

Documentation of Findings

Range Environmental Vulnerability Assessment

Periodic Review 2

Marine Corps Base Camp Lejeune, North Carolina

Headquarters United States Marine Corps



Prepared for:

Headquarters United States Marine Corps

Prepared by:

AECOM Technical Services, Inc.
3101 Wilson Boulevard, Suite 900
Arlington, VA 22201

Prepared under:

Contract/Task Order Number: N62470-16-D-9002 / N62470-20-F-5641

April 2024

This page intentionally left blank.

Documentation of Findings

Contents

1.	Introduction	1-1
1.1	Purpose of REVA Program	1-1
1.1.1	Munitions Constituents	1-1
1.1.2	Off-Range Areas.....	1-1
1.1.3	Risk Evaluation	1-2
1.2	Objectives of Periodic Review	1-2
2.	MCB Camp Lejeune Overview	2-1
2.1	Location.....	2-1
2.2	Munitions Use.....	2-1
2.3	Range Changes at MCB Camp Lejeune (2015-2022)	2-1
3.	Summary of Previous REVA Review Findings	3-1
3.1	Operational Ranges	3-1
3.1.1	Munitions Constituents Screening-Level Fate and Transport Assessment Summary and Results.....	3-1
3.2	Small Arms Range Assessment Protocol Assessment Summary and Results.....	3-2
3.3	Previous Sampling Results	3-3
3.3.1	Surface Water Sampling Results.....	3-3
3.3.2	Groundwater Sampling Results.....	3-4
3.3.3	Range-100 (R-100) Skeet Range and Wallace Creek Sampling Results..	3-5
3.3.4	Sampling Results from 2015, 2016, and 2017	3-6
3.4	PR1 Results and Recommendations	3-7
4.	CSM for Current REVA Review Period (PR2)	4-1
4.1	Primary Source Areas (Ranges)	4-1
4.1.1	Range Layout, Impact Areas, and Training Areas.....	4-1
4.1.2	Range Management	4-3
4.1.3	Expenditure Data	4-4
4.1.4	Primary MC Source Areas	4-4
4.2	Transport Mechanisms	4-4
4.3	MCB Camp Lejeune Environmental Setting.....	4-5
4.3.1	Surface Water.....	4-5
4.3.2	Groundwater	4-7
4.4	Off-Range Receptors	4-8
4.4.1	Human	4-8
4.4.2	Ecological	4-8
4.4.3	Summary of Off-Range Receptors	4-9
5.	Summary of Field Sampling (2023)	5-1
5.1	Sample Locations and Analyses	5-2
5.2	Sample Results	5-6
5.3	Sample Discussion.....	5-7
5.3.1	Explosives and Perchlorate	5-7
5.3.2	Lead.....	5-7

Documentation of Findings

6.	REVA PR2 Conclusions.....	6-1
7.	References.....	7-1

List of Figures

Figure 2-1: MCB Camp Lejeune Site Location
Figure 4-1: MCB Camp Lejeune Subwatersheds

List of Tables

Table 1-1: MCB Camp Lejeune REVA Assessments
Table 3-1: PR1 MC Screening-level Assessment Results
Table 3-2: PR1 SARAP Rating Summary
Table 3-3: Summary of PR1 Surface Water Sample Results
Table 3-4: Summary of PR1 Groundwater Sample Results
Table 3-5: Summary of PR1 Skeet Range Sample Results
Table 3-6: 2015, 2016, and 2017 Sampling Results Summary
Table 4-4: PR2 Summary of MC Source Areas by Subwatershed
Table 5-1: Recommended Samples for REVA PR2 at MCB Camp Lejeune
Table 5-2: Sample Summary and Locations
Table 5-3: Sampling Results Summary

List of Appendices

Appendix A Figures
Appendix B REVA Factsheet

Documentation of Findings

List of Acronyms

AECOM	AECOM Technical Services, Inc.
AFSC	Airfield Seizure Complex
amsl	above mean sea level
CSM	Conceptual Site Model
DoD	Department of Defense
EOD	Explosive Ordnance Disposal
EPA	United States Environmental Protection Agency
ETA	Engineer Training Area
FOB	Forward Operating Base
GP	Gun Position
GSRA	Greater Sandy Run Area
HE	High Explosives
HMX	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine
LOD	Limit of Detection
MAC	MOUT Assault Course
MC	Munitions Constituents
MCAS	Marine Corps Air Station
MCB	Marine Corps Base
MEC	Munitions and Explosives of Concern
mg/kg	milligrams per kilogram
MOUT	Military Operations in Urban Terrain
MP	Mortar Position
MS	Matrix Spike
MSD	Matrix Spike Duplicate
msl	mean sea level
NAVFAC	Naval Facilities Engineering Systems Command
NCAC	North Carolina Administrative Code
ORA	Operational Range Assessment
ORC	Operational Range Clearance
PAH	Polycyclic Aromatic Hydrocarbon

Documentation of Findings

PR	Periodic Review
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
REVA	Range Environmental Vulnerability Assessment
RFMSS	Range and Facility Management Support System
SAR	Small Arms Range
SARAP	Small Arms Range Assessment Protocol
SCS	Soil Conservation Service
SDZ	Surface Danger Zone
TA	Training Area
TECOM	Training and Education Command
THQ	Target Hazard Quotient
TNT	2,4,6-Trinitrotoluene
UCAS	Urban Close Air Support
USDA	United States Department of Agriculture
USGS	United States Geological Survey
USMC	U.S. Marine Corps

Executive Summary

The Range Environmental Vulnerability Assessment (REVA) Periodic Review 2 (PR2) for Marine Corps Base (MCB) Camp Lejeune, North Carolina, was completed to determine whether off-range munitions constituents (MC) migration from operational ranges and training areas creates an unacceptable risk to human health or the environment. This report documents changes to the Conceptual Site Model (CSM) since Periodic Review (PR1) (Arcadis 2016) and assesses munitions use that occurred from 1 January 2015 through 31 December 2022 at the operational range facilities.

The United States Marine Corps assesses operational ranges at each of its installations in accordance with United States Department of Defense (DoD) Instruction (DoDI) 4715.14 (DoD 2018) and the draft REVA Guidance Manual (HQMC 2023). These assessments are conducted approximately every 5 years, or sooner if changes in range use or conditions warrant, to determine whether there is a substantial threat or occurrence of off-range MC migration that creates an unacceptable risk to human health or the environment. This is the fourth REVA assessment for MCB Camp Lejeune. The previous three assessments did not identify an immediate threat to human health or the environment from off-range migration of MC. **Table ES-1** lists all REVA assessments conducted to date for MCB Camp Lejeune.

Table ES-1: MCB Camp Lejeune REVA Periodic Reviews

REVA Assessment	Evaluated Munitions Use
Baseline Assessment (Malcolm Pirnie 2009)	Historical and current munitions use through 2004
Five-Year Review (Arcadis 2012)	2005-2010
Periodic Review 1 (Arcadis 2016)	2011-2014

Notes:

MCB = Marine Corps Base

REVA = Range Environmental Vulnerability Assessment

This PR2 assesses munitions use at all operational range facilities at MCB Camp Lejeune from January 2015 through December 2022. In total, 231 MCB Camp Lejeune operational range and training areas were identified and assessed. These areas were subdivided into 85 operational training areas, 3 operational impact areas, and 143 operational ranges.

REVA analysis focuses on the most common and mobile sources of MC, referred to as indicator MC, found in military munitions. The REVA indicator MC are lead; octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX); hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX); 2,4,6-trinitrotoluene (TNT); and perchlorate.

A total of 32 MC source areas were identified during this review. The MC source areas identified are geographically located within 11 subwatersheds, as defined in the United States Geological Survey Watershed Boundary Dataset (2013).

This CSM update concluded the absence of any human health or environmental threats resulting from the off-range migration of MCs within 5 out of the 11 subwatersheds. The CSM pathways in these particular areas are considered incomplete. Conversely, for the remaining six

Documentation of Findings

subwatersheds, the CSM pathways are inconclusive. Therefore, further data were needed to establish whether any of these CSM pathways were complete and, in such cases, could potentially pose an unacceptable risk to human health or the environment. Sampling was conducted at off-range locations as presented in **Table ES-2**.

Table ES-2: Recommended Samples for REVA PR2 at MCB Camp Lejeune

Subwatershed	Sampling Matrix	Analyte	Criteria for Choosing
Southwest Creek	Surface water, Sediment	Perchlorate	Increase in perchlorate-containing expenditures from PR1 to PR2.
New River at Stones Bay (North)	Surface water, Sediment and Groundwater	Explosives, Perchlorate	Increase in explosives and perchlorate-containing expenditures.
New River at Stones Bay (South)	Surface water, Sediment	Lead	High number of small arms expenditures in PR2.
New River between Stick Creek and Whitehurst Creek	Surface water, Sediment and Groundwater	Perchlorate	Although a decrease in expenditures since PR1, it contains the highest number of perchlorate-containing expenditures of all subwatersheds.
New River between Town Creek and Stones Bay (West)	Surface water, Sediment and Groundwater	Explosives, Perchlorate, Lead	Increase in all three expenditure types from PR1 to PR2.
New River between Town Creek and Stones Bay (East)	Surface water, Sediment and Groundwater	Explosives, Perchlorate, Lead	Increase in all three expenditure types from PR1 to PR2.
Bear Creek-Bear Inlet (South)	Surface water, Sediment and Groundwater	Perchlorate	Increase in perchlorate-containing expenditures from PR1 to PR2.
Bear Creek-Bear Inlet (North)	Groundwater	Perchlorate	Increase in perchlorate-containing expenditures from PR1 to PR2.
New River between Stones Bay and Intracoastal Waterway	Surface water, Sediment and Groundwater	Lead	Increase in small arms expenditures from PR1 to PR2.

Notes:

MCB = Marine Corps Base

PR = Periodic Review

The REVA Technical Support Team collected 30 total samples originating from six subwatersheds as listed in Table ES-2 at MCB Camp Lejeune during April 2023. Surface water, sediment, and groundwater samples were analyzed for the presence of explosives, lead (both total and dissolved in water), and/or perchlorate. The primary objective was to determine whether complete migration pathways exist between MC source areas and off-range receptor locations.

Documentation of Findings

Lead was the sole MC detected across all three media types. No traces of explosives or perchlorate were found in any of the samples. None of the samples exceeded the Human Health Receptor or Ecological Project Action Limits.

The results of the PR2 evaluation indicate that MC migration pathways from range areas to off-range receptors are incomplete and do not present an unacceptable risk to human health or the environment. In accordance with DoDI 4715.14 (DoD 2018), the next MCB Camp Lejeune periodic review will be conducted in approximately 5 years or sooner if significant changes occur that may affect determinations made in this assessment.

This page intentionally left blank.

1. Introduction

This Documentation of Findings for the U.S. Marine Corps (USMC) Range Environmental Vulnerability Assessment (REVA) Program reports the assessment of munitions use at Marine Corps Base (MCB) Camp Lejeune, North Carolina, from 1 January 2015 through 31 December 2022.

1.1 Purpose of REVA Program

The Department of Defense (DoD) conducts non-regulatory, proactive, and comprehensive operational range assessments (ORAs) to support the long-term sustainability of operational ranges while protecting human health and the environment. The purpose of an ORA is to determine whether there is a release or substantial threat of a release of munitions constituents (MC) from an operational range to an off-range area that exceeds an applicable regulatory standard or creates a potential unacceptable risk to human health or the environment. The USMC REVA Program is designed to meet the requirements of DoD Instruction 4715.14 (DoD 2018) to ensure continued sustainability and usability of the USMC training ranges.

1.1.1 Munitions Constituents

The REVA Program focuses on the most common and mobile MC found on USMC ranges, referred to as indicator MC. The REVA indicator MC are lead; octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX); hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX); 2,4,6-trinitrotoluene (TNT); and perchlorate.

Metals associated with small arms include lead, antimony, copper, and zinc. REVA focuses on lead as the MC indicator for metals because it is primarily associated with small arms munitions, and it is the most prevalent metal found in soils on operational ranges. Lead has limited vertical migration potential through soil matrices; however, it has the potential to migrate when in surface water media. Studies indicate that metallic lead (such as recently fired, unweathered bullets and shot) generally has low chemical reactivity, has low solubility in water, and is relatively inactive in the environment under most ambient conditions. However, lead deposited on a range may become mobile in certain conditions (e.g., acidic soils, shallow groundwater, soils with low cation exchange capacity [i.e., lead does not easily bind to these soils], high erosion rates, and proximity to surface waters) (Clausen et al. 2007, Cao et al. 2003).

Among the explosive MC, REVA focuses on TNT, HMX, and RDX. Perchlorate is also evaluated as a component in some propellants and pyrotechnics. These MC are the most frequently detected explosive constituents at training ranges and can persist in the environment (Jenkins, Bartolini, and Ranney 2003). Studies show that RDX, HMX, and perchlorate are the most mobile of these constituents within the environment and have the highest potential to migrate off-range (Jenkins 2005).

1.1.2 Off-Range Areas

Off-range areas are outside the operational range complex. For purposes of this assessment, operational range complexes include operational ranges, impact areas, and training areas

Documentation of Findings

(TAs). The off-range area closest to the operational range complex boundary may be outside the installation boundary or on installation property, such as cantonment areas.

Per DoD Instruction 4715.14 (DoD 2018), the REVA Program uses a conceptual site model (CSM) to evaluate current or potential off-range MC migration (i.e., off-range MC source-receptor interaction). A CSM pathway consists of an MC source, transport mechanism from the MC source to off-range exposure media (e.g., groundwater, surface water, sediment, and soil), and receptor interaction with the off-range exposure media.

- **Source:** Includes MC deposition on the ranges (primary source) and a release mechanism (e.g., dispersion, adsorption, or dissolution) to surface soil and/or surface water (media). The media may then have the potential of an additional release mechanism. In this event, the media thereby also becomes a secondary source.
- **Transport mechanism:** Includes surface water transport via current/flow/hydraulic connection to additional surface water or sediment; stormwater infiltration or percolation to groundwater; and stormwater runoff that transports surface soil to off-range surface water, sediment, or surface soil.
- **Receptor:** Includes humans and/or biota with interaction to media via ingestion, incidental ingestion, or dermal contact.

A CSM pathway can be complete, incomplete, or inconclusive.

- **Complete:** A viable connection exists between all the CSM pathway components that results in an off-range receptor interacting with MC in off-range exposure media.
- **Incomplete:** One or more CSM components is not viable, which results in no interaction between an off-range receptor and MC in off-range exposure media.
- **Inconclusive:** Additional data are needed to determine whether the CSM pathway is complete or incomplete.

1.1.3 Risk Evaluation

If a CSM pathway is complete, then initial risk screening is performed by comparing the MC concentration(s) in off-range environmental media samples (e.g., drinking water, surface water, groundwater, sediment) to available regulatory limits and/or screening values. The REVA Program focuses on comparison of MC concentration data to state-specific regulatory values, as states typically are the primary regulating authority for environmental compliance on USMC installations. If state regulatory values are unavailable, then federal regulatory values may be used. If the MC do not have established federal or state regulatory values, screening values are selected from a hierarchy of scientific sources with recognized authority, acceptance, and applicability. Additional risk evaluation may be performed, as outlined in the REVA Guidance Manual (HQMC 2023).

1.2 Objectives of Periodic Review

Approximately every 5 years, or sooner if changes in range use or conditions warrant, USMC assesses the ranges at each of its installations in accordance with DoD Instruction 4715.14 (DoD 2018) and the REVA Guidance Manual (HQMC 2023). The periodic review assesses munitions use in training operations since the last review to determine whether there is a

Documentation of Findings

substantial threat or occurrence of off-range MC migration that creates an unacceptable risk to human health or the environment. **Table 1-1** list REVA assessments conducted to date for MCB Camp Lejeune.

Table 1-1: MCB Camp Lejeune REVA Assessments

REVA Assessment	Evaluated Munitions Use
Baseline Assessment (Malcolm Pirnie 2009)	Historical munitions use through 2004
Five-Year Review (Arcadis 2012)	2005-2010
Periodic Review 1 (Arcadis 2016)	2011-2014
Periodic Review 2	2015-2022

Notes:

MCB = Marine Corps Base

REVA = Range Environmental Vulnerability Assessment

AECOM Technical Services, Inc., as part of the REVA Technical Support Team, was tasked under Contract N62470-16-D-9002, Delivery Order N62470-20-F-5641, to implement the REVA Program Periodic Reviews for operational ranges, including MCB Camp Lejeune.

This document presents the results of MCB Camp Lejeune PR2. The first step of PR2 was to update the CSM for operational ranges and TAs. Existing site data were reviewed to identify potential MC sources, transport mechanisms, and off-range receptors. If there is sufficient evidence to indicate there are no off-range source-receptor interactions (i.e., incomplete CSM pathway), then conclusions are documented in this REVA PR Documentation of Findings, and the assessments for those pathways are finalized. If pathways are identified as complete or inconclusive, the evaluation of those pathways would proceed to further analysis (e.g., sampling, modeling) prior to preparation of the Documentation of Findings. The current CSM update for MCB Camp Lejeune is discussed in detail in Section 4.

This page intentionally left blank.

2. MCB Camp Lejeune Overview

MCB Camp Lejeune and Marine Corps Air Station (MCAS) New River is an approximately 143,835-acre military installation located in Onslow County, North Carolina. These areas are collectively referred to as Marine Corps Installations East-MCB Camp Lejeune (MCIEAST-MCB CAMLEJ). For purposes of this report, the installation is referred to as MCB Camp Lejeune.

MCB Camp Lejeune was commissioned in 1941, with the mission to maintain combat-ready units for expeditionary deployment. Functioning as a training base, MCB Camp Lejeune plays a crucial role in enhancing the combat readiness of operational forces and various tenant commands. This is achieved by furnishing training facilities, services, and comprehensive support, effectively addressing the needs of Marines, sailors, and their families. Distinguished as the largest amphibious training base in the USMC, MCB Camp Lejeune serves as the residence for the world's most extensive assembly of Marines. Its purpose extends to offering specialized training to personnel affiliated with the U.S. Marine Forces Command, housing notable institutions such as the Marine Corps Engineer School, the U.S. Coast Guard's Special Missions Training Center, the Marine Special Operations Command, the School of Infantry-East, the II Marine Expeditionary Force, and additional formal schools under the Training and Education Command (TECOM). Additionally, MCAS New River accommodates two aviation training squadrons (USMC 2021).

2.1 Location

MCB Camp Lejeune is located along the Atlantic coast in eastern North Carolina, within Onslow County, adjacent to the City of Jacksonville. The base encompasses approximately 143,835 acres and consists of 14 miles of beach front along the Atlantic Ocean. The New River runs north/south through the base, and U.S. Highway 24 separates MCB Camp Lejeune from the City of Jacksonville. MCB Camp Lejeune has 231 operational ranges and TAs distributed across 107,263 acres designated for training purposes. A site location map is provided as **Figure 2-1** in Appendix A.

2.2 Munitions Use

A total of 231 operational ranges and TAs were identified and assessed at MCB Camp Lejeune as part of PR2. These areas were subdivided into 85 operational TAs, 3 operational impact areas, and 143 operational ranges, which are discussed in Section 4.1.

2.3 Range Changes at MCB Camp Lejeune (2015-2022)

Several range changes have occurred at MCB Camp Lejeune since PR1:

- Eleven new ranges opened at MCB Camp Lejeune since PR1. Two of these ranges, RR-531 and RR-532, are indoor ranges, and therefore, are not evaluated as part of REVA. The remaining nine ranges are:
 - G-27 and G-30 in the G-10 Impact Area
 - SR-9 and Forward Operating Base (FOB) Greater Sandy Run Area (GSRA)

Documentation of Findings

- G-28 and G-36 located within TA-GI near the eastern coast
- RR-534, RR-534A, and RR-534B located in TA-LC, just south of Stones Bay
- Marine Corps Outlying Field Oak Grove was transferred to MCAS Cherry Point and therefore is not included with MCB Camp Lejeune in this assessment.
- One range, G-6, was renamed to G-36 in 2015.
- In PR1, Range G-29 had a, b, and c sub-designations; these were dissolved in 2020 and they are now collectively referred to as range G-29.
- Four ranges that had expenditures in the PR1 period, SR-12, Military Operations in Urban Terrain (MOUT) Assault Course (MAC) MAC-7, Naval Gunfire, and Davis Tube-Launched, Optically Tracked, Wire-Guided (TOW), reported zero expenditures during the PR2 period and therefore are not evaluated further in this assessment.

3. Summary of Previous REVA Review Findings

A REVA Baseline Assessment (2009), Five-Year Review (2012), and PR1 (2016) were previously conducted at MCB Camp Lejeune. Through fate and transport modeling, qualitative assessments, and field sampling, these studies concluded that range operations did not pose a known unacceptable risk to human health or the environment. A summary of the last assessment, PR1, is presented in the following subsections.

3.1 Operational Ranges

The PR1 assessed munitions use at all operational range facilities from 2011 to 2014. This encompassed a total of 222 operational facilities and TAs, which were further categorized into 85 distinct operational TAs, along with 3 operational impact areas, and 134 operational ranges. These ranges were situated either within, or in close proximity to, 13 subwatersheds. These operational facilities were consolidated into 37 MC source areas, referred to as MC loading areas, that indicated the primary locations of MC deposition during training exercises. Screening level modeling was used to assess off-range migration of high explosives (HE) and perchlorate from MC loading areas. Simultaneously, an assessment was conducted on the 41 small arms ranges (SARs) to gauge the likelihood of lead migration beyond their boundaries. The methodology used to evaluate the small arms ranges was the Small Arms Range Assessment Protocol (SARAP) (HQMC 2009).

3.1.1 Munitions Constituents Screening-Level Fate and Transport Assessment Summary and Results

PR1 utilized screening level fate and transport modeling to predict potential MC concentrations at potential off-range receptor locations. Explosives and/or perchlorate concentrations were modeled. Modeling was conducted for 36 of 37 MC loading area downgradient off-range receptor locations in surface water, groundwater, and sediment. **Table 3-1** summarizes the MC screening-level fate and transport assessment results and resulting follow-on actions.

Table 3-1: PR1 MC Screening-level Assessment Results

Medium	PR1 MC Screening-level Assessment Predictions	PR1 Samples
Surface water	Potential for detectable concentrations of RDX and TNT in surface water at two receptor locations: New River between Town Creek and Stones Bay subwatershed and Bear Creek subwatershed.	Surface water sampling was conducted within the subwatersheds of Bear Creek and the segment of the New River between Town Creek and Stones Bay.
Sediment	Below detectable MC concentrations in sediment at all off-range downgradient receptor locations.	No additional assessment was recommended for sediment.

Documentation of Findings

Medium	PR1 MC Screening-level Assessment Predictions	PR1 Samples
Groundwater	Potential for detectable perchlorate concentrations in groundwater at seven water supply wells.	Groundwater sampling was conducted in three potable supply wells, three non-potable supply wells, and one monitoring well.

Notes:

MC = Munitions constituents

PR1 = Periodic Review 1

RDX = Hexahydro-1,3,5-trinitro-1,3,5-triazine

TNT = 2,4,6-Trinitrotoluene

3.2 Small Arms Range Assessment Protocol Assessment Summary and Results

Previously, SARs were assessed qualitatively via the SARAP (HQMC 2009). The SARAP evaluated characteristics of a range and the surrounding area and used weighted criteria to calculate a score of minimal, moderate, or high. The score correlated to the likelihood of the presence or threat of an off-range release of MC. Per the REVA Guidance Manual updates (HQMC 2023), the SARAP process is no longer used. Under current REVA guidance, SARs are evaluated in conjunction with the other operational ranges and may be assessed as appropriate. The SARAP scores from PR1 (Arcadis 2016) are listed in **Table 3-2**.

Table 3-2: PR1 SARAP Rating Summary

Small Arms Range	Surface Water / Sediment Ranking	Groundwater Ranking
Alpha, Bravo, Charlie	Moderate	Moderate
D-30	Moderate	N/A
Dodge City	Moderate	Minimal
F-18	High	Moderate
G-21	Moderate	Moderate
Hathcock	Moderate	Moderate
K-325	High	Moderate
K-402/A	Moderate	Minimal
K-406A/B	High	Moderate
K-501/A	Moderate	Moderate
K-503/A	High	Moderate
K-506	Moderate	Minimal
K-507	Moderate	Minimal
K-508	High	Moderate
K-509	Moderate	Minimal

Documentation of Findings

Small Arms Range	Surface Water / Sediment Ranking	Groundwater Ranking
MAC-1, MAC-2, , MAC-4, MAC-5, MAC-6	Moderate	Minimal
R-100	High	Minimal
SR-8	Moderate	Moderate

Notes:

N/A = Not assessed using Small Arms Range Assessment Protocol based on the screening evaluation.

High = Greatest level of environmental concern and requires additional action.

Moderate = Likely not an immediate environmental concern.

Minimal = Minimal or no concern for lead migration and minimal environmental concern.

The PR1 SARAP results indicated SARs with a high score for surface water and sediment were in the K-2 Impact Area; K-325, K-406A and K-406B, K-503 and K-503A, and K-508, as well as at F-18 and R-100.

3.3 Previous Sampling Results

Sampling was conducted in September 2014 as part of PR1. Sample locations were identified based on the results of the MC screening-level assessments (**Table 3-1**), SARAPs (**Table 3-2**), previously conducted annual monitoring, and lead loading at the subwatershed level.

3.3.1 Surface Water Sampling Results

Surface water samples were collected from 10 locations. Nine of the 10 locations received drainage from range areas. An additional location was sampled at the northern end of the installation in the New River to provide a reference for background lead concentrations. **Table 3-3** provides a summary of PR1 surface water sample results. Samples were screened against DoD screening values (DoD 2013) and State of North Carolina Protection Standards for aquatic life and human health (North Carolina Administrative Code [NCAC] 2021).

Table 3-3: Summary of PR1 Surface Water Sample Results

General Location	Associated Range or Receptor Location	MC Analytes	Results
K-2 Impact Area draining to New River	New River between Town Creek and Stones Bay Subwatershed	Explosives Perchlorate	No detections
K-2 Impact Area draining to New River	New River between Town Creek and Stones Bay Subwatershed; SARs around K-2 Impact Area	Explosives Perchlorate	Total and dissolved lead detected below screening values
G-10 Impact Area draining to New River	New River between Town Creek and Stones Bay Subwatershed	Explosives Perchlorate	No detections
G-10 Impact Area draining to New River	New River between Town Creek and Stones Bay Subwatershed	Explosives Perchlorate	No detections

Documentation of Findings

General Location	Associated Range or Receptor Location	MC Analytes	Results
Bear Creek near Intracoastal Waterway	Bear Creek	Explosives Perchlorate	No detections
K-2 Impact Area draining into Stones Bay	K-406A and K-406B	Total/Dissolved Lead	Total and dissolved lead detected below screening values
Wallace Creek draining into New River	F-18	Total/Dissolved Lead	No detections
GSRA draining off-installation	SR-8	Total/Dissolved Lead	Total lead detected below screening values
Stones Bay	Alpha, Bravo, and Charlie Ranges	Total/Dissolved Lead	Total and dissolved lead detected below screening values
Reference Sample	Northern New River	Explosives Perchlorate	Total and dissolved lead detected below screening values

Notes:

GSRA = Greater Sandy Run Area

MC = Munitions constituents

PR1 = Periodic Review 1

SAR = Small Arms Range

3.3.2 Groundwater Sampling Results

Ten groundwater samples were collected from four monitoring wells, three potable supply wells, and three non-potable supply wells. Samples were screened against DoD screening values (DoD 2013) and State of North Carolina Protection Standards (NCAC 2021). **Table 3-4** summarizes groundwater sample results.

Table 3-4: Summary of PR1 Groundwater Sample Results

General Location	MC Analytes	Results
G-10 Impact Area boundary	Perchlorate	Not detected
G-10 Impact Area boundary	Perchlorate	Not detected
G-10 Impact Area boundary	Perchlorate	Not detected
G-10 Impact Area boundary	Perchlorate	Not detected
Northeast of G-10 Impact Area	Perchlorate	Not detected
Northeastern installation boundary	Total and dissolved lead	Total and dissolved lead below screening values
K-2 Impact Area boundary	Total and dissolved lead	Total and dissolved lead below screening values
K-2 Impact Area boundary	Perchlorate	Not detected

Documentation of Findings

General Location	MC Analytes	Results
K-2 Impact Area boundary	Perchlorate Total and dissolved lead	Total and dissolved lead below screening values
West of Stones Bay	Perchlorate	Not detected

Notes:

MC = Munitions constituents

PR1 = Periodic Review 1

3.3.3 Range-100 (R-100) Skeet Range and Wallace Creek Sampling Results

Commencing operations in 2012, the R-100 Skeet Range underwent a baseline assessment involving the collection of samples from surface water, sediment, and soil. This assessment was done to establish a fundamental understanding of the initial state, assess the impact of range management protocols, and ascertain the potential off-range migration of MC. Given the existence of polycyclic aromatic hydrocarbons (PAHs) within skeet targets, analyses included lead and PAHs. **Table 3-5** summarizes the R-100 Skeet Range sample results.

Table 3-5: Summary of PR1 Skeet Range Sample Results

Media	Location	Number of Samples	Results
Surface Water	Drainage ditch parallel to and just south of the southern range boundary	2	<ul style="list-style-type: none"> PAHs not detected. Total lead detected above ecological screening value in one sample. Dissolved lead detected above ecological screening value in both samples.
Sediment	Drainage ditch parallel to and just south of the southern range boundary	4	<ul style="list-style-type: none"> Lead detected above screening value in one sample. PAHs not detected in three of four samples
Soil	Southern and northern range boundaries	6	<ul style="list-style-type: none"> Lead detected below screening values One PAH detected above screening value PAHs not detected in three of six samples

Notes:

PAH = Polycyclic aromatic hydrocarbons

PR1 = Periodic Review 1

Surface runoff from the Skeet Range drains to Wallace Creek. Although lead was detected in samples collected on-range, lead was not detected in the sample collected downgradient of the Skeet Range in Wallace Creek.

Documentation of Findings

3.3.4 Sampling Results from 2015, 2016, and 2017

Due to the results of the September 2014 sampling event, additional sampling was recommended, and multiple events were therefore executed in 2015, 2016, and 2017. **Table 3-6** provides a summary of these sampling results.

Table 3-6: 2015, 2016, and 2017 Sampling Results Summary

Sampling Activities	Surface Water	Groundwater	Sediment/Soil
2015			
<p>Surface water samples were collected from nine locations: one in Stones Bay, one on the western boundary of the K-2 Impact Area, one in the New River (background reference location), one on the western boundary of the GSRA, and five on the southern boundary of the R-100 Skeet Range.</p> <p>Four groundwater samples were collected from three groundwater monitoring wells and one potable supply well.</p> <p>Seven surface sediment, three surface soil, and three subsurface soil samples were collected from the R-100 Skeet range for analysis of lead.</p>	<p>The GSRA sample had a low concentration of dissolved lead in surface water slightly above the North Carolina standard.</p> <p>All other non-skeet range-related surface water sample results were consistent with previous results and did not exceed applicable standards for total and dissolved lead.</p> <p>The skeet range results indicate surface water contained elevated lead in the western surface water drainage closest to the firing line. Three samples had dissolved lead concentrations that exceeded the North Carolina standards and two exceeded the DoD screening level values.</p>	<p>Groundwater detections were below screening values for total and dissolved lead and explosives.</p>	<p>Lead detections in sediment from R-100 were below screening values.</p> <p>Lead detections in all soil samples (both surface and subsurface) were below screening values.</p>
2016			
<p>Surface water samples were collected from six locations: one on the western boundary of the GSRA and five on the southern boundary of the R-100 Skeet Range.</p> <p>One groundwater sample was taken from a potable supply well.</p> <p>Eight sediment, two surface soil, and one subsurface soil samples were collected from the R-100 Skeet Range.</p>	<p>The GSRA sample had a minimal exceedance of dissolved lead.</p> <p>Lead was detected in all five R-100 Skeet Range samples. However, these are all on-range locations.</p> <p>One sample nearest to the firing line exceeded both the DoD and North Carolina screening levels for dissolved lead.</p> <p>Results from all other locations were below screening values for total and dissolved lead.</p>	<p>Total lead was below screening values; dissolved lead was not detected.</p>	<p>Lead was detected in all sediment samples below screening values.</p> <p>Lead was detected in all soil samples (surface and subsurface) below screening values.</p>

Documentation of Findings

Sampling Activities	Surface Water	Groundwater	Sediment/Soil
2017			
Four surface water samples were collected at GSRA, and four at the reference location. Four sediment samples were collected. One at the GSRA, two at R-100, and one reference location.	The average dissolved lead concentration at the GSRA location still slightly exceeds the ecological screening criteria, but it was concluded MC migration is minimal and it is not adversely impacting the environment.	Groundwater not sampled.	One sample at the skeet range showed a lead increase from the previous year but was still below screening level values. Total and dissolved lead were below screening values at all other locations.

Notes:

DoD = United States Department of Defense

GSRA = Greater Sandy Run Area

MC = Munitions constituents

The 2015 and 2016 surface water sampling results for the R-100 Skeet Range showed lead concentrations exceeding screening level values. These sampling locations were on-range. PR1 acknowledged that range management practices were being implemented at R-100 to prevent further migration of lead.

3.4 PR1 Results and Recommendations

The PR1 evaluation concluded that range operations did not pose an unacceptable risk to human health or the environment from potential off-range MC migration.

This page intentionally left blank.

4. CSM for Current REVA Review Period (PR2)

The REVA Technical Support Team reviewed CSM information from the previous REVA reports, focusing primarily on the most recent assessment (PR1), to determine where updated data inputs were necessary. New information was gathered to capture changes that have occurred since 2016, focusing on operational ranges (e.g., range inventory, expenditures, changes in use/design) and receptors (e.g., new developments, land acquisition, ecological). The REVA Technical Support Team developed a CSM update, which incorporated information collected during previous REVA studies and updated data collected for this study.

During the previous REVA studies, SARs were evaluated qualitatively using the SARAP (HQMC 2009), as described in Section 3.2. Revised REVA Guidance (HQMC 2018) for periodic reviews instructs that SARs be assessed in the same manner as multi-use ranges by evaluating sources, receptors, and pathways for the presence of a complete pathway between MC source and off-range receptors.

The REVA Technical Support Team held a PR2 kickoff meeting with MCB Camp Lejeune, HQMC, Naval Facilities Engineering Systems Command (NAVFAC), and TECOM in March 2021 to address the REVA process and initiate data collection with installation personnel. A site visit was not conducted in support of the CSM update, but the ranges were toured during sampling efforts in April 2023.

Updated information for the operational ranges and TAs was gathered from the following USMC sources: Range Facility Management Support System (RFMSS), GeoFidelis (the USMC Installation Geospatial Information and Services [IGI&S] program for Installation and Environmental geospatial products and services), and installation environmental and range documents.

Current MC sources, transport mechanisms, and receptors for MCB Camp Lejeune are presented in the following subsections.

4.1 Primary Source Areas (Ranges)

4.1.1 Range Layout, Impact Areas, and Training Areas

A comprehensive assessment of the MCB Camp Lejeune Range Control Standard Operating Procedure (USMC 2021) conducted during PR2 identified 231 operational ranges and TAs within the MCB Camp Lejeune boundary. These areas were subdivided into 85 TAs, 3 impact areas, and 143 operational ranges. MCAS New River is situated in the northernmost region of the installation, and the GSRA is positioned to the west.

The installation features three major impact areas to facilitate ground and air-to-ground operations: Impact Areas G-10 and N1/BT-3 are situated on the eastern side of the New River, while K-2 is positioned on the western side of the river. G-10 and K-2 are high hazard impact areas that receive dud-producing ordnance. The N1/BT-3 Impact Area does not support dud-producing ordnance.

Documentation of Findings

Operational ranges are strategically positioned around the G-10 and K-2 Impact Areas, with their trajectories oriented towards the center of each impact area. Distributed across the installation are several gun positions (GPs), with the majority located on the eastern side of the New River, and six situated on the western side. Additionally, seven mortar positions (MPs) are situated along the periphery of the G-10 Impact Area, with their firing trajectory directed into the G-10 Impact Area.

A significant portion of the reported expenditures during this review period are attributed to the G-10 and K-2 impact areas.

Two Explosive Ordnance Disposal (EOD) ranges (EOD-2 and EOD-3) are used for demolition training and emergency destruction. EOD-2 is located on the western bank of the New River just north of the K-2 Impact Area, and EOD-3 is east of the New River and west of the G-10 Impact Area.

4.1.1.1 MCAS New River

MCAS New River is located in the northwest area of the installation, and it is bounded to the east by the New River. It contains four fixed ranges: Military Operations in Urban Terrain (MOUT) Geiger FOB, located in the cantonment area of Camp Geiger; MOUT Devil Dog, located northwest of the K-2 Impact Area; and SARs A-1 and B-12. Ranges A-1 and B-12 have covered bullet traps that drastically reduce the potential for off-range MC migration.

4.1.1.2 Northeast

The Northeast area is bound to the west by the New River and to the south by the G-10 Impact Area. It contains GPs that fire towards the G-10 Impact Area and ranges including live-fire F-ranges, the MOUT-Mobile Complex, and MAC-1 to MAC-6 live-fire assault courses.

F-Ranges include F-2, F-4, F-5, F-6, F-11A, F-11B, and F-18. The MOUT-Mobile Complex facility has concrete block buildings to support training for combat in an urban environment. MAC-1 to MAC-6 are maintained for individual, fire team, and squad level urban live-fire training.

4.1.1.3 G-10 Impact Area

The G-10 Impact Area is bound to the west by the New River. There are 27 GPs and 7 MPs that fire into the Impact Area. Live-fire ranges inside and around the Impact Area include G-3, G-10 UCAS, G-10A, G-10 Convoy Site 3, G-19A, G-19B, G-21, G-27, G-27A, G-28, G-29A, G-29B, G-30/30A, and G-36.

4.1.1.4 Courthouse Bay

The Courthouse Bay area is located southwest of the G-10 Impact Area and east of the New River. It contains 10 of the 11 Engineer Training Area (ETA) ranges and several GPs. ETA-1, ETA-2, ETA-4, ETA-5, ETA-7A/B/C/D, ETA-8, ETA-9, and ETA-10 conduct live-fire operations on the east side of Courthouse Bay. ETA-5 is located on the western bank of the New River near the K-2 Impact Area. The primary function of ETAs is to provide operational engineering units and schools with facilities to conduct demolition and explosives training. The remaining ETA, Range I-1, is a pistol qualification range and has a covered bullet trap.

Documentation of Findings

4.1.1.5 K-2 Impact Area

The K-2 Impact Area is a high hazard impact area with ranges positioned along the northern and western sides of the impact area boundary. Authorized munitions include all pistol, shotgun, rifle, and machine gun rounds, as well as mortars, rockets, and practice rounds/bombs. All K-ranges contribute to this impact area, except for K-510, which is a grenade range located north of the K-2 Impact Area.

4.1.1.6 Stones Bay

Stones Bay Rifle Ranges are located on the western side of the New River. Stones Bay contains three rifle ranges (Alpha, Beta, and Charlie Ranges), two pistol ranges (Mechanical Pistol and Walk Down), two sniper ranges (Hathcock and Dodge City), and the Multi-purpose Range. These ranges are used primarily for annual marksmanship qualification/requalification training and familiarization firing. Mechanical Pistol, Multi-purpose Range, Walk Down, and Square Bay Ranges have covered bullet traps.

Additional ranges at Stones Bay, within the Expeditionary Operations Training Group compound, include breacher pit/facilities, a non-lethal grenade range, Square Bay pistol and rifle ranges, and RR-534/A/B ranges. Range L-5 is west of the Stones Bay Rifle Complex and is an automated infantry fire team/squad small arms live-fire and maneuver range.

4.1.1.7 Greater Sandy Run Area

The GSRA Training Complex has over 41,000 acres of training area west of the K-2 Impact Area that includes Camp Davis, a World War II Army Airfield. The GSRA Training Complex has seven live-fire ranges (SR-6, SR-7, SR-8, SR-9, SR-10, SR-11, and SR-12); two Camp Davis airfield seizure complexes (AFSC North and AFSC South); and one forward operating base (GSRA FOB). SR-11 has a covered bullet trap.

4.1.1.8 N-1/BT-3 Impact Area

The N-1/BT-3 Impact Area contains bomb and target ranges (Brown's Island Range). Its primary use is attributed to the H-1 Range (H-ranges), which is a live-fire riverine familiarization range. In addition, E-1, G-5, and G-7 ranges fire towards the impact area. The Naval Gunfire Range is located southeast of this area in the Atlantic Ocean but recorded no use during the current review period (see Section 2.3).

4.1.2 Range Management

Operational range clearance (ORC) is conducted by TECOM as a safety measure to reduce the hazards to Marines from material potentially presenting an explosive hazard and munitions and explosives of concern (MEC). REVA benefits from the ORC program because it reduces MC sources.

Since PR1, ORC activities were conducted in 2016 and 2020. In 2016, range clearance projects recovered and disposed of MEC items from K-500A, K-506, and G-3. In 2020, range clearance operations were focused on the G-3 range, specifically a 6-acre high-density area. It was partially investigated to 3 feet (below ground surface).

Documentation of Findings

4.1.3 Expenditure Data

Munitions expenditure data were queried from the RFMSS database for each operational range at MCB Camp Lejeune that was active during the current review period (2015–2022). In accordance with DoD Instruction 4715.14 (DoD 2018), expenditures associated with indoor ranges were not assessed. Expenditures associated with practice, blank, and simulator munitions that have none or minuscule REVA MCs were also not included.

Total average annual HE expenditures at MCB Camp Lejeune increased from PR1 to PR2.

Total average annual perchlorate-containing expenditures and small arms expenditures at MCB Camp Lejeune decreased from PR1 to PR2.

4.1.4 Primary MC Source Areas

Primary source areas were determined based on average annual expenditure counts. In order to identify the areas with the most concentrated MC, a minimum value of 100,000 expenditures was used for SAR expenditures and a minimum value of 1,000 expenditures was used for HE and perchlorate-containing munitions. Any operational range area showing an exceedance of these minimum values was identified as a primary source area. Ranges with bullet traps were excluded from identification as MC source areas because bullets do not land on the ground; they are contained in a bullet trap and periodically removed, which reduces the opportunity for off-range migration. Ranges that exceeded the minimum criteria but have bullet traps are B-12, D-29A, D-29B, Multi-purpose Range, F-11A, I-1, Mechanical Pistol, and Square Bay Pistol.

A total of 32 MC source areas were identified. Twenty-six MC source areas are identified as individual ranges. In addition, six other MC source areas were identified because multiple range facilities fire into a single area, creating a concentrated source. These include MCB Camp Lejeune's three impact areas, the combined F-Ranges; Mobile MOUT Complex; and Stones Bay Area.

4.2 Transport Mechanisms

A CSM transport mechanism is a method in which MC in the secondary source/media (surface water or surface soil in the MC deposition area) travels to exposure media (surface water, sediment, surface soil, or groundwater) off-range. The identified transport mechanisms for MC to potentially travel off-range at MCB Camp Lejeune are as follows:

- Transport via surface water/sediments via hydraulic connection, current, or flow.
- Infiltration/percolation via groundwater.

When rain events occur, stormwater runoff can pick up sediments and travel over the landscape (overland flow) or infiltrate into surficial soils, which then has the potential to percolate downward into the groundwater over time. MC may dissolve into surface water, stormwater, or groundwater. The CSM transport mechanisms for MC to travel off-range in surface soil via stormwater runoff and infiltration/percolation are discussed further in Sections 4.3.1 and 4.3.2, respectively.

4.3 MCB Camp Lejeune Environmental Setting

MCB Camp Lejeune has a warm, temperate climate. Winters are mild with occasional short, cold periods. Historical weather data collected from Jacksonville, North Carolina, and New Bern, North Carolina, spanning from 1970 to 2005, indicated an average annual precipitation of 72.5 inches (Malcolm Pirnie 2009). The average annual snowfall measures around 3 inches. Notably, the region is susceptible to hurricanes that can lead to substantial flooding and damage in low-lying zones near the ocean, sounds, bays, rivers, and creeks. According to the U.S. Department of Agriculture (USDA) Soil Conservation Service (SCS) (1992), between 1900 and 1986, a total of 56 hurricanes passed close to the North Carolina coast.

The elevation of MCB Camp Lejeune spans from mean sea level (msl) to 72 feet above msl. The majority of the land area occupies a geomorphic terrace with an elevation ranging between 24 and 42 feet above msl (USDA SCS 1992). Along the coast of MCB Camp Lejeune, a narrow strip of land occupies a lower terrace, ranging from sea level to 24 feet above msl.

Positioned within the Tidewater region of the Atlantic Coastal Plain physiographic province, MCB Camp Lejeune lies within the lower Coastal Plain of North Carolina. The topography can be described as flat terraces that rest upon unconsolidated sediments. While most of the installation features relatively even terrain with slopes of less than 2 percent, certain areas, particularly the valleys of the branching stream systems, exhibit steeper topography with slopes ranging from 2% to 15%. The land classification at MCB Camp Lejeune includes upland regions, floodplains, riparian wetlands, barrier islands, and low-lying pocosin areas (Arcadis 2016).

4.3.1 Surface Water

Estimated surface water runoff rates were previously calculated at the identified MC source areas during PR1. These estimated values indicated there is a high potential for MC to migrate via surface water runoff. The estimated surface water runoff rate at MC source areas is attributed to the high precipitation (average of 72.5 inches per year), the sparse vegetation on some of the ranges and proximity to waterways, and soil types.

The operational ranges and TAs evaluated in PR2 are located within 11 subwatersheds; the MC source areas are found within 10 of these subwatersheds. The subwatersheds are as defined in the USGS Watershed Boundary Dataset (USGS 2013). Subwatersheds were queried for hydrologic unit code (HUC) 10. The 11 subwatersheds along with some of the surrounding subwatersheds can be seen on **Figure 4-1** in Appendix A. These subwatersheds and the MC source areas, ranges, and TAs that contribute to each are listed in **Table 4-4**. SARs with bullet traps are excluded.

Table 4-1: PR2 Summary of MC Source Areas by Subwatershed

	Subwatershed	MC Source Areas ^a	Contributing Ranges and TAs
1	Shelter Swamp Creek	SR-06, SR-07 (66%), SR-08, SR-09, SR-10 (34%)	MOUT GSRA, TA-SL
2	Southwest Creek	SR-07 (34%), MOUT Devil Dog	TA-MA, TA-MB, TA-MD, TA-ME, TA-MC (50%), TA-SD

Documentation of Findings

	Subwatershed	MC Source Areas ^a	Contributing Ranges and TAs
3	Stones Creek	L-5, Stones Bay Alpha, Bravo, Charlie (20%)	TA-LA, TA-LB, Dodge City
4	Juniper Swamp	SR-10 (66%)	AFD SZ FAC SOUTH, TA-SP, TA-ST
5	New River at Stones Bay	Hathcock, Stones Bay Alpha, Bravo, Charlie (80%) Stones Bay Area, K-2 Impact Area (30%)	RR-534/Breacher 215, TA-MF, TA-LC
6	New River between Stick Creek and Whitehurst Creek	K-510, EOD-2	MOUT Geiger FOB, TA-MC (50%), TA-KA, TA-KB, TA-KC, TA-AA, TA-AC, K-501A, K-502, TA-BB, TA-BD
7	Northeast Creek	N/A	N/A ^b
8	Wallace Creek	F Ranges, R-100	TA-FA, TA-FB, TA-FC, TA-FE, TA-FF, TA-FG, TA-QA, TA-RB, F-11B, F-18
9	New River between Town Creek and Stones Bay	K-2 Impact Area (70%), ETA-5, ETA-7A/B/C/D, EOD-3, Combat Town, G-10 Impact Area (60%), F-6	D-30, ETA-10, ETA-8, ETA-9, TA-HA, TA-HB, TA-HC, TA-HD, TA-HE, TA-HG, TA-HH, TA-IE (50%), TA-JA, MOUT-Hawk FOB, TA-FD, TA-GB
10	Bear Creek-Bear Inlet	Mobile MOUT Complex, MAC-3, MAC-6, G-10 Impact Area (40%), N1/BT-3 Impact Area, ETA-4	MAC-1, MAC-2, MAC-4, MAC-5, TA-GG, G-5, G-7, G-21 (50%), TA-GC, TA-QB, TA-HF
11	New River between Stones Bay and Intracoastal Waterway	N/A	ETA-01, ETA-02, TA-IC, TA-ID, TA-IF, TA-IG, TA-JC, TA-Hammock Bay, G-21 (50%), TA-IE (50%), TA-IB, TA-AIWW, TA-IA, TA-EB

Notes:

^a Percentages (%) are provided for ranges that cross into/fire into two subwatersheds.

^b Range A-1 is in this subwatershed but has a covered and maintained bullet trap; therefore, it is excluded from the contributing ranges.

FOB = Forward Operating Base

GSRA = Greater Sandy Run Area

MC = Munitions constituents

MOUT = Military Operations in Urban Terrain

N/A = Not Applicable

PR2 = Periodic Review 2

TA = Training Area

4.3.1.1 Subwatershed Evaluation

Expenditures for all ranges and TAs within each subwatershed were combined to determine the overall MC source in the subwatershed. A subwatershed evaluation was conducted comparing the average annual munitions expenditures between PR1 and PR2.

Some MC source areas are located in more than one subwatershed, and therefore, only part of the MC source from that range contributes to each subwatershed. In such cases, only an

Documentation of Findings

applicable percentage of the MC source area expenditures is attributed to the subwatershed. Percentages for each applicable MC source area were calculated based on the geographical position of the range as well as the position of applicable surface danger zones (SDZs) of the range. Range SDZs in many cases cross over two differing subwatersheds, and MC deposition could therefore be occurring in multiple subwatersheds concurrently. These percentages were applied in calculating the average annual total for each subwatershed.

Five subwatersheds experienced notable increases in average annual expenditures:

- (1) Southwest Creek and (2) Bear Creek-Bear Inlet had an increase in perchlorate-containing rounds.
- (3) New River at Stones Bay had an increase in both HE expenditures and perchlorate-containing rounds.
- (4) New River between Town Creek and Stones Bay exhibited an increase in HE, perchlorate-containing rounds, and small arms expenditures.
- (5) New River between Stones Bay and Intracoastal Waterway had an increase in small arms rounds.

Although small arms use within most subwatersheds decreased, average annual small arms had notable expenditures exceedances in two subwatersheds:

- New River at Stones Bay (although less expenditures in PR2 were fired compared with PR1)
- New River between Town Creek and Stones Bay (where expenditures increased)

HE expenditures increased in the subwatershed New River between Town Creek and Stones Bay; HE usage at the installation was highest within this subwatershed. The G-10 and K-2 Impact Areas accounted for the majority of this HE usage. Perchlorate-containing expenditures decreased in the subwatershed New River between Stick Creek and Whitehurst Creek; however, use was highest in this subwatershed. Range K-510 accounted for over 90% of this perchlorate use.

4.3.2 Groundwater

MC may percolate through the soil and reach groundwater due to the relatively shallow water table and the prevalence of sandy soils. These factors contribute to a higher recharge rate, ranging approximately from 5 to 21 inches per year (Heath 1989). Additional factors influencing MC migration towards groundwater include mass deposits at the surface, the solubility of compounds in water, and the deceleration of MC due to soil properties.

In the surficial aquifer, shallow groundwater generally moves towards streams and other surface water features. The shallow groundwater from the surficial aquifer serves as a source of replenishment for the underlying confined aquifers, including the Castle Hayne aquifer. While a confining layer restricts the flow rate towards the Castle Hayne aquifer across most of the installation, this layer is absent in certain regions, creating a direct linkage between the surficial and Castle Hayne aquifers. The semi-confined Castle Hayne aquifer serves as the primary drinking water source for the installation, surrounding areas, and the city of Jacksonville, North Carolina (Arcadis 2016).

Documentation of Findings

Significant withdrawals from installation and adjacent county water supply wells have induced a prominent localized hydraulic gradient towards these water supply wells. Given the semi-confined nature of the Castle Hayne aquifer and the absence of the confining layer in some areas, the potential for elevated MC loads to travel from the upper surficial aquifer to the Castle Hayne aquifer exists, which could subsequently transport them to drinking water supply wells.

4.4 Off-Range Receptors

The third component of a complete CSM pathway is receptor interaction with the source and media at an off-range location. Receptors include humans or biota that interact with the source/media via ingestion, incidental ingestion, or through dermal contact.

4.4.1 Human

The primary potential exposure pathway for humans is ingestion of groundwater. Public supply wells located throughout MCB Camp Lejeune draw water from the Castle Hayne aquifer, serving as the primary source of drinking water for both the base and its inhabitants. This aquifer's groundwater is also utilized as a drinking water source for the City of Jacksonville, North Carolina, and Onslow County.

Surface water, present in the New River embayment and its tributaries, as well as the Intracoastal Waterway and its tributaries, and the Atlantic Ocean, is used for recreational activities. Surface water presents a potential pathway for human exposure, primarily through dermal contact and incidental ingestion.

All previously detected lead concentrations in soil and sediment from samples collected during previous REVA studies (Section 3.3) are over an order of magnitude below the United States Environmental Protection Agency (USEPA) Industrial Regional Screening Levels. Extended dermal contact or ingestion of these soil/sediments by humans is unlikely; therefore, soil and sediment are not considered a viable pathway for human exposure.

4.4.2 Ecological

Surface water-related ecological receptor interaction locations include streams, tidal creeks, swamps, wetlands, and near shore marine environments (such as the New River and Onslow Bay). Sediment/soil-related ecological receptor interaction locations include the banks and beds of streams and creeks, and surface water bodies. Potential species present with a "special" status at each of the subwatersheds showing an increase in expenditures are listed below.

- Southwest Creek: red-cockaded woodpecker and American alligator.
- New River at Stones Bay: red-cockaded woodpecker.
- New River between Town Creek and Stones Bay: red-cockaded woodpecker, rough-leaved loosestrife, and American alligator.
- Bear Creek-Bear Inlet: red-cockaded woodpecker and rough-leaved loosestrife.
- New River between Stones Bay and Intracoastal Waterway: red-cockaded woodpecker, rough-leaved loosestrife, and bald eagle.

The potential presence of these species makes surface water/sediment an important ecological exposure pathway. No direct ecological receptors were identified for groundwater.

4.4.3 Summary of Off-Range Receptors

A potential exposure pathway for human receptors is present through groundwater as it is a drinking water source and can be consumed via ingestion/incidental ingestion. Surface water presents a potential pathway for human exposure as well, primarily through dermal contact and incidental ingestion.

Ecological special status species and their habitats are present, including the red-cockaded woodpecker, rough-leaved loosestrife, American alligator, and bald eagle. Surface water and sediment/soil are both potential exposure pathways for ecological receptors as the surface water and sediments comprise these species' habitats. No direct ecological receptors were identified for groundwater.

This page intentionally left blank.

5. Summary of Field Sampling (2023)

Based on results of the CSM update (see Section 4), sampling was recommended for sediment, surface water, and groundwater in six subwatersheds with an “inconclusive” determination to characterize potential MC migration/pathways. A summary of the recommended sampling activities is presented in **Table 5-1**.

Surface water, sediment, and groundwater samples were analyzed for explosives, lead (total and dissolved in water), and/or perchlorate to determine whether migration pathways are complete from MC source areas to off-range receptor locations. Across the media types sampled for PR2, lead was the only MC detected; explosives and perchlorate were not detected in any samples. None of the samples exceeded Human Health Receptor or Ecological PALs.

Table 5-1: Recommended Samples for REVA PR2 at MCB Camp Lejeune

Subwatershed	Sampling Matrix	Analyte	Criteria for Choosing
Southwest Creek	Surface water, Sediment	Perchlorate	Increase in perchlorate-containing expenditures from PR1 to PR2.
New River at Stones Bay (North)	Surface water, Sediment and Groundwater	Explosives, Perchlorate	Increase in explosives and perchlorate-containing expenditures.
New River at Stones Bay (South)	Surface water, Sediment	Lead	High number of small arms expenditures in PR2.
New River between Stick Creek and Whitehurst Creek	Surface water, Sediment and Groundwater	Perchlorate	Although a decrease in expenditures since PR1, contains the highest number of perchlorate-containing expenditures of all subwatersheds.
New River between Town Creek and Stones Bay (West)	Surface water, Sediment and Groundwater	Explosives, Perchlorate, Lead	Increase in all three expenditure types from PR1 to PR2.
New River between Town Creek and Stones Bay (East)	Surface water, Sediment and Groundwater	Explosives, Perchlorate, Lead	Increase in all three expenditure types from PR1 to PR2.
Bear Creek-Bear Inlet (South)	Surface water, Sediment and Groundwater	Perchlorate	Increase in perchlorate-containing expenditures from PR1 to PR2.
Bear Creek-Bear Inlet (North)	Groundwater	Perchlorate	Increase in perchlorate-containing expenditures from PR1 to PR2.
New River between Stones Bay and Intracoastal Waterway	Surface water, Sediment and Groundwater	Lead	Increase in small arms expenditures from PR1 to PR2.

Notes:

MCB = Marine Corps Base

PR2 = Periodic Review 2

Documentation of Findings

5.1 Sample Locations and Analyses

A total of 30 samples were collected inside installation boundaries and outside operational range boundaries within 6 subwatersheds as identified in **Table 5-1**. During sample collection, the daytime air temperatures ranged from 70 to 82 degrees Fahrenheit, and skies were clear and sunny. Installation personnel escorted the REVA Technical Support Team to each sample location.

Quality control samples included duplicates collected at a rate of 10% for the analyses, matrix spike (MS)/MS duplicate (MSD) samples collected at a rate of 5%, and equipment blanks collected from non-disposable equipment that potentially contacted samples. Samples were shipped for analysis to Eurofins Lancaster Laboratories in Lancaster, Pennsylvania.

Table 5-2: Sample Summary and Locations

Subwatershed	Matrix	Analyte / Analytical Group	Sample Rationale	Salinity	Notes
Southwest Creek	SW	Perchlorate	Surface flow at Devil Dog runs southeast into Southwest Creek. Sample locations are downgradient and capture runoff from the range. Increase in perchlorate-containing expenditures from PR1 to PR2.	Brackish	—
	SD	Perchlorate		N/A	Collected with an Ekman sediment sampler due to sediment depth below the water surface.
New River at Stones Bay (North)	SW	Explosives Perchlorate	Surface water in the K-2 Impact Area generally flows in the direction toward the New River. Many small streams drain the K-2 Impact Area. Sample locations are downgradient and capture runoff from the range. Increase in explosives and perchlorate-containing expenditures.	Brackish	—
	SD	Explosives Perchlorate		N/A	—
	GW	Explosives Perchlorate		N/A	—
New River at Stones Bay (South)	SW	Total Lead Dissolved Lead	One surface water and 1 sediment sample were taken from the stream that drains to the east before feeding into the New River. One surface water and one sediment sample taken from the stream that drains to the north before converging with the New River.	Brackish	—
	SW	Total Lead Dissolved Lead		Brackish	—
	SD	Lead		N/A	—
	SD	Lead		N/A	—

Documentation of Findings

Subwatershed	Matrix	Analyte / Analytical Group	Sample Rationale	Salinity	Notes
New River between Stick Creek and Whitehurst Creek	SW	Perchlorate	Highest number of perchlorate-containing expenditures of the subwatersheds despite having an overall decrease since PR1. One surface water and one sediment sample from Town Creek captures any runoff from range K-510 before it converges with the New River.	Brackish	—
	SD	Perchlorate		N/A	—
New River between Town Creek and Stones Bay (West)	SW	Explosives Perchlorate Total Lead Dissolved Lead	Increase in three expenditure types from PR1 to PR2. Many small streams drain the K-2 Impact Area in the subwatershed; taking multiple samples from the headwaters region to the mouth of these streams captures runoff from the high use ranges present in this area.	Brackish	Duplicate sample collected.
	SW	Explosives Perchlorate Total Lead Dissolved Lead		Brackish	Not sampled due to access and safety concerns. Determined prior to field event.
	SW	Explosives Perchlorate Total Lead Dissolved Lead		Brackish	—
	SD	Explosives Perchlorate Lead		N/A	Not sampled due to safety concerns. Determined during field event.
	SD	Explosives Perchlorate Lead		N/A	Not sampled due to access and safety concerns. Determined prior to field event.

Documentation of Findings

Subwatershed	Matrix	Analyte / Analytical Group	Sample Rationale	Salinity	Notes
	SD	Explosives Perchlorate Lead		N/A	Not sampled due to safety concerns. Determined during field event.
	GW	Explosives Perchlorate Total Lead Dissolved Lead		N/A	Not sampled due to well damage. Unable to access water column to sample.
New River between Town Creek and Stones Bay (East)	SW	Explosives Perchlorate Total Lead Dissolved Lead	The high use ranges in this subwatershed sit on the western border of the G-10 Impact Area, which drains into two small streams to the west - Jumping Run and Cowhead Creek- and then into the New River. Increase in three expenditure types from PR1 to PR2.	Freshwater	—
	SW	Explosives Perchlorate Total Lead Dissolved Lead		Freshwater	—
	SD	Explosives Perchlorate Lead		N/A	Duplicate sample collected.
	SD	Explosives Perchlorate Lead		N/A	Duplicate sample collected.
	GW	Explosives Perchlorate Total Lead Dissolved Lead		N/A	Duplicate sample collected.
	GW	Explosives Perchlorate Total Lead Dissolved Lead		N/A	—
Bear Creek-Bear Inlet (South)	SW	Perchlorate	The eastern portion of the Impact Area generally drains in the direction of the New River to the southeast.	Brackish	—
	SW	Perchlorate		Brackish	—
	SD	Perchlorate		N/A	—

Documentation of Findings

Subwatershed	Matrix	Analyte / Analytical Group	Sample Rationale	Salinity	Notes
	SD	Perchlorate	Increase in perchlorate-containing expenditures from PR1 to PR2.	N/A	—
	GW	Perchlorate		N/A	—
Bear Creek-Bear Inlet (North)	GW	Perchlorate	Increase in perchlorate-containing expenditures from PR1 to PR2. MOUT Complex- Lejeune is located just north of the G-10 Impact Area and has no direct surface water drainage as this is a highland area. No viable surface water locations are available for sampling; however, one monitoring well was sampled, G10-MW-6, which is located just south and downgradient of this range.	N/A	—
New River between Stones Bay and Intracoastal Waterway	SW	Total Lead Dissolved Lead	Increase in small arms expenditures from PR1 to PR2. Runoff from Range G-21 travels to the south/east. To best capture runoff from this range, surface water and sediment were sampled at the southern stream, Gillets Creeks, as well as an inlet to the east.	Brackish	—
	SW	Total Lead Dissolved Lead		Brackish	—
	SD	Lead		N/A	—
	SD	Lead		N/A	—
	GW	Total Lead Dissolved Lead		N/A	—
Equipment blank	Water	Perchlorate Explosives Total Lead Dissolved Lead	Collect equipment blank using deionized water to sample potential cross contamination from water level meter and Ekman sediment sampler.	N/A	—

Notes:

GW = Groundwater

MOUT = Military Operations in Urban Terrain

N/A = Not applicable

PR1 = Periodic Review 1

PR2 = Period Review 2

SD = Sediment

SW = Surface water

Documentation of Findings

5.2 Sample Results

A summary of analytical results is presented in **Table 5-3**. Analytical results were validated by AECOM in accordance with the *Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review* (USEPA 2020a) and *Contract Laboratory Program National Functional Guidelines for Superfund Inorganic Methods Data Review* (USEPA 2020b).

Surface water, sediment, and groundwater were sampled. Throughout all subwatersheds and media types sampled, lead was the only MC detected. Neither explosives nor perchlorate were reported above their respective laboratory limits of detection (LOD). Sixteen of the 17 samples analyzed for lead had detectable concentrations.

Table 5-3: Sampling Results Summary

Subwatershed	Samples by Media	Analyses	Detections	Exceedances
Southwest Creek	1 SW 1 SD	All media: Perchlorate	N/A	N/A
New River at Stones Bay (North)	1 SW 1 SD 1 GW	All media: Explosives, Perchlorate	N/A	N/A
New River at Stones Bay (South)	2 SW 2 SD	All media: Lead (total/dissolved)	Lead detected in all media	Below PALs
New River between Stick Creek and Whitehurst Creek	1 SW 1 SD	All media: Perchlorate	N/A	N/A
New River between Town Creek and Stones Bay (West)	2 SW	All media: Explosives, Lead (total/dissolved), Perchlorate	Lead detected in all media	Below PALs
New River between Town Creek and Stones Bay (East)	2 SW 2 SD 2 GW	All media: Explosives, Lead (total/dissolved), Perchlorate	Lead detected in all media	Below PALs
Bear Creek-Bear Inlet (South)	2 SW 2 SD 1 GW	All media: Perchlorate	N/A	N/A
Bear Creek-Bear Inlet (North)	1 GW	All media: Perchlorate	N/A	N/A
New River between Stones Bay and Intracoastal Waterway	2 SW 2 SD 1 GW	All media: Lead (total/dissolved)	Lead detected in all media	Below PALs

Notes:

GW = Groundwater

N/A = Not applicable

PAL = Project Action Limit

SD = Sediment

SW = Surface water

5.3 Sample Discussion

PALs were established in the Uniform Federal Policy Quality Assurance Project Plan (AECOM 2023) and were derived from state and federal standards:

- Surface Water
 - USEPA Regional Screening Levels for Tap Water with target hazard quotient (THQ) of 0.1 (USEPA 2022b) – Human Health PAL
 - USEPA Region IV Chronic Surface Water Screening Values for freshwater and saltwater (USEPA 2018a) – Ecological PAL
 - North Carolina Protection Standards for protection of freshwater and saltwater aquatic life (NCAC 2021) – Ecological PAL
- Sediment
 - USEPA Regional Screening Levels for Industrial Soil with THQ of 0.1 (USEPA 2022a) – Human Health PAL
 - USEPA Region IV Sediment Screening Values for Hazardous Waste Sites Table 2a and Table 2b (USEPA 2018b) – Ecological PAL
- Groundwater
 - USEPA Regional Screening Levels for Tap Water with THQ of 0.1 (USEPA 2022b) – Human Health PAL

5.3.1 Explosives and Perchlorate

No explosives or perchlorate analytes were reported above the laboratory LODs. The LODs for perchlorate were below the PALs.

5.3.2 Lead

Of the 17 samples analyzed for lead, 16 displayed detectable concentrations. None of the detections exceeded the human health or ecological PALs for lead; therefore, off-range migration pathways for lead from these source areas at MCB Camp Lejeune to off-range human health and ecological receptors are concluded to be incomplete.

The highest lead detection by media type is presented below; none exceeded their respective PALs.

- LESW0923B01 collected in the Bear Creek-Bear Inlet subwatershed had the highest concentration of total lead (3.9 micrograms per liter [$\mu\text{g/L}$]) detected in surface water. The detection was below the human health PAL (15 $\mu\text{g/L}$) and the marine ecological PAL (8.1 $\mu\text{g/L}$). LESW0923B01 was compared to the marine ecological PAL because the sample location (Freeman Creek) is identified by North Carolina as a high-quality tidal salt waterbody (North Carolina Department of Environmental Quality 2022).
- LESD0623A01 collected in the New River between Town Creek and Stones Bay subwatershed had the highest concentration of lead (24 milligrams per kilogram [mg/kg])

Documentation of Findings

detected in sediment. The detection was below the human health PAL (800 mg/kg) and the ecological PAL (35.8 mg/kg).

- G10-MW-7-040423 collected in the New River between Town Creek and Stones Bay subwatershed had the highest concentration of dissolved lead (0.18 µg/L) detected in groundwater. The detection was below the human health PAL (15 µg/L). Groundwater detections were not compared to an ecological PAL because direct pathways to ecological receptors were not identified.

6. REVA PR2 Conclusions

The results of the MCB Camp Lejeune PR2 evaluation do not indicate off-range MC migration, and all off-range migration pathways are incomplete. The updated CSM and 2023 MC sample data indicate no known off-range MC migration that presents an unacceptable risk to human health or the environment; therefore, no further assessment is warranted under the REVA Program at this time. In accordance with DoDI 4715.14 (DoD 2018), the next MCB Camp Lejeune PR will be conducted in 5 years, or sooner if significant changes occur that may affect determinations made in this assessment.

This page intentionally left blank.

7. References

- AECOM. 2023. United States Marine Corps Range Environmental Vulnerability Assessment Program Installation-Specific United Federal Policy Quality Assurance Project Plan, MCB Camp Lejeune. March.
- Arcadis. 2012. Range Environmental Vulnerability Assessment Five-Year Review, MCB Camp Lejeune.
- Arcadis. 2016. Range Environmental Vulnerability Assessment Periodic Review, Marine Corps Installations East 0- MCB Camp Lejeune.
- Cao, X., L.Q. Ma, M. Chen, D.W. Hardison, Jr., and W.G. Harris. 2003. "Weathering of lead bullets and their environmental effects at outdoor shooting ranges." *Journal Environ. Qual.* 32:526–534.
- Clausen, J. L., N. Korte, B. Bostick, B. Rice, M. Walsh, and A. Nelson. 2007. Environmental assessment of lead at Camp Edwards, Massachusetts Small Arms Ranges. Hanover, NH: Cold Regions Research and Engineering Laboratory, U.S. Army Engineer Research and Development Center.
- DoD. 2013. Department of Defense Screening Values. Updated 2013.
- DoD. 2018. DoD Instruction 4715.14, Operational Range Assessments. 15 November 2018.
- Heath, Ralph. 1989. Basic Groundwater Hydrology. Water Supply Paper 22220. U.S. Geological Survey.
- HQMC. 2009. Small Arms Range Assessment Protocol (SARAP).
- HQMC. 2023. Draft USMC Range Environmental Vulnerability Assessment Guidance Manual. October.
- Jenkins, T.F. 2005. Identity and distribution of residues of energetic compounds at military live fire training ranges. U.S. Army Engineering Research Center.
- Jenkins, T.F., C. Bartolini, and T.A. Ranney. 2003. Stability of CL-20, TNAZ, HMX, RDX, NG, and PETN in moist, unsaturated soil. ERDC/CRREL TR 03-7.
- Malcolm Pirnie. 2009. Range Environmental Vulnerability Assessment, MCB Camp Lejeune, Baseline Assessment.
- NCAC. 2021. North Carolina Protection Standards for protection of freshwater and saltwater aquatic life. July.
- North Carolina Department of Environmental Quality. 2022. 2022 North Carolina Final 303(d) List.
- USDA SCS. 1992. Soil Survey of Onslow County. United States Department of Agriculture, Soil Conservation Services.

Documentation of Findings

USEPA. 2018a. Region IV Chronic Surface Water Screening Values for freshwater and saltwater. March.

USEPA. 2018b. Region IV Sediment Screening Values for Hazardous Waste Sites Tables 2a and 2b. March.

USEPA. 2020a. National Functional Guidelines for Inorganic Superfund Methods Data Review. EPA 542-R-20-006. November.

USEPA. 2020b. National Functional Guidelines for Organic Superfund Methods Data Review. EPA 540-R-20-005. November.

USEPA. 2022a. Regional Screening Levels for Industrial Soil with a THQ of 0.1. November.

USEPA. 2022b. Regional Screening Levels for Tap Water with THQ of 0.1. November

USGS. 2013. Groundwater Elevation Data for the Castle Hayne Aquifer Measured in 2013. United States Geological Survey.

USMC. 2021. Camp Lejeune Range Control Standing Operating Procedures. United States Marine Corps.

Appendix A
Figures

Documentation of Findings

This page intentionally left blank.

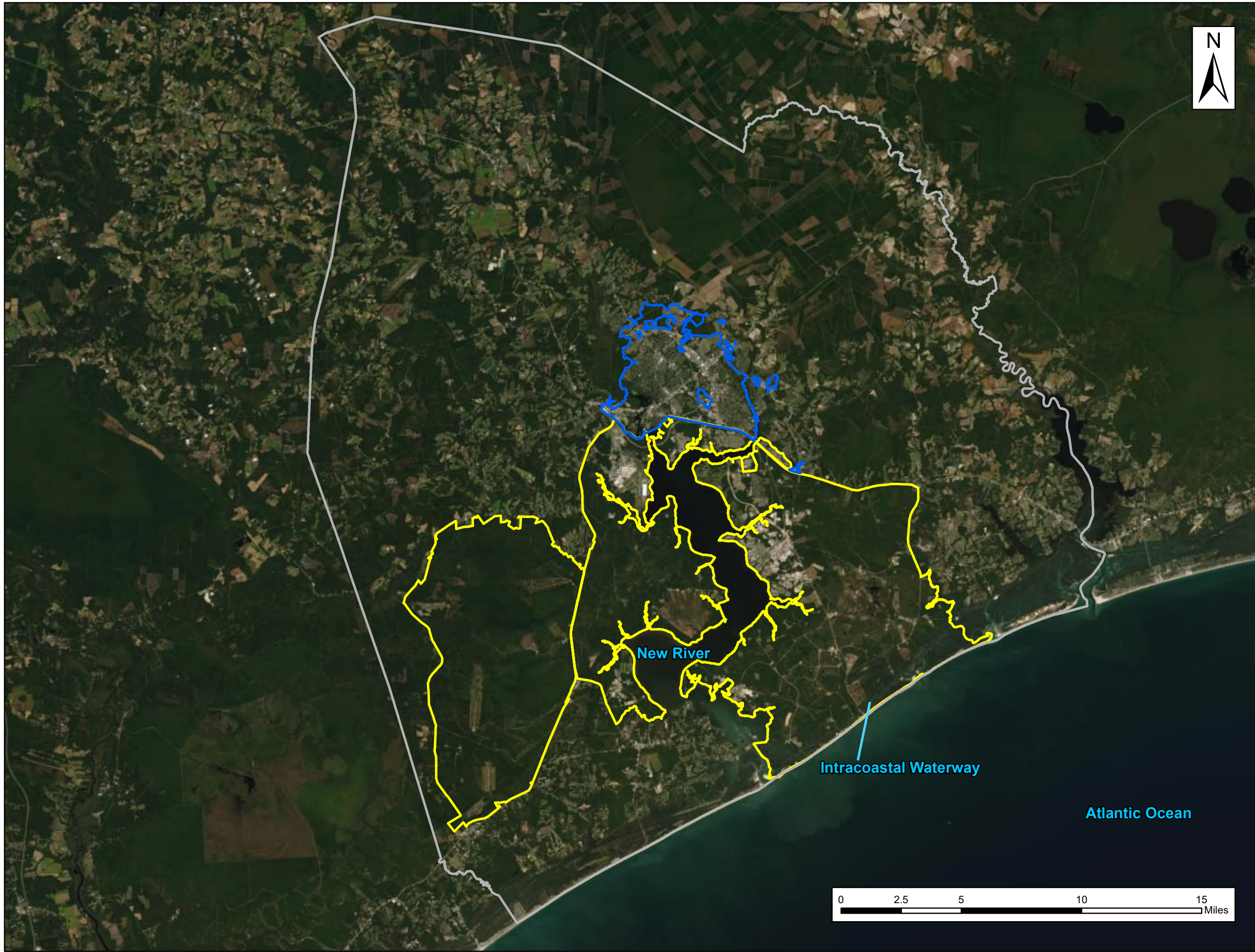



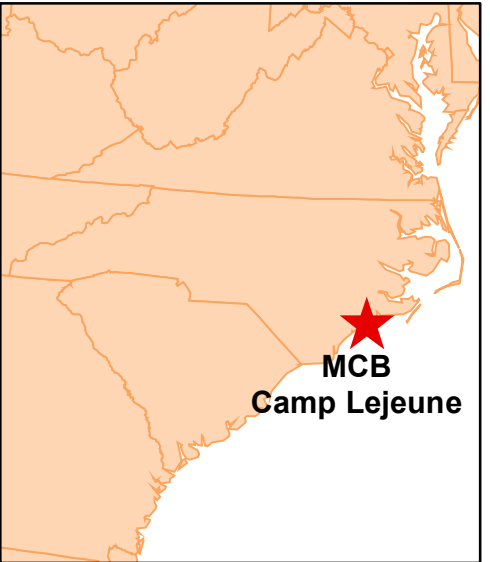


Figure 2-1
MCB Camp Lejeune
Site Location

Range Environmental
Vulnerability Assessment
MCB Camp Lejeune
Onslow County, North Carolina

- Legend**
-  Onslow Co. Boundary
 -  City of Jacksonville Boundary
 -  Installation Boundary



Coordinate System: Universal Transverse Mercator
 Zone: 18 N
 Datum: WGS84
 Units: Meters

Date: October 2022

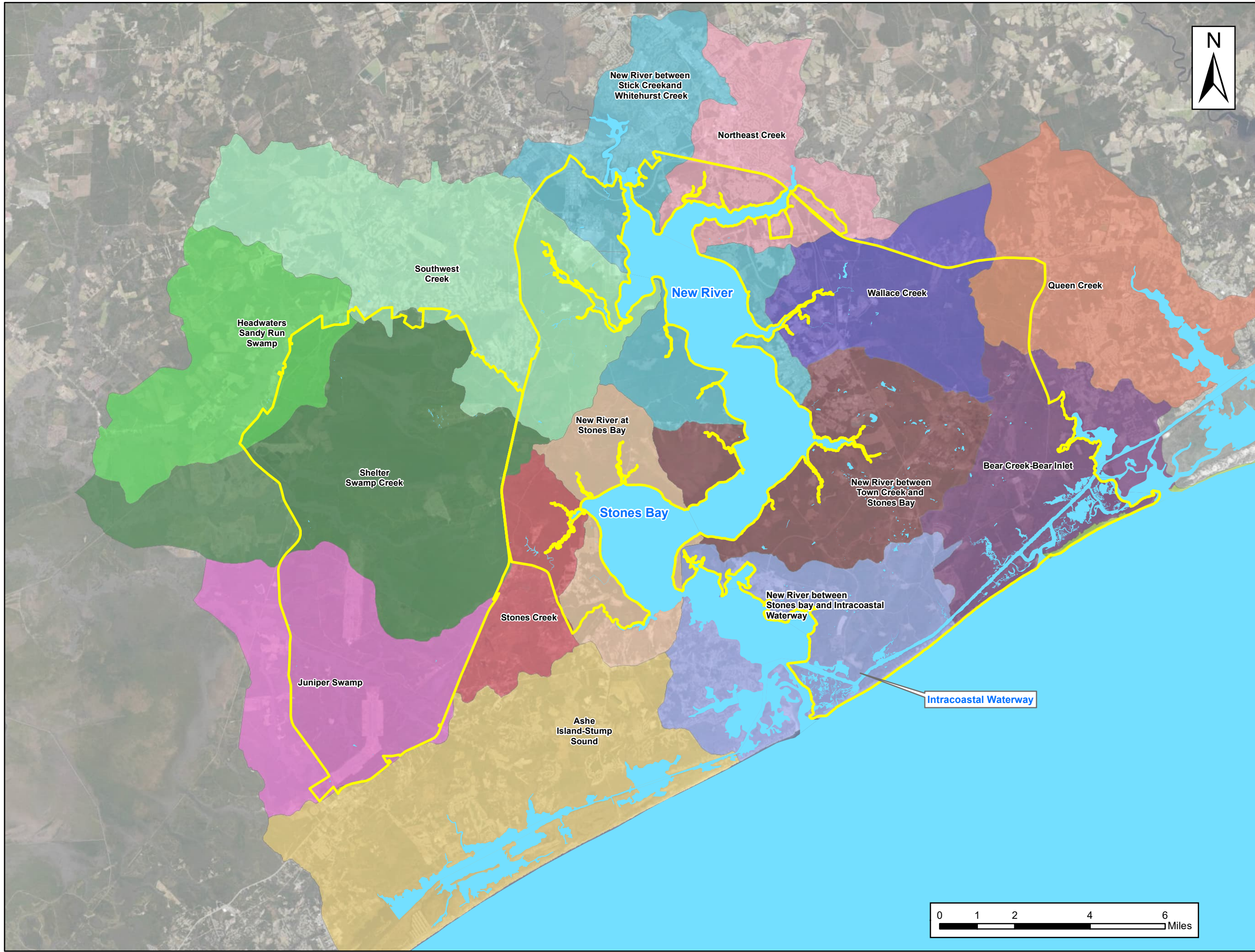
-USMC Installation Geospatial Information & Services MCB Camp Lejeune

- ESRI World Imagery Service





Figure 4-1
MCB Camp Lejeune
Subwatersheds

Range Environmental
Vulnerability Assessment
MCB Camp Lejeune
Onslow County, North Carolina



Legend

-  Installation Boundary
-  Water Feature



Coordinate System: Universal Transverse
 Mercator
 Zone: 18 N
 Datum: WGS84
 Units: Meters

Date: October 2022

-USMC Installation Geospatial Information &
 Services MCB Camp Lejeune

- ESRI World Imagery Service



Appendix B
REVA Factsheet

This page intentionally left blank.



Marine Corps Base Camp Lejeune, North Carolina

Range Environmental Vulnerability Assessment (REVA) Factsheet

April 2024

Background

The Department of Defense (DoD) uses and manages operational ranges to support national security objectives and maintain the high state of operational readiness essential to its mission requirements.

DoD conducts non-regulatory, proactive, and comprehensive operational range assessments (ORAs) to support the long-term sustainability of these ranges while protecting human health and the environment.

The purpose of an ORA is to determine whether there is a release or substantial threat of a release of munitions constituents (MC) from an operational range to an off-range area that exceeds an applicable regulatory standard or creates a potential unacceptable risk to human health or the environment.

The Range Environmental Vulnerability Assessment (REVA) Program is the U.S. Marine Corps program implemented to meet the DoD ORA requirements.

Operational Ranges Overview

The primary mission of MCB Camp Lejeune is to maintain combat-ready units for expeditionary deployment. The installation is located in eastern North Carolina adjacent to the city of Jacksonville consisting of 14 miles of beach front along the Atlantic Ocean. Its 107,263-acre training footprint includes 85 training areas, 3 impact areas, and 143 operational ranges.

A total of 32 MC source areas were identified during PR2 (2015-2022). These areas were broken into 26 individual ranges and 6 aggregate areas where multiple locations fire into a single point. The 6 aggregate MC source areas include the G-10 Impact Area, K-2 Impact Area, N1/BT-3 Impact Area, F-Ranges, Mobile MOUT Complex, and the Stones Bay Area. Primary MC evaluated during PR2 were HE, perchlorate, and lead.

ORA Findings

Marine Corps Base Camp Lejeune Periodic Review 2 (PR2) concluded that the MC source-receptor pathways are incomplete for groundwater, surface water, and soil, indicating there is no known off-range migration of MC (lead, high explosives [HE], perchlorate) that presents a potential unacceptable risk to human or environmental health. Potential for off-range migration of MC is limited due to periodic range clearance activities, use of bullet traps at multiple small arms ranges, and distance between human and environmental receptors to source areas. Sampling conducted in previous periodic reviews as well as during PR2 further confirmed incomplete MC source-receptor pathways.

Next Steps

The operational ranges will be reassessed during the next REVA PR (5 years), or sooner if there are changes to site conditions or training.



Range Assessment Overview

Scope and Previous Assessment: The REVA PR2 evaluated munitions use at MCB Camp Lejeune from 2015 to 2022. The previous REVA study (PR1) concluded there was no immediate threat to off-range receptors due to MC migration from operational ranges.

Approach: REVA uses a Conceptual Site Model (CSM) to inform decision making. A complete CSM pathway consists of an MC source (lead, HE, and/or perchlorate), transport mechanism of MC to an off-range exposure media, and receptor interaction with the off-range media. For PR2, data were collected to update the previous CSM (2011-2014). This included reviewing operational ranges and any changes in range use, migration pathways, and off-range receptors.

Source: MC source areas were identified at 26 individual ranges and 6 impact areas into which multiple range facilities fire. These MC source areas are located in 10 of 11 subwatersheds within MCB Camp Lejeune’s range boundaries.

Transport Mechanisms: A CSM transport mechanism is a method in which MC in the secondary source/media (surface water or surface soil in the MC deposition area) travels to exposure media (surface water, sediment, surface soil, or groundwater) off-range. The identified transport mechanisms for MC to potentially travel off-range at MCB Camp Lejeune include (1) through surface water and sediments via hydraulic connection, current or flow and/or (2) infiltration and percolation through groundwater.

Off-Range Receptors: A potential exposure pathway for human receptors is present through groundwater as it is a possible drinking water source and can be consumed via ingestion/incidental ingestion. Surface water presents a potential pathway for human exposure as well, primarily through dermal contact and incidental ingestion.



MCB Camp Lejeune

= installation boundary

Ecological special status species and their habitats are present, including the red-cockaded woodpecker, rough-leaved loosestrife, American alligator, and bald eagle. Surface water and sediment/soil are both potential exposure pathways for ecological receptors as the surface water and sediments comprise these species’ habitats. No direct ecological receptors were identified for groundwater.

Results: The CSM pathways were determined to be incomplete for migration of all MC to off-range receptors. Initial analyses determined CSM pathways to be unviable for MC source areas located within 5 of 11 subwatersheds. Surface water, sediment, and soil samples collected at or near range boundaries within the remaining 6 of 11 subwatersheds confirmed no known MC migration within those watersheds that pose an unacceptable risk to human health and the environment.

Conclusion: The REVA PR2 for MCB Camp Lejeune concludes there is no known MC off-range migration that creates an unacceptable risk to human health or the environment. The operational ranges will be reassessed during the next REVA Periodic Review.

For more information, contact Ian Thompson (ian.thompson@usmc.mil).

For more information on the DoD Operational Range Assessment Program, visit <http://www.denix.osd.mil/sri/home/>