Headquarters Marine Corps

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

FINAL

Range Environmental Vulnerability Assessment

Marine Corps Base Camp Pendleton

September 2009

Report Prepared By:

Malcolm Pirnie, Inc.

8001 Irvine Center Drive
Suite 1100
Irvine, CA 92618-2989
949-450-9901

6285024

Contents

Tables

Figures

Appendices

Acronym List

^{o}F	Degrees Fahrenheit
µg/L	Micrograms per Liter
AC/S	Assistant Chief of Staff
AC/S-ES	Assistant Chief of Staff, Environmental Security
AFA	Artillery Firing Area
amsl	Above Mean Sea Level
ASR	Archive Search Report
AsT	Altamont Clay
$CaCO_3$	Calcium Carbonate
CPAAA	Camp Pendleton Amphibious Assault Area
CPAVA	Camp Pendleton Amphibious Vehicle Area
CPLO/PAO	Community Planning and Liaison Office/Public Affairs Office
CSM	Conceptual Site Model
deg C	Degrees Celcius
DoD	Department of Defense
DoDIC	Department of Defense Identification Code
DQO	Data Quality Objective
EOD	Explosive Ordnance Disposal
ES	Executive Summary
ft	feet
GaF	Gaviota
GIS	Geographic Information System
GW	Groundwater
HaG	Hambright Gravelly Clay Loam
HE	High Explosive
HMX	Cyclotetramethylene Tetranitramine
HQMC	Headquarters Marine Corps
ICM	Improved Conventional Munition
ID	Identification
INRMP	Integrated Natural Resources Management Plan
IRP	Installation Restoration Program
kg/m^2	Kilograms per Square Meter
LeD	Los Flores Loamy Fine Sand
LFAM	Live-Fire and Maneuver
m^2	Square Meters
MC	Munitions Constituents

MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MCRD	Marine Corp Recruiting Depot
MDL	Method Detection Limit
mg/L	milligrams per liter
MIDAS	Munitions Items Disposition Action System
mm	millimeter
mS/cm	milliSiemens per centimeter
N/A	Not Available
NDAA	National Defense Authorization Act
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Units
O&T	Operations and Training
OWR	Office of Water Resources
PRA	Preliminary Range Assessment
QAPP	Quality Assurance Project Plan
RDX	Cyclotrimethylene trinitramine
REVA	Range Environmental Vulnerability Assessment
RIPRA	Range Identification and Preliminary Range Assessment
RL	Reporting Limit
RMUS	Range and Munitions Use Subcommittee
RSOP	Reconnaissance, Selection, Occupation or Position
RTA	Range Training Area
RuF	Rough Broken Land
RUSLE	Revised Universal Soil Loss Equation
SAP	Sampling and Analysis Plan
SAR	Small Arms Range
SARAP	Small Arms Range Assessment Protocol
SDZ	Surface Danger Zone
StG	Steep Gullied Land
SW	Surface Water
T/E	Threatened and Endangered
TECOM	Training and Educational Command
TeF	Terrace Escarpments
T&LAV	Training and Light Armored Vehicles
TNT	Trinitrotoluene
TRI	Toxic Release Inventory
TRMD	Training Resources Management Division

UCMR	Unregulated Contaminant Monitoring Rule
U.S.	United States
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
UST	Underground Storage Tanks
UXO	Unexploded Ordnance
VaD	Visalia Sandy Loam

Executive Summary

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

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

This report presents the assessment results for the operational ranges and training areas at Marine Corps Base (MCB) Camp Pendleton, California (MCB Camp Pendleton[1]). This report is the first comprehensive report on MC associated with the operational ranges at MCB Camp Pendleton and serves as the baseline of environmental conditions and potential vulnerabilities of the operational ranges. This report presents:

- details on the installation's operational ranges and use of military munitions;
- estimates of "loading rates" of MC at each range or training area based on records of munitions use;
- a prioritization of operational ranges and training areas for evaluation through the REVA process;
- a description of the Conceptual Site Model (CSM) for MCB Camp Pendleton that forms the basis of most assumptions for potential surface water and groundwater pathways for off-range migration of MC;
- screening-level methods for analysis of surface water and groundwater pathways and the results of those analyses;
- a separate, qualitative assessment of selected Small Arms Ranges (SARs); and

[1] All operational ranges and training areas occur on MCB Camp Pendleton; thus, this report reflects the MCB unless otherwise noted.

- results of the REVA field sampling effort in 2008.

REVA is a voluntary, conservative, and tiered process. It applies readily-available information or conservative assumptions on munitions use and physical conditions at the installation to EPA-approved screening-level models. The models are used to predict whether detectable concentrations of MC could migrate off the ranges to areas where human or ecological receptors could potentially be exposed to MC. If the screening-level models predict a detectable concentration of MC off-ranges, then further assessment, such as a field sampling effort, will be conducted. The results of the field activities are compared to screening values identified by the Department of Defense (DoD, 2009) to evaluate the potential for detected concentrations to affect human health or ecological receptors. The potential for off-range migration is assessed separately for SARs because the potential for lead migration and release is not reliably modeled without site specific information, which was not obtained during the baseline assessment.

At MCB Camp Pendleton, screening-level modeling was conducted in three watersheds, San Mateo, San Onofre, and Las Flores, as a first step to assess the potential off-range migration of MC from three high priority (primary) MC loading areas identified through REVA. The models predicted that some MC may be detected on an average annual basis just above the trigger value used for REVA in the surface water and groundwater in the San Onofre and Las Flores watersheds. This trigger value is based on the median value for a set of conservative laboratory method detection limits for individual MC (HQMC, 2006).

Although the MC concentrations were predicted below levels of potential concern, the Marine Corps conducted field sampling activities at off-range surface water and groundwater locations down gradient of the primary MC loading areas in the San Onofre and Las Flores watersheds. The field sampling was conducted to determine whether actual MC migration had occurred as well as provide a general, although not direct, confirmation of the modeling results. Trace concentrations of MC were detected in both watersheds below screening values identified by DoD to assess impact to human health and environment, with one exception for a slight exceedence of an ecological screening value. Nevertheless, to ensure the sustainability of MCB Camp Pendleton operational ranges, options for further management and assessment are being considered for high priority ranges identified through this REVA baseline assessment. In addition, subsequent vulnerability assessments will be conducted on operational ranges at MCB Camp Pendleton on a five-year cycle or when significant changes are made to existing operational ranges that potentially affect the determinations made during this baseline assessment, as described in the *REVA Reference Manual* (HQMC, 2006).

Military Munitions Training and Operations

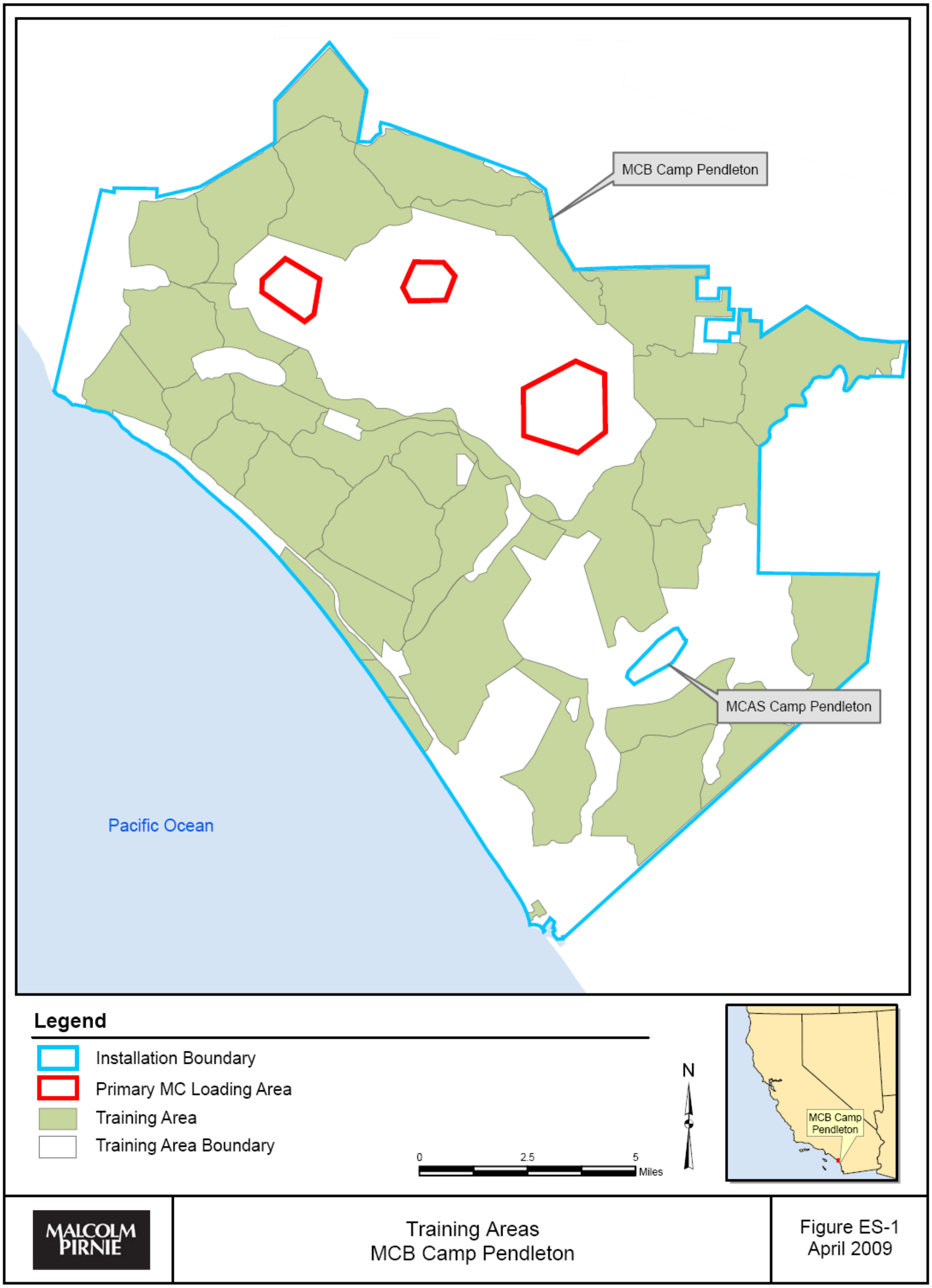
MCB Camp Pendleton is a Marine Corps live-fire training facility that encompasses approximately 125,000 acres of coastal San Diego County, California. MCB Camp Pendleton is located about halfway between San Diego and Los Angeles and has been in existence since 1942. The mission of MCB Camp Pendleton is “to operate the finest amphibious base possible; to promote the combat readiness of Marines and Sailors by providing necessary facilities and services; to support the deployment of the Fleet Marine Force and other organizations; and to provide support and services responsive to the needs of the Marines, Sailors, retirees and families aboard Camp Pendleton” (MCBCP, 2006). The installation is administratively subdivided into 37 Range Training Areas (RTAs), 7 impact areas, approximately 100 live-fire facilities, and 5 amphibious assault beaches (MCB Camp Pendleton, 2006). Three hundred thirty-eight operational range, historical use areas, and fixed ranges are located within the 37 RTAs identified under MCB Camp Pendleton. These training ranges are heavily used, not only by active Marine and Navy units, but also by the Marine Corps Reserve, Army National Guard, local community law enforcement agencies, and private research firms. In addition, the installation includes a number of SARs. The outlines for RTAs and primary impact areas at MCB Camp Pendleton are shown in Figure ES-1.

MC Loading Rates

The REVA fate and transport screening-level modeling / analysis requires estimation of the amount of indicator MC deposited on operational ranges over time in order to predict if there is a potential release or substantial threat of a release of MC. Within the REVA program, this deposition is referred to as MC loading. Operational range usage, boundaries, and other characteristics typically change over time; therefore, an analysis of their history must be performed to map the affected areas over time and to estimate the historical and current MC loading. The MC loading for the operational ranges was estimated separately for each area and period of interest and for each REVA indicator MC.

For the purposes of the REVA program, MC loading estimates were expressed as the average mass deposited annually in the defined area of interest (kilograms per square meter) for the duration of the period that the operational range activities generating the MC loading were conducted. Based on MCB Camp Pendleton interviews, the Quebec, Whiskey and Zulu impact areas were identified as areas where most military munitions were deposited.

Figure ES-1: Training Areas



P:\6285\024\GIS\MXD\059_Figure ES-1_Training Areas and Operational Range_PRD.mxd

Range Control estimates that approximately 95% of all current munitions expenditures (excluding small arms) are deposited within the Zulu Impact Area. Although MC loading estimates did not always reflect the information provided through interviews, these areas were identified as the primary target areas receiving the majority of high explosive (HE) munitions. Surface water and groundwater screening-level modeling were performed for these three impact areas.

Fate and transport of lead at SARs is strongly influenced by site-specific geochemical conditions that cannot be determined solely by physical observation. Therefore, MC loading and fate and transport modeling were not conducted for the SARs. Rather, the SARs were qualitatively assessed through the Small Arms Range Assessment Protocol (SARAP). This assessment employs a consistent qualitative approach to identify and assess factors that influence the potential for lead migration at an operational range. As noted above, over 100 live-fire ranges are present at MCB Camp Pendleton. Fifteen small arms ranges were identified with concurrence from Assistant Chief of Staff, Environmental Security (AC/S-ES) and Range Operations & Training Department for qualitative assessment using the SARAP. These SARs were selected using the following general guidelines: the presence of berms; current munitions use, as well as those locations of high munitions expenditures at the installation; and representative of the varied range designs present at MCB Camp Pendleton.

Conceptual Site Model

The REVA process examines surface water and groundwater flow at MCB Camp Pendleton in order to evaluate the potential off-range migration of MC. To this end, a CSM was developed that characterizes the representative physical features of the installation. Key assumptions about surface water and groundwater flow are derived from the CSM and used in the screening-level modeling for MCB Camp Pendleton, such as the following physical descriptors.

The installation area includes about 17 miles of coastline and portions of the Peninsular Range and Coastal Plains physiographic provinces in Southern California. The Coastal Plain extends from the base of the San Onofre Mountains to the Pacific Coast. These mountains occur as erosionally-resistant ridges that rise above the coastal plain to a maximum height of nearly 1800 feet (ft) above mean sea level (amsl). The Peninsular Range extends eastward from the San Onofre Mountains and is characterized by northwest striking faults. Steep-sided river canyons have been incised into the mountains by creeks. The Santa Margarita Mountains are separated from the coastal mountains by low-rolling topography and rise higher than 2000 ft amsl within the boundaries of the installation. The eastern edges of these mountains are part of the Cleveland National Forest.

The area has a mild climate with an annual average daily high temperature of 75 degrees Fahrenheit (°F) and a low of 51°F at lower elevations (NOAA, 2008). Based on 100 years of data, the 2007 Integrated Natural Resources Management Plan (INRMP) reports that lower areas of the base receive an average of about 14 inches of rain each year, with wide swings of minimum/maximum precipitation. Precipitation at higher elevations averages approximately 22 inches, based on 40 years of records. Wide variability in minimum and maximum occurs at the higher elevations as well. Approximately 75% of the installation's precipitation occurs between November and March of each year. The area's year-to-year variability is an important climate characteristic (MCB Camp Pendleton, 2007b). Periods of drought, heavy seasonal rains, and fire are common. Wildfires occur seasonally from May through November, typically during hot, dry Santa Ana wind conditions and when a heavy vegetative fuel load exists.

There are seven major watersheds within MCB Camp Pendleton, two of which extend up gradient beyond the boundary of the installation. They include Aliso, Horno/Coastal, San Luis Rey, Santa Margarita, Las Flores, San Onofre, and San Mateo. Of the seven watersheds, the Santa Margarita watershed has the largest drainage area; however, a large percentage of this drainage area is located outside of the installation boundary. The San Onofre and Las Flores watersheds occur almost entirely within the boundaries of MCB Camp Pendleton. Several of the watersheds on the installation form broad alluvial plains as they approach the Pacific Ocean. The three largest estuaries on the installation are situated at the mouths of the Santa Margarita, Las Flores, and San Mateo streams. Most of the streams on the installation are ephemeral and only flow following successive, major rain events. As noted above, lower precipitation generally occurs in the coastal areas of the installation rather than in the western mountainous areas. Due to the extreme variability of precipitation and runoff, the potential for large floods is high on MCB Camp Pendleton (MCB Camp Pendleton, 2007b).

The CSM prepared for MCB Camp Pendleton depicts a generalized east-west trending geologic cross section for the installation just north of the Las Flores watershed (Ehlig, 1979). The Las Flores watershed is associated with the Zulu Impact Area. This impact area was selected for the development of the generalized CSM because the general physical, topographical, geologic, and hydrologic features in the CSM are similar to those of the other watersheds at the installation where non-small arms are utilized.

The generalized CSM is also used to reflect physical conditions at the San Onofre and San Mateo watersheds on the installation, where the Whiskey and Quebec impact areas are located. The CSM does not reflect the Santa Margarita watershed; however, this watershed was not subject to screening-level modeling through the REVA program due to very low loading of HE and the predominant use of small arms ammunition on operational ranges within that watershed. Selected SARs associated with this watershed were assessed qualitatively.

The CSM for MCB Camp Pendleton strongly suggests that surface water flow drives the potential for off-range migration of MC to human and threatened and endangered (T/E) ecological receptors. In order to migrate to groundwater where drinking water supply wells are located, the CSM suggests that MC must first be present in surface water. Then, surface water must carry MC to the points where alluvial groundwater basins occur and, ultimately, where drinking water wells are found. The steep topography, soil characteristics, fire frequency, and climatic variability at MCB Camp Pendleton produce high erosion rates in many areas. Slopes are particularly vulnerable to erosion following wildfires (MCB Camp Pendleton, 2007b). Erosion and transport of MC from the impact areas to the alluvium may represent an important mechanism for movement off range.

Human and Ecological Receptors

The presence of human and T/E ecological receptors along potential off-range MC migration pathways is central to the MCB Camp Pendleton REVA evaluation. Human receptors may be impacted through potable water supply and recreational water use. Ephemeral streams and other surface water bodies, such as coastal lagoons and freshwater lakes that are located in and around MCB Camp Pendleton, are not used as a potable water supply. Humans potentially use these waters for recreational purposes (such as swimming and fishing), but because a large majority of the water bodies only contain water during the wet season when rain events occur, the potential for their recreational use is limited. In addition, no direct pathways were identified between loading areas and freshwater lakes. The ephemeral streams rarely carry enough flow to reach coastal lagoons or the ocean.

Ephemeral streams draining from MC loading areas largely recharge alluvial groundwater basins that are used as drinking water sources located in the coastal plain downstream of MC loading areas. The alluvial groundwater basins that are located downstream of MC loading areas evaluated through REVA include San Mateo, San Onofre and Las Flores basins. Drinking water supply wells for MCB Camp Pendleton are located in each of these basins. For this reason, ephemeral streams draining from MC loading areas have potential human receptors (through drinking water use).

Additionally, the ephemeral streams can provide temporary support to aquatic/wildlife habitat during wet periods of the year. Federally and state-listed T/E species may consume surface water and shallow groundwater in habitat areas along San Mateo, San Onofre, and Las Pulgas (Las Flores) creeks and the Santa Margarita River; in lagoons shoreward of the beach; and in the Pacific Ocean.

Surface Water Analysis Summary

Under REVA, the screening-level surface water analysis is used to estimate the MC concentrations potentially in surface water runoff at the edge of the MC loading areas. If this analysis predicts impacts at the edge of the loading area, then further calculations are performed to estimate the MC concentration at a downstream receptor.

At MCB Camp Pendleton, surface water screening-level analysis was conducted for three watersheds that receive the most MC loading: the San Mateo, San Onofre, and Las Flores watersheds. Ranges and impact areas were grouped by each of these watersheds for modeling. For each watershed, MC contributions in runoff from the three primary MC loading areas (Quebec, Whiskey and Zulu) were used to estimate the total loads reaching potential human and ecological receptors.

Average annual surface water concentrations of the indicator MC (TNT, RDX, HMX, and perchlorate) were estimated based on the average annual MC loading of each indicator MC to each MC loading area. The concentrations draining from MC loading areas to surface water entering the alluvial groundwater basins were also estimated. These estimated concentrations were compared to established REVA trigger values for each MC (Table ES-1).

Table ES-1
REVA Trigger Values

MC	REVA Trigger Value (µg/L)[a]
HMX	0.08
RDX	0.16
TNT	0.08
Perchlorate	0.98

Note:
µg/L – micrograms per liter
[a]REVA trigger values are the median representative screening threshold values, for surface water or groundwater modeling, obtained from certified analytical laboratories for each indicator MC as defined in the *REVA Reference Manual (HQMC,2006)*.

Surface water modeling results indicate that surface runoff could potentially exceed REVA trigger values for one or more indicator MC at all modeled MC loading area boundaries and at locations where the surface water recharges groundwater in the San Onofre and Las Flores watersheds. Potentially complete pathways exist for both human and T/E ecological receptors. Drinking water supply wells are installed in the alluvial groundwater basins in the San Onofre and Las Flores watersheds, where MC concentrations in surface water recharging the groundwater are expected to be above the REVA trigger values. Based on these predicted results, surface water sampling was conducted down gradient of operational ranges in the San Onofre and Las Flores watersheds. A background surface water sample was collected up gradient of operational ranges in the San Mateo watershed.

Groundwater Analysis Summary

Based on the CSM and the results of the surface water modeling, fate and transport modeling of potential MC concentrations in groundwater through screening-level analysis was conducted for the San Onofre and Las Flores alluvial groundwater basins. These groundwater basins are located within MCB Camp Pendleton and are down gradient of the primary MC loading areas (Quebec, Whiskey and Zulu).

Ranges and impact areas were grouped by watershed for modeling. For each watershed, MC contributions in runoff from the three primary MC loading areas were used to estimate the total loads reaching potential receptors. The results of the surface water screening-level model were used as the input for the groundwater modeling based on the analysis of the CSM. The screening-level groundwater methodology was used to estimate the concentration of MC at drinking water wells located down gradient of the surface water recharge points. These estimated MC concentrations were compared to established REVA trigger values for each MC.

Screening-level model results for MCB Camp Pendleton watersheds predicted the groundwater concentration of RDX within the San Onofre alluvial groundwater basin above the REVA trigger value in the drinking water supply well located closest to the up gradient groundwater recharge area. The concentration of TNT in the San Onofre groundwater basin and the concentrations of RDX and TNT in the Las Flores groundwater basins are predicted to be below the REVA trigger values. Based on the screening-level analysis that predicts the concentration of RDX above the REVA trigger value, a conservative decision was made to conduct groundwater sampling in both the San Onofre and Las Flores alluvial groundwater basins.

SAR Assessments

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

There are 15 SARs located at MCB Camp Pendleton assessed using the REVA SARAP. Two are located within the Santa Margarita watershed, one is located in the Las Flores watershed, five are within the San Onofre watershed, and one is located in the San Mateo watershed. Six of the SARs are located in the Aliso watershed; however, no drinking water wells are located in this watershed.

These SARs were selected to correspond with a separate small arms study conducted by the installation in 2007 with concurrence from AC/S-ES and Range Operations & Training Department. The SARs represent a cross-section of range designs, with SAR-only use, as well as locations of high munitions use and environmental sensitivity related to potential lead migration. The name, size and orientation of each range were collected from the MCB Camp Pendleton Final Range Identification and Preliminary Range Assessment (RIPRA) (MCB Camp Pendleton, 2001a) and Installation Map (MCB Camp Pendleton, 2001b).[2]

The installation's small arms study was completed as a voluntary pollution prevention program in response to reporting requirements for facilities that manufacture, process, or otherwise use listed constituents above certain thresholds. Consequently, the purpose of the installation's small arms study was to proactively identify and assess opportunities to implement engineering controls at selected small arms ranges at the installation to reduce potential migration of lead and other constituents related to small arms munitions. The information compiled for the installation's study, together with these REVA SARAP results, forms a basis for prioritizing SARs for further action and provides an assessment of potential control options to prevent lead migration from these ranges.

The analysis of 15 SARs at the installation resulted in minimal, moderate, or minimal to moderate environmental concern rankings for surface water, based on the SARAP and professional judgment. These SARs received minimal to moderate, moderate, or moderate to high environmental concern rankings for groundwater. Eight ranges located in the San Onofre, San Mateo, and Santa Margarita watersheds received a moderate to high environmental concern ranking for groundwater, primarily based on uncertainties in groundwater information used in the assessment. Where uncertainties exist, a conservative scoring approach is used in the SARAP. The differences in rankings for the ranges were due primarily to the amount of lead loading (based on number of rounds fired and type of small arms ammunition use) and factors that may increase or decrease the potential for lead migration and bioavailability, such as soil type, slope of berm, condition of berm, drainage and vegetation, and engineering controls or berm maintenance applied at each SAR.

Field Sampling Activities

The initial assessment of the screening-level surface water and groundwater modeling

[2] Visual estimates of range size and orientation are provided based on site visit measurements and observations and GIS mapping when RIPRA sizing did not match current range operations.

predicted low levels of explosives potentially present within the Las Flores and San Onofre watersheds. As a result, groundwater and surface water sampling was recommended for these watersheds. Sampling events were conducted between December 2007 and April 2008.

The field sampling effort did not include the Santa Margarita watershed because the operational ranges within this watershed are primarily SARs, which were assessed qualitatively. Further assessment of the watershed for lead by field sampling or the application of best management practices is continually being evaluated by the Marine Corps based on the results of the SAR assessments. The installation routinely samples drinking water at MCB Camp Pendleton for lead and reports results in accordance with U.S. Environmental Protection Agency (USEPA) and California requirements.

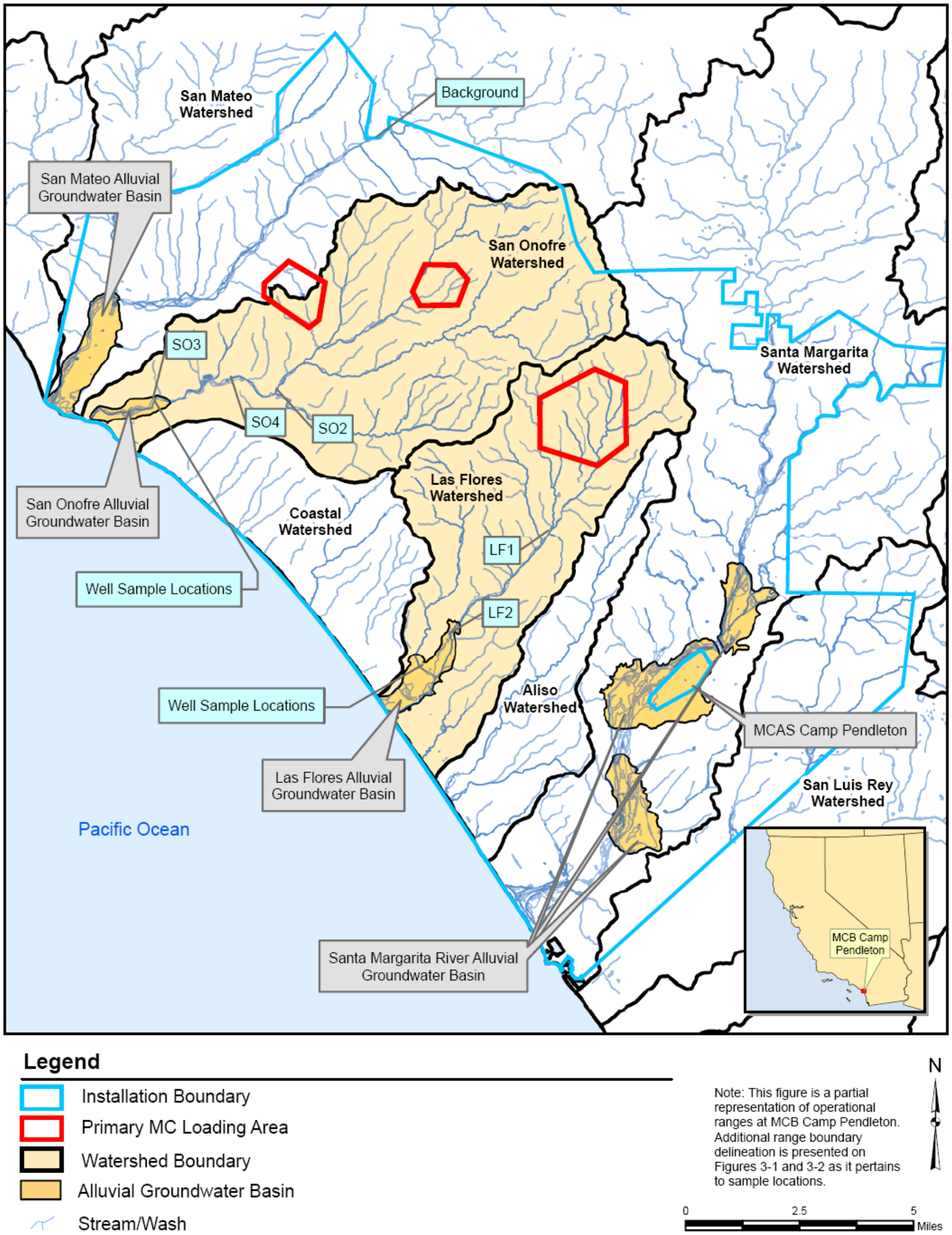
Field activities included sampling of off-range surface water and groundwater at the following locations (Figure ES-2):

- Five surface water locations, down gradient of operational ranges, in the Las Flores and San Onofre watersheds, following three rain events in the 2007–2008 rainy season
- Raw water from seven operational or proposed drinking water supply wells (three wells in Las Flores and four wells in San Onofre watershed)
- Surface water at one background location, upgradient of operational ranges, in upper San Mateo Creek

Sample locations were selected based on modeling results for HE at mixed use ranges, not on the results of the SARAP.

All samples were analyzed for the full suite of explosives, excluding perchlorate, and total and dissolved lead. Perchlorate was not included in these REVA sampling events for two reasons. First, concentrations were not predicted in the conservative REVA modeling results. In addition, drinking water supply wells are routinely sampled and analyzed for perchlorate to comply with the Unregulated Contaminant Monitoring Rule (UCMR).

Figure ES-2: Installation Map and Sample Locations



MALCOLM PIRNIE	Installation Map and Sample Locations MCB Camp Pendleton	Figure ES-2 April 2009

P:\6285\024\GIS\MXD\061_Figure ES-2_Installation Map and Sample Locations_PRD.mxd

On the basis of that sampling program, the installation reports that water supply wells do not contain detectable concentrations of perchlorate (MCB Camp Pendleton OWR, 2008).

Lead was included in the field sampling as a proactive measure at locations already selected on the basis of predicted HE concentrations. Lead is also known to be a constituent of HE munitions, therefore, its inclusion was expected to provide an indicator of possible heavy metal constituents.

Groundwater Sampling Results

Nine groundwater samples were collected from seven wells on December 12, 2007, and six groundwater samples from three wells on April 30, 2008. Samples collected on December 12, 2007, were analyzed for the full suite of explosives as described above and total and dissolved lead. Follow-up samples collected on April 30, 2008, were analyzed for the full suite of explosives or total and dissolved lead, based on earlier sampling results. Follow-up samples were collected from wells and analyzed for the corresponding analyses (explosives or lead) that were detected in the initial sampling event.

The analytical results were compared to DoD Range and Munitions Use Subcommittee (RMUS) screening values (DoD, 2009), which were developed from existing USEPA or state standards and guidelines to promote consistency across the services' operational range assessment programs.

Sample results within Las Flores indicate that no explosives were detected in drinking water supply wells. Total and dissolved lead were detected in raw groundwater at one well for samples collected in December 2007 and April 2008, but these detections are below DoD RMUS screening values.

Sampling results within the San Onofre watershed indicate trace amounts of explosives (2-nitrotoluene, 3-nitrotoluene, and RDX), but concentrations are below DoD RMUS screening values. The explosive 2-nitrotoluene, a daughter product of TNT, was detected in only one groundwater well during the December 2007 sampling event. It was re-sampled in April 2008, and no explosives were detected. This well is not yet used as a water supply well. Trace concentrations of total lead were positively identified in two other wells in December 2007, but were not detected in one of the two wells in April 2008. The second well was not available for re-sampling in April 2008 due to mechanical issues with the pump.

Surface Water Sampling Results

Surface water sampling events were timed to occur within 24 hours of three separate storms that produced surface flow in either or both of the watersheds selected for field activities. Two sampling events were conducted at each watershed. The events provide insight to surface water quality in the early and middle part of the 2007–2008 rainy season. All samples were analyzed for the full suite of explosives and total and dissolved lead, excluding perchlorate, as discussed earlier.

Explosives and total lead were not detected in the background sample taken in surface water in the upper San Mateo watershed. Due to issues with sample preservation, the result for dissolved lead is not usable for project objectives; however, the analytical results for total lead suggest that concentrations of dissolved lead were below the laboratory method detection limit.

The analytical results for the surface water samples collected in the Las Flores watershed are summarized as follows:

- Explosives were not detected in surface water samples.
- Dissolved lead was detected at one downstream sampling location in December 2007 at concentrations above the DoD RMUS ecoreceptor screening value for surface water of 2.5 µg/L.[3] However, when the screening value was adjusted to reflect site-specific water hardness, dissolved lead concentrations were below the adjusted screening value.
- Dissolved lead was not detected in either Las Flores surface water sampling location in the February 2008 sampling event.

The analytical results for the surface water samples collected in the San Onofre watershed are summarized as follows:

- Trace amounts of explosives were detected in some surface water samples. All detections were below DoD RMUS screening values for these MC or an applicable screening value was not available.
    - 2-Nitrotoluene was detected in surface water at two of the downstream locations in this watershed; however, one detection was slightly above the laboratory reporting limit (RL). There is no DoD RMUS screening value for 2-nitrotoluene in surface water at this time.
    - 3-Nitrotoluene was detected below the laboratory RL at a downstream location in the February 2008 sampling event.

[3] Values are based on DoD RMUS screening values as Surface Water Values-Ecological Receptors (DoD, 2009)

- RDX was detected above the laboratory RL at all three sampling locations in the January 2008 sampling event, but was not detected in the February 2008 sampling event. The detections were below the DoD RMUS screening value of 190 μg/L.[4]

- Total lead was detected in all surface water samples during both sampling events. Total lead results in surface water were above the laboratory RL at all three sampling locations in January 2008. Corresponding nephelometric turbidity units (NTU) values for turbidity were also high in this early season event (70 to greater than 999 NTU).

- Dissolved lead was detected in all samples collected during the January 2008 sampling event, but was not detected during the February 2008 sampling event. All dissolved lead concentrations were above the DoD RMUS ecoreceptor screening value of 2.5 μg/L.[5] However, when the screening value was adjusted to reflect site-specific water hardness, the dissolved lead concentration at one sample location slightly exceeded the adjusted screening value.

Following a review of the sample results, a literature review was conducted in concert with installation natural resources personnel in order to evaluate whether the concentrations of lead in surface waters in the watersheds at MCB Camp Pendleton would affect threatened and endangered species. The literature review indicated that adverse effects were unlikely to occur because: exposure was unlikely due to the intermittent nature of the surface water creeks, species studied would not be exposed to waters in the creeks, or concentrations of lead were below levels that would adversely affect certain species.

However, base flow had been observed by the REVA assessment team at the upstream sampling location in the Las Flores watershed prior to the 2007–2008 rainy season.

Conclusions and Further Action

The results suggest that a seasonal first flow of MC may have been followed by diminished concentrations as the rainy season continued. Comparing the seasonal first flow results to the DoD RMUS screening values reflects a conservative approach because the values are calculated based on exposure over long periods of time. For example, hydrologists at MCB Camp Pendleton have observed that surface water flow in the San Onofre watershed is, at a maximum, sustained for only a few days per year, depending on

[4] Ibid.
[5] Ibid.

seasonal rainfall. At the San Onofre watershed sampling locations, no surface water flow had occurred for three years prior to starting these field activities.

Overall, the field sampling effort generally confirmed modeling results, which were based on conservative assumptions. Although modeling results reflects concentrations over an average year, the conditions prior to field sampling are not reflective of average conditions. There had been little to no rainfall for three years, potentially allowing for accumulation of indicator MC and lead. Severe wildfires had burned through both watersheds just prior to sampling, increasing the potential for erosion and runoff. It is of note that concentrations decreased from the December 2007 sampling event to the February 2008 sampling event. From this perspective, sampling results may be considered a conservative snapshot of off-range MC migration at the time they were collected and are not necessarily representative of a long-term trend.

Based on the assessment results presented in this report, no immediate environmental concern was identified through the screening level models, field sampling activities, or the use of the SARAP. Nevertheless, the Marine Corps is evaluating further actions to continue to mitigate the possibility of MC migration from operational ranges at MCB Camp Pendleton and to ensure future range sustainability.

1. Introduction

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 4715.14 *Operational Range Assessments*.

The REVA program is a proactive and comprehensive program designed to support the Marine Corps' environmental range sustainment initiative. Operational ranges across the Marine Corps are being assessed to identify areas and activities that are subject to possible impacts from external influences, such as development of adjacent off-installation areas, 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 and, where applicable, the use of fate and transport modeling / analysis of the REVA indicator MC based upon site-specific environmental conditions at the operational ranges and training areas. In areas where MC are predicted to migrate off range, sampling may be used to further evaluate off-range migration of MC.

In recent years, the DoD and the Marine Corps have experienced a dramatic increase in encroachment pressures associated with operational range activities. In some instances, encroachment issues have impacted training. The early identification of encroachment issues will allow the Marine Corps installation to minimize external pressures, thereby minimizing potential impacts to training. Operational ranges and maneuver areas are essential to Marine Corps training; therefore, sustaining these areas for use is critical to mission readiness.

The REVA program is a component of the Marine Corps Range Sustainment Program. The operational range assessments conducted through the REVA program enhance the Marine Corps' ability to prevent or respond to a release or substantial threat of a release of MC from an operational range or range complex to off-range areas. The assessments also provide information to support operational range sustainment.

This report presents the assessment results for the operational ranges and training areas at Marine Corps Base (MCB) Camp Pendleton in Oceanside, California. This report is the first comprehensive report on MC associated with the operational ranges at MCB and

Marine Corps Air Station (MCAS) Camp Pendleton[1] and, as such, serves as the baseline of environmental conditions and potential vulnerabilities of the ranges. Subsequent vulnerability assessments will be conducted for operational ranges at MCB and MCAS Camp Pendleton on a five-year cycle or when significant changes are made to existing ranges that potentially affect the determinations made during this baseline assessment, as described in the *REVA Reference Manual* (HQMC, 2006).

1.2. Scope of 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, small arms ranges (SARs), buffer areas, and training areas where military munitions are known or suspected to be used currently or to have been used historically. The presence of other-than-operational ranges is noted where applicable, but they are not assessed under the REVA program. Other-than-operational ranges are being addressed under the Marine Corps' Munitions Response Program.

Site-specific environmental conditions and MC loading rates are used to develop conceptual site models (CSMs) 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. Where applicable, screening-level fate and transport models are also used to conservatively estimate the concentrations of MC potentially migrating to off-range exposure points. Exposure pathways considered in the REVA process include consumption of surface water and groundwater for off-range human and threatened and endangered (T/E) ecological receptors, as described in the *REVA Reference Manual* (HQMC, 2006). Other off-range exposures scenarios (e.g., soil ingestion, incidental dermal contact, bioaccumulation and food chain exposure) currently are not considered in the REVA process.

The MC evaluated in the REVA program include trinitrotoluene (TNT), cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), and perchlorate. TNT, HMX, and RDX are considered to be indicator MC. Studies have shown that they are detected in a high percentage of samples containing MC due to their chemical stability within the environment. They are common high explosives used in a wide variety of military munitions. Perchlorate is a component of the solid propellants used in some military munitions. Perchlorate is also considered an indicator MC, as its high solubility, low sorption potential, and low natural degradation rate make the compound highly mobile in the environment. Additional information pertaining to the

[1] All operational ranges and training areas occur on MCB Camp Pendleton; thus, this report reflects the MCB unless otherwise noted.

physical and chemical characteristics of the REVA indicator compounds is provided in the *REVA Reference Manual* (HQMC, 2006).

The primary MC of concern at SARs is lead because it is the most prevalent (by weight) potentially hazardous constituent associated with small arms ammunition. The mobility of lead in the environment is highly variable depending on site-specific conditions; modeling of lead would require site-specific geochemical data that generally are unavailable during a baseline assessment. Therefore, instead of modeling lead transport, active SARs at the installation are qualitatively reviewed and assessed to identify factors that influence the potential for lead migration. These factors include a range's design and layout, the physical and environmental conditions of the area, and current and past operation and maintenance practices. The amount of lead that has been loaded to the operational ranges has also been determined.

This report presents: 1) the analysis of the data collected during site visits, 2) the results of screening-level fate and transport modeling, and 3) results of the field sampling program at MCB Camp Pendleton. The process and assumptions used in estimating the MC deposited onto operational ranges, defined in REVA as MC loading, are discussed in **Section 3**. The CSM developed for MCB Camp Pendleton to guide fate and transport modeling appears in **Section 4**. The fate and transport modeling and analysis methods and assumptions for surface water and groundwater are discussed in **Sections 5** and **6**, respectively. Screening-level modeling results for specific operational range training areas are discussed in **Section 7**. The SAR assessment appears in **Section 8**. REVA field sampling methods and results are discussed in **Section 9**.

Additional details of the REVA assessment methods are outlined in the *REVA Reference Manual*, which includes the data needed to run the fate and transport models, as well as recommended sources for data. In addition, the *REVA Reference Manual* provides a detailed description of the REVA MC Loading Rate Calculator (HQMC, 2006).

This baseline range environmental vulnerability assessment report presents the conditions of the operational ranges at the time the assessment was conducted. The baseline environmental range assessment was performed using available data and personnel interviews and is supplemented with information from external sources, including reports and documentation.

1.3. Report Organization

This REVA baseline environmental range assessment report for MCB Camp Pendleton is organized into the following sections:

Section 1 – Introduction
Section 2 – Summary of Data Collection Effort

Section 3 – Munitions Constituents Loading Rates and Assumptions
Section 4 – Conceptual Site Model
Section 5 – Surface Water Analysis Method and Assumptions
Section 6 – Groundwater Analysis Method and Assumptions
Section 7 – Screening-Level Assessment Results
Section 8 – Small Arms Range Assessments
Section 9 – Field Data Collection Results
Section 10 – References

2. Summary of Data Collection Effort

Data required for the operational range assessments were obtained from Headquarters Marine Corps (HQMC), from the installation during site visits by the REVA assessment team, and from external data sources. Data obtained from HQMC and the installation includes various documents and reports prepared for the installation (e.g., Master Plans, Archive Search Reports [ASRs], Preliminary Range Assessment [PRA] and Installation Restoration Program [IRP] reports). External data sources include reports and online information from organizations such as the U.S. Geological Survey (USGS) and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS).

The REVA assessment team conducted its first visit to MCB Camp Pendleton on September 12–17, 2005. HQMC and Training and Education Command (TECOM) personnel accompanied the team during the site visit. The installation site visit involved a review of various data repositories and interviews with installation personnel from the following offices:

- Air Traffic Control (ATC)
- Assistant Chief of Staff (AC/S) / Environmental Security
- AC/S / Facilities
- Community Planning and Liaison Office / Public Affairs Office (CPLO/PAO)
- Explosive Ordnance Disposal (EOD)
- Explosives Safety
- Geographic Information Systems (GIS)
- Historian
- Office of Water Resources (OWR)
- Training Resources Management Division (TRMD)
- Range Operations and Control

The REVA assessment team interviewed subject matter experts within each of these offices 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.

3. Munitions Constituents Loading Rates and Assumptions

The REVA fate and transport modeling / analysis requires estimation of the amount of indicator MC deposited on operational ranges over time in order to predict if there is a potential release or substantial threat of a release of MC. Within the REVA program, this deposition is referred to as MC loading. Operational range usage, boundaries, and other characteristics typically change over time; therefore, an analysis of their history must be performed to map the affected areas over time and to estimate the historical and current MC loading. Some operational ranges were conceptually subdivided into one or more areas of interest when MC loading was estimated not to be consistent across their area. Similarly, different loading periods were assumed to account for changes in training rates and historical uses. The MC loading for the operational ranges was estimated separately for each area and period of interest and for each REVA indicator MC. For the purposes of the REVA program, MC loading estimates were expressed as the average mass deposited annually in the defined area of interest (kilograms per square meter [kg/m^2]) for the duration of the period that the operational range activities generating the MC loading were conducted.

Assumptions about the temporal and spatial distribution of MC in the MC loading areas were made throughout the MC loading estimation process. The REVA methodology for estimating MC loading is described in Sections 3.1 through 3.4. Section 3.5 describes the range training area (RTA) use. The overall assumptions for MC loading on the operational ranges at MCB Camp Pendleton are summarized in Section 3.6. Section 3.6 also presents the results of the MC loading process. Finally, Section 3.7 prioritizes the MC loading areas for further analysis. More detailed data on each high priority MC loading area, including maps and tables listing the assumptions made for each operational RTA that was assessed, are located in **Section 7**.

3.1. MC Loading Process

The MC loading was estimated based on mass-loading principles. Studies have shown that MC are deposited on the operational range through low- and high-order detonations and can leach from corroded unexploded ordnance (UXO). These processes are presented in the equation below:

Total MC loading = MC (low order) + MC (high order) + MC (UXO)

Where:
MC (low order) is the amount of MC deposited as a result of low-order detonations.
MC (high order) is the amount of MC deposited as a result of high-order detonations.

MC (UXO) is the amount of MC deposited as a result of UXO with breached casings.

Studies conducted by the DoD have shown that the MC remaining from high-order detonations are much less significant than the amount of MC deposited from low-order detonations. Corrosion studies conducted by the U.S. Army have shown that it can take 10 to 30 years for UXO to corrode. Although MC remaining from low-order detonations are the most significant contributor to MC loading, the REVA program accounts for MC from all three of these potential sources.

MC loading estimates for low-order and high-order detonations and UXO for the MC loading areas associated with each operational range were estimated using the equations below:

MC (low order) = (number of military munitions expended) x (low-order detonation rate) x (amount of residual remaining from a low-order detonation)

MC (high order) = (number of military munitions expended) x (high-order detonation rate) x (amount of residual remaining from a high-order detonation)

MC (UXO) = (number of military munitions expended) x (dud rate) x (amount of residual exposed as a result of damage to UXO casings)

Dud rate and low-order detonation rate data for REVA were estimated based upon the July 2000 study completed by the U.S. Army Environmental Technical Center for Explosives Safety entitled *Report of Finding for Study of Ammunition Dud and Low Order Detonation Rates*. Dud and low-order detonation rates for military munitions in this report were tracked, reported, and made available according to military munitions DoD Identification Code (DoDIC). For the DoDICs that do not have dud or low-order detonation rates available, the default values listed in the referenced report of 3.45% (dud rate) and 0.028% (low-order detonation rate) were used (USAEC, 2000). In addition, for the purposes of the REVA program, it was assumed that the amount of residual explosives remaining after a low-order detonation and a high-order detonation were 50% and 0.1%, respectively. These numbers are consistent with those used in the U.S. Navy's Range Sustainability Environmental Program Assessment.

The primary source of information for the types and amounts of energetic fillers associated with military munitions was the Defense Ammunition Center's Munitions Items Disposition Action System (MIDAS) Web site. Data were retrieved from MIDAS by performing searches for the MC, which produced a list of military munitions with their respective amounts of MC. The list of military munitions was then evaluated, as more than one matching National Stock Number was often listed, and the highest and lowest MC quantities were captured and averaged for REVA MC loading estimate calculations.

In addition to MIDAS, other sources of military munitions data for MC loading included the ORDDATA II software *(Enhanced International Deminer's Guide to UXO Identification, Recovery and Disposal*; Version 1.0, 1999) and various ordnance technical manuals. In cases where specific military munitions use data were unavailable, the military munitions types selected were based upon common military munitions used during the active time periods of the operational range.

3.2. Expenditure Data

MC loading data for MCB Camp Pendleton were derived from the Unit Expenditure Reports and the Toxic Release Inventory (TRI) reporting. At the time of the 2005 site visit, military munitions expenditures for 2001 through 2004 were obtained in hard copy format from Range Control and the AC/S, Environmental Security. The 2005 site visit confirmed that these data are the same as those provided to or developed by Environmental Security each year for MCB Camp Pendleton's TRI reporting. Discussions with Environmental Security personnel indicated that the most consistent and complete expenditure data from this time frame are for year 2004. Therefore, the 2004 TRI data based on range expenditure data were selected as the basis for the current military munitions expenditure analysis.

3.3. REVA MC Loading Rate Calculator

The REVA MC Loading Rate Calculator and its Training Factor are explained in more detail in the *REVA Reference Manual* (HQMC, 2006). All site-specific environmental and operational data and assumptions input into the REVA MC Loading Rate Calculator for each operational range area being assessed are documented in **Section 7**. The following discussion provides a brief summary of the MC Loading Rate Calculator.

The REVA MC Loading Rate Calculator provides an automated method to calculate the overall loading of the operational range based upon military munitions expenditure estimating methods. The MC Loading Rate Calculator estimates an average expenditure rate that is then applied to each year the operational range was known or expected to have been operational where expenditure data are missing or incomplete.

The MC Loading Rate Calculator also applies values for the data discussed earlier (dud rate, low-order and high-order detonation rates, and residual amount of MC remaining) and loading area (square meters [m^2]) so that the estimated MC concentrations are presented in the units needed for the fate and transport analysis (kg/m^2). Additionally, the calculator applies a training factor to account for fluctuations in training due to world events, such as conflicts and wars, during which there was an increase or decrease in training.

3.4. Training Factor

Historically, the level of military training operations has been strongly affected by conflicts and wars. This usually resulted in an increase in training prior to a conflict or war and a tapering off during it, with training increasing again toward the end of the event and then, subsequently, decreasing again to a nonconflict/nonwar level. The REVA program attempts to account for this training effect by developing a training timeline of significant military conflicts and wars from 1914 through today. This timeline accounts for the following:

- World War I
- World War II (WWII)
- The Cold War
- The Korean War
- The Vietnam Conflict
- The Persian Gulf
- Afghanistan
- Iraq

Subject matter experts within the Marine Corps were queried to establish time periods of increased training throughout history. This inquiry resulted in the establishment of a baseline training level period, as well as the development of four periods that increase the MC loading rate by a Training Factor. The periods identified and their associated Training Factors are as follows:

- Period A: 1914–1924 (baseline + 40%)
- Period B: 1925–1937 (baseline)
- Period C: 1938–1976 (baseline + 50%)
- Period D: 1977–1988 (baseline + 20%)
- Period E: 1989–present (baseline + 50%)

The baseline expenditure rate was applied to each year an operational range was in use. At MCB Camp Pendleton, operational ranges were present beginning in 1942. The MC Loading Rate Calculator automatically applies the training factor adjustments according to the time period so that MC loading rates are estimated for each year the operational range is known or suspected to have been in use.

3.5. MC Loading at MCB Camp Pendleton

The process used to develop MC loading rates for MCB Camp Pendleton ranges is described in this section. MC loading rates are estimates of the mass per unit area of REVA indicator MC deposited annually on a range. MCB Camp Pendleton documentation was first evaluated to identify all operational range areas meeting the definition presented in **Section 1**. Assumptions about current patterns of MC deposition were made by observing firing point configurations on current installation maps and through interviews with installation personnel in Range Control and Range Operations and Training (O&T). According to the Integrated Natural Resources Management Plan (INRMP), numerous training events are scheduled at MCB Camp Pendleton each year. Training activities include, but are not limited to, amphibious landings, use of tracked vehicles, infantry and vehicle maneuvers, artillery and small arms firing, aerial weapons delivery, engineer support, communications, airlift support for troops and weapons, equipment maintenance, and field medical treatment (MCB Camp Pendleton, 2007).

Inland training areas consist of nearly 114,000 acres of live-fire ranges, impact areas, and training areas. According to the installation's MCB Camp Pendleton Range Regulations, Military Installation Map (MCB Camp Pendleton, 2000), and 366 Report (United States Marine Corp, 2004), MCB Camp Pendleton currently has 37 RTAs, 7 impact areas, approximately 100 live-fire facilities, and 5 amphibious assault landing beaches. MCB Camp Pendleton's training ranges are heavily used, not only by active Marine and Navy units, but also by the Marine Corps Reserve, Army National Guard, local community law enforcement agencies, and private research firms for weapons testing.

Operational range usage, boundaries, and other characteristics typically change over time; therefore, an analysis of the history of the ranges associated with MCB Camp Pendleton was performed to map the MC loading areas over time. The analysis was done for current operational ranges and for historical use areas. Historical use areas are formerly used areas that are located on or overlap operational range areas. Information on historical use areas was extracted from the ASR and PRA report that were available for MCB Camp Pendleton.

Within the identified 37 operational RTAs, 338 operational areas (historical use areas and fixed ranges) were identified at MCB Camp Pendleton. Table 3-1 provides a summary of these operational range training areas for MCB Camp Pendleton. The operational range training areas presented in the table are shown in Figures 3-1 through 3-3 and are described in the following sections. The current and historical RTAs, impact areas, and live-fire facilities were screened to eliminate ranges where no high explosive (HE) use currently is authorized (non-live-fire) and ranges for which insufficient data are available to permit MC loading calculations.

Target areas or operational ranges that are authorized for inert munitions only and historical use areas with no data available were not considered MC loading areas and, therefore, were not loaded using the MC Loading Calculator. The MC loadings, or calculated concentrations (kg/m^2) estimated to be deposited annually in each MC loading area, are discussed in the following sections.

The RTAs, impact areas, and other ranges described in the following sections are the primary operational range features, which include locations and usages of current fixed targets, fixed training ranges, amphibious landing areas, and SARs. The MC loading process and related assumptions are then described, and the MC loading results are presented along with the prioritization of the primary MC loading areas for modeling.

3.5.1. RTAs

The base's natural areas are unique and irreplaceable to the Marine Corps because they combine over 17 miles of coastline and extensive, diverse inland training areas. The RTAs are designed in this natural environment to facilitate all phases of combat readiness training. Of the identified 37 operational RTAs, 21 were determined to have HE use (current or historical) with sufficient available data to permit MC loading calculations. The 21 RTAs that passed this screening were designated MC loading areas, and numerical estimates of MC loading rates were calculated for each of these areas.

A review of historical data revealed a lack of readily available information on military munitions expenditures for historical use RTAs. Military munitions used on operational ranges with historical use areas at MCB Camp Pendleton were retrieved primarily from the ASR and PRA documents (USACE, 2001a; USACE, 2001b). Historical Surface Danger Zones (SDZs) were not available in a single GIS layer; however, the ASR and PRA report plates depict historical impact areas. For the purposes of REVA, current and historical expenditure data were assumed to be relatively consistent. As a result, an impact area was treated in the same manner for current and historical use military munitions expenditures.

Table 3-1:
Summary of Operational Ranges and Training Areas, MCB Camp Pendleton

NDAA Section 366 Report Range	Name	Status	Size (acres)[a]	Begin Use[b]	End Use	Description of Use	Notes	Overall Priority (HE Consideration Only)
	Alpha One	Operational and historical use	1,034	1944	Present	Training area	Operational; however, no current MC loading	**Medium**
	Alpha Two	Operational and historical use	1,329	1942	Present	Training area, impact area	Operational; however, no current MC loading	**Low**
	Alpha Three	Operational and historical use	1,265	1942	Present	Training area		**Low**
D706, D710	**Bravo One**	Operational and historical use	2,443	1942	Present	Training area, impact area		**Medium**
	Bravo Two	Operational and historical use	1,986	1942	Present	Training area	Operational; however, no current MC loading	**Medium**
	Bravo Three	Operational and historical use	2,443	1942	Present	Training area, impact area	Operational; however, no current MC loading	**Low**
D710	**Charlie**	Operational and historical use	1,641	1968	Present	Training area		**Low**
	Combat Town 25 Area	Operational	N/A	1971	Present	Maneuvers		**Low**
	Delta	Operational and historical use	2,713	1944	Present	Training area		**Low**
	Echo	Operational and historical use	2,097	1944	Present	Training area	Operational; however, no current MC loading	**Medium**
	Edson Range Impact Area	Operational and historical use	2,177	1942	Present	Secondary impact area		**Medium**
	Finch "No Name" (unknown)	Operational and historical use	1,733	1942	Present	Training area	Operational; however, no current MC loading	**Low**
	Foxtrot	Operational	2,664	N/A	Present	Training area, impact area		**Low**
	Golf	Operational	2,542	N/A	Present	Training area, impact area		**Medium**
	Hotel	Operational and historical use	3,746	1944	Present	Training area	Operational; however, no current MC loading	**Low**
D700	**India**	Operational and historical use	3,757	1944	Present	Training area, LFAM	Operational; however, no current MC loading	**Low**
	Jardine Canyon	Operational and historical use	264	1944	Present	Secondary impact area		**Medium**
	Juliett	Operational and historical use	3,014	1942	Present	Training area, impact area		**Medium**
D700	**Kilo One**	Operational and historical use	3,165	1944	Present	Training area, impact area, LFAM		**Medium**
D700	**Kilo Two**	Operational and historical use	1,064	1944	Present	Training area, LFAM	Operational; however, no current MC loading	**Medium**
	Lima	Operational and historical use	1,488	1944	Present	Training area		**Low**
	Mike	Operational and historical use	1,907	1942	Present	Training area		**Medium**
	November	Operational and historical use	3,245	1942	Present	Training area, impact area		**Medium**
	Ocean Range	Operational	N/A	N/A	Present	N/A		**N/A**
	Oscar One	Operational	3,095	1989	Present	Training area, impact area		**Low**

NDAA Section 366 Report Range	Name	Status	Size (acres)[a]	Begin Use[b]	End Use	Description of Use	Notes	Overall Priority (HE Consideration Only)
	Oscar Two	Operational and historical use	5,079	1944	Present	Training area, impact area		**Medium**
D702	**Papa One**	Operational and historical use	2,298	1944	Present	Training area	Operational; however, no current MC loading	**Medium**
D702, D705	**Papa Two**	Operational and historical use	3,606	1942	Present	Training area	Operational; however, no current MC loading	**Low**
D702	**Papa Three**	Operational and historical use	1,273	1942	Present	Training area	Operational; however, no current MC loading	**Medium**
CIA	**Quebec Impact Area**	Operational and historical use	2,862	1942	Present	Dudded impact area		**High**
	Range 107	Operational	N/A	1960s	Present		May have been a historical munitions disposal area	**Low**
	Range 401 (EOD Training)	Operational and historical use	69	1942	Present	Training area		**Medium**
	Range 403 (Small Arms)	Operational and historical use	252	1944	Present	Secondary impact area		**Low**
	Range 409 Impact Area	Operational and historical use	3,312	1942	Present	Secondary impact area		**Low**
D705	**Romeo One**	Operational and historical use	1,690	1944	Present	Training area, impact area		**Low**
D705	**Romeo Two**	Operational and historical use	2,665	1942	Present	Training area		**Low**
	Romeo Three	Operational	1,172	N/A	Present	Training area		**Low**
	San Mateo Canyon Impact Area	Operational and historical use	2,480	1942	Present	Secondary impact area		**Low**
	Section A San Onofre Beach (Green)	Operational	1,728	N/A	Present	Training area		**Low**
	Section C Las Pulgas Beach (Red)	Operational and historical use	323	1944	Present	Training area	Operational; however, no current MC loading	**Low**
	Section E Aliso Beach (White)	Operational and historical use	364	1944	Present	Training area	Operational; however, no current MC loading	**Low**
	Section G Margarita Beach (Blue)	Operational and historical use	298	1961	Present	Training area		**Low**
D704	**Tango**	Operational	1,592	N/A	Present	Training area		**Low**
	Uniform	Operational and historical use	663	1952	Present	Training area		**Low**

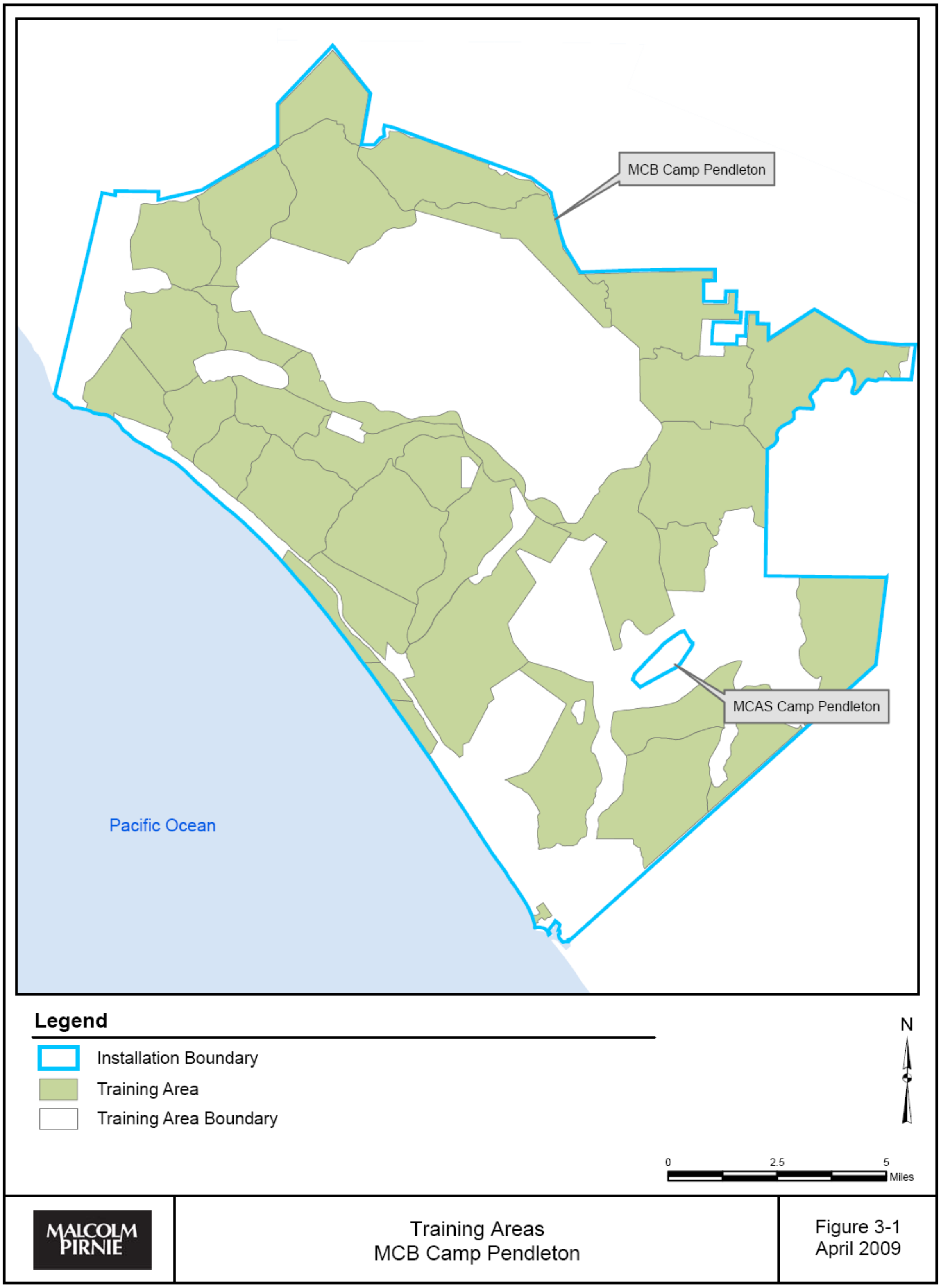
NDAA Section 366 Report Range	Name	Status	Size (acres)[a]	Begin Use[b]	End Use	Description of Use	Notes	Overall Priority (HE Consideration Only)
	Victor	Operational	323	N/A	Present	Training area		**Low**
CIA	**Whiskey Impact Area**	Operational and historical use	20,025	1942	Present	Dudded impact area, LFAM		**High**
CIA	**Zulu Impact Area**	Operational and historical use		1942	Present	Dudded impact area		**High**
	X-Ray Impact Area	Operational and historical use	5,000	1942	Present	Secondary impact area		**Medium**

Notes:

Blue Highlight on table reviews to areas which are high priority areas for modeling.
CIA = Central Impact Area (Quebec, Whiskey, and Zulu areas)
EOD = Explosive Ordnance Disposal
HE = High Explosive
LFAM = Live-Fire Maneuver Areas
NDAA = National Defense Authorization Act
Secondary Impact area = Non-dud-producing impact area

[a] Size is equal to total number of acres for training area. MC loading areas sizes were determined by installation interviews and determined to be smaller than the overall area.
[b] N/A within this column indicates that the begin use date is unknown; however, the begin use date is assumed to be 1942–1944.

Figure 3-1: Training Areas, MCB Camp Pendleton



P:\6285\024\GIS\MXD\044_Figure 3-1_Training Areas and Operational Range_PRD.mxd

3.5.2. Impact Areas

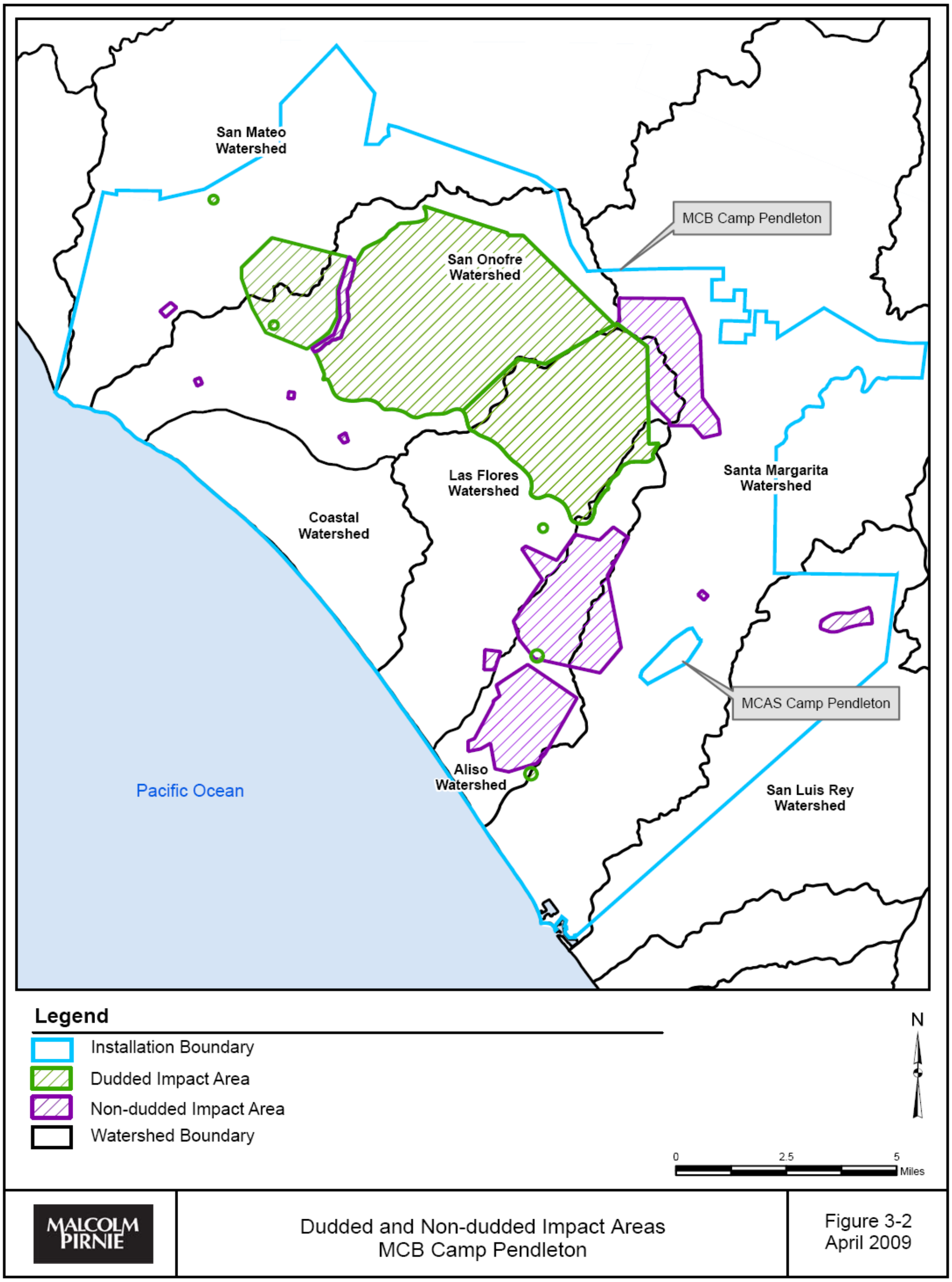
Several locations on MCB Camp Pendleton have been designated specifically for the receipt of live-fire ordnance and serve as targeting areas for associated live-fire exercises for the various weapons used in training. These locations, designated as impact areas, cover approximately 33,200 acres of the installation. Of this amount, nearly 4,200 acres overlap with the training area acreage provided in Table 3-1. Impact areas within MCB Camp Pendleton are classified as either *dud-producing* or *non-dud-producing* (Figure 3-2).

Dud-producing impact areas may contain unexploded (dud) ordnance. Dud-producing impact areas are designated as the Quebec, Whiskey, and Zulu impact areas. These three impact areas contain most of the live-fire ranges on base and are bordered on all sides by safety zones and the remaining training areas (Figure 3-1).

No maneuver activities are conducted within the Quebec, Whiskey, and Zulu impact areas, with the exception of transit in limited areas. Transit in these areas can occur with authorization from the AC/S O&T and is preceded by safety sweeps (locate, detonate, and/or remove munitions/explosives) and validation by an EOD team. Access to dud-producing ordnance impact areas is tightly controlled due to safety reasons. Wildfires in these areas normally are not suppressed due to safety concerns. Firebreaks are used to contain wildfires in dud-producing impact areas. Dud-producing ordnance impact areas have been in use throughout the base's existence. As a result, the Quebec, Whiskey, and Zulu impact areas are off-limits to all ground activities and personnel unless authorized by the AC/S O&T.

Based on MCB Camp Pendleton interviews, of the seven identified impact areas, the Quebec, Whiskey and Zulu impact areas were identified as areas where most munitions were deposited. Range Control estimates that approximately 95% of all current munitions expenditures (excluding small arms) is deposited within the Zulu Impact Area. Since these areas are the primary target areas receiving the majority of munitions, MC loading calculations were performed for these impact areas and they were determined to be the primary MC loading areas.

Figure 3-2: Dudded and Non-dudded Impact Areas, MCB Camp Pendleton



P:\6285\024\GIS\MXD\046_Figure 3-2_Dudded and Non-dudded Impact Areas_PRD.mxd

Non-dud-producing impact areas, referred to collectively as secondary impact areas, support training activities that utilize small arms firing and the use of non-dud-producing ordnance in live-fire exercises. Secondary impact areas are scattered across the base and include Edson Range Impact Area, X-Ray Impact Area, 409 Impact Area, and specific ranges within the Juliett training area. MC loading was conducted for these areas where expenditure data show munitions used that contained the REVA indicator MC. Ranges located within the Edson Range Impact Area were assessed qualitatively as part of the SAR assessment since lead was the primary constituent of concern at this location (see **Section 8**).

3.5.3. Fixed Ranges

Based on a review of operational range data, there are currently 102 fixed ranges, 53 Artillery Firing Areas (AFAs), 7 Mortar Positions (MPs), and 11 Mortar Firing Areas (MFAs) at MCB Camp Pendleton. A live-fire fixed range is a designated area equipped with a variety of targets and monitoring/scoring devices for live-fire training. These ranges are designed to accommodate a broad spectrum of weapons. With a few exceptions, the firing ranges are located within and along the perimeter of the impact areas. Over 100 live-fire ranges are present at MCB Camp Pendleton.

Several of the fixed ranges were established by the installation as being used for small arms ammunition only. Fate and transport of lead at SARs is strongly influenced by site-specific geochemical conditions that cannot be determined solely by physical observation. Therefore, MC loading and fate and transport modeling were not conducted for the SARs. Fifteen SARs were qualitatively assessed through the REVA SARAP, which employs a consistent, qualitative approach to identify and assess factors that influence the potential for lead migration at an operational range. The 15 SARs were selected with concurrence from Assistant Chief of Staff, Environmental Security (AC/S-ES) and Range Operations Training Department. Their selection was based on the following general guidelines: the presence of berms; current munitions use, as well as those locations of the high munitions expenditures at the installation; and representative of the varied range designs present at MCB Camp Pendleton. The methodology results of the SAR assessments are provided in **Section 8**.

In addition to fixed ranges, AFAs, MPs, and MFAs are designated locations for the firing of inert munitions and high explosives into the impact areas. AFAs are fairly large and relatively flat areas, usually free of brush and scrubs. MPs are similar to AFAs but smaller in area. MFAs are generally larger than MPs and are used for simulating emergency suppression tactics. Specially designated AFAs are also used in conjunction with live-fire operations using wheeled and tracked assault vehicles AFA or MP training is conducted in accordance with the range and training regulations, equipment technical manuals, and operation manuals.

In addition to the live-fire AFAs, there are six non-firing AFAs located on MCB Camp Pendleton.These AFAs are known as reconnaissance, selection, occupation or position (RSOPs), which are used for AFA types of training without the use of live fire.

3.5.4. Other Related Training Areas

3.5.4.1. Amphibious Operations

MCB Camp Pendleton's amphibious training operations take place within a variety of offshore ocean training areas that extend the base's operational capabilities. The waters immediately west of the base, known as the Camp Pendleton Amphibious Assault Area (CPAAA), contain 294 square miles of amphibious assault training and maneuvering areas. The CPAAA includes an area dedicated to Landing Craft Air Cushion (LCAC) training and operations, as well as the Camp Pendleton Amphibious Vehicle Area (CPAVA). The CPAVA is located immediately adjacent to the shoreline and it includes an LCAC Transit Lane. The CPAVA is used for amphibious operations. However, no live ordnance is used within the CPAVA except for occasional operations-in limited parts of the area; therefore, MC loading was not conducted for the amphibious training areas. No live or inert ordnance is expended in the CPAVA; therefore, no MC loading was conducted.

The majority of amphibious assault training activity occurs at Red Beach. Other amphibious assault training can take place at Gold, Green, White, and Blue beaches. These four beaches, though, have environmental and physical limitations that reduce their effectiveness for training and ingress opportunities. Of the five amphibious landing beaches, Red Beach has the fewest environmental and physical constraints on training activities.

3.5.4.2. Maneuver Corridors

A key to developing weapons proficiency is ready access to the various firing ranges spread across the base's interior, particularly those firing positions located around the perimeter of the Zulu, Whiskey, and Quebec impact areas located generally in the center of the base. One of the primary components of accessing the interior ranges is the availability of inland transit routes, called maneuver corridors. These maneuver corridors represent key locations where movement of military personnel, equipment, and vehicles is facilitated or at least relatively unrestricted by terrain, vegetation, man-made constraints (e.g., buildings, developed areas), and/or rigid environmental regulations (e.g., designated critical habitat, sensitive species, archaeological locations, wetlands). Since these maneuver corridors are used strictly for access and no military munitions are used within these areas, MC loading was not performed for these areas.

3.5.4.3. LFAM Operations

LFAM activities are field-training exercises that practice the coordination of maneuvers and combat service support operations allowing military personnel to experience realistic combat scenarios. At MCB Camp Pendleton there are 12 specific locations designated for LFAM operations (Figure 3-3). Live or inert munition expenditures in these 12 areas were considered insignificant, and therefore no MC loading calculations were conducted.

3.6. MC Loading Rates

MC loading rates were calculated using the expenditure data from the expenditure reports and the methods presented in this section. The MC loading was calculated following the MC loading process described in the *REVA Reference Manual* (HQMC, 2006). MC loading is expressed as an average concentration (kg/m^2) deposited annually in the defined area of primary MC loading for the duration of the period that range activities involving the use of military munitions were conducted. The MC loading was calculated using one of two approaches. The first approach, used for all of the RTAs and Edson and Range 409 impact areas, assumed that MC were loaded across the entire training or impact area. The second approach, used for Quebec, Whiskey, and Zulu impact areas, assumed a smaller MC loading area rather than the entire impact areas. The MC loading areas were delineated based on discussions with installation Range Control and TRMD.

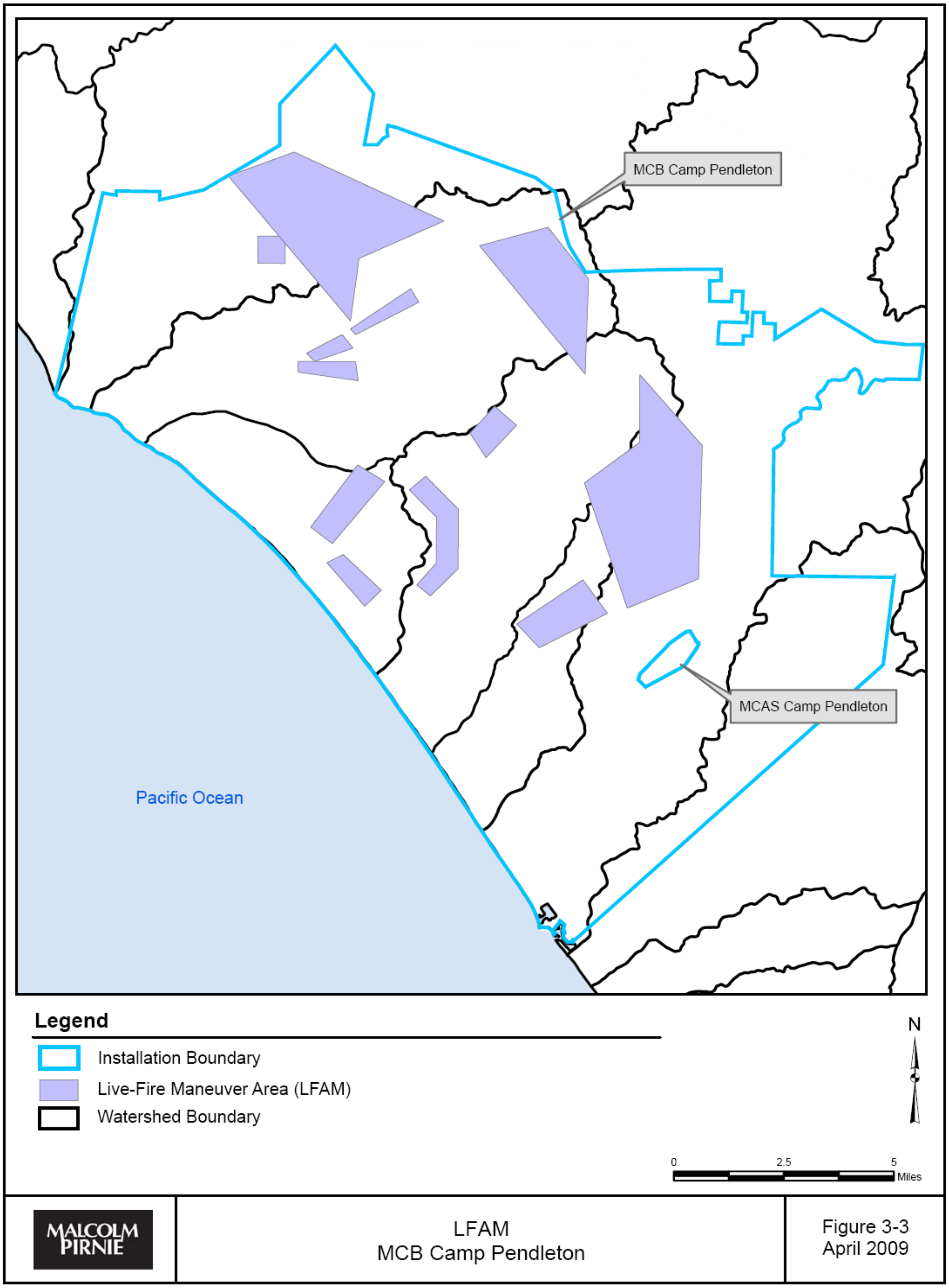
This assumption is conservative because a smaller MC loading area results in an increase in the loading rate. The ASR and PRA report for MCB Camp Pendleton were used, along with professional judgment, to estimate the MC loading periods.

In order to estimate MC loading to specific areas, two main assumptions were required to address data gaps identified for MCB Camp Pendleton. The first data gap was that the munitions expenditure data collected during the 2005 site visit did not link the firing of munitions to a specific impact area. Instead, the expenditure data were associated with the individual firing area. Several potential impact areas could have received fire from many of the firing areas. Consequently, the typical target area for each firing location was assumed, based on discussions with range personnel. The MC loading associated with each firing area was then loaded to the appropriate designated MC loading area.

The second data gap identified was that SDZs were not available for all firing areas.

For these areas, the MC loading for each firing area was not based on SDZ and firing directions; rather, it was based on discussions with range personnel regarding the configuration of the typical firing area.

Figure 3-3: LFAM, MCB Camp Pendleton



P:\6285\024\GIS\MXD\045_Figure 3-3_Maneuver Corridors and Live-Fire Maneuver Areas_PRD.mxd

One year of expenditure data (2004) was collected during the site visit. Because no other comprehensive and reliable expenditure data were available, the training factor method discussed in Section 3.4 was used to estimate the MC loading associated with historical use. This is a conservative assumption for MC loading. For example, prior to the early 1960s, perchlorate was not present in military munitions. Therefore, the training factor method overestimates the total amount of MC loaded for each MC loading area.

One of the major limitations to the historical MC loading rates is that the current expenditure data are not consistent with historical military munitions use. As noted above, the training factor method was used to calculate the MC loading rates for historical use training areas and impact areas that overlap current MC loading areas. There were limited or no data available for several training areas and impact areas. MC loading rates were not estimated if no information was available from installation personnel or documents reviewed by the REVA assessment team regarding munitions use at the area.

MC loading rates were calculated for a total of 24 areas. The MC loading rates were separated into three time periods based on the Training Factor method, Period C (1938–1976), Period D (1977–1988), and Period E (1989–2005). The MC loading rates are summarized in Table 3-2.

3.7. MC Loading Prioritization

Based on MC loading rates in Table 3-2, each MC loading area was categorized as low, medium, or high priority in terms of the overall MC loading in Table 3-3. These prioritizations were based on discussions with installation range personnel. High priority MC loading areas will be referred to as primary MC loading areas for the remainder of the document. These categories were established for the sole purpose of prioritizing screening-level modeling efforts. Two training areas, Hotel and Papa Two, are not included in Table 3-3 due to lack of loading.

The MC loading rates at Quebec, Whiskey, and Zulu impact areas were found to be potentially significant (high priority); these areas are designated "primary" MC loading areas (Figure 3-4). Primary MC loading areas are assessed for surface water and groundwater vulnerability using the methods described in **Sections 5** and **6**, respectively. MC loading areas with a low or medium MC loading priority were not prioritized further for surface water and groundwater vulnerability unless they were in proximity to one or more sensitive receptors. Table 3-3 lists the priorities assigned for each of the 24 MC loading areas with sufficient information to prioritize and calculate MC loading rates. Prioritization for surface and groundwater modeling is based on information discussed in **Sections 4**, **5**, and **6.**

Table 3-2: MC Loading Summary Table for MCB Camp Pendleton

Loading Area[a]	Area (m^2)	Period C (1938–1976), $kg/m^2/yr$					
		Begin Use	End Use	HMX	RDX	TNT	Perc
Historical Use							
Alpha One	8.37E+05	1944	1946	**9.22E-10**	**7.04E-06**	**4.46E-06**	**7.13E-08**
Alpha Two	1.08E+06	1942	1944	0.00E+00	**1.89E-06**	**1.99E-06**	**5.54E-07**
Alpha Three	1.02E+06	1942	1946	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Bravo One	1.98E+06	1942	1946	**3.90E-10**	**2.98E-06**	**1.89E-06**	**3.06E-08**
Bravo Two	1.61E+06	1942	1946	**4.80E-10**	**4.18E-06**	**2.60E-06**	**3.76E-08**
Bravo Three	1.98E+06	1942	1946	**1.17E-09**	**8.94E-06**	**5.67E-06**	**9.05E-08**
Echo	1.70E+06	1944	1946	**4.55E-10**	**3.47E-06**	**2.20E-06**	**3.51E-08**
Edson Range Impact Area	1.76E+06	1942	1946	0.00E+00	0.00E+00	**1.24E-12**	**1.26E-11**
Finch (“No-Name”)	1.40E+06	1944	1946	**5.50E-10**	**4.20E-06**	**2.66E-06**	**4.25E-08**
Hotel	3.03E+06	1944	1946	0.00E+00	0.00E+00	0.00E+00	0.00E+00
India	3.04E+06	1944	1946	**5.08E-10**	**3.88E-06**	**2.53E-06**	**3.92E-08**
Kilo Two	8.62E+05	1944	1976	0.00E+00	0.00E+00	0.00E+00	**6.93E-09**
Papa One	1.86E+06	1944	1946	0.00E+00	**2.72E-07**	**2.84E-07**	0.00E+00
Papa Two	2.92E+06	1944	1946	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Papa Three	1.03E+06	1942	1946	**1.50E-09**	**1.14E-05**	**7.25E-06**	**1.16E-07**
Range 401	5.62+04	1942	1976	0.00E+00	**1.03E-08**	**3.58E-06**	**2.37E-11**
Range 403	2.04E+05	1944	1976	0.00E+00	**8.00E-10**	**5.51E-07**	**0.00E+00**
Range 409 Impact Area	2.68E+06	1942	1950	0.00E+00	**1.33E-08**	**1.58E-08**	**1.04E-08**
Romeo One	1.37E+06	1944	1946	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Loading Area[a]	Area (m^2)	Period C (1938–1976), $kg/m^2/yr$					
		Begin Use	End Use	HMX	RDX	TNT	Perc
Historical Use							
X-Ray Impact Area	3.16E+06	1942	1976	**7.72E-10**	**6.41E-07**	**3.34E-07**	**4.15E-08**
Section C (Red Beach)	2.61E+05	1944	1965	0.00E+00	0.00E+00	**7.32E-08**	**5.88E-09**
Section E (White Beach)	2.95E+05	1944	1946	0.00E+00	0.00E+00	**1.72E-13**	**5.84E-09**
Quebec Impact Area	3.05E+06	1942	1976	**5.44E-10**	**3.11E-05**	**5.46E-05**	**1.16E-07**
Whiskey Impact Area	2.21E+06	1942	1976	**3.76E-09**	**5.35E-06**	**6.47E-06**	**3.26E-09**
Zulu Impact Area	7.97E+06	1942	1976	**2.93E-09**	**2.44E-06**	**4.54E-06**	**1.16E-09**

Loading Area[a]	Area (m^2)	Period D (1977–1988), $kg/m^2/yr$					
		Begin Use	End Use	HMX	RDX	TNT	Perc
Current Use							
X-Ray Impact Area	3.16E+06	1977	1988	0.00E+00	0.00E+00	0.00E+00	**1.79E-10**
Edson Range Impact Area	1.76E+06	1977	1988	**8.88E-11**	**1.62E-07**	**1.19E-07**	**2.49E-08**
Range 401	5.62e+04	1977	1988	0.00E+00	**1.72E-09**	**4.21E-08**	**9.17E-12**
Range 409 Impact Area	2.68E+06	1977	1988	0.00E+00	**1.06E-08**	**6.97E-09**	**8.36E-09**
San Mateo Canyon Impact Area	2.01E+06	1977	1988	N/A	N/A	N/A	N/A
Quebec Impact Area	3.05E+06	1977	1988	**2.03E-10**	**1.31E-06**	**7.30E-07**	**9.38E-08**
Whiskey Impact Area	2.21E+06	1977	1988	**2.70E-09**	**2.84E-06**	**3.67E-06**	**1.32E-09**
Zulu Impact Area	7.97E+06	1977	1988	**5.50E-09**	**2.41E-06**	**2.35E-06**	**2.06E-09**

Loading Area[a]	Area (m^2)	Period E (1989–2005), kg/m²/yr					
		Begin Use	End Use	HMX	RDX	TNT	Perc
Current Use							
X-Ray Impact Area	3.16E+06	1989	2005	0.00E+00	**4.79E-10**	**3.04E-11**	**2.45E-10**
Edson Range Impact Area	1.76E+06	1989	2005	**1.11E-10**	**1.12E-06**	**1.22E-06**	**3.38E-07**
Range 401	5.62E+06	1989	2005	0.00E+00	**2.15E-098**	**5.27E-08**	**1.15E-11**
Range 409 Impact Area	2.68E+06	1989	2005	0.00E+00	**1.33E-08**	**8.71E-09**	**1.04E-08**
San Mateo Canyon Impact Area	2.01E+06	1989	2005	N/A	N/A	N/A	N/A
Quebec Impact Area	3.05E+06	1989	2005	**2.53E-10**	**1.64E-06**	**9.12E-07**	**1.17E-07**
Whiskey Impact Area	2.21E+06	1989	2005	**3.37E-09**	**3.54E-06**	**4.61E-06**	**1.73E-09**
Zulu Impact Area	7.97E+06	1989	2005	**6.87E-09**	**3.01E-06**	**2.93E-06**	**2.57E-09**

Note:
Perc – perchlorate
$kg/m^2/yr$ – kilograms per square meter per year
m^2 – squared meter

Bold indicates MC loading for the munition constituent was calculated for the range.

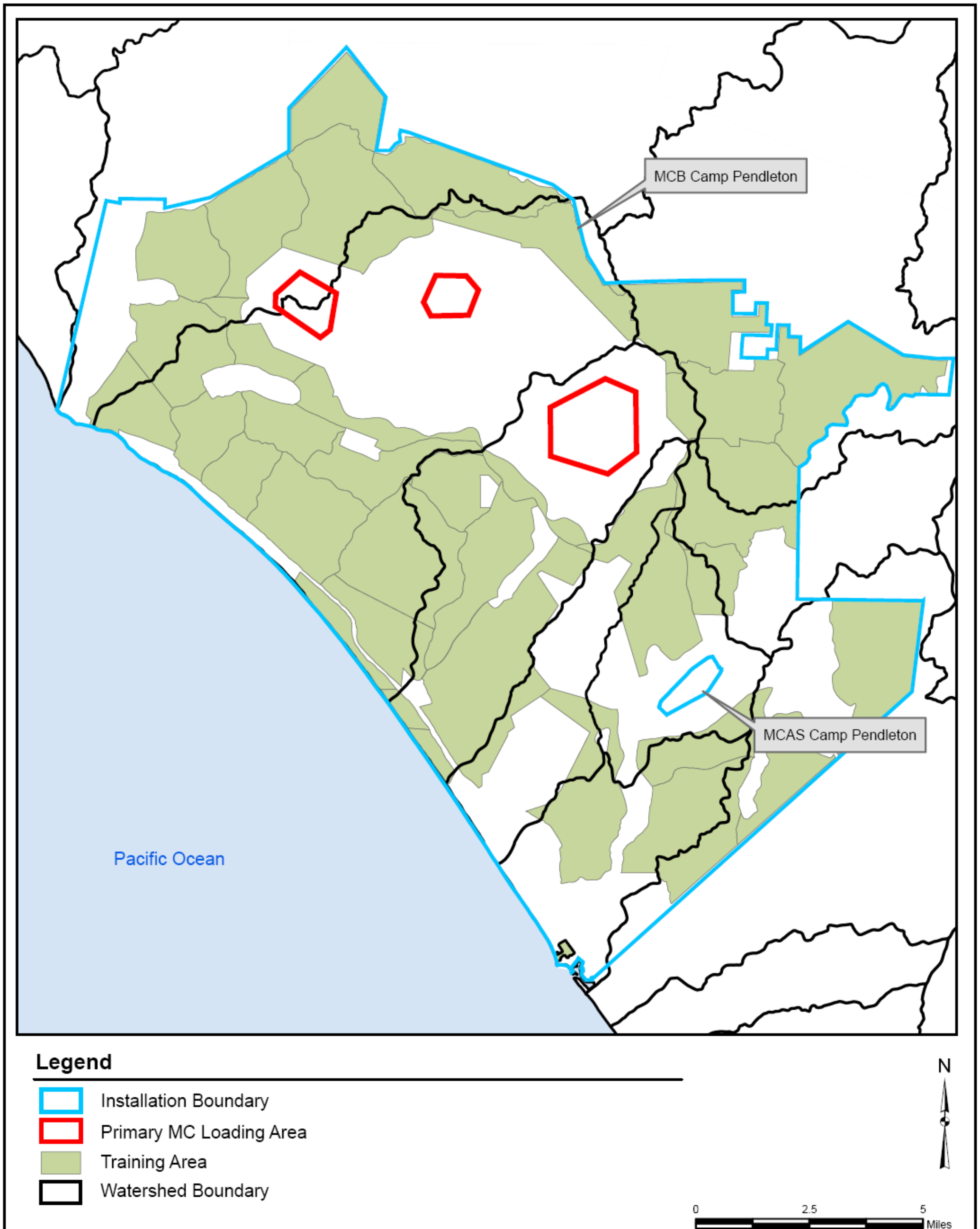
[a] For Quebec, Whiskey, and Zulu impact areas, the loading area is based on discussions with installation personnel. All other areas were loaded using the entire training or impact area.

Table 3-3: MCB Camp Pendleton Range Prioritization for MC Loading

Loading Area	SW Modeling Prioritization	GW Modeling Prioritization	MC Loading Priority Current Use	MC Loading Priority Historical Use	Overall Priority (HE Consideration Only)
Alpha One	Medium	Medium	N/A	Low	Medium
Alpha Two	Low	Low	Low	Low	Low
Alpha Three	Low	Medium	Low	Low	Low
Bravo One	Medium	Medium	Medium	Medium	Medium
Bravo Two	Medium	High	Medium	Medium	Medium
Bravo Three	Low	High	Low	Low	Low
Echo	High	High	Medium	Medium	Medium
Edson Range Impact Area	Medium	Low	Medium	Medium	Medium
Finch	Medium	Low	Low	Low	Low
India	Medium	Low	Low	Low	Low
Kilo Two	Medium	High	Medium	Medium	Medium
Papa One	High	Medium	Medium	Medium	Medium
Papa Three	High	Low	Medium	Low	Medium
Quebec Impact Area	High	Medium	High	High	High
Range 401	Medium	Medium	Medium	Medium	Medium
Range 403	Medium	High	Low	Low	Low
Range 409 Impact Area	Medium	Low	Low	Low	Low
Romeo One	Low	Low	Low	Low	Low
San Mateo Canyon Impact Area	Medium	High	Low	Low	Low
Section C Las Pulgas Beach (Red)	Low	Low	Low	Low	Low
Section E -Aliso Beach (White)	Low	Low	Low	Low	Low
Whiskey Impact Area	High	Low	High	High	High
Zulu Impact Area	High	Medium	High	High	High
X-Ray Impact Area	Medium	Medium	Medium	Medium	Medium

Note:
GW – groundwater
SW – surface water
HE – high explosive

Figure 3-4: Primary MC Loading Areas and Training Areas, MCB Camp Pendleton



MALCOLM PIRNIE	Primary MC Loading Areas and Training Areas MCB Camp Pendleton	Figure 3-4 April 2009

P:\6285\024\GIS\MXD\062_Figure 3-4_Training Areas and Operational Range_PRD.mxd

4. Conceptual Site Model

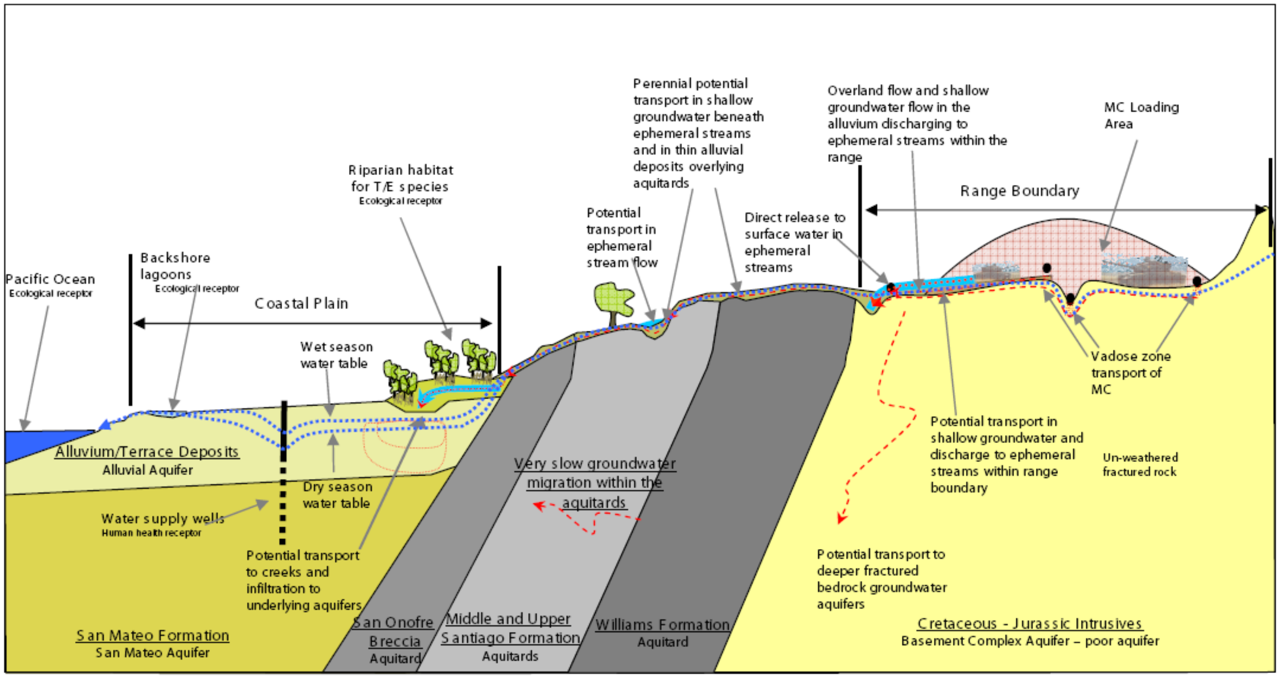
The REVA process examines surface water and groundwater flow and transport characteristics at MCB Camp Pendleton in order to evaluate the potential off-range migration and fate of MC. To this end, the MCB Camp Pendleton REVA assessment team developed a CSM that characterizes the representative physical features of the installation. The CSM aids the understanding of potential MC migration through surface water and groundwater to various receptors. It was developed on the basis of installation tours, environmental documents obtained from MCB Camp Pendleton, and reference documents on local geologic field studies and modeling. Documents obtained from AC/S Environmental Security include information on the Installation Restoration Program (IRP) and underground storage tank (UST) program, GIS data, and the water supply system and modeling reports.

The CSM prepared for MCB Camp Pendleton is presented graphically in Figure 4-1. It depicts a generalized east-west trending geologic cross section for the installation just north of the Las Flores watershed (Ehlig, 1979). The geologic structures are shown on the CSM relative to the MC loading area, the range boundary (in this case, the edge of the impact area), and potential off-range receptors (e.g., T/E species, drinking water wells). The Las Flores watershed is associated with the Zulu Impact Area. This impact area was selected for the development of the generalized CSM for groundwater because the general physical, topographical, geologic, and hydrologic features in the CSM are representative of the other watersheds at the installation where munitions other than small arms are utilized.

The generalized CSM is also used to reflect physical conditions at the San Onofre and San Mateo watersheds on the installation, where the Whiskey and Quebec impact areas are located. However, additional watershed-specific conditions were used to evaluate potential MC migration. However, the CSM does not reflect the Santa Margarita watershed; this watershed was not subject to screening-level modeling through the REVA program due to very low loading of indicator MC and the predominant use of small arms ammunition on ranges within that watershed. As noted in **Section 1**, potential off-range migration of lead from SARs is assessed qualitatively through a protocol developed through REVA but is not modeled.

Key assumptions about surface water and groundwater flow are derived from the CSM and used in REVA modeling for MCB Camp Pendleton (**Sections 5** and **6**).

Figure 4-1: Conceptual Site, Model MCB Camp Pendleton



Notes:
The cross section is based on geological features of the Las Flores Basin and the Zulu Impact Area. However, these features present a typical representation of drainage basins relative to potential MC.

Four major processes control the movement of MC from the loading areas:

1. Surface water potential transport from the impact area to the range boundary, including runoff to the ephemeral streams within the range and potential transport to the alluvium aquifer toward the coastal plain, which discharges to the Alluvium/San Mateo Aquifers and the Pacific Ocean;
2. Potential transport in the alluvial groundwater basins that supply drinking water to the installation;
3. Shallow groundwater potential transport from the impact area to discharge points in ephemeral streams draining the range; and
4. Vadose zone potential transport through soil in the impact area to shallow groundwater.

Potential transport to deeper fractured bedrock groundwater systems below the impact area may also occur, but site conditions suggest this is a negligible pathway.

Installation drinking water supply wells may be affected by off-range MC migration.

T/E species may be affected by MC present in surface water and groundwater in off-range habitat areas.

Geology modified from P.L. Ehlig, 1979.

MALCOLM PIRNIE	Conceptual Site Model MCB Camp Pendleton	Figure 4-1 April 2009

\\oakland\projects\6285\024\GIS\PDF\Public\Figure 4-1.pdf

In particular, the CSM for MCB Camp Pendleton strongly suggests that surface water flow drives the potential for off-range migration of MC to human and ecological receptors. In order for MC to migrate from the loading areas to groundwater used for drinking water, the CSM suggests that the MC first must be transported by surface water downstream to the alluvial groundwater basins tapped by the drinking water well. The following sections describe the physical characteristics and features of the area reflected by the CSM, as well as the human and ecological receptors found there.

4.1. Physical Profile of Study Area

MCB Camp Pendleton is located about halfway between San Diego and Los Angeles on the California Pacific Coast. The installation area includes portions of the Peninsular Range and Coastal Plains physiographic provinces in Southern California (Palmer, 1994). The Coastal Plain extends from the base of the San Onofre Mountains to the Pacific Coast. These mountains, composed of the San Onofre Breccia, occur as erosionally resistant ridges that rise above the coastal plain to a maximum height of nearly 1,800 ft amsl. The Peninsular Range extends eastward from the San Onofre Mountains and is characterized by northwest striking faults. Steep-sided river canyons have been incised into the mountains by creeks, including the Las Flores and Piedra de Lumbre creeks. The Santa Margarita Mountains are separated from the coastal mountains by low-rolling topography and rise to heights greater than 2,000 ft amsl within the boundaries of the installation. The eastern edges of these mountains are part of the Cleveland National Forest.

The area has a mild climate with an annual average daily high temperature of 75 degrees Fahrenheit (°F) and a low of 51°F at lower elevations (NOAA, 2008). Based on 100 years of data, the 2007 INRMP reports that lower areas of the base receive an average of about 14 inches of rain each year, with a minimum of 4.51 inches and a maximum of 38.23 inches. Precipitation at higher elevations averages approximately 22 inches (based on 40 years of record at Case Springs in the San Mateo watershed), with a minimum of 6.08 inches and a maximum of 50.42 inches. Approximately 75% of the installation's precipitation occurs between November and March of each year (MCB Camp Pendleton, 2007b). Major rain events can occur during the annual rainy season. Coastal fog conditions also exist in fall and winter months. "Up-canyon" winds are typical due to the northeast-southwest trending canyons on MCB Camp Pendleton and onshore winds (west-southwest). The area's "year-to-year variability" is an important climate characteristic (MCB Camp Pendleton, 2007b). Periods of drought, heavy seasonal rains, and fire are common. Wildfires occur seasonally from May through November, typically during hot, dry Santa Ana wind conditions and when a heavy vegetative fuel load exists.

4.2. Surface Hydrology

MCB Camp Pendleton drains into ephemeral streams that flow southwesterly within the installation boundary and discharge into the Pacific Ocean. Some of the significant drainages within MCB Camp Pendleton include the Santa Margarita River, San Mateo Canyon, San Onofre Canyon, and Las Pulgas Canyon (Figure 4-2). Because the streams are ephemeral, they only flow following successive, major rain events. As noted above, lower precipitation generally occurs in the coastal areas of the installation rather than in the western mountainous areas. Due to the extreme variability of precipitation and runoff, the potential for large floods is high on MCB Camp Pendleton (MCB Camp Pendleton, 2007b).

There are seven major watersheds within Camp Pendleton: Aliso, Horno/Coastal, San Luis Rey, Santa Margarita, Las Flores, San Onofre, and San Mateo. Of the seven watersheds, the Santa Margarita watershed has the largest drainage area; however, a large percentage of this drainage area is located outside of the installation boundary. As shown in Figure 4-2, the San Onofre and Las Flores watersheds occur almost entirely within the boundaries of MCB Camp Pendleton. With the exception of the Aliso and Coastal watersheds, watersheds on the installation extend up gradient beyond the northern and eastern boundaries of the installation.

The seven watersheds are divided by mountain ranges. Headwaters of the watersheds originate on the western slopes of the Peninsular Ranges. Several of the watersheds on the installation form broad alluvial plains as they approach the Pacific Ocean. The three largest estuaries on the installation are situated at the mouths of the Santa Margarita, Las Flores, and San Mateo streams (MCB Camp Pendleton, 2007b).

Alluvial groundwater basins are located in the coastal plain areas just inland of the Pacific Ocean. Stream loss is a dominant recharge mechanism to the alluvial groundwater basins and associated well fields, based on an evaluation correlating the water table height to stream stage (Palmer, 1990). However, the discontinuous and narrow saturated alluvial deposits along the streams in the upland areas farther upstream may either gain or lose water to the streams depending on seasonal changes in water table elevation.

The three MC loading areas identified as high priority and discussed in **Section 3** are the Quebec, Whiskey, and Zulu impact areas located within the San Mateo, San Onofre, and Las Flores watersheds. These three watersheds and the Santa Margarita watershed are discussed below. Watersheds, streams, and the locations of primary (high priority)[1] MC loading areas within MCB Camp Pendleton are shown in Figure 4-2.

The steep topography, soil characteristics, fire frequency, and climatic variability at MCB Camp Pendleton produce high erosion rates in many areas. Slopes are particularly vulnerable to erosion following wildfires (MCB Camp Pendleton, 2007b). Erosion and transport of MC from the impact areas to the alluvium may represent an important mechanism for movement off-range.

4.2.1. San Mateo Watershed

The San Mateo Watershed is the second largest watershed draining through the installation. It has an area of approximately 87,680 acres (MCB Camp Pendleton, 2007b). This watershed lies on the western edge of MCB Camp Pendleton and extends northward into the Cleveland National Forest. Approximately 21% of the total watershed area is within the MCB Camp Pendleton boundary. The watershed includes San Mateo Canyon, which originates several miles up gradient of the installation boundary and flows southwesterly with a dendritic drainage pattern through the installation and discharges into the Pacific Ocean. Major tributaries of San Mateo Canyon include Cristianitos and Talega canyons.

Approximately one-half of the Quebec primary MC loading area is located within the San Mateo watershed. This portion of the Quebec primary MC loading area drains into small tributary streams of San Mateo Canyon that drain northwestward into San Mateo Canyon.

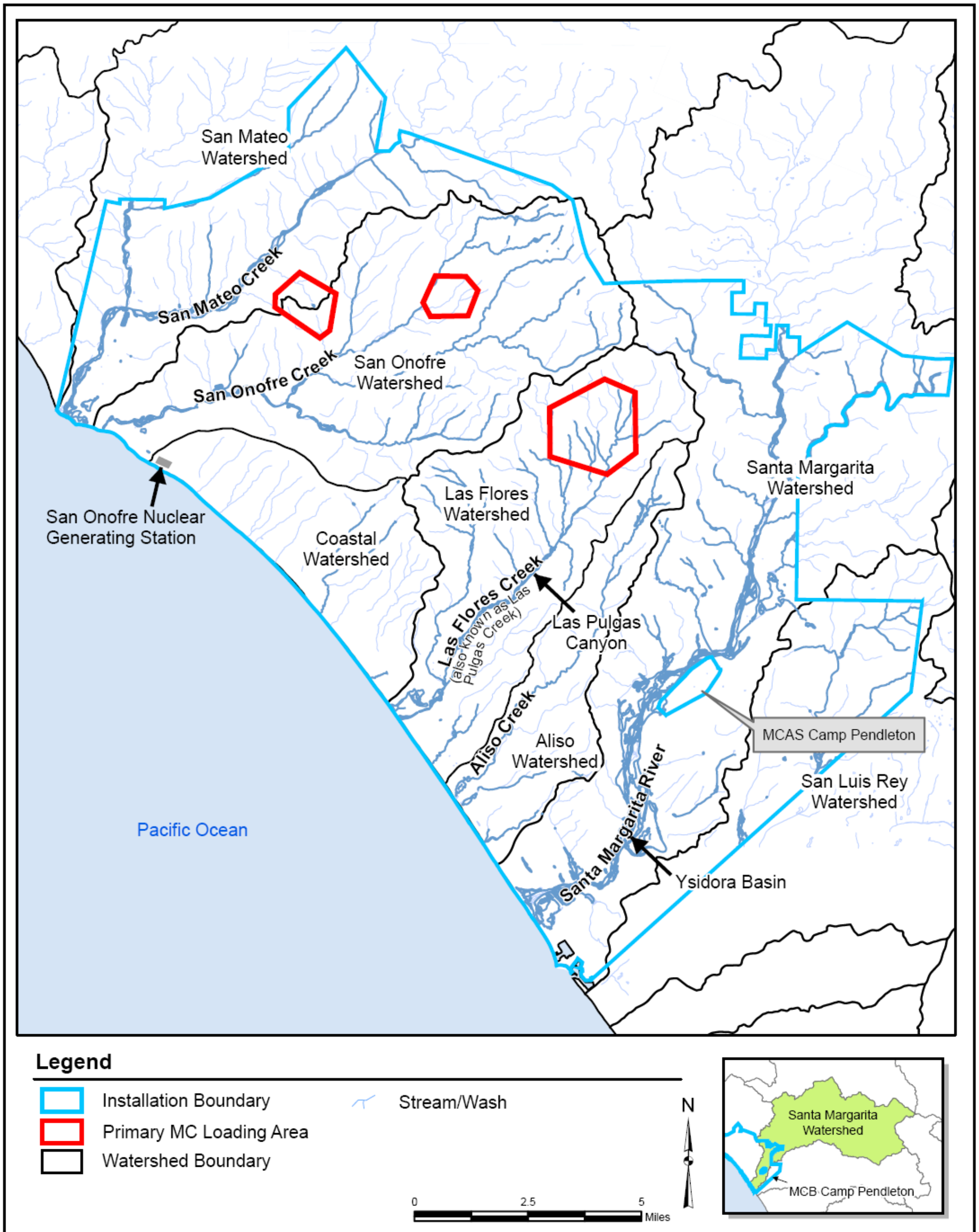
4.2.2. San Onofre Watershed

The San Onofre Watershed lies almost completely within MCB Camp Pendleton. Only a small portion of the northern portion of the watershed is outside of the installation boundary (approximately 1% of the total watershed). The watershed has an area of approximately 27,520 acres and is located between the Las Flores watershed on the east and the San Mateo watershed to the west. From west to northeast, it drains an area extending from the western slopes of Jardine Canyon to Case Springs. It includes the San Onofre Canyon, which flows southwesterly within the installation boundary and discharges to the Pacific Ocean just north of the San Onofre Nuclear Generating Station. Jardine Canyon is one of the major tributaries to San Onofre Canyon (MCB Camp Pendleton, 2007b).

Approximately one-half of the Quebec primary MC loading area and all of the Whiskey primary MC loading area are located within the San Onofre watershed.

[1] The tem "primary" MC loading area will be used to identify those MC loading areas with high priority for modeling based on the REVA assessment.

Figure 4-2: Surface Hydrology, MCB Camp Pendleton



MALCOLM PIRNIE | Surface Hydrology MCB Camp Pendleton | Figure 4-2 April 2009

P:\6285\024\GIS\MXD\043_Figure 4-2_Surface Hydrology_PRD.mxd

The portion of Quebec primary MC loading area located within the San Onofre watershed drains into small tributary streams of Jardine Canyon that drain southwestward into Jardine Canyon just upstream of its confluence with San Onofre Canyon. Whiskey primary MC loading area drains into an unnamed tributary stream of Jardine Canyon that drains southwestward into Jardine then into San Onofre Canyon.

4.2.3. Las Flores Watershed

The Las Flores watershed is almost entirely located within the boundary of MCB Camp Pendleton. It is one of the smaller watersheds draining through the installation. It has an area of approximately 16,900 acres and is located between the Aliso watershed on the east and the San Onofre watershed on the west (MCB Camp Pendleton, 2007b). As noted in the **Section 4** introduction, this watershed served as the basis for the generalized CSM. Surface water in the Las Flores watershed includes a freshwater lake, coastal lagoons, and intermittent creeks. Approximately 1 mile east of the Pacific Ocean, the Las Pulgas and Piedre de Lumbre creeks join to form Las Flores Creek (also called Las Pulgas). The Las Flores Creek originates approximately 10 miles from the Pacific Ocean in the Santa Margarita Mountains. The REVA assessment team observed continuous base flow along portions of the Las Flores Creek near the Basilone Road overpass. Nevertheless, at least one reference indicates that all creeks in this watershed are intermittent and flow only after major rainfall events (Palmer, 1990).

The Las Flores watershed includes all of the Zulu primary MC loading area. This MC loading area directly drains into Las Flores Creek.

4.2.4. Santa Margarita Watershed

The Santa Margarita watershed is the largest watershed draining through MCB Camp Pendleton. It has an area of approximately 474,880 acres, and over 90% of the watershed is located outside of the installation boundary. This watershed covers the eastern portion of the installation and extends northward into the Cleveland National Forest. Most of the developed area of MCB Camp Pendleton and all of MCAS Camp Pendleton lie within the Santa Margarita watershed. The major hydrologic feature in this watershed is the Santa Margarita River, which flows southwesterly to the Pacific Ocean from Palomar, Santa Ana, Santa Margarita Mountains, and the Santa Rosa Plateau. The watershed drains Murrieta and Temecula creeks within the upper Santa Margarita basin and drains Rainbow, Sandia, and De Luz creeks within the lower Santa Margarita basin.

None of the three identified primary MC loading areas (refer to **Section 3**) are located within the Santa Margarita watershed. However, portions of the Edson Range complex and X-Ray Range lie within this watershed. An EOD range is near the down gradient end of the watershed and drains to the Ysidora basin approximately 3 miles from the Pacific Ocean.

4.3. Hydrogeology and Aquifer Systems

The geology and aquifer systems at MCB Camp Pendleton are complex and highly variable across the installation. The information presented in the following sections are based on site conditions in the Las Flores basin[2]. As noted previously, the generalized CSM is appropriate because geologic structures relative to water-bearing units for the other basins modeled at MCB Camp Pendleton are similar to the Las Flores basin. Figure 4-3 shows the impact areas, and primary MC loading areas relative to the watershed boundaries, and alluvial groundwater basins. The 2007 INRMP reports that the alluvial valleys in lower portions of the four watersheds described above (San Mateo, San Onofre, Las Flores, and Santa Margarita) contain the principal water source for the installation (MCB Camp Pendleton, 2007b).

4.3.1. Stratigraphic Units

Figure 4-4 shows a stratigraphic column for the coastal plain area of MCB Camp Pendleton. The entire installation is underlain by a Triassic-Jurassic basement complex of igneous intrusives. In inland areas, this basement rock is close to the ground surface, cropping out to form the Santa Margarita Mountains and overlain only by a thin alluvial layer in the river valleys. Seaward of the Santa Margarita Mountains, the basement rock is overlain by three formations: Upper Cretacious Trabuco, Williams Formation, and Eocene Santiago Formation. In the foothills between the San Onofre and Santa Margarita mountains, only a thin alluvial layer overlies these formations. The San Onofre Breccia, which forms the San Onofre Mountains, drops below the surface between the mountains and the ocean and is overlain by the Capistrano and Monterrey formations in the Coastal Plains area. The Pleistocene terrace deposits and Holocene alluvium deposits, in turn, underlie much of the California coast.

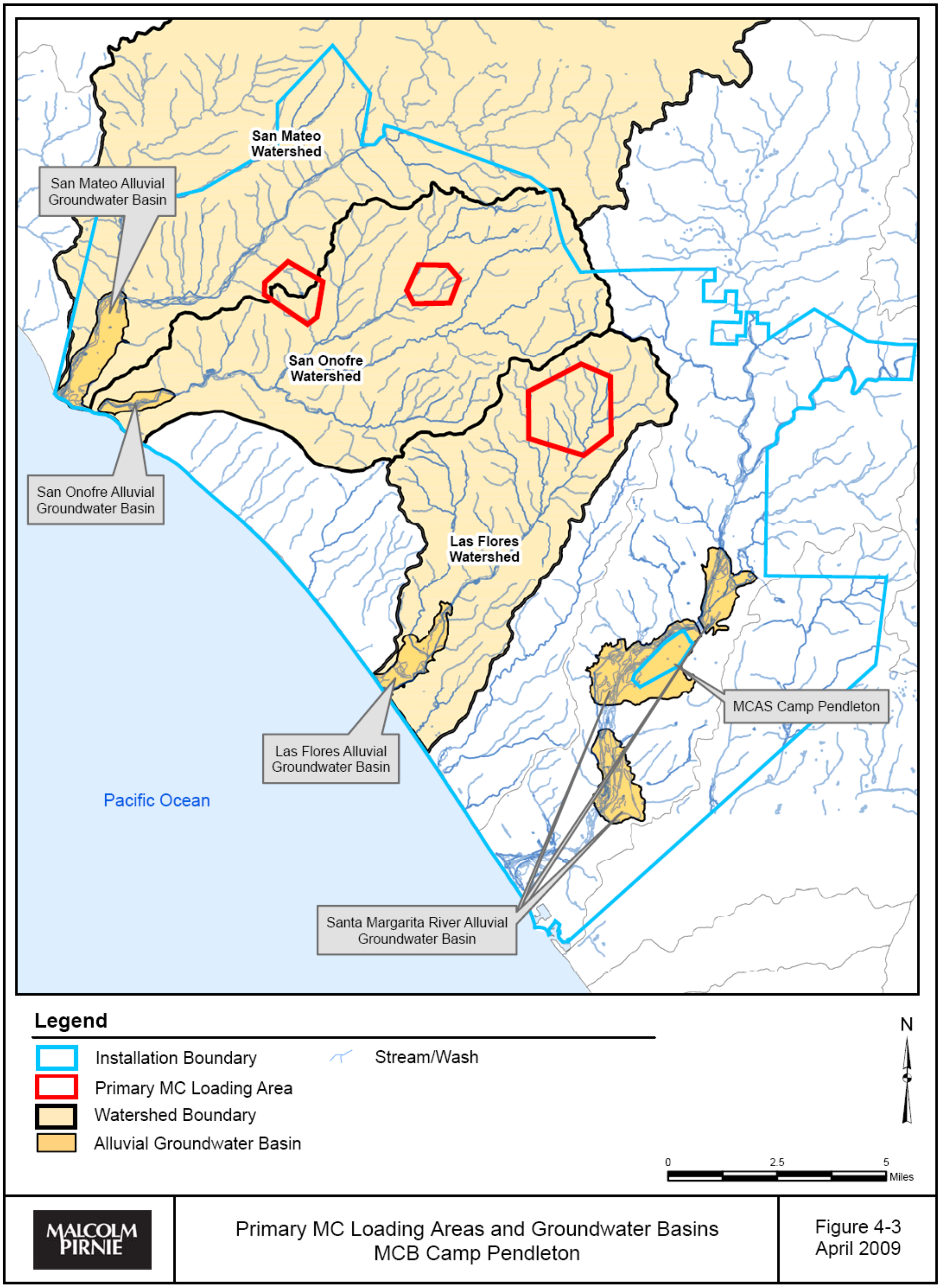
4.3.2. Hydrostratigraphic Units

Hydrostratigraphic units are geologic deposits with continuous lateral extent and similar hydraulic conductivity and porosity. The hydrostratigraphic units within the Las Flores basin include:

- narrow discontinuous alluvium aquifers along intermittent surface streams in mountain valleys;
- an alluvial aquifer in the coastal plain area, used for water supply;
- San Mateo aquifer;
- aquitards consisting of the Cretaceous and Eocene Trabuco, Williams and Santiago formations, and the Miocene San Onofre Breccia; and

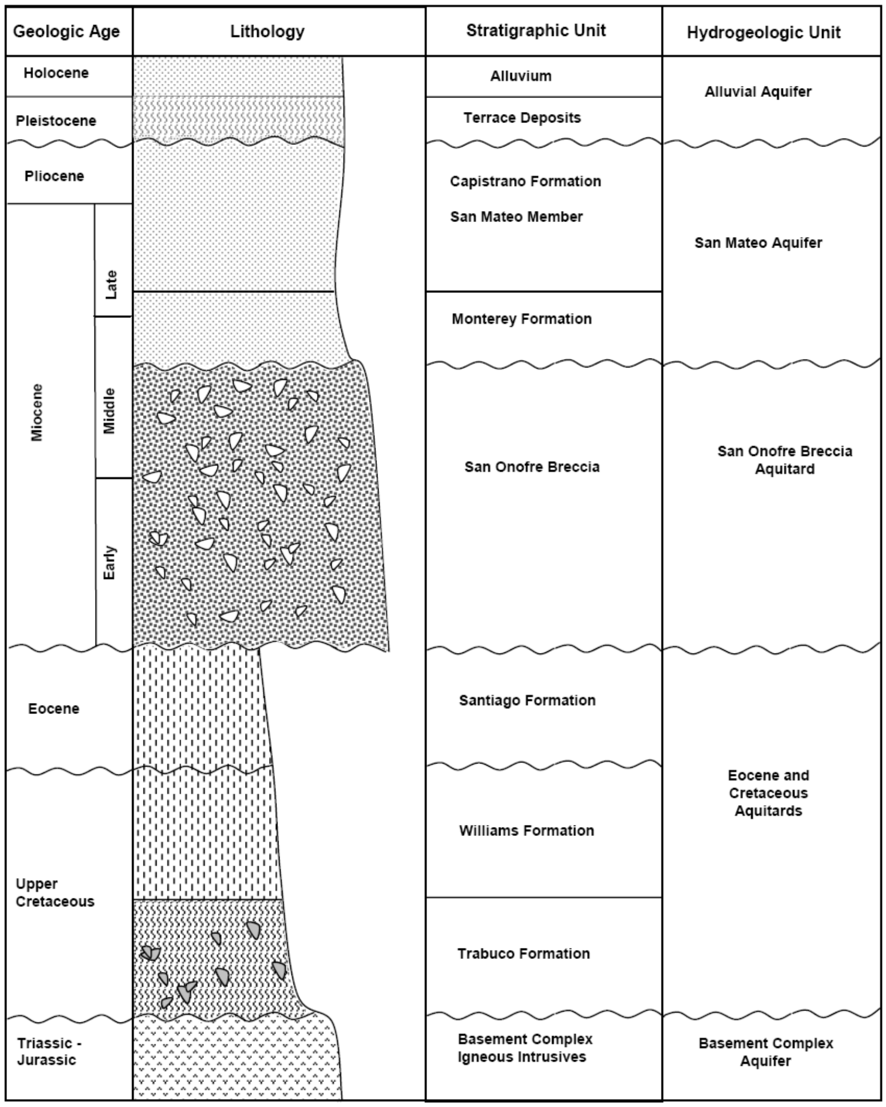
[2] As the discussion turns to hydrogeology, the term “basin” rather than “watershed” is used.

Figure 4-3: Primary MC Loading Areas and Groundwater Basins, MCB Camp Pendleton



P:\6285\024\GIS\MXD\042_Figure 4-3_Loading Areas and GW Basins_PRD.mxd

Figure 4-4: Lithology and Hydrostratigraphy, MCB Camp Pendleton



Adapted from Palmer, 1994

Notes:
1) Typical water supply wells are screened in the Alluvium and San Mateo Aquifers.
2) A description of the lithologic units is provided in Palmer, 1994.

Stratigraphic Column
MCB Camp Pendleton

Figure 4-4
April 2009

\\oakland\projects\6285\024\GIS\PDF\Public\Figure 4-4.pdf

- a basement complex aquifer.

The most important aquifers in the Las Flores basin are the alluvial and San Mateo aquifers (Palmer, 1990; Worthington, 1994). Groundwater extracted from these aquifers is used by MCB Camp Pendleton for drinking water and for localized landscape irrigation (Palmer, 1990). These aquifers are potential pathways for off-range migration of MC. A review of available information, observed site conditions, and interviews with MCB Camp Pendleton personnel indicates that deeper saturated aquifer deposits are not currently used because of their low yields or inaccessibility. For this reason, the deeper saturated aquifer deposits are not considered as potential pathways for MC migration.

4.3.2.1. Alluvial Aquifers

The alluvial aquifers in the coastal plain area of the installation are the most relevant aquifers for REVA due to their connection with both surface water and the San Mateo aquifer. MC migration, if any, is expected to occur mostly within these aquifers. These quaternary alluvial deposits are located in many of the deeply incised mountain valleys and consist of unconsolidated silts, sands, gravels, and conglomerates (Cranham et al., 1994). The thicknesses of the alluvial aquifers vary from 18 to 105 ft; the aquifers are generally thickest toward the center of the stream valleys (Palmer, 1990).

Infiltration of streamflow is a dominant groundwater recharge mechanism to the alluvial aquifers (Palmer, 1990). Seasonal climatic changes impact the volume and mechanisms for water infiltrating into shallow groundwater in the alluvial deposits. The alluvium in impact areas is likely unsaturated for much of the year. When water is flowing in the streams, water infiltrates through the vadose zone and recharges the alluvial aquifer. Groundwater flows in the alluvium during periods of active streamflow and for periods of days to weeks afterward. The groundwater in the alluvial aquifer then discharges to the underlying San Mateo aquifer, the lagoons near the shore, and the riparian vegetation in the alluvial basin.

4.3.2.2. San Mateo Aquifer

The Monterey Formation and San Mateo Member of the Capistrano Formation are assumed to be hydraulically similar and comprise the San Mateo aquifer, which ranges in thickness from 33 to 1,400 ft (Palmer, 1990). The San Mateo Formation is in direct contact with the alluvial aquifers and the Pacific Ocean. According to Palmer (1994), the San Mateo aquifer is the major water-producing aquifer in the Las Flores basin. The Monterey Formation has been estimated to be less than 100 ft thick in the Las Flores basin and has been described as a very light gray, thinly bedded, sandy siltstone and mudstone separated by diatomite parting (Craig, 1984). The siltstones and mudstones interfinger with thick, massive, grayish orange, pebbly sandstone (Craig, 1984).

For this analysis, the San Mateo aquifer is assumed to be present and is represented as a sequence of sandstone and sandy conglomerate.

4.3.2.3. Aquitards

The San Onofre Breccia, which underlies the San Mateo aquifer, is not considered to contain or transmit substantial quantities of groundwater. It is defined as an aquitard due to its poor sorting and high percentage of fine-grained materials (Peterson, 1978). No wells exist in the San Onofre Breccia aquitard within the Las Flores basin (Palmer, 1994). Three additional layers classified as aquitards (because of low permeability) underlie this breccia layer: the Santiago, Williams, and Trabuco formations.

Between the impact areas and the coastal plain, variably saturated alluvial deposits overlie the aquitard layers. The amount of groundwater flowing downward into these aquitards from the alluvium is likely insignificant.

4.3.2.4. Basement Complex

Exposures of the basement complex in the impact areas suggest that a small proportion of the precipitation may infiltrate to this saturated formation. However, because of the steep slopes, most of this water is expected to flow overland into the ephemeral streams and infiltrate the alluvial aquifers running through Las Pulgas Canyon. As described in other studies, the Peninsular Range Batholith (basement complex) forms the backbone of the upper watersheds, but the water within the fractures and joints is currently not considered economically viable for water supply purposes (Stetson, 2005). In the coastal plain where drinking water is pumped from the alluvium and San Mateo aquifers, the basement complex is separated from these aquifers by thick sequences of aquitards. The basement complex will not be assessed through REVA due to the assumed small amount of infiltration, low yields, and the lack of receptors exposed to groundwater in these saturated deposits. If this basement complex were to be considered, in the future, as a viable water supply then this aquifer would be evaluated.

4.4. Groundwater Flow

Groundwater within the San Mateo aquifer is found primarily under unconfined conditions with water levels in the coastal plain ranging from 40 to 60 ft amsl (or approximately 10 to 30 ft below ground surface). Water level maps for the Las Flores basin, based on 1987 data, indicate that groundwater is moving in a southwest direction, down the axis of Las Pulgas Canyon (along Las Flores/Las Pulgas Creek). The gradient ranges from 0.08 in Las Pulgas Canyon to a flatter slope of 0.01 near the coast. Aquifer tests for wells screened within the San Mateo aquifer indicated a hydraulic conductivity ranging from 0.03 to 0.19 ft per minute and a specific yield of 0.12. The small range of hydraulic conductivities from different wells suggests fairly homogeneous deposits that comprise the San Mateo aquifer (Palmer, 1990).

There are differing opinions in the literature about which of the aquifers is supplying water to the wells in the Las Flores basin. Palmer (1990) reports that groundwater extracted from the Las Flores Basin is primarily produced from the San Mateo aquifer in the coastal plain, but the alluvial aquifer may also be providing water. However, other sources believe that the alluvial layer is the major water-bearing aquifer within MCB Camp Pendleton (DWR, 1967; Peterson, 1978). Ephemeral streams have the potential to drain MC loading areas into recharging alluvial groundwater basins. In practice, there is no separation between the two aquifers, and water is probably produced from both formations.

4.5. Receptors

Receptors are human populations or T/E species (ecological receptors) that use or are exposed to surface water and groundwater at MCB Camp Pendleton. These users would represent receptors of potential MC if a complete transport pathway existed. A key concern in this baseline REVA assessment was the potential for off-range migration of MC to affect human receptors through drinking water wells. Ecological receptors along stream segments down gradient of primary loading areas were also considered.

4.5.1. Surface Water Receptors

Ephemeral streams and other surface water bodies are located in and around MCB Camp Pendleton. These water bodies include coastal lagoons and freshwater lakes. Surface waters on the installation are not used as a potable water supply. Humans potentially use these waters for recreational purposes (such as swimming and fishing), but because a large majority of the water bodies only contain water during the wet season when rain events occur, the actual recreational use is limited. Freshwater lakes were identified at MCB Camp Pendleton during the initial review of the installation while developing the modeling assumptions. However, no direct pathways exist between primary MC loading areas and freshwater lakes. Therefore, a discussion of potential ecological receptors associated with freshwater lakes was not included in this baseline REVA.

Ephemeral streams draining primary MC loading areas recharge alluvial groundwater basins that are used as drinking water sources located in the coastal plain downstream of primary MC loading areas. The alluvial groundwater basins that are located downstream of primary MC loading areas include the San Mateo, San Onofre, and Las Flores basins. Drinking water supply wells for MCB Camp Pendleton are located in each of these basins. For this reason, ephemeral streams draining from primary MC loading areas have potential human receptors (through drinking water use). Additionally, the ephemeral streams can provide temporary support to aquatic/wildlife habitat during wet periods of the year. Federally and state-listed T/E species may consume surface water and shallow groundwater in habitat areas along Las Flores Creek, in lagoons shoreward of the beach, and in the Pacific Ocean.

This section identifies potential surface water receptors near operational ranges, training areas, and primary MC loading areas at MCB Camp Pendleton, based on information contained in the 2007 INRMP and the 2007 MCB Camp Pendleton Environmental Operations Map.

4.5.1.1. Quebec MC Loading Area

The Quebec primary MC loading area drains to San Mateo and San Onofre canyons. Surface water in these canyons potentially recharges the San Mateo and San Onofre alluvial groundwater basins, which are used as drinking water sources downstream of the Quebec primary MC loading area. Additionally, San Mateo Canyon flows near potential habitat areas of the endangered Arroyo toad species (*Bufo californicus*) and areas of the threatened California gnatcatcher species (*Polioptila californica*) downstream of the Quebec primary MC loading area.

4.5.1.2. Whiskey MC Loading Area

The Whiskey primary MC loading area drains to San Onofre Canyon. Surface water in this canyon potentially recharges the San Onofre alluvial groundwater basin, which is used as a drinking water source downstream of the Whiskey primary MC loading area. Additionally, San Onofre Canyon flows near potential habitat areas of the endangered Arroyo toad species and areas of other threatened species like the Stephens' kangaroo rat (*Dipodomys stephensi*) downstream of the Whiskey primary MC loading area.

4.5.1.3. Zulu MC Loading Area

The Zulu primary MC loading area drains into Las Pulgas Canyon. Surface water in this canyon potentially recharges the Las Flores alluvial groundwater basin, which is used as a drinking water source downstream of the Zulu primary MC loading area. Additionally, Las Pulgas Canyon flows near potential habitat areas of the threatened California gnatcatcher and Stephens' kangaroo rat species downstream of the Zulu primary MC loading area.

4.5.2. Groundwater Receptors

The primary exposure to groundwater for humans is groundwater pumped from the drinking water supply wells found in four of the groundwater basins at MCB Camp Pendleton. According to the MCB Camp Pendleton OWR, over 99% of the installation's water supply is derived from groundwater on base. Two major well fields (San Mateo and Santa Margarita) and two smaller well fields (San Onofre and Las Flores) supply groundwater to the base (Figure 4-3). The northern system includes wells in the San Mateo and San Onofre groundwater basins. The southern well field is located mostly in alluvial basins along the Santa Margarita River. Two water supply wells in the southern system are also located in the Las Flores alluvial basin. The current and future pumping projections are presented in Table 4-1.

Table 4-1: 2004 and 2025 Pumping Projections

Basin	Year 2004	Year 2025
North System		
San Mateo	2,148 AFY	2,100 AFY
San Onofre	529 AFY	575 AFY
South System		
Santa Margarita	6,200 AFY	11,745 AFY
Las Flores	597 AFY	600 AFY

Source: MCB Camp Pendleton OWR, 2005

Note: AFY – acre-feet per year

4.6. Pathways

The CSM includes the identification of possible pathways for MC migration from the loading area to the receptors identified in Section 4.5. The surface water and groundwater pathways are described below. At MCB Camp Pendleton, however, the CSM assumes that the surface water and groundwater pathways are combined when considering the potential for exposure by human receptors through drinking water wells. By contrast, the surface water pathway is the most critical for consideration of exposure to ecological receptors. The concepts developed in the CSM are important to understanding potential transport mechanisms for MC and the potential for receptors to be impacted. The screening-level modeling discussed in **Sections 5** and **6** is used to address the issue in a more quantitative manner.

4.6.1. Surface Water Pathways

Surface water runoff is the primary MC transport mechanism within ranges at MCB Camp Pendleton. Although rainstorms are infrequent, the potential for surface runoff is high during storm events. The predominant surface water drainage direction is to the southwest. A significant portion of the installation has steep slopes (with most areas exceeding a slope of 15%); flatter areas (with slopes less than 5%) exist near the coast (MCB Camp Pendleton, 2007b).

Most soils at MCB Camp Pendleton (specifically those located at primary MC loading areas) are erodible; in general, the steep topography, soil characteristic, fire frequency, and climatic variability at MCB Camp Pendleton make soil erosion and sedimentation quite common at the installation (Palmer, 1994). Following rainstorm events, surface drainage occurs by way of natural topographic gradients and drainage directly into canyons. Such drainage systems can transport MC to canyons from soil through dissolution in runoff water or erosion of soil and sediments. MC transported through canyons can recharge alluvial aquifers downstream of primary MC loading areas. By way of surface drainage, dissolved and soil-associated MC could be transported to habitats containing ecological receptors (e.g., endangered Arroyo toad, threatened California gnatcatchers, threatened Stephens' kangaroo rat) located downstream of primary MC loading areas at MCB Camp Pendleton.

As discussed in Section 4.2, primary MC loading areas are located in three of the seven watersheds draining through MCB Camp Pendleton: the San Mateo, San Onofre, and Las Flores watersheds. All canyons that drain these three watersheds potentially recharge alluvium groundwater basins that are used as drinking water sources downstream from primary MC loading areas. For this reason, canyons that drain the watersheds where primary MC loading areas are located have potential human receptors (through drinking water use). In addition, all canyons within watersheds where primary MC loading areas are located flow to areas that have been documented to be associated with potential T/E ecological species.

The streams assessed in this report are typically ephemeral, and flow rarely reaches the edge of the alluvial basin, coastal lagoons, or the ocean. Some flow to these water bodies may occur in some extreme storm events. Surface water and groundwater sampling conducted as part of the baseline assessment and discussed in **Section 9** indicated minimal to no detections of MC at locations or drinking water wells upstream of coastal lagoons and the ocean. Assessment of the ocean pathway was, therefore, not further assessed.

4.6.2. Groundwater Pathways

Many of the well fields at MCB Pendleton are located down gradient of primary MC loading areas. MC may migrate with the groundwater toward the drinking water wells. The data and analysis presented in **Section 3** indicate that the greatest primary MC loading occurs at the Zulu, Whiskey, and Quebec impact areas. For this reason, only those loading areas are analyzed through screening-level modeling for possible pathways to receptors.

- The Zulu Impact Area is located in the Las Flores basin, and water supply wells are located near the down gradient end of the Las Flores basin.
- The Quebec Impact Area drains to the San Mateo and San Onofre basins. The San Mateo and San Onofre well fields are located several miles downstream of the Quebec Impact Area in their respective groundwater basins.

- The Whiskey Impact Area drains to the San Onofre basin and the San Onofre well field, which is located several miles down gradient of the impact area.

The modeling presented in **Sections 5** and **6** focuses only on these three watersheds. The qualitative assessment of SARs occurring within the Santa Margarita watershed appears in **Section 8**.

5. Surface Water Analysis Method and Assumptions

Under REVA, the screening-level surface water analysis is used to estimate the MC concentrations in surface water runoff at the edge of the MC loading areas. If the analysis predicts potential impacts to this location, then additional calculations are performed to estimate MC concentrations at downstream locations where receptors could be exposed. Average annual surface water concentrations of the indicator MC (TNT, RDX, HMX, and perchlorate) are estimated based on the average annual MC loading of each indicator MC to each MC loading area. For MCB Camp Pendleton, the surface water screening analysis was carried out for the time period from 1942 to 2005.

At impact areas on MCB Camp Pendleton, MC that survived detonations initially would be distributed in the shallow soil zone. The estimation of MC concentrations in surface water assumes that a portion of the MC could enter the surface water by several mechanisms: (1) erosion of particulate or adsorbed MC in soil; (2) direct dissolution of MC in runoff; and (3) discharge of groundwater to surface water. At MCB Camp Pendleton, it was assumed that MC primarily enter surface water through either erosion or dissolution into surface water runoff.

The mass loading of the indicator MC on each operational range was estimated as described in **Section 3**. For surface water modeling purposes, it was conservatively assumed that the entire annual MC load was uniformly mixed in the upper 6 inches of soil and was distributed uniformly across the loading area. This assumption infers that the total load remains within the top 6 inches of the soil. As such, it is assumed to be available for surface water transport with runoff water through dissolution and erosion with soil and sediments. Typically, the surface soil thickness available for surface transport would be less than 6 inches. Assuming a thicker surface soil layer serves to increase the amount of MC that would likely be transported with surface water.

Next, screening-level modeling was used to estimate the annual average concentrations of MC in surface water runoff from the MC loading areas. Results of the surface water screening-level analysis were compared to the REVA trigger values (Table 5-1) to evaluate the potential for MC releases to off-range receptors and the need for further assessment, including field sampling analyses. The screening-level surface water analysis method is described briefly in the following sections. Additional details on the method are provided in the *REVA Reference Manual* (HQMC, 2006).

Table 5-1:
REVA Trigger Values

MC	Trigger Value (µg/L)[a]
HMX	0.08
RDX	0.16
TNT	0.08
Perchlorate	0.98

Note:
µg/L – micrograms per liter
[a] REVA trigger values are the median representative screening threshold values, for surface water or groundwater modeling, obtained from analytical laboratories for each indicator MC as defined in the *REVA Reference Manual* (HQMC, 2006).

5.1. Losses to Surface Water in MC Loading Areas

Based on the CSM developed in **Section 4**, the primary transport mechanisms in surface water bodies at MCB Camp Pendleton were assumed to be erosion and direct dissolution into surface water runoff. These mechanisms are quantified in this section.

5.1.1. Erosion

The amount of soil eroded was estimated using the Revised Universal Soil Loss Equation (RUSLE), which incorporates the major factors affecting erosion to predict the rate of soil loss in mass per area per year. The RUSLE is expressed as follows:

$$A = RKLSCP$$

Where:

A = predicted soil loss, metric tons per hectare per year
R = rainfall and runoff factor
K = soil erodibility factor
LS = topographic factor (factor influenced by length and steepness of slope)
C = cover and management factor
P = erosion control practice factor

These factors were estimated for each modeled primary MC loading area using available information, such as soil type from the USDA Soil Conservation and Forest Service's soil survey of the San Diego, California, area, land use, land cover, and topography. The estimated amount of soil eroded from the MC loading area was used to calculate the mass of MC transported with the eroded soil from MC loading areas to downstream receptors. Estimation of the soil erosion to calculate transported MC mass is especially important for MC that strongly adsorb to soil (such as TNT). Table 5-2 lists the parameter values used in estimating soil erosion.

**Table 5-2:
Parameters Used to Estimate Soil Erosion for MC Loading Areas at MCB Camp Pendleton**

Primary MC Loading Area	R[a]	K[b]	LS[c]	C[d]	P	A (kg/m^2/day)
Quebec	35	0.45	15.8	0.13	1	8.6E-03
Whiskey	35	0.45	26.3	0.13	1	1.4E-02
Zulu	35	0.45	25.7	0.13	1	1.4E-02

Note:
Kg/m^2/day – kilograms per square meter per day
R – rainfall and runoff factor
K – soil erodibilility factor
LS – topographic factor (influence of length and steepness of slope)
C – cover and management factor
P – erosion control practice factor
A – predicted soil loss
[a] Brady, 1984
[b] USDA, 1973
[c] Slope length and gradient were used to select LS values from Ontario Agriculture and Food (2000).
[d] Highest crop factor with no tillage was selected to account for erosion due to sparsely vegetated cover and higher soil disturbances at target areas (Brady, 1984).
[e] Highest factor used due to unknown erosion control practice implemented at MC loading areas.

5.1.2. Surface Water Runoff

Annual surface runoff rates were estimated by multiplying the annual precipitation rate with runoff coefficients selected from published tabular values and the surface area of the primary MC loading area (Table 5-3). Annual precipitation data were obtained from National Climatic Data Center for a station in Escondido, California, near MCB Camp Pendleton for 1979 through 2005. The average annual precipitation rate calculated from these data was 14.8 inch/year (0.38 meters/year).

5.1.3. Partitioning into Surface Water

A multimedia partitioning model, CalTOX, was used to estimate the mass of MC transported from surface soil to surface water runoff. This model simulates the major transport mechanisms (erosion of adsorbed MC in soil and direct dissolution in runoff and leaching to the subsurface environment) that are likely to affect MC from their point of origin in surface soils to their release into surface water runoff. The rate at which MC will partition between these media is dependent upon both the chemical properties of the MC and the physical/hydrological properties of the site. CalTOX requires the input of both landscape properties of the primary MC loading areas (Tables 5-2 and 5-3) and chemical properties of the compounds of interest (Tables 5-4 and 5-5). Values of landscape and chemical properties were selected based on local reports, soil surveys, mapping information, and the scientific literature. The chemical parameter values used were selected as the most recent available at the time the modeling was conducted out. It was noted that some of the parameter values have variability in the literature, with the MC decay rate having the most variability. Variability of other chemical parameters is not wide enough to cause significant variations in model results. Estimates of soil erosion and surface water runoff were calculated as described in **Sections 5.1.1** and **5.1.2** and entered into CalTOX.

Table 5-3:
Soil Types and Hydrologic Properties of Primary MC Loading Areas at MCB Camp Pendleton

Primary MC Loading Areas	Land Cover	Predominant Soil Types	Hydrologic Soil Group	Soil Organic Content (%)[a]	Soil Bulk Density (kg/m^3)[a]	Runoff Coefficient[b]	Annual Recharge (% of precip)[c]
Quebec	Sparse valley needle grass and Diegan coastal sage scrub	LeD and TeF	Group B/A	0.55	1600	0.5	6
Whiskey	Valley needle grass and southern mixed chaparral	CmE2 and FeE2	Group A	0.55	1555	0.33	6
Zulu	Valley needle grass, southern mixed chaparral, and dense Engelman oak woodland	FaC and RcD	Group A	0.5	1600	0.36	6

Note:
kg/m^3 – kilograms per cubic meter
precip – precipitation
CmE2 – Cieneba coarse sandy loam
FaC – Fallbrook sandy loam
FeE2 – Fallbrook rocky sandy loam
LeD – Las Flores loamy fine sand
RcD – Ramona gravelly sandy loam
TeF – terrace escarpments

[a] USDA SC and FS, 1973
[b] McCuen, 1998
[c] Low recharge rate assumed to account for discharge of shallow groundwater into ephemeral streams through lateral flows on top of the bedrock intrusive, within impact areas

Table 5-4:
Chemical Properties of Indicator MC

MC	Molecular Weight (g/mol)	K_{ow} [a,b]	Melting Point (K)[a]	Vapor Pressure (Pa)[a]	Solubility (mol/m^3)[a]	Henry's Law Constant ($Pa\text{-}m^3/mol$)	Half-life in Surface Soil (days)
RDX	222.1	7.24	477.25	5.47E-07	1.90E-01	2.67E-06	2.5E+06[c]
TNT	227.1	72.4	354.00	1.47E-04	5.72E-01	2.40E-02	1.0E+07[d]
HMX	296.2	1.15	551.15	4.40E-12	1.69E-02	2.63E-10	1.2E+06[c]
Perchlorate	99.4	1.45E-06	571.09	3.75E-09	2.01E+03	Calculated by model[e]	1.0E+07[d]

Note:
K_{ow} – octanol-water partition coefficient
g/mol – grams per mole
K – degrees Kelvin
Pa – Pascals
mol/m^3 – moles per cubic meter
Pa- m^3 /mole – Pascal cubic meters per mole
[a] Walsh et al, 1995
[b] Meylan and Howard, 1995
[c] Value was obtained from the Multimedia Environmental Pollutant Assessment System model parameter.
[d] No reported values were available; input variables used are based on conservative assumptions. Diffusion coefficient in air used was 7.0E-0.2 m^2/day, and diffusion coefficient in water used was 1.0E+0.5 m^2/day.
[e] CalTOX includes an option for estimating the Henry's law constant from the chemical vapor pressure and solubility values.

Table 5-5:
Organic Carbon Fractions (f_{oc}), MC Organic Carbon Partition Coefficients (K_{OC}), and MC Soil Partition Coefficients (K_D) at MCB Camp Pendleton

Primary MC Loading Area	f_{oc} (%)[a]	MC	K_{oc} (mL/g)[b]	K_D (mL/g)[c]
Quebec and Whiskey	0.55	HMX	5.52E-01	3.0E-03
		RDX	3.48E+00	1.9E-02
		TNT	3.48E+01	1.9E-01
		Perchlorate	6.94E-07	3.8E-09
Zulu	0.5	HMX	5.52E-01	2.7E-03
		RDX	3.48E+00	1.7E-02
		TNT	3.48E+01	1.7E-01
		Perchlorate	6.94E-07	3.5E-09

Note:
mL/g – milliliters per gram
f_{oc} – organic carbon fraction
K_{oc} – organic carbon partition coefficient
K_D – soil partition coefficient
[a] USDA SC and FS, 1973
[b] Estimated in CalTOX model from the chemical octanol-water partition coefficient
[c] Estimated in CalTOX model from the chemical organic carbon partition coefficient and the soil organic fraction on site

Decay rate values for the analysis at MCB Camp Pendleton were selected from available rates to result in the most conservative modeling effort possible at that time. Variability of other chemical parameters are not wide enough to cause significant variations in model results. Estimates of soil erosion and surface water runoff were calculated as described in **Sections 5.1.1** and **5.1.2** and entered into CalTOX.

The CalTOX output of interest for the surface water screening-level analysis was the MC mass transferred from surface soil to surface water, which CalTOX expresses as an average daily load in grams per day. This daily mass transfer rate was divided by the daily runoff volume to estimate the MC concentration in surface water runoff at the edge of primary MC loading area, prior to down gradient mixing/dilution in streams and washes. Although CalTOX requires input of daily loading rates, the MC mass loading is available only as annual values. For this reason, the model has an effective time step of one year, and the results are interpreted as annual average concentrations in surface water runoff.

For MC that have elevated soil partition coefficient values, such as TNT and RDX, the residual mass in surface soil after each time step (year) was calculated as the product of the MC partition coefficient, the dissolved MC concentration in runoff, and the mass of the surface soil. This provided an estimate of the mass of MC that would be sorbed to the surface soil compartment assuming sorption equilibrium. The estimated residual MC mass was added to the "new" MC loading to surface soil for the following year.

5.2. Estimation of MC Concentration in Surface Water Entering Alluvial Groundwater Basins

The primary MC loading areas analyzed (Quebec, Whiskey, and Zulu) drain into ephemeral streams that largely recharge alluvial groundwater basins located in the coastal plain downstream of primary MC loading areas. The alluvial groundwater basins that include San Mateo, San Onofre, and Las Flores alluvial basins potentially are used as drinking water sources. Drinking water supply wells for MCB Camp Pendleton are located in each of these basins.

Only the primary MC loading areas are assumed to be sources to down gradient areas because other loading areas were determined to have insignificant MC contributions to down gradient areas. A large majority of the non-primary MC loading areas within the watersheds are historical use areas that have not had MC loading since 1946.

It was conservatively assumed that the MC load draining downstream to the coastal plain areas, where the alluvial groundwater basins are located, recharges the groundwater basins. As noted, the goal of REVA modeling is to estimate MC concentrations in surface water potentially entering these alluvial groundwater basins downstream from primary MC loading areas. To this end, an approach was taken to estimate the order of magnitude of reduction in the concentrations at primary MC loading area boundaries that would be expected to be caused by down gradient mixing with runoff from non-loading areas. The estimated concentrations at the edge of primary MC loading areas were multiplied by the ratio of the loading area to the total drainage area upstream of the point where the coastal plain area containing the alluvial groundwater basins starts. GIS data obtained from the installation were used to delineate the boundaries and the size of the total drainage areas upstream of the alluvial groundwater basins (Figure 5-1). The down gradient, "mixed" concentrations in surface water entering the alluvial groundwater basins were estimated as an areally weighted sum of the concentrations from the individual loading areas draining to the groundwater basins:

$$C_{mixed} = [\sum (C_{runoff} \times A_{LA})] / A_{DA}$$

Where:

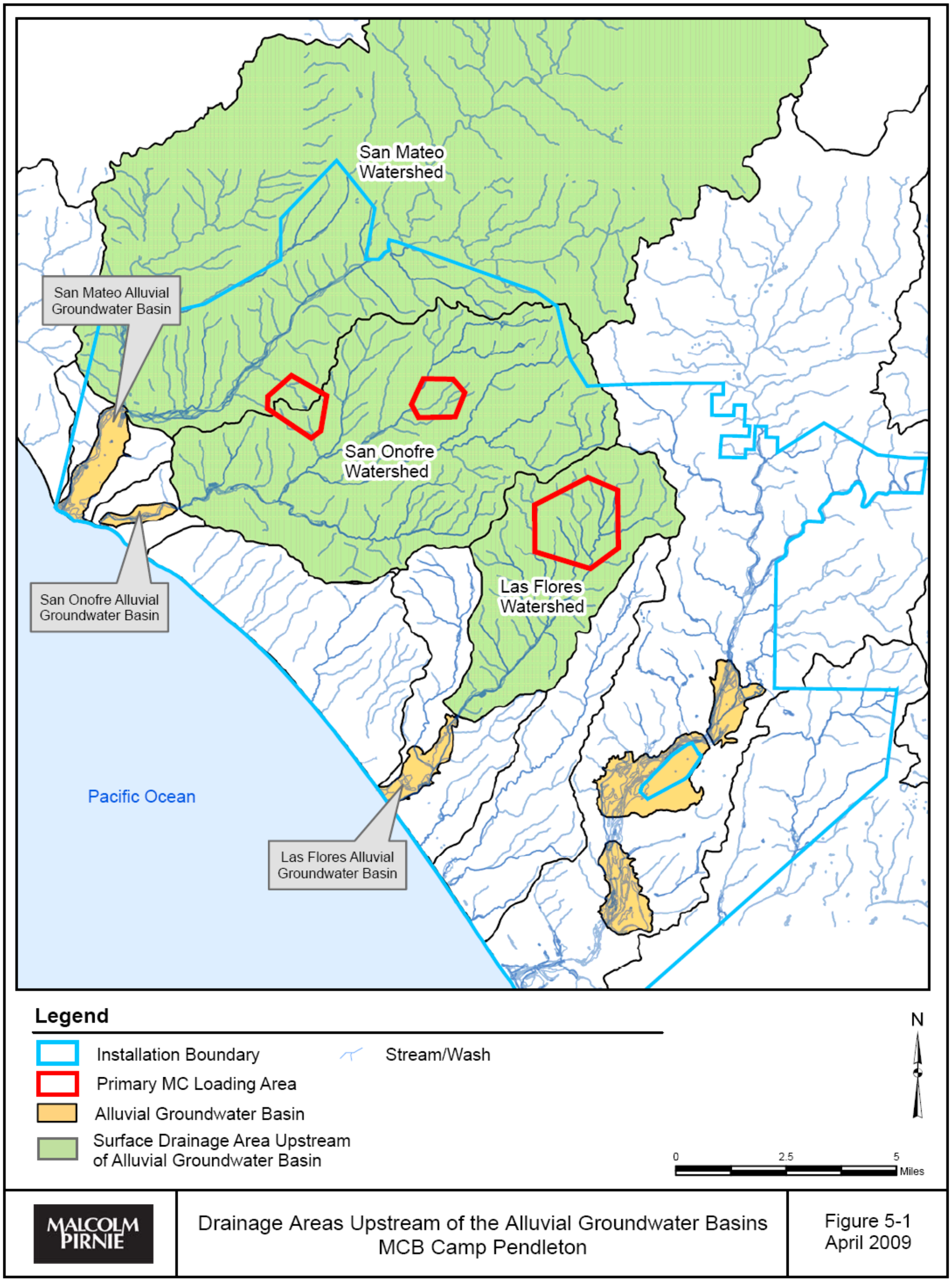
C_{mixed} = post-mixed concentrations in surface water entering groundwater basins (µg/L)
C_{runoff} = concentration in runoff from loading areas (µg/L)
A_{LA} = area receiving MC loading (m^2)
A_{DA} = total drainage area upstream of groundwater basin (m^2)

Inherent in this method is the assumption that all areas other than primary MC loading areas contribute runoff that has negligible MC concentrations. This provides a simple estimate of the potential for predicted concentrations at primary MC loading area boundaries to be reduced by mixing with other runoff downstream prior to entry into alluvial groundwater basins.

5.3. Interpretation of Results

Results of the screening-level modeling conducted for individual watersheds are presented and discussed in **Section 7**. The estimated concentrations of indicator MC resulting from each of the screening analyses were compared to the REVA trigger values to determine the potential for off-range releases to surface water and to evaluate the potential impacts to downstream receptors. For the San Onofre and Las Flores watersheds, the screening-level analysis resulted in estimated concentrations of MC exceeding the REVA trigger values. Therefore, surface water sampling in these two watersheds was carried out to further evaluate the potential for off-range migration in surface water. Because human receptors potentially are exposed to surface water recharging alluvial groundwater basins (through drinking water sources), groundwater sampling was carried out in the two watershed areas where detectable MC concentrations in surface water were predicted to be recharging groundwater basins (San Onofre and Las Flores).

Figure 5-1: Watershed Drainage Upstream of Alluvial Groundwater Basins, MCB Camp Pendleton



P:\6285\024\GIS\MXD\047_Figure 5-1_Drainage Areas Upstream of the Alluvial GW Basins_PRD.mxd

6. Groundwater Analysis Method and Assumptions

The purpose of the groundwater analysis in the REVA program is to make best use of the available information to infer whether indicator MC can be transported in groundwater from MC loading areas off range and to off-range receptors. Both conceptual and quantitative methods are used. The first step in the groundwater analysis is the development of a CSM of MC transport, including a description of the groundwater flow system and identification of groundwater receptors. Even without modeling, the CSM provides an initial evaluation for the potential for MC to reach receptors and allows for the prioritization of each MC loading area. The CSM for MCB Camp Pendleton is presented in **Section 4** with individual ranges and training areas discussed in **Section 7**.

After development of the CSM, quantitative analysis methods were used at selected ranges, in accordance with the groundwater analysis approach described in the *REVA Reference Manual* (HQMC, 2006). The quantitative methods used in REVA are considered screening-level models. The models rely on multiple conservative assumptions, are more likely to overestimate than underestimate MC concentrations, and are used to evaluate if ranges merit additional investigation. The groundwater screening analysis methods discussed below were employed for three primary MC loading areas designated as high priority for MC transport to human health or ecological receptors at MCB Camp Pendleton.

Groundwater modeling was used to simulate the movement of potential MC in groundwater to wells located in the San Onofre and Las Flores groundwater basins. These basins, along with the San Mateo basin, were given primary ratings for MC transport to a receptor based on their locations down gradient of three primary loading areas: Zulu, Whiskey, and Quebec MC loading areas. (Groundwater modeling in the San Mateo basin was not necessary due to the concentrations below REVA trigger values predicted from surface water modeling.) Because of the close connection between groundwater and surface water at MCB Camp Pendleton, a slightly different procedure was used than that presented in the *REVA Reference Manual* (HQMC, 2006). The surface water modeling, as described in **Section 5**, was used to estimate the concentration of MC in the surface water when it reached the up gradient edge of the alluvial basins containing groundwater wells. The modeled concentration flowing in the streambed was assumed to infiltrate immediately to the groundwater without any reduction in concentration (a conservative assumption), and a simple two-dimensional analytical groundwater fate and transport model (BIOCHLOR) was used to predict the possible movement of that MC to the groundwater wells. The concentrations at the wells were compared to the REVA trigger values (Table 5-1), which were presented in the *REVA Reference Manual* (HQMC, 2006).

6.1. Model Assumptions

The governing equations behind the BIOCHLOR model include contaminant transport by advection (in one dimension), diffusion (in three dimensions), adsorption (linear isotherm), and first-order decay. The results are presented on a two-dimensional array in a horizontal plane oriented parallel to the groundwater flow direction with the source location centered at one end. This assumes that groundwater flows directly from the source location to the receptor location. Since the highest concentrations are found along the centerline, only these conservative centerline concentrations are presented in this report. Because of the assumption that the source was constant in time, the resulting plume eventually reaches steady state. For a conservative result, decay was eliminated from these runs by setting the first-order decay constant to 0.

The models were set up to model flow from the up gradient edge of each alluvial aquifer where the streambed enters the alluvium to the approximate locations of the drinking water supply wells located within the lateral extent of the alluvial aquifer. Estimates of hydraulic gradient were based on ground surface slopes without any attempt to model the cones of depression that would result from pumping in the wells. This model setup also ignores any MC-laden water that might flow on the land surface over the alluvium and infiltrate at some location below the up gradient edge of the aquifer, either closer or down gradient of the wells.

6.2. Model Input Parameters

Model parameters were estimated from literature values, GIS data, and professional experience. Table 6-1 lists the input variables used in the model with a short explanation of the basis for selection of the value. (The San Mateo basin parameters are not presented in Table 6-1 because the surface water modeling eliminated this basin as a concern for MC transport.) Parameters were chosen to be conservative, thus overestimating the MC concentrations in the groundwater at the drinking water wells. The gradient values are the only values that are not considered to be conservative because they do not take into consideration the increased gradient during pumping conditions. Results of the modeling for each basin are presented in **Section 7**.

Table 6-1:
Groundwater Modeling Parameters for MCB Camp Pendleton

Model Parameter	Units	Parameter Value		Rationale
		San Onofre Basin	Las Flores Basin	
Hydraulic conductivity, k	cm/s	0.035		From Stetson (2005)
Hydraulic gradient, i	ft/ft	0.055	0.003	Based on rough approximation of slopes estimated from GIS data
Effective porosity, n_e		0.25		From Stetson (2005) and soil descriptions in MCB Camp Pendleton GIS database
Longitudinal dispersion, α_x	ft	30		Based on professional experience
Transverse dispersion, α_y	ft	3		Based on professional experience
Vertical dispersion, α_z	ft	0.3		Based on professional experience
Bulk density, ρ_b	kg/L	1.6		Based on soil descriptions in MCB Camp Pendleton GIS database
Fraction organic carbon, f_{oc}		0.0055		Based on soil descriptions in MCB Camp Pendleton GIS database and reduced slightly to be conservative
TNT organic carbon partition coefficient, K_{oc}	L/kg	34.8		From ATSDR (1995a)
RDX organic carbon partition coefficient, K_{oc}	L/kg	3.4		From ATSDR (1995b)
Temporal length of simulation	yr	30		Model is at steady state within 30 years, so the length of simulation does not affect the results.
Model grid width	ft	3000		Because we only report the centerline concentration, this parameter does not affect the outcome.
Model grid length	ft	6000		Does not affect the results; only affects where the results are available This value was set higher than the distance to the wells.
Source thickness	ft	40	30	From Stetson (2005)
Source width	ft	100	50	Approximate width of the aquifer area at the up gradient edge

Model Parameter	Units	Parameter Value		Rationale
		San Onofre Basin	Las Flores Basin	
TNT initial concentration, C_o	µg/L	0.19	0.91	From output of surface water model
RDX initial concentration, C_o	µg/L	0.7	3.75	From output of surface water model

Note:
cm/s – centimeters per second
ft – feet
ft/ft – feet per foot
kg/L – kilograms per liter
L/kg – liters per kilogram
yr – years
µ/L – micrograms per liter

7. Screening-Level Assessment Results

The operational ranges assessed in REVA include LFAM areas, fixed ranges, SARs, and training areas where military munitions are known or suspected to have been used. Based on MC loading prioritization, three impact areas were determined to require surface water and groundwater modeling to evaluate the potential MC migration to off-site human and T/E ecological receptors. The three impact areas (Quebec, Whiskey, and Zulu) were determined to have a high overall priority based upon discussions with Range Control and installation personnel at MCB Camp Pendleton and the data presented in the *Training Range Sustainment Planning and Training Range Inventory, 2004 National Defense Authorization Act Section 366 Report* (Table 3-4). These areas were considered the primary MC loading areas.

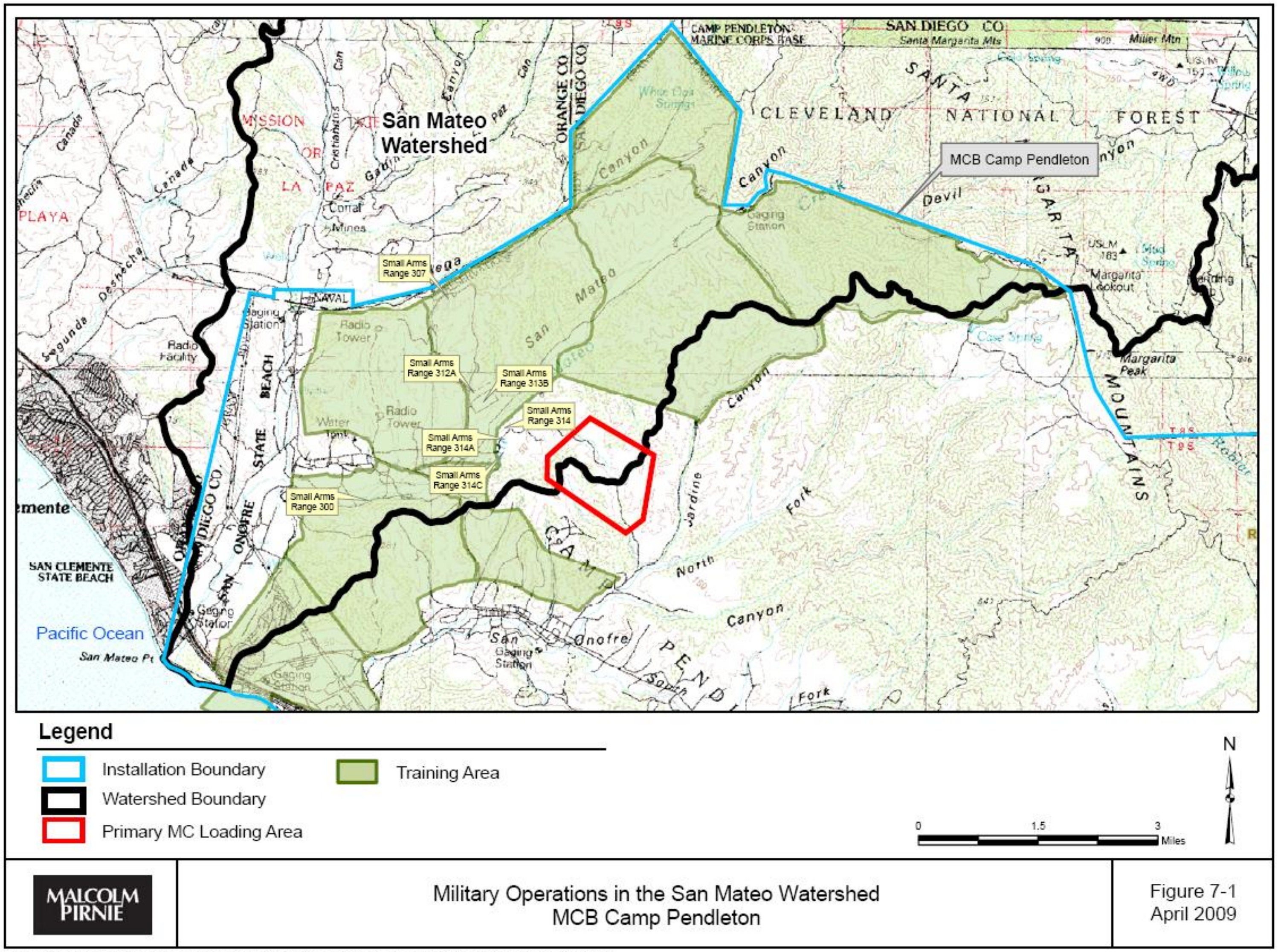
These three areas (Quebec, Whiskey, and Zulu) were assumed to be potential upgradient sources and were modeled using surface water and groundwater screening-level analyses. The remaining areas (training areas and impact areas) were ranked with a lower HE priority (low or medium) or had inadequate information available to estimate MC loading rates; therefore, these other areas were not modeled. As noted previously, fifteen SARs were assessed qualitatively and are discussed in **Section 8**.

7.1. San Mateo Watershed

The San Mateo watershed is located in the western portion of MCB Camp Pendleton; it is approximately 85,461 acres in size, with 18,677 acres located within MCB Camp Pendleton (Figure 7-1). Eight RTAs and two impact areas are located within the San Mateo watershed. The training areas and impact areas are summarized in Table 7-1. The Quebec Impact Area is the only area contributing a significant amount of REVA MC within the San Mateo watershed based on the current training conducted at MCB Camp Pendleton. This area was given a high overall priority, compared to no, low, and medium priorities for all other training and impact areas within the watershed. The San Mateo Impact Area is not used for live-fire training; therefore, for the purpose of screening-level modeling, no MC loading was conducted in this area.

In addition to the training and impact areas, as summarized in Table 7-1, seven live-fire fixed ranges are located within the San Mateo watershed. Range 300 is a fixed range with only small arms ammunition use. It was qualitatively assessed and is described in **Section 8**.

Figure 7-1: Military Operations in the San Mateo Watershed, MCB Camp Pendleton



P:\6285\024\GIS\MXD\048_Figure 7-1_Military Operations in the San Mateo Watershed_PRD.mxd

Table 7-1: Training and Impact Areas within the San Mateo Watershed

Area	Type	Area (acres)	Percent within San Mateo Watershed	Overall HEPrioritization
Alpha One	Training area	1,034	22.1	Medium
Bravo One	Training area	2,443	100.0	Medium
Bravo Two	Training area	1,986	63.1	Medium
Bravo Three	Training area	2,443	51.3	Low
Charlie	Training area	1,641	100.0	N/A
Delta	Training area	2,713	86.5	N/A
Quebec	**Impact area / primary MC loading area**	**2,862/754**	**43.6/48.6**	**High**
San Mateo	Impact area	2,480	99.6	Low
Section A	Training area	1,728	28.5	N/A
Yankee	Training area	3,899	75.6	N/A

Note:
N/A indicates a training area that was not given an HE priority based on the information available.
Bold indicates an area prioritized with a high overall HE ranking.

The only primary MC loading area identified within the San Mateo watershed is the Quebec Impact Area, which overlaps the San Mateo and San Onofre watersheds. The San Mateo watershed includes 43.6% of the Quebec Impact Area. Approximately one-half (48.6%) of the MC loading area within this impact area is located within the San Mateo watershed. The remainder of the Quebec Impact Area is located in the San Onofre watershed.

Detailed assumptions for the determination of MC loading rates are provided in **Section 3** and in the *REVA Reference Manual* (HQMC, 2006).

7.1.1. Screening-Level Assessment for San Mateo Watershed

7.1.1.1. Estimated MC Loading

The primary MC loading area for the San Mateo watershed is a portion of the Quebec primary MC loading area. In addition to the training and impact areas, seven live-fire fixed ranges are located within the San Mateo watershed. Range 300 is a fixed range with only small arms ammunition use. It was qualitatively assessed and is described in **Section 8** (Figure 7-1). The MC Loading Rate Calculator was used to estimate the amount of MC loaded to this area over time. It was conservatively assumed that all military munitions expenditures for the Quebec Impact Area were loaded within the boundaries of the primary MC loading area, rather than across the entire impact area. Therefore, the MC loading amounts estimated for each identified time period during which the impact area was used, Time Periods C, D, and E, were assumed to occur only within the primary MC loading area (Table 7-2). Expenditure data were extrapolated for time periods for which expenditure data were not available.

Table 7-2: Estimated Annual MC Loading for the San Mateo Watershed

Primary MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Quebec	C	1942	1976	5.44E-10	3.11E-05	5.46E-05	1.16E-07
	D	1977	1988	2.03E-10	1.31E-06	7.30E-07	9.38E-08
	E	1989	2005	2.53E-10	1.64E-06	9.12E-07	1.17E-07

Note: kg/m^2 – kilograms per squared meter

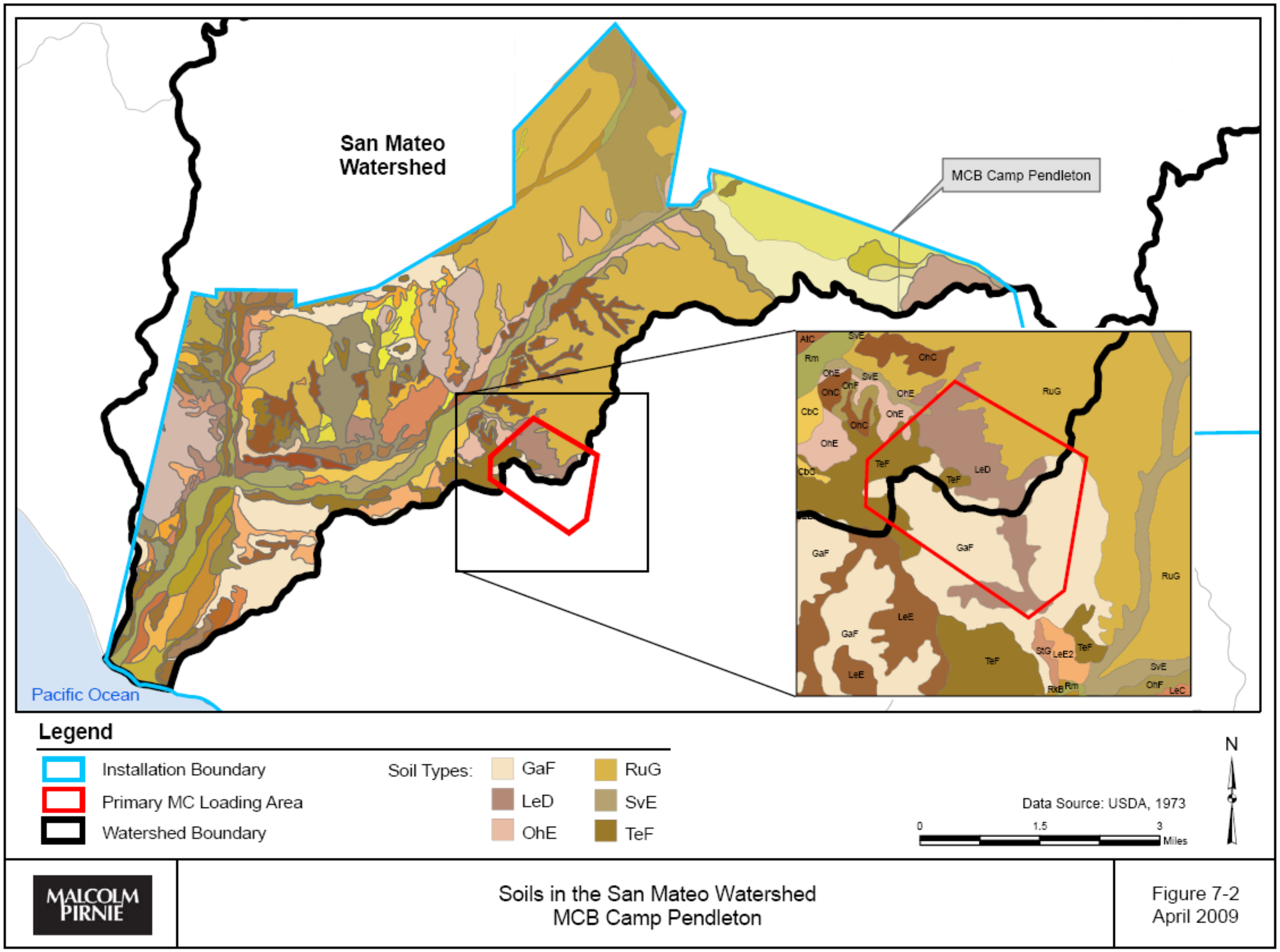
7.1.1.2. Physical Environment

Within the San Mateo watershed, the Quebec primary MC loading area was modeled using screening-level analyses to predict the concentration of REVA MC in surface water and groundwater. The physical characteristics of the environment were used to develop the input parameters to the model.

As noted above, the primary MC loading area straddles the watershed boundary between the San Mateo and San Onofre watersheds. Approximately one-half of the Quebec primary MC loading area is located within the San Mateo watershed. It is located on the southern slopes of valley uplands that have high slope grades (between 9% and 50% or more). The following four predominant soil series types were identified in the primary Quebec MC loading area based on a review of the United States Department of Agriculture Soil Conservation Service and Forest Service maps for the San Diego area (USDA, 1973): Las Flores loamy fine sand (9% to 15% grade) (LeD), terrace escarpments (TeF), rough broken land (RuF), and Gaviota fine sandy loam (30% to 50% grade) (GaF). The erosion potential of these soils is moderate. For the Gaviota soil series the soil is generally well-drained, shallow fine sandy loams that were formed from marine sandstone. The surface water runoff of these soils is moderate to rapid and the erosion hazard is high (Figure 7-2). The Las Flores soil series has a moderate runoff potential with loamy fine sand at the surface, underlain by sandy clay. The permeability is defined as very slow.

The rough broken land and terrace escarpments are both well-drained to excessively drained soil with steep to very steep land forms. Runoff is generally rapid to very rapid, and erosion rates are very high with little to no vegetation present in areas defined as rough broken terrain to prevent soil erosion. Terraces escarpments, particularly north-facing ones like the ones present within the Quebec primary MC loading area, have more dense vegetative cover (USDA, 1973).

Figure 7-2: Soils in the San Mateo Watershed, MCB Camp Pendleton



P:\6285\024\GIS\MXD\055_Figure 7-2_Soils in the San Mateo Watershed_PRD.mxd

Based on the soil and vegetation characteristics of the primary MC loading area, soil, and hydrologic properties were selected to determine the amount of soil loss. The results of the soil loss calculation are described in Section 5. The soil erosion rate calculated for the Quebec primary MC loading area was 8.6E-03 kg/m2/day.

In addition to the soil erosion rates, the surface runoff rates were calculated based on soil types and hydrologic properties within the Quebec primary MC loading area. Based on the runoff characteristics of the soil types present within the primary MC loading area, a runoff coefficient of 0.5 was selected to represent the high to rapid runoff rates.

Due to the steep grades of the soils, water falling on the area travels through the ephemeral washes and into the dendritic and intermittent San Mateo Creek, located at the base of the valley. The surface water then travels down the creek bed and over the alluvial groundwater basins of the river valley (Figure 7-3). The alluvial groundwater basin in the San Mateo watershed is used to supply drinking water to MCB Camp Pendleton. The Water Quality Control Plan for the San Diego Basin lists the beneficial uses of the San Mateo surface water as noncontact recreational use, freshwater habitat (warm and cold), wildlife habitat, and spawning (California Regional Water Quality Control Board, 2007).

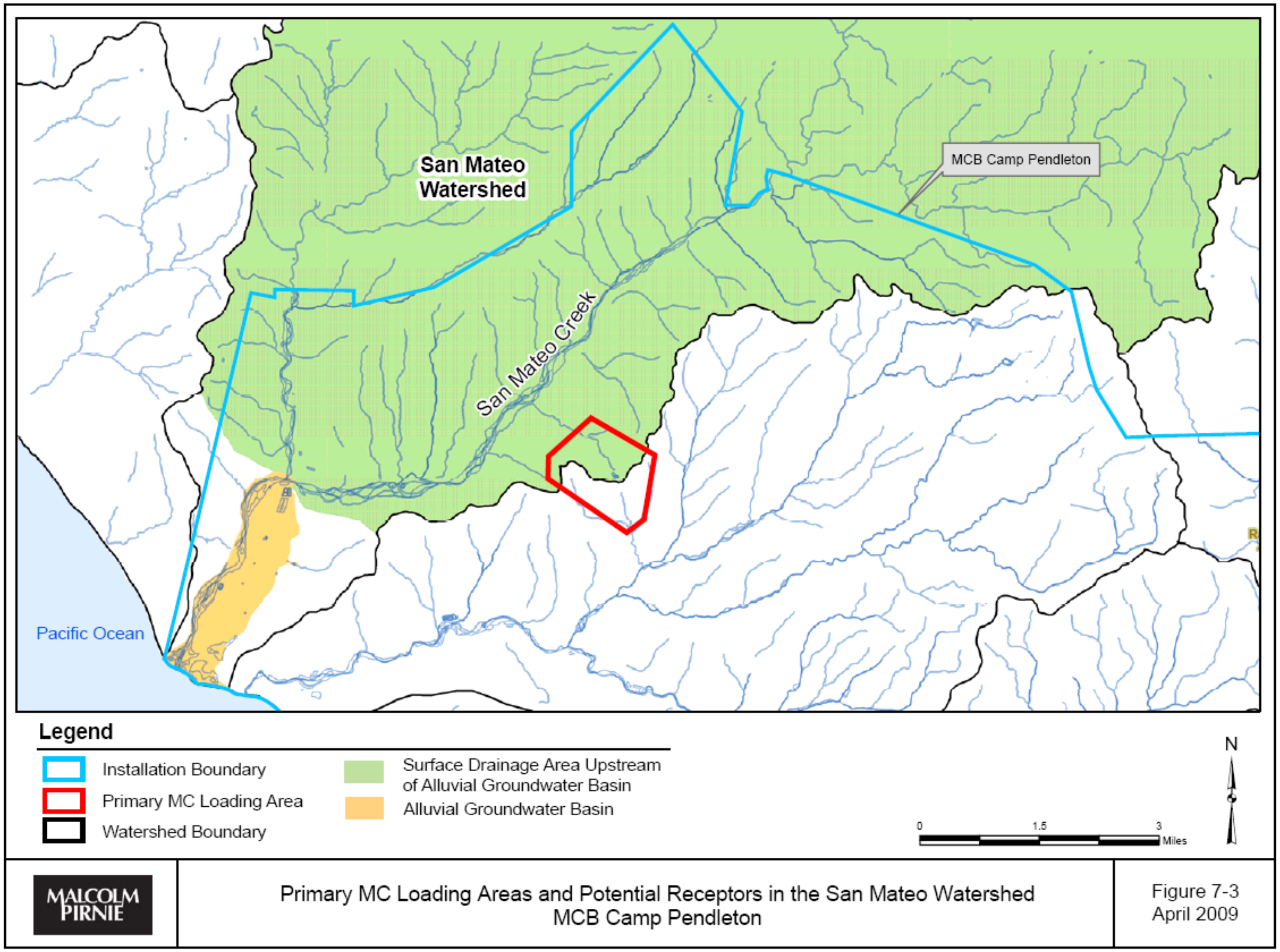
Surface water flow in the San Mateo Creek discharges to underlying aquifers and is assumed to be the dominant recharge mechanism to the San Mateo alluvial groundwater basin. This recharge occurs as the stream flows out over the alluvial sediments of the groundwater basin.

As such, water seeps through the streambed as a continuous line source to the underlying aquifer when water is flowing within surface water bodies in the alluvial groundwater basin. The modeling effort conservatively assumed the water enters the aquifer as a point source, which results in a higher concentration of MC estimated in the aquifer (the line source serves to dilute the MC over a larger area). The alluvial groundwater basin is composed of unconsolidated silts, sands, gravels, and conglomerates (Cranham et al., 1994). The thickness of the alluvial aquifer varies from 18 to 105 ft; the aquifer is thickest toward the center of the stream valley (Palmer, 1990).

Table 7-3 presents the estimated MC concentrations in surface water recharging the San Mateo alluvial groundwater basin, following downstream mixing. Concentrations of the REVA MC in surface water runoff recharging the San Mateo alluvial groundwater basin, after downstream mixing, were predicted to be below the REVA trigger values.

Based on the results of the screening-level modeling of runoff recharge entering the San Mateo alluvial groundwater basin located downstream of the Quebec Impact Area boundary, the concentrations of REVA indicator MC are expected to be below the REVA trigger values.

Figure 7-3: Primary MC Loading Areas and Potential Receptors in the San Mateo Watershed, MCB Camp Pendleton



P:\6285\024\GIS\MXD\051_Figure 7-3_MC Loading and Potential Receptors in San Mateo_PRD.mxd

Table 7-3: Screening-Level Estimates of Annual Average MC Concentrations in Runoff Recharging the San Mateo Alluvial Groundwater Basin

MC	REVA Trigger Value (μg/L) [a]	Post-Mixing Predicted Concentrations Entering Groundwater Basin (μg/L)
HMX	0.08	1.1E-05
RDX	0.16	3.9E-02
TNT	0.08	6.4E-03
Perchlorate	0.98	4.6E-03

Note:
μ/L – micrograms per liter
[a]REVA trigger values are the median representative screening threshold values, for surface water or groundwater modeling, obtained from certified analytical laboratories for each indicator MC as defined in the *REVA Reference Manual* (HQMC, , 2006).

7.1.2. Groundwater Analysis Results

Based on the results of the surface water screening-level analysis, all MC were predicted to be below REVA trigger values for surface water recharging groundwater in the San Mateo groundwater alluvial basin. Therefore, no groundwater modeling was conducted for the San Mateo watershed.

7.2. San Onofre Watershed

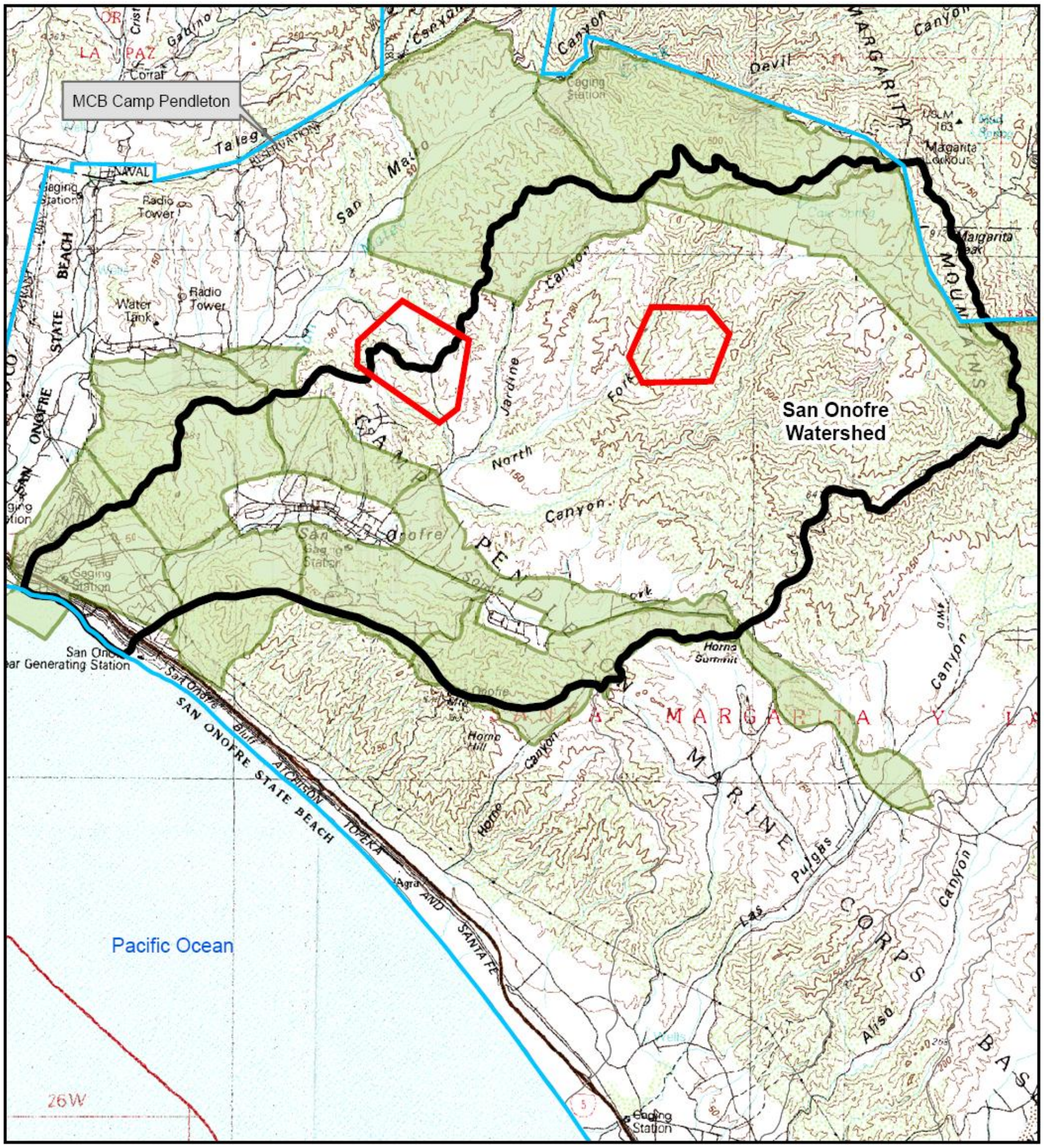
The San Onofre watershed is located east of the San Mateo watershed and almost entirely contained within MCB Camp Pendleton. San Onofre watershed is approximately 27,116 acres in size, with 26,678 acres located within MCB Camp Pendleton. Located within the San Onofre watershed are 11 RTAs and three impact areas (Figure 7-4). The training areas and impact areas are summarized in Table 7-4.

The Quebec and Whiskey primary impact areas potentially contribute the largest amount of REVA MC to the watershed based on the current training conducted at MCB Camp Pendleton within the San Onofre watershed. The Quebec and Whiskey primary impact areas were given a high overall priority, compared to no, low, and medium priorities for all other training and impact areas within the watershed.

In addition to the training and impact areas, 23 live-fire fixed ranges are located within the San Mateo watershed.Ranges 210C, 212A, 213, and 214 are fixed ranges with only small arms ammunition use. They were qualitatively assessed during REVA and are described in **Section 8**.

Detailed assumptions for the determination of MC loading rates are provided in **Section 3** and in the *REVA Reference Manual* (HQMC, 2006).

Figure 7-4: Military Operations in the San Onofre Watershed, MCB Camp Pendleton



Legend

- Installation Boundary
- Primary MC Loading Area
- Training Area
- Watershed Boundary

0 1.5 3 Miles

N

MALCOLM PIRNIE	Military Operations in the San Onofre Watershed MCB Camp Pendleton	Figure 7-4 April 2009

P:\6285\024\GIS\MXD\049_Figure 7-4_Military Operations in the San Onofre Watershed_PRD.mxd

Table 7-4: Training and Impact Areas within the San Onofre Watershed

Area	Type	Area (acres)	Percent within San Onofre Watershed	Overall HE Prioritization
Alpha One	Training area	1,034	77.9	Medium
Alpha Two	Training area	1,329	86.9	Low
Alpha Three	Training area	1,265	57.9	Low
Bravo Three	Training area	2,443	47.5	Low
Delta	Training area	2,713	13.5	N/A
Echo	Training area	2,097	99.9	Medium
Finch	Training area	1,733	3.1	Low
Foxtrot	Training area	2,664	39.9	N/A
Quebec	**Impact area / primary MC loading area**	**2,862/754**	**56.4/ 51.4**	**High**
Romeo One	Training area	1,690	78.7	Low
Section A	Training area	1,728	59.3	N/A
Whiskey	**Impact area / primary MC loading area**	**20,025[a] Whiskey: 221[b] Zulu: 797[b]**	**64.6/100 100.0 0**	**High**
Yankee	Training area	3,899	24.4	N/A

Note:
N/A indicates a training area that was not given an HE priority based on the information available.
Bold indicates an area prioritized with a high overall HE ranking.
[a] Based on total area of both impact areas
[b] Area in acres of MC loading area

7.2.1. Screening-Level Assessment for San Onofre Watershed

7.2.1.1. Estimated MC Loading

The primary MC loading areas for the San Onofre watershed are a portion of the Quebec primary MC loading area and the entire Whiskey primary MC loading area (Table 7-5). The MC Loading Rate Calculator was used to estimate the amount of MC loaded to this area over time. It was conservatively assumed that all military munitions expenditures for the Quebec and Whiskey impact areas were loaded within the boundaries of the MC loading area, rather than across the entire impact area. Therefore, the MC loading amounts estimated for each identified time period during which the impact area was used, Time Periods C, D, and E, were assumed to occur only within the primary MC loading area (Table 7-5). Expenditure data were extrapolated for time periods when expenditure data were not available.

Table 7-5: Estimated Annual MC Loading for the San Onofre Watershed

Primary MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Quebec	C	1942	1976	5.44E-10	3.11E-05	5.46E-05	1.16E-07
	D	1977	1988	2.03E-10	1.31E-06	7.30E-07	9.38E-08
	E	1989	2005	2.53E-10	1.64E-06	9.12E-07	1.17E-07
Whiskey	C	1942	1976	3.76E-09	5.35E-06	6.47E-06	3.26E-09
	D	1977	1988	2.70E-09	2.84E-06	3.67E-06	1.32E-09
	E	1989	2005	3.37E-09	3.54E-06	4.61E-06	1.73E-09

Note: kg/m^2 – kilograms per square meter

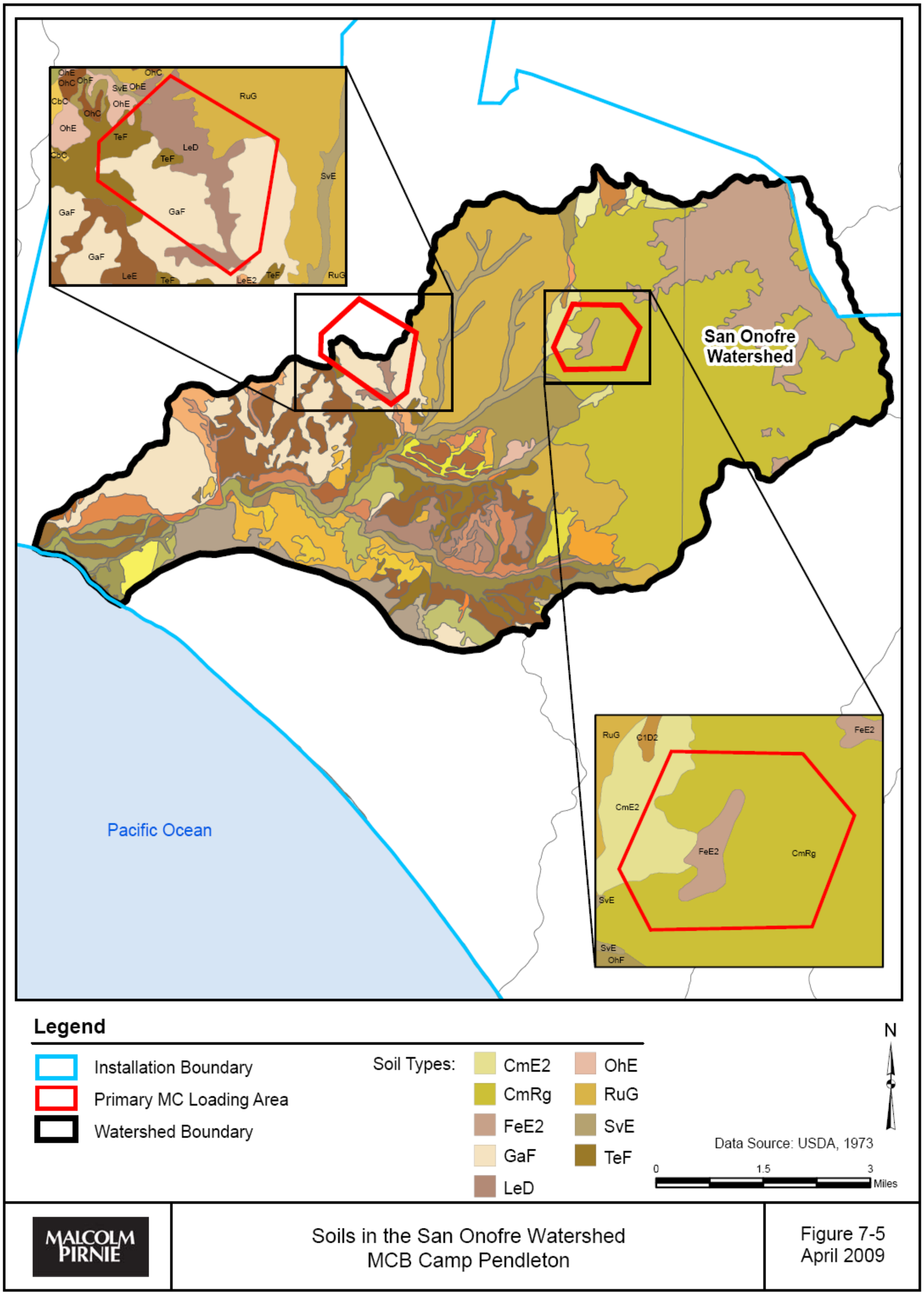
7.2.1.2. Physical Environment

The Quebec and Whiskey primary MC loading areas were modeled using screening-level analyses to predict the concentration of REVA MC in surface water and groundwater within the San Onofre watershed. The physical characteristics of the environment were used to develop the input parameters to the model.

The San Onofre watershed area includes approximately one-half of the Quebec primary MC loading area and all of the Whiskey primary MC loading area. The portion of Quebec primary MC loading area located within the San Onofre watershed drains into tributary streams of San Onofre Canyon that drain southwestward into San Onofre Canyon just downstream of the confluence with Jardine Canyon. The Whiskey primary MC loading area drains into one of the major tributary streams of San Onofre Canyon that drains southwestward into San Onofre Creek.

The Quebec primary MC loading area is located on the northern slopes of valley uplands that have slope grades between 9% and 50% (or more). The following two predominant soil series types were identified in the Quebec primary MC loading area based on a review of the United States Department of Agriculture Soil Conservation Service and Forest Service maps for the San Diego area (USDA, 1973): Las Flores loamy fine sand (9% to 15% grade) (LeD) and Gaviota fine sandy loam (30% to 50% grade) (GaF), with some terrace escarpments (TeF) (Figure 7-5). These soil series are typical of upland soils. The Las Flores soil series has a moderate runoff potential with loamy fine sand at the surface and a sandy clay underneath. The permeability is defined as very slow. The erosion potential of this soil is moderate. The Gaviota soil series is generally well drained, with shallow, fine, sandy loams that were formed from marine sandstone. The surface water runoff of these soils is moderate to rapid, and the erosion hazard is high (USDA, 1973).

Figure 7-5: Soils in the San Onofre Watershed, MCB Camp Pendleton



P:\6285\024\GIS\MXD\055_Figure 7-5_Soils in the San Onofre Watershed_PRD.mxd

Based on the soil and vegetation characteristics of the Quebec primary MC loading area, soil and hydrologic properties were selected to determine the amount of soil loss. The results of the soil loss calculation are described in **Section 5**. The soil erosion rate calculated for the Quebec primary MC loading area was 8.6E-03 kg/m^2/day. In addition to the soil erosion rates, the surface runoff rates were calculated based on soil types and hydrologic properties within the Quebec primary MC loading area. A runoff coefficient of 0.5 was selected to represent the high to rapid runoff rates based on the runoff characteristics of the soil types within the primary MC loading area.

The following two predominant soil series types were identified in the Whiskey primary MC loading area based on a review of the United States Department of Agriculture Soil Conservation Service and Forest Service maps for the San Diego area (USDA, 1973): Cieneba (very rocky, coarse, sandy loam) and Fallbrook (rocky, sandy loam).

The Cieneba soil series generally consists of excessively drained, very shallow to shallow, coarse sandy loams. Rocky sandy loams (slopes 9% and 30%) (CmE2) have well-drained soils with medium to rapid runoff and moderate to high erosion hazard. Rock outcrops occur over more than 5% of the land surface and large boulders, approximately 10% of the land surface. Cieneba very rocky, coarse, sandy loam (slopes 30% to 75%) (CmRg) is steep to very steep land with large rock outcrops over 20% of the land surface and very large boulders over another 30%. Runoff in these soils is rapid to very rapid with high to very high erosion hazard. The Fallbrook rocky sandy loam (slopes 9% to 30%) eroded (FeE2) are strongly sloped to moderately steep. Large boulders cover 10% to 25% of the land surface, and rock outcrops cover 10% of the land.

The Fallbrook soil series generally consists of deep sandy loams formed in well-weathered material. Runoff is slow to medium, and the erosion hazard is slight to moderate (USDA, 1973).

Based on the soil and vegetation characteristics of the Whiskey primary MC loading area, soil and hydrologic properties were selected to determine the amount of soil loss. The results of the soil loss calculation are described in **Section 5**. The soil erosion rate calculated for the Whiskey primary MC loading area was 1.4E-02 kg/m^2/day; erosion rates in the Whiskey primary MC loading area is almost twice the erosion rate in the Quebec primary MC loading area.

Due to the steep grades of the soils, water falling on the Whiskey primary MC loading area travels through the ephemeral washes and into the dendritic and intermittent San Onofre North Fork, located at the base of the valley. The surface water then travels down the river valley. The Jardine Canyon and San Onofre North Fork intersect and become the San Onofre Canyon. MC from the Quebec primary MC loading area enter the San Onofre Canyon downstream of this canyon from an unnamed wash. The alluvial groundwater basin in the San Mateo watershed is used to supply drinking water to MCB Camp Pendleton. The San Diego Water Quality Control Plan lists the beneficial uses of the San Onofre Canyon surface water as agricultural, contact and noncontact recreational use, freshwater habitat (warm and cold), wildlife habitat**,** and spawning (California Regional Water Quality Control Board, 2007).

Surface water flow in the San Onofre Creek discharges to underlying aquifers and is the dominant recharge mechanism to the San Onofre alluvial groundwater basin. Recharge occurs as the stream flows out over the alluvial sediments of the groundwater basin. Water seeps through the streambed as a line source to the underlying aquifer. The modeling effort conservatively assumed the water enters the aquifer as a point source, which results in a higher concentration of MC estimated in the aquifer (the line source serves to dilute the MC over a larger area). The alluvial groundwater basin is composed of unconsolidated silts, sands, gravels, and conglomerates (Cranham et al., 1994). The thickness of the alluvial aquifer varies from 18 to 105 ft; the aquifer is thickest toward the center of the stream valley (Palmer, 1990).

7.2.2. Surface Water Analysis Results

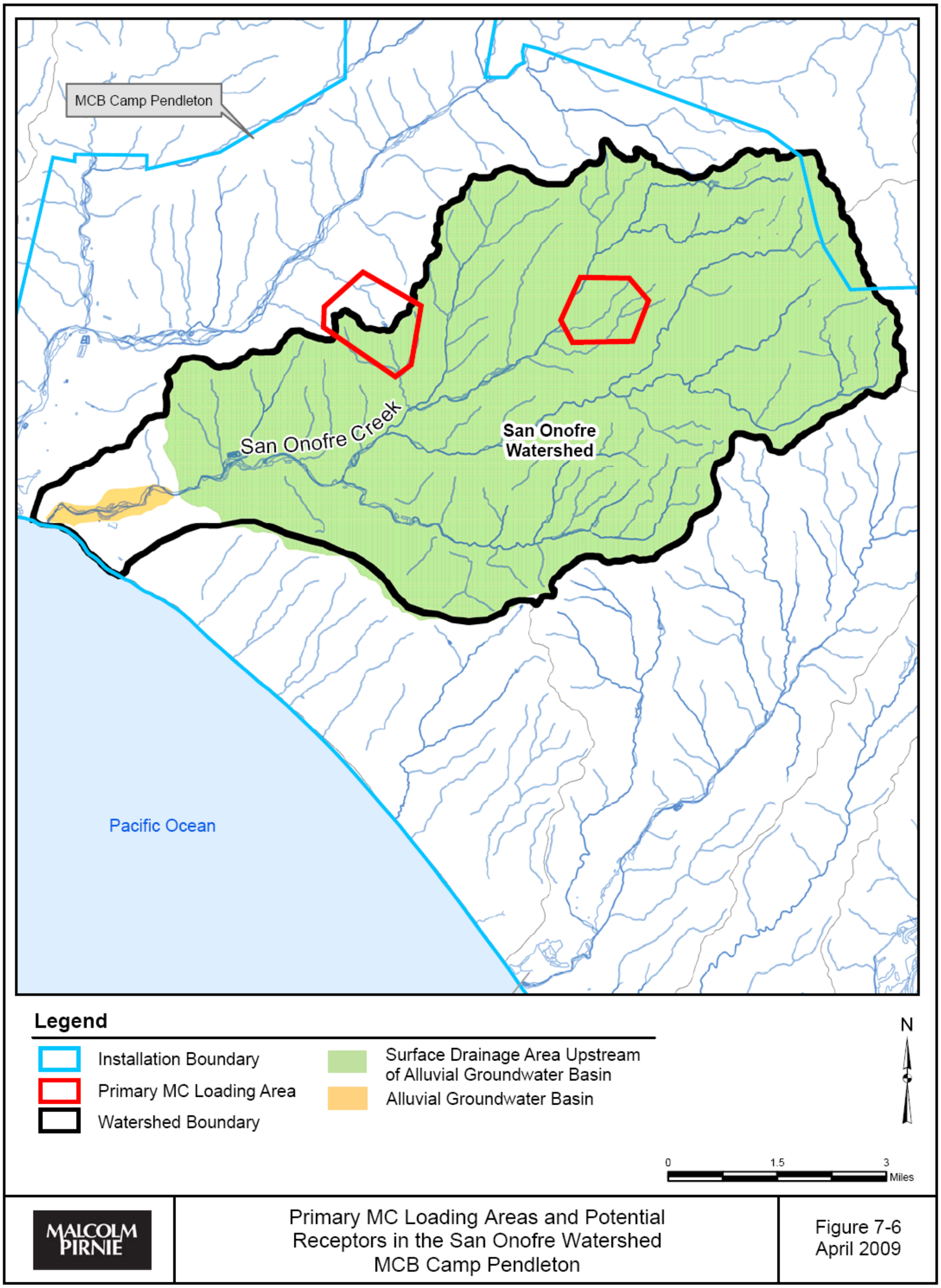
A screening-level analysis of MC concentrations in surface water was conducted for the San Onofre watershed, based on the high prioritization of the Quebec and Whiskey impact areas. The San Onofre watershed area includes approximately one-half of the Quebec primary MC loading area and all of the Whiskey primary MC loading area (Figure 7-6). The screening-level analysis was used to estimate MC concentrations in surface water potentially recharging the San Onofre alluvial groundwater basin. The surface water screening-level analysis was conducted as described in **Section 5**.

The surface water screening-level analysis was carried out for a time period ranging from 1942 to 2005.

Historical MC loading areas that existed within the San Onofre watershed include several training areas; however, due to their short period of use (1942 through 1946) and the length of time between the end of MC loading to the present (approximately 60 years), the MC loading rates from these historical loading areas were not used in the surface water screening-level analysis.

Table 7-6 presents the estimated percentage of MC mass contributed by individual loading areas to San Onofre alluvial groundwater basin from surface water recharging the groundwater basin. The Whiskey primary MC loading area was predicted to contribute a significant percentage of the total HMX, RDX, and TNT mass into the San Onofre alluvial groundwater basin from surface water. However, the Quebec primary MC loading area was predicted to contribute almost all of the total perchlorate mass (98%) into the San Onofre alluvial groundwater basin from surface water.

Figure 7-6: Primary MC Loading Areas and Potential Receptors in the San Onofre Watershed, MCB Camp Pendleton



P:\6285\024\GIS\MXD\052_Figure 7-6_MC Loading and Potential Receptors in San Onofre_PRD.mxd

Table 7-6: Screening-Level Estimates of Percent MC Mass Contributed by Individual MC Loading Areas into San Onofre Alluvial Groundwater Basin from Surface Water

MC	From Quebec primary MC Loading Area	From Whiskey primary MC Loading Area
HMX	5.2	94.8
RDX	23.6	76.4
TNT	10.6	89.4
Perchlorate	98.0	2.0

Note: Data are provided in percent mass.

Table 7-7 presents the estimated average annual edge-of-loading-area concentrations in surface water runoff from the Quebec and Whiskey primary MC loading areas. Based on surface water screening-level calculations, concentrations of RDX and TNT leaving the Quebec and Whiskey primary MC loading areas are estimated to exceed the REVA trigger values. In addition, the concentration of perchlorate leaving the Quebec MC loading area is also estimated to exceed the REVA trigger value. Concentrations of HMX leaving both Quebec and Whiskey primary MC loading areas and the concentration of perchlorate leaving the Whiskey primary MC loading area are estimated to be below the REVA trigger values.

Table 7-7: Screening-Level Estimates of Annual Average Edge-of-Loading-Area MC Concentrations in Runoff from Quebec and Whiskey MC Loading Areas

MC	REVA Trigger Value (µg/L)[a]	From Quebec primary MC Loading area (µg/L)	From Whiskey primary MC Loading Area
HMX	0.08	2.3E-03	0.031
RDX	0.16	**8.50**	**27.40**
TNT	0.08	**1.40**	**8.70**
Perchlorate	0.98	**1.00**	0.015

Note:
µg/L – micrograms per liter[a] REVA trigger values are the median representative screening threshold values, for surface water or groundwater modeling, obtained from certified analytical laboratories for each indicator MC as defined in the *REVA Reference Manual* (HQMC, 2006).
Bold indicates that the predicted concentration is above the REVA trigger value.

Table 7-8 presents the total watershed drainage area upstream of the San Onofre alluvial groundwater recharge point and the primary MC loading areas contributing MC to the downstream groundwater recharge point. The contributing primary MC loading areas and the total watershed drainage presented in Table 7-8, and the annual average loading area concentrations presented in Table 7-7, include the specific inputs used in the equation presented in **Section 5**, which calculates the downstream mixed concentrations.

Table 7-8: Area of the Total Watershed Drainage and Individual Primary MC Loading areas Contributing MC to the Downstream Groundwater Recharge Point of the San Onofre Alluvial Groundwater Basin

Watershed/Primary MC Loading Areas	Area (acres)
San Onofre Watershed upstream of the groundwater recharge point	25,688
Quebec primary MC loading area drainage to the groundwater recharge point	377
Whiskey primary MC loading area draining to the groundwater recharge point	547

Table 7-9 presents the estimated MC concentrations in surface water recharging the San Onofre alluvial groundwater basin, following downstream mixing. Concentrations of RDX and TNT in surface water runoff recharging the San Onofre alluvial groundwater basin, after downstream mixing, were predicted to remain above the REVA trigger values. However, post-mixing concentrations of HMX and perchlorate in surface water recharging the San Onofre alluvial groundwater basin were predicted to be below the REVA trigger values.

Table 7-9: Screening-Level Estimates of Annual Average MC Concentrations in Runoff Recharging the San Onofre Alluvial Groundwater Basin

MC	REVA Trigger Value (µg/L)[a]	Post-Mixing Predicted Concentrations Entering Groundwater Basin (µg/L)
HMX	0.08	6.9E-04
RDX	0.16	**0.7**
TNT	0.08	**0.2**
Perchlorate	0.98	0.015

Note:
µg/L – micrograms per liter
[a]REVA trigger values are the median representative screening threshold values, for surface water or groundwater modeling, obtained from certified analytical laboratories for each indicator MC as defined in the *REVA Reference Manual* (HQMC, 2006).
Bold indicates that the predicted concentration is above the REVA trigger value.

The screening-level surface water analysis predicted that concentrations of RDX and TNT in surface water recharging the San Onofre alluvial groundwater basin could exceed the REVA trigger values. As mentioned above, the San Onofre alluvial groundwater basin is used as a drinking water source. In addition, potential T/E ecological receptors are located within the San Onofre Canyon, downstream of the Quebec and Whiskey primary MC loading areas. A surface water sampling plan was implemented based on the results of this screening-level analysis. The results of the sampling are presented in **Section 9**.

7.2.3. Groundwater Analysis Results

A groundwater screening-level analysis was conducted for the alluvial groundwater basin located within the San Onofre watershed. As described in **Section 6**, the BIOCHLOR fate and transport model was run for RDX and TNT in the San Onofre Basin. The input parameters and assumptions are presented in **Section 6**. The input concentrations for the groundwater modeling were based on the predicted concentrations calculated from the surface water modeling (Table 7-9) and were represented in the model as a point source. Starting concentrations used as the inputs to the groundwater model were chosen by assuming that the MC reached the groundwater table instantaneously without any reduction in RDX or TNT concentrations. As discussed above, in reality, recharge will not be instantaneous and the source will be continuous when the creek is flowing, as opposed to a point source. These factors contribute to reduce concentrations that may migrate to the aquifer. BIOCHLOR was then run to model the movement of MC in the saturated zone toward the drinking water supply wells. The model includes advection, dispersion, and adsorption.

For RDX, the model reached steady state within 10 years (input MC at the source location is equal to loss of concentration due to dispersion). The drinking water supply wells in the San Onofre groundwater basin are located about one-half mile down gradient of the up gradient edge of the groundwater basin. The concentrations calculated by the screening-level model at these locations are summarized in Table7-10 and depicted in Figure 7-7. Both values are predicted to be above the REVA trigger value for RDX, indicating that RDX may be detectable in water supply wells in the San Onofre groundwater basin.

For TNT, the model reached steady state in about 25 years. The model-calculated concentrations are also summarized in Table 7-10. Both are below the REVA trigger value for TNT and, based on modeling, are not anticipated to be detectable in water supply wells.

The modeling results indicate that groundwater sampling should be conducted to evaluate if MC are migrating to the drinking water supply wells. Because of the line source represented by the stream, samples were collected from all the water supply wells tapping the San Onofre alluvial groundwater basin near where recharge is suspected to occur.

Table 7-10: MC Groundwater Modeling Results for the San Onofre Watershed

Indicator MC	REVA Trigger Value (µg/L)[a]	San Onofre Basin [b] (Input from Quebec and Whiskey Ranges)		
		SW	GW @ 1,200 ft[c, d]	GW @ 2,400 ft[c, d]
HMX	0.08	NP	NP	NP
RDX	0.16	**0.7**	**0.27**	**0.16**
TNT	0.08	**0.2**	0.07	0.04
Perchlorate	0.98	NP	NP	NP

Note:
SW - predicted surface water concentration at alluvial recharge area, in µg/L; a highlighted value indicates a result above the REVA trigger value, suggesting a concentration that may be detectable.
GW - predicted groundwater concentration at given distance (in feet) from surface water input, in µg/L
µg/L – micrograms per liter
Bold - highlighted and bolded value indicates a result above the REVA trigger value, suggesting a concentration that may be detectable.
NP - not predicted to be present based on modeling results (assumed that surface water dominates input of MC to groundwater).
[a]REVA trigger values are the median representative screening threshold values, for surface water or groundwater modeling, obtained from certified analytical laboratories for each indicator MC as defined in the *REVA Reference Manual* (HQMC, 2006).
[b]Modeling results based on use of conservative parameters, reflective of conditions ideal for movement of MC in the environment.
[c]Distances are shown from the source area to an estimated linear distance where predicted groundwater concentrations are above REVA trigger values. The one-dimensional modeling does not readily allow for a delineation of up gradient and down gradient wells because the alluvial aquifer system was simplified. Infiltration occurring along the stream is not represented in the model.
[d]Some water supply wells are located within the estimated linear distances where predicted groundwater concentrations are above. REVA trigger values in the San Onofre groundwater basin.

Figure 7-7: Modeled Concentration of RDX in the San Onofre Groundwater Basin

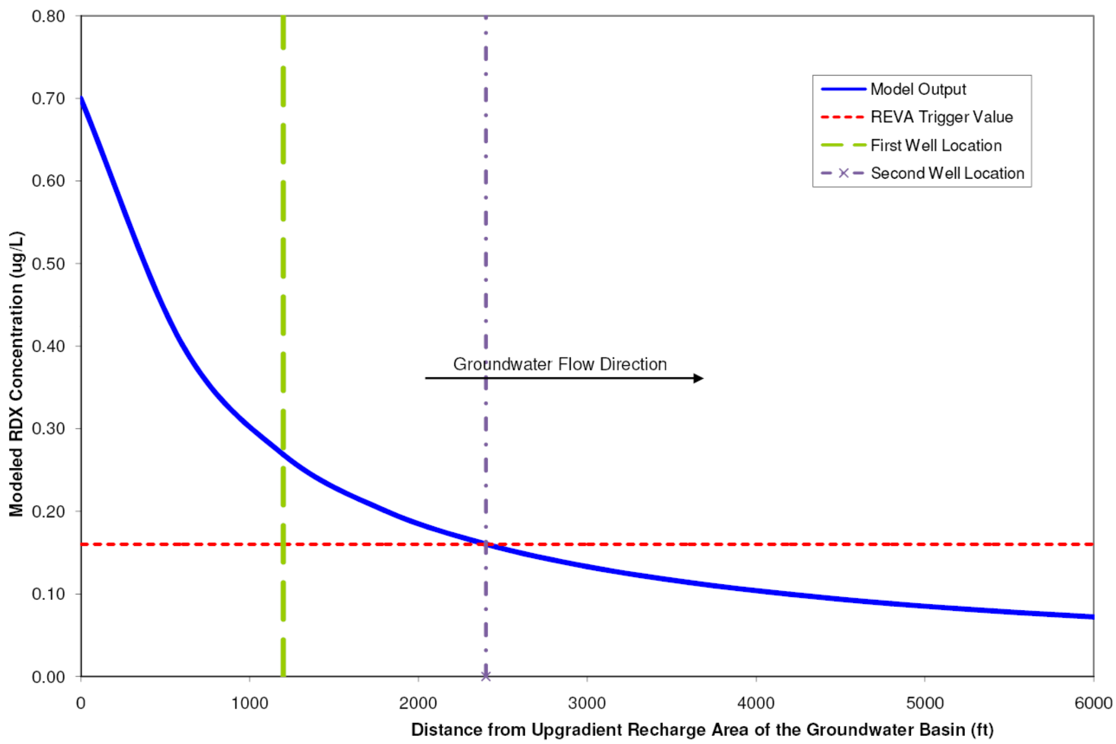
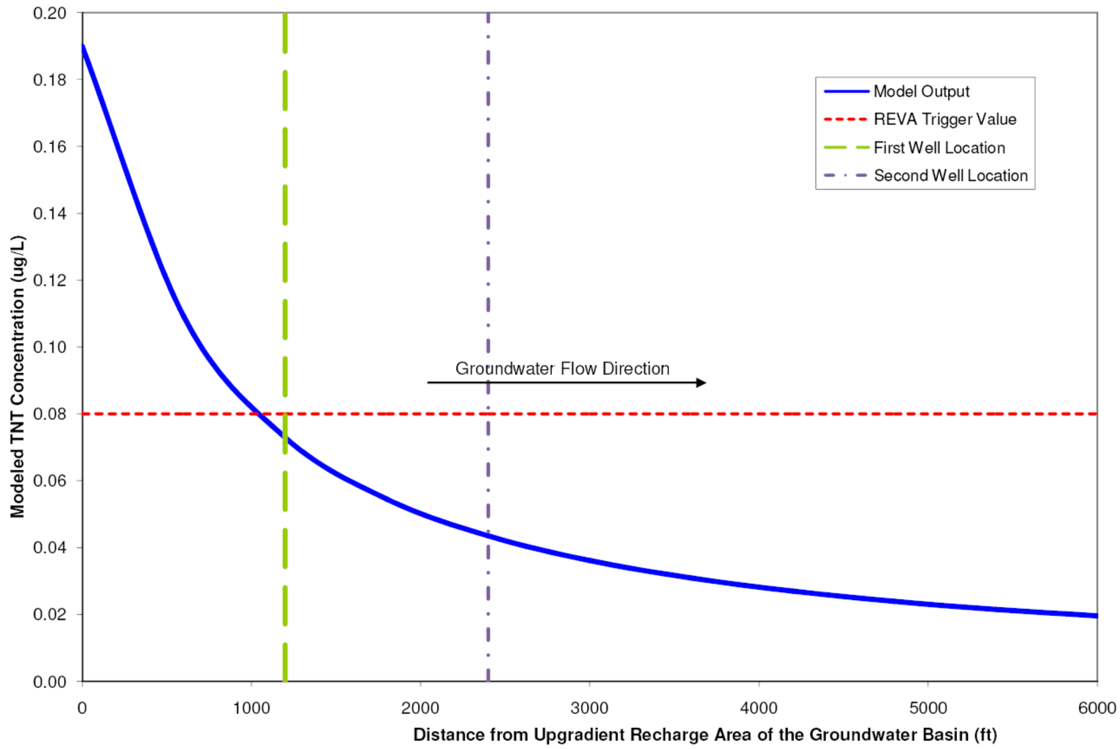


Figure 7-8: Modeled Concentration of TNT in the San Onofre Groundwater Basin

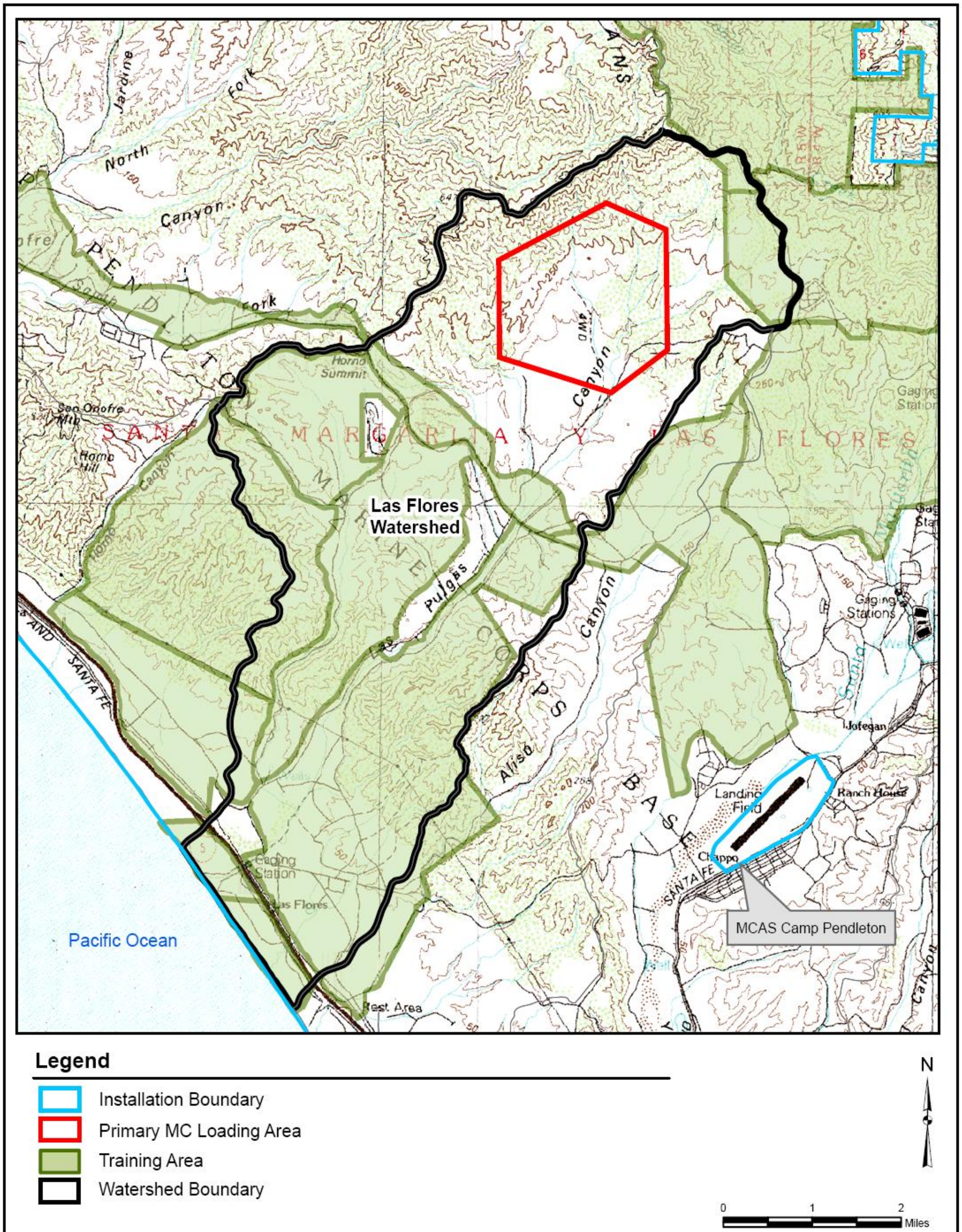


Groundwater modeling predicted concentrations of RDX above the REVA trigger value. However, the explosive 2-nitrotoluene, a daughter product of TNT, was detected at trace concentrations in only one groundwater well during the December 2007 sampling event. That well was resampled in April 2008, and no explosives were detected. Additional details regarding these sampling results are presented in **Section 9**.

7.3. Las Flores Watershed

The Las Flores watershed is located entirely within the boundaries of MCB Camp Pendleton and is 19,066 acres in size (Figure 7-9). Thirteen RTAs and four impact areas are located within the Las Flores watershed. The training areas and impact areas are summarized in Table 7-11. Range 409 and X-Ray Range were not prioritized with a high overall HE priority due to the estimated MC loading significantly lower than the loading within the Zulu primary MC loading area. The Zulu primary MC loading area was used as the sole contributor of MC mass into the Las Flores alluvial groundwater basin from surface water recharge. Zulu Impact Area is the only area contributing a significant amount of REVA MC within the Las Flores watershed based on the current training conducted at MCB Camp Pendleton. The Zulu Impact Area was given a high overall priority, compared to no, low, and medium priorities for all other training and impact areas within the watershed.

Figure 7-9: Military Operations in the Las Flores Watershed, MCB Camp Pendleton



MALCOLM PIRNIE

Military Operations in the Las Flores Watershed
MCB Camp Pendleton

Figure 7-9
April 2009

P:\6285\024\GIS\MXD\050_Figure 7-9_Military Operations in the Las Flores Watershed_PRD.mxd

Table 7-11: Training and Impact Areas within the Las Flores Watershed

Area	Type	Area (acres)	Percent within Las Flores Watershed	Overall HE Prioritization
Finch	Training area	1,733	38.6	Low
Foxtrot	Training area	2,664	3.4	N/A
Golf	Training area	2,542	20.4	Medium
India	Training area	3,757	0.2	Low
Kilo One	Training area	3,165	10.7	Medium
Oscar Two	Training area	5,079	85.7	Medium
Papa One	Training area	2,298	100.0	Medium
Papa Two	Training area	3,606	31.0	Low
Papa Three	Training area	1,273	100.0	Medium
Romeo One	Training area	1,690	35.3	Low
Range 409	Impact area	3,312	18.7	Low
Section C	Training area	323	66.3	Low
Tango	Training area	1,591	14.9	N/A
Victor	Training area	323	89.0	N/A
Whiskey	**Impact area/ primary MC loading area**	**20,025[a] Whiskey: 221[b] Zulu: 797[b]**	**64.6/100 0 100.0**	**High**
X-Ray	Impact area	3,593	7.4	Medium

Note:
kg/m^2 – kilograms per square meters
N/A indicates a training area that was not given an HE priority based on the information available.
Bold indicates an area prioritized with a high overall HE ranking.
[a] Based on total area of both impact areas
[b] Area in acres of MC loading area

With respect to the Las Flores watershed, the drainage area used in the calculation is the area upstream where groundwater recharge to the Las Flores alluvial groundwater basin begins. This upgradient area is approximately 11,237 acres and leads to a potential MC concentration of approximately 18 percent of the source MC concentration in the recharge area.

Detailed assumptions for the determination of MC loading rates are provided in **Section 3** and in the *REVA Reference Manual* (HQMC, 2006).

In addition to the training and impact areas, there are 28 live-fire fixed ranges located within the Las Flores watershed. Ranges 111, 130, Bay 1, and 130, Bay 2 are fixed ranges with only small arms ammunition use. They were qualitatively assessed using the SARAP and are described in **Section 8**.

7.3.1. Screening-Level Assessment for Las Flores Watershed

7.3.1.1. Estimated MC Loading

The primary MC loading area for the Las Flores watershed is the Zulu primary MC loading area (Figure 7-9). The MC Loading Rate Calculator was used to estimate the amount of MC loaded to this area over time. It was conservatively assumed that all military munitions expenditures for the Zulu Impact Area were loaded within the boundaries of the MC loading area, rather than across the entire impact area. Therefore, the MC loading amounts estimated for each identified time period during which the impact area was used, Time Periods C, D, and E, were assumed to occur only within the primary MC loading area (Table 7-12). Expenditure data were extrapolated for time periods when expenditure data were not available.

Table 7-12: Estimated Annual MC Loading for the Las Flores Watershed

Primary MC Loading Area	Period	Begin Use	End Use	HMX (kg/m^2)	RDX (kg/m^2)	TNT (kg/m^2)	Perchlorate (kg/m^2)
Zulu	C	1942	1976	2.93E-09	2.44E-06	4.54E-06	1.16E-09
	D	1977	1988	5.50E-09	2.41E-06	2.35E-06	2.06E-09
	E	1989	2005	6.87E-09	3.01E-06	2.93E-06	2.57E-09

Note: kg/m^2 – Kilograms per square meters

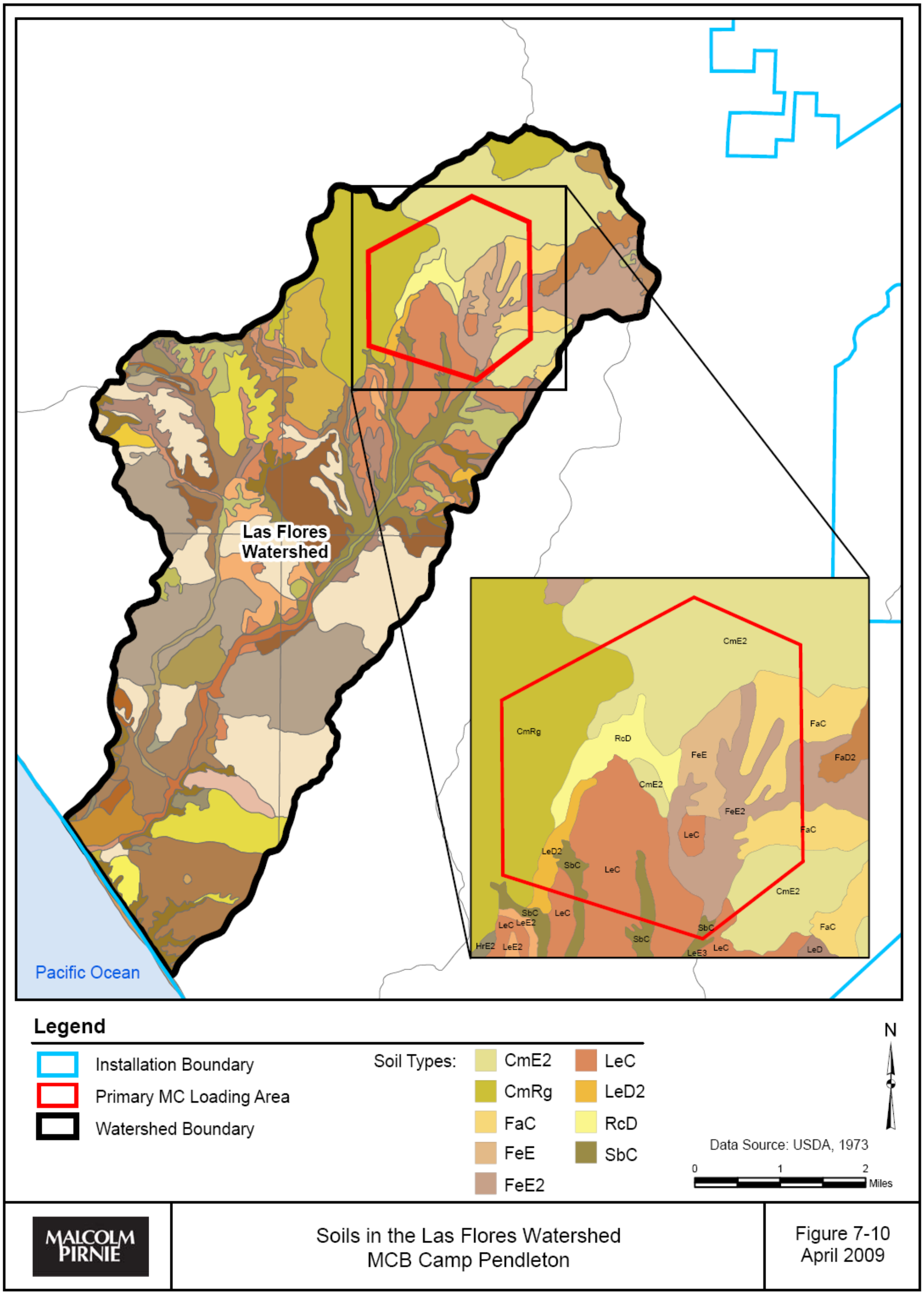
7.3.1.2. Physical Environment

Within the Las Flores watershed, the Zulu primary MC loading area was modeled using screening-level analyses to predict the concentration of REVA MC in surface water and groundwater. The physical characteristics of the environment were used to develop the input parameters to the model.

The Las Flores watershed area includes the entire Zulu primary MC loading area (Figure 7-9). The Zulu primary MC loading area and portions of Range 409 and X-Ray Range impact areas are located within the Las Flores watershed. All of these areas drain into Las Pulgas Canyon.

The following three predominant soil series types were identified in the Zulu primary MC loading area based on a review of the United States Department of Agriculture Soil Conservation Service and Forest Service maps for the San Diego area (USDA, 1973): Cieneba very rocky, coarse, sandy loam (CmE2 and CmRg); Fallbrook rocky sandy loam (FeE and FeF2); and Las Flores loamy fine sand (LeC and LeD2) (Figure 7-10).

Figure 7-10: Soils in the Las Flores Watershed, MCB Camp Pendleton



P:\6285\024\GIS\MXD\056_Figure 7-10_Soils in the Las Flores Watershed_PRD.mxd

The Cieneba soil series generally consists of excessively drained, very shallow to shallow, coarse sandy loams, which are well-drained soils with medium to rapid runoff and moderate to high erosion hazard. The Fallbrook soil series generally consists of deep sandy loams formed in well-weathered material. Runoff is slow to medium, and the erosion hazard is slight to moderate. The Las Flores soil series has a moderate runoff potential with loamy fine sand at the surface and a sandy clay underneath. The permeability is defined as very slow. The erosion potential of this soil is moderate (USDA, 1971).

Based on the soil and vegetation characteristics of the Zulu primary MC loading area, soil and hydrologic properties were selected to determine the amount of soil loss. The results of the soil loss calculation are described in **Section 5**. The soil erosion rate calculated for the Zulu primary MC loading area was 1.4E-02 kg/m^2/day.

Due to the steep grades of the soils, water falling on the Zulu primary MC loading area travels through the ephemeral washes and into the intermittent Las Plugas Canyon. MC from the Zulu primary MC loading area enter the Las Pulgas Canyon downstream of this canyon from an unnamed wash. The alluvial groundwater basin in the Las Flores watershed is used to supply drinking water to MCB Camp Pendleton.

The Water Quality Control Plan for the San Diego Basin lists the beneficial uses of the Las Flores Creek surface water as agricultural, contact and noncontact recreational use, freshwater habitat (warm and cold), wildlife habitat, rare and T/E species habitat, and spawning (California Regional Water Quality Control Board, 2007).

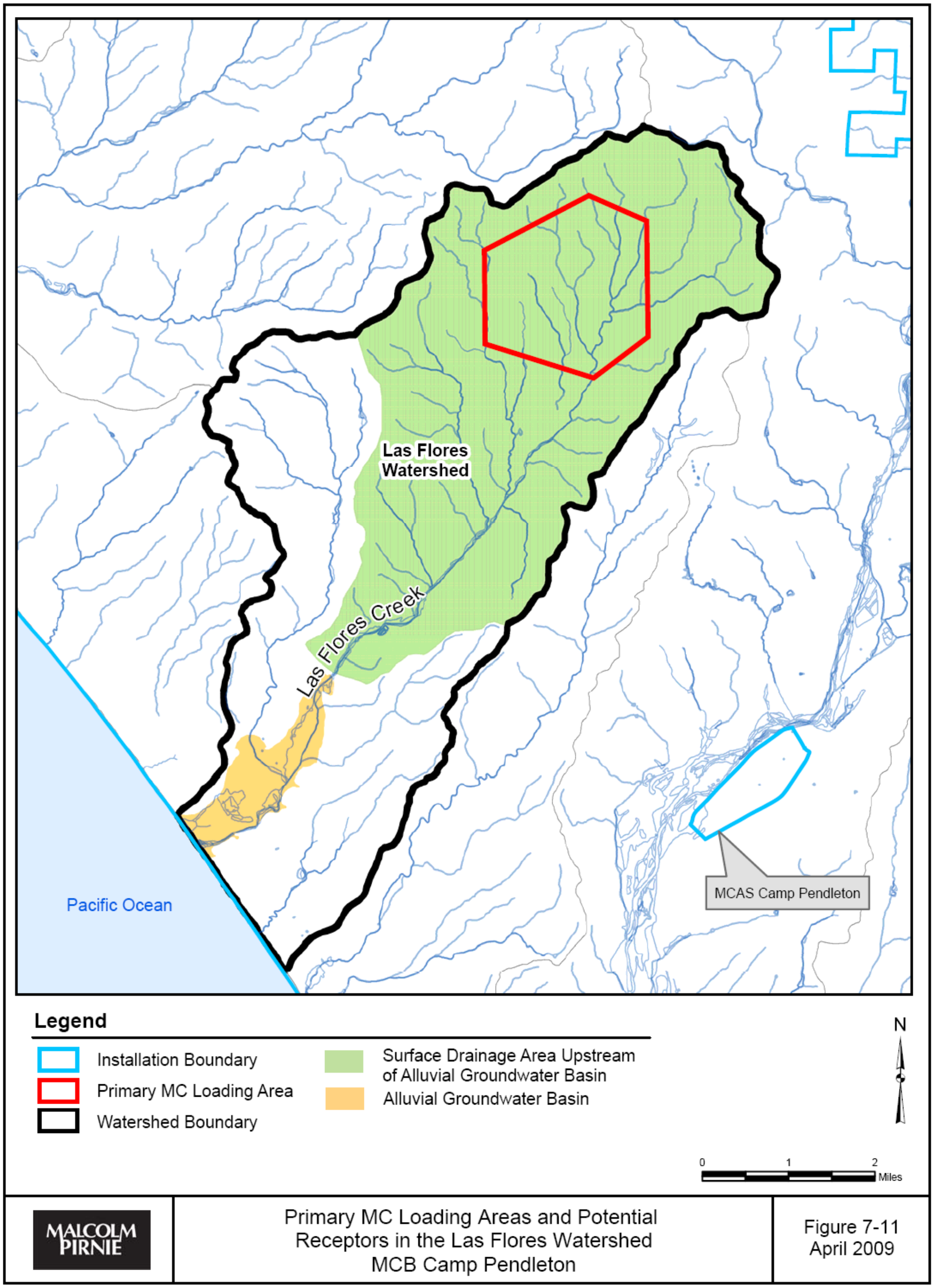
Surface water flow in the Las Flores Creek discharges to underlying aquifers and is the dominant recharge mechanism to the Las Flores alluvial groundwater basin. Recharge occurs as the stream flows out over the alluvial sediments of the groundwater basin, where water seeps through the streambed as a line source to the underlying aquifer.

The modeling effort conservatively assumed the water enters the aquifer as a point source, which results in a higher concentration of MC estimated in the aquifer (the line source serves to dilute the MC over a larger area). The alluvial groundwater basin is composed of unconsolidated silts, sands, gravels, and conglomerates (Cranham et al., 1994). The thickness of the alluvial aquifer varies from 18 to 105 ft, and the aquifer is thickest toward the center of the stream valley (Palmer, 1990).

7.3.2. Surface Water Analysis Results

A screening-level analysis of MC concentrations in surface water was conducted for the Las Flores watershed, based on the high prioritization of the Zulu Impact Area. The Las Flores watershed area includes all of the Zulu primary MC loading area (Figure 7-11).

Figure 7-11: Primary MC Loading Area and Potential Receptors in the Las Flores Watershed, MCB Camp Pendleton



P:\6285\024\GIS\MXD\053_Figure 7-11_MC Loading and Potential Receptors in Las Flores_PRD.mxd

The screening-level analysis was used to estimate MC concentrations in surface water potentially recharging the Las Flores alluvial groundwater basin. The surface water screening-level analysis was conducted as described in **Section 5**.

The surface water screening-level analysis was carried out for a time period ranging from 1942 to 2005. Historical MC loading areas that existed within the Las Flores watershed include several training areas; however, due to their short period of use (1942 through 1946) and the length of time between the end of MC loading to the present (approximately 60 years), the MC loading rates from these historical loading areas were not used in the surface water screening-level analysis.

Table 7-13 presents the estimated average annual edge-of-loading-area concentrations in surface water runoff from the Zulu primary MC loading area. Based on surface water screening-level calculations, concentrations of HMX, RDX, and TNT leaving the Zulu primary MC loading area are estimated to exceed the REVA trigger values. The concentration of perchlorate leaving the Zulu primary MC loading area is estimated to be below the REVA trigger value.

Table 7-13: Screening-Level Estimates of Annual Average Edge-of-Loading-Area MC Concentrations in Runoff from Zulu MC Loading Area

MC	REVA Trigger Value (µg/L)[a]	Predicted Concentration (µg/L)
HMX	0.08	0.09
RDX	0.16	**21.4**
TNT	0.08	**5.2**
Perchlorate	0.98	0.03

Note:
µg/L – micrograms per liter
[a]REVA trigger values are the median representative screening threshold values, for surface water or groundwater modeling, obtained from certified analytical laboratories for each indicator MC as defined in the *REVA Reference Manual* (HQMC, 2006)
Bold indicate that the predicted concentration is above the REVA trigger value.

Table 7-14 presents the total watershed drainage area upstream of the Las Flores alluvial groundwater recharge point and the Zulu primary MC loading area contributing to the downstream groundwater recharge point. The entire Zulu primary MC loading area is the sole area contributing to the downstream recharge point of the Los Flores alluvial groundwater basin. The Zulu primary MC loading area and the total watershed drainage presented in Table 7-14, and the annual average edge of loading area concentration presented in Table 7-13, include the specific inputs used in the equation presented in **Section 5**, which calculated the downstream mixed concentrations.

Table 7-14: Area of the Total Watershed Drainage and the Zulu MC Loading area Contributing MC to the Downstream Groundwater Recharge Point of the Las Flores Alluvial Groundwater Basin

Watershed/Primary MC Loading Area	Area (acres)
Las Flores watershed upstream of the groundwater recharge point	11,237
Zulu primary MC loading area draining to the groundwater recharge point	1970

Table 7-15 presents the estimated MC concentrations in surface water recharging the Las Flores alluvial groundwater basin, following downstream mixing. Concentrations of RDX and TNT in surface water runoff recharging the Las Flores alluvial groundwater basin, after downstream mixing, were predicted to remain above the REVA trigger values. However, the post-mixing concentration of HMX in surface water runoff recharging the Las Flores alluvial groundwater basin was predicted to fall below the REVA trigger value. The concentration of perchlorate is predicted to be below the REVA trigger value leaving the Zulu primary MC loading area, even before any downstream mixing (as discussed above).

Table 7-15: Screening-Level Estimates of Annual Average MC Concentrations in Runoff Recharging the Las Flores Alluvial Groundwater Basin

MC	REVA Trigger Value (µg/L)[a]	Post-Mixing Estimated Concentrations Entering Groundwater Basin (µg/L)
HMX	0.08	0.02
RDX	0.16	**3.75**
TNT	0.08	**0.91**
Perchlorate	0.98	0.005

Note:
µg/L – micrograms per liter
[a]REVA trigger values are the median representative screening threshold values, for surface water or groundwater modeling, obtained from certified analytical laboratories for each indicator MC as defined in the *REVA Reference Manual* (HQMC, 2006)
Bold indicates that the predicted concentration is above the REVA trigger value.

The screening-level surface water analysis predicted detectable concentrations of RDX and TNT in surface water potentially recharging the Las Flores alluvial groundwater basin above the REVA trigger values. Las Pulgas Canyon drains southwestward downstream of the MC loading areas through the Las Flores alluvial groundwater basin. Groundwater in the Las Flores alluvial groundwater basin that is recharged by surface water from Las Pulgas Canyon potentially is used as a drinking water source. For this reason, Las Pulgas Canyon downstream of the identified MC loading area has potential human receptors (through drinking water use).

A surface water sampling plan was implemented based on the results of this screening-level analysis. The results of the sampling are presented in **Section 9**.

7.3.3. Groundwater Analysis Results

A groundwater screening-level analysis was conducted for the alluvial groundwater basin located within the Las Flores watershed. As described in **Section 6**, the BIOCHLOR fate and transport model was run for RDX and TNT in the Las Flores basin. The input parameters and assumptions are presented in **Section 6**. The input concentrations for the groundwater modeling were based on the predicted concentrations calculated from the surface water modeling (Table 7-15) and were represented as a point source in the models. Starting concentrations used for inputs to the groundwater model were chosen by assuming that the MC reached the groundwater table instantaneously without any reduction in RDX or TNT concentrations. As discussed above, in reality, recharge will not be instantaneous and the source will be the line of the stream, both of which serve to reduce the concentration that would arrive at the aquifer. BIOCHLOR was then run to model the movement of MC in the saturated zone toward the drinking water supply wells. The model includes advection, dispersion, and adsorption.

For RDX, the model reached steady state within 25 years (input MC at the source location is equal to loss of concentration due to dispersion). The drinking water supply wells in the Las Flores basin are more than one mile down gradient of the up gradient edge of the groundwater basin. The concentration calculated by the model at this location is summarized in Table 7-16 and is depicted in Figure 7-12. The value is just below the REVA trigger value for RDX, indicating that RDX may or may not be detectable in water supply wells.

For TNT, the model reached steady state in about 35 years. The model-calculated concentration for TNT is also shown in Table 7-16 and is depicted in Figure 7-13. It is below the REVA trigger and is not anticipated to be detectable in water supply wells.

The modeling results did not indicate that additional sampling was necessary at the site to determine whether MC are migrating to the drinking water supply wells. However, groundwater sampling was conducted due to the results of the screening-level analysis for surface water, which indicated potential detections of MC in surface water. Because of the potential line source represented by the groundwater recharge, all water supply wells tapping the Las Flores alluvial groundwater basin near where recharge is suspected to occur were sampled. As predicted, sampling results were non-detect for explosives. Additional details regarding these sampling results are presented in **Section 9**.

Figure 7-12: Modeled Concentration of RDX in the Las Flores Groundwater Basin

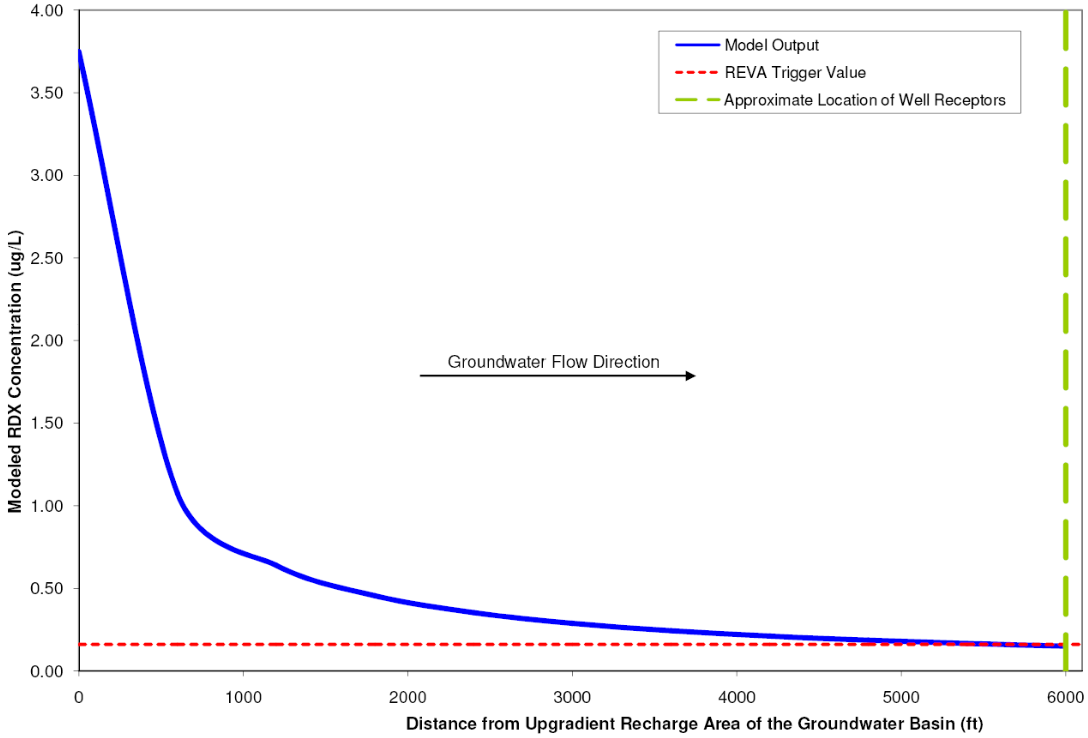


Figure 7-13: Modeled Concentration of the TNT in the Las Flores Groundwater Basin

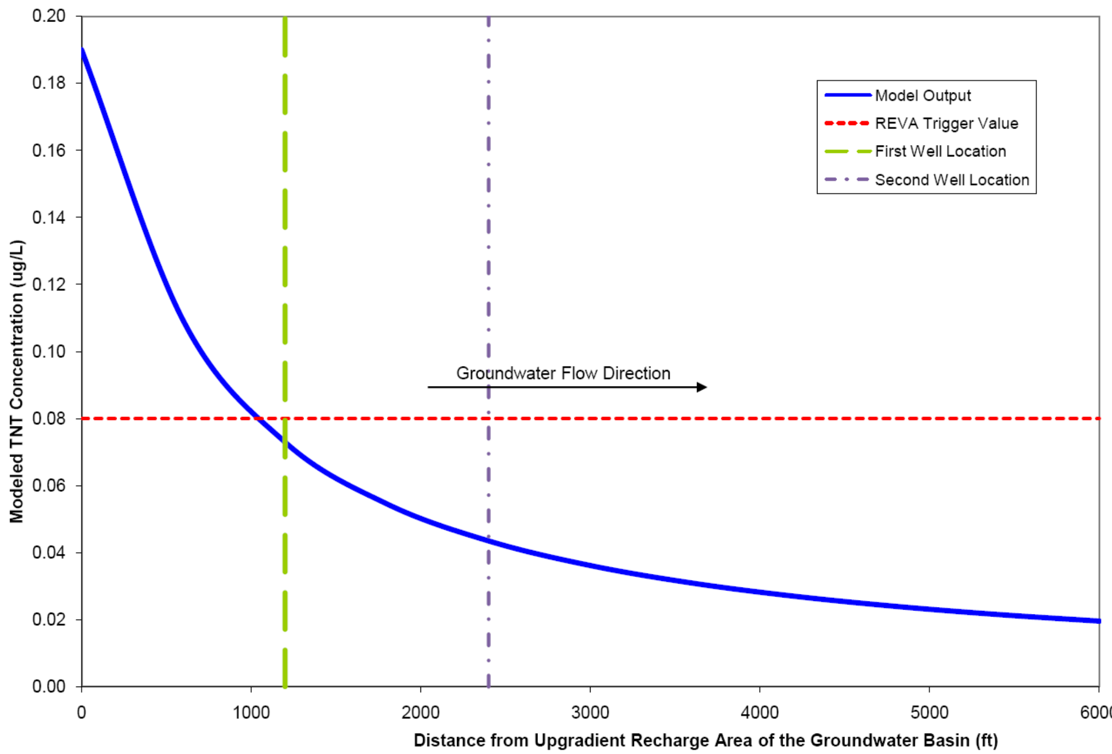


Table 7-16: MC Groundwater Modeling Results for the Las Flores Watershed

Indicator MC	REVA Trigger (µg/L)[a]	Las Flores Basin [b] (Input from Zulu Range)	
		SW	GW @ 4,800 ft [c,d]
HMX	0.08	NP	NP
RDX	0.16	**3.75**	**0.19**
TNT	0.08	**0.91**	0.04
Perchlorate	0.98	NP	NP

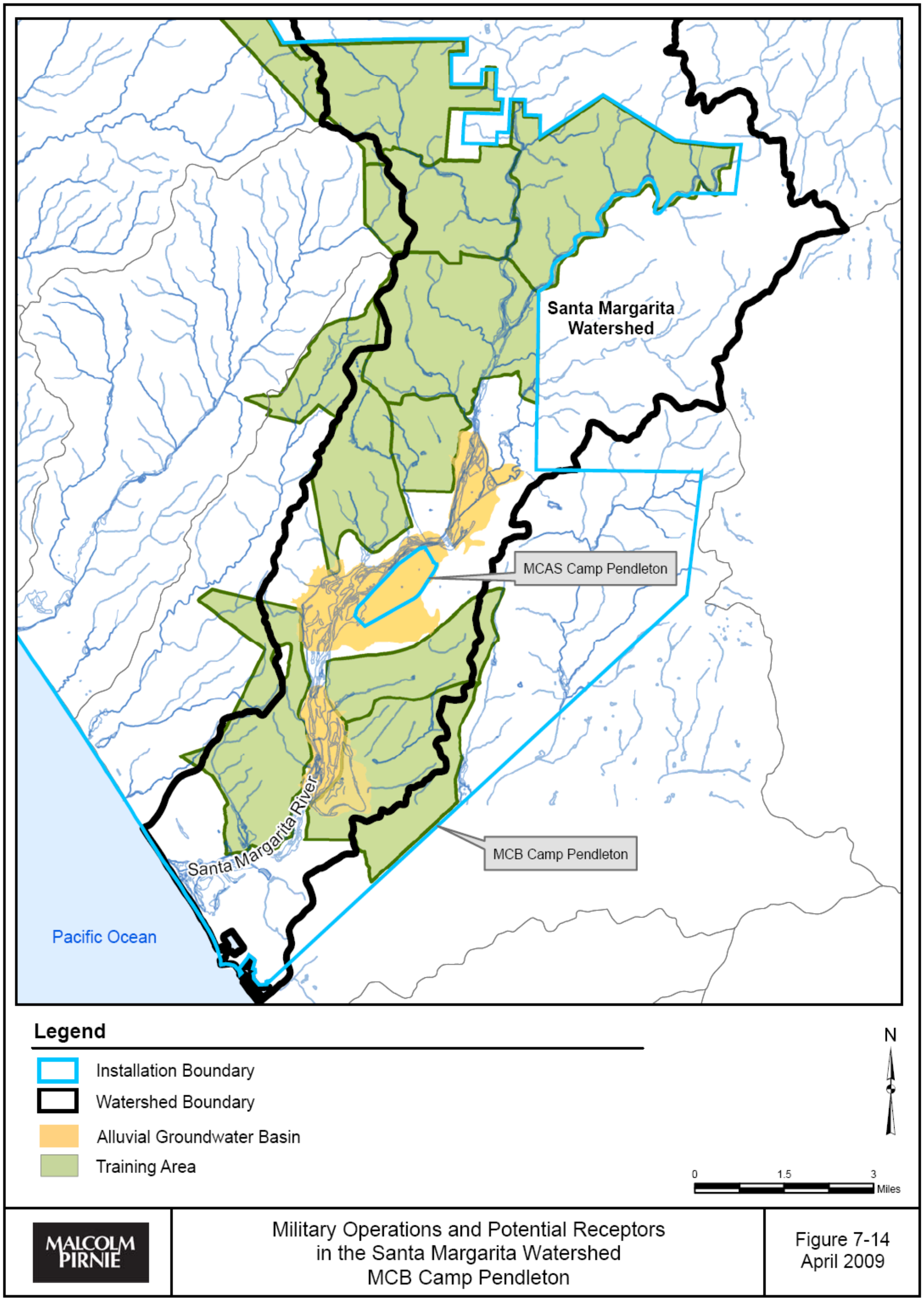
Note:
SW - predicted surface water concentration at alluvial recharge area, in µg/L; a highlighted value indicates a result above the REVA trigger value, suggesting a concentration that may be detectable.
µg/L – micrograms per liter
GW - predicted groundwater concentration at given distance (in feet) from surface water input, in µg/L
Bold - bolded value indicates a result above the REVA trigger value, suggesting a concentration that may be detectable.
NP - not predicted to be present above the REVA trigger value based on surface water modeling results (assumed that surface water dominates input of MC to groundwater)
[a]REVA trigger values are the median representative screening threshold values, for surface water or groundwater modeling, obtained from certified analytical laboratories for each indicator MC as defined in the *REVA Reference Manual* (HQMC, 2006).
[b]Modeling results based on use of conservative parameters, reflective of conditions ideal for movement of MC in the environment.
[c] Distances are shown from the source area to an estimated linear distance where predicted groundwater concentrations are above REVA trigger values. The one-dimensional modeling does not readily allow for a delineation of up gradient and down gradient wells because the alluvial aquifer system was simplified. Infiltration occurring along the stream is not represented in the model.
[d]Some water supply wells are located within the estimated linear distances where predicted groundwater concentrations are above REVA trigger values in the Las Flores groundwater basin.

7.4. Other Watersheds

In addition to the three watersheds described and modeled above, there are four other watersheds located within the boundaries of MCB Camp Pendleton. Of these, the Santa Margarita watershed is largest watershed located on MCB Camp Pendleton. The entire watershed, extending east of the installation, is 66,090 acres in size, with 39,026 acres contained within MCB Camp Pendleton (Figure 7-14). Within the Santa Margarita watershed is the Santa Margarita River, which flows perennially from the Santa Margarita Mountains to the east to the Pacific Ocean. Within the alluvial groundwater aquifer located in the Santa Margarita watershed is the largest drinking water well field used for drinking water at MCB Camp Pendleton. Based on the Water Quality Control Plan for the San Diego Basin, the beneficial uses of the Santa Margarita watershed include municipal drinking water, agricultural, industrial service water, contact and noncontact recreation, freshwater habitat (cold and warm), and T/E species habitat. There are also several smaller coastal watersheds with intermittent streams that discharge to the Pacific Ocean; these watersheds are not used as drinking water supply but are designated as contact and noncontact recreation, as well as ecological habitat (California Water Quality Control Board, 2007).

Several training and impact areas, including the X-Ray Range and Edson Range impact areas, are within the Santa Margarita and other watersheds. No primary HE areas are located within the Santa Margarita watershed.

Figure 7-14: Military Operations in the Santa Margarita Watershed, MCB Camp Pendleton



P:\6285\024\GIS\MXD\054_Figure 7-14_MC Loading and Potential Receptors in Santa Margarita_PRD.mxd

The training areas contained within these watersheds have no, low, or medium HE priorities and, therefore, were not modeled, or contain ranges with only small arms ammunition use. These watersheds were not assessed using screening-level analysis of either surface water or groundwater modeling.

Within the Santa Margarita and other watersheds, there are eight fixed ranges with only small arms ammunition use that were assessed using the SARAP and are discussed in **Section 8**.

8. Small Arms Range Assessments

As noted previously, MC associated with small arms ammunition commonly used at operational ranges includes lead, antimony, copper, and zinc. The REVA indicator MC for SARs is lead, as it is the most prevalent (by weight) potentially hazardous constituent associated with small arms ammunition. MC loading and fate and transport modeling is not conducted to assess the potential for off-range migration of lead. Instead, operational ranges that solely utilize small arms ammunition (defined as nonexplosive ammunition, .50-cal or smaller) for training purposes are qualitatively assessed under the REVA program.

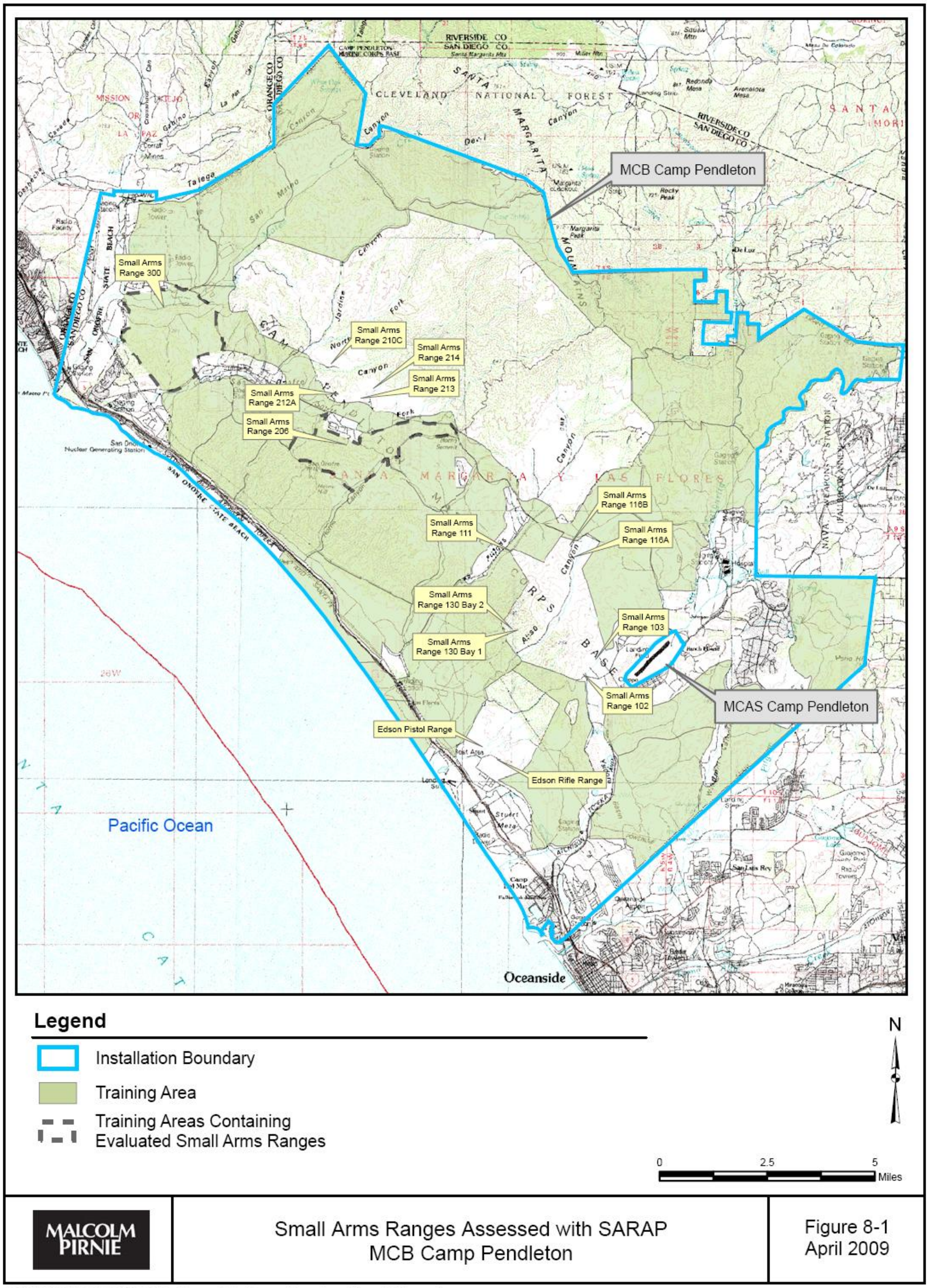
This qualitative approach is referred to as the REVA SARAP (**Appendix A**). The REVA SARAP employs a consistent methodology to identify and assess factors that influence the potential for lead migration at an operational range. Through this protocol, ranges are prioritized for possible further assessment or management practices.

Of the 102 fixed-ranges at MCB Camp Pendleton, 15 small arms ranges were identified for assessment using the REVA SARAP and are shown in Figure 8-1. These SARs were selected to correspond with a separate small arms study conducted by the installation in 2007 with concurrence from AC/S-Environmental Security and Range Operations & Training Department. The SARs were selected using the following general guidelines: the presence of berms; current munitions use, as well as those locations with high munitions expenditures at the installation; environmental sensitivity related to potential lead migration; and representative of the varied range designs present at MCB Camp Pendleton. The name, size and orientation of each range were collected from the MCB Camp Pendleton Final Range Identification and Preliminary Range Assessment (RIPRA) (MCB Camp Pendleton, 2001a).[1]

The study was completed as a voluntary pollution prevention program in response to reporting requirements for facilities that manufacture, process, or otherwise use listed constituents above certain thresholds.

[1] Visual estimates of range size and orientation are provided based on site visit measurements and observations and GIS mapping when RIPRA sizing did not match current range operations.

Figure 8-1: Small Arms Ranges Assessed with SARAP



P:\6285\024\GIS\MXD\058_Figure 8-1_Range Location Map_PRD.mxd

Consequently, the purpose of the installation's small arms study was to proactively identify and assess opportunities to implement engineering controls at selected small arms ranges at the installation to reduce potential migration of lead and other constituents related to small arms munitions. The information compiled for the installation's study, together with these REVA SARAP results, forms a basis for prioritizing SARs for further action and provides an assessment of potential control options to prevent lead migration from these ranges.

The REVA SARAP uses existing data characterizing range operations, the physical environment, transport mechanisms, and potential receptors which were gathered to complete the SAR assessments. The data were used to populate SARAP tables, which produce prioritizations for specific factors that may influence potential MC transport and exposure to receptors. The scores are aggregated to determine the overall environmental concern evaluation rankings for surface water and groundwater conditions. The scoring system assigns minimal, moderate, and high values for both surface water and groundwater environmental concerns: Minimal (0 to 29 points), Moderate (30 to 49 points), and High (50 to 65 points). During the assessment the following data discrepancies in the surface water and groundwater assessments were noted:

- pH of surface water and groundwater
- Slope of range (slope of berm only is readily available)
- pH of soil
- Depth to groundwater
- Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational
- Number and location of agricultural well, potable water wells, and potable water supply wells relative to the location of the range

The data used in the SAR assessment for MCB Camp Pendleton were obtained through the range use and expenditure data, field water quality parameters and sampling results, ecological receptor information and the CSM compiled or developed through the REVA process. Information regarding ecological receptor toxicity was obtained from the *Draft Water Quality Ecological Evaluation (Marine Corps Base Camp Pendleton,* April 2008 (Malcolm Pirnie, 2008)**.** A summary of the results of these range assessments is provided in the following sections. Table 8-1 provides a prioritization summary for each range. Completed SARAP forms used for these ranges appear in **Appendix A**.

**Table 8-1:
Summary of SAR Prioritization**

Range Number	Surface Water Environmental Concern	Groundwater Environmental Concern
Range 102	Minimal/Moderate	Moderate/High
Range 103	Minimal/Moderate	Moderate/High
Range 111	Moderate	Moderate/High
Range 116A	Minimal/Moderate	Minimal/Moderate
Range 116B	Minimal/Moderate	Minimal/Moderate
Range 130, Bay 1	Minimal	Minimal/Moderate
Range 130, Bay 2	Minimal/Moderate	Minimal/Moderate
Range 206	Minimal/Moderate	Moderate/High
Range 210C	Moderate	Moderate
Range 212A	Moderate	Moderate/High
Range 213	Moderate	Moderate/High
Range 214	Minimal/Moderate	Moderate/High
Range 300	Moderate	Moderate/High
Edson Pistol Range	Minimal	Moderate
Edson Rifle Range B	Minimal/Moderate	Moderate

Note:
Ranking was based on professional judgment and the qualitative assessment completed through the use of the SARAP.

8.1. Range 102 and Range 103

8.1.1. Site Background

Range 102 and Range 103 are located in the southwest portion of the X-Ray Impact Area. Some of the basic information used to assess these ranges is presented in Tables 8-2 and 8-3, respectively.

Range 102 has been used for small arms training since February 1, 1961. The range consists of several firing lines and an earthen berm with a 2:1 slope ratio for bullet containment. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that over 155,000 rounds of small arms ammunition were expended at this range over the course of the reporting year.

The Visalia sandy loam (VaD) berm at Range 102 is vegetated with brush and grass (USDA, 1973). A range manager noted that the berm is periodically raked to remove lead and rocks; it is weeded during the summer months to minimize fire risks.

**Table 8-2:
Range 102**

Size
216 meters by 46 meters
Primary orientation
345°, towards X-Ray Impact Area
SSURGO soil classification
Visalia sandy loam (VaD)
Firing lane material
Primarily asphalt; sand and grass adjacent to target line
Surrounding vegetation
Brush and grass; gravel parking area to the south

**Table 8-3:
Range 103**

Size
1,014 meters by 438 meters, though visually est. 580 meters by 475 meters
Primary orientation
322°, towards X-Ray Impact Area
SSURGO soil classification
Visalia sandy loam (VaD)
Firing lane material
Primarily grass and dirt
Surrounding vegetation
Low-growing brush

Range 103 has been used for small arms training since 1942. The range consists of several firing lines and an earthen berm with a 2:1 slope ratio for bullet containment. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that over 2 million rounds of small arms ammunition were expended at this range over the course of the reporting year.

The berm at Range 103 is also comprised of Visalia sandy loam (VaD) soil (USDA, 1973). The lower face of the berm was partially vegetated with dry grass over 50% of its length. Range Management noted that vegetation across the entire berm is more prevalent during spring and summer months. The berm is periodically resurfaced, though it otherwise receives no maintenance. A silt fence was observed along much of the rear part of the berm, separating neighboring brush areas from the top of the berm.

The ranges are located in a flood zone associated with the Santa Margarita River; a Range Officer noted the area is prone to flooding during notable storm events.

- Visual observations recorded at Range 102 suggest surface water run-off generated during storm events drains down the slope face and washes across a 42-foot wide, sandy area separating the berm from the target line. Water that does not infiltrate into the ground following a storm event appears to drain towards the east-northeast.
- Visual observations at Range 103 suggest surface water run-off generated from storm events generally drains down the slope face into a narrow dirt strip immediately adjacent to the asphalt access road. Water travels down this strip of land towards the southwest until it exits the range.

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4).

The Environmental Operations Map (MCB Camp Pendleton, 2007a) indicates the presence of riparian habitat within the immediate vicinity of this range; current Installation Range and Training Regulations (2003) note the presence of Least Bell's Vireo (*Vireo bellii pusillus*) habitat adjacent to the range. Bell's vireo is migratory, inhabiting the shrub cover of early and mid-successional riparian habitat during nesting and foraging, typically from mid to late-March through August. As nests are found on the active floodplain they are about 300 feet from surface water. They feed on prey found on vegetative substrates. The birds likely meet their daily water need from their insect diet and do not require free water, although they may drink from the creek surface waters (Malcolm Pirnie, 2008).

8.1.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Range 102 and Range 103, based on SARAP scoring, ranges from minimal to moderate (score: 29 to 43 points and 27 to 41 points, respectively). On the basis of the SAR Assessment for these ranges in Appendix A, a potential for lead migration and environmental concern exists, particularly as a result of seasonal flooding of portions of the range (firing lines) and high munitions use at Range 103. The concern is mitigated in part by typically low precipitation rates, 14 inches per year (MCB Camp Pendleton, 2007b), and partial engineered controls (earthen berms) and periodic resurfacing that reduce the potential for lead transport. As noted, the pH of the surface water within the boundaries of the installation and at locations down gradient of the installation is above 6.5, which suggests that lead is not mobile or available for release. These factors are likely to inhibit off-range migration of lead unless flooding of the ranges increase erosion and the potential for transport. Based on professional judgment, therefore, these ranges are conservatively ranked moderate for surface water in Table 8-1.

Groundwater

The groundwater environmental concern evaluation ranking for Range 102 and Range 103 ranges from moderate to high (score: 38 to 53 for Range 102 and Range 103). On the basis of the SAR Assessment for these ranges in **Appendix A**, these ranges may have the potential for lead migration and environmental concern, but the assessment most likely indicates no immediate environmental concern. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. In addition, a large range of site scores have been chosen on some of the assessment evaluation factors due to unknown data. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results collected as part of the assessment (**Section 9**), the evaluation does not suggest off-range migration of lead to groundwater.

8.2. Range 111

8.2.1. Site Background

Range 111 is located in the northeast portion of the X-Ray Impact Area. It has been in use for small training since February 1, 1961. Some of the basic information used to assess this range is presented in Table 8-4. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that a total over 290,000 rounds of small arms ammunition were expended at this range over the course of the reporting year.

The range contains an earthen berm which generally consists of two faces stacked upon one another for bullet containment. The berm consists of two soil types Gaviota fine sandy loam (GaF) and Las Flores loamy fine sand (LeD) (USDA, 1973). Although, the berm is predominantly exposed sand and silt, it transitions to mostly grass along the upper 25 feet of the face. No formal maintenance activities were noted for this range.

The range is situated in an area that slopes downwards to the northeast towards nearby Las Pulgas Creek, approximately 250 meters away. Surface water run-off generated from storm events is believed to flow down the face of the berm and across a grassy, sandy area until it reaches a well-defined channel that runs east to west across the range. The channel is vegetated with grass; rip-rap consisting of rocks averaging approximately one foot in diameter is unevenly spread across the length of the channel. Drainage from this channel ultimately reaches a brushy patch where it is anticipated to move as sheet flow off the western corner of the range.

Based on field parameters obtained during surface water sampling described in Section 8.1.1, pH of the surface water within the boundaries of the installation and at locations down gradient of the installation ranges from 6.24-8.07 (**Appendix A**).

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4).

**Table 8-4:
Range 111**

Size
500 meters by 150 meters, though visually est. 260 meters by 115 meters
Primary orientation
130°, towards X-Ray Impact Area
SSURGO Soil classification
Gaviota fine sandy loam (GaF); Las Flores loamy fine sand (LeD)
Firing lane material
Primarily grass and dirt; channeled rip-rap (see below)
Surrounding vegetation
Grass; more brush towards back and behind range

Current Installation Range and Training Regulations (2003) note the presence of Least Bell's Vireo habitat behind the firing line; Stephens' Kangaroo Rats are also known to live on and around this range. The Bell's Vireo utilize riparian habitat and likely meet their daily water needs from their insect diet and do not require free water, although they may drink from the creeks. The Stephen's kangaroo rat prefers disturbed sandy or gravelly soil habitats in sparse sage scrub or sparse grassy upland areas, presumably to facilitate burrowing. On the San Onofre and Las Flores watersheds, the rats are found up gradient of upstream sampling locations; although periodic flooding would limit burrowing in the creek bottoms, they could inhabit creek valley walls where they could potentially contact creek surface water. They have the ability to subsist on dry seeds with no requirement for drinking water or succulent foods, and although it is unlikely that they consume creek surface water this possibility cannot be entirely ruled out (Malcolm Pirnie, 2008).

8.2.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Range 111 is in the moderate range (score: 30 to 45). On the basis of the SAR Assessment for Range 111 in **Appendix A**, the potential for lead transport in surface water exists due to lack of formal maintenance, observed runoff patterns, and the location of the range upslope of Las Pulgas Creek. Based on the chemical conditions in surface water at the installation (i.e., pH > 6.5) and the regionally-related analytical lead results (**Section 9**), the ranges may have the potential for lead migration, but the assessment indicates no immediate environmental concern.

Groundwater

The groundwater environmental concern evaluation ranking for Range 111 ranges from moderate to high (score: 38 to 53). On the basis of the SAR Assessment for Range 111 in **Appendix A**, the potential for lead transport in groundwater may exist. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. In addition, a large range of site scores have been chosen on some SARAP evaluation factors due to unknown data. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest an immediate environmental concern.

8.3. Range 116A

8.3.1. Site Background

Ranges 116A and 116B are located in the northeast portion of the X-Ray Impact Area. Some of the basic information used to assess these ranges is presented in Tables 8-5 and 8-6, respectively. Range 116A range has been in use for small arms training since 1997, but was constructed over a historical range from the 1940s. The range consists of several firing lines and an earthen berm with a 1.5:1 slope ratio for bullet containment. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that almost 4,000 rounds of small arms ammunition were expended at this range over the course of the reporting year.

There are two distinct earthen berms at Range 116A consisting of Salinas clay loam (SbC) soil utilized at this range (USDA, 1973). The Range Officer reported that the main berm had recently been resurfaced; resurfacing is performed approximately once every 5 years. Lead bullets are expected to still be embedded within the berm, as removal activities have not been performed since the 1980s.

Range 116B has been used since 1997, but was constructed over a historical range from the 1940s. The range consists of several firing lines and an earthen berm with a 1.5:1 slope ratio for bullet containment. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that 3,000 rounds were expended at Range 116B over the course of the reporting year. However, based on conversations with the Range Officer, it is believed that typical expenditures at this range may be notably higher.

The berm, made up of Las Flores loamy fine sand (LeD) soil, is minimally vegetated with sparse weeds and grass (USDA, 1973). The Range Officer noted that the berm is periodically resurfaced as well as mined, though could not provide details regarding the frequency of this latter activity.

These ranges are located immediately west of an ephemeral stream that flows from the north out of Aliso Canyon through X-Ray Impact Area to the south.

Table 8-5:
Range 116A

Size
250 yards by 875 yards
Primary orientation
198°, towards X-Ray Impact Area
SSURGO soil classification
Salinas clay loam (SbC)
Firing lane material
Primarily dirt
Surrounding vegetation
Low (dry) brush

Table 8-6:
Range 116B

Size
Not available; est. 250 feet by 200 feet
Primary orientation
Not available; est. 227°, towards X-Ray Impact Area
SSURGO soil classification
Las Flores loamy fine sand (LeE)
Firing lane material
Gravel, then concrete up to target line
Surrounding vegetation
Minimal; sparse weeds and grass

- Visual observations recorded at Range 116A suggest surface water run-off generated during storm events generally drains down the berms and towards this creek, though it is believed a small percentage of run-off drains in the opposite direction to the west.

- Range 116B is located approximately 1,250 feet west-northwest of an ephemeral stream that is located on the opposite side of Range 116A. The range is positioned in an area with a slight slope towards the east; it appears that surface water run-off generated from storm events that does not infiltrate into the ground would generally flow towards this direction.

The pH values used in the SAR assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

The Environmental Operations Map (MCB Camp Pendleton, 2007a) indicates the ranges may be located within Stephens' Kangaroo Rat habitat, and may be near rare plant areas.

The Stephen's kangaroo rats are found burrowing up gradient of upstream sampling locations with the potential for contact with creek surface water; however, they prefer sparse sage scrub or sparse grassy upland areas. Although this animal is primarily a granivore, it also feeds on fresh vegetation and it is unlikely it consumes creek surface water. If the animal were exposed to any potential lead in surface waters of the creeks, its exposure would be several orders of magnitude below that shown by toxicological data to cause adverse effects (Malcolm Pirnie, 2008). Additionally, current Installation Range and Training Regulations (2003) indicate that archaeological sites are also located at these ranges.

8.3.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Range 116A and Range 116B ranges from minimal to moderate (scores: 28 to 32, and 26 to 30, respectively). On the basis of the SAR Assessment for these ranges in **Appendix A**, the ranges may have the potential for lead migration and environmental concern, but the assessment indicates no immediate environmental concern. Use of these ranges is relatively low over a moderate period of time. They have partial engineered controls (earthen berm) to help reduce surface runoff from entering the range floor. Based on the pH of surface water at the installation (i.e., documented pH > 6.5) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest off-range migration of lead. Slight differences in scores between these ranges are related primarily to soils and location with respect to drainage pathways.

Groundwater

The groundwater environmental concern evaluation ranking for Range 116A range from minimal to moderate (score: 25 to 33). On the basis of the SAR Assessment for Range 116A in **Appendix A**, the range may have the potential for lead migration and environmental concern, but the assessment indicates no immediate environmental concern. The soil consists of clayey loam which allows less infiltration of surface water due to low soil porosity. Lead also attaches to clay soil more readily than any other soil types. A large range of site scores have been chosen on some SARAP evaluation factors due to unknown data. However, transport of lead is likely minimized by the limited precipitation and clay soil in the area.

The groundwater environmental concern evaluation ranking for Range 116B ranges from minimal to moderate (score: 29 to 37). On the basis of the SAR Assessment for Range 116B in **Appendix A**, the range may have the potential for lead migration and environmental concern, but the assessment most likely indicates no immediate environmental concern. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. In addition, a large range of site scores have been chosen on some SARAP evaluation factors due to unknown data. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results collected as part of the assessment (**Section 9**), the evaluation does not suggest off-range migration of lead to groundwater.

8.4. Range 130, Bay 1 and Range 130, Bay 2

8.4.1. Site Background

Range 130, Bay 1 and Range 130, Bay 2, are located in the southwest portion of the X-Ray Impact Area. Some of the basic information used to assess these ranges is presented in Tables 8-7 and 8-8, respectively.

Range 130, Bay 1 has been in use for small arms training since 1993. The range consists of several firing lines and an earthen berm with a 2.5:1 slope ratio for bullet containment. The 2005 annual expenditure roll-up generally reports munitions use for the entire Range 130 complex and cannot provide a clear estimate of munitions use at Range 130 Bay 1; approximately 31,500 rounds were used throughout the complex; however, it is unknown how many of these are associated with Range 130, Bay 1. Regardless, based on conversations with Range Operations & Training Department, it is believed that this range, along with Range 130 Bay 2, currently represents the densest use of munitions per target at MCB Camp Pendleton.

The face of the berm at Bay 1 is minimally vegetated with sparse weeds and grass. The soil matrix of the berm consists largely of silt, along with a small fraction of clay and fine sand (Hambright gravelly clay loam (HaG)) (USDA, 1973). Relatively large pieces of rock up to 3 inches in diameter were noted throughout the face of the berm.

Visual observations indicated that the berm face had recently been resurfaced; the Range Officer indicated that the top layer of lead embedded in the berm was removed and recycled. This maintenance activity occurs approximately every 5 years at this range.

Range 130, Bay 2, has also been used for small arms training since 1993. The range consists of several firing lines and an earthen berm with a 2:1 slope ratio for bullet containment. As noted above, the 2005 annual expenditure roll-up generally reports munitions use for the entire Range 130 complex and cannot provide a clear estimate of munitions use at Range 130 Bay 2; approximately 31,500 live munitions were used throughout the complex. Regardless, based on conversations with Range Operations & Training Department, it is believed that this range, along with Range 130 Bay 1, currently represents the densest use of munitions per target at MCB Camp Pendleton.

**Table 8-7:
Range 130, Bay 1**

Size
Not available; est. 130 feet by 200 feet
Primary orientation
Not available; estimated 80°, towards X-Ray Impact Area
SSURGO soil classification
Hambright gravelly clay loam (HaG)
Firing lane material
Gravel, then concrete up to target line
Surrounding vegetation
Minimal; sparse weeds and grass

**Table 8-8:
Range 130, Bay 2**

Size
Not available; est. 180 feet by 220 feet
Primary orientation
Not available; est. 80°, towards X-Ray Impact Area
SSURGO soil classification
Hambright gravelly clay loam (HaG)
Firing lane material
Gravel
Surrounding vegetation
Minimal; sparse weeds and grass

The face of the berm at Bay 2 is minimally vegetated with sparse weeds and grass. The soil matrix of the berm consists largely of silt, along with a small fraction of clay and fine sand (Hambright gravelly clay loam (HaG)) (USDA, 1973). Relatively large pieces of rock up to 3 inches in diameter were noted throughout the face. Visual observations indicated that the face had been resurfaced; the Range Officer indicated that the top layer of lead embedded in the berm was removed and recycled. This maintenance activity occurs approximately every 5 years.

Installation maps (MCB Camp Pendleton, 2001b) note an ephemeral stream that drains out of the Range 130 complex, ultimately reaching the stream running through Aliso Canyon, approximately 2,000 feet to the southeast in the southern portion of the X-Ray Impact Area.

- Visual observations at Range 130, Bay 1 suggest surface water run-off generated from storm events drains down the slope face and washes across a relatively flat, unpaved area separating the berm from the target line. Due to the observed height of the concrete pad and topography of this dirt area, it is believed that surface water run-off which does not infiltrate into the ground drains to either side of the range. The south side of the range has a partially buried concrete pipe positioned to capture drainage and direct it along the side of the concrete portion of the firing lane. At the end of the pipe, run-off continues to drain down a shallow, lined culvert running alongside the gravel portion of the firing lane until it reaches the access road at the rear of the range where it drains downhill towards the south. The north side of the range does not have such improvements, consisting only of a dirt strip slightly lower in height than the concrete portion of the firing lane.

- Visual observations at Range 130, Bay 2, suggest precipitation run-off drains down the slope face and washes across a 12-foot wide unpaved area separating the berm from the target line. It is believed that surface water run-off generated during storm events which does not infiltrate into the ground may flow to either side of the range. However, because of the irregular deposition of soil material around the northeast corner of the range, it is believed that the majority of drainage from the berm area travels across the exposed dirt area along south side of the range.

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

Current Installation Range and Training Regulations (2003) indicate there is California Gnatcatcher habitat in the brush areas near the Range 130 complex. The California gnatcatcher is a non-migratory bird of open sage habitat, most abundant in the sage scrub-grassland interface rather than the sage scrub-chaparral interface. It does not utilize riparian habitat, so exposure to lead in surface waters is unlikely to occur. The California gnatcatcher likely meets its daily water need from its insectivorous diet and do not require free water, although given access to standing water, it is possible it may drink from the creeks. Even if this species were to drink water from the creeks, exposures to lead would be several orders of magnitudes below that expected to cause adverse effect (Malcolm Pirnie, 2008).

8.4.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Range 130, Bay 1 and Range 130, Bay 2 is minimal and ranges from minimal to moderate respectively (score: 19 to 27 and 24 to 32 points respectively). On the basis of the SAR Assessment for these ranges in **Appendix A**, they may have the potential for lead migration and environmental concern, but the assessment indicates no immediate environmental concern. Based on the pH of surface water at the installation (i.e., pH > 6.5) and the regionally-related analytical lead results (**Section 9**), and recent berm resurfacing and removal of lead, the ranges do not appear to pose an immediate environmental concern. However, these ranges are believed to represent the densest use of munitions per target at MCB Camp Pendleton, and additional actions to enhance range sustainability may be warranted to eliminate or reduce potential exposure to nearby receptors.

Groundwater

The groundwater environmental concern evaluation ranking for Range 130, Bay 1 and Range 130, Bay 2 ranges from minimal to moderate (score: 25 to 37 for both Range 130, Bay 1 and Range 130, Bay 2). On the basis of the SAR Assessment for these ranges in **Appendix A**, these ranges may have the potential for lead migration and environmental concern, but the assessment most likely indicates no immediate environmental concern. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. Based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b), the regionally-related analytical lead results collected as part of the assessment (**Section 9**), and recent resurfacing and lead removal at the ranges, the evaluation does not suggest off range migration of lead to groundwater.

8.5. Range 206

8.5.1. Site Background

Range 206 is located in the northern portion of Romeo One. It has been in use since 1968. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that a total of approximately 174,000 rounds of small arms ammunition were expended at this range over the course of the reporting year. Some of the basic information used to assess this range is presented in Table 8-9.

The range consists of an earthen berm with a 1.5:1 slope ratio for bullet containment. This range utilizes a small, sandy (Las Flores loamy fine sand (LeD)) (USDA, 1973), eroded berm positioned among three tall, semi-vegetated exposed rock faces. The Range Operations & Training Department indicated that this range underwent a retrofit during the summer of 2007, which included the addition of defined firing lanes and more height to the berm, as well as removal of encroaching vegetation.

The range is situated at the end of a dirt access road that slopes downwards to the east. Surface water run-off generated during a storm event likely flows down the face of the berm and across the sandy firing lanes. A shallow gully was observed in this sandy area, generally running southwest to northeast across the range. It is believed run-off may collect in this gully and drain away from the range in a well-vegetated, unlined, eroded ditch running along the north side of the access road. The nearest water body to this range is an ephemeral creek, approximately 0.5 kilometers to the north, which ultimately drains west to San Onofre Creek.

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

Table 8-9:
Range 206 Assessment Results

Size
50 meters by 50 meters
Primary orientation
Not available; estimated 280°
SSURGO soil classification
Las Flores loamy fine sand (LeE3)
Firing lane material
Sand
Surrounding vegetation
Well vegetated with brush; more predominantly grass on the top of and behind the berm

8.5.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Range 206 ranges from minimal to moderate (score: 25 to 35). On the basis of the SAR Assessment for Range 206 in **Appendix A**, the range may have the potential for lead migration and environmental concern, but the assessment most likely indicates no immediate environmental concern. Transportation of lead is likely minimized by limited precipitation rates. Although intense storms in the rainy season (typically November – March (MCB Camp Pendleton, 2007b)) might cause runoff to act as a transport mechanism, any lead washed from these ranges is not expected to reach the San Onofre Creek in high concentrations or quantities since the nearest intermittent surface water body is 0.5 km to the north. Most stream reaches in the San Onofre watershed are ephemeral. A hydrologist at MCB Camp Pendleton stated that no flow had been recorded for three years in the reaches of San Onofre Creek which included the sampling locations investigated. Despite the condition of the berm, the evaluation does not suggest off-range migration of lead to surface water, based on the distance to a receiving stream, limited precipitation, the pH of surface water at the installation (i.e., pH > 6.5) and the regionally-related analytical lead results (**Section 9**).

Groundwater

The groundwater environmental concern evaluation ranking for Range 206 ranges from moderate to high (score: 38 to 55) based strictly on SARAP scoring in **Appendix A**. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. In addition, a large range of site scores have been chosen on some SARAP evaluation factors due to unknown data. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest an immediate environmental concern.

8.6. Range 210C

8.6.1. Site Background

Range 210C is located in the southwest portion of the Whiskey Impact Area. The range consists of several firing lines and an earthen berm with a 2:1 slope ratio for bullet containment. It has been in use since 1971. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that a total of over 308,000 rounds of small arms ammunition were expended at this range over the course of the reporting year. Some of the basic information used to assess this range is presented in Table 8-10. The berm at Range 210C is made of compacted dirt (Altamont clay (AtC) (USDA, 1973). Large rocks typically 1 inch to 3 inches in diameter were spread throughout the face, with some rocks as large as 1 foot in diameter. No formal maintenance activities were noted for this range.

Table 8-10:
Range 210C

Size
200 meters by 5,000 meters, though visually est. 80 meters by 100 meters
Primary orientation
020°, towards Whiskey Impact Area
SSURGO soil classification
Altamont clay (AtC)
Firing lane material
Compacted dirt
Surrounding vegetation
Sparse grass; more brush SE of range

The range is situated in an area that slopes downwards to the west-northwest. Surface water run-off generated during a storm event is believed to flow down the face of the berm and across the dirt area around the target line. Based on visual observation, water that does not infiltrate into the soil is anticipated to follow surface topography and move as sheet flow to the west-northwest, with a portion of the run-off draining to the rear west corner of the range. The nearest water body to this range is an ephemeral creek located on the opposite side of the dirt access road immediately to the southwest; this creek ultimately drains west to the San Onofre Creek.

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4.

The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

Besides the riparian habitat surrounding the nearby creek, habitat for Arroyo Toad and Stephens' Kangaroo Rat may be within close proximity to the range, based on the Environmental Operations Map (MCB Camp Pendleton, 2007a). The Arroyo Toad is a small amphibian that uses riparian habitat for egg laying and breeding, and requires various upland habitats for other parts of its life cycle. MCB Camp Pendleton contains some of its largest remaining populations within the Santa Margarita, San Onofre, and San Mateo drainages, and the toad is reported to reproduce in San Onofre but not Los Flores creek. Although the toad may be exposed to lead in the San Onofre drainage, the toxicological data suggests that the lead concentrations in the surface water in this drainage will not cause adverse effects (Malcolm Pirnie, 2008). The Stephen's Kangaroo Rats are found burrowing up gradient of upstream sampling locations with the potential to contact creek surface water; however, they prefer sparse sage scrub or sparse upland areas for nesting. Although this animal is primarily a granivore, it also feeds on fresh vegetation and it is unlikely it consumes creek surface water. If the animal were exposed to possible lead in surface waters of the creeks, its exposure would be several orders of magnitude below that shown by toxicological data to cause adverse effects (Malcolm Pirnie, 2008).

8.6.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Range 210C is moderate (score: 36 to 42). On the basis of the SAR Assessment for Range 210C in **Appendix A**, the range may have the potential for lead migration and environmental concern. Nevertheless, limited precipitation rates, the pH of surface water at the installation (i.e., pH > 6.5), and the presence of the earthen berm reduce the potential for lead transport. Although intense storms in the rainy season (typically November – March (MCB Camp Pendleton, 2007b)) might cause runoff to act as a transport mechanism; any lead washed from these ranges would not be expected to reach the San Onofre Creek in high concentrations or quantities. Most stream reaches in the San Onofre watershed are ephemeral. Hydrologist in MCB Camp Pendleton stated that no flow had been recorded for three years in the reaches of San Onofre Creek that include the sampling locations. Nevertheless, the evaluation suggests the potential for off-range migration of lead to surface water due to the relative proximity of the range to a stream that ultimately flows to San Onofre Creek with successive storm events and the regionally-related analytical lead results (**Section 9**).

Groundwater

The groundwater environmental concern evaluation ranking for Range 210C is moderate (score: 36 to 47). On the basis of the SAR Assessment for Range 210C in **Appendix A**, the range may have the potential for lead migration and environmental concern, but the assessment most likely indicates no immediate environmental concern. The soil consists of clay which allows less infiltration of surface water due to low soil porosity. Lead also attaches to clay soil more readily than any other soil types. A large range of site scores have been chosen on some SARAP evaluation factors due to unknown data. However, transport of lead to groundwater is likely minimized by the limited precipitation and clay soil in the area.

8.7. Range 212A

8.7.1. Site Background

Range 212A is located in the southwest portion of the Whiskey Impact Area. The range consists of a firing lane and an earthen berm with a 1.5:1 slope ratio for bullet containment. It has been in use since 1971. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that over 467,000 rounds of small arms ammunition were expended at this range over the course of the reporting year.

The impact berm is compacted sand and silt (Terrace escarpment (TeF)) (USDA, 1973). No formal maintenance activities were noted for this range. Some of the basic information used to assess this range is presented in Table 8-11.

The range is situated at the end of a dirt access road that slopes downwards to the southwest. Surface water run-off generated from a storm event likely flows down the face of the berm and across the exposed firing lanes. Visual evidence that drainage gradually coalesces and generally travels beneath metal bleachers behind the firing lines and along the access road, or diverts in a southerly direction to an apparent dry creek bed was visually apparent along the east side of the range. The nearest water body indicated on the current installation map (MCB Camp Pendleton, 2001b) is an ephemeral riparian creek approximately 400 meters to the southwest; the creek ultimately drains west to San Onofre Creek.

Table 8-11:
Range 212

Size
300 meters by 600 meters, though visually est. 50 meters by 70 meters
Primary orientation
Not available; est. 30°, towards Whiskey Impact Area
SSURGO soil classification
Terrace escarpment (TeF)
Firing lane material
Compacted sand and silt
Surrounding vegetation
Dry brush and grass

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

The current Environmental Operations Map (MCB Camp Pendleton, 2007a) indicates there may be isolated pockets of rare plant areas to the south of the range, as well as riparian and potential Arroyo Toad habitat to the north of the range. As noted above, the Arroyo Toad is a small amphibian that uses riparian habitat for egg laying and breeding, and requires various upland habitats for other parts of its life cycle. MCB Camp Pendleton contains some of its largest remaining populations within the Santa Margarita, San Onofre, and San Mateo drainages, and the toad is reported to reproduce in San Onofre but not Los Flores Creek. Although the toad may be exposed to lead in the San Onofre drainage, the toxicological data suggests that the lead concentrations in the surface water in this drainage will not cause adverse effects (Malcolm Pirnie, 2008).

8.7.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Range 212A is moderate (score: 30 to 38 points). On the basis of the SAR Assessment for Range 212A in **Appendix A**, the potential for lead transport in surface water exists. However, transportation of lead is likely minimized by limited precipitation rates. Although intense storms in the rainy season (typically November – March (MCB Camp Pendleton, 2007b)) might cause runoff to act as a transport mechanism, any lead washed from this range by flood events would not be expected to reach the San Onofre Creek in high concentrations or quantities. Most stream reaches in the San Onofre watershed are ephemeral. Hydrologists at MCB Camp Pendleton stated that no flow had been recorded for three years in the reaches of San Onofre Creek that include the REVA sampling locations. The range may have the potential for lead migration and environmental concern, but the evaluation indicates no immediate environmental concern. This finding is based on the limited precipitation, the pH of surface water at the installation (i.e., pH > 6.5), the potential for flow to San Onofre Creek in successive storm events, and the regionally-related analytical lead results (**Section 9**).

Groundwater

The groundwater environmental concern evaluation ranking for Range 212A ranges from moderate to high (score: 44 to 55). On the basis of the SAR Assessment for Range 212A in **Appendix A**, the potential for lead transport in groundwater exists. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. In addition, a large range of site scores have been chosen on some SARAP evaluation factors due to unknown data. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results (Section 9), the evaluation does not suggest an immediate environmental concern.

8.8. Range 213

8.8.1. Site Background

Range 213 is located in the southwest portion of the Whiskey Impact Area. It has been used for small arms training since 1968. The range consists of several firing lines and an earthen berm with a varied slope ratio of 3:1 to 2:1 for bullet containment. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that over 348,000 rounds were expended at this range over the course of the reporting year.

The berm, steep gullied land (StG) soil, is sparsely vegetated with short grass and trees (USDA, 1973). Operations & Training indicated that this berm is periodically resurfaced, about once every five years. Some of the basic information used to assess this range is presented in Table 8-12.

Table 8-12:
Range 213

Size
60 meters by 400 meters
Primary orientation
Not available; est 330°, towards Whiskey Impact Area
SSURGO soil classification
Steep gullied land (StG)
Firing lane material
Asphalt; dirt and gravel immediately adjacent to target line
Surrounding vegetation
Sparse with short grass and trees

Visual observations suggest surface water run-off generated during storm events drains down the slope face and washes across the wide sandy area separating the berm from the target line. Surface topography and observations of sediment deposition around the edges of the firing lanes indicates that water which does not infiltrate into the ground following a storm event will generally drain towards the east, though a limited amount of run-off is anticipated to go towards the rear south corner of the range. The nearest water body indicated on the current installation map (MCB Camp Pendleton, 2001b) is an ephemeral stream that runs through Range 214 to the east; the creek ultimately drains into other streams that flow west towards San Onofre Creek.

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

The current Environmental Operations Map (MCB Camp Pendleton, 2007a) indicates there may be isolated pockets of rare plant areas to the south of the range.

8.8.2. Assessment

Surface Water

The surface water environmental concern evaluation ranking for Range 213 is moderate (score: 30 to 38 points). On the basis of the SAR Assessment for Range 213 in **Appendix A**, the potential for lead transport in surface water exists. However, transportation of lead is likely minimized by limited precipitation rates and the pH of surface water at the installation (i.e., pH > 6.5). Although intense storms in the rainy season (typically November – March (MCB Camp Pendleton, 2007b)) might cause runoff to act as a transport mechanism; any lead washed from this range by flood events would not be expected to reach the San Onofre Creek in high concentrations or quantities. Most stream reaches in the Las Flores watershed are ephemeral. A hydrologist at MCB Camp Pendleton stated that no flow had been recorded for three years in the reaches of San Onofre Creek that include the REVA sampling locations. Nevertheless, the evaluation suggests the potential for off-range migration of lead to surface water due to the relative proximity of the range to a stream that ultimately flows to San Onofre Creek with successive storm events and the regionally-related analytical lead results (**Section 9**).

Groundwater

The groundwater environmental concern evaluation ranking for Range 213 ranges from moderate to high (score: 44 to 55). On the basis of the SAR Assessment for Range 213 in **Appendix A**, the potential for lead transport in groundwater exists. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest an immediate environmental concern.

8.9. Range 214

8.9.1. Site Background

Range 214 is located in the southwest portion of the Whiskey Impact Area. The range consists of several firing lines and an earthen berm with a 2:1 slope ratio for bullet containment. It has been in use since February 1, 1961. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that over 1.25 million rounds of small arms ammunition were expended at this range over the course of the reporting year. Some of the basic information used to assess this range is presented in Table 8-13.

The berm is made of loamy fine sand (Las Flores loamy fine sand (LeC); steep gullied land (StG)) (USDA, 1973). No vegetation was noted on the berm with the exception of grasses around a single, large drainage pipe constructed into the lower face. An unidentified coating has been applied across the lower face, apparently to minimize erosion. Operations & Training indicated that this berm is periodically resurfaced, about every five years.

**Table 8-13:
Range 210**

Size
225 meters by 600 meters
Primary orientation
Not available; est 345°, towards Whiskey Impact Area
SSURGO soil classification
Las Flores loamy fine sand (LeC); steep gullied land (StG)
Firing lane material
Primarily grass and dirt
Surrounding vegetation
Sparse grass and brush

Surface water run-off generated during a storm event is expected to drain down the upper face and across the dirt access road separating the two faces of the berm. Observations noted very narrow channels cut into the lower berm face, presumably by repeated drainage of precipitation. The narrow shape of the channels is presumably attributable to the coating identified on the lower portion of the berm. Once drainage reaches the dirt margin of the adjacent asphalt access road, it drains in two directions: to the west-southwest, where it appears to pond in front of the western edge of the berm and infiltrate into the soil; or to a subsurface drainage pipe constructed towards the middle of the berm. Water collected at this latter point drains beneath the asphalt road and target line/butts, where it is channeled across the firing lanes until it exits the range at the approximate midpoint of its western boundary. This ephemeral stream ultimately drains into other streams that flow west towards San Onofre Creek.

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

The Environmental Operations Map (MCB Camp Pendleton, 2007a) indicates there may be isolated pockets of rare plant areas to the south of the range.

8.9.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Range 214 ranges from minimal to moderate (score: 18 to 33 points). On the basis of the SAR Assessment for Range 214 in **Appendix A**, the potential for lead transport in surface water exists, particularly in light of high munitions use and observed drainage patterns. However, transportation of lead is likely minimized by limited precipitation rates and partial engineered controls (earthen berm, narrow channel cut into the lower berm face, and coating identified on the lower portion of the berm). A large range of site scores have been chosen on some SARAP evaluation factors due to unknown data. The potential for lead transport is expected to be mitigated by the engineering controls in place at this range.

Groundwater

The groundwater environmental concern evaluation ranking for Range 214 ranges from moderate to high (score: 38 to 53). On the basis of the SAR Assessment for Range 214 in **Appendix A**, the potential for lead transport in groundwater exists. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. In addition, a large range of site scores have been chosen on some SARAP evaluation factors due to unknown data. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest an immediate environmental concern.

8.10. Range 300

8.10.1. Site Background

Range 300 is located in the northern portion of Bravo Three. The range consists of several firing lines and an earthen berm with a varied slope ratio of 1.5:1 to 2:1 for bullet containment. It has been in use since 1968. Based on the 2005 annual expenditure roll-up for MCB Camp Pendleton, it is estimated that over 360,000 rounds of small arms ammunition were expended at this range over the course of the reporting year. Some of the basic information used to assess this range is presented in Table 8-14.

Visual observation indicated the berm consists of sand and silt with organic matter (Terrance escarpments (TeF); Gaviota fine sandy loam (GaF)), though no vegetation was noted on the face of the berm (USDA, 1973). No formal maintenance activities are reported for this range.

The range is situated along the side of a dirt access road. Surface water run-off generated during storm events likely flows down the face of the berm, between a discontinuous line of wooden logs and sandbags, and across the firing lanes. Water that does not infiltrate into the ground may gradually drain off-range, with perhaps a slight bias towards the west-northwest. The nearest water body to this range is San Mateo Creek, an ephemeral stream approximately 125 meters north of the range.

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

**Table 8-14:
Range 300**

Size
75 meters by 600 meters, though visually est. 40 meters by 75 meters (not including sniper positions)
Primary orientation
Not available; estimated 135°
SSURGO soil classification
Terrance escarpments (TeF); Gaviota fine sandy loam (GaF)
Firing lane material
Compacted dirt, sparse grass
Surrounding vegetation
Vegetated mix of grass brush and trees

The range is immediately adjacent to the riparian area surrounding this stream; observations of the California Gnatcatcher, Arroyo Toad, and rare plants have been documented in this riparian area. As noted earlier, the California gnatcatcher is a non-migratory bird of open sage habitat, most abundant in the sage scrub-grassland interface rather than the sage scrub-chaparral interface. It does not utilize riparian habitat, so exposure to lead in surface waters is unlikely to occur (Malcolm Pirnie, 2008). The California gnatcatcher likely meets its daily water need from its insectivorous diet and do not require free water, although given access to standing water it is possible it may drink from the creeks. Even if this species were to drink water from the creeks, exposures to lead would be several orders of magnitude below that expected to cause adverse affect (Malcolm Pirnie, 2008). The Arroyo Toad is a small amphibian that uses riparian habitat for egg laying and breeding, and requires various upland habitats for other parts of its life cycle. MCB Camp Pendleton contains some of its largest remaining populations within the Santa Margarita, San Onofre, and San Mateo drainages. If the toad may be exposed to lead in the creeks' drainage, the toxicological data suggests that the lead concentrations in the surface water in this drainage will not cause adverse effects (Malcolm Pirnie, 2008). Current Installation Range and Training Regulations (MCB Camp Pendleton, 2003) note that the riparian area serves as habitat for the Arroyo Toad, Least Bell's Vireo, and Southwestern Willow Flycatcher (*Empidonax traillii extimus*).

8.10.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Range 300 is moderate (score: 34 to 45 points). On the basis of the SAR Assessment for Range 300 in **Appendix A**, the range may have the potential for lead migration and environmental concern due to its proximity to San Mateo Creek and observed drainage patterns. Nevertheless, the limited precipitation rates, 14 inches per year (MCB Camp Pendleton, 2007b), and partial engineered controls (earthen berms) reduce the potential for lead transport. In addition, the pH of the surface water within the boundaries of the installation (i.e. > 6.5) and regionally-related analytical lead results (**Section 9)** indicate no immediate environmental concern to surface water.

Groundwater

The groundwater environmental concern evaluation ranking for Range 300 ranges from moderate to high (score: 40 to 55). On the basis of the SAR Assessment for Range 300 in **Appendix A**, the potential for lead transport in groundwater exists. The groundwater pathway score is biased high by the sandy nature of the soils and lack of clay in the soil unit. In addition, a large range of site scores have been chosen on some SARAP evaluation factors due to unknown data. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest an immediate environmental concern.

8.11. Edson Pistol Range

8.11.1. Site Background

Edson Pistol Range is located in the southwest portion of the Edson Impact Area. The range consists of several firing lines and an earthen berm with a slope ratio between 1.5:1 and 2:1 for bullet containment. It has been in use since 1990. Given its location in the Edson training complex, munitions use at this range tends to be collectively tracked with other ranges sharing the Edson moniker. The annual expenditure roll-up for 2005 indicates that a total of nearly 7.5 million rounds of small arms ammunition expended across the entire Edson complex. Some of the basic information used to assess this range is presented in Table 8-15.

The berm at Edson Pistol Range is comprised of Huerhuero loam (HrE2, HrC), a soil that ranges from clay loam to sandy loam, with rocky calcareous subsoils (USDA, 1973). Observations made during January 2007 found the berm face to be relatively well-vegetated with dry grass. From the bottom of the berm, the ground gently slopes downward for approximately 13 feet before leveling over a line of sandbags and dropping into a concrete channel, approximately 3 feet across, positioned immediately beneath the target line. Range Operations & Training Department indicated that the berm is resurfaced approximately once every five years.

**Table 8-15:
Edson Pistol Range**

Size
25 meters by 50 meters, though visually est. 40 meters by 125 meters
Primary orientation
Not available; est. 345°, towards Edson Impact Area
SSURGO soil classification
Huerhuero loam (HrE2, HrC)
Firing lane material
Asphalt alternating with dirt/grass
Surrounding vegetation
Primarily dry grass; more vegetation and brush on top of berm

Surface water run-off generated during storm events likely drains down the berm and into the concrete channel spanning the width of the range. Sandbags are positioned in the channel beneath the observed target line, positioned in the approximate midpoint of the range. As a result, run-off in the channel should flow to either end of the concrete channel. Water that flows to the east-northeast end would be channeled into a shallow, lined culvert that would predominantly direct drainage along the eastern boundary of the range to a storm water drain. Water that flows to the west-southwest end would predominantly be channeled into a metal pipe buried just beneath the surface. Observations indicate this pipe runs alongside the western boundary and surfaces approximately 20 feet south of the southwest corner of the range, thereby discharging water away from the range towards the access road to the south.

An ephemeral creek is located on the opposite side of this access road, just beyond the boundary of the Edson Impact Area.

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

The Environmental Operations Map (MCB Camp Pendleton, 2007a) and the 2007 INRMP (MCB Camp Pendleton, 2007b) indicate riparian habitat to be within close proximity of the range, along with sightings of the California Gnatcatcher. There are short lengths of ephemeral streams located within the Edson Pistol Range boundary that drain into coastal lagoon areas. Newton Canyon is one of the ephemeral streams near the Edson Pistol Range boundary, and it flows near developed and potential habitat areas such as areas of threatened California Gnatcatcher species and areas of endangered Arroyo Toad species downstream of the Edson Pistol Range. In addition, wildlife can potentially be exposed to lagoons receiving water from ephemeral streams originating from impact areas (Malcolm Pirnie, 2008).

8.11.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Edson Pistol Range is minimal (score: 20 to 29). On the basis of the SAR Assessment for Edson Pistol Range in **Appendix A**, the range may have the potential for lead migration and environmental concern, but the assessment most likely indicates no immediate environmental concern. The range has been in use for a moderate period of time and partial engineered controls (earthen berm, concrete channel and sandbags) help to minimize surface runoff from entering the range floor. Based on the pH of surface water at the installation (i.e., documented pH > 6.5) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest off-range migration of lead. However, the Edson ranges represent the largest fraction of small arms munitions use at MCB Camp Pendleton, and additional actions may be warranted to enhance range sustainability and eliminate or reduce potential exposure to nearby receptors.

Groundwater

The groundwater environmental concern evaluation ranking for Edson Pistol Range is moderate (score: 33 to 35). On the basis of the SAR Assessment for Edson Pistol Range in **Appendix A**, the potential for lead transport in groundwater exists. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest an immediate environmental concern. There are no drinking water wells in the groundwater basin where this range is located. However, the Edson ranges represent the largest fraction of small arms munitions use at MCB Camp Pendleton, and additional actions may be warranted to enhance range sustainability and eliminate or reduce potential exposure to nearby receptors.

8.12. Edson Rifle Range B

8.12.1. Site Background

Edson Rifle Range B is located in the southern portion of the Edson Impact Area. The range consists of several firing lines and a terraced earthen berm with an upper face slope ratio between 2.5:1 to 3:1 and lower face slope ratio of 1.5:1 for bullet containment. It has been in use since 1990. This range is immediately adjacent to three other similarly constructed ranges labeled “A” through “D”, all considered part of the Edson training complex. Consequently, munitions use at these ranges tends to be collectively tracked under the Edson moniker. The annual expenditure roll-up for 2005 indicates that a total of nearly 7.5 million rounds of small arms ammunition are expended across the entire Edson complex. Range Operations & Training Department personnel indicated that the Edson ranges represent the largest fraction of small arms munitions use at MCB Camp Pendleton. Some of the basic information used to assess this range is presented in Table 8-16.

Table 8-16:
Edson Rifle Range B

Size
175 meters by 600 meters
Primary orientation
Not available; est. 035°, towards Edson Impact Area
SSURGO soil classification
Huerhuero loam (HrE3, HrC)
Firing lane material
Primarily dirt
Surrounding vegetation
Mix of brush and dry grass

The berm is comprised of Huerhuero loam (HrE2, HrC), a soil that ranges from clay loam to sandy loam, with rocky calcareous subsoils and is vegetated with dry grass (USDA, 1973). Range Operations & Training Department indicated that the berm had recently been resurfaced. This maintenance activity is performed approximately once every 5 years.

The Edson Impact Area sits just outside the coastal zone, approximately one kilometer northeast of the Pacific Ocean. Visual observations suggest surface water run-off generated during storm events generally drains down the berm and onto the asphalt road. The slight slope of the road should cause run-off to drain to the southeast where it follows an asphalt access road separating Ranges B and C.

Additionally, small pipe outlets, approximately 2 inches in diameter, were observed protruding from the bottom of the southeast end of the berm, adjacent to the access road. Pieces of gravel were noted around each outlet; this suggested that these pipes may be designed to drain run-off from the gravel-covered access road running across the berm. However, confirmation or additional information regarding the purpose and design of these pipes was not available. All surface water run-off generated during a storm event would travel between the berms of Ranges B and C and would likely follow observed topography and flow to the northwest along a road immediately behind the berm. The nearest water body to this range is an ephemeral stream that flows through French Canyon in the Edson Impact Area, just north of the Edson ranges.

The pH values used in the SAR Assessment for surface water within the boundaries of the installation are based on REVA sampling conducted in the 2007-2008 rainy season (**Section 9**). Surface water pH values for down gradient, off-range areas are assumed to be from 6.24 to 8.07. The pH of groundwater in alluvial basins is 7.32 to 8.4. The pH above 6.5 suggests that lead is not mobile, which is consistent with the regionally-related data for lead (Tables 9-2 and 9-4). These results are applicable for the SARAP for all of the ranges because they are each located in the uplands and are part of three hydrologic watersheds that extend to the coastal alluvial aquifers along the Pacific Ocean (from north to south): San Mateo watershed, San Onofre watershed, and the Las Flores watershed.

The Environmental Operations Map (MCB Camp Pendleton, 2007a) and the 2007 INRMP (MCB Camp Pendleton, 2007b) indicate sightings of the California Gnatcatcher and Pacific Pocket Mouse (*Perognathus longimembris pacificus*) have been made within areas adjacent to these ranges. There are short lengths of ephemeral streams located within the Edson Rifle Range B boundary that drain into coastal lagoon areas. Newton Canyon is one of the ephemeral streams near the Edson Rifle Range B boundary, and it flows near developed and potential habitat areas such as areas of threatened California Gnatcatcher species and areas of endangered Arroyo Toad species downstream of the Edson Range. In addition, wildlife can potentially be exposed to lagoons receiving water from ephemeral streams originating from impact areas (Malcolm Pirnie, 2008).

8.12.2. Assessment Results

Surface Water

The surface water environmental concern evaluation ranking for Edson Rifle Range B is minimal to moderate (score: 20 to 31). On the basis of the SAR Assessment for Edson Rifle Range in **Appendix A**, the range may have the potential for lead migration and environmental concern, but the assessment most likely indicates no immediate environmental concern. The range has been in use for a moderate period of time and partial engineered controls (earthen berm, concrete channel and sandbags) help to minimize surface runoff from entering the range floor. Based on the pH of surface water at the installation (i.e., documented pH > 6.5) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest off-range migration of lead. However, the Edson ranges represent the largest fraction of small arms munitions use at MCB Camp Pendleton, and additional actions may be warranted to eliminate or reduce potential exposure to nearby receptors.

Groundwater

The groundwater environmental concern evaluation ranking for Edson Rifle Range B is moderate (score: 33 to 35). On the basis of the SAR Assessment for Edson Rifle Range B in **Appendix A**, the potential for lead transport in groundwater exists. However, based on the annual precipitation of 14 inches per year (MCB Camp Pendleton, 2007b) and the regionally-related analytical lead results (**Section 9**), the evaluation does not suggest an immediate environmental concern. There are no drinking water wells in the groundwater basin where this range is located. However, the Edson ranges represent the largest fraction of small arms munitions use at MCB Camp Pendleton, and additional actions may be warranted to eliminate or reduce potential exposure to nearby receptors.

8.13. Further Action

The SARAP was utilized to assess 15 ranges identified by installation personnel as being used primarily for small arms ammunition. The results obtained as part of this qualitative assessment are intended to assist installation personnel in further prioritization of SARs for management of potential lead migration at MCB Camp Pendleton. The installation is investigating the best management control options for these 15 ranges with regards to possible lead migration.

The SARAP was applied to the SARs independent of field sampling at MCB Camp Pendleton discussed in **Section 9** and irrespective of other assessment for HE. Based on the SARAP results in **Section 8**, however, additional lead assessment will be conducted as necessary to further control and prevent possible MC migration.

Other small arms-only ranges exist at MCB Camp Pendleton that were not specifically assessed. These SARs are currently not anticipated to contribute a significant environmental concern due to minimal munitions use and surrounding environmental characteristics (e.g. no nearby surface water drainage, vegetation, etc.).

9. Field Data Collection Results

As previously described, screening-level groundwater and surface water modeling was conducted for the Quebec, Whiskey, and Zulu impact areas to predict whether MC could be migrating to off range areas. The modeling predicted low but possibly detectable concentrations of explosives potentially present in groundwater and surface water of the Las Flores and San Onofre watersheds. As a result, sampling of both groundwater and surface water was performed in Las Flores and San Onofre watersheds to determine whether MC was actually migrating to off range areas. This fieldwork of groundwater and surface water sampling provides an actual baseline assessment of potential off-range migration of MC.

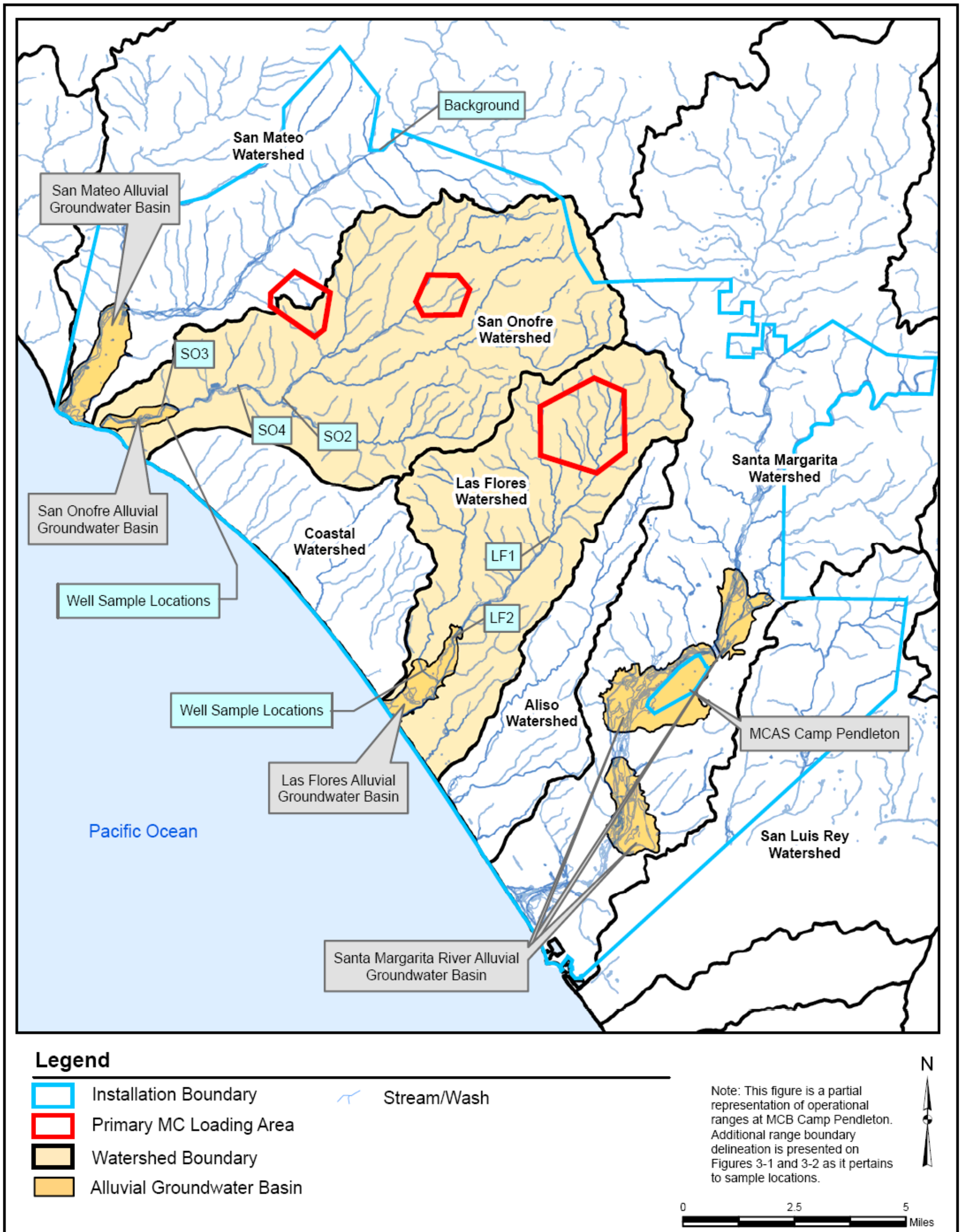
The field sampling effort did not include sampling the Santa Margarita watershed since screening-level modeling was not conducted for this watershed. Operational ranges within this watershed are primarily SARs, some of which were assessed qualitatively using the REVA SARAP (**Section 8**). Further assessment of the watershed for lead by field sampling or the application of best management practices is continually being evaluated by the Marine Corps based, in part, on the results of the SAR assessments. The installation routinely samples drinking water at MCB Camp Pendleton for lead and reports results, in accordance with U.S. Environmental Protection Agency (USEPA) and California requirements.

9.1. Field Activities

Field activities included sampling of off-range groundwater and surface water at the following locations (Figure 9-1):

- Raw water from seven operational or proposed drinking water supply wells (three wells in the Las Flores watershed and four wells in the San Onofre watershed)
- Surface water at one background location, off range and up gradient of operational ranges, in upper San Mateo Creek
- Five surface water locations, off range and down gradient of operational ranges, in the Las Flores and San Onofre watersheds, following three rain events in the 2007–2008 rainy season

Figure 9-1: Installation Map and Sample Locations, MCB Camp Pendleton



MALCOLM PIRNIE	Installation Map and Sample Locations MCB Camp Pendleton	Figure 9-1 April 2009

P:\6285\024\GIS\MXD\057_Figure 9-1_Installation Map and Sample Locations_PRD.mxd

Field sampling locations were selected based on the modeling results for HE, not on the SARAP. The SARAP had not yet been completed, and was developed independently of the modeling effort. Field sampling was conducted prior to completion of the SARAP, in part, due to timing of the annual rainy season and the need to conduct sampling immediately following successive storm events.

Sampling activities were coordinated with the installation to minimize interference with training activities, confirm safe access, identify appropriate water supply wells for sampling, and comply with habitat considerations and restrictions on the MCB Camp Pendleton Environmental Operations Map (MCB Camp Pendleton, 2007).

9.2. Data Quality Objectives

Data quality objectives (DQOs) are statements that specify the quantity and quality of the data required to support the REVA task project decisions. Although this is a voluntary evaluation, DQOs were developed for the Sampling and Analysis Plan (SAP) / Quality Assurance Project Plan (QAPP) using the seven-step process listed in the *Uniform Federal Policy for Implementing Environmental Quality Systems* and are presented using the USEPA format for DQOs (Intergovernmental Data Quality Task Force, 2005; USEPA, 2000). The primary goals of the field data collection activities were to evaluate if analytical results for groundwater and surface water samples suggest an off-range release of MC and to evaluate if analytical results correspond with screening-level modeling results. The intent of the REVA baseline assessment sampling did not include assessment of total comprehensive risk through a remedial site characterization.

The analytical approaches contained in the SAP/QAPP DQO tables indicate that no further action would be required until the next REVA (in 5 years) if concentrations of explosives and lead were below laboratory method detection limits (MDLs). For concentrations above the laboratory MDLs, but below the 2009 draft DoD Range and Munitions Use Subcommittee (RMUS) screening values, results would be compared to background samples and, if necessary, risks to human or ecological receptors would be evaluated. Additional sampling would be considered, if necessary. If concentrations were above the 2009 draft DoD RMUS screening values, results would be compared to background samples, if available, and additional sampling would be conducted to further assess and confirm results.

DoD RMUS screening values were developed based on existing state and USEPA guidelines to promote consistency across the services’ operational range assessment programs. This list of screening values is intended to be a general list of commonly found MC used in various range training activities. A hierarchy of sources was developed to guide the selection of screening values. The hierarchy is a prioritized list of screening value sources in order of recognized authority and applicability. All services compare their groundwater and surface water sampling data to these screening values to determine if further assessment is recommended. DoD RMUS screening values are contained in **Appendix B**.

9.3. Field Methods and Observations

Four sampling events were completed between December 2007 and April 2008. These events were conducted to obtain samples at the seasonal “first flow” as well as at subsequent times during the rainy season when water flow continued at surface water sampling locations. A background surface water sample was collected from a location within the Upper San Mateo Creek. All samples were analyzed for the full suite of explosives, excluding perchlorate, and total and dissolved lead.

Perchlorate was not included in these REVA sampling events for two reasons. First, concentrations were not predicted in the conservative REVA modeling results. In addition, drinking water supply wells are routinely sampled and analyzed for perchlorate to comply with the Unregulated Contaminant Monitoring Rule (UCMR). On the basis of that sampling program, the installation reports that water supply wells do not contain detectable concentrations of perchlorate (MCB Camp Pendleton OWR, 2008).

Lead was included in the field sampling as a proactive measure at locations already selected on the basis of predicted HE concentrations. Lead is also known to be a constituent of HE munitions; therefore, its inclusion was expected to provide an indicator of possible heavy metal constituents even though it could not be reliably modeled.

9.3.1. Groundwater Sampling

Groundwater sampling was performed on December 12, 2007, by Malcolm Pirnie staff with oversight by a representative from MCB Camp Pendleton Facilities and Maintenance Department. Groundwater samples were collected from seven drinking water supply wells. Four of these wells currently are used for drinking water supply. Three of these groundwater wells were resampled on April 30, 2008. Follow-up samples were collected from wells and analyzed for the corresponding analyses (explosives or lead) that were detected in the initial sampling event.

9.3.1.1. Las Flores Watershed

The three drinking water supply wells sampled in the Las Flores watershed are located in training areas Oscar Two and Papa One. The water from wells “1” and “2” was not observed when the pumps were turned on because water is pumped directly through pipes to on-site reservoirs. The pump for a third well (“3”) is rarely turned on. Therefore, the water discharged to the ground from this well was extremely turbid when the pump was turned on. Discharge water from well “3” became visibly clear after approximately 5 minutes of pumping.

9.3.1.2. San Onofre Watershed

The four drinking water supply wells sampled in the San Onofre watershed have well identification numbers “4”, “5”, “6”, and “7” and are located near the San Onofre housing areas within the area designated as “Section A San Onofre Beach”. The discharge water from wells “4” and “5” was not observed when the pumps were turned on because water is pumped directly through pipes to on-site reservoirs. The pumps for wells “6” and “7” are rarely turned on. The water discharged to the ground from these latter two wells was extremely turbid when the pumps were turned on. Discharge water from wells “6” and “7” became visibly clear after approximately 5 minutes of pumping.

9.3.2. Surface Water Sampling

Surface water samples were collected in the Las Flores and San Onofre watersheds utilizing two approaches: grab sampling and deployment of unattended first-flow storm water collection devices. Each surface water grab sample was collected after obtaining water quality field parameters. Each sample was analyzed for the full suite of explosives (excluding perchlorate) and total and dissolved lead. In addition, samples collected on February 5, 2008, were analyzed for total hardness as calcium carbonate ($CaCO_3$).

Different hydrologic conditions prevail throughout the area of interest. Although most stream reaches in the Las Flores watershed are ephemeral, base flow at the upstream sampling location has been observed throughout the REVA process (2005–2008). Hydrologists at MCB Camp Pendleton stated that no flow had been recorded for three years in the reaches of San Onofre Creek that include the sampling locations.

The samples collected in the "early rainy season" and "middle rainy season" are used to evaluate relative changes over the course of the rainy season. Early rainy season sampling designates that samples were obtained following rain events in the beginning of the 2007–2008 rainy season (typically November–January). Less than one month prior to these rain events, significant wildfires occurred in Southern California. Sections of the Las Flores and San Onofre watersheds burned severely, and vegetation was eliminated in several areas along the creek beds or upstream of sampling locations. Sediment load was expected to increase and may have had an effect on sample results, particularly lead, which is adsorbed to soil particles. Middle rainy season sampling designates that samples were obtained following a rain event later in the 2007–2008 season (sampling conducted on February 5, 2008). Storm events sufficient to produce stream flow, as well as the severity of the 2007 wildfire season, differentiate the 2007–2008 rainy season from previous seasons.

9.3.2.1. Early Rainy Season Surface Water Sampling

On December 7, 2007, grab samples were collected in the Las Flores watershed at locations LF01 and LF02 (sample identifications [IDs] LF01-SW01 and LF02-SW01, respectively). Duplicate samples also were collected at each location (sample IDs LF01-

SW02 and LF02-SW02, respectively). Flow was not present in the San Onofre watershed on December 7, 2007, so samples could not be collected on that date. A subsequent visit on January 7, 2008, allowed collection of San Onofre watershed grab samples at locations SO02, SO03, and SO04 (sample IDs SO02-SW01, SO03-SW01, and SO04-SW01, respectively, along with corresponding duplicate samples SO02-SW02, SO03-SW02, and SO04-SW02). These dates were selected since both were preceded by a significant local precipitation event.

Grab samples were collected using an extension arm with a polyethylene container attached to its end. Water was collected repeatedly from the midpoint and approximate mid-depth of the flowing water and dispensed into appropriate sample containers. A calibrated multiparameter water quality meter was used at each location to gather data regarding pH, conductivity, dissolved oxygen, salinity, temperature, and turbidity. Nalgene® storm water sampling devices were installed at the designated sampling locations. As the devices become submerged, they collect a first-flow water sample by funneling it through a grated entry port; a floating ball valve rises inside the container to eventually seal off the collection port.

9.3.2.2. Middle Rainy Season Surface Water Sampling

On February 5, 2008, grab samples were collected in the Las Flores watershed at locations LF01 and LF02 (sample IDs LF01-SW03 and LF02-SW03, respectively). Duplicate samples were also collected at each location (sample IDs LF01-SW04 and LF02-SW04, respectively). During the same site visit, grab samples were collected at locations SO02 and SO04 with sample IDs SO02-SW03 and SO04-SW03, respectively, along with corresponding duplicate samples SO02-SW04 and SO04-SW04. An additional sample was not collected at SO03 because no flow was present. Field activities involved the same methodology for grab surface water sampling as described in Section 9.3.2.1. The purpose of this additional sampling event was to assess MC concentrations after multiple rain events had triggered flow in the two watersheds.

9.3.2.3. Background Surface Water Sampling

A representative background surface water sample location was selected based on accessibility and the location being up gradient of operational ranges (Figure 9-1). The location selected was at the installation boundary on the upper reaches of San Mateo Creek.

Consistent with the grab sampling procedures performed at Las Flores and San Onofre watershed sample locations, a grab sample and a duplicate were obtained for background on December 11, 2007 (sample IDs BG01-SW01 and BG01-SW02, respectively). The sample collected at the background location was very clear and appeared less turbid than surface water samples collected in the San Onofre and Las Flores watersheds. A calibrated multiparameter water quality meter was used to gather data regarding pH, conductivity, dissolved oxygen, salinity, temperature, and turbidity.

9.4. Water Quality and Analytical Results

Section 9.4 summarizes the water quality parameters and analytical results for groundwater and surface water samples collected during these field activities.

9.4.1. Groundwater

Nine groundwater samples from seven wells were collected on December 12, 2007, and six groundwater samples from three wells were collected on April 30, 2008. Samples collected on December 12, 2007, were analyzed for the full suite of explosives (excluding perchlorate) and total and dissolved lead. Samples collected on April 30, 2008, were analyzed for the full suite of explosives (excluding perchlorate) or total and dissolved lead. Perchlorate was not included, as noted in Section 9.3. The analytical results were compared to DoD RMUS screening values, which were developed to promote consistency across the services' operational range assessment programs.

9.4.1.1. Las Flores Watershed Results

Sample results within the Las Flores watershed indicate that no explosives were detected in drinking water supply wells. Total and dissolved lead were detected in raw groundwater at one well ("2") during the December 2007 and April 2008 sampling events, but these detections were below DoD RMUS screening values.

Groundwater field data parameters are summarized in Table 9-1, and analytical results for groundwater samples collected in the Las Flores watershed are shown in Table 9-2.

9.4.1.2. San Onofre Watershed Results

Sampling results within the San Onofre watershed indicate trace amounts of explosives (2-nitrotoluene and 3-nitrotoluene [daughter products of TNT] and RDX), but concentrations are below DoD RMUS screening values. 2-Nitrotoluene was detected in only one groundwater well ("6") during the December 2007 sampling event. This well ("6") was resampled in April 2008, and no explosives were detected; it is not yet used as a drinking water supply well. Trace concentrations of total lead were identified in two other wells ("5" and "7") in December 2007, but lead was not detected in well "7" in April 2008. Well "5" was not available for resampling in April 2008 due to mechanical issues with the pump.

Groundwater field data parameters are summarized in Table 9-1, and analytical results for groundwater samples collected in the San Onofre watershed are shown in Table 9-2.

Table 9-1
Groundwater Field Parameters for MCB Camp Pendleton

Watershed	Well ID	Collection Date	Field Parameters					
			pH	*Dissolved Oxygen (mg/L)*	*Temperature (°C)*	*Specific Conductance (mS/cm)*	*Salinity (%)*	*Turbidity (NTU)*
Las Flores	"1"	12-Dec-07	8.22	5.01	19.7	1.40	0.06	< 10
	"2"	12-Dec-07	8.40	5.00	18.9	1.34	0.06	< 10
		30-Apr-08	7.40	3.20	19.3	1.4	0.06	10
	"3"	12-Dec-07	8.38	5.98	19.4	1.32	0.06	< 10
San Onofre	"4"	12-Dec-07	8.09	5.14	20.4	0.97	0.04	< 10
	"5"	12-Dec-07	8.21	5.75	19.2	0.94	0.04	N/A
	"6"	12-Dec-07	8.28	7.57	18.7	0.97	0.05	N/A
		30-Apr-08	7.54	8.5	18.9	1.03	0.05	29
	"7"	12-Dec-07	8.20	9.10	18.9	1.04	0.04	N/A
		30-Apr-08	7.32	8.50	19.0	1.13	0.05	31

Note:
Field parameters were read with a calibrated Horiba U-10 multiparameter water quality meter.
mg/L – milligrams per liter
mS/cm – milliSiemens per centimeter
N/A – not available. (The Horiba U-10 multiparameter water quality meter was not measuring properly for these wells, although the water was visibly clear when the wells were sampled following several minutes of purging more turbid water.)
NTU – nephelometric turbidity units
°C – degrees Celsius
μ/L – micrograms per liter

Table 9-2
Groundwater Analytical Results for MCB Camp Pendleton

Watershed	Sample ID	Collection Date	Analytical Result (µg/L)				
			Lead, Total	*Lead, Dissolved*	*2-Nitrotoluene*	*3-Nitrotoluene*	*RDX*
Las Flores	GW01	12-Dec-07	< 0.12	< 0.15	< 0.086	< 0.083	< 0.052
	GW02	12-Dec-07	**0.16 J**	**0.23 J**	< 0.086	< 0.083	< 0.052
	GW10	30-Apr-08	**0.44 J**	**0.29 J**	NA	NA	NA
	GW11 (DUP)	30-Apr-08	**0.50 J**	**0.27 J**	NA	NA	NA
	GW03	12-Dec-07	< 0.12	< 0.15	< 0.086	< 0.083	< 0.052
	GW04 (DUP)	12-Dec-07	< 0.12	< 0.15	< 0.086	< 0.083	< 0.052
San Onofre	GW07	12-Dec-07	< 0.12	< 0.15	< 0.086	< 0.083	< 0.052
	GW08	12-Dec-07	**0.27 J**	< 0.15	< 0.086	< 0.083	< 0.052
	GW09 (DUP)	12-Dec-07	**0.15 J**	< 0.15	NA	NA	NA
	GW06	12-Dec-07	< 0.12	< 0.15	**0.12 J**	< 0.083	< 0.052
	GW14	30-Apr-08	NA	NA	< 0.086	< 0.083	< 0.052
	GW15 (DUP)	30-Apr-08	NA	NA	< 0.086	< 0.083	< 0.052
	GW05	12-Dec-07	**0.14 J**	< 0.15	< 0.086	< 0.083	< 0.052
	GW12	30-Apr-08	< 0.12	< 0.15	NA	NA	NA
	GW13 (DUP)	30-Apr-08	< 0.12	< 0.15	NA	NA	NA
DoD RMUS Screening Value[a]			15	15	370	122	0.61

Note:
DUP - duplicate
J - Estimated; the analyte was positively identified, though the quantitation is an estimate.
mg/L - milligrams per liter
mS/cm - milliSiemens per centimeter
NA - Not analyzed
NTU - Nephelometric Turbidity Units
< - Analyte was not detected above listed MDL.
Bold indicates analyte was detected above the MDL.
Lead analyses were completed by USEPA Method 200.8; explosive analyses were completed by USEPA Method 8330A.
No explosives other than those listed were detected above the respective MDL.
[a] Values based on DoD RMUS screening values as Human Drinking Water Standards defined in the *Range Assessment Screening Values* (DoD, 2009)

9.4.2. Surface Water

Surface water sampling events were timed to occur within 24 hours of three separate storms that produced surface flow in either or both of the watersheds selected for field activities. As noted in Section 9.3.2, two sampling events were conducted at each watershed. The events provide insight to surface water quality in the early and middle parts of the 2007–2008 rainy season. Surface water samples were analyzed for the full suite of explosives and total and dissolved lead. Perchlorate was not included, as noted in Section 9.3. The water quality parameters measured during surface water sampling activities are summarized in Table 9-3.

9.4.2.1. Las Flores Watershed Results

The analytical results for surface water samples collected in the Las Flores watershed are presented in Table 9-4 and summarized below.

- Explosives were not detected.
- Total lead was detected in surface water samples at concentrations above the laboratory reporting limit (RL[1]) of 1.5 µg/L during the December 2007 sampling event. During the February 2008 event, total lead was detected, but it was below the RL.
- Dissolved lead was detected above the DoD RMUS ecological receptor screening value for surface water of 2.5 µg/L (assumes a water hardness of 100 µg/L as $CaCO_3$) in a sample collected at the downstream sampling location in December 2007 (DoD, 2008). However, dissolved lead was not detected in samples from either Las Flores surface water sampling location during the February 2008 sampling event.

The DoD RMUS ecological receptor screening value of 2.5 µg/L is based on the National Recommended Water Quality Criterion for lead (USEPA, 2006). The freshwater criteria for lead and several others metals are hardness-dependent, and the USEPA (2006) allows the criteria to be adjusted to reflect site-specific water hardness. Based on the data presented in Table 9-4, the mean hardness value for the Las Flores watershed was 375 mg/L as $CaCO_3$, whereas the mean for San Onofre was 165 mg/L as $CaCO_3$. Differences in hardness values between watersheds occur due to factors such as differing soil/rock types and amount and type of vegetation.

On the basis of the mean hardness values, adjusted surface water screening values were calculated to be 10.2 µg/L for the Las Flores watershed and 4.3 µg/L for the San Onofre watershed. Comparing these benchmarks to the early rainy season sampling events,

[1] A laboratory RL is a fairly standard level at which laboratories can quantitatively report a detection of an analyte. RLs are typically above the laboratory-specific MDL. MDLs were used in the REVA DQOs to determine if further assessment of results would be recommended.

dissolved lead detected at one downstream location sample in the San Onofre watershed was slightly higher than the adjusted value (4.5 μg/L in SO03-SW01). It is noted that water hardness data were available only for the middle rainy season sampling event, and uncertainty is associated with extrapolation of these data to the early rainy season sampling event.

Table 9-3
Surface Water Field Parameters for MCB Camp Pendleton

General Location	Sample Location	Collection Date	Field Parameters					
			pH	*Dissolved Oxygen (mg/L)*	*Temperature (°C)*	*Specific Conductance (mS/cm)*	*Salinity (%)*	*Turbidity (NTU)*
Background	BG01	11-Dec-07	7.12	9.36	10.8	0.707	0.02	< 10
Las Flores watershed	LF01	7-Dec-07	7.33	6.95	14.5	0.832	0.03	< 10
	LF01	5-Feb-08	7.52	11.61	13.7	1.100	0.04	< 10
	LF02	7-Dec-07	7.76	9.02	14.4	0.255	0.00	602
	LF02	5-Feb-08	8.07	12.68	13.8	1.290	0.05	< 10
San Onofre watershed	SO02	7-Jan-08	7.38	12.04	12.9	0.464	0.01	70
	SO02	5-Feb-08	6.24	13.05	10.5	0.439	0.01	< 10
	SO03	7-Jan-08	7.47	11.75	13.3	0.598	0.02	> 999
	SO04	7-Jan-08	7.77	12.26	12.5	0.668	0.02	650
	SO04	5-Feb-08	7.40	12.58	10.1	0.369	0.01	< 10

Note:
Field parameters were measured with a calibrated Horiba U-10 multiparameter water quality meter.
Sample location SO03 is farthest downstream on San Onofre Creek.
> 999 - Actual value is higher than the maximum calibrated range.

Table 9-4
Surface Water Analytical Results for MCB Camp Pendleton

General Location	Sample ID	Collection Date	Analytical Result					
			Lead, Total (µg/L)	*Lead, Dissolved (µg/L)*	*Hardness (mg/L)*	*2-Nitrotoluene (µg/L)*	*3-Nitrotoluene (µg/L)*	*RDX (µg/L)*
Background	BG01-SW01	11-Dec-07	< 0.12	< 0.15 R	N/A	< 0.086	< 0.083	< 0.052
Background	BG01-SW02 (DUP)	11-Dec-07	< 0.12	< 0.15 R	N/A	< 0.086	< 0.083	< 0.052
Las Flores watershed	**EARLY[a] RAINY SEASON SAMPLES**							
Las Flores watershed	LF01-SW01	7-Dec-07	< 0.12	< 0.15	N/A	< 0.086	< 0.083	< 0.052
Las Flores watershed	LF01-SW02 (DUP)	7-Dec-07	< 0.12	< 0.15	N/A	< 0.086	< 0.083	< 0.052
Las Flores watershed	LF02-SW01	7-Dec-07	**23**	**4.3**	N/A	< 0.086	< 0.083	< 0.052
Las Flores watershed	LF02-SW02 (DUP)	7-Dec-07	**22**	**3.9**	N/A	< 0.086	< 0.083	< 0.052
Las Flores watershed, continued	**MIDDLE[a] RAINY SEASON SAMPLES**							
Las Flores watershed, continued	LF01-SW03	5-Feb-08	**0.13 J**	< 0.15	**350**	< 0.086	< 0.083	< 0.052
Las Flores watershed, continued	LF01-SW04 (DUP)	5-Feb-08	< 0.12	< 0.15	**340**	< 0.086	< 0.083	< 0.052
Las Flores watershed, continued	LF02-SW03	5-Feb-08	< 0.12	< 0.15	**390**	< 0.086	< 0.083	< 0.052
Las Flores watershed, continued	LF02-SW04 (DUP)	5-Feb-08	**0.13 J**	< 0.15	**420**	< 0.086	< 0.083	< 0.052
San Onofre watershed	**EARLY RAINY SEASON SAMPLES**							
San Onofre watershed	SO02-SW01	7-Jan-08	**2.2 B**	**0.61 J**	N/A	<0.086	< 0.083	**1.1**
San Onofre watershed	SO02-SW02 (DUP)	7-Jan-08	**2.1 B**	**0.62 J**	N/A	< 0.086	< 0.083	**1.1**
San Onofre watershed	SO03-SW01	7-Jan-08	**27 B**	**4.5 J**	N/A	<0.086	< 0.083	**0.99**
San Onofre watershed	SO03-SW02 (DUP)	7-Jan-08	**27 B**	**2.8 J**	N/A	< 0.086	< 0.083	**0.95**

General Location	Sample ID	Collection Date	Analytical Result					
			Lead, Total (µg/L)	*Lead, Dissolved (µg/L)*	*Hardness (mg/L)*	*2-Nitrotoluene (µg/L)*	*3-Nitrotoluene (µg/L)*	*RDX (µg/L)*
	SO03-SW03[b]	7-Jan-08	**42 B**	**3.0**	N/A	**0.70**	< 0.083	**0.70**
	SO04-SW01	7-Jan-08	**11 B**	**3.6**	N/A	< 0.086	< 0.083	**2.5**
	SO04-SW02 (DUP)	7-Jan-08	**11 B**	**2**	N/A	< 0.086	< 0.083	**2.6**
	EARLY RAINY SEASON SAMPLES (SPLIT SAMPLE ANALYTICAL RESULTS)							
	SO02-SW01	7-Jan-08	**2.5**	N/A	N/A	N/A	N/A	N/A
	SO02-SW02 (DUP)	7-Jan-08	**2.5**	N/A	N/A	N/A	N/A	N/A
	SO03-SW01	7-Jan-08	**37**	N/A	N/A	N/A	N/A	N/A
	SO03-SW02 (DUP)	7-Jan-08	**36**	N/A	N/A	N/A	N/A	N/A
	SO03-SW03[b]	7-Jan-08	**74**	N/A	N/A	N/A	N/A	N/A
	SO04-SW01	7-Jan-08	**17**	N/A	N/A	N/A	N/A	N/A
	SO04-SW02 (DUP)	7-Jan-08	**15**	N/A	N/A	N/A	N/A	N/A
	MIDDLE RAINY SEASON SAMPLES							
	SO02-SW03	5-Feb-08	**0.15 J**	< 0.15	**160**	< 0.086	< 0.083	< 0.052
	SO02-SW04 (DUP)	5-Feb-08	**0.18 J**	< 0.15	**160**	< 0.086	< 0.083	< 0.052
	SO04-SW03	5-Feb-08	**0.26 J**	< 0.15	**170**	**0.20 J**	**0.11 J**	< 0.052
	SO04-SW04 (DUP)	5-Feb-08	**0.26 J**	< 0.15	**170**	< 0.086	< 0.083	< 0.052
DoD RMUS Screening Value[c]				2.5	N/A	N/A	750	190

Note:
B – Blank contamination; the analyte was detected above one-half the RL in an associated blank (batch method blank 0.63 µg/L J).
J – Estimated; the analyte was positively identified, though the quantitation is an estimate.

mg/L – milligrams per liter
N/A – not applicable
R – Rejected; result is not usable for project objectives.
< – Analyte was not detected above the listed MDL.
µg/L – micrograms per liter
Bold indicates a detectable concentration.
Lead analyses were completed by USEPA Method 200.8. Explosive analyses were completed by USEPA Method 8330A. Total hardness as $CaCO_3$ was analyzed by Method SM18 SM 2340B.
No explosives other than those listed were detected above the respective MDL.
Hardness values were obtained to adjust the DoD RMUS screening values for lead to account for stream-specific conditions. Adjustments to screening values were made using USEPA guidance. See Section 9.5.1.
Sample location SO03 is farthest downstream on San Onofre Creek.

[a] Early sampling events designate that samples were obtained following a rain event in the beginning of the rainy season (typically November–January) that may produce surface water flow. Middle sampling events designate that samples were obtained following a rain event in the middle of the rainy season (typically February) that may produce surface water flow. Each sampling event represents unique site conditions and is intended to evaluate relative changes over time.
[b] Sample was collected from a Nalgene® storm water sample bottle installed on December 13, 2007.
[c] Values are based on DoD RMUS screening values as Surface Water Values-Ecological Receptors defined in the *Range Assessment Screening Values* (DoD, 2009).

9.4.2.2. San Onofre Watershed Results

The analytical results for the surface water samples collected in the San Onofre watershed are presented in Table 9-4. Early rainy season results can be summarized as follows:

- Trace amounts of explosives were detected in some surface water samples. All detections were below DoD RMUS screening values for these MC or an applicable screening value was not available.
  - 2-Nitrotoluene was detected in surface water samples collected at two of the downstream locations in this watershed; however, only one detection was above the laboratory RL.
  - 3-Nitrotoluene was detected below the laboratory RL at a downstream surface water sampling location during the February 2008 sampling event.
  - RDX was detected above the laboratory RL in surface water samples collected at all three sampling locations during the January 2008 sampling event but was not detected in surface water samples collected during the February 2008 sampling event.
- Analytical results indicate the surface water samples collected in the San Onofre watershed had low but detectable concentrations of dissolved and total lead during the January 2008 sampling event. Concentrations decreased to below the laboratory RL or to nondetectable levels in the February 2008 sampling event.
  - Total lead results in surface water were above the laboratory RL in samples collected at all three sampling locations in January 2008. These results were qualified due to method blank contamination in the January

2008 sampling event; however, a split of the original sample matrix and reanalysis indicate that the analytical results were acceptable.

- Dissolved lead results from January 2008 were above the DoD RMUS screening value in two sample locations. When the screening value was adjusted to reflect site-specific water hardness, the dissolved lead concentration at one sample location slightly exceeded the adjusted screening value.

9.4.2.3. Background Sample

The background surface water sample was collected up gradient of operational ranges in the San Mateo watershed. The field water quality measurements for the background sample are summarized in Table 9-3, and the analytical results are summarized in Table 9-4. Explosives and total lead were not detected in the background sample. Due to issues with sample preservation, the result for dissolved lead is not usable for project objectives. However, the analytical results for total lead suggest that concentrations of dissolved lead were below the MDL.

9.5. Discussion

This section compares the groundwater and surface water data to the screening values identified by the DoD RMUS for assessing drinking water and surface water results in the voluntary, proactive operational range assessment programs including REVA.

The analytical results for the groundwater (Table 9-2) and surface water (Table 9-4) samples collected in the **Las Flores watershed** are summarized as follows:

- Explosives were not detected in groundwater supply well samples or surface water samples.
- Total lead was detected in surface water above the laboratory RL of 1.5 µg/L in both samples at location LF02 collected during the December 2007 sampling event, which was estimated to be the second storm of the season. Turbidity was high at this location (602 NTU). At each location where total lead was not detected, turbidity values were low (< 10 NTU; Table 9-3). In the February 2008 event, total lead was detected, but it was below the laboratory RL. Corresponding turbidity diminished to 10 NTU or less, signifying clear waters and low sediment content.
- Dissolved lead was detected at the downstream sampling location (LF02) in December 2007 at concentrations above the DoD RMUS ecological receptor screening value for surface water of 2.5 µg/L. When the screening value was adjusted to reflect site-specific water hardness, dissolved lead concentrations were below the adjusted screening value.

- Dissolved lead was not detected in either Las Flores surface water sampling location during the February 2008 sampling event.
- Total lead and dissolved lead were detected below the laboratory RL in one raw groundwater sample from a drinking water well (“2”) in December 2007 and April 2008.

The analytical results for the groundwater (Table 9-2) and surface water (Table 9-4) samples collected in the **San Onofre** watershed are summarized as follows:

- Trace amounts of explosives were detected in some surface water samples and one groundwater supply well sample. All detections were below DoD RMUS screening values for these MC or an applicable screening value was not available.
  - 2-Nitrotoluene was identified in well “6” in December 2007. The concentration is an estimate because the detection is below the laboratory RL. No explosives were detected in well “6” when it was re-sampled in April 2008.
  - 2-Nitrotoluene was detected in surface water at two of the downstream locations in this watershed. One detection was slightly above the laboratory RL. There is no DoD RMUS screening value for 2-nitrotoluene in surface water at this time.
  - 3-Nitrotoluene was detected below the laboratory RL at a downstream location in the February 2008 sampling event.
- Total lead detections in groundwater wells (“5” and “7”) are estimates because the detections were below the laboratory RL. However, lead was not detected in well “7” in April 2008. Well “5” was not available for re-sampling in April 2008 due to mechanical issues with the pump.
- Total lead was detected in all surface water samples during both sampling events. Total lead results in surface water were above the laboratory RL at all three sampling locations in January 2008. Corresponding NTU values for turbidity were also high in this early season event (70 – > 999 NTU; Table 9-3). The total lead analytical results were qualified due to method blank contamination in the January 2008 sampling event; however, a split of the original sample matrix and reanalysis indicate that the analytical results were acceptable. In the February event, total lead was detected below the RL and turbidity was also low (< 10 NTU) (Table 9-3).

- Dissolved lead was detected in all samples collected during the January 2008 sampling event, but was not detected during the February 2008 sampling event. All dissolved lead concentrations were above the DoD RMUS ecological receptor screening value of 2.5 µg/L. When the screening value was adjusted to reflect site-specific water hardness, the dissolved lead concentration at one sample location slightly exceeded the adjusted screening value.

Detected lead results of the field sampling effort are representative of potential mixed use ranges, not as a direct result of the SARAP discussed in Section 8.

9.5.1. Issues Related to Lead Results

Malcolm Pirnie reviewed the lead results with TestAmerica Laboratories during its data validation process and concluded the following:

1. Total lead results reported in January 2008 are acceptable despite the qualifier for method blank contamination (results noted with a "B" in Table 9-4), based on (a) the reanalysis and split of the samples collected for total lead and (b) the fact that the method blank contamination in the original sample batch was less than one-half of the laboratory RL for total lead.
2. The slight increase in total lead detected in the February 2008 reanalysis appears to be the result of sample receipt and retention in an acidified state for one month after sample collection.
3. Samples for analysis of dissolved lead at the background location and for the January 2008 sampling event at the San Onofre watershed were inadvertently collected in preserved containers. The result of this lab error is to produce a conservative (i.e., higher than would be expected) result for dissolved lead in the San Onofre watershed and total lead in the background sample.

Once the validity of the results for lead were evaluated, the team also reviewed the DoD RMUS ecological receptor screening value for lead as it applies to the Las Flores and San Onofre watersheds. The basis of the DoD RMUS ecological receptor screening value of 2.5 µg/L for lead is the National Recommended Water Quality Criteria (Appendix B). The freshwater criteria for lead and several others metals are hardness-dependent and USEPA (2006) allows the criteria to be adjusted to reflect site-specific water hardness. Based on the data presented in Table 9-4, the mean hardness value for the Las Flores watershed was 375 mg/L as CaCO3, whereas the mean for San Onofre was 165 mg/L as CaCO3. Differences in hardness values between watersheds occur due to factors such as differing soil/rock types and amount and type of vegetation.

On the basis of the mean hardness value for the Las Flores watershed, adjusted surface water screening values were calculated to be 10.2 µg/L for Las Flores and 4.3 µg/L for San Onofre. Comparing these benchmarks to the early rainy season sampling events, dissolved lead detected at one downstream location sample in the San Onofre watershed was slightly higher than the adjusted value (4.5 µg/L in SO03-SW01). It is noted that water hardness data were available only for the middle rainy season sampling event, and uncertainty is associated with extrapolation of this data to the early rainy season sampling event.

Following a review of the sample results, a literature review was conducted in concert with installation natural resources personnel in order to evaluate whether the concentrations of lead in surface waters in the watersheds at MCB Camp Pendleton would affect threatened and endangered species. The literature review indicated that adverse effects were unlikely to occur because exposure was unlikely due to the intermittent nature of the surface water creeks, species studied would not be exposed to waters in the creeks, or that concentrations of lead were below levels that would adversely affect certain species (Malcolm Pirnie, 2008).

9.5.2. Relevance of Hydrologic Conditions of Sampling Events

After three years of below average rainfall, the 2007–2008 rainy season in Southern California was characterized by numerous storms in quick succession. The season started in November, less than one month after severe wildfires burned through the Las Flores and San Onofre watersheds, removing vegetation and increasing the potential for erosion and sediment transport. Increased sediment load may have had an effect on sample results, particularly lead, which is adsorbed to soil particles. When sample results are considered in the context of the storm sequences in the 2007–2008 rainy season, the following conclusions can be made:

- The December 2007 and January 2008 sampling rounds occurred during or shortly after the first two or three storm events of the season. The samples are identified as “early” for their general seasonal description.
    - In the San Onofre watershed, these storm events occurred after a period of approximately three years with no flow in locations sampled in the San Onofre watershed.
    - Early rainy season results for lead concentrations were low in comparison to the screening values.
    - In the Las Flores watershed surface water samples, the relatively high concentrations of dissolved and total lead correlated with elevated turbidity measurements.
- By contrast, the February 2008 sampling round occurred at approximately the 10th to 15th storm event of the season. The samples are noted as “middle” in terms of their general seasonal description. Constituent concentrations decreased or were not detected in this sampling event. Turbidity values also decreased.

The results suggest that a seasonal first flow of MC may have been followed by diminished concentrations as the rainy season continued. Comparing the seasonal first-flow results to the DoD RMUS screening values reflects a conservative approach because the values are calculated based on exposure over long periods of time. For example, hydrologists at MCB Camp Pendleton have observed that surface water flow in the San Onofre watershed is, at a maximum, sustained for only a few days per year, depending on seasonal rainfall. At the San Onofre watershed sampling locations, no surface water flow had occurred for three years prior to starting these field activities. However, base flow had been observed by the REVA assessment team at the upstream sampling location in the Las Flores watershed prior to the 2007–2008 rainy season.

9.5.3. Conclusions and Further Action

The field sampling was a continuation of the baseline assessment but was not intended to be a direct confirmation of the modeling results. Nevertheless, this REVA sampling provides a general confirmation of modeling results, which were based on conservative assumptions. Although modeling results reflect concentrations over an average year, the conditions prior to field sampling are not reflective of average conditions. There had been little to no rainfall for three years, potentially allowing for accumulation of indicator MC and lead. Severe wildfires had burned through both watersheds just prior to sampling, increasing the potential for erosion and runoff. From this perspective, sampling results may be considered a conservative snapshot of off-range MC migration at the time they were collected.

The REVA field data collection results for MCB Camp Pendleton indicate that lead was detected at a much higher frequency than explosives in the Las Flores and San Onofre watersheds. Most of the detections of lead and the only detections of explosives occurred in the San Onofre watershed. Results show that only a single sample of dissolved lead in the San Onofre watershed had a concentration slightly greater than adjusted DoD RMUS screening values. In addition, DNT was detected in the San Onofre watershed but is not an indicator MC. Degradation products, such as DNT, were not anticipated in this baseline assessment since they were included in the sampling analysis methodology as analytes. RDX concentrations in the San Onofre watershed may have resulted from underestimating the source term. These findings may be considered for adjustment in future iterations of the REVA process.

It is of note that detected concentrations decreased from the December 2007 sampling event to the February 2008 sampling event. The results suggest that a seasonal first flow of MC in the early part of the rainy season was followed by diminished concentrations as the rainy season continued. As noted above, these results are a snapshot in the 2007–2008 rainy season and are not necessarily representative of a long-term trend. Based on the assessment results presented in this report, no immediate environmental concern was identified; however, further actions may be evaluated to continue to mitigate the possibility of MC migration from operational ranges at MCB Camp Pendleton to ensure future range sustainability.

10. References

10 U.S.C. § 101(e) (3) (2006).

Agency for Toxic Substances and Disease Registry (ATSDR). 1995a. *ToxicologicalProfile for 2,4,6-Trinitrotoluene.* Public Health Service, United States Department of Health and Human Services.

------. 1995b. *Toxicological Profile for RDX.* Public Health Service, United States Department of Health and Human Services.

------. 1997. *Toxicological Profile for HMX*. Public Health Service, United States Department of Health and Human Services.

Brady, Nyle C. 1984. *The Nature and Properties of Soils.* Ninth edition.

California Department of Water Resources (DWR). 1967. *Groundwater Occurrence and Quality.* San Diego Region: California Department of Water Resources Bulletin, v. 100-2, pt. 1-2, p. 235.

California Regional Water Quality Control Board. 2007. *Water Quality Control Plan: San Diego – Region 9.* Original September 8, 1994, with amendments April 25, 2007.

Craig, C. 1984. *Geology and Eocene Sedimentation of the Southwestern Portion of the Camp Pendleton Marine Corps Base, San Diego County*: Masters Thesis, San Diego, California.

Cranham, G.T., P.A. Camilleri, and G.R. Jaffe. 1994. *Geologic Overview of the San Onofre Mountains, Camp Pendleton Marine Corps Base, San Diego County, California*: in Geology and Natural History of Camp Pendleton Marine Corps Base, San Diego County, California, San Diego Association of Geologists, Phillip S. Rosenberg, Editor.

Defense Ammunition Center. Munitions Items Disposition Action System (MIDAS). https://midas.dac.army.mil/.

Department of Defense (DoD). 2005a. DoD Directive 4715.11. *Environmental and Explosives Safety Management on Operational Ranges within the United States.*

------. 2005b. DoD Instruction 4715.14. *Operational Range Assessments.*

------. 2007. *Procedure for Choosing Screening Values for Operational Range Assessments.*

Jan. 28, 2009. *Range Assessments Screening Values.* Final Version 5.0

DWR. See California Department of Water Resources.

Ehlig, P.L. 1979. *Miocene Stratigraphy and Depositional Environments of the San Onofre Area and their Tectonic Significance*: in Stuart, C.J., ed., Miocene Lithofacies and Depositional Environments, Coastal Southern California and Northwestern Baja California Field Trip Guidebook, Geological Society of America, Annual Meeting: S.E.P.M., Pacific Section, p.42-51.

Enhanced International Deminer's Guide to UXO Identification, Recovery and Disposal. Version 1.0. 1999.

Headquarters Marine Corps (HQMC). 2006. *REVA Reference Manual.*

Intergovernmental Data Quality Task Force. 2005. *Uniform Federal Policy for Implementing Environmental Quality Systems.*

Malcolm Pirnie, Incorporated. 2008. *Draft Water Quality Ecological Evaluation, Marine Corps Base Camp Pendleton.*

Marine Corps Base (MCB) Camp Pendleton. 2001a. Final Range Identification and Preliminary Range Assessment (RIPRA).

------. 2004a. Range Facility Management Support System (RFMSS) database report. Range Control.

------. 2003. Installation Range and Training Regulations.

------. 2004b. Toxic Release Inventory (TRI) report.

------. 2005-2007. Assistant Chief of Staff/Environmental Security, Geographical Information Systems (GIS) Department files.

------. 2006. *Integrated Natural Resources Management Plan (INRMP).*

------. 2007a. Camp Pendleton Environmental Operations Map.

------. 2007b. *Integrated Natural Resources Management Plan. (INRMP).*

Meylan, W.M. and Howard, P.H. 1995. *Atom/Fragment Contribution Method for Estimating OCtanol-Water Partition Coefficient.* J.Phrm. Sci. 84: 83-92.

------. Office of Water Resources (OWR), personal communications, 2008.

McCuen, Richard H. 1998. *Hydrologic Analysis and Design*, second edition. Prentice Hall.

National Climatic Data Center. 2006. Official website. http://www.ncdc.noaa.gov Accessed January 2006.

NOAA. Official website. http://www.noaa.gov/sgx/climate/san-nfg.htm

Ontario Ministry Agricultural and Food. 2000. Fact Sheet.

Palmer, M.A. 1990. *Hydrogeologic Investigation of the Las Flores Basin, San Diego County, California*: Masters Thesis, San Diego State University, San Diego, California.

Peterson, J.E. 1978. *Water Resources and Hydrogeology of the San Onofre Basin, San Diego County, California*: Masters Thesis, San Diego State University, San Diego, California.

Stetson Engineers, Inc. 2005. *Three-Dimensional Groundwater Flow Model of the San Mateo and San Onofre Basins, USMC Base Camp Pendleton*.

Training and Education Command (TECOM). 2003. *Mission-Capable Ranges, Training Range Sustainment Planning and Training Range Inventory FY 2004 Update, pursuant to Fiscal Year 2003 National Defense Authorization Act Section 366 Information Request (NDAA 366 Report).*

United States Army Corps of Engineers (USACE). 2001a. FINAL – *Archives Search Report Marine Corps Base, Camp Pendleton.*

------. 2001b. FINAL – *Range Identification and Preliminary Range Assessment Marine Corps Base Camp Pendleton.*

United States Army Environmental Technical Center for Explosives Safety. 2000. *Report of Finding for Study of Ammunition Dud and Low Order Detonation Rates.*

United States Department of Agriculture (USDA) Soil Conservation Service (SCS) and Forest Service (FS). 1973. *Soil Survey San Diego Area, California.*

United States Environmental Protection Agency. 2006. *National Recommended Water Quality Criteria.*

Walsh, M.E., T.F. Jenkins, and P.G. Thorne. 1995. *Laboratory and Field Analytical Methods for Explosive Residues in Soil.* Proceedings of the Symposium on Alternatives to Incinerations for Disposal of Chemical Munitions and Energetics. Vol. 2, p. 17.

Worthington, W. 1994. Personal communication with M. Palmer: in Rosenberg, P.S., ed., Geology and Natural History, Camp Pendleton United States Marine Corps Base, San Diego County, California: San Diego Association of Geologists.

Appendix A
Small Arms Range Assessment Forms

SMALL ARMS RANGE ASSESSMENT

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.

For small arms ranges, the fate and transport parameters 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,
- 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 on 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 Small Arms Range Assessment Protocol outlines a qualitative approach to assess the small arms ranges in the REVA process in lieu of collecting site-specific geochemical properties at every range. This qualitative approach helps to identify and assess factors that influence the potential for lead to migrate at an operational range.

This protocol is to be used for:

1) Identifying the small arms ranges within the Marine Corps that have the greatest potential for environmental concern (i.e., potential for lead migration to impact 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 capturing 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
- Groundwater and soil
- 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

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. The primary factors influencing the potential for dissolved 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

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 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 risk to potential 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 environmental concerns posed by MC. Environmental concern evaluation rankings for surface water and groundwater conditions are established for each small arms range. The rankings range between High (indicating the highest potential environmental concern) and MINIMAL (indicating the lowest potential environmental concern). Sites for which there is insufficient information to complete the evaluation are placed into an Evaluation Pending ranking. Possible recommended actions are based on the relative environmental concern evaluation rankings assigned by the protocol. High rankings necessitate further actions. Further actions may included 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. Professional judgment may be used at any time to override a designated score. If professional judgment is used, mark the score column appropriately (*) and fill in the notes section at the bottom of the table with text detailing why professional judgment was used and how it impacted the scores.
   b. 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 environmental concern 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 concern evaluation ranking and the groundwater concern 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 and environmental concern, creating the greatest level of environmental concern and requiring additional action(s).
- Moderate = Small arms range may have the potential for lead migration and environmental concern, most likely indicating that there is no immediate environmental concern, but actions may be necessary to prevent a greater concern.
- Minimal = Small arms range has minimal or no potential for lead migration and environmental concern, indicating minimal threat of environmental concern, but actions may be necessary to ensure that the no concerns elevate.

These rankings are used to determine whether additional actions are appropriate. The higher environmental concern 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).

The overall range evaluation rankings should be compared to each range within the installation and to the overall rankings of all ranges across the Marine Corps. These rankings will assist in determining how funding should best be allocated across the Marine Corps to prevent environmental concerns due to small arms ranges.

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, BMPs may be recommended based on the environmental concern 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.

TABLES

Small Arms Range Protocol Evaluation Forms

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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	
Source Element Score			
Notes:			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	
Surface Water Pathway Score			
Notes:			

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	
Groundwater Pathway Score			
Notes:			

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	
Surface Water Receptor Score			
Notes:			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 iare not moving appreciably 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	
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	
Groundwater Receptor Score			
Notes:			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	
Surface Water Pathways	2	
Surface Water Receptors	4	
Sum of Surface Water Element Scores		
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	
Groundwater Pathways	3	
Groundwater Receptors	5	
Sum of Groundwater Element Scores		
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		
Groundwater Environmental Concern Evaluation Ranking		
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Edson Pistol Range

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	3
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			13
Notes: Duration of Range Use: described in Training and Performance Data Center Report 1990 MC Loading Rates: Pb = based on small arms rounds expended expected to be >1000 lbs/yr; 332,000 rounds Range Maintenance: resurfaced 1/5yr			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3~5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	3
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	(-10) ~ (-5)
Surface Water Pathway Score			3~10

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report= 14"/yr
Slope of Range: Berm = 2:1; 1.5:1
Vegetation: Firing Lane = asphalt alternating with dirt & grass; primarily dry grass vegetation & brush on berm
Soil Type/Runoff Conditions: Huerhuero loam (HrE2; HrC)
Runoff/Erosion Engineering Controls: concrete channel with sandbags. Drains to either shallow lined culvert to storm water drain or to pipe for discharge towards the access road to the south.

Small Arms Range Protocol Evaluation Forms

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3
Groundwater Pathway Score			16~18

Notes:
Depth to Groundwater: NOAA: 75’
Precipitation: INRMP report-14”/yr
pH of Water: Field Data Report, Table 4-1 (7.32~8.40)
pH of Soil: unknown
Soil Type/Infiltration Conditions: HrE2; HrC
Clay Contents in Soil: HrE2; HrC

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1~3
Surface Water Receptor Score			4~6
Notes: Surface Water Body: Edson Pistol Range is located in the Santa Margarita Watershed Drinking Water Usage: ephemeral creek Sensitive Species Habitat and Threatened or Endangered Species: California Gnatcatcher			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	2
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	1
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1
Groundwater Receptor Score			4
Notes: Drinking water supply wells are located downgradient of the range. Sensitive Species Habitat and Threatened or Endangered Species: California Gnatcatcher			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13
Surface Water Pathways	2	3~10
Surface Water Receptors	4	4~6
Sum of Surface Water Element Scores		**20~29**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13
Groundwater Pathways	3	16~18
Groundwater Receptors	5	4
Sum of Groundwater Element Scores		**33~35**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal**
Groundwater Environmental Concern Evaluation Ranking		**Moderate**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Edson Rifle Range B

Table 1: Range Use and Range Management (*Source*) Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	3
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			13
Notes: Duration of Range Use: described in Training and Performance Data Center Report 1990 MC Loading Rates: Pb = expected to be >1000 lbs/yr; 7.5 million rounds Range Maintenance: resurfaced 1/5yr			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3~5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	3
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	(-10) ~ (-5)
Surface Water Pathway Score			3~10

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report= 14"/yr
Slope of Range: Berm = 2.5:1; 1.5:1
Vegetation: Firing Lane= primarily dirt; mix of brush & dry grass
Soil Type/Runoff Conditions: Huerhuero loam (HrE3; HrC)Runoff/Erosion Engineering Controls: small pipe outlets, approx. 2 inches in diameter, protrude from the bottom of the southeast end of the berm, adjacent to the access road. Pieces of gravel were noted around each outlet; this suggested that these pipes may be designed to drain run-off from the gravel-covered access road running across the berm. The ranges possess a thick layer of gravel on the access road that bisects the berms; this gravel intercepts and slows drainage.

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3
Groundwater Pathway Score			16~18

Notes:
Depth to Groundwater: NOAA: 75'
Precipitation: INRMP report-14"/yr
pH of Water: Field Data Report, Table 4-1 (7.32~8.40)
pH of Soil: unknown
Soil Type/Infiltration Conditions: HrE3; HrC
Clay Contents in Soil: HrE3; HrC

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1~5
Surface Water Receptor Score			4~8
Notes: Surface Water Body: Edson Rifle Range B is located in the Santa Margarita Watershed Drinking Water Usage: ephemeral creek flows through French Canyon; 1km from Pacific Ocean Sensitive Species Habitat and Threatened or Endangered Species: California Gnatcatcher; Pacific Pocket Mouse			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	2
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	1
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1
Groundwater Receptor Score			4
Notes: Drinking water supply wells are located down gradient of the range. Sensitive Species Habitat and Threatened or Endangered Species: California Gnatcatcher; Pacific Pocket Mouse			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13
Surface Water Pathways	2	3~10
Surface Water Receptors	4	4~8
Sum of Surface Water Element Scores		**20~31**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13
Groundwater Pathways	3	16~18
Groundwater Receptors	5	4
Sum of Groundwater Element Scores		**33~35**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 102

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			15
Notes: Duration of Range Use: In use since February 1, 1961 MC Loading Rates: Pb = 4192 lbs/yr; 155,000 rounds Range Maintenance: periodically raked to remove Pb and rocks			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3~5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1~3
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	-5
Surface Water Pathway Score			6~10

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14”/yr
Slope of Range: Berm = 2:1
Vegetation: Firing Lane = brush & grass
Soil Type/Runoff Conditions: Visalia sandy loam (VaD)
Runoff/Erosion Engineering Controls: some gravel noted throughout the parking area (mitigate impacts from flooding)

Table 3: Groundwater Pathways Characteristics Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Groundwater Pathway Score			16~22
Notes: Depth to Groundwater: NOAA: 75’ Precipitation: INRMP report-14”/yr pH of Water: Field Data Report, Table 4-1 (7.32~8.40) pH of Soil: unknown Soil Type/Infiltration Conditions: VaD Clay Contents in Soil: VaD			

Small Arms Range Protocol Evaluation Forms

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2~5
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1~3
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	5~10
Surface Water Receptor Score			8~18
Notes: Surface Water Body: Range 102 is located in the Santa Margarita Watershed Sensitive Species Habitat and Threatened or Endangered Species: Least Bell's Vireo			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	5~10
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	1~3
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1~3
Groundwater Receptor Score			7~16
Notes: Drinking water supply wells are located downgradient of the range Sensitive Species Habitat and Threatened or Endangered Species: Least Bell's Vireo			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water Pathways	2	6~10
Surface Water Receptors	4	8~18
Sum of Surface Water Element Scores		**29~43**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	16~22
Groundwater Receptors	5	7~16
Sum of Groundwater Element Scores		**38~53**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate/High**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 103

Table 1: Range Use and Range Management (*Source*) Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			15
Notes: Duration of Range Use: 1942 to present MC Loading Rates: Pb = 9,375 lbs/yr; over 2 million rounds Range Maintenance: Periodically resurfaced, otherwise receives no maintenance			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	3~5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1~3
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	-5
Surface Water Pathway Score			4~8

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14”/yr
Slope of Range: Berm = 2:1
Vegetation: Firing Lane = grass & dirt; low growing brush
Soil Type/Runoff Conditions: Visalia sandy loam (VaD)
Runoff/Erosion Engineering Controls: silt fence

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Groundwater Pathway Score			16~22
Notes: Depth to Groundwater: NOAA: 75’ Precipitation: INRMP report-14”/yr pH of Water: Field Data Report, Table 4-1 (7.32~8.40) pH of Soil: unknown Soil Type/Infiltration Conditions: VaD Clay Contents in Soil: VaD			

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2~5
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1~3
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	5~10
Surface Water Receptor Score			8~18
Notes: Surface Water Body: Range 103 is located in the Santa Margarita Watershed Sensitive Species Habitat and Threatened or Endangered Species: Least Bell's Vireo			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	5~10
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	1~3
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1~3
Groundwater Receptor Score			7~16
Notes: Drinking water supply wells are located downgradient of the range. Sensitive Species Habitat and Threatened or Endangered Species: Least Bell's Vireo			

Table 6: Relative Environmental Concern Evaluation **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water Pathways	2	4~8
Surface Water Receptors	4	8~18
Sum of Surface Water Element Scores		**27~41**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	16~22
Groundwater Receptors	5	7~16
Sum of Groundwater Element Scores		**38~53**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate/High**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 111

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			15
Notes: Duration of Range Use: Operational since February 1, 1961 MC Loading Rates: Pb = 1389 lbs/yr; 290,000 rounds Range Maintenance: No formal maintenance			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3~5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1~3
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	-5
Surface Water Pathway Score			6~10
Notes: pH of Water: Field Data Report, Table 4-3 (6.24-8.07) Precipitation: INRMP report = 14"/yr Vegetation: Firing Lane = primarily grass & dirt; grass & brush Soil Type/Runoff Conditions: Gaviota fine sandy loam (GaF); Las Flores loamy fine sand (LeD) Runoff/Erosion Engineering Controls: Well defined channel berm; short grasses are naturally present over much of the range			

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Groundwater Pathway Score			16~22
Notes: Depth to Groundwater: NOAA: 75' Precipitation: 14"/yr pH of Water: Field Data Report, Table 4-1 (7.32~8.40) pH of Soil: unknown Soil Type/Infiltration Conditions: GaF; LeD Clay Contents in Soil: GaF; LeD			

Small Arms Range Protocol Evaluation Forms

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	5~10
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	3~5
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1~5
Surface Water Receptor Score			9~20
Notes: Surface Water Body: Range 111 is located in the Las Flores Watershed Sensitive Species Habitat and Threatened or Endangered Species: Least Bell's Vireo; Stephens' Kangaroo Rats			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	5~10
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	1~3
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1~3
Groundwater Receptor Score			7~16
Notes: Drinking water supply wells are located downgradient of the range and analytical results show the presence of Pb although the source of Pb is not known (Field Data Collection Results). Sensitive Species Habitat and Threatened or Endangered Species: Least Bell's Vireo; Stephens' Kangaroo Rats			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water Pathways	2	6~10
Surface Water Receptors	4	9~20
Sum of Surface Water Element Scores		**30~45**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	16~22
Groundwater Receptors	5	7~16
Sum of Groundwater Element Scores		**38~53**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: <u>Environmental Concern Evaluation Ranking*</u> — <u>Score Range</u> High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate/High**
Notes:		

Table 7: Guidelines for Recommended Actions

Environmental Concern Evaluation Ranking	Recommended Action
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 116A

Table 1: Range Use and Range Management (*Source*) Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	3~5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	1
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			9~11
Notes: Duration of Range Use: Appears as 116A in 1997 & constructed over historical range from 1940's MC Loading Rates: Pb = 54 lbs/yr; 4,000 rounds Range Maintenance: Removal activities have not been performed since the 1980's; resurfacing 1/5yr			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	3~5
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	0
Surface Water Pathway Score			15~17

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14"/yr
Slope of Range: Berm = 1.5:1
Vegetation: Firing Lane = primarily dirt; low (dry) brush
Soil Type/Runoff Conditions: Salinas clay loam (SbC)

Small Arms Range Protocol Evaluation Forms

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	1~3
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	1~3
Groundwater Pathway Score			12~18
Notes: NOAA: 75' Precipitation: 14"/yr pH of Water: Field Data Report, Table 4-1 (7.32~8.40) pH of Soil: unknown Soil Type/Infiltration Conditions: SbC Clay Contents in Soil: SbC			

Table 4: Surface Water Receptors Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1
Surface Water Receptor Score			4
Notes: Surface Water Body: Range116A is located in the Santa Margarita Watershed Drinking Water Usage: ephemeral stream from the north out of the Aliso Canyon through X-Ray Impact Area to the south; Low MC loading Sensitive Species Habitat and Threatened or Endangered Species: Stephens' Kangaroo Rats; rare plants			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	2
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	1
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1
Groundwater Receptor Score			4
Notes: Drinking water supply wells are located downgradient of the range. Sensitive Species Habitat and Threatened or Endangered Species: Least Bell's Vireo; Stephens' Kangaroo Rats; rare plants			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9~11
Surface Water Pathways	2	15~17
Surface Water Receptors	4	4
Sum of Surface Water Element Scores		**28~32**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9~11
Groundwater Pathways	3	12~18
Groundwater Receptors	5	4
Sum of Groundwater Element Scores		**25~33**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 116B

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	3~5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	1
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			9~11

Notes:
Duration of Range Use: Assume same as Range 116A - Appears as 116A in 1997 & constructed over historical range from 1940's
MC Loading Rates: Pb = 23 lbs/yr; 3,000 rounds
Range Maintenance: Periodically resurfaced as well as mined; no details regarding frequency for later (note Range 116A resurfacing = 1/5yr)

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1~3
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	0
Surface Water Pathway Score			13~15

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14”/yr
Slope of Range: Berm = 1.5:1
Vegetation: Firing Lane = gravel, concrete to target; sparse weeds & grass
Soil Type/Runoff Conditions: Las Flores loamy fine sand (LeE)

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Groundwater Pathway Score			16~22
Notes: Depth to Groundwater: NOAA: 75' Precipitation: INRMP report-14"/yr pH of Water: Field Data Report, Table 4-1 (7.32~8.40) pH of Soil: unknown Soil Type/Infiltration Conditions: LeE Clay Contents in Soil: LeE			

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1
Surface Water Receptor Score			4
Notes: Surface Water Body: Range 116B is located in the Santa Margarita Watershed Drinking Water Usage: 1250 ft west-northwest of an ephemeral stream; Low MC loading Sensitive Species Habitat and Threatened or Endangered Species: Stephens' Kangaroo Rats; rare plants			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	2
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	1
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1
Groundwater Receptor Score			4
Notes: Drinking water supply wells are located downgradient of the range. Sensitive Species Habitat and Threatened or Endangered Species: Least Bell's Vireo; Stephens' Kangaroo Rats; rare plants			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9~11
Surface Water Pathways	2	13~15
Surface Water Receptors	4	4
Sum of Surface Water Element Scores		**26~30**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9~11
Groundwater Pathways	3	16~22
Groundwater Receptors	5	4
Sum of Groundwater Element Scores		**29~37**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 130, Bay 1

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	3
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	1~3
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			9~11
Notes: Duration of Range Use: Operational since May 2, 1996 as described in “Range and Training Regulations” MC Loading Rates: Pb = <100 lbs/yr (however recommend adjust higher); 31,500 rounds Range Maintenance: Resurface berm face top layer of lead embedded in the berm was removed and recycled-approximately 1/5yr			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3~5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1~5
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	-5
Surface Water Pathway Score			6~12

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14”/yr
Slope of Range: Berm = 2.5:1
Vegetation: Firing Lane = gravel, then concrete to target line; minimal sparse weeds & grass
Soil Type/Runoff Conditions: Hambright gravelly clay loam (HaG)
Runoff/Erosion Engineering Controls: Drainage channel along south side of range.

Table 3: Groundwater Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	1~5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	1~5
Groundwater Pathway Score			12~22
Notes: Depth to Groundwater: NOAA: 75’ Precipitation: INRMP report-14”/yr pH of Water: Field Data Report, Table 4-1 (7.32~8.40) pH of Soil: unknown Soil Type/Infiltration Conditions: HaG Clay Contents in Soil: HaG			

Small Arms Range Protocol Evaluation Forms

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1
Surface Water Receptor Score			4
Notes: Surface Water Body: Range 130, Bay 1 is located in the Santa Margarita Watershed Drinking Water Usage: ephemeral stream drains out of the Range 130 complex ultimately reaching the stream running through Aliso Canyon Sensitive Species Habitat and Threatened or Endangered Species: California Gnatcatcher			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	2
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	1
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1
Groundwater Receptor Score			4
Notes: Drinking water supply wells are located downgradient of the range Sensitive Species Habitat and Threatened or Endangered Species: California Gnatcatcher			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9~11
Surface Water Pathways	2	6~12
Surface Water Receptors	4	4
Sum of Surface Water Element Scores		**19~27**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9~11
Groundwater Pathways	3	12~22
Groundwater Receptors	5	4
Sum of Groundwater Element Scores		**25~37**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal**
Groundwater Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 130, Bay 2

Table 1: Range Use and Range Management (*Source*) Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	3
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	1~3
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			9~11
Notes: Duration of Range Use: Operational since May 2, 1996 as described in “Range and Training Regulations” MC Loading Rates: Pb = <100 lbs/yr (however recommend adjust higher); 31,500 rounds Range Maintenance: Resurface berm 1/5yr			

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3~5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1~5
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	0
Surface Water Pathway Score			11~17

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14”/yr
Slope of Range: Berm = 2:1
Vegetation: Firing Lane = gravel; minimal sparse weeds & grass
Soil Type/Runoff Conditions: Hambright gravelly clay loam (HaG)

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	1~5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	1~5
Groundwater Pathway Score			12~22

Notes:
Depth to Groundwater: NOAA: 75'
Precipitation: INRMP report-14"/yr
pH of Water: Field Data Report, Table 4-1 (7.32~8.40)
pH of Soil: unknown
Soil Type/Infiltration Conditions: HaG
Clay Contents in Soil: HaG

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1
Surface Water Receptor Score			4
Notes: Surface Water Body: Range 130, Bay 2 is located in the Santa Margarita Watershed Drinking Water Usage: ephemeral stream Sensitive Species Habitat and Threatened or Endangered Species: California Gnatcatcher			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	Evaluation Characteristics	Score Criteria	Site Score
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	2
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	1
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1
Groundwater Receptor Score			4
Notes: Drinking water supply wells are located downgradient of the range Sensitive Species Habitat and Threatened or Endangered Species: California Gnatcatcher			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9~11
Surface Water Pathways	2	11~17
Surface Water Receptors	4	4
Sum of Surface Water Element Scores		**24~32**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	9~11
Groundwater Pathways	3	12~22
Groundwater Receptors	5	4
Sum of Groundwater Element Scores		**25~37**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 206

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	3~5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			13~15

Notes:
Duration of Range Use: First identified on map in 1968
Bullet Capturing Technology: due to retrofit
MC Loading Rates: Pb = 965 lbs/yr (however recommend adjust higher >1000 lb); 174,000 rounds
Range Maintenance: Retrofit during the summer of 2007

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1~3
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	-5
Surface Water Pathway Score			8~10
Notes: pH of Water: Field Data Report, Table 4-3 (6.24-8.07) Precipitation: INRMP report = 14"/yr Slope of Range: Berm = 1.5:1 Vegetation: Firing Lane = sand; well vegetated with brush grass on top and behind berm Soil Type/Runoff Conditions: Las Flores loamy fine sand (LeE3) Runoff/Erosion Engineering Controls: shallow gully eroded ditch well-vegetated, unlined			

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Groundwater Pathway Score			16~22

Notes:
Depth to Groundwater: NOAA: 75'
Precipitation: INRMP report-14"/yr
pH of Water: Field Data Report, Table 4-1 (7.32~8.40)
pH of Soil: unknown
Soil Type/Infiltration Conditions: LeE3
Clay Contents in Soil: LeE3

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1~3
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1~5
Surface Water Receptor Score			4~10
Notes: Surface Water Body: Range 206 is located in the San Onofre Watershed Drinking Water Usage: ephemeral stream drains to San Onofre Creek Sensitive Species Habitat and Threatened or Endangered Species: none defined			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	5~10
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	3~5
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1~3
Groundwater Receptor Score			9~18
Notes: Drinking water supply wells are located downgradient of the range and analytical results show the presence of Pb, although the source of Pb is not known (Field Data Collection Results). Sensitive Species Habitat and Threatened or Endangered Species: none defined			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13~15
Surface Water Pathways	2	8~10
Surface Water Receptors	4	4~10
Sum of Surface Water Element Scores		**25~35**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13~15
Groundwater Pathways	3	16~22
Groundwater Receptors	5	9~18
Sum of Groundwater Element Scores		**38~55**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate/High**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 210C

Table 1: Range Use and Range Management (*Source)* Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			15
Notes: Duration of Range Use: First identified on map in 1971 MC Loading Rates: Pb = 1499 lbs/yr (estimate); 308,000 rounds Range Maintenance: no formal maintenance			

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	5
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	0
Surface Water Pathway Score			17
Notes: pH of Water: Field Data Report, Table 4-3 (6.24-8.07) Precipitation: INRMP report = 14"/yr Slope of Range: Berm = 2:1 Vegetation: Firing Lane = compact dirt; sparse grass; more brush SE of range Soil Type/Runoff Conditions: Altamont clay (AtC)			

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	1
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	1
Groundwater Pathway Score			12~14
Notes: Depth to Groundwater: NOAA: 75’ Precipitation: INRMP report-14”/yr pH of Water: Field Data Report, Table 4-1 (7.32~8.40) pH of Soil: unknown Soil Type/Infiltration Conditions: AtC Clay Contents in Soil: AtC			

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1~3
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1~5
Surface Water Receptor Score			4~10
Notes: Surface Water Body: Range 210C is located in the San Onofre Watershed Drinking Water Usage: ephemeral stream drains to San Onofre Creek Sensitive Species Habitat and Threatened or Endangered Species: Arroyo Toad; Stephens' Kangaroo Rat			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	5~10
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	3~5
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1~3
Groundwater Receptor Score			9~18
Notes: Drinking water supply wells are located downgradient of the range and analytical results show the presence of Pb, although the source of Pb is not known (Field Data Collection Results). Sensitive Species Habitat and Threatened or Endangered Species: Arroyo Toad; Stephens' Kangaroo Rat			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water Pathways	2	17
Surface Water Receptors	4	4~10
Sum of Surface Water Element Scores		**36~42**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	12~14
Groundwater Receptors	5	9~18
Sum of Groundwater Element Scores		**36~47**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 212A

Table 1: Range Use and Range Management (*Source*) Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			15
Notes: Duration of Range Use: first on map in 1971 Bullet Capturing Technology: due to no Range Maintenance MC Loading Rates: Pb = 2252 lbs/yr; 467,000 rounds Range Maintenance: none defined			

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3~5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	0
Surface Water Pathway Score			11~13

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14”/yr
Slope of Range: Berm = 2:1; 1.5:1
Vegetation: Firing Lane = compact sand & silt; dry brush & grass
Soil Type/Runoff Conditions: Terrace escarpment (TeF)

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
Groundwater Pathway Score			20~22
Notes: Depth to Groundwater: NOAA: 75’ Precipitation: INRMP report-14”/yr pH of Water: Field Data Report, Table 4-1 (7.32~8.40) pH of Soil: unknown Soil Type/Infiltration Conditions: TeF Clay Contents in Soil: TeF			

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1~3
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1~5
Surface Water Receptor Score			4~10
Notes: Surface Water Body: Range 212A is located in the San Onofre Watershed Drinking Water Usage: ephemeral riparian creek drains to San Onofre Creek Sensitive Species Habitat and Threatened or Endangered Species: Arroyo Toad; rare plants			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	5~10
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	3~5
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1~3
Groundwater Receptor Score			9~18
Notes: Drinking water supply wells are located downgradient of the range and analytical results show the presence of Pb, although the source of Pb is not known (Field Data Collection Results). Sensitive Species Habitat and Threatened or Endangered Species: Arroyo Toad; rare plants			

Table 6: Relative Environmental Concern Evaluation **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water Pathways	2	11~13
Surface Water Receptors	4	4~10
Sum of Surface Water Element Scores		**30~38**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	20~22
Groundwater Receptors	5	9~18
Sum of Groundwater Element Scores		**44~55**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate/High**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 213

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			15
Notes: Duration of Range Use: first on map in 1968 MC Loading Rates: Pb = 4788 lbs/yr; 348,000 rounds Range Maintenance: resurfaced 1/5yr			

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3~5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	0
Surface Water Pathway Score			11~13

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14"/yr
Slope of Range: Berm = 3:1; 2:1
Vegetation: Firing Lane = asphalt, dirt & gravel; sparse with/short grass and trees
Soil Type/Runoff Conditions: Steep gullied land (StG)

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	5
Groundwater Pathway Score			20~22

Notes:
Depth to Groundwater: NOAA: 75'
Precipitation: INRMP report-14"/yr
pH of Water: Field Data Report, Table 4-1 (7.32~8.40)
pH of Soil: unknown
Soil Type/Infiltration Conditions: StG
Clay Contents in Soil: StG

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1~3
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1~5
Surface Water Receptor Score			4~10
Notes: Surface Water Body: Range 213 is located in the San Onofre Watershed Drinking Water Usage: ephemeral riparian creek drains to San Onofre Creek Sensitive Species Habitat and Threatened or Endangered Species: rare plants			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	5~10
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	3~5
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1~3
Groundwater Receptor Score			9~18
Notes: Drinking water supply wells are located downgradient of the range and analytical results show the presence of Pb, although the source of Pb is not known (Field Data Collection Results). Sensitive Species Habitat and Threatened or Endangered Species: rare plants			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water Pathways	2	11~13
Surface Water Receptors	4	4~10
Sum of Surface Water Element Scores		**30~38**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	20~22
Groundwater Receptors	5	9~18
Sum of Groundwater Element Scores		**44~55**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate/High**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 214

Table 1: Range Use and Range Management (*Source*) Element **(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)**			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			15
Notes: Duration of Range Use: first identified on map in February 1, 1961 MC Loading Rates: Pb = 5715 lbs/yr; over 1.25 million rounds Range Maintenance: resurfaced 1/5yr			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	1~3
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1~3
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	(-10) ~(-5)
Surface Water Pathway Score			(-1)~8

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14"/yr
Slope of Range: Berm = 2:1; 1.5:1
Vegetation: Firing Lane = grass & dirt; sparse grass & brush
Soil Type/Runoff Conditions: Las Flores loamy fine sand (LeC); gullied land (StG)
Runoff/Erosion Engineering Controls: narrow channel; pond & infiltration into soil drainage pipe to stream

Table 3: Groundwater Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	1~5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3
Groundwater Pathway Score			14~20
Notes: Depth to Groundwater: NOAA: 75' Precipitation: INRMP report-14"/yr pH of Water: Field Data Report, Table 4-1 (7.32~8.40) pH of Soil: unknown Soil Type/Infiltration Conditions: LeC; StG Clay Contents in Soil: LeC; StG			

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	2
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	1~3
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	1~5
Surface Water Receptor Score			4~10
Notes: Surface Water Body: Range 214 is located in the San Onofre Watershed Drinking Water Usage: ephemeral stream drains into other streams that flow towards San Onofre Creek Sensitive Species Habitat and Threatened or Endangered Species: rare plants			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	5~10
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	3~5
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1~3
Groundwater Receptor Score			9~18
Notes: Drinking water supply wells are located downgradient of the range and analytical results show the presence of Pb, although the source of Pb is not known (Field Data Collection Results). Sensitive Species Habitat and Threatened or Endangered Species: rare plants			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water Pathways	2	(-1)~8
Surface Water Receptors	4	4~10
Sum of Surface Water Element Scores		**18~33**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	14~20
Groundwater Receptors	5	9~18
Sum of Groundwater Element Scores		**38~53**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Minimal/Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate/High**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Small Arms Range Protocol Evaluation Forms

Range 300

Table 1: Range Use and Range Management (*Source)* Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Duration of Range Use	Length of time the range has been used	5 if usage > 30 years 3 if usage is 10 to 30 years 1 if usage < 10 years	5
Bullet-Capturing Technology	The presence and duration of bullet-capturing technologies Compare the duration of the range use to the duration of bullet-capturing technologies.	If [range usage duration = bullet capture duration], then apply a **negative** score so that the [range usage duration + bullet capture duration] = 1 If [range usage duration – bullet capture duration] = 10 to 30 years, then apply a **negative** score so that the [range use duration + bullet capture duration] = 3 0 if [range usage duration – bullet capture duration] > 30 years	0
MC Loading Rates	The amount and types of small arms ammunition expended on the range Estimate the MC loading by using a time weighted average of MC loading rates	5 if MC loading > 1000 pounds/year 3 if MC loading = 100 to 1000 pounds/year 1 if MC loading < 100 pounds/year	5
Range Maintenance	Frequency of any range maintenance activities involving the removal of lead from the ranges	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
Source Element Score			15
Notes: Duration of Range Use: first identified on map in 1968 MC Loading Rates: Pb = 1872 lbs/yr; 360,000 rounds Range Maintenance: no formal maintenance			

Small Arms Range Protocol Evaluation Forms

Table 2: Surface Water Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥6.5	1
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Slope of Range	The amount of deviation from the horizontal for the berm / target area	5 if slope > 10% 3 if slope = 5% to 10% 1 if slope < 5%	5
Vegetation	Approximate vegetation cover within and directly downslope of the surface danger zone	5 if vegetation cover < 20% 3 if vegetation cover = 20% to 50% 1 if vegetation cover > 50%	3~5
Soil Type/Runoff Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is clay / silty clay 3 if soil type is clayey sand / silt 1 if soil type is sand/gravel	1~3
Runoff/ Erosion Engineering Controls	The presence of engineering controls or BMPs to modify or control surface water runoff and erosion Partial engineering controls include using erosion controls such as a proper groundcover or use of berms or backstops. Using a combination of multiple partial engineering controls may create an effective engineering control. Other effective engineering controls include bullet containment technologies.	0 if no engineering controls -5 if partial engineering controls -10 if effective engineering controls	-5
Surface Water Pathway Score			6~10

Notes:
pH of Water: Field Data Report, Table 4-3 (6.24-8.07)
Precipitation: INRMP report = 14"/yr
Slope of Range: Berm = 2:1; 1.5:1
Vegetation: Firing Lane = compacted dirt, sparse grass; vegetated mix of grass, brush & trees
Soil Type/Runoff Conditions: Terrace escarpments (TeF); Gaviota fine loamy sand (GaF)
Runoff/Erosion Engineering Controls: at the base of the berm- discontinuous line of wooden logs and sandbags.

Table 3: Groundwater Pathways Characteristics Element
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Criteria	Evaluation Characteristics	Score Criteria	Site Score
Depth to Groundwater	The potential for impact to the groundwater decreases with an increasing depth to the water table.	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	3~5
Precipitation	Intensity and frequency of precipitation	5 if precipitation > 40 inches/year 3 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
pH of Water	pH below 6.5 increases the rate of lead dissolution.	5 if pH < 6.5 1 if pH ≥ 6.5	1
pH of Soil	Lead tends to stay dissolved at pH conditions less than 6.5 and tends to attach to soil particles at pH conditions above 8.5.	5 if pH < 6.5 3 if 6.5 ≤ pH ≤ 8.5 1 if pH > 8.5	5
Soil Type/Infiltration Conditions	Soil with a higher porosity (sands/gravels) has more infiltration and less runoff compared to soil with low porosity (silts/clays).	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Clay Content in Soil	Amount of clay in the soil Lead attaches to clay soil more readily than any other soil types.	5 if soil type is sand/gravel 3 if soil type is clayey sand / silt 1 if soil type is clay / silty clay	3~5
Groundwater Pathway Score			16~22

Notes:
Depth to Groundwater: NOAA: 75’
Precipitation: INRMP report-14”/yr
pH of Water: Field Data Report, Table 4-1 (7.32~8.40)
pH of Soil: unknown
Soil Type/Infiltration Conditions: TeF; GaF
Clay Contents in Soil: TeF; GaF

Table 4: Surface Water Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Drinking Water Usage	Identify if nearby surface water bodies are used as a drinking water source.	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 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 2 if low possibility for contamination in the media to be present at or migrate to a point of exposure	5~10
Agricultural or Other Beneficial Usage	Identify if nearby surface water bodies are used as an agricultural or other beneficial use, such as recreational (excluding drinking water).	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 3 if contamination in the media has moved only slightly beyond the source (tens of feet) or could move but is not moving appreciably. 1 if low possibility for contamination in the media to be present at or migrate to a point of exposure	3~5
Sensitive Species Habitat and Threatened or Endangered Species	Identify if nearby surface water bodies are downgradient of or nearby any sensitive species habitat or threatened or endangered species.	10 if identified receptors have access to possibly contaminated media and/or are located adjacent to the range boundary 5 if potential for receptors to have access to possibly contaminated media 1 if little or no potential for receptors to have access to possible contaminated media	5
Surface Water Receptor Score			13~20
Notes: Surface Water Body: Range 300 is located in the San Mateo Watershed Drinking Water Usage: San Mateo Creek Sensitive Species Habitat and Threatened or Endangered Species: Arroyo Toad; Least Bell's Vireo; Southwestern Willow Flycatcher; California Gnatcatcher; rare plants			

Table 5: Groundwater Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Wells Identified as Potable Water Sources	Number and location of potable water or potable water supply wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 2 if low possibility for MC to be present at or migrate to within a reasonable radius of influence or point of exposure	5~10
Wells Identified for Agricultural or Other Beneficial Usage	Number and location of agricultural wells relative to the location of the range Evaluate well construction / radius of influence data and hydrogeologic setting to assess if wells are potential receptors.	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 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 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	3~5
Sensitive Species Habitat and Threatened and Endangered Species	Evaluate of groundwater discharge or usage near areas of sensitive species habitat or areas where threatened and endangered species are located within proximity of the range	5 if identified receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 3 if potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources 1 if little or no potential for receptors exposed to potentially MC-impacted water from groundwater or groundwater sources	1~3
Groundwater Receptor Score			9~18
Notes: Drinking water supply wells are located downgradient of the range. Sensitive Species Habitat and Threatened or Endangered Species: Arroyo Toad; Least Bell's Vireo; Southwestern Willow Flycatcher; California Gnatcatcher; rare plants			

Table 6: Relative Environmental Concern Evaluation (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)		
Surface Water		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Surface Water Pathways	2	6~10
Surface Water Receptors	4	13~20
Sum of Surface Water Element Scores		**34~45**
Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	15
Groundwater Pathways	3	16~22
Groundwater Receptors	5	9~18
Sum of Groundwater Element Scores		**40~55**
The relative environmental concern evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media: Environmental Concern Evaluation Ranking* — Score Range High — 50-65 Moderate — 30-49 Minimal — 0-29 *Use the Environmental Concern Evaluation Ranking to determine if further actions are warranted based on the guidelines for recommended actions, as defined in Table 7.		
Surface Water Environmental Concern Evaluation Ranking		**Moderate**
Groundwater Environmental Concern Evaluation Ranking		**Moderate/High**
Notes:		

Table 7: Guidelines for Recommended Actions	
Environmental Concern Evaluation Ranking	**Recommended Action**
High	Action required. 1) Sample appropriate media (groundwater, surface water, and/or soil). 2) Implement BMPs.
Moderate	1) Implement BMPs. 2) Consider sampling appropriate media (groundwater, surface water, and/or soil).
Minimal	1) No further action needed. 2) Consider implementing BMPs.

Appendix B
Current Range and Munitions Use Subcommittee (RMUS) Screening Values (2009)

Operational Range Assessment Screening Value Tables

Table 1 - Human Drinking Water Values

MC	CAS #	Screening Value Value (µg/L)	Screening Value Source
Antimony	7440-36-0	15	EPA RSL Table[a]
Arsenic	7440-38-2	0.045	EPA RSL Table[a]
Barium	7440-39-3	7300	EPA RSL Table[a]
Cadmium	7440-43-9	18	EPA RSL Table[a]
Chromium[1]	7440-47-3	110	EPA RSL Table[a]
Copper	7440-50-8	1500	EPA RSL Table[a]
Lead	7439-92-1	15	Region 6[b]
Manganese	7439-96-5	880	EPA RSL Table[a]
Mercury[2]	7487-94-7	0.63	EPA RSL Table[a]
Molybdenum	7439-98-7	180	EPA RSL Table[a]
Nickel	7440-02-0	730	EPA RSL Table[a]
Silver	7440-22-4	180	EPA RSL Table[a]
Vanadium	7440-62-2	180	EPA RSL Table[a]
Zinc	7440-66-6	11000	EPA RSL Table[a]
HMX	2691-41-0	1800	EPA RSL Table[a]
RDX	121-82-4	0.61	EPA RSL Table[a]
TNT	118-96-7	2.2	EPA RSL Table[a]
1,3,5-TNB	99-35-4	1100	EPA RSL Table[a]
1,3-DNB	99-65-0	3.7	EPA RSL Table[a]
tetryl	479-45-8	150	EPA RSL Table[a]
NB	98-95-3	3.4	EPA RSL Table[a]
2A-4,6-DNT	35572-78-2	73	EPA RSL Table[a]
4A-2,6-DNT	1946-51-0	73	EPA RSL Table[a]
DNT-mixture 2,4/2,6	25321-14-6	.099	EPA RSL Table[a]
2,6-DNT	606-20-2	37	EPA RSL Table[a]
2,4-DNT	121-14-2	73	EPA RSL Table[a]
2-NT (o-)	88-72-2	370	EPA RSL Table[a]
3-NT (m-)	99-08-1	122	Region 6[b]
4-NT (p-)	99-99-0	4.2	EPA RSL Table[a]
Nitroglycerin	55-63-0	3.7	EPA RSL Table[a]
PETN	78-11-5	NA	
Perchlorate	14797-73-0	15	DoD[c]

Notes:
These values are "default" values. Local standards may be more stringent and take precedence.
NA – Not Available (Screening levels were not developed due to the lack of scientific data on the specific constituents.
1 - Screening value is for Total Chromium
2 - Screening value is for Elemental Mercury
Sources:
a - EPA Regional Screening Levels (RSL) table – From "Regional Screening Levels for Chemical Contaminants at Superfund Sites" which is an update for Region 3 RBCs, Region 6 MSSLs, and Region 9 PRGs. From: http://epa-prgs.ornl.gov/chemicals/index.shtml (23 June 2008)
b - Region 6 – Region 6 MSSL Values
c - DoD – The Department of Defense has established a screening value for perchlorate of 15 ppb.

Table 2 – Ecological Freshwater Surface Water System Values

		Freshwater Surface Water		Freshwater Sediment	
MC	**CAS #**	**Value (µg/L)**	**Source**	**Value (mg/kg)**	**Source**
Antimony	7440-36-0	30	EPA Region 3[a]	12	EPA Region 4[d]
Arsenic	7440-38-2	150	EPA NRWQC[2,b]	8.2	EPA OSWER[*,c]
Barium	7440-39-3	3.9	EPA OSWER[c]	20	EPA Region 6[f]
Cadmium	7440-43-9	0.25	EPA NRWQC[2,3,b]	1.2	EPA OSWER[c]
Chromium (VI)	7440-47-3	11	EPA NRWQC[2,b]	81	EPA OSWER[c]
Copper	7440-50-8	9	EPA NRWQC[2,3,b]	34	EPA OSWER[c]
Lead	7439-92-1	2.5	EPA NRWQC[2,3,b]	47	EPA OSWER[c]
Manganese	7439-96-5	80	EPA OSWER[c]	460	Ontario Guidelines[i]
Mercury	22967-92-6	0.77	EPA NRWQC[2,b]	0.15	EPA OSWER[c]
Molybdenum	7439-98-7	240	EPA OSWER[c]	4	D.D.MacDonald et al., 1994[g]
Nickel	7440-02-0	52	EPA NRWQC[2,3,b]	21	EPA OSWER[c]
Silver	7440-22-4	3.2	EPA NRWQC[2,3,b]	2	EPA Region 4[d]
Vanadium	7440-62-2	19	EPA OSWER[c]	50	NOAA Screening Tables[h]
Zinc	7440-66-6	120	EPA NRWQC[2,3,b]	150	EPA OSWER[c]
HMX	2691-41-0	150	EPA Region 3[a]	.0047-.47	EPA Region 4[1,d]
RDX	121-82-4	190	EPA Region 4[d]	.013-1.3	EPA Region 4[1,d]
TNT	118-96-7	90	EPA Region 4[d]	.092-9.2	EPA Region 4[1,d]
1,3,5-TNB	99-35-4	11	EPA Region 4[d]	.0024-.24	EPA Region 4[1,d]
1,3-DNB	99-65-0	20	EPA Region 4[d]	.0067-.67	EPA Region 4[1,d]
tetryl	479-45-8	NA		53.4	Nipper et al., 2002[j] (fine grain sediment)
NB	98-95-3	270	EPA Region 4[d]	0.488	EPA Region 4[d]
2A-4,6-DNT	35572-78-2	20	EPA Region 4[d]	NA	
4A-2,6-DNT	1946-51-0	NA		NA	
2,6-DNT	606-20-2	42	EPA Region 4[d]	0.0206	EPA Region 4[d]
2,4-DNT	121-14-2	44	EPA Region 3[a]	0.0751	EPA Region 4[d]
2-NT (o-)	88-72-2	NA		NA	
3-NT (m-)	99-08-1	750	EPA Region 3[a]	NA	
4-NT (p-)	99-99-0	1900	EPA Region 3[a]	NA	
Nitroglycerin	55-63-0	138	EPA Region 3[a]	NA	
PETN	78-11-5	85000	EPA Region 3[4,a]	NA	
Perchlorate	14797-73-0	9300	Dean et al.[e]	NA	

Notes:

NA – Not Available (Screening levels were not developed due to the lack of scientific data on the specific constituents.

* - Arsenic values for sediment will be compared to background sampling data, if available. The range will not be considered a source of MC migration when the sampling results are less than or equivalent to background concentrations.

1 - These values are dependent on the sediment TOC. The lower bound is for 1% TOC. Upper bound is for 100% TOC. To determine the site specific value, multiply the % TOC by the lower bound. E.g. for TNT in sediment w/ 5% TOC it would be: 0.46 (5*0.092=0.46)

2 - Value applies to dissolved metals

3 - The value is dependent on the hardness of the water, provided value is for a water hardness of 100 mg/L as CaCO3.

4 – For PETN, EPA Region III values came from TNRCC 2001 & 2000, which are documented sources k & l below.

Sources:

a - EPA Region 3, Ecological Risk Assessment Freshwater Screening Benchmarks, March 2007

b - EPA, Office of Water, Office of Science and Technology (4304T), National Recommended Water Quality Criteria, 2006.

c - EPA Office of Solid Waste and Emergency Response Ecotox Thresholds, January 1996

d - EPA Region 4, Ecological Risk Assessment Bulletins – Supplement to RAGS (EPA 2001)
e - Dean, K.E., R.M. Palachek, J.L. Noel, R. Warbritton, J. Aufderheide, and J. Wireman. 2004. Development of Freshwater Water-Quality Criteria for Perchlorate. Environmental Toxicology and Chemistry 23(6):1441-1451.
f - EPA Region 6, Screening Level Ecological Risk Assessment Protocol, Aug 1999.
g – A Review of Environmental Quality Criteria and Guidelines for Priority substances in the Fraser River Basin, Prepared by D.D. MacDonald, MacDonald Environmental Sciences Limited, March 1994
h - NOAA Screening Quick Reference Tables, NOAA HAZMAT Report 99-1, Seattle WA, Coastal Protection and Restoration Division, National Oceanic and Atmospheric Administration, 12 pages. Buchman, M.F., 1999.
i - Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario. Persaud, D., R. Jaagumagi, and A. Hayton. 1993.
j - Nipper, M., R.S. Carr, J.M. Biedenbach, R.L. Hooten, and K. Miller. 2002. Toxicological and Chemical Assessment of Ordnance Compounds in Marine Sediments and Porewaters. Marine Pollution Bulletin, 44: 789-806.
k - TNRCC 2001 Guidance for Conducting Ecological Risk Assessment and Remediation Sites in Texas, Toxicology and Risk Assessment Section, December.
l - TNRCC 2000 Texas Surface water Quality Standards, Texas Administrative Code, Title 30, Chapter 307, Effective 17, 2000.

Table 3 – Ecological Marine Surface Water System Values

		Marine Surface Water		Marine Sediment	
MC	**CAS #**	**Value (µg/L)**	**Source**	**Value (mg/kg)**	**Source**
Antimony	7440-36-0	30	Suter and Tsao, 1996[e]	2	NOAA 1990[g]
Arsenic	7440-38-2	36	USEPA, 2004[b]	7.24	MacDonald et al., 2000[*,h]
Barium	7440-39-3	4	Suter and Tsao, 1996[e]	NA	
Cadmium	7440-43-9	8.8	USEPA, 2004[b]	0.68	MacDonald et al., 2000[h]
Chromium (VI)	7440-47-3	50	USEPA, 2004[b]	52.3	MacDonald et al., 2000[h]
Copper	7440-50-8	3.1	USEPA, 2004[b]	18.7	MacDonald et al., 2000[h]
Lead	7439-92-1	8.1	USEPA, 2004[b]	30.2	MacDonald et al., 2000[h]
Manganese	7439-96-5	120	Suter and Tsao, 1996[e]	460	Ontario Guidelines[i]
Mercury	22967-92-6	0.94	USEPA, 2004[b]	0.14	
Molybdenum	7439-98-7	370	Suter and Tsao, 1996[e]	NA	
Nickel	7440-02-0	8.2	USEPA, 2004[b]	15.9	MacDonald et al., 2000[h]
Silver	7440-22-4	1.9	USEPA, 2004[b]	0.73	MacDonald et al., 2000[h]
Vanadium	7440-62-2	20	Suter and Tsao, 1996[e]	NA	
Zinc	7440-66-6	81	USEPA, 2004[b]	124	MacDonald et al., 2000[h]
HMX	2691-41-0	330	Talmage et al., 1999[o]	.0047-.47	EPA Region 4[1,a]
RDX	121-82-4	5000	Nipper et al., 2001[k]	.013-1.3	EPA Region 4[1,a]
TNT	118-96-7	180	Nipper et al., 2001[k]	.092-9.2	EPA Region 4[1,a]
1,3,5-TNB	99-35-4	25	Nipper et al., 2001[k]	.0024-.24	EPA Region 4[1,a]
1,3-DNB	99-65-0	180	Nipper et al., 2001[k]	.0067-.67	EPA Region 4[1,a]
tetryl	479-45-8			53.4	Nipper et al., 2002[l] (fine grain sediment)
NB	98-95-3	66.8	USEPA, 2002[c]	27	Talmage and Opresko, 1995[j]
2A-4,6-DNT	35572-78-2	1480	TNRCC, 2001[m] and TNRCC, 2000[n]	NA	
4A-2,6-DNT	1946-51-0	NA	NA	NA	
2,6-DNT	606-20-2	1000	Nipper et al., 2001[k]	0.55	Nipper et al., 2002[l]
2,4-DNT	121-14-2	480	Nipper et al., 2001[k]	0.23	Talmage and Opresko, 1995[j]
2-NT (o-)	88-72-2	NA	NA	NA	
3-NT (m-)	99-08-1	NA	NA	NA	
4-NT (p-)	99-99-0	NA	NA	NA	
Nitroglycerin	55-63-0	138	TNRCC, 2001[m] and TNRCC, 2000[n]	NA	
PETN	78-11-5	85000	EPA Region 3[2,d]	NA	
Perchlorate	14797-73-0	9300	Dean et al., 2004[f]	NA	

Notes:
NA – Not Available (Screening levels were not developed due to the lack of scientific data on the specific constituents.
* - Arsenic values for sediment will be compared to background sampling data, if available. The range will not be considered

a source of MC migration when the sampling results are less than or equivalent to background concentrations.

1 - These values are dependent on the sediment TOC. The lower bound is for 1% TOC. Upper bound is for 100% TOC. To determine the site specific value, multiply the % TOC by the lower bound. (e.g. for TNT in sediment w/ 5% TOC it would be: 0.46)(5*0.092=0.46)
2 - EPA Region III for PETN marine water refers to US EPA Region 3's Freshwater Screening Benchmark table for a value. These values came from TNRCC 2001 & 2000, which are documented sources m & n below.

Sources:
a - EPA Region 4, Ecological Risk Assessment Bulletins - Supplement to RAGS (EPA 2001)
b – EPA – USEPA 2004 National Recommended Water Quality Criteria Office of Water and Office of Science and Technology.
c – EPA – USEPA 2002 Ecological Risk Assessment Bulletin 2/11/2002. Waste Management Division, Freshwater Surface Screening Values for Hazardous Waste Sites, February.
d - EPA Region 3, Ecological Risk Assessment Freshwater Screening Benchmarks, March 2007
e – Suter and Tsao, 1996 Toxicological Benchmarks for Screening Potential Contaminants of Concern for Effects on Aquatic Biota: 196 Revision. ES/ER/Tm-96/R2.
f – Dean, K.E., R.M. Palachek, J.L. Noel, R. Warbritton, J. Aufderheide, and J. Wireman. 2004. Development of Freshwater Water-Quality Criteria for Perchlorate. Environmental Toxicology and Chemistry 23(6):1441-1451.
g - The potential for biological effects of sediment-sorbed contaminants tested in the national status and trends program. NOAA Technical Memorandum NOS OMA 52. Long, E.R. and L.G. Morgan. 1990.
h - MacDonald, D.D., C.G. Ingersoll, and T.A. Berger. 2000. Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems. Archives of Environmental Contamination and Toxicology, 39: 20-31.
i - Guidelines for the protection and management of aquatic sediment quality in Ontario. Ontario Ministry of the Environment. Queen's Printer of Ontario. Persaud, D., R. Jaagumagi, and A. Hayton. 1993.
j - Talmage, S.S., and D.M. Opresko. 1995. Draft Ecological Criteria Documents for Explosives, Oak Ridge National Laboratory, Oak Ridge, Tennessee.
k – Nipper, M., R.S. Carr, J.M. Biedenbach, R.L. Hooten, K. Miller, and S. Saepoff, 2001. Development of Marine Toxicity Data for Ordnance Compounds, Archives of Environmental Contamination and Toxicology, 41:308-31.
l - Nipper, M., R.S. Carr, J.M. Biedenbach, R.L. Hooten, and K. Miller. 2002. Toxicological and Chemical Assessment of Ordnance Compounds in Marine Sediments and Porewaters. Marine Pollution Bulletin, 44: 789-806.
m – TNRCC 2001 Guidance for Conducting Ecological Risk Assessment and Remediation Sites in Texas, Toxicology and Risk Assessment Section, December.
n – TNRCC 2000 Texas Surface water Quality Standards, Texas Administrative Code, Title 30, Chapter 307, Effective 17, 2000.
o – Talmage, S.S., D.M. Opresko, C.J. Maxwell, J.E. Welsh, M. Cretelia, P.H. Reno, and F.B. Daniel. 1999. Nitroaromatic munition compounds: Environmental effects and screening values. Reviews in Environmental Contamination and Toxicology, 161: 1-156.