

FINAL

Range Compatible Use Zones (RCUZ) Study
Marine Corps Base Camp Lejeune, North Carolina

September 2014

02:EE-002958-0006-02TTO

RANGE COMPATIBLE USE ZONES (RCUZ) STUDY

MARINE CORPS BASE CAMP LEJEUNE, NORTH CAROLINA

SEPTEMBER 2014

Prepared by

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This study was completed for the
United States Marine Corps
Marine Corps Base Camp Lejeune
Jacksonville, North Carolina
under
Naval Facilities Engineering Command – Atlantic
Contract #N62470-10-D-2024

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ACRONYMS AND ABBREVIATIONS

"	inch
°	degree
AAV	Amphibious Assault Vehicle
ADNL	A-weighted Day-Night Average Sound Level
AGL	above ground level
AICUZ	Air Installations Compatible Use Zones
AIWW	Atlantic Intracoastal Waterway
ALZ	administrative landing zone
ANSI	American National Standards Institute
APZ	accident potential zone
ARTCC	Air Route Traffic Control Center
ASP	ammunition storage point
ATC	Air Traffic Control
BASH	bird/wildlife aircraft strike hazards
BNOISE2	Blast Noise Version 2
BO	Base Order
BP	Battle Position
CAMA	Coastal Area Management Act
CAS	close air support
CDNL	C-weighted Day-Night Average Sound Level
CFA	Controlled Firing Area
CFR	Code of Federal Regulations
CIP	Capital improvement program
CMP	Combat Marksmanship
CPLO	Community Plans and Liaison Officer
CQB	close quarters battle
CY	Calendar Year
CZ	clear zone
dB	decibels
dBA	A-weighted decibels

dBC	C-weighted decibels
dBPk	Peak Sound Pressure Level
DNL	Day-Night Average Sound Level
DOD	United States Department of Defense
DODIC	Department of Defense Identification Code
DON	United States Department of the Navy
EA	Environmental Assessment
EFV	Expeditionary Fighting Vehicle
EIS	Environmental Impact Statement
EMI	electromagnetic interference
EOD	Explosive Ordnance Disposal
ETA	Engineer Training Area
ETJ	extra-territorial jurisdictions
FAA	Federal Aviation Administration
FAC	Forward Area Controller
FOB	Forward Operating Base
FY	Fiscal Year
GIS	Geographic Information System
GP	gun position
GSRA	Greater Sandy Run Area
HE	high-explosive
HUD	United States Department of Housing and Urban Development
Hz	hertz
IFR	Instrument Flight Rules
IP	Initial Points
JLUS	Joint Land Use Study
JSF	Joint Strike Fighter
LAV	Light Armored Vehicle
Ldnmr	onset rate-adjusted Day-Night Average Sound Level
L_{max}	Maximum Sound Level
MAC	Military Operations in Urban Terrain Assault Course
MAGTF	Marine Air/Ground Task Force
Marine Corps	United States Marine Corps
MARSOC	Marine Forces Special Operations Command
MCAS	Marine Corps Air Station

MCB	Marine Corps Base
MCO	Marine Corps Order
MCOLF	Marine Corps Outlying Landing Field
MEU	Marine Expeditionary Unit
MILCON	Military Construction
mm	millimeter
MOA	Military Operations Area
MOUT	Military Operations in Urban Terrain
MP	mortar position
MSA	Metropolitan Statistical Area
MSL	mean sea level
MTR	military training route
MWR	morale, welfare, and recreation
NATO	North Atlantic Treaty Organization
Navy	United States Department of the Navy
NCCC	North Carolina Commanders Council
NCMAC	North Carolina Military Affairs Commission
NEPA	National Environmental Policy Act
NLR	Noise- level reduction
NSFS	Naval Surface Fire Support
OEA	Office of Economic Adjustment
OLF	outlying landing field
OPNAVINST	Chief of Naval Operations Instruction
ORM	operational risk management
PAO	Public Affairs Officer
PDR	purchase of development rights
PDZ	parachute drop zone
RA	Restricted Area
RAICUZ	Range Air Installations Compatible Use Zone
RCUZ	Range Compatible Use Zone
RCZ	Range Compatibility Zone
RFMSS	Range Facility Management Support System
RMTK	Range Managers Toolkit
RNM	Rotorcraft Noise Model
RTA	range training area

SARNAM	Small Arms Range Noise Assessment Model
SAT	stationary armor target
SEL	Sound Exposure Level
SFCP	shore fire control party
SOC	Special Operations Capable
SOP	Standard Operating Procedure
SOUM	Safety of Use Memorandum
SRR	special range request
SUA	Special Use Airspace
TDR	transfer of development rights
TECOM	Training and Education Command
TLZ	tactical landing zone
TOW	tube-launched, optically tracked, wire-guided
U.S.C.	United States Code
UCAS	Urban Close Air Support
USAPHC	United States Army Public Health Command
VCP	Vehicle Check Point
VFR	Visual Flight Rules
WDZ	weapon danger zone

Executive Summary

This Range Compatible Use Zones (RCUZ) Study for Marine Corps Base (MCB) Camp Lejeune, North Carolina, promotes compatibility between existing and proposed land uses and military air-to-ground and ground-to-ground training operations carried out at the installation. Incompatible development surrounding MCB Camp Lejeune can restrict training operations due to public safety and welfare hazards, thus obstructing the mission of the installation.

The purpose of this RCUZ Study is to determine where current and projected training operations may limit land uses and to suggest strategies to promote compatible development, allowing the potential of the land to be realized without hampering current or future training operations or exposing the public or installation personnel to unnecessary annoyance or risk.

This RCUZ Study uses noise and safety analyses to identify where current or projected military training operations can affect human health and safety or cause community annoyance due to noise levels associated with training at the installation. Using standard United States Department of Defense (DOD) computer-based models and operations data from MCB Camp Lejeune, noise zones and range compatibility zones (RCZs) were identified in accordance with Marine Corps Order (MCO) 3550.13, *Marine Corps Installations Range Compatible Use Zones (RCUZ) Program*.

The MCB Camp Lejeune RCUZ Study analyzed operations in the air, on land, and at sea to determine areas of current and future incompatibility in relation to potential noise and safety impacts from range training operations. Current operations, as well as prospective operations estimated between now and 2020, were analyzed and modeled to develop noise zones and RCZs for noise and safety impacts, respectively.

All ranges and impact areas at MCB Camp Lejeune were within the scope of this effort. Principal ranges included, but were not limited to, the Greater Sandy Run Area (GSRA), the K-2 Impact Area, the G-10 Impact Area, the N-I/BT-3 Impact Area, and the Engineer Training Areas (ETAs).

The noise zones and RCZs developed for MCB Camp Lejeune were then superimposed over local land use data to identify areas of current and potential future incompatibilities. A number of areas were identified as having land uses that may be incompatible. Off-installation areas of potential incompatibilities include:

- Areas to the south of Highway 24 and east of Highway 172;
- North of Highway 24 in the town of Hubert;
- West of Highway 17 near the intersection of High Hill Road;
- East of Highway 172 near the community of Bear Creek; and
- South of Stone Bay near Snead's Ferry.

In addition, projected land uses for the areas surrounding MCB Camp Lejeune show the potential for more incompatible land uses to develop at low, medium, or high densities within off-Base RCUZ areas that may be impacted by noise from training operations.

It is recommended that MCB Camp Lejeune and Onslow County utilize the results of this study to continue their long history of collaboration to maintain the viability of the installation while minimizing encroachment. Specific suggested measures and strategies for mitigating noise and safety impacts on incompatible land uses and precluding future incompatible development are identified in Section 7 of this RCUZ Study. Key recommendations include the following:

- Encourage compatible land use zoning and development and implement noise level reduction measures, both on and off the installation;

- Incorporate RCUZ Study results and recommendations into MCB Camp Lejeune Master Planning documents;
- Encourage the use of noise and safety disclosure statements in off-installation real estate transactions;
- Disseminate RCUZ information to banking and financial institutions that provide loans for real estate acquisition and development; and
- Disseminate relevant information about MCB Camp Lejeune's training operations to the local government officials, businesses, and the public.

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1

Introduction

1.1 Background

In 1998, the United States Department of the Navy (DON; *also* Navy) instituted the Range Air Installations Compatible Use Zones (RAICUZ) program to protect public health, safety, and welfare, and to prevent encroachment from degrading the operational capability of air-to-ground ranges. RAICUZ studies primarily focus on air-to-ground ordnance training; however, because United States Marine Corps (Marine Corps) ranges typically conduct both air-to-ground and ground-to-ground live-fire combat training, the Marine Corps expanded the RAICUZ concept to encompass both types of live-fire training and developed the Range Compatible Use Zones (RCUZ) program.

The RCUZ program encourages mutual coordination between range installations and neighboring communities to increase public awareness of the importance of range operations and the need to address mission requirements and associated noise and risk factors. As the communities that surround a range grow and develop, the Marine Corps has the responsibility to communicate with local governments regarding land use planning, zoning, and mission impacts. To be most effective, the RCUZ program requires that the installation command collaborate with nearby communities, as well as federal, state, regional, and local agencies, to prevent incompatible development both within and adjacent to the installation.

1.2 RCUZ UPDATE

Every Marine Corps installation with a live-fire training component must complete an RCUZ Study. This document represents the first approved RCUZ Study for Marine Corps Base (MCB) Camp Lejeune. As recently as 2008, the installation initiated the RCUZ Study process; however, the RCUZ Study process was delayed in consideration of substantial military construction (MILCON) projects at the installation.

This study has been prepared in consideration of expected changes in mission and projected operational levels that will occur through calendar year (CY) 2020 at MCB Camp Lejeune. As the training mission at MCB Camp Lejeune continues to evolve, the installation will conduct updates to this RCUZ Study, as required.

The goal of the RCUZ Program is to protect military operational capabilities while also protecting the health, welfare, and safety of the public.

1.2.1 Purpose and Need

Under Marine Corps Order (MCO) 11011.22C, installation Commanders are required to establish an Encroachment Control program to prevent incompatible development of land adjacent to military training ranges. RCUZ studies provide the basis for the installation's Encroachment Control program.

The purpose of the RCUZ program is to help local communities identify land uses that are compatible, as well as incompatible, with noise zones and Range Compatibility Zones (RCZs) associated with military aviation range and/or military ground range operations. RCUZ studies analyze community development trends, land use tools, and mission requirements at a military range to develop recommended strategies that will protect the long-term viability of the range, while maintaining a high degree of public safety. RCUZ recommendations are based on the impacts of noise, safety considerations, and economic considerations related to public funds and local economic sustainability.

1.2.2 Scope

This RCUZ Study was prepared in accordance with Navy and Marine Corps guidelines under the instructions of MCO 3550.13, titled *Marine Corps Installation Range Compatible Use Zones Program* (Appendix A). MCO 3550.13 guides the determination of compatible land use recommendations for all Marine Corps installation ranges.

The scope of this RCUZ Study includes:

- Noise levels generated by aircraft, air-to-ground ordnance, and ground-to ground ordnance and their resulting weapons impact and detonation;
- A range safety analysis and description of RCZs associated with live-fire operations across all training ranges;
- Guidelines for compatible land uses in various noise and safety zones;
- Descriptions of existing and future land use on- and off-base and land use controls;
- An analysis of existing and future land use compatibility within noise zones and RCZs;
- Possible solutions to existing and potential incompatible land use issues; and,
- Partnering opportunities with appropriate federal, state, and local government agencies to promote compatible land use near and around the ranges.

1.2.3 Study Methodology

This RCUZ Study for MCB Camp Lejeune focuses on noise and safety impacts related to weapons delivery across the entire installation. In support of the RCUZ Study, the Marine Corps completed a noise study and a safety study for the installation in 2013. Noise and safety modeling are based on the input of the Marine Corps subject matter experts, as well as Navy and Marine Corp instructions, environmental studies, and standard operating procedures (SOPs).

A baseline of current operations was developed from data collected during interviews with MCB Camp Lejeune personnel. Installation personnel reviewed baseline conditions, and projected how each operation could change through CY 2020 as operational tempos changed, new vehicles and weapons were introduced, and as legacy systems were removed from the Marine Corps inventory. Operations used to model the 2014 RCUZ noise contours and RCZs are based on projected conditions at MCB Camp Lejeune through CY 2020.

The noise analysis uses multiple computer modeling applications to generate noise contours that reflect the sound levels associated with live-fire training operations at MCB Camp Lejeune. Noise modeling was completed for both small caliber arms and large caliber arms training activities[1]. These noise contours are visual depictions of the noise associated with ordnance operations that generate blast noise from large caliber ground-to-ground fire, small arms caliber fire, air-to-ground fire, projectile detonations (if they contain a high-explosive [HE] charge), and associated noise from projectile bow shock for supersonic projectiles. The noise contours and additional details on the methodology used to model noise at MCB Camp Lejeune are discussed in Chapter 5 of this RCUZ Study.

To assess safety hazards associated with air-to-ground ordnance delivery and incompatible property uses surrounding MCB Camp Lejeune, weapon danger zones (WDZs) were developed for each aircraft/ordnance/target combination using the United States Department of Defense's (DOD's) WDZ Tool (version 9.2.0.4.16.1). WDZs define the areas of potential safety hazard based upon containment of ordnance, fragments, ricochets, and debris, but they do not define the risk associated with the operation. The WDZ Tool incorporates a weapons database, a digitized range database, and an impact probability distribution function.

To assess safety hazards at MCB Camp Lejeune, WDZs were modeled for all air-to-ground operations, and SDZs were developed for all ground-to-ground and air-to-ground live-fire missions.

Surface danger zones (SDZs) were developed by MCB Camp Lejeune's Range Safety Department. Similar to WDZs, SDZs depict the lateral safety limits associated with ground-to-ground and ground-to-air firing of weapon

[1] Large arms include all weapons systems greater than .50 caliber as well as explosives. Small caliber ordnance are weapon systems firing ammunition less than or equal to .50 caliber.

systems at the installation. SDZs and WDZs were then combined to develop RCZs for the installation. Further discussion on WDZ and SDZ methodologies and modeling results and the RCZs are discussed in Chapter 4.

The RCZs and noise contours were overlaid with local land use data to identify existing and potential areas of incompatibility using the specific guidance for identifying incompatibility provided in MCO 3550.13. Chapter 6 of this RCUZ Study provides a comprehensive analysis of land use compatibility concerns.

1.2.4 RCUZ Study Objectives

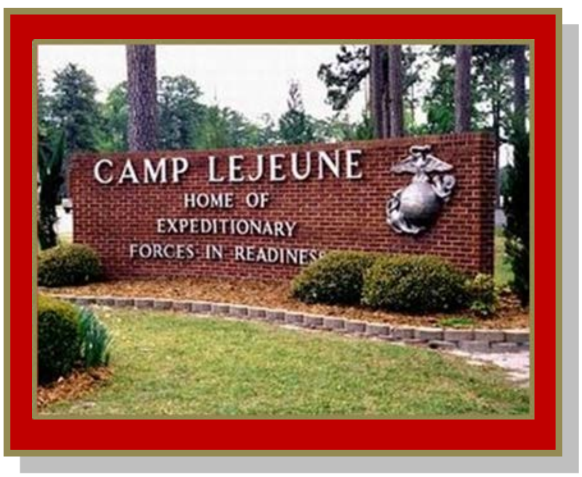
The main objective of the RCUZ program is to promote compatible land use within the range environs, both on-base and off-base, in order to:

- Minimize public exposure to hazards and noise associated with operations in Marine Corps range training areas (RTAs);
- Protect DON investments by safeguarding current and potential operational capabilities of the RTAs, and protect the public health, safety, and welfare;
- Promote compatible land use within the RCZs, to the extent practicable;
- Inform the public about the RCUZ program and seek cooperative efforts to minimize encroachment; and
- Establish and foster working relationships between the Commanding Officer and appropriate federal, state, and local agencies and stakeholders to contribute to mutual communication regarding proposed actions that could affect public health, safety, and welfare, as well as operational and training capabilities and compatible land use recommendations.

1.2.5 Document Organization

Chapter 1 of this MCB Camp Lejeune RCUZ Study includes an installation and programmatic overview, and identifies the roles and responsibility for implementing the RCUZ program. Chapter 2 provides a description of the ranges and airspace that comprise the training area, and Chapter 3 describes the operations and training activities that occur at the installation. Chapters 4 and 5 present the updated RCZs and noise zones, respectively. In Chapter 6, the RCZs and noise zones are compared to land uses within the surrounding community to identify current and future potential areas of incompatibility. Recommendations for achieving compatible land use in the future are outlined in Chapter 7, and a list of references used in this RCUZ Study is provided in Chapter 8.

1.3 LOCATION



MCB Camp Lejeune is located along North Carolina's Atlantic coastline in Onslow County, just south of the city of Jacksonville (Figure 1-1). The New River provides a natural divide that separates the Greater Sandy Run Area (GSRA) and western training ranges from the eastern side of MCB Camp Lejeune. Training areas and administrative facilities are located in the eastern side of the installation.

MCB Camp Lejeune encompasses approximately 156,000 acres and includes 11 miles of beaches. The unique location of the installation and the structure of the land, air, and maritime training areas afford the Marine Corps with the capability to train as they fight in a multi-dimensional training battle space. MCB Camp Lejeune provides an essential training area for Marines preparing for operations in amphibious, coastal, and urban environments.

Figure 1-1
Regional Location Map
MCB Camp Lejeune
North Carolina

Source:
ESRI, 2010

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1.4 Military Mission

The primary mission of MCB Camp Lejeune is to maintain combat-ready units for expeditionary deployment. Today, MCB Camp Lejeune supports more than 47,000 Marines and sailors serving major commands, including the II Marine Expeditionary Force, II Marine Expeditionary Force Augmentation Command Element, Marine Forces Special Operations Command (MARSOC), 2nd Marine Division, Reserve Support Group, Marine Corps Base, School of Infantry, 2nd Marine Logistic Group, and the 4th Marine Expeditionary Brigade (Anti-terrorism), as well as other tenant commands.

MCB Camp Lejeune provides the necessary rural, urban, and riverine training environments required by Marine Air/Ground Task Forces (MAGTFs) and Marine Expeditionary Unit (MEU) (Special Operations Capable [SOC]). MEU SOCs provide the President and the unified combatant commanders with forward-deployed units that can conduct a variety of quick-reaction, sea-based, crisis-response options either in a conventional amphibious/expeditionary role or in the execution of maritime special operations.

1.5 Responsibilities for Compatible Land Use

Military installations and local government agencies with planning and zoning authority share the responsibility for preserving land use compatibility near the installations. Installation commands, which are responsible for the ranges, are encouraged to participate in partnering efforts with adjacent landowners, users, community councils, commissions, and planning and zoning agencies. Cooperative action by all parties is essential in preventing land use incompatibility and encroachment.

Table 1-1 identifies roles and responsibilities shared by the Marine Corps, state and local governments, and various community stakeholders.

Table 1-1: Responsibilities for Compatible Land Use

Marine Corps	➢ Examine the air mission for operations changes that could reduce impacts. ➢ Conduct noise and safety studies and develop RCUZ maps. ➢ Examine local land uses and growth trends. ➢ Actively participate in the land use planning process. ➢ Release an RCUZ Study and update the study as required. ➢ Work with local governments and private citizens. ➢ Monitor operations and address noise concerns.
State and Local Government	➢ Incorporate RCUZ guidelines into a comprehensive development plan and zoning ordinance. ➢ Regulate height and obstruction regulations ➢ Regulate acoustical treatment in new construction. ➢ Require fair disclosure in real estate for all buyers, renters, lessees, and developers.
Builders/Developers	➢ Develop properties in a manner that appropriately protects the health, safety, and welfare of the civilian population by constructing facilities that are compatible with aircraft operations (e.g., sound attenuation features, densities, and occupational noise considerations).
Real Estate Professionals	➢ Ensure potential buyers and renters receive and understand RCUZ information on affected properties.
Private Citizens	➢ Seek information and self-education on the established zones and the impacts they may have for individuals. ➢ Identify RCUZ considerations in all property transactions. ➢ Understand RCUZ effects before buying, renting, leasing, or developing property.

1.5.1 Federal Authority

Authority for the establishment and implementation of the RCUZ process is derived from:

➢ The Noise Control Act of 1972 (42 U.S.C. 4901 et seq.), which seeks to protect Americans from "noise that jeopardizes their health or welfare" and directs federal agencies to further this policy with their programs;

- MCO 11011.22B, dated 27 July 2010, which establishes responsibility for control of encroachment on Marine Corps operations and real property; and
- MCO 3550.13, which establishes the RCUZ program and details specific responsibilities for land use compatibility within the Marine Corps.

1.5.2 Community Authority

While the Marine Corps can make recommendations and advise community decision makers on land use compatibility, the ultimate responsibility for preserving land use lies with local governments.

The Marine Corps can provide recommendations or advise community decision makers regarding land use compatibility; however, local governments have ultimate authority for preserving land use compatibility near the installation.

Local governments manage land use and future growth through zoning regulations, land use plans/comprehensive plans, subdivision regulations, and building codes. These planning tools define standards to restrict or permit land uses, density, and development. Elected city or county legislators enact zoning laws and appoint agencies/boards to review proposed development and administer zoning regulation provisions. Although land use activities directly outside an installation's fence line can impact DOD operations, the use and development of the surrounding properties are under the jurisdiction of local governments. Planning and zoning authority for land uses around MCB Camp Lejeune is predominantly within the jurisdiction of the City of Jacksonville, or Onslow County for all unincorporated areas.

The State of North Carolina also has a role in land use planning for military installations. North Carolina General Statutes 153A-323(b) and 160A-364, as amended in 2013, require that counties and cities provide written notice to the installation Commander (or Commander's designee) of:

- Proposed changes to zoning;
- Proposed changes to permitted uses of land;

- Changes related to telecommunication towers or windmills;
- New major subdivision preliminary plats; or
- Changes that increase the size of an approved subdivision by more than 50 percent of the subdivision's total land area.

Written notification is required for any of these proposed changes within 5 miles of the perimeter boundary of a military installation at least ten days prior to the public hearing date. The installation may provide comments within 30 days of the notice.

North Carolina General Statutes Chapter 143, Article 9G (Military Lands Protection Act of 2013) requires a written letter of endorsement from the State of North Carolina's Building Code Council prior to constructing a building or structure[2] greater than 200 feet tall within the 5-mile area beyond the boundary of a major installation (including MCB Camp Lejeune). Endorsement applicants must send a copy of their notice of intent to all military installations within 5 miles of the proposed structure/building, as well as obtain a written "Determination of No Hazard to Air Navigation" issued by the Federal Aviation Administration (FAA) pursuant to Subpart D, Part 77, Title 14 of the Code of Federal Regulations (CFR). The Building Code Council is required to solicit a written statement from the installation Commanding Officer determining if the proposed structure would adversely affect military operations or interfere with air navigation routes, Air Traffic Control (ATC) areas, military training routes (MTRs), or radar.

[2] Wind energy facilities and temporary cellular and television towers erected to replace towers damaged in a natural disaster are exempt from this requirement.

2

Range and Airspace Overview

This chapter provides background on the training areas within MCB Camp Lejeune that are the focus of this study. This chapter includes details about the history and location of the ranges and their ordnance and airspace operations.

2.1 HISTORY

Construction of Marine Barracks

MCB Camp Lejeune began as a tent camp in 1940. After the outbreak of World War II, the DOD identified the need for an East Coast amphibious training facility and purchased an 110,000-acre tract of land south of Jacksonville, Onslow County, North Carolina. The DOD chose the site due to its proximity to the ports at Wilmington and Morehead City and because the remote pine forests and miles of beaches were appropriate training environments for the Marines. The Base was officially established on May 1, 1941, as Marine Barracks New River. At the end of 1942, the Base was renamed Camp Lejeune in honor of Lieutenant General John A. Lejeune, Commander of the Marines in France during World War I and later the 13th Commandant of the Marine Corps.

Various training facilities and ranges were constructed at MCB Camp Lejeune by the end of 1942, including the Artillery Training Area, Infantry Combat Range (Tank and Anti-Tank), Stone Bay Rifle Range, Boat Gun and Anti-Boat Gun Ranges, and Anti-Aircraft and 5-inch Gun Range. Maneuver areas were also located throughout the installation. In 1944, 2,600 acres of the MCB Camp Lejeune property were delineated for the Peterfield Point Air Station, which is now Marine Corps Air Station (MCAS) New River. By the 1950s, Camp Lejeune had designated artillery impact areas within the range boundary, as well as over the Atlantic Ocean. These areas remain in use today and have expanded in size over the years to accommodate new weapons. Further descriptions of the MCB Camp Lejeune's impact areas are provided in Section 2.2.1.

As World War II tactical theories evolved from extensive beach operations to vertical envelopment warfare, new training ranges, and facilities were developed with accompanying airspace to support various tactical air operations with new types of amphibious assault. The types and configurations of training facilities at MCB Camp Lejeune evolved further as the Marines trained for wars in Korea, Vietnam, and Kuwait and for various noncombatant evacuation operations throughout the past decade.

In 1992, the DOD acquired the GSRA. The additional 41,000 acres of land west of MCB Camp Lejeune was necessary to expand training areas and to develop additional firing ranges. Marine Corps Outlying Landing Field (MCOLF) Camp Davis, a former Army airfield complex, was included as an additional asset with the GSRA acquisition (Figure 2-1).

2.2 Range Descriptions

Contained within MCB Camp Lejeune's installation boundaries are three large impact areas and more than 80 live-fire training ranges, allowing for the use of the majority of the weapon systems employed by the Marine Corps. In addition, the installation has several Military Operations in Urban Terrain (MOUT) facilities, 28 artillery and eight mortar positions, Engineer Training Areas (ETAs), and Explosive Ordnance Disposal (EOD) areas, and the capability

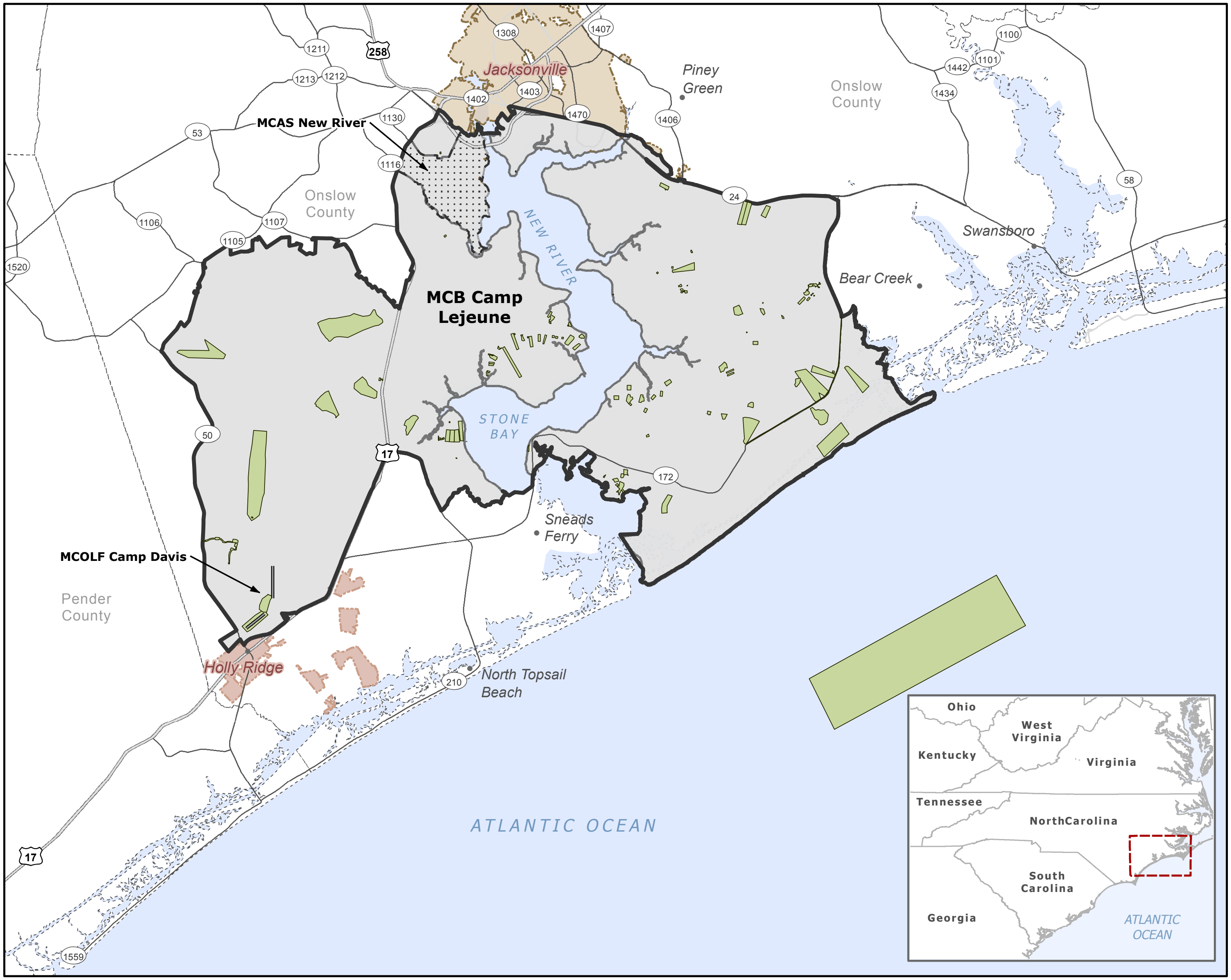

Figure 2-1
MCB Range Complex
Camp Lejeune
North Carolina

MCB Camp Lejeune Boundary
MCAS New River
Range Boundary
Runway
Town of Holly Ridge
City of Jacksonville
County Boundaries
Water Bodies

Source:
ESRI, 2010; Onslow County, 2011.

0 1 2 4 Miles
0 1.5 3 6 Kilometers

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to conduct air-to-ground and ground-to-ground training at select ranges and impact areas. In addition, MCB Camp Lejeune is authorized to conduct Naval Surface Fire Support (NSFS) missions, which enhances combined Navy and Marine Corps readiness in honing operations using ship-to-shore gunnery. The following sections identify training range and Special Use Airspace (SUA) features that are part of this RCUZ Study.

2.2.1 Impact Areas

Figure 2-1 is a depiction of the entire MCB Camp Lejeune installation indicating some of the larger ranges and weapons impact areas. The major impact areas are K-2, G-10, and N-1/BT-3. In addition, the GSRA, which is located on the western side of the installation, contains ranges SR-6, SR-7, SR-8, SR-9, SR-10, and SR-11.

2.2.1.1 K-2 Impact Area

The K-2 Impact Area is located between the GSRA and the New River, with its southern border located on the western bank of the New River (Figure 2-2). The K-2 Impact Area is primarily used as a familiarization range and alternatively used as an Infantry Weapons and Mortar Range.

The K-2 Impact Area has an SDZ, which is an area in which a hazard is known to exist. When artillery is being fired, the K-2 Impact Area restricts the use of other ranges in the MCB Camp Lejeune Range Complex and closes portions of the New River to boat traffic.

The K-2 Impact Area includes 23 ranges, 15 of which are used for heavy weapons, as well as small arms. Out-of-traverse artillery firing missions from artillery positions east of the New River are also authorized to utilize targets within K-2 Impact Area. No fixed-wing aircraft operations are permitted in the K-2 Impact Area; however, door gunnery from rotary-wing aircraft takes place within this area. Aircraft used for training operations in the K-2 Impact Area include the CH-53, MV-22, AH-1, and UH-1. Ranges that accommodate heavy weapons are summarized in Table 2-1.

Table 2-1: Range Descriptions for K-2 Impact Area

Range	Description
K-325	Combat Marksmanship Program Range
K-402	Fire and Maneuver Range
K-402A	House/Room Clearing Range
K-406A	Combat Marksmanship (CMP) Range
K-406B	Close Combat Range
K-407	Live Fire Ambush Range
K-408	Urban Obstacle Course
K-500	Mortar Range (60/81mm)
K-500A	MK-19 Grenade Launcher Range
K-501	M16/M4/M249 SAW Range
K-501A	M16/M4/M249 SAW BZO/Zero/CMP Range
K-502	Light Anti-Armor (Sub-Cal only) Weapons and Shoulder Launched Multi-Purpose Assault Tracking Range
K-503	CMP BZO
K-504A/B	M203 Practice and Live
K-505	Live Rocket (Anti-Armor) Range
K-506	CMP Range
K-507	CMP Range
K-508	CMP Range
K-509	Infantry Squad Battle Course

2.2.1.2 G-10 Impact Area

The G-10 Impact Area is a multi-purpose range on the eastern side of MCB Camp Lejeune that allows for the use of air-to-ground weapons as well as ground-based weapons and NSFS (Figure 2-3). This area accommodates indirect artillery firings, infantry weapons, select aviation ordnance, and laser operations. Both fixed-wing and rotary-wing aircraft are authorized to train in the G-10 Impact Area. Some dud-producing ammunition is authorized (e.g., rockets); however, HE-filled bombs area not permitted. Because the G-10 Impact Area serves as a dedicated impact area in which dud-producing ordnance may be delivered, no maneuvers are authorized, and no personnel are allowed to enter the area without an EOD escort.

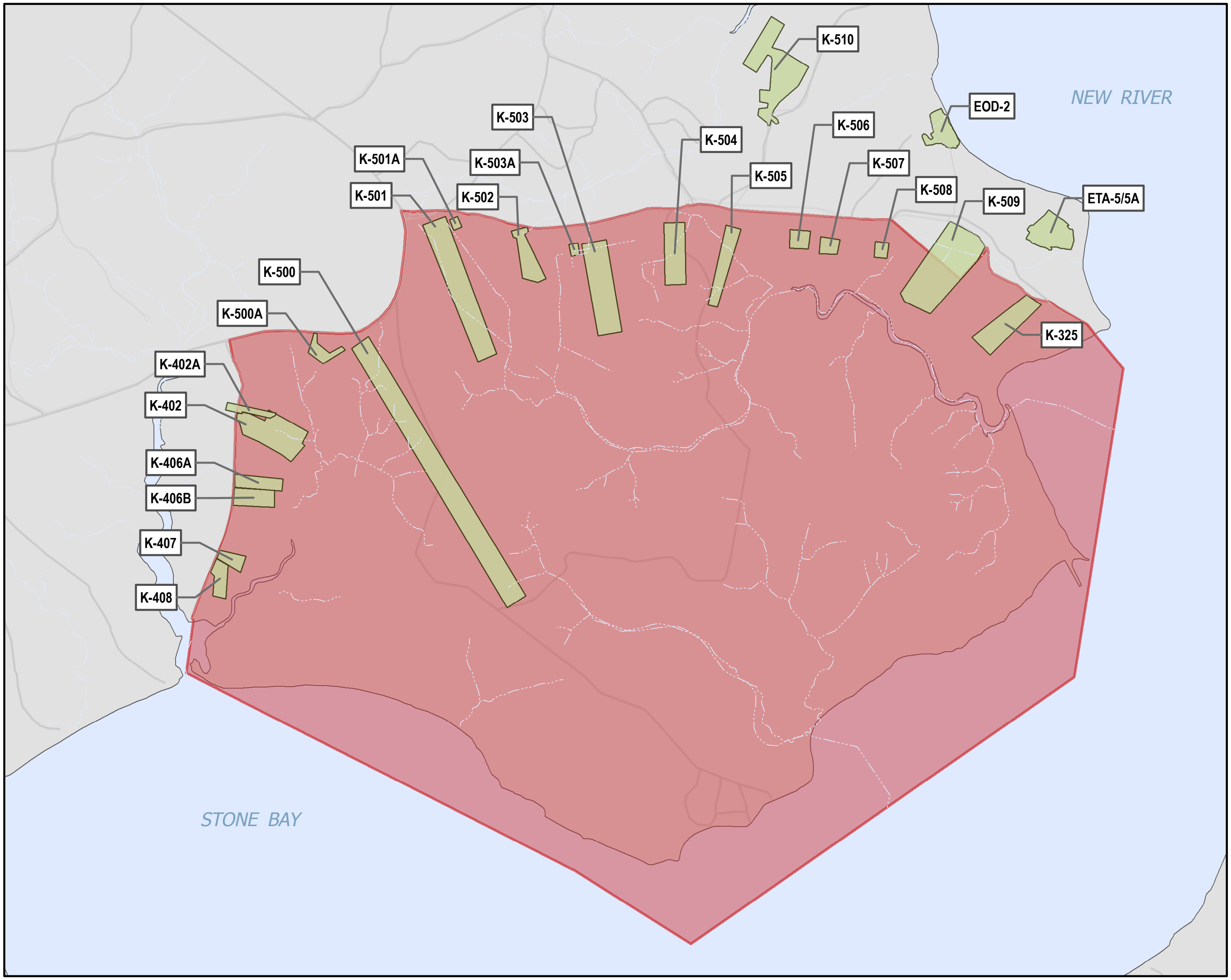
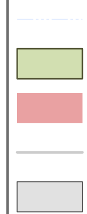
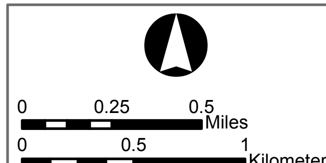


Figure 2-2
K-2 Impact Area
MCB Camp Lejeune
North Carolina



Source:
ESRI, 2010



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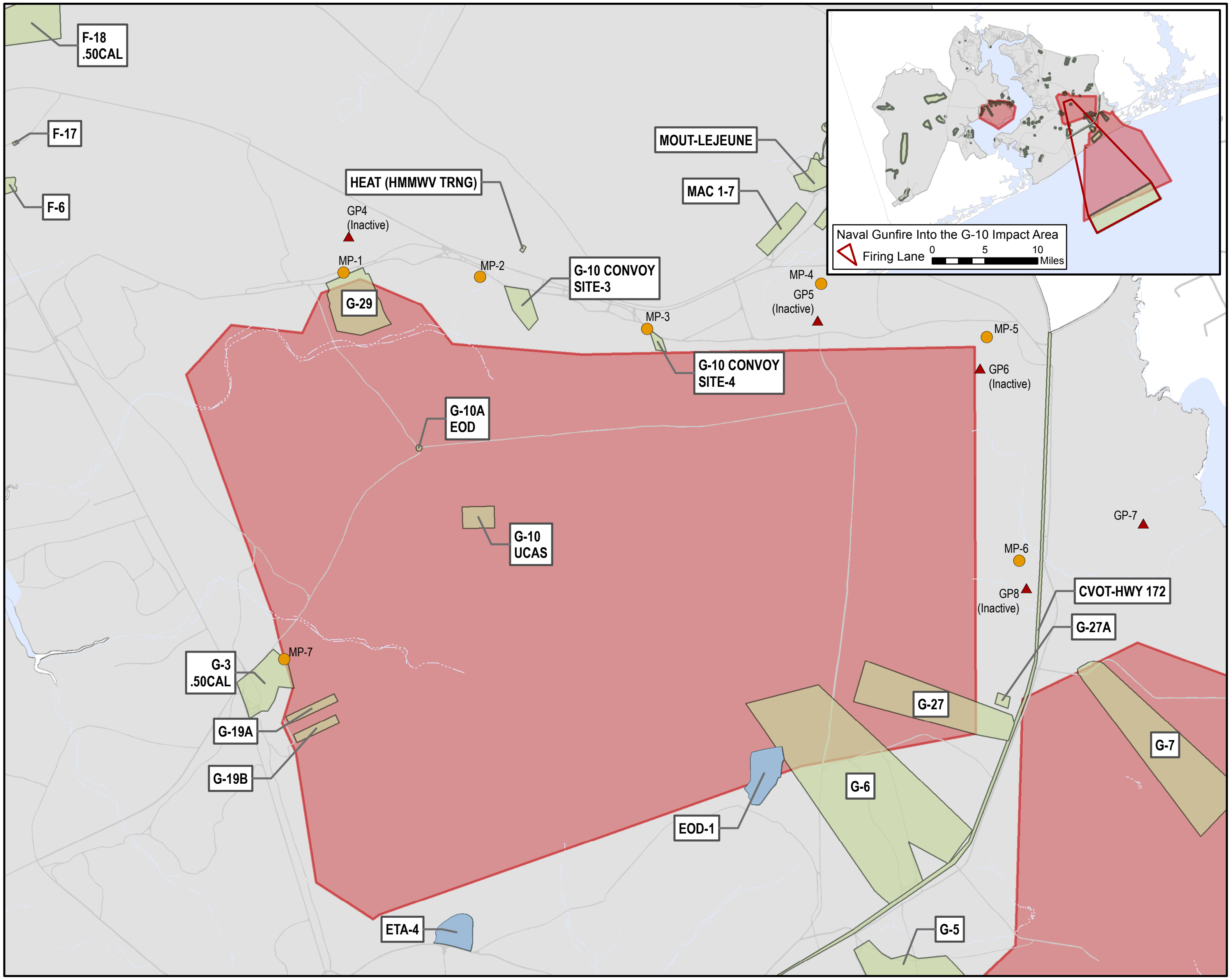

Figure 2-3
G-10 Impact Area
MCB Camp Lejeune
North Carolina

Artillery
Mortar
Road
Stream
Impact Area
Range Boundary
MCB Camp Lejeune
EOD/ETA Boundary

Source:
ESRI, 2010; Onslow County, 2011;
MCB Camp Lejeune

0 0.5 1 Miles
0 0.5 1 Kilometers

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The G-10 Impact Area comprises an impact area that encompasses 4,800 acres. Unprotected personnel and equipment are not permitted in either area due to probable risk of injury or damage. There are multiple targets within the G-10 Impact Area, and it is expected that targets will be added, removed, and relocated in the coming years. The G-10 Impact Area consists of vehicle hulks with intact drivetrains.

Multiple active fire ranges encircle the G-10 Impact Area: G-3, G-3A, G-6 Company Battle Course (CBC), G-10, G-19A, and G-19B (Table 2-2). Each range can support multiple direct and indirect fire weapon systems. Ranges G-3 and G-3A are oriented to support infantry weapons training evolutions with all ordnance impacting in the G-10 Impact Area. The G-6 CBC is a company-sized, combined arms, live-fire, and maneuver attack range. The G-10 Impact Area also includes the Urban Close Air Support Facility (UCAS) site.

The G-10 Impact Area was evaluated in 2002 for possible use for naval gunfire training, and naval gunfire training commenced that year. The training is related to indirect NSFS operations (i.e., naval gunfire directed at enemy targets that cannot be seen from a naval ship is termed indirect NSFS). For this training, Marine and Navy shore fire control parties (SFCPs), positioned at vantage points on land, guide naval ships by providing coordinates of the targets, thus becoming the “eyes” of the naval ships. SFCP training must be conducted with live ordnance to determine accuracy. The Marine Corps requires quarterly training for its East Coast-based SFCPs to ensure that the equipment and skills necessary to conduct effective, indirect NSFS are current. The training occurs approximately 30 times per year by DON ships pre-qualified in naval gunfire. Training normally takes place between 0700 and midnight, depending on the amount of daylight. Two 4-hour sessions, for a total of 8 hours within a 24-hour period, are authorized. During these hours, Highway 172 must be closed, along with the Atlantic Intracoastal Waterway (AIWW), in accordance with Base Order P3570.1.

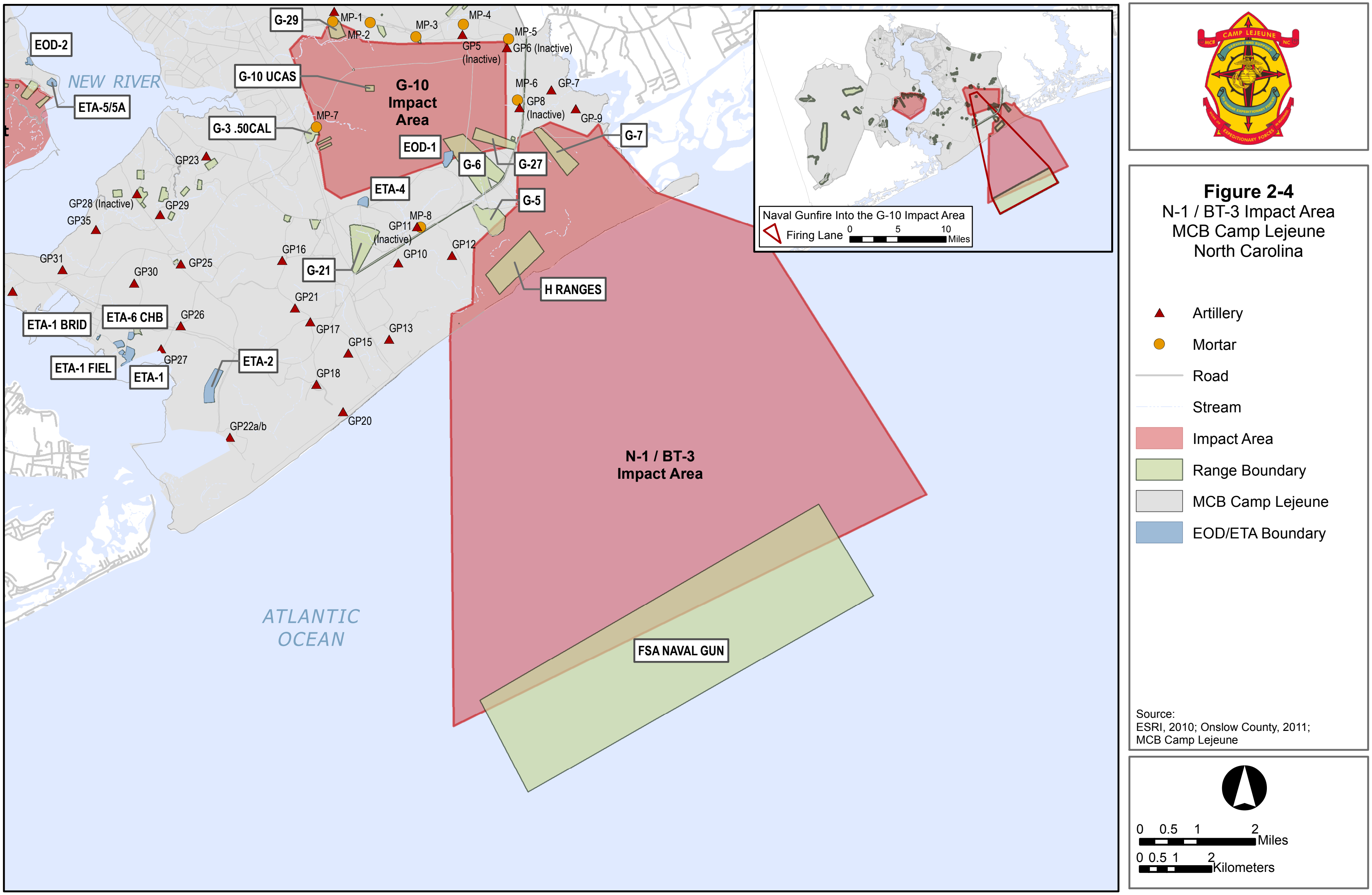
Table 2-2: Range Descriptions for G-10 Impact Area

Range	Description
G-3A	M257 Smoke Grenade Launcher System Range
G-6 CBC	Infantry Company Battle Course
G-10	Convoy Range
G-10A EOD	Explosive Ordnance Disposal Range (G-10 Impact Area)
G-10 UCAS	G-10 Urban CAS Training Facility
G-19A	Light Anti-Armor Weapons and Shoulder-Launched Multipurpose Assault Range
G-19B	Grenade Launcher Range
G-27	Infantry Squad Battle Course
G-29	Multi-range Tank/Rocket

Additionally, there are 28 designated artillery gun positions for firing 155-millimeter (mm) ammunition. There are also eight field mortar positions for 60mm, 81mm, and 120mm ammunition, from which indirect fire is delivered into the G-10 Impact Area. Air-to-ground weapons activity, known as Close Air Support (CAS), also takes place within the G-10 Impact Area.

2.2.1.3 N-1/BT-3 Impact Area

The N-1/BT-3 Impact Area, also known as Brown's Island, is a bomb and target range extending into the Atlantic Ocean from the southeast corner of MCB Camp Lejeune (Figure 2-4). The range is primarily used for boat-based gunnery in the AIWW. The range is alternately used as an air-to-ground weapons range, a field artillery direct fire range, a helicopter gunnery range, and a machine gun familiarization range. Night operations are authorized at the N-1/BT-3 Impact Area.



EOD-2
NEW RIVER
ETA-5/5A
G-29
MP-1
MP-2
MP-3
MP-4
MP-5
GP5 (Inactive)
GP6 (Inactive)
G-10 UCAS
G-10 Impact Area
MP-6
GP-7
GP8 (Inactive)
GP-9
MP-7
G-3 .50CAL
EOD-1
G-6
G-27
G-7
ETA-4
G-5
GP23
GP28 (Inactive)
GP29
GP35
MP-8
GP11 (Inactive)
GP16
GP12
GP10
G-21
GP31
GP30
GP25
H RANGES
GP21
GP26
ETA-6 CHB
ETA-1 BRID
GP17
GP13
GP15
GP27
ETA-1 FIEL
ETA-1
ETA-2
GP18
GP20
GP22a/b
N-1 / BT-3 Impact Area
ATLANTIC OCEAN
FSA NAVAL GUN
Naval Gunfire Into the G-10 Impact Area
Firing Lane
0 5 10 Miles
Figure 2-4
N-1 / BT-3 Impact Area
MCB Camp Lejeune
North Carolina
Artillery
Mortar
Road
Stream
Impact Area
Range Boundary
MCB Camp Lejeune
EOD/ETA Boundary
Source:
ESRI, 2010; Onslow County, 2011;
MCB Camp Lejeune
0 0.5 1 2 Miles
0 0.5 1 2 Kilometers

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Within the N-1/BT-3 impact areas, there are two impact areas. The first impact area is located in the Atlantic Ocean, and Range Control provides specific grid coordinate to a sector of the open ocean for aircraft to release inert munitions. These areas at sea can change and there are no permanent targets on the ocean. The second impact area is known as "Brown's Island." This barrier island system extends from the eastern fence line of MCB Camp Lejeune to the H-Range. This is a multi-purpose range that allows for the use of air-to-ground weapons as well as riverine, live-fire, direct field artillery, and machine gun training.

Table 2-3: Range Inventory and Weapons Accommodated at N-1/BT-3 Impact Area

Range	Description
E-1	Air Defense Firing Range
H-1	Waterborne Live Fire Range
G-5	Vehicle Convoy Range, Infantry Weapons Range, AAV/LAV Gunnery Range
G-7	Infantry Weapons Range, Field Artillery Direct Fire Range

2.2.2 Live-Fire Training Ranges

"Live-fire" consists of any training that involves the use of ammunition that fires a projectile. Projectiles can range from low-energy markers (similar to paint-ball) to shotgun and ball ammunition (i.e., traditional ammo).

Over 98,000 acres of land are dedicated to maneuver, live-fire, amphibious, and tactical training at MCB Camp Lejeune. Four main areas are designated for live-fire operations and training: the GSRA, the K-2 Impact Area, G-10 Impact Area, and the N-1/BT-3 Impact Area. Within these areas and others, MCB Camp Lejeune has over 98 live-fire ranges available to meet various training requirements. Appendix B, Table B-1, provides a brief description the live-fire ranges at MCB Camp Lejeune.

2.2.3 Artillery Firing Areas

At MCB Camp Lejeune, artillery is only permitted to be fired from designated and surveyed gun positions (GPs). The artillery GPs were surveyed by the 10th Marines and artillery weapons are not allowed to be fired from any other positions without authorization. Twenty-seven GPs are located at MCB

Camp Lejeune, with 24 currently active (Appendix B, Table B-2) and firing 155mm ammunition. The primary impact area for indirect artillery fire is at G-10 impact area. Direct fire is only authorized into the N-1/BT-3 Impact Area using range G-7.

2.2.4 Mortar Firing Positions

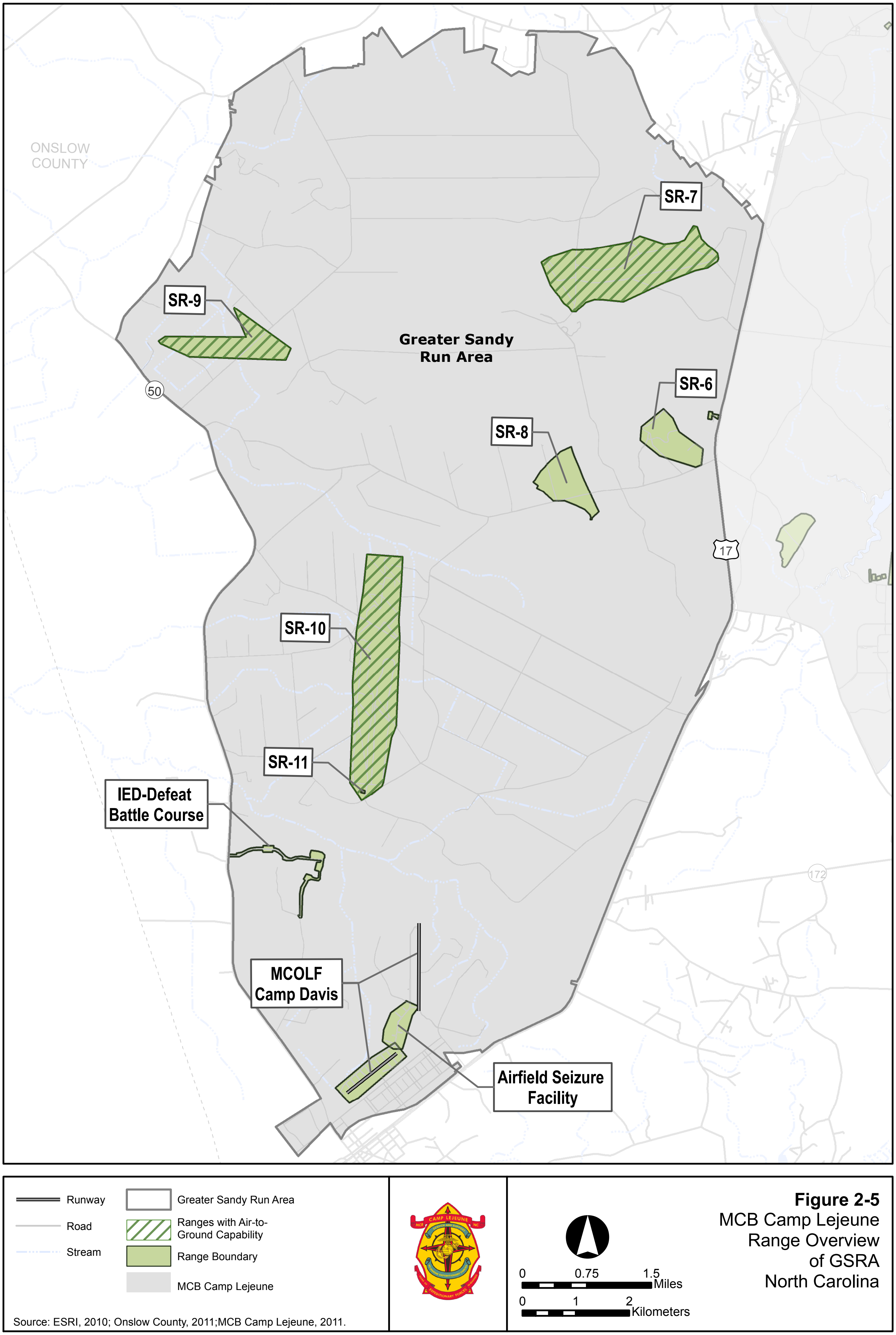
Eight field mortar positions (MPs) firing 60mm, 81mm, and 120mm ammunition are located at MCB Camp Lejeune (Appendix B, Table B-3). The minimum range is restricted to 300 meters for 60mm mortars, 400 meters for 81mm mortars, and 600 meters for 120mm mortars. Mortars are only permitted to be fired into the G-10 and K-2 impact areas.

2.2.5 Training Areas

2.2.5.1 Greater Sandy Run Area Ranges

The GSRA is a training and maneuver area located west of the New River that encompasses 41,000 acres (64 square miles) (Figure 2-5). The GSRA is bounded to the north by Dawson Cabin Road and Haws Run Road, to the west by Padgett Road and State Highway 50, and to the east by US Highway 17. MCOLF Camp Davis is located in the southern portion of the GSRA. Only rotary-wing and tilt-rotor aircraft are authorized to conduct air-to-ground weapons delivery at these ranges.

The GSRA training area contains two ranges used for air-to-ground weapons training, SR-7 and SR-10. At the time of data collection, a third air-to-ground range, SR-9, was in the planning stages and is now complete. SR-9 is not available for training at this time (September 2014), although the range is expected to be available by early 2015.



Source: ESRI, 2010; Onslow County, 2011;MCB Camp Lejeune, 2011.

Figure 2-5
MCB Camp Lejeune
Range Overview
of GSRA
North Carolina

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GSRA ground-to-ground ranges that accommodate heavy weapons are summarized in Table 2-4 and include the air-to-ground ranges, as well as SR-6, SR-8, and SR-11. These ranges primarily support Tank, Light Armored Vehicles (LAV), Amphibious Assault Vehicles (AAV), and infantry platoon training. SR-10 serves as the Tank Crew qualification range and SR-11 is the Baffled Pistol Range for individual qualifications. Also located within the GSRA is the Camp Davis Airfield Seizure Facility (Marine Corps 2011a). Dud-producing projectiles, ammunition, and ordnance, as well as pyrotechnics, are not authorized at any ranges within the GSRA.

Table 2-4: Range Descriptions for GSRA

Range	Description
SR-6	Infantry Platoon Battle Course
SR-7	Multi-purpose Training Range
SR-8	Multi-Purpose Machinegun Range (MPMG)
SR-9	Multi-purpose Range Complex
SR-10	Multi-purpose Range Complex
SR-11	Baffled Pistol Range

SR-7 is a multi-purpose training range located in the northeastern corner of the GSRA that allows helicopter gunnery, inert 2.75-inch (”) rockets, and inert, tube-launched, optically tracked, wire-guided (TOW) II B missiles. Aircraft using SR-7 must be routed into and out of the range along specific tracks to avoid any over-flights of civilian homes along the northern section of High Hill Road. The range is divided into north and south firing lanes by an imaginary line running through the range tower on a 273-degree (º) magnetic heading. SR-7 contains both stationary and moving targets; however, only the stationary armor targets (SATs) can be engaged for helicopter operations. There are 20 SATs within SR-7: 10 targets are located north of the 273º dividing line, and 10 targets are located to the south of the dividing line. All SR-7 SATs can be engaged with small caliber ammunition. Large caliber inert weapons (20mm, 2.75” rockets, and TOW II B) can only be used on SATs beyond the second turnaround road on the range. SATs in SR-7 are constructed of building materials (e.g., plywood, plastic) and are not actual vehicles.

SR-9 is a range that was in the planning and development stage at the time of data collection and validation. Since the RCUZ Study is a forward-looking planning document, SR-9 has been included in this analysis. The SR-9 range was planned to be a multi-purpose training range, similar to SR-7, and it will be located in the western GSRA directly across from SR-7. The range will contain stationary armor targets constructed from metal vehicle “hulks.” Since this range was still under development, input from MCB Camp Lejeune Range Control/Range Development indicated that aircraft operations should be assumed to be the same as SR-7 with a primary direction of fire of 095º magnetic.

SR-10 is a multi-purpose training range located in the southern GSRA, just north of MCOLF Camp Davis. This range allows helicopter gunnery and inert 2.75” rockets. The SR-10 range is divided into east and west firing lanes by an imaginary line running through the range on a 008º magnetic heading. As with SR-7, only SATs can be engaged by aircraft for air-to-ground operations. There are 40 SATs, and all SR-10 SATs can be engaged with small caliber ammunition. Large caliber inert weapons (20mm and 2.75” rockets) can only be used on SATs beyond the second turnaround road on the range. SATs in SR-10 are constructed of building materials (e.g., plywood, plastic) and are not actual vehicles.

2.2.6 Amphibious Landing Beaches

MCB Camp Lejeune has 11 miles of beach capable of supporting amphibious operations. Onslow Beach presents assets for both amphibious training and recreational use. The beach is located along the AIWW east of the New River Inlet. Land uses in that area include recreational lodges, community facilities, troop housing, and supporting administrative uses and utilities. Military forces from around the world come to MCB Camp Lejeune on a regular basis for bilateral and North Atlantic Treaty Organization (NATO)-sponsored exercises

2.2.7 Other Ground-Based Training Areas

2.2.7.1 Engineer Training Areas

There are seven ETAs aboard MCB Camp Lejeune. The primary function of the ETAs is to provide operational engineering units and the Marine Corps Engineer School with facilities to conduct engineer demolition training. Alternative uses of the ETAs include an infiltration course; a mechanized assault course and breaching operations range; execution of live-fire breaching exercises; a close quarters battle (CQB) area; and MOUT breaching house.

2.2.7.2 Explosive Ordnance Disposal Areas

MCB Camp Lejeune also has two separate EOD ranges (EOD-1 and EOD-2) in addition to the ETAs. Three ETAs and EOD-1 were projected to be replaced by an Engineer Training Complex at the time of data collection.

2.2.7.3 Military Operations in Urban Terrain

The MOUT complex is located off Lyman Road in the eastern part of MCB Camp Lejeune. The MOUT Facility is a 31-building facility focused on training for combat in urban areas. Within the MOUT Facility training area, there are six live-fire assault courses. The new Urban Training Facility (Mobile MOUT), located nearby, has 71 buildings (including five live-fire shoot houses) and is laid out to resemble a Middle East village that includes a market area, tunnels, walls, and courtyards, with a Forward Operating Base (FOB) and Vehicle Check Point (VCP) nearby. Combat Town, located in the center of MCB Camp Lejeune, off Sneads Ferry Road, has 14 older wooden structures and 48 metal containers with compound walls and gates.

2.3 AIRSPACE DESCRIPTIONS

2.3.1 Definitions

The National Airspace System comprises two airspace classifications—controlled and uncontrolled airspace—to accommodate the safe use of airspace by multiple users, such as general aviation, commercial aircraft, and military aircraft.

Controlled airspace exists in areas where ATC is capable of providing traffic separation. This includes areas where radar coverage is available or at high altitudes where only Instrument Flight Rules (IFR) flight is allowed and is controlled by ATC. With the exception of remote and mountainous areas where radar coverage and radio communications may not be available, most airspace in the United States that is more than 1,200 feet above ground level (AGL) is controlled airspace and is identified as Class A, B, C, D, or E airspace.

SUA consists of that airspace wherein activities must be confined because of their nature, or wherein limitations are imposed upon aircraft operations that are not a part of those activities, or both. Figure 2-6 shows the special airspace units that are associated with flight training, including air-to-ground ordnance delivery at MCBCL. Figure 2-7, presented in Section 2.3.3, provides a view of the local air routes primarily utilized by rotorcraft as they train within and around the range complex.

Types of SUA include Restricted Areas (RAs), Military Operations Areas (MOAs), and Controlled Firing Areas (CFAs). Figure 2-6 illustrates SUA in the vicinity of MCB Camp Lejeune. Descriptions of SUA are provided below:

- **Restricted Areas** are established by the FAA when determined necessary to confine or segregate activities considered hazardous to non-participating aircraft.
- **MOAs** are designated by the FAA to contain non-hazardous military flight activities including, but not limited to, air combat maneuvers, air intercepts, low altitude tactics, etc.
- **CFAs** are designated by the FAA to contain activities that, if not conducted in a controlled environment, would be hazardous to non-participating aircraft. Only those activities that can be immediately suspended on notice that a non-participating aircraft is approaching are appropriate for a CFA.

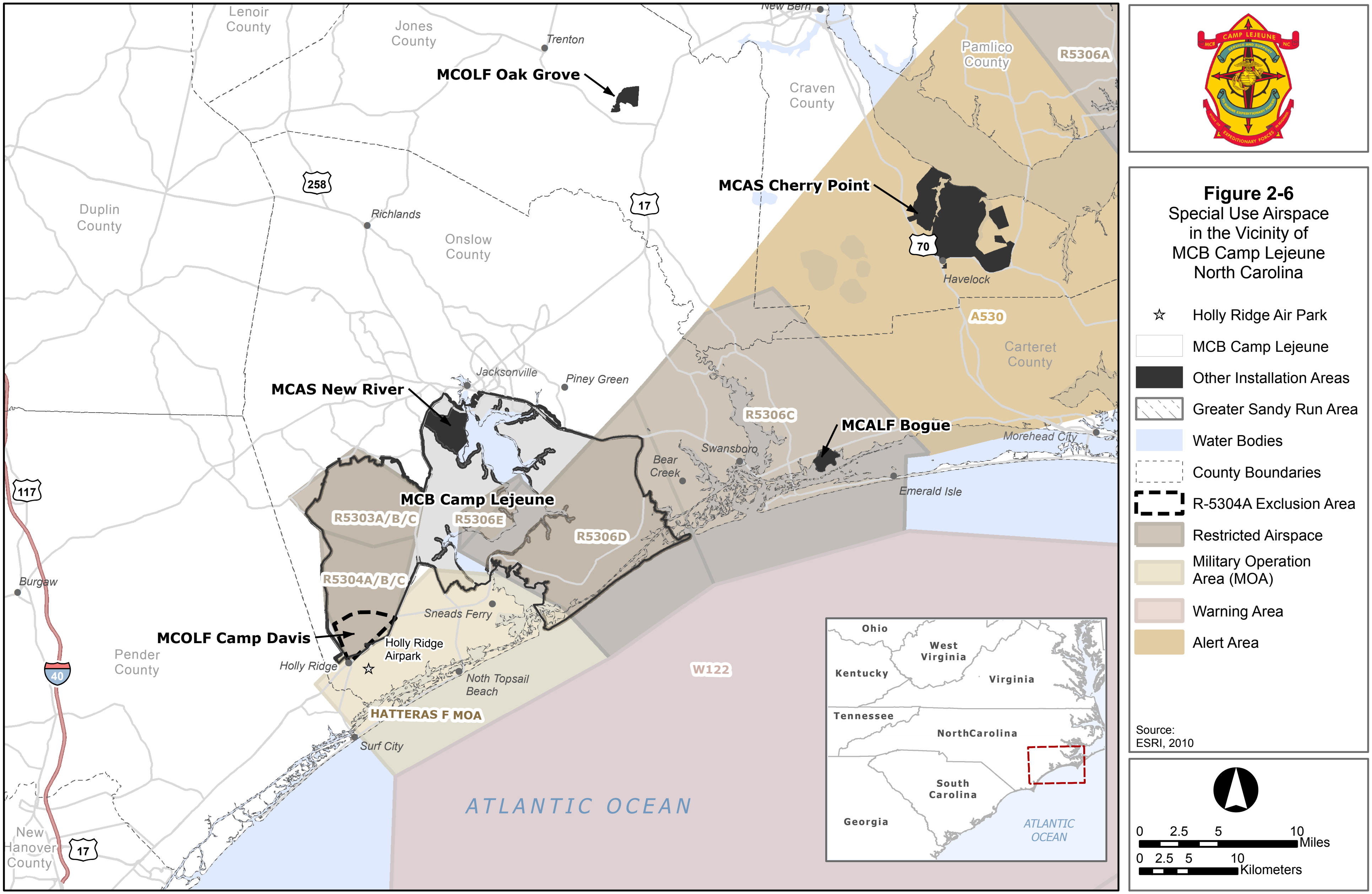

Figure 2-6
Special Use Airspace in the Vicinity of MCB Camp Lejeune North Carolina

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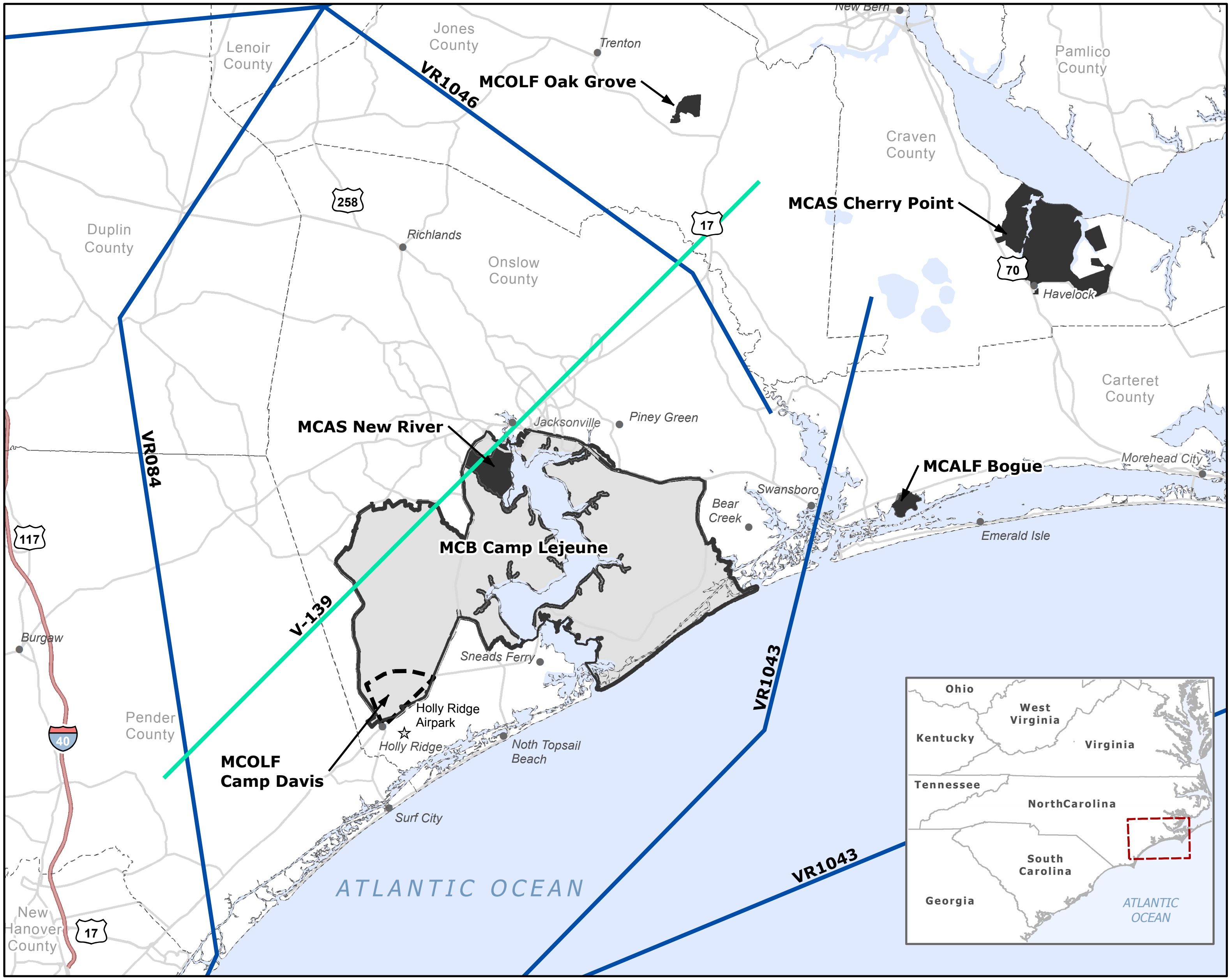

Figure 2-7
Air Routes in and around
MCB Camp Lejeune
North Carolina

- ☆ Holly Ridge Air Park
- Military Training Routes
- Instrument Route
- MCB Camp Lejeune
- Other Installation Areas
- Water Bodies
- County Boundaries
- R-5304A Exclusion Area

Source:
ESRI, 2010

0 2.5 5 10 Miles
0 2.5 5 10 Kilometers

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Airways with centerlines defined by radio navigation aids are established within controlled airspace to serve as transportation corridors. Low-altitude airways, which extend upward from 1,200 feet AGL to, but not including, 18,000 feet mean sea level (MSL), are designed to handle mainly general aviation flying by Visual Flight Rules (VFR). High-altitude airways extend from 18,000 feet MSL up to 45,000 feet MSL and are designed to handle commercial jet aviation flying by IFR.

2.3.2 Restricted Airspace

A major portion of MCB Camp Lejeune is within airspace designated by the FAA as RAs (R-5303, R-5304, R-5306D, and R-5306E). Airspace operations associated with the GSRA take place in R-5303 and R-5304. Those associated with the G-10 Impact Area take place in R-5306D. Airspace operations associated with the K-2 Impact Area take place in R-5306D and R-5306E. Altitude definitions for each block of airspace are as follows:

- **R-5303A**: Surface to 6,999 feet MSL;
- **R-5303B**: 7,000 feet MSL to 9,999 feet MSL;
- **R-5303C**: 10,000 feet MSL to 17,999 feet MSL;
- **R-5304A**: Surface to 6,999 feet MSL;
- **R-5304B**: 7,000 feet MSL to 9,999 feet MSL;
- **R-5304C**: 9,999 feet MSL to 17,999 feet MSL;
- **R-5306D**: Surface to 17,999 feet MSL;
- **R-5306E**: Surface to 17,999 feet MSL; and
- **Hatteras F MOA**: 3,000 feet AGL to 13,000 feet MSL.

2.3.3 Typical Airspace Flight Corridors

Fixed-wing aircraft utilize Initial Points (IPs) (GP-20, Bravo, November, Oscar, Mike, and Foxtrot) for ingress and egress to the maximum extent possible. These “corridors” are designed for standardization and safety of flight. Two additional flight corridors (V-139 and VR-1043) are located over and adjacent to the airspace above MCB Camp Lejeune, as described below:

- **V-139** is commercial and military (18,000 feet MSL and above) airway utilized by aircraft on an instrument flight plan with the FAA.
- **VR-1043** is a visual MTR that is over the Atlantic Ocean east of MCB Camp Lejeune and provides a visual flight corridor up to 1,500 feet AGL for training and to transit along the coast.
- **VR-084 and VR-1046** are visual MTRs that are primarily over land for training, at altitudes between 200 feet and 1,500 feet AGL, except near towns. These MTRs avoid towns and populated areas by 1 nautical mile or overfly 1,000 feet AGL, and avoid airports by 3 nautical miles or overfly 1,500 feet AGL.

Additionally aircraft using the two runways at MCOLF Camp Davis follow specific paths over the ground during approaches, departures, and touch-and-go patterns. The dimensions of these paths, or flight tracks, vary among the different aircraft. It is important to note that during day-to-day operations, these flight tracks can slightly vary due to aircraft performance, pilot technique, and weather conditions. Figure 2-7 illustrates air routes in and around MCB Camp Lejeune.

2.3.4 Federal Airways

The use of airspace over and adjacent to MCB Camp Lejeune is dictated by the FAA's National Airspace System. This system is designed to ensure the safe, orderly, and efficient flow of commercial, private, and military aircraft. MCOLF Camp Davis is located in airspace assigned by the FAA to the Washington Air Route Traffic Control Center (ARTCC). "Washington Center" has delegated control of local SUA to MCAS Cherry Point Approach Control.

2.3.5 Installation Airspace

The airspace at MCB Camp Lejeune includes six RAs in which various aircraft types may perform training exercises. Table 2-5 includes the aircraft that operate in each of the installation's airspaces. Note: F/A-18 and AV-B are not authorized to release ordnance in K-2.

Table 2-5: MCB Camp Lejeune Installation Airspace

Impact Area	Airspace	Aircraft Type
GSRA	R-5303A	AH-1,, CH-53, C-130, UH-1, MV-22
	R-5303B	
	R-5304A	
G-10	R-5306D	CH-53, C-130, F/A-18, AV-8, A-10, AH-1
K-2	R-5306D	CH-53 and AH-1
	R-5306E	CH-53 and AH-1

MCOLF Camp Davis is located under R-5304. This airspace extends vertically from the surface of the earth up to 17,999 feet MSL and horizontally over the southern half of the GSRA (Figure 2-6). This airspace is subdivided into three separate levels:

- **R-5304A** is the lowest block of airspace and extends from the ground up to 6,999 feet MSL;
- **R-5304B** is the next level and extends from 7,000 feet to 9,999 feet MSL; and
- **R-5304C** is the uppermost level and extends from 10,000 feet to 17,999 feet MSL.

To allow civilian aircraft access to the Holly Ridge Air Park, an exclusion zone has been established in R-5304A. This zone limits the restricted airspace starting altitude to 1,500 feet AGL within 3 nautical miles of the Holly Ridge Air Park. This exclusion zone allows civilian aircraft to operate at the airpark without entering R-5304A

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3 Exercises, Range, and Airspace Operations

3.1 Training/Exercise Ordnance

Ordnance usage data were obtained from the number of firings recorded in the Range Facility Management Support System (RFMSS) from 2008, 2009, and 2010, provided by the Range Control Office. Based on a review of the 2008–2010 RFMSS data, 2020 projected munitions expenditures were developed for the MCB Camp Lejeune installation. Operations were divided into range and airspace.

3.2 Range Live-Fire Operations

3.2.1 Small Arms

The M249 is an individually portable machine gun capable of delivering a large volume of effective fire to support combat and combat support operations.

Reported small arms operations for the MCB Camp Lejeune Complex consist of firings of multiple weapon types, such as shotguns, rifles, and pistols. Based on the reported daily firing activity, 82,855,387 small arms rounds were fired within the MCB Camp Lejeune Complex from 2008 to 2010. Small arms firing activity has increased each year over this period, with a peak of 28,789,179 firings in 2010. Projected 2020 small arms rounds were calculated using the highest total at each range of the 80 ranges, and the result was approximately 36,700,000.

Table 3-1 provides an example of the table used to calculate the total reported annual small arms activity at MCB Camp Lejeune Complex. It was noted that there was a wide variation in usage on some of the ranges. Year-to-year variations in usage are expected for a variety of reasons, such as annual differences in operational tempos, deployment of units, and range development activities.

Table 3-1: Example of Munitions Counts for a Small Arms Range

Small vs. Large	Facility/Airspace Subdivision	DOD Identification Code	Nomenclature	2008	2009	2010	Totals to be modeled in RCUZ (Circa 2020)
S	A-1	A010	10 Gauge Shotgun Blank (Salute Requirements)		110		110
S		A011	12 Gage Shotgun #00 Buckshot M19	2,404	10,342	13,163	13,163
S		A260, A360, A363	9MM Live	104,907	175,935	219,778	219,778

The LW 155 Howitzer is the world's first 155mm towed Howitzer with a flyweight of less than 9,800 pounds (with digital fire control).

3.2.2 Large Caliber

Based on the reported daily firing activity provided by the Range Control Office, 2,245,630 large caliber firings occurred within the MCB Camp Lejeune Complex from 2008 to 2010. Large caliber firing activity peaked in 2009, with 843,438 firings recorded. Projected 2020 large caliber rounds were calculated using the highest total at each range of the 69 ranges, and the result was approximately 1,106,000. It was also noted that there was a wide variation in usage on some of the ranges, similar to that for small arms. Reported large caliber firing operations for the MCB Camp Lejeune Complex consist of firings of multiple weapon types and ammunition sizes from 20mm to 155mm. Approximately 68 percent of the projected large caliber ordnance is expected to be 40mm; while the Lightweight 155 Howitzer (155mm) will account for less than 2 percent of projected operations.

Table 3-2 provides an example of the table used to calculate reported annual large caliber firing activity within the MCB Camp Lejeune Complex.

Table 3-2: Example of Munitions Counts for a Large Arms Range (Large-Caliber Weapons)

Small vs. Large	Facility/Airspace Subdivision	DOD Identification Code	Nomenclature	2008	2009	2010	Totals to be modeled in RCUZ (Circa 2020)
L	G-10 HELO/FIXED WING	A655, A876, A892, A896, A926	CTG, 20 MM TP MK105 MOD O SNGL RD	24,455	71,555	42,944	71,555
L		A975, A976	CTG 25 MM HEIT M792	500	1,555	600	1,555
L		B116	CTG 30 MM LINKED TP PGU-15/B	120	600		600
L		B571	40 MM-HE	32			32
L		C496, 518	105 MM-HE	140			140
L		E485, F244, X100	BOMB, PRACTICE, 500LB	80	11	3	80
L		E962	BOMB, PRACTICE, 9LB, BDU-48	188	142	177	172
L		E969	BOMB, PRAC 25LB BDU-33 80/PL	1,670	1,625	865	1,489

3.3 AIRSPACE OPERATIONS

Aircraft operations occur throughout the airspace over and adjacent to MCB Camp Lejeune. Training operations require separation from non-participating aircraft and other ordnance operations, including air-to-ground and surface-to-surface ordnance delivery. All ordnance deliveries are confined within the assigned range area and range boundaries.

3.3.1 Ranges

There are live-fire training ranges at MCB Camp Lejeune that allow the capability to conduct air-to-ground and ground-to-ground training at select ranges and impact areas. The following sections will discuss airspace, ordnance delivery, and features of the GSRA "ranges" and the K-2, G-10, and N-1/BT-1 impact areas.

3.3.1.1 Greater Sandy Run Area Range Operations

The GSRA is a multi-purpose training range complex with multiple ranges used for air-to-ground weapons training, including SR-7 and SR-10. A third air-to-ground range, SR-9, was in the planning stages at the time of data collection for this RCUZ Study and is now complete. Additional features of the GSRA include tactical landing zones (TLZs), parachute drop zones (PDZs), and runways (MCOLF Camp Davis). There are 11 TLZs and 2 PDZs in the GSRA. There also is one administrative landing zone (ALZ), which is a designated a helicopter landing zone that provides ready access to air transportation and medical evacuation.

Airspace operations associated with the GSRA take place in R-5303A/B/C and R-5304A/B/C. Authorized ammunition for rotary-wing and tilt-rotor aircraft is 7.62mm, 2.75" rockets, and 20mm ammunition. Fixed-wing aircraft do not release weapons in the GSRA, and their operations are limited in accordance with definitions of the SUA over that area. Table 3-3 shows the total reported annual airspace operations within R-5303A, R-5304A, R-5306C/D/E, and Hatteras F MOA that were compiled based on daily sheets provided by the Range Control Office and in consultations with MCB Camp Lejeune personnel.

Table 3-3: Annual Airspace Operations

		5303A	5304A	5306C	5306D	5306E	Hatteras F MOA
Fiscal Year	Altitude	Surface to 6,999' MSL	Surface to 6,999' MSL	1,200' AGL to 18,000' MSL	Surface to 18,000' MSL	Surface to 18,000' MSL	3000' to 13,000' MSL
FY-06	830	2,278	919	6,829	4,124	770	830
FY-07	633	988	1,317	7,261	3,888	939	633
FY-08	607	669	807	5,694	3,028	691	607
FY-09	801	912	996	6,895	2,642	863	801
FY-10	1,382	1,631	723	6,773	2,582	651	1,382
FYs 06-10 Average	**851**	**1,296**	**952**	**6,690**	**3,253**	**783**	**851**

3.3.1.2 K-2 Impact Area Airspace Operations

The K-2 Impact Area is primarily used as a familiarization range. Typical aviation operations are door gunnery from tilt-rotor and rotary-wing aircraft that is permitted within the K-2 Impact Area. Authorized ammunition for both aircraft is 7.62mm. Airspace operations associated with the K-2 Impact Area take place in R-5306D and R-5306E.

3.3.1.3 G-10 Airspace Operations

The G-10 Impact Area is a multi-purpose range that includes air-to-ground weapons, a helicopter gunnery range, and missile range. Both fixed-wing and rotary-wing aircraft are authorized to conduct training in the G-10 Impact Area. Authorized ammunition for fixed-wing aircraft includes MK76 and MK80 series inert bombs, as well as 2.75” rockets, and 20mm, 25mm, and 30mm ammunition. Authorized ammunition for rotary-wing aircraft includes 2.75” rockets, and 7.62mm and 20mm ammunition. Airspace operations associated with the G-10 Impact Area take place in R-5306D.

CAS firing activity takes place within the G-10 Impact Area; therefore, when the G-10 Impact Area is in use, aircraft not participating in CAS missions are vectored around the G-10 Impact Area. The approved altitudes and attack headings for the G-10 Impact Area are provided in Table 3-4.

Table 3-4: Approved Attack Heading and Altitude for the G-10 Impact Area

Initial Point	Altitude	Attack Heading
Risley Pier (GP-20)	700 ft.	340° -070°
Gillette (Bravo)	1,000 (off-Base) and 700 ft. (on-Base)	030°-100°
Silverdale PR Bridge (November)	1,200 ft.	150°-270°
Queens Creek Bridge (Oscar)	1,200 ft.	150°-270°
Bogue Inlet (Mike)	1,200 ft.	180°-300°
Bear Inlet (Foxtrot)	1,000 ft.	206°-360°

G-10 Urban Close Air Support

A separate training facility within the G-10 Impact Area is the G-10 UCAS facility. The UCAS is designed to simulate an urban environment by using stacked freight containers to represent buildings. To minimize damage to the containers, dud-producing ordnance, and heavyweight (MK-80 series) ordnance is not authorized in the UCAS. Rotary-wing aircraft use five Battle Positions (BPs) as boundaries from which weapons may be released onto targets within the G-10 Impact Area and the UCAS (Table 3-5).

Table 3-5: G-10 Impact Area Battle Positions and Attack Headings

Battle Position	Attack Headings
BP Ox	040°–120°; 180°–300°
BP Eel	245°–260°
BP Newt	150°–165°
BP Sidewinder	265°–285
Wolf	080°–090°

Fixed-wing aircraft operate using six IPs to ingress into the impact area (Table 3-6 and Figure 4-5). In the case of AC-130 gunships, aircraft conduct operations from a 1.3- to 2.0-nautical-mile orbit around the center of the G-10 Impact Area.

3.3.1.4 N-1/BT-3 Impact Area Airspace Operations

Both fixed-wing and rotary-wing aircraft are authorized to train on Brown's Island. When this range is in use, the AIWW is closed to non-participating traffic. Fixed-wing aircraft use five IPs as the ingress starting point for runs onto targets on Brown's Island and in N-1/BT-3 (Table 3-7).

Table 3-6: N-1/BT-3 Initial Points for Fixed-Wing Ingress

Initial Point	Latitude	Longitude	Minimum Altitude (AGL)	Aircraft Heading
GP-20	34° 33.583 N	77° 12.217 W	700'	000°–120°
Bravo	34° 36.117 N	77° 23.483 W	700'; 1000' off-base	180°–255°
November	34° 45.717 N	77° 10.133 W	1200'	180°–255°
Oscar	34°41.183 N	77° 10.083 W	1000'	180°–255°
Mike	34° 38.433 N	77° 06.667 W	1000'	215°–255°

3.3.2 Tilt-Rotor and Rotary-Wing Aircraft

Air-to-ground weapons delivery operations occur at MCB Camp Lejeune, and additional aircraft operations occur at MCOLF Camp Davis, which is primarily used for rotary- and tilt-wing aircraft operations. In CY 2010, an estimated 22,904 operations were conducted at MCOLF Camp Davis. This includes departures, arrivals, and touch-and-go pattern work for the AH-1W, CH-53E, MV-22, UH-1N, and C-130 aircraft. MCB Camp Lejeune also controls air operations MCOLF Oak Grove that has three runways. On rare occasions, certain fixed-wing aircraft, such as the C-130, may use the MCOLF Camp Davis. The aircraft that account for the majority of the operations at the range and both MCOLFs are described in this section.


MV-22 "Osprey"

3.3.2.1 MV-22 Osprey

The Osprey is a twin-engine, joint-service, multi-mission, tilt-rotor aircraft with vertical take-off and landing capability. This aircraft performs vertical take-off and landings like a helicopter, while having the range and speed of a twin turboprop aircraft. As the replacement for the CH-46 "Sea Knight," the MV-22 is an assault transport for troops, equipment, and supplies and is capable of operating from ships or from expeditionary airfields ashore.

AH-1W "Super Cobra"

3.3.2.2 AH-1W Super Cobra

The AH-1W Super Cobra is a twin-engine, day/night marginal weather Marine Corps attack helicopter that provides en route escorts for assault helicopters and their embarked forces. The primary mission of the AH-1W aircraft is as an armed tactical helicopter capable of close air support (CAS), target search and acquisition, reconnaissance, and troop helicopter support. A new variant, the AH-1Z, is currently being fielded in the Marine Corps inventory. Over the next five to ten years, all Super Cobras used at MCOLF Camp Davis will be AH-1Zs.

CH-53E "Super Stallion"

3.3.2.3 CH-53E Super Stallion

The Super Stallion is the largest helicopter in the U.S. military inventory. It is a heavy-lift aircraft used by the Marine Corps to transport personnel and equipment. With three engines and a maximum lift capacity of 30,000 pounds, the CH-53E is the only helicopter capable of lifting some of the weapon systems in the Marine Corps, including the M-198 Howitzer. It also can carry up to 55 combat-loaded Marines. A future variant of this aircraft, the CH-53K, is currently in development and testing and is expected to be introduced in the next decade.

UH-1N "Iroquois (Huey)"

3.3.2.4 UH-1N Iroquois (Huey)

The UH-1N is a twin-engine helicopter that is widely used in transport, airborne battlefield command and control, troop insertion/extraction, fire support coordination, medical evacuation, search and rescue, reconnaissance, CAS, or utility roles in the Marine Corps. The UH-1N provides utility combat helicopter support to the landing force commander during ship-to-shore movement and in subsequent operations ashore. As with the Super Cobra, the Marine Corps UH-1N inventory is currently being upgraded with the new UH-1Y "Yankee" variant. In accordance with the Fiscal Year (FY) 2012 Marine Aviation Plan, MAG-29 began to receive the UH-1Y variant in FY 2011, and transition will be complete in FY 2014.

3.3.3 Fixed-Wing Aircraft

The Super Hornet can perform both air-to-air and air-to-ground missions.

Fixed-wing aircraft generally train in R-5306D, which overlays the G-10 Impact Area; however, they may also fly within any of the overhead or adjacent airspace, such as R-5303A/B/C, R-5304A/B/C, R-5306C/E, the Hatteras MOA, Warning Area 122, or any of the MTRs in the vicinity. Primary training for fixed-wing aircraft involves coordination with Forward Area Controllers (FACs) to attack simulated ground targets. Air-to-ground weapons delivery operations occur at the G-10 and N-1/BT-3 impact areas. The aircraft that account for the majority of the operations at the range are described in this section and the noise exposure levels in Section 5.4.3.

3.3.3.1 F/A-18C/D "Hornet"


F/A-18C/D "Hornet"

The F/A-18C/D Hornet and the F/A 18 E/F Super Hornet are a supersonic, single seat (C and E models) or tandem seat (D and F models), twin-engine, all-weather, night, combined fighter, and attack aircraft. The F/A-18 multi-mission aircraft can operate from either aircraft carriers or land bases. The F/A-18 fills a variety of roles: air superiority, fighter escort, suppression of enemy air defenses, reconnaissance, forward air control, close and deep air support, and day and night strike missions.

KC-130J "Hercules"

3.3.3.2 KC-130J Hercules

The KC-130 is a four-engine, fixed-wing aircraft used by the Marine Corps for aerial in-flight refueling, and cargo and personnel transport. This aircraft can take off and land in a relatively short distance, making it a valuable asset for Marines ashore. With a takeoff distance as short as 3,127 feet (at 155,000 pounds gross weight), the KC-130J is capable of operating at shorter runways, such as those at MCOLF Camp Davis.

AV-8B "Harrier"

3.3.3.3 AV-8B Harrier

The AV-8B Harrier is a single-engine, fixed wing, attack aircraft used by the Marine Corps. The Harrier is capable of short takeoff and vertical landing, offering the versatility to conduct an assortment of missions. Primarily, the Harrier is employed in surface and air attacks, fighter escort, and reconnaissance missions. The AV-8B Harrier is expected to remain in operation until at least 2030, when the Lockheed Martin F-35B Lightning II will replace it.

3.4 FUTURE RANGE OPERATIONS

The best estimates of future operations from MCB Camp Lejeune indicate a continuation of the types and levels of operations currently conducted. The noise analysis reviewed all of the large arms and small arms ranges that are expected to be operating in 2020, and identified those ranges that are projected to utilize munitions that generate significant noise. The noise metrics used in this study are discussed in Section 5.1, and the scenario modeled for the noise analysis incorporates some of the projected increases in ordnance activity as a result of these projects. For small arms ranges, noise is expected to be masked by the noise from heavy weapons activity at MCB Camp Lejeune. An increase in small arms and large caliber round calculations were utilized to produce noise contours for MCB Camp Lejeune, which will become the 2014 noise contours.

A number of planned MILCON projects may have an impact on the elements addressed in this RCUZ Study, including noise and safety. In addition, several range enhancement proposals are currently in the planning stages and are outlined in the MCB Camp Lejeune 2020 Transformation Plan. As part of the planning process for each project, an Environmental Assessment (EA) or Environmental Impact Statement (EIS), as required under the National Environmental Policy Act (NEPA) of 1970, would include noise and safety analyses.

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4

Range Compatibility Zones

This chapter focuses on the RCZs and the safety analysis of air-to-ground and ground-to-ground live-fire operations based on the weapon systems currently used or projected to be used onboard MCB Camp Lejeune by 2020. The objective of this analysis is to provide information and guidance about potential safety hazards generated by range training, including live-fire ranges, artillery, mortar firing, and tank gunnery. The goal of the safety analysis is to minimize exposure of military and civilian activities to dangers associated with weapons ranges and maneuver areas.

4.1 General

RCZs translate ordnance delivery safety concerns into recommended compatible land use zones. The size of an RCZ is not affected by the number of annual range operations, but is based on the types of operations performed on the range. Each RCZ has specific restrictions and permissions related to the land use that exists within each zone, which, due to safety concerns, are more stringent than land use recommendations related to noise. RCZs are not predictors of safety hazards but, instead, depict areas where mishaps are likely to occur if they do occur. Modeled operations reflect current training activities as well as those that are either planned or predicted to occur in the future.

There are three RCZs related to air-to-ground ranges.

- **RCZ-I**: Defines the area of the greatest potential safety hazard and designates the minimum surface area needed to contain all ordnance. It is the composite of all SDZs and WDZs authorized at the installation.

- **RCZ-II**: Defines the area of armed aircraft over-flight. It is less restrictive than RCZ-I, but more restrictive than RCZ-III because there are safety concerns associated with the arming/de-arming of aircraft.
- **RCZ-III**: Defines the area within the designated SUA that provides aircraft with tactical maneuvering room and access to and from the air-to-ground targets. This zone has the least stringent land use compatibility requirements.

4.2 Airfield Safety

MCB Camp Lejeune has two active runways located at MCOLF Camp Davis. This airfield is located in the southern part of the GSRA, just north of the town of Holly Ridge. The likelihood of an aircraft mishap occurring is remote. However, areas of accident potential have been identified for MCOLF Camp Davis based on historical data from aircraft mishaps to assist in land-use planning. The Marine Corps recommends that certain land uses that concentrate large numbers of people—apartments, churches, and schools—be located outside accident potential zones (APZs).

Mishaps are more likely to occur along the flight path of an aircraft and increase in likelihood near the runways. In accordance with Chief of Naval Operations Instruction (OPNAVINST) 11010.36C/MCO 11010.16, all active runways are required to have a clear zone (CZ). The placement and dimensions of APZs depend upon the classification of the runway, the number of operations for a given runway flight track, and the shape of the flight track. The three APZs in order of diminishing accident potential with distance from the runway are the CZ, APZ-I, and APZ-II. The 2014 MCOLF Camp Davis APZs were developed and approved in a separate Air Installations Compatible Use Zones (AICUZ) Study that was completed in 2014.

4.2.1 Imaginary Surfaces

Imaginary flight surfaces define the required airspace that must remain free of obstructions to ensure safety of flight near an airfield or an approach to a landing zone. These obstructions may include natural features, such as trees and manmade features (e.g., buildings, towers, and other vertical objects). Typically, the closer the aircraft is to the airfield, the closer it is to the ground. The closer the aircraft is to the ground, the higher the likelihood that a building, tower, or tree will become a hazard to flight.

Figure 4-1 shows that some of the imaginary surfaces for MCOLF Camp Davis extend beyond the installation boundary. The FAA monitors and documents height obstructions that may affect navigable airspace. Three height obstructions currently documented by the FAA are either within the imaginary surfaces or located close to the airfield at MCOLF. The flight safety zones are designed to maximize the safety of aircraft using an airfield while minimizing the potential harm if a mishap does occur.

Other hazards to flight safety that should be avoided near the airfield include the following (discussed in Section 4.7):

- Uses that would attract birds, especially waterfowl;
- Lighting (direct or reflected) that would impair pilot vision;
- Uses that would generate smoke, steam, or dust; and
- Electromagnetic interference (EMI) with aircraft communication, navigation, or other electrical systems.

4.2.2 Accident Potential Zones

The Marine Corps has identified airfield safety issues that necessitate the development of compatible land uses to ensure the health and safety of the community while allowing the installation to continue its operations. These issues include accident potential and hazards within the airfield vicinity that obstruct or interfere with aircraft approaches and departures, pilot vision, communications, or aircraft electronics.

While the likelihood of an aircraft mishap occurring is remote, the Marine Corps has identified areas of accident potential at MCOLF Camp Davis to assist in land use planning. These APZs are areas where a mishap is most likely to occur if one were to occur. APZs are not predictors of accidents.

4.2.2.1 APZ Requirements and Dimensions

In accordance with OPNAVINST 11010.36C/MCO 11010.16, all active runways are required to have a CZ. The placement and dimensions of APZs depend upon the classification of the runway, the number of operations for a given runway flight track, and the shape of the flight track. MCOLF Camp Davis comprises two tilt-rotor outlying landing field (OLF) runways.

The components of these zones for tilt-rotor aircraft operating at an OLF are identified on Figure 4-1 and are defined as follows:

- **CZ**: This is the area immediately beyond the runway/helipad threshold. This zone has the greatest potential for aircraft accidents, and should remain undeveloped and clear of obstructions to flight. The CZ measures 1,000 feet wide and extends 400 feet immediately beyond the end of the primary surface. The primary surface, itself, extends 200 feet beyond the end of each runway.
- **APZ-I**: This is the area immediately beyond the CZ that still has a measurable, but lower, potential for accidents relative to the CZ. This zone for tilt-rotor aircraft is 1,000 feet wide and extends 800 feet beyond the CZ.
- **APZ-II**: This is an area beyond APZ-I (or the CZ, if APZ-I is not required) that has the lowest measurable potential for mishaps relative to APZ-I and the CZ. This zone is not required for MCOLF Camp Davis.

Very few land uses are compatible with military aircraft operations within the CZ. For this reason, the Marine Corps typically acquires sufficient real property interests in land within this zone to ensure incompatible development does not occur. Within APZ-I, a variety of land uses are compatible; however, people-intensive uses (e.g., schools, apartments) should be restricted because of the greater risk in these areas.

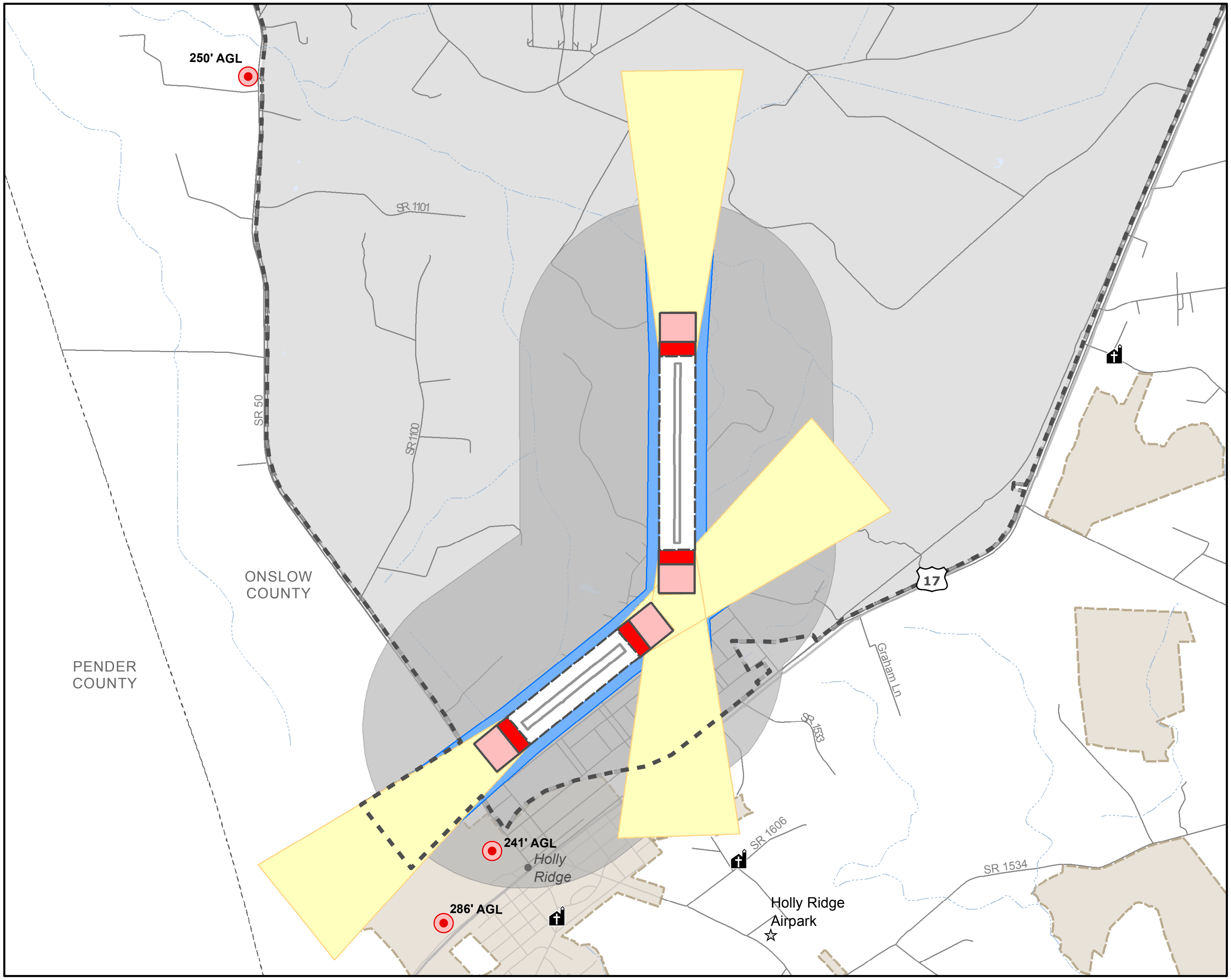

Figure 4-1
Imaginary Surfaces for
MCB Camp Lejeune
(at MCOLF Camp Davis)
North Carolina

- ☆ Holly Ridge Air Park
- FAA-Identified Vertical Obstruction
- Church
- Runway
- MCB Camp Lejeune
- Town of Holly Ridge
- County Boundary
- Clear Zone
- APZ I
- Approach/Departure Surface
- Primary Surface
- Transitional Surface
- Horizontal Surface

Source:
ESRI, 2010, Onslow County, 2011;
FAA, 12/15/2011.

0 0.25 0.5 1 Miles
0 0.25 0.5 1 Kilometers

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When development results in threats to the mission of the installation, and when local communities are unwilling or unable to take the necessary steps to promote land use compatibility via their own land use and zoning authority, the Marine Corps may consider land acquisition or restrictive easements.

4.3 Live-Fire Safety

In accordance with Base Order (BO) 3570.1C, safety is the responsibility of every individual and all unit commanders at all times. Safety and operations must intertwine so that risk management and safety are a part of the planning and execution of all missions, exercises, live-fire events, and daily evolutions.

4.3.1 Air-to-Ground Operations Safety

Pilots and gunners will be familiar with the impact area, firing limits, sectors of fire, SDZs/WDZs for the weapons and ammunition being fired, and safety regulations for the range on which they will fire (BO 3570.1C).

4.3.2 Ground-to-Ground Operations Safety

Range personnel are trained on the ground-to-ground safety with the regulations, general information, and precautions to be taken in the firing of U.S. military weapons, approved foreign weapons, the use of live ammunition, munitions, non-lethal weapons devices, energy producing weapons/equipment (lasers), pyrotechnics, training devices, and explosives.

4.4 Weapon Danger Zones

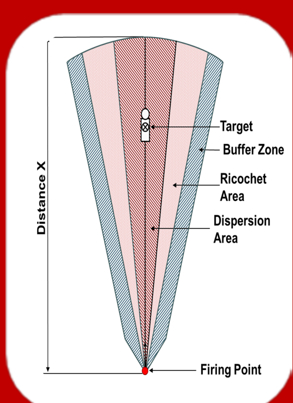
WDZs define the areas of potential safety hazard based upon containment of ordnance, fragments, ricochets, and debris associated with weapons launched or released from aircraft. Fixed-wing, rotary-wing, and tilt-rotor aircraft are all used at MCB Camp Lejeune, and each specific aircraft has a suite of weapons that are authorized for use at the installation.

MCO 3550.13 mandates the use of the WDZ Tool, which is part of the Range Managers Toolkit (RMTK), to model the potential effects of these air-to-ground weapons. The WDZ Tool is an application that is used with Geographic Information System (GIS) software and models the potential hazard areas of air-to-ground ordnance use. For this RCUZ Study, air-to-ground operations were modeled with version 9.2.0.4.16.1 of the WDZ Tool. Upon completion of preliminary WDZ modeling and initial installation review, 869 individual WDZs were retained and used in this RCUZ Study.

Of all the military services, the Marine Corps requires the most conservative modeling parameters. In accordance with the Marine Corps Training and Education Command (TECOM) Safety of Use Memorandum (SOUM) 6-09, dated 28 August 2009, all WDZs were modeled to the 99.9999 percent level of containment (to the 95 percent confidence factor). This means that there is less than a 1-in-1,000,000 chance that a bomb, bullet, fragment, or ricochet will land beyond an individual WDZ or the installation's composite WDZ.

WDZs depict a 3-D area that includes the initial weapon impacts, any subsequent ricochet impacts, and fragmentation debris, which reflects the minimum land and air requirements needed to safely employ a given weapon from an aircraft.

It is important to note that MCB Camp Lejeune does have a special range request (SRR) process in place to increase training capabilities. The SRR process allows for the use of ammunition and ordnance or to conduct non-standard training missions that are either not explicitly authorized in the MCB Camp Lejeune Range Control SOPs or require a deviation from the SOPs. In short, the SRR process allows for a greater range of training capabilities at the installation through custom WDZ modeling and an associated operational risk management (ORM) assessment by the installation prior to approval of the mission.



Distance X of an SDZ is the maximum distance a projectile will travel when fired from a weapon system. The dispersion area accounts for human error, weapon error, or propellant malfunction.

Three rotary-wing and one tilt-rotor aircraft operate most frequently at the ranges onboard MCB Camp Lejeune: the AH-1W Super Cobra, UH-1N Iroquois/Huey, CH-53E Super Stallion, and the MV-22 Osprey. In the cases of the UH-1N and AH-1W, it is important to note that the Marine Corps will be implementing updated versions of these helicopters in the next decade. At the time of WDZ modeling, the new variants (UH-1Y "Venom" and AH-1Z "Viper") were not available as selectable platforms within the WDZ Tool. Therefore, all WDZs were modeled based upon the current aircraft and not the next generation. Other rotary-wing aircraft from other services or from foreign militaries may use ranges at MCB Camp Lejeune from time to time, but their limited use will necessitate WDZ modeling through the SRR process and are not included in this study.

Four fixed-wing aircraft with the capability to release air-to-ground ordnance operate at MCB Camp Lejeune on a regular basis: the AV-8B Harrier, F/A-18D Hornet, AC-130H/U Spectre/Spooky gunship, and the Alpha Jet. The AC-130 is an Air Force special operations gunship, and the Alpha Jet is a contract aircraft used to conduct CAS training missions for forward air controllers (FACs). The EA-6B Prowler does operate at MCB Camp Lejeune, but it does not release any ordnance. The F-35B Lightning II Joint Strike Fighter (JSF) is expected replace the Harrier in the next five to ten years, but the WDZ Tool does not yet have the capability to model the effects of weapons for that new aircraft.

4.5 SURFACE DANGER ZONES

As discussed in Section 1, ground-to-ground and ground-to-air SDZs were provided by the MCB Camp Lejeune Range Safety Department for direct inclusion in this RCUZ Study. These SDZs were obtained as GIS shape files. No additional external modeling of SDZs using the RMTK was conducted as part of this study.

This section of the RCUZ analysis presents the installation's SDZ files depicting live-fire operations on MCB Camp Lejeune ranges. To aid in discerning individual features of the SDZs, the results are separated geographically between the GSRA and all other ranges. All SDZs provided by the installation are contained within the boundaries of government-controlled property. In areas where SDZs overlap adjacent training areas, roads, or other installation features that may be used by additional forces, BO 3570.1C outlines specific range-by-range procedures to de-conflict adjacent training or to secure road and waterways when ranges are in use. Individual SDZs were combined to create a composite RCZ-I (Figures 4-2 and 4-3).

4.6 Range Compatibility Zones

Both quantitative and qualitative analysis was required to develop the three RCZs at MCB Camp Lejeune. RCZ-I was developed quantitatively through WDZ modeling and the incorporation of installation-modeled GIS files for SDZs. In accordance with MCO 3550.13, all of the individual WDZs and SDZs were combined using GIS software to develop an installation-wide composite shape file. This WDZ-SDZ composite is referred to as RCZ-I.

No model can be used to identify the area of armed overflight or tactical maneuvering airspace, so RCZ-II and RCZ-III required a qualitative approach. The MCB Camp Lejeune Range Control SOPs, data collection interviews with pilots and airspace managers, and a review of local airspace structure were all used to identify the areas where armed overflight is authorized (RCZ-II), and where the extent of the airspace necessary for tactical maneuvering into and out of the ranges is located (RCZ-III). The following sections within this chapter describe the locations of the three RCZs at MCB Camp Lejeune.

4.6.1 RCZ-I

RCZ-I is defined in MCO 3550.13 as the area of greatest potential safety hazard and designated minimum surface area needed to contain all ordnance. It is the composite of all individual WDZs and SDZs that are authorized to occur at MCB Camp Lejeune. Figures 4-2 and 4-3 display the location of RCZ-I in the eastern and western ranges, respectively.

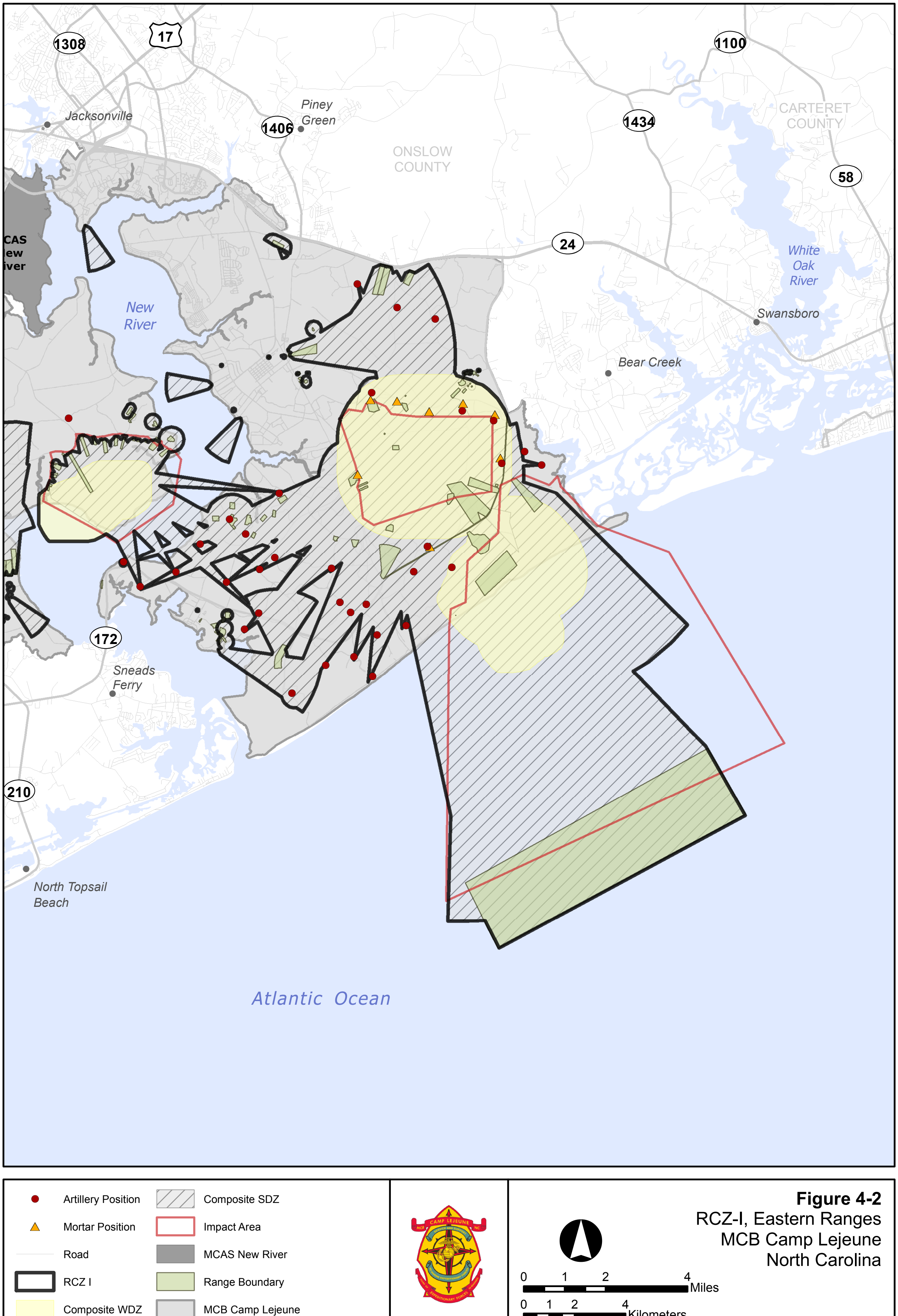


Figure 4-2
RCZ-I, Eastern Ranges
MCB Camp Lejeune
North Carolina

Source: ESRI, 2010; Onslow County, 2011;MCB Camp Lejeune, 2011.

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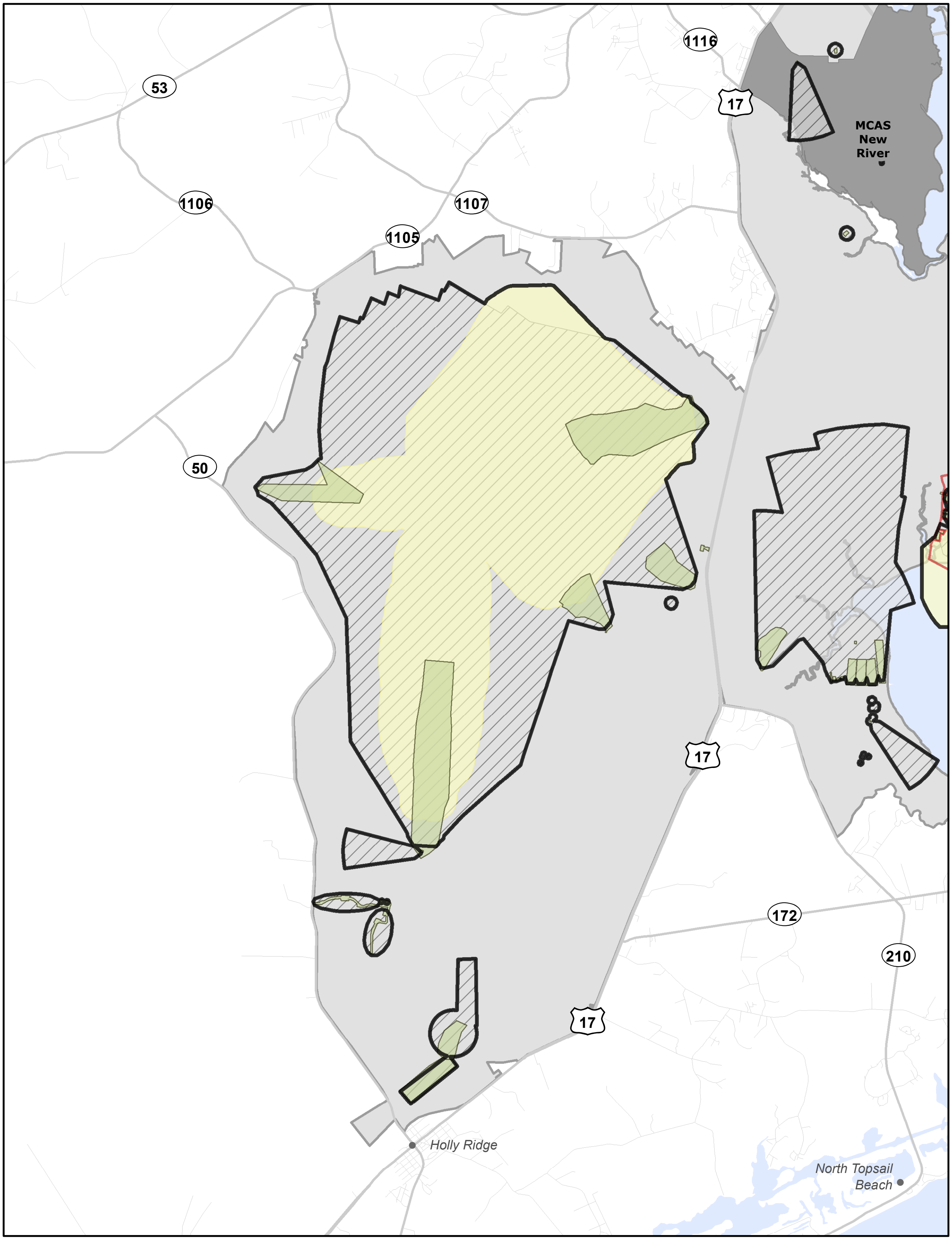

Road
RCZ I
Composite WDZ
Composite SDZ
Impact Area
MCAS New River
Range Boundary
MCB Camp Lejeune

Source: ESRI, 2010; Onslow County, 2011;MCB Camp Lejeune, 2011.

0 0.5 1 2 Miles
0 0.5 1 2 Kilometers

Figure 4-3
RCZ-I, Western Ranges
MCB Camp Lejeune
North Carolina

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As illustrated in these figures, RCZ-I remains within installation boundaries or is projected out over the open ocean or the New River. At MCB Camp Lejeune, the size and shape of RCZ-I is primarily defined by ground-to-ground training missions. Air-to-ground WDZs are nearly completely enveloped by the SDZs.

It is important to note that RCZ-I represents the sum of all air and ground-training missions, but that does not mean that all ranges can be activated simultaneously. During day-to-day operations, MCB Camp Lejeune Range Control de-conflicts training missions and ensures the safety of personnel by activating and deactivating ranges based upon WDZ and SDZ considerations affecting adjacent training areas. As a planning document, the RCUZ Study seeks to minimize encroachment with the surrounding community; therefore, it was necessary that RCZ-I include all training operations as if they could occur at the same time. This provides the Marine Corps with a comprehensive picture of the safety considerations across the entire installation.

4.6.2 RCZ-II

RCZ-II defines the area of aircraft armed overflight. Armed overflight begins when an aircraft with ordnance places the cockpit-arming switch to the "armed" position. The point at which this occurs must be within the restricted airspace and at a point where any inadvertent releases would land within the confines of DOD property.

MCB Camp Lejeune Range and Training Regulations (BO 3570.1C) identify additional restrictions on arming of aircraft:

- For all aircraft, the master arm shall not be "armed" until sights are on the target and are "cleared hot" by a Terminal Controller; and
- For rotary-wing and tilt-rotor aircraft, the arming switch shall be secured at the cease-fire lines for each battle position prior to the pull-off.

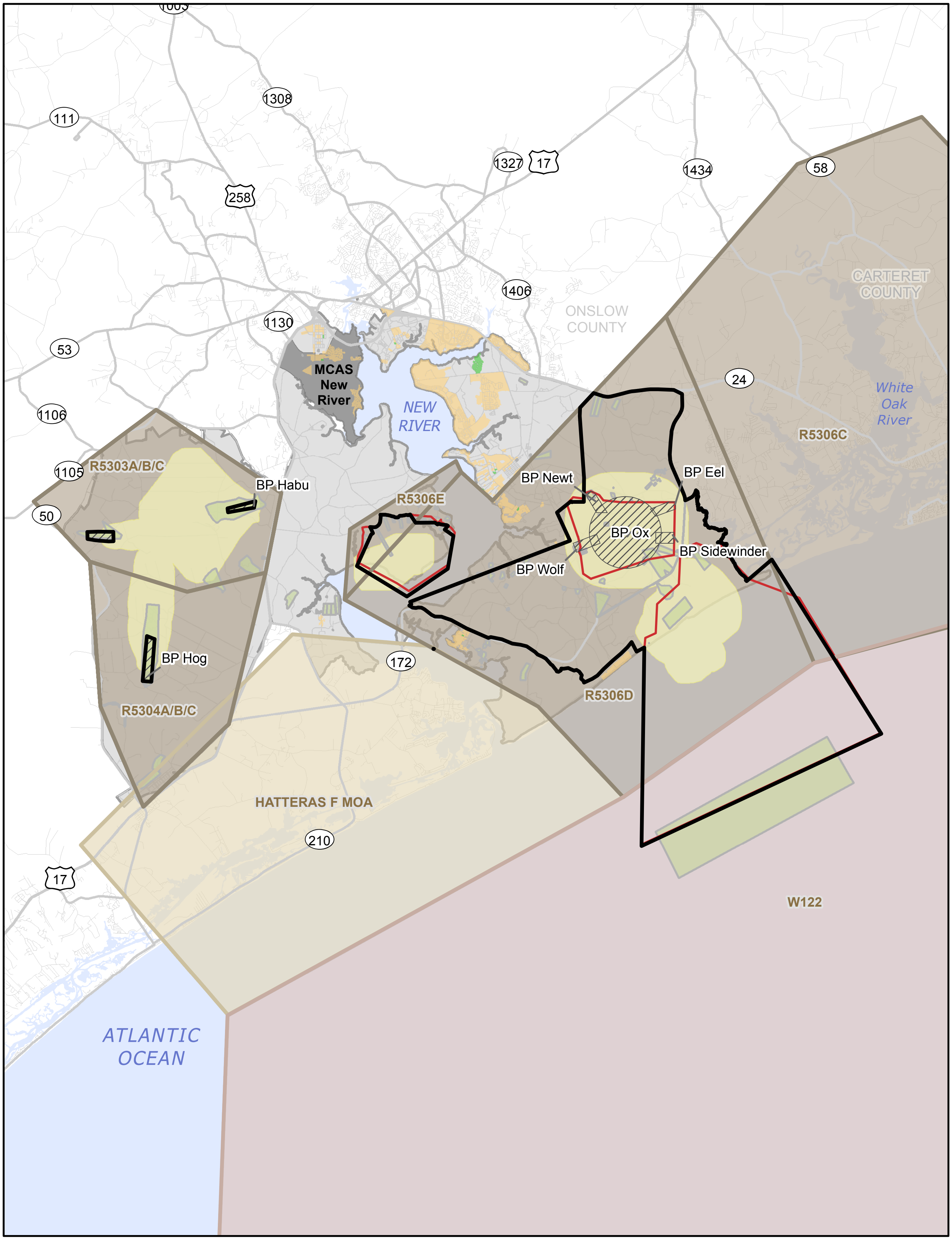
The period of armed over-flight only applies to air-to-ground operations and is defined as beginning when an aircraft with ordnance places the cockpit arming switch in the "ARMED" position.

RCZ-II is less restrictive than RCZ-I in terms of land use compatibility. However, RCZ-II still poses a level of potential safety concern and, therefore, does have specific land use compatibility recommendations. Safety concerns are due to the fact that, while the aircraft is "armed," there is increased potential for an inadvertent release of ordnance due to the deactivation of electro-mechanical safety features in preparation for weapon release.

During data collection interviews, pilots were asked to define where they arm and de-arm their respective aircrafts during air-to-ground operations. This information was examined in association with BO 3570.1C, MCO 3550.13, and Range Control and Range Safety personnel to develop the boundary of RCZ-II. Ultimately, the extent of RCZ-II attempts to ensure that any inadvertent release of munitions will land within the Range Training Area of DOD-controlled property. Figure 4-4 depicts the boundary for RCZ-II for MCB Camp Lejeune.

Several of the air-to-ground ranges at MCB Camp Lejeune have arming and attack areas that have been specifically designated for rotary-wing and tilt-rotor ordnance delivery. These areas, referred to as "BPs," or "battle positions," define the lateral limits within which a helicopter or MV-22 must be located prior to arming (and firing). These BPs are depicted on Figure 4-5 to provide the reader with an understanding of the extent of armed overflight between rotary-wing/tilt-rotor aircraft and the much larger area authorized for fixed-wing arming.

Within the GSRA, the areas of armed overflight are limited to the three BPs associated with SR-7, SR-9, and SR-10. Fixed-wing ordnance delivery is not authorized in the GSRA. For all other ranges, the area of armed overflight is predominantly dictated by fixed-wing flight profiles. In all situations, the area of armed overflight is contained over DOD-controlled property or over the ocean and beneath restricted airspace. RCZ-II has been developed to prevent armed overflight over the cantonment areas along the New River, as well as morale, welfare, and recreation (MWR) areas along the intracoastal waterway, the ammunition storage point (ASP), and the industrial and administrative areas located onboard MCB Camp Lejeune.



RCZ II
Battle Position Area
Composite WDZ
Impact Area
Restricted Airspace
Military Operation Area (MOA)
Warning Area
Hospital and Medical Facilities
Housing and Community Facilities
MCB Camp Lejeune
MCAS New River
Road

Source: ESRI, 2010; Onslow County, 2011;MCB Camp Lejeune, 2011.

0 1 2 4 Miles
0 1 2 4 Kilometers

Figure 4-4
RCZ-II,
MCB Camp Lejeune
North Carolina

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4.6.3 RCZ-III

RCZ-III defines the area within the designated SUA, beyond RCZ-I and RCZ-II, associated with the RTA. RCZ-III is the area required to provide access to and from the targets that provides the aircraft with tactical maneuvering room, safely separates participating and non-participating aircraft, and allows for initial alignment for target acquisition. RCZ-III presents the least significant hazards of the three RCZs. However, since the aircraft may be maneuvering aggressively to line up with targets or are conducting flight procedures that are beyond normal cruise flight, the potential for hazards still exists. Therefore, there are land use compatibility suggestions associated with RCZ-III.

The boundary for RCZ-III, as depicted on Figure 4-5, was developed primarily through interviews with pilots and Range Control personnel with an examination of the SUA surrounding the installation as it related to the safe ingress and egress of aircraft into the target areas. In the case of rotary-wing and tilt-rotor air-to-ground operations, several holding areas are defined in BO 3570.1C around the G-10 Impact Area to contain helicopters and tilt-rotor (MV-22) aircraft as they wait for clearance into a BP for ordnance delivery. These holding areas are depicted on Figure 4-5 to provide the reader with an understanding of how rotary-wing/tilt-rotor maneuvering airspace, in the vicinity of the G-10 Impact Area, relates to the total RCZ-III area. In the GSRA, there are no designated holding areas. As such, this RCUZ Study used the boundary of the SUA above the GSRA (R-5303 and R-5304) to define RCZ-III for training areas west of the New River. For air-to-ground operations east of the GSRA, RCZ-III was developed using two principal references. The first reference was the SUA located above those ranges. This includes R-5306D and R-5306E. To the east of R-5306D, another block of restricted airspace (R-5306C) is also used for ingress into the G-10 Impact Area and other air-to-ground targets. The second reference was qualitative descriptions from pilots of the airspace required to maneuver for target engagement.

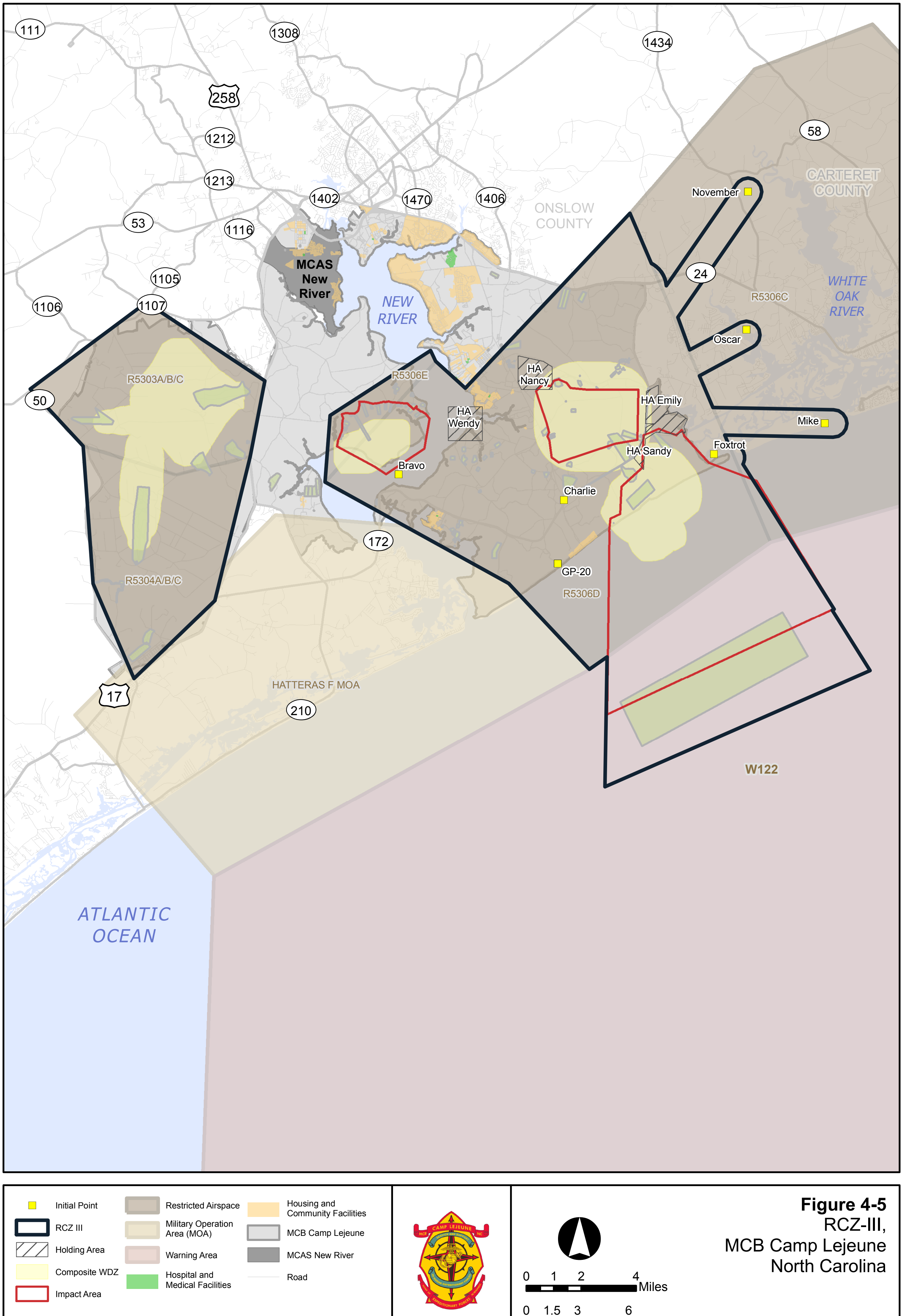
Using pilot interviews and input from installation personnel, it was determined that four ingress corridors should also be included as part of the MCB Camp Lejeune RCZ-III. These corridors begin from aircraft control points located within R-5306C and east of the installation boundary, designated as "November," "Oscar," "Mike," and "Foxtrot," and extend inward towards MCB Camp Lejeune to the boundary of R-5306D. These ingress corridors are 1 statute mile wide (0.5 statute mile on either side of centerline).

4.7 OTHER SAFETY CONCERNS

4.7.1 Bird and Wildlife Aircraft Strike Hazards

Wildlife represents a significant hazard for flight operations. Birds, in particular, are drawn to the open, grassy areas, wetlands, and the warm pavement of airfields. Seventy-eight percent of bird strikes occur below 1,000 feet AGL and 90 percent occur below 3,000 feet AGL (FAA 2007). Because of the speed of the aircraft, collisions with wildlife can happen with considerable force. Although most bird and wildlife strikes do not result in crashes, they can cause structural and mechanical damage to aircraft and require extensive inspections and potential repairs.

To reduce bird/wildlife aircraft strike hazards (BASH), the FAA recommends a minimum distance of 10,000 feet between the airfield serving turbine-powered aircraft and land uses that attract birds and other wildlife (FAA 2007). These land uses include waste disposal operations, wastewater management facilities, wetlands, storm water ponds, golf courses, and agricultural activities.



Source: ESRI, 2010; Onslow County, 2011;MCB Camp Lejeune, 2011.

Figure 4-5
RCZ-III,
MCB Camp Lejeune
North Carolina

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4.7.2 Electromagnetic Interference

Military aircraft are highly dependent on complex electronic systems for navigation and critical flight and mission-related functions. Consequently, care should be taken in siting any activities that create EMI. American National Standards Institute (ANSI) defines EMI as any electromagnetic disturbance that causes, or is capable of causing, undesired responses, or degradation of performance in electrical or electronic equipment. It can be induced intentionally, as in forms of electronic warfare, or unintentionally as a result of spurious emissions and responses, such as high-tension line leakage.

As the demand for alternative energy sources increases, the implementation of wind turbines and wind farms is resulting in a new source of EMI that can affect air- and ground-based radar systems. As the blades of a wind turbine spin, they can cause interference and "clutter" with radar systems (The MITRE Corporation 2008). Since the military uses a variety of radar systems on a day-to-day basis, the adverse effects of wind farms on military systems can degrade the capabilities of radars at an installation or in the aircraft.

4.7.3 Lighting

Bright lights in the vicinity of an airfield can impair a pilot's vision. A sudden flash from a bright light causes a spot or "halo" to remain at the center of the visual field for a few seconds or more, rendering a pilot virtually blind until their vision returns. This is particularly dangerous at night when the flash can diminish the eye's adaptation to darkness. Partial recovery is usually achieved in minutes, but full adaptation typically requires 40 to 45 minutes.

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5

Noise

The impact of aircraft and weapon delivery noise is a critical factor in the planning of future land use near air facilities. How a military range manages noise can play a significant role in shaping the range's relationship with the community. In the vicinity of a training range on which ordnance can be expended from aircraft, the community response to noise is a particular concern near training ranges and under the SUA because of the noise exposure characteristics commonly associated with low-altitude high-speed aircraft operations and the detonation of ordnance. MCB Camp Lejeune has defined noise contours for its target ranges, using the guidance provided in MCO 3550.13. These noise contours provide the community with a tool to plan for compatible development near ranges.

This chapter of the RCUZ Study describes the noise environment at MCB Camp Lejeune's target ranges and impact areas, including the GSRA, the K-2, G-10, and N-1/BT-3 impact areas, the ETAs, and the EOD areas. This chapter also explains how environmental noise is measured and modeled, and includes the projected noise contours based on future operations through 2020.

5.1 Methodology

5.1.1 What is Sound/Noise?

Sound is vibrations in the air, which can be generated by a multitude of sources. When sound is invasive or deemed as unwanted or invasive to a listener, it becomes noise. Further discussion on noise and its effects on people and the environment is provided in Appendix C.

Noise sources at military bases can be classified as continuous noise (e.g., on-base vehicular traffic and aircraft operations) or impulsive noise (e.g., weapons firing or detonation of explosives). Not all noise sources are directly associated with training activities, but the noise environment on military bases is typically dominated by their training operations. The main sources of noise at MCB Camp Lejeune are impulsive noise events, including EOD operations, and large caliber and small arms weapons firing. Aircraft operations are a continuous noise source at MCB Camp Lejeune; however, aircraft noise levels are minimal in comparison to noise levels from impulsive noise sources.

Humans perceive and react differently to impulsive and continuous noise events, depending on the level, frequency, and duration of the event. Because of the difference in human response to these types of noise events, military operational noise is measured using several different noise metrics. The two most commonly used metrics are the Day-Night Average Sound Level (DNL) and the Peak Sound Pressure Level (dBPk).

5.1.1.1 Day-Night Average Sound Level

The DNL is the federally recommended noise metric that is commonly used to define the level of noise exposure on communities in the vicinity of airfields. The DNL, which is expressed in decibels (dB), averages the cumulative sound levels from all noise events at a location over a 24-hour period. DNL does not represent the noise level at a particular time or the noise level from any singular event. The DNL metric also adds an additional 10 dB to events occurring between 10:00 p.m. and 7:00 a.m. This 10-dB “nighttime penalty” represents the added intrusiveness of sounds due to the increased sensitivity to noise when ambient sound levels are low.

Sound frequency is measured in hertz (Hz). Humans can detect sounds within the approximate range of 20 Hz to 15,000 Hz, but are most sensitive to sounds within the 1,000 to 4,000 Hz range.

To accurately assess the impact of different types of noise events on human hearing, different weighting scales that emphasize certain parts of the audio frequency spectrum are used with the DNL metric. A-weighting and C-weighting are the most common weighting scales. A-weighting adjusts the very low and very high sound frequencies to approximate the human ear’s lower sensitivity to those frequencies. Noise from small arms activity and aviation is measured in A-weighted decibels (dBA). Because the A-weighting scale closely resembles the frequency response of the human ear, it provides a good indication of the impact on humans of noise produced by these activities. In contrast, the C-weighting scale incorporates only a slight de-emphasis of the low and high portion of the audible frequency spectrum. Large-amplitude impulse sounds, in which the total amount of energy is an important factor, are measured in C-weighted decibels (dBC). For example, high-energy impulsive sounds, such as those produced by weapons 20mm or greater, shell bursts, surface blasting, and cratering charges, produce significantly higher energy at low frequencies. This low-frequency component can induce structural vibrations, causing buildings and windows to rattle and shake, which may generate additional annoyance to people beyond the audibility of the sound created by the blast. The C-weighting scale includes more of the low-frequency components of noise than does the A-weighting scale.

5.1.1.2 Peak Sound Pressure Level

The dBPk is the highest instantaneous, un-weighted sound level over any given period time. It is used to quantify impulsive, short duration events, such as a large caliber weapon firing or an explosive detonation. High peak sound levels can generate complaints from people in the local community.

Peak sound levels can vary significantly due to varying weather conditions; therefore, computer-based models use a special metric, the PK 15 metric, when measuring peak sound levels. PK 15 is the peak sound level, factoring in the statistical variations caused by weather that is likely to be exceeded only 15 percent of the time (i.e., 85 percent certainty that the sound will be within this range). The PK 15 metric can be used to illustrate how loud an area will get during one noise event, which is beneficial for understanding the potential for complaints. However, the PK 15 metric does not account for the frequency or duration of an event and; therefore, modeled noise contours are not used to evaluate land use compatibility.

5.1.2 Noise Zones and Land Use Planning

The noise exposure from small arms range operations at MCB Camp Lejeune is calculated using the A-weighted Day-Night Average Sound Level (ADNL), measured in dBA. Small arms fire noise (muzzle blast and projectile detonation) is also assessed using un-weighted peak sounds levels (dBPk). Noise from large caliber range operations, which includes low frequency noise components, is calculated using the C-weighted Day-Night Average Sound Level (CDNL), measured in dBC, as well as PK 15 metrics. The DNL and peak sound levels are visually depicted as a noise contour[3] that connects points of equal value. The area between two noise contours is known as a noise zone.

For land use planning purposes, the DOD generally divides noise exposure from aircraft and weapons into three noise zones, as described below. Table 5-1 provides the noise level limits of each noise zone associated with land use planning for small arms and impulse noise.

- **Noise Zone 1**: Represents the lowest area of noise exposure. Individuals can hear noise, but can also adapt to noise levels. Most land uses are compatible within Noise Zone 1.
- **Noise Zone 2**: Represents the area of moderate impact where some land use control measures are recommended for both on- and off-installation locations.

  Noise Zone 3: Represents the most severely impacted areas where the greatest degree of land use control is recommended for both on- and off-installation.

[3] Calculated noise contours do not represent exact measurements. Noise levels inside a contour may be similar to those outside a contour line. When the contour lines are close, the change in noise level is greater. When the contour lines are far apart, the change in noise level is gradual.

Table 5-1: Noise Zone Definitions

Noise Zone	Aircraft and Small Arms Noise (ADNL)	Impulse Noise (CDNL)	Small Arms dBPk (peak)
Zone 1	< 65 dBA	< 62 dBC	<87 dBPk
Zone 2	65 to 75 dBA	62 to 70 dBC	87 to 104 dBPk
Zone 3	> 75 dBA	> 70 dBC	>104 dBPk

While DNL contours are widely accepted for use in land use planning and zoning, they do not represent what an individual hears when a noise event occurs. Weather conditions and environmental aspects can contribute to the sound from an individual range being heard several miles away. Supplemental noise metrics are used to help explain this situation in a range environs. For example, high-energy impulsive sound from firing large weapons or detonations can be heard as well as cause vibrations for an instant, and can be a source of noise complaints. Table 5-2 shows the risk of noise complaints with increasing levels of impulsive noise from large caliber weapons and EOD detonations.

Table 5-2: Risk of Noise Complaints from Impulsive Noise

Risk of Complaints	Large Caliber Weapons Noise Limits (dB) PK 15 (metric)
Low	<115 dBPk
Moderate	115-130 dBPk
High	130-140 dBPk
Risk of permanent physiological damage to unprotected human ears and structural damage claims	>140 dBPk

5.1.3 Noise Models Used in this Study

Noise exposure was modeled for the projected 2020 range ordnance operations at MCB Camp Lejeune, including ground-based weapon systems and airborne weapon systems. Ordnance operations generate blast noise from large caliber ground-to-ground fire, small arms fire, air-to-ground fire, detonation of the projectile (if it contains an HE charge), and associated noise from projectile bow shock for supersonic projectiles. Modeling parameters include an average operating year of 244 days and acoustical day/night split of 90/10.

Noise contours were developed using the standard DOD computer noise software: Small Arms Range Noise Assessment Model (SARNAM) for small arms weapon operations and Blast Noise Version 2 (BNOISE2) for large caliber weapon operations. Large caliber ordnance includes explosives and all weapons systems greater than .50 caliber (artillery, armor, and missiles), and small caliber ordnance include weapon systems firing ammunition less than or equal to .50 caliber.

Aircraft operations occur at MCB Camp Lejeune; however, their contribution to the overall noise environment is lower than the large caliber, EOD, and small arms firings. Therefore, noise contours for aircraft operations at MCB Camp Lejeune were not generated as part of this RCUZ Study.

5.1.3.1 Small Arms Noise Metrics

Noise from small arms range operations at MCB Camp Lejeune, which consists of muzzle blast and projectile detonation (if HE charged), was assessed using SARNAM version 2.6. SARNAM calculates different sound exposure metrics, such as ADNL and peak sound levels, based on range attributes (size and structure, number of targets, and direction of fire), type of weapons and ammunition, number of rounds and time of firing, and atmospheric conditions. The model also accounts for spectrum and directivity of muzzle blast and projectile bow shock and downwind propagation conditions.

5.1.3.2 Heavy Weapons Noise Metrics

Impulse noise resulting from large ordnance activity was assessed using BNOISE2, which was developed by the United States Army Public Health Command (USAPHC). BNOISE2 produces CDNL contours and PK metric contours for large caliber weapon firing and blasting activities. Primary modeling parameters include range attributes, such as range firing and target point coordinates, munitions type (large caliber guns or explosive ordnance), and the number of daytime and nighttime rounds or operations. The upgraded BNOISE2 includes updated weapons source models and improved propagation algorithms. In addition, BNOISE2 accounts for the effects of weather, land-water boundaries, and terrain.

5.1.3.3 Aircraft Noise Metrics

The secondary source of noise at MCB Camp Lejeune is aircraft operations. Aircraft noise is represented using the DNL noise metric. Operational data was collected from MCB Camp Lejeune range personnel and from pilots of aircraft that regularly use the airfield to model aircraft noise at MCOLF Camp Davis. Aircraft noise contours are provided in the 2013 MCOLF Camp Davis AICUZ Study.

5.1.4 Noise Data Validation

To ensure that noise modeling considered the most recent and accurate projections of noise-generating range operations, MCB Camp Lejeune prepared a Munitions Data Validation Package. This data package includes: (1) a summary of ordnance utilization by weapon type on each range; (2) figures showing the locations of new ranges that were added to the study; and (3) range modeling parameters. The final data summary from the Munitions Data Validation Package was approved by the installation on August 11, 2011. In addition, the noise model results were externally reviewed and approved by the USAPHC's Operational Noise Program Office.

5.2 Baseline Noise Exposure Levels

Baseline noise exposure levels are based on the 2002 RCUZ Study. For the 2002 RCUZ Study, DNL noise contours were developed for average daily firings based on annual events for ordnance, and onset rate-adjusted Day-Night Average Sound Level (L_{dnmr}) calculations were developed for airspace operations within the GSRA and G-10 impact areas using CY 2000 data. In that RCUZ Study, noise contours for small arms (A-weighted) and heavy weapons (C-weighted) noise were combined to present the overall noise condition at MCB Camp Lejeune. This approach is no longer considered valid. This 2014 RCUZ Study presents the ADNL contours for small arms range operations separately from CDNL contours for large caliber range operations.

Figures 5-1 and 5-2 present the 2002 Baseline Noise Exposure Levels for Combined DNL Contours for small arms (A-weighted) and heavy weapons (C-weighted) operations within the GSRA and G-10 impact areas, respectively.

5.2.1 Changes from Previous RCUZ Noise Contours

Several previous noise studies have been conducted at MCB Camp Lejeune; however, changing technologies and guidelines have resulted in evolving approaches and formats for these studies, thereby making a direct comparison of any one study with another difficult to achieve. For example, although the studies all measured noise in decibels, with subscripts to indicate the metrics or scales used, the scope of these studies was not always the same, and they often approached the noise issues in a variety of ways, used differing weapons usage assumptions, or were based on limited, short-term field measurements. The studies also used different metrics and differing noise scales to report the results. Comparison of numerical values of decibels from various noise studies could be deceiving, as it would not be a valid comparison. Peak noise exposures levels were not modeled for the 2002 RCUZ Study.

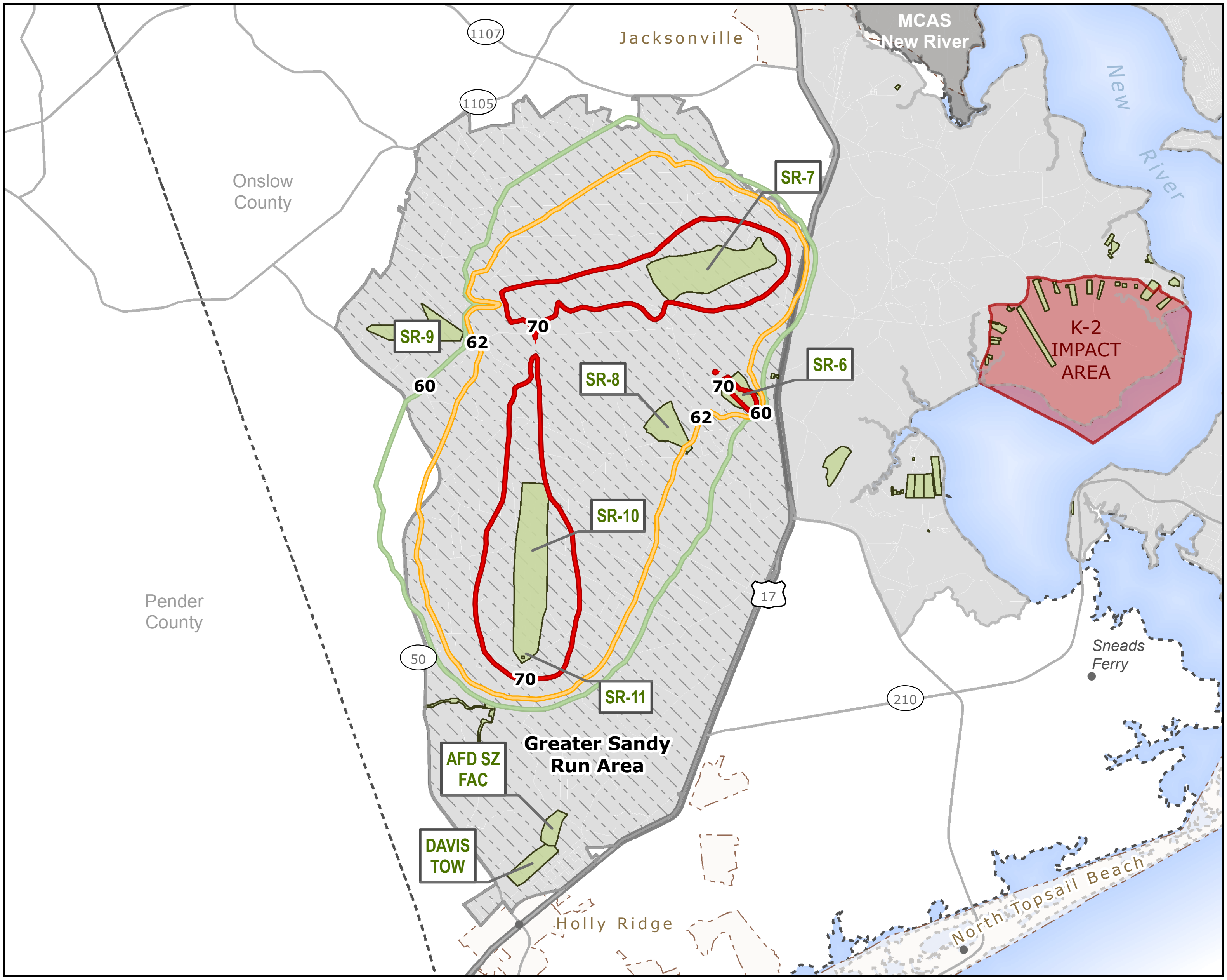

Figure 5-1
2002 Basline DNL Contours for Small Arms and Large Caliber Operations within the GSRA
MCB Camp Lejeune
North Carolina

Noise Contours
- 60 DNL
- 62 DNL
- 70 DNL
- Range Boundary
- Greater Sandy Run Area
- Impact Area
- MCB Camp Lejeune
- MCAS New River
- County Boundary
- Major Road
- Local Road

Source:
BRRC, 2011; ENE, 2011; ESRI, 2010;
Navy, 2010; Onslow County, 2011.

0 0.5 1 2 Miles
0 0.75 1.5 3 Kilometers

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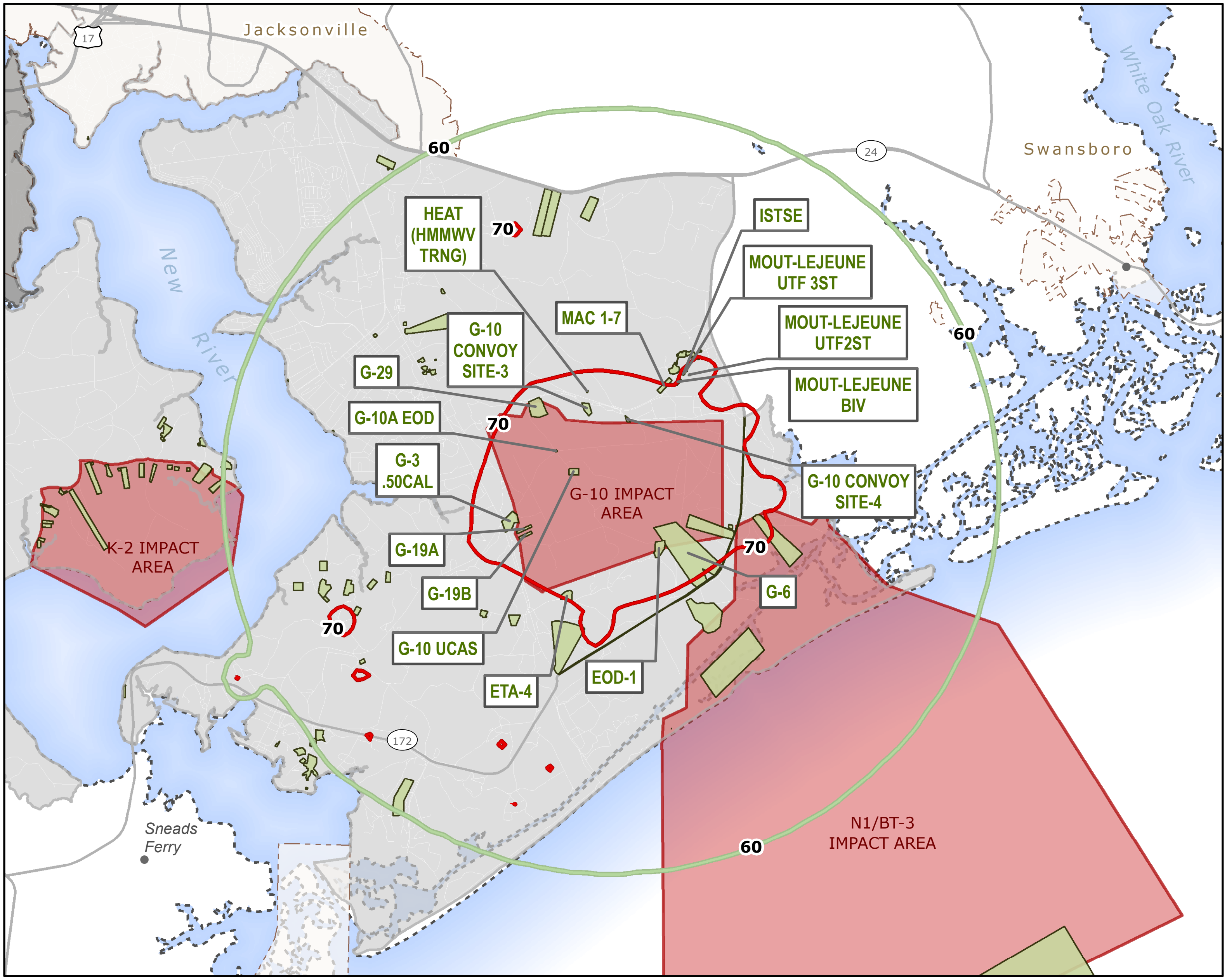

Figure 5-2
2002 Basline DNL Contours for Small Arms and Large Caliber Operations within the G-10 Impact Area
MCB Camp Lejeune
North Carolina

Source:
BRRC, 2011; ENE, 2011; ESRI, 2010; Navy, 2010; Onslow County, 2011.

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5.3 Noise Complaints

Noise complaint data help to gain a better understanding of MCB Camp Lejeune's overall noise impact on the surrounding communities and, consequently, help directs installation personnel efforts to effectively address and minimize noise concerns while sustaining mission requirements. Noise complaints are received and recorded by the Range Control Office, which maintains a dedicated complaint hotline that is staffed between 7:00 a.m. and 5:00 p.m. and recorded on voice mail between 5:00 p.m. and 7:00 a.m. The Range Control Office investigates all complaints by reviewing the range activity records and noise monitoring equipment to determine whether complaints correlate with specific training events. Whenever possible, Range Control Office personnel will return calls to discuss the complaint and provide information about MCB Camp Lejeune's noise mitigation procedures. Although MCAS New River has a dedicated hotline for noise complaints, the MCB Camp Lejeune Range Control Office also receives and researches complaints related to aviation activities associated with the installation. MCB Camp Lejeune is also responsible for recording and investigating complaints from MCOLF Camp Davis to determine if any corrective actions are appropriate.

5.4 Projected Noise Exposure Levels

Noise contour maps provide the Marine Corps, local community planning organizations, and the public with modeled noise-related impacts from range operations. Noise contours, when overlaid with local land uses, can help identify areas of incompatible land uses and plan for future development around a range.

The RCUZ Instructions require modeling and analyzing existing conditions and any future operational changes that can be reasonably predicted. Using the operational data described in Chapter 3, the MCB Camp Lejeune RCUZ noise contours were developed with DOD-approved computer-based models. Noise events at MCB Camp Lejeune were modeled with CDNL and PK-15 for large caliber operations and with ADNL and Peak Sound Level for small arms.

The 2014 RCUZ noise contours represent the projected noise exposure levels based on projected operations through CY 2020. Operations are projected into the future to help ensure that the future operational capability of the installation is considered. Future year planning is necessary to consider the effects of expected changes in mission, aircraft, and range operational levels. As a planning document, this RCUZ Study forecasts aircraft and range operations based upon estimates of future mission requirements, including new platforms and ordnance, within the next 10 years to assess the installation's impact on the local community.

5.4.1 Projected Small Arms Noise Exposure (A-Weighted)

Small arms ADNL noise contours were modeled for ranges within the GSRA, F Ranges, Stone Bay, and N-1/BT-3 impact areas, the ETAs, and the EOD areas. Small arms noise contours for the K-2 and G-10 impact areas were not modeled since noise exposure from adjacent large caliber operations masks any small arms noise in that area. Figure 5-3 illustrates the 2014 RCUZ ADNL contours for small arms range operations at MCB Camp Lejeune.

The largest small arms noise ADNL noise contour area is east of New River, within the Stones Bay Ranges, and the eastern portion of the GSRA, within ranges SR-6, SR-7, and SR-8. Within the GSRA, other small arms ADNL contours are generated from operations at the SR-9 and SR-11 ranges. Within the eastern portion of the installation, the larger noise contour areas are generated from operations at the N-1/BT-3 Impact Area along the southern boundary and the F-2, F-4, and F-5 ranges along the northeast boundary north of State Highway 24/Freedom Way in Onslow County.

Small arms ADNL noise contours are largely contained within the installation boundary. The 60 dB ADNL noise contour from ranges F-2, F-4, and F-5 at the northeast corner of the installation boundary extends slightly off base to the north of State Highway 24. Additionally, some noise contours extend over water at various ranges along the shorelines of New River and the coastline.

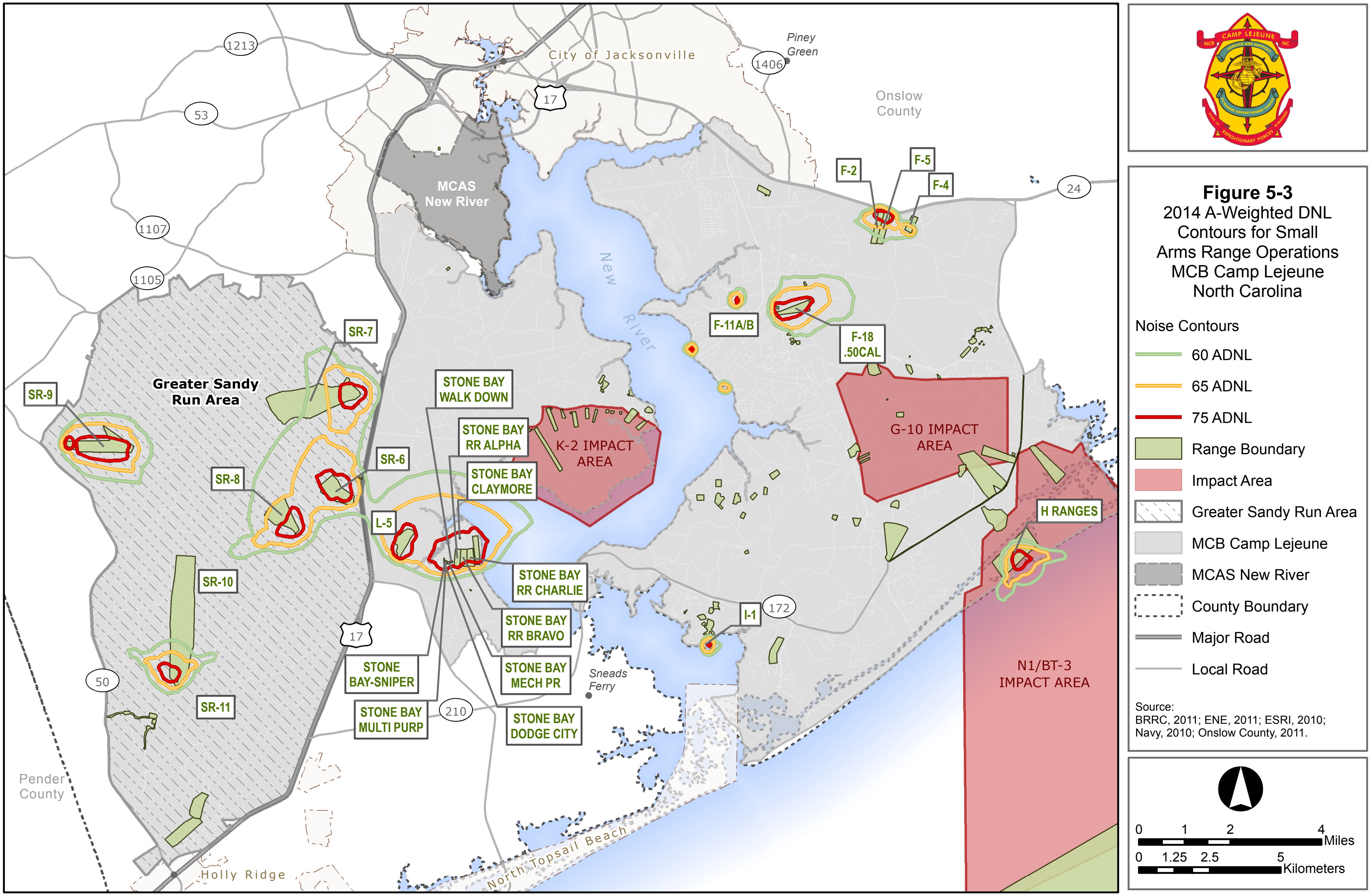

Figure 5-3
2014 A-Weighted DNL Contours for Small Arms Range Operations
MCB Camp Lejeune
North Carolina
Noise Contours
60 ADNL
65 ADNL
75 ADNL
Range Boundary
Impact Area
Greater Sandy Run Area
MCB Camp Lejeune
MCAS New River
County Boundary
Major Road
Local Road
Source:
BRRC, 2011; ENE, 2011; ESRI, 2010; Navy, 2010; Onslow County, 2011.
0 1 2 4 Miles
0 1.25 2.5 5 Kilometers
City of Jacksonville
Piney Green
Onslow County
MCAS New River
New River
Greater Sandy Run Area
SR-7
SR-9
SR-6
SR-8
SR-10
SR-11
L-5
F-2
F-5
F-4
F-11A/B
F-18 .50CAL
I-1
H RANGES
K-2 IMPACT AREA
G-10 IMPACT AREA
N1/BT-3 IMPACT AREA
STONE BAY WALK DOWN
STONE BAY RR ALPHA
STONE BAY CLAYMORE
STONE BAY RR CHARLIE
STONE BAY RR BRAVO
STONE BAY MECH PR
STONE BAY DODGE CITY
STONE BAY-SNIPER
STONE BAY MULTI PURP
Sneads Ferry
North Topsail Beach
Holly Ridge
Pender County
1213
53
1107
1105
17
1406
24
172
50
210

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5.4.2 Projected Large Caliber Weapons Noise Exposure (C-Weighted)

Large caliber CDNL noise contours were modeled for ranges within the GSRA, the K-2, G-10, and N-1/BT-3 impact areas, the ETAs, and the EOD areas. Figure 5-4 illustrates the 2014 RCUZ CDNL contours for large caliber range operations at MCB Camp Lejeune. For large weapon noise, Noise Zone 1 (<62 dBC CDNL) and portions of Noise Zone 2 (between 62 to 70 dBC CDNL) extend beyond the MCB Camp Lejeune boundary. With respect to Noise Zone 2, these areas include:

- To the east, generally along Sand Ridge Road;
- To the north, between GSRA and K-2 along Verona Road;
- To the west, approximately 1.3 nautical miles past Route 50; and
- To the south, into the northern portions of Snead's Ferry.

These areas also correspond to regions of potential complaints (>115 dBPk). Noise Zone 3 (greater than 70 dBC CDNL) areas remain within the range boundaries.

5.4.3 Peak Level Noise Supplemental Analysis

As described above, in terms of peak levels, there are small areas just outside the installation boundary that are exposed to small arms peak noise levels associated with moderate risk levels of complaints (>115 dBPk) (Figure 5-5, provided at the end of this section). These areas are west of State Route 50 (due west of Stone Bay) and north of Freedom Way between Kellumtown Road and Walton Road.

As described in Section 5.4.2, the large arms peak levels encompass a small area at the shoreline east of the range (Figure 5-6, provided at the end of this section). This area is exposed to peak noise levels with a high risk of noise complaints (> 130 dBPk) and is contained within e government-owned property or over the shoreline of the Atlantic Ocean.

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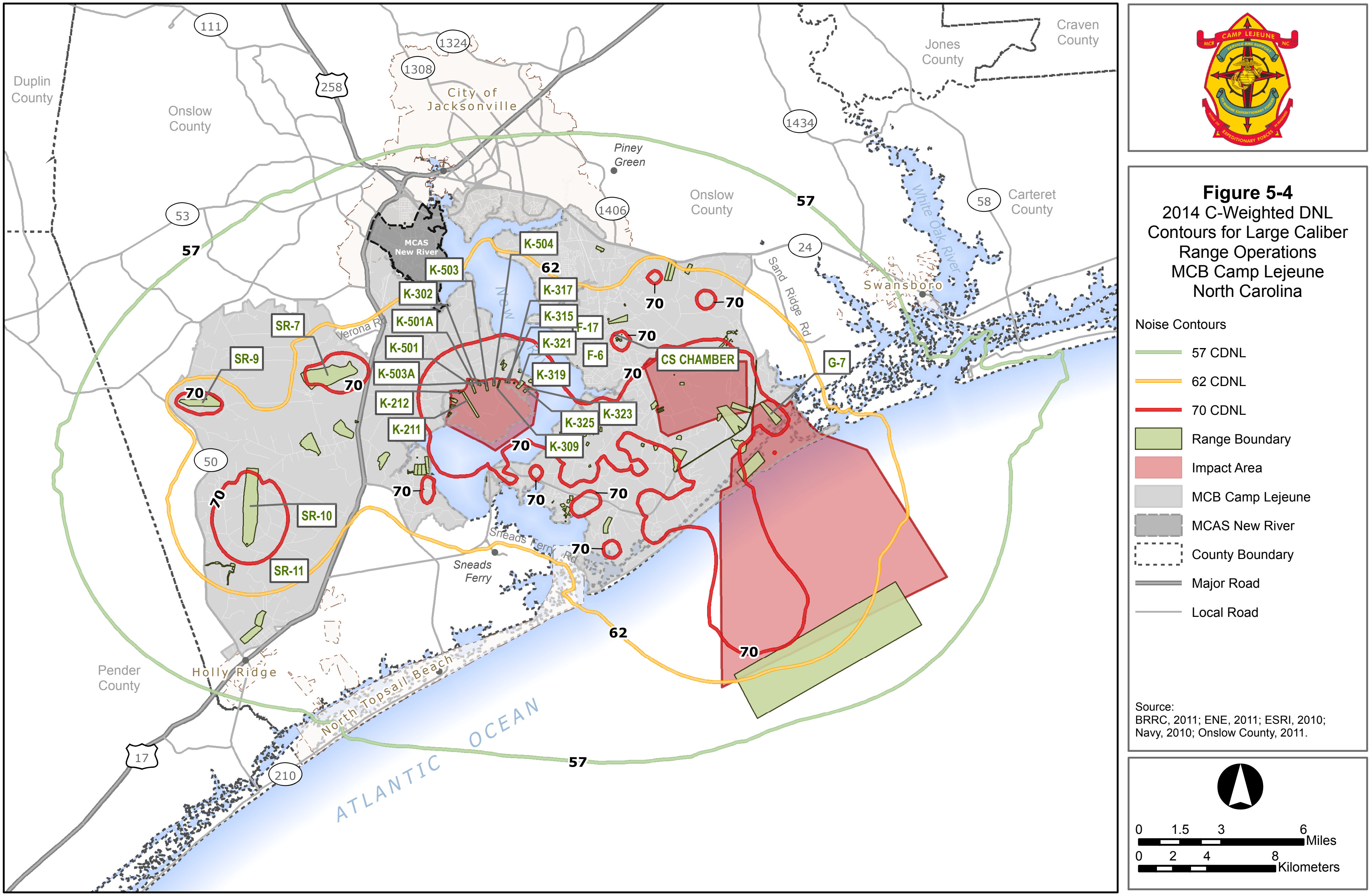
Figure 5-4
2014 C-Weighted DNL Contours for Large Caliber Range Operations
MCB Camp Lejeune
North Carolina
Noise Contours
57 CDNL
62 CDNL
70 CDNL
Range Boundary
Impact Area
MCB Camp Lejeune
MCAS New River
County Boundary
Major Road
Local Road
Source:
BRRC, 2011; ENE, 2011; ESRI, 2010; Navy, 2010; Onslow County, 2011.
0 1.5 3 6 Miles
0 2 4 8 Kilometers
Duplin County
Onslow County
Jones County
Craven County
Carteret County
Pender County
City of Jacksonville
Piney Green
Swansboro
Sneads Ferry
Holly Ridge
North Topsail Beach
ATLANTIC OCEAN
White Oak River
New River
Sand Ridge Rd
Verona Rd
Sneads Ferry Rd
MCAS New River
CS CHAMBER
K-504
K-503
K-302
K-501A
K-501
K-503A
K-212
K-211
K-317
K-315
K-321
K-319
K-325
K-323
K-309
F-17
F-6
G-7
SR-7
SR-9
SR-10
SR-11
111
1324
1308
258
53
1406
1434
58
24
50
17
210
57
62
70

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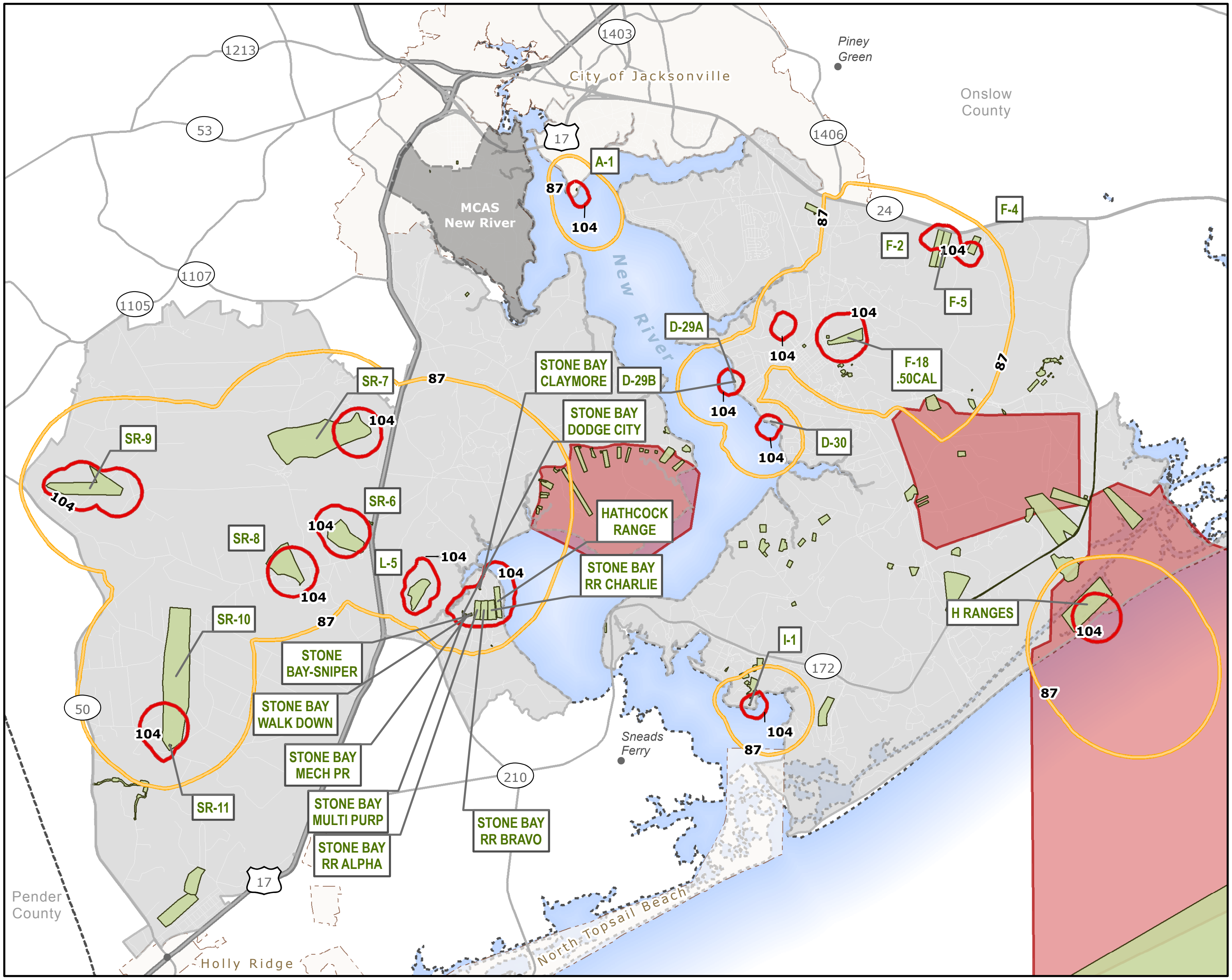

Figure 5-5
2014 Peak Noise Sound Levels for Small Arms Range Operations
MCB Camp Lejeune
North Carolina

Noise Contours
- 87 dBPk
- 104 dBPk
- Impact Area
- Range Boundary
- MCB Camp Lejeune
- MCAS New River
- County Boundary
- Major Road
- Local Road

Source:
BRRC, 2011; ENE, 2011; ESRI, 2010; Navy, 2010; Onslow County, 2011.

0 1 2 4 Miles
0 1.25 2.5 5 Kilometers

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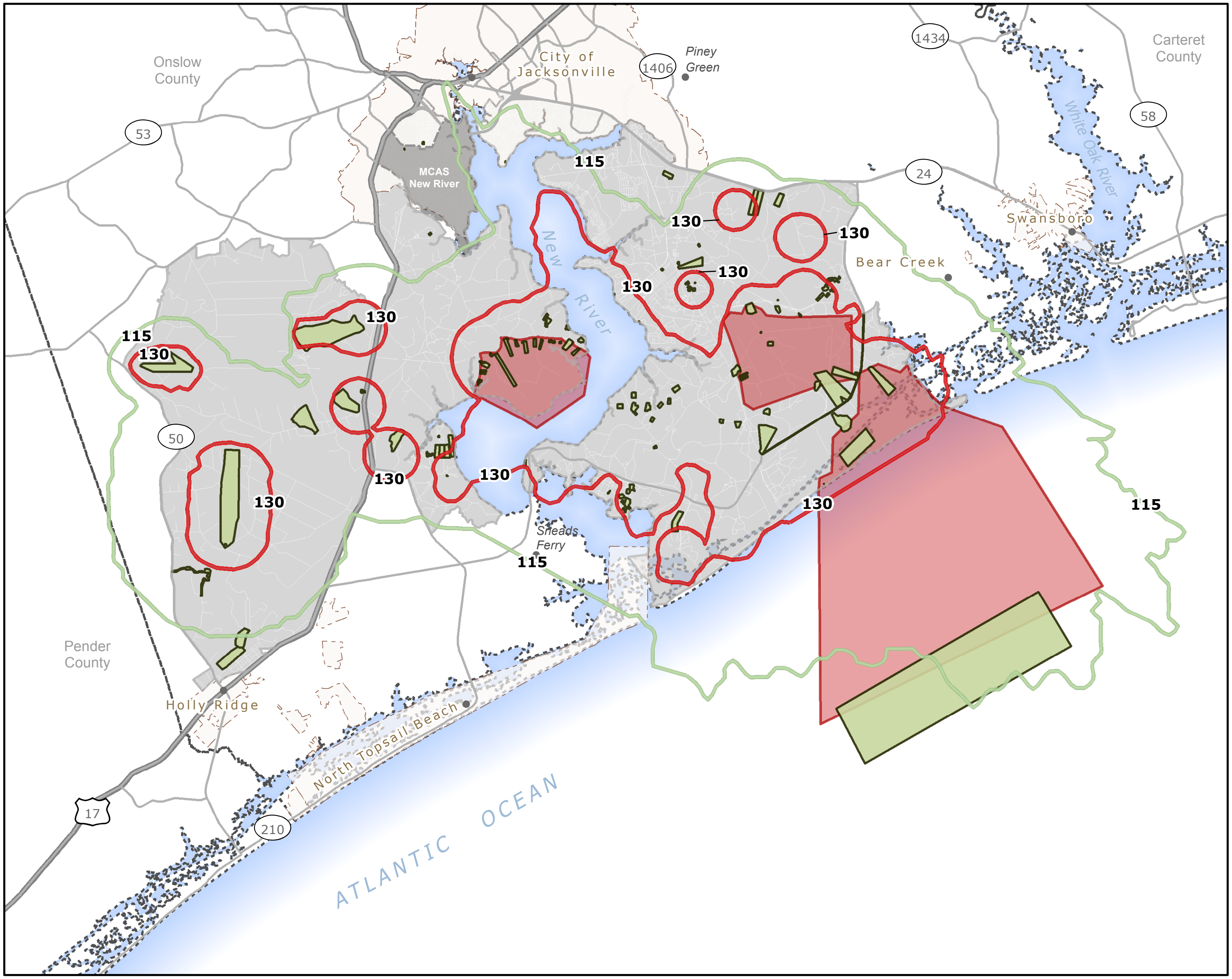

Figure 5-6
2014 Peak Noise Sound Levels for Large Arms Range Operations
MCB Camp Lejeune
North Carolina

Noise Contours
- 115 dBPk
- 130 dBPk
- Range Boundary
- Impact Area
- MCB Camp Lejeune
- MCAS New River
- County Boundary
- Major Road
- Local Road

Source:
BRRC, 2011; ENE, 2011; ESRI, 2010; Navy, 2010; Onslow County, 2011.

0 1.5 3 6 Miles
0 1.5 3 6 Kilometers

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5.4.4 Projected Aviation Noise Exposure (A-Weighted)

Aircraft training occurs within the MCB Camp Lejeune complex; however, its contribution to the overall noise environment is lower than that of the large weapon, EOD, and small arms firings. Representative noise levels for both fixed-wing and rotary-wing aircraft are shown in Tables 5-3 to 5-8, provided at the end of this section.

Simple metrics quantify the sound levels occurring during an individual aircraft overflight (single event) and the total noise exposure from the event. Single noise events can be described with Maximum Sound Level (L_{max}) and Sound Exposure Level (SEL).

The L_{max} is the highest A-weighted integrated sound level measured during a single event in which the sound level changes value with time (e.g., an aircraft overflight). During an aircraft overflight, the noise level starts at the ambient or background noise level, rises to the maximum level as the aircraft flies closest to the observer, and returns to the background level as the aircraft recedes into the distance.

SEL is a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: the sound level that changes throughout the event and the period of time during which the event is heard. SEL provides a measure of the net impact of the entire acoustic event, but it does not directly represent the sound level heard at any given time. During an aircraft flyover, SEL would include both the maximum noise level and the lower noise levels produced during onset and recess periods of the overflight.

Aircraft generally train in R-5306D, which overlays the G-10 Impact Area; however, aircraft may also fly within any of the overhead or adjacent airspace such as R-5303, R-5304, R-5306C/E, the Hatteras MOA, Warning Area 122, or any of the MTRs in the vicinity of MCB Camp Lejeune.

Primary flight modes for fixed-wing aircraft involve the "run-in" on the target as well as holding and cruise flight. For these two modes, various altitudes are involved, depending on the tactics. Table 5-3 provides the L_{max} values and Table 5-4 provides SEL values for fixed-wing aircraft during the run-in portion of their training flights. It should be noted that these noise levels are for areas directly underneath the flight tracks. Table 5-5 and Table 5-6 provide the same metrics for holding and cruise modes of flight.

Table 5-3: Representative L_{max} (dBA) Values for Fixed-Wing "Run-In" Operational Mode

Aircraft		F/A-18E/F	F/A-18C/D	EA-6B	AV-8B	C-130
Engine Power		94% N2	92% NC	100% RPM	95% RPM	970 C TIT
Airspeed (kts)		450	500	400	450	300
Altitude (ft. AGL)	500	119	116	117	109	92
	1,000	111	108	110	101	85
	2,500	101	96	99	90	75
	5,000	91	85	89	80	66
	10,000	80	71	77	68	57
	20,000	68	54	62	55	47

Table 5-4: Representative SEL (dBA) Values for Fixed-Wing "Run-In" Operational Mode

Aircraft		F/A-18E/F	F/A-18C/D	EA-6B	AV-8B	C-130
Engine Power		94% N2	92% NC	100% RPM	95% RPM	970 C TIT
Airspeed (kts)		450	500	400	450	300
Altitude (ft. AGL)	500	119	114	117	110	94
	1,000	113	108	112	104	89
	2,500	105	99	103	94	81
	5,000	97	89	95	86	75
	10,000	88	77	85	77	67
	20,000	77	62	72	65	59

Table 5-5: Representative L_{max} (dBA) Values for Fixed-Wing Holding and Cruise Operational Modes

Aircraft		F/A-18E/F	F/A-18C/D	EA-6B	AV-8B	C-130
Engine Power		83% N2	88% NC	95% RPM	80% RPM	970 C TIT
Airspeed (kts)		400	400	300	400	300
Altitude (ft. AGL)	500	106	104	111	106	92
	1,000	99	96	104	99	85
	2,500	87	85	94	87	75
	5,000	77	75	85	77	66
	10,000	65	64	75	66	57
	20,000	52	50	64	53	47

Table 5-6: Representative SEL (dBA) Values for Fixed-Wing Holding and Cruise Operational Modes

Aircraft		F/A-18E/F	F/A-18C/D	EA-6B	AV-8B	C-130
Engine Power		83% N2	88% NC	95% RPM	80% RPM	970 C TIT
Airspeed (kts)		400	400	300	400	300
Altitude (ft. AGL)	500	109	106	113	107	94
	1,000	103	100	108	101	89
	2,500	94	91	101	92	81
	5,000	86	83	94	84	75
	10,000	76	73	86	74	67
	20,000	64	62	76	63	59

Table 5-7: Representative Noise Levels for Rotary-Wing Aircraft

AH-1W									
	Level Cruise			Descent	Ascent	Pattern		Hold	Hover
						Standard	Speed		
Airspeed (kts)	100	100	100	80	70	80	80	80	0
Altitude, ft. AGL	500	1,000	1,200	670	560	500	500	300	20
SEL, dBA	91	87	86	96	97	92	91	96	
L_{max}, dBA	83	76	74	87	85	84	84	89	56
UN-1N									
	Level Cruise			Descent	Ascent	Pattern		Hold	Hover
						Standard	Speed		
Airspeed (kts)	100	100	100	80	70	80	80	80	0
Altitude, ft. AGL	500	1,000	1,200	670	560	500	500	300	50
SEL, dBA	91	87	86	96	97	92	91	96	
L_{max}, dBA	83	76	74	87	85	84	84	89	58
CH53-E									
	Level Cruise			Descent	Ascent	Pattern		Hold	Hover
						Standard	Speed		
Airspeed (kts)	120	120	120	90	85	85	85	80	0
Altitude, ft. AGL	500	1,000	1,200	670	560	500	500	300	100
SEL, dBA	97	93	92	93	96	96	103	97	
L_{max}, dBA	91	84	83	84	87	87	87	91	65
MV-22									
	Level Cruise			Descent	Ascent	Pattern		Hold	Hover
						Standard	Speed		
Airspeed (kts)	70	200	220	72	160	170	85	80	0
Altitude, ft. AGL	1,000	2,000	2,500	590	470	500	500	300	10
SEL, dBA	87	77	80	90	84	85	96	96	
L_{max}, dBA	80	66	70	81	77	78	88	92	58

6 Land Use Compatibility

This RCUZ Study is a planning document for the Marine Corps to use when working with government entities to adopt programs, policies, and regulations that support the Marine Corps mission and encourage compatible development near MCB Camp Lejeune. The land use compatibility analysis is based on an assessment of existing land use and proposed development, both on and off the installation, within the 2014 Composite RCUZ footprint.

Planning practices and population, housing, and economic trends were evaluated to determine how local and regional development patterns could impact future operations at the range installation. Recommended strategies for RCUZ implementation are based on the findings from the land use compatibility analysis.

6.1 Range Safety and Noise Zones (RCUZ Footprint)

The 2014 Composite RCUZ footprint is a composite of the noise zones and RCZs associated with each of the operations areas. The RCZs and the noise zones that are included in the RCUZ footprint reflect projected operations through 2020. The RCUZ footprint is used as the basis for the land use compatibility analysis. The RCUZ footprint defines the minimum area within which land use control measures are recommended to protect public health, safety, and welfare and to preserve the range installation's mission.

MCB Camp Lejeune's RCUZ footprint and the land use recommendations presented in this RCUZ Study are fundamental tools for effective compatible land use planning. The 2014 Composite RCUZ footprint is depicted on Figure 6-1.

6.2 LAND USE COMPATIBILITY GUIDELINES AND CLASSIFICATIONS

The Marine Corps has developed guidelines for compatible land use and development within a range installation's noise zones and RCZs. These land use guidelines are provided in the Marine Corps RCUZ Instructions (MCO 3550.13).

Tables 6-1 and 6-2 provide a list of common land use classifications and their compatibility recommendations within RCUZ noise zones (Table 6-1) and RCZs (Table 6-2). Land use classifications presented in these tables are general and do not represent the local communities' land use designations. When current land uses and proposed development in the RCUZ footprint are compared to these guidelines, compatible and incompatible land uses can be identified.

The Marine Corps' land use recommendations are more stringent for RCZs than for noise zones. The land use recommendations for RCZs take into consideration the possible harmful consequences of injury and damage to property, which are considered more serious than the potential harm caused by aircraft and range noise impacts.

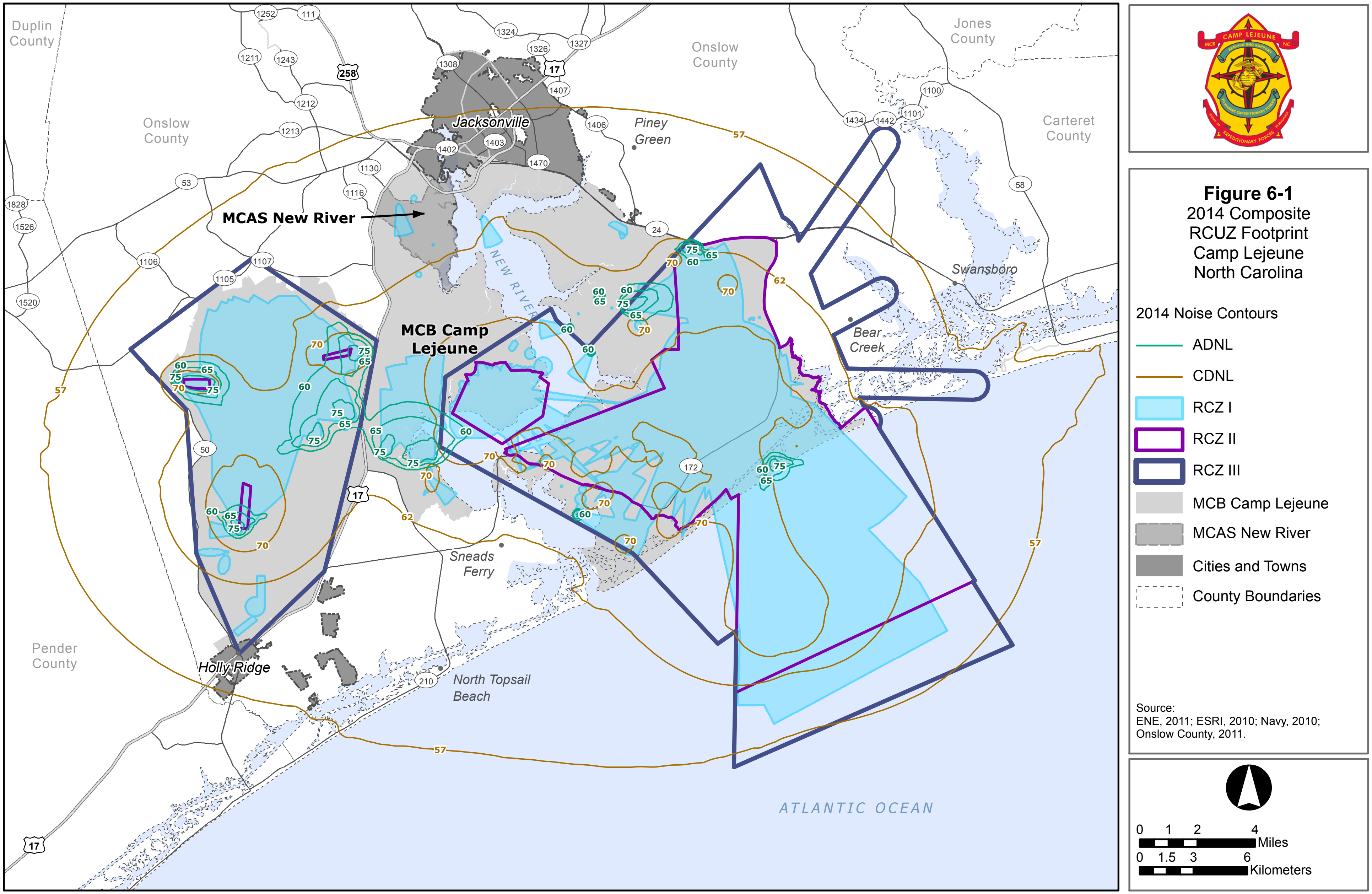

Figure 6-1
2014 Composite RCUZ Footprint
Camp Lejeune
North Carolina

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Table 6-1: Land Use Classifications and Compatibility Guidelines in Noise Zones

Land Use		Land Use Compatibility with Noise Zone (DNL) and Peak15 (dBPk)						
		Noise Zone 1		Noise Zone 2		Noise Zone 3		
	ADNL	<55	55–64	65–69	70–74	75–79	80–84	>85+
	CDNL	<62		62–70		>70		
Single Family Residential, Duplex, Mobile Homes				(3)	(3)			
Multi-Family Residential, Transient Lodging				(3)	(3)			
Public Assembly, Auditoriums, Concert Halls				(1)	(1)			
Schools, Churches, Child Care, and Hospitals				(1)	(1)			
Playgrounds, Neighborhood Parks					(1)			
Shopping Centers and Superstores					(1)	(1)		
Business Services					(1)	(2)		
Manufacturing (ex. Petrol/chem.; textile)					(1)	(2)	(2)	
Agriculture, Forestry Fishing, and Mining								

Source: Adapted from MCO 3550.13 (LFL)
Notes:
This generalized land-use table provides an overview of recommended land use. To determine specific land-use compatibility, see Appendix A.
(1) = Land use and related structures generally compatible; however, measures to achieve recommended noise-level reduction (25 to 30 NLR) should be incorporated into design and construction of the structures.
(2) = Land use and related structures generally compatible; however, measures to achieve recommended noise- level (30 to 35 NLR) reduction should be incorporated into design and construction of the structures.
(3) = Residential use is discouraged in DNL 65–69 and strongly discouraged in DNL 70–74. Where the community determines that these uses must be allowed, a NLR of at least 25 dB should be incorporated into building codes.
Key:

Compatible
Incompatible

Table 6-2: Land Use Classifications and Compatibility Guidelines in RCZs

Land Use	Land Use Compatibility with RCZs		
	RCZ-I	RCZ-II	RCZ-III
Single Family Residential, Duplex, Mobile Homes			(3)
Multi-Family Residential, Transient Lodging			
Schools, Churches, and Libraries			
Hospitals and Nursing Homes			
Public Assembly, Auditoriums, Concert Halls			
Offices and Business Services			(2)
Commercial and Retail			(2)
Manufacturing			(2)
Utilities			
Playgrounds, Neighborhood Parks, and Outdoor Sports Arenas			(2)
Golf Courses, Riding Stables, and Water Recreation		(4)	(2)
Industrial, Warehouse, and Supplies			
Livestock, Farming, and Animal Breeding		(1)	(2)
Agriculture (Except Livestock), Mining, Forestry and Fishing		(1)	
Recreational Wilderness Areas		(2)	(2)

Source: Adapted from MCO 3550.13 (LFL)
Notes:
(1) = RCZ-II is an area of armed overflight. Land uses that have the potential to attract people are not compatible.
(2) = Incompatible when the training mission requires low altitude overflight (less than 500 ft.).
(3) = Suggested maximum density of RCZ-III is no more than 1 or 2 dwellings per acre.
(4) = Clubhouses, chapels, and other public assembly facilities are not compatible in RCZ-III.
Key:

Compatible
Incompatible

6.3 PLANNING AUTHORITIES

Local governments manage land use and future growth through zoning regulations, land use plans, subdivision regulations, and building codes. These planning tools define standards for the type, density, and physical dimensions of local land uses. Elected city or county legislators enact zoning laws and appoint agencies/boards to review proposed development and administer zoning regulation provisions. In North Carolina, adopting and enforcing land use regulations, including zoning ordinances and comprehensive planning, are all within the authority of the local municipality or county.

The State of North Carolina does have a role in land use planning as it applies to military installations. In accordance with Sections 153A-323(b) and 160A-364 of the North Carolina General Statutes, Onslow County and the surrounding cities are required to provide written notice to the MCB Camp Lejeune Commanding General of any proposed changes to zoning or land uses within 5 miles of the installation perimeter at least ten days prior to the public hearing date. If the installation provides comments or analysis on the proposed ordinance or amendment, the local governing body must consider these comments before making a final determination. While authority over use and development of properties surrounding a range installation is under the jurisdiction of local governments, Sections 153A-323(b) and 160A-364 of the North Carolina General Statutes recognize that land uses outside of an installation's fence line can have tangible effects on Marine Corps operations.

6.3.1 Onslow County Planning Authority

6.3.1.1 Zoning Authority

The County Board of Commissioners is the governing body of the county, and consists of five elected commissioners. The Commissioners are all elected at-large and represent the entire county population versus individual districts.

All properties within Onslow County are classified into zoning districts that permit or prohibit various types of land use and development. Zoning laws are adopted and amended by the County Board of Commissioners. The Planning Board is an advisory board to the County Board of Commissioners and is responsible for reviewing development proposals and proposed zoning amendments to ensure consistency with the Onslow County Comprehensive Plan.

The County Board of Commissioners holds public hearings to seek comment from interested parties on proposed zoning amendments, and then the Board of Commissioners approves or denies the amendment, or approves a modified amendment. Zoning appeals, special use permit applications, and variance requests are evaluated by the Zoning Board of Adjustment.

The Planning Board consists of seven members: one appointee from each of the five townships in Onslow County, one appointee who may be recommended by developers, and one appointee who may be recommended by one or more environmental groups" (Onslow County 2014).

6.3.1.2 Land Use and Comprehensive Plans

Onslow County has developed several planning documents to guide future land use and development. In 1991, the county adopted its first Coastal Area Management Act (CAMA) Land Use Plan (in compliance with North Carolina's CAMA regulations), which primarily focused on the protection of environmentally sensitive areas. The CAMA Land Use Plan was updated in 1997 and most recently in 2009. The 2009 CAMA Land Use Plan was certified by the North Carolina Coastal Resources Commission in 2010, and currently serves as the county's sole comprehensive land use planning document.

In 2003, Onslow County adopted the Citizen's Comprehensive Plan, which outlines growth strategies and development policies. Four representatives from MCB Camp Lejeune served as members of the Comprehensive Plan Committee. This comprehensive plan was the foundation for establishing countywide zoning. Following adoption of the Citizen's Comprehensive Plan, the Onslow County Board of Commissioners adopted the county's first Zoning Ordinance regulations and Official Zoning Map in December 2003.

6.3.1.3 Joint Land Use Study

The DOD developed the Joint Land Use Study (JLUS) program, managed by the DOD's Office of Economic Adjustment, to enhance coordination between military installations and their neighboring communities and to address existing and future land use compatibility issues. Onslow County conducted a

JLUS Study in 2003 to balance the county's needs for future growth and the MCB Camp Lejeune's operational mission requirements. The JLUS was a collaborative land use planning effort among Onslow County, the City of Jacksonville, the Town of Holly Ridge, the Town of North Topsail Beach, the Town of Richlands, the Town of Swansboro, MCB Camp Lejeune, and MCAS New River. The study identifies land use compatibility concerns and provides recommended compatible land use management strategies and implementation actions. In August 2006, the Board of Commissioners identified specific JLUS recommendations for implementation.

6.3.2 Local Municipalities Planning Authority

Onslow County includes both incorporated municipalities and unincorporated areas. Incorporated municipalities with local planning authorities within the MCB Camp Lejeune RCUZ footprint include the city of Jacksonville and the towns of Swansboro, Holly Ridge, and North Topsail Beach. These city and towns each have local zoning ordinances. Jacksonville, Swansboro, and North Topsail Beach also have land use plans that summarize recommended policies, strategies, programs, and projects that will enable each municipality to achieve its overall vision for development.

Many of the county's incorporated municipalities also have extra-territorial jurisdictions (ETJs) adjacent to the municipalities, giving municipal authorities planning jurisdiction over areas outside the municipality without extending the boundaries of the municipality. North Carolina General Statute 160A-360(b) provides that ETJs must be based on "existing or projected urban development and areas of critical concern to the city, as evidenced by officially-adopted plans for its development." Within the RCUZ footprint, Jacksonville, Swansboro, and Holly Ridge have ETJs.

6.4 ON-BASE LAND USE

6.4.1 Existing On-Base Land Use

The installation primarily consists of forested areas and undeveloped land, which is divided into four large areas designated for live-fire operations and training: the GSRA, G-10 Impact Area, K-2 Impact Area, and N-1/BT-3 Impact Area. Operations and training areas are the main designated land uses on base. Existing on-base land uses are illustrated on Figure 6-2. On-base land use categories include:

- Administration;
- Operations and Training;
- Research and Development;
- Housing and Community;
- Hospital and Medical;
- Maintenance, Production, and Industrial;
- Storage and Supply; and
- Utilities and Transportation.

Developed areas on MCB Camp Lejeune include administration facilities, medical facilities, maintenance and production facilities, housing, development and testing facilities, supply facilities, and utilities. The majority of on-base development is concentrated east of the New River. On-base residential areas are primarily located in the northern portion of the installation, east of the New River and south of State Highway 24 and the City of Jacksonville. Additional pockets of residential land uses are located to west of the New River within the perimeters of MCAS New River and further south along the eastern shoreline of Courthouse Bay.

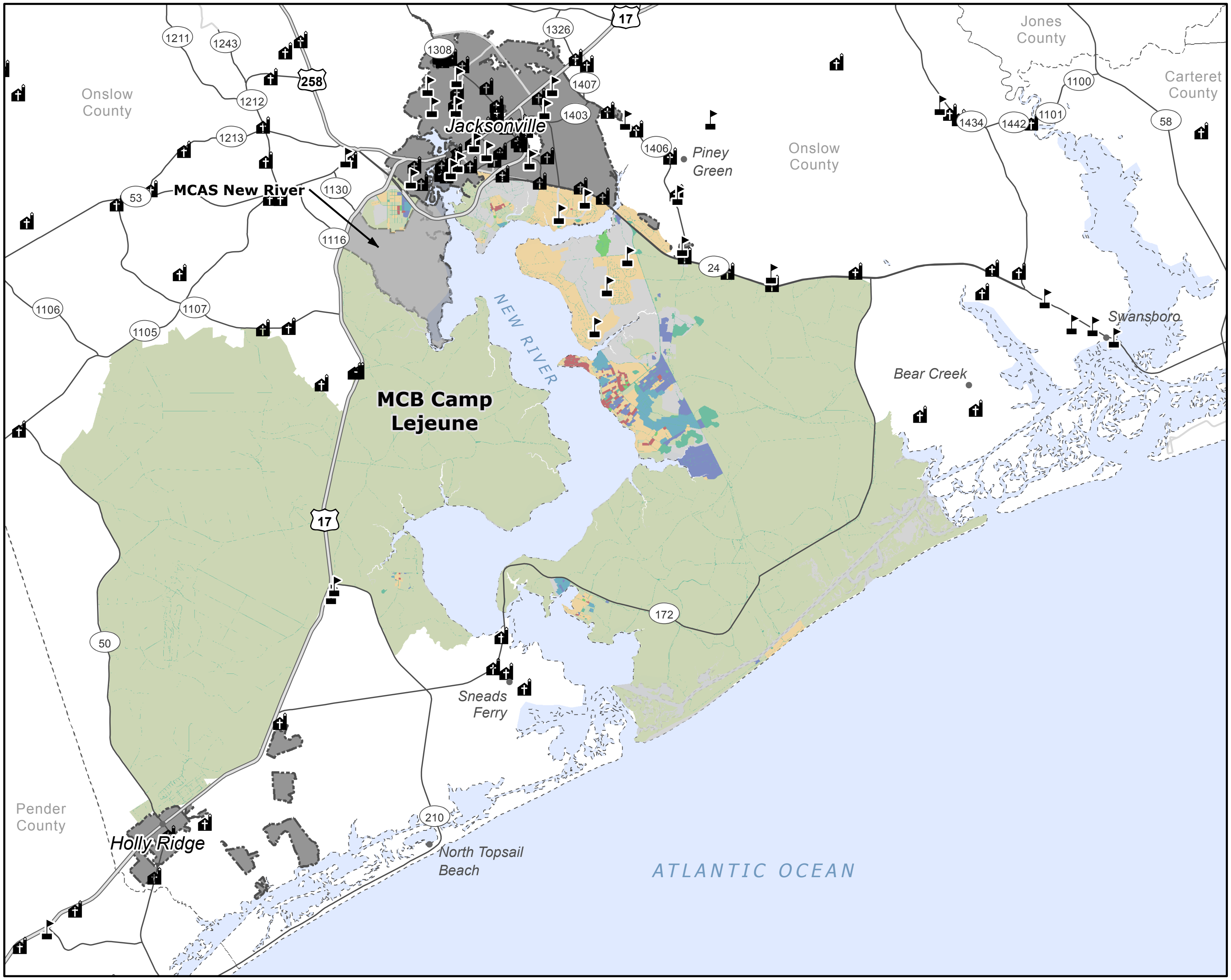

Figure 6-2
Existing On-Base Land Use
Camp Lejeune
North Carolina

Churches
Schools
On-Base Land Use
Administrative Facilities
Hospital and Medical Facilities
Housing and Community Facilities
Maintenance and Production Facilities
Research, Development and Test Facilities
Supply Facilities
Utilities and Ground Improvements
Operational and Training Facilities
MCB Camp Lejeune
MCAS New River
Cities and Towns
County Boundaries

Source:
ESRI, 2010; Navy, 2010;
Onslow County, 2011.

0 1 2 4 Miles
0 1.5 3 6 Kilometers

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6.4.2 RCUZ Impact Analysis for Existing On-Base Land Use

The analysis of existing on-base land use compatibility is based on the Marine Corps land use guidelines for both RCUZ noise zones and RCZs (Appendix A). To assess whether existing on-base land uses are compatible with operations at MCB Camp Lejeune, the 2014 RCUZ noise contours (ADNL and CDNL contours) and RCZs were overlaid on land use data, and/or aerial photographs. Peak15 (dBPk) noise contours are not used to evaluate land use compatibility because peak noise levels measured with PK15 metric do not account for frequency or duration of noise events as described in Chapter 5. Existing on-base land uses within the noise zones and RCZs are shown on Figures 6-3 and 6-4, respectively.

The predominant land uses within the MCB Camp Lejeune RCUZ footprint are open and undeveloped areas used for training operations, which do not pose compatibility concerns.

Approximately 67 acres of housing and community facilities along the southern boundary of the installation are located within RCZ-I. RCZ-I is the most restrictive zone, and residential land use is not compatible within RCZ-I; however, a detailed analysis determined that those areas are within the SDZ footprint from artillery and Naval Gunfire positions. In accordance with the Department of Army Range Safety Guidelines (DA PAM 385-63), the Marine Corps is approved for overhead fire in these areas. Risk Analysis concludes that these areas are compatible with current land uses (McCurry 2014).

A total of approximately 7 acres of hospital and medical facilities are located within RCZ-III. These hospital and medical facilities are located within the developed area in the center of the range and within the pocket of developed area directly south of Highway 172. Hospitals are not considered compatible within any of the RCZs. Approximately 671 acres of housing and community facilities are located throughout RCZ-III. Residential development is generally considered compatible within RCZ-III, based on dwellings per acre; however, other community facilities, such as schools and churches, are not compatible within any of the RCZs.

Approximately 2 acres of housing and community facilities are located within noise contours greater than 75 dB ADNL (Noise Zone 3), and 140 acres of housing and community facilities are located within noise contours greater than 70 dB CDNL (Noise Zone 3). These housing and community facilities areas are located in developed areas of the center portion of the installation. Noise Zone 3 is a high noise exposure area, and residential development is not considered compatible. Additionally, 2,038 acres of housing and community facilities are located within the 62 to 70 dB CDNL noise contour and 20 acres of housing and community facilities are located within the 60 to 65 dB ADNL noise contour.

Residential use is discouraged in Noise Zone 2 without design and construction noise attenuation. Approximately 18 acres of hospital and medical facilities and 289 acres of administrative facilities are located within the 62 to 70 dB CDNL noise contours. These land uses are considered generally compatible by the Marine Corps guidelines if noise level reduction measures are incorporated into building design and construction.

Table 6-3 summarizes the total acreages for land uses within MCB Camp Lejeune 2014 RCUZ RCZs and noise zones.

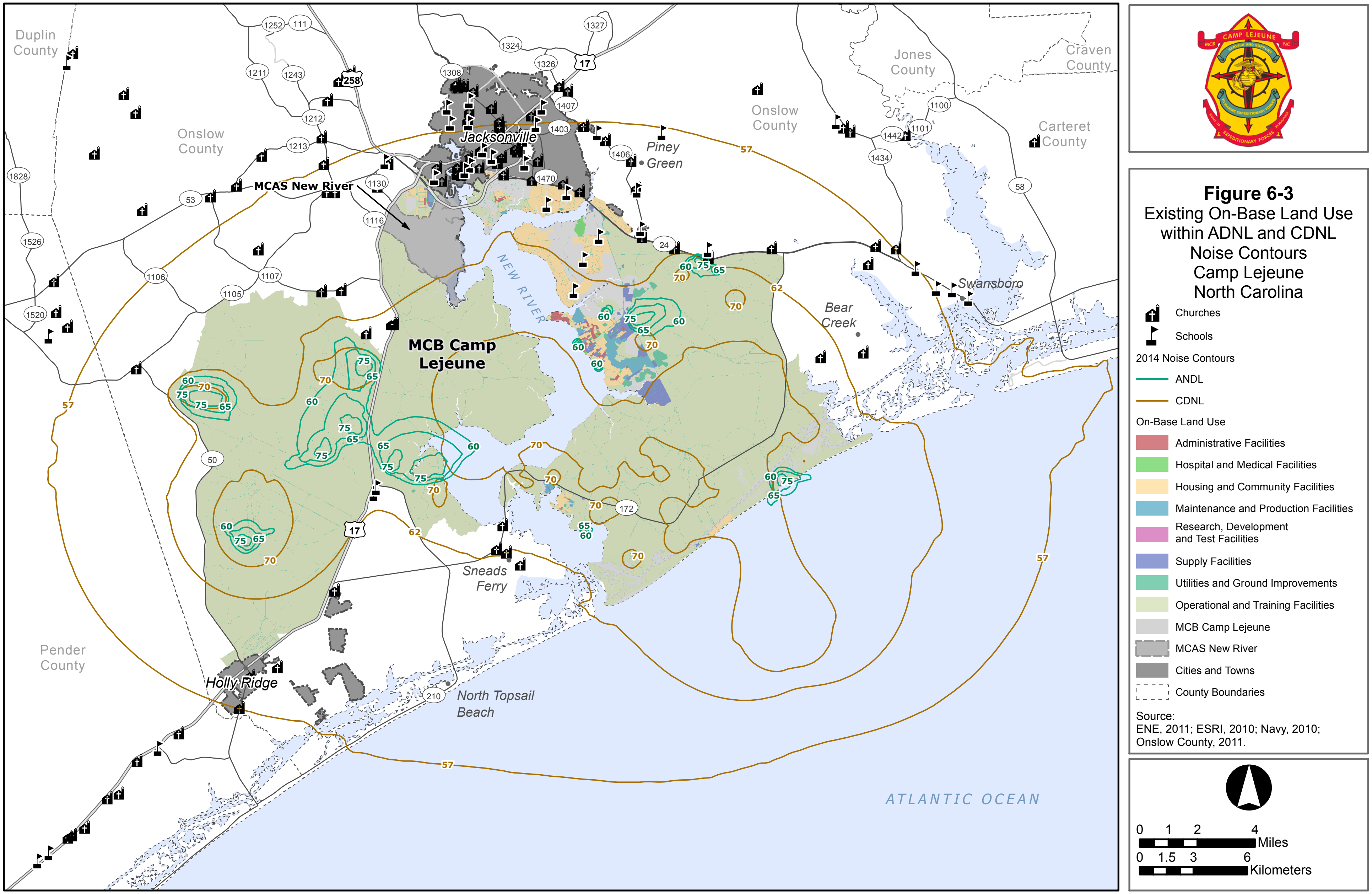

Figure 6-3
Existing On-Base Land Use within ADNL and CDNL Noise Contours
Camp Lejeune
North Carolina

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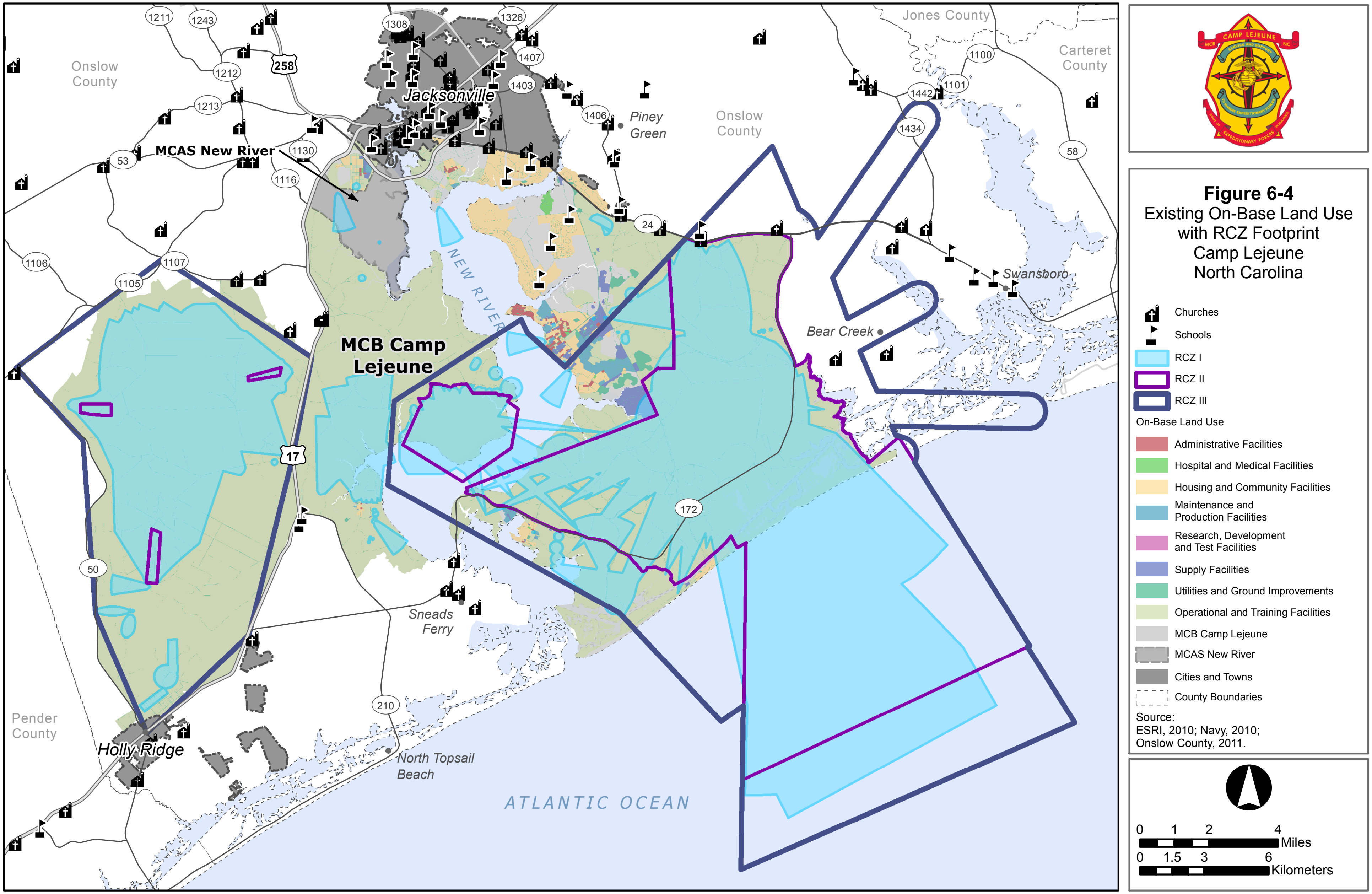

Figure 6-4
Existing On-Base Land Use with RCZ Footprint
Camp Lejeune
North Carolina

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Table 6-3: Existing On-Base Land Use within the MCB Camp Lejeune RCUZ Footprint

Land Use	ADNL	RCUZ Noise Zone (acres)			RCUZ RCZs (acres)		
		Noise Zone 1	Noise Zone 2	Noise Zone 3	RCZ-I	RCZ-II	RCZ-III
		60–65	65–70	>75			
Administrative Facilities		5	2	0	0	0	38
Hospital and Medical Facilities		0	0	0	0	0	7
Housing and Community Facilities		20	19	2	67	0	671
Maintenance and Production Facilities		2	3	0	1	1	517
Operational and Training Facilities		5,544	4,300	1,771	56,171	34,264	81,962
Research, Development and Test Facilities		0	0	0	0	0	0
Supply Facilities		26	8	1	147	0	661
Utilities and Ground Improvements		60	43	23	592	374	1,226
Vacant		29	15	0	5	0	374
Land Use	**CDNL**	**<62**	**62-70**	**>70**	**RCZ-I**	**RCZ-II**	**RCZ-III**
Administrative Facilities		37	289	0	(1)	(1)	(1)
Hospital and Medical Facilities		111	18	0	(1)	(1)	(1)
Housing and Community Facilities		2,790	2,038	140	(1)	(1)	(1)
Maintenance and Production Facilities		39	706	8	(1)	(1)	(1)
Operational and Training Facilities		17,664	55,196	33,955	(1)	(1)	(1)
Research, Development and Test Facilities		0	1	0	0	0	0
Supply Facilities		77	677	347	(1)	(1)	(1)
Utilities and Ground Improvements		494	1,128	422	(1)	(1)	(1)
Vacant		2,872	1,513	30	(1)	(1)	(1)

Note: (1) Acreages are the same as described above.

6.4.3 Future Land Use

Future on-base land use at MCB Camp Lejeune was analyzed to target areas where future incompatibility may exist (Figure 6-5). Overall, land use at the installation is not expected to drastically change in the future. The largest change in land use will be the addition of 3,026 acres of housing and community facilities located south of Highway 24 along the bank of the New River. An additional 548 acres of administrative facilities are also proposed in the same areas of future housing and community facilities.

6.4.4 RCUZ Impact Analysis for Future On-Base Land Use

Analysis of future on-base land use compatibility is based on Marine Corps land use guidelines for both RCUZ noise zones and RCZs (Appendix A). The additional acreage for housing and community facilities and administrative facilities should have limited impact on compatibility within the RCUZ footprint. Future land use plans for MCB Camp Lejeune illustrate that the majority of the future housing and community facilities will be located outside of the RCUZ footprint.

Approximately 100 acres of the planned housing and community facilities will be built within RCZ-III within the existing developed area in the center of the installation property. If developed at a density greater than 1 to 2 dwellings per acre, residential development is not recommended within RCZ-III.

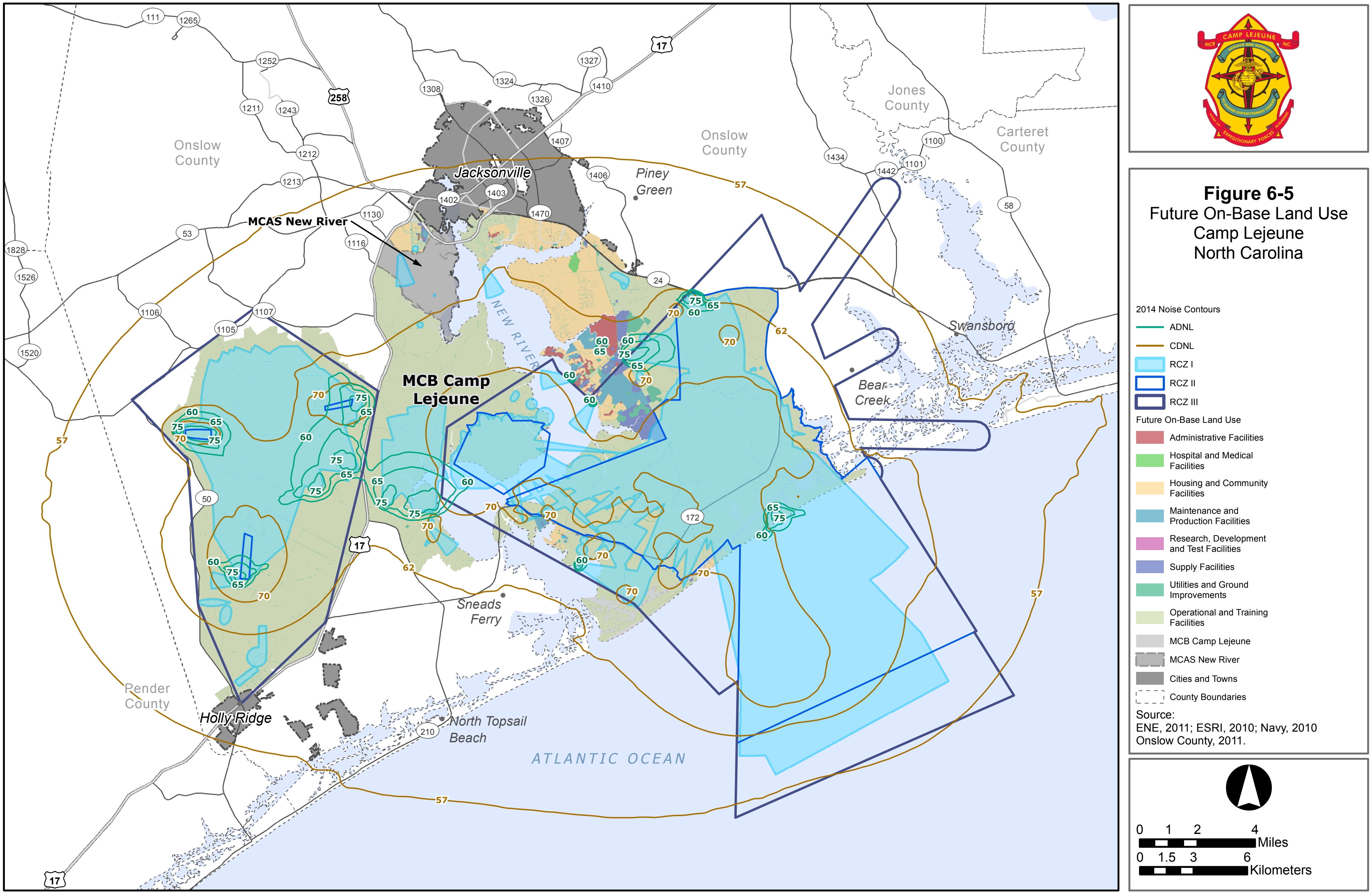

Figure 6-5
Future On-Base Land Use
Camp Lejeune
North Carolina

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6.5 OFF-BASE LAND USE

The off-base land use compatibility analysis presented in the following sections considers existing and future off-base land uses within the 2014 Composite RCUZ footprint (Figure 6-1).

6.5.1 Existing Off-Base Land Use

Existing land use data for properties in the RCUZ footprint were derived from Onslow County GIS parcel data and were verified using aerial photographs. For this analysis, land uses surrounding MCB Camp Lejeune were designated as single-family residential, multi-family residential, commercial, industrial, office/ institutional, recreation and open space, or undeveloped. Additional land use analysis was derived from local comprehensive land use plans. Figures 6-6 and 6-7 illustrate the existing off-base land uses surrounding MCB Camp Lejeune.

Most of the land surrounding MCB Camp Lejeune is largely undeveloped with scattered areas of residential use. Areas of concentrated development are located north, east, and south of the installation. A mix of urban development is located north of the installation within the city of Jacksonville, including commercial business, single-family and multi-family residential, and office/institutional. Single-family residential communities are also located north of the GSRA perimeter. Isolated pockets of residential development are located west of the GSRA, but the majority of the area west of the installation is undeveloped.

Other developed areas north and east of the installation and State Highway 24 include the unincorporated areas of Piney Green and Hubert. The area between Piney Green and Hubert is largely undeveloped. The unincorporated area of Bear Creek is located east of the installation and State Highway 172. Land uses in this area are primarily single-family residential or undeveloped land. Commercial businesses are located along major roadways.

Almost half of the southern perimeter of the installation extends to the Atlantic Ocean shoreline. The area south of the GSRA includes the towns of Holly Ridge, Sneads Ferry, and North Topsail Beach. This area is a developed mix of single-family, multi-family, and commercial uses with large areas of undeveloped land remaining. A few industrial developments and recreation and open space areas are also located south of the GSRA.

6.5.2 Future Off-Base Land Use

Future development in Onslow County is guided by the county's comprehensive plan. The comprehensive plan provides principles to manage growth and encourage efficient development patterns. According to the Onslow County's Future Land Use component of their comprehensive plan, the areas to the east and south of the installation, including the vacant areas surrounding Holly Ridge, Sneads Ferry, and Bear Creek, were identified as areas for future growth. The Onslow County Future Land Use map indicates that vacant areas to the east of the installation and north of Highway 24 are projected to be developed as medium density residential and small pockets of high-density residential use. To the south of the installation, undeveloped areas near the towns of Holly Ridge and Sneads Ferry are projected to be developed as medium-density residential use. The undeveloped areas west of the installation are projected to remain as agriculture/forestry and conservation use.

Onslow County is projected to continue to increase in population over the next 20 years. The residential/housing demand is projected to increase over 12,000 acres through 2030 (Holland Consulting 2009). Commercial and industrial demand is projected to increase by approximately 2,700 acres and 9,100 acres respectively (Holland Consulting 2009). The coastal communities to the south of MCB Camp Lejeune are projected to grow and increase in densities, as is much of coastal North Carolina.

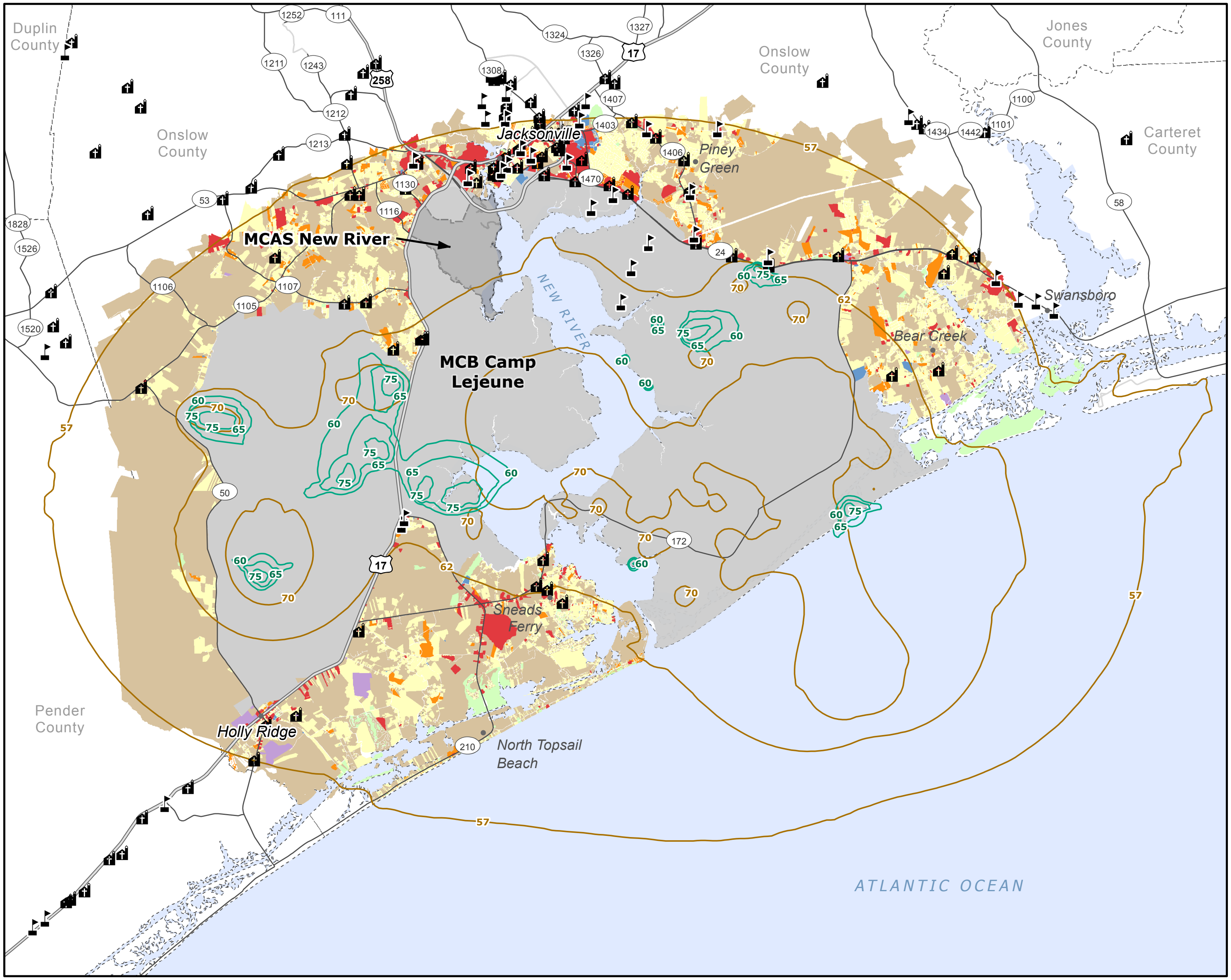

Figure 6-6
Existing Off-Base Land Use within ADNL and CNDL Noise Contours
Camp Lejeune
North Carolina

Churches
Schools

2014 Noise Contours
ADNL
CDNL

Existing Land Use
Commercial
Industrial
Multi Family Residential
Single Family Residential
Office and Institutional
Recreation and Open Space
Undeveloped
MCB Camp Lejeune
MCAS New River
County Boundaries

Source:
ENE, 2011; ESRI, 2010; Navy, 2010; Onslow County, 2011.

0 1 2 4 Miles
0 1.5 3 6 Kilometers

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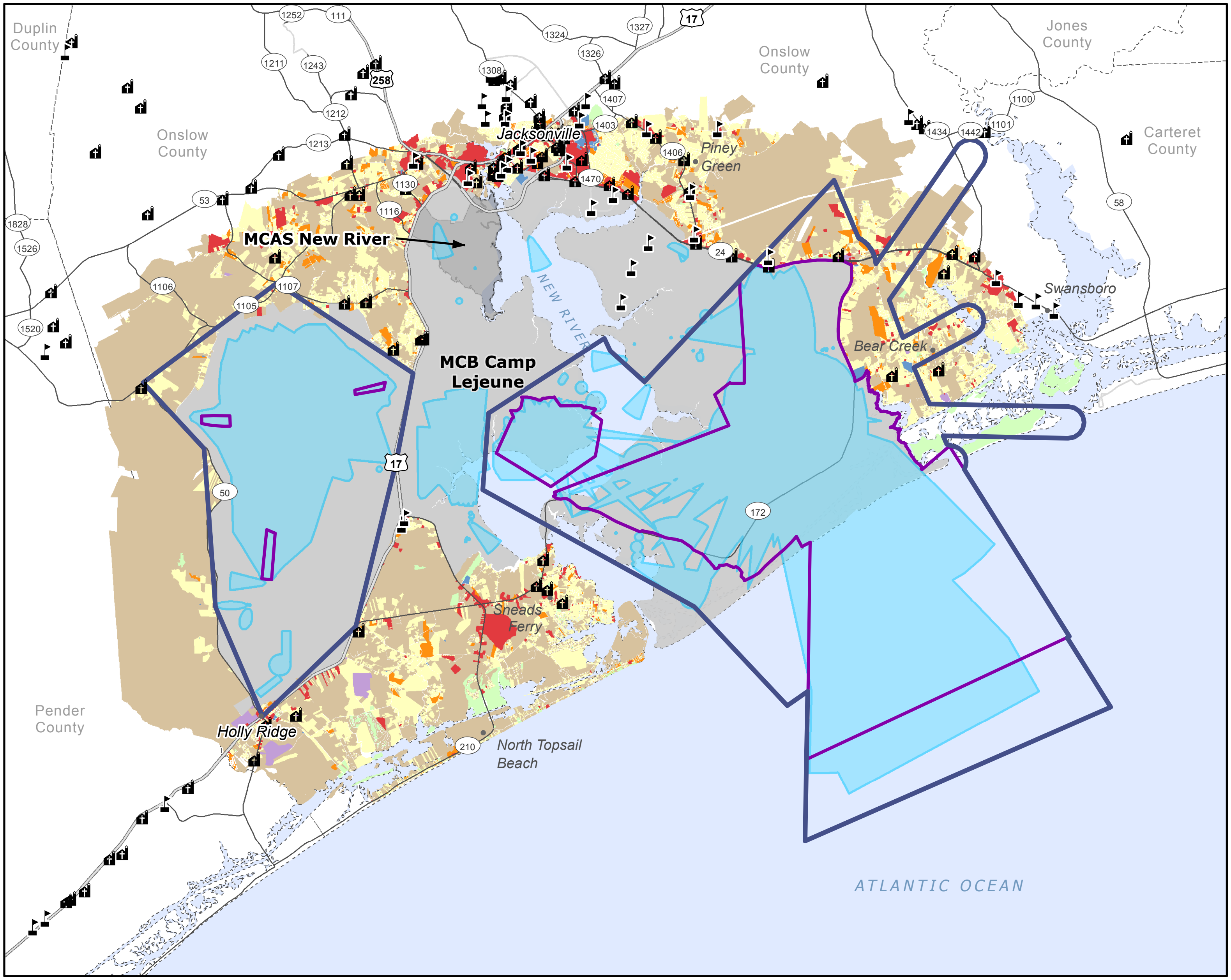

Figure 6-7
Existing Off-Base Land Use with RCZ Footprint
Camp Lejeune
North Carolina

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6.5.3 RCUZ Impact Analysis for Off-Base Land Use

The land use compatibility analysis of existing off-base land uses is based on the Marine Corps land use guidelines for both RCUZ noise zones and RCZs (Appendix A). To assess whether existing land uses are compatible with operations at MCB Camp Lejeune, the 2014 Composite RCUZ noise contours (ADNL and CDNL contours) and RCZs were overlaid on existing land use data and/or aerial photographs. Table 6-4 summarizes the total acreages of existing off-base land uses within the noise zones and RCZs. Overall, the area around the installation consists of moderate-density development, with areas of undeveloped property to the northeast and to the west of the installation.

Table 6-4: Existing Off-Base Land Use within the MCB Camp Lejeune RCUZ Footprint

Land Use	ADNL	RCUZ Noise Zone (acres)			RCUZ RCZs (acres)		
		Noise Zone 1	Noise Zone 2	Noise Zone 3	RCZ-I	RCZ-II	RCZ-III
		60-65	65-75	>75			
Commercial		5	3	0	0	0	304
Industrial		0	0	0	0	0	45
Multi-Family Residential		0	0	0	0	1	757
Single-Family Residential		5	1	0	0	0	4,427
Office and Institutional		0	0	0	0	0	148
Recreational and Open Space		0	0	0	0	0	970
Undeveloped		2	2	0	2	15	8,170
Water		779	658	101	1,201	1,255	1,631
Land Use	**CDNL**	**<62**	**62-70**	**>70**	**RCZ-I**	**RCZ-II**	**RCZ-III**
Commercial		4,984	155	0	(1)	(1)	(1)
Industrial		760	0	0	(1)	(1)	(1)
Multi-Family Residential		3,169	361	0	(1)	(1)	(1)
Single-Family Residential		25,477	2,978	0	(1)	(1)	(1)
Office and Institutional		363	178	0	(1)	(1)	(1)
Recreational and Open Space		2,601	502	0	(1)	(1)	(1)
Undeveloped		70,292	6,319	3	(1)	(1)	(1)
Water		111	1,530	656	(1)	(1)	(1)

Note: (1) Acreages are the same as described above.

RCZ-I and II do not extend beyond the boundary of the installation, except over water. RCZ-III includes approximately 4,427 acres of single-family and 757 acres of multi-family residential land use to the east of the installation and around the GSRA. Single-family residential development is generally considered compatible within RCZ-III based on dwellings per acres; however, multi-family housing is not recommended within RCZ-III. Multi-family land use within RCZ-III is located south of Highway 24, east of Highway 172, and north of Highway 24 in the town of Hubert. People intensive land uses such as schools and churches are not recommended within any of the RCZs; however, one school and three churches located east of the installation are within RCZ-III.

Noise exposure from small arms range operations (ADNL noise contours) is largely contained within the boundary of the base or over the waters of the New River and Atlantic Ocean. The 60 dB ADNL noise contours at the F-5 and F-2 target ranges (at the northeastern portion of the installation) cross the base boundary and extend over Highway 24; however, according to the Marin Corps guidelines, noise contours below 65 dB ADNL have limited noise impacts and all land uses are considered compatible. No large caliber range operation noise contours above 70 dB CDNL extend beyond the boundary of the base, except over water.

Residential use is discouraged in Noise Zone 2; however, along the perimeter of the installation, a few areas of residential and related community land uses are located within the 62 to 70 dB CDNL noise contour (i.e., Noise Zone 2). Northwest of the installation, single-family and multi-family residential land uses are located within Noise Zone 2 between the GSRA and Highway 17. To the east of the installation, residential (single- and multi-family) development is located east of Highway 172, near the community of Bear Creek. To the south of the installation, single-family residential, multi-family residential, and commercial use is also located within Noise Zone 2. Mobile home parks, which are more susceptible to noise impacts, are categorized as a multi-family land use in the Onslow County CAMA Land Use Plan. These land uses are considered incompatible with Marine Corps land use compatibility guidelines. Intermittent noise may interfere with daily activities in these areas because of the proximity of existing development to range operations. Several churches and schools are also located within the 62 to 70 dB CDNL noise contour; however, churches and schools are generally considered compatible by the Marine Corps guidelines if noise level reduction measures are incorporated into building design and construction.

Vacant property, in its present state, is compatible with the Marine Corps' land use compatibility guidance; however, if vacant properties are developed to their fullest potential, they may present future compatibility concerns. Based on the Onslow County Future Land Use maps, projected high- and medium-density residential use directly to the east of the installation, near Bear Creek, would be located within the 62 to 70 dB CDNL noise contour (i.e., Noise Zone 2), and residential use is discouraged in this noise zone.

6.6 POPULATION TRENDS

MCB Camp Lejeune is located in Onslow County, North Carolina, between the coast and the city of Jacksonville, the largest municipality in the county. Approximately eight other towns surround MCB Camp Lejeune, including two unincorporated towns and Emerald Isle in neighboring Carteret County. Other residential communities are located in unincorporated parts of the county near MCB Camp Lejeune.

As of March 2014, there were 41,817 active duty personnel on-board MCB Camp Lejeune (Onslow County Data Center 2014). The most recent estimate of Onslow County's combined population is 185,220 people (2013); therefore, active duty service members at MCB Camp Lejeune comprise up to 23 percent of the county's entire population, assuming all active duty personnel live on-base or in Onslow County (U.S. Census Bureau 2013a). This personnel number does not include dependent family members or MCB Camp Lejeune's civilian workforce, which would increase this percentage share substantially if the majority of them also lived in Onslow County.

Table 6-5 includes 2010 population statistics for the state of North Carolina, Onslow County, and local jurisdictions in the study area around MCB Camp Lejeune (U.S. Census Bureau 2010a). Jacksonville, the anchor city in Onslow County, had a population of 70,145 in 2010 and an estimated population of 69,079 in 2013. U.S Census estimates indicate that Jacksonville's population has been fluctuating above and below 69,000 for the past four years (U.S. Census Bureau 2013a). The next largest communities in the study area, Piney Green and Hubert, had 2010 populations of 13,293 and 15,500 residents, respectively. The remaining towns and communities in the study area had populations under 4,000 residents.

Table 6-5: Population Statistics for State and Local Jurisdictions in the Study Area

Location	Population 2000	Population 2010	%Change 2002-2010	Population 2020	Population 2030	%Change 2010-2020	%Change 2020-2030
North Carolina	8,049,313	9,535,483	18%	10,564,551	11,576,088	11%	10%
Onslow County	150,355	177,772	18%	217,809	251,602	23%	16%
Jacksonville	66,715	70,145	5%	N/A	N/A	N/A	N/A
Hubert	12,507	15,469	24%	N/A	N/A	N/A	N/A
Piney Green	11,658	13,293	14%	N/A	N/A	N/A	N/A
Bear Creek	3,809	3,795	0%	N/A	N/A	N/A	N/A
Emerald Isle	3,488	3,655	5%	N/A	N/A	N/A	N/A
Sneads Ferry	2,248	2,646	18%	N/A	N/A	N/A	N/A
Swansboro	1,426	2,663	87%	N/A	N/A	N/A	N/A
North Topsail Beach	843	743	-12%	N/A	N/A	N/A	N/A
Holly Ridge	831	1,268	53%	N/A	N/A	N/A	N/A

Sources: U.S. Census Bureau 2000a, 2010a; North Carolina Office of State Budget and Management 2014a,b

The growth trends among the towns in the study area did not follow an obvious pattern from 2000 to 2010 and differed widely from place to place (Table 6-5). Swansboro, a community of 2,663 people northeast along the coast from MCB Camp Lejeune, grew 87 percent in 10 years. Jacksonville's population increase was 5 percent, considerably low compared with the county average increase of 18 percent, indicating that a large portion of new growth in the past ten years settled in communities outside of the anchor city (U.S. Census Bureau 2000a, 2010a).

Population forecasts for the county and state through 2030 are also summarized in Table 6-5. Onslow County is projected to grow to 217,809 residents by 2020 and to 251,602 residents by 2030. The majority of the population increase is expected to come from natural growth (births exceeding deaths), with only a small percentage increase resulting from net migration. Onslow County's projected growth rate is expected to slow slightly after 2020 but should still exceed the State's growth rate during both decades (Table 6-5). Ten- and 20-year projections are not generally available for local jurisdictions, though they are available for Metropolitan Statistical Areas (MSA). The Jacksonville MSA intersects the study area and, in fact, has the same boundary as Onslow County. Therefore, population and forecasts for the Jacksonville MSA are the same as those listed for Onslow County. During the peak tourist season, Onslow County's population increases by an estimated 17,200 people, including seasonal residents and tourists (Onslow County 2009). The most recent seasonal population study of the County was done in 1988; therefore, the current peak number of visitors may actually be much higher. Given available data, it can be assumed that Onslow County's functional population (the average combined number of permanent and seasonal residents) during the highest point in the visitor season is approximately 195,000 or more. The greatest number of visitors can be expected to be on or near the coast (Onslow County 2009). In fact, Emerald Isle, the Carteret County island community that is also in the study area, has a permanent population of 3,655, but the functional population increases to as many as 40,000 people during its peak visitor season (Town of Emerald Isle North Carolina 2014).

6.7 Housing Trends

Characteristics of the housing supply in North Carolina, Onslow County, and the local jurisdictions around MCB Camp Lejeune are compared in Table 6-6. The housing supply in the state and Onslow County increased at similar rates during the 2000s (U.S. Census Bureau 2000b, 2010b). Significantly, from July 2011 to July 2012, the Onslow County had the thirteenth fastest housing growth rate in the country (U.S. Census Bureau 2013b). Given population projections for Onslow County, the rate of future growth in the housing supply will likely remain on pace with or slightly higher than the state's housing growth rate. In the long term, both the county's population and housing supply are expected to increase due to the draw of the North Carolina coast and the region's history of growth.

Table 6-6: Housing Trends in State and Local Jurisdictions in the Study Area

Location	Housing Unit % increase from 2000 to 2010	Total Housing Units 2010	Vacant Housing (not including seasonal) 2010	Seasonal Housing 2010	2012 Median Home value
North Carolina	23%	4,327,528	9%	4%	$153,600
Onslow County	22%	68,226	6%	6%	$149,900
Swansboro	79%	1,379	7%	9%	$220,200
Holly Ridge	52%	759	10%	13%	$171,100
North Topsail Beach	22%	2,547	6%	78%	$300,000
Hubert	22%	6,303	7%	3%	$151,000
Sneads Ferry	17%	1,552	8%	17%	$149,400
Jacksonville	15%	21,135	5%	0%	$153,800
Emerald Isle	12%	6,735	16%	58%	$422,300
Piney Green	11%	5,191	6%	0%	$145,100
Bear Creek	4%	1,714	11%	1%	$110,800

Sources: U.S. Census Bureau 2000b, 2010b, 2012b

Among the local jurisdictions surrounding MCB Camp Lejeune, the housing supply in Swansboro and Holly Ridge increased at a faster rate than in other towns, just as the populations of these communities increased at a faster rate. Vacancy rates in the surrounding towns and unincorporated areas were generally 10 percent or less, with the exception of Emerald Isle and Bear Creek. Emerald Isle and North Topsail Beach, which are primary vacation destinations, had seasonal housing percentages of 58 percent and 78 percent respectively. Sneads Ferry was the only other town to exceed a seasonal housing percentage of 15 percent (U.S. Census Bureau 2000b, 2010b). Homes in Emerald Isle and North Topsail Beach had the highest median values, followed by Swansboro and Holly Ridge (U.S. Census Bureau 2012b). Overall, the vacancy rate in Onslow County was slightly lower than in North Carolina, and its percentage of seasonal and recreational housing was slightly higher (U.S. Census Bureau 2000b, 2010b).

6.8 Employment and Economic Trends

The military provides direct, indirect, and induced economic benefits to the regional and local communities through jobs and wages. Benefits include employment opportunities and increases in local business revenue, property sales, and tax revenue. In fiscal year (FY) 2013, the Marine Corps Installations East provided over $9.7 billion to states of Florida, Georgia, North Carolina, South Carolina, and Virginia (Marine Corps Installations Command East 2013).

The military is the largest economic contributor in Onslow County, in terms of both jobs and direct and indirect spending. The DOD and MCB Camp Lejeune are the first and third largest employers in the region, respectively (Jacksonville Onslow Economic Development 2013). MCB Camp Lejeune, alone, generated a total economic impact of $43.5 billion in 2013, including $2.6 billion in salaries and $6.9 million in construction (Marine Corps Installations Command East 2013).

An exceptionally large percentage of the labor force in Onslow County is in the armed forces, as shown in Table 6-7. In North Carolina, approximately 2 percent of the total labor force consists of members of the armed forces, while 32 percent of the total labor force in Onslow County consists of service members (U.S. Census Bureau2012c). The majority is affiliated with MCB Camp Lejeune.

Table 6-7: Labor Force in the Armed Forces in North Carolina and Onslow County, 2012

	Total Labor Force	Labor Force in Armed Forces	% Labor Force in Armed Forces
North Carolina	4,832,418	88,733	2%
Onslow County	96,267	31,115	32%

Source: U.S. Census Bureau2012c

Other major employers in Onslow County are the Onslow County Board of Education, Onslow Memorial Hospital, County of Onslow, and Wal-Mart Associates Inc. (Jacksonville Onslow Economic Development 2013). Not including retail, accommodations, and food services, industries employing the highest number of civilians are health care and social assistance, educational services, and public administration (North Carolina Department of Commerce 2014a). As shown in Table 6-8, the total number of private business establishments, associated employees, and combined payroll in the Jacksonville, North Carolina MSA (which is equivalent to Onslow County) has been increasing overall since 2004. The number of private firms and employees dipped slightly in 2010, but rebounded by 2012 (U.S. Census Bureau 2012d).

Table 6-8: Jacksonville, North Carolina Metropolitan Statistical Area (MSA) Business Patterns

	2004	2006	2008	2010	2012
Total Business Establishments	2,587	2,713	2,718	2,692	2,754
Paid employees	30,976	31,723	34,327	33,244	34,474
Annual Payroll ($1,000)	$627,766	$706,208	$784,177	$841,376	$913,789

Source: U.S. Census Bureau 2012d

Table 6-9 includes several economic statistics comparing Onslow County to North Carolina. Per capita income, an indicator of a community's relative wealth, was approximately 15 percent lower in Onslow County than in North Carolina in 2012. Median household income, a measure of combined income by household wage earners, was only slightly lower in Onslow County than in North Carolina (about 1 percent lower) (U.S. Census Bureau 2012c). A notable positive trend in Onslow County is its relatively low unemployment rate over the last several years. The county's unemployment rates were less than or equal to North Carolina's from 2012 to 2014, and seem to have rebounded from the high unemployment rates following the nation-wide 2008 recession (Bureau of Labor Statistics 2014).

Table 6-9: Employment Trends, North Carolina and Onslow County

	Per capita income (2012 dollars)[1]	Median Household Income (2012 dollars)[1]	Unemployment Rate Annual 2012[a2]	Unemployment Rate Annual 2013[a2]	Unemployment Rate Apr 2014[b2]
North Carolina	$25,285	$46,450	9.2%	8.0%	6.0%
Onslow County	$21,455	$45,812	8.4%	7.6%	6.0%

Sources: U.S. Census Bureau2012c; Bureau of Labor Statistics 2014

Tourism is an important industry in coastal Onslow County, and local tourism trends are one indicator of the economic health of the region. The combined economic impact of tourism in Onslow County increased by 4.0 percent or more every year from 2002 to 2012, except in 2009. In 2012, the estimated economic impact of the tourism industry was $203.4 million, making Onslow County's tourism industry the 21st largest among the 100 counties in the state. At least 1,700 jobs were attributed to travel and tourism in that year. Major attractions in the county include Hammocks Beach State Park (near Swansboro), Topsail Island, Sneads Ferry, and Jacksonville (North Carolina Department of Commerce 2014b).

6.9 Summary of RCUZ Land Use Compatibility Analysis

MCB Camp Lejeune primarily consists of undeveloped and forest lands. These lands are largely used for operations and training areas. The greatest land use compatibility concern on base is the 67 acres of housing and community facilities within RCZ-I. The Marine Corps guidelines recommend no housing or community structures within RCZ-I; however, the Marine Corps is approved for overhead fire in this area (McCurry 2014).

Off-base land uses are not a significant compatibility concern. A few areas of residential development within RCUZ Noise Zone 2 are deemed incompatibility with Marine Corps guidelines. Additionally, multi-family residential land use within the RCZ-II is considered incompatible. Several churches and schools are located within the RCUZ footprint. These types of land uses, along with any type of public assembly facilities, are considered “people-intensive” and may raise compatibility concerns when in proximity to range operations.

7

RCUZ Recommendations

7.1 Introduction

The purpose of the RCUZ Program—to help local communities plan for compatible land use within noise and range compatibility zones associated with military aviation range and/or military ground range operations—can most effectively be accomplished by active participation of all interested parties. These may include the Marine Corps, state, regional, and local governments, private citizens, developers, real estate professionals, and others. This chapter discusses specific actions that can be taken to mitigate the RCUZ impact on incompatible land uses identified in the previous chapter, and to avoid future incompatible development.

Although the emphasis of RCUZ program implementation is focused on off-base areas within the RCUZ footprint (noise and safety impact area), MCB Camp Lejeune, as an adjacent "landowner," can take a position and comment on land use issues outside the footprint that might lead to incompatible development. For example, large-scale developments bordering the RCUZ footprint or new transportation or utility corridors could make adjacent areas in the RCUZ footprint more desirable for potentially incompatible development. Such development could also impact mission changes or mission expansion in the future. Therefore, MCB Camp Lejeune should monitor proposed development beyond the RCUZ footprint, and, if needed, present those concerns in appropriate forums.

7.2 Achieving Compatible Land Use

With the focus of promoting land use compatibility between MCB Camp Lejeune and surrounding communities, the RCUZ Program recognizes the local government's responsibility to protect the public health, safety, and welfare through various land use tools such as zoning ordinances, building codes, subdivision regulations, building permits, and disclosure statements. Continuing the working relationship between the Marine Corps, local governments, and private citizens can help to resolve incompatibilities in land uses and prevent future incompatible land use or development in the vicinity of the installation. This section discusses various recommendations for programs, controls, and regulations that will aid the installation and the local communities in achieving land use compatibility.

7.2.1 Noise Abatement and Mitigation

MCB Camp Lejeune takes precautions to reduce impacts on noise sensitive areas located near the installation. The Marine Corps conducts noise-abatement procedures to the best of its ability, keeping in-line with safety and operational training requirements.

Quiet hours are in place at MCB Camp Lejeune from Midnight to 6:00 a.m. Monday through Saturday and from Midnight to 12:00 p.m. on Sunday. During quiet hours, the Marine Corps restricts the firing of all artillery, naval gunfire, mortars, explosives/demolitions, grenade launchers, rockets, missiles, and any other large caliber weapon systems, and other systems as directed. In order to fire restricted weapons during quiet hours, requests must be endorsed by the unit's chain of command and forwarded to the CO of MCB Camp Lejeune and Director of the Range Control Division for approval at least 30 working days in advance.

MCB Camp Lejeune implements other abatement procedures, including limiting flights below 1,000 feet over densely populated areas, and ceasing demolition training at the installation one hour prior to sunset unless approved by Range Control.

The Marine Corps, in very limited situations, can adjust operational procedures to reduce (abate) aircraft and ordnance noise exposure. The options available to military authorities vary among air-to-ground ranges depending upon specific local conditions, local air operations, and local mission requirements.

Only after careful consideration of all options should changes in operational procedures be made. No changes that compromise the mission of MCB Lejeune should be instituted.

7.2.1.1 Marine Corps Noise Monitoring

The Blast Analysis and Monitor (BLAM) system was installed in 2001 to monitor the noise resulting from firing operations at the installation. The BLAM system is designed to detect, measure, and report short-duration noise events such as explosions, gunshots, and sonic booms. Sensors are installed near areas producing the noise events causing community concern, and the sensors send signals back to range control for real-time monitoring of significant noise events. Noise is measured in peak decibels (dBPk), and the alert threshold is set at 120 dBPk. The Range Control Office receives a weekly summary of information from sensor sites and investigates any anomalies or any events with noise levels exceeding 120 dip. When noise levels exceed 130 dip, the Range Control Office will modify or halt firing activities. To date, no event has raised a BLAM alert, which has caused firing operations to be discontinued.

7.2.2 Information Sharing

MCB Camp Lejeune has completed various studies, created programs, and notification protocols to help keep the community up-to-date with operations at MCB Camp Lejeune. These information-sharing programs help to keep surrounding residents and visitors informed of potential impacts from operations at the installation, and to maintain and strengthen the relationship between MCB Camp Lejeune and the surrounding communities.

Additionally, the Base posts planned training activities on its websites, issues news releases, and has installed permanent signs located along US-17 and NC-24. The installation’s Community Plans and Liaison Officer also provides regular updates on training activities and provides regular updates on training activities to the county and local communities.

7.2.2.1 Joint Land Use Study (JLUS) Planning Initiative

A JLUS is a cooperative-planning initiative between an installation and the surrounding city (ies)/county (ies). Sponsored by the DOD's Office of Economic Adjustment (OEA), the goal of a JLUS is to encourage local governments to coordinate with military installations to promote compatible community growth that supports military training and operational missions. The JLUS program aids in the understanding and introduction of the RCUZ technical data into local planning and outreach programs. The jurisdictional partnership results in the identification of actions that can be taken jointly by the community and installation to promote compatible development and address current and future encroachment. Onslow County completed its most recent JLUS study in February 2003.

7.2.2.2 Real Estate Disclosures

Real estate disclosures allow prospective buyers, lessees, or renters of property in the vicinity of military operations areas to make informed decisions regarding the purchase or lease of property. Disclosure of noise and safety zones is a crucial tool in protecting and notifying the community about expected impacts of aviation noise and locations of RCZs, subsequently reducing frustration by those who were not adequately informed prior to purchase of properties within impact areas.

7.2.3 Noise Compliant Response

To mitigate noise complaints and provide citizens with prompt response, MCB Camp Lejeune created a direct noise complaint "hotline." Tracking and assessing noise complaints submitted through the hotline helps the base identify noise-sensitive areas, determine which operational activities are responsible for the noise complaints, and ultimately abate future noise complaints.

Through the installation's noise abatement program, MCB Camp Lejeune personnel evaluate operational procedures to reduce noise impacts on the surrounding communities. Additionally, the program emphasizes both the installation's commitment to the public and demonstrates the importance of noise abatement.

7.2.4 Land Use Controls

Local governments have the authority to implement regulations and programs to control development and direct growth in order to ensure compatible land use and development within the RCUZ footprint. Future land use and development is guided by the federal regulations and local comprehensive land use planning controls discussed below.

7.2.4.1 Local Government Comprehensive Plans

Comprehensive plans can be adopted in North Carolina to guide future development and growth, establish long-range planning policies, and ultimately provide the framework for zoning and land use regulations. Comprehensive plans are decision-making tools to evaluate proposed development and/or land use activities in context with the community's long range-planning policies. While comprehensive plans provide guidance for future land uses and development, these plans do not constitute zoning regulations or establish zoning district boundaries. Components of a comprehensive plan may include future land use, annexation, transportation, infrastructure, conservation, recreation and open space, intergovernmental coordination, and capital improvements. Comprehensive plans can also influence the capital budget and funding of capital improvement plans to purchase open land or development rights.

7.2.4.2 Zoning

While comprehensive planning allows municipalities and counties to consider the impacts of current and future development, zoning is the legal tool used to implement a municipality's land use plan. Zoning regulates land use, density, and height of structures, and can be used to prohibit the creation of other hazards, including smoke, radio interference, and glare. In North Carolina, zoning authority is carried out through the county or municipality, depending on the property's location. Through zoning regulations, cities/counties are authorized to create zoning districts that permit or prohibit various property uses and development densities, as well as set construction standards.

7.2.4.3 Special Planning Districts

Special Planning Districts are established to implement tailor-made policies, development standards, design guidelines, and land uses that overlay the existing zoning for designated areas within jurisdictional boundaries. The districts' regulations supersede the underlying zoning and may be either more or less restrictive. Local governments and commissions have the power to create Special Planning Districts, such as "military influence areas" or "airport overlay zones/districts" where local governments can either enact restrictions on land development or require notification for proposed development within the special planning area. Special Planning Districts can help mitigate the negative effects of certain projects or land use activities, for example to prevent the development of buildings and towers within the airfield imaginary surfaces that could present a hazard to flight. Onslow County has adopted a Flight Path Overlay District to encourage compatible land use around MCB Camp Lejeune and MCAS New River.

7.2.4.4 Capital Improvements Programs

Capital improvement program (CIP) projects, such as extension of potable water lines or transmission lines, road paving and/or improvements, right-of-way acquisition, and school construction/renovation, can encourage new development to under-served areas. CIPs can be used to direct future growth patterns and ensure that the areas near military ranges are developed in accordance with the RCUZ Program's recommended land use guidelines. Local governments can coordinate CIP projects to avoid extending infrastructure into or near high noise zones or RCZs.

7.2.4.5 Building Codes

Building codes, which are enforced through local ordinances, are standards applied to the construction, modification, and/or use of buildings. Local building codes may be modified to ensure consistency with the noise attenuation recommendations of the RCUZ Program through construction permits. By using proper sound insulation construction techniques and materials, impacts from aircraft noise can be minimized and noise interference with regular indoor activities can be reduced. Although building codes will not prevent incompatible development, they can help reduce impacts.

7.2.5 Acquisition

Local governments can establish land acquisition programs to support the RCUZ Program. Land acquisition programs are designed to eliminate or prevent land use incompatibilities through voluntary transactions in the real estate market and local development process. Land acquisition strategies can support goals of preventing urban growth near an airfield, while protecting the environment, maintaining agricultural lands, and conserving open spaces. Local governments can partner with an installation to identify areas of conservation interest and determine protection priorities around installations.

When the operational integrity of an installation is threatened by incompatible land use and development, and when the local community is unwilling or unable to address the threat using their own authority, the Marine Corps may also seek to acquire interest in properties (acquisition) to protect its mission.

7.2.5.1 DOD Encroachment Partnering Program

Title 10, United States Code (U.S.C.) § 2684a authorizes the Secretary of Defense or the Secretary of a military department to enter into agreements with an eligible entity or entities to address the use or development of real property in the vicinity of, or ecologically related to, a military air-to-ground range or military airspace, to limit encroachment or use of the property that would be incompatible with the mission of the range or place other constraints on military training, testing, and operations. Eligible entities include a state, a political subdivision of a state, or a private entity that has as its principal organizational purpose or goal the conservation, restoration, or preservation of land and natural resources, or a similar purpose or goal.

Encroachment partnering agreements provide for an eligible entity to acquire fee title, or a lesser interest, in land for the purpose of limiting encroachment on the mission of a military range and/or to preserve habitat off the range to relieve current or anticipated environmental restrictions that might interfere with military operations or training at the range. The DOD can share the real estate acquisition costs for projects that support the purchase of fee or conservation or other restrictive easement for such property. The eligible entity negotiates and acquires the real estate interest for encroachment partnering projects with a voluntary seller. The eligible entity must transfer the agreed-upon restrictive easement interest to the United States of America upon the request of the Secretary of Defense.

7.2.5.2 Transfer of Development Rights

Transfer of development rights (TDR) allows landowners in development-restricted areas to sell the rights to develop their property (sending property) and transfer those development rights to another landowner's property (receiving property) that can support greater density development. Transfers are typically administered through a local TDR program, which is typically established through local zoning ordinances. TDR programs are established to preserve environmentally sensitive areas, agricultural resources, historic properties, or valuable open space. A successful TDR program should identify the public purpose of the program, sending and receiving districts/areas, and the procedures to carry out the transaction.

Development rights from the sending property are purchased as TDR credits. After development rights are transferred, the sending property is secured from future development under a conservation easement or deed restrictions, and the TDR credit is applied to the receiving property as a density bonus. The value of TDR credits should be defined in the local TDR program.

7.2.5.3 Purchase of Development Rights

Local governments (or a land trust) can also establish purchase of development rights (PDR) programs to manage growth and preserve open space. A local government or agency provides landowners compensation for not developing their land—essentially buying the development rights—and then obtains a legal easement (conservation easement) that further restricts development on the property. The landowner maintains ownership of the property and can use the land under conditions specified in the terms of the easement (e.g., farming, timber production, or hunting). The local government may consider PDR for agricultural land within the RCUZ footprint.

7.2.6 Federal Policies and Regulations

Certain federal policies and regulations are in place to assist state and local governments as well as private citizens in minimizing any issues with nearby military installations. The regulations listed below discuss these regulations and how they are used to ensure compatibility between the military and the surrounding communities.

7.2.6.1 Executive Order 12372, Intergovernmental Review of Federal Programs (July 1982)

Executive Order 12372 allows state governments, in consultation with local governments, to establish review periods and processes for federal projects. In accordance with the Intergovernmental Cooperation Act of 1968, the United States Office of Management and Budget requires federal agencies to coordinate and communicate with state, regional, and local officials in the early planning stages of any federal aid development projects. The Intergovernmental Review Program provides an early entry point into the process for the Marine Corps to introduce RCUZ concepts and discuss RCUZ issues.

7.2.6.2 Housing and Urban Development Circular 1390.2: Noise Abatement and Control

In 1971, the United States Department of Housing and Urban Development (HUD) established noise standards and polices for approving HUD-assisted housing projects in high noise areas and noise attenuation measures under HUD Circular 1390.2: Noise Abatement and Control. HUD published new noise regulations in 1979 with the same standards set forth in Circular 1390.2, and included new noise measurement descriptions to account for improvements in noise modeling technology. The approval of all mortgage loans from the Federal Housing Administration or the Veterans Administration is subject to the standards and polices of the HUD noise regulations. The HUD regulations set forth a discretionary policy to withhold funds for housing projects when noise exposure is in excess of prescribed levels. The HUD regulations allow for new housing construction assisted or supported by HUD within a noise area of 65 dB DNL or less. Construction within a 65 to 75 dB DNL noise area is subject to appropriate sound attenuation measures, and construction within an area exceeding a 75 dB DNL noise level is not acceptable. Due to the discretionary framework of the HUD policy, variances may be permitted, depending on regional interpretation and local conditions.

7.2.6.3 Environmental Review

Federal agencies, including the Marine Corps, are required to consider the environmental impacts of any federal project that could significantly impact the environment by conducting a comprehensive environmental review. NEPA mandates full disclosure of the environmental effects resulting from proposed federal actions, approvals, or funding. Impacts of the action are generally documented in an EIS or EA. The environmental review process is a viable means for incorporating the fundamentals of the RCUZ Study in the planning review process of a project.

7.2.7 State Programs

In addition to the federal regulations and policies previously listed, several state programs also allow representatives of military bases from across the state of North Carolina to convene and discuss issues affecting the bases. The primary purpose of these programs is to protect the mission of the installation, while remaining a good neighbor to surrounding communities.

7.2.7.1 North Carolina Military Affairs Commission

The North Carolina Military Affairs Commission (NCMAC) is a 50-member commission established in 2013 within the Office of the Governor. The North Carolina Department of Commerce is responsible for the organizational, budgetary, and administrative purposes of the Commission. The vision of the

NCMAC is to make North Carolina the most military friendly state in the county. The NCMAC protects the missions and existing installations within the State of North Carolina by advising state and local officials, including the Governor, on ways to protect the military community's infrastructure, training ranges, and low-level routes from encroachment challenges. The NCMAC works to expand defense related economic development by supporting economic opportunities that focus on the military (North Carolina Department of Commerce 2014).

7.2.7.2 North Carolina Commanders Council

The North Carolina Commanders Council (NCCC) was established in 2009, as a group consisting of installation commanders from major military bases and agencies in North Carolina, including MCB Camp Lejeune. The NCCC, "provides a forum for installation commanders to communicate, collaborate, and coordinate actions and/or support from the state and regional organizations on actions and issues affecting military training and operational readiness in North Carolina" (North Carolina Department of Commerce 2009).

7.3 Recommendations

7.3.1 Federal/Marine Corps Recommendations

7.3.1.1 Engage in the Local Planning Process

MCB Camp Lejeune should maintain routine communication with local governments to stay informed of local land use plans and regulations and to ensure the Marine Corps' input is offered in the early stages of any long-range planning initiatives.

The MCB Camp Lejeune ICO and/or the Community Plans and Liaison Officer (CPLO) should attend public hearings and provide comments on actions that affect RCUZ planning including land use studies, capital improvement plans, and other land development regulation updates/amendments. The CPLO should advise counties of future Marine Corps operations and offer guidance on identifying areas of potential incompatibilities.

In addition to ongoing community involvement, the ICO and/or the CPLO should attend Board of Commissioners meetings. Attendance and participation will keep the installation engaged in the local planning process and provide a forum for comments as they affect RCUZ planning. During local planning meetings, MCB Camp Lejeune can also address current and future operation activities, noise complaints (both the process for filling and resolving complaints), and other relevant topics related to the interaction between MCB Camp Lejeune and the communities surrounding the installation.

7.3.1.2 Community Outreach Activities

Outreach and information sharing assist in educating the community about the Marine Corps' mission and help build alliances with the community and regional decision makers to ensure continuation of mission-essential operations. MCB Camp Lejeune should provide community decision makers with the information necessary to make informed decisions regarding the impacts of their actions on mission readiness. The CPLO should be responsible for communicating MCB Camp Lejeune program changes and offering supporting information and resources to the community decision makers. Through outreach efforts, the CPLO and Public Affairs Officer (PAO) can educate the public on the importance of MCB Camp Lejeune training operations, its economic impact on the community, and the ability of the installation to support military activities to sustain a combat-ready Marine Corps.

7.3.1.3 Presentation of the RAICUZ Study and Educational Materials

To encourage community interaction and facilitate a better understanding of the Marine Corps' scope of operations, MCB Camp Lejeune should develop a package of RCUZ outreach materials, including community presentations and educational brochures, on training activities and the Marine Corps' mission.

MCB Camp Lejeune should create a brochure for a civilian audience with appropriate verbiage and maps to explain the basic elements of the RCUZ Program and the ways incompatible development within the RCUZ footprint can impact Installation operations. The brochure should detail the significance of RCZs and noise zones to protect both Marine Corps pilots and civilian safety.

Maps illustrating the RCZs and noise zones should be included in the brochure, and these maps should be provided to real estate brokers for property disclosure.

MCB Camp Lejeune should prepare a presentation outlining elements of the RCUZ Program for community decision makers, including the Board of Commissioners, Economic Development Councils, Board of Realtors, and local civic organizations. The RCUZ Program presentation should also discuss how land uses and local policies (e.g., infrastructure siting, schools, rezoning) can influence Marine Corps operations.

MCB Camp Lejeune should post the 2014 RCUZ Study and related educational materials on their website. Presentation and distribution materials, including RCUZ poster boards, maps of the installation, and fact sheets, should also be posted to the website and used for community outreach activities.

7.3.1.4 Installation Study Integration

The Marine Corps is continually examining local operations in response to changing national defense demands, Unit level training requirements, and public involvement. Several noise and safety-related studies either have been or will be completed for military facilities associated with MCOLF Camp Davis and MCAS New River. These separate studies should be integrated with studies related to MCB Camp Lejeune at the installation-level to provide the community with an operational picture of not only a single location such as MCB Camp Lejeune but also how this installation is part of a larger training concentration area in eastern North Carolina.

7.3.1.5 Continue to Maintain Noise Complaint Hotline

MCB Camp Lejeune will continue to collect, document, and research noise complaints. All noise complaints are investigated by the MCB Camp Lejeune staff, and corrective actions are taken, as appropriate. Noise complaint procedures for MCB Camp Lejeune are established in the installation’s Range and Training Regulations, Standard Operating Procedure. All complaints will be collected in a standard format for plotting locations in a spatial database for future planning use. Recording these complaints can help to:

- Provide land use planning information for local governments.

- Determine which operational procedure may be responsible for the noise complaint and at what time most complaints occur.

- Provide valuable information for real estate transactions.

7.3.1.6 Real Estate Disclosures

MCB Camp Lejeune should provide local real estate agencies with RCUZ-related materials and maps showing military training routes, MOAs, RCUZ boundaries, and high-impact areas. The CPLO should meet with the local Board of Realtors to discuss the importance of real estate disclosure when clients are buying or selling property within or near the RCUZ footprint. Similarly, MCB Camp Lejeune should approach the North Carolina Home Builders Association and provide guidelines regarding construction techniques and the use of materials for noise attenuation to mitigate potential airborne noise.

7.3.2 State/Regional Recommendations

MCB Camp Lejeune should work with the NCMAC and the NCCC to propose statewide regulations that prohibit the development of structures that may interfere with the use of military training routes or compromise the mission and operations at MCB Camp Lejeune. The Installation should provide these agencies with information regarding air operations and flight courses.

7.3.3 Local Government Recommendations

7.3.3.1 Pursue Funding from the OEA for a JLUS Study Update

It is recommended that Onslow County apply for funding from the OEA to update the 2003 JLUS study. There have been many changes within the community as well as aboard MCB Camp Lejeune since the study was completed. Updating the JLUS to include this RCUZ information will provide Onslow County with an updated tool to encourage land uses that are compatible with military operations.

7.3.3.2 Planning Partnerships with the Installation

Just as the Marine Corps should ask to be part of the local planning process, it is incumbent upon the counties to seek input from the Marine Corps. When local governments consider land use decisions near a military installation and the established RCUZ footprint, they should realize the following:

- Their decisions may decrease the capabilities of the installation, increasing the chances of the local commands having to relocate resources to ensure training is completed.
- Noise contours and RCZs comprising the RCUZ footprint are dynamic and may change over time.
- A proactive approach to planning with the Marine Corps will serve the local population by mitigating, in advance, potential problems with noise and safety concerns.
- As mentioned previously, they have a statutory obligation to notify MCB Camp Lejeune of any proposed land use changes within five miles of the installation perimeter in accordance with North Carolina General Statutes and to evaluate any comments from the Marine Corps regarding the proposed action.

7.3.3.3 Adopt RCUZ Study Recommendations

Local governments are encouraged to adopt and implement all or parts of the RCUZ study, including amending their comprehensive plan and zoning ordinances to be consistent with the RCUZ composite map and recommended land uses. The study is the installations defining statement regarding the impact of the installation on the surrounding community. The RCUZ Program is intended to support local government land use planning programs and processes by providing scientifically based technical information on military activities.

7.3.3.4 Regulate Land Uses within Identified Noise Zones and RCZs

Incompatible land use concerns are mostly a conflict between military and civilian land uses. To minimize these impacts, local planning tools can be used to encourage compatible development and discourage incompatible development around the installation's fence line or under any of the flight operational areas. A comprehensive zoning map amendment designed to prevent encroachment can be one of the strongest tools available to local governments to synchronize the plan's land use recommendations with the zoning code and official zoning map.

7.3.3.5 Local Development Review

Local governments should invite a representative of the installation to participate on the local development review staff team as a way to integrate the military's missions with the local government's planning and development review processes. The military is a major stakeholder in the community, and its input is needed if decision makers are to consider the full impact of a development proposal on all stakeholders. The review process presents an opportunity for a military representative to work with a local government's development review team to identify issues and opportunities associated with the development application.

7.3.3.6 Communication

MCB Camp Lejeune is responsible for informing and educating community decision makers about the RCUZ Program; however, local governments have a role to play in educating members of the community and to actively inform and request input from MCB Camp Lejeune regarding land use decisions that could impact the operational integrity of the installation. Local government websites should include information about the RCUZ Program for MCB Camp Lejeune and provide a link to the MCB Camp Lejeune website for information regarding range operations.

7.3.3.7 Capital Improvement Plans

All capital improvement projects in proximity to MCB Camp Lejeune should be evaluated and reviewed for potential direct and indirect impacts that such improvements may have on the ability to implement a successful RCUZ Program.

7.3.3.8 Building Codes

Local governments should continue to monitor and/or amend their building codes to require noise attenuation techniques for new construction within the noise zones footprint. Additional insulation and soundproofing should be included in the local building standards for all new single- and multi-family residential construction within the footprint.

7.3.3.9 Real Estate Disclosures

Onslow County should continue to or begin providing disclosure notification for all real estate transactions for properties surrounding the installation. The county may consider establishing a real estate disclosure area around the installation to enforce disclosure regulations.

7.3.4 Private Citizens/Real Estate Professionals/Businesses Recommendations

7.3.4.1 Business Development and Construction Loans to Private Contractors

Lending institutions should consider whether to limit financing for real estate purchases or construction incompatible with the RCUZ Program. This strategy encourages evaluation of noise and accident potential as part of a lender's investigation of potential loans to private interests for real estate acquisition and development. Diligent lending practices will promote compatible development of the area surrounding MCB Camp Lejeune and protect lenders and developers alike. Local banking and financial institutions should be encouraged to incorporate a "Due Diligence Review" of all loan applications to determine possible noise or RCZ impacts on the mortgaged property. The Marine Corps can help facilitate this strategy by providing RCUZ seminars to lenders throughout the region.

7.3.4.2 Real Estate Professionals Cooperation

Real estate professionals should continue to ensure that prospective buyers or lessees have all available information concerning the noise environment and accident potential zones surrounding an air-to-ground range prior to purchasing or leasing property near the range. They should provide written disclosure to prospective purchasers, renters, or lessees when a property is located within an RCZ or high noise zone. Real estate professionals should also show properties at a time when noise exposure is expected to be at its worst in order to provide full awareness of the potential magnitude of noise exposures.

7.3.4.3 Private Citizens

The citizens of the local communities surrounding MCB Camp Lejeune should become informed about the RCUZ Program and learn about the program's goals and objectives; its value in protecting the health, safety, and welfare of the population; the limits of the program; and the positive community aspects of a successful RCUZ Program.

Citizens considering purchasing, renting, or leasing properties near MCB Camp Lejeune should ask local real estate professionals, lending institutions, and/or a MCB Camp Lejeune representative if the property is within an RCZ and/or noise zone.

Citizens should also provide sufficient and accurate information when registering a noise complaint with the range. Range personnel need sufficient and accurate information to assess the potential causes resulting in the complaint and to assess any practical remedies for reducing future complaints.

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APPENDIX A

Marine Corps Order 3550.13

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DEPARTMENT OF THE NAVY
HEADQUARTERS UNITED STATES MARINE CORPS
3000 MARINE CORPS PENTAGON
WASHINGTON, DC 20350-3000

MCO 3550.13
I&L

MARINE CORPS ORDER 3550.13

From: Commandant of the Marine Corps
To: Distribution List

Subj: MARINE CORPS INSTALLATIONS RANGE COMPATIBLE USE ZONES (RCUZ) PROGRAM

Ref: (a) MCO 3550.11
(b) 10 U.S.C. 101
(c) MCO 3570.1C
(d) MCO 11011.22B
(e) MCO P3550.10
(f) MCO P5090.2A
(g) OPNAVINST 3770.2K
(h) 49 U.S.C. 40103,44718
(i) SECNAV M-5210.1

Encl: (1) RCUZ Program Procedures and Guidelines for Marine Corps Ranges

1. Situation.

a. The Department of Navy's (DON) Range Compatible Use Zones (RCUZ), reference (a), is designed to protect the public health, safety, and welfare, and to prevent encroachment from degrading the operational capabilities of air-to-ground (A-G)/laser ranges.

b. A range is defined in reference (b) as a designated land or water area that is set aside, managed and used for range activities of the Department of Defense (DOD). The term includes airspace areas designated for military use in accordance with the regulations and procedures prescribed by the Administrator of the Federal Aviation Administration (FAA). Range activities means research, development, testing and evaluation of military munitions, other ordnance and weapons systems, laser systems, and the training of members of the armed forces in the use and handling of military munitions, other ordnance, and weapons systems.

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c. The principles and objectives of the RCUZ program conceptually apply to ground-to-ground (G-G) ranges as well as to air-to-ground (A-G) ranges, which also incorporate the laser range areas. Reference (c) establishes USMC range safety policies and addresses Surface Danger Zones (SDZ), Weapon Danger Zones (WDZ), and Laser Surface Danger Zones (LSDZ), all of which can be created through tools as part of the Range Manager's Tool Kit (RMTK). SDZs and WDZs identify hazardous areas that result from the firing and/or delivery of weapons and ordnance on all USMC ranges, and LSDZs depict where laser radiation levels may exceed maximum permissible exposure levels, thereby requiring control during laser operations. The intent of this order is to provide a single document that will guide the determination of compatible land use recommendations for all USMC installation ranges, per reference (b) through (h).

2. Cancellation. MCO 3550.11. (reference ((a))

3. Mission

a. Reference (d) establishes overall responsibilities for encroachment control management within the Marine Corps. This order establishes responsibilities, and prescribes policies and procedures for the RCUZ program for the Marine Corps. The RCUZ program will establish Range Compatibility Zones (RCZ) which will guide land use recommendations in the vicinity of USMC ranges. The RCUZ study will include an analysis of noise generated by aircraft as well as A-G and G-G ordnance firing, with or without laser use, with the resulting weapons impact and detonation. It will also include a range safety analysis through the use of a composite SDZ/WDZ/LSDZ footprints and the Laser Range Management Tool (LRMT). Program implementation procedures for Marine Corps Ranges are contained in enclosure (1).

b. The RCUZ Program requires that the Installation Commander's Encroachment Control Program work to prevent incompatible development of land adjacent to military training ranges. These land areas are typically identified as part of an installation RCUZ study (or other installation planning study). The RCUZ Process involves four steps:

(1) Develop, and periodically update RCUZ studies for each range installation as outlined in this order

(a) Analyze existing range utilization, and any known or emerging training requirements that may affect range utilization, such as new weapon systems and or platforms with a planned initial operational capability (IOC) within the next ten years to the extent practicable. Forecast danger zones shall be distinguished from danger zones associated with existing training.

(b) Identify critical areas where actions occur to assure land use compatibility within the RCUZ area through on-base master planning, local government land use controls, or Encroachment Partnering acquisition may be necessary.

(c) Submit RCUZ study to MCICOM for approval.

(2) Consult with stakeholders and refer to the range installation ECP to develop strategies for lands affected by potential weapons or noise impacts.

(3) Prepare a compatible land use plan for the range and surrounding areas.

(4) Develop a strategy to promote compatible development of land within those areas.

(5) Implement the RCUZ Study in coordination with USMC Policies and Procedures for Encroachment Control outlined in Ref (d).

(6) Identify RCUZ update requirements in advance to allow for program management and funding projection,

4. <u>Execution</u>

a. <u>Commander’s Intent and Concept of Operations</u>

(1) <u>Commander’s Intent</u>. This order establishes the Deputy Commandant (DC), Installations & Logistics (I&L) as the principal HQMC resource sponsor and Marine Corps proponent for the RCUZ Program.

(2) <u>Concept of Operations</u>

(a) The Marine Corps RCUZ Program is under the direction of DC I&L who will exercise approval authority and responsibility for the RCUZ program within the Marine Corps.

(b) The Commanding General (CG) Marine Corps Combat Development Command (MCCDC) (C465) is the executive agent and resource sponsor for aviation and ground range and training areas management (RTAM) programs, and the proponent for all range safety matters.

(c) The Assistant Deputy Commandant (ADC), Installations & Logistics (Facilities), (GF) is the executive agent for Marine Corps RCUZ policies and program.

b. Coordinating Instructions

(1) Comply with the intent and content of this order. The terms "shall," "will," and "must" as used in this order are directive and require compliance. Words such as "may" and "can" are advisory and do not require compliance.

(2) Submit all recommendations concerning this order to Commandant of the Marine Corps (CMC) (MCICOM GF) via the appropriate chain of command.

(3) Existing approved RAICUZ and RCUZ studies remain in effect. Periodic updates will be in accordance with this order.

5. Administration and Logistics

a. MCICOM GF-6 will administer the requirements and ensure the accuracy, modification, and distribution of this order.

b. Requests for deviations from any of the provisions of this order must be submitted to Commandant of the Marine Corps (MCICOM GF-6), 3000 Marine Corps Pentagon, Washington, DC 20350-3000.

c. Chapter 1 provides information and guidance on RCUZ responsibilities.

d. Chapter 2 provides information and guidance on the RCUZ Program and its relationship to Encroachment Control.

e. Chapter 3 provides information and guidance on Weapons Impact Analysis.

f. Chapter 4 provides information and guidance on laser use.

g. Chapter 5 provides information and guidance on Noise Exposure.

h. Chapter 6 provides information and guidance on the RCUZ Plan.

i. Chapter 7 provides information and guidance on RCUZ implementation.

j. Appendix A lists Marine Corps Installations with RAICUZ and/or RCUZ Studies.

k. Appendix B Provides Land Use Compatibility recommendations Tables.

l. Appendix C provides a Table of Contents for RCUZ studies.

m. Appendix D provides a listing of common ACRONYMS.

n. RCUZ studies will be prepared for Marine Corps Bases and Air Stations with ranges within the confines of the United States, its territories, trusts, and possessions. RCUZ studies, or portions thereof, may be prepared for U.S. activities in foreign countries if such action supports host nation policy for protecting the operational capabilities of those activities, or for USMC facility planning on-base. However, this order will be implemented in foreign countries only to the extent the requirements of the order do not contravene existing Status of Forces Agreements (SOFAs) or other treaties/executive agreements with a Host nation or otherwise contravene mandatory policy guidance issued by a joint command or sub-unified command.

o. Records created as a result of this order shall be managed according to National Archives and Records Administration approved dispositions per reference (i) to ensure proper maintenance, use, accessibility and preservation, regardless of format or medium.

6. Command and Signal

a. Command. This order is applicable to the Marine Corps Total Force.

b. Signal. This order is effective the date signed.

W. M. Faulkner
Deputy Commandant for
Installations and Logistics

DISTRIBUTION: PCN 10203368100

LOCATOR SHEET

Subj: POLICIES AND PROCEDURES FOR RCUZ PROGRAM

Location:

____
(Indicate the location(s) of the copy(ies) of this order.)

RECORD OF CHANGES

Log completed change action as indicated.

Change Number	Date of Change	Date Entered	Signature of Person Incorporated Change

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Chapter 1

Responsibilities

1. General. This chapter provides information and guidance on command and installation responsibilities.

2. Purpose. The purpose of this chapter is to delineate responsibility and authority pertaining to the execution and management of the RCUZ program. RCUZ Studies that are produced under this program provide basic foundation documents for use in the USMC Encroachment Control program. Responsibilities for encroachment control and management are outlined in reference (d).

3. Deputy Commandant, Installations and Logistics (DC I&L)

a. In addition to the responsibilities outlined in the references, DC I&L is the proponent for all matters pertaining to the oversight and coordination of RCUZ studies, including issuing policy and guidance, education, tasking of responsibilities, and monitoring accomplishment and resolution of conflicts that may exist with the administration of RCUZ policy and programs.

b. MCICOM (GF)) is the executive agent for RCUZ issues within the Marine Corps, coordinates uniform implementation of encroachment control policies and programs, and provides courses of action and recommendations to DC I&L when regional-level resolution of an RCUZ issue cannot be attained. MCICOM (GF) provides technical assistance and guidance to Marine Corps organizations on RCUZ policy decisions and implementation; promotes a RCUZ education program in cooperation with Commanding General, Marine Corps Combat Development Command (CG MCCDC) (C465) and Commander, Navy Installations Command (CNIC) (N-5); provides concept review, recommendations and approval of RCUZ plans; funds Marine Corps RCUZ plans, and coordinates with CGMCCDC(C465) on all matters pertaining to WDZs, SDZs, and LSDZs in RCUZ plans.

c. HQMC Facilities Branch (LF) is the central point of contact for all Marine Corps facilities, infrastructure and Major Repair (M2) and Minor Construction (R2) projects associated with operational ranges and training areas, and coordinates with CG MCCDC (C465) for application of associated Facility Sustainment Model (FSM) facility condition codes to guide decisions on the use of O&MMC funds for operational range and training area facilities.

d. Marine Corps Installations Command (MCICOM)Land Use and Military Construction Branch (GF) serves as the managing level point of contact for RCUZ and compatible land use and represents the Marine Corps at DOD, joint, and inter service-level meetings pertaining to RCUZ and encroachment control and management.

(1) GF-4 (MILCON Program Section) coordinates with CG, MCCDC (C465) for prioritization of Military Construction (MILCON) and requirements for operational ranges, training area enhancements and projects; and coordinates with Commander, Marine Forces Reserve (Deputy, Assistant Chief of Staff Facilities) for prioritization of Military Construction Naval Reserve (Marine Corps Specific) requirements for reserve facility projects.

(2) GF-5 (Environmental Management Section) establishes policy and manages programs related to environmental compliance, pollution prevention, and environmental restoration to include munitions response on closed ranges.

(3) GF-6 (Real Estate and Asset Utilization Section) is the HQMC section responsible for encroachment policy and programs related to real property acquisition, management, and disposal, compatible land use, encroachment partnering, community planning and outreach, and noise and noise complaint management. GF-6 also coordinates all actions related to real property asset accountability, and geospatial and facilities data.

(4) GF-7 (Conservation and Planning Section) establishes policy and programs related to natural and cultural resources, and the National Environmental Policy Act (NEPA). In coordination with CG MCCDC (C465) and Deputy Commandant, Aviation (DC, AVN) formulates, reviews, and executes policies, plans, and programs related to current and future force structure basing, installation and facilities requirements, land and airspace use requirements plans and studies.

4. Commanding General, Marine Corps Combat Development Command (CG MCCDC (C465))

a. In addition to the responsibilities outlined in references (a),(c),(d),and (e), CG MCCDC (C465) is the proponent for all matters pertaining to the oversight and coordination of operational ranges and training areas (RTAs), including issuing policy and guidance. As the executive agent for RTA issues within the Marine Corps, CG MCCDC (C465) is the proponent for all range safety matters.

b. CGMCCDC (C465) serves as the Service single point of contact for all RTA management issues and as such, the Director, RTAM will review and comment on all RCUZ studies and approve all RCUZ matters that affect range operational capabilities and safety.

5. Deputy Commandant, Aviation (DC AVN)

a. In accordance with reference (d) and (e), DC AVN is the principal HQMC resource sponsor and Marine Corps proponent for planning, prevention, and control of encroachment in associated special use airspace; Marine Corps liaison to the Chief of Naval Operations staff on military airspace operational issues and coordinates with CG MCCDC (C465) and ADC I&L(LF) on airspace issues and requirements.

b. Coordinate airspace for military operations and air traffic control procedures (ATC) in support of RTA projects.

c. Review and comment on RCUZ studies.

6. Counsel for the Commandant (CL)

a. CL will assist CG MCCDC (C465) and ADC I&L(LF), by providing land use, environmental, and procurement law guidance on RCUZ issues affecting the Marine Corps.

b. CL, through the Field and Area Counsel Offices, will provide legal support in matters under the Counsel's primary cognizance including land use, environmental, and procurement law.

7. Director, Public Affairs. In coordination with MCICOM (GF), establish and maintain Marine Corps message objectives and Questions and Answers (Q&As), pertinent to the policies and procedures in this order, for public affairs purposes, to include installation programs, community relations, media relations and internal relations.

8. Director, Office of Legislative Affairs

a. In coordination with MCICOM (GF), establish and maintain a federal legislative monitoring process pertinent to the policies and procedures in this order.

b. In coordination with ADC I&L (LF) and CL, develop, propose, and support legislative, regulatory, and administrative initiatives pertinent to the policies and procedures in this order.

9. Inspector General of the Marine Corps. In coordination with ADC I&L(LF), establish and maintain an RCUZ program assessment process to promote Marine Corps combat readiness, integrity, efficiency, effectiveness, and credibility.

10. Commander, Marine Corps Forces Command (COMMARFOR). Review and concurrence on RCUZ studies.

11. Commander, Marine Corps Installations Command (MCICOM). Review, comment and forward RCUZ studies to DC/I&L for approval.

12. Commanding Generals, Marine Corps Installations (CG MCI)

a. Exercise overall responsibility for coordinating Marine Corps RCUZ study development, and implementation strategies within respective region.

b. Monitor political, environmental, social, economic, governmental and administrative matters at the regional level in maintaining and updating RCUZ implementation strategies.

c. In coordination with CG MCCDC (C465), ensure that RCUZ issues affecting existing airspace procedures or areas are properly planned and processed through the Regional Airspace Coordinator (RAC).

d. Provide implementation guidance/ concurrence with priorities and recommendations in RCUZ studies submitted by Bases and Air Stations under their cognizance.

13. Commanders, Marine Corps Bases and Air Stations

a. Exercise overall responsibility for implementation of the RCUZ program at their installation.

b. Maintain documentation on the implementation of the RCUZ Study. Such documentation should contain, among other things, a chronological narrative of important events such as official implementation actions, newspaper articles, operational data and references; aerial and ground photographs, and pertinent correspondence.

c. Assign the installations CPLO point of contact to coordinate RCUZ Study development and installation-wide RCUZ implementation functions.

d. Assign the Range Control Officer (RCO) as the Range Management point of contact to coordinate RTA participation with the RCUZ program.

e. In coordination with CG MCI (respective region), coordinate installation-level RCUZ implementation initiatives with public officials and conservators within local area of interest.

14. <u>Commanders, Operational Forces</u>

a. Operational Force Commanders and training coordinators will review TEEP resource (land, air, water, frequency) training requirements with appropriate Region and Installation level Commander and staff on a recurrent basis, to identify changes in training tactics, platforms or weapons requirements for specific ranges to enable determination of potential RCZs.

b. Operational Force Commanders and training coordinators will review and comment on the potential training impacts of proposed RCUZ mitigation actions.

Chapter 2

Programs and Objectives

1. General. This chapter provides information and guidance on the RCUZ program and its relationship with encroachment control.

2. Purpose. The purpose of this chapter is to delineate the RCUZ program objectives and to establish strategies and procedures to achieve those objectives.

3. RCUZ Program Objectives. The main objective of the RCUZ program is to promote compatible land use within the range environs both on-base and off-base in order to:

(a) Minimize public exposure to hazards and noise associated with operations in Marine Corps RTAs;

(b) Protect DON investment by safeguarding current and potential operational capabilities of the RTAs, and protect the public health, safety and welfare;

(c) Promote compatible land use within the Range Compatibility Zones (RCZs) to the extent practicable;

(d) Inform the public about the RCUZ program and seek cooperative efforts to minimize encroachment;

(e) Establish working relationships between Commanding Officers of Marine Corps Bases and Air Stations and appropriate federal agencies; local; regional, and state community councils; commissions; Indian tribes, Native Hawaiian Organizations, and planning and zoning organizations. Contribute to mutual communications within these relationships regarding proposed actions that could affect public health, safety and welfare as well as operational and training capabilities and compatible land use recommendations.

(f) Provide technical inputs to the Encroachment Control Plan (ECP) required by reference (d) and to the RTA master plan required by reference (e).

4. Requirements

a. The development of a RCUZ study requires the establishment of RCZs as described in Chapter 3. RCZ I is a composite WDZ/SDZ/LSDZ “footprint” for all authorized range operations. MCB/MCAS commanders, working with RTAM and G3 Operations as appropriate, shall construct and make available for the RCUZ study the composite WDZ/SDZ/LSDZ footprint.

b. The development of a RCUZ study also requires a noise analysis to be conducted as described in Chapter 4.

c. Alternatives to achieve compatible land use must be in compliance with references (c) and (f).

d. RCUZ plan must be approved prior to release of any study analysis information to the public and prior to plan implementation.

5. Airspace Considerations

a. The Federal Aviation Act of 1958 directs the FAA to act as the “single manager” of the National Airspace System (NAS) to control the use of navigable airspace of the US and regulate both civil and military operations in such airspace in the interest of safety and efficiency. Reference (h) grants the FAA Administrator the authority to assign by regulation or order the use of airspace to ensure the safety of aircraft and efficient use of the airspace. A primary means for segregating military activities from non-participating aircraft, and thereby enhancing the safety of aircraft, is through the assignment of Special Use Airspace (SUA) to contain these activities. Reference (h) further directs the FAA Administrator to consider the requirements of national defense and commercial and general aviation, and the public right of freedom of transit through the navigable airspace, when making a determination on the assignment of airspace. Thus RCUZ studies must be cognizant of not only what is happening on the surface, but also what is taking place in the air over that surface when determining compatible land use areas.

b. Special Use Airspace (SUA) consists of that airspace wherein activities must be confined because of their nature, or limitations are imposed upon aircraft operations that are not part of those activities, or both. Types of SUA associated with RTAs include Restricted Areas (RA), Military Operations Areas (MOA), and Controlled Firing Areas (CFA). In addition, low-level Military Training Routes (MTR) may be utilized to provide ingress and egress to RTAs.

c. To insure sufficient range and airspace capability will be available to support existing and future mission requirements, an analysis of special use airspace may need to be conducted for RTAs. Findings and recommendations will be administered in accordance with reference (g).

d. The Department of Navy's Naval Aviation Simulation Model (NASMOD) provides an effective tool to determine range and airspace capacity as well as supporting proposals for new SUA if required to meet mission requirements. In addition to providing the capability to assess military airspace training requirements, the impact to military training from proposed changes in civilian and general aviation operations can be evaluated.

6. Other Considerations

a. Potential changes in operational procedures or RTA activities may constitute a major federal action requiring National Environmental Policy Act (NEPA) compliance actions. Proposals for use of new platforms, weapons or tactics that could result in a significant change to the environmental status quo (such as significant increases in off range noise and/or the size/ locations of RCZs) could require preparation of NEPA documentation prior to implementation in accordance with reference (f).

b. The use of lasers within the RTA will be governed by reference (c). LSDZs will be defined through LRMT methodologies which will include laser class (defining the NOHD), laser buffer angle, location of both the laser source and the Laser Target Area (LTA), and the terrain.

c. RTA management policies and procedures are outlined in reference (e). The Range Facility Management Supporting System (RFMSS) supports all major Marine Corps range management processes including scheduling, range control, utilization, and inventory. The Range Managers Toolkit (RTMK) provides access to the WDZ, SDZ, and LRMT tools.

7. Implementation

a. RCUZ implementation must be a continuous effort at each Marine Corps Base and Air Station. The installation Commander's involvement and support for the CPLO and staff personnel responsible for achieving compatible land use is critical to the program's success. The Community Plans and Liaison Officer (CPLO) has the lead for these implementation efforts but must be assisted by the entire staff.

b. The RCUZ provides final plan and technical input and underpinning to the Encroachment Control, Strategic Engagement Plans for the Marine Corps Base or Air Station. The intent of the ECP is to reduce the negative intrusion of encroachment on Marine Corps operations and training to achieve installations and operational areas that are fully capable of performing present and future missions minimizing encroachment impacts. The purpose of a Strategic Engagement Plan is to communicate to the general public, the importance of the installation's military mission, contribution to military readiness, and the threats posed by encroachment. Installation commanders should also integrate the RCUZ analysis into the installation facilities Master Plan, the regional airspace plan, and the RTA master plan.

8. Other Studies and Programs

a. The Sustainable Ranges Initiative (SRI) was chartered in 2002 by OSD Senior Readiness Oversight Council (SROC). The goal of SRI is to ensure the long term sustainment of military testing and training ranges while providing good stewardship of the resources on these properties. The strategy to achieve this overarching goal is to focus on four areas: (a) Compatible land use planning; (b) Community partnering; (c) Education and outreach, and (d) Regional partnerships. A key element of the SRI is a comprehensive, multi-tiered outreach effort focusing on encroachment issues and challenges facing DOD range managers and users. The RCUZ document provides technical data and underpinning for noise and hazard related compatible land use recommendations within the RCZs.

b. The purpose of the Air Installations Compatible Use Zones (AICUZ) program is to identify land uses compatible with noise levels, accident potential, and obstruction clearance criteria associated with military airfield operations. The AICUZ document provides the technical data and underpinning for compatible land use recommendations within an aviation installation.

c. The purpose of the RCUZ program is to identify land uses that will be compatible with noise levels and range danger zones associated with military aviation range operations. Existing approved RAICUZ documents for USMC aviation installations remain in effect until an update is required. All updates of existing RAICUZ studies for USMC installations will be as a RCUZ study.

d. The Range Complex Management Plans (RCMPs) address long term sustainable use, management procedures, and record keeping to support current and future operations. The documents support the sustainable ranges initiative and often include AICUZ and RCUZ analysis recommendations developed in these studies.

e. The RTA Master Plan is the Installation Commander's strategic RTA plan and also supports the project development process for MILCON.

f. The Joint Land Use Study (JLUS) is a cooperative land planning effort between military installations and surrounding communities sponsored by the DOD Office of Economic Adjustment (OEA) to promote community growth and development compatible with the training and operational mission of the military installation. This effort is led by the local community with financial grant assistance from OEA and cooperation from local installation personnel with a community implementation focus. The JLUS uses AICUZ/RAICUZ/RCUZ study findings and recommendations as technical inputs that are considered in the community JLUS plan in association with community and land use plan.

g. The ECP is the Marine Corps Base and Air Station Commander/Commanding Officer's tactical-level plan to support the Marine Corps' overall encroachment control strategy aboard the installation and in the surrounding areas.

h. As described in reference (g) the Naval Airspace Plan (NAP), in the form of Project Blue Air (PBA), an analysis of Navy/Marine Corps airspace utilization and requirements, defines and prioritizes Navy and Marine Corps SUA current and projected requirements. The NAP/PBA is the central basis for documentation and justification of all SUA within the DON. This allows for a focused and coordinated approach by the DON in optimizing the use of current airspace resources and competing aggressively for the retention and expansion of airspace resources in the future. This document is produced and updated, in part, by data provided by the DON regional airspace plans. The contents of the NAP/PBA will be the foundation for DON input into the Department of Defense Airspace Master Plan.

Chapter 3

Weapons Impact Analysis

1. General. This chapter provides information and guidance on weapons impact analysis for RCUZ studies.

2. Purpose. The purpose of this chapter is to describe weapons impact analysis procedures related to air-to-ground (A-G) and ground-to-ground (G-G) ranges as part of the Range Compatibility Zones portion of an RCUZ study.

3. Range Compatibility Zones (RCZs)

a. A principal component of the RCUZ study is a compatible land use plan specifically tailored for each range. RCZs are an inherent part of that land use plan.

b. RCZs translate safety and ordnance delivery safety concerns into recommended compatible land use zones. RCZ size is not affected by the number of annual range operations, but is based upon the types of operations performed on the range. The operations should be outlined in current local Range Operations Manuals or local orders and the current range certification. A prospective future composite RCZ is used as the basis for identifying types of compatible land uses, both on and off the military installation, that reflect current as well as operations forecast for training in the foreseeable future. RCZ land use recommendations are more stringent than those for noise impacts because the possible harmful consequences of allowing incompatible development in proximity to an RCZ are more serious. For land use planning purposes, RCZ’s define areas based on a level of protection to public health, safety, and welfare and to recommend compatible land uses to prevent encroachment and the potential degrading of operational range capability. RCZs are not predictors of safety hazards but depict areas where mishaps are likely to occur if they occur.

The final Composite RCZ will be used in the JLUS and Marine Corps ECPs. There are three RCZs where A-G ordnance delivery is involved:

(1)Range Compatibility Zone-I (RCZ-I) defines the area of the greatest potential safety hazard and designates the minimum range surface area needed to contain all ordnance and LSDZs delivered at Marine Corps ranges. RCZ-I is a composite of the SDZs, WDZs, and LSDZ authorized for the Range Complex. LSDZs will be contained within the range complex.

(2) Range Compatibility Zone-II (RCZ-II) defines the area of aircraft armed over flight. RCZ-II is less restrictive than RCZ-I. Installation Commanders may alternately, at their discretion, identify RCZ-II as that area where ordnance would impact if released inadvertently following activation of the arming switch. This option is intended to support the standoff capabilities of precision guided munitions. If this method is utilized, RCZ-II must be completely contained with the range boundary. However, RCZ-II still poses a level of potential safety concern and does come with compatible land use recommendations.

(3) Range Compatibility Zone-III (RCZ-III) defines the minimum level of safety concern and recognizes airspace which is restricted for safety of flight. This zone also comes with compatible land use recommendations.

c. RCZs noted above will vary at installations with ranges where there are no A-G ordnance delivery operations conducted. RCZ I will always contain SDZs, WDZs and LSDZs, but may not have an associated RCZ II or RCZ III if the range does not include aircraft delivered ordnance. [However, when aircraft takeoff and landings are conducted leading to delivery of ordnance on the installation range(s), specific compatible land use area depictions and land use criteria recommendations exist for applicable aircraft operations.] These include areas within aircraft lateral safety clearances and under imaginary surfaces, as well as accident potential zone contained in the Unified Facilities Criteria Airport and Heliport planning and Design Criteria (UFC 3-260-1). These areas also require land use compatibility designations and protection. Where an AICUZ study of an associated airfield has been conducted these considerations may or may not have been reflected in that document.

d. It is the responsibility of the Range Control Officer and Range Planning Staff to ensure range structures and range orientations are in the correct positions to safely support live fire activity.

e. Additionally, there also may be the need to include a special designated RCZ for specific Training and Maneuver areas at an individual installation (exclusive of any associated laser training activity). This RCZ would cover areas designated for tactical exercises and field training by troops and equipment. Live firing within maneuver areas is restricted to established ranges; training in the use of pyrotechnics, demolitions, mines, and booby traps; and driver training. These areas are of minimal safety concern, but should remain undeveloped. The only compatible development is that facilitating the training mission.

4. Development of RCZs

a. Range Compatibility Zone I (RCZ-I) is the composite footprint of the individual WDZs, SDZs, and LSDZs. These danger zones for each range are developed using the RMTK tools in accordance with reference (c) and TECOM SAFETY OF USE MEMORANDUM 6-09 of 28 Aug 2009.

(1) RCZ-I is the most restrictive of the three RCZs; there are no compatible land uses permitted within the RCZ-I (see Appendix B). If specific situations require the establishment of the RCZ-I outside the range boundary, efforts to either acquire the necessary property or negotiate a use agreement with the owner or agent controlling the land should be made in accordance with reference (i) and forwarded for approval. Operations may not commence until the land has either been acquired or use agreements put in place. Note: Per reference (c), LSDZs must be contained within the certified laser range area – never off range.

(2) In some instances, an "example RCZ-I" footprint may be useful to communicate the risks and required mitigation associated with higher risk operations that are being considered only occasionally to be supported on the range. Examples could include individual RCZ-I depictions for precision guided munitions (PGM) or larger scale exercises (LSE) that are not regularly conducted on the range. The example RCZ I can provide the Commander/Commanding Officer of the Range information on the risks and required mitigation associated with the proposed operations. Example RCZs may or may not be included in the RCUZ study as appropriate.

b. Range Compatibility Zone II (RCZ II) is the area of armed over-flight. For the purposes of this order, the period of armed over-flight is defined as beginning when an aircraft with ordnance places the cockpit arming switch in the “ARMED” position. The point at which this is authorized is set forth in the local range operating procedures / regulations, in accordance with USMC range safety policies. For scored targets the corridor width is normally 1000 feet, centered on the run-in centerline to the target, extending to the edge of RCZ I. For tactical targets, the length of the zone also begins at the arming point. However, additional analysis is required to determine the width of the corridor dependent on specific local requirements and electronic warfare threats that may exist, and of the ordnance being expended. The width of the corridor should extend an additional 500 feet beyond all possible flight tracks associated with the target. Installation Commanders may alternately, at their discretion, identify RCZ-II as that area where ordnance would impact if released inadvertently following activation of the arming switch. This option is intended to support the standoff capabilities of precision guided munitions. If this method is utilized, RCZ-II must be completely contained with the range boundary

c. Range Compatibility Zone III (RCZ-III) defines the area within the designated Special Use Airspace (SUA)associated with the RTA outside of the areas designated as RCZ I and RCZ II. RCZ III is that area required providing access to and from the target, safely separating participating and non-participating aircraft, providing the range user with tactical maneuvering room allowing for initial alignment for target acquisition. RCZ III is normally within the Restricted Area (RA) airspace associated with the range. While RCZ-III correlates to required airspace, it is the land use underlying the airspace that is considered for encroachment protection within the range complex.

5. SDZ and WDZ Tools

a. SDZs as outlined in reference (c) represent Army and USMC minimum safety requirements. Munitions will not be fired or employed on a range outside SDZs that have been developed and maintained for the range to depict overall danger areas for ground fire activities. Laser use and the associated LSDZ will be determined through the laser certification process, and may exceed the limits of the SDZ, as provided for the RCUZ-1 determination. LSDZ constraints and considerations will be reviewed in more detail in Chapter 4.

b. WDZs identify the minimum area necessary to contain munitions and hazardous fragments within the installation or range boundary that result from air-to-ground ordnance delivery operations. While containment levels on the WDZ tool are adjustable from 1:10,000 to a 1:1,000,000 probability on munitions (for inert ordnance) or a hazardous fragment (for live ordnance) from escaping the containment area, a containment of 1:1,000,000 probability is the USMC range safety standard. Accordingly, WDZs for RCUZ studies will be based on a 99.9999% (1:1,000,000) level of containment.

c. SDZs, WDZs, and LSDZs associated with USMC Range use are constructed utilizing tools found in RMTK. The RMTK is available within the Range Management System https://rtam.tecom.usmc.mil.

d. Range and training area management assistance in the functions of the SDZ tool, WDZ tool, and LRMT is available from installation range control officers, as well as the Range and Safety Design Branch, RTAM Division of TECOM.

6. Compatible Land Use Guidelines in RCZs

a. Compatible land use information and general guidance, listed by land use category, is presented in Appendix B for use on-base and by local governments in their land use planning and zoning deliberations. Land uses within RCZ I are highly restricted due to the inherent nature of operations within this area. Recommended land uses in RCZ II and RCZ III which have the potential to attract congregations of people are not compatible. Factors such as population density, labor intensity, and extent and height of structures need to be considered in determining the size of these land use compatibility zones. Consistency in the application of these land use recommendations at installations is important. Further amplification is available from "Standard Land Use Coding Manual" U. S. Department of Transportation, Federal Highway Administration, March 1977). Where a specific local land use is not adequately described in the standard guidance document, refinement and interpretation of the basic data is encouraged, within the constraints of accepted land use planning practice and with the approval of ADC I&L (LF).

b. Where local authorities have adopted specific land use recommendations that are more stringent than the criteria herein provided, the RCUZ plan may incorporate and support the specific local criteria. However, land use planning recommendations proposed for publication in RCUZ documents that vary from Appendix B require CMC approval prior to public dissemination. In all cases, the land use recommendations must consider the allowed aircraft operating altitudes in the corresponding airspace and preclude uses or height of natural or manmade objects that would pose a safety hazard to aircraft operations.

7. Renewable Energy Development Proposals

a. There has been a significant increase in the number of proposals for renewable energy projects in recent years and this trend is likely to continue. Project proposals are often oriented in close proximity to installations, ranges, and Military Training Routes (MTRs). While the DoD is a key stakeholder in the robust development of renewal energy projects, it must also ensure that any adverse impacts on military operations and readiness are minimized through collaboration and risk mitigation.

b. In order to ensure that project proposals with potential mission impacts are identified, there must be a concerted effort by the Operational Forces and the Installations Enterprise to actively engage communities and developers to thoroughly analyze and quantify associated risk, and develop potential mitigation measures when such projects are proposed. These efforts will be conducted with close coordination between MCICOM G-7, Regional G-7s, and the installations.

c. In the event that early efforts to identify and minimize mission impacts are unsuccessful, project analyses and mitigation options will be elevated to the OSD Energy Siting Clearinghouse for further review. In accordance with the National Defense Authorization Act of 2011, Section 358, the Clearinghouse is responsible for OSD level review of project proposals and whether adverse impacts can be reasonably mitigated based on previous analyses. The final determination of whether project would have an unacceptable risk to national security is the sole responsibility of the Deputy Secretary of Defense.

Chapter 4

Laser Use Analysis

1. General. This chapter provides information and guidance on laser use analysis for RCUZ studies.

2. Purpose. The purpose of this chapter is to describe laser analysis procedures related to air-to-ground (A-G) and ground-to-ground (G-G) ranges as part of the Range Compatibility Zones portion of an RCUZ study.

3. Range Compatibility Zones (RCZs)

a. A principal component of the RCUZ study is a compatible land use plan specifically tailored for each range. RCZs are an inherent part of that land use plan.

b. RCZs translate pilot and ordnance delivery operations safety concerns into recommended compatible land use zones. RCZ size is not affected by the number of annual range operations, but is based upon the types of operations performed on the range. The operations should be outlined in current local Range Operations Manuals or local orders and the current range certification. A prospective future composite RCZ is used as the basis for identifying types of compatible land uses, both on and off the military installation, that reflect current as well as range operations forecast for training in the foreseeable future. RCZ land use recommendations are more stringent than those for noise impacts because the possible harmful consequences of allowing incompatible development in proximity to an RCZ are more serious. For land use planning purposes, RCZ’s define areas based on a level of protection to public health, safety, and welfare and to recommend compatible land uses to prevent encroachment and the potential degrading of operational range capability. RCZs are not predictors of safety hazards but depict areas where mishaps are likely to occur if they occur.

The final Composite RCZ will be used in the JLUS and Marine Corps ECPs. As a LSDZ must be contained within the certified laser range area, the only RCZ relevant to laser use is RCZ-1.

(a) Range Compatibility Zone-I (RCZ-I) defines the area of the greatest potential safety hazard and designates the minimum range surface area needed to contain all ordnance and

LSDZs delivered at Marine Corps ranges. RCZ-I is a composite of the SDZs, WDZs, and LSDZ authorized for the Range Complex. LSDZs will be contained within the range complex.

(b) It is the responsibility of the Range Control Officer and Range Planning Staff to ensure range structures and range orientations are in the correct positions to safely support live fire activity with laser use. Additionally, the RCO/RSO must ensure that there are no specular reflectors present to divert the laser from the intended target, and the all ground locations/personnel requiring PPE are identified.

(c) Additionally, there also may be the need to include a special designated RCZ for specific Training and Maneuver areas at an individual installation. This RCZ would cover areas designated for tactical exercises and field training by troops and equipment. Live firing within maneuver areas is restricted to established ranges; training in the use of pyrotechnics, demolitions, mines, and booby traps; and driver training. These areas are of minimal safety concern, but should remain undeveloped. The only compatible development is that facilitating the training mission.

4. Development of RCZs

a. Range Compatibility Zone I (RCZ-I) is the composite footprint of the individual WDZs, SDZs, and LSDZs. These danger zones for each range are developed using the RMTK tools in accordance with reference (c) and TECOM SAFETY OF USE MEMORANDUM 6-09 of 28 Aug 2009. The composite footprint will also include the noise contour associated with range ops.

(1) RCZ-I is the most restrictive of the three RCZs; there are no compatible land uses permitted within the RCZ-I (see Appendix B). If specific situations require the establishment of the RCZ-I outside the range boundary, efforts to either acquire the necessary property or negotiate a use agreement with the owner or agent controlling the land should be made in accordance with reference (i) and forwarded for approval. Operations may not commence until the land has either been acquired or use agreements put in place. Note: Per reference (c), LSDZs must be contained within the certified laser range area – never off range.

(2) In some instances, an "example RCZ-I" footprint may be useful to communicate the risks and required mitigation

associated with higher risk operations that are being considered only occasionally to be supported on the range. Examples could include individual RCZ-I depictions for precision guided munitions (PGM) or larger scale exercises (LSE) that are not regularly conducted on the range, showing the variance between the LSDZ and the WDZ or SDZ that will require a composite analysis. The example RCZ I can provide the Commander/Commanding Officer of the Range information on the risks and required mitigation associated with the proposed operations. Example RCZs may or may not be included in the RCUZ study as appropriate.

Chapter 5

Noise Exposure

1. General. This chapter provides information and guidance on the range ops noise exposure analysis.

2. Purpose. The purpose of this chapter is to describe noise models and range noise operations exposure analysis procedures and the requirements in the RCUZ study for a detailed noise analysis of aircraft noise, blast noise from A-G, large caliber G-G fire, noise from small-arms fire, (and noise from supersonic operations where applicable), as part of the RCUZ study.

3. Noise Metrics

a. Noise represents one of the most prominent environmental topics associated with military training operations. The following is a brief overview of commonly used noise metrics and their use in the context of RCUZ studies.

b. Since the human ear is not uniformly sensitive to all frequencies, weighting scales have been developed so that the intensity of a sound (or noise) can be equalized and brought in line with actual human perception. The *A-weighting* of decibels (dBA) corresponds to the natural response of the human ear, which is most sensitive to frequencies in the 1,000 to 4,000 HZ while de-emphasizing the very low and very high frequencies. For military generated noise, this would encompass such sounds as those from generators, aircraft, general transportation, and sometimes small arms. The *C-weighting* of decibels (dBC) is nearly flat through the audible frequency range. This weighting scale is used to describe impulsive sounds. This takes into account sounds characterized as impulsive that generally contain low frequency energy which may induce secondary effects such as vibrations and rattling of windows that emanate from large caliber weapons firing, sonic booms, and detonations. The differences in weighting scales produce different numerical values reflecting different mechanism underlying annoyance. Transportation noise is primarily related to sounds heard; blast or impulse noise is also annoying due to resulting vibrations that can cause shaking within a structure. Individual annoyance to levels in both scales is also related to time; numbers of events and their duration; acoustic energy and frequency, and whether the event is unexpected. The predisposition of the individual to the nature of the event itself is also a factor in their response.

c. As used in environmental noise analyses, a metric refers to the unit that quantitatively measures the effect of noise on the environment. To quantify these effects, DOD and other federal agencies use three noise-measuring techniques, or metrics: first, a measure of the highest sound level occurring during an individual event (single event); second, a combination of the maximum level of that single event with its duration; and third, a description of the noise environment based on the cumulative effects of all noise-generating activities. Single noise events can be described with Maximum Sound Level (Lmax), Sound Exposure Level (SEL), or Peak Sound Pressure Level (Lpk) values. The cumulative energy noise metric used for most analyses is the Day-Night Average Sound Level (DNL). For some airspace operations, the monthly DNL is adjusted for the onset rate of aircraft and designated the Average Monthly Onset-Rate Adjusted DNL. These metrics and their uses are described below.

(1) Maximum Sound Level (Lmax) (or maximum A-weighted sound level) is the highest A-weighted integrated sound level measured during a single event in which the sound level changes value with time (e.g., an aircraft overflight). During an aircraft overflight, the noise level starts at the ambient or background noise level, rises to the maximum level as the aircraft flies closest to the observer and returns to the background level as the aircraft recedes into the distance. The maximum sound level indicates the maximum sound level occurring during the event. The maximum sound level is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities. Although it provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the period of time that the sound is heard.

(2) Sound Exposure Level (SEL) is a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events (e.g., aircraft over-flights) have two main characteristics: a sound level that changes throughout the event and a period of time during which the event is heard. The SEL provides a measure of the net impact of the entire acoustic event, but it does not directly represent the sound level heard at any given time. During an aircraft flyover, SEL would include both the maximum noise level and the lower noise levels produced during onset and recess periods of the over-flight. SEL is a logarithmic measure of the total acoustic energy transmitted to the listener during the event. Mathematically, it represents the sound level of a

constant sound that would, in one second, generate the same acoustic energy as the actual time-varying noise event. For sound from aircraft over-flights, which typically lasts more than one second, the SEL is usually greater than the Lmax because an individual over-flight generally takes seconds to occur and the maximum sound level (Lmax) occurs instantaneously. SEL represents the best metric to compare noise levels from over-flights.

(3) Peak Sound Pressure Level is the highest instantaneous level based on an un-weighted or linear response. However, Peak sound levels can vary significantly based on varying weather conditions. Therefore, when using computer models to predict Peak levels, the contours displayed are the PK15(met). The PK15(met) is the peak sound level, factoring in the statistical variations caused by weather, that is likely to be exceeded only 15% of the time (i.e., 85% certainty that sound will be within this range). This metric exists only in modeling—one cannot take a PK15(met) measurement on the ground. PK15(met) is also used for land use planning with small arms, and as additional supplemental information for large arms and other impulsive sounds. It has gained popularity for military applications in recent years because it is a metric that works very well at showing just how loud things are likely to get at a particular location. Unfortunately, PK15(met) does not take duration or frequency of events into consideration, so it cannot tell how often things will be that loud.

(4) Day-Night Average Sound Level (DNL) (and Community Noise Equivalent level (CNEL) used in the State of California) are cumulative sound levels that account for the exposure of all noise events in a 24-hour period. To account for increased human sensitivity to noise at night, DNL includes a 10 dB penalty to "acoustic" nighttime events (2200 to 0700 hours and CNEL also adds a 5dB penalty to "acoustic" evening 1900 to 2200 hours). The penalties added to the DNL/CNEL account for the added intrusiveness of sounds that occur during normal sleeping hours, both because of the increased sensitivity to noise during those hours and because ambient sound levels during nighttime are typically about 10 dB lower than during daytime hours. DNL/CNEL represent an average quantity, mathematically representing the continuous A-weighted source for transportation (or C-weighted for impulse noise from large weapons) sound levels that would be present if all of the variations in sound level that occur over a 24-hour period were smoothed out so as

to contain the same total sound energy. These composite metrics account for the maximum noise levels, the duration of the events (sorties, operations, etc.), and the number of events that occur over a 24-hour period. This metric does not represent the sound level heard at any particular time, but quantifies the total sound energy received over the 24-hour period. While it is normalized as an average, it represents all of the sound energy, and is therefore a cumulative measure. DNL and CNEL are commonly used in land use planning.

(5) The inclusion of time periods (acoustic day or acoustic night) in the computation of the DNL/CNEL (either A or C weighted) reflects their basic 24-hour definition. It can, however, be derived from operations over periods of multiple days. For application to military installations, where operations are routinely conducted day to day, these metrics are usually applied as an Average Annual Day (AAD) where the total range operations are divided by 365 days. For other military installations or ranges where operations are not necessarily consistent from day to day, these metrics can be computed based on an Average Busy Day (ABD), such that the calculated noise is not diluted by periods of low activity. An ABD occurs when the range operations level on a given day is at least 50 percent of the AAD operations level. The ABD is calculated by determining the number of operations on busy days and dividing the total number of operations on those busy days by the number of busy days. Another basis that can be used is the Average Operating Day, which computes DNL/CNEL as an average over the number of days an event has occurred. Some analyses include a busiest month calculation. Onset-Rate adjusted DNL (DNLmr or CNELmr) is often used to model aircraft flying along MTRs and in RA/ Ranges to adjust the SEL of the aircraft upward in the modeling to account for the "surprise" effect of the sudden onset of aircraft noise events on humans in areas that only experience sporadic occurrences of aircraft. These methods can be useful to illustrate the cumulative effect of noise events when there is a large degree of variance among the noise sources. However, care must be taken to explain or avoid presenting a worst case depiction of noise without a clear explanation of how often the time periods that were used in the modeling reflected in the resulting noise contours are expected to occur.

(6) Noise from ordnance delivery (blast noise) is impulsive in nature and of short duration. Blast noise is often a source of annoyance for persons. The accompanying vibrations of buildings and structures induced by blast noise may also result in increased annoyance. Blast noise contours will be

developed using the latest version of the Department of Defense BNOISE2 program. The use of the C-weighted average sound level (CDNL) is an appropriate noise metric to represent the effects of blast noise from both air-to-ground ranges using live ordnance and Marine Corps heavy weapons ground training ranges. Initial BNOISE2 analysis input data must be coordinated with the Noise Staff of the U.S. Army Public Health Command if the noise analysis is done by a contractor.

(7) Small Arms noise consists of the muzzle blast and detonation of the projectile, if it contains an HE charge. SARNAM Version 2.6 can produce contours resulting noise from small arms fire operations based on peak (dBP) as well as ADNL.

4. Noise Contours

a. Part of the RCUZ study includes preparation of a noise plan to develop noise exposure contours and compare them to prior noise contours published in the last approved RCUZ document. The noise contours are developed by a computerized simulation of aircraft activity at the range and reflect site-specific conditions (e.g. terrain) and operational data; e.g., flight tracks, type and mix of aircraft, aircraft profiles (airspeed, altitude, power settings), and number/types of munitions employed as well as the frequency and times of operations. Future year planning is necessary to consider the effects of expected changes in mission, aircraft, and range operational levels, etc. Therefore, in addition to the current year analysis of operations, RCUZ updates will include an analysis of projected operations. The resultant noise contours will be referred to as the "prospective" noise contours. Projections of aircraft and range operations will be based upon currently available unclassified estimates of future mission requirements including new platforms and ordnance with an IOC or FOC within the next 10 years that is projected to be employed at the range. Where such estimates are not available, or where little or no change is expected in the next 5 to 10 years, the current year noise contours may also be used as the prospective noise contours. It is important to recognize that noise does not stop at a contour line. Unlike topographic contours, noise contours are not intended to be precise representations of what an individual hears at a specific instant in time from a specific noise event. Geographic features, weather, the individual's perception of the source, and the level of background noise all influence what is heard. It is important to clearly describe the estimated frequency of the period of operations that was used in modeling the noise contour presented.

b. Noise impacts from aircraft and ordnance operations will be graphically portrayed, and operational alternatives that could reduce noise impact on the installation and on the nearby community should be evaluated when practicable from the perspectives of aircraft safety and ability to maintain operational and training requirements.

c. DNL shall be used to develop noise contours for RCUZ studies except in the State of California, where CNEL will be used. Aircraft noise contours in ADNL of 55, 60, 65, 70, 75, and 80 (where applicable) shall be plotted on separate maps for Marine Corps ranges as part of RCUZ studies. Contours below 60 ADNL/ACNEL for aircraft are not required but may be provided if local conditions warrant discussion of lower aircraft noise levels, or where a substantial number of noise complaints have been received outside of 60 ADNL/ACNEL contours. Blast noise contours in CDNL of 57, 62, and 70 CDNL shall be included, along with a supplemental analysis using peak noise PK15(met) values and distances for representative events. For small arms ranges, the areas exposed to PK15(met) noise values <87dB; 87dB to 104dB, and > 104dB as well as ADNL contours of 55, 60, 65, 70 and 75 will be indicated on separate map(s)in noise studies. The most appropriate contours will be included in the RCUZ.

d. Even though noise contours below ADNL of 65 and CDNL of 62 may imply limited noise impact, individuals living near a range or air station in such areas can become annoyed and some may complain. Supplemental metrics can be useful in explaining potential impacts in these areas. Issuing advance public notice of periods of increased operational activity, and the length of time the increased level will last for example, can also be helpful in fostering public awareness and understanding of the importance and need for the increased level of activity that is associated with the event.

e. The MCB/MCAS Commander/Commanding Officer shall recommend the most appropriate noise footprints to be used in the RCUZ document for approval by ADC I&L(LF).

5. <u>Noise Modeling Methodologies to Be Used</u>

a. The NOISEMAP program or Military Operation Area (MOA) and Range Noise Map program (MR_NMAP) may be used for developing noise contours for fixed-wing aircraft. For ranges with a fixed run-in heading, NOISEMAP will be utilized. For ranges with variable run-in headings, the MR_NMAP will be utilized.

b. The Rotorcraft-Noise Model (RNM) program will be used for developing noise contours for rotary-wing and tilt-rotor aircraft operations.

c. The Advanced Acoustics Model is a new aircraft noise model in the final stages of development. When formally adopted by DOD this model will initially supplement, and ultimately replace the Noise Map and RNM programs. Execution guidance will be promulgated subsequent to OSD approval for use.

d. For low-level military training routes (MTR) to and from the range, MR_NMAP will be utilized.

e. BNOISE2 will be used for modeling heavy weapons and blast noise at Marine Corps Ranges.

f. SARNAM is the computer model that is to be used for modeling small arms noise at Marine Corps ranges.

g. In a RCUZ study the selection criteria and rationale for the noise contours (e.g., AAD/ABD, busiest month etc); the current year or prospective future use to reflect aircraft noise, as well as blast and small arms noise must be documented. The rationale shall be included in the Installation Commander's request for approval of the RCUZ plan, concurred with by the chain of command, and approved by ADC I&L(LF).

6. Supplemental Metrics. While DNL contours are widely accepted for use in land use planning and zoning actions, they do not represent what an individual hears when a noise event occurs. Weather conditions and sound focusing environment aspects can contribute to the sound from an individual range being heard several miles away, and beyond where zoning recommendations are typically made. Supplemental noise metrics are often used to help explain this situation in a range environs. The high-energy impulsive sound from the firing of heavy weapons and detonation of high-explosive charges can be both heard as well as sometimes cause vibrations (windows and pictures rattling, for example) for an instant and can be a source of complaints. Peak noise level guidelines are used by the Army to help address this challenge. Please see further discussion in Appendix B. Supplemental metrics can also help explain special situations (e. g. noise at a school during school hours; noise at certain peak periods of the year when a

major exercise is conducted, etc.). Single event noise data (e.g. SELs at various distances during a single aircraft over-flight; etc.) may be employed where appropriate to provide additional information on the effects of noise in certain situations where appropriate. Such use of supplemental metrics is in addition to the required use of PK15 for small arms and heavy weapons as outlined above.

7. Compatible Land Use Guidelines for Noise Zones

a. For land use planning purposes, the noise exposure from aircraft and weapons is divided by DON into three noise zones as outlined below:

- Noise Zone 1: The lowest area of noise exposure, where the DNL is less that 65 ADNL or 62CDNL. This is an area where most individuals can adapt to the noise. However, noise can be heard in this area.
- Noise Zone 2: Defined as an area of moderate impact, where the DNL is between 65 ADNL and 74 ADNL or between 62 CDNL and 70 CDNL, and compatible land use recommendations are made for both on-base and off-base locations.
- Noise Zone 3: Defined as an area of most noise impact, equal to or greater than 75 ADNL or equal to or greater than 70 CDNL, and where the most compatible land use recommendations are made for both on-base and off-base locations.

b. In addition to the noise zones described above, areas of concern may be defined where noise levels less than 65 ADNL/CNEL, but some degree of land use control/ disclosure notification is recommended (e.g., areas under ingress and egress routes to and from training ranges, areas exposed to peak noise over 115dB PK15(met)).

c. Appendix B provides land use compatibility guidelines for noise. Because less is known about public response to noise of gun fire, caution is needed when applying Appendix B to weapons ranges. Where specific local land uses are not adequately described, refinement and interpretation of the basic data is encouraged, within the constraints of accepted land use planning practice and with prior coordination with ADC I&L(LF).

Chapter 6

The RCUZ Plan

1. General. This chapter provides information and guidance on RCUZ studies and the resulting Plan.

2. Purpose. The purpose of this chapter is to describe the RCUZ Plan Sections and general content to be included.

3. RCUZ Plan Content

a. The RCUZ study or RCUZ study update can be prepared in-house, or by a contractor.

b. For the installations, outlined in Appendix A, the plan should include the following Sections, and content as outlined in Appendix C. For other Marine Corps Installations that have smaller range complexes, the content outlined below can be limited to be more descriptive of the location and range(s) involved.

(1) Table of Contents.

(2) Executive Summary which provides a concise summary of the findings, conclusions, and recommendations of the RCUZ study. This section will also include a brief discussion of any extenuating or mitigating requirements necessary for safe range operations.

(3) Introduction. This section includes a discussion of the RCUZ program and provides the plan user with a familiarity of the operational aspects of the range. In particular, information relating to the RCUZ program will include a general description of the purpose, scope, authority, objectives, program history, and roles and responsibilities for implementing the RCUZ Program. Range specific information will include the mission that this range fulfills and how its role supports MAGTF or Joint Service weapons delivery training or testing; a description of applicable NEPA documentation; a list of any assumptions that were utilized; and changes in operations, aircraft, or weapons that have necessitated an update when appropriate.

(4) Range and Airspace Overview. This section includes a discussion and appropriate figures to depict the location of the range, associated special use airspace, military training

routes, and the range, including features of importance, impact areas, targets, and restrictions. This section should also identify other local features of concern that may affect range utilization such as waterways, danger areas outlined in 33 CFR 334, nearby airfields, towers, or other man-made or natural features that may be of concern including a discussion of (1) uses that may cause smoke, dust or steam that could obscure pilot and range safety personnel vision; (2) direct and indirect lighting that could interfere with pilot vision; (3) uses that may cause electromagnetic interference (EMI) with aircraft navigation, communication or weapons systems; (4) uses that attract birds, such as landfills, wastewater treatment facilities, dredge disposal sites, seafood processing plants, etc., and (5) uses that may affect aircraft radar or low level training capability such as wind energy turbines.

A description of other pertinent information that may add value to the overall analysis and land planning should also be included. This may include information relating to locations of past aircraft mishaps, locations of off-site ordnance drops, history of the area (especially if range boundaries have changed over time), use of lasers and footprints or safety considerations that they introduce, etc. Airspace matters shall be coordinated through the appropriate Regional Airspace Coordinator (RAC) in accordance with reference (g).

(5) Exercises, Range and Airspace Operations. This section includes a description of major exercises supported on the range, live fire operations, types and numbers of annual airspace utilization, current operations for each of the ranges involved (small arms, large caliber, amphibious, maneuver, rotary-wing, tilt-rotor and fixed wing operations) users of the range, normal days and times of operations, range utilization, avoidance areas, etc. A description of projected future operations and training requirements will be included in this section and analyzed in the subsequent RCZ and Noise Sections.

(6) Range Compatibility Zones (RCZs). This section introduces what RCZs are and how they are developed. For updates to an existing RAICUZ/RCUZ study, this section should include a comparison of the new RCZs (including Laser Range Areas) to the previous weapons safety footprint areas (WSFAs) or WDZs and SDZs presented in the previous approved RAICUZ/RCUZ study. A description of the notable differences and causal factors between the two RCZ depictions will be included, when appropriate.

(7) Noise. This section describes the methodology to develop noise contours and provide the aircraft, small-arms and impulse (blast) noise contours as appropriate. The use of the RMTK noise tool will optimize this analysis. Contours presented should reflect operations into the future as best available data allows. Inclusion of the long-range prospective noise contours should minimize the requirement to update the plan as often. This is important as most state or local planning offices update their plans on long-term intervals and installations should strive to coordinate with these agencies. Include a discussion of other local factors that may influence range operations. As necessary, prepare any single event noise analysis and develop the appropriate rationale to incorporate this information into the plan. Discuss alternatives considered to minimize off-site noise impacts if appropriate. Provide a discussion of noise complaints that have been received associated with range operations. For updates to an existing RCUZ plan, this section should include a comparison of new noise contours to contours presented in the previous approved RCUZ plan with a description of the differences.

(8) Alternative Noise Analysis. (Additional section where applicable). An alternative noise analysis should also be included when significant noise impacts are outside the range boundary. The alternatives analysis should consider altering flight tracks, run-ins, target placement, operational parameters (altitude, dive angle, airspeed), without compromising flight safety or essential mission requirements in order to examine impacts of high noise. A discussion of the decision to implement or not implement alternatives outlined will be included with supporting rationale.

(9) Land Use Compatibility. This section will include a map and description of existing land uses in the study area on and off the installation, a discussion of land use compatibility guidelines for the RCZ and noise zones, and a discussion of existing land use compatibility, identification of local planning authorities and existing measures, tools, or regulations available to control zoning or land use. This section should also discuss the conclusions or recommendations from any existing planning studies, development plans, comprehensive plans, or any similar types of studies or plans that may be applicable.

(10) Recommendations. This section should provide conclusions and recommendations to implement the RCUZ plan for the range. Recommendations for land use changes, zoning, noise

and safety impact disclosure zones and implementation of other strategies should be presented. The recommendations should include roles and responsibilities of stakeholders in the implementation of the RCUZ program.

(11) Appendices should include any pertinent information, such as suggested land use compatibility tables for RSZs and Noise; existing land use agreements, or other local land use control information that does not fit into the body of the plan, and adds valuable information to users.

4. RCUZ Plan Review and Approval

a. Once the RCUZ Study or Plan update is prepared, the installation must submit the document to MCICOM (GF) for approval via the chain-of-command, with copy to: CGMCCDC (C465), and the appropriate COMMARFOR.

b. Copy to addressees provide comments as appropriate to CMC (LF). If no comments are received by MCICOM (GF) within 60 days of submission, it will be presumed none exist.

c. Information developed such as noise contours, RCZ footprints or RCUZ recommendations shall not be shared with individuals or other agencies including state and local government agencies, officials or planning offices until the RCUZ plan has been formally approved by MCICOM (GF).

d. Once the Plan has been approved by MCICOM (GF), a letter acknowledging approval of the plan shall be sent by MCICOM (GF) to the installation, range and training area command. The signed letter of approval shall be inserted in the front of the RCUZ study prior to final printing, dissemination, and implementation.

5. RCUZ Plan Distribution

a. After MCICOM (GF) approval, a copy of the RCUZ study should be distributed to appropriate Federal, state and local agencies for information purposes by the installation. The installation shall retain file CD/DVDs including the word document, an Adobe PDF version, supporting noise studies, and GIS geo-referenced data that is formatted to meet USMC GEOFidelis (Installation Geospatial Information and Services) digital spatial and Geospatial Standards as outlined in MCO 11000.25. The RCZ and noise footprints along with land use data layers will be incorporated into installation, NAVFAC, and/or MCI Geographic Information Systems by the GIS users.

Chapter 7

RCUZ Implementation

1. General. This chapter provides information and guidance on implementation of RCUZ Plans.

2. Purpose. The purpose of this chapter is to describe RCUZ Plan implementation action opportunities and associated real property considerations for Marine Corps Bases and Air Stations.

3. Implementation

a. This order is applicable to the Total Marine Corps Force. All Marine Corps Installations shall comply with the RCUZ program, as appropriate for their geographical location and extent of ranges on the Installation. Program implementation includes developing current and future RCZs and current and prospective noise analysis for the range, examining land use compatibility within the installation and partnering with appropriate federal, state, and local government agencies (working with these agencies for compatible land use near and around the ranges), considering operational alternatives as necessary, implementing a complaint response system for complaints from the surrounding communities, and developing strategies to protect the long term viability of the range while maintaining a high degree of public safety. Marine Corps Installations listed in Appendix A currently have a RAICUZ or a RCUZ document that is either Approved, or in an "Unapproved Administrative Draft" stage. The approved documents remain in effect until an update is required based on local determination. Installations with unapproved or "Administrative Draft" documents shall update their RCUZ/RAICUZ document to reflect this order, and submit for approval as soon as practicable.

b. Department of the Navy policy is predicated on promoting compatibility between range installations, neighboring communities, states, other federal agencies, and Native American Tribes responsible for land management in the vicinity of Navy and Marine Corps ranges. This policy recognizes the local governments' responsibility to protect public health, safety and welfare through zoning control ordinances, building codes, subdivision regulations, building permits, and disclosure statements. Local government implementation of RCUZ land use recommendations, through their local land use planning and zoning processes, is discretionary on their part. However, such implementation encourages compatible development in areas within and surrounding established RCZs and noise zones. Successful implementation of the RCUZ program depends on a close working relationship between the installation and local community.

4. Working Outside the Fence

a. The RCUZ Study (or RCUZ updates) implementation is an important element in the overall RTA Master planning and encroachment control for the RTA. The study helps to ensure the range is sustainable and will continue meeting Marine Corps future training requirements.

b. The key factor in implementation is effectively working with stakeholders, taking advantage of opportunities for communication and actions to protect and enhance the range for future training. There are numerous tools available to assist in this effort but the key action proponent must be the local Marine Base and Air Station Commander/Commanding Officer.

c. RCUZ implementation efforts provide an important portion of the overall encroachment control implementation and are interrelated with overall SRI implementation efforts within the Marine Corps.

d. Marine Corps Bases and Air Stations Commanders/ Commanding Officers, and Range Planners, and the CPLO, should meet with local governments, to socialize particularly the planning and zoning agencies about the RCUZ plan. To most effectively communicate requirements and have open discussions with various agencies, tribes, and community organizations, it is recommended that each installation commander take actions to create a Land Use Planning Partnering Team. Partnering teams should meet on a regular basis to discuss current topics of concern or interest and present information to other team members on foreseeable actions that may be occurring within the affected areas.

e. Although the emphasis of the RCUZ implementation effort must be on areas within the RCUZ footprint (noise zones and RCZs), the range installation can comment on land use issues outside the footprint, which might impact on it, e.g. large scale developments near the RCUZ footprint, or transportation system or utility corridor developments which could make the RCUZ area more desirable for development. The Installation Commanding Officer should convey to the local land use agencies that the range is a major land use in the local community and merits special consideration and protection. Development which occurs near the RCZs and noise zones could prevent mission changes or expansion in the future. Therefore, Commanders through their staffs should monitor proposed development beyond the RCZs and noise zones, and, if needed, present those concerns in appropriate local forums. CMC (LF), (regional) MCIs. NAVFACENGCCOM COE on the east and west coasts can provide assistance as needed.

f. Community Plans and Liaison Officers (CPLOs) and Regional Airspace Coordinators need to be cognizant of potential actions which may encroach upon the use of range training airspace. Open communication and partnering with, when appropriate, local aviation interests is encouraged to facilitate current and projected future access to training airspace.

g. Pursuit of an acquisition or withdrawal of land near the range may be appropriate if local, regional or state initiatives to prevent incompatible development prove unsuccessful or where analysis indicates other alternatives are not practicable to prevent encroachment. The installation should, on a regular basis inform local governments, state governments, tribes, other federal agencies, citizens groups, and the general public on: (a) the requirements of the military RTA; (b) range operations; (c) the efforts underway and planned to reduce potential off-range weapons impacts and noise where practicable; and (d) the recommendations listed in Appendix B on specific land use issues.

h. The importance of the RTA having sensitivity to long-range encroachment indicators cannot be overemphasized. Local community capital improvement plans and comprehensive land-use plans provide clues far in advance of actual incompatible actions. These plans generally address land areas far greater than the RCUZ and must be evaluated to determine their influence on the RCZs and noise zones either directly or indirectly.

i. Particular attention must be paid to proposals within the RTA environs to introduce utility services, new road access or transportation improvements. These actions should be viewed as "growth shapers" and precursors to additional or new developments in the future that can result in or exacerbate encroachment pressures on the RTA.

5. Real Property Considerations

a. This MCO shall not be used as the sole justification for either the acquisition or the retention of owned interests beyond the minimum required to protect the Government. Detailed procedural requirements related to the Navy’s real estate program are set forth in NAVFAC P-73 (Real Estate Procedural manual) (NOTAL), or as implemented within the Marine Corps by MCO P11000.14.

b. When threats to operational integrity of the RTA from incompatible development (encroachment) are anticipated, and when local communities are unwilling or unable to take the initiative in combating the threat via their own authority, consideration can be given to pursue land acquisition or withdrawal of public lands when appropriate. Documentation of community unwillingness or inability will be required to support acquisition projects. Where the mission of the range is threatened, acquisition of fee title or restrictive easements over the impacted lands in any RCZ or noise zone may be appropriate to maintain operational capability for present and future operational training. These actions can take several approaches including use of operations and maintenance as well as MILCON funding for acquisition of interests in land, encroachment partnering initiatives (10 USC 2684a, as amended), and/or leases or MOUs with land owners as a proactive buffering strategy. The Installation Commanders’ Guide to Encroachment Partnering, dated 10 February 2006 provides Marine Corps installation commanders and their staffs with the information they need to help plan and execute successful encroachment partnering projects.

c. The RCUZ provides a technical vehicle for protection of ranges, but increased pressure to excess property can dilute that protection. To avoid the forced disposal of lands required for the protection of the range from encroachment, ranges will ensure that required lands or easements are fully justified. Where disposal is directed, those rights and interests required for the protection of the future operational integrity of the installation through restrictions to ensure compatible land use will be retained. Particular attention must be paid to property located outside of RCZ-II – area of armed over-flight as depicted in the RCUZ study, which if excessed, would attract uses that would induce incompatible development within the RCUZ area. Additionally, the prior history of RCUZ areas and potential growth should be fully considered. Once property rights are relinquished, they are not easily, if ever, regained.

The dynamic nature of Marine Corps operational needs must be evaluated in encroachment control decisions.

d. It is important that potential buyers, renters or lessees be notified of possible noise and safety issues associated with range operations. This disclosure is encouraged in the noise zones greater than 65 DNL (or 60 CNEL), Noise Zones from weapons firing, Range Compatibility Zones, and areas that could be subjected to PK15(met) > 115. Disclosure should also be encouraged within the general vicinity of the RTAs where operations may result in public annoyance.

6. Real Property Interests to be Considered for RCUZ

a. When it is necessary for the Department of the Navy to acquire interests in land, a careful assessment must be made of the type of interest to be acquired either in the form of restricted use easements or by fee simple. In deciding what interest to acquire, the following factors are examined: The minimum interest necessary to protect the DON; when the property is needed; available funds; type of acquisition (e.g., fee v. restrictive easements; encroachment partnering) and environmental considerations (e.g., contaminated property, potential partners, NEPA).

b. Real property interests to be considered for acquisition include but are not limited to; specific land use allowance or prohibitions, the provisions for making low and frequent over flights, high aircraft noise, prohibiting light emissions that interfere with pilot vision, prohibiting electromagnetic and radio frequency emissions that interfere with aircraft communication or navigation equipment, control of the height of buildings, structures, towers, trees or other obstructions that interfere with aircraft operations, and access by government representatives, prohibiting entry of non-authorized persons.

7. Real Property Management

a. Marine Corps Regional Commanders and Marine Corps Base and Air Station Commanding Officers shall be responsible for the administration, use, and management of real property assets as related to the readiness and effectiveness of Marine Corps RTAs. This responsibility is particularly relevant to documentation, oversight, and enforcement of government interests in land outside the installation boundary as encroachment protection, whether that land is acquired in fee, easement, encroachment partnering, or controlled through lease, MOU, or through local zoning actions.

b. Installation Commanders shall develop a real property management plan to establish standard operating procedures to maintain DOD control of acquired property interests. This plan should also include updated base mapping incorporating RCUZ areas containing land use restrictions.

8. Documentation of Local Efforts

a. Records of important discussions, negotiations, testimony, etc., with and before local officials, boards, etc., should be maintained by the local command for at least seven years. This will ensure that documentation is available to indicate reasonable and prudent efforts were made to preclude incompatible land use through cooperation with local and state government officials and other federal agencies as appropriate, and that recourse to such actions has been exhausted.

b. Documentation of routine inspections by the installation for compliance with the use provisions and to ensure compliance is a necessary part of on-going real property management of these lands.

APPENDIX A

MARINE CORPS INSTALLATIONS WITH RAICUZ AND/OR RCUZ STUDIES

MCB TWENTY-NINE PALMS, CA (R-2501)

MCB CAMP PENDLETON, CA (R-2503)

MCAS YUMA (PORTIONS OF THE BOB STUMP TRAINING RANGE COMPLEX)

CHOCOLATE MOUNTAINS AERIAL GUNNERY RANGE (R-2507N/S/E)

BARRY M. GOLDWATER RANGE (R-2301W)

MCB QUANTICO, VA (R-6608)

MCB CAMP LEJEUNE, NC (R-5303, R-5304, R-5306D, R-5306E)

MCAS CHERRY POINT, NC (R-5306A)

MCAS BEAUFORT, SC (TOWNSEND RANGE) (R-3307)

APPENDIX B(1)

SUGGESTED LAND USE COMPATIBILITY IN RANGE COMPATIBILITY ZONES

LAND USE	RCZ I	RCZ II	RCZ III
RESIDENTIAL - SINGLE FAMILY, DUPLEX, MOBILE HOMES	N	N	Y^3
RESIDENTIAL - MULTIPLE FAMILY HOMES	N	N	N
TRANSIENT LODGING	N	N	N
SCHOOL CLASSROOMS, LIBRARIES, CHURCHES	N	N	N
HOSPITALS	N	N	N
NURSING HOME	N	N	N
AUDITORIUMS, CONCERT HALLS	N	N	N
OFFICE BUILDINGS - PERSONAL, BUSINESS, PROFESSIONAL	N	N	Y^2
COMMERCIAL, RETAIL	N	N	Y^2
MANUFACTURING	N	N	Y^2
UTILITIES	N	N	Y
PLAYGROUNDS, NEIGHBORHOOD PARKS	N	N	Y^2
GOLF COURSES, RIDING STABLES, WATER RECREATION, CEMETERIES	N	Y^4	Y^2
OUTDOOR SPECTATOR SPORTS	N	N	Y^2
INDUSTRIAL, WAREHOUSE, SUPPLIES	N	N	Y
LIVESTOCK, FARMING, ANIMAL BREEDING	N	Y^1	Y^2
AGRICULTURAL (EXCEPT LIVESTOCK), MINING, FISHING	N	Y^1	Y
RECREATIONAL, WILDERNESS AREAS	N	Y^2	Y^2

NOTES:
1. Range Compatible Use Zone-II is an area of armed overflight. Land uses which have the potential to attract congregations of people are not compatible. For scored targets, no development within 500 feet either side of the run-in line centerline. For tactical targets, further analysis is required. Factors to be considered: labor intensity, structural coverage, aircraft type/frequency/ordnance load, altitude (weapons dispersion).
2. Incompatible when the training mission requires low altitude overflight (less than 500 ft).
3. Suggested maximum density in RCZ-III is no more than 1-2 dwelling units per acre.
4. Clubhouses, chapels and other facilities where people congregate are not compatible in RCZ-III.

APPENDIX B(2)

RECOMMENDED LAND USE COMPATIBILITY IN NOISE ZONES

Suggested land use compatibility guidelines in noise zones are shown in the Table below. Additions to some land use categories have been incorporated into Table subsequent to issuance of the SLUCM to reflect additional land uses and to clarify the categorization of certain uses. The land use compatibility recommendations are provided for local governments as well as DoD personnel for on-base planning.

Land Use Compatibility in Noise Zones

LAND USE		SUGGESTED LAND USE COMPATIBILITY				
SLUCM NO.	LAND USE NAME	DNL or CNEL 65-69	DNL or CNEL 70-74	DNL or CNEL 75-79	DNL or CNEL 80-84	DNL or CNEL 85+
10	Residential	N[1]	N[1]	N	N	N
11	Household units	N[1]	N[1]	N	N	N
11.11	Single units: detached	N[1]	N[1]	N	N	N
11.12	Single units: semidetached	N[1]	N[1]	N	N	N
11.13	Single units: attached row	N[1]	N[1]	N	N	N
11.21	Two units: side-by-side	N[1]	N[1]	N	N	N
11.22	Two units: one above the other	N[1]	N[1]	N	N	N
11.31	Apartments: walk-up	N[1]	N[1]	N	N	N
11.32	Apartment: elevator	N[1]	N[1]	N	N	N
12	Group quarters	N[1]	N[1]	N	N	N
13	Residential hotels	N[1]	N[1]	N	N	N
14	Mobile home parks or courts	N	N	N	N	N
15	Transient lodgings	N[1]	N[1]	N[1]	N	N
16	Other residential	N[1]	N[1]	N	N	N
20	Manufacturing					
21	Food and kindred products; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
22	Textile mill products; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
23	Apparel and other finished products; products made from fabrics, leather, and similar materials; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
24	Lumber and wood products (except furniture); manufacturing	Y	Y[2]	Y[3]	Y[4]	N
25	Furniture and fixtures; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
26	Paper and allied products; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
27	Printing, publishing, and allied industries	Y	Y[2]	Y[3]	Y[4]	N

APPENDIX B(2)
LAND USE COMPATIBILITY IN NOISE ZONES-CONTINUED

Land Use		Suggested Land Use Compatibility				
SLUCM NO.	LAND USE NAME	DNL or CNEL 65-69	DNL or CNEL 70-74	DNL or CNEL 75-79	DNL or CNEL 80-84	DNL or CNEL 85+
20	Manufacturing (continued)					
28	Chemicals and allied products; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
29	Petroleum refining and related industries	Y	Y[2]	Y[3]	Y[4]	N
30	Manufacturing (continued)					
31	Rubber and misc. plastic products; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
32	Stone, clay and glass products; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
33	Primary metal products; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
34	Fabricated metal products; manufacturing	Y	Y[2]	Y[3]	Y[4]	N
35	Professional scientific, and controlling instruments; photographic and optical goods; watches and clocks	Y	25	30	N	N
39	Miscellaneous manufacturing	Y	Y[2]	Y[3]	Y[4]	N
40	Transportation, communication and utilities					
41	Railroad, rapid rail transit, and street railway transportation	Y	Y[2]	Y[3]	Y[4]	N
42	Motor vehicle transportation	Y	Y[2]	Y[3]	Y[4]	N
43	Aircraft transportation	Y	Y[2]	Y[3]	Y[4]	N
44	Marine craft transportation	Y	Y[2]	Y[3]	Y[4]	N
45	Highway and street right-of-way	Y	Y	Y	Y	N
46	Automobile parking	Y	Y	Y	Y	N
47	Communication	Y	25[5]	30[5]	N	N
48	Utilities	Y	Y[2]	Y[3]	Y[4]	N
49	Other transportation, communication and utilities	Y	25[5]	30[5]	N	N
50	Trade					
51	Wholesale trade	Y	Y[2]	Y[3]	Y[4]	N
52	Retail trade – building materials, hardware and farm equipment	Y	25	30	Y[4]	N
53	Retail trade – including shopping centers, discount clubs, home improvement stores, electronics superstores, etc.	Y	25	30	N	N
54	Retail trade – food	Y	25	30	N	N

APPENDIX B(2)
LAND USE COMPATIBILITY IN NOISE ZONES-CONTINUED

Land Use		Suggested Land Use Compatibility				
SLUCM NO.	LAND USE NAME	DNL or CNEL 65-69	DNL or CNEL 70-74	DNL or CNEL 75-79	DNL or CNEL 80-84	DNL or CNEL 85+
50	Trade (Continued)					
55	Retail trade – automotive, marine craft, aircraft and accessories	Y	25	30	N	N
56	Retail trade – apparel and accessories	Y	25	30	N	N
57	Retail trade – furniture, home, furnishings and equipment	Y	25	30	N	N
58	Retail trade eating and drinking establishments	Y	25	30	N	N
59	Other retail trade	Y	25	30	N	N
60	Services					
61	Finance, insurance and real estate services	Y	25	30	N	N
62	Personal services	Y	25	30	N	N
62.4	Cemeteries	Y	Y[2]	Y[3]	Y[4,11]	Y[6,11]
63	Business services	Y	25	30	N	N
63.7	Warehousing and storage	Y	Y[2]	Y[3]	Y[4]	N
64	Repair services	Y	Y[2]	Y[3]	Y[4]	N
65	Professional services	Y	25	30	N	N
65.1	Hospitals, other medical facilities	25	30	N	N	N
65.16	Nursing homes	N[1]	N[1]	N	N	N
66	Contract construction services	Y	25	30	N	N
67	Government services	Y[1]	25	30	N	N
68	Educational services	25	30	N	N	N
68.1	Child care services, child development centers, and nurseries	25	30	N	N	N
69	Miscellaneous	Y	25	30	N	N
69.1	Religious activities	Y	25	30	N	N
70	Cultural, entertainment and recreational					
71	Cultural activities (& churches)	25	30	N	N	N
71.2	Nature exhibits	Y[1]	N	N	N	N
72	Public assembly	Y	N	N	N	N
72.1	Auditoriums, concert halls	25	30	N	N	N
72.11	Outdoor music shells, amphitheaters	N	N	N	N	N
72.2	Outdoor sports arenas, spectator sports	Y[7]	Y[7]	N	N	N
73	Amusements	Y	Y	N	N	N

APPENDIX B(2)
LAND USE COMPATIBILITY IN NOISE ZONES-CONTINUED

Land Use		Suggested Land Use Compatibility				
SLUCM NO.	LAND USE NAME	DNL or CNEL 65-69	DNL or CNEL 70-74	DNL or CNEL 75-79	DNL or CNEL 80-84	DNL or CNEL 85+
70	Cultural, entertainment and recreational (continued)					
74	Recreational activities (including gold courses, riding stables, water recreation)	Y	25	30	N	N
75	Resorts and group camps	Y	25	N	N	N
76	Parks	Y	25	N	N	N
79	Other cultural, entertainment and recreation	Y	25	N	N	N
80	Resource production and extraction					
81	Agriculture (except live stock)	Y^{8}	Y^{9}	Y^{10}	$Y^{10,11}$	$Y^{10,11}$
81.5	Livestock farming	Y^{8}	Y^{9}	N	N	N
81.7	Animal breeding	Y^{8}	Y^{9}	N	N	N
82	Agriculture related activities	Y^{8}	Y^{9}	Y^{10}	$Y^{10,11}$	$Y^{10,11}$
83	Forestry activities	Y^{8}	Y^{9}	Y^{10}	$Y^{10,11}$	$Y^{10,11}$
84	Fishing activities	Y	Y	Y	Y	Y
85	Mining activities	Y	Y	Y	Y	Y
89	Other resource production or extraction	Y	Y	Y	Y	Y

KEY TO TABLE – LAND USE COMPATIBILITY IN NOISE ZONES

SLUCM – Standard Land Use Coding Manual, U.S. Department of Transportation

Y (Yes) – Land use and related structures compatible without restrictions.

N (No) – Land use and related structures are not compatible and should be prohibited.

Y^{x} – Yes with restrictions. The land use and related structures generally are compatible. However, see note(s) indicated by the superscript.

N^{x} – No with exceptions. The land use and related structures are generally incompatible. However, see note(s) indicated by the superscript.

25, 30, or 35 – The numbers refer to noise level reduction (NLR) levels. NLR (outdoor to indoor) is achieved through the incorporation of noise attenuation into the design and construction of a structure. Land use and related structures are generally compatible; however, measures to achieve NLR of 25, 30, or 35 must be incorporated into design and construction of structures. However, measures to achieve an overall noise reduction do not necessarily solve noise difficulties outside the structure and additional evaluation is warranted. Also, see notes indicated by superscripts where they appear with one of these numbers.

DNL – Day-Night Average Sound Level.

CNEL – Community Noise Equivalent Level (normally within a very small decibel difference of DNL)

Ldn – Mathematical symbol for DNL.

APPENDIX B(2)
LAND USE COMPATIBILITY IN NOISE ZONES-CONTINUED

NOTES FOR TABLE – LAND USE COMPATIBILITY IN NOISE ZONES

1. General

a. Although local conditions regarding the need for housing may require residential use in these zones, residential use is discouraged in DNL 65-69 and strongly discouraged in DNL 70-74. The absence of viable alternative development options should be determined and an evaluation should be conducted locally prior to local approvals indicating that a demonstrated community need for the residential use would not be met if development were prohibited in these zones. Existing residential development is considered as pre-existing, non-conforming land uses.

b. Where the community determines that these uses must be allowed, measures to achieve outdoor to indoor NLR of at least 25 decibels (dB) in DNL 65-69 and 30 dB in DNL 70-74 should be incorporated into building codes and be considered in individual approvals; for transient housing, an NLR of at least 35 dB should be incorporated in DNL 75-79.

c. Normal permanent construction can be expected to provide an NLR of 20 dB, thus the reduction requirements are often stated as 5, 10, or 15 dB over standard construction and normally assume mechanical ventilation, upgraded sound transmission class ratings in windows and doors, and closed windows year round. Additional consideration should be given to modifying NLR levels based on peak noise levels or vibrations.

d. NLR criteria will not eliminate outdoor noise problems. However, building location, site planning, design, and use of berms and barriers can help mitigate outdoor noise exposure particularly from ground level sources. Measures that reduce noise at a site should be used wherever practical in preference to measures that only protect interior spaces.

2. Measures to achieve NLR of 25 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.

3. Measures to achieve NLR of 30 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.

4. Measures to achieve NLR of 35 must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas, or where the normal noise level is low.

5. If project or proposed development is noise sensitive, use indicated NLR; if not, land use is compatible without NLR.

6. Buildings are not permitted.

7. Land use is compatible provided special sound reinforcement systems are installed.

8. Residential buildings require an NLR of 25

9. Residential buildings require an NLR of 30.

APPENDIX B(2)
LAND USE COMPATIBILITY IN NOISE ZONES- CONTINUED

NOTES FOR TABLE – LAND USE COMPATIBILITY IN NOISE ZONES
10. Residential buildings are not permitted.
11. Land use that involves outdoor activities is not recommended, but if the community allows such activities, hearing protection devices should be worn when noise sources are present. Long-term exposure (multiple hours per day over many years) to high noise levels can cause hearing loss in some unprotected individuals.

Source: Adapted from DODI 4165.57 of 2 May 2011

APPENDIX B(3)

NOISE ZONES AND SUPPLEMENTAL METRICS

1. Supplemental metrics, such as single event noise data (for example, Peak 15(met)), are to be employed where appropriate to provide additional information and notification on the effects of noise from heavy weapons on test and training ranges.

2. Disclosure statements should be recommended to inform renters and owners of housing of the risk of annoyance that can result in noise complaints from large caliber impulsive noise resulting from testing and training activities, (e.g. armor, artillery, mortars, air-dropped live ordnance, and demolition activities). The areas for disclosure for noise associated with these activities should be assessed in terms of a single event metric, peak sound pressure level PK15 (met). The metric PK 15(met) accounts for statistical variation in received single event peak noise level that is due to weather. It is the calculated peak noise level, without frequency weighting, expected to be exceeded by 15 percent of all events that might occur. If there are multiple weapon types fired from one location, or multiple firing locations, the single event level used shall include the loudest level that occurs at each receiver location and may include other representative events to present additional.

3. Noise from small arms ranges will be assessed using un-weighted peak levels (dBP) {PK 15(met)} as well as ADNL contours in Marine Corps RCUZ Studies.

4. Table B(3)-1 summarizes noise zones for aircraft, heavy weapons and small arms.

Table B(3)-1 Army Noise Zones

Noise Zone	Noise Levels(dB)	Noise Levels(dB)	Noise Levels(dB)
	Aviation (ADNL)	Impulsive CDNL	Small Arms Peak (dBP)
LUPZ	60-64	57-62	N/A
1	<65	<62	<87
2	65-74	62-70	87-104
3	75 and above	>70	>104

Legend for Table B(3)-1.

dB = decibel LUPZ = Land use planning zone; ADNL= A weighted DNL; CDNL = C weighted DNL; N/A=not applicable; PK 15(met) =Single event peak level exceeded by 15 percent of events

5. Single event noise levels in Table B3(-2) correspond to areas of low to high risk of noise complaints from large caliber weapons and weapons systems. The levels in Table B(3)-2 should be used to supplement the noise zones defined in Table B(3)-1 and provide recommended disclosure areas for blast noise.

Though supplemental in nature, noise sensitive land uses are normally discouraged in areas on and off-base equal to or greater than PK15(met) of 130 due to potential impacts.

Where the PK15(met) is between 115dB and 130dB, the Installation Commander should determine if limited development should be pursued for mission protection, land use compatibility based on the frequency of events and with consideration of existing and future proposed land use.

However, for areas impacted by infrequent single noise events, such a detonation of large amounts of explosives, the Installation Commander should determine if land use compatibility within these areas is necessary for mission protection.

However, advance notification of such events should be communicated to the public when practicable.

Table B(3)-2 Risk of Noise Complaints by Level of Impulse Noise

Risk of Noise complaints	Large caliber weapons noise limits (dB) PK 15(met)
Low	< 115
Medium	115 - 130
High	130 - 140
Risk of physiological damage to unprotected human ears and structural damage claims	> 140

Legend for Table B(3)-2:
dB = decibel
PK 15(met) = Single event peak level exceeded by 15 percent of events

Notes:

[1] Although local conditions regarding the need for housing may require noise-sensitive land uses in Noise Zone II, on or off post, this type of land use is strongly discouraged. The absence of viable alternative development options should be determined and an evaluation should be conducted locally prior to local approvals indicating that a demonstrated community need for the noise-sensitive land use would not be met if development were prohibited in Noise Zone II.

[2] Where the community determines that these uses must be allowed, measures to achieve an outdoor to indoor noise level reduction (NLR) of at least 25 dB to 30 dB in Noise Zone II, from small arms and aviation noise, should be incorporated into building codes and be in individual approvals. The NLR for communities subject to large caliber weapons and weapons system noise is lacking scientific studies to accomplish the recommended NLR. For this reason it is strongly discouraged that noise-sensitive land uses be allowed in Noise Zone II from large caliber weapons.

[3] Normal permanent construction can be expected to provide a NLR of 20 dB, for aircraft and small arms, thus the reduction requirements are often stated as 5, 10 or 15 dB over standard construction and normally assume mechanical ventilation, upgraded Sound Transmission Class (STC) ratings in windows and doors and closed windows year round. Additional consideration should be given to modifying NLR levels based on peak noise levels or vibrations.

[4] NLR criteria will not eliminate outdoor noise problems. However, building location and site planning, and design and use of berms and barriers, can help mitigate outdoor noise exposure NLR particularly from ground level aircraft sources. Barriers are generally not effective in noise reduction for large arms such as artillery and armor, large explosions, or from high-level aircraft sources.

APPENDIX C

RECOMMENDED TABLE OF CONTENTS FOR RCUZ STUDIES

APPENDIX D

TYPICAL RCUZ ACRONYMS AND ABBREVIATIONS

AAV	Amphibious Assault Vehicles
ACC	Area of Critical Concern
ADNL	A weighted day-night sound level (DNL)
AFA	Artillery Firing Area
A-G	Air to ground
AGL	Above Ground Level
AICUZ	Air Installations Compatible Use Zones
AIR	Air Inflatable Retard
ALUCP	Airport Land Use Compatibility Plan
APOBS	Anti-personnel obstacle breaching system
APZ	Accident Potential Zone
AT	Anti-tank
ATC	Air Traffic Control
BDU	Bomb Dummy Unit
BLM	Bureau of Land Management
BRAC	Base Realignment and Closure
BSU	Bomb Simulated Unit
BZ0	Battle Sight Zero
cal	Caliber
CAL	Confined Area Landing
CPLO	Community and Plans Liaison Officer
CAS	Close Air Support
CBT	Combat Training Town
CFA	Controlled Firing Area
CNEL	Community Noise Equivalent Level
CY	Calendar year
CZ	Clear Zone
dB	Decibel
dBA	A-weighted decibels
dBC	C-weighted decibels
ADNL	A-weighted day-night average sound level
CDNL	C-weighted day-night average sound level
DON	Department of the Navy
DZ	Drop Zone

ECP	Encroachment Control Plan
EFSS	Expeditionary Fire Support System
EOD	Explosive Ordnance Disposal
FAA	Federal Aviation Administration
FAC	Forward Air Controller
FAC(A)	Forward Air Controller Airborne
FAR	Federal Aviation Regulation
FIREX	Firing exercises
FOC	Full Operational Capability
FY	Fiscal Year
GEOFidelis	Common pseudonym given to the Marine Corps IGIS Program
G-G	Ground to Ground
HE	High explosive
HEDP	High Explosive Dual Purpose
HIMARS	High Mobility Artillery Rocket System
HLZ	Helicopter Landing Zone
HOLF	Helicopter Outlying Landing Field
ICM	Improved Conventional Munitions
IFR	Instrument Flight Rules
IGIS	Installation Geospatial Information and Services
IOC	*I*nitial Operational Capability
IP	Initial Point
JSF	Joint Strike Fighter (F-35)
JLUS	Joint Land Use Study
KIAS	Knots Indicated Air Speed
lb	Pound
LAAD	Low Altitude Anti-aircraft Defense
LAV	Light Armored Vehicle
LCAC	Landing Craft, Air Cushioned
Ldn	day-night average sound level
Ldnc	C-weighted day-night average sound level
LFAM	Live Fire and Maneuver
LRMT	Laser Range Management Tool
LSDZ	Laser Surface Danger Zone
LHA	landing ship, helicopter assault
Lpk	Peak Sound Pressure Level
PPE	Personal Protection Equipment
PK15(met)	Peak sound level, without frequency weighting and accounting for the statistical variation

	cause by weather, expected to be exceeded by 15 percent of all events that might occur.
Lmax	Maximum sound level
LW155	Lightweight 155mm howitzer
LZ	Landing Zone
MAGTF	Marine Air Ground Task Force
MAWTS-1	Marine Aviation Weapons and Tactics Squadron One
MCB	Marine Corps Base
MCAS	Marine Corps Air Station
MCI (Area)	Marine Corps Installations (Region)
MEB	Marine Expeditionary Brigade
MEF	Marine Expeditionary Forces
MG	machine gun
MICLICs	Mine Clearing Line Charges
MILCON	Military Construction
MK	Mark
MLRS	Multiple Launch Rocket System
mm	millimeter
MOA	Military Operations Area
MOU	Memorandum of Understanding
MOUT	Military Operations in Urban Terrain
MMG	Medium machine gun
MPF	Maritime Prepositioned Force
MPRC	Multi-purpose Range Complex
MSL	Mean sea level
MTR	Military Training Routes
NAVFAC	Naval Facilities Engineering Command
NEW	Net Explosive Weight
NOHD	Nominal Occular Hazard Distance
NOTAM	Notice to Airmen
NWS	Naval Weapons Station
OP	Observation post
OTH	Over-the-horizon
PADS	Position Azimuth Determining System
RA	Restricted Areas
RAICUZ	Range Air Installations Compatible Use Zone
RCUZ	Range Compatible Use Zone
RCO	Range Control Officer
RCZs	Range Compatibility Zones
REPI	Readiness and Environmental Protection Initiative
RFMSS	Range Facility Management Supporting System

RMTK	Range Managers TOOLKIT
RSOP	Reconnaissance, Selection, Occupation of Position
RTA	Ranges and Training Areas
SDZ	Surface Danger Zone
SEL	Sound Exposure Level
SRI	Sustainable Ranges Initiative
SROC	Senior Readiness Oversight Council
SUA	Special Use Airspace
SMAW	Shoulder-launched Multi-purpose Assault Weapons
SOP	Standard Operating Procedure
SOUM	Safety of Use Memorandum (interim safety guidance from TECOM for base, station, and operational commanders).
TACP	Tactical Air Control Party
TECOM	Training and Education Command, Quantico, VA
TERF	Terrain (following) flight
TRACON	Terminal Radar Approach Control
TOW	Tube-launched, Optically-guided, Wire-guided
TNT	Trinitrotoluene
TP	Training practice
UAV	Unmanned Aerial Vehicle
UAS	Unmanned Aircraft Systems
V/STOL	Vertical/Short Take Off and Landing
VFR	Visual Flight Rules
WSFA	Weapons Safety Footprint Area *(Term in previously used SAFE-RANGE model replaced by WDZ)*
WDZ	Weapons Danger Zone

APPENDIX B

MCB Camp Lejeune Ranges

from MCBCL BO 3570.1C

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Table B-1: Live-Fire Ranges at MCB Camp Lejeune

Live-Fire Range	Grid	Primary Use or Description
A-1	18S TD 790443	Pistol Qualification/Requalification Range
B-12	18S TD 743451	Pistol Qualification/Requalification Range
D-9/R-100	18S TD 854396	Skeet/Trap Firing Range
D-29A	18S TD 839382	Pistol Qualification/Requalification Range
D-29B	18S TD 851380	Pistol Qualification/Requalification Range
D-30	18S TD 851369	Pistol Qualification/Requalification Range
E-1	18S TD 937292	Anti-Aircraft Range
ETA-1	18S TD 842281	Engineer Demolition Training
ETA-2	18S TD 865271	Engineer Demolition Training
ETA-3	18S TD 878408	Engineer Demolition Training
ETA-4	18S TD 910325	Engineer Demolition Training
ETA-5	18S TD 824359	Engineer Demolition Training
ETA-5A	18S TD 824329	Breaching Options
ETA-6	18S TD 847293	Combat Vehicle Operators Training (CVOT) Confidence Course
ETA-7	18S TD 848329	Engineer Demolition Training
F-2	18S TD 907429	Squad Automatic Rifle Transition Range
F-4	18S TD 918421	Rifle Familiarization Range
F-5	18S TD 910428	Squad Life Fire Maneuver Course
F-6	18S TD 877383	Hand Grenade Qualification with Grenade Assault Course
F-11A	18S TD 870395	Basic 30 Meter Firing Range (ZERO)
F-11B	18S TD 870396	Pistol Qualification/Requalification Range
F-17	18S TD 876384	Training Tower/Fast Roping/Rappelling/Climbing Tower
F-18	18s TD 872392	Machinegun Field Fire Range
G-3	18S TD 898344	Infantry Weapons Range
G-3A	18S TD 892357	Vehicle Mounted Smoke Grenade Launcher Range
G-5	18S TD 942323	Infantry Weapons Range/AAV/LAV Gunnery Range
G-6/CBC	18S TD 947330	Infantry Company Battle Course (Company Live-Fire and Maneuver)
G-7	18S TD 957345	Field Artillery Direct Fire Range/Infantry Weapons Range
G-19A	18S TD 897342	Grenade Launcher Range
G-19B	18S TD 898340	Light Anti-Armor/Antitank Weapons Range

Live-Fire Range	Grid	Primary Use or Description
H-Range	18S TD 953307	Riverine Assault Range Waterborne Gunnery Range
I-1	18S TD 842276	Pistol Qualification/Requalification Range
K-211	18S TD 784355	Grenade Launcher Range
K-212	18S TD 781355	Temporary Anti-Tank Range
K-302	18S TD 792360	Rifle Familiarization, Battle Sight Zero Range
K-315	18S TD 809361	Infantry Familiarization Firing Range
K-317	18S TD 811360	Close Combat Range
K-319	18S TD 814360	Fire and Movement Range (Short Distance)
K-321 K-321A	18S TD 818360	Squad Automatic Weapon Transition Range
K-323	18S TD 821357	Grenade Launcher Range
K-325	18S TD 823356	Enhanced Marksmanship Program Range
K-402	18S TD 777351	Individual Tactical Training Range
K-402A	18S TD 778351	Military Operations in Urbanized Terrain (MOUT) (Shoot House)
K-406A	18S TD 777347	Combat Marksmanship Range
K-406B	18S TD 775346	Close Combat Range
K-407	18S TD 777343	Live-Fire Ambush Range
K-408	18S TD 775341	Urbanized Obstacle Course
K-501/K-501A	18S TD 788361	Electronic Target Rifle/Squad Automatic Weapon (SAW/IAR) Range
K-503/K-503A	18S TD 797360	Electronic Target Rifle Range
K-504/K-504B	18S TD 802361	M203/M32 Grenadier Range K-504A (HE/HEDP Only) K-504B (TP Only)
K-510	18S TD 775349	K-510 Hand Grenade Range K-510 Hand Grenade Assault Course
L-5	18S TD 735309	Infantry Live-Fire Maneuver Range
MAC-1	18S TD 935377	Urban Quick Kill Range, Basic Room Entry and Clearing Range
MAC-2	18S TD 935377	Search and Kill Range, Basic Room Entry and Clearing Range
MAC-3	18S TD 935378	Live-Fire Grenade House
MAC-4	18S TD 936378	Fire Team MOUT Range
MAC-5	18S TD 936379	Basic Squad MOUT Range
MAC-6	18S TD 937379	Combat Marksmanship Range (CMP Range)
MAC-7	18S TD 937380	Urban M203/M32 Grenadier Range

Live-Fire Range	Grid	Primary Use or Description
SR-6	18S TD 719329	Infantry Platoon Battle Course (Platoon Fire and Maneuver Range)
SR-7	18S TD 722368	LAR Crew Qualification Firing Range
SR-8	18S TD 669321	Multi-Purpose Machinegun Range
SR-10	18S TD 656267	Tank Crew Qualification Firing Range (Individual/Platoon Through Table 12)
SR-11	18S TD 655265	Pistol Qualification/Requalification Range
A, B, C, Range	18S TD 755307	Stone Bay Known Distance Rifle Qualification Ranges (Alpha, Bravo, Charlie Ranges)
Hathcock Range	18S TD 762307	Stone Bay 1000 Meter Sniper Range
Mechanical Pistol	18S TD 752308	Stone Bay Pistol Qualification Range
Walk Down Pistol	18S TD 753308	Stone Bay Pistol Qualification Range
Dodge City	18S TD 751308	Stone Bay Urban Shooting Range
Multi-Purpose	18S TD 751308	Stone Bay 100 m Small Arms Range
RR-215 Breacher	18S TD 760301	SOTG Breacher Training Facility
Breacher Pit	18S TD 761301	SOTG Breacher Pit Training Area
Square Bay	18S TD 760299	SOTG Small Arms Range
RR-249	18S TD 760301	SOTG CQB One Story Shoot house
RR-243	18S TD 761302	SOTG Three Story Urban Training Facility
NLW Ranges 1 & 2	18S TD 760298	Non-Lethal Grenades and Weapons Ranges
Murphy's Mountain	18S TD 761303	Climbing Wall
Rollins Peak	18S TD 761303	Training Tower
Combat Town	18S TD 888322	Combat in Built-up Area/Military Operations in Urbanized Terrain
Mobile MOUT Complex	18S TD 944388	Military Operations in Urbanized Terrain (Includes Live-Fire Mobile MOUT)
MOUT Lejeune UTF	18S TD 942382	MOUT Lejeune Urban Training Facility
Airfield Seizure Facilities	18S TD 664224	MCOLF Camp Davis, Tactical Airfield Assault and Seizure
Area 5 Training Tank	18S TD 853368	MCWST Qualification and Requalification
Courthouse Bay Training Tank	18S TD 833295	Courthouse Bay Training Tank
EOD-1	18S TD 932333	Explosive Ordnance Disposal Range
EOD-2	18S TD 817365	Explosive Ordnance Disposal Range

Live-Fire Range	Grid	Primary Use or Description
Gas Chamber	18S TD 876387	M40 Field Protection Mask Qualification Area
G-10 Live-Fire Convoy Range	18S TD 916374	G-10 Live-Fire Convoy Range
Search House Facility	18S TD 941382	Intermediate Search/Tactical Site Exploitation (ISTSE) Facility Search Houses
UCAS Lego City	18S TD 906358	G-10 Urban Close Air Support Facility (UCAS)Lego City
HSTL GSRA CIED Battle Course	18S TD 648256	Home Station Lane Training Complex CIED Battle Course, JIEDDO Battle Course/Complex (SOPs to be published separately)

Table B-2: Gun Positions at MCB Camp Lejeune

Artillery Gun Positions	Gun Position Grids
GP-1	18S TD 8974 4226
GP-2	18S TD 9140 4134
GP-3	18S TD 9280 4090
GP-4 (Inactive)	18S TD 9031 3792
GP-5 (Inactive)	18S TD 9387 3721
GP-6 (Inactive)	18S TD 9630 3564
GP-7	18S TD 9632 3561
GP-8 (Inactive)	18S TD 9542 3514
GP-9	18S TD 9694 3513
GP-10	18S TD 9205 3093
GP-11 (Inactive)	18S TD 9250 3188
GP-12	18S TD 9348 3101
GP-13	18S TD 9161 2866
GP-14	18S TD 9003 2961
GP-15	18S TD 9057 2832
GP-16	18S TD 8870 3095
GP-17	18S TD 8936 2915
GP-18	18S TD 8955 2743
GP-19	18S TD 8940 2694
GP-20	18S TD 9033 2677

Artillery Gun Positions	Gun Position Grids
GP-21	18S TD 8889 2960
GP-22A	18S TD 8698 2609
GP-22B	18S TD 8742 2591
GP-23	18S TD 8667 3396
GP-24 (Inactive)	18S TD 8650 3144
GP-25	18S TD 8586 3091
GP-26	18S TD 8583 2921
GP-27	18S TD 8520 2856
GP-28 (Inactive) Now ETA-7	18S TD 8472 3295
GP-29	18S TD 8526 3237
GP-30	18S TD 8453 3050
GP-31	18S TD 8252 3080
GP-32	18S TD 8199 3025
GP-33	18S TD 8051 3120
GP-34 (Inactive)	18S TD 7852 3693
GP-35	18S TD 8355 3197

Table B-3: Mortar Positions at MCB Camp Lejeune

Mortar Position	Grid Location
MP 1	18S TD 90273765
MP 2	18S TD 91313759
MP 3	18S TD 92493731
MP 4	18S TD 93423739
MP 5	18S TD 95143719
MP 6	18S TD 95433535
MP 7	18S TD 89763471
MP 8 (Inactive)	18S TD 92603186

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APPENDIX C

Discussion of Noise and Its Effects on the Environment

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Discussion of Noise and its Effects on the Environment

March 2012

wyle

Prepared for:
Ecology and Environment, Inc.

Authors:
Wyle Staff

Table of Contents

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1 Basics of Sound

Noise is unwanted sound. Sound is all around us; sound becomes noise when it interferes with normal activities, such as sleep or conversation.

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air, and are sensed by the human ear. Whether that sound is interpreted as pleasant (e.g., music) or unpleasant (e.g., jackhammers) depends largely on the listener's current activity, past experience, and attitude toward the source of that sound.

The measurement and human perception of sound involves three basic physical characteristics: intensity, frequency, and duration. First, intensity is a measure of the acoustic energy of the sound vibrations and is expressed in terms of sound pressure. The greater the sound pressure, the more energy carried by the sound and the louder the perception of that sound. The second important physical characteristic of sound is frequency, which is the number of times per second the air vibrates or oscillates. Low-frequency sounds are characterized as rumbles or roars, while high-frequency sounds are typified by sirens or screeches. The third important characteristic of sound is duration or the length of time the sound can be detected.

The loudest sounds that can be detected comfortably by the human ear have intensities that are a trillion times higher than those of sounds that can barely be detected. Because of this vast range, using a linear scale to represent the intensity of sound becomes very unwieldy. As a result, a logarithmic unit known as the decibel (abbreviated dB) is used to represent the intensity of a sound. Such a representation is called a sound level. A sound level of 0 dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB; sound levels above 120 dB begin to be felt inside the human ear as discomfort. Sound levels between 130 to 140 dB are felt as pain (Berglund and Lindvall 1995).

Because of the logarithmic nature of the decibel unit, sound levels cannot be arithmetically added or subtracted and are somewhat cumbersome to handle mathematically. However, some simple rules are useful in dealing with sound levels. First, if a sound's intensity is doubled, the sound level increases by 3 dB, regardless of the initial sound level. For example:

60 dB + 60 dB = 63 dB, and

80 dB + 80 dB = 83 dB.

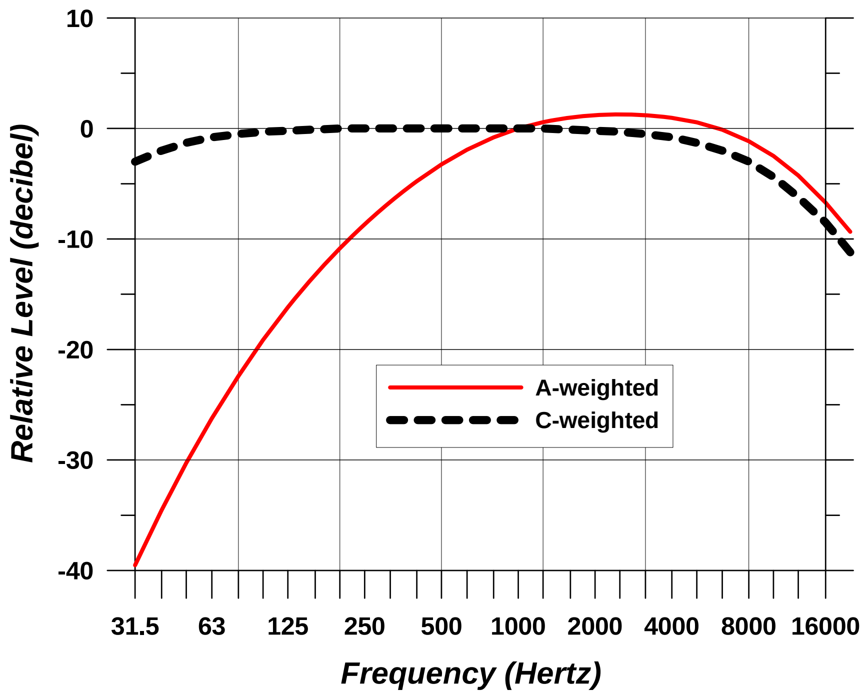
Second, the total sound level produced by two sounds of different levels is usually only slightly more than the higher of the two. For example:

60.0 dB + 70.0 dB = 70.4 dB.

Because the addition of sound levels is different than that of ordinary numbers, such addition is often referred to as "decibel addition" or "energy addition." The latter term arises from the fact that what we are really doing when we add decibel values is first converting each decibel value to its corresponding acoustic energy, then adding the energies using the normal rules of addition, and finally converting the total energy back to its decibel equivalent.

The minimum change in the sound level of individual events that an average human ear can detect is about 3 dB. On average, a person perceives a change in sound level of about 10 dB as a doubling (or halving) of the sound's loudness, and this relation holds true for loud and quiet sounds. A decrease in sound level of 10 dB actually represents a 90 percent decrease in sound intensity but only a 50 percent decrease in perceived loudness because of the nonlinear response of the human ear (similar to most human senses).

Sound frequency is measured in terms of cycles per second (cps), or hertz (Hz), which is the standard unit for cps. The normal human ear can detect sounds that range in frequency from about 20 Hz to about 15,000 Hz. All sounds in this wide range of frequencies, however, are not heard equally by the human ear, which is most sensitive to frequencies in the 1,000 to 4,000 Hz range. Weighting curves have been developed to correspond to the sensitivity and perception of different types of sound. A-weighting and C-weighting are the two most common weightings. A-weighting accounts for frequency dependence by adjusting the very high and very low frequencies (below approximately 500 Hz and above approximately 10,000 Hz) to approximate the human ear's lower sensitivities to those frequencies. C-weighting is nearly flat throughout the range of audible frequencies, hardly de-emphasizing the low frequency sound while approximating the human ear's sensitivity to higher intensity sounds. The two curves shown in Figure A-1 are also the most adequate to quantify environmental noises.



Source: ANSI S1.4A -1985 "Specification of Sound Level Meters"

Figure A-1. Frequency Response Characteristics of A- and C-Weighting Networks

1.1 A-weighted Sound Level

Sound levels that are measured using A-weighting, called A-weighted sound levels, are often denoted by the unit dBA or dB(A) rather than dB. When the use of A-weighting is understood, the adjective “A-weighted” is often omitted and the measurements are expressed as dB. In this report (as in most environmental impact documents), dB units refer to A-weighted sound levels.

Noise potentially becomes an issue when its intensity exceeds the ambient or background sound pressures. Ambient background noise in metropolitan, urbanized areas typically varies from 60 to 70 dB and can be as high as 80 dB or greater; quiet suburban neighborhoods experience ambient noise levels of approximately 45-50 dB (U.S. Environmental Protection Agency (EPA) 1978).

Figure A-2 is a chart of A-weighted sound levels from typical sounds. Some noise sources (air conditioner, vacuum cleaner) are continuous sounds which levels are constant for some time. Some (automobile, heavy truck) are the maximum sound during a vehicle pass-by. Some (urban daytime, urban nighttime) are averages over extended periods. A variety of noise metrics have been developed to describe noise over different time periods, as discussed below.

Aircraft noise consists of two major types of sound events: aircraft takeoffs and landings, and engine maintenance operations. The former can be described as intermittent sounds and the latter as continuous. Noise levels from flight operations exceeding background noise typically occur beneath main approach and departure corridors, in local air traffic patterns around the airfield, and in areas immediately adjacent to parking ramps and aircraft staging areas. As aircraft in flight gain altitude, their noise contribution drops to lower levels, often becoming indistinguishable from the background.

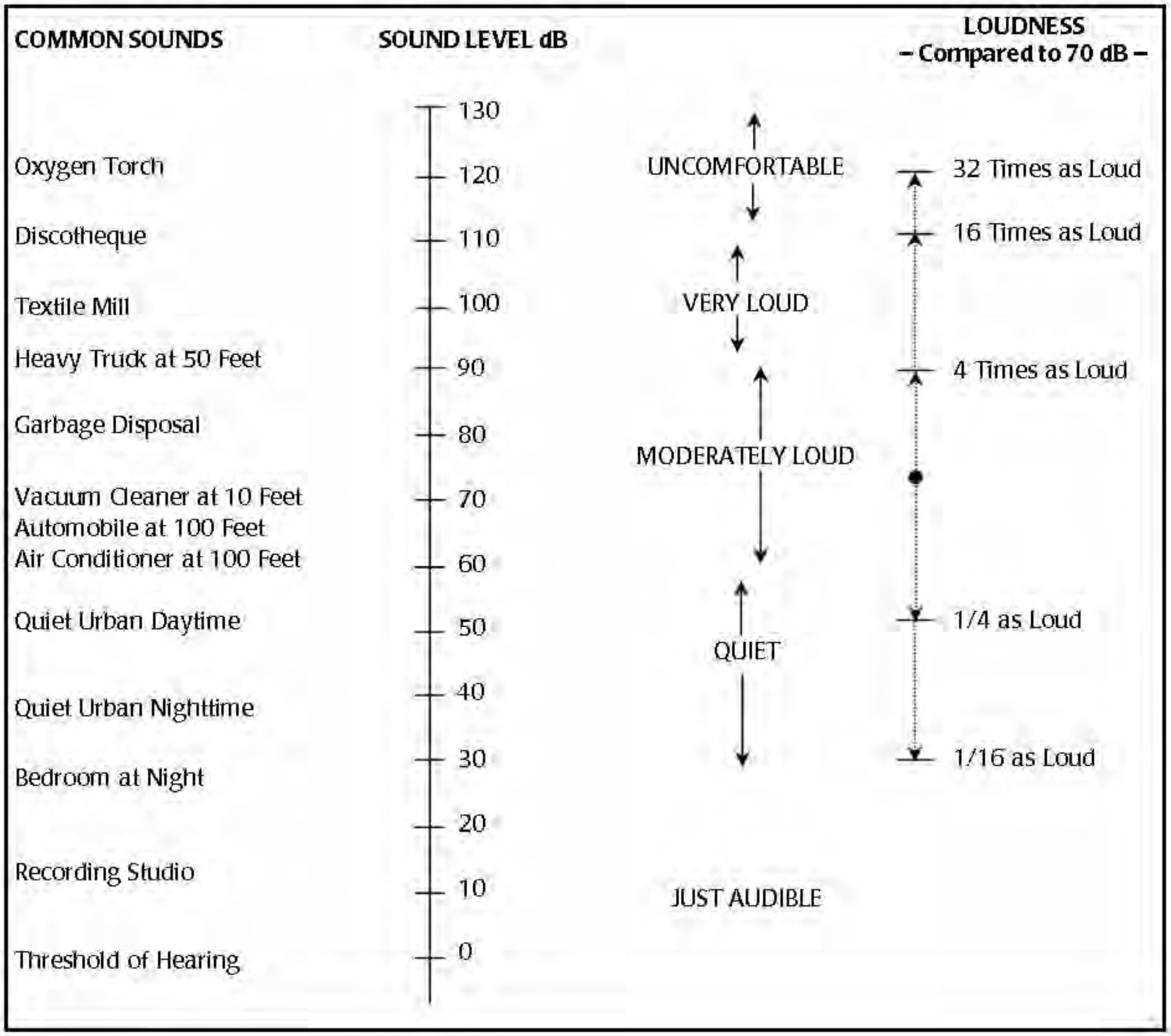
C-weighted Sound Level

Sound levels measured using a C-weighting are most appropriately called C-weighted sound levels (and denoted dBC). C-weighting is nearly flat throughout the audible frequency range, hardly de-emphasizing the low frequency. This weighting scale is generally used to describe impulsive sounds. Sounds that are characterized as impulsive generally contain low frequencies. Impulsive sounds may induce secondary effects, such as shaking of a structure, rattling of windows, inducing vibrations. These secondary effects can cause additional annoyance and complaints.

The following definitions in the American National Standard Institute (ANSI) Report S12.9, Part 4 provide general concepts helpful in understanding impulsive sounds (ANSI 1996).

Impulsive Sound: Sound characterized by brief excursions of sound pressure (acoustic impulses) that significantly exceeds the ambient environmental sound pressure. The duration of a single impulsive sound is usually less than one second (ANSI 1996).

Highly Impulsive Sound: Sound from one of the following enumerated categories of sound sources: small-arms gunfire, metal hammering, wood hammering, drop hammering, pile driving, drop forging, pneumatic hammering, pavement breaking, metal impacts during rail-yard shunting operation, and riveting.



SOURCE: Handbook of Noise Control, *C.M. Harris, Editor McGraw-Hill Book Co., 1979, and FICAN 1997*

Figure A-2. Typical A-weighted Sound Levels of Common Sounds

High-energy Impulsive Sound: Sound from one of the following enumerated categories of sound sources: quarry and mining explosions, sonic booms, demolition and industrial processes that use high explosives, military ordnance (e.g., armor, artillery and mortar fire, and bombs), explosive ignition of rockets and missiles, explosive industrial circuit breakers, and any other explosive source where the equivalent mass of dynamite exceeds 25 grams.

2 Noise Metrics

In general, a metric is a statistic for measuring or quantifying. A noise metric quantifies the noise environment. There are three families of noise metrics described herein – one for single noise events such as an aircraft flyby, one for cumulative noise events such as a day's worth of aircraft activity and one which quantifies the events or time relative to single noise events.

Within the single noise event family, metrics described below include Peak Sound Pressure Level, Maximum Sound Level and Sound Exposure Level. Within the cumulative noise events family, metrics described below include Equivalent Sound Level, Day-Night Average Sound Level and several others. Within the events/time family, metrics described below include Number of Events Above a Threshold Level and Time Above a Specified Level.

2.1 Maximum Sound Level (L_{max})

The highest A-weighted integrated sound level measured during a single event in which the sound level changes value with time (e.g., an aircraft overflight) is called the maximum A-weighted sound level or Maximum Sound Level.

During an aircraft overflight, the noise level starts at the ambient or background noise level, rises to the maximum level as the aircraft flies closest to the observer, and returns to the background level as the aircraft recedes into the distance. The L_{max} indicates the maximum sound level occurring for a fraction of a second. For aircraft noise, the "fraction of a second" over which the maximum level is defined is generally one-eighth of a second, and is denoted as "fast" response (ANSI 1988). Slowly varying or steady sounds are generally measured over a period of one second, denoted "slow" response. The L_{max} is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities. Although it provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the period of time that the sound is heard.

2.2 Peak Sound Pressure Level (L_{pk})

The Peak Sound Pressure Level, is the highest instantaneous level obtained by a sound level measurement device. The L_{pk} is typically measured using a 20 microseconds or faster sampling rate, and is typically based on unweighted or linear response of the meter.

2.3 Sound Exposure Level (SEL)

Sound Exposure Level is a composite metric that represents both the intensity of a sound and its duration. Individual time-varying noise events (e.g., aircraft overflights) have two main characteristics: a sound level that changes throughout the event and a period of time during which the event is heard. SEL provides a measure of the net impact of the entire acoustic event, but it does not directly represent the sound level heard at any given time. During an aircraft flyover, SEL would include both the L_{max} and the lower noise levels produced during onset and recess periods of the overflight.

SEL is a logarithmic measure of the total acoustic energy transmitted to the listener during the event. Mathematically, it represents the sound level of a constant sound that would, in one second, generate the same acoustic energy as the actual time-varying noise event. For sound from aircraft overflights, which typically lasts more than one second, the SEL is usually greater than the L_{max} because an individual overflight takes seconds and the L_{max} occurs instantaneously. SEL represents the best metric to compare noise levels from overflights.

2.4 Equivalent Sound Level (L_{eq})

A cumulative noise metric useful in describing noise is the Equivalent Sound Level. L_{eq} is the continuous sound level that would be present if all of the variations in sound level occurring over a specified time period were smoothed out as to contain the same total sound energy.

Just as SEL has proven to be a good measure of the noise impact of a single event, L_{eq} has been established to be a good measure of the impact of a series of events during a given time period. Also, while L_{eq} is defined as an average, it is effectively a sum over that time period and is, thus, a measure of the cumulative impact of noise. For example, the sum of all noise-generating events during the period of 7 a.m. to 4 p.m. could provide the relative impact of noise generating events for a school day.

2.5 Day-Night Average Sound Level (DNL or L_{dn}) and Community Noise Equivalent Level (CNEL)

Day-Night Average Sound Level and Community Noise Equivalent Level are composite metrics that account for all noise events in a 24-hour period. In order to account for increased human sensitivity to noise at night, a 10 dB penalty is applied to nighttime events (10:00 p.m. to 7:00 a.m. time period). A variant of the DNL, the CNEL includes a 5 dB penalty on noise during the 7:00 a.m. to 10:00 p.m. time period, and a 10 dB penalty on noise during the 10:00 p.m. to 7:00 a.m. time period. The notations DNL and L_{dn} are both used for Day-Night Average Sound Level and are equivalent.

Like L_{eq}, DNL and CNEL without their penalties are average quantities, mathematically representing the continuous A-weighted or C-weighted sound level that would be present if all of the variations in sound level that occur over a 24-hour period were smoothed out so as to contain the same total sound energy. These composite single-measure time-average metrics account for the SELs, L_{max}, the duration of the events (sorties or operations), and the number of events that occur over a 24-hour period but do not provide specific information on the number of noise events or the individual sound levels that occur during the 24-hour day. Like SEL, neither DNL nor CNEL represent the sound level heard at any particular time, but quantifies the total sound energy received. While it is normalized as an average, it represents all of the sound energy, and is therefore a cumulative measure.

The nighttime penalties in both DNL and CNEL account for the added intrusiveness of sounds that occur during normal sleeping hours, both because of the increased sensitivity to noise during those hours and because ambient sound levels during nighttime are typically about 10 dB lower than during daytime hours. The evening penalty in CNEL accounts for the added intrusiveness of sounds during that period.

The inclusion of daytime, evening and nighttime periods in the computation of the DNL and CNEL reflects their basic 24-hour definition. They can, however, be applied over periods of multiple days. For application to civil airports, where operations are consistent from day to day, DNL and CNEL are usually applied as an annual average.

The logarithmic nature of the decibel unit causes the noise levels of the loudest events to control the 24-hour average. A DNL of 65 dB could result from a very few noisy events or a large number of quieter events.

As a simple example of this characteristic, consider a case in which only one aircraft overflight occurs during the daytime over a 24-hour period, creating a sound level of 100 dB for 30 seconds. During the remaining 23 hours, 59 minutes, and 30 seconds of the day, the ambient sound level is 50 dB. The DNL for this 24-hour period is 65.9 dB. Assume, as a second example that 10 such 30-second overflights occur during daytime hours during the next 24-hour period, with the same ambient sound level of 50 dB during the remaining 23 hours and 55 minutes of the day. The DNL for this 24-hour period is 75.5 dB. Clearly, the averaging of noise over a 24-hour period does not ignore the louder single events and tends to emphasize both the sound levels and number of those events.

Daily average sound levels are typically used for the evaluation of community noise effects (i.e., long-term annoyance), and particularly aircraft noise effects. In general, scientific studies and social surveys have found a high correlation between the percentages of groups of people highly annoyed and the level of average noise exposure measured in DNL (EPA 1978 and Schultz 1978).

2.6 Onset-Rate Adjusted Monthly Day-Night Average Sound Level (L_{dnmr}) and Onset-Rate Adjusted Monthly Community Noise Equivalent Level ($CNEL_{mr}$)

Military aircraft utilizing Special Use Airspace (SUA) such as Military Training Routes (MTRs), Military Operating Areas (MOAs) and Restricted Areas/Ranges generate a noise environment that is somewhat different from that associated with airfield operations. As opposed to patterned or continuous noise environments associated with airfields, flight activity in SUAs is highly sporadic and often seasonal ranging from ten per hour to less than one per week. Individual military overflight events also differ from typical community noise events in that noise from a low-altitude, high-airspeed flyover can have a rather sudden onset, exhibiting a rate of increase in sound level (onset rate) of up to 150 dB per second.

To represent these differences, the conventional SEL metric is adjusted to account for the “surprise” effect of the sudden onset of aircraft noise events on humans with an adjustment ranging up to 11 dB above the normal SEL (Stusnick, et al. 1992). Onset rates between 15 to 150 dB per second require an adjustment of 0 to 11 dB, while onset rates below 15 dB per second require no adjustment. The adjusted SEL is designated as the onset-rate adjusted sound exposure level (SEL_r).

Because of the sporadic characteristic of SUA activity and so as not to dilute the resultant noise exposure, the month with the most operations or sorties from a yearly tabulation for the given SUA is examined -- the so-called busiest month. The cumulative exposure to noise in these areas is computed by DNL over the busy month, but using SEL_r instead of SEL. This monthly average is denoted L_{dnmr}. If onset rate adjusted DNL is computed over a period other than a month, it would be designated L_{dnr} and the period must be specified. In the state of California, a variant of the L_{dnmr} includes a penalty for evening operations (7 p.m. to 10 p.m) and is denoted $CNEL_{mr}$.

2.7 Number-of-Events Above (NA) a Threshold Level (L)

The Number-of-events Above metric (NA) provides the total number of noise events that exceed the selected noise level threshold during a specified period of time. Combined with the selected threshold level (L), the NA metric is symbolized as NAL. The threshold L can be defined in terms of either the SEL or L_{max} metric, and it is important that this selection is reflected in the nomenclature. When labeling a contour line or point of interest (POI) on a map the NAL will be followed by the number of events in parentheses for that line or POI. For example, the noise environment at a location where 10 events exceed an SEL of 90 dB, over a given period of time, would be represented by the nomenclature NA90SEL(10). Similarly, for L_{max} it would be NA90L_{max}(10). The period of time can be an average 24-hour day, daytime, nighttime, school day, or any other time period appropriate to the nature and application of the analysis.

NA can be portrayed for single or multiple locations, or by means of noise contours on a map similar to the common DNL contours. A threshold level is selected that best meets the need for that situation. An L_{max} threshold is normally selected to analyze speech interference, whereas an SEL threshold is normally selected for analysis of sleep disturbance.

The NA metric is the only supplemental metric that has been developed that combines single-event noise levels with the number of aircraft operations. In essence, it answers the question of how many aircraft (or range of aircraft) fly over a given location or area at or above a selected threshold noise level.

2.8 Time Above (TA) a Specified Level (L)

The Time Above (TA) metric is a measure of the total time that the A-weighted aircraft noise level is at or above a defined sound level threshold. Combined with the selected threshold level (L), the TA metric is symbolized as TAL. TA is not a sound level, but rather a time expressed in minutes. TA values can be calculated over a full 24-hour annual average day, the 15-hour daytime and 9-hour nighttime periods, a school day, or any other time period of interest, provided there is operational data to define the time period of interest.

TA has application for describing the noise environment in schools, particularly when comparing the classroom or other noise sensitive environments for different operational scenarios. TA can be portrayed by means of noise contours on a map similar to the common DNL contours.

The TA metric is a useful descriptor of the noise impact of an individual event or for many events occurring over a certain time period. When computed for a full day, the TA can be compared alongside the DNL in order to determine the sound levels and total duration of events that contribute to the DNL. TA analysis is usually conducted along with NA analysis so the results show not only how many events occur above the selected threshold(s), but also the total duration of those events above those levels for the selected time period.

3 Noise Effects

This noise effects section includes discussions of annoyance, speech interference and sleep disturbance, and the effects of noise on hearing, health, performance, learning, animals, property values, terrain and archaeological sites.

3.1 Annoyance

The primary effect of aircraft noise on exposed communities is one of long-term annoyance, defined by the Environmental Protection Agency (EPA) as any negative subjective reaction on the part of an individual or group. The scientific community has adopted the use of long-term annoyance as a primary indicator of community response because it attempts to account for all negative aspects of effects from noise, e.g., increased annoyance due to being awakened the previous night by aircraft and interference with everyday conversation.

Numerous laboratory studies and field surveys have been conducted to measure annoyance and to account for a number of variables, many of which are dependent on a person's individual circumstances and preferences. Laboratory studies of individual response to noise have helped isolate a number of the factors contributing to annoyance, such as the intensity level and spectral characteristics of the noise, duration, the presence of impulses, pitch, information content, and the degree of interference with activity. Social surveys of community response to noise have allowed the development of general dose-response relationships that can be used to estimate the proportion of people who will be highly annoyed by a given noise level. The results of these studies have formed the basis for criteria established to define areas of compatible land use.

A wide variety of responses have been used to determine intrusiveness of noise and disturbances of speech, sleep, audio/video entertainment, and outdoor living; but the most useful metric for assessing peoples' responses to noise is the percentage of the population expected to be "highly annoyed." The concept of "percent highly annoyed" has provided the most consistent response of a community to a particular noise environment. In his synthesis of several different social surveys that employed different response scales, Schultz (1978) defined "highly annoyed" respondents as those respondents whose self-described annoyance fell within the upper 28 percent of the response scale where the scale was numerical or un-named. For surveys where the response scale was named, Schultz counted those who claimed to be highly annoyed, combining the responses of "very annoyed" and "extremely annoyed." Schultz's definition of "percent highly annoyed" (%HA) became the basis for the Federal policy on environmental noise. Daily average sound levels are typically used for the evaluation of community noise effects, such as long-term annoyance.

In general, scientific studies and social surveys have found a correlation between the percentages of groups of people highly annoyed and the level of average noise exposure. Thus, the results are expressed as the average %HA at various exposure levels measured in DNL. The classic analysis is Schultz's original 1978 study, whose results are shown in Figure A-3. This figure is commonly referred to as the Schultz curve. It represents the synthesis of a large number of social surveys (161 data points in all), that relates the long-term community response to various types of noise sources, measured using the DNL metric.

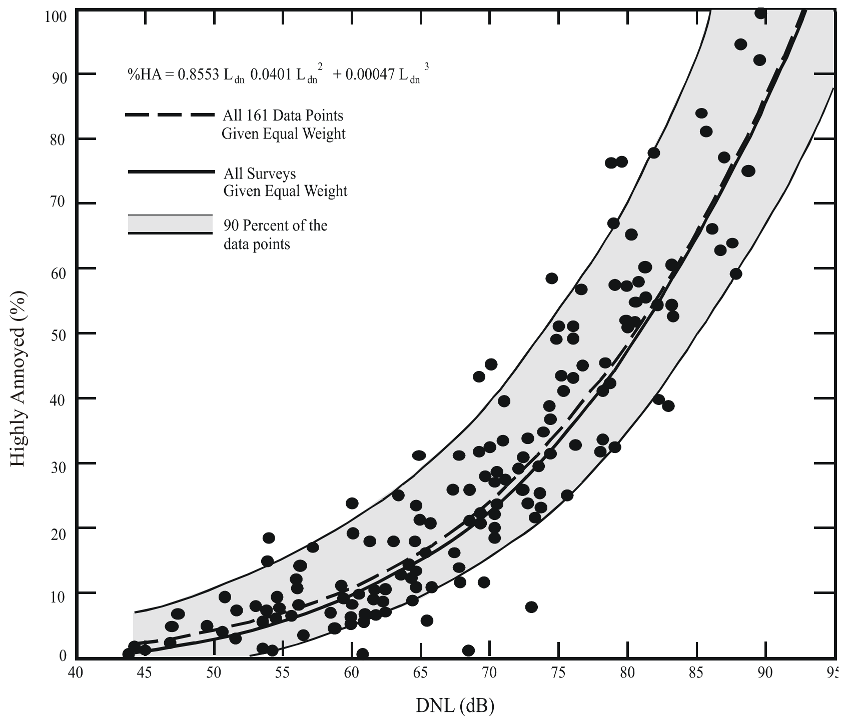
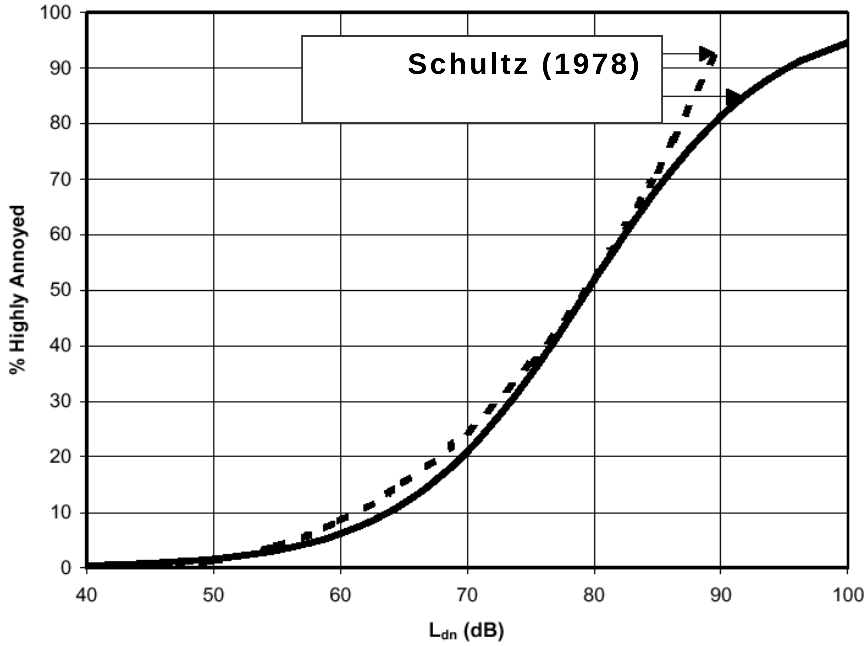


Figure A-3. Community Surveys of Noise Annoyance

An updated study of the original Schultz data based on the analysis of 400 data points collected through 1989 essentially reaffirmed this relationship. Figure A-4 shows an updated form of the curve fit in comparison with the original Schultz curve (Finegold 1994). The updated fit, which does not differ substantially from the original, is the preferred form in the U.S. The relationship between %HA and DNL is:

$$\%HA = 100/[1 + \exp(11.13 - 0.141L_{dn})]$$



SOURCE:(Schultz, 1978) and Current (Finegold, et al. 1994) Curve Fits

Figure A-4. Response of Communities to Noise; Comparison of Original

In general, correlation coefficients of 0.85 to 0.95 are found between the percentages of groups of people highly annoyed and the level of average noise exposure. However, the correlation coefficients for the annoyance of individuals are relatively low, on the order of 0.5 or less. This is not surprising, considering the varying personal factors that influence the manner in which individuals react to noise.

A number of non-acoustic factors have been identified that may influence the annoyance response of an individual. Newman and Beattie (1985) divided these factors into emotional and physical variables.

Emotional Variables:

- Feelings about the necessity or preventability of the noise;
- Judgment of the importance and value of the activity that is producing the noise;
- Activity at the time an individual hears the noise;
- Attitude about the environment;
- General sensitivity to noise;
- Belief about the effect of noise on health; and
- Feeling of fear associated with the noise.
- Physical Variables:
- Type of neighborhood;
- Time of day;

- Season;
- Predictability of noise;
- Control over the noise source; and
- Length of time an individual is exposed to a noise.

The low correlation coefficients for individuals' reactions reflect the large amount of scatter among the data drawn from the various surveys and point to the substantial uncertainty associated with the equation representing the relationship between %HA and DNL. Based on the results of surveys it has been observed that noise exposure can explain less than 50 percent of the observed variance in annoyance, indicating that non-acoustical factors play a major role. As a result, it is not possible to accurately predict individual annoyance in any specific community based on the aircraft noise exposure. Nevertheless, changes in %HA can be useful in giving the decision maker more information about the relative effects that different alternatives may have on the community.

The original Schultz curve and the subsequent updates do not separate out the annoyance from aircraft noise and other transportation noise sources. This was an important element, in that it allowed Schultz to obtain some consensus among the various social surveys from the 1960s and 1970s that were synthesized in the analysis. In essence, the Schultz curve assumes that the effects of long-term annoyance on the general population are the same, regardless of whether the noise source is road, rail, or aircraft. In the years after the classical Schultz analysis, additional social surveys have been conducted to better understand the annoyance effects of various transportation sources.

Miedema & Vos (1998) present synthesis curves for the relationship between DNL and percentage "Annoyed" and percentage "Highly Annoyed" for three transportation noise sources. Separate, non-identical curves were found for aircraft, road traffic, and railway noise. Table A-1 illustrates that, for a DNL of 65 dB, the percent of the people forecasted to be Highly Annoyed is 28 percent for air traffic, 18 percent for road traffic, and 11 percent for railroad traffic. For an outdoor DNL of 55 dB, the percent highly annoyed would be close to 12 percent if the noise is generated by aircraft operations, but only 7 percent and 4 percent, respectively, if the noise is generated by road or rail traffic. Comparing the levels on the Miedema & Vos curve to those on the updated Schultz curve indicates that the percentage of people highly annoyed by aircraft noise may be higher than previously thought when the noise is solely generated by aircraft activity.

Table A-1. Percent Highly Annoyed for Different Transportation Noise Sources

DNL (dB)	Percent Hightly Annoyed (% HA)			
	Miedema and Vos			Schultz Combined
	Air	Road	Rail	
55	12	7	4	3
60	19	12	7	6
65	28	18	11	12
70	37	29	16	22
75	48	40	22	36

Source: Miedema & Vos 1998

As noted by the World Health Organization (WHO), even though aircraft noise seems to produce a stronger annoyance response than road traffic, caution should be exercised when interpreting synthesized data from different studies (WHO 2000). The WHO noted that five major parameters should be randomly distributed for the analyses to be valid: personal, demographic, and lifestyle factors, as well as the duration of noise exposure and the population experience with noise.

The FICON found that the updated Schultz curve remains the best available source of empirical dosage effect information to predict community response to transportation noise without any segregation by transportation source (FICON 1992); a position held by the FICAN in 1997 (FICAN 1997). However, FICON also recommended further research to investigate the differences in perceptions of aircraft noise, ground transportation noise (highways and railroads), and general background noise.

3.2 Speech Interference

Speech interference associated with aircraft noise is a primary cause of annoyance for communities. The disruption of routine activities such as radio or television listening, telephone use, or family conversation gives rise to frustration and irritation. The quality of speech communication is particularly important in classrooms and offices. In industrial settings it can cause fatigue and vocal strain in those who attempt to communicate over the noise.

The disruption of speech in the classroom is a primary concern, due to the potential for adverse effects on children's learning ability. There are two aspects to speech comprehension:

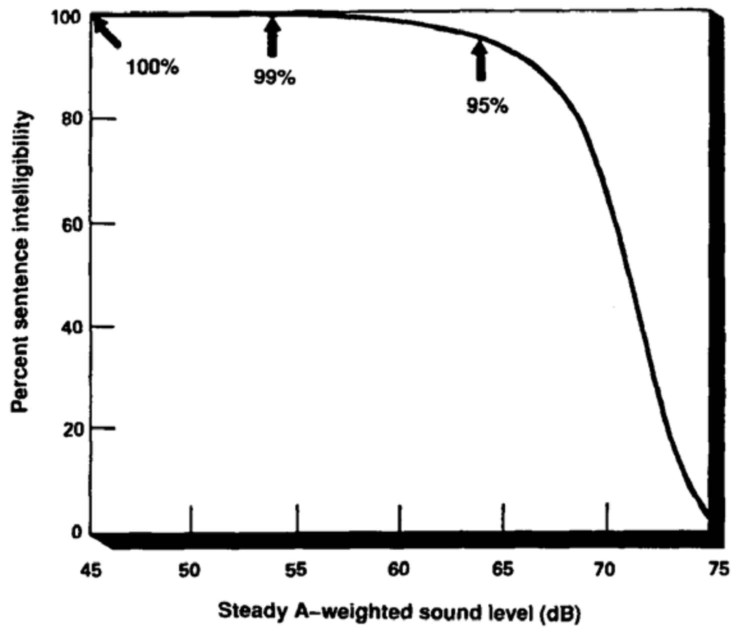
1. *Word Intelligibility* - the percent of words transmitted and received. This might be important for students in the lower grades who are learning the English language, and particularly for students who have English as a Second Language.
2. S*entence Intelligibility* – the percent of sentences transmitted and understood. This might be important for high-school students and adults who are familiar with the language, and who do not necessarily have to understand each word in order to understand sentences.

For teachers to be clearly understood by their students, it is important that regular voice communication is clear and uninterrupted. Not only does the background sound level have to be low enough for the teacher to be clearly heard, but intermittent outdoor noise events also need to be minimized. It is therefore important to evaluate the steady background level, the level of voice communication, and the single-event level due to aircraft overflights that might interfere with speech.

Several research studies have been conducted and guideline documents been developed resulting in a fairly consistent set of noise level criteria for speech interference. This section provides an overview of the results of these studies.

U.S. Federal Criteria for Interior Noise

In 1974, the EPA identified a goal of an indoor 24-hour average sound level $L_{eq(24)}$ of 45 dB to minimize speech interference based on the intelligibility of sentences in the presence of a steady background noise (EPA 1974). Intelligibility pertains to the percentage of speech units correctly understood out of those transmitted, and specifies the type of speech material used, i.e. sentences or words. The curve displayed in Figure A-5 shows the effect of steady indoor background sound levels on sentence intelligibility. For an average adult with normal hearing and fluency in the language, steady background sound levels indoors of less than 45 dB L_{eq} are expected to allow 100 percent intelligibility of sentences.



Source: EPA 1974

Figure A-5. Speech Intelligibility Curve

The curve shows 99 percent sentence intelligibility for background levels at a L_{eq} of 54 dB, and less than 10 percent intelligibility for background levels above a L_{eq} of 73 dB. Note that the curve is especially sensitive to changes in sound level between 65 dB and 75 dB - an increase of 1 dB in background sound level from 70 dB to 71 dB results in a 14 percent decrease in sentence intelligibility, whereas a 1 dB increase in background sound level from 60 dB to 61 dB results in less than 1 percent decrease in sentence intelligibility.

Classroom Criteria

For listeners with normal hearing and fluency in the language, complete sentence intelligibility can be achieved when the signal-to-noise ratio (i.e., the difference between the speech level and the level of the interfering noise) is in the range 15-18 dB (Lazarus 1990).

Both the ANSI and the American Speech-Language-Hearing Association (ASHLA) recommend at least a 15 dB signal-to-noise ratio in classrooms, to ensure that children with hearing impairments and language disabilities are able to enjoy high speech intelligibility (ANSI 2002; ASHLA 1995). As such, provided that the average adult male or female voice registers a minimum of 50 dB L_{max} in the rear of the classroom, the ANSI standard requires that the continuous background noise level indoors must not exceed a L_{eq} of 35 dB (assumed to apply for the duration of school hours).

The WHO reported for a speaker-to-listener distance of about 1 meter, empirical observations have shown that speech in relaxed conversations is 100 percent intelligible in background noise levels of about 35 dB, and speech can be fairly well understood in the presence of background levels of 45 dB. The WHO recommends a guideline value of 35 dB L_{eq} for continuous background levels in classrooms during school hours (WHO 2000).

Bradley suggests that in smaller rooms, where speech levels in the rear of the classroom are approximately 50 dB L_{max}, steady-state noise levels above 35 dB L_{eq} may interfere with the intelligibility of speech (Bradley 1993).

For the purposes of determining eligibility for noise insulation funding, the Federal Aviation Administration (FAA) guidelines state that the design objective for a classroom environment is 45 dB L_{eq} resulting from aircraft operations during normal school hours (FAA 1985).

However, most aircraft noise is not continuous and consists of individual events where the sound level exceeds the background level for a limited time period as the aircraft flies over. Since speech interference in the presence of aircraft noise is essentially determined by the magnitude and frequency of individual aircraft flyover events, a time-averaged metric alone, such as L_{eq}, is not necessarily appropriate when evaluating the overall effects. In addition to the background level criteria described above, single-event criteria, which account for those sporadic intermittent outdoor noisy events, are also essential to specifying speech interference criteria.

In 1984, a report to the Port Authority of New York and New Jersey recommended utilizing the Speech Interference Level (SIL) metric for classroom noise criteria (Sharp and Plotkin 1984). This metric is based on the maximum sound levels in the frequency range (approximately 500 Hz to 2,000 Hz) that directly affects speech communication. The study identified an SIL (the average of the sound levels in the 500, 1000, and 2000 Hz octave-bands) of 45 dB as the desirable goal, which was estimated to provide 90 percent word intelligibility for the short time periods during aircraft over-flights. Although early classroom level criteria were defined in terms of SIL, the use and measurement of L_{max} as the primary metric has since become more popular. Both metrics take into consideration the L_{max} associated with intermittent noise events and can be related to existing background levels when determining speech interference percentages. An SIL of 45 dB is approximately equivalent to an A-weighted L_{max} of 50 dB for aircraft noise (Wesler 1986).

In 1998, a report also concluded that if an aircraft noise event's indoor L_{max} reached the speech level of 50 dB, 90 percent of the words would be understood by students seated throughout the classroom (Lind, Pearsons, and Fidell 1998). Since intermittent aircraft noise does not appreciably disrupt classroom communication at lower levels and other times, the authors also adopted an indoor L_{max} of 50 dB as the maximum single-event level permissible in classrooms. Note that this limit was set based on students with normal hearing and no special needs; at-risk students may be adversely affected at lower sound levels.

Bradley recommends SEL as a better indicator of indoor estimated speech interference in the presence of aircraft overflights (Bradley 1985). For acceptable speech communication using normal vocal efforts, Bradley suggests that the indoor SEL be no greater than 64 dB. He assumes a 26 dB outdoor-to-indoor noise reduction that equates to 90 dB SEL outdoors. Aircraft events producing outdoor SEL values greater than 90 dB would result in disruption to indoor speech communication. Bradley's work indicates that, for speakers talking with a casual vocal effort, 95 percent intelligibility would be achieved when indoor SEL values did not exceed 60 dB, which translates approximately to an L_{max} of 50 dB.

In the presence of intermittent noise events, ANSI states that the criteria for allowable background noise level can be relaxed since speech is impaired only for the short time when the aircraft noise is close to its maximum value. Consequently, they recommend when the background noise level of the noisiest hour is dominated by aircraft noise, the indoor criteria (35 dB L_{eq} for continuous background noise) can be increased by 5 dB to an Leq of 40 dB, as long as the noise level does not exceed 40 dB for more than 10 percent of the noisiest hour. (ANSI 2002).

The WHO does not recommend a specific indoor L_{max} criterion for single-event noise, but does place a guideline value at L_{eq} of 35 dB for overall background noise in the classroom. However, WHO does report that "for communication distances beyond a few meters, speech interference starts at sound pressure levels below 50 dB for octave bands centered on the main speech frequencies at 500 Hz, 1kHz, and 2 kHz." (WHO 2000). One can infer this can be approximated by an L_{max} value of 50 dB.

The United Kingdom Department for Education and Skills (UKDFES) established in its classroom acoustics guide a 30-minute time-averaged metric [$L_{eq(30min)}$] for background levels and $L_{A1,30}$ min for intermittent noises, at thresholds of 30-35 dB and 55 dB, respectively. $L_{A1,30}$ min represents the A-weighted sound level that is exceeded one percent of the time (in this case, during a 30 minute teaching session) and is generally equivalent to the L_{max} metric (UKDFES 2003).

Summary

As the previous section demonstrates, research indicates that it is not only important to consider the continuous background levels using time-averaged metrics, but also the intermittent events, using single-event metrics such as L_{max}. Table A-2 provides a summary of the noise level criteria recommended in the scientific literature.

Table A-2. Indoor Noise Level Criteria Based on Speech Intelligibility

Source	Metric/Level (dB)	Effects and Notes
U.S. FAA (1985)	L_{eq}(during school hours) = 45 dB	Federal assistance criteria for school sound insulation; supplemental single-event criteria may be used
Lind et al. (1998), Sharp and Plotkin (1984), Wesler (1986)	L_{max} = 50 dB / SIL 45	Single event level permissible in the classroom
WHO (1999)	L_{eq} = 35 dB L_{max} = 50 dB	Assumes average speech level of 50 dB and recommends signal to noise ratio of 15 dB
U.S. ANSI (2002)	L_{eq} = 40 dB, Based on Room Volume	Acceptable background level for continuous noise/ relaxed criteria for intermittent noise in the classroom
U.K. DFES (2003)	$L_{eq(30min)}$ = 30-35 dB L_{max} = 55 dB	Minimum acceptable in classroom and most other learning environs

When considering intermittent noise caused by aircraft overflights, a review of the relevant scientific literature and international guidelines indicates that an appropriate criteria is a limit on indoor background noise levels of 35 to 40 dB L_{eq} and a limit on single events of 50 dB L_{max}.

3.3 Sleep Disturbance

The disturbance of sleep is a major concern for communities exposed to nighttime aircraft noise. There have been numerous research studies that have attempted to quantify the complex effects of noise on sleep. This section provides an overview of the major noise-induced sleep disturbance studies that have been conducted, with particular emphasis placed on those studies that have influenced U.S. federal noise policy. The studies have been separated into two groups:

1. Initial studies performed in the 1960s and 1970s, where the research was focused on laboratory sleep observations.
2. Later studies performed in the 1990s up to the present, where the research was focused on field observations, and correlations to laboratory research were sought.

Initial Studies

The relationship between noise levels and sleep disturbance is complex and not fully understood. The disturbance depends not only on the depth of sleep, but also on the previous exposure to aircraft noise, familiarity with the surroundings, the physiological and psychological condition of the recipient, and a host of other situational factors. The most readily measurable effect of noise on sleep is the number of arousals or awakenings, and so the body of scientific literature has focused on predicting the percentage of the population that will be awakened at various noise levels. Fundamentally, regardless of the tools used to measure the degree of sleep disturbance (awakenings, arousals, etc.), these studies have grouped the data points into bins to predict the percentage of the population likely to be disturbed at various sound level thresholds.

FICON produced a guidance document that provided an overview of the most pertinent sleep disturbance research that had been conducted throughout the 1970s (FICON 1992). Literature reviews and meta-analysis conducted between 1978 and 1989 made use of the existing datasets that indicated the effects of nighttime noise on various sleep-state changes and awakenings (Lukas 1978; Griefahn 1978; Peasons et. al. 1989). FICON noted that various indoor A-weighted sound levels – ranging from 25 to 50 dB were observed to be thresholds below which significant sleep effects were not expected. Due to the large variability in the data, FICON did not endorse the reliability of the results.

However, FICON did recommend the use of an interim dose-response curve—awaiting future research—which predicted the percent of the exposed population expected to be awakened as a function of the exposure to single event noise levels expressed in terms of SEL. This curve was based on the research conducted for the U.S. Air Force (Finegold 1994). The dataset included most of the research performed up to that point, and predicted that ten percent of the population would be awakened when exposed to an interior SEL of approximately 58 dB. The data utilized to derive this relationship were primarily the results of controlled laboratory studies.

Recent Sleep Disturbance Research – Field and Laboratory Studies

It was noted in the early sleep disturbance research that the controlled laboratory studies did not account for many factors that are important to sleep behavior, such as habituation to the environment and previous exposure to noise and awakenings from sources other than aircraft noise. In the early 1990s, field studies were conducted to validate the earlier laboratory work. The most significant finding from these studies was that an estimated 80 to 90 percent of sleep disturbances were not related to individual outdoor noise events, but were instead the result of indoor noise sources and other non-noise-related factors. The results showed that there was less of an effect of noise on sleep in real-life conditions than had been previously reported from laboratory studies.

FICAN

The interim FICON dose-response curve that was recommended for use in 1992 was based on the most pertinent sleep disturbance research that was conducted through the 1970s, primarily in laboratory settings. After that time, considerable field research was conducted to evaluate the sleep effects in peoples' normal, home environment. Laboratory sleep studies tend to show higher values of sleep disturbance than field studies because people who sleep in their own homes are habituated to their environment and, therefore, do not wake up as easily (FICAN 1997).

Based on the new information, FICAN updated its recommended dose-response curve in 1997, depicted as the lower curve in Figure A-6. This figure is based on the results of three field studies (Ollerhead 1992; Fidell et. al. 1994; Fidell et al. 1995a and 1995b), along with the datasets from six previous field studies.

The new relationship represents the higher end, or upper envelope, of the latest field data. It should be interpreted as predicting the "maximum percent of the exposed population expected to be behaviorally awakened" or the "maximum percent awakened" for a given residential population. According to this relationship, a maximum of 3 percent of people would be awakened at an indoor SEL of 58 dB, compared to 10 percent using the 1992 curve. An indoor SEL of 58 dB is equivalent to outdoor SEL's of 73 and 83 dB respectively assuming 15 and 25 dB noise level reduction from outdoor to indoor with windows open and closed, respectively.

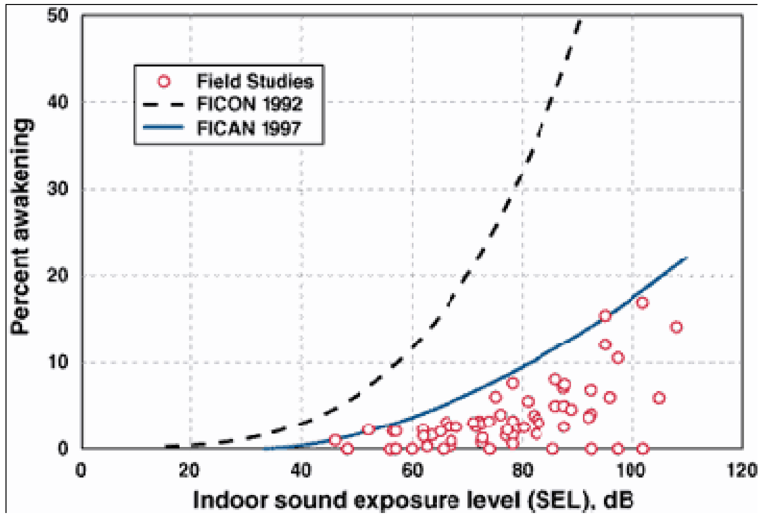


Figure A-6. FICAN's 1997 Recommended Sleep Disturbance Dose-Response Relationship

The FICAN 1997 curve is represented by the following equation:

$$\text{Percent Awakenings} = 0.0087 \times [SEL - 30]^{1.79}$$

Note the relatively low percentage of awakenings to fairly high noise levels. People think they are awakened by a noise event, but usually the reason for awakening is otherwise. For example, the 1992 UK CAA study found the average person was awakened about 18 times per night for reasons other than exposure to an aircraft noise – some of these awakenings are due to the biological rhythms of sleep and some to other reasons that were not correlated with specific aircraft events.

Number of Events and Awakenings

In recent years, there have been studies and one proposal that attempted to determine the effect of multiple aircraft events on the number of awakenings. The German Aerospace Center (DLR) conducted an extensive study focused on the effects of nighttime aircraft noise on sleep and other related human performance factors (Basner 2004). The DLR study was one of the largest studies to examine the link between aircraft noise and sleep disturbance and involved both laboratory and in-home field research phases. The DLR investigators developed a dose-effect curve that predicts the number of aircraft events at various values of L_{max} expected to produce one additional awakening over the course of a night. The dose-effect curve was based on the relationships found in the field studies.

In July 2008 ANSI and the Acoustical Society of America (ASA) published a method to estimate the percent of the exposed population that might be awakened by multiple aircraft noise events based on statistical assumptions about the probability of awakening (or not awakening) (ANSI 2008). This method relies on probability theory rather than direct field research/experimental data to account for multiple events.

Figure A-7 depicts the awakenings data that form the basis and equations of ANSI S12.9-2008. The curve labeled 'Eq. (B1)' is the relationship between noise and awakening endorsed by FICAN in 1997. The ANSI recommended curve labeled 'Eq. (1)' quantifies the probability of awakening for a population of sleepers who are exposed to an outdoor noise event as a function of the associated indoor SEL in the bedroom. This curve was derived from studies of behavioral awakenings associated with noise events in "steady state" situations where the population has been exposed to the noise long enough to be habituated. The data points in Figure A-7 come from these studies. Unlike the FICAN curve, the ANSI 2008 curve represents the average of the field research data points.

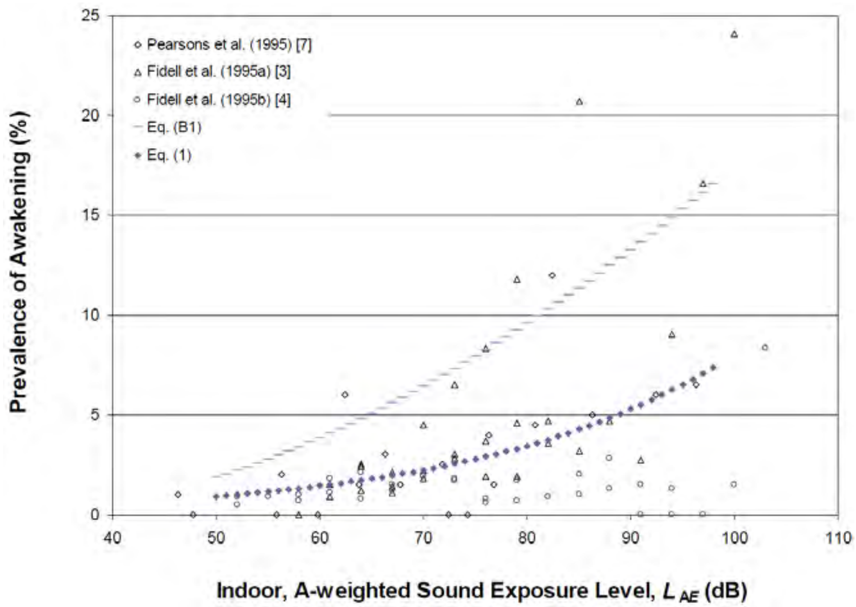


Figure A-7. Plot of Sleep Awakening Data versus Indoor SEL

In December 2008, FICAN recommended the use of this new estimation procedure for future analyses of behavioral awakenings from aircraft noise. In that statement, FICAN also recognized that additional sleep disturbance research is underway by various research organizations, and results of that work may result in additional changes to FICAN's position. Until that time, FICAN recommends the use of ANSI S12.9-2008.

3.4 Noise-Induced Hearing Impairment

Residents in surrounding communities express concerns regarding the effects of aircraft noise on hearing. This section provides a brief overview of hearing loss caused by noise exposure. The goal is to provide a sense of perspective as to how aircraft noise (as experienced on the ground) compares to other activities that are often linked with hearing loss.

Hearing Threshold Shifts

Hearing loss is generally interpreted as a decrease in the ear's sensitivity or acuity to perceive sound; i.e. a shift in the hearing threshold to a higher level. This change can either be a Temporary Threshold Shift (TTS), or a Permanent Threshold Shift (PTS) (Berger 1995).

TTS can result from exposure to loud noise over a given amount of time, yet the hearing loss is not necessarily permanent. An example of TTS might be a person attending a loud music concert. After the concert is over, the person may experience a threshold shift that may last several hours, depending upon the level and duration of exposure. While experiencing TTS, the person becomes less sensitive to low-level sounds, particularly at certain frequencies in the speech range (typically near 4,000 Hz). Normal hearing ability eventually returns, as long as the person has enough time to recover within a relatively quiet environment.

PTS usually results from repeated exposure to high noise levels, where the ears are not given adequate time to recover from the strain and fatigue of exposure. A common example of PTS is the result of working in a loud environment such as a factory. It is important to note that a temporary shift (TTS) can eventually become permanent (PTS) over time with continuous exposure to high noise levels. Thus, even if the ear is given time to recover from TTS, repeated occurrence of TTS may eventually lead to permanent hearing loss. The point at which a Temporary Threshold Shift results in a Permanent Threshold Shift is difficult to identify and varies with a person's sensitivity.

Criteria for Permanent Hearing Loss

Considerable data on hearing loss have been collected and analyzed by the scientific/medical community. It has been well established that continuous exposure to high noise levels will damage human hearing (EPA 1978). The Occupational Safety and Health Administration (OSHA) regulation of 1971 standardizes the limits on workplace noise exposure for protection from hearing loss as an average level of 90 dB over an 8-hour work period or 85 dB over a 16-hour period (the average level is based on a 5 dB decrease per doubling of exposure time) (US Department of Labor 1970). Even the most protective criterion (no measurable hearing loss for the most sensitive portion of the population at the ear's most sensitive frequency, 4,000 Hz, after a 40-year exposure) is an average sound level of 70 dB over a 24-hour period.

The US EPA established 75 dB for an 8-hour exposure and 70 dB for a 24-hour exposure as the average noise level standard requisite to protect 96 percent of the population from greater than a 5 dB PTS (EPA 1978). The National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics identified 75 dB as the minimum level at which hearing loss may occur (CHABA 1977). Finally, the WHO has concluded that environmental and leisure-time noise below an L_{eq24} value of 70 dB "will not cause hearing loss in the large majority of the population, even after a lifetime of exposure" (WHO 2000).

Hearing Loss and Aircraft Noise

The 1982 EPA Guidelines report specifically addresses the criteria and procedures for assessing the noise-induced hearing loss in terms of the Noise-Induced Permanent Threshold Shift (NIPTS), a quantity that defines the permanent change in hearing level, or threshold, caused by exposure to noise (EPA, 1982). Numerically, the NIPTS is the change in threshold averaged over the frequencies 0.5, 1, 2, and 4 kHz that can be expected from daily exposure to noise over a normal working lifetime of 40 years, with the exposure beginning at an age of 20 years. A grand average of the NIPTS over time (40 years) and hearing sensitivity (10 to 90 percentiles of the exposed population) is termed the Average NIPTS or Ave NIPTS for short. The Average Noise Induced Permanent Threshold Shift (Ave. NIPTS) that can be expected for noise exposure as measured by the DNL metric is given in Table A-3.

Table A-3. Ave. NIPTS and 10th Percentile NIPTS as a Function of DNL

DNL	Ave. NIPTS dB*	10th Percentile NIPTS dB*
75-76	1.0	4.0
76-77	1.0	4.5
77-78	1.6	5.0
78-79	2.0	5.5
79-80	2.5	6.0
80-81	3.0	7.0
81-82	3.5	8.0
82-83	4.0	9.0
83-84	4.5	10.0
84-85	5.5	11.0

* Rounded to the nearest 0.5 dB

For example, for a noise exposure of 80 dB DNL, the expected lifetime average value of NIPTS is 2.5 dB, or 6.0 dB for the 10^{th} percentile. Characterizing the noise exposure in terms of DNL will usually overestimate the assessment of hearing loss risk as DNL includes a 10 dB weighting factor for aircraft operations occurring between 10 p.m. and 7 a.m. If, however, flight operations between the hours of 10 p.m. and 7 a.m. account for 5 percent or less of the total 24-hour operations, the overestimation is on the order of 1.5 dB.

From a civilian airport perspective, the scientific community has concluded that there is little likelihood that the resulting noise exposure from aircraft noise could result in either a temporary or permanent hearing loss. Studies on community hearing loss from exposure to aircraft flyovers near airports showed that there is no danger, under normal circumstances, of hearing loss due to aircraft noise (Newman and Beattie 1985). The EPA criterion (L_{eq24} = 70 dBA) can be exceeded in some areas located near airports, but that is only the case outdoors. Inside a building, where people are more likely to spend most of their time, the average noise level will be much less than 70 dBA (Eldred and von Gierke 1993). Eldred and von Gierke also report that "several studies in the U.S., Japan, and the U.K. have confirmed the predictions that the possibility for permanent hearing loss in communities, even under the most intense commercial take-off and landing patterns, is remote."

With regard to military airbases, as individual aircraft noise levels are increasing with the introduction of new aircraft, a 2009 DoD policy directive requires that hearing loss risk be estimated for the at risk population, defined as the population exposed to DNL greater than or equal to 80 dB and higher (DoD 2009). Specifically, DoD components are directed to "*use the 80 Day-Night A-Weighted (DNL) noise contour to identify populations at the most risk of potential hearing loss*". This does not preclude populations outside the 80 DNL contour, i.e. at lower exposure levels, from being at some degree of risk of hearing loss. However, the analysis should be restricted to populations within this contour area, including residents of on-base housing. The exposure of workers inside the base boundary area should be considered occupational and evaluated using the appropriate DoD component regulations for occupational noise exposure.

With regard to military airspace activity, studies have shown conflicting results. A 1995 laboratory study measured changes in human hearing from noise representative of low-flying aircraft on MTRs (Nixon, et al. 1993). The potential effects of aircraft flying along MTRs is of particular concern because of maximum overflight noise levels can exceed 115 dB, with rapid increases in noise levels exceeding 30 dB per second. In this study, participants were first subjected to four overflight noise exposures at A-weighted levels of 115 dB to 130 dB. Fifty percent of the subjects showed no change in hearing levels, 25 percent had a temporary 5 dB *increase* in sensitivity (the people could hear a 5 dB wider range of sound than before exposure), and 25 percent had a temporary 5 dB decrease in sensitivity (the people could hear a 5 dB narrower range of sound than before exposure). In the next phase, participants were subjected to a single overflight at a maximum level of 130 dB for eight successive exposures, separated by 90 seconds or until a temporary shift in hearing was observed. The temporary hearing threshold shifts showed an *increase* in sensitivity of up to 10 dB.

In another study of 115 test subjects between 18 and 50 years old in 1999, temporary threshold shifts were measured after laboratory exposure to military low-altitude flight noise (Ising, et al. 1999). According to the authors, the results indicate that repeated exposure to military low-altitude flight noise with L_{max} greater than 114 dB, especially if the noise level increases rapidly, may have the potential to cause noise induced hearing loss in humans.

Summary

Aviation and typical community noise levels near airports are not comparable to the occupational or recreational noise exposures associated with hearing loss. Studies of aircraft noise levels associated with civilian airport activity have not definitively correlated permanent hearing impairment with aircraft activity. It is unlikely that airport neighbors will remain outside their homes 24 hours per day, so there is little likelihood of hearing loss below an average sound level of 75 dB DNL. Near military airbases, average noise levels above 75 dB may occur, and while new DoD policy dictates that NIPTS be evaluated, no research results to date have definitively related permanent hearing impairment to aviation noise.

3.5 Nonauditory Health Effects

Studies have been conducted to determine whether correlations exist between noise exposure and cardiovascular problems, birth weight, and mortality rates. The nonauditory effect of noise on humans is not as easily substantiated as the effect on hearing. The results of studies conducted in the United States, primarily concentrating on cardiovascular response to noise, have been contradictory (Cantrell 1974). Cantrell concluded that the results of human and animal experiments show that average or intrusive noise can act as a stress-provoking stimulus. Prolonged stress is known to be a contributor to a number of health disorders. Kryter and Poza (1980) state, “It is more likely that noise-related general ill-health effects are due to the psychological annoyance from the noise interfering with normal everyday behavior, than it is from the noise eliciting, because of its intensity, reflexive response in the autonomic or other physiological systems of the body.” Psychological stresses may cause a physiological stress reaction that could result in impaired health.

The National Institute for Occupational Safety and Health and EPA commissioned CHABA in 1981 to study whether established noise standards are adequate to protect against health disorders other than hearing defects. CHABA’s conclusion was that:

Evidence from available research reports is suggestive, but it does not provide definitive answers to the question of health effects, other than to the auditory system, of long-term exposure to noise. It seems prudent, therefore, in the absence of adequate knowledge as to whether or not noise can produce effects upon health other than damage to auditory system, either directly or mediated through stress, that insofar as feasible, an attempt should be made to obtain more critical evidence.

Since the CHABA report, there have been more recent studies that suggest that noise exposure may cause hypertension and other stress-related effects in adults. Near an airport in Stockholm, Sweden, the prevalence of hypertension was reportedly greater among nearby residents who were exposed to energy averaged noise levels exceeding 55 dB and maximum noise levels exceeding 72 dB, particularly older subjects and those not reporting impaired hearing ability (Rosenlund, et al. 2001). A study of elderly volunteers who were exposed to simulated military low-altitude flight noise reported that blood pressure was raised by L_{max} of 112 dB and high speed level increase (Michalak, et al. 1990). Yet another study of subjects exposed to varying levels of military aircraft or road noise found no significant relationship between noise level and blood pressure (Pulles, et al. 1990).

The U.S. Department of the Navy prepared a programmatic Environmental Assessment (EA) for the continued use of non-explosive ordnance on the Vieques Inner Range. Following the preparation of the EA, it was learned that research conducted by the University of Puerto Rico, Ponce School of Medicine, suggested that Vieques fishermen and their families were experiencing symptoms associated with vibroacoustic disease (VAD) (U.S. Department of the Navy 2002). The study alleged that exposure to noise and sound waves of large pressure amplitudes within lower frequency bands, associated with Navy training activities—specifically, air-to-ground bombing or naval fire support—was related to a larger prevalence of heart anomalies within the Vieques fishermen and their families. The Ponce School of Medicine study compared the Vieques group with a group from Ponce Playa. A 1999 study conducted on Portuguese aircraft-manufacturing workers from a single factory reported effects of jet aircraft noise exposure that involved a wide range of symptoms and disorders, including the cardiac issues on which the Ponce School of Medicine study focused. The 1999 study identified these effects as VAD.

Johns Hopkins University (JHU) conducted an independent review of the Ponce School of Medicine study, as well as the Portuguese aircraft workers study and other relevant scientific literature. Their findings concluded that VAD should not be accepted as a syndrome, given that exhaustive research across a number of populations has not yet been conducted. JHU also pointed out that the evidence supporting the existence of VAD comes largely from one group of investigators and that similar results would have to be replicated by other investigators. In short, JHU concluded that it had not been established that noise was the causal agent for the symptoms reported and no inference can be made as to the role of noise from naval gunfire in producing echocardiographic abnormalities (U.S. Department of the Navy 2002).

Most studies of nonauditory health effects of long-term noise exposure have found that noise exposure levels established for hearing protection will also protect against any potential nonauditory health effects, at least in workplace conditions. One of the best scientific summaries of these findings is contained in the lead paper at the National Institutes of Health Conference on Noise and Hearing Loss, held on 22 to 24 January 1990 in Washington, D.C.:

> "The nonauditory effects of chronic noise exposure, when noise is suspected to act as one of the risk factors in the development of hypertension, cardiovascular disease, and other nervous disorders, have never been proven to occur as chronic manifestations at levels below these criteria (an average of 75 dBA for complete protection against hearing loss for an 8-hour day). At the recent (1988) International Congress on Noise as a Public Health Problem, most studies attempting to clarify such health effects did not find them at levels below the criteria protective of noise-induced hearing loss, and even above these criteria, results regarding such health effects were ambiguous. Consequently, one comes to the conclusion that establishing and enforcing exposure levels protecting against noise-induced hearing loss would not only solve the noise-induced hearing loss problem, but also any potential nonauditory health effects in the work place" (von Gierke 1990).

Although these findings were specifically directed at noise effects in the workplace, they are equally applicable to aircraft noise effects in the community environment. Research studies regarding the nonauditory health effects of aircraft noise are ambiguous, at best, and often contradictory. Yet, even those studies that purport to find such health effects use time-average noise levels of 75 dB and higher for their research.

For example, two UCLA researchers apparently found a relationship between aircraft noise levels under the approach path to Los Angeles International Airport (LAX) and increased mortality rates among the exposed residents by using an average noise exposure level greater than 75 dB for the "noise-exposed" population (Meacham and Shaw 1979). Nevertheless, three other UCLA professors analyzed those same data and found no relationship between noise exposure and mortality rates (Frerichs, et al. 1980).

As a second example, two other UCLA researchers used this same population near LAX to show a higher rate of birth defects for 1970 to 1972 when compared with a control group residing away from the airport (Jones and Tauscher 1978). Based on this report, a separate group at the Center for Disease Control performed a more thorough study of populations near Atlanta's Hartsfield International Airport (ATL) for 1970 to 1972 and found no relationship in their study of 17 identified categories of birth defects to aircraft noise levels above 65 dB (Edmonds, et al. 1979).

In summary, there is no scientific basis for a claim that potential health effects exist for aircraft time-average sound levels below 75 dB.

The potential for noise to affect physiological health, such as the cardiovascular system, has been speculated; however, no unequivocal evidence exists to support such claims (Harris 1997). Conclusions drawn from a review of health effect studies involving military low-altitude flight noise with its unusually high maximum levels and rapid rise in sound level have shown no increase in cardiovascular disease (Schwartze and Thompson 1993). Additional claims that are unsupported include flyover noise producing increased mortality rates and increases in cardiovascular death, aggravation of post-traumatic stress syndrome, increased stress, increase in admissions to mental hospitals, and adverse effects on pregnant women and the unborn fetus (Harris 1997).

3.6 Performance Effects

The effect of noise on the performance of activities or tasks has been the subject of many studies. Some of these studies have established links between continuous high noise levels and performance loss. Noise-induced performance losses are most frequently reported in studies employing noise levels in excess of 85 dB. Little change has been found in low-noise cases. It has been cited that moderate noise levels appear to act as a stressor for more sensitive individuals performing a difficult psychomotor task.

While the results of research on the general effect of periodic aircraft noise on performance have yet to yield definitive criteria, several general trends have been noted including:

- A periodic intermittent noise is more likely to disrupt performance than a steady-state continuous noise of the same level. Flyover noise, due to its intermittent nature, might be more likely to disrupt performance than a steady-state noise of equal level.
- Noise is more inclined to affect the quality than the quantity of work.
- Noise is more likely to impair the performance of tasks that place extreme demands on the worker.

3.7 Noise Effects on Children

In response to noise-specific and other environmental studies, Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks (1997), requires federal agencies to ensure that policies, programs, and activities address environmental health and safety risks to identify any disproportionate risks to children.

A review of the scientific literature indicates that there has not been a tremendous amount of research in the area of aircraft noise effects on children. The research reviewed does suggest that environments with sustained high background noise can have variable effects, including noise effects on learning and cognitive abilities, and reports of various noise-related physiological changes.

3.7.1 Effects on Learning and Cognitive Abilities

In 2002 ANSI refers to studies that suggest that loud and frequent background noise can affect the learning patterns of young children (ANSI 2002). ANSI provides discussion on the relationships between noise and learning, and stipulates design requirements and acoustical performance criteria for outdoor-to-indoor noise isolation. School design is directed to be cognizant of, and responsive to surrounding land uses and the shielding of outdoor noise from the indoor environment. The ANSI acoustical performance criteria for schools include the requirement that the one-hour-average background noise level shall not exceed 35 dBA in core learning spaces smaller than 20,000 cubic-feet and 40 dBA in core learning spaces with enclosed volumes exceeding 20,000 cubic-feet. This would require schools be constructed such that, in quiet neighborhoods indoor noise levels are lowered by 15 to 20 dBA relative to outdoor levels. In schools near airports, indoor noise levels would have to be lowered by 35 to 45 dBA relative to outdoor levels (ANSI 2002).

The studies referenced by ANSI to support the new standard are not specific to jet aircraft noise and the potential effects on children. However, there are references to studies that have shown that children in noisier classrooms scored lower on a variety of tests. Excessive background noise or reverberation within schools causes interferences of communication and can therefore create an acoustical barrier to learning (ANSI 2002). Studies have been performed that contribute to the body of evidence emphasizing the importance of communication by way of the spoken language to the development of cognitive skills. The ability to read, write, comprehend, and maintain attentiveness, are, in part, based upon whether teacher communication is consistently intelligible (ANSI 2002).

Numerous studies have shown varying degrees of effects of noise on the reading comprehension, attentiveness, puzzle-solving, and memory/recall ability of children. It is generally accepted that young children are more susceptible than adults to the effects of background noise. Because of the developmental status of young children (linguistic, cognitive, and proficiency), barriers to hearing can cause interferences or disruptions in developmental evolution.

Research on the impacts of aircraft noise, and noise in general, on the cognitive abilities of school-aged children has received more attention in recent years. Several studies suggest that aircraft noise can affect the academic performance of schoolchildren. Although many factors could contribute to learning deficits in school-aged children (e.g., socioeconomic level, home environment, diet, sleep patterns), evidence exists that suggests that chronic exposure to high aircraft noise levels can impair learning.

Specifically, elementary school children attending schools near New York City's two airports demonstrated lower reading scores than children living farther away from the flight paths (Green, et al. 1982). Researchers have found that tasks involving central processing and language comprehension (such as reading, attention, problem solving, and memory) appear to be the most affected by noise (Evans and Lepore 1993; Hygge 1994; and Evans, et al. 1998). It has been demonstrated that chronic exposure of first- and second-grade children to aircraft noise can result in reading deficits and impaired speech perception (i.e., the ability to hear common, low-frequency [vowel] sounds but not high frequencies [consonants] in speech) (Evans and Maxwell 1997).

The Evans and Maxwell (1997) study found that chronic exposure to aircraft noise resulted in reading deficits and impaired speech perception for first- and second-grade children. Other studies found that children residing near the Los Angeles International Airport had more difficulty solving cognitive problems and did not perform as well as children from quieter schools in puzzle-solving and attentiveness (Bronzaft 1997; Cohen, et al. 1980). Children attending elementary schools in high aircraft noise areas near London's Heathrow Airport demonstrated poorer reading comprehension and selective cognitive impairments (Haines, et al. 2001a, and 2001b). Similarly, a 1994 study found that students exposed to aircraft noise of approximately 76 dBA scored 20% lower on recall ability tests than students exposed to ambient noise of 42-44 dBA (Hygge 1994). Similar studies involving the testing of attention, memory, and reading comprehension of school children located near airports showed that their tests exhibited reduced performance results compared to those of similar groups of children who were located in quieter environments (Evans, et al. 1998; Haines, et al. 1998). The Haines and Stansfeld study indicated that there may be some long-term effects associated with exposure, as one-year follow-up testing still demonstrated lowered scores for children in higher noise schools (Haines, et al. 2001a, and 2001b). In contrast, a 2002 study found that although children living near the old Munich airport scored lower in standardized reading and long-term memory tests than a control group, their performance on the same tests was equal to that of the control group once the airport was closed. (Hygge, et al. 2002).

Finally, although it is recognized that there are many factors that could contribute to learning deficits in school-aged children, there is increasing awareness that chronic exposure to high aircraft noise levels may impair learning. This awareness has led the World Health Organization and a North Atlantic Treaty Organization working group to conclude that daycare centers and schools should not be located near major sources of noise, such as highways, airports, and industrial sites (World Health Organization 2000; North Atlantic Treaty Organization 2000).

3.7.2 Health Effects

Physiological effects in children exposed to aircraft noise and the potential for health effects have also been the focus of limited investigation. Studies in the literature include examination of blood pressure levels, hormonal secretions, and hearing loss.

As a measure of stress response to aircraft noise, authors have looked at blood pressure readings to monitor children's health. Children who were chronically exposed to aircraft noise from a new airport near Munich, Germany, had modest (although significant) increases in blood pressure, significant increases in stress hormones, and a decline in quality of life (Evans, et al. 1998). Children attending noisy schools had statistically significant average systolic and diastolic blood pressure ($p<0.03$). Systolic blood pressure means were 89.68 mm for children attending schools located in noisier environments compared to 86.77 mm for a control group. Similarly, diastolic blood pressure means for the noisier environment group were 47.84 mm and 45.16 for the control group (Cohen, et al. 1980).

Although the literature appears limited, studies focused on the wide range of potential effects of aircraft noise on school children have also investigated hormonal levels between groups of children exposed to aircraft noise compared to those in a control group. Specifically, two studies analyzed cortisol and urinary catecholamine levels in school children as measurements of stress response to aircraft noise (Haines, et al. 2001b and 2001c). In both instances, there were no differences between the aircraft-noise-exposed children and the control groups.

Other studies have reported hearing losses from exposure to aircraft noise. Noise-induced hearing loss was reportedly higher in children who attended a school located under a flight path near a Taiwan airport, as compared to children at another school far away (Chen, et al. 1997). Another study reported that hearing ability was reduced significantly in individuals who lived near an airport and were frequently exposed to aircraft noise (Chen and Chen 1993). In that study, noise exposure near the airport was reportedly uniform, with DNL greater than 75 dB and maximum noise levels of about 87 dB during overflights. Conversely, several other studies that were reviewed reported no difference in hearing ability between children exposed to high levels of airport noise and children located in quieter areas (Fisch 1977; Andrus, et al. 1975; Wu, et al. 1995).

3.8 Effects on Domestic Animals and Wildlife

Hearing is critical to an animal's ability to react, compete, reproduce, hunt, forage, and survive in its environment. While the existing literature does include studies on possible effects of jet aircraft noise and sonic booms on wildlife, there appears to have been little concerted effort in developing quantitative comparisons of aircraft noise effects on normal auditory characteristics. Behavioral effects have been relatively well described, but the larger ecological context issues, and the potential for drawing conclusions regarding effects on populations, has not been well developed.

The relationships between potential auditory/physiological effects and species interactions with their environments are not well understood. Manci, et al. (1988), assert that the consequences that physiological effects may have on behavioral patterns is vital to understanding the long-term effects of noise on wildlife. Questions regarding the effects (if any) on predator-prey interactions, reproductive success, and intra-inter specific behavior patterns remain.

The following discussion provides an overview of the existing literature on noise effects (particularly jet aircraft noise) on animal species. The literature reviewed here involves those studies that have focused on the observations of the behavioral effects that jet aircraft and sonic booms have on animals.

A great deal of research was conducted in the 1960's and 1970's on the effects of aircraft noise on the public and the potential for adverse ecological impacts. These studies were largely completed in response to the increase in air travel and as a result of the introduction of supersonic jet aircraft. According to Manci, et al. (1988), the foundation of information created from that focus does not necessarily correlate or provide information specific to the impacts to wildlife in areas overflown by aircraft at supersonic speed or at low altitudes.

The abilities to hear sounds and noise and to communicate assist wildlife in maintaining group cohesiveness and survivorship. Social species communicate by transmitting calls of warning, introduction, and other types that are subsequently related to an individual's or group's responsiveness.

Animal species differ greatly in their responses to noise. Noise effects on domestic animals and wildlife are classified as primary, secondary, and tertiary. Primary effects are direct, physiological changes to the auditory system, and most likely include the masking of auditory signals. Masking is defined as the inability of an individual to hear important environmental signals that may arise from mates, predators, or prey. There is some potential that noise could disrupt a species' ability to communicate or could interfere with behavioral patterns (Manci, et al. 1988). Although the effects are likely temporal, aircraft noise may cause masking of auditory signals within exposed faunal communities. Animals rely on hearing to avoid predators, obtain food, and communicate with, and attract, other members of their species. Aircraft noise may mask or interfere with these functions. Other primary effects, such as ear drum rupture or temporary and permanent hearing threshold shifts, are not as likely given the subsonic noise levels produced by aircraft overflights. Secondary effects may include non-auditory effects such as stress and hypertension; behavioral modifications; interference with mating or reproduction; and impaired ability to obtain adequate food, cover, or water. Tertiary effects are the direct result of primary and secondary effects, and include population decline and habitat loss. Most of the effects of noise are mild enough that they may never be detectable as variables of change in population size or population growth against the background of normal variation (Bowles 1995). Other environmental variables (e.g., predators, weather, changing prey base, ground-based disturbance) also influence secondary and tertiary effects, and confound the ability to identify the ultimate factor in limiting productivity of a certain nest, area, or region (Smith, et al. 1988). Overall, the literature suggests that species differ in their response to various types, durations, and sources of noise (Manci, et al. 1988).

Many scientific studies have investigated the effects of aircraft noise on wildlife, and some have focused on wildlife "flight" due to noise. Apparently, animal responses to aircraft are influenced by many variables, including size, speed, proximity (both height above the ground and lateral distance), engine noise, color, flight profile, and radiated noise. The type of aircraft (e.g., fixed wing versus rotor-wing [helicopter]) and type of flight mission may also produce different levels of disturbance, with varying animal responses (Smith, et al. 1988). Consequently, it is difficult to generalize animal responses to noise disturbances across species.

One result of the 1988 Manci, et al., literature review was the conclusion that, while behavioral observation studies were relatively limited, a general behavioral reaction in animals from exposure to aircraft noise is the startle response. The intensity and duration of the startle response appears to be dependent on which species is exposed, whether there is a group or an individual, and whether there have been some previous exposures. Responses range from flight, trampling, stampeding, jumping, or running, to movement of the head in the apparent direction of the noise source. Manci, et al. (1988), reported that the literature indicated that avian species may be more sensitive to aircraft noise than mammals.

3.8.1 Domestic Animals

Although some studies report that the effects of aircraft noise on domestic animals is inconclusive, a majority of the literature reviewed indicates that domestic animals exhibit some behavioral responses to military overflights but generally seem to habituate to the disturbances over a period of time. Mammals in particular appear to react to noise at sound levels higher than 90 dB, with responses including the startle response, freezing (i.e., becoming temporarily stationary), and fleeing from the sound source. Many studies on domestic animals suggest that some species appear to acclimate to some forms of sound disturbance (Manci, et al. 1988). Some studies have reported such primary and secondary effects as reduced milk production and rate of milk release, increased glucose concentrations, decreased levels of hemoglobin, increased heart rate, and a reduction in thyroid activity. These latter effects appear to represent a small percentage of the findings occurring in the existing literature.

Some reviewers have indicated that earlier studies, and claims by farmers linking adverse effects of aircraft noise on livestock, did not necessarily provide clear-cut evidence of cause and effect (Cottereau 1978). In contrast, many studies conclude that there is no evidence that aircraft overflights affect feed intake, growth, or production rates in domestic animals.

Cattle

In response to concerns about overflight effects on pregnant cattle, milk production, and cattle safety, the U.S. Air Force prepared a handbook for environmental protection that summarizes the literature on the impacts of low-altitude flights on livestock (and poultry) and includes specific case studies conducted in numerous airspaces across the country. Adverse effects have been found in a few studies but have not been reproduced in other similar studies. One such study, conducted in 1983, suggested that 2 of 10 cows in late pregnancy aborted after showing rising estrogen and falling progesterone levels. These increased hormonal levels were reported as being linked to 59 aircraft overflights. The remaining eight cows showed no changes in their blood concentrations and calved normally (U.S. Air Force 1994b). A similar study reported abortions occurred in three out of five pregnant cattle after exposing them to flyovers by six different aircraft (U.S. Air Force 1994b). Another study suggested that feedlot cattle could stampede and injure themselves when exposed to low-level overflights (U.S. Air Force 1994b).

A majority of the studies reviewed suggests that there is little or no effect of aircraft noise on cattle. Studies presenting adverse effects to domestic animals have been limited. A number of studies (Parker and Bayley 1960; Casady and Lehmann 1967; Kovalcik and Sottnik 1971) investigated the effects of jet aircraft noise and sonic booms on the milk production of dairy cows. Through the compilation and examination of milk production data from areas exposed to jet aircraft noise and sonic boom events, it was determined that milk yields were not affected. This was particularly evident in those cows that had been previously exposed to jet aircraft noise.

A study examined the causes of 1,763 abortions in Wisconsin dairy cattle over a one-year time period and none were associated with aircraft disturbances (U.S. Air Force 1993). In 1987, Anderson contacted seven livestock operators for production data, and no effects of low-altitude and supersonic flights were noted. Three out of 43 cattle previously exposed to low-altitude flights showed a startle response to an F/A-18 aircraft flying overhead at 500 feet above ground level and 400 knots by running less than 10 meters. They resumed normal activity within one minute (U.S. Air Force 1994b). Beyer (1983) found that helicopters caused more reaction than other low-aircraft overflights, and that the helicopters at 30 to 60 feet overhead did not affect milk production and pregnancies of 44 cows and heifers in a 1964 study (U.S. Air Force 1994b).

Additionally, Beyer reported that five pregnant dairy cows in a pasture did not exhibit fright-flight tendencies or disturb their pregnancies after being overflown by 79 low-altitude helicopter flights and 4 low-altitude, subsonic jet aircraft flights (U.S. Air Force 1994b). A 1956 study found that the reactions of dairy and beef cattle to noise from low-altitude, subsonic aircraft were similar to those caused by paper blowing about, strange persons, or other moving objects (U.S. Air Force 1994b).

In a report to Congress, the U. S. Forest Service concluded that “evidence both from field studies of wild ungulates and laboratory studies of domestic stock indicate that the risks of damage are small (from aircraft approaches of 50 to 100 meters), as animals take care not to damage themselves (U.S. Forest Service 1992). If animals are overflown by aircraft at altitudes of 50 to 100 meters, there is no evidence that mothers and young are separated, that animals collide with obstructions (unless confined) or that they traverse dangerous ground at too high a rate.” These varied study results suggest that, although the confining of cattle could magnify animal response to aircraft overflight, there is no proven cause-and-effect link between startling cattle from aircraft overflights and abortion rates or lower milk production.

Horses

Horses have also been observed to react to overflights of jet aircraft. Several of the studies reviewed reported a varied response of horses to low-altitude aircraft overflights. Observations made in 1966 and 1968 noted that horses galloped in response to jet flyovers (U.S. Air Force 1993). Bowles (1995) cites Kruger and Erath as observing horses exhibiting intensive flight reactions, random movements, and biting/kicking behavior. However, no injuries or abortions occurred, and there was evidence that the mares adapted somewhat to the flyovers over the course of a month (U.S. Air Force 1994b). Although horses were observed noticing the overflights, it did not appear to affect either survivability or reproductive success. There was also some indication that habituation to these types of disturbances was occurring.

LeBlanc, et al. (1991), studied the effects of F-14 jet aircraft noise on pregnant mares. They specifically focused on any changes in pregnancy success, behavior, cardiac function, hormonal production, and rate of habituation. Their findings reported observations of “flight-fright” reactions, which caused increases in heart rates and serum cortisol concentrations. The mares, however, did habituate to the noise. Levels of anxiety and mass body movements were the highest after initial exposure, with intensities of responses decreasing thereafter. There were no differences in pregnancy success when compared to a control group.

Swine

Generally, the literature findings for swine appear to be similar to those reported for cows and horses. While there are some effects from aircraft noise reported in the literature, these effects are minor. Studies of continuous noise exposure (i.e., 6 hours, 72 hours of constant exposure) reported influences on short-term hormonal production and release. Additional constant exposure studies indicated the observation of stress reactions, hypertension, and electrolyte imbalances (Dufour 1980). A study by Bond, et al. (1963), demonstrated no adverse effects on the feeding efficiency, weight gain, ear physiology, or thyroid and adrenal gland condition of pigs subjected to observed aircraft noise. Observations of heart rate increase were recorded, noting that cessation of the noise resulted in the return to normal heart rates. Conception rates and offspring survivorship did not appear to be influenced by exposure to aircraft noise.

Similarly, simulated aircraft noise at levels of 100 dB to 135 dB had only minor effects on the rate of feed utilization, weight gain, food intake, or reproduction rates of boars and sows exposed, and there were no injuries or inner ear changes observed (Manci, et al. 1988; Gladwin, et al. 1988).

Domestic Fowl

According to a 1994 position paper by the U.S. Air Force on effects of low-altitude overflights (below 1,000 ft) on domestic fowl, overflight activity has negligible effects (U.S. Air Force 1994a). The paper did recognize that given certain circumstances, adverse effects can be serious. Some of the effects can be panic reactions, reduced productivity, and effects on marketability (e.g., bruising of the meat caused during “pile-up” situations).

The typical reaction of domestic fowl after exposure to sudden, intense noise is a short-term startle response. The reaction ceases as soon as the stimulus is ended, and within a few minutes all activity returns to normal. More severe responses are possible depending on the number of birds, the frequency of exposure, and environmental conditions. Large crowds of birds, and birds not previously exposed, are more likely to pile up in response to a noise stimulus (U.S. Air Force 1994a). According to studies and interviews with growers, it is typically the previously unexposed birds that incite panic crowding, and the tendency to do so is markedly reduced within five exposures to the stimulus (U.S. Air Force 1994a). This suggests that the birds habituate relatively quickly. Egg productivity was not adversely affected by infrequent noise bursts, even at exposure levels as high as 120 to 130 dBA.

Between 1956 and 1988, there were 100 recorded claims against the Navy for alleged damage to domestic fowl. The number of claims averaged three per year, with peak numbers of claims following publications of studies on the topic in the early 1960s (U.S. Air Force 1994a). Many of the claims were disproved or did not have sufficient supporting evidence. The claims were filed for the following alleged damages: 55% for panic reactions, 31% for decreased production, 6% for reduced hatchability, 6% for weight loss, and less than 1% for reduced fertility (U.S. Air Force 1994a).

Turkeys

The review of the existing literature suggests that there has not been a concerted or widespread effort to study the effects of aircraft noise on commercial turkeys. One study involving turkeys examined the differences between simulated versus actual overflight aircraft noise, turkey responses to the noise, weight gain, and evidence of habituation (Bowles, et al. 1990a). Findings from the study suggested that turkeys habituated to jet aircraft noise quickly, that there were no growth rate differences between the experimental and control groups, and that there were some behavioral differences that increased the difficulty in handling individuals within the experimental group.

Low-altitude overflights were shown to cause turkey flocks that were kept inside turkey houses to occasionally pile up and experience high mortality rates due to the aircraft noise and a variety of disturbances unrelated to aircraft (U.S. Air Force 1994a).

3.8.2 Wildlife

Studies on the effects of overflights and sonic booms on wildlife have been focused mostly on avian species and ungulates such as caribou and bighorn sheep. Few studies have been conducted on marine mammals, small terrestrial mammals, reptiles, amphibians, and carnivorous mammals. Generally, species that live entirely below the surface of the water have also been ignored due to the fact they do not experience the same level of sound as terrestrial species (National Park Service 1994). Wild ungulates appear to be much more sensitive to noise disturbance than domestic livestock (Manci, et al. 1988). This may be due to previous exposure to disturbances. One common factor appears to be that low-altitude flyovers seem to be more disruptive in terrain where there is little cover (Manci, et al. 1988).

3.8.2.1 MAMMALS

Terrestrial Mammals

Studies of terrestrial mammals have shown that noise levels of 120 dBA can damage mammals' ears, and levels at 95 dBA can cause temporary loss of hearing acuity. Noise from aircraft has affected other large carnivores by causing changes in home ranges, foraging patterns, and breeding behavior. One study recommended that aircraft not be allowed to fly at altitudes below 2,000 feet above ground level over important grizzly and polar bear habitat (Dufour 1980). Wolves have been frightened by low-altitude flights that were 25 to 1,000 feet off the ground. However, wolves have been found to adapt to aircraft overflights and noise as long as they were not being hunted from aircraft (Dufour 1980).

Wild ungulates (American bison, caribou, bighorn sheep) appear to be much more sensitive to noise disturbance than domestic livestock (Weisenberger, et al. 1996). Behavioral reactions may be related to the past history of disturbances by such things as humans and aircraft. Common reactions of reindeer kept in an enclosure exposed to aircraft noise disturbance were a slight startle response, raising of the head, pricking ears, and scenting of the air. Panic reactions and extensive changes in behavior of individual animals were not observed. Observations of caribou in Alaska exposed to fixed-wing aircraft and helicopters showed running and panic reactions occurred when overflights were at an altitude of 200 feet or less. The reactions decreased with increased altitude of overflights, and, with more than 500 feet in altitude, the panic reactions stopped. Also, smaller groups reacted less strongly than larger groups. One negative effect of the running and avoidance behavior is increased expenditure of energy. For a 90-kg animal, the calculated expenditure due to aircraft harassment is 64 kilocalories per minute when running and 20 kilocalories per minute when walking. When conditions are favorable, this expenditure can be counteracted with increased feeding; however, during harsh winter conditions, this may not be possible. Incidental observations of wolves and bears exposed to fixed-wing aircraft and helicopters in the northern regions suggested that wolves are less disturbed than wild ungulates, while grizzly bears showed the greatest response of any animal species observed.

It has been proven that low-altitude overflights do induce stress in animals. Increased heart rates, an indicator of excitement or stress, have been found in pronghorn antelope, elk, and bighorn sheep. As such reactions occur naturally as a response to predation, infrequent overflights may not, in and of themselves, be detrimental. However, flights at high frequencies over a long period of time may cause harmful effects. The consequences of this disturbance, while cumulative, is not additive. It may be that aircraft disturbance may not cause obvious and serious health effects, but coupled with a harsh winter, it may have an adverse impact. Research has shown that stress induced by other types of disturbances produces long-term decreases in metabolism and hormone balances in wild ungulates.

Behavioral responses can range from mild to severe. Mild responses include head raising, body shifting, or turning to orient toward the aircraft. Moderate disturbance may be nervous behaviors, such as trotting a short distance. Escape is the typical severe response.

Marine Mammals

The physiological composition of the ear in aquatic and marine mammals exhibits adaptation to the aqueous environment. These differences (relative to terrestrial species) manifest themselves in the auricle and middle ear (Manci, et al. 1988). Some mammals use echolocation to perceive objects in their surroundings and to determine the directions and locations of sound sources (Simmons 1983 in Manci, et al. 1988).

In 1980, the Acoustical Society of America held a workshop to assess the potential hazard of manmade noise associated with proposed Alaska Arctic (North Slope-Outer Continental Shelf) petroleum operations on marine wildlife and to prepare a research plan to secure the knowledge necessary for proper assessment of noise impacts (Acoustical Society of America, 1980). Since 1980 it appears that research on responses of aquatic mammals to aircraft noise and sonic booms has been limited. Research conducted on northern fur seals, sea lions, and ringed seals indicated that there are some differences in how various animal groups receive frequencies of sound. It was observed that these species exhibited varying intensities of a startle response to airborne noise, which was habituated over time. The rates of habituation appeared to vary with species, populations, and demographics (age, sex). Time of day of exposure was also a factor (Muyberg 1978 in Manci, et al. 1988).

Studies accomplished near the Channel Islands were conducted near the area where the space shuttle launches occur. It was found that there were some response differences between species relative to the loudness of sonic booms. Those booms that were between 80 and 89 dBA caused a greater intensity of startle reactions than lower-intensity booms at 72 to 79 dBA. However, the duration of the startle responses to louder sonic booms was shorter (Jehl and Cooper 1980 in Manci, et al. 1988).

Jehl and Cooper (1980) indicated that low-flying helicopters, loud boat noises, and humans were the most disturbing to pinnipeds. According to the research, while the space launch and associated operational activity noises have not had a measurable effect on the pinniped population, it also suggests that there was a greater “disturbance level” exhibited during launch activities. There was a recommendation to continue observations for behavioral effects and to perform long-term population monitoring (Jehl and Cooper 1980).

The continued presence of single or multiple noise sources could cause marine mammals to leave a preferred habitat. However, it does not appear likely that overflights could cause migration from suitable habitats as aircraft noise over water is mobile and would not persist over any particular area. Aircraft noise, including supersonic noise, currently occurs in the overwater airspace of Eglin, Tyndall, and Langley AFBs from sorties predominantly involving jet aircraft. Survey results reported in Davis, et al. (2000), indicate that cetaceans (i.e., dolphins) occur under all of the Eglin and Tyndall marine airspace. The continuing presence of dolphins indicates that aircraft noise does not discourage use of the area and apparently does not harm the locally occurring population.

In a summary by the National Parks Service (1994) on the effects of noise on marine mammals, it was determined that gray whales and harbor porpoises showed no outward behavioral response to aircraft noise or overflights. Bottlenose dolphins showed no obvious reaction in a study involving helicopter overflights at 1,200 to 1,800 feet above the water. Neither did they show any reaction to survey aircraft unless the shadow of the aircraft passed over them, at which point there was some observed tendency to dive (Richardson, et al. 1995). Other anthropogenic noises in the marine environment from ships and pleasure craft may have more of an effect on marine mammals than aircraft noise (U.S. Air Force 2000). The noise effects on cetaceans appear to be somewhat attenuated by the air/water interface. The cetacean fauna along the coast of California have been subjected to sonic booms from military aircraft for many years without apparent adverse effects (Tetra Tech, Inc. 1997).

Manatees appear relatively unresponsive to human-generated noise to the point that they are often suspected of being deaf to oncoming boats [although their hearing is actually similar to that of pinnipeds (Bullock, et al. 1980)]. Little is known about the importance of acoustic communication to manatees, although they are known to produce at least ten different types of sounds and are thought to have sensitive hearing (Richardson, et al. 1995). Manatees continue to occupy canals near Miami International Airport, which suggests that they have become habituated to human disturbance and noise (Metro-Dade County 1995). Since manatees spend most of their time below the surface and do not startle readily, no effect of aircraft overflights on manatees would be expected (Bowles, et al. 1991b).

3.8.2.2 BIRDS

Auditory research conducted on birds indicates that they fall between the reptiles and the mammals relative to hearing sensitivity. According to Dooling (1978), within the range of one to five kHz, birds show a level of hearing sensitivity similar to that of the more sensitive mammals. In contrast to mammals, bird sensitivity falls off at a greater rate to increasing and decreasing frequencies. Passive observations and studies examining aircraft bird strikes indicate that birds nest and forage near airports. Aircraft noise in the vicinity of commercial airports apparently does not inhibit bird presence and use.

High-noise events (like a low-altitude aircraft overflight) may cause birds to engage in escape or avoidance behaviors, such as flushing from perches or nests (Ellis, et al. 1991). These activities impose an energy cost on the birds that, over the long term, may affect survival or growth. In addition, the birds may spend less time engaged in necessary activities like feeding, preening, or caring for their young because they spend time in noise-avoidance activity. However, the long-term significance of noise-related impacts is less clear. Several studies on nesting raptors have indicated that birds become habituated to aircraft overflights and that long-term reproductive success is not affected (Grubb and King 1991; Ellis, et al. 1991). Threshold noise levels for significant responses range from 62 dB for Pacific black brant (Branta bernicla nigricans) (Ward and Stehn 1990) to 85 dB for crested tern (Sterna bergii) (Brown 1990).

Songbirds were observed to become silent prior to the onset of a sonic boom event (F-111 jets), followed by "raucous discordant cries." There was a return to normal singing within 10 seconds after the boom (Higgins 1974 in Manci, et al. 1988). Ravens responded by emitting protestation calls, flapping their wings, and soaring.

Manci, et al. (1988), reported a reduction in reproductive success in some small territorial passerines (i.e., perching birds or songbirds) after exposure to low-altitude overflights. However, it has been observed that passerines are not driven any great distance from a favored food source by a nonspecific disturbance, such as aircraft overflights (U.S. Forest Service 1992). Further study may be warranted.

A recent study, conducted cooperatively between the DoD and the USFWS, assessed the response of the red-cockaded woodpecker to a range of military training noise events, including artillery, small arms, helicopter, and maneuver noise (Pater, et al. 1999). The project findings show that the red-cockaded woodpecker successfully acclimates to military noise events. Depending on the noise level that ranged from innocuous to very loud, the birds responded by flushing from their nest cavities. When the noise source was closer and the noise level was higher, the number of flushes increased proportionately. In all cases, however, the birds returned to their nests within a relatively short period of time (usually within 12 minutes). Additionally, the noise exposure did not result in any mortality or statistically detectable changes in reproductive success (Pater, et al. 1999). Red-cockaded woodpeckers did not flush when artillery simulators were more than 122 meters away and SEL noise levels were 70 dBA.

Lynch and Speake (1978) studied the effects of both real and simulated sonic booms on the nesting and brooding eastern wild turkey (Meleagris gallopavo silvestris) in Alabama. Hens at four nest sites were subjected to between 8 and 11 combined real and simulated sonic booms. All tests elicited similar responses, including quick lifting of the head and apparent alertness for between 10 and 20 seconds. No apparent nest failure occurred as a result of the sonic booms.

Twenty-one brood groups were also subjected to simulated sonic booms. Reactions varied slightly between groups, but the largest percentage of groups reacted by standing motionless after the initial blast. Upon the sound of the boom, the hens and poults fled until reaching the edge of the woods (approximately 4 to 8 meters). Afterward, the poults resumed feeding activities while the hens remained alert for a short period of time (approximately 15 to 20 seconds). In no instances were poults abandoned, nor did they scatter and become lost. Every observation group returned to normal activities within a maximum of 30 seconds after a blast.

3.8.2.2.1 RAPTORS

In a literature review of raptor responses to aircraft noise, Manci, et al. (1988), found that most raptors did not show a negative response to overflights. When negative responses were observed they were predominantly associated with rotor-winged aircraft or jet aircraft that were repeatedly passing within 0.5 mile of a nest.

Ellis, et al. (1991), performed a study to estimate the effects of low-level military jet aircraft and mid- to high-altitude sonic booms (both actual and simulated) on nesting peregrine falcons and seven other raptors (common black-hawk, Harris' hawk, zone-tailed hawk, red-tailed hawk, golden eagle, prairie falcon, bald eagle). They observed responses to test stimuli, determined nest success for the year of the testing, and evaluated site occupancy the following year. Both long- and short-term effects were noted in the study. The results reported the successful fledging of young in 34 of 38 nest sites (all eight species) subjected to low-level flight and/or simulated sonic booms. Twenty-two of the test sites were revisited in the following year, and observations of pairs or lone birds were made at all but one nest.

Nesting attempts were underway at 19 of 20 sites that were observed long enough to be certain of breeding activity. Reoccupancy and productivity rates were within or above expected values for self-sustaining populations.

Short-term behavior responses were also noted. Overflights at a distance of 150 m or less produced few significant responses and no severe responses. Typical responses consisted of crouching or, very rarely, flushing from the perch site. Significant responses were most evident before egg laying and after young were "well grown." Incubating or brooding adults never burst from the nest, thus preventing egg breaking or knocking chicks out of the nest. Jet passes and sonic booms often caused noticeable alarm; however, significant negative responses were rare and did not appear to limit productivity or reoccupancy. Due to the locations of some of the nests, some birds may have been habituated to aircraft noise. There were some test sites located at distances far from zones of frequent military aircraft usage, and the test stimuli were often closer, louder, and more frequent than would be likely for a normal training situation.

Manci, et al. (1988), noted that a female northern harrier was observed hunting on a bombing range in Mississippi during bombing exercises. The harrier was apparently unfazed by the exercises, even when a bomb exploded within 200 feet. In a similar case of habituation/non-disturbance, a study on the Florida snail-kite stated the greatest reaction to overflights (approximately 98 dBA) was "watching the aircraft fly by." No detrimental impacts to distribution, breeding success, or behavior were noted.

Bald Eagle

A study by Grubb and King (1991) on the reactions of the bald eagle to human disturbances showed that terrestrial disturbances elicited the greatest response, followed by aquatic (i.e., boats) and aerial disturbances. The disturbance regime of the area where the study occurred was predominantly characterized by aircraft noise. The study found that pedestrians consistently caused responses that were greater in both frequency and duration. Helicopters elicited the highest level of aircraft-related responses. Aircraft disturbances, although the most common form of disturbance, resulted in the lowest levels of response. This low response level may have been due to habituation; however, flights less than 170 meters away caused reactions similar to other disturbance types. Ellis, et al. (1991), showed that eagles typically respond to the proximity of a disturbance, such as a pedestrian or aircraft within 100 meters, rather than the noise level. Fleischner and Weisberg (1986) stated that reactions of bald eagles to commercial jet flights, although minor (e.g., looking), were twice as likely to occur when the jets passed at a distance of 0.5 mile or less. They also noted that helicopters were four times more likely to cause a reaction than a commercial jet and 20 times more likely to cause a reaction than a propeller plane.

The USFWS advised Cannon AFB that flights at or below 2,000 feet AGL from October 1 through March 1 could result in adverse impacts to wintering bald eagles (U.S. Fish and Wildlife Serice 1998). However, Fraser, et al. (1985), suggested that raptors habituate to overflights rapidly, sometimes tolerating aircraft approaches of 65 feet or less.

Osprey

A study by Trimper, et al. (1998), in Goose Bay, Labrador, Canada, focused on the reactions of nesting osprey to military overflights by CF-18 Hornets. Reactions varied from increased alertness and focused observation of planes to adjustments in incubation posture. No overt reactions (e.g., startle response, rapid nest departure) were observed as a result of an overflight. Young nestlings crouched as a result of any disturbance until they grew to 1 to 2 weeks prior to fledging. Helicopters, human presence, float planes, and other ospreys elicited the strongest reactions from nesting ospreys. These responses included flushing, agitation, and aggressive displays. Adult osprey showed high nest occupancy rates during incubation regardless of external influences.

The osprey observed occasionally stared in the direction of the flight before it was audible to the observers. The birds may have been habituated to the noise of the flights; however, overflights were strictly controlled during the experimental period. Strong reactions to float planes and helicopter may have been due to the slower flight and therefore longer duration of visual stimuli rather than noise-related stimuli.

Red-tailed Hawk

Anderson, et al. (1989), conducted a study that investigated the effects of low-level helicopter overflights on 35 red-tailed hawk nests. Some of the nests had not been flown over prior to the study. The hawks that were naïve (i.e., not previously exposed) to helicopter flights exhibited stronger avoidance behavior (nine of 17 birds flushed from their nests) than those that had experienced prior overflights. The overflights did not appear to affect nesting success in either study group. These findings were consistent with the belief that red-tailed hawks habituate to low-level air traffic, even during the nesting period.

3.8.2.2.2 MIGRATORY WATERFOWL

A study of caged American black ducks was conducted by Fleming, et al. in 1996. It was determined that noise had negligible energetic and physiologic effects on adult waterfowl. Measurements included body weight, behavior, heart rate, and enzymatic activity. Experiments also showed that adult ducks exposed to high noise events acclimated rapidly and showed no effects.

The study also investigated the reproductive success of captive ducks, which indicated that duckling growth and survival rates at Piney Island, North Carolina, were lower than those at a background location. In contrast, observations of several other reproductive indices (i.e., pair formation, nesting, egg production, and hatching success) showed no difference between Piney Island and the background location. Potential effects on wild duck populations may vary, as wild ducks at Piney Island have presumably acclimated to aircraft overflights. It was not demonstrated that noise was the cause of adverse impacts. A variety of other factors, such as weather conditions, drinking water and food availability and variability, disease, and natural variability in reproduction, could explain the observed effects. Fleming noted that drinking water conditions (particularly at Piney Island) deteriorated during the study, which could have affected the growth of young ducks. Further research would be necessary to determine the cause of any reproductive effects.

Another study by Conomy, et al. (1998) exposed previously unexposed ducks to 71 noise events per day that equaled or exceeded 80 dBA. It was determined that the proportion of time black ducks reacted to aircraft activity and noise decreased from 38 percent to 6 percent in 17 days and remained stable at 5.8 percent thereafter. In the same study, the wood duck did not appear to habituate to aircraft disturbance. This supports the notion that animal response to aircraft noise is species-specific. Because a startle response to aircraft noise can result in flushing from nests, migrants and animals living in areas with high concentrations of predators would be the most vulnerable to experiencing effects of lowered birth rates and recruitment over time. Species that are subjected to infrequent overflights do not appear to habituate to overflight disturbance as readily.

Black brant studied in the Alaska Peninsula were exposed to jets and propeller aircraft, helicopters, gunshots, people, boats, and various raptors. Jets accounted for 65% of all the disturbances. Humans, eagles, and boats caused a greater percentage of brant to take flight. There was markedly greater reaction to Bell-206-B helicopter flights than fixed wing, single-engine aircraft (Ward, et al. 1986).

The presence of humans and low-flying helicopters in the Mackenzie Valley North Slope area did not appear to affect the population density of Lapland longspurs, but the experimental group was shown to have reduced hatching and fledging success and higher nest abandonment. Human presence appeared to have a greater impact on the incubating behavior of the black brant, common eider, and Arctic tern than fixed-wing aircraft (Gunn and Livingston 1974).

Gunn and Livingston (1974) found that waterfowl and seabirds in the Mackenzie Valley and North Slope of Alaska and Canada became acclimated to float plane disturbance over the course of three days. Additionally, it was observed that potential predators (bald eagle) caused a number of birds to leave their nests. Non-breeding birds were observed to be more reactive than breeding birds. Waterfowl were affected by helicopter flights, while snow geese were disturbed by Cessna 185 flights. The geese flushed when the planes were under 1,000 feet, compared to higher flight elevations. An overall reduction in flock sizes was observed. It was recommended that aircraft flights be reduced in the vicinity of premigratory staging areas.

Manci, et al. 1988 reported that waterfowl were particularly disturbed by aircraft noise. The most sensitive appeared to be snow geese. Canada geese and snow geese were thought to be more sensitive than other animals such as turkey vultures, coyotes, and raptors (Edwards, et al. 1979).

3.8.2.2.3 WADING AND SHORE BIRDS

Black, et al. (1984), studied the effects of low-altitude (less than 500 feet AGL) military training flights with sound levels from 55 to 100 dBA on wading bird colonies (i.e., great egret, snowy egret, tricolored heron, and little blue heron). The training flights involved three or four aircraft, which occurred once or twice per day. This study concluded that the reproductive activity--including nest success, nestling survival, and nestling chronology--was independent of F-16 overflights. Dependent variables were more strongly related to ecological factors, including location and physical characteristics of the colony and climatology. Another study on the effects of circling fixed-wing aircraft and helicopter overflights on wading bird colonies found that at altitudes of 195 to 390 feet, there was no reaction in nearly 75 percent of the 220 observations. Ninety percent displayed no reaction or merely looked toward the direction of the noise source. Another 6 percent stood up, 3 percent walked from the nest, and 2 percent flushed (but were without active nests) and returned within 5 minutes (Kushlan 1978). Apparently, non-nesting wading birds had a slightly higher incidence of reacting to overflights than nesting birds. Seagulls observed roosting near a colony of wading birds in another study remained at their roosts when subsonic aircraft flew overhead (Burger 1981). Colony distribution appeared to be most directly correlated to available wetland community types and was found to be distributed randomly with respect to military training routes. These results suggest that wading bird species presence was most closely linked to habitat availability and that they were not affected by low-level military overflights (U.S. Air Force 2000).

Burger (1986) studied the response of migrating shorebirds to human disturbance and found that shorebirds did not fly in response to aircraft overflights, but did flush in response to more localized intrusions (i.e., humans and dogs on the beach). Burger (1981) studied the effects of noise from JFK Airport in New York on herring gulls that nested less than 1 kilometer from the airport. Noise levels over the nesting colony were 85 to 100 dBA on approach and 94 to 105 dBA on takeoff. Generally, there did not appear to be any prominent adverse effects of subsonic aircraft on nesting, although some birds flushed when the concorde flew overhead and, when they returned, engaged in aggressive behavior. Groups of gulls tended to loaf in the area of the nesting colony, and these birds remained at the roost when the Concorde flew overhead. Up to 208 of the loafing gulls flew when supersonic aircraft flew overhead. These birds would circle around and immediately land in the loafing flock (U.S. Air Force 2000).

In 1970, sonic booms were potentially linked to a mass hatch failure of Sooty Terns on the Dry Tortugas (Austin, et al. 1970). The cause of the failure was not certain, but it was conjectured that sonic booms from military aircraft or an overgrowth of vegetation were factors. In the previous season, Sooties were observed to react to sonic booms by rising in a “panic flight,” circling over the island, then usually settling down on their eggs again. Hatching that year was normal. Following the 1969 hatch failure, excess vegetation was cleared and measures were taken to reduce supersonic activity. The 1970 hatch appeared to proceed normally. A colony of Noddies on the same island hatched successfully in 1969, the year of the Sooty hatch failure.

Subsequent laboratory tests of exposure of eggs to sonic booms and other impulsive noises (Bowles, et al. 1991a; Bowles, et al. 1994; Cottereau 1972; Cogger and Zegarra 1980) failed to show adverse effects on hatching of eggs. A structural analysis (Ting, et al. 2002) showed that, even under extraordinary circumstances, sonic booms would not damage an avian egg.

Burger (1981) observed no effects of subsonic aircraft on herring gulls in the vicinity of JFK International Airport. The Concorde aircraft did cause more nesting gulls to leave their nests (especially in areas of higher density of nests), causing the breakage of eggs and the scavenging of eggs by intruder prey. Clutch sizes were observed to be smaller in areas of higher-density nesting (presumably due to the greater tendency for panic flight) than in areas where there were fewer nests.

3.8.3 Fish, Reptiles, and Amphibians

The effects of overflight noise on fish, reptiles, and amphibians have been poorly studied, but conclusions regarding their expected responses have involved speculation based upon known physiologies and behavioral traits of these taxa (Gladwin, et al. 1988). Although fish do startle in response to low-flying aircraft noise, and probably to the shadows of aircraft, they have been found to habituate to the sound and overflights. Reptiles and amphibians that respond to low frequencies and those that respond to ground vibration, such as spadefoots (genus Scaphiopus), may be affected by noise. Limited information is available on the effects of short-duration noise events on reptiles. Dufour (1980) and Manci, et al. (1988), summarized a few studies of reptile responses to noise. Some reptile species tested under laboratory conditions experienced at least temporary threshold shifts or hearing loss after exposure to 95 dB for several minutes. Crocodilians in general have the most highly developed hearing of all reptiles. Crocodile ears have lids that can be closed when the animal goes under water. These lids can reduce the noise intensity by 10 to 12 dB (Wever and Vernon 1957). On Homestead Air Reserve Station, Florida, two crocodilians (the American Alligator and the Spectacled Caiman) reside in wetlands and canals along the base runway suggesting that they can coexist with existing noise levels of an active runway including DNLs of 85 dB.

3.8.4 Summary

Some physiological/behavioral responses such as increased hormonal production, increased heart rate, and reduction in milk production have been described in a small percentage of studies. A majority of the studies focusing on these types of effects have reported short-term or no effects.

The relationships between physiological effects and how species interact with their environments have not been thoroughly studied. Therefore, the larger ecological context issues regarding physiological effects of jet aircraft noise (if any) and resulting behavioral pattern changes are not well understood.

Animal species exhibit a wide variety of responses to noise. It is therefore difficult to generalize animal responses to noise disturbances or to draw inferences across species, as reactions to jet aircraft noise appear to be species-specific. Consequently, some animal species may be more sensitive than other species and/or may exhibit different forms or intensities of behavioral responses. For instance, wood ducks appear to be more sensitive and more resistant to acclimation to jet aircraft noise than Canada geese in one study. Similarly, wild ungulates seem to be more easily disturbed than domestic animals.

The literature does suggest that common responses include the “startle” or “fright” response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the numbers and frequencies of exposures, suggesting no long-term adverse effects. The majority of the literature suggests that domestic animal species (cows, horses, chickens) and wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms.

Animal responses to aircraft noise appear to be somewhat dependent on, or influenced by, the size, shape, speed, proximity (vertical and horizontal), engine noise, color, and flight profile of planes. Helicopters also appear to induce greater intensities and durations of disturbance behavior as compared to fixed-wing aircraft. Some studies showed that animals that had been previously exposed to jet aircraft noise exhibited greater degrees of alarm and disturbance to other objects creating noise, such as boats, people, and objects blowing across the landscape. Other factors influencing response to jet aircraft noise may include wind direction, speed, and local air turbulence; landscape structures (i.e., amount and type of vegetative cover); and, in the case of bird species, whether the animals are in the incubation/nesting phase.

3.9 Property Values

Property within a noise zone (or Accident Potential Zone) may be affected by the availability of federally guaranteed loans. According to U.S. Department of Housing and Urban Development (HUD), Federal Housing Administration (FHA), and Veterans Administration (VA) guidance, sites are acceptable for program assistance, subsidy, or insurance for housing in noise zones of less than 65 dB DNL, and sites are conditionally acceptable with special approvals and noise attenuation in the 65 to 75 dB DNL noise zone and the greater than 75 dB DNL noise zone. HUD's position is that noise is not the only determining factor for site acceptability, and properties should not be rejected only because of airport influences if there is evidence of acceptability within the market and if use of the dwelling is expected to continue. Similar to the Navy's and Air Force's Air Installation Compatible Use Zone Program, HUD, FHA, and VA recommend sound attenuation for housing in the higher noise zones and written disclosures to all prospective buyers or lessees of property within a noise zone (or Accident Potential Zone).

Newman and Beattie (1985) reviewed the literature to assess the effect of aircraft noise on property values. One paper by Nelson (1978), reviewed by Newman and Beattie, suggested a 1.8 to 2.3 percent decrease in property value per decibel at three separate airports, while at another period of time, they found only a 0.8 percent devaluation per decibel change in DNL. However, Nelson also noted a decline in noise depreciation over time which he theorized could be due to either noise sensitive people being replaced by less sensitive people or the increase in commercial value of the property near airports; both ideas were supported by Crowley (1978). Ultimately, Newman and Beattie summarized that while an effect of noise was observed, noise is only one of the many factors that is part of a decision to move close to, or away from, an airport, but which is sometimes considered an advantage due to increased opportunities for employment or ready access to the airport itself. With all the issues associated with determining property values, their reviews found that decreases in property values usually range from 0.5 to 2 percent per decibel increase of cumulative noise exposure.

More recently Fidell, et al. (1996) studied the influences of aircraft noise on actual sale prices of residential properties in the vicinity of two military facilities and found that equations developed for one area to predict residential sale prices in areas unaffected by aircraft noise worked equally well when applied to predicting sale prices of homes in areas with aircraft noise in excess of 65 dB DNL. Thus, the model worked equally well in predicting sale prices in areas with and without aircraft noise exposure. This indicates that aircraft noise had no meaningful effect on residential property values. In some cases, the average sale prices of noise exposed properties were somewhat higher than those elsewhere in the same area. In the vicinity of Davis-Monthan AFB in Tucson, AZ, Fidell found the homes near the AFB were much older, smaller and in poorer condition than homes elsewhere. These factors caused the equations developed for predicting sale prices in areas further away from the base to be inapplicable with those nearer the AFB. However, again Fidell found that, similar to other researchers, differences in sale prices between homes with and without aircraft noise were frequently due to factors other than noise itself.

3.10 Noise Effects on Terrain

It has been suggested that noise levels associated with low-flying aircraft may affect the terrain under the flight path by disturbing fragile soil or snow, especially in mountainous areas, causing landslides or avalanches. There are no known instances of such effects, and it is considered improbable that such effects would result from routine, subsonic aircraft operations.

3.11 Noise Effects on Historical and Archaeological Sites

Because of the potential for increased fragility of structural components of historical buildings and other historical sites, aircraft noise may affect such sites more severely than newer, modern structures. Particularly in older structures, seemingly insignificant surface cracks initiated by vibrations from aircraft noise may lead to greater damage from natural forces (Hanson, et al. 1991). There are few scientific studies of such effects to provide guidance for their assessment.

One study involved the measurements of sound levels and structural vibration levels in a superbly restored plantation house, originally built in 1795, and now situated approximately 1,500 feet from the centerline at the departure end of Runway 19L at Washington Dulles International Airport. These measurements were made in connection with the proposed scheduled operation of the Concorde airplane at Dulles (Wesler 1977). There was special concern for the building's windows, since roughly half of the 324 panes were original. No instances of structural damage were found. Interestingly, despite the high levels of noise during Concorde takeoffs, the induced structural vibration levels were actually less than those induced by touring groups and vacuum cleaning.

As noted above for the noise effects of noise-induced vibrations of conventional structures, assessments of noise exposure levels for normally compatible land uses should also be protective of historic and archaeological sites.

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