during March 2012 site visit.			

**Project:** MCLB Barstow

**Location:** Barstow, California

**Project No.**  
06285037.0000

**Photo No.**  
16

**Date:**  
3-22-2012

**Description:**  
Shotgun Range berm during March 2012 site visit.



**Project:** MCLB Barstow

**Location:** Barstow, California

**Project No.**  
06285037.0000

**Photo No.**  
18

**Date:**  
3-22-2012

**Description:**  
Shotgun Range berm during March 2012 site visit.



<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 19	<b>Date:</b> 3-22-2012		
<b>Description:</b> Shotgun Range: top of berm during March 2012 site visit. Note slight slope away from berm face.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 20	<b>Date:</b> 3-22-2012		
<b>Description:</b> Shotgun Range: view of the back of the berm, notice terrace down to road bed.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 22	<b>Date:</b> 3-22-2012		
<b>Description:</b> Shotgun Range: View from top of Shotgun Range berm towards firing points.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 23	<b>Date:</b> 3-22-2012		
<b>Description:</b> Behind Shotgun Range berm during March 2012 site visit.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 25	<b>Date:</b> August 2012	<p><small>Date &amp; Time: Wed Aug 15 2:21:43 PDT 2012                  Position: 11 N 501438 380090                  Altitude: 2162ft                  Azimuth Bearing: 078° N78E 1367ftds (Magnetic)                  Elevation Angle: -22.1°                  Horizon Angle: +05.2°                  Zoom: 1X</small></p> 	
<p><b>Description:</b> Shotgun Range: View after berm mining and resurfacing in August 2012. View is from berm towards firing position of completed Shotgun Range as prepped for Shotgun Pistol Qualification.</p>			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 26	<b>Date:</b> August 2012	<p><small>Date &amp; Time: Thu Aug 2 11:05:19 PDT 2012                  Position: 11 N 507676 3866794                  Altitude: 2172ft                  Azimuth Bearing: 156° S24E 2773ftds (Magnetic)                  Elevation Angle: -02.3°                  Horizon Angle: +03.8°                  Zoom: 1X                  EnviroGrid Install on Shotgun Berm Complete</small></p> 	
<p><b>Description:</b> Shotgun Range: Side view of EnviroGrid on Shotgun Berm during lead resurfacing in August 2012.</p>			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 27	<b>Date:</b> August 2012	<p><small>Date &amp; Time: Thu Aug 2 11:06:00 PDT 2012            Position: 11 N 507677 866677E            Altitude: 2202ft            Azimuth/Bearing: 123° S57E 2167mile (Magnetic)            Elevation Angle: -15.1°            Horizon Angle: +06.0°            Zoom: 1X            EnviroGrid Instal on Shotgun Berm Complete</small></p> 	
<b>Description:</b> Top view of EnviroGrid on Shotgun Berm during berm resurfacing in August 2012.			

## Rifle Range

		<b>Photographic Log</b>
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California
		<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 28	<b>Date:</b> 3-22-2012	
<b>Description:</b> Rifle Range: View from 500 foot firing position towards targets during March 2012 site visit.		

		<b>Photographic Log</b>
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California
		<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 24	<b>Date:</b> 3-22-2012	
<b>Description:</b> Rifle Range 500 foot firing position on March 2012 site visit.		

		<b>Photographic Log</b>	
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 29	<b>Date:</b> 3-22-2012		
<b>Description:</b> Rifle Range: Surface water drainage observed on Rifle Range during March 2012 site visit.			

		<b>Photographic Log</b>	
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 30	<b>Date:</b> 3-22-2012		
<b>Description:</b> Rifle Range: Surface water drainage observed on Rifle Range during March 2012 site visit.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 31	<b>Date:</b> 3-22-2012		
<b>Description:</b> Rifle Range: Targets and impact berm observed on March 2012 site visit.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 32	<b>Date:</b> 3-22-2012		
<b>Description:</b> Rifle Range: targets on March 2012 site visit.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 33	<b>Date:</b> 3-22-2012		
<b>Description:</b> Rifle Range: Top of impact berm observed on March 2012 site visit.			

<b>ARCADIS MALCOLM PIRNIE</b> <i>Infrastructure · Water · Environment · Buildings</i>		<b>Photographic Log</b>	
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 34	<b>Date:</b> 3-22-2012		
<b>Description:</b> Rifle Range: Backside of impact berm on March 2012 site visit.			

**Project:** MCLB Barstow

**Location:** Barstow, California

**Project No.**  
06285037.0000

**Photo No.**  
35

**Date:**  
3-22-2012

**Description:**  
Rifle Range: Front of impact berm on March 2012 site visit.



**Project:** MCLB Barstow

**Location:** Barstow, California

**Project No.**  
06285037.0000

**Photo No.**  
36

**Date:**  
3-22-2012

**Description:**  
Rifle Range View from impact berm towards firing positions on March 2012 site visit.



<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 37	<b>Date:</b> 3-22-2012		
<b>Description:</b> Rifle Range: Between target berm and impact berm on March 2012 site visit.			

**After**

<b>ARCADIS MALCOLM PIRNIE</b> <i>Infrastructure · Water · Environment · Buildings</i>		<b>Photographic Log</b>	
<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 40	<b>Date:</b> August 2012	<p>Date &amp; Time: Wed Aug 15 11:43:24 PDT 2012                      Position: 11 N 507404 3856871                      Altitude: 2188ft                      Azimuth/Bearing: 212° S32W 3769mils (Magnetic)                      Elevation Angle: -01.7°                      Horizon Angle: +03.0°                      Zoom: 1X</p> 	
<b>Description:</b> Rifle Range: Berm being covered with EnviroGrid in August 2012.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 41	<b>Date:</b> August 2012	<p><small>Date &amp; Time: Wed Aug 15 11:53:07 PDT 2012                  Position: 11 N 507327 3856947                  Altitude: 2179ft                  Azimuth/Bearing: 174° S06E 3093mils (Magnetic)                  Elevation Angle: -14.4°                  Horizon Angle: +13.5°                  Zoom: 1X</small></p> 	
<b>Description:</b> Rifle Range: Confirming slope of Completed Rifle Berm in August 2012.			

<b>Project:</b> MCLB Barstow		<b>Location:</b> Barstow, California	<b>Project No.</b> 06285037.0000
<b>Photo No.</b> 42	<b>Date:</b> August 2012	<p><small>Date &amp; Time: Wed Aug 15 11:47:32 PDT 2012                  Position: 11 N 507325 3856908                  Altitude: 2203ft                  Azimuth/Bearing: 156° S24E 2773mils (Magnetic)                  Elevation Angle: -20.9°                  Horizon Angle: +06.6°                  Zoom: 1X</small></p> 	
<b>Description:</b> Rifle Range: Top view of Envirogrid in place on Rifle Range impact berm in August 2012.			