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Range Environmental Vulnerability Assessment Five-Year Review

Marine Corps Air Station Yuma

August 2015

Appendices

Acronym	Definition
AFA	Artillery Firing Area
bgs	below ground surface
BMGR	Barry M. Goldwater Range
CMAGR	Chocolate Mountains Aerial Gunnery Range
CSM	Conceptual Site Model
CSOC	Convoy Security Operations Course
DNT	2,4-dinitrotoluene
DoD	Department of Defense
DoDI	Department of Defense Instruction
DoDIC	Department of Defense Identification Code
DON	Department of Navy
EOD	Explosive Ordnance Disposal
FY	Fiscal Year
HE	High Explosive
HMX	Cyclotetramethylene Tetranitramine
HQMC	Headquarters Marine Corps
ICM	Improved Conventional Munition
INRMP	Integrated Natural Resources Management Plan
KD	known distance
lbs	pounds
$m^3/m^2/yr$	cubic meters per square meters per year
MC	Munitions Constituents
MCAS	Marine Corps Air Station
MDL	method detection limit
MFA	Mortar Firing Area
MGD	million gallons per day
MLT	Moving Land Target
MIDAS	Munitions Items Disposition Action System
MOUT	Military Operations in Urban Terrain
MP	Mortar Position
ORC	Operational Range Clearance
PETN	Pentaerythritol tetranitrate
RDX	Cyclotrimethylene Trinitramine
REVA	Range Environmental Vulnerability Assessment
RFMSS	Range Facility Management Scheduling System
SAR	Small Arms Range
SARAP	Small Arms Range Assessment Protocol
SEAL	Sea, Air, Land
SDZ	Surface Danger Zone
SWAT	Special Warfare Training Area
TNT	Trinitrotoluene
U.S.	United States

Acronyms and Abbreviations

UTC	Urban Training Complex
UXO	Unexploded Ordnance
µg/L	micrograms per liter

Executive Summary

Introduction

The United States (U.S.) Marine Corps (Marine Corps) Range Environmental Vulnerability Assessment (REVA) program meets the requirements of the Department of Defense (DoD) Instruction 4715.14 *Operational Range Assessments*. (2005). This report presents the 5-year review for Marine Corps Air Station (MCAS) Yuma and documents the review of munitions loading from fiscal years 2007 through 2013, referred to as the five-year review period.

The REVA program is a proactive and comprehensive program designed to support the Marine Corps' Range Sustainment Program. Operational ranges across the Marine Corps are assessed to identify areas and activities that are subject to possible impacts from external influences, as well as to determine whether a release or substantial threat of a release of munitions constituents (MC) from operational ranges to off-range areas creates an unacceptable risk to human health or the environment. This is accomplished through periodic assessments of operational range areas and, where applicable, the use of fate and transport modeling and analysis of the REVA indicator MC based on site-specific environmental conditions at the operational ranges and training areas. Sampling may be conducted based on results of the assessments. REVA indicator MC are evaluated to determine the potential for an off-range release of MC. These MC were selected because they are common constituents used in a wide variety of military munitions and because of their chemical stability in the environment. The indicator MC include cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), trinitrotoluene (TNT), perchlorate, and lead. HMX, RDX, TNT, and perchlorate are evaluated at ranges where high explosives (HE) are used, while lead is evaluated at small arms ranges (SARs).

Marine Corps Air Station (MCAS) Yuma is located in southwestern Arizona and southeastern California. Training ranges at MCAS Yuma are located in three primary range complexes: Barry M. Goldwater Range (BMGR) West (also known as 2301W), the Chocolate Mountain Aerial Gunnery Range (CMAGR) North (also known as 2507N), and CMAGR South (also known as 2507S). BMGR West is located in Yuma County, Arizona, and includes 692,816 acres. The CMAGR is located in Riverside and Imperial Counties, California, and includes approximately 228,465 acres of withdrawn federal public land and 229,903 acres of federal land (Department of the Navy [DON,], 2013). In addition to the U.S. Marine Corps, the ranges support training of U.S. Navy, U.S. Air Force, U.S. Army, U.S. Reserve Components, and U.S. National Guard personnel.

Summary of Areas Assessed

The REVA five-year review installation visit occurred in January 2014; at that time, training range areas identified included 32 aerial targets, 11 artillery firing areas (AFAs), 4 mortar positions (MPs), 31 fixed HE ranges, and 9 SARs. Fifteen of the fixed ranges located in CMAGR North are live-fire military operations in urban terrain (MOUT) facilities.

MC loading areas are identified in REVA to describe where the majority of MC is deposited during training missions on a range or training area. These areas may encompass an entire range, target area, or a

portion of the range area. During this five-year review period, 56 MC loading areas were identified at MCAS Yuma, as listed in **Table ES-1.**

Table ES-1: MC Loading Areas at MCAS Yuma

MC Loading Areas			
BMGR West	CMAGR North		CMAGR South
Cactus West - Target	S-4-1	S-5-2	1S
Cactus West - Strafe Berm	S-4-2	S-5-3	2S
CSOC1	S-4-3	1N	3S
CSOC2	S-4-4	2N	4S
Murrayville East	S-4-8	3N	5S
Murrayville West	S-4-10	6N	6S
Panel Stager	S-4-11A/S-4-11B	7N	7S
Yodaville – UTC	S-4-12A/S-4-12B	8N	8S
Yodaville – MLT[1]	S-4-13	9N	10S
	S-4-14	10N	11S
	S-4-15	11N	12S
	S-4-17	12N	13S
	S-4-19	13N	14S
	S-4-21	14N	15S
	S-4-22	15N	Mt. Barrow
	S-4-23	ICM Box	

Note:
CSOC = convoy security operations course
ICM = Improved Conventional Munitions
MLT = moving land target
UTC = urban training complex
1. The boundary of the Yodaville – MLT MC loading area includes the strafe berm located adjacent to the MLT.

Nine SARs were qualitatively evaluated in this five-year review, as presented in **Table ES-2**.

Table ES-2: SARs at MCAS Yuma

MC Loading Areas	
BMGR West	CMAGR North
Known Distance (KD) Pistol Range	S-4-5
KD Rifle Range	S-4-6A
Range 1	S-4-6B
Range 1A	S-4-7
	S-4-9

Average annual MC loading (mass per area per year) was estimated for TNT, RDX, HMX, and perchlorate for each MC loading area using expenditure data recorded at the installation. Annual lead deposition (mass per year) was estimated for each MC loading area and SAR. These estimates were used in screening-level assessments to determine potential fate and transport of MC in surface water, sediment, and groundwater. Lead deposition estimates were used in the qualitative evaluation of SARs.

Screening-Level Assessment Results

Screening-level fate and transport assessments were conducted for the 56 identified MC loading areas at MCAS Yuma to determine conservative estimates of MC concentrations in surface water, sediment, and groundwater at identified downgradient potential off-range receptor locations.

Surface Water and Sediment

The nine MC loading areas assessed at BMGR West are within the Yuma desert watershed. Surface drainage from the MC loading areas flows west toward the installation boundary; however, drainages are discontinuous and do not have a downstream connection to any large water bodies. The downgradient ecological receptor location for these MC loading areas was considered the installation boundary. Although ephemeral streams within the installation could be infrequently used by ecological receptors, the installation boundary was used to predict potential off-installation releases.

The 47 MC loading areas assessed at the CMAGR drain within several watersheds with ephemeral streams and washes where heavy rainfall events can produce flash floods capable of moving large volumes of sediment. All ephemeral washes within the CMAGR all flow off the installation boundary where they can potentially impact off-site receptors. The washes within CMAGR North ultimately discharge into the Salton Sea. At the installation boundary of CMAGR North, the ephemeral washes are hydraulically separated from the Coachella Canal by a series of siphons that allow surface water runoff bypass the canal. These siphons were identified as potential downstream ecological receptor locations and endpoints of the screening-level assessments in CMAGR North. In CMAGR South, Milpitas Wash receives drainage from the MC loading areas and ultimately drains to the Colorado River. Milpitas Wash at the installation boundary was identified as the potential downstream receptor location and endpoint of the screening-level assessment in CMAGR South. Although ephemeral streams within the installation could be infrequently used by ecological receptors, the installation boundary was used to predict potential releases.

Two MC loading areas within CMAGR North (10N and 11N) drain to the Tadlock Guzzler, which is an artificial open water source that collects water from the small upstream wash and is used to support the on-range wildlife population. This guzzler was identified as a downstream receptor location point and endpoint for the screening-level assessment.

The screening-level assessment predicted all sediment concentrations to be below detectable concentrations at the off-range downgradient potential receptor locations at the installation boundary.

However, results of the surface water modeling demonstrated estimated detectable concentrations of REVA MC (explosives and/or perchlorate) at the receptor locations in Tadlock Guzzler, Iris Wash, Siphon 9 and Siphon 11 in CMAGR North; and the Milpitas Wash receptor point in CMAGR South. Surface water sampling was recommended for Iris Wash, Siphon 11, Siphon 9, Tadlock Guzzler, and Milpitas Wash based on model-predicted detectable concentrations at these locations. Additional evaluation of the other watershed receptor locations was not warranted during this periodic review; however, the contributing loading areas to these locations will be reevaluated in the next periodic review.

Groundwater

Groundwater depth within BMGR West was measured at 200 feet below ground surface (bgs) in 2014. Groundwater flows to the south and southeast toward the United States–Mexico border and away from Yuma and adjacent populated and agricultural areas. Groundwater recharge is extremely limited because of low precipitation rates (approximately 3-inches per year), high evaporation rates, and the large depth to groundwater. Recharge is further limited in the broad, flat, sandy lowland areas where range areas are located because of the high average temperatures and low rainfall. No known drinking water wells exist downgradient of the range areas at BMGR West. There is one supply well identified downgradient of MC loading areas at BMGR West, which was used as the receptor location for the screening-level assessments.

Active water supply wells are not present at the CMAGR, and groundwater resources within CMAGR are extremely limited. Little rainfall (approximately 3- inches per year) and rapid runoff results in minimal groundwater recharge. The California Department of Water Resources classifies the bedrock in this area as non-water-bearing. Saturated zone modeling was not conducted at CMAGR North because potential downgradient receptors were not identified. Two wells at CMAGR South are hydraulically downgradient of target areas. Information on the nature and status of these wells was not available, but installation personnel indicated that groundwater near CMAGR is not used as a potable source. These two wells were conservatively identified as human receptor locations for the screening-level assessments.

Of the REVA MC modeled in the groundwater pathway, only perchlorate was predicted to reach groundwater wells at detectable, but very low, concentrations at both BMGR West and CMAGR South. The model estimated it would take over 100 years to migrate to the groundwater wells because of the low infiltration rate and depth to groundwater. This evaluation is considered highly conservatives because the modeling did not account for the potential impedance of perchlorate by discontinuous clay layers in the subsurface. These factors demonstrate it would be unlikely to detect perchlorate in groundwater wells and based on this analysis, no additional evaluations were required during this periodic review. The contributing areas will be reevaluated at the next periodic review to ensure continued protectiveness of the groundwater aquifer.

Small Arms Range Assessments

Nine SARs were identified at the installation, and a qualitative evaluation of each SAR was based on the following factors:

- Range use

- Range design and layout
- Physical and chemical characteristics of the area
- Past and present operation and maintenance practices
- Lead migration pathways and receptors (groundwater, surface water, and sediment)

An overall ranking of minimal, moderate, or high was determined for the surface water and groundwater migration pathways based on a scoring of these factors. A high ranking indicates the greatest potential for lead migration and receptor impact. Results of the SAR evaluations are provided in **Table ES- 3**. The SARs at CMAGR North have the greatest potential for migration of lead through surface water and sediment. A moderate result indicates that the existing range is not expected to currently be impacting human health and the environment; however, the range could be evaluated for implementation of best management practices to prevent future impacts. No additional action is required at the SARs during this periodic review. The areas will be reevaluated in the next periodic review to ensure protectiveness of surface water, sediment, and groundwater receptors.

Table ES-3: Summary of SARAP Results

SAR	Surface Water / Sediment Ranking (Score)	Groundwater Ranking (Score)
KD Rifle Range	Minimal	Minimal
KD Pistol Range	Minimal	Minimal
Range 1	Minimal	Minimal
Range 1A	Minimal	Minimal
S-4-5	Moderate	Minimal
S-4-6A	Moderate	Minimal
S-4-6B	Moderate	Minimal
S-4-7	Moderate	Minimal
S-4-9	Moderate	Minimal

Field Sampling

Field sampling of surface water using passive samplers was completed in September 2014 as part of the five-year review at CMAGR South and in March 2015 at CMAGR North. The receptor locations recommended for surface water sampling based on predicted detectable MC concentrations in the screening assessments were Tadlock Guzzler, Milpitas Wash, Iris Wash, Siphon 9, and Siphon 11. A sample could not be collected at Tadlock Guzzler because the guzzler was filled with sediment and contained no water. The guzzler was unusable as a wildlife drinking water source. Passive samplers were

placed in August and September 2014 at the CMAGR South and North, respectively, to collect surface water runoff during a storm event; samplers were then retrieved after the storm event. Multiple samplers were placed in each receptor location as the precise location of drainage channels during rain events could not be predicted; multiple samplers increased the likelihood of capturing runoff.

Six locations were selected in drainage channels of Milpitas Wash for samples to be collected and analyzed for explosives. Three locations were selected within each of the siphons at Iris Wash, Siphon 9, and Siphon 11. These samples were to be analyzed for perchlorate, total lead, dissolved lead, and hardness. Samples from Siphon 9 and 11 were also to be analyzed for explosives. Analytical results were compared to DoD screening values.

CMAGR South received approximately 0.50 inches of rainfall on September 10, 2014. Samples were retrieved from six samplers and one duplicate sampler on September 11, 2014, and analyzed for explosives. CMAGR North received approximately 0.21 inches of rainfall on 1 March 2015. Samples were retrieved on 4 March 2015; however, sufficient volume was not collected for explosives analysis, and therefore, only total lead, dissolved lead, perchlorate, and hardness were analyzed.

Explosives analysis of all samples in Milpitas Wash yielded only one detection of 2,4-dinitrotoluene at an estimated concentration of 0.58 micrograms per liter (µg/L) (result from confirmation analysis of this sample was 1.0 µg/L). This concentration is two orders of magnitude below the DoD freshwater ecological screening value of 44 µg/L. The SW-04 location potentially receives the greatest influence from the ranges when compared to the other sample locations because a number of channels aggregate near and flow through that location before dispersing downgradient. Explosives were not detected in the sample collected downgradient of sample SW-04. Sample results indicate that there is not a release of MC from CMAGR South in Milpitas Wash, and no potential threat to human health or the environment exists.

Total and dissolved lead and perchlorate were detected in the three siphons sampled in CMAGR North. Total lead concentrations ranged from 1.7 to 14 µg/L; dissolved lead ranged from 0.24 to 0.35 µg/L; and perchlorate ranged from 0.34 to 0.82 µg/L. Dissolved lead and perchlorate concentrations were well below DoD screening values, and total lead DoD screening values have not been established. Explosives were recommended for analysis in Siphons 9 and 11, but sample volume was not sufficient for analysis and therefore, conclusions cannot be made about the presence of explosives in surface water runoff. The concentrations detected do not indicate an immediate concern to human health or the environment.

Summary

Surface water, sediment, and groundwater assessments including field sampling did not indicate off-installation releases of MC from operational ranges at MCAS Yuma. An imminent threat to human health or the environment is not indicated by this review. Monitoring efforts will be conducted as needed, and a full re-evaluation of all operational ranges will be conducted in the REVA periodic review cycle.

1. Introduction

1.1 Purpose

The United States (U.S.) 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* (2004) and DoD Instruction (DoDI) 4715.14 *Operational Range Assessments* (2005).

The REVA program is a proactive and comprehensive program designed to support the Marine Corps' Range Sustainment Program. Operational ranges across the Marine Corps are being assessed to identify areas and activities that are subject to possible impacts from external influences, as well as to determine whether a release or substantial threat of a release of munitions constituents (MC) from operational ranges to off-range areas creates an unacceptable risk to human health and/or the environment. This is accomplished through periodic assessments of operational range areas and, where applicable, the use of fate and transport modeling and analysis of the REVA indicator MC based on site-specific environmental conditions at the operational ranges and training areas.

This report presents the five-year review assessment for Marine Corps Air Station (MCAS) Yuma, located in southwestern Arizona and southeastern California. This report serves as the review assessment documenting the period of munitions loading from fiscal year (FY) 2007 through FY 2013. The results of the prior REVA assessment are provided in *Range Environmental Vulnerability Assessment Marine Corps Air Station Yuma* (Malcolm Pirnie [MP], 2008).

1.2 Scope and Applicability

The scope of the REVA program includes Marine Corps operational ranges located within the United States and overseas. Operational ranges (as defined in 10 United States Code 101 (e)(3)) include, but are not limited to, fixed ranges, live-fire maneuver areas, small arms ranges (SARs), buffer areas, and training areas where military munitions are known or suspected currently to be or historically to have been used.

The indicator MC evaluated in the REVA program include cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), trinitrotoluene (TNT), perchlorate, and lead. Studies have shown that HMX, RDX, and TNT are detected in a high percentage of samples containing MC because they are common high explosives (HE) used in a wide variety of military munitions and because of their chemical stability within the environment. Perchlorate is a component of the solid propellants used in some military munitions. Perchlorate also is considered an indicator MC because its high solubility, low sorption potential, and low natural degradation rate make the compound highly mobile in the environment. Lead is the most prevalent (by weight) potentially hazardous constituent in small arms ammunition and is used as an indicator to identify potential impacts of training related to small arms usage. Additional information pertaining to the physical and chemical characteristics of the REVA indicator compounds is provided in the *REVA Reference Manual* (Headquarters Marine Corps [HQMC], 2009).

1.3 Installation Overview

Marine Corps Air Station (MCAS) Yuma is located in southwestern Arizona and southeastern California (**Figure 1-1**). Training ranges at MCAS Yuma are located in three primary range complexes: Barry M. Goldwater Range (BMGR) West (also known as 2301W), the Chocolate Mountain Aerial Gunnery Range (CMAGR) North (also known as 2507N), and CMAGR South (also known as 2507S) (**Figures 1-2 through 1-4**). BMGR West is located in Yuma County, Arizona, and includes 692,816 acres. BMGR also contains BMGR East; however, ranges in this area are owned by the United States (U.S.). Air Force and are not included in this review. The CMAGR is located in Riverside and Imperial Counties, California, and includes approximately 228,465 acres of withdrawn federal public land and 229,903 acres of federal land (DON, 2013). In addition to the U.S. Marine Corps, the ranges support training of U.S. Navy, U.S. Air Force, U.S. Army, U.S. Reserve Components, and U.S. National Guard personnel.

The REVA five-year review installation visit occurred in January 2014; at that time, training range areas identified included 32 aerial targets (23 designated as high explosive [HE] and 9 designated as inert), 11 artillery firing areas (AFAs), 4 mortar positions (MPs), 31 fixed HE ranges, and 9 SARs. Fifteen of the fixed ranges located in CMAGR North are live-fire military operations in urban terrain (MOUT) facilities. A summary of the training range areas for each range complex is included in **Appendix A**.

Eleven of the ranges identified at MCAS Yuma during the five-year review were constructed after the 2008 baseline assessment was conducted:

- Two AFAs: AFA 15 (CMAGR North), AFA Burt (CMAGR South)
- Two MPs (located in CMAGR South): MP Feets, Mortar Firing Area (MFA) Burt
- Four convoy security operations courses (CSOCs) (located in BMGR West): CSOC1, CSOC2, Murrayville East, Murrayville West
- Two SARs (located in BMGR West): Range 1, Range 1A
- One multi-purpose range: Panel Stager

Panel Stager Range, located in BMGR West, originally was used for aerial munitions but had been inactive prior to 2005 when it was reactivated as a multipurpose live-fire ground range. This range was evaluated as a historical use range during the baseline assessment, but it remained active throughout the five-year review period and is included as a new range in this review.

Fourteen of the fixed range areas listed in **Appendix A** were inactive during all or a portion of the five-year review period. This included seven AFAs and seven Special Warfare Training areas (SWAT) ranges, all located in CMAGR North.

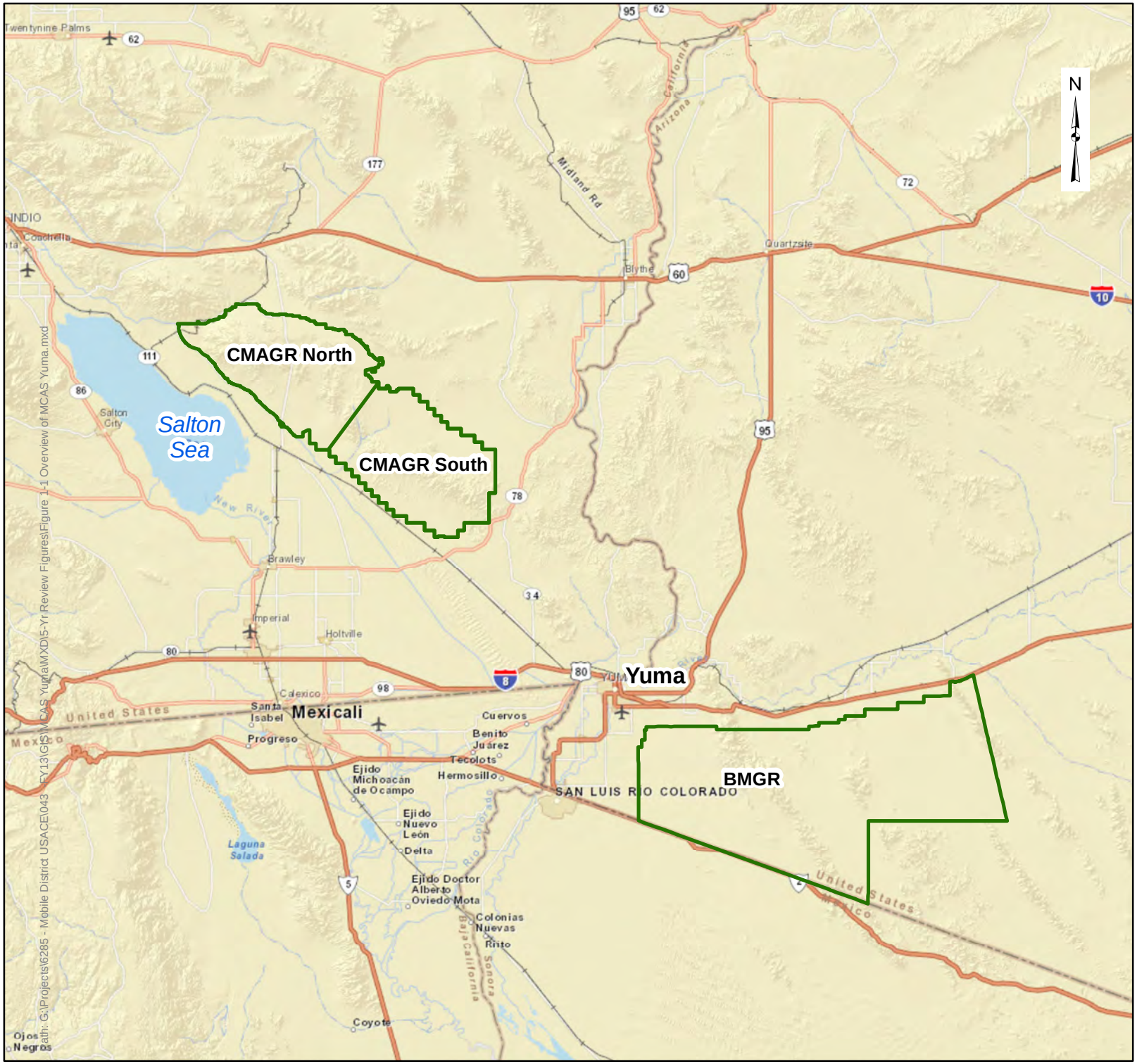

Figure 1-1
Overview of MCAS Yuma

Range Environmental Vulnerability Assessment
MCAS Yuma, AZ

LEGEND

Installation Boundary

0 5 10 15 20 25
Miles

COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: DECEMBER 2014

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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Path: G:\Projects\6285 - Mobile District USACE\043 - FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Figure 1-1 Overview of MCAS Yuma.mxd

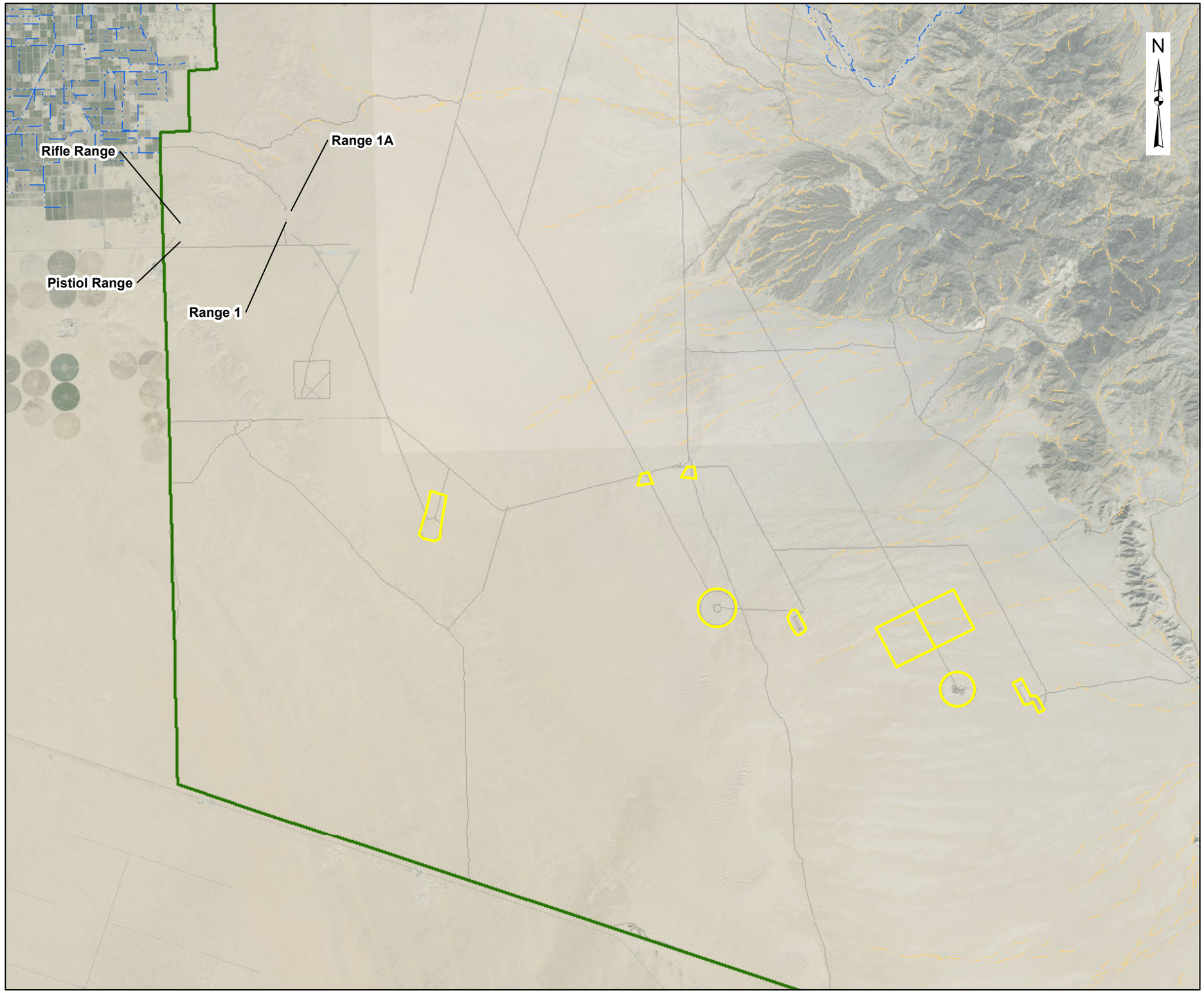
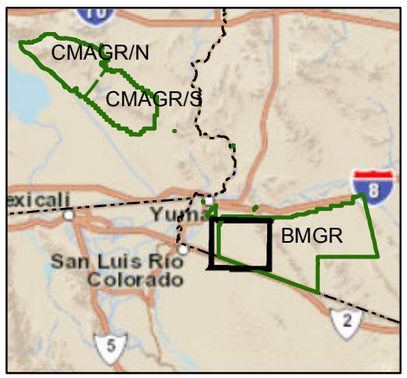


Figure 1-2
BMGR West MC Loading Areas

Range Environmental
Vulnerability Assessment
MCAS Yuma, AZ

LEGEND

- Installation Boundary
- MC Loading Area
- Intermittent Stream
- Dry Stream
- Road



0 1 2 3 Miles

COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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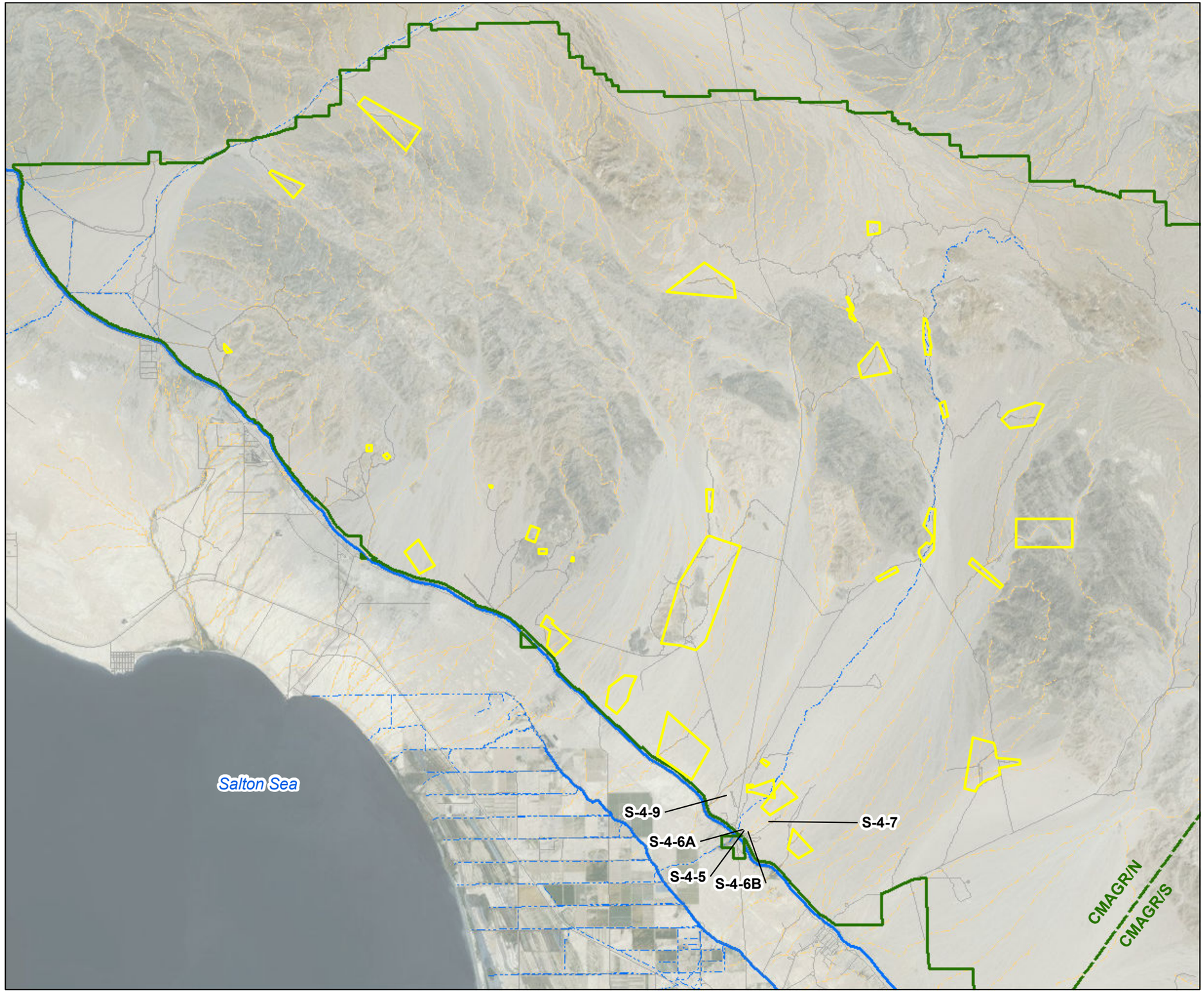
Path: G:\Projects\6285 - Mobile District USACE\043 - FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Public Version\Figure 1-2 BMGR West MC Loading Areas.mxd

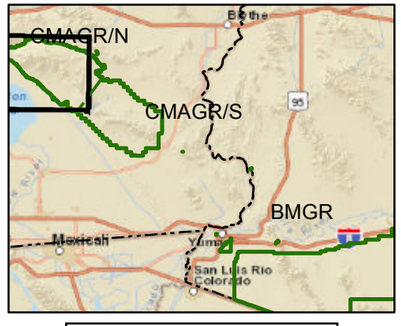
Figure 1-3
CMAGR North MC Loading Areas

Range Environmental
Vulnerability Assessment
MCAS Yuma, AZ



LEGEND

- Installation Boundary
- MC Loading Area
- Permanent Stream
- Intermittent Stream
- Dry Stream
- Road



0 1 2 3 Miles

COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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Path: G:\Projects\6285 - Mobile District USACE\043 -FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Public Version\Figure 1-3 CMAGR North MC Loading Areas.mxd

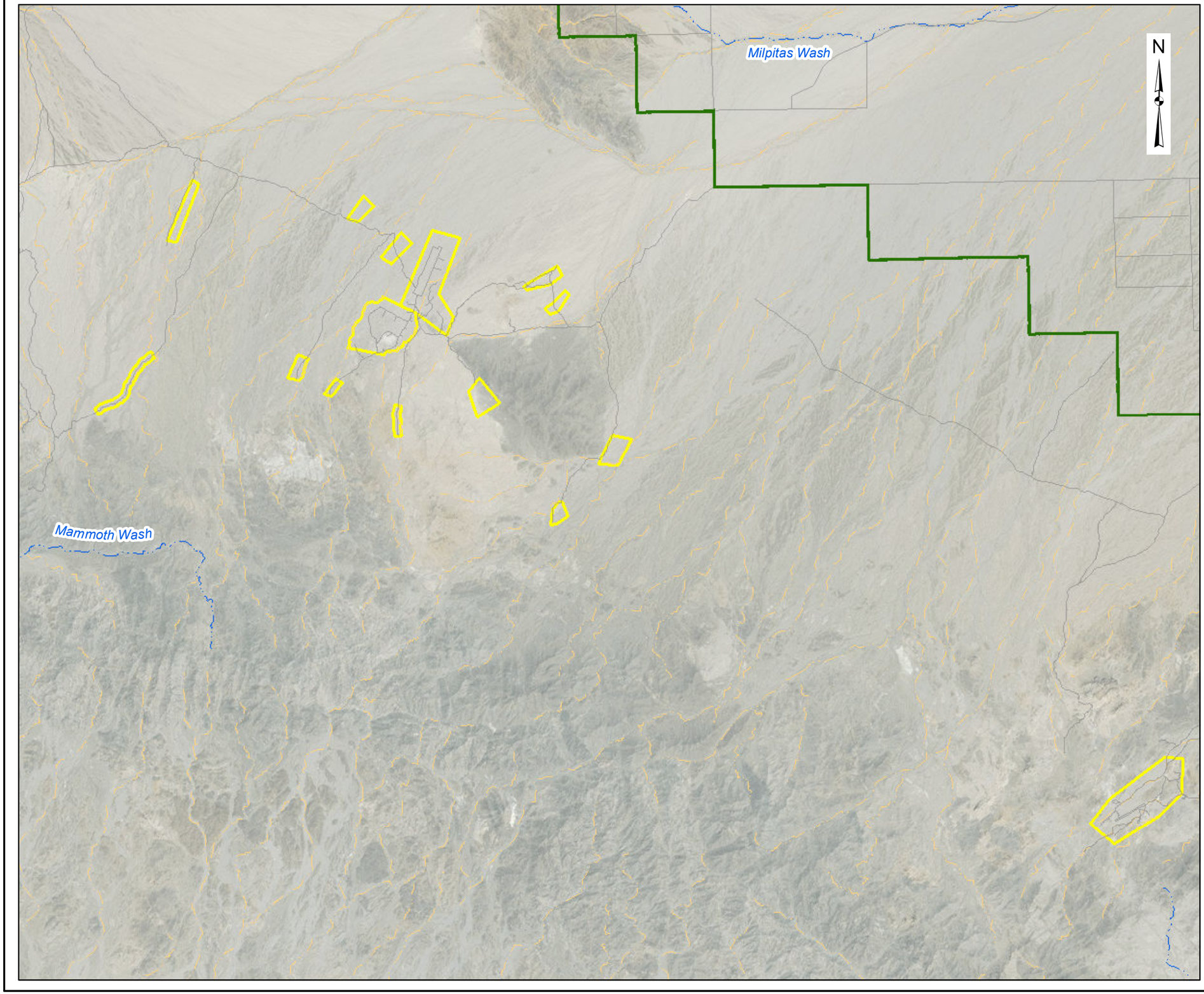
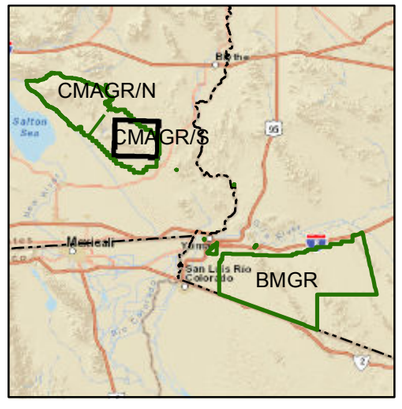


Figure 1-4
CMAGR South MC Loading Areas

Range Environmental
Vulnerability Assessment
MCAS Yuma, AZ

LEGEND

- Installation Boundary
- MC Loading Area
- Intermittent Stream
- Dry Stream
- Road



0 0.5 1 1.5 2 Miles

COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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Path: G:\Projects\6285 - Mobile District USACE\043 - FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Public Version\Figure 1-4 CMAGR South MC Loading Areas.mxd

1.4 Summary of Areas Addressed in the Five-Year Review

Discrete MC loading areas are those areas where the majority of munitions are deposited during training. These areas may be target or impact areas associated with ranges, or they may be the footprint of a fixed range. MC loading areas determined in the baseline assessment were adjusted for the five-year review to reflect updated information about range facilities, known targets, and surface danger zones (SDZs), and information gathered from aerial imagery, range personnel, visual observations during the site visit, and munitions data. Training-specific information for some ranges and training areas indicated minimal use and/or use of munitions that would not be anticipated to cause significant MC loading since the baseline REVA assessment. Therefore, no MC loading areas were defined in these circumstances. Fifty-six (56) MC loading areas were identified at MCAS Yuma for the five-year review period, as listed in **Table 1-1** and shown in **Figures 1-2 through 1-4**. In addition to the MC loading areas identified for use of HE, nine small arms ranges (SARs) were identified, as listed in **Table 1-2**.

Table 1-1: MC Loading Areas at MCAS Yuma

MC Loading Areas			
BMGR West	**CMAGR North**		**CMAGR South**
Cactus West - Target	S-4-1	S-5-2	1S
Cactus West - Strafe Berm	S-4-2	S-5-3	2S
CSOC1	S-4-3	1N	3S
CSOC2	S-4-4	2N	4S
Murrayville East	S-4-8	3N	5S
Murrayville West	S-4-10	6N	6S
Panel Stager	S-4-11A/S-4-11B	7N	7S
Yodaville - UTC	S-4-12A/S-4-12B	8N	8S
Yodaville – MLT	S-4-13	9N	10S
	S-4-14	10N	11S
	S-4-15	11N	12S
	S-4-17	12N	13S
	S-4-19	13N	14S
	S-4-21	14N	15S
	S-4-22	15N	Mt. Barrow
	S-4-23	ICM Box	

Note:
CSOC = convoy security operations courses
ICM = improved conventional munitions
MLT = moving land target
UTC = urban training complex

Table 1-2: SARs at MCAS Yuma

MC Loading Areas	
BMGR West	**CMAGR North**
Known Distance (KD) Pistol Range	S-4-5
KD Rifle Range	S-4-6A
Range 1	S-4-6B
Range 1A	S-4-7
	S-4-9

During the baseline review, 52 MC loading areas were identified. All but seven (located in the CMAGR) of these 52 MC loading areas were evaluated in the five-year review. These seven MC loading areas were located in CMAGR: S-4-9, S-4-16, S-4-18, S-4-20, S-5-1, S-5-4, and S-5-5. Of these seven, five (S-4-16, S-4-20, S-5-1, S-5-4, and S-5-5) were not used during the five-year review period; one (S-4-18) was used only for small arms blanks (S-4-18); and one (S-4-9) was evaluated as a SAR.

There were 12 MC loading areas identified during the five-year review that were not evaluated during the baseline assessment. Five of these are located in BMGR West (CSOC1, CSOC2, Murrayville East, Murrayville West, and Panel Stager), and seven of the new MC loading areas are located in CMAGR North (1N, 6N, 7N, 8N, 12N, 15N, and S-4-23). Four of the BMGR West ranges were constructed after the baseline assessment was completed, and Panel Stager was evaluated as a historical range in the baseline review. It was reconstructed and was active throughout the five-year review period. Six of the seven CMAGR North targets were identified during the baseline, but were not further evaluated because only inert munitions with minimal MC loading were used at that time. The seventh range, S-4-23, was not identified during the baseline review.

2. Assessment Methods and Results

MCAS Yuma was assessed qualitatively through the development of a site-specific conceptual site model (CSM) and quantitatively through screening-level transport assessments. This section contains the MC loading estimates, the site-specific CSM, and the screening-level modeling results.

2.1 Munitions Constituents Loading Estimation

Estimates of MC deposited onto MC loading areas during the five-year review period were calculated using expenditure data and operational range clearance (ORC) reports. These MC loading estimates are used in the screening-level fate and transport models to determine potential off-range migration of MC.

2.1.1 Operational Range Clearance

During the five-year review period, ORC at MCAS Yuma was conducted at 27 operational ranges and target areas, one siphon area along MCAS Yuma's southern boundary, one auxiliary landing field, and three areas adjacent to the improved conventional munitions (ICM) Range. Over 7,810 tons of range debris and demilitarized unexploded ordnance (UXO) were removed as part of these efforts. These were primarily surface clearances with some subsurface clearances performed at specified target locations and access pathways. A summary of clearance activities conducted at the installation from 2007 through 2013 is provided in **Appendix B**.

While these range clearance activities were undertaken to reduce the explosive risk to training and construction activities, the removal of UXO also serves as a means to reduce the MC loading occurring at these operational ranges. As such, the ORC activities have been factored into the MC loading process to reduce the estimated MC loads for appropriate ranges during this five-year review. This adjustment to the MC loading approach is discussed in **Section 2.1.2**.

2.1.2 Munitions Constituents Loading Approach

MC loading areas were defined based on known history and current training activities in order to estimate MC loading rates, which is the MC loading input in the screening-level models. These areas represent locations at which significant MC loading is occurring or suspected to have occurred from training with munitions containing HE (TNT, RDX, and HMX), illumination rounds, or other munitions containing solid propellants (perchlorate) and metals (lead).

The MC loading of HE and perchlorate was estimated based on mass-loading principles using military munitions expenditure data and dud / high order / low order detonation rates, as described in the MCAS Yuma REVA Report (Malcolm Pirnie, 2008) and the REVA Five-Year Review Manual (HQMC, 2010). Studies have shown that MC are deposited on the operational range through low and high order detonations and may leach from corroded UXO. These processes are represented in the equation:

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

Note:

1. MC (low orders) is the amount of MC deposited as a result of low order detonations.
2. MC (high orders) is the amount of MC deposited as a result of high order detonations.
3. MC (UXO) is the amount of MC deposited as a result of UXO with breached casings.

The REVA process accounts for MC contributed from all three of these potential sources, but MC remaining from low order detonations are the most significant contributors to MC loading. MC loading rates for low order detonations, high order detonations, and UXO were estimated for each MC loading area using the following equations:

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

MC (high order) = (number of military munitions expended) x (high order 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 casing)

MC loading was estimated using the REVA MC Loading Rate Calculator (described in the REVA Five-Year Review Manual) [HQMC, 2010]) and modified to account for standard management practices at demolition and explosive ordnance disposal (EOD) ranges and for ORC activities that occurred during the five-year review period. These modifications are described in **Section 2.1.3**. The MC loading areas identified are shown in **Figures 1-2 through 1-4,** and the associated loading rates generated by the MC Loading Rate Calculator are provided in **Appendix B**.

Deposition of lead assumes no lead consumption from impact and that all of the lead contained in the munition remains upon impact. Potential total lead deposition at impact areas or HE ranges was estimated based solely on lead content of the ordnance items used. Lead loading at SARs was determined using the total number of projectiles used at the range, as reported in available expenditure data, and the amount of lead in each projectile. The estimated deposition of lead in each MC loading area and SAR is presented in **Appendix B**.

2.1.3 Munitions Constituents Loading Assumptions

MC loading is based primarily on munitions expenditure data obtained from the MCAS Yuma Range Scheduling office and the Training and Education Command (TECOM), covering the period from FY 2007 through FY 2013 (7 years). These expenditure data were used to develop annual averages of expenditures for each MC loading area identified. These averages were then applied to the MC loading calculator to generate estimated MC loading rates for each MC loading area. Expenditure data from FY2007 and FY2008 were not used to determine average loading rates, and use of data from FY2009 through FY2012 was limited, as described below. One series of assumptions was made to address a quality review of the expenditure data provided:

- The primary expenditure data provided by the TECOM Range and Training Area Management (RTAM) Division were Range Facility Management Scheduling System (RFMSS) data. According to range personnel, these data capture expenditure use for all training operations at MCAS Yuma, as well as EOD and Naval Special Warfare training operations. The RFMSS data provided for the period listed above was broken out by year and range area and represented expenditures over a period of 7 years. Annual average expenditure totals were calculated for each munition type based on a period of 12 months.

    - According to range personnel, ground expenditure data from the special warfare training area ranges used by Naval Special Warfare personnel were not fully tracked in RFMSS until 2009. Installation personnel indicated that training patterns and rates have not experienced significant shifts during this review period. Therefore, it was assumed that RFMSS data covering the period of FY 2009 through FY 2013 could be extrapolated to estimate annual averages of expenditures. The annual expenditure averages developed for each range from the 5 years of RFMSS data were assumed to be representative of the entire review period.

    - Likewise, aviation expenditures were not tracked in RFMSS at MCAS Yuma until approximately 2009. According to range personnel, the most accurate tracking of aviation expenditures occurred in 2013. Since training patterns and rates have not experienced significant shifts during this review period, only aviation expenditures data from FY 2013 were used to generate annual average aviation expenditures, which were assumed to be representative of the entire review period.

    - The aviation expenditure data were not tracked in RFMSS by aerial target location but instead by general range areas (i.e. CMAGR North [R-2507N], CMAGR South [R-2507S], and BMGR West [R-2301W]). Therefore, expenditure deposition locations were assumed based on installation documentation, including range standard operating procedures and range certifications.

- The expenditure summaries contain some DoD Identification Codes (DoDICs) for which data regarding MC content were not available in Munitions Items Disposition Action System (MIDAS) or other inventories.

    - In some of these instances, a general description of the munitions associated with these DoDICs was identified, either as part of the installation data or as found in other readily available sources. This was reviewed, along with available information regarding the associated range, its design, and its regulations, and a surrogate MC loading factor was selected from available data for similar munitions for use in MC loading calculations.

    - In other instances, no description of the munitions was provided. The associated expenditure counts for the unknown DoDICs were proportionally distributed among other known DoDICs (and within known locations, when available), based on totals for the other DoDICs listed for the same range within that given year.

- According to EOD personnel, all donor charges and destroyed items associated with EOD operations were tracked in RFMSS; therefore, commitment sheet data were not incorporated into MC loading calculations.

Calculations incorporating expenditures associated with EOD and demolition activities were adjusted to reflect an assumed 100% high order detonation. Additionally, lead deposition was conservatively reduced to 5% of potential deposition in these instances. Interviews with EOD personnel indicate that it is standard operating procedure to collect munitions debris following demolition activities. This reduction to 5% conservatively indicates that as much as 5% of the lead content of the item destroyed could remain on the range after debris is removed.

Dud/UXO rates associated with DoDICs reported in the RFMSS data were not used in place of the standard dud assumptions used in the REVA MC Loading Rate Calculator because these data were not reported for a long enough period to develop meaningful dud rates. As such, the REVA standard dud rate assumptions were used in order to maintain a higher level of conservatism in the estimate.

2.2 Conceptual Site Model

A CSM is used to characterize the dynamics that may affect off-range migration of MC, including potential exposure pathways and possible receptors. The site-specific CSM for MCAS Yuma builds on and updates the installation CSM developed for the baseline assessment (MP, 2008).

2.2.1 Potential Pathways and Receptors

MC accumulated in the range or target area potentially can migrate to potential receptors via the following exposure pathways:

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

Exposure pathways evaluated in the REVA process include consumption of surface water and groundwater by off-range human receptors, as described in the *REVA Reference Manual* (HQMC, 2009). For groundwater, water supply wells located within and outside the installation boundary are considered receptor locations because the water from the wells is distributed to consumers within the installation and to nearby residents outside the installation. Exposure pathways for off-range ecological receptors include direct consumption of or exposure to surface water and sediment. Other off-range exposure scenarios (e.g., soil ingestion, incidental dermal contact, bioaccumulation, food chain exposure) are not considered in the REVA process. The potential receptors at MCAS Yuma include the following:

- Human receptors (through contact and noncontact recreation) for surface water in the Salton Sea and the Colorado River
- Potential human users of groundwater

- Ecological receptors that may use surface water; special status species include:
    - Federally listed threatened, sensitive, and protected species: Agassiz desert tortoise (also state listed), Cooper's hawk, burrowing owl, and golden eagle
    - Bureau of Land Management sensitive species: desert bighorn sheep
    - State of California sensitive species, including the American badger, Couch's spadefoot, loggerhead shrike, golden eagle, burrowing owl, and Cooper's hawk.
    - State of Arizona sensitive species: flat-horned lizard

2.2.2 Surface Water and Sediment Pathway

The climate at MCAS Yuma is characterized by low precipitation, hot summers, mild winters, limited cloud cover, moderate winds, and low relative humidity. While the precipitation events can be intense and potentially cause flash flooding, the average annual precipitation is low (approximately 3 inches). Potential evaporation averages approximately 100 inches per year. Due to the limited precipitation and high evaporation, little surface water runoff typically is produced; however, heavy rainfall events can produce flash floods that can carry large quantities of soil/sediment during these isolated events.

2.2.2.1 BMGR West

MC loading areas and SARs located in BMGR West are in the Yuma Desert watershed. Natural surface water features at BMGR West are ephemeral with surface water flows occurring during heavy rainfall events. Ephemeral streams are found on the slopes of the mountains in BMGR West. Surface water runoff flows down and out from mountains, and then northwest toward the Gila and Colorado Rivers. However, ephemeral streams on the range complex lose surface water to subsurface infiltration or evaporation and likely terminate before reaching the major rivers, which are more than 10 miles from the ranges (**Figure 2-1**). **Figure 2-2** is a graphical CSM showing surface water features for BMGR West.

The topographic areas occupied by BMGR West are referred to as Yuma Mesa and Upper Mesa (**Figure 2-1**). Yuma Mesa extends from north of the range complex into the northwestern part of BMGR West. Upper Mesa is located south of Yuma Mesa and extends to the Gila Mountains. Ranges are located in Upper Mesa. Yuma Mesa is topographically lower than Upper Mesa by approximately 30 to 60 feet, causing regional surface water flow to move from the ranges toward Yuma Mesa. Upper Mesa generally consists of sand dunes adjacent to dissected pediment slopes along the western portion of the Gila Mountains. The Yuma Mesa is a river terrace and former valley and delta plain of the Colorado and Gila Rivers.

Training ranges and aerial targets are located within the Yuma Desert watershed area in broad alluvial valleys. Manmade tanks for wildlife use (guzzlers) and natural features collect rainwater at BMGR West. Surface water features include tinajas (natural bedrock depressions), sand tanks (saturated sand pits), charcos (mud holes), playa lakes, and springs. Tinajas are the most common surface water features in BMGR West. Playa lakes are seasonally important to migratory birds, but the only sizable playa in BMGR West is located at the northeastern end of BMGR in the Mohawk-Papago Valley. Information provided by the MCAS Yuma staff shows that guzzlers for wildlife use are located upgradient of ranges in the mountains east of the ranges (**Figure 2-1**).

The surface water runoff rate at the nine MC loading areas was estimated to be equivalent to 0.046 cubic meters per square meter per year ($m^3/m^2/yr$), which indicates low potential for MC to migrate via surface water runoff from the MC loading areas. Although rainfall may be intense during infrequent storm events, rainfall intensity is accounted for in the surface water runoff rate. The low potential for MC migration is attributed to the very low annual precipitation in the area, flat topography at the MC loading areas, and soil types at the MC loading areas that have low to very low estimated runoff potentials (belonging to hydrologic groups A and B).

Natural springs and seeps, or points of groundwater discharge on the land surface, are found in BMGR West; however, for most of the year, the springs are dry. Groundwater discharge from bedrock joints and fractures within the mountains of BMGR are ephemeral.

Ground disturbance from vehicles at BMGR West is a primary influence in soil stability and erosion. Decisions implemented in the 2012 BMGR Integrated Natural Resources Management Plan ([INRMP]; DON, 2013) closed the range to off-road driving except by approved personnel for specific purposes in limited areas. Some roads through BMGR West were closed to encourage vegetation growth and minimize ground disturbance. The Border Patrol occasionally travels off-road in pursuit of undocumented immigrants crossing the United States border and traveling across the BMGR. The Border Patrol maintains drag roads to support their efforts in tracking undocumented immigrants. This is accomplished by dragging tires across the ground to create a smooth surface so that recent traffic is more evident. These drag roads have, in effect, created berms that divert surface water runoff and inadvertently create drainage channels that intercept and affect natural flows. The Border Patrol is working with MCAS Yuma to form an agreement regarding maintenance and repair of these roads (Department of the Air Force and DON, 2012).

Well-developed drainage channels are not present near the range areas in BMGR West, and no major erosion channels were observed during the REVA site visit in January 2014. Surface water flows in the washes are not used as a potable water source, an irrigation water source, or for known recreational activities, either on or off range. Therefore, incidental human contact may occur, but no specific human receptors were identified.

Potential ecological receptors include special status species: the Agassiz desert tortoise and the flat-tailed horned lizard. These are discussed further in **Section 2.1.6.1**.

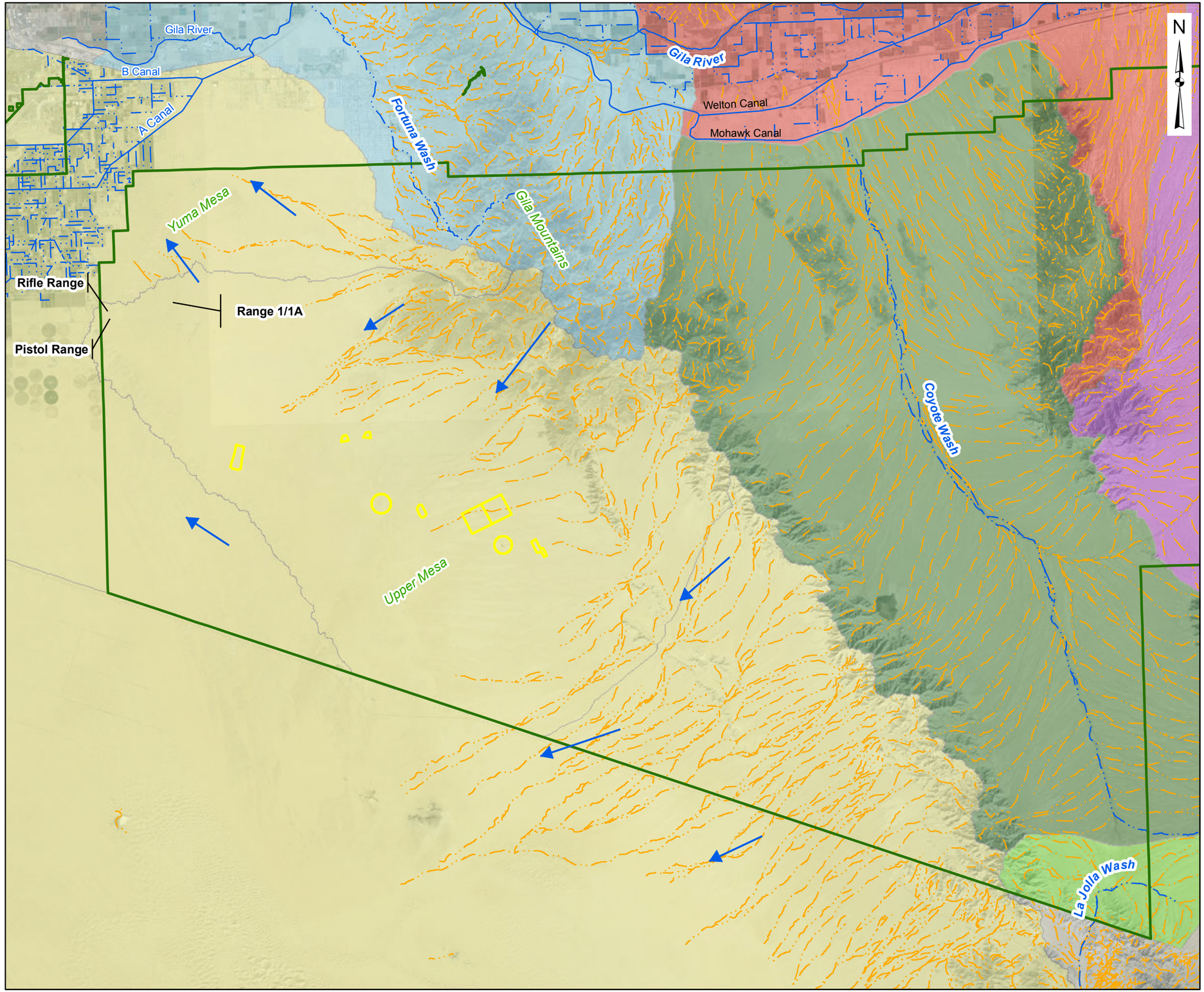


Figure 2-1
BMGR West Surface Water Features

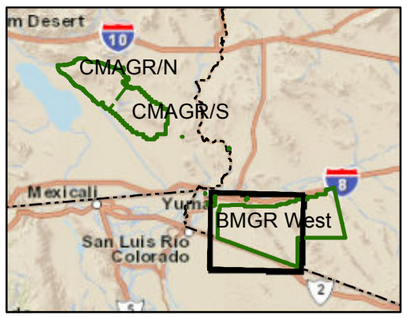
Range Environmental
Vulnerability Assessment
MCAS Yuma, AZ

LEGEND

- Installation Boundary
- MC Loading Area
- Perennial Stream
- Intermittent Stream
- Ephemeral Stream

Watershed

- Coyote Wash
- Fortuna Wash-Gila River
- La Jolla Wash
- Lower Mohawk Wash
- Morgan Wash-Gila River
- Yuma Desert
- Surface Water Flow Direction



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ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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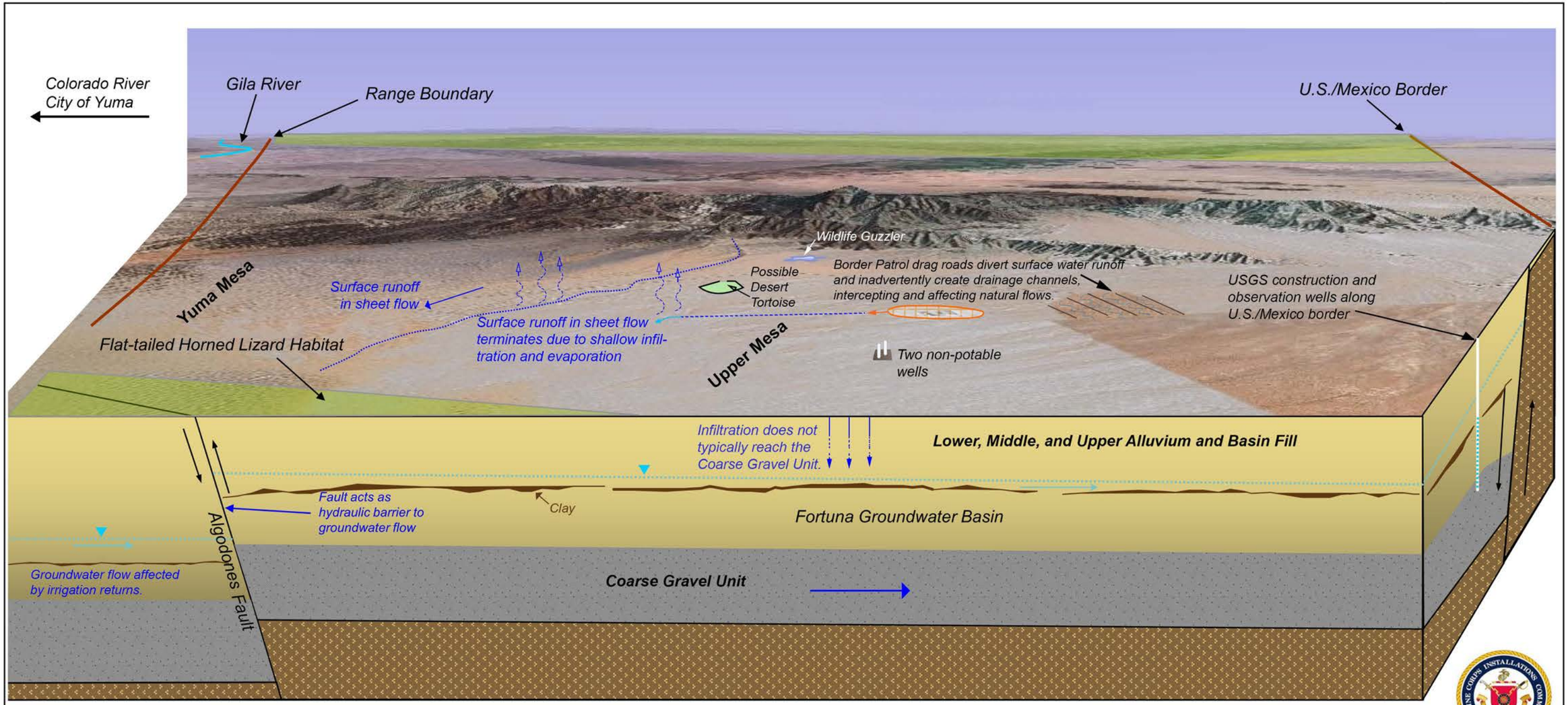
Path: G:\Projects\6285 - Mobile District USACE\043 - FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Public Version\Figure 2-1 BMGR West Surface Water.mxd



NOTE:
This block-diagram is based on the generalized distribution of mapped geological units and features in the BMGR West and is not a geological cross section depicting accurate outcrop areas and subsurface contacts. This diagram represents an idealized conceptual model of the surface and groundwater systems in the area and potential routes of MC migration from loading areas to human and ecological receptors.

Legend

- Range Boundary
- Range or Target Area
- Potential MC Migration Pathway
- Ephemeral Stream
- Clay
- Threatened and Potentially Threatened Species Habitat
- Water Table
- Groundwater Flow/Recharge
- Flow Direction
- Bedrock
- Alluvium and Basin Fill
- Coarse Gravel

Bedrock consists of Precambrian intrusive and metamorphic rocks, Mesozoic granite, Tertiary volcanics, and Pliocene to Holocene basalt flows. Water resources in bedrock areas are limited and consist of mainly seasonal springs or seeps, *tinajas,* or water-filled bedrock depressions along washes, and man-made tanks or guzzlers.

Quaternary Alluvium consists of gravel, sand, silt, and clay, eroded from uplifted bedrock formations or transported by wind from adjacent river systems. Groundwater flow in the Fortuna Basin is affected by excess irrigation and flows away from the Colorado and Gila River valleys.

Ecological Receptors include the desert tortoise and flat-tailed horned lizard. The presence of the desert tortoise is based on a single siting in 2008 or 2009. The flat-tailed horned lizard is found throughout the western part of BMGR West.

Figure 2-2
BMGR WEST CONCEPTUAL SITE MODEL

REVA Five-Year Review
MCAS Yuma

2.2.2.2 CMAGR

The CMAGR is in the Lower Colorado River Valley subdivision of the Sonoran Desert and is characterized by rugged terrain consisting of desert, mountains, and dry washes. The range complex lies at elevations ranging between approximately 0 feet and 3,000 feet above mean sea level. Water is extremely scarce at the CMAGR, as there are no naturally occurring perennial surface water features on the range complex. The Salton Sea, Coachella Canal, and the Colorado River are perennial surface water features located near but outside the installation boundary.

The CMAGR is located within two regional watersheds: the Salton Sea-Transboundary watershed and the Imperial Reservoir watershed. CMAGR North lies almost entirely within the Salton Sea-Transboundary watershed. Within this regional watershed, all the target areas and ranges are located within the Imperial Valley-Frontal Salton Sea and the Salt Creek subwatersheds (**Figure 2-3**). These subwatersheds ultimately drain south to the Salton Sea by way of several drainages extending from the mountains, the largest of which is Iris Wash. MC loading areas in CMAGR North are located within 11 subwatersheds, as shown on **Figure 2-4**. These desert washes only flow during heavy rainfall events and often have braided channels and sorted sandy stream bottoms. Flash floods have the potential to move large quantities of sediment and transport munitions debris. Surface water runoff passes through agricultural fields south of the CMAGR prior to entering the Salton Sea.

The majority of the MC loading areas within CMAGR North have soil types with high estimated runoff potentials (belonging to hydrologic group D), and several of the MC loading areas have steep topographic slopes. However, based on the estimated surface water runoff rates at the MC loading areas within CMAGR North (0.064 to 0.096 $m^3/m^2/yr$) (**Appendix C**), there is a low potential for MC to migrate via surface water runoff from these areas. Although rainfall may be intense during infrequent storm events, rainfall intensity is accounted for in the surface water runoff rate. The low potential for MC migration is largely attributed to the very low annual precipitation in the area.

CMAGR South lies mostly within the Imperial Reservoir watershed. Within this watershed, all target areas lie within the Arroyo Seco-Upper Milpitas Wash and the Lower Milpitas Wash watersheds, which drain to the Colorado River (**Figure 2-5**). These watersheds are further divided into subwatersheds, as shown on **Figure 2-6**. **Figure 2-7** is a graphical CSM is showing surface water features at the CMAGR. A low MC migration potential via surface water runoff from MC loading areas with CMAGR South was based on the very low precipitation of the area and estimated surface water runoff rates ranging from 0.066 to 0.085 $m^3/m^2/yr$ (**Appendix C**). Additional, factors contributing to the low surface runoff migration potential include soil types with low estimated runoff potentials at a majority of the MC loading areas (belonging to hydrologic group B) and relatively flat slopes at some of the MC loading areas.

Path: G:\Projects\6285 - Mobile District USACE\043 -FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Public Version\Figure 2-3 CMAGR North Surface Water.mxd

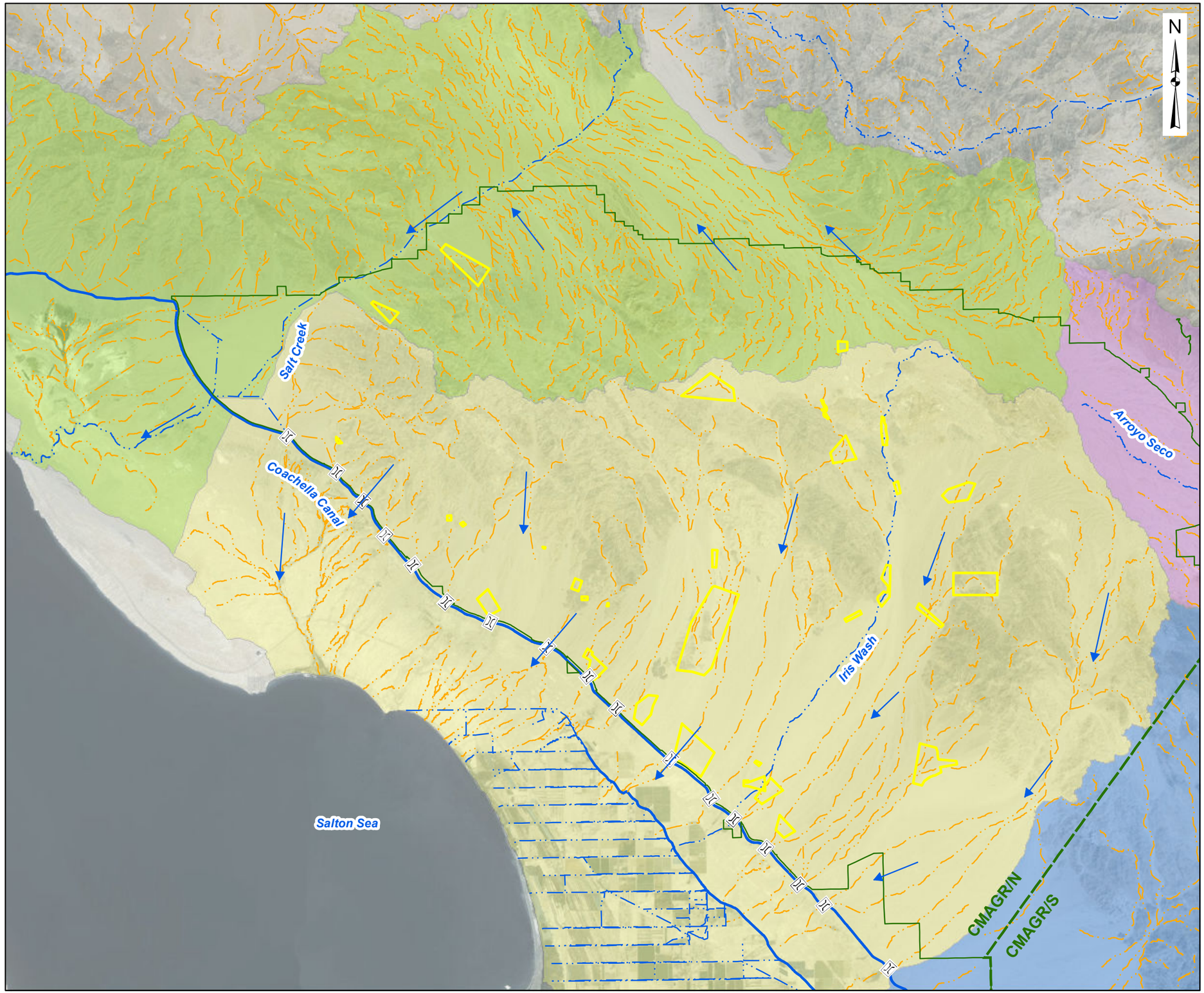


Figure 2-3
CMAGR North Surface Water Features

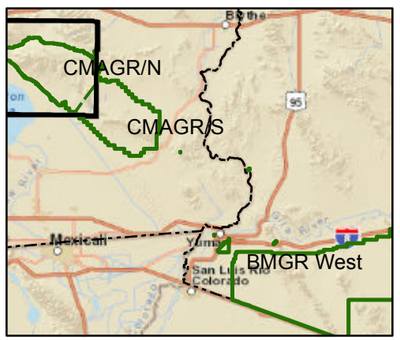
Range Environmental
Vulnerability Assessment
MCAS Yuma, AZ

LEGEND

- Installation Boundary
- MC Loading Area
- Perennial Stream (includes Coachella Canal)
- Intermittent Stream
- Ephemeral Stream
- Siphons

Watershed

- Alamo River
- Arroyo Seco-Upper Milpitas Wash
- Imperial Valley-Frontal Salton Sea
- Salt Creek
- Surface Water Flow Direction



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COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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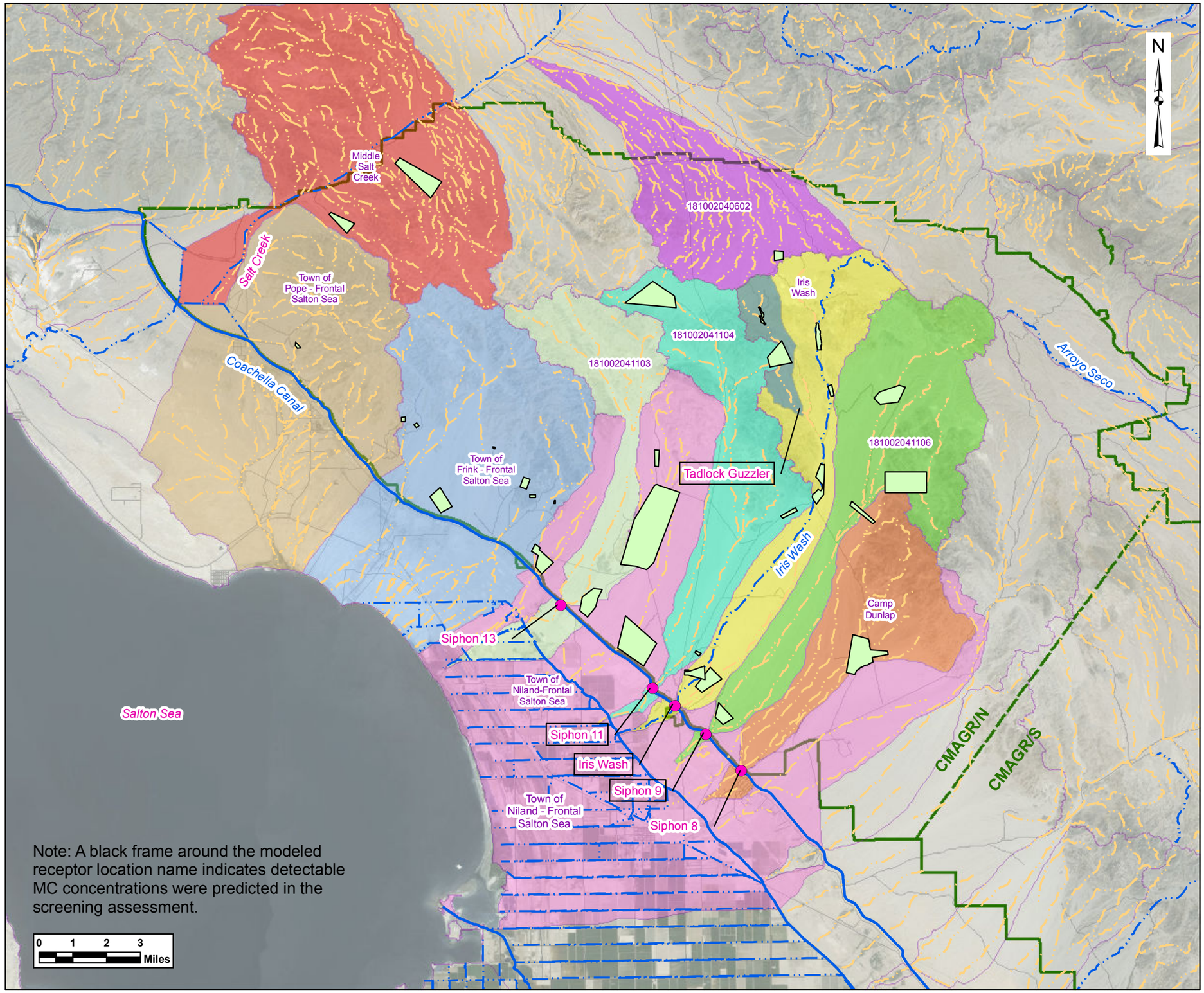
Figure 2-4
Subwatersheds and Modeled Receptor Locations CMAGR North

Range Environmental Vulnerability Assessment
MCAS Yuma, AZ



LEGEND

- Installation Boundary
- MC Loading Area
- Road
- Permanent Stream (includes Coachella Canal)
- Intermittent Stream
- Ephemeral Stream
- Modeled Siphon Receptor Location
- Subwatershed - not modeled

Subwatershed - modeled

- 181002040602
- 181002041103
- 181002041104
- 181002041106
- Camp Dunlap
- Iris Wash
- Middle Salt Creek
- Town of Frink - Frontal Salton Sea
- Town of Niland - Frontal Salton Sea
- Town of Pope - Frontal Salton Sea
- Tadlock Guzzler

COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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Path: G:\Projects\6285 - Mobile Distrct USACE\043 - FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Public Version\Figure 2-4 CMAGR North Subwatersheds.mxd

Guzzlers and tinajas are the only open water sources within CMAGR available to wildlife. The artificial water sources are designed to collect rainwater from small peripheral washes (rather than the large major desert washes) using concrete basins and/or natural topography to support on-range wildlife populations (primarily bighorn sheep and mule deer). The storage capacities of the tanks and guzzlers range from 1,000 to 24,000 gallons. Water can be retained in these systems for several months to more than 1 year, depending on weather and wildlife use. There are currently 26 guzzlers in the CMAGR, and 5 additional guzzlers are pending construction (DON, 2013). These are primarily located in the Chocolate Mountains and not downgradient of range or target areas; however, topographic mapping and overland flow patterns indicate that one guzzler may intercept surface water runoff from two target areas in CMAGR North. Guzzlers and other wildlife water sources in CMAGR South do not appear to be downgradient of range or target areas.

California's largest lake, the Salton Sea, is located south of the CMAGR and historically was used for fishing and recreation. It is approximately 35 miles long, and varies from 9 to 15 miles wide; the surface of the lake lies approximately 227 feet below mean sea level. The Salton Sea watershed is identified as a Category I (impaired) watershed, and approximately 75 percent of the freshwater inflow is from agricultural drainage. The lake is largely sustained by irrigation flow and has no outlets; therefore, it continues to increase in salinity and is currently more saline than ocean water. The Salton Sea Authority is a cooperative effort chartered by the State of California to improve the health of the Salton Sea and ensure future beneficial use. The Salton Sea is classified for beneficial uses of AQUA (aquaculture), IND (industrial service supply), RARE (preservation of rare, threatened, or endangered species), REC I (water contact recreation), REC II (non-contact water recreation), WARM (warm freshwater habitat), and WILD (wildlife habitat) (CalEPA, 2003).

The Colorado River is a source of electricity and supplies most of the irrigation, livestock, and drinking water in the Imperial Valley. The Bureau of Reclamation manages the critical resources of the Colorado River. The Clean Colorado River Alliance is focusing on mitigating some of the water quality issues in the Colorado River, including nutrients, metals (selenium, chromium, mercury, uranium), perchlorate (originating from ammonium perchlorate manufacturing facilities in Nevada), salinity/ / total dissolved solids, and sediment. The Colorado River is classified for beneficial uses of AGR (agricultural supply), AQUA, (aquaculture), COLD (cold freshwater habitats), GWR (groundwater recharge), IND, (industrial service supply), MUN (municipal and domestic supply), POW (hydropower generation), RARE, (preservation of rare, threatened, or endangered species), REC I, (water contact recreation), REC II, (non-contact water recreation), WARM, (warm freshwater habitat), and WILD. (wildlife habitat) (CalEPA, 2003).

Perennial surface water is present in the Coachella Canal, which is 123 miles long and is located just outside the southern boundary of CMAGR. Water in the canal is derived from the Colorado River and is diverted at the Imperial Dam, approximately 20 miles upstream from Yuma, Arizona (DON, 2013). The canal is used to irrigate over 78,000 acres of farmland in the Imperial Valley. The Coachella Canal is separated from local storm water runoff by a series of siphons that are perpendicular to the length of the canal and act as passes through the canal. The canal is diverted underground beneath the siphon, allowing stormwater to flow above ground through the siphon. These siphons range in width from approximately 75

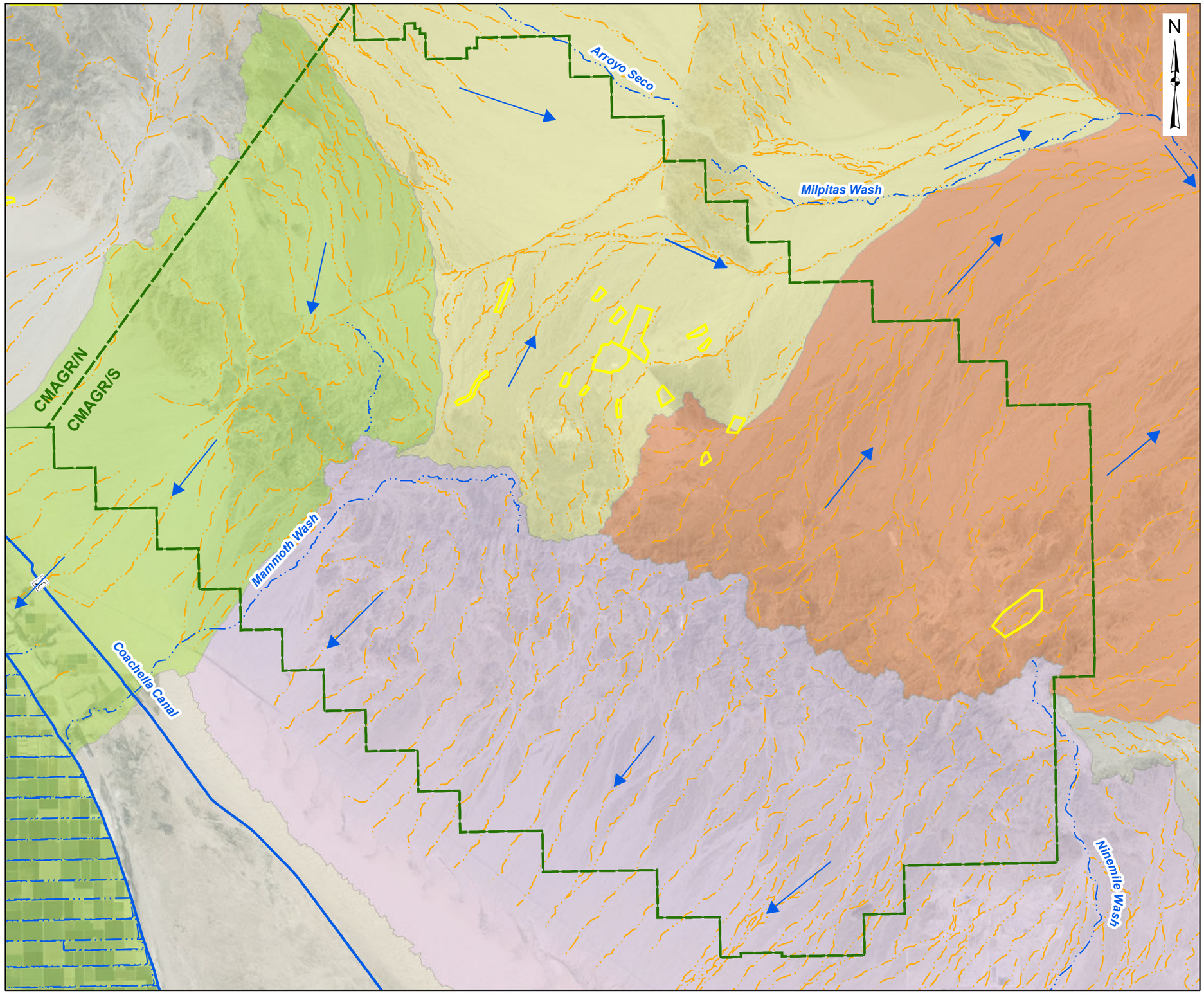


Figure 2-5
CMAGR South Surface Water Features

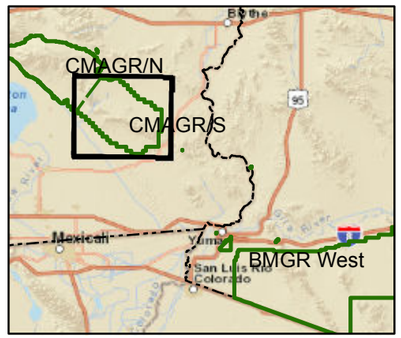
Range Environmental
Vulnerability Assessment
MCAS Yuma, AZ

Legend

- Installation Boundary
- MC Loading Area
- Siphon
- Perennial Stream (includes Coachella Canal)
- Intermittent Stream
- Ephemeral Stream

Watershed

- Alamo River
- Algodones Dunes-Chocolate Mountain
- Arroyo Seco-Upper Milpitas Wash
- Lower Milpitas Wash
- Surface Water Flow Direction



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ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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Path: G:\Projects\6285 - Mobile District USACE\043 -FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Public Version\Figure 2-5 CMAGR South Surface Water.mxd

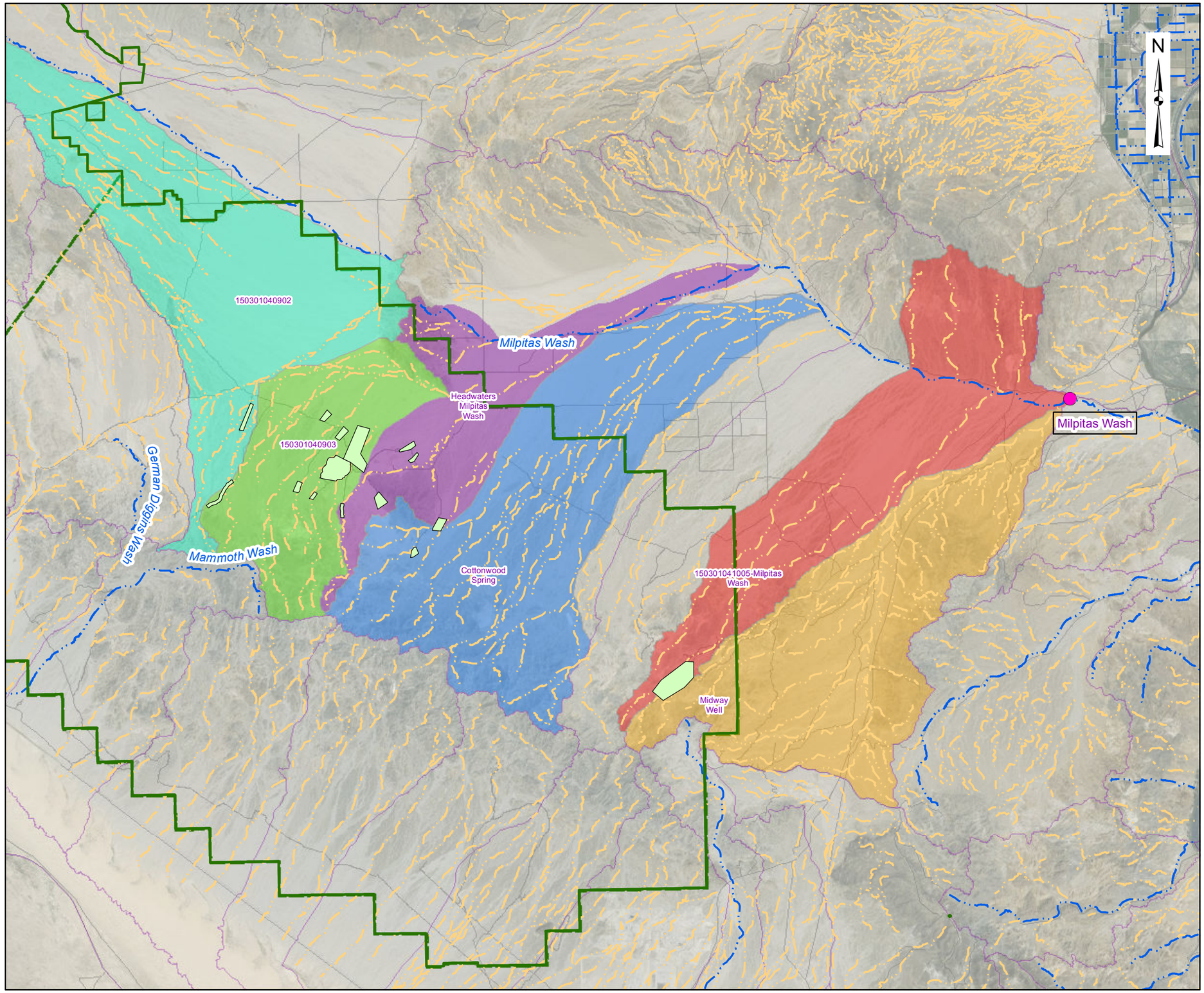


Figure 2-6
Subwatersheds and Modeled Receptor Locations CMAGR South

Range Environmental Vulnerability Assessment
MCAS Yuma, AZ

LEGEND

- Installation Boundary
- MC Loading Area
- Road
- Intermittent Stream
- Ephemeral Stream
- Modeled Receptor Location
- Subwatershed - not modeled

Subwatershed - modeled

- 150301040902
- 150301040903
- 150301041005-Milpitas Wash
- Cottonwood Spring
- Headwaters Milpitas Wash
- Midway Well

Note: A black frame around the modeled receptor location name indicates detectable MC concentrations were predicted in the screening assessment.

0 2 4 6 Miles

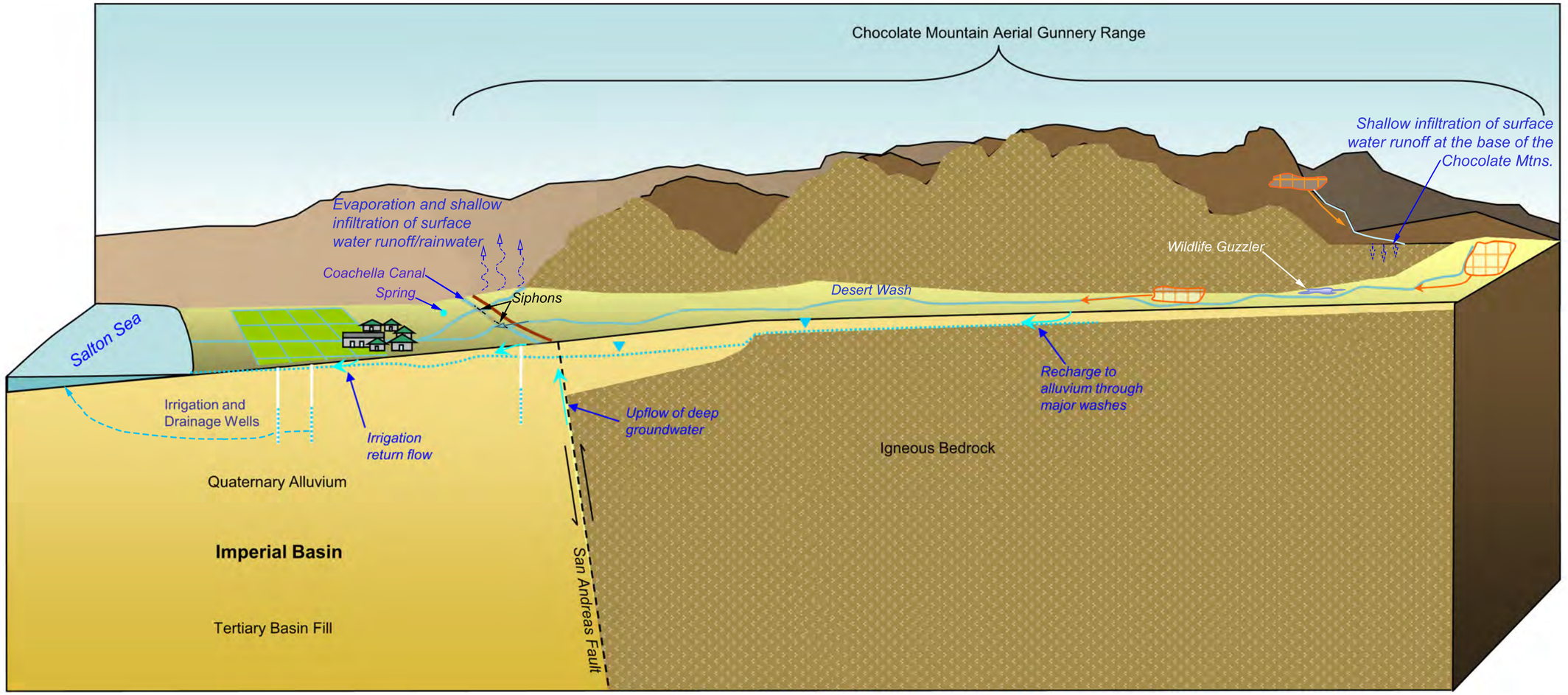
COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

ARCADIS

Path: G:\Projects\6285 - Mobile District USACE\043 - FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Public Version\Figure 2-6 CMAGR South Subwatersheds.mxd



NOTE: This block-diagram is based on the generalized distribution of mapped geological units and features in the CMAGR and is not a geological cross section depicting accurate outcrop areas and subsurface contacts. This diagram represents an idealized conceptual model of the surface and groundwater systems in the area and potential routes of MC migration from loading areas to human and ecological receptors.

Surface water transport is the dominant mechanism of potential MC migration from CMAGR loading areas. Surface water runoff is not expected to reach the Salton Sea or the groundwater table due to shallow infiltration and evaporation. Groundwater recharge to basin fill aquifers may occur during occasional flash floods, especially at the base of major washes along the San Andreas fault zone, but most infiltration occurs at the base of the Chocolate Mountains. There are no known drinking water supply wells in the CMAGR, as shallow groundwater is too saline for use as a drinking water source or for agriculture. Two USGS wells were identified north of CMAGR North and two additional wells were identified north of CMAGR South. These wells are believed to be used only for observation. Small irrigation and livestock wells are located south of the CMAGR, and they primarily tap deep groundwater aquifers.

Legend

- Range Boundary
- Range or Target Area
- Potential MC Migration Pathway
- Groundwater Flow or Recharge
- Water Table
- Ephemeral Stream
- Bedrock
- Alluvium and Basin Fill
- Irrigated Cropland

Bedrock consists of Precambrian gabbro and gneiss, Mesozoic granite, and minor Tertiary basaltic and andesitic volcanics. Water resources in bedrock areas are extremely limited and are restricted to *tinajas,* or water-filled bedrock depressions along washes, and man-made tanks or guzzlers.
Tertiary Basin Fill consists of coarse Oligocene alluvium; shallow marine conglomerate, sandstone, and siltstone of the Miocene Imperial Formation; and Pliocene Borrego Formation deposits of lacustrine sandstone, siltstone, and clay. Water quality in deeper portions of the basin is poor.
Quaternary Alluvium consists of gravel, sand, and silt derived from uplifted bedrock formations. Well developed dune fields are present along the San Andreas and Algodones faults, near the southwestern boundary of the range. Little or no groundwater is present in the thin upper alluvial fans except beneath major washes; lower portions of the alluvium are recharged by leakage from the canals and excess irrigation.
Ecological Receptors include the desert tortoise which has a critical habitat designation in the northern part of CMAGR. The golden eagle is a federally protected species and may move in and out of the CMAGR. No nests have been identified. Other sensitive species include birds, the American badger, and desert bighorn sheep.

Figure 2-7
CMAGR CONCEPTUAL SITE MODEL

REVA Five-Year Review
MCAS Yuma

feet to more than 600 feet and are also used as roads to enter the range complex. The siphons are bounded on both ends by berms around the Coachella Canal. The siphons are located at the southern installation boundary along the canal. Storm water is directed toward the siphons by a series of low, earthen dikes on the upgradient side of the canal.

Beneficial uses of surface water within the CMAGR boundaries are primarily groundwater recharge (GWR) and wildlife use (WILD) (DON, 2013). Most surface water runoff is not expected to reach as far as the Salton Sea or the Colorado River due to high evaporation and infiltration, but these are potential contact exposure points for humans and ecological receptors. Potential ecological receptors include special status species: Agassiz desert tortoise, golden eagle, Cooper's hawk, burrowing owl, desert bighorn sheep, American badger, Couch's spadefoot, and the loggerhead shrike. These species are discussed in **Section 2.1.6.2**.

2.2.3 Groundwater Pathway

2.2.3.1 BMGR West

The Fortuna groundwater basin underlies the range areas at BMGR West and is northeast of the Algodones Fault. The fault bisects BMGR West southwest of the fixed ranges and is generally parallel with the Gila Mountains. All range areas in BMGR West are northeast of the Algodones Fault, and the San Luis groundwater basin is located southwest of the fault (**Figure 2-8**). Land surface southwest of the fault is approximately 30 to 60 feet higher than the land surface to the northeast; however, groundwater elevation is generally 10 to 20 feet lower in the San Luis Basin southwest of the fault line. Offsets in water levels across the Algodones Fault indicate the presence of a barrier or restriction to groundwater movement across the fault. A graphical CSM is provided as **Figure 2-2**.

Groundwater depth within BMGR West was measured at 200 feet below ground surface (bgs) in 2014 at two non-potable water supply construction wells (used to support construction projects; information obtained from well registry reports provided by MCAS Yuma personnel). A groundwater mound has developed under the agricultural fields northwest of BMGR West (north of the fault line) due to the recharge from irrigation water derived from the Colorado River. Groundwater elevations in this area may be as much as 30 feet higher than the ranges in BMGR West. Groundwater flows to the south and southeast toward the United States–Mexico border and away from Yuma and adjacent populated and agricultural areas (**Figure 2-8**).

Groundwater withdrawals are typically from the coarse-gravel unit, located approximately 180 or more feet bgs in the Yuma and Upper Mesas with a thickness of 0 to 150 feet. Alluvium and basin fill units located above the coarse-gravel unit are interspersed with one to two clay layers (referred to as Clay A and Clay B) approximately 100 feet bgs. Where present, Clay A is inches to 35 feet thick and Clay B is 10 to 15 feet thick. These clay layers have been identified under Yuma Mesa and may extend southeast to Upper Mesa. The clay limits infiltration to the deeper coarse-gravel unit and causes variations in observed water levels where the water is perched above the clay (**Figure 2-2**). Much of the groundwater in the alluvium and basin fill units is from irrigation recharge (USGS, 2006).

Groundwater recharge is extremely limited because of low precipitation (approximately 3 inches per year), high evaporation rates, and the large depth to groundwater. Recharge is further limited in the broad, flat, sandy lowland areas where range areas are located because of the high average temperatures, and low rainfall.

Four groundwater supply wells are present at BMGR West: three are non-potable and infrequently used while one is currently out of service. MCAS Yuma personnel stated that one of the non-potable wells may be converted to a potable supply well in the near future. A fifth well previously used for exploration (unspecified) was abandoned in February 2014. Bureau of Reclamation monitoring/observation wells used to collect groundwater elevation data are also located within the BMGR West (ADEQ, 2014). Potable water to support ground activities at BMGR West is brought onto the range by Marines or other personnel using the range complex. Water from on-site wells is currently not used as a source of drinking water. According to MCAS Yuma staff, two wells will be installed at BMGR West. One well will be for non-potable supply to support construction, and the other will be a potable water source.

The main drinking water source for the city of Yuma, Arizona is the Colorado River, but groundwater is used as an additional source at times. Three water supply wells for the city of Yuma are located north of Highway 8, approximately 15 miles north and upgradient of BMGR West. Each well has a capacity of 3 million gallons per day (MGD); however, according to City of Yuma water personnel, a total of approximately 2 MGD are typically withdrawn from the three wells combined when the wells are in use. Four groundwater wells are located northwest of BMGR West within the MCAS Yuma installation boundary, but these wells are also hydraulically upgradient of the range areas. Information on the nature and status of these wells was not available, but installation personnel confirmed that they do not supply potable water for the installation. More than 100 non-potable wells are located west, south, and southeast of the installation, but fewer than 10 are downgradient of the range areas (USGS, 2006). Several of these are construction wells associated with the United States–Mexico border fence or other construction projects. Other wells are for observation, irrigation, and/or drainage (excess irrigation water is pumped from these wells to maintain water levels at acceptable distances below the land surface). No known drinking water wells currently exist downgradient of the range areas. Although groundwater on the range is not currently intended for potable use, wells are present downgradient of the ranges and provide the possibility of use; therefore, potential human receptors were identified at BMGR West.

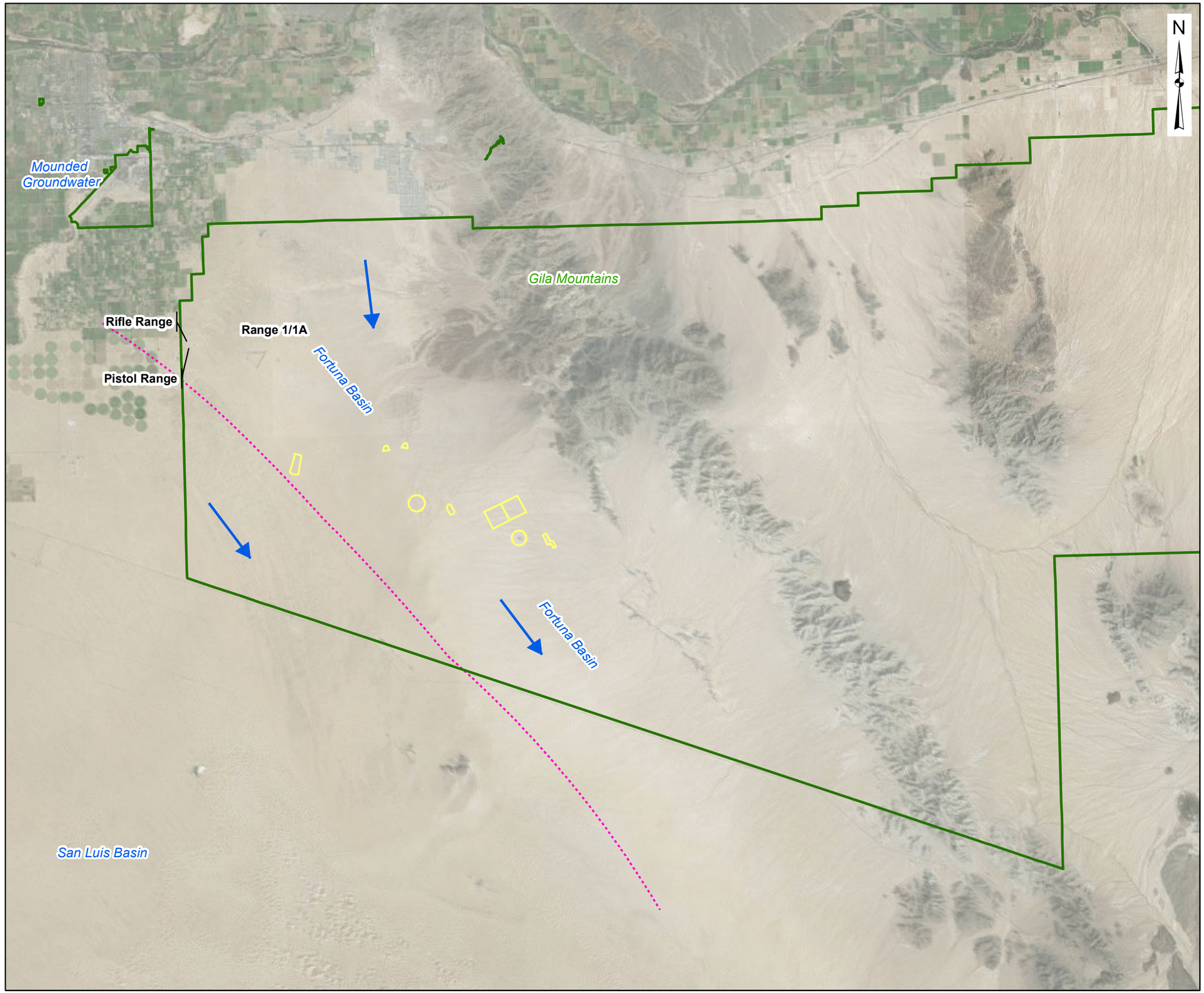
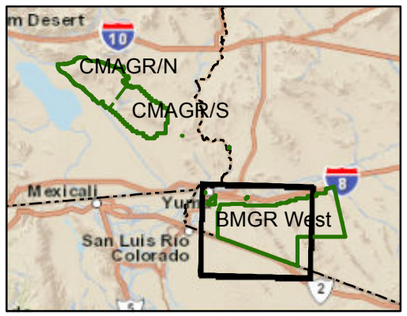


Figure 2-8
BMGR West Groundwater Features

Range Environmental
Vulnerability Assessment
MCAS Yuma, AZ

LEGEND

- Installation Boundary
- MC Loading Area
- Approximate Algodonoes Fault
- Approximate Groundwater Flow Direction



0 2 4 6 Miles

COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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Path: G:\Projects\62285 - Mobile District USACE\043 - FY13\GIS\MCAS Yuma\MXD\5-Yr Review Figures\Public Version\Figure 2-8 BMGR West Groundwater_r1.mxd

2.2.3.2 CMAGR

Active water supply wells are not present at the CMAGR, and groundwater resources within CMAGR are extremely limited. Little rainfall (approximately 3 inches per year) and rapid runoff results in minimal groundwater recharge. The installation is east of the San Andreas Fault, and bedrock east of the fault is shallow and highly limited in groundwater potential. The California Department of Water Resources classifies the bedrock in this area as non-water-bearing. Any infiltration that may occur would be derived primarily from runoff at the base of the Chocolate Mountains; however, because of low rainfall, high evaporation, and rapid runoff, only 10 to 14 percent of precipitation is expected to infiltrate to groundwater basins (CDM Federal Programs, 2003). Historically, water from the Coachella Canal leaked and provided some recharge to groundwater, but this was minimized when most of the canal along the CMAGR boundary was lined during two construction phases in 1980 and 2004 (Bureau of Land Management [BLM], 2009).

Most of the target areas in CMAGR North overlie the East Salton Sea groundwater basin with groundwater flow directed to the Salton Sea. Two target areas farthest west overlie the Chocolate Valley groundwater basin where groundwater flows west before flowing south toward the Salton Sea. Target areas in CMAGR South overlie the Arroyo Seco Valley groundwater basin, which flows east across the range area and the northeast toward the Colorado River (**Figure 2-9** and **Figure 2-10**) (DON, 2013).

One well is located west of CMAGR North in the Chocolate Valley groundwater basin. Four wells were identified near CMAGR South in the California well registry: two wells located 3 and 6 miles north of CMAGR South and two wells 1.5 and 2 miles south of the installation boundary. The two wells to the north are hydraulically downgradient of target areas in the Arroyo Seco basin. Information on the nature and status of these wells was not available, but installation personnel indicated that groundwater near CMAGR is not used as a potable source and groundwater use beneath the CMAGR is precluded by Public Water Reserve 65. Little information about groundwater in the Chocolate Mountains is available because few wells have been drilled in the area.

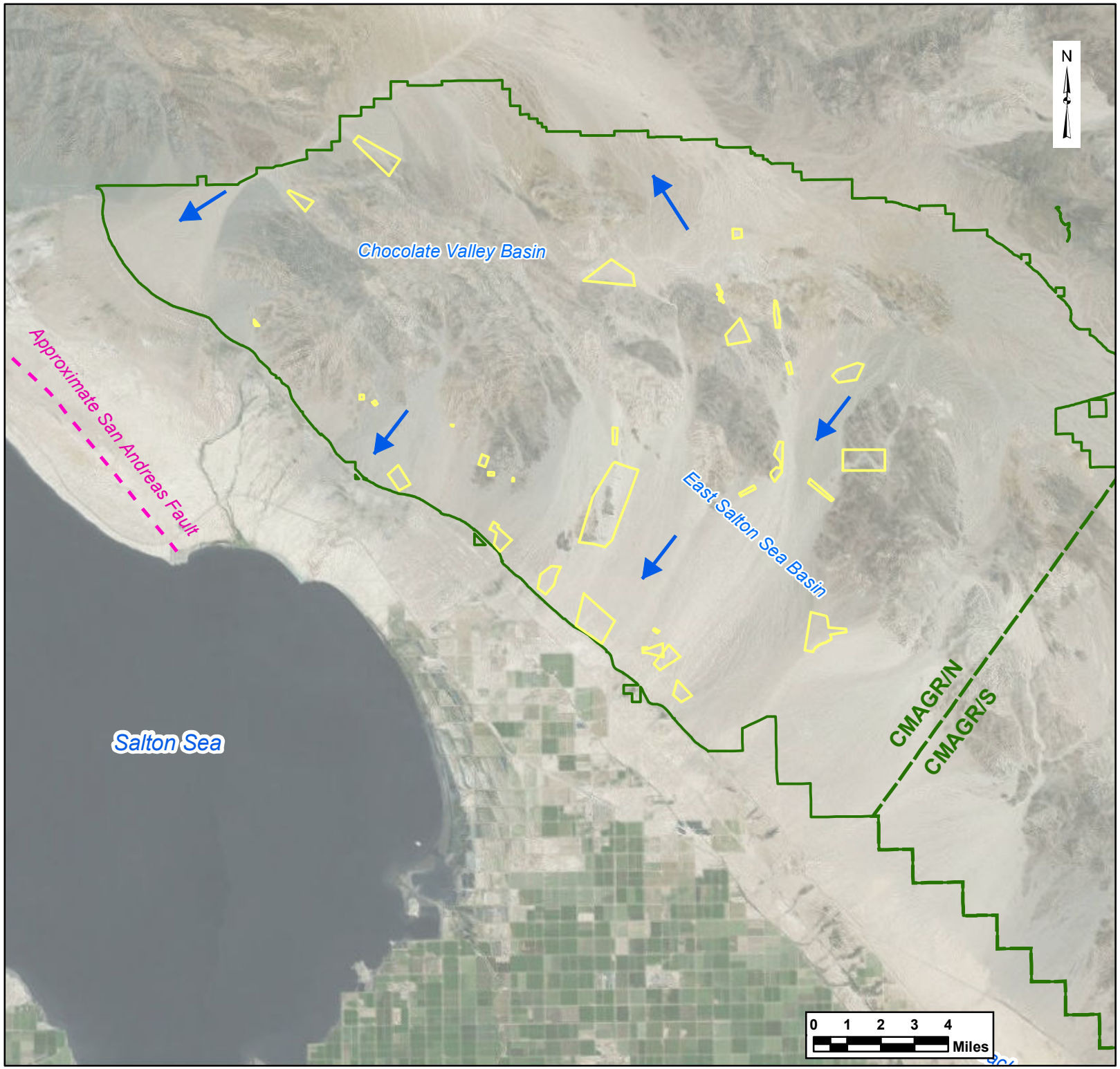
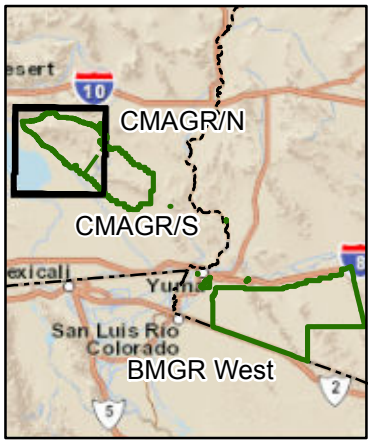


Figure 2-9
CMAGR North Groundwater Features

Range Environmental Vulnerability Assessment
MCAS Yuma, AZ

LEGEND

- Installation Boundary
- MC Loading Area
- Fault Line
- Groundwater Flow Direction



COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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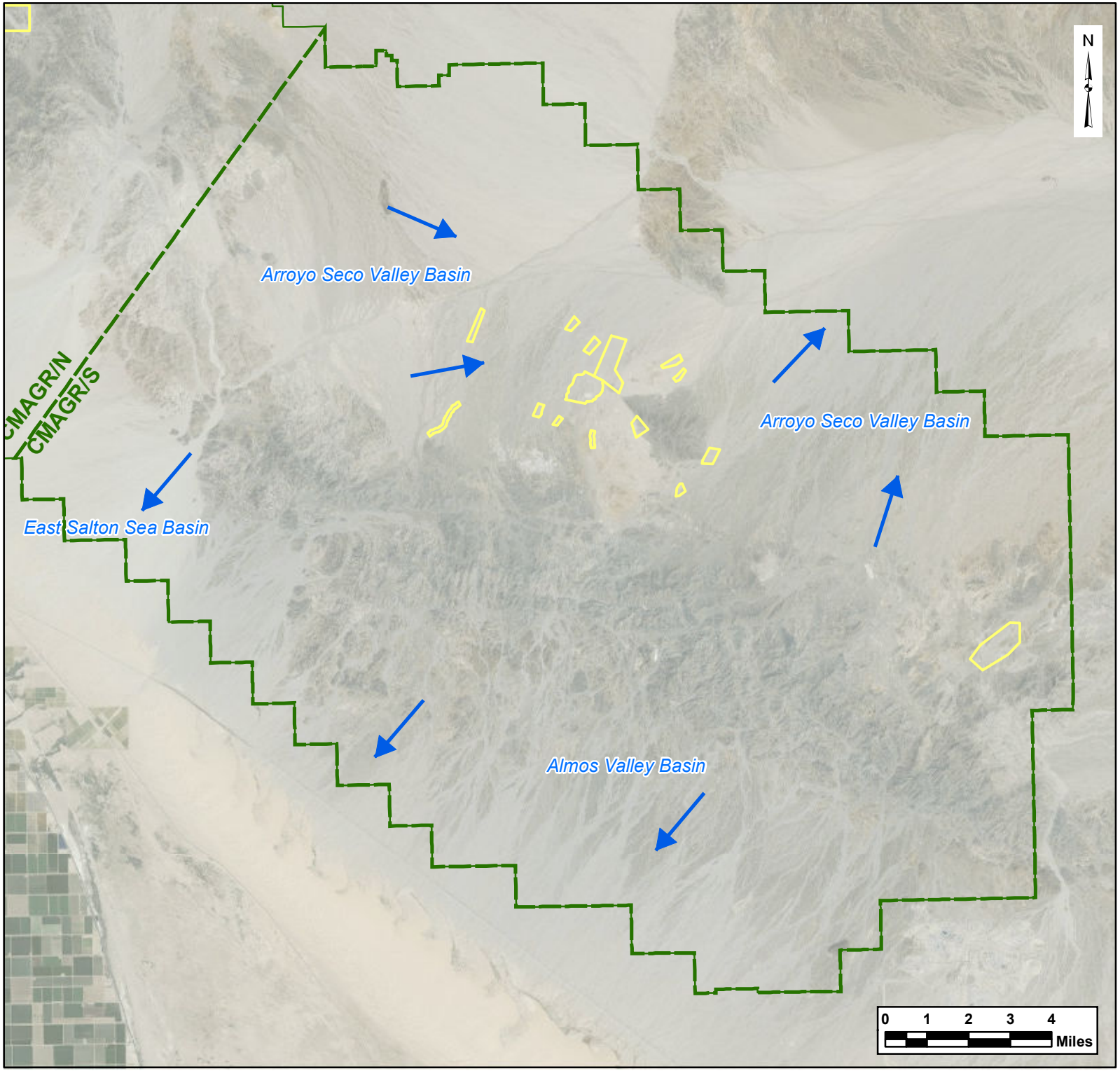
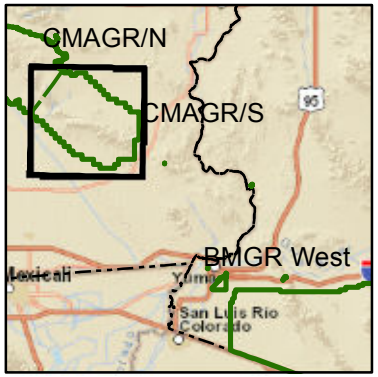


Figure 2-10
CMAGR South Groundwater Features

Range Environmental Vulnerability Assessment
MCAS Yuma, AZ

LEGEND

- Installation Boundary
- MC Loading Area
- Groundwater Flow Direction



COORDINATE SYSTEM: UTM
ZONE: 11N
DATUM: WGS 1984
UNITS: METERS

DATE: JUNE 2015

SOURCE: MCAS YUMA RANGE CONTROL OFFICE 2014, ESRI 2014

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Wells are present in the Imperial Valley southwest of CMAGR, most of which are small irrigation or livestock wells. None are known to be drinking water wells. Shallow groundwater is too saline for use in agriculture, so wells withdraw from deeper confined groundwater at depths of 350 to 1,300 feet. Shallow groundwater in the Imperial Valley discharges to a network of drains underlying the irrigated land. These drains are designed to collect and remove excess irrigation water. Some of the water collected in the drains is water that has moved upward from the deeper aquifers, mostly along faults near the eastern edge of the basin. The drains contain a mixture of groundwater, excess irrigation water, and surface runoff, and they discharge to the Salton Sea (Loeltz et al., 1975).

2.2.4 Special Status Species

2.2.4.1 BMGR West

The **Agassiz desert tortoise** is the only federally listed threatened species present in BMGR West, but its presence on the western side of the BMGR is thought to be very limited based on only a single sighting in 2008 or 2009 (Department of the Air Force and DON, 2012). It is an opportunistic surface water user that may drink from accumulated puddles if available, but most of the water it needs to survive is derived from the plants it eats. During rainfalls, the tortoise may create a depression in the ground in which it sits and collects rainwater (BLM, 2014).

The **flat-tailed horned lizard** is listed as a species of concern by the Arizona Game and Fish Department, and it is found throughout the western portion of BMGR West. The flat-tailed horned lizard is managed in accordance with an Interagency Conservation Agreement and Flat-Tailed Horned Lizard Rangewide Management Strategy. They are not known to drink standing water, but they rain-harvest, which is a behavior that some horned lizard species use to channel precipitation or condensation collected on the lizard's body to its mouth for consumption (United States Fish and Wildlife Service, 2011). The majority of the water consumed by the flat-tailed horned lizard is from the food they eat.

The **Sonoran pronghorn** is a federally endangered species; however, its habitat is located within BMGR East. The Sonoran pronghorn habitat is not located within the Yuma Desert watershed, and it does not have exposure to the surface water runoff from BMGR West.

2.2.4.2 CMAGR

The **Agassiz desert tortoise** is federally and state-listed (California) as threatened. MCAS Yuma conducts Agassiz desert tortoise surveys in the designated CMAGR habitat in the Chuckwalla Desert Wildlife Management Area. Approximately 40 percent of the CMAGR lies within desert tortoise critical habitat, and approximately 30 percent of this critical habitat is used for military activity. The critical habitat is located along the entire northern boundary and extends into approximately half of the CMAGR.

The **golden eagle** is federally protected and listed by the State of California as a sensitive species. The golden eagle is common near water bodies where it fishes and may eat waterfowl. Fresh water is important for the golden eagle where it bathes and may drink large amounts of water (San Diego Zoo, 2011).

Cooper's hawk and the **burrowing owl** are federally and California state-listed as sensitive. The Cooper's hawk is also federally protected. One Cooper's hawk was observed in SWAT 4 in 2012. The Cooper's hawk may forage throughout the CMAGR, but it is not likely to nest there (DON, 2013). Cooper's hawk uses pools and streams to drink, but it may be able to derive the water it needs to survive from the tissues of its prey (Arizona Game and Fish Department, 1998). It typically is not found in areas with no surface water. The owl has been observed most frequently in the northeastern areas of SWAT 5 in 2507N (DON, 2013).

The **desert bighorn sheep** is listed by the Bureau of Land Management and the U.S. Forest Service as sensitive; however, it is not federally or state listed. Although it typically is found on rocky, steep terrain, it will move through valleys to reach other habitat sites and water. Guzzlers fed by rainwater and surface water runoff are maintained in the CMAGR to support this species (Department of the Air Force and DON, 2012). It needs water at least every 3 days to survive but can derive some of this water from plants it eats (Blue Planet Biomes, 2002).

The **American badger** is a California state-listed sensitive species. Its presence in the CMAGR is not well understood. Evidence of its presence has been found, but it has not observed in the field. It derives the water it needs to survive from prey and does not depend on locating water sources; however, it will drink water if it is available (Laudenslayer, 2007).

The **Couch's spadefoot** is a California state-listed sensitive toad species. Well-documented habitat exists along the southern border of the CMAGR. It spends most of the year underground and then emerges during intense rainfall to breed in the temporary ponds created.

The **loggerhead shrike** is listed as a state sensitive bird species. It forages throughout SWATs 4 and 5 in 2507N (DON, 2013). This bird derives the water it needs from the tissues of its prey (BLM, 2014).

2.2.5 Summary of Pathways and Receptors

Surface water and sediment transport is the dominant mechanism of potential MC migration at MCAS Yuma, and ecological receptors may opportunistically use available surface water. The climate and physiography of BMGR West limit the potential for off-range MC migration, as surface water drainages mostly end within BMGR West with water typically lost in shallow infiltration or evaporation. Flash flooding may occur in CMAGR following heavy rainfall events and can carry large quantities of sediment. Surface water runoff flows off the mountains and down desert washes. Due to high evaporation and infiltration, surface water runoff is not typically expected to reach larger waterbodies downgradient. One wildlife guzzler may be located downgradient of two target areas in CMAGR North and could potentially intercept surface water runoff from this target area.

The very low groundwater recharge in the range areas significantly limits the potential transport of MC from the surface to the groundwater. No known drinking water wells are currently located downgradient of any of the range or target areas at MCAS Yuma.

Table 2-1 summarizes the pathways, receptors and MC identified for screening-level modeling assessment.

Table 2-1. Modeled Pathways and Receptors

BMGR West	Receptor and Modeled MC	
Pathway	**Human (Drinking Water)**	**Ecological**
Surface Water/Sediment	None	HE, Perchlorate
Groundwater	HE, Perchlorate	None
CMAGR North and CMAGR South	**Receptor**	
Pathway	**Drinking Water**	**Ecological**
Surface Water/Sediment	None	HE, Perchlorate
Groundwater	HE, Perchlorate	None

2.3 Screening-Level Assessments

Screening-level fate and transport assessments were conducted for 56 MC loading areas throughout BMGR West, CMAGR North, and CMAGR South to determine conservative estimates of MC concentrations in surface water, sediment, and groundwater at identified potential receptor locations. Nine of the MC loading areas assessed are located within BMGR West, 32 are within CMAGR North, and 15 are within CMAGR South. The MC loading areas were selected for quantitative screening-level assessments based on range use and their potential for MC migration to receptor locations. The average annual MC concentrations in surface water, sediment, and groundwater were estimated based on the average annual MC loading of each MC at the loading areas. The procedures used are presented in the REVA Five-Year Review Manual (HQMC, 2010). The screening-level assessments were conducted for the period between 2007 and 2013, with the exception of Ranges S-5-2 and S-5-3. The MC loading for ranges S-5-2 and S-5-3 was based on MC loading data for the period between 2007 and 2010 because these ranges became inactive in 2010.

Summaries of the surface water, sediment, and groundwater screening-level assessment results are presented in the following sections. Results were compared to REVA median method detection limits (MDLs) to evaluate the potential for detectable MC releases to off-range receptors. The median values were determined using MDLs from several laboratories to establish a set of comparison values to identify next steps in the REVA process. MDLs do not represent a regulatory action level but are used only within REVA to determine if the predicted concentrations of REVA MC generated from the fate and transport models are detectable concentrations. Parameter values used in the screening-level assessment are presented in **Appendix C**. .

2.3.1 Surface Water Screening-Level Results

The nine MC loading areas assessed at BMGR West are within the Yuma desert watershed (**Figure 1-2**). Surface drainage from the MC loading areas flows west toward the installation boundary. The downgradient ecological receptor location for these MC loading areas was considered the installation boundary. Although ephemeral streams within the installation may be used by ecological receptors, the installation boundary was used in order to predict potential off-installation releases.

The 47 MC loading areas assessed at the CMAGR drain within several watersheds with ephemeral streams and washes where heavy rainfall events can produce flash floods capable of moving large volumes of sediment (**Figure 1-3 and Figure 1-4**). Siphons located at the installation boundary were identified as downstream ecological receptor locations and endpoints of the screening-level assessments in CMAGR North. In CMAGR South, Milpitas Wash receives drainage from the MC loading areas, and the Milpitas Wash at the installation boundary was identified as the downstream receptor location and endpoint of the screening-level assessment in CMAGR South.

Two MC loading areas within CMAGR North (10N and 11N) drain to the Tadlock Guzzler. This guzzler is identified as a downstream receptor location point and endpoint for the screening-level assessment. Other guzzlers located primarily in the Chocolate Mountains are not downgradient of MC loading areas and, therefore, were not identified as downstream receptor locations.

The REVA screening-level surface water assessment at MCAS Yuma involved: 1) estimating the average annual MC concentrations in surface water runoff at the edge of each MC loading area, and 2) conducting a mixing calculation to determine the cumulative contribution of MC from individual MC loading areas draining to an off-range receptor location at the installation boundary or the identified guzzler.

MC concentrations in surface water entering downstream receptor locations were based on the edge-of-loading area predicted MC concentrations combined from MC loading areas located within the same subwatersheds. **Appendix C** contains a table showing the proportion of each MC loading area draining to multiple receptor locations.

Receptor locations with a predicted MC concentration above the medial MDL (detectable concentration) are bold and highlighted pink in **Table 2-2** and shown on **Figure 2-4** and **Figure 2-6**. MC were not predicted to reach the edge of the Yuma Desert watershed at concentrations above median MDLs in BMGR West. The surface water assessment predicted the following detectable concentrations:

- HMX and RDX to reach the Tadlock Guzzler, Siphon 9, and Siphon 11 from MC loading areas within CMGR North.
    - MC loading areas predicted to contribute most of the HMX and RDX mass to these receptor locations include 10N (to Tadlock Guzzler), ICM Box (to Siphon 9), and 3N (to Siphon 11).
- Perchlorate to reach the Tadlock Guzzler, Iris Wash, Siphon 9, and Siphon 11 from MC loading areas within CMGR North.

- MC loading areas predicted to contribute most of the perchlorate mass to these receptor locations include 10N (to Tadlock Guzzler), S-4-3 (to Iris Wash), ICM Box (to Siphon 9)), and 3N (to Siphon 11).

- RDX to reach Milpitas Wash from MC loading areas within CMAGR South.
  - MC loading areas predicted to contribute most of the RDX mass to this receptor location include 15S and 12S.

Based on the predicted detectable MC concentrations in five of the downstream surface water receptor locations, field sampling was recommended for Tadlock Guzzler, Siphon 9, Siphon 11, Iris Wash, and Milpitas Wash at the installation boundary. Field sampling is discussed in **Section 2.6**.

Table 2-2: Screening-Level Estimates of Annual Average MC Concentrations in Surface Water Entering the Downstream Receptor Locations.

Subwatershed	Receptor Location	Estimated MC Concentration (µg/L)			
		HMX	RDX	TNT	Perchlorate
BMGR West					
Yuma Desert	Edge of Yuma Desert	0.002	0.001	0.002	~0
CMAGR North					
Middle Salt Creek	Salt Creek	0.003	0.006	~0	0.002
Town of Pope – Frontal Salton Sea	Salton Sea	N/A	~0	~0	0.001
Town of Frink – Frontal Salton Sea	Siphon 13	N/A	~0	~0	0.001
Town of Niland – Frontal Salton Sea	**Iris Wash**	0.049	0.026	0.001	**0.099**
181002041104	**Siphon 11**	**0.238**	**0.547**	0.026	**0.140**
181002041106	**Siphon 9**	**0.261**	**0.591**	0.029	**0.156**
Camp Dunlap	Siphon 8	0.027	0.061	0.003	0.016
Tadlock Guzzler	**Tadlock Guzzler**	**0.237**	**0.510**	0.022	**0.144**
CMAGR South					
Milpitas Wash[a]	**Milpitas Wash**	0.049	**0.191**	0.009	0.005
REVA median MDL for water		*0.114*	*0.110*	*0.113*	*0.021*

Note:
µg/L = micrograms per liter
N/A = not modeled, as the MC loading rate was estimated to be negligible
Shading and bold indicate concentration exceeds the median MDL.
[a] The predicted downstream MC concentrations for the subwatersheds of Milpitas Wash were combined to estimate concentrations reaching Milpitas Wash.

2.3.2 Sediment Screening-Level Results

The soil types at the MC loading areas at MCAS Yuma largely consist of sand, sandy loam, and gravelly loam that have low to moderate inherent soil erodibility and overall low estimated soil erosion potential. The low erosion potential is largely attributed to very low precipitation in the area and flat topography at the MC loading areas. Despite the overall low soil loss rates, the sediment transported from the MC loading areas during any single storm event could be significant due to flash floods that occur during heavy rainfall events.

Similar to the surface water screening-level assessment, average annual MC concentrations in sediment were estimated at the edge of the identified MC loading areas and then potentially entering downstream surface water receptor locations at the installation boundary and identified guzzler. .

The RDX concentrations from two MC loading areas (S-4-1 and ICM Box) and TNT concentrations from five MC loading areas (10N, 3N, S-4-1, 13N, and ICM Box) were estimated to be at detectable concentrations at the edge of the MC loading areas. These MC loading areas drain to four receptor locations: Siphon 8, Siphon 9, Siphon 11, and Tadlock Guzzler. Based on predicted detectable concentrations at the edge of MC loading areas, further assessments were conducted to estimate MC concentrations in sediment entering these downstream receptor locations. Predicted concentrations at the receptor locations were below detectable concentrations, as shown in **Table 2-3**. No additional assessment is recommended at this time for sediment at MCAS Yuma.

Table 2-3: Screening-Level Estimates of Annual Average MC Concentrations in Sediment Entering the Downstream Receptor Locations

Subwatershed	Receptor Location	Estimated MC Concentration (µg/kg)			
		HMX	RDX	TNT	Perchlorate
CMAGR North					
181002041104	Siphon 11	NM	1.55	3.59	NM
181002041106	Siphon 9	NM	1.63	3.80	NM
Camp Dunlap	Siphon 8	NM	0.188	0.438	NM
Tadlock Guzzler	Tadlock Guzzler	NM	0.109	0.262	NM
REVA median MDL for water		*51*	*32.5*	*25*	*0.18*

Note:
µg/kg = micrograms per kilogram
NM = not modeled because MC was eliminated from further assessment based on the concentration predicted at the edge of the MC loading area

2.3.3 Groundwater Screening-Level Results

The REVA screening-level groundwater assessment at MCAS Yuma was a three-step process to assess the potential for MC to migrate from MC loading areas: 1) estimate maximum MC concentrations in

infiltrating water at each MC loading area, 2) model the potential for MC to migrate from the MC loading areas vertically through the vadose zone to groundwater, and 3) model the potential for MC to migrate horizontally within the saturated zone to potential groundwater receptors (non-potable wells). At each step of the process, the predicted MC concentrations were compared to median MDL values, and only the MC exceeding median MDLs were assessed in the next step. .

Saturated zone modeling was not conducted at CMAGR North because potential downgradient receptors were not identified. The saturated zone modeling was conducted at two of the seven MC loading areas within BMGR West where perchlorate was predicted to reach the water table at a detectable concentration (CSOC1 and CSOC2). The other five MC loading areas within BMGR West were not further assessed for transport in the saturated zone because a potential downgradient receptor was not identified near the MC loading areas. The saturated zone modeling was conducted for the 14 MC loading areas within CMAGR South where perchlorate was predicted to reach the water table at a detectable concentration.

Model-predicted perchlorate concentrations potentially reaching the nearest downgradient groundwater well are presented in **Table 2-4**. The model predicted the following:

- Perchlorate to reach the groundwater well at detectable concentrations from both CSOC1 and CSOC2 MC loading areas modeled within BMGR West.
- Perchlorate to reach the closest groundwater well located northeast of the CMAGR South installation boundary at detectable concentrations from 12 of the 14 MC loading areas modeled within CMAGR South (**Table 2-4**)

Table 2-4: Model-Estimated MC Concentrations Potentially Reaching Groundwater Receptors

MC Loading Area	Distance to Well (miles)	Concentration at Groundwater Well (µg/L)			
		HMX	RDX	TNT	Perchlorate
BMGR West					
CSOC1	0.5	N/A	NM	NM	**0.230**
CSOC2	0.25	N/A	NM	NM	**0.0480**
CMAGR South					
1S	15	NM	NM	NM	0.00697
3S	13	NM	NM	NM	**0.0550**
5S	16	NM	NM	NM	**0.0461**
15S	12.5	NM	NM	NM	**0.293**
12S	12.5	NM	NM	NM	**0.253**
6S	12	NM	NM	NM	**0.0669**
10S	13	NM	NM	NM	**0.0371**
7S	12	NM	NM	NM	**0.0582**
Mt. Barrow	11	NM	NM	NM	**0.467**

MC Loading Area	Distance to Well (miles)	Concentration at Groundwater Well (µg/L)			
		HMX	RDX	TNT	Perchlorate
4S	4	NM	NM	NM	**0.0287**
13S	14	NM	NM	NM	**0.0263**
2S	9	NM	NM	NM	**0.0222**
11S	11	NM	NM	NM	0.0207
14S	7	NM	NM	NM	**0.0286**
REVA median MDL for water		*0.110*	*0.113*	*0.114*	*0.021*

Note:
µg/kg = micrograms per kilogram
N/A = not modeled, as the MC loading was estimated to be negligible
NM = not modeled because MC was eliminated for further assessment based on previous steps of the groundwater screening assessment
Shading and **bold** indicates concentration exceeds the median MDL.

Although perchlorate was predicted to reach the groundwater wells at detectable concentrations from most of the MC loading areas modeled, the model predicted that it would take over 100 years (130 and 140 years at the MC loading areas within BMGR West, and between 300 and 900 years at the MC loading areas within CMAGR South) because of the low infiltration rate and depth to groundwater. The predicted perchlorate concentrations potentially reaching the groundwater wells are extremely low (at least two orders of magnitude below the Arizona drinking water standard of 14 micrograms per liter (µg/L) for perchlorate from MC loading areas in BMGR West and at least one order of magnitude below the California drinking water standard of 6 µg/L for perchlorate from MC loading areas in CMAGR South) and are not expected to approach the state-specific guidance criteria. Additionally, the groundwater wells within BMGR West that are located closest to identified MC loading areas are screened within the coarse gravel zone of the water bearing unit, which is overlain by fine-grained alluvium and basin fill interspersed with one or two discontinuous clay layers 15 to 35 feet thick. Where present, the clay layers can impede vertical movement of groundwater potentially containing perchlorate. Thus, the model-predicted concentrations potentially reaching the wells are conservative, as the modeling did not account for the potential impedance of MC by the discontinuous clay layers.

As a result of the very slow transport of perchlorate to groundwater and the extremely low perchlorate concentrations predicted to reach groundwater receptors based on conservative assumptions, negligible impact is anticipated to potential downgradient groundwater receptors. Therefore, no additional groundwater assessment was conducted for the MC loading areas at MCAS Yuma.

2.4 Small Arms Range Assessment Results

Ranges that primarily use small arms ammunition for training purposes at MCAS Yuma are qualitatively assessed under the REVA program. The REVA indicator MC for SARs is lead because it is the most prevalent (by weight) potentially hazardous constituent associated with small arms ammunition. The qualitative assessment is completed using the Small Arms Range Assessment Protocol (SARAP) to

determine where there is a perceived potential risk of lead migration and receptor impact by evaluating the migration potential of lead at an individual SAR based on several factors, including:

- range use
- range design and layout
- physical and chemical characteristics of the area
- past and present operation and maintenance practices
- lead migration pathways and receptors (groundwater, surface water, and sediment)

An overall ranking of minimal, moderate, or high is determined for surface water/sediment and for groundwater based on a scoring of these factors. A high ranking indicates the greatest potential for lead migration and receptor impact.

Four SARs were identified at BMGR West, and five SARs were identified at CMAGR North. The SARAP evaluations are provided in **Appendix D**, and **Table 2-5** provides a summary of the results.

Table 2-5: Summary of SARAP Results

SAR	Surface Water / Sediment Ranking (Score)	Groundwater Ranking (Score)
KD Rifle Range	Minimal (32)	Minimal (25)
KD Pistol Range	Minimal (31)	Minimal (22)
Range 1	Minimal (25)	Minimal (18)
Range 1A	Minimal (24)	Minimal (18)
S-4-5	Moderate (34)	Minimal (26)
S-4-6A	Moderate (41)	Minimal (32)
S-4-6B	Moderate (42)	Minimal (32)
S-4-7	Moderate (39)	Minimal (29)
S-4-9	Moderate (36)	Minimal (28)

All SARs received minimal rankings for groundwater receptors, largely because groundwater receptors were not identified close to any of the ranges. SARs located in BMGR West received minimal rankings for surface water/sediment receptors, while SARs in CMAGR North received moderate rankings for surface water/sediment receptors. The difference in scores is due primarily to the presence of surface water (ephemeral washes) near the SARs in CMAGR North and thus, potential ecological receptors, while SARs in BMGR West are farther from surface water. All of the ranges experience low precipitation (but potential

for flash flood conditions), have little to no vegetation, have mostly flat topography, and the ground surface is composed of fine sand or silt. Soil pH is between 6.5 and 8.5, and this neutral range should reduce dissolution of lead. Flat topography and sand promote infiltration of surface water rather than runoff conditions; however, flash flooding and little vegetation can carry large loads of sediment during one storm event.

2.5 Lead in Subwatersheds

Lead is not modeled within REVA because the site-specific information needed for reasonable prediction is typically not available. Although the highest quantities of lead used at Marine Corps Installation are typically expended at SARs, significant quantities of lead are also expended at some mixed use ranges. Total lead loading within each subwatershed was calculated by combining average annual lead loading from MC loading areas. Subwatershed lead loading from MC loading areas is presented in **Table 2-6.**

Table 2-6: Annual Lead Deposition in Subwatersheds at MCAS Yuma

Subwatershed / Modeled Receptor Location	MC Loading Area (% located within the subwatershed)[1]	Annual Lead Deposition (lb/year)[2]
Yuma Desert / Installation Boundary	Cactus West	1,662
	CSOC 1	212
	CSOC 2	120
	Murrayville East	74
	Murrayville West	155
	Panel Stager	893
	Yodaville	1,690
	All Yuma Desert MC Loading Areas	**4,806**
Middle of Salt Creek / Salt Creek	S-5-2	536
	S-5-3	2,757
	All Middle of Salt Creek MC Loading Areas	**3,293**
Town of Pope – Frontal Salton Sea / Salton Sea	S-4-22 (21%)	4
	S-4-23	310
	All Town of Pope – Frontal Salton Sea MC Loading Areas	**314**
Town of Frink – Frontal Salton Sea / Salton Sea	S-4-12A/S-4-12B (8%)	1,460
	S-4-13	7,724

Subwatershed / Modeled Receptor Location	MC Loading Area (% located within the subwatershed)[1]	Annual Lead Deposition (lb/year)[2]
	S-4-14	156
	S-4-15	47
	S-4-17	31
	S-4-19	112
	S-4-21	41
	S-4-22 (79%)	33
	All Town of Frink – Frontal Salton Sea MC Loading Areas	**9,604**
Town of Niland – Frontal Salton Sea / Salton Sea	S-4-10	10,495
	S-4-11A/S-4-11B (60%)	1,124
	S-4-12A/S-4-12B (92%)	16,792
	8N	79
	12N (5%)	2,783
	15N (12%)	105
	All Town of Niland – Frontal Salton Sea MC Loading Areas	**31,378**
181002041103 / Siphon 13	S-4-11A/S-4-11B (40%)	450
	12N (5%)	146
	All Siphon 13 MC Loading Areas	**596**
Iris Wash / Iris Wash	S-4-2	0
	S-4-3	28
	S-4-8	0
	2N	179
	7N (96%)	240
	9N (3%)	4
	14N	70
	All Iris Wash MC Loading Areas	521
Tadlock Guzzler / Tadlock Guzzler	10N (58%)	349

Subwatershed / Modeled Receptor Location	MC Loading Area (% located within the subwatershed)[1]	Annual Lead Deposition (lb/year)[2]
	11N	58
	All Tadlock MC Loading Areas	**407**
181002041104 / Siphon 11	S-4-1	0
	3N	1,244
	6N	62
	7N (4%)	10
	10N (42%)	252
	All Siphon 11 MC Loading Areas	**1,568**
181002040602 / Salt Creek	9N (97%)	129
	All Salt Creek MC Loading Areas	**129**
181002041106 / Siphon 9	S-4-4	1,681
	ICM Box (93%)	1,375
	1N (52%)	67
	13N	620
	All Siphon 9 MC Loading Areas	**3,743**
Camp Dunlap / Siphon 8	1N (48%)	62
	15N (88%)	770
	ICM Box (7%)	103
	All Siphon 8 MC Loading Areas	**935**
Multiple / Milpitas Wash[3]	Mt Barrow	4,602
	1S	615
	2S	262
	3S	696
	4S	363
	5S	473
	6S	696
	7S	663

Subwatershed / Modeled Receptor Location	MC Loading Area (% located within the subwatershed)[1]	Annual Lead Deposition (lb/year)[2]
	8S	158
	10S	421
	11S	238
	12S	3,078
	13S	323
	14S	294
	15S	3,553
	All Milpitas Wash MC Loading Areas	**16,435**

Note:
lbs = pounds
1. % is indicated for MC loading areas located in more than one subwatershed.
2. Lead deposition is allocated according to the % of MC loading area within a subwatershed.
3. Multiple subwatersheds converge at the modeled receptor location within Milpitas Wash.

Lead deposition at MC loading areas is much higher within the subwatersheds of Town of Niland – Frontal Salton Sea and Milpitas Wash. Lead at Milpitas Wash is spread throughout several target areas, while lead deposition in the Town of Niland – Frontal Salton Sea is concentrated within two MC loading areas: S-4-10 and S-4-12A/S-4-12B. Although lead loading is high in these subwatersheds, the MC runoff potential is low due to low annual precipitation, flat topography, and sandy soils that promote infiltration. Additionally, the slightly basic soils inhibit corrosion and dissolution of lead into surface water runoff.

2.6 Summary of Field Sampling

The model predicted detectable MC concentrations at four receptor locations: Milpitas Wash, Iris Wash, Siphon 9, and Siphon 11. Therefore, these locations were recommended for surface water sampling. Sampling was completed in accordance with the *Draft Sampling and Analysis Plan – Quality Assurance Project Plan, REVA, MCAS Yuma* (ARCADIS, 2014a) and the *Draft Sampling and Analysis Plan Addendum* (ARCADIS, 2014b). Field sampling using passive samplers was completed in September 2014 and March 2015 as part of the five-year review at the CMAGR. Sample locations were identified in the screening-level assessments, as detailed in **Section 2.3.1**.

Sampling methods are detailed in the *Draft Sampling and Analysis Plan, Range Environmental Vulnerability Assessment, MCAS Yuma* (ARCADIS, 2014) and *Sampling and Analysis Plan Addendum, MCAS Yuma* (ARCADIS, 2014a; ARCADIS, 2014b). Passive samplers were placed in August and September 2014 at the CMAGR South and North, respectively, to collect surface water runoff during a storm event and were then be retrieved after the event. Multiple samplers were placed at each potential receptor location

because the precise location of drainage channels during rain events could not be predicted because of the significant braiding. Multiple samplers increased the likelihood of capturing runoff.

Table 2-7 presents surface water sample identifications, associated ranges and/or receptor locations, and analytes. Explosives and perchlorate were selected for analysis based on modeling results; lead was selected because ranges depositing lead are located close to the installation boundary.

Table 2-7: Summary of Samples at MCAS Yuma

Surface Water Sample ID	Associated Ranges and Target Areas	Analytes	Samples Retrieved
Milpitas Wash_SW-01	Aerial Targets: 3S, 1S, 4S, 5S, 13S, 8S, 12S, 15S, 2S	Explosives	September 11, 2014
Milpitas Wash_SW-02	Aerial Targets: 3S, 1S, 4S, 5S, 13S, 8S, 12S, 15S, 2S	Explosives	September 11, 2014
Milpitas Wash_SW-03	Aerial Targets: 3S, 1S, 4S, 5S, 13S, 8S, 12S, 15S, 2S	Explosives	September 11, 2014
Milpitas Wash_SW-04	Aerial Targets: 3S, 1S, 4S, 5S, 13S, 8S, 12S, 15S, 2S, 6S, 10S, 11S	Explosives	September 11, 2014
Milpitas Wash_SW-05	Aerial Targets: 3S, 1S, 4S, 5S, 13S, 8S, 12S, 15S, 2S, 6S, 10S, 11S	Explosives	September 11, 2014
Milpitas Wash_SW-06	Aerial Targets: 3S, 1S, 4S, 5S, 13S, 8S, 12S, 15S, 2S	Explosives	September 11, 2014
Iris_SW-01[1]	SARs: S-4-5, S-4-6A, S-4-6B, S-4-7 Aerial Targets: S-4-2, S-4-3, S-4-8, 2N, 7N, 10N, 11N, 14N	Perchlorate, Total and Dissolved Lead	March 4, 2015
Iris_SW-02[1]	SARs: S-4-5, S-4-6A, S-4-6B, S-4-7 Aerial Targets: S-4-2, S-4-3, S-4-8, 2N, 7N, 10N, 11N, 14N	Perchlorate, Total and Dissolved Lead	March 4, 2015
Iris_SW-03[1]	SARs: S-4-5, S-4-6A, S-4-6B, S-4-7 Aerial Targets: S-4-2, S-4-3, S-4-8, 2N, 7N, 10N, 11N, 14N	Perchlorate, Total and Dissolved Lead	March 4, 2015
SIP09_SW-01[1]	Aerial Targets: S-4-4, 1N, ICM Box, 13N	Explosives, Perchlorate, Total and Dissolved Lead[4]	March 4, 2015
SIP09_SW-02[2]	Aerial Targets: S-4-4, 1N, ICM Box, 13N	Explosives, Perchlorate, Total and Dissolved Lead[4]	March 4, 2015
SIP09_SW-03[2]	Aerial Targets: S-4-4, 1N, ICM Box, 13N	Explosives, Perchlorate, Total and Dissolved Lead[4]	March 4, 2015
SIP11_SW-01[3]	SAR: S-4-9 Aerial Targets: S-4-1, 3N, 6N, 10N	Explosives, Perchlorate, Total and Dissolved Lead[4]	March 4, 2015
SIP11_SW-02[3]	SAR: S-4-9 Aerial Targets: S-4-1, 3N, 6N, 10N	Explosives, Perchlorate, Total and Dissolved Lead[4]	March 4, 2015
SIP11_SW-03[3]	SAR: S-4-9 Aerial Targets: S-4-1, 3N, 6N, 10N	Explosives, Perchlorate, Total and Dissolved Lead[4]	March 4, 2015

Note: ID = identification
1. Sufficient sample volume was not collected at each sampler location so one composite sample was collected (IRIS_SW)

2. Sufficient sample volume was not collected at each sampler location so one composite sample was collected (SIP09_SW)
3. Sufficient sample volume was not collected at each sampler location so one composite sample was collected (SIP11_SW)
4. Sufficient sample volume was not collected to run the explosives analysis.

CMAGR South received approximately 0.50 inches of rainfall on September 10, 2014. Samples were retrieved from six samplers and one duplicate sampler on September 11, 2014 in Milpitas Wash and sent to RTI Laboratories in Lavonia, Michigan, for analysis of explosives. CMAGR North received approximately 0.21 inches of rainfall, and samples were retrieved from three siphons on March 4, 2015. Each sampler captured only 1 to 5 ounces of surface water; therefore, one composite sample from each siphon was submitted to RTI Laboratories for analysis. Dissolved lead and perchlorate samples were not filtered or acidified in the field. Samples from Siphons 9 and 11 were not analyzed for explosives because sufficient volume was not captured. **Table 2-8** presents a summary of analytical results.

Analytical results were compared to DoD screening values. Explosives analysis of all samples from Milpitas Wash yielded only one detection of 2,4-dinitrotoluene (DNT) at an estimated concentration of 0.58 µg/L in sample Milpitas_SW-04. The laboratory re-analyzed this sample to confirm the detection (second analysis reported 1.0 µg/L); however, the first result is presented in this report since quality control samples are associated with the first analysis. The detected concentration is two orders of magnitude below the DoD freshwater ecological screening value of 44 µg/L. The SW-04 location potentially receives the greatest influence from the ranges when compared to the other sample locations because a number of channels aggregate near and flow through that location. There were no detections in the other samples or in the sample downgradient of this location. Sample results indicate that there is not a release of MC from CMAGR South in Milpitas Wash, and no potential threat to human health or the environment.

Total and dissolved lead and perchlorate were detected at the three locations sampled in CMAGR North. Total lead concentrations ranged from 1.7 to 14 µg/L; dissolved lead ranged from 0.24 to 0.35 µg/L; and perchlorate ranged from 0.34 to 0.82 µg/L. Dissolved lead and perchlorate concentrations were well below DoD screening values, and total lead DoD screening values have not been established. Explosives analysis was recommended for Siphons 9 and 11 based on model results, but conclusions cannot be made about the presence of explosives in surface water runoff since sample volume was not available for this analysis. The concentrations detected do not indicate an immediate concern to human health or the environment.

Table 2-8
Surface Water Sampling Results, September 2014 and March 2015
Range Environmental Vulnerability Assessment
MCAS Yuma, Arizona

CONSTITUENT SCREENING		CMAGR South							CMAGR North		
Sample ID	**DoD Screening Values**	**MILPITAS-SW-01**	**MILPITAS-SW-02**	**MILPITAS-SW-03**	**MILPITAS-SW-04**	**MILPITAS-SW-05**	**MILPITAS-SW-05 DUPLICATE**	**MILPITAS-SW-06**	**SIP-09-SW**	**SIP-11-SW**	**IRIS-SW**
Sample Date	**Ecological Freshwater[a]**	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Sep-14	Mar-15	Mar-15	Mar-15
Metals (µg/L)											
Lead, Total	---	NA	NA	NA	NA	NA	NA	NA	**8.2**	**14**	**1.7**
Lead, Dissolved	---	NA	NA	NA	NA	NA	NA	NA	**0.35 J**	**0.29 J**	**0.24 J**
Adjusted CMC Hardness Criteria (Acute)	Varies[b]	--	--	--	--	--	--	--	43.02	136.14	136.14
Explosives (µg/L)											
1,3,5-Trinitrobenzene	---	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
1,3-Dinitrobenzene	---	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
2,4,6-Trinitrotoluene	100	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
2,4-Dinitrotoluene	44	0.10 UJ	0.095 UJ	0.11 UJ	**0.58 J[d]**	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
2,6-Dinitrotoluene	81	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
2-Amino-4,6-dinitrotoluene	1,480	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
2-Nitrotoluene	---	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
3-Nitrotoluene	750	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
4-Amino-2,6-dinitrotoluene	---	0.10 UJ	0.095 UJ	0.11 UJ	0.53 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
4-Nitrotoluene	1,900	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
HMX	150	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
Nitrobenzene	270	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
Nitroglycerin	138	0.21 UJ	0.19 UJ	0.21 UJ	0.21 UJ	0.21 UJ	0.20 UJ	0.21 UJ	NA[c]	NA[c]	NA
PETN	85,000	0.52 UJ	0.48 UJ	0.53 UJ	0.53 UJ	0.52 UJ	0.51 UJ	0.52 UJ	NA[c]	NA[c]	NA
RDX	360	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
Tetryl	---	0.10 UJ	0.095 UJ	0.11 UJ	0.11 UJ	0.10 UJ	0.10 UJ	0.10 UJ	NA[c]	NA[c]	NA
Other											
Perchlorate (µg/L)	9,300	NA	NA	NA	NA	NA	NA	NA	**0.82**	**0.78**	**0.34**
Hardness (mg/L as $CaCO_3$)	--	NA	NA	NA	NA	NA	NA	NA	69	200	200

Notes

"---" = Not listed in standards

J = Estimated value

UJ = Analyte not detected; limit of detection (LOD) shown is estimated

NA = Not analyzed

Yellow = detected concentration

= total hardness

a) DoD operational range assessment screening values for protection of ecological freshwater surface water (Version 6.2, September 2013).

b) Screening value adjusted per USEPA National Recommended Water Quality Criteria parameter for calculating dissolved metals that are hardness-dependent.

Criteria Maximum Concentration for dissolved metals calculated with formula CMC (dissolved) = $\exp\{m_A [\ln(\text{hardness})] + b_A\}$ (CF)

where $m_A = 1.273$; $b_A = -1.460$; CF = 1.46203-[ln(hardness)(0.145712)]

c) Recommended for analysis; however, not analyzed due to insufficient sample volume

d) Sample was re-analyzed to confirm detection and result was 1.0 ug/L.

$CaCO_3$ = Calcium carbonate

mg/L = milligrams per Liter

µg/L = Micrograms per liter

3. Findings and Conclusions

Table 3-1: Summary of Results and Conclusions of the Five-Year Review

Yuma Desert Subwatershed	
Analysis	**Findings/Results**
MC Loading Areas	**Panel Stager, CSOC1, CSOC2, Murrayville West, Murrayville East, Yodaville UTC, Yodaville MLT, Cactus West Strafe Berm, Cactus West Target**
Identified Receptors	• Surface Water/Sediment: ecological • Groundwater: human (non-potable supply wells; future potable supply well)
Surface water screening-level modeling	• Estimated MC concentrations in surface water runoff at the downstream receptor location were predicted to be below detectable concentrations. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate concentrations were predicted to reach the downstream receptor location from CSOC1 and CSOC2 at concentrations two orders of magnitude below the Arizona drinking water standard; however, it was predicted to take in excess of 100 years for perchlorate to reach the water table. • No additional groundwater assessment is recommended at this time.
SARs	**Rifle Range, Pistol Range, Range 1, Range 1A**
Qualitative Evaluation	• Surface Water/Sediment ranking = MINIMAL • Groundwater ranking = MINIMAL • Total annual lead use (HE ranges and SARs) within this subwatershed is approximately 4,806 lbs/ yr.
Sampling	**None**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate or HE at detectable concentrations to surface water or sediment at the installation boundary, or to groundwater above regulatory criteria from the MC loading areas identified in the Yuma Desert Watershed.
Middle of Salt Creek	
Analysis	**Findings/Results**
MC Loading Areas	**S-5-2, S-5-3**

Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: human (potential water supply well)
Surface water screening-level modeling	• Estimated MC concentrations in surface water runoff at the edge of MC loading areas were predicted to be near 0. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Estimated annual edge-of-load-area MC concentrations in sediment were predicted to be near 0. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Estimated MC concentrations in infiltrating water from the SR-10 MC loading area were predicted to be below detectable concentrations. • No additional groundwater assessment is recommended at this time.
SARs	**None** • Total lead use within this subwatershed is moderate with approximately 3,293 lb/year.
Sampling	**None**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate, HE, or lead to surface water, sediment, or groundwater at detectable concentrations from the MC loading areas in the Middle of Salt Creek subwatershed.
Town of Pope – Frontal Salton Sea	
Analysis	**Findings/Results**
MC Loading Areas	**S-4-22, S-4-23**
Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: None
Surface water screening-level modeling	• Estimated MC concentrations in surface water runoff at the edge of MC loading areas were predicted to be below detectable concentrations. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Predicted annual edge-of-loading-area MC concentrations in sediment were below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed, as downgradient receptors were not identified. • No additional groundwater assessment is recommended at this time.

SARs	**None** • Total lead use within this subwatershed is low with approximately 352 pounds per lbs/year.
Sampling	**None**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate or HE to surface water or sediment. Perchlorate was predicted to reach the water table at detectable concentrations from the MC loading areas identified within the Town of Pope – Frontal Salton Sea subwatershed, but additional modeling was not completed because no downgradient receptors were identified.
Town of Frink – Frontal Salton Sea Subwatershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the subwatershed)	**S-4-12A/B** (8%), **S-4-13, S-4-14, S-4-15, S-4-17, S-4-19, S-4-21, S-4-22** (79%)
Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: None
Surface water screening-level modeling	• Estimated MC concentrations in surface water runoff at edge of MC loading areas were predicted to be below detectable concentrations. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Predicted annual edge-of-loading-area MC concentrations in sediment were below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed, as downgradient receptors were not identified. • No additional groundwater assessment is recommended at this time.
SARs	**None** • Total lead use within this subwatershed is moderate with approximately 9,448 lbs/year.
Sampling	**None**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate or HE to surface water or sediment. Perchlorate was predicted to reach the water table at detectable concentrations from the MC loading areas identified within the Town of Frink – Frontal Salton Sea subwatershed, but additional modeling was not completed because no downgradient receptors were identified.
Town of Niland – Frontal Salton Sea Subwatershed	
Analysis	**Findings/Results**

MC Loading Areas (% area in the subwatershed)	**S-4-10, S-4-11A/B** (60%), **S-4-12A/B** (92%), **8N, 12N** (95%), **15N** (12%)
Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: None
Surface water screening-level modeling	• Predicted MC concentrations were below detectable concentrations at the downgradient receptor location. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Predicted annual edge-of-loading-area MC concentrations in sediment were below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed, as downgradient receptors were not identified. • No additional groundwater assessment is recommended at this time.
SARs	**None** • Total lead use within this subwatershed is low with approximately 596 lbs/year.
Sampling	**None**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate or HE to surface water or sediment. Perchlorate was predicted to reach the water table at detectable concentrations from the MC loading areas identified within the Town of Niland– Frontal Salton Sea subwatershed, but additional modeling was not completed because no downgradient receptors were identified.
Iris Wash Subwatershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the subwatershed)	**S-4-2, S-4-3, S-4-8, 2N, 7N** (96%), **9N** (3%), **14N**
Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: None
Surface water screening-level modeling	• Estimated perchlorate concentrations in surface water runoff were predicted to be at detectable concentrations at the downgradient receptor location. • Surface water sampling was recommended.

Sediment screening-level modeling	• Predicted annual edge-of-loading-area MC concentrations in sediment were below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed, as downgradient receptors were not identified. • No additional groundwater assessment is recommended at this time.
SARs	**S-4-5, S-4-6A, S-4-6B, S-4-7**
Qualitative Evaluation	• Surface Water/Sediment ranking = MODERATE • Groundwater ranking = MINIMAL • Total annual lead use within this subwatershed is approximately 7,704 lb/year.
Sampling	**IRIS_SW**
Sample Results	One sample analyzed for total lead, dissolved lead, and perchlorate. • Total lead = 1.7 µg/L (No DoD screening value) • Dissolved lead = 0.24 µg/L (estimated) (Acute DoD screening value = 136.14 µg/L) • Perchlorate = 0.34 µg/L (DoD screening value = 9,300 µg/L)
Conclusion	The screening-level assessment results predicted detectable concentrations of perchlorate at the modeled surface water receptor location. The measured perchlorate and dissolved lead concentrations in surface water runoff were far below the DoD screening values. The results of this evaluation do not indicate an immediate threat to human health or the environment. Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed since downgradient receptors were not identified.
Tadlock Guzzler Subwatershed	
Analysis	**Findings/Results**
MC Loading Areas (% area in the subwatershed)	**10N (58%), 11N**
Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: None
Surface water screening-level modeling	• Concentrations of HMX, RDX, and perchlorate were predicted at detectable concentrations at the downgradient receptor location. • Surface water sampling was recommended.
Sediment screening-level modeling	• Predicted MC concentrations in sediment were below detectable concentrations at the modeled downgradient receptor location (Iris Wash siphon). • No additional sediment assessment is recommended at this time.

Groundwater screening-level modeling	• Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed, as downgradient receptors were not identified. • No additional groundwater assessment is recommended at this time.
SARs	**None** • Total lead use within this subwatershed is approximately 407 pounds per lbs/year.
Sampling	**Attempted to collect a surface water sample, but the guzzler was full of sediment. There was no standing water.**
Conclusion	The screening-level assessment results predicted detectable concentrations of HMX, RDX, and perchlorate at a downgradient surface water receptor; however, the guzzler was unusable by wildlife and, therefore, does not currently represent a complete receptor pathway. Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed since downgradient receptors were not identified.
18111002041104 (Siphon 11)	
Analysis	**Findings/Results**
MC Loading Areas (% area in the subwatershed)	**3N, 6N, 7N** (4%), **10N** (42%), **S-4-1**
Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: None
Surface water screening-level modeling	• Estimated HMX, RDX, and perchlorate concentrations in surface water runoff were predicted to be at detectable concentrations at the downgradient receptor location (Siphon 11). • Surface water sampling was recommended.
Sediment screening-level modeling	• Predicted MC concentrations in sediment were below detectable concentrations at the modeled downgradient receptor location. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed, as downgradient receptors were not identified. • No additional groundwater assessment is recommended at this time.
SAR	**S-4-9**
Qualitative Evaluation	• Surface Water/Sediment ranking = MINIMAL • Groundwater ranking = MINIMAL • Total annual lead use within this subwatershed is approximately 3,067 lbs/year.

Sampling	**SIP-11_SW**
Sample Results	One sample analyzed for total lead, dissolved lead, and perchlorate. • Total lead = 14 µg/L (No DoD screening value) • Dissolved lead = 0.29 µg/L (estimated) (Acute DoD screening value = 136.14 µg/L) • Perchlorate = 0.78 µg/L (DoD screening value = 9,300 µg/L)
Conclusion	The screening-level assessment results predicted detectable concentrations of HMX, RDX, and perchlorate at the modeled surface water receptor location. The measured perchlorate and dissolved lead concentrations in surface water runoff were far below the DoD screening values. A surface water sample could not be obtained for explosives analysis; however, the conservative model predicted HMX and RDX concentrations almost three orders of magnitude below the DoD freshwater screening values. The results of this evaluation do not indicate an immediate threat to human health or the environment. Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed since downgradient receptors were not identified. It is recommended that efforts are made to collect samples for explosives analysis during a future rain event.
181002040602 (Salt Creek)	
Analysis	**Findings/Results**
MC Loading Areas (% area in the subwatershed)	**9N** (97%)
Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: None
Surface water screening-level modeling	• Predicted MC concentrations were below detectable concentrations at the downgradient receptor location. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Predicted annual edge-of-loading-area MC concentrations in sediment were below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed, as downgradient receptors were not identified. • No additional groundwater assessment is recommended at this time.
SARs	**None** • Total lead use within this subwatershed is approximately 129 lbs/year.
Sampling	**None**

Conclusion	The screening-level assessment results do not indicate a current release of perchlorate, HE, or lead to surface water or sediment from the MC loading areas in the Salt Creek subwatershed at the installation boundary. Perchlorate was predicted to reach the water table at detectable concentrations, but additional modeling not completed since downgradient receptors were not identified.
181002041106 (Siphon 9)	
Analysis	**Findings/Results**
MC Loading Areas (% area in the subwatershed)	**1N** (52%), **13N, S-4-4, ICM Box** (93%)
Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: None
Surface water screening-level modeling	• Estimated HMX, RDX, and perchlorate concentrations in surface water runoff were predicted to be at detectable concentrations at the downgradient receptor location (Siphon 9). • Surface water sampling was recommended.
Sediment screening-level modeling	• Predicted MC concentrations in sediment were below detectable concentrations at the modeled downgradient receptor location. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed, as downgradient receptors were not identified. • No additional groundwater assessment is recommended at this time.
SARs	**None** • Total lead use within this subwatershed is moderate with approximately 3,743 pounds per lbs/year.
Sampling	**SIP-09_SW**
Sample Results	One sample analyzed for total lead, dissolved lead, and perchlorate. • Total lead = 8.2 µg/L (No DoD screening value) • Dissolved lead = 0.35 µg/L (estimated) (Acute DoD screening value = 43.02 µg/L) • Perchlorate = 0.82 µg/L (DoD screening value = 9,300 µg/L)

Conclusion	The screening-level assessment results predicted detectable concentrations of HMX, RDX, and perchlorate at the modeled surface water receptor location. The measured perchlorate and dissolved lead concentrations in surface water runoff were far below the DoD screening values. A surface water sample could not be obtained for explosives analysis; however, the conservative model predicted HMX and RDX concentrations almost three orders of magnitude below the DoD freshwater screening values. The results of this evaluation do not indicate an immediate threat to human health or the environment. Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling not completed since downgradient receptors were not identified. It is recommended that efforts are made to collect samples for explosives analysis during a future rain event.
Camp Dunlap (Siphon 8)	
Analysis	**Findings/Results**
MC Loading Areas (% area in the subwatershed)	**1N** (48%), **15N** (88%), **ICM Box** (7%)
Identified Receptors	• Surface Water/Sediment: Ecological • Groundwater: None
Surface water screening-level modeling	• Predicted MC concentrations were below detectable concentrations at the downgradient receptor location. • No additional surface water assessment is recommended at this time.
Sediment screening-level modeling	• Predicted annual edge-of-loading-area MC concentrations in sediment were below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate was predicted to reach the water table at detectable concentrations, but saturated zone modeling was not completed, as downgradient receptors were not identified. • No additional groundwater assessment is recommended at this time.
SARs	**None** • Total lead use within this subwatershed is low with approximately 935 lbs/year.
Sampling	**None**
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate, HE, or lead to surface water or sediment from the MC loading areas in the Camp Dunlap subwatershed. Perchlorate was predicted to reach the water table at detectable concentrations, but additional modeling not completed since downgradient receptors were not identified.
Milpitas Wash Subwatershed	
Analysis	**Findings/Results**

MC Loading Areas	**1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S, 10S, 11S, 12S, 13S, 14S, 15S, Mt. Barrow**
Identified Receptors	• Surface Water/Sediment: ecological • Groundwater: human (potential water supply well)
Surface water screening-level modeling	• RDX concentration in surface water runoff was predicted to reach the downgradient receptor location (Milpitas Wash at the installation boundary). All other estimated MC concentrations were below detectable concentrations. • Surface water sampling for explosives was recommended.
Sediment screening-level modeling	• Annual average edge-of-loading-area MC concentrations in sediment were predicted to be below detectable concentrations. • No additional sediment assessment is recommended at this time.
Groundwater screening-level modeling	• Perchlorate concentrations were predicted to reach the modeled receptor location; however, perchlorate was not predicted to reach the water table for in excess of 1,000 years. • No additional groundwater assessment is recommended at this time.
SARs	**None** • Total lead use within this subwatershed is approximately 16,435 lbs/year.
Sampling	**Six surface water samples** (MILPITAS-SW-01, MILPITAS-SW-02, MILPITAS-SW-03, MILPITAS-SW-04, MILPITAS-SW-05, MILPITAS-SW-06)
Sample Results	Six samples were analyzed for explosives. • 2,4-DNT = 0.58 µg/L in MILPITAS-SW-04 (confirmation analysis result was 1.0 µg/L) (DoD screening criterion is 44 µg/L)
Conclusion	The screening-level assessment results do not indicate a current release of perchlorate, HE, or lead to surface water or sediment at detectable concentrations from the MC loading areas in the Milpitas Wash subwatershed. Perchlorate was predicted to reach the modeled receptor location at detectable concentrations; however, this was predicted to occur in over 1,000 years, indicating no immediate threat to human health or the environment.

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ARCADIS

Appendix A

Operational Range
Summary Table

Appendix A
Operational Range Summary Table
MCAS Yuma

Range Name/Target Area	Range Type	Period of Use	SAR	MOUT	Range Status	Notes / Comments
Chocolate Mountain Aerial Bombing and Gunnery Range (R-2507N)						
1N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Located in zone unauthorized for HE.
2N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Punchbowl area.
3N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Deadman area.
6N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Located in zone unauthorized for HE.
7N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Located in zone unauthorized for HE.
8N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Located in zone unauthorized for HE.
9N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Artillery munitions not permitted due to target area location proximity to the installation boundary.
10N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Punchbowl area.
11N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Punchbowl area.
12N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Located in zone unauthorized for HE.
13N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Iris Wash area.
14N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Iris Wash area.
15N	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Located in zone unauthorized for HE. Offers MLT training. Located in Wiss Airfield.
ICM Box	Air-to-Ground Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Located in Rockeye area.
AFA 1	Artillery Position	--	--	--	Inactive (~2007-present)	AFAs have capability of firing into any of the HE authorized target areas depending on availability and range regulations.
AFA 2	Artillery Position	prior to 2007 - present	--	--	Active	AFAs have capability of firing into any of the HE authorized target areas depending on availability and range regulations.
AFA 4	Artillery Position	--	--	--	Inactive (~2007-present)	AFAs have capability of firing into any of the HE authorized target areas depending on availability and range regulations.
AFA 6	Artillery Position	--	--	--	Inactive (~2007-present)	AFAs have capability of firing into any of the HE authorized target areas depending on availability and range regulations.
AFA 7	Artillery Position	--	--	--	Inactive (~2007-present)	AFAs have capability of firing into any of the HE authorized target areas depending on availability and range regulations.
AFA 8	Artillery Position	--	--	--	Inactive (~2007-present)	AFAs have capability of firing into any of the HE authorized target areas depending on availability and range regulations. Used briefly in 2013.
AFA 9	Artillery Position	--	--	--	Inactive (~2007-present)	AFAs have capability of firing into any of the HE authorized target areas depending on availability and range regulations.
AFA 10	Artillery Position	--	--	--	Inactive (~2007-present)	AFAs have capability of firing into any of the HE authorized target areas depending on availability and range regulations.
AFA 11	Artillery Position	prior to 2007 - present	--	--	Active	AFAs have capability of firing into any of the HE authorized target areas depending on availability and range regulations.
AFA 15	Artillery Position (HIMARS)	2012 - present	--	--	Active	HIMARS artillery only.
Navy SEALs Special Warfare Training Area S-4-1	Demolition Range	prior to 2007 - present	--	--	Active	Utilized for training by US Navy SEALs or by EOD units for demolition activities.
Navy SEALs Special Warfare Training Area S-4-2	Hand Grenade	prior to 2007 - present	--	--	Active	Utilized as part of the SQT training sequence.
Navy SEALs Special Warfare Training Area S-4-3	Anti-Mechanized/Grenade	prior to 2007 - present	--	--	Active	Was previously divided into SWAT-4-3A and SWAT-4-3B. Used for training personnel in the use of individual anti-mechanized weapons. Also utilized as part of the SQT training sequence.
Navy SEALs Special Warfare Training Area S-4-4	HE Impact Range	prior to 2007 - present	--	--	Active	Target locations are variable and pre-set by the using units depending on the scenario desired. Utilized by small teams for LFAM training.
Navy SEALs Special Warfare Training Area S-4-5	Small Arms Range	prior to 2007 - present	X	--	Active	Utilized as part of the SQT training sequence. Ten targets and five firing lines.
Navy SEALs Special Warfare Training Area S-4-6A	KD Rifle Range	prior to 2007 - present	X	--	Active	Utilized as part of the SQT training sequence.
Navy SEALs Special Warfare Training Area S-4-6B	Machine Gun Range	prior to 2007 - present	X	--	Active	Utilized as part of the SQT training sequence. Impact area shared with SWAT-4-8 (mortar range).
Navy SEALS Special Warfare Training Area S-4-7	2000 Meter Sniper Range	prior to 2007 - present	X	--	Active	Utilized for sniper training as well as SQT training.
Navy SEALs Special Warfare Training Area S-4-8	Mortar Range	prior to 2007 - present	--	--	Active	Shares an impact area with SWAT-4-6B. Utilized as part of SQT training.
Navy SEALs Special Warfare Training Area S-4-9	KD Sniper Range	prior to 2007 - present	X	--	Active	Sniper training range equipped with impact berm, target carriages, and 12 firing lanes. Split into SWAT-4-9 and SWAT-4-9A during baseline assessment.
Navy SEALs Special Warfare Training Area S-4-10	Platoon Live-Fire Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-11 (A and B)	Platoon Live-Fire Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-12 (A and B)	Platoon Live-Fire Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-13	Platoon Live-Fire Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-14	Platoon Pre-Planned Attack/Live-Fire and Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-15	Platoon Pre-Planned Attack/Live-Fire and Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-16	Platoon Pre-Planned Attack/Live-Fire and Maneuver	prior 2007 - 2012	--	X	Inactive (~2012-present)	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-17	Platoon Pre-Planned Attack/Live-Fire and Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-18	Platoon Pre-Planned Attack/Live-Fire and Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-19	Platoon Pre-Planned Attack/Live-Fire and Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-20	Platoon Pre-Planned Attack Mortar	prior 2007 - 2012	--	X	Inactive (~2012-present)	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-21	Platoon Pre-Planned Attack Anti-Mechanized	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-22	Platoon Pre-Planned Attack/Grenade Launcher	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-23	Platoon Pre-Planned Attack/Live-Fire and Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.
Navy SEALs Special Warfare Training Area S-4-24	Platoon Pre-Planned Attack/Live-Fire and Maneuver	prior to 2007 - present	--	X	Active	Utilized for IADs by US Navy SEAL platoons.

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Operational Range Summary Table
MCAS Yuma

Range Name/Target Area	Range Type	Period of Use	SAR	MOUT	Range Status	Notes / Comments
Navy SEALs Special Warfare Training Area S-5-1	FTX Target Site	prior 2007 - 2007	--	--	Inactive (~2007-present)	--
Navy SEALs Special Warfare Training Area S-5-2	FTX Target Site	prior 2007 - 2007	--	--	Inactive (~2007-present)	Used briefly from 2007-2010 for emergency training when other resources were not available.
Navy SEALs Special Warfare Training Area S-5-3	FTX Target Site	prior 2007 - 2007	--	--	Inactive (~2007-present)	Used briefly from 2007-2010 for emergency training when other resources were not available.
Navy SEALs Special Warfare Training Area S-5-4	FTX Target Site	prior 2007 - 2007	--	--	Inactive (~2007-present)	--
Navy SEALs Special Warfare Training Area S-5-5	FTX Target Site	prior 2007 - 2007	--	--	Inactive (~2007-present)	--
Mortar Position (MP) Slats	Mortar Range	prior to 2007 - present	--	--	Active	Fires into Punchbowl aviation targets.
Chocolate Mountain Aerial Bombing and Gunnery Range (R-2507S)						
Artillery Firing Area (AFA) Burt	Artillery Position	2009 - present	--	--	Active	AFAs have capability of firing into any of the HE authorized target areas in R-2507S depending on availability and range regulations.
1S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions.
2S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Blue Mountain area.
3S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions.
4S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions.
5S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions.
6S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Blue Mountain area.
7S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions.
8S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Blue Mountain area.
10S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions.
11S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions.
12S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions. Located in Blue Mountain area.
13S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions.
14S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. Can also receive artillery munitions.
15S	Target Area	prior to 2007 - present	--	--	Active	Aviation target area. TP/inert versions of munitions only permitted on the runway at 15S. Located in Blue Mountain area.
Mortar Firing Area (MFA) Burt	Mortar Range	--	--	--	Active	Fires into multiple target areas within 2507S.
MP Feets	Mortar Range	2007 - present	--	--	Active	Fires into multiple target areas within 2507S.
Mt. Barrow	Target Area	prior to 2007 - present	--	--	Active	Aviation target area for rotary-winged aircraft only.
BMGR, USMC (R-2301W)						
Yodaville	Urban Target Complex - Air-to-Ground Target Area	prior to 2007 - present	--	X	Active	Aviation target area. According to the Range Regulations, Station Order 3710.6J - consists of a tactical target area and two strafe pits. Yodaville consists of an urban training complex (UTC), two strafe berms, and offers moving land target (MLT) training.
Cactus West	Air-to-Ground Target Area	prior to 2007 - present	--	--	Active	Aviation target area. According to the Range Regulations, Station Order 3710.6J - consists of a conventional bomb circle and two strafe targets (berms). The strafing targets are located southeast of the bombing target.
CSOC 1	Convoy Security Operations Course	2007 - present	--	--	Active	According the range personnel, the CSOCs were constructed in 2007. Firing direction on this range is to the south only.
CSOC 2	Convoy Security Operations Course	2007 - present	--	--	Active	According the range personnel, the CSOCs were constructed in 2007. Firing direction on this range is to the south only.
Murrayville East	Convoy Security Operations Course	2007 - present	--	--	Active	According the range personnel, the CSOCs were constructed in 2007. Firing direction on this range is to the east only. Firing line (road) is co-located with firing point for Murrayville West.
Murrayville West	Convoy Security Operations Course	2007 - present	--	--	Active	According the range personnel, the CSOCs were constructed in 2007. Firing direction on this range is to the west only. Firing line (road) is co-located with firing point for Murrayville West.
Pistol Range	Pistol Range	prior to 2007 - present	X	--	Active	Used approximately 10 months per year. Equipped with impact berm.
Rifle Range	Rifle Range	prior to 2007 - present	X	--	Active	Used approximately 10 months per year. Equipped with impact berm.
Range 1	Small Arms Range	~2011-present	X	--	Active	Supports static small arms fire training. This range was constructed in 2010.
Range 1A	Quick Reaction Course	~2011-present	X	X	Active	Supports live fire and maneuver training in an urban setting. This range was constructed in 2007. Although other munitions are authorized, only small arms were recorded in the expenditure data for the five-year review period. Therefore, this range is evaluated as a small arms range.
Tactical Aircrew Combat Training System (TACTS) Range (Laser)	Air-to-Air Range	prior to 2007 - present	--	--	Active	Acreage represents main ground support facility. Air-to-air operations cover entire 670,000 acres of R2301W.
Panel Stager	Multipurpose Live-Fire Range	~2005-present	--	--	Active	Supports multipurpose static small arms training and ground laser training. Use as a multipurpose range was initiated in approximately 2005.

Acronyms:

AFA: Artillery Firing Area
CSOC: Convoy Security Operations Course
EOD: Explosive Ordnance Disposal
FARP: Forward Arming and Refueling Point
FASP: Field Ammunition Supply Point
FTX: Field Training Exercise
GSA: Ground Support Area
HE: High Explosive
HIMARS: High Mobility Artillery Rocket System
IAD: Immediate Action Drill
KD: Known Distance
LFAM: Live Fire and Maneuver
LZ: Landing Zone
MLT: Moving Land Target
MP: Mortar Position
SEAL: Sea Air and Land
SWAT: Special Warfare Training Area
SQT: SEAL Qualification Training
TACTS: Tactical Aircrew Combat Training System

Note:

New training area or range since the baseline REVA assessment
Dormant ranges

Newly constructed gas chamber at MCAS Yuma not included in this table - does not support live fire and is a contained indoor facility; therefore, it is not assessed under REVA.
New "Invader" range was not included in this table as construction/use of the range has not been initiated.
Munitions Treatment Range not included in this table - RCRA permitted facilities are not assessed under REVA.
Cargo and personnel drop zones, FASPs, FARPs, LZs, and GSAs were not included in this table - do not support live fire and therefore are not assessed under REVA.
Navy Special Warfare Training Areas Lion's Head, Beal's Well, Surveyor's Pass, Salvation Pass, and Pegleg Mine were not included in this table as they are historic use areas and are not part of the active range inventory.
"Prior to 2007" indicates that the range was active at the start of the five-year review period, but the date the range became operational is not known.

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Appendix B

MC Loading Rates and Lead Deposition Estimates

Table B-1: Operational Range Clearance Summary

Location	Clearance Dates	Clearance Area (acres)	Debris Removed (lb of metal)	MEC/MPPEH Items Destroyed	Incorporated into MC loading Calculations
2N	3/1/2011 – 3/16/2011	60	10,850	283	X
14N	3/1/2011 – 3/16/2011	23			X
6N	11/7/2011 – 12/9/2011	31	153,944	1,378	X
13N	11/7/2011 – 12/9/2011	207			X
15N	3/18/2012 – 3/26/2012	55	30	37	X
1S	6/1/2011 - 6/28/2011	60	89,074	155	X
3S	6/1/2011 - 6/28/2011	67			X
15S	6/1/2011 - 6/28/2011	52			X
MILCON P-575	5/6/2012 – 5/16/2012	319	N/A	1	
Mt. Barrow	11/9/2010 – 12/29/2010	442	30,000	7,562	X
MTR and Access Paths	6/19/2012 – 8/8/2012	250	6,275	687	
Siphon 9	4/23/2012 – 4/30/2012	7.5	8,150	1	
Yodaville UTC	5/21/2012 – 6/21/2012	207	15,885	3,183	X
ICM Range Zones 1, 2, and 3	11/7/2011 – 12/8/2011	382.2	N/A	991	
3N	6/2/2010 – 8/18/2010	161	2,398,000	335	X
SWAT-4-1	8/30/2012 – 9/28/2012	23.45	779,930	199	
SWAT-4-3	8/30/2012 – 9/28/2012				X
4S	11/4/2010 – 12/18/2010	147	149,432	68	X
5S	11/4/2010 – 12/18/2010				X
6S	11/4/2010 – 12/18/2010				X
7N	11/3/2011 – 12/17/2011	188	1,060,460	38	X
9N	11/3/2011 – 12/17/2011				X
11N	11/3/2011 – 12/17/2011				X
Cactus West	5/24/2012 – 6/26/2012	6.48	736,740	220	X
7S	3/18/2009 – 3/25/2009	84	2,372,000	N/A	X
10S	3/11/2009 – 3/14/2009	N/A		N/A	X
11S	3/11/2009 – 3/14/2009	N/A		N/A	X
12S	10/26/2006 – 3/26/2009	138		N/A	X
14S	3/18/2009 – 3/25/2009	40		N/A	X
15S	10/26/2006 – 3/26/2009	275		N/A	X

Note: N/A = not available; information not found in completion report

Table B-2: Estimated MC Loading and Lead Deposition

MC Loading Area	Years of Use Assessed		Assumed Loading Area (m^2)	Estimated Annual Loading Rate ($kg/m^2/yr$)				Lead Deposition
	Begin	End		HMX	RDX	TNT	Perchlorate	Total lb/yr
BMGR WEST								
Cactus West	2007	2013	1.09E+06	4.23E-08	7.65E-07	4.05E-07	4.68E-09	1,662
CSOC 1	2007	2013	9.81E+04	0.00E+00	1.10E-09	3.62E-13	4.00E-09	212
CSOC 2	2007	2013	9.23E+04	0.00E+00	1.10E-09	1.41E-13	5.69E-10	120
Murrayville East	2007	2013	1.48E+06	0.00E+00	6.89E-11	8.79E-15	3.56E-11	74
Murrayville West	2007	2013	1.48E+06	0.00E+00	1.08E-09	1.28E-14	3.75E-10	155
Panel Stager	2007	2013	6.45E+05	0.00E+00	5.17E-12	1.16E-12	3.83E-12	893
Yodaville	2007	2013	9.91E+05	4.76E-08	7.14E-07	3.64E-07	5.27E-09	1,690
CMAGR NORTH								
2507N HE	2007	2013	5.93E+06	1.26E-06	2.32E-05	2.48E-05	8.16E-07	4,373
2507N Inert	2007	2013	8.75E+06	0.00E+00	0.00E+00	0.00E+00	2.03E-09	4,321
SWAT-4-1	2007	2013	3.35E+04	0.00E+00	8.29E-05	4.37E-05	7.05E-12	3.28E-04
SWAT-4-2	2007	2013	1.14E+04	0.00E+00	4.37E-06	2.80E-06	1.23E-08	1.81E-02
SWAT-4-3	2007	2013	3.51E+05	5.50E-07	2.58E-06	3.40E-07	8.16E-07	28
SWAT-4-4	2007	2013	4.51E+05	0.00E+00	7.44E-09	4.66E-10	2.03E-09	1,681
SWAT-4-8	2007	2013	6.90E+05	1.90E-11	5.50E-07	2.97E-07	8.16E-07	0
SWAT-4-10	2007	2013	2.33E+06	0.00E+00	7.48E-10	2.41E-13	0.00E+00	10,495
SWAT-4-11	2007	2013	8.20E+05	0.00E+00	1.92E-10	1.13E-14	1.64E-09	1,124
SWAT-4-12	2007	2013	6.22E+05	0.00E+00	1.75E-12	3.11E-13	6.01E-12	18,252
SWAT-4-13	2007	2013	6.33E+05	0.00E+00	2.34E-11	3.44E-12	2.02E-09	7,724
SWAT-4-14	2007	2013	8.23E+03	0.00E+00	0.00E+00	0.00E+00	9.60E-11	156
SWAT-4-15	2007	2013	4.22E+04	0.00E+00	0.00E+00	4.01E-13	1.27E-10	47
SWAT-4-17	2007	2013	1.67E+05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	31
SWAT-4-19	2007	2013	6.14E+03	0.00E+00	0.00E+00	0.00E+00	4.07E-12	112
SWAT-4-21	2007	2013	2.77E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	41
SWAT-4-22	2007	2013	3.65E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	42
SWAT-4-23	2007	2013	3.53E+04	0.00E+00	2.65E-10	1.80E-10	0.00E+00	310
SWAT-5-2	2007	2010	4.34E+05	0.00E+00	4.71E-12	0.00E+00	0.00E+00	536
SWAT-5-3	2007	2010	1.48E+06	0.00E+00	3.24E-11	1.72E-11	1.33E-11	2,757
ICM Box	2007	2013	2.00E+06	1.26E-06	2.32E-05	2.48E-05	8.16E-07	1,478
1N	2007	2013	2.60E+05	0.00E+00	0.00E+00	0.00E+00	2.03E-09	129
2N	2007	2013	2.42E+05	1.26E-06	2.32E-05	2.48E-05	8.16E-07	179

3N	2007	2013	1.68E+06	1.26E-06	2.32E-05	2.48E-05	8.16E-07	1,244
6N	2007	2013	1.24E+05	0.00E+00	0.00E+00	0.00E+00	2.03E-09	62
7N	2007	2013	5.05E+05	0.00E+00	0.00E+00	0.00E+00	2.03E-09	250
8N	2007	2013	1.60E+05	0.00E+00	0.00E+00	0.00E+00	2.03E-09	79
9N	2007	2013	1.79E+05	1.26E-06	2.32E-05	2.48E-05	8.16E-07	133
10N	2007	2013	8.13E+05	1.26E-06	2.32E-05	2.48E-05	8.16E-07	601
11N	2007	2013	7.77E+04	1.26E-06	2.32E-05	2.48E-05	8.16E-07	58
12N	2007	2013	5.93E+06	0.00E+00	0.00E+00	0.00E+00	2.03E-09	2,929
13N	2007	2013	8.38E+05	1.26E-06	2.32E-05	2.48E-05	8.16E-07	620
14N	2007	2013	9.36E+04	1.26E-06	2.32E-05	2.48E-05	8.16E-07	70
15N	2007	2013	1.77E+06	0.00E+00	0.00E+00	0.00E+00	2.03E-09	875
CMAGR SOUTH								
2507S	2007	2013	6.39E+06	2.07E-07	1.69E-05	1.35E-05	1.19E-08	16,418
Mt Barrow	2007	2013	1.79E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	4,602
1S	2007	2013	2.39E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	615
2S	2007	2013	1.02E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	262
3S	2007	2013	2.71E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	696
4S	2007	2013	1.41E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	363
5S	2007	2013	1.84E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	473
6S	2007	2013	2.71E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	696
7S	2007	2013	2.58E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	663
8S	2007	2013	6.12E+04	2.07E-07	1.69E-05	1.35E-05	1.19E-08	158
10S	2007	2013	1.64E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	421
11S	2007	2013	9.25E+04	2.07E-07	1.69E-05	1.35E-05	1.19E-08	238
12S	2007	2013	1.20E+06	2.07E-07	1.69E-05	1.35E-05	1.19E-08	3,078
13S	2007	2013	1.25E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	323
14S	2007	2013	1.14E+05	2.07E-07	1.69E-05	1.35E-05	1.19E-08	294
15S	2007	2013	1.38E+06	2.07E-07	1.69E-05	1.35E-05	1.19E-08	3,553

Note:

Aviation expenditures were not tracked in RFMSS by target location, and therefore, a single MC loading estimate for each MC was generated for 2507 North and 2507 South. This total estimated rate was conservatively applied to each target location.

Table B-3: Estimated Annual Lead Deposition on SARs

MC Loading Area	Lead Deposition Rate	
	kg/yr	lb/yr
BMGR West		
KD Rifle	2.16E+03	4,755
KD Pistol	1.48E+03	3,271
Range 1	4.38E+02	965
Range 1A	9.86E+01	217
CMAGR North		
S-4-5	5.31E+01	117
S-4-6A	1.17E+03	2,578
S-4-6B	1.30E+03	2,877
S-4-7	7.32E+02	1,614
S-4-9	6.81E+01	217

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Appendix C

Modeling Parameters

Surface Water Screening-Level Assessment
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Table C-1: Climate Data used in the Surface Water Screening Assessment

Data Type	Value	Reference(s)
Annual Average Precipitation BMGR (in/yr)	5	DoAF, Luke AFB & DoN, MCAS Yuma 2012 (BGMR INRMP)
Annual Average Precipitation CMAGR (in/yr)	7	DoN, MCAS Yuma 2013 (CGAMR INRMP)
Recharge Rate for SW transport (% ppt)[a]	10-14	CDM, 2003
Annual Average Wind Speed BMGR (mph)	3	Western Regional Climate Center (Yuma WSO, AZ 1948-2011) accessed 2014
Annual Average Wind Speed CMAGR (mph)	2.6	Western Regional Climate Center (Niland, CA 1914-2012) accessed 2014
Annual Average Ambient Environmental Temperature BMGR (^{0}F)	74.7	Western Regional Climate Center (Yuma WSO, AZ 1948-2011) accessed 2014
Annual Average Ambient Environmental Temperature CMAGR (^{0}	79.2	Western Regional Climate Center (Niland, CA 1914-2012) accessed 2014

Note:

$ft^3/sec/mile^2$ = cubic feet per second per square mile

in/yr = inches per year

mph = miles per hour

^{0}F = degrees Fahrenheit

% ppt = percent precipitation

Table C-2: Soil Types and Hydrologic Properties at Identified MC Loading Areas

MC Loading Area	Land Cover[a]	Slope (%)[b]	Predominant Soil Type Name and Map Symbol[b,c]	Soil Description[b]	Soil Water Content[d]	Soil Air Content[e]	Hydrologic Soil Group[c]	Soil Organic Carbon Content (%)[f]	Soil Bulk Density (kg/m^3)[c]	Runoff Coefficient[g]	Annul Recharge (% ppt)[h]
BMGR											
Cactus West - Target	Largely Unvegetated	0.15	Superstition-Rositas	sand	0.1	0.33	A	0.25	1810	0.36	14
Cactus West - Strafe Berm	Largely Unvegetated	0.57	Ligurta-Cristobal Complex	gravelly loam	0.2	0.24	B	0.25	1375	0.36	14
Yodaville - UTC	Largely Unvegetated	0.34	Superstition-Rositas	sand	0.1	0.33	A	0.25	1810	0.36	14
Yodaville - MLT	Largely Unvegetated	0.64	Superstition-Rositas	sand	0.1	0.33	A	0.25	1810	0.36	14
Murrayville West	Largely Unvegetated	0.23	Ligurta-Cristobal Complex	gravelly loam	0.2	0.24	B	0.25	1375	0.36	14
Panel Stager	Largely Unvegetated	0.14	Superstition-Rositas	sand	0.1	0.33	A	0.25	1810	0.36	14
CSOC1	Largely Unvegetated	0.13	Superstition-Rositas	sand	0.1	0.33	A	0.25	1810	0.36	14
CSOC2	Largely Unvegetated	0.37	Superstition-Rositas	sand	0.1	0.33	A	0.25	1810	0.36	14
Murrayville East	Largely Unvegetated	0.24	Ligurta-Cristobal Complex	gravelly loam	0.2	0.24	B	0.25	1375	0.36	14
CMAGR North											
S-5-3	Largely Unvegetated	7.36	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.45	13
S-5-2	Largely Unvegetated	8.76	Rock Outcrop-Hyder Complex	unweathered bedrock/sandy loam	0.22	0.2107	D	1	1550	0.46	13
S-4-23	Largely Unvegetated	25.16	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.54	10
S-4-22	Largely Unvegetated	21.7	Rock Outcrop-Hyder Complex	unweathered bedrock/sandy loam	0.22	0.2107	D	1	1550	0.52	10.5
S-4-21	Largely Unvegetated	17.78	Rock Outcrop-Hyder Complex	unweathered bedrock/sandy loam	0.22	0.2107	D	1	1550	0.5	11
S-4-19	Largely Unvegetated	6.85	Tecopa-Rock outcrop-Lithic Torriorthents	unweathered bedrock/gravelly sandy loam/coarse sandy loam	0.2	0.2289	D	1	1550	0.43	13
S-4-17	Largely Unvegetated	11.89	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.49	12
S-4-15	Largely Unvegetated	20.75	Tecopa-Rock outcrop-Lithic Torriorthents	unweathered bedrock/gravelly sandy loam/coarse sandy loam	0.2	0.2289	D	1	1550	0.52	11
S-4-14	95% unvegetated; 5% semi-desert scrub & grassland	21.9	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.52	10.5
S-4-12A, S-4-12B	Largely Unvegetated	1.88	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.38	14
S-4-11A, S-4-11B	Largely Unvegetated	1.51	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.38	14
S-4-10	Largely Unvegetated	1.45	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.38	14
S-4-1	Largely Unvegetated	2.95	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.39	13.5
S-4-2	95% unvegetated; 5% semi-desert scrub & grassland	0.33	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.36	14
S-4-8	Largely Unvegetated	0.82	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.37	14

Table C-2: Soil Types and Hydrologic Properties at Identified MC Loading Areas

MC Loading Area	Land Cover[a]	Slope (%)[b]	Predominant Soil Type Name and Map Symbol[b,c]	Soil Description[b]	Soil Water Content[d]	Soil Air Content[e]	Hydrologic Soil Group[c]	Soil Organic Carbon Content (%)[f]	Soil Bulk Density (kg/m^3)[c]	Runoff Coefficient[g]	Annul Recharge (% ppt)[h]
S-4-3	90% unvegetated; 10% semi-desert scrub & grassland	0.83	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.37	14
S-4-4	90% unvegetated; 10% semi-desert scrub & grassland	1.6	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.38	14
S-4-13	Largely Unvegetated	2.83	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.39	13.5
12N	Largely Unvegetated	5.24	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.42	13
6N	Largely Unvegetated	2.49	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.39	13.5
8N	Largely Unvegetated	3.29	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.4	13.5
7N	Largely Unvegetated	14.24	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.5	12
1N	Largely Unvegetated	3.22	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.4	13.5
15N	Largely Unvegetated	1.46	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.37	14
ICM Box	Largely Unvegetated	6.77	Tecopa-Rock outcrop-Lithic Torriorthents	unweathered bedrock/gravelly sandy loam/coarse sandy loam	0.2	0.2289	D	1	1550	0.43	13
13N	Largely Unvegetated	2.29	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.39	13.5
14N	Largely Unvegetated	4.35	Rubble land-Rock outcrop-Glaciers-Avis variant	unweathered bedrock/fragmental material/gravelly loamy sand	0.19	0.2374	D,A	1.5	1600	0.41	13.5
10N	Largely Unvegetated	2.84	Tecopa-Rock outcrop-Lithic Torriorthents	unweathered bedrock/gravelly sandy loam/coarse sandy loam	0.2	0.2289	D	1	1550	0.39	13.5
3N	Largely Unvegetated	2.99	Cajon-Bitterwater-Bitter-Badland	weathered bedrock/sandy loam/gravelly loam	0.2	0.229	D,B	0.75	1550	0.4	13.5
2N	Largely Unvegetated	5.24	Tecopa-Rock outcrop-Lithic Torriorthents	unweathered bedrock/gravelly sandy loam/coarse sandy loam	0.2	0.2289	D	1	1550	0.42	13
11N	Largely Unvegetated	4.96	Cajon-Bitterwater-Bitter-Badland	weathered bedrock/sandy loam/gravelly loam	0.2	0.229	D,B	0.75	1550	0.42	13
9N	Largely Unvegetated	1.67	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.38	14
CMAGR South											
1S	Largely Unvegetated	1.21	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.37	14
3S	Largely Unvegetated	2.92	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.4	13.5
4S	Largely Unvegetated	1.49	Vaiva-Quilotosa-Hyder-Cipriano-Cherioni	gravelly loam	0.2	0.2321	D	0.5	1250	0.37	14

Table C-2: Soil Types and Hydrologic Properties at Identified MC Loading Areas

MC Loading Area	Land Cover[a]	Slope (%)[b]	Predominant Soil Type Name and Map Symbol[b,c]	Soil Description[b]	Soil Water Content[d]	Soil Air Content[e]	Hydrologic Soil Group[c]	Soil Organic Carbon Content (%)[f]	Soil Bulk Density (kg/m^3)[c]	Runoff Coefficient[g]	Annul Recharge (% ppt)[h]
5S	Largely Unvegetated	1.45	Vaiva-Quilotosa-Hyder-Cipriano-Cherioni	gravelly loam	0.2	0.2321	D	0.5	1250	0.37	14
15S	Largely Unvegetated	1.85	Vaiva-Quilotosa-Hyder-Cipriano-Cherioni	gravelly loam	0.2	0.2321	D	0.5	1250	0.37	14
12S	Largely Unvegetated	1.64	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.37	14
13S	Largely Unvegetated	2.6	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.39	13.5
8S	Largely Unvegetated	5.66	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.42	13
2S	Largely Unvegetated	4.85	Vaiva-Rock Outcrop-Quilotosa	gravelly loam	0.2	0.2357	D	0.75	1200	0.42	13
6S	Largely Unvegetated	9.24	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.48	12
10S	Largely Unvegetated	2.06	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.38	13.5
11S	Largely Unvegetated	2.06	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.38	13.5
7S	Largely Unvegetated	2.08	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.38	13.5
14S	Largely Unvegetated	5.9	Rillito-Gunsight Complex	Gravelly sandy loam/gravelly loam	0.18	0.2546	B	0.5	1375	0.43	13
Mt Barrow	Largely Unvegetated	7.13	Upspring-Sparkhule	Gravelly Sandy Loam	0.2	0.2334	D	0.5	1350	0.45	13

Note:
kg/m^3 = kilograms per cubic meter

[a] Bing aerial map
[b] Spatial data (MCAS Yuma, 2014)
[c] USDA NRCS, 1988
[d] Estimated field capacity value for soil type (Fetter, 1994)
[e] Estimated as porosity (based on soil type[McWhorter and Sundada, 1977]) less water content
[f] Estimated from soil organic content obtained from the soil survey report (USDA NRCS, 1988)
[g] McCuen, 1998
[h] Estimated from reference value (Swain et al., 1991; McFarland, 1996; Nelm et al., 1997; Heath, 1984) adjusted for MC loading area based on land cover and slope

Table C-3: Parameter Values used to Estimate Soil Erosion

MC Loading Area/Watershed Area	Area (m^2)	K[a]	LS[b]	C[c]	A ($kg/m^2/d$)
BMGR					
Cactus West - Target	879,483	0.15	0.12	0.2	2.21E-05
Cactus West -Strafe Berm	213,639	0.28	0.2168	0.2	7.46E-05
Yodaville - UTC	712,912	0.15	0.1573	0.2	2.90E-05
Yodaville - MLT	278,493	0.15	0.2336	0.2	4.30E-05
Murrayville West	1,476,817	0.28	0.128	0.2	4.40E-05
Panel Stager	644,988	0.15	0.12	0.2	2.21E-05
CSOC1	98,055	0.15	0.12	0.2	2.21E-05
CSOC2	92,342	0.15	0.1653	0.2	3.05E-05
Murrayville East	1,476,544	0.28	0.131	0.2	4.51E-05
CMAGR North					
S-5-3	1,479,727	0.37	1.93	0.2	8.77E-04
S-5-2	433,631	0.24	2.246	0.2	6.62E-04
S-4-23	35,305	0.2	4.27	0.2	1.05E-03
S-4-22	36,525	0.32	3.78	0.2	1.49E-03
S-4-21	27,666	0.32	3.5	0.2	1.38E-03
S-4-19	6,136	0.24	1.803	0.2	5.32E-04
S-4-17	167,367	0.2	2.764	0.2	6.79E-04
S-4-15	42,169	0.24	3.837	0.2	1.13E-03
S-4-14	8,230	0.2	3.954	0.2	9.71E-04
S-4-12A, S-4-12B	621,521	0.2	0.549	0.2	1.35E-04
S-4-11A, S-4-11B	820,258	0.2	0.453	0.2	1.11E-04
S-4-10	2,325,081	0.2	0.437	0.2	1.07E-04
S-4-1	33,540	0.2	0.8175	0.2	2.01E-04
S-4-2	11,427	0.2	0.155	0.2	3.81E-05
S-4-8	689,674	0.2	0.2768	0.2	6.80E-05
S-4-3	350,963	0.2	0.2792	0.2	6.86E-05
S-4-4	451,422	0.2	0.476	0.2	1.17E-04
S-4-13	633,145	0.2	0.7875	0.2	1.93E-04
12N	5,933,745	0.2	1.4	0.2	3.44E-04
6N	123,860	0.2	0.7025	0.2	1.73E-04
8N	155,028	0.2	0.9025	0.2	2.22E-04
7N	505,105	0.2	3.08	0.2	7.57E-04
1N	259,579	0.2	0.8325	0.2	2.05E-04
15N	1,770,282	0.2	0.4396	0.2	1.08E-04
ICM Box	2,000,001	0.24	1.7825	0.2	5.25E-04
13N	838,156	0.2	0.6525	0.2	1.60E-04
14N	93,590	0.2	1.171	0.2	2.88E-04
10N	813,267	0.24	0.79	0.2	2.33E-04
3N	1,683,288	0.43	0.8275	0.2	4.37E-04
2N	242,178	0.24	0.14	0.2	4.13E-05
11N	77,744	0.43	1.3296	0.2	7.02E-04
9N	178,931	0.37	0.4942	0.2	2.25E-04
CMAGR South					
1S	239,150	0.37	0.3746	0.2	1.70E-04
3S	270,727	0.37	0.81	0.2	3.68E-04
4S	140,907	0.52	0.4474	0.2	2.86E-04
5S	183,951	0.52	0.437	0.2	2.79E-04
15S	1,382,126	0.52	0.541	0.2	3.46E-04
12S	1197554.772	0.37	0.4864	0.2	2.21E-04
13S	125,377	0.37	0.73	0.2	3.32E-04
8S	61,224	0.37	1.505	0.2	6.84E-04
2S	101,734	0.26	1.301	0.2	4.16E-04
6S	270,764	0.37	2.3442	0.2	1.07E-03
10S	163,542	0.37	0.595	0.2	2.70E-04
11S	924,604	0.37	0.595	0.2	2.70E-04
7S	257,943	0.37	0.6	0.2	2.73E-04
14S	114,129	0.37	0.1565	0.2	7.11E-05
Mt Barrow	1,790,378	0.32	1.8725	0.2	7.36E-04
Watershed Area of surface water receptor locations					
BMGR					
Yuma Desert	576,046,240	0.19	0.15	0.2	3.50E-05
CMAGR North					
Middle Salt Creek	153,015,823	0.3	2.09	0.2	7.74E-04
Town of Pope-Frontal Salton Sea	148,503,575	0.26	2.85	0.2	1.28E-03
Town of Frink-Frontal Salton Sea	135,719,544	0.24	2.94	0.2	7.66E-04
Town of Niland-Frontal Salton Sea	265,202,876	0.2	0.71	0.2	1.72E-04
181002041103	52,508,009	0.2	0.96	0.2	2.28E-04
Iris	70,565,098	0.25	1.08	0.2	2.64E-04
181002041104	69,270,103	0.37	0.71	0.2	2.23E-04
181002040602	62,677,768	0.21	0.96	0.2	2.42E-04
181002041106	88,047,533	0.21	1.02	0.2	2.63E-04
Camp Dunlap	54,523,345	0.21	1.02	0.2	2.63E-04
CMAGR South					
150301040902	151,433,501	0.37	0.58	0.2	2.64E-04
150301040903	73,126,760	0.52	0.955	0.2	6.10E-04
Headwaters Milpitas Wash	71,220,689	0.37	1.08	0.2	4.91E-04
Cottonwood Spring	159,899,532	0.37	1.08	0.2	4.91E-04
150301041005	122,255,641	0.32	1.59	0.2	6.25E-04
Midway Well	131,187,061	0.32	1.59	0.2	6.25E-04

Note:

R factor was estimated to be 176 from an isoerodent map for the eastern United States (USDA ARS, 1997)

P factor was selected to be 1 based on a conservative assumption

A = predicted soil loss

C = cover and management factor

K = soil erodibility factor

$kg/m^2/d$ = kilogram per square meter per day

LS = topographic factor (influence of length and steepness of slope)

P = erosion control practice factor

R = rainfall and runoff factor

[a] USDA NRCS, 2007

[b] Slope length and gradient were used to select LS (USDA ARS, 1997).

[c] Estimated based on vegetation cover (USDA ARS, 1997)

Table C-4: Chemical Properties of TNT

Installation name:	MCAS Yuma
Date:	4/1/2014
Munitions Constituent:	TNT

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units	Necessary Actions / Data Gaps
1	Molecular weight	Molecular weight of TNT	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995		227.1	g/mol	
2	Solubility	Water solubility of TNT	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 5.72E-01 	mol/m^3	
3	Vapor pressure	Vapor pressure of TNT	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 1.47E-04 	Pa	
4	Henry's law constant	Henry's law constant of TNT	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 1.10E-08 	atm-m^3/mol	
5	Kow	Octanol-water partition coefficient for TNT	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 72.4 	unitless	
6	Koc	Organic carbon partition coefficient for TNT	☐ Literature ☐ Site Data ☑ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 525 	mL/g	
7	K_D	Equilibrium distribution coefficient	☐ Literature ☑ Site Data ☐ Assumption	Values presented in Table C-8		Minimum: Average: Maximum:	 	mL/g	
8	Diffusion coefficient in air	Diffusion coefficient of TNT in air	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.40E-02 	cm^2/sec	
9	Diffusion coefficient in water	Diffusion coefficient of TNT in water	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.71E-06 	cm^2/sec	
10	Half-life in soil	Reaction half-life of TNT in soil	☑ Literature ☐ Site Data ☐ Assumption	A representative value selected by subjuect matter expert based on a compilation of academic, industrial and government references	HQMC, 2009	Minimum: Most likey: Maximum:	 23.1 	days	

Table C-5: Chemical Properties of HMX

Installation name:	MCAS Yuma
Date:	4/1/2014
Munitions Constituent:	HMX

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units	Necessary Actions / Data Gaps
1	Molecular weight	Molecular weight of HMX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995		296.2	g/mol	
2	Solubility	Water solubility of HMX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 1.69E-02 	mol/m^3	
3	Vapor pressure	Vapor pressure of HMX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 4.40E-12 	Pa	
4	Henry's law constant	Henry's law constant of HMX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 2.63E-15 	atm-m^3/mol	
5	Kow	Octanol-water partition coefficient for HMX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 1.15 	unitless	
6	Koc	Organic carbon partition coefficient for HMX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 3.47 	mL/g	
7	K_D	Equilibrium distribution coefficient	☐ Literature ☑ Site Data ☐ Assumption	Values presented in Table C-8		Minimum: Average: Maximum:	 	mL/g	
8	Diffusion coefficient in air	Diffusion coefficient of HMX in air	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.30E-02 	cm^2/sec	
9	Diffusion coefficient in water	Diffusion coefficient of HMX in water	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.02E-06 	cm^2/sec	
10	Half-life in soil	Reaction half-life of HMX in soil	☑ Literature ☐ Site Data ☐ Assumption	A representative value selected by subjuect matter expert based on a compilation of academic, industrial and government references	HQMC, 2009	Minimum: Most likely: Maximum:	 51.3 	days	

Table C-6: Chemical Properties of RDX

Installation name:	MCAS Yuma
Date:	4/1/2014
Munitions Constituent:	RDX

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units	Necessary Actions / Data Gaps
1	Molecular weight	Molecular weight of RDX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995		222.1	g/mol	
2	Solubility	Water solubility of RDX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 1.90E-01 	mol/m^3	
3	Vapor pressure	Vapor pressure of RDX	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 5.47E-07 	Pa	
4	Henry's law constant	Henry's law constant of RDX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 1.20E-05 	atm-m^3/mol	
5	Kow	Octanol-water partition coefficient for RDX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 6.45 	unitless	
6	Koc	Organic carbon partition coefficient for RDX	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 7.76E+00 	mL/g	
7	K_D	Equilibrium distribution coefficient	☐ Literature ☑ Site Data ☐ Assumption	Values presented in Table C-8		Minimum: Average: Maximum:	 	mL/g	
8	Diffusion coefficient in air	Diffusion coefficient of RDX in air	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 7.40E-02 	cm^2/sec	
9	Diffusion coefficient in water	Diffusion coefficient of RDX in water	☑ Literature ☐ Site Data ☐ Assumption		HQMC, 2009	Minimum: Average: Maximum:	 7.15E-06 	cm^2/sec	
10	Half-life in soil	Reaction half-life of RDX in soil	☐ Literature ☐ Site Data ☑ Assumption	A representative value selected by subjuect matter expert based on a compilation of academic, industrial and government references	HQMC, 2009	Minimum: Average: Maximum:	 14.2 	days	

Table C-7: Chemical Properties of Perchlorate

Installation name:	MCAS Yuma
Date:	4/1/2014
Munitions Constituent:	Perchlorate

Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units	Necessary Actions / Data Gaps
1	Molecular weight	Molecular weight of perchlorate	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995		99.45	g/mol	
2	Solubility	Water solubility of perchlorate	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 2.01E+03 	mol/m^3	
3	Vapor pressure	Vapor pressure of perchlorate	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995	Minimum: Average: Maximum:	 3.75E-09 	Pa	
4	Henry's law constant	Henry's law constant of perchlorate	☐ Literature ☐ Site Data ☑ Assumption	No reported values available; Estmated by CalTOX from vapor pressure and solubility values		Minimum: Most Likely: Maximum:	 1.85E-17 	atm-m^3/mol	
5	Kow	Octanol-water partition coefficient for Perchlorate	☑ Literature ☐ Site Data ☐ Assumption		Walsh et al., 1995 Meylan and Howard, 1995	Minimum: Average: Maximum:	 1.40E-06 	unitless	
6	Koc	Organic carbon partition coefficient for Perchlorate	☐ Literature ☐ Site Data ☑ Assumption	Estimated by the CalTOX model based on the Kow for perchlorate		Minimum: Average: Maximum:	 6.94E-07 	mL/g	
7	K_D	Equilibrium distribution coefficient	☐ Literature ☐ Site Data ☑ Assumption	Values presented in Table C-8		Minimum: Average: Maximum:	 	L/Kg	
8	Diffusion coefficient in air	Diffusion coefficient of perchlorate in air	☐ Literature ☐ Site Data ☑ Assumption	No reported values available, input variables used are based on conservative assumptions		Minimum: Average: Maximum:	 7.00E-10 	cm^2/sec	
9	Diffusion coefficient in water	Reaction half-life of perchlorate in water	☐ Literature ☐ Site Data ☑ Assumption	No reported values available, input variables used are based on conservative assumptions		Minimum: Average: Maximum:	 1.90E-12 	cm^2/sec	
10	Half-life in soil	Reaction half-life of perchlorate in soil	☐ Literature ☐ Site Data ☑ Assumption	No reported values available, input variables used are based on conservative assumptions		Minimum: Average: Maximum:	 1.00E+07 	days	

Table C-8: MC Equilibrium Distribution Coefficient Values at MC Loading Areas

MC Loading Area	Soil Organic Carbon Content	MC	Koc (ml/g)	K_D (ml/g)[a]
BMGR				
Cactus West Target	0.0025	HMX	3.47	0.01
		RDX	7.76	0.02
		TNT	525	1.3
		Perhlorate	6.94E-07	1.7E-09
Cactus West Strafe Berm	0.0025	HMX	3.47	0.01
		RDX	7.76	0.02
		TNT	525	1.3
		Perhlorate	6.94E-07	1.7E-09
Yodaville UTC	0.0025	HMX	3.47	0.01
		RDX	7.76	0.02
		TNT	525	1.3
		Perhlorate	6.94E-07	1.7E-09
Yodaville MLT	0.0025	HMX	3.47	0.01
		RDX	7.76	0.02
		TNT	525	1.3
		Perhlorate	6.94E-07	1.7E-09
Murrayville West	0.0025	HMX	3.47	0.01
		RDX	7.76	0.02
		TNT	525	1.3
		Perhlorate	6.94E-07	1.7E-09
Panel Stager	0.0025	HMX	3.47	0.01
		RDX	7.76	0.02
		TNT	525	1.3
		Perhlorate	6.94E-07	1.7E-09
CSOC 1	0.0025	HMX	3.47	0.01
		RDX	7.76	0.02
		TNT	525	1.3
		Perhlorate	6.94E-07	1.7E-09
CSOC 2	0.0025	HMX	3.47	0.01
		RDX	7.76	0.02
		TNT	525	1.3
		Perhlorate	6.94E-07	1.7E-09
Murrayville East	0.0025	HMX	3.47	0.01
		RDX	7.76	0.02
		TNT	525	1.3
		Perhlorate	6.94E-07	1.7E-09
CMAGR North				
S-5-3	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.6
		Perhlorate	6.94E-07	3.5E-09
S-5-2	0.01	HMX	3.47	0.03
		RDX	7.76	0.08
		TNT	525	5.3
		Perhlorate	6.94E-07	6.9E-09
S-4-23	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.9
		Perhlorate	6.94E-07	1.0E-08

Table C-8: MC Equilibrium Distribution Coefficient Values at MC Loading Areas

MC Loading Area	Soil Organic Carbon Content	MC	Koc (ml/g)	K_D (ml/g)[a]
S-4-22	0.01	HMX	3.47	0.03
		RDX	7.76	0.08
		TNT	525	5.3
		Perhlorate	6.94E-07	6.9E-09
S-4-21	0.01	HMX	3.47	0.03
		RDX	7.76	0.08
		TNT	525	5.3
		Perhlorate	6.94E-07	6.9E-09
S-4-19	0.01	HMX	3.47	0.03
		RDX	7.76	0.08
		TNT	525	5.3
		Perhlorate	6.94E-07	6.9E-09
S-4-17	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.9
		Perhlorate	6.94E-07	1.0E-08
S-4-15	0.01	HMX	3.47	0.03
		RDX	7.76	0.08
		TNT	525	5.3
		Perhlorate	6.94E-07	6.9E-09
S-4-14	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.9
		Perhlorate	6.94E-07	1.0E-08
S-4-12A/B	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.9
		Perhlorate	6.94E-07	1.0E-08
S-4-11A/B	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.9
		Perhlorate	6.94E-07	1.0E-08
S-4-10	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
S-4-1	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
S-4-2	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
S-4-8	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
S-4-3	0.015	HMX	3.47	0.05
		RDX	7.76	0.12

Table C-8: MC Equilibrium Distribution Coefficient Values at MC Loading Areas

MC Loading Area	Soil Organic Carbon Content	MC	Koc (ml/g)	K_D (ml/g)[a]
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
S-4-4	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
S-4-13	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
12N	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
6N	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
8N	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
7N	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
1N	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
15N	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
ICM Box	0.01	HMX	3.47	0.03
		RDX	7.76	0.08
		TNT	525	5.25
		Perhlorate	6.94E-07	6.94E-09
13N	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
14N	0.015	HMX	3.47	0.05
		RDX	7.76	0.12
		TNT	525	7.88
		Perhlorate	6.94E-07	1.04E-08
10N	0.01	HMX	3.47	0.03
		RDX	7.76	0.08
		TNT	525	5.25
		Perhlorate	6.94E-07	6.94E-09

Table C-8: MC Equilibrium Distribution Coefficient Values at MC Loading Areas

MC Loading Area	Soil Organic Carbon Content	MC	Koc (ml/g)	K_D (ml/g)[a]
3N	0.0075	HMX	3.47	0.03
		RDX	7.76	0.06
		TNT	525	3.9
		Perhlorate	6.94E-07	5.2E-09
2N	0.01	HMX	3.47	0.03
		RDX	7.76	0.08
		TNT	525	5.3
		Perhlorate	6.94E-07	6.9E-09
11N	0.0075	HMX	3.47	0.03
		RDX	7.76	0.06
		TNT	525	3.9
		Perhlorate	6.94E-07	5.2E-09
9N	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.6
		Perhlorate	6.94E-07	3.5E-09
CMAGR South				
1S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.47E-09
3S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.47E-09
4S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.47E-09
5S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.47E-09
15S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.47E-09
12S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.47E-09
13S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.5E-09
8S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.5E-09
2S	0.0075	HMX	3.47	0.03

Table C-8: MC Equilibrium Distribution Coefficient Values at MC Loading Areas

MC Loading Area	Soil Organic Carbon Content	MC	Koc (ml/g)	K_D (ml/g)[a]
		RDX	7.76	0.06
		TNT	525	3.94
		Perhlorate	6.94E-07	5.21E-09
6S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.47E-09
10S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.47E-09
11S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.5E-09
7S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.5E-09
14S	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.63
		Perhlorate	6.94E-07	3.5E-09
Mt Barrow	0.005	HMX	3.47	0.02
		RDX	7.76	0.04
		TNT	525	2.6
		Perhlorate	6.94E-07	3.5E-09

Note:

[a] Evaluated from the product of organic carbon partition coefficient and soil organic carbon fraction

Groundwater Screening-Level Assessment

Modeling Parameters

Table C-9: Groundwater Modeling Parameters - Vadose Zone Properties for MC Loading Areas at BMGR West

VLEACH Parameters	MC Loading Area										
1) Polygon Data											
Parameter	**Cactus West - Target**	**Cactus West - Strafe Berm**	**Yodaville - UTC**	**Yodaville - MLT**	**Murrayville West**	**Panel Stager**	**CSOC 1**	**CSOC 2**	**Murrayville East**	**Rationale**	**Reference(s)**
Area (feet^2)	9,461,835	2,298,416	7,669,795	2,996,143	15,888,185	6,939,034	1,054,916	993,456	15,885,252	Delineated area based on data from range control	
Vertical Cell Dimension (feet)	5.45	5.4	5.25	5.25	5.3	5.9	5.7	5.7	5.35		
Number of Cells (-)	20	20	20	20	20	20	20	20	20		
Height of Polygon (feet)	109	108	105	105	106	118	114	114	107	Based on Dept of the Interior Bureau of Reclamation Yuma Area Water Management System data	
2) Soil Parameter											
Parameter	**Cactus West - Target**	**Cactus West - Strafe**	**Yodaville - UTC**	**Yodaville - MLT**	**Murrayville West**	**Panel Stager**	**CSOC 1**	**CSOC 2**	**Murrayville East**		
Dry Bulk Density (g/cm^2)	1.81	1.375	1.81	1.81	1.375	1.81	1.81	1.81	1.375		USDA NRCS, 2014
Effective Porosity (-)	0.33	0.2204	0.33	0.33	0.2204	0.33	0.33	0.33	0.2204	Estimated based on soil type present	McWhorter and Sundada, 1977
Volumetric Water Content (-)	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.2	Estimated field capacity value for the soil type	Fetter, 1994
Soil Organic Carbon Content (-)	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	Estimated organic carbon content of soil type from soil survey report	USDA NRCS, 2014
3a) Boundary Condition											
Parameter	**Cactus West - Target**	**Cactus West - Strafe**	**Yodaville - UTC**	**Yodaville - MLT**	**Murrayville West**	**Panel Stager**	**CSOC 1**	**CSOC 2**	**Murrayville East**		
Recharge Rate (feet/year)	0.0583333	0.0583333	0.0583333	0.0583333	0.05833333	0.0583333	0.0583333	0.0583333	0.0583333	Assumed based on land cover and slope	
Concentration of HMX in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
Concentration of RDX in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
Concentration of TNT in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
Concentration of Perchlorate in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
Upper Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0	0	0	MC modeled are non-volatile	
Lower Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0	0	0	MC modeled are non-volatile	
Upper Cell Number (-)	1	1	1	1	1	1	1	1	1		
Lower Cell Number (-)	20	20	20	20	20	20	20	20	20		
Initial Contaminant Concentration in Cells (µg/Kg	0	0	0	0	0	0	0	0	0	Based on loading rate estimate	

Notes:
EIM = estimated if modeled
EFPL = estimated from previous loading period

Table C-10: Groundwater Modeling Parameters - Vadose Zone Properties for MC Loading Areas at CMAGR North

VLEACH Parameters																			
1) Polygon Data															**MC Loading Area**				
Parameter	**S-5-3**	**S-5-2**	**S-4-23**	**S-4-22**	**S-4-21**	**S-4-19**	**S-4-17**	**S-4-15**	**S-4-14**	**S-4-12A, S-4**	**S-4-11A, S-4**	**S-4-10**	**S-4-1**	**S-4-2**	**S-4-8**	**S-4-3**	**S-4-4**	**S-4-13**	
Area (feet^2)	15919498.35	4665180.373	379825.4106	392949.4221	297642.2713	66015.91447	1800600.428	453670.7431	88537.2229	6686572.7	8824663.2	25014152	360839.33	122941.294	7419792	3775797.3	4856580.6	6811627.7	
Vertical Cell Dimension (feet)	4	3.75	2.5	3.5	3.5	4	3.5	3.5	3.5	2	2	2	2.5	2	2.5	2.5	2	2	
Number of Cells (-)	20	20	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
Height of Polygon (feet)	80	75	25	35	35	40	35	35	35	20	20	20	25	20	25	25	20	20	
2) Soil Parameter																			
Parameter	**S-5-3**	**S-5-2**	**S-4-23**	**S-4-22**	**S-4-21**	**S-4-19**	**S-4-17**	**S-4-15**	**S-4-14**	**S-4-12A, S-4-12B**	**S-4-11A, S-4-11B**	**S-4-10**	**S-4-1**	**S-4-2**	**S-4-8**	**S-4-3**	**S-4-4**	**S-4-13**	
Dry Bulk Density (g/cm^2)	1.375	1.55	1.6	1.55	1.55	1.55	1.6	1.55	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	
Effective Porosity (-)	0.2532	0.2685	0.2464	0.2685	0.2685	0.2534	0.2464	0.2534	0.2464	0.2464	0.2464	0.2464	0.2464	0.2464	0.2464	0.2464	0.2464	0.2464	
Volumetric Water Content (-)	0.18	0.22	0.19	0.22	0.22	0.2	0.19	0.2	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	0.19	
Soil Organic Carbon Content (-)	0.005	0.01	0.015	0.01	0.01	0.01	0.015	0.01	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	
3a) Boundary Condition																			
Parameter	**S-5-3**	**S-5-2**	**S-4-23**	**S-4-22**	**S-4-21**	**S-4-19**	**S-4-17**	**S-4-15**	**S-4-14**	**S-4-12A, S-4-12B**	**S-4-11A, S-4-11B**	**S-4-10**	**S-4-1**	**S-4-2**	**S-4-8**	**S-4-3**	**S-4-4**	**S-4-13**	
Recharge Rate (feet/year)	0.039758333	0.039758333	0.030583333	0.0321125	0.033641667	0.039758333	0.0367	0.033641667	0.0321125	0.0428167	0.0428167	0.0428167	0.0412875	0.04281667	0.0428167	0.0428167	0.0428167	0.0412875	
Concentration of HMX in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	
Concentration of RDX in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	
Concentration of TNT in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	
Concentration of Perchlorate in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	
Upper Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Lower Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Upper Cell Number (-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Lower Cell Number (-)	20	20	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
Initial Contaminant Concentration in Cells (µg/Kg)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

Notes:
EIM = estimated if modeled
EFPL = estimated from previous loading period

Table C-10: Groundwater Modeling Parameters - Vadose Zone Properties for MC Loading Areas at CMAGR North

12N	6N	8N	7N	1N	15N	ICM Box	13N	14N	10N	3N	2N	11N	9N	Rationale	Reference(s)
63,837,604	1,332,531	1,667,854	5,434,126	2,792,652	19,045,402	21,516,808	9,017,216	1,006,883	8,749,454	18,109,483	2,605,444	836,399	1,925,013	Delineated area based on data from range control	
4	5	4.5	5	3.75	4	4	6.25	5	5	7	6.5	6	7.5		
10	10	10	10	20	10	20	20	20	20	20	20	20	20		
40	50	45	50	75	40	80	125	100	100	140	130	120	150	Depth to water table. Estimated based on the correlation of ground surface elevation and known depth to groundwater values from California Department of Water Resources wells	CDWR, 2014
12N	**6N**	**8N**	**7N**	**1N**	**15N**	**ICM Box**	**13N**	**14N**	**10N**	**3N**	**2N**	**11N**	**9N**		
1.6	1.6	1.6	1.6	1.6	1.6	1.55	1.6	1.6	1.55	1.55	1.55	1.55	1.375		USDA NRCS, 2014
0.2464	0.2464	0.2464	0.2464	0.2464	0.2464	0.2534	0.2464	0.2464	0.2534	0.2561	0.2534	0.2561	0.2532	Estimated based on soil type present	McWhorter and Sundada, 1977
0.19	0.19	0.19	0.19	0.19	0.19	0.2	0.19	0.19	0.2	0.2	0.2	0.2	0.18	Estimated field capacity value for the soil type	Fetter, 1994
0.015	0.015	0.015	0.015	0.015	0.015	0.01	0.015	0.015	0.01	0.0075	0.01	0.0075	0.005	Estimated organic carbon content of soil type from soil survey report	USDA NRCS, 2014
12N	**6N**	**8N**	**7N**	**1N**	**15N**	**ICM Box**	**13N**	**14N**	**10N**	**3N**	**2N**	**11N**	**9N**		
0.03975833	0.0412875	0.0412875	0.0367	0.0412875	0.04281667	0.03975833	0.0412875	0.0412875	0.0412875	0.0412875	0.0397583	0.0397583	0.0428167	Assumed based on land cover and slope	
EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	MC modeled are non-volatile	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	MC modeled are non-volatile	
1	1	1	1	1	1	1	1	1	1	1	1	1	1		
10	10	10	10	20	10	20	20	20	20	20	20	20	20		
0	0	0	0	0	0	0	0	0	0	0	0	0	0	Based on loading rate estimate	

Table C-11: Groundwater Modeling Parameters - Vadose Zone Properties for MC Loading Areas at CMAGR South

VLEACH Parameters	MC Loading Area																
1) Polygon Data																	
Parameter	**1S**	**3S**	**4S**	**5S**	**15S**	**12S**	**13S**	**8S**	**2S**	**6S**	**10S**	**11S**	**7S**	**14S**	**Mt Barrow**	**Rationale**	**Reference(s)**
Area (feet^2)	2572876.174	2912592.181	1515928.853	1979022.132	14869459.31	12883773.26	1348860.504	658673.2417	1094499.158	2912982.1	1759455.2	9947264.1	2775051.2	1227842.7	19261602	Delineated area based on data from range control	
Vertical Cell Dimension (feet)	8	7.5	8.75	8.75	8.75	8	7.75	7.75	7.75	8	9	9	8	7.75	4		
Number of Cells (-)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20		
Height of Polygon (feet)	160	150	175	175	175	160	155	155	155	160	180	180	160	155	80	Depth to water table. Estimated based on the correlation of ground surface elevation and known depth to groundwater values from California Department of Water Resources wells	CDWR, 2014
2) Soil Parameter																	
Parameter	**1S**	**3S**	**4S**	**5S**	**15S**	**12S**	**13S**	**8S**	**2S**	**6S**	**10S**	**11S**	**7S**	**14S**	**Mt Barrow**		
Dry Bulk Density (g/cm^2)	1.375	1.375	1.25	1.25	1.25	1.375	1.375	1.375	1.2	1.375	1.375	1.375	1.375	1.375	1.35		USDA NRCS, 2014
Effective Porosity (-)	0.2532	0.2532	0.2661	0.2661	0.2661	0.2532	0.2532	0.2532	0.2293	0.2532	0.2532	0.2532	0.2532	0.2532	0.2744	Estimated based on soil type present	McWhorter and Sundada, 1977
Volumetric Water Content (-)	0.18	0.18	0.2	0.2	0.2	0.18	0.18	0.18	0.2	0.18	0.18	0.18	0.18	0.18	0.2	Estimated field capacity value for the soil type	Fetter, 1994
Soil Organic Carbon Content (-)	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.0075	0.005	0.005	0.005	0.005	0.005	0.005	Estimated organic carbon content of soil type from soil survey report	USDA NRCS, 2014
3a) Boundary Condition																	
Parameter	**1S**	**3S**	**4S**	**5S**	**15S**	**12S**	**13S**	**8S**	**2S**	**6S**	**10S**	**11S**	**7S**	**14S**	**Mt Barrow**		
Recharge Rate (feet/year)	0.042816667	0.0412875	0.042816667	0.042816667	0.042816667	0.042816667	0.0412875	0.039758333	0.039758333	0.0367	0.0412875	0.0412875	0.0412875	0.03975833	0.0397583	Assumed based on land cover and slope	
Concentration of HMX in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
Concentration of RDX in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
Concentration of TNT in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
Concentration of Perchlorate in Recharge Water (mg/L)	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	EIM	Estimated from initial mass balance analysis	
Upper Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	MC modeled are non-volatile	
Lower Boundary Vapor Condition (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	MC modeled are non-volatile	
Upper Cell Number (-)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		
Lower Cell Number (-)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20		
Initial Contaminant Concentration in Cells (µg/Kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Based on loading rate estimate	

Notes:
EIM = estimated if modeled
EFPL = estimated from previous loading period

Table C-12: Chemical Properties of MC used in the VLEACH Vadose zone Model

CHEMICAL PARAMETER	HMX	RDX	TNT	PERCHLORATE	Rationale	Reference(s)
Organic Carbon Distribution Coefficient (mL/g)	3.47	7.76	525	6.91E-07	HQMC, 2009	HQMC, 2009
Henry's Constant (-)	1.07E-13	4.90E-04	4.50E-07	7.54E-16	equivalent to the Henry's constant divided by the ideal gas constant and the ambient temperature	HQMC, 2009
Water Solubility (mg/L)	5	42.2	130	200,000	Walsh et al., 1995	Walsh et al., 1995
Free Air Diffusion Coefficient (m^2/day)	0.544	0.639	0.553	7.00E-10	HQMC, 2009	HQMC, 2009
Molecular Weight (g/mol)	296.2	222.1	227.1	99.45		

Table C-13: Saturated Zone Modeling Parameters (Interlayerd lava and tuff - Shallow Groundater Flow)

Site Name:	MCAS Yuma (CMAGR North)
Date:	4/1/2014
Zone:	Saturated Zone - Salton Sea Basin

	Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units	Necessary Actions / Data Gaps
Flow, Fate & Transport, Model Parameters	1	Material Type	Alluvium	☑ Literature ☐ Site Data ☐ Assumption			unconsolidated and semi-consolidated alluvial deposits			
	Advection									
	2	Groundwater velocity		☐ Literature ☐ Site Data ☐ Assumption			Minimum: Average: Maximum:		ft/d	
	OR									
	3	Horizontal Hydraulic Conductivity	Conductivity for sand and gravel associated with an alluvial wash system	☐ Literature ☐ Site Data ☑ Assumption	value estimated to represent an unconfined aquifer in sand and gravel associated with an alluvial wash system		Minimum: Average: Maximum:	 2.80E-03 	cm/sec	
	4	Hydraulic Gradient	Slope of the Water Table	☑ Literature ☑ Site Data ☑ Assumption	Based on the assumption that the water tabel paralles the surface topography, it is assumed to be equivalent to surface slope	MCAS Yuma, 2014	Minimum: Average: Maximum:	0.14 2.09 6.77	%	
	5	Effective porosity	Effective porosity of unconsolidated and semi-consolidated alluvial deposits	☑ Literature ☐ Site Data ☐ Assumption		McWhorter and Sundada, 1977; USDA 1996	Minimum: Average: Maximum:	0.2464 0.2498 0.2561		
	Dispersion									
	6	Longitudinal Dispersion	Dispersion in the direction of flow (horizontally)	☐ Literature ☐ Site Data ☑ Assumption			Minimum: Average: Maximum:	0 3 30	ft	
	7	Ratio of Transverse to Longitudinal Dispersion	Dispersion ratio perpendicular to the direction of flow (horizontally)	☐ Literature ☐ Site Data ☑ Assumption			Minimum: Average: Maximum:	0 0.1 0.3	ft	
	8	Ratio of Vertical to Longitudinal Dispersion	Dispersion ratio perpendicular to the direction of flow (vertically)	☐ Literature ☐ Site Data ☑ Assumption			Minimum: Average: Maximum:	0 0.03 0.3	ft	
	Retardation									
	9	Bulk Density	Density of unconsolidated and semi-consolidated alluvial deposits	☑ Literature ☑ Site Data ☐ Assumption	Estimated based on material description	Fetter, 1994; USDA NRCS, n.d.; McWhorter and Sundada, 1977	Minimum: Average: Maximum:	1375 1563 1600	Kg/m^3	
	10	foc	Fraction of organic carbon (unconsolidated and semi-consolidated alluvial deposits)	☑ Literature ☑ Site Data ☑ Assumption	The organic carbon content estimated for the soil types at MC loading area	USDA NRCS, 2014	Minimum: Average: Maximum:	0.0029 0.007043 0.0087	unitless	
	Model Parameters									
	11	Width of model	Larger than width of plume	☐ Literature ☐ Site Data ☑ Assumption	Does not affect model result		Equivalent to model width. Refer to table A-11			
	12	Length of model	Larger than final length of plume		Does not affect model result		Equivalent to model width. Refer to table A-11			
	13	Source thickness	Saturated thickness of aquifer layer		Approximate thickess of aquifer layer		150		ft	
	14	Source Width	Width of plume		Assumed to be width of MC loading area perpendicular to flow direction		Equivalent to model width. Refer to table A-11		ft	

Notes:
Green highlight = option one for defining the advection term
Blue highlight = option two for defining the advection term
Gray highlight = not applicable

Table C-14: Saturated Zone Modeling Parameters (Interlayerd lava and tuff - Shallow Groundater Flow)

Site Name:	MCAS Yuma (BMGR & CMAGR South)
Date:	4/1/2014
Zone:	Saturated Zone - Lower Colorado Basin

	Row	Data Type	Description	Source Type	Rationale	Reference(s)	Value/Result		Units	Necessary Actions / Data Gaps
Flow, Fate & Transport, Model Parameters	1	Material Type	Coarse Gravel Zone	☑ Literature ☐ Site Data ☐ Assumption			Sand and gravel associated with an alluvial wash system			
	Advection									
	2	Groundwater velocity		☐ Literature ☐ Site Data ☐ Assumption			Minimum: Average: Maximum:		ft/d	
	OR									
	3	Horizontal Hydraulic Conductivity	Conductivity for sand and gravel associated with an alluvial wash system	☐ Literature ☐ Site Data ☑ Assumption	value estimated to represent an unconfined aquifer in sand and gravel associated with an alluvial wash system		Minimum: Average: Maximum:	 2.80E-03 	cm/sec	
	4	Hydraulic Gradient	Slope of the Water Table	☑ Literature ☑ Site Data ☑ Assumption	Based on the assumption that the water tabel paralles the surface topography, it is assumed to be equivalent to surface slope	MCAS Yuma, 2014	Minimum: Average: Maximum:	0.13 2.57 9.24		
	5	Effective porosity	Effective porosity of Sand and gravel associated with an alluvial wash system	☑ Literature ☐ Site Data ☐ Assumption		McWhorter and Sundada, 1977; USDA 1996	Minimum: Average: Maximum:	0.2204 0.2692 0.33		
	Dispersion									
	6	Longitudinal Dispersion	Dispersion in the direction of flow (horizontally)	☐ Literature ☐ Site Data ☑ Assumption			Minimum: Average: Maximum:	0 3 30	ft	
	7	Ratio of Transverse to Longitudinal Dispersion	Dispersion ratio perpendicular to the direction of flow (horizontally)	☐ Literature ☐ Site Data ☑ Assumption			Minimum: Average: Maximum:	0 0.1 0.3	ft	
	8	Ratio of Vertical to Longitudinal Dispersion	Dispersion ratio perpendicular to the direction of flow (vertically)	☐ Literature ☐ Site Data ☑ Assumption			Minimum: Average: Maximum:	0 0.03 0.3	ft	
	Retardation									
	9	Bulk Density	Density of Sand and gravel associated with an alluvial wash system	☑ Literature ☑ Site Data ☐ Assumption	Estimated based on material description	Fetter, 1994; USDA NRCS, n.d.; McWhorter and Sundada, 1977	Minimum: Average: Maximum:	1200 1455 1810	Kg/m^3	
	10	foc	Fraction of organic carbon (Sand and gravel associated with an alluvial wash system)	☑ Literature ☑ Site Data ☑ Assumption	The organic carbon content estimated for the soil types at MC loading area	USDA NRCS, 2014	Minimum: Average: Maximum:	0.00145 0.0029 0.0087	unitless	
	Model Parameters									
	11	Width of model	Larger than width of plume	☐ Literature ☐ Site Data ☑ Assumption	Does not affect model result		Equivalent to model width. Refer to table A-11			
	12	Length of model	Larger than final length of plume		Does not affect model result		Equivalent to model width. Refer to table A-11			
	13	Source thickness	Saturated thickness of aquifer layer		Approximate thickess of aquifer layer		140		ft	
	14	Source Width	Width of plume		Assumed to be width of MC loading area perpendicular to flow direction		Equivalent to model width. Refer to table A-11		ft	

Notes:
Green highlight = option one for defining the advection term
Blue highlight = option two for defining the advection term
Gray highlight = not applicable

ARCADIS

Appendix D

Small Arms Range
Assessment Protocols

KD PISTOL RANGE
BMGR WEST, MCAS YUMA
Yuma, Arizona

Date of SARAP update: 25 June 2014

DESCRIPTION

Range Mission: Qualification KD Pistol Range	
Training Start Date: Prior to 2007	
Direction of Fire: Northeast	
Firing Positions: 40	
Target Range: 7, 15, and 25 yards	
Impact Area(s):	☐ Open area ☐ Hillside ☐ Building ☒ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		3,271
Surface Water / Sediment	***RANK***	Minimal
	Source	10
	Pathway	17
	Receptor	4
	TOTAL SCORE	31
Groundwater	***RANK***	Minimal
	Source	10
	Pathway	17
	Receptor	0
	TOTAL SCORE	22

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: _____

☐ Collect site-specific field data to further assess potential off-range migration.

KD PISTOL RANGE
MCAS YUMA

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**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	8
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	3
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	-3
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			10

Notes:

Annual lead deposition – 3,271 pounds/year

The berm was mined in 2012. No previous lead removal actions have ever occurred at the range.

KD PISTOL RANGE
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	4
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	6
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	3
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	-1

KD PISTOL RANGE
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			17

Notes:

MCAS Yuma receives approximately 3 inches of rain per year.

No vegetation is present on the range, and little to no vegetation is present in the drainage areas off the range.

The slope is approximately 2.5% moving from the berm off the range in the southwest direction off the range.

pH measured at the range was approximately 8.0. The USDA's Web Soil Survey indicates the pH of the soil in the vicinity is approximately 8.2.

The area in which the projectiles are deposited for this range is comprised primarily of Rositas sand which is a gravelly fine sand.

Erosion was observed at the foot of the berm and on the face of the berm.

Side berms prevent run-on from entering the range. The range slopes toward the firing line, so side berms do not prevent runoff from leaving the range.

KD PISTOL RANGE
MCAS YUMA

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**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	0
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).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	1
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	6
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			12

Notes:

The Pistol Range is located in the Upper Mesa basin where groundwater has been measured 100-120 feet below ground surface.

The area in which the projectiles are deposited for this range is comprised primarily of Rositas

KD PISTOL RANGE
MCAS YUMA

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**
sand which is a gravelly fine sand near the surface. The most restrictive soil layer between the surface and the typical well withdrawal elevation is clay. Two distinct clay layers overlay the coarse gravel unit (typical well withdrawal layer) and serve to limit infiltration to the gravel unit. Clay A is inches to 35 feet thick and Clay B is 10 to 15 feet thick.			

KD PISTOL RANGE
MCAS YUMA

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	0
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			4

Notes:

The first identified downgradient surface water body according to the USGS National Hydrography Map is the Southwest Lateral located approximately 12 miles west of the Pistol Range. Any surface water flowing off of the range is most likely to evaporate, infiltrate, or drain into one of the several man-made drainages between the range and the Southwest Lateral prior to reaching it. A small intermittent stream/drainage is present approximately 9,800 feet northeast of the range however it is upgradient and flows away from the Pistol Range.

There are no surface water bodies that are used as drinking water sources within 6 miles of the Pistol Range.

There is no identified downgradient surface water source into which surface water from the Pistol Range drains that crosses the installation boundary. The installation boundary is located approximately 0.4 miles down gradient to the west of the Pistol Range.

KD PISTOL RANGE
MCAS YUMA

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.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			0

Notes:

There are no drinking water wells down-gradient of the range and no known uses of groundwater within 1500 feet of the range.

Four groundwater supply wells are present at BMGR West. One is currently out-of-service, the three remaining wells are used for non-potable supply. Water supply wells were not identified down gradient of any BMGR West ranges.

KD PISTOL RANGE
MCAS YUMA

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	10
Surface Water / Sediment Pathways	2	17
Surface Water / Sediment Receptors	4	4
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**31**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	10
Groundwater Pathways	3	12
Groundwater Receptors	5	0
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**22**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Minimal**
Groundwater Evaluation Ranking	**Minimal**

Notes:

RANGE 1
BMGR WEST, MCAS YUMA
Yuma, Arizona

Date of SARAP update: 25 June 2014

DESCRIPTION

Range Mission: Multipurpose Live Fire Range	
Training Start Date: 2011	
Direction of Fire: East	
Firing Positions: ~26	
Target Range: ~7 to 25 yards	
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		965
Surface Water / Sediment	***RANK***	Minimal
	Source	9
	Pathway	14
	Receptor	2
	TOTAL SCORE	25
Groundwater	***RANK***	Minimal
	Source	9
	Pathway	9
	Receptor	0
	TOTAL SCORE	18

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: _____

☐ Collect site-specific field data to further assess potential off-range migration.

RANGE 1
MCAS YUMA

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**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	5
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	0
Source Element Score *Minimum: -4 Maximum: 20*			9

Notes:

Annual lead deposition – 965 pounds/year

Range 1 was constructed in 2010 and became operational in 2011.

RANGE 1
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	4
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	4
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

RANGE 1
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			14

Notes:

MCAS Yuma receives approximately 3 inches of rain per year.

The SDZ where projectiles are deposited is partially vegetated.

The slope is approximately 1-2% moving from targets in the northeast direction. The land slopes approximately 2-3% to the south from the SDZ.

The USDA's Web Soil Survey indicates the pH of the soil in the vicinity is approximately 8.2.

RANGE 1
MCAS YUMA

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**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	0
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).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	1
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	3
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			9

Notes:

Range 1 is located in the Upper Mesa basin where groundwater has been measured 100-120 feet below ground surface.

RANGE 1
MCAS YUMA

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**
Coarse-grained soils occur on 98% of the BMGR and are typically associated with the basin-fill areas. The soil consists of gravel, cobbles, boulders, and sand (primarily) with some silt and little clay. Fine-grained soil deposits occur on the remaining 2% of the BMGR and consist of clay (primarily) with some silt (DON, 2013). The most restrictive soil layer between the surface and the typical well withdrawal elevation is clay. Two distinct clay layers overlay the coarse gravel unit (typical well withdrawal layer) and serve to limit infiltration to the gravel unit. Clay A is inches to 35 feet thick and Clay B is 10 to 15 feet thick.			

RANGE 1
MCAS YUMA

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	0
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	2
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			2

Notes:

The first identified downgradient surface water body according to the USGS National Hydrography Map is the Southwest Lateral located approximately 13.5 miles west of Range 1. Any surface water flowing off of the range is most likely to evaporate, infiltrate, or drain into one of the several man-made drainages between the range and the Southwest Lateral prior to reaching it. A small intermittent stream/drainage is present approximately 5,600 feet north of Range 1, however it is upgradient and drains away from the range.

There are no surface water bodies that are used as drinking water sources within 6 miles of Range 1.

There is no identified downgradient surface water source into which surface water from Range 1 drains that crosses the installation boundary. The installation boundary is located approximately 2.2 miles downgradient to the west of Range 1.

RANGE 1
MCAS YUMA

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.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			0

Notes:

There are no drinking water wells down-gradient of the range and no known uses of groundwater within 1500 feet of the range.

Four groundwater supply wells are present at BMGR West. One is currently out-of-service, the three remaining wells are used for non-potable supply. Water supply wells were not identified down gradient of any BMGR West ranges.

RANGE 1
MCAS YUMA

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment

Element	Table	Score
Range Use and Range Management (Source)	1	9
Surface Water / Sediment Pathways	2	14
Surface Water / Sediment Receptors	4	2
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**25**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	9
Groundwater Pathways	3	9
Groundwater Receptors	5	0
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**18**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Minimal**
Groundwater Evaluation Ranking	**Minimal**

Notes:

RANGE 1A
BMGR WEST, MCAS YUMA
Yuma, Arizona

Date of SARAP update: 25 June 2014

DESCRIPTION

Range Mission:	Quick Reaction Course
Training Start Date:	2011
Direction of Fire:	East-Northeast
Firing Positions:	Two at various locations
Target Range:	Varies
Impact Area(s):	☒ Open area ☐ Hillside ☒ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		217
Surface Water / Sediment	***RANK***	Minimal
	Source	6
	Pathway	16
	Receptor	2
	TOTAL SCORE	24
Groundwater	***RANK***	Minimal
	Source	6
	Pathway	12
	Receptor	0
	TOTAL SCORE	18

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: _____

☐ Collect site-specific field data to further assess potential off-range migration.

RANGE 1A
MCAS YUMA

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**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	2
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	0
Source Element Score *Minimum: -4 Maximum: 20*			6

Notes:

Annual lead deposition – 217 pounds/year

Range 1A was constructed in 2010 and became operational in 2011.

RANGE 1A
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	4
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	6
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

RANGE 1A
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			16

Notes:

MCAS Yuma receives approximately 3 inches of rain per year.

Shrubs are scattered around the range, but provides little vegetative cover.

There are mounds throughout the range with slopes >5%; however, the overall area of the range and drainage pathways moving away from the range are generally flat.

The USDA's Web Soil Survey indicates the pH of the soil in the vicinity is approximately 8.2.

RANGE 1A
MCAS YUMA

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**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	0
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).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	1
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	6
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			12

Notes:

Range 1A is located in the Upper Mesa basin where groundwater has been measured 100-120 feet below ground surface.

Coarse-grained soils occur on 98% of the BMGR and are typically associated with the basin-fill areas. The soil consists of gravel, cobbles, boulders, and sand (primarily) with some silt and

RANGE 1A
MCAS YUMA

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**
little clay. Fine-grained soil deposits occur on the remaining 2% of the BMGR and consist of clay (primarily) with some silt (DON, 2013). The area in which the projectiles are deposited for this range is comprised primarily of Rositas sand which is a gravelly fine sand near the surface. The most restrictive soil layer between the surface and the typical well withdrawal elevation is clay. Two distinct clay layers overlay the coarse gravel unit (typical well withdrawal layer) and serve to limit infiltration to the gravel unit. Clay A is inches to 35 feet thick and Clay B is 10 to 15 feet thick.			

RANGE 1A
MCAS YUMA

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	0
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	2
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			2

Notes:

The first identified downgradient surface water body according to the USGS National Hydrography Map is the Southwest Lateral located approximately 13.5 miles west of Range 1A. Any surface water flowing off of the range is most likely to evaporate, infiltrate, or drain into one of the several man-made drainages between the range and the Southwest Lateral prior to reaching it. A small intermittent stream/drainage is present approximately 5,600 feet north of Range 1A, however it is upgradient and drains away from the range.

There are no surface water bodies that are used as drinking water sources within 6 miles of Range 1A.

There is no identified downgradient surface water source into which surface water from Range 1A drains that crosses the installation boundary. The installation boundary is located approximately 2.2 miles downgradient to the west of Range 1A.

RANGE 1A
MCAS YUMA

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.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			0

Notes:

There are no drinking water wells down-gradient of the range and no known uses of groundwater within 1500 feet of the range.

Four groundwater supply wells are present at BMGR West. One is currently out-of-service, the three remaining wells are used for non-potable supply. Water supply wells were not identified down gradient of any BMGR West ranges.

RANGE 1A
MCAS YUMA

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment

Element	Table	Score
Range Use and Range Management (Source)	1	6
Surface Water / Sediment Pathways	2	16
Surface Water / Sediment Receptors	4	2
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**24**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	6
Groundwater Pathways	3	12
Groundwater Receptors	5	0
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**18**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Minimal**
Groundwater Evaluation Ranking	**Minimal**

Notes:

KD RIFLE RANGE
BMGR WEST, MCAS YUMA
Yuma, Arizona

Date of SARAP update: 25 June 2014

DESCRIPTION

Range Mission: Qualification KD Rifle Range	
Training Start Date: Prior to 2007	
Direction of Fire: Northeast	
Firing Positions: 30	
Target Range: 100 – 500 yards	
Impact Area(s):	☐ Open area ☐ Hillside ☐ Building ☒ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		4,755
Surface Water / Sediment	***RANK***	Minimal
	Source	13
	Pathway	15
	Receptor	4
	TOTAL SCORE	32
Groundwater	***RANK***	Minimal
	Source	13
	Pathway	12
	Receptor	0
	TOTAL SCORE	25

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: _____

☐ Collect site-specific field data to further assess potential off-range migration.

KD RIFLE RANGE
MCAS YUMA

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**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	11
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	3
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	-3
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			13

Notes:

Annual lead deposition – 4,755 pounds/year

The berm was mined in 2012. No previous lead removal actions have ever occurred at the range.

KD RIFLE RANGE
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	4
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	6
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	3
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	-1

KD RIFLE RANGE
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			15

Notes:

MCAS Yuma receives approximately 3 inches of rain per year.

No vegetation is present on the berm or range floor, and very little vegetation is present in the drainage areas off the range.

The slope is approximately 1% moving from the berm off the range in the southwest direction off the range.

pH measured at the range during the site visit was 8.0. The USDA's Web Soil Survey indicates the pH of the soil in the vicinity is approximately 8.2.

The area in which the projectiles are deposited for this range is comprised primarily of Rositas sand which is a gravelly fine sand.

Erosion was apparent on the face of the impact berm.

Side berms prevent run-on from entering the range. The range slopes toward the firing line, so side berms do not prevent runoff from leaving the range.

KD RIFLE RANGE
MCAS YUMA

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**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	0
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).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	1
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	6
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Groundwater Pathway Score *Minimum: 4* *Maximum: 27*			12

Notes:

The Rifle Range is located in the Upper Mesa basin where groundwater has been measured 100-120 feet below ground surface.

The area in which the projectiles are deposited for this range is comprised primarily of Rositas

KD RIFLE RANGE
MCAS YUMA

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**
sand which is a gravelly fine sand near the surface. The most restrictive soil layer between the surface and the typical well withdrawal elevation is clay. Two distinct clay layers overlay the coarse gravel unit (typical well withdrawal layer) and serve to limit infiltration to the gravel unit. Clay A is inches to 35 feet thick and Clay B is 10 to 15 feet thick.			

KD RIFLE RANGE
MCAS YUMA

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	0
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			4

Notes:

The first identified downgradient surface water body according to the USGS National Hydrography Map is the Southwest Lateral located approximately 12 miles west of the Rifle Range. Any surface water flowing off of the range is most likely to evaporate, infiltrate, or drain into one of the several man-made drainages between the range and the Southwest Lateral prior to reaching it. A small intermittent stream/drainage is present approximately 8,000 feet northeast of the range however it is upgradient and flows away from the Rifle Range.

There are no surface water bodies that are used as drinking water sources within 6 miles of the Rifle Range.

There is no identified downgradient surface water source into which surface water from the Rifle Range drains that crosses the installation boundary. The installation boundary is located approximately 0.2 miles downgradient to the west of the Rifle Range.

KD RIFLE RANGE
MCAS YUMA

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.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			0

Notes:

There are no drinking water wells down-gradient of the range and no known uses of groundwater within 1500 feet of the range.

Four groundwater supply wells are present at BMGR West. One is currently out-of-service, the three remaining wells are used for non-potable supply. Water supply wells were not identified down gradient of any BMGR West ranges.

KD RIFLE RANGE
MCAS YUMA

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13
Surface Water / Sediment Pathways	2	15
Surface Water / Sediment Receptors	4	4
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**32**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	13
Groundwater Pathways	3	12
Groundwater Receptors	5	0
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**25**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Minimal**
Groundwater Evaluation Ranking	**Minimal**

Notes:

S–4-5
CMAGR NORTH, MCAS YUMA
Niland, California

Date of SARAP update: 25 June 2014

DESCRIPTION

Range Mission:	Pistol Range
Training Start Date:	
Direction of Fire:	Northeast
Firing Positions:	18
Target Range:	3, 7, 10, 15, and 25 yards
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		117
Surface Water / Sediment	***RANK***	Moderate
	Source	8
	Pathway	17
	Receptor	12
	TOTAL SCORE	37
Groundwater	***RANK***	Minimal
	Source	8
	Pathway	18
	Receptor	0
	TOTAL SCORE	26

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: _____

☐ Collect site-specific field data to further assess potential off-range migration.

S-4-5
MCAS YUMA

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**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	2
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			8

Notes:

Annual lead deposition – 117 pounds/year

Target berms are present but there are no impact berms.

S-4-5
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	4
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	6
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	3
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	-1

S-4-5
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			17

Notes:

MCAS Yuma receives approximately 3 inches of rain per year.

No vegetation is present on the range or in the drainage areas off the range.

The range slopes approximately 1% moving from the deposition area to the firing line. The slope continues at approximately 1% moving southwest off the range.

Surface soil pH measured at the range was 8.2.

The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) (DON, 2013). These soils are excessively drained and primarily made up of very fine sands and some gravelly sands.

Drainage lines were present during the REVA site visit (January 2014) and are signs of erosion.

Side berms are present that reduce run-on to the range.

S-4-5
MCAS YUMA

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**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	1
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).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	6
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	6
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			18

Notes:

The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) which is excessively drained and primarily made up of very fine sands and some gravelly sands (BLM, 2012). According to the USDA, these soils typically have a slightly alkaline pH ranging from approximately 7.8 to 8.6.

S-4-5
MCAS YUMA

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**
The range slopes approximately 1% moving from the deposition area to the firing line. The slope continues at approximately 1% moving southwest off the range. Measurements of groundwater levels in the area made between 1963 and 2000 range between 20 to 48 feet below ground surface (BLM, 2012).			

S-4-5
MCAS YUMA

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

The closest downgradient surface water according to the USGS National Hydrography Map is a wash located approximately 145 feet to the southeast of the range. This wash flows southwest into Iris Wash located approximately 1,300 feet downgradient from the range.

There are no downgradient surface water bodies used as drinking water sources within 6 miles of Range S-4-5.

Surface water from S-4-5 drains into the adjacent wash and flows southwest to the Iris Wash. This drainage pathway crosses the installation boundary approximately 0.3 miles from the range.

S-4-5
MCAS YUMA

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.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			0

Notes:

One well is located north of CMAGR North. Installation personnel indicate that wells in the areas adjacent to CMAGR North and CMAGR South are not used for potable water. The wells are located at distances much greater than 1,500 feet from SWAT ranges.

S-4-5
MCAS YUMA

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	8
Surface Water / Sediment Pathways	2	17
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**37**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	8
Groundwater Pathways	3	18
Groundwater Receptors	5	0
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**26**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes:

S–4-6A
CMAGR NORTH, MCAS YUMA
Niland, California

Date of SARAP update: 25 June 2014

DESCRIPTION

Range Mission:	Rifle Range
Training Start Date:	
Direction of Fire:	Northeast
Firing Positions:	18
Target Range:	75, 200, and 500 yards
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		2,578
Surface Water / Sediment	***RANK***	Moderate
	Source	14
	Pathway	15
	Receptor	12
	TOTAL SCORE	41
Groundwater	***RANK***	Minimal
	Source	14
	Pathway	18
	Receptor	0
	TOTAL SCORE	32

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: _____

☐ Collect site-specific field data to further assess potential off-range migration.

S-4-6A
MCAS YUMA

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**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	8
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			14
Notes: Annual lead deposition – 2,578 pounds/year			

S-4-6A
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	4
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	6
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	-1

S-4-6A
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	The presence of engineering controls or BMPs to modify or control ***surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			15

Notes:

MCAS Yuma receives approximately 3 inches of rain per year.

No vegetation is present on the range or in the drainage areas off the range.

The range slopes approximately 1% moving from the deposition area to the firing line. The slope continues at approximately 1% moving southwest off the range.

Surface soil pH measured at the range was 8.2.

The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) (DON, 2013). These soils are excessively drained and primarily made up of very fine sands and some gravelly sands.

Side berms prevent run-on from entering the range.

S-4-6A
MCAS YUMA

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**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	1
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).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	6
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	6
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			18

Notes: The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) which is excessively drained and primarily made up of very fine sands and some gravelly sands (BLM, 2012). According to the USDA, these soils typically have a slightly alkaline pH ranging from approximately 7.8 to 8.6.

The range slopes approximately 1% moving from the deposition area to the firing line. The

S-4-6A
MCAS YUMA

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**
slope continues at approximately 1% moving southwest off the range. Measurements of groundwater levels in the area made between 1963 and 2000 range between 20 to 48 feet below ground surface (BLM, 2012).			

S-4-6A
MCAS YUMA

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

The closest downgradient surface water according to the USGS National Hydrography Map is a wash located approximately 115 feet to the southeast of the range. This wash flows southwest into Iris Wash located approximately 1,400 feet downgradient from the range.

There are no downgradient surface water bodies used as drinking water sources within 6 miles of Range S-4-6A.

Surface water from S-4-6A drains into the adjacent wash and flows southwest to the Iris Wash. This drainage pathway crosses the installation boundary approximately 0.4 miles from the range.

S-4-6A
MCAS YUMA

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.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			0

Notes:

One well is located north of CMAGR North. Installation personnel indicate that wells in the areas adjacent to CMAGR North and CMAGR South are not used for potable water. The wells are located at distances substantially greater than 1,500 feet from SWAT ranges.

S-4-6A
MCAS YUMA

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	14
Surface Water / Sediment Pathways	2	15
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**41**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	14
Groundwater Pathways	3	18
Groundwater Receptors	5	0
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**32**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes:

S–4-6B
CMAGR NORTH, MCAS YUMA
Niland, California

Date of SARAP update: 25 June 2014

DESCRIPTION

Range Mission:	Machine Gun Unknown Distance Range
Training Start Date:	
Direction of Fire:	Northeast
Firing Positions:	
Target Range:	Varies
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		2,877
Surface Water / Sediment	***RANK***	Moderate
	Source	14
	Pathway	16
	Receptor	12
	TOTAL SCORE	42
Groundwater	***RANK***	Minimal
	Source	14
	Pathway	18
	Receptor	0
	TOTAL SCORE	32

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: _____

☐ Collect site-specific field data to further assess potential off-range migration.

S-4-6B
MCAS YUMA

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**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	8
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			14
Notes: Annual lead deposition – 2,877 pounds/year			

S-4-6B
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	4
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	6
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

S-4-6B
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			16

Notes:

MCAS Yuma receives approximately 3 inches of rain per year.

No vegetation is present on the range and very little is present in the drainage areas off the range.

The range slopes approximately 1% moving from the deposition area to the firing line. The slope continues at approximately 1% moving southwest off the range.

Surface soil pH measured at the range was 7.9 – 8.1.

The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) (DON, 2013). These soils are excessively drained and primarily made up of very fine sands and some gravelly sands.

S-4-6B
MCAS YUMA

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**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	1
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).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	6
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	6
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			18

Notes:

The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) which is excessively drained and primarily made up of very fine sands and some gravelly sands (BLM, 2012). According to the USDA, these soils typically have a slightly alkaline pH ranging from approximately 7.8 to 8.6.

S-4-6B
MCAS YUMA

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**
The range slopes approximately 1% moving from the deposition area to the firing line. The slope continues at approximately 1% moving southwest off the range. Measurements of groundwater levels in the area made between 1963 and 2000 range between 20 to 48 feet below ground surface (BLM, 2012).			

S-4-6B
MCAS YUMA

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, S-4-6B is partially located within a wash. This wash flows southwest into Iris Wash located approximately 2,300 feet downgradient from the range.

There are no downgradient surface water bodies used as drinking water sources within 6 miles of Range S-4-6B.

Surface water from S-4-6B drains into the wash and flows southwest to the Iris Wash. This drainage pathway crosses the installation boundary approximately 0.5 miles from the range.

S-4-6B
MCAS YUMA

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.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			0

Notes:

One well is located north of CMAGR North. Installation personnel indicate that wells in the areas adjacent to CMAGR North and CMAGR South are not used for potable water. The wells are located at distances substantially greater than 1,500 feet from SWAT ranges.

S-4-6B
MCAS YUMA

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	14
Surface Water / Sediment Pathways	2	16
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**42**

Groundwater		
Element	**Table**	**Score**
Range Use and Range Management (Source)	1	14
Groundwater Pathways	3	18
Groundwater Receptors	5	0
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**32**

Field Sampling and Observed Releases		
Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes:

S–4-7
CMAGR NORTH, MCAS YUMA
Niland, California

Date of SARAP update: 25 June 2014

DESCRIPTION

Range Mission: Multipurpose Range	
Training Start Date:	
Direction of Fire: Northeast	
Firing Positions:	
Target Range: Up to 1,400 meters	
Impact Area(s):	☒ Open area ☐ Hillside ☐ Building ☐ Earthen berm ☐ Bullet trap
Existing BMPs:	☐ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation
	Other:
Reference(s):	

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		1,614
Surface Water / Sediment	***RANK***	Moderate
	Source	11
	Pathway	16
	Receptor	12
	TOTAL SCORE	39
Groundwater	***RANK***	Minimal
	Source	11
	Pathway	18
	Receptor	0
	TOTAL SCORE	29

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: _____

☐ Collect site-specific field data to further assess potential off-range migration.

S-4-7
MCAS YUMA

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**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	5
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	4
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			11
Notes: Annual lead deposition – 1,614 pounds/year			

S-4-7
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	4
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	6
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	1
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

S-4-7
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	0
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			16

Notes:

MCAS Yuma receives approximately 3 inches of rain per year.

No vegetation is present on the range and very little is present in the drainage areas off the range.

The slope is approximately 0.7% moving from the deposition area off the range in the southwest direction off the range.

Surface soil pH measured at the range was approximately 8.0.

The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) (DON, 2013). These soils are excessively drained and primarily made up of very fine sands and some gravelly sands.

S-4-7
MCAS YUMA

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**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	1
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).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	6
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	6
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			18

Notes:

The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) which is excessively drained and primarily made up of very fine sands and some gravelly sands (BLM, 2012). According to the USDA, these soils typically have a slightly alkaline pH ranging from approximately 7.8 to 8.6.

S-4-7
MCAS YUMA

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**
The slope is approximately 0.7% moving from the deposition area off the range in the southwest direction. Measurements of groundwater levels in the area made between 1963 and 2000 range between 20 to 48 feet below ground surface (BLM, 2012).			

S-4-7
MCAS YUMA

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	4
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			12

Notes:

According to the USGS National Hydrography Map, S-4-7 is partially located within a wash. This wash flows southwest into Iris Wash located approximately 1,900 feet downgradient from the range.

There are no downgradient surface water bodies used as drinking water sources within 6 miles of Range S-4-7.

Surface water from S-4-7 drains into the wash and flows southwest to the Iris Wash. This drainage pathway crosses the installation boundary approximately 0.5 miles from the range.

S-4-7
MCAS YUMA

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.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			0

Notes:

One well is located north of CMAGR North. Installation personnel indicate that wells in the areas adjacent to CMAGR North and CMAGR South are not used for potable water. The wells are located at distances substantially greater than 1,500 feet from SWAT ranges.

S-4-7
MCAS YUMA

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment

Element	Table	Score
Range Use and Range Management (Source)	1	11
Surface Water / Sediment Pathways	2	16
Surface Water / Sediment Receptors	4	12
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**39**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	11
Groundwater Pathways	3	18
Groundwater Receptors	5	0
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**29**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes:

S–4-9
CMAGR NORTH, MCAS YUMA
Niland, California

Date of SARAP update: 25 June 2014

DESCRIPTION

Range Mission: Sniper Known Distance Range		
Training Start Date:		
Direction of Fire: North		
Firing Positions: 12		
Target Range: Up to 1,100 yards		
Impact Area(s):	☐ Open area ☐ Hillside ☐ Building ☒ Earthen berm ☐ Bullet trap	
Existing BMPs:	☒ Basin/vault ☐ Control fabric ☐ Diversion ☐ Fencing ☐ Rip-rap ☐ Silt check ☐ Vegetation	
	Other:	
Reference(s):		

FINDINGS

Review Period		**Periodic Review**
Estimated Lead Deposition (lb/yr)		1,502
Surface Water / Sediment	***RANK***	Moderate
	Source	10
	Pathway	16
	Receptor	10
	TOTAL SCORE	36
Groundwater	***RANK***	Minimal
	Source	10
	Pathway	18
	Receptor	0
	TOTAL SCORE	28

RECOMMENDATIONS

☒ Periodically review operations for significant changes in training, management, and use.

☐ Gather additional data regarding ☐ range use, ☐ pathways, or ☐ receptors associated with the range: _____

☐ Collect site-specific field data to further assess potential off-range migration.

S-4-9
MCAS YUMA

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**
MC Loading Rates	*The amount of small arms ammunition expended on the range.* *Estimate the MC loading as average lead deposition rate.*	14 if MC loading > 8,000 pounds/year 11 if MC loading = 4,001-8,000 pounds/year 8 if MC loading = 2,001-4,000 pounds/year 5 if MC loading = 501-2,000 pounds/year 2 if MC loading < 501 pounds/year	5
Impact Area	*The bullet deposition scenario at the range.*	4 if projectiles are scattered in SDZ 3 if range has an impact berm 1 if range has a bullet trap	3
Lead Management	*Frequency of activities that result in the removal of lead from an EARTHERN BERM or SDZ.* *This includes MINOR removal (e.g. scraping and sifting of berm/area, soil amendments) as well as MAJOR removals (e.g. lead mining).*	0 if no notable mining -1 if a MINOR action completed once during either of the last two periodic reviews -2 if MINOR action completed during each of the two previous periodic reviews -3 if MAJOR action was completed once during either of the last two periodic reviews -4 if MAJOR action completed during each of the two previous periodic reviews	0
	Frequency of activities that result in the significant removal of lead from a BULLET TRAP.	-3 if bullet trap was not been serviced during last two periodic reviews -5 if bullet trap was serviced once during either of the last two periodic reviews -7 if bullet trap was serviced during each of the last two periodic reviews	
Duration of Range Use	*Length of time the range has been used.*	2 if > 5 years 0 if ≤ 5 years	2
Source Element Score *Minimum: -4 Maximum: 20*			10
Notes: Annual lead deposition – 1,502 pounds/year			

S-4-9
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Precipitation	*Rate of precipitation.*	8 if precipitation > 40 inches/year 6 if precipitation = 20-40 inches/year 4 if precipitation < 20 inches/year	4
Vegetation	*Approximate vegetation cover **within and directly downslope of the projectile deposition area.***	6 if vegetation cover < 10% 4 if vegetation cover = 10% to 90% 2 if vegetation cover > 90%	6
Slope of Range	*Average slope **from deposition area along the overland pathway to the first defined channel.***	5 if slope > 10% (5.71°) 3 if slope = 5% to 10% 2 if slope < 5% (2.86°)	2
pH of Soil	*pH below 6.5 and above 8.5 increases the rate of lead dissolution.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Soil Type/ Erosion	*Erosion potential is greatest for fine sands and silt. Clay has the lowest erosion potential. **The area where projectiles are deposited should be scored.***	2 if soil type is fine sand / silt 1 if soil type is clayey sand or silt / coarse sands 0 if soil type is clay	2
	Erosion observed at the projectile deposition area.	5 if there is visual evidence of eroded material being transported from the projectile deposition area 3 if bullet pockets or other indicators of erosion were observed 1 if no erosion was observed	3
Engineering Controls	*The presence of engineering controls or BMPs to modify or control **surface water run-on.*** *Controls may include barriers or diversions that reduce run-on to the range.*	0 if no engineering controls -1 if partial engineering controls -2 if effective engineering controls	0

S-4-9
MCAS YUMA

Table 2: Surface Water / Sediment Pathways Characteristics Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
	*The presence of engineering controls or BMPs to modify or control **surface water run-off or erosion.*** *Run-off controls may include silt fencing, rip-rap, sedimentation basins, or detention ponds that control run-off from the range. Erosion controls may include soil mix, irrigation, or netting.*	0 if no engineering controls -2 if partial engineering controls -4 if effective engineering controls	-2
Surface Water Pathway Score *Minimum: 4 Maximum: 29*			16

Notes:

MCAS Yuma receives approximately 3 inches of rain per year.

No vegetation is present on the impact berm or in the drainage area.

The slope is approximately 2.9% moving from the berm off the range in the southwest direction off the range.

Surface soil pH measured at the range was approximately 8.0.

The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) (DON, 2013). These soils are excessively drained and primarily made up of very fine sands and some gravelly sands.

Erosion was evident on the face of the berm.

A sedimentation basin is present at the base of the impact berm, thus limiting sediment laden run-off from leaving the range.

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MCAS YUMA

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**
Precipitation	*Intensity and frequency of precipitation.*	3 if precipitation > 40 inches/year 2 if precipitation = 20-40 inches/year 1 if precipitation < 20 inches/year	1
Depth to Groundwater	*The potential for impact to the groundwater decreases with an increasing depth to the water table.*	6 if depth to groundwater < 3 feet 3 if depth to groundwater = 3-20 feet 1 if depth to groundwater = 20-100 feet 0 if in a groundwater discharge area or depth to groundwater > 100 feet	1
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).* ***Most hydraulically restrictive infiltration horizon between the surface and groundwater is scored.***	6 if soil type is sand / gravel 3 if soil type is sand and silt 1 if soil type is clay / clayey sand/silt	6
	Vegetation impedes infiltration and groundwater recharge.	6 if vegetation cover < 10% 3 if vegetation cover = 10% to 90% 1 if vegetation cover > 90%	6
	Average slope from deposition area along the overland pathway to the first defined channel.	3 if slope < 2% (1.15°) 1 if slope = 2% to 20% 0 if slope > 20% (11.31°)	3
pH of Soil	*Lead tends to stay dissolved at pH conditions less than 6.5 and greater than 8.5 but tends to attach to soil particles at pH conditions between these levels.*	3 if pH < 4 or >10 2 if pH ≥ 4 < 6.5 or > 8.5 ≤ 10 1 if pH 6.5 ≤ pH ≤ 8.5	1
Groundwater Pathway Score *Minimum: 4 Maximum: 27*			18
Notes: The soils in the area of this range are classified as Myoma-Carsitas-Carrizo (s991) which is			

S-4-9
MCAS YUMA

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**
excessively drained and primarily made up of very fine sands and some gravelly sands (BLM, 2012). According to the USDA, these soils typically have a slightly alkaline pH ranging from approximately 7.8 to 8.6. The slope is approximately 2.9% moving from the berm off the range in the southwest direction off the range. Measurements of groundwater levels in the area made between 1963 and 2000 range between 20 to 48 feet below ground surface (BLM, 2012).			

S-4-9
MCAS YUMA

Table 4: Surface Water / Sediment Receptors Element (These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)			
Criteria	**Evaluation Characteristics**	**Score Criteria**	**Site Score**
Surface Water Body	*Identify if a nearby surface water body is present down gradient,* ***as defined on the National Hydrography Dataset (NHD) map****.*	8 if surface water body is located downgradient of the range within 1,500 feet 4 if surface water body is located downgradient of the range 1,500-5,000 feet 0 if surface water body is located downgradient of the range over 5,000 feet	8
Drinking Water Use	*Identify if a down gradient surface water body is used as a drinking water source (drainage distance).*	4 if surface water body used as a drinking water source is located downgradient of the range within 1 mile 2 if surface water body used as a drinking water source is located downgradient of the range within 1 to 6 miles 0 if no known drinking water intakes are identified within 6 miles of the range	0
Drainage Distance to Installation Boundary	*Identify downgradient drainage distance to first potential ecological exposure off installation (i.e., installation boundary).*	4 if the installation boundary is located downgradient of the range within 0.5 miles 2 if the installation boundary is located downgradient of the range within 0.5 to 3 miles 0 if the installation boundary is located downgradient of the range greater than 3 miles, or if surface water runoff from the range does not discharge off the installation	2
Surface Water Receptor Score *Minimum: 0 Maximum: 16*			10

Notes:

According to the USGS National Hydrography Map, the closest downgradient surface water to S-4-9 is an intermittent stream located approximately 620 feet southwest of the range.

There are no downgradient surface water bodies used as drinking water sources within 6 miles of Range S-4-9.

Surface water from S-4-9 drains southwest towards the intermittent stream and then continues southwest across the installation boundary as it crosses the Coachella Canal. This drainage pathway crosses the installation boundary approximately 0.7 miles from the range.

S-4-9
MCAS YUMA

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.*	6 if a drinking water well is located within <50 feet of the range 3 if a drinking water well is located downgradient of the range within 50-1,500 feet 0 if there are no drinking water wells located within 1,500 feet downgradient of the range or if groundwater is not used as a drinking water source.	0
	*Into what **type of aquifer is the well set***	6 if unconfined 3 if semi-confined 0 if confined	0
Groundwater wells identified for purpose other than drinking water	*Groundwater wells used for purposes other than drinking water supply identified down gradient of the range.*	3 if a groundwater well is located within 50 feet of the range 1 if a groundwater well is located downgradient of the range within 50-1,500 feet 0 if groundwater <1,500 feet downgradient of the range is not used for any purpose.	0
Groundwater Receptor Score *Minimum: 0 Maximum: 15*			0

Notes:

One well is located north of CMAGR North. Installation personnel indicate that wells in the areas adjacent to CMAGR North and CMAGR South are not used for potable water. The wells are located at distances substantially greater than 1,500 feet from SWAT ranges.

S-4-9
MCAS YUMA

Table 6: Evaluation Score
(These definitions only apply for the purposes of the Small Arms Range Assessment Protocol.)

Surface Water / Sediment

Element	Table	Score
Range Use and Range Management (Source)	1	10
Surface Water / Sediment Pathways	2	16
Surface Water / Sediment Receptors	4	10
Sum of Surface Water / Sediment Element Scores *Minimum: 0 Maximum: 65*		**36**

Groundwater

Element	Table	Score
Range Use and Range Management (Source)	1	10
Groundwater Pathways	3	18
Groundwater Receptors	5	0
Sum of Groundwater Element Scores *Minimum: 0 Maximum: 62*		**28**

Field Sampling and Observed Releases

Surface Water / Sediment	Surface water sampling conducted Yes ☐ No ☒ Sediment sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	**Surface Water / Sediment** ☒ No Modification ☐ High **Groundwater** ☒ No Modification ☐ High
Groundwater	Groundwater sampling conducted Yes ☐ No ☒ Results exceed DoD screening value Yes ☐ No ☐	

The relative evaluation ranking for each media is determined by selecting the appropriate score based on the data elements for that media:

Evaluation Ranking*	Score Range
High	45-65
Moderate	33-44
Minimal	0-32

Surface Water Evaluation Ranking	**Moderate**
Groundwater Evaluation Ranking	**Minimal**

Notes: