Range Air Installations Compatible Use Zones Study for the Pinecastle Range Complex

Final – September 2017

Prepared for:
United States Department of the Navy
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RANGE AIR INSTALLATIONS COMPATIBLE USE ZONES STUDY

FOR THE

PINECASTLE RANGE COMPLEX

FINAL – SEPTEMBER 2017

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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The purpose of the United States Department of the Navy (Navy) Range Air Installations Compatible Use Zones (RAICUZ) Program is to achieve compatibility between the existing and proposed land uses and airspace in the vicinity of air-to-ground ranges. The RAICUZ Program's goal is to protect the public health, safety, and welfare of those living near air-to-ground training ranges while preserving military operational capabilities. A RAICUZ Study is a planning document for the Navy to use when working with government entities to adopt programs, policies, and regulations that support the Navy's mission and encourage compatible development within the vicinity of military training ranges. RAICUZ studies analyze community development trends, land use tools, and range installation mission requirements to develop recommendations for compatible land use.

The scope of the RAICUZ Study includes an analysis of the Pinecastle Range Complex's (PRC) existing (Fiscal Year [FY] 2013) and projected (FY2020) range utilization, Special Use Airspace (SUA), Military Training Routes (MTRs), aircraft noise, aerial gunnery noise, and Range Compatibility Zones (RCZs). The RAICUZ Study also provides an analysis of existing and projected land use compatibility within the noise zones and RCZs and recommendations for compatible development.

ES.2 Pinecastle Range Complex: Range and Restricted Airspace Operations

The PRC's ranges consists of two land ranges and one freshwater range in North Central Florida: Pinecastle Range, Rodman Range, and Lake George Range, respectively. These facilities are located in and around Ocala National Forest (ONF) within a four-county region, approximately 75 miles south of Naval Air Station (NAS) Jacksonville. The PRC (Pinecastle, Rodman, and Lake George ranges) is part of the larger Jacksonville Range Complex, which offers a variety of air, land, and open ocean training venues in support of operating forces and research, development, test, and evaluation (RDT&E) in the southeast region.

The primary mission of the PRC is to train U.S. Department of the Navy (Navy) and U.S. Marine Corps (Marine Corps) personnel in the delivery of air-to-ground ordnance. Additionally, the PRC is also used by the U.S. Air Force (Air Force), U.S. Coast Guard (Coast Guard), Air National Guard, and other federal and state agencies and law enforcement organizations. The PRC is a critical training complex and includes Pinecastle Range, the Navy's only air-to-ground range on the East Coast that allows high explosives. The PRC is an integral part of the Navy's East Coast Virtual Training Range, which supports all U.S. Atlantic Fleet intermediate and advanced training requirements including Composite Training Unit Exercises, Sustainment Exercises, Fleet Exercises, and carrier and expeditionary strike group training.

The PRC supports its users by permitting strike warfare training through the delivery of air-to-ground explosive and non-explosive ordnance and air-to-ground gunnery (strafing). Strike warfare addresses combat activities by air and surface forces against hostile land-based forces and assets.

In addition to air-to-ground training, the PRC also supports various training activities that may incorporate a ground-based element supporting the mission. These scenarios are pre-coordinated events with the Range Department and, after conducting a Range Safety Brief, may be allowed to operate downrange in different locations throughout the PRC.

ES.3 Range Compatibility Zones

An analysis of potential safety hazards related to the air-to-ground and ground-to-ground training activities that occur at the PRC was conducted. To aid in land use compatibility analyses, the RAICUZ Study presents RCZs associated with the various live-fire training operations at the PRC.

RCZs define the area with potential safety hazards from weapon/ordnance delivery and designates the surface area and/or airspace needed to protect public health, safety, and welfare from live-fire training operations. To define the areas with potential safety hazards, the RCZs translate live-fire ammunition and ordnance training activities into land areas that can then be evaluated for land use compatibility and recommendations for compatible land use. Each RCZ has specific recommended guidelines related to the land uses. RCZs were developed for the PRC and were used to conduct the land use compatibility analysis for the RAICUZ Study.

There are three RCZs related to live-fire activities at the ranges: RCZ-I, RCZ-II, and RCZ-III:

- RCZ-I defines the area of the greatest potential safety hazard and designates the minimum range surface area needed to contain all ordnance delivered/deployed at the respective range. RCZ-I is the sum, or composite, of all individual Weapon Danger Zones (WDZs) and Surface Danger Zones (SDZs) generated for a particular range. Because this area depicts the space required for containment of projectiles, fragments, and debris from weapon systems, it is the most restrictive area in terms of land use compatibility and poses the greatest potential for safety concerns.

- RCZ-II defines the area of aircraft armed over-flight whereby an aircraft commits to the target attack. The period of armed over-flight applies only 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 and is identified as the area that could be impacted by ordnance, if inadvertently released, following activation of the arming switch.

- RCZ-III defines the minimum airspace within the designated SUA required for maneuvering into and out of the air-to-ground target area, outside of the areas designated as RCZ-I and RCZ-II. RCZ-III is the area required to provide access to and from the target, safely separate participating and non-participating aircraft, and provide the range user with tactical maneuvering room allowing for initial alignment for target acquisition. While RCZ-III correlates to required airspace, it is the land underlying the airspace that is considered for safety reasons. RCZ-III represents the least restrictive area associated with a range that requires land use compatibility measures.

ES.4 Noise Analysis

Noise contours provide an installation, local community planning organizations, and the public with maps of the modeled noise-related impacts from aircraft operations and ordnance events. Noise contours, when overlaid with local land uses, can help identify the compatibility of these land uses and assist in planning for future development around a range.

The primary sources of operational data used for the noise analysis are the training and readiness manual, interviews with aircrews and range personnel, and annual reports. Department of Defense (DOD) computer-based programs were used for analysis of aircraft, ordnance, and small arms weapon fire noise exposure and compatible land uses. Each model focused on a different area or source of noise. Major sources of noise at the PRC include rotary-wing and fixed-wing aircraft involved in air warfare, electronic combat, strike warfare, and insertion/extraction training activities, as well as impulsive events associated with live-fire activities.

Noise contours are visually depicted as a contour line that connects points of equal value. The land use compatibility analysis and land use recommendations are based on these noise exposure levels, or "noise zones," and each zone has recommended guidelines for land use compatibility. The operations modeled and resultant noise contours were used to conduct the land use compatibility analysis for the RAICUZ Study

ES.5 Planning Authorities and Land Use Compatibility

The major elements in a RAICUZ Study are noise zones and RCZs, which collectively make up the RAICUZ footprint. The RAICUZ footprint for the PRC was developed by combining the RCZs and the noise zones. The RAICUZ footprint defines the minimum area within which land use controls are recommended to protect public health, safety, and welfare, while maintaining the viability of the range and associated training. The Navy has developed recommended guidelines for compatible development and land use within a range's noise zones and RCZs. These land use guidelines are provided in the RAICUZ Instruction (Office of the Chief of Naval Operations Instruction [OPNAVINST] 3550.1A). The land use compatibility analysis provided in the RAICUZ Study is based on the assessment of existing and future land use in the vicinity of the PRC.

The PRC RAICUZ footprint is located in the jurisdictions of Marion, Putnam, Volusia, and Lake counties. The local governments manage land use and future growth through zoning regulations, land use 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.

ES.6 Land Use Tools and Recommendations

The goal of the Navy RAICUZ Program can most effectively be accomplished by the active participation of all interested parties. Federal, state, regional, and local governments, businesses, real estate professionals, and citizens, along with the Navy, all play key roles in successfully implementing the RAICUZ land use compatibility study.

The RAICUZ Study assists the PRC in collaborating with local communities to promote compatible land uses by depicting the locations of RCZs and identifying any land uses that are currently incompatible, as well as those areas that could be incompatible in the future. Specific tools and recommendations are provided for various stakeholders (i.e., the federal government, state government, regional planning organizations, local government, private citizens, real estate professionals, and local businesses). While some incompatible land uses and areas of compatability concern were identified within the RAICUZ footprint, continued execution of the current mitigation policies and tools and implementation of the recommended measures identified in the RAICUZ would effectively manage compatibility concerns in these areas.

The Navy has the responsibility to communicate and collaborate with local governments on land use planning, zoning, and compatibility concerns that can affect its mission. Fleet Area Control and Surveillance Facility Jacksonville (FACSFACJAX) is responsible for informing and educating community decision makers about the RAICUZ Program; however, local governments should continue to actively inform and request input from FACSFACJAX regarding land use decisions that could impact the readiness of the PRC. Local governments have the authority to implement regulations and programs to control development and direct growth to ensure land use activities are compatible with range operations. Local governments should recognize their responsibility in providing land use control in areas encumbered by the RAICUZ footprint by incorporating RAICUZ information into their planning policies and regulations. Mutual cooperation between the PRC and neighboring communities is key to the RAICUZ Program's success.

There are numerous land use tools available for the various stakeholders that each could consider for implementation. Each land use tool and recommendation, when implemented, could reduce the overall compatibility concerns at the PRC. Minimizing current

compatibility concerns and alleviating future concerns involves active participation from several stakeholders often implementing one or more of the recommendations that address a specific area or a broader area of concern. Managing compatibility concerns is an ongoing process that requires monitoring, maintenance, and targeted planning.

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ACRONYMS AND ABBREVIATIONS

ACC	Area of Critical Concern
ADNL	A-weighted day-night average sound level
Air Force	U.S. Air Force
ANVIS-HUD	Aviator Night Vision Imaging Systems Heads Up Display
AR	Army Regulation
Army	U.S. Department of the Army
ATCAA	Air Traffic Control Assigned Airspace
BNOISE	Blast Noise (noise model)
BOCC	Board of County Commissioners
CDNL	C-weighted day-night average sound level
Coast Guard	U.S. Coast Guard
COMUSFLTFORCOMINST	Commander, United States Fleet Forces Command Instruction
CPLO	Community Planning and Liaison Officer
dB	decibel
dBA	A-weighted decibels
dBC	C-weighted decibels
DNL	day-night average sound level
DOD	Department of Defense
FAA	Federal Aviation Administration
FACSFACJAX	Fleet Area Control and Surveillance Facility Jacksonville
FACSFACJAXINST	Fleet Area Control and Surveillance Facility Jacksonville Instruction
FDEP	Florida Department of Environmental Protection
FLUCCS	Florida Land Use, Cover, and Forms Classification System
F.S.	Florida Statute
FY	Fiscal Year
GPS	global positioning system
HUD	U.S. Department Housing and Urban Development
I-	Interstate
IFR	Instrument Flight Rules

ISR	intelligence, surveillance, and reconnaissance
L_{eq}	equivalent average sound level
L_{max}	maximum sound level
Marine Corps	U.S. Marine Corps
MCO	Marine Corps Order
mm	millimeter
MOA	Military Operating Area
MR_NMAP	Military Operating Area Range NoiseMap
MTR	Military Training Route
NAS	Naval Air Station
Navy	U.S. Department of the Navy
NEPA	National Environmental Policy Act
ONF	Ocala National Forest
OPNAVINST	Office of the Chief of Naval Operations Instruction
PK_{15}	Single Event Peak Level Exceeded by 15 Percent of Events (sound)
PRC	Pinecastle Range Complex
R-	Restricted Area
RAICUZ	Range Air Installations Compatible Use Zones
RCZ	Range Compatibility Zone
RDT&E	research, development, test, and evaluation
REPI	Readiness and Environmental Protection Integration
SARNAM	Small Arms Range Noise Assessment Model
SDZ	Surface Danger Zone
SEL	sound exposure level
SR	State Route
SUA	Special Use Airspace
U.S.C.	United States Code
USDA	U.S. Department of Agriculture
VFR	Visual Flight Rules
WDZ	Weapon Danger Zone

1 INTRODUCTION

Pinecastle Range, part of the PRC, is the only air-to-ground range on the East Coast that allows high explosives.

The Pinecastle Range Complex (PRC), located in North Central Florida, consists of two land ranges and one freshwater range: Pinecastle Range, Rodman Range, and Lake George Range, respectively. The PRC is a critical training complex and includes the Pinecastle Range, the Navy's only air-to-ground range on the East Coast that allows high explosives. The PRC is an integral part of the U.S. Department of the Navy's (Navy's) East Coast Virtual Training Range, which supports all U.S. Atlantic Fleet intermediate and advanced training in preparation for deployment. The primary mission of the PRC is to train Navy and U.S. Marine Corps (Marine Corps) personnel in the delivery of air-to-ground ordnance. Additionally, the PRC is currently utilized for ground-to-ground small arms qualifications and weapons familiarization training. The PRC is also used by the U.S. Air Force (Air Force), U.S. Coast Guard (Coast Guard), Air National Guard, and other federal and state agencies and law enforcement organizations. The PRC regularly supports training for installations located in Florida, Georgia, North Carolina, South Carolina, and Virginia.

1.1 RAICUZ PROGRAM

This Range Air Installations Compatible Use Zones (RAICUZ) Study has been prepared in accordance with guidelines outlined in the joint Navy and Marine Corps instruction titled "*Office of the Chief of Naval Operations Instruction (OPNAVINST) 3550.1A and Marine Corps Order (MCO) 3550.11, Range Air Installations Compatible Use Zones (RAICUZ) Program*," dated January 28, 2008. The RAICUZ Instruction provides guidance for assessing noise exposure, safety concerns, and compatibility of air-to-ground range operations with surrounding land uses.

To assess compatibility of the ground-to-ground operations that also occur at the PRC, the Navy used the noise methodology and standards set forth in U.S. Department of the Army (Army) Regulation (AR) 200-1, "*Environmental Protection and Enhancement*," dated December 13, 2007.

A RAICUZ Study is a planning document that shows the modeled effects of aircraft noise, ordnance noise, WDZs, and SDZs to assess the compatibility of range operations and surrounding land uses.

The Navy's RAICUZ Program is designed to protect public health, safety, and welfare, and to minimize incompatible land uses and activities from degrading the operational capability of air-to-ground ranges. The RAICUZ Program includes guidance on range safety and noise analyses for air-to-ground operations, and provides land use recommendations that are compatible with Range Compatibility Zones (RCZs) and noise levels associated with military range operations. Following RAICUZ methodology, RCZs are modeled and presented within a RAICUZ Study to define the area with potential safety hazards from weapons/ordnance delivery and designate the surface area and/or airspace needed to protect public health, safety, and welfare from live-fire training operations. To aid in land use compatibility analyses, this RAICUZ Study presents RCZs and Noise exposure zones, or "noise zones," associated with the various live-fire training operations at the PRC.

For the purposes of this RAICUZ Study, "live-fire" operations consist of any training activities that involve the release of ordnance or the use of ammunition that fires a projectile. These can range from low-energy Special Effects Small Arms Marking System projectiles, also referred to as "simunitions," to shotgun and ball ammunition.

The RAICUZ Program recommends that noise contours, RCZs, height and obstruction requirements, and associated land use recommendations be incorporated into local community planning to reduce incompatibilities and ensure operational capabilities of the range. As the communities that surround an air-to-ground range grow and develop, the Navy has the responsibility to communicate and collaborate with local governments regarding land use planning. Cooperation between ranges and neighboring communities serves to increase public awareness of the importance of air-to-ground ranges and the need to address mission requirements and associated noise and risk factors.

1.2 PURPOSE, SCOPE, AND OBJECTIVES

1.2.1 Purpose

The RAICUZ Study is a planning document. The purpose of the Study is to disclose the projected future range operations at the PRC, associated noise exposure areas and areas of safety concerns, and compatible land use recommendations.

1.2.2 Scope

The scope of this RAICUZ Study includes an analysis of the PRC's existing (Fiscal Year [FY] 2013) and projected (FY2020) range utilization, which includes not only air-to-ground ordnance training and flight operations, but also ground-to-ground live-fire training at the PRC.

1.2.3 Objective

The primary objectives of the RAICUZ Program are as follows:

- Precluding public exposure to hazards and noise associated with air-to-ground ranges;
- Protecting Navy and Marine Corps investments by safeguarding the current and potential operations capabilities of those ranges;

The objective of the RAICUZ Program is to achieve compatibility between the A-G ranges, existing and projected land use, and airspace in the vicinity of the ranges.

- Promoting compatible land use near air-to-ground ranges;
- Informing the public about the RAICUZ Program and seeking cooperative efforts to minimize potential safety and noise impacts in the vicinity of the air-to-ground ranges; and
- Establishing working relationships between the installation and appropriate local, regional, and state community councils, commissions, Native American tribes, and planning and zoning departments in order to communicate proposed actions that could affect public health, safety, and welfare, as well as operational and training capabilities and compatible land use recommendations.

In meeting the objectives of the RAICUZ Program, this RAICUZ Study will support the program by:

- Fulfilling Department of Defense (DOD) and Navy requirements to disclose projected operations and identify land uses and activities that are incompatible with military training operations at the PRC;
- Promoting compatible development and land uses within the high-noise exposure areas;
- Minimizing exposure of Navy personnel and civilians to safety hazards associated with air-to-ground and ground-to-ground training operations; and
- Providing a reference document to be used in conjunction with other land use planning studies and for promoting land use compatibility in future development near the PRC.

1.2.4 Document Organization

This RAICUZ Study is organized into the following chapters:

- Chapter 1: Provides background information on the RAICUZ Program and this RAICUZ Study;
- Chapter 2: Describes the location and history of the PRC, as well as the installation's mission, training operations, and operational areas;
- Chapter 3: Discusses range safety and the development of RCZs;
- Chapter 4: Outlines the methodology for development of noise contours and discusses measures the Navy has implemented to mitigate any community noise concerns;
- Chapter 5: Evaluates the compatibility of existing and projected surrounding land uses with range operations; and
- Chapter 6: Provides recommendations for promoting land use compatibility consistent with the goals of the RAICUZ Program.

1.3 Responsibilities for Compatible Land Use

The RAICUZ Program promotes compatible land use development around military ranges through mutual cooperation and engagement with the community. Therefore, ensuring land use compatibility near a range is a collaborative effort by many organizations

and groups (e.g., DOD, Navy, local naval installation command, state and local governments, planning and zoning agencies, developers, real estate agencies, and residents).

State and local governments have the responsibility to protect public health, safety, and welfare. The Navy has similar responsibilities, while concurrently preserving the mission and operations of the range. The Navy actively works with state and local government agencies to engage and inform the local communities throughout the process of developing and implementing compatible land use recommendations that minimize noise impacts and the potential for accidents around ranges. While the military can advise local government agencies on land use near the range by providing information on aircraft noise and safety hazards, it is the state and local government agencies that have the authority to preserve land use compatibility through the adoption and implementation of appropriate control measures recommended in this RAICUZ Study.

The Navy can provide recommendations on land use; however, local leaders must take the necessary actions to help ensure land use compatibility near the range.

Cooperative action by all parties is essential in promoting compatible land use and deterring potential hazards. Chapter 6, Land Use Tools and Recommendations, discusses the Navy's compatible land use tools and recommendations in more detail.

1.3.1 Federal Authority

The authority for establishing and implementing the RAICUZ Program, guidance on assessing operational noise, and the guidance on range operations and procedures for the PRC are derived from:

- OPNAVINST 3550.1A/ MCO 3550.11, "*Range Air Installations Compatible Use Zones (RAICUZ) Program*," January 28, 2008;
- AR 200-1, Environmental Protection and Enhancement, December 13, 2007;
- Fleet Area Control and Surveillance Facility, Jacksonville Instruction (FACSFACJAXINST) 3000.1F, "*Operations Manual;*"
- Commander, United States Fleet Forces Command Instruction (COMUSFLTFORCOMINST) 3550.1, "*Weapon Danger Zone (WDZ) Program Procedures and Guidelines*," January 7, 2013;
- PRC Handbook version 6.8, October 2, 2013;
- DOD Flight Information Publication AP/1B, "*Area Planning – Military Training Routes: North and South America;*" and

- Federal Aviation Administration (FAA) Air Traffic Organization Policy, Order JO 7400.8Z, "*Special Use Airspace,*" February 2, 2017.

1.3.2 State Authority

The State of Florida has policies and agencies in place to help manage growth, as well as manage and protect the environment surrounding the PRC. The Florida Department of Environmental Protection (FDEP) is one of the state's lead agencies for environmental stewardship management. The FDEP oversees Florida's state parks and trails and works to protect air, water, and land through ecosystem enhancement and natural resource protection.

1.3.3 Local Government Authority

Regulation of land use in the communities that surround the PRC is a responsibility of the local government planning agencies, including Putnam, Marion, Lake, and Volusia counties. These agencies make decisions that protect the health, safety, and welfare of their residents that live outside of the ranges' fence line. Tools used by the local planning authorities to regulate development and ensure land use compatibility in the ranges' operational areas include zoning ordinances, comprehensive plans, and building code adoption and enforcement.

1.4 Previous RAICUZ Efforts and Related Studies

This is the first official RAICUZ Study for the PRC. Numerous other studies and reports have been completed for the training activities at the PRC. The following documents supported the preparation of this RAICUZ Study:

- "*RAICUZ Noise Study for Pinecastle Range Complex*" (BRRC 2017);
- "*Safety Study for the Pinecastle Range Complex*" (Navy 2017a);
- "*Final Environmental Assessment Addressing the Expansion of the Pinecastle Range Complex Restricted Area*" (Navy 2012); and
- "*Final Supplemental Environmental Impact Statement to the Final Environmental Impact Statement for Renewal of Authorization to Use Pinecastle Range*" (Navy 2010).

1.5 CHANGES THAT REQUIRE A RAICUZ STUDY

OPNAVINST 3550.1A dictates that each Navy and Marine Corps air-to-ground range shall have a RAICUZ Study. This RAICUZ Study meets this requirement and, additionally, will update the Pinecastle RCZs from those presented in the Final Supplemental Environmental Impact Statement to the Final Environmental Impact Statement for Renewal of Authorization to Use Pinecastle Range (Navy 2010).

OPNAVINST 3550.1A recommends that a RAICUZ Study be updated as necessary to account for new aircraft, weapons, and/or tactics.

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Chapter 2

2 RANGE AND RESTRICTED AIRSPACE OPERATIONS

2.1 LOCATION AND HISTORY

The PRC's ranges consists of two land ranges and one freshwater range in North Central Florida: Pinecastle Range, Rodman Range, and Lake George Range, respectively. These facilities are located in and around Ocala National Forest (ONF) within a four-county region, approximately 75 miles south of Naval Air Station (NAS) Jacksonville (Figure 2-1). NAS Jacksonville manages and maintains the physical resources of the PRC, while Fleet Area Control and Surveillance Facility, Jacksonville (FACSFACJAX) is the principal scheduling authority for the three ranges and maintains operational and administrative command. All range activities are coordinated through the Centroid Facility, which is located a short distance from the northeast corner of Pinecastle Range.


Centroid Facility

Pinecastle Range, Rodman Range, and Lake George Range provide a variety of targets for the delivery of explosive and inert (non-explosive) air-to-ground ordnance, which provide realistic air-to-ground weapons delivery training, an integral component of the Navy's training program that prepares combat squadrons for deployment. The ranges also support integrated group training exercises conducted by the U.S. Atlantic Fleet, including Composite Training Unit Exercises, Sustainment Exercises, Fleet Exercises, and carrier and expeditionary strike group training.

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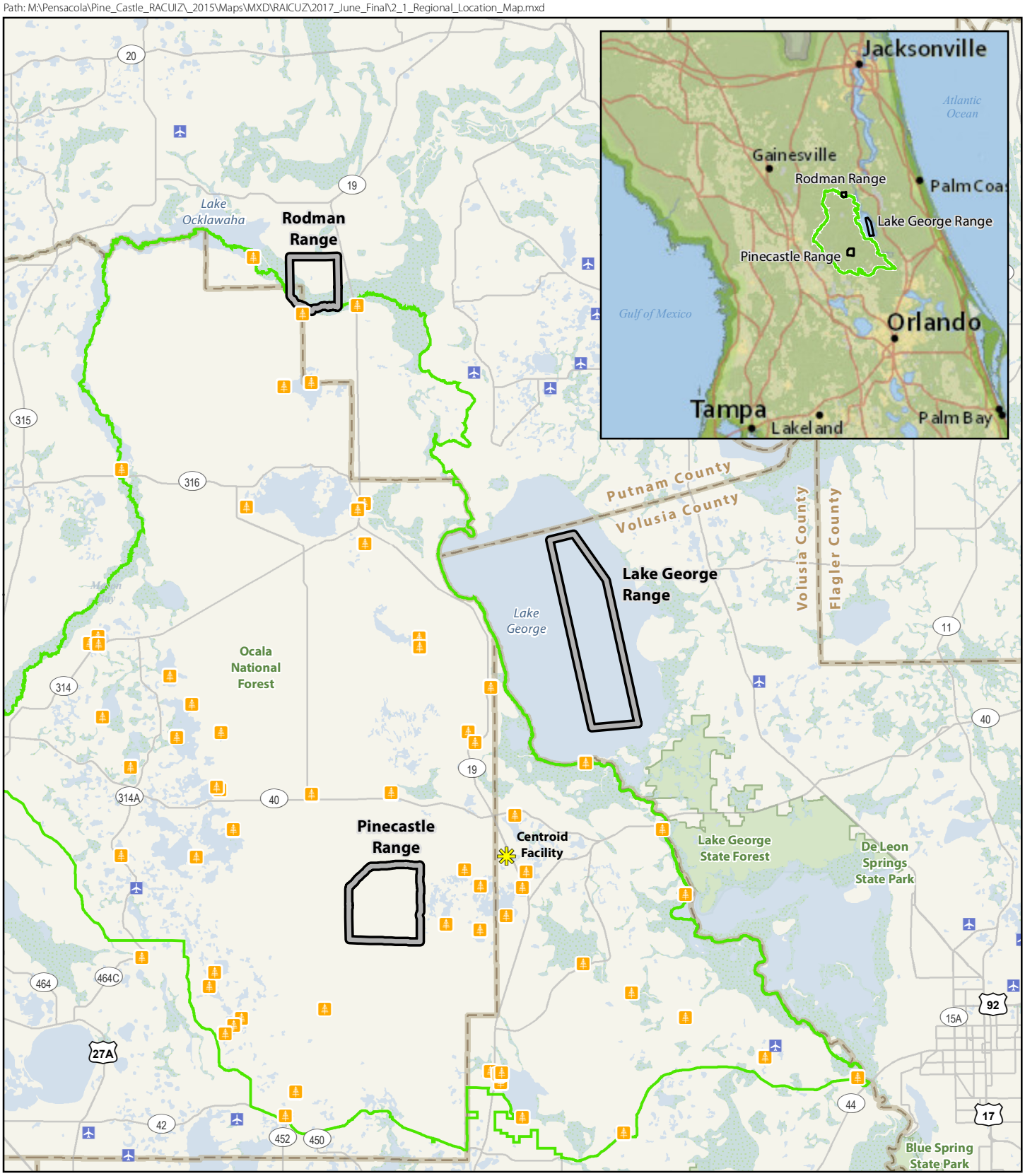

SCALE

0 2 4 Miles

SOURCE: ESRI 2010; FAA 2012; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2016.

Legend

- Range Boundary
- Centroid Facility
- Airport
- Recreation Site (includes camping)
- Major Highway
- County Boundary
- Water
- Wetland
- State Park/Forest
- Ocala National Forest

Figure 2-1

Regional Location

Pinecastle Range Complex
Ocala National Forest
Lake, Marion, Putnam, and Volusia Counties, Florida

2.1.1 Pinecastle Range

Pinecastle Range is located approximately 75 miles south of NAS Jacksonville, in Marion County, Florida (Figure 2-3). The range is accessible from the north and south by State Route (SR) 19 and from the east and west by SR 40. The range is entirely surrounded by U.S. Department of Agriculture (USDA) Forest Service land that is part of the 383,000-acre ONF, which supports timber harvesting and management and recreational activities including hiking, camping, hunting, and fishing.


Pinecastle Range

In the early 1940s, the War Department acquired use of 40,587 acres of ONF for the Lake Bryant Bombing and Gunnery Range used by the U.S. Army Air Forces Command. The site was used for practice bombing, ground gunnery, and rocket missions. Following World War II, the War Department determined the entire site was no longer required and it was transferred to the U.S. Department of Agriculture (USDA) by letter of transfer dated May 20, 1947. Several years later, the Navy reacquired the use of a central portion of the original Lake Bryant Bombing and Gunnery Range. The area, renamed the Pinecastle Range, has been in continuous operation by the Navy since August 2, 1951, under various agreements between the Navy and the USDA.

Today, Pinecastle Range consists of approximately 5,698 acres of land leased by the Navy from the USFS under a special use permit (USDA Forest Service 2002) and Annual Operating Plan (Navy 2017c). The current special use permit, which was established in 2002, is valid through 2022. The permit specifies the roles and responsibilities for the use, operation, and maintenance of Pinecastle Range, as agreed to by both organizations. Pinecastle Range is considered a Special Administration Management Area within ONF, as designated in the Revised Land and Resource Management Plan, which also acknowledges its dedicated use as a bombing range (USDA Forest Service 1999). The Land and Resource Management Plan was most recently published in 1999; however, the USDA Forest Service routinely incorporates amendments related to land management (Navy 2012).

The primary mission of Pinecastle Range is to support strike warfare training. The range provides a realistic training environment for Navy and Marine Corps pilots and navigators to develop proficiency in delivering air-to-ground munitions (Naval Facilities Engineering Command, Southeast 2011).

2.1.2 Lake George Range

Lake George Range is approximately 69 miles south of Jacksonville, Florida, and 29 miles west of the Atlantic Coast, in Volusia County, Florida (Figure 2-4). Lake George Range is located within the confines of Lake George (a wide segment of the St. Johns River) that borders the eastern side of the ONF. The range covers approximately 8,960 acres of the lake's approximately 46,000-acre surface area.


Lake George

Lake George is managed by the FDEP and the St. John's River Water Management District. Although the State of Florida retains jurisdiction over lake waters, military operations are authorized through a Sovereignty Submerged Land Letter of Consent (FDEP 2014), which was renewed in 2014 indefinitely.

2.1.3 Rodman Range

Rodman Range is approximately 58 miles south of Jacksonville, Florida, and 40 miles west of the Atlantic Coast (Figure 2-5). The range comprises approximately 2,690 acres of Navy-owned land. The Ocklawaha River separates the range from ONF's northern border. The range is situated south of the Caravelle Ranch Wildlife Management Area, east of Rodman Reservoir, and west of the St. Johns River in Putnam County, Florida. A small portion of the southwest corner of Rodman Range is within Marion County, Florida.


Rodman Range

In 1961, the United States acquired the lands composing the Rodman Range. After Cecil Field closed in 1999, Rodman Range continued to provide valuable service as a back-up inert ordnance bombing target for Pinecastle Range. In 1997, helicopter landing zones for combat search and rescue training were developed at Rodman Range (Navy 2012). Training exercises conducted at Rodman Range continue to focus on strike warfare and combat search and rescue training.

2.2 MISSION

The Navy's mission is to organize, train, and equip combat-ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas. This mission is mandated by federal law (10 United States Code [U.S.C.] §5062), which ensures the readiness of the United States' naval forces. The Navy executes this responsibility by establishing and executing training programs and ensuring naval forces have access to the ranges, operating areas, and airspace needed to develop and maintain skills for conducting military operations.

The PRC (Pinecastle, Rodman, and Lake George ranges) is part of the larger Jacksonville Range Complex, which offers a variety of air, land, and open ocean training venues in support of operating forces and research, development, test, and evaluation (RDT&E) in the southeast region.

The main purpose of the PRC is to provide an environment wherein aircrews may learn the proper maneuvering tactics and techniques required while delivering air-to-ground weapons to targets within a potentially hostile environment, thus enhancing the potential for increased aircrew survivability and weapons delivery accuracy (FACSFACJAX 2013). The PRC is critical to U.S. Atlantic Fleet training, as it contains the Navy's only air-to-ground range on the East Coast that allows high explosives (i.e., Pinecastle Range). The PRC is also an integral part of the Navy's East Coast Tactical Training Range Complex, which supports U.S. Atlantic Fleet pre-deployment intermediate and advanced training requirements including Composite Training Unit Exercises, Sustainment Exercises, Fleet Exercises, and carrier and expeditionary strike group training.

2.3 PINECASTLE RANGE COMPLEX OPERATIONS

The Navy is the primary user of the PRC; however the PRC supports military aviation units from the Navy, Air Force, Coast Guard, and Marine Corps, among others. The PRC supports aircraft carrier battle groups preparing for deployment and aircrews of local units needing Unit Level Training to maintain proficiency in their weapon systems by permitting strike warfare training in the delivery of air-to-ground high-explosive munitions and non-explosive practice munitions, plus air-to-ground gunnery (helicopter and fixed-wing) up to 30 millimeters (mm). The employment of explosive ordnance in naval training is essential to achieve the necessary level of proficiency in support of shore and carrier embarked ordnance breakout, buildup and loading crews, and delivery aircrew firing weapons in a high stress, realistic environment. Explosive ordnance used includes guided and unguided

air-to-ground bombs and air-to-ground rockets. Aircraft engaged in this training require adequate Restricted Area volume to minimize risks to nonparticipating aircraft and permit realistic tactical training using laser-guided missiles (Navy 2012).

2.3.1 Existing Training Operations

The PRC supports its users by permitting strike warfare training through the delivery of air-to-ground explosive and non-explosive ordnance and air-to-ground gunnery (strafing). Strike warfare addresses combat (or interdiction) activities by air and surface forces against hostile land-based forces and assets. Other existing training and testing activities conducted at the PRC are further described by range:

- Pinecastle Range: Pinecastle Range and its associated airspace are used for live ordnance training (including air-to-ground bombing), lasing, and strafing. Pinecastle Range consists of two high-explosive ordnance target areas, eight inert ordnance target areas, a strafe pit with three different target areas, and a laser target that can be scored (Navy 2017b). Overall, Pinecastle Range has 17 unique targets or target areas. In addition, the USDA Forest Service helicopter base is within Pinecastle Range. This helicopter base is used by the USDA Forest Service and the Navy. Under the Navy-USDA Forest Service Annual Operating Plan, when air-delivered ordnance training is scheduled at the range under authorized conditions, an air support helicopter is dispatched to suppress any wildfires. Aerial lasing operations occur at the Pinecastle Range and are directed only at certified laser targets on the ground. These operations only include laser targeting; weaponized lasers are not used. Lasing can occur in combination with bombing operations or alone. Laser operations at the PRC are conducted in accordance with applicable procedures (Navy 2012).
- Lake George Range: Lake George Range is used for sea search-and-rescue training and mine warfare exercises in Lake George. In the late 1960s, Lake George became the only electronic warfare range on the East Coast with approved use of flares for small missile simulation. Temporary Electronic Warfare equipment (i.e., man-portable air-defense systems and mobile threat emitters) can be installed to support flare operations (Navy 2012). Electronic warfare is intended to deny the enemy the ability to effectively use electronic equipment to see, communicate, and control the battlespace.
- Rodman Range: Rodman Range is used for helicopter operations and search and rescue training. The range consists mainly of a 600-foot-diameter cleared area with a central target. The target is equipped with a lighting system to

accommodate night ordnance training (Navy 2012). Helicopter training operations can include training in a variety of aviation tasks including low-level flight and hoisting operations that involve lowering a crew member by winch for search and rescue training.

In addition to air-to-ground training, the PRC also supports various training activities that may incorporate a ground-based element supporting the mission. These scenarios are pre-coordinated events with the Range Department and, after conducting a Range Safety Brief, may be allowed to operate downrange in different locations throughout the PRC. These events include:

- Pilot Recovery Events: Pilots are placed down range in order to evade capture and be rescued;
- Opposition Force Events: Role players conduct aggression scenarios against aircraft or downed pilots down range;
- Convoy Tracking Events: Vehicles are driven throughout the Pinecastle Military Operating Areas (MOAs) for different scenarios following a pre-planned script;
- Close Air Support Events: Joint Terminal Air Controler/Forward Air Controler/Tactical Air Control Party are placed downrange, and control of events are turned over in order to support close air support with air assets;
- Ground Base Weapons Qualifications: Small-sized elements conduct small arms qualifications and weapons familiarization training;
- Convoy Training: Small convoy elements drive around desert-like terrain to practice convoy tactics;
- Man-portable Air-Defense Systems: Mobile man-portable air-defense systems teams are deployed down range in order to engage aircraft during a variety of scenarios;
- Medical Evacuation Training: A rescue dummy or injured role player is dropped down range and airlifted to safety; and
- Squad Movement Training: Small elements conduct clearing movements in different scenarios utilizing weapons loaded with blanks.

2.3.2 Projected Training Operations

The operations conducted within the PRC are expected to remain mostly unchanged in the future. The operations and activities discussed in Section 2.3.1 will continue to be conducted; however, the number of times the operations are conducted, the aircraft conducting the operations, and the types of ordnance and ammunition used during the operations may change. Section 2.3.3 details the differences between the existing (FY2013) conditions and those projected to occur (FY2020).

A long-term goal for FACSFACJAX and range personnel is to increase the ground-to-ground training capabilities at Pinecastle and Rodman ranges. Pinecastle Range currently accommodates the use of both individual and crew-served weapons for qualifications and weapons familiarization training. The projected increase in ground-to-ground training at Pinecastle Range would be accomplished through the use of both static and area targets. This would require creating new static targets and incorporating existing air-to-ground targets into target areas for ground-based operations. The projected ground-to-ground operations at Rodman Range would involve creating area targets including the current air-to-ground target and a larger area target that would incorporate the eight landing zones. The static targets at Pinecastle Range would provide qualification and training ranges for a variety of weapons, and the area targets at Pinecastle and Rodman ranges would allow for live-fire training to occur while moving through the training environment.

Increasing ground-to-ground training activities is still in the planning stages and, therefore, surface danger zones (SDZs) are not included in the RCZ-Is discussed in Section 3.2.1. Any changes to ground-to-ground activities would require safety modeling to ensure the SDZs fit within the applicable range boundary or RCZ-I.

2.3.2.1 Surface Danger Zones

SDZs represent mathematically predicted, three-dimensional areas that projectiles or fragments could travel through and impact the earth, either by direct fire or ricochet from surface-delivered ordnance. SDZs are deterministic and based on the worst-case scenario for how far a given munition type could travel. SDZs are designed to make the probability of a hazardous fragment escaping from range boundaries unlikely and minimize the danger to the public, range personnel, facilities/equipment, and property.

SDZs define the mathematically predicted area of potential safety hazard based on the worst-case scenario for how far a given munition could travel.

SDZ sizes and shapes are dependent on the characteristics of the weapon system, ammunition, training requirements, geographical location, and environmental conditions. Figure 2-2 depicts notional parameters of a basic cone SDZ and its components. "distance X" of an SDZ is the maximum distance a projectile will travel when fired from a weapon system. The "dispersion area" is the area directly outside the gun target line that accounts for human error, weapon error, or propellant malfunction. The "ricochet area" is located outside the dispersion area and contains any projectiles after they make contact with the target. The "buffer zone" is the secondary danger area that laterally parallels the ricochet area and contains fragments, debris, and components from frangible or explosive projectiles and warheads functioning on the outside edge of the ricochet area.

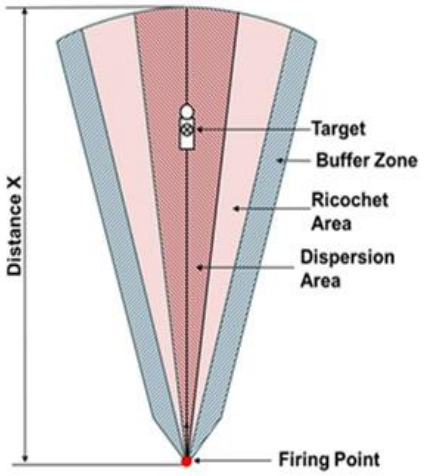

Figure 2-2 Surface Danger Zone

2.3.3 Air-to-Ground Operations Summary

Existing (FY2013) and projected (FY2020) training and testing activities conducted at the PRC are organized by range and described and summarized further below.

The operations numbers discussed in Section 2.3.3 provided the input data for the development of the WDZs, SDZs, and noise contours.

For this RAICUZ Study, a sortie is defined as a single entry and exit from the PRC airspace. While the aircraft is within the PRC airspace, it may participate in multiple training events prior to leaving the airspace and concluding the sortie. For example, an aircraft may enter the airspace and perform an Air Combat Maneuver training event and, subsequently, make two air-to-ground passes, dropping a non-explosive practice bomb during each pass before leaving the airspace. While this would only represent one aircraft sortie, there would be a total of three training events. The operations numbers presented in this section provided the input data for development of the RCZs that are discussed in Chapter 3, as well as the noise zones discussed in Chapter 4.

For this RAICUZ Study, a sortie is defined as a single entry and exit from the PRC airspace. While the aircraft is within the PRC airspace, it may participate in multiple training events prior to leaving the airspace and concluding the sortie. Section 2.3.3 provides summaries of each range's existing and projected training and testing activities numbers associated with the range's operations.

The data summarized in the following sections were obtained from multiple sources, including range users, range control staff, and other organizations. Data were initially collected from February 19 to 22, 2013, using face-to-face and telephone interviews and at the project kickoff meeting. Data collection with range users continued until July 2015, when all weapons data were obtained.

Throughout this time and continuing until October 2016, information was obtained from FACSFACJAX and range personnel on new targets, landing zones, weapons, and aircraft that were projected to increase training capabilities at the PRC. The various organizations that provided data for use in the PRC RAICUZ effort are listed in Table 2-1.

Table 2-1: Data Collection Participants

AIRLANT/CNAL	MAG-14: VMGR 252
AFSOC: 4th SOS	MAG-14: MATSS Cherry Point
AFSOC: 73rd SOS	MAG-26
CPRW-11	MAG-29
CSFTL	MAG-31
FACSFACJAX	USFF
FL ANG	USCG HITRON
HS-11	USMC SOTG
HSCWSL	VP-30
HSMWL	

2.3.3.1 Pinecastle Range

Table 2-2 summarizes the existing (FY2013) operational conditions and the projected (FY2020) increases in operations for Pinecastle Range. The total projected sortie total is anticipated to increase to approximately 2,111 when compared to the existing condition total of 995.

Table 2-2: Pinecastle Range Sortie Data Summary

Aircraft Type	FY2013 Existing Condition	FY2020 Projected
A-10	184	150
AC-130	7	10
AH-1	0	150
AV-8	8	15
CESNA	4	5
EA-6/EA-18G	1	10
F-15	79	60
F-16	33	55
F/A-18	495	600
F-35*	0	543
H-53	0	150
H-60	164	175
KC-130	0	5
MH-65	11	15
P-3/P-8	6	8
UH-1	0	150
V-22	3	10
TOTAL	995	2,111

Note:

* The Florida Air National Guard's projected F-35 sorties are not specific to Pinecastle Range. The Florida Air National Guard's projected 493 annual F-35 sorties are added to the Navy and Marine Corps totals; however, not all 493 sorties will take place at Pinecastle Range.

Total ordnance expenditures at Pinecastle Range are projected to increase from 63,832 to 92,851. Approximately 97% of both the existing and projected ordnance expenditures are from bullets fired during strafing operations. Bomb and rocket expenditures account for approximately 3% of the total. Both guided munitions (smart weapons) and explosive munitions (high-explosive) are projected to more than double in use by FY2020 in order to keep up with modern training tactics. Helicopter sidefire air gunnery ordnance expenditures are also projected to increase from 97,706 to 104,250 rounds.

2.3.3.2 Lake George Range

The data presented in Table 2-3 summarize the existing (FY2013) sorties and the projected (FY2020) increases in operations for Lake George Range. The total number of sorties is projected to increase to 1,325 sorties compared to the existing condition of 723 total sorties.

Table 2-3: Lake George Range Sortie Data Summary

Aircraft Type	FY2013 Existing Condition	FY2020 Projected
A-10	133	125
AC-130	5	5
AV-8	8	8
CESNA	3	3
EA-6/EA-18G	0	1
F-15	67	30
F-16	17	17
F/A-18	437	550
F-35*	0	518
H-60	41	45
KC-130	0	5
P-3/P-8	9	15
V-22	3	3
TOTAL	723	1,325

Note:
* The Florida Air National Guard's projected F-35 sorties are not specific to Lake George Range. The Florida Air National Guard's projected 493 annual F-35 sorties are added to the Navy and Marine Corps totals; however, not all 493 sorties will take place at Lake George Range.

Total ordnance expenditures at Lake George Range are projected to increase from 114 to 178. Bomb and rocket expenditures account for 100% of the total. All ordnance currently used and projected to be used are non-guided inert munitions. Helicopter sidefire air gunnery ordnance expenditures are also projected to increase from 0 to 5,000 rounds; however, all 5,000 rounds are planned to be blanks.

2.3.3.3 Rodman Range

The data presented in Table 2-4 summarize the existing (FY2013) sorties for Rodman Range and the projected (FY2020) increases in operations.

Table 2-4: Rodman Range Sortie Data Modeling Summary

Aircraft Type	FY2013 Existing Condition	FY2020 Projected
A-10	52	45
AC-130	2	2
AH-1	0	50
AV-8	8	15
E-2	0	1
EA-6/EA-18G	0	1
F-15	0	10
F-16	0	5
F/A-18	431	500
F-35*	0	518
H-53	0	50
H-60	100	90
KC-130	0	5
UH-1	0	50
V-22	3	2
TOTAL	596	1,344

Note:
* The Florida Air National Guard's projected F-35 sorties are not specific to Rodman Range. The Florida Air National Guard's projected 493 annual F-35 sorties are added to the Navy and Marine Corps totals; however, not all 493 sorties will take place at Rodman Range.

Total ordnance expenditures at Rodman Range are projected to decrease from 29 to 21. Bomb expenditures account for 100% of the total. All ordnance currently used and projected to be used are non-guided inert munitions. Helicopter sidefire air gunnery ordnance expenditures are also projected to increase from 0 to 5,000 rounds; however, all 5,000 rounds are planned to be blanks.

2.3.4 Common Aircraft and Users Training at the Pinecastle Range Complex

The PRC supports a number of fixed-wing, rotary-wing aircraft. The primary missions executed at the PRC include ground attacks by fixed-wing aircraft, which may include the A-10C Thunderbolt II, AC-130U/W Spooky/Stinger II, AV-8B Harrier II, F-15C/D Eagle, F-15E Strike Eagle, F-16 Fighting Falcon, F/A-18C Hornet, F/A-18E/F Super Hornet, F-35C Lightning II, KC-130J Hercules, EA-6B Prowler, P-3C Orion, and P-8A Poseidon airframes. Rotary-wing aircraft may include the AH-1W/Z Super Cobra/Viper, CH-53E Super Stallion,

MH-60R/S Seahawk, UH-1N/Y Iroquois/Venom, MH-65D Dolphin, AH-64 Apache, MH-60L Direct Action Penetrator, MH-47E Chinook, and MV-22B Osprey airframes.

The Navy began transitioning to the F-35 in 2015. Although existing operations at the PRC do not involve the F-35, this aircraft is expected to make up a strong majority of the Navy and Marine Corps tactical airpower over the next 10 to 15 years, which will result in increased operations by this aircraft at the PRC.

The PRC regularly supports training for installations located in Florida, Georgia, North Carolina, South Carolina, and Virginia. Installations and the aircraft that use Pinecastle Range, Rodman Range, and Lake George Range are briefly described below.

- Naval Station Mayport, a major Navy installation in the Jacksonville, Florida, area contains a busy harbor and runway capable of handling most aircraft in the DOD inventory, including MH-60R helicopters that are stationed at Naval Station Mayport.
- NAS Jacksonville, located on the peninsula that divides the St. Johns and Ortega rivers in Duval County, is approximately 8 miles south of downtown Jacksonville, Florida. As a multi-mission installation with more than 3,800 acres of land, NAS Jacksonville provides support, training, and maintenance facilities and services to more than 100 tenant commands. It is the third-largest naval air station in the United States and supports approximately 24,500 active and reserve duty, civilian, and military personnel. NAS Jacksonville is home to P-8A and P-3C aircraft, as well as three squadrons of MH-60Rs.
- Camp Blanding Joint Training Center, located near Starke, Florida, supports the training of active National Guard and Army Reserve units;
- NAS Oceana, located in Virginia Beach, Virginia, is approximately 640 miles north of NAS Jacksonville. NAS Oceana is the only Navy Master Jet Base on the East Coast, and is home to 17 strike fighter squadrons of F/A-18C/D and F/A-18E/F (16 operational and one Fleet Replacement Squadron). The PRC is a critical range asset for the squadrons that are based at NAS Oceana;
- Marine Corps Air Station Cherry Point, is located in Havelock, North Carolina, and is currently home to the 2nd Marine Aircraft Wing and the AV-8B and EA-6B aircraft;

- Marine Corps Air Station New River, is located in Jacksonville, North Carolina, and is home to the 2nd Marine Aircraft Wing and the AH-1W/Z, MV-22B, and UH-1Y aircraft;
- Shaw Air Force Base, located outside of Sumpter, South Carolina, is home to the Air Force's largest combat F-16 wing—the 20th Fighter Wing—that includes F-16 aircraft;
- Moody Air Force Base, located near Valdosta, Georgia, is home to the 23rd Wing, which includes A-10C, HC-130J, and HH-60 aircraft, and carries out worldwide close air support, force protection, and combat search and rescue training operations;
- Pope Field (formerly Pope Air Force Base), located north of Fayetteville, North Carolina, is operated by the Army as part of Fort Bragg;
- Marine Corps Air Station Beaufort, located in Beaufort, South Carolina, is home to the Marine Corps' Atlantic Coast fixed-wing, fighter-attack aircraft assets. Marine Corps Air Station Beaufort is home to the VMFAT-501 F-35 fleet replacement squadron, nine F/A-18 squadrons, and hosts all three versions of the F/A-18;
- Seymour Johnson Air Force Base, located in Goldsboro, North Carolina, is home to the 4th Fighter Wing) of the Air Combat Command and hosts multiple variants of the F-15;
- Eglin Air Force Base, located southwest of Valparasio, Florida, is home to the 33rd Fighter Wing, which historically flew the F-15E aircraft and is transitioning to support Navy and Air Force F-35s;
- Homestead Air Reserve Base, located near Homestead, Florida, is home to the 482nd Fighter Wing, which is equipped with a fully combat-ready unit of F-16C/D multi-purpose fighter aircraft;
- Cecil Field, located in Duval County, Florida, is a joint civil-military airfield that support Coast Guard helicopter operations; and
- Jacksonville International Airport, in Jacksonville, Florida, is a civilian-military public airport that is home to the 125th Fighter-Interceptor Group (125th Fighter Interceptor Group) of the Florida Air National Guard.

The most common aircraft are described in the following sections.

2.3.4.1 Fixed-Wing Aircraft

F/A-18C/D Hornet

The F/A-18C/D Hornet, an all-weather aircraft, is used as an attack aircraft as well as a fighter. In its fighter mode, the F/A-18C/D is primarily used as a fighter escort and for fleet air defense. In its attack mode, it is used for force projection, interdiction, and close and deep air support. The F/A-18C/D is the nation's first strike-fighter. The aircraft was designed for traditional strike applications, such as interdiction and close air support without compromising its fighter capabilities. (NAVAIR 2017a)

F/A-18C Hornet

F/A-18E/F Super Hornet

The F/A-18E/F Super Hornet is a multi-role attack and fighter aircraft built on the nation's first strike fighter, the F-18C/D. Today's F/A-18E/F is an attack aircraft as well as a fighter through selected use of external equipment and advanced networking capabilities to accomplish specific missions. In its fighter mode, the F/A-18E/F serves as an escort and for fleet air defense. In its attack mode, this aircraft provides force projection, interdiction, and close and deep air support. (NAVAIR 2017b)

F/A-18F Super Hornet

A-10C Thunderbolt II

The A-10C Thunderbolt II is also known as the Warthog. This aircraft's mission is ground attack against tanks, armored vehicles, and installations, and close air support of ground forces. The A-10C is suitable for operation from forward air bases, with short take-off and landing capability (Air Force 2015).

A-10C Thunderbolt II

F-35C Lightning II

The F-35C Lightning II is a 5th Generation fighter, combining advanced stealth with fighter speed and agility, fully-fused sensor information, network-enabled operations, and advanced sustainment. Three variants of the F-35 will replace the A-10 and F-16 for the Air Force, the F/A-18 for the Navy, the F/A-18 and AV-8 for the Marine Corps, and a variety of fighters

F-35C Lightning II

for at least ten other countries. The F-35 is optimized to be a multi-role fighter, with the ability to perform air-to-air, air-to-ground, and intelligence, surveillance, and reconnaissance (ISR) missions. Missions that were traditionally performed by small numbers of specialized aircraft, such as ISR and electronic attack missions, can now be executed by a squadron of F-35s, bringing new capabilities to many allied forces. (Lockheed Martin 2017)

P-3C Orion/P-8A Poseidon

The P-3C Orion is a four-engine, turboprop, anti-submarine, and maritime surveillance aircraft. The P-3 was developed in the 1960s and was one of the world's premier multi-mission long-endurance aircraft. The P-8A Poseidon is the Navy's newest maritime, patrol, and reconnaissance aircraft. It is a multi-mission capable replacement aircraft for the legacy P-3C. The P-8A is designed to be combat-capable, improving an operator's ability to efficiently conduct anti-submarine warfare, anti-surface warfare, and ISR missions.

P-8A Poseidon

P-3C Orion

2.3.4.2 Rotary-Wing Aircraft

MH-60 R/S Seahawk

The MH-60 R/S Seahawk is a four-blade, twin-engine, medium-lift, utility helicopter designed for various missions. The MH-60R focuses on anti-submarine warfare, anti-surface warfare, surveillance, communications relay, combat search and rescue training, naval gunfire support, and logistics support. The MH-60S missions include anti-surface warfare, combat support, humanitarian disaster relief, combat search and rescue training, and medical evacuation.

MH-60S Seahawk

CH-53E Super Stallion

CH-53E Super Stallion

The mission of the CH-53E Super Stallion is the transportation of heavy equipment and supplies for amphibious assault. It has a crew of four, including a pilot, co-pilot, crew chief, and mechanic/gunner. The CH-53 incorporates global positioning system (GPS),

Forward-looking Infrared Radar, and Aviator Night Vision Imaging Systems Heads-Up Display (ANVIS-HUD) sensors, and carries three 50 caliber guns (NAVAIR 2017c).

UH-1N/Y Iroquois/Venom

The UH-1N Iroquois is a light-lift utility helicopter used to support various missions such as battlefield command and control, maritime special operations, and SAR. The UH-1N has a crew of three, including a pilot, co-pilot, and flight engineer, and can be configured for passengers. The UH-1N is being replaced by the UH-1Y Venom. The UH-1Y utility helicopter was developed to support Marine Corps mission requirements and provides battlefield command and control and assault support under day/night and adverse weather conditions. A significant upgrade to the UH-1N is a new four-bladed, all-composite and ballistically tolerant (up to 23mm) rotor system.

UH-1N Iroquois

AH-1Z Viper

AH-1W/Z Super Cobra/Viper

The AH-1W Super Cobra is a two-blade, single-engine attack helicopter. Its main mission includes close air support, armed escort, and armed reconnaissance by the Marine Corps. A crew of two operates the AH-1W. In 2006, the AH-1Z Viper began replacing the AH-1W as part of a remanufacture program. The Last AH-1W is expected to be replaced in FY2020. AH-1Ws are fielded in Marine Light Attack Helicopter Squadrons along with the UH-1N.

2.4 Pinecastle Range Complex Operational Areas

As previously discussed, the PRC is part of the larger Jacksonville Range Complex, which offers a variety of air, land, and open ocean training venues in support of operating forces and RDT&E in the southeast region. NAS Jacksonville manages and maintains the physical resources of the PRC, while FACSFACJAX is the principal scheduling authority for the three ranges (Pinecastle, Rodman, and Lake George ranges). All range activities are coordinated through the Centroid Facility, which is located a short distance from the northeast corner of Pinecastle Range.

2.4.1 Range Area

Pinecastle Range

Pinecastle Range accommodates the use of both inert and explosive ordnance in a variety of training scenarios. The Pinecastle Range consists of two high-explosive ordnance target areas, eight inert ordnance target areas, a strafe pit with three different target areas, and a laser target that can be scored (Navy 2017b). Overall, Pinecastle Range has 17 unique targets or target areas that can be used, each with its own authorized ordnance, events, and run-in headings. Most targets share these same variables, but due to geographic location within the range and proximity to areas of concern, some events are not allowed on all targets (Navy 2017a). Figure 2-3 shows training areas for the Pinecastle Range.

The Pinecastle Range has two designated aircraft ingress routes (arrival flights) and egress routes (departure flights), a southern route for fixed-wing aircraft, and an eastern route for rotary-wing aircraft accessing the landing zones within SUA Restricted Area (R-) 2910A (BRRC 2017). Pinecastle Range currently accommodates the use of both individual and crew-served weapon qualification and familiarization training on static targets. The Road 038 Target is currently the only target used for ground-to-ground training.

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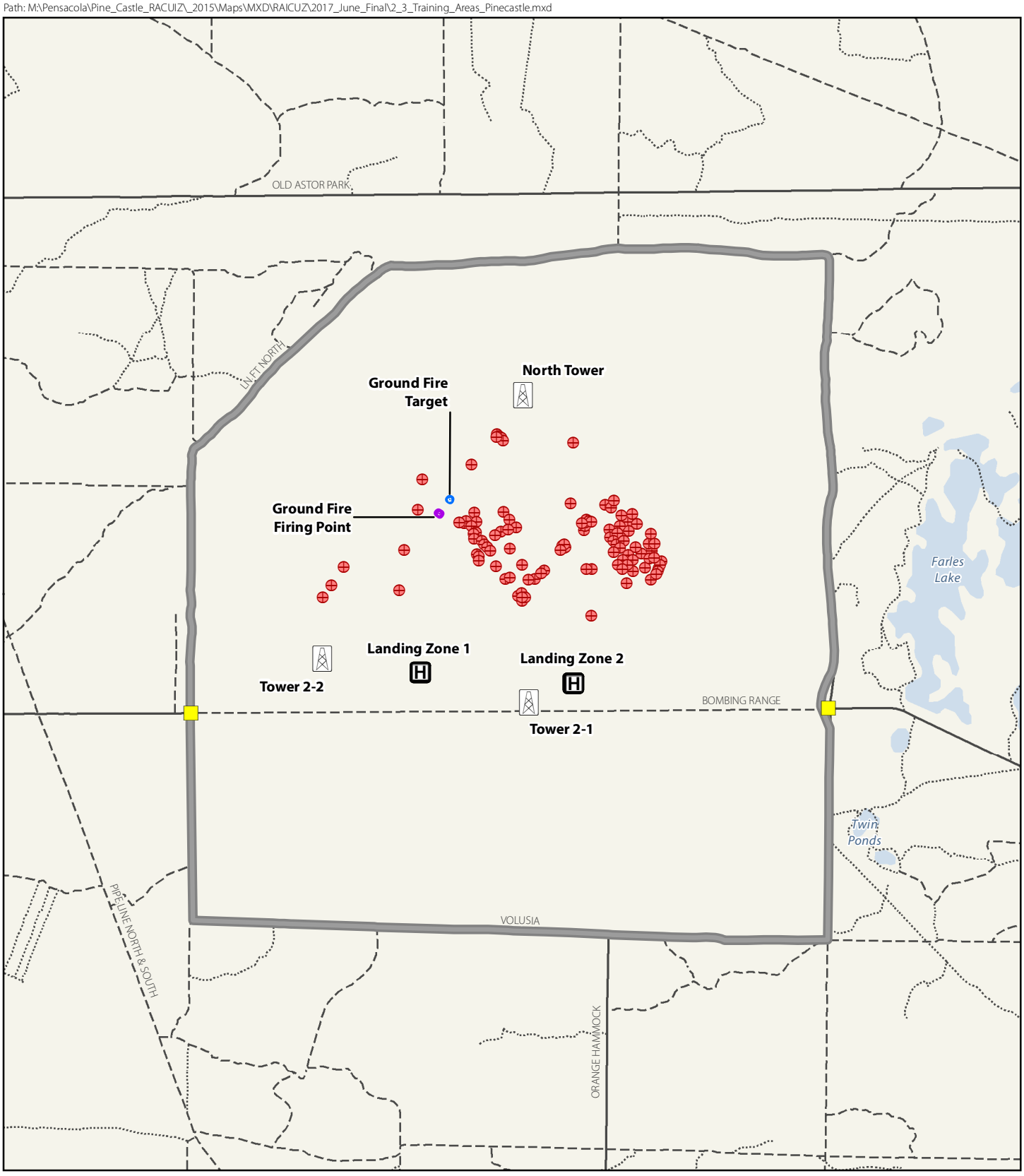

Legend

- Target
- Gate
- Landing Zone
- Tower
- Range Boundary
- Ground Fire Firing Point
- Ground Fire Target
- Water
- National Forest System Roads
- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

SCALE

0 0.25 0.5 Miles

SOURCE: ESRI 2010, 2012; US Navy 2009, 2014.

Figure 2-3

Pinecastle Range Training Areas

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Lake George Range

At Lake George Range, the total target area is approximately 8,960 acres. The range has three standard targets consisting of the north, center, and south targets for air-to-ground ordnance delivery and four pre-planned splash points for mining exercise. Figure 2-4 shows the training area in more detail for the Lake George Range.

Rodman Range

Rodman Range features eight landing zones utilized by rotary-wing aircraft. The range currently consists of a single target with an array of Conex boxes forming a small village complex (Figure 2-5).

Lake George Range

Rodman Village Target
Rodman Range

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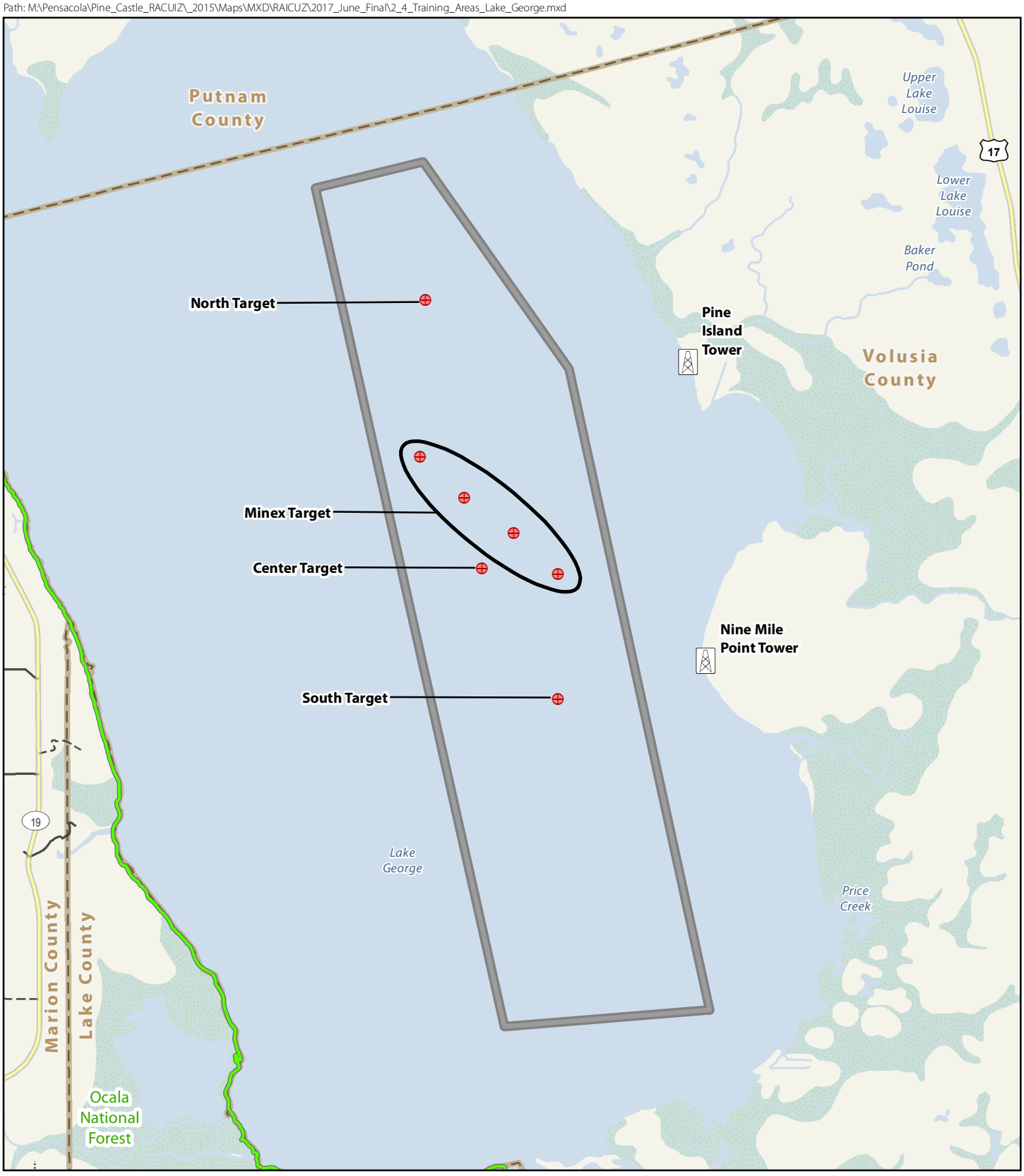

SCALE

0 0.5 1 Miles

Legend

- Target
- Tower
- Range Boundary
- Ocala National Forest
- Water
- Wetland
- County Boundary
- Major Highway
- National Forest System Roads
- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

SOURCE: ESRI 2010, 2012; US Navy 2009, 2014; USDA Forest Service 2015.

Figure 2-4

Lake George Range Training Areas

Pinecastle Range Complex
Ocala National Forest
Volusia County, Florida

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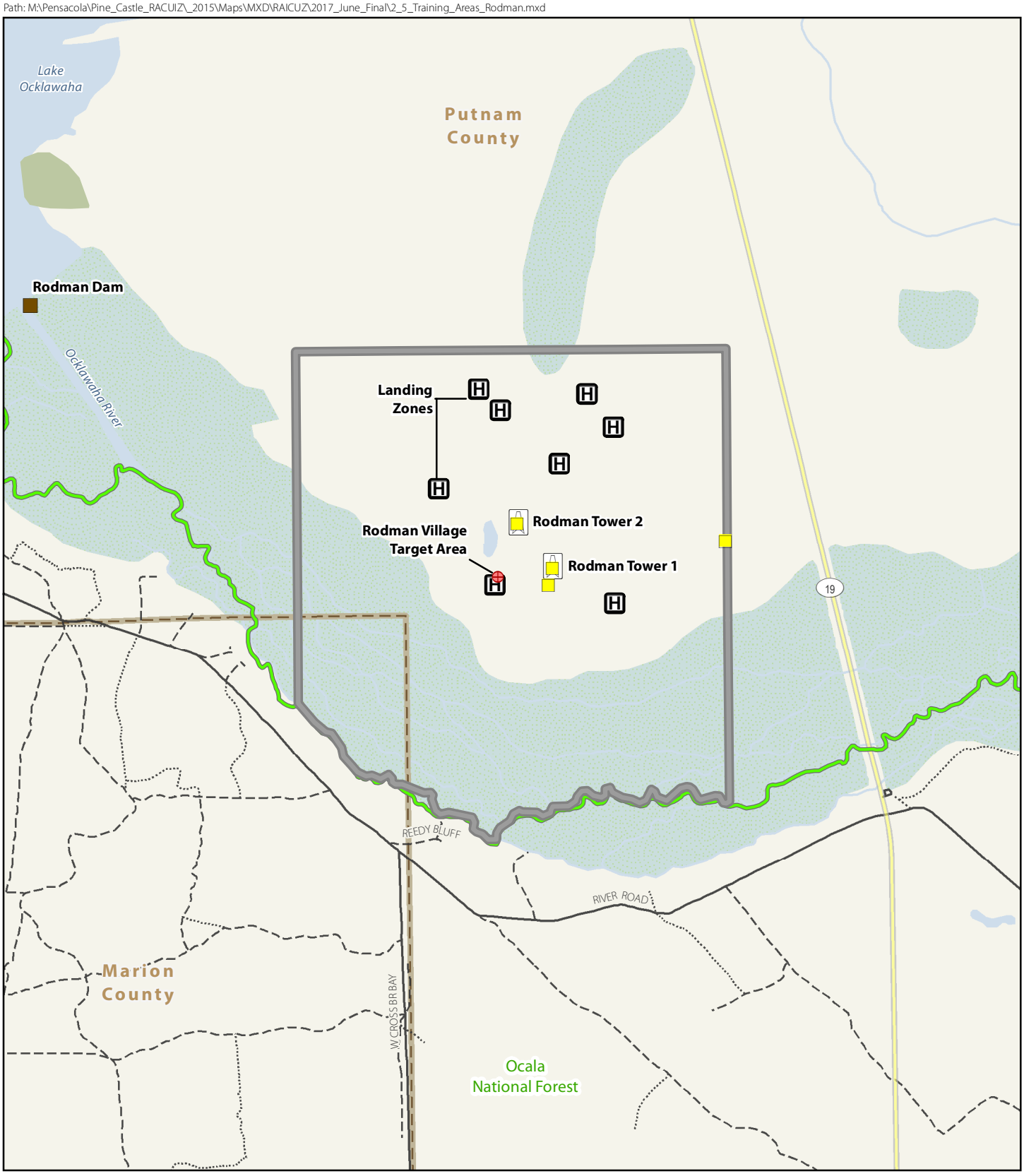

SCALE

0 0.25 0.5 Miles

Legend

- Target
- Gate
- Dam
- Landing Zone
- Tower
- Range Boundary
- Ocala National Forest
- Water
- Wetland
- County Boundary
- Major Highway
- National Forest System Roads
- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

SOURCE: ESRI 2010, 2012; US Navy 2009, 2014; USDA Forest Service 2015.

Figure 2-5

Rodman Range Training Areas

Pinecastle Range Complex
Ocala National Forest
Marion and Putnam Counties, Florida

2.4.2 Airspace

The use and control of U.S. airspace is dictated by the FAA National Airspace System, which seeks to ensure the safe, orderly, and efficient flow of commercial, private, and military aircraft. There are two categories of airspace: regulatory and non-regulatory. Within these two categories are four types of airspace: controlled, uncontrolled, SUA, and other airspace.

2.4.2.1 Airspace Definitions

Special Activity Airspace may be Restricted Areas, Prohibited Areas, MOAs, Air Traffic Control Assigned Airspace (ATCAA), and any other designated airspace areas. The types of airspace associated with PRC are briefly defined below.

- Special Use Airspace: SUA is the designation of airspace in which specific activities must be confined or where limitations may be imposed on aircraft operations that are not part of those activities. The SUA dimensions are defined so that military activities can operate and have boundaries that limit access by non-participating aircraft. Types of SUA occurring at the PRC are described below:
  - Military Operating Areas: MOAs are established to separate or segregate certain non-hazardous military activities from Instrument Flight Rules (IFR) aircraft traffic and identify, for Visual Flight Rules (VFR) aircraft traffic, where these military activities are conducted. MOAs exist at altitudes up to, but not including, 18,000 feet mean sea level.
  - Restricted Areas: Restricted Areas support ground or flight activities that could be hazardous to non-participating aircraft. Entry into restricted airspace without approval from the using or controlling agency is prohibited. Restricted Areas commonly overlay ranges and may extend to the surface.

Instrument Flight Rules (IFR) are rules for flying an aircraft by using the instrument panel for navigation and/or following Air Traffic Control instruction. Use of IFR is necessary when weather conditions are poor or the pilot deems it necessary, and is mandatory when flying at or above 18,000 feet mean sea level, also known as "Class A" airspace. In addition, pilots and controllers use IFR to indicate the type of flight plan.

Visual Flight Rules (VFR) are rules that govern the procedures for conducting flight under visual conditions. The term "VFR" is also used in the United States to indicate weather conditions that are equal to or greater than minimum VFR requirements. In addition, pilots and controllers use VFR to indicate the type of flight plan. In the National Airspace System, VFR may only be used below 18,000 feet mean sea level.

- **Air Traffic Control Assigned Airspace**: ATCAA is airspace controlled by the FAA Air Route Traffic Control Center that, if not required for other purposes, may be available for military use by a Letter of Agreement. ATCAA is typically created above and in conjunction with MOAs, Restricted Airspace, or aerial refueling tracks for additional maneuver space. All ATCAA starts at 18,000 feet mean sea level or higher.
- **Military Training Routes:** MTRs are flight corridors used by the military to practice low-altitude, high-speed training missions. Generally, MTRs are established below 10,000 feet mean sea level for operations at speeds in excess of 250 knots. MTRs are described by a centerline, with defined horizontal limits on either side of the centerline and vertical limits expressed as minimum and maximum altitudes along the flight track. (FAA 2008)

2.4.2.2 Pinecastle Range Complex Special Use Airspace

The airspace over the PRC is comprised of three interconnected Restricted Areas. The Pinecastle Range Restricted Area is R-2910A/B/C/D/E. The Lake George Range Restricted Area is R-2907A/B/C. The Rodman Range Restricted Area is R-2906. Additionally, the Palatka MOA, which is divided into two parts, surrounds and overlaps a majority of the Restricted Area. Table 2-5 provides basic altitude information for each airspace unit and Figure 2-6 shows the location of each airspace unit. Other SUA associated with the PRC are the Pinecastle ATCAA, which is positioned on top of the Palatka MOA, and eight MTRs that either originate or terminate within the designated SUA (Navy 2017a). The MTRs are shown on Figure 2-7, and Table 2-6 provides additional details.

Table 2-5: Pinecastle Range Complex Special Use Airspace

Airspace	Altitude Floor	Altitude Ceiling
R-2910A	Surface	23,000 feet MSL
R-2910B	Surface	6,000 feet MSL
R-2910C	Surface	6,000 feet MSL
R-2910D	2,000 feet MSL	23,000 feet MSL
R-2910E	500 feet MSL	1,999 feet MSL
R-2907A	Surface	23,000 feet MSL
R-2907B	2,000 feet MSL	23,000 feet MSL
R-2907C	500 feet MSL	1,999 feet MSL
R-2906	Surface	14,000 feet MSL
Palatka MOA 1	3,000 feet MSL	17.999 feet MSL
Palatka MOA 2	3,000 feet MSL	17,999 feet MSL

Note:
Specific details for the Restricted Areas and SUAs for the PRC can be found in FAA Joint Order 7400.8, Special Use Airspace.
Key:
MOA = Military Operating Area; MSL = Mean Sea Level; SUA = Special Use Airspace

Table 2-6: Pinecastle Range Complex Military Training Routes

MTR	Point of Origin	No. of Segments	Termination
VR-1005	Western Portion of the Moody 3 MOA Northwest Fort Gaines, GA	9	Pinecastle Range
VR-1008	2 NM West of Sanderson, FL	4	Pinecastle Range
VR-1009	Warning Area 136E Atlantic Ocean	5	Pinecastle Range
VR-1010	4 NM West of Keystone Heights, FL	2	Rodman Range
VR-1039	Western Portion of R-2907A	1	Northern Portion of R-2910A South of SR 40
VR-1040	Western Portion of the Gamecock MOA Northwest of Boardman, NC	13	Eastern Boundary of R-2907A
VR-1041	Eastern Portion of the Beaufort 1 MOA	14	Eastern Boundary of R-2907A
IR-023	2 NM North of Pulaski, GA	7	Pinecastle Range

Key:
MOA = Military Operating Area
MTR = Military Training Route
NM = nautical mile
R- = Restricted Area

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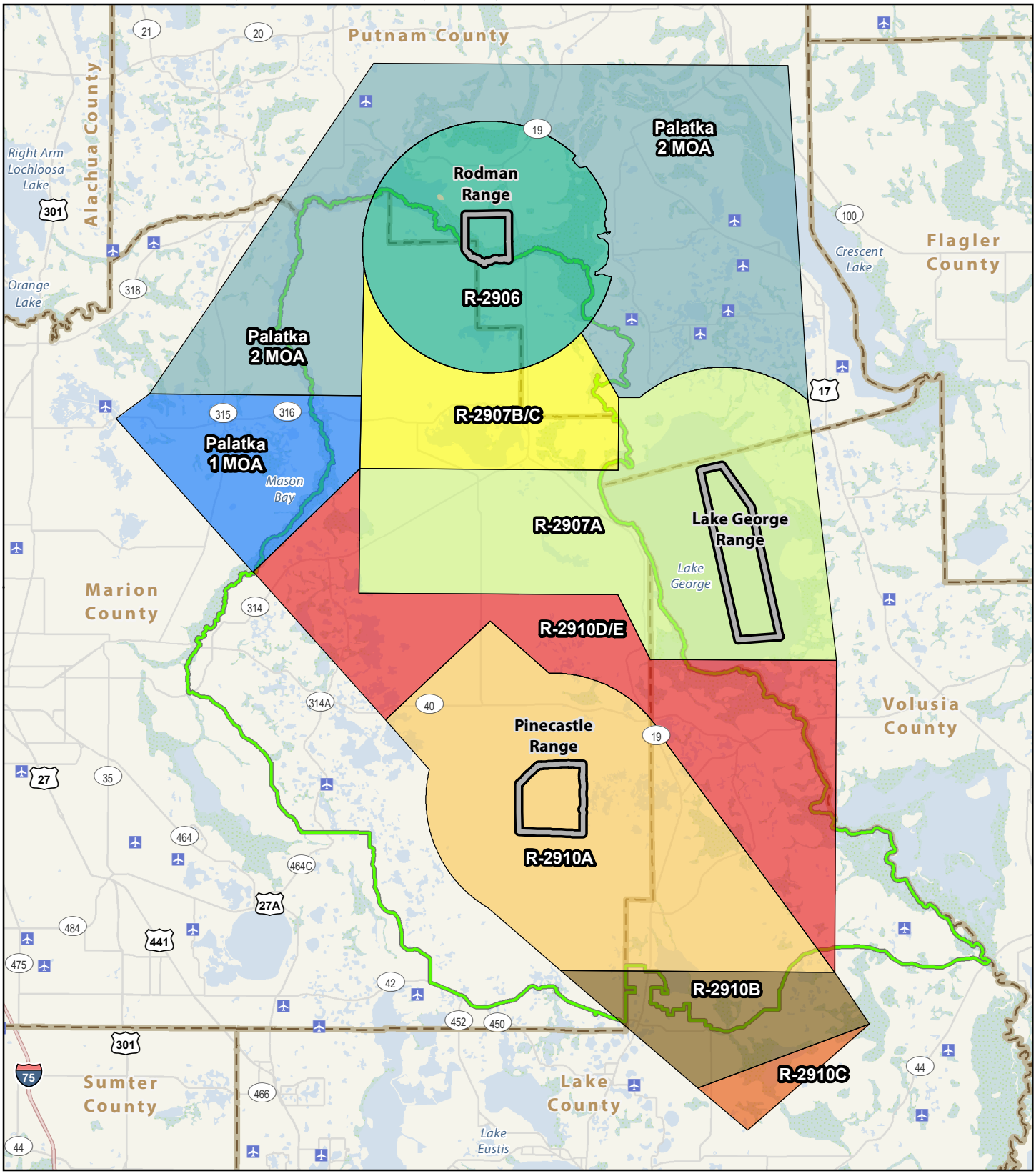

SCALE

0 2 4 Miles

Legend

- Range Boundary
- Airport
- Interstate
- Major Highway
- County Boundary
- Water
- Wetland
- Ocala National Forest

Special Use Airspace

- Palatka 1 MOA
- Palatka 2 MOA
- R-2906
- R-2907A
- R-2907B/C
- R-2910A
- R-2910B
- R-2910C
- R-2910D/E

Figure 2-6

Special Use Airspace

Pinecastle Range Complex

Ocala National Forest

Lake, Marion, Putnam, and Volusia Counties, Florida

SOURCE: ESRI 2010, 2012; FAA 2012; US Navy 2009, 2014.

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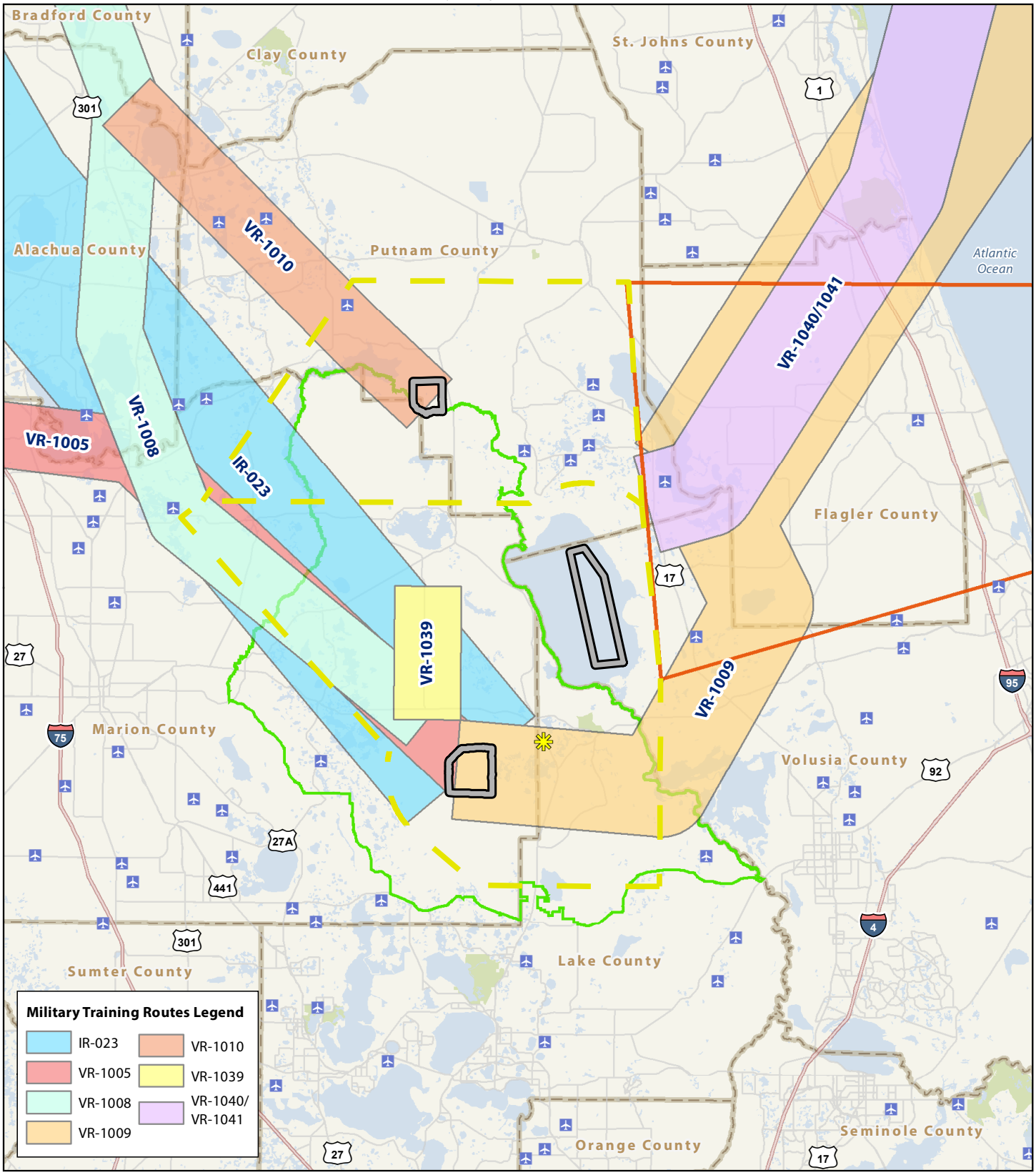

Legend

- Range Boundary
- Centroid Facility
- Airport
- Interstate
- Major Highway
- County Boundary
- Military Operating Area
- Water
- State Park/Forest
- Ocala National Forest Boundary
- Strike Altitude Reservation (ALTRV)

SCALE

0 4 8 Miles

SOURCE: ESRI 2010, 2012; FAA 2012; FL Geographic Data Library 2015; Navy EIMS 2013; University of Florida GeoPlan Center, 2012.

Figure 2-7

Military Training Routes

Pinecastle Range Complex
Ocala National Forest
Lake, Marion, Putnam,
and Volusia Counties, Florida

Chapter 3

RANGE COMPATIBILITY ZONES

The Navy established the RAICUZ Program to assist in preserving the health, safety, and welfare of the people living near military ranges. This chapter presents information about potential safety hazards related to the air-to-ground and ground-to-ground training activities that occur at the PRC.

RCZs define the area with potential safety hazards from weapon/ordnance delivery and designate the surface area and/or airspace needed to protect public health, safety, and welfare from live-fire training operations. RCZs translate live-fire ammunition and ordnance training activities into land areas that can then be evaluated for land use compatibility and recommendations for compatible land use. The Navy instruction includes land use recommendations for each RCZ. A principal component of this RAICUZ Study is a compatible land use analysis specifically tailored to the PRC.

Refer to Chapter 5 for further discussion on the compatibility of land uses with range operations and the associated safety zones discussed in this chapter. Refer to Chapter 6 for recommendations that promote public safety and land use compatibility between the installation ranges and land uses within the installation environs.

3.1 RANGE SAFETY

The RAICUZ Study provides information and recommendations to aid in protecting the public's health, safety, and welfare by minimizing both local community and on-installation exposure to noise and potential safety hazards.

The Navy is responsible for minimizing potential safety hazards from air-to-ground and ground-to-ground training, to the extent practicable, without affecting operational and training capabilities. The Navy works with federal, state, and local planning officials to implement the objectives of the RAICUZ Study. To aid in land use compatibility analyses, this RAICUZ Study presents RCZs associated with the various live-fire training operations at the PRC. The RAICUZ Study assists the PRC in collaborating with local communities to promote compatible land uses by depicting the locations of RCZs and identifying any land uses that are currently incompatible, as well as those areas that could be incompatible in the future.

Range safety includes the various policies, plans, and procedures in place at the ranges that are designed to mitigate the potential safety hazards related to the use of ordnance, ammunition, demolition, and explosives. Range safety programs are established for all training ranges in accordance with OPNAVINST 3550.1A/MCO 3550.11 to ensure the highest degree of safety is applied. The various programs outline specific safety policies and responsibilities to protect civilian and military populations who live and work near live-fire operational ranges. The programs also minimize, to the extent practical, the potential safety hazards. The Navy personnel stationed at the PRC monitor range activities and ensure that training occurs in accordance with approved safety procedures.

3.2 RANGE COMPATIBILITY ZONES

RCZs translate ammunition and ordnance training activities into land areas that can then be evaluated for land use incompatibilities and aid in the development of compatible land use recommendations.

There are three RCZs that are relevant to live-fire activities: RCZ-I, RCZ-II, and RCZ-III. Each RCZ has specific recommendations related to land use within that specific zone. The overwhelming majority of the training associated with the PRC is air-to-ground training, which involves all three RCZs. The ground-to-ground training that occurs at the PRC is applicable to RCZ-I only.

- RCZ-I defines the area of the greatest potential safety hazard and designates the minimum range surface area needed to contain all ordnance delivered/deployed at the respective range. RCZ-I is the sum, or composite, of all individual WDZs

and SDZs generated for a particular range. Since this area depicts the space required for containment of projectiles, fragments, and debris from weapon systems, it is the most restrictive area in terms of land use compatibility and poses the greatest potential for safety concerns.

- RCZ-II defines the area of aircraft armed over-flight whereby an aircraft commits to the target attack. The period of armed over-flight applies only 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 and is identified as the area that could be impacted by ordnance, if ordnance were inadvertently released following activation of the arming switch.
- RCZ-III defines the minimum airspace within the designated SUA required for maneuvering into and out of the air-to-ground target area, outside of the areas designated as RCZ-I and RCZ-II. RCZ-III is the area required to provide access to and from the target, safely separate participating and non-participating aircraft, and provide the range user with tactical maneuvering room allowing for initial alignment for target acquisition. While RCZ-III correlates to required airspace, it is the land underlying the airspace that is considered for safety reasons. RCZ-III represents the least restrictive area associated with a range that requires land use compatibility measures.

As previously discussed, this RAICUZ Study assists the PRC in collaborating with local communities to promote compatible land uses by showing the locations of RCZs and identifying any land uses that are incompatible. The following sections describe the RCZs and the amount and type of area they affect surrounding the PRC. While much of the RCZs may cover areas that are located off-range, it is important to note that the ranges that comprise the PRC are largely located within ONF, are over water, or are areas that are not densely populated. The boundaries of each RCZ were used to conduct the land use compatibility analysis for this RAICUZ Study (refer to Chapter 5).

3.2.1 Range Compatibility Zone I

RCZ-I is defined in OPNAVINST 3550.1A as the composite footprint based on each of the individual WDZs and SDZs associated with air-to-ground and ground-to-ground weapons delivery. RCZ-I represents the entire weapons impact area, including potential ricochets, fragments, and debris. In terms of land use, RCZ-I is the most restrictive. The RCZ-Is associated with each range in the PRC do not overlap or connect with each other.

RCZ-I is the composite WDZ and composite SDZ generated by combining all individual WDZs and SDZs associated with air-to-ground and ground-to-ground weapons delivery.

3.2.1.1 Weapon Danger Zones

A WDZ is a three-dimensional zone that represents the ground and airspace necessary for the lateral and vertical containment of projectiles, fragments, debris, and components resulting from the firing, launching, and/or detonation of aviation-delivered ordnance (Figure 3-1). WDZs are probabilistic and are developed using sophisticated computer modeling that considers weapons dynamics (accuracy and fail rates), release parameters (airspeed, altitude, release angle, release distance, and run-in heading), target material, and soil types. The modeling allows various containment levels to be used based on the probability of containment desired.

WDZs define the modeled area of potential safety hazard based on various release parameters to account for the containment of ordnance, fragments, ricochets, debris, and potential weapon malfunctions.

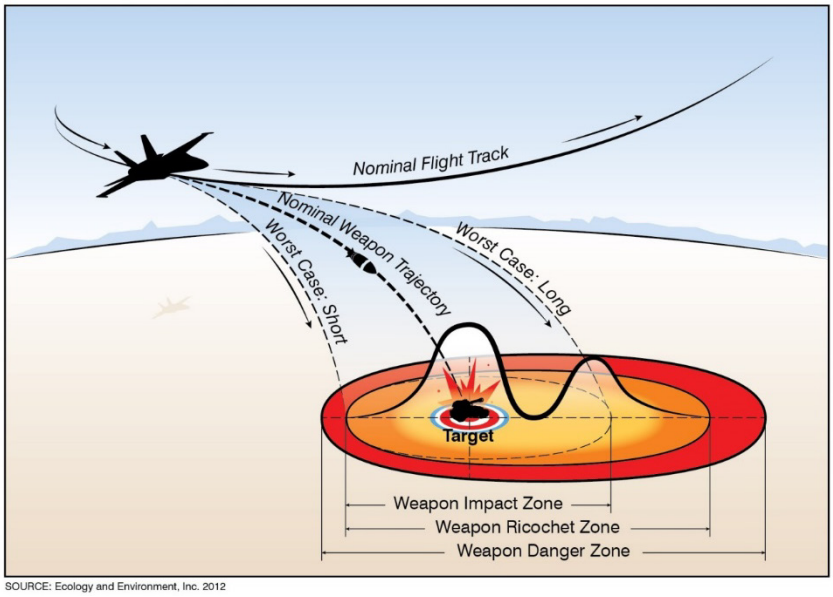

Figure 3-1: Weapon Danger Zone

WDZ modeling for projected (FY2020) air-to-ground operations was completed using the DOD approved WDZ Tool modeling software as part of this RAICUZ Study. Over the course of the modeling process, various versions of the WDZ Tool were utilized; however, all WDZs were verified using Version 10.3.0.0.4 of the WDZ Tool.

The Navy requires that WDZs developed for all aircraft-delivered gun ammunition be modeled to contain at least 99.999 percent of munitions within the WDZ (i.e., a 1 out of 100,000 chance of a munition impacting an area outside of the WDZ). All other aviation-delivered ordnance must be modeled to contain at least 99.99 percent within the WDZ (i.e., 1 out of 10,000 chance of a munition impacting an area outside of the WDZ).

The data collection came from multiple sources, including range users, range control staff, and other organizations. Data were initially collected from February 2013 and continued until October 2016, when information was obtained on new targets, landing zones, weapons, and aircraft that were projected to increase training capabilities at the PRC.

Each specific training profile (i.e., the various combinations of aircraft type, weapon type, altitude, airspeed, release angle, release distance, run-in heading, and target) represents a training event that occurs. Each training event is modeled and has a unique WDZ developed. The weapon impact area for a specific target, or all the air-to-ground targets as a whole, can then be defined by combining all of the individual WDZs into a composite WDZ. The operations information discussed in Section 2.3.3 determined the training profiles that required WDZs. Additionally, release parameters obtained during data collection were used to develop the WDZs.

3.2.1.2 Pinecastle Range

Pinecastle Range's existing RCZ-I was implemented as part of the "*Final Supplemental Environmental Impact Statement to the Final Environmental Impact Statement for Renewal of Authorization to Use Pinecastle Range*" (Navy 2010) and encompasses 19,014 acres. Changes in ordnance (i.e., next generation smart weapons) and tactics (i.e., releasing weapons from a higher altitude and farther distance from the target) have led to larger WDZs and, subsequently, a larger RCZ-I.

The projected RCZ-I was developed from the composite WDZs for all air-to-ground training activities using explosive and inert ordnance at the 17 unique air-to-ground targets or target areas. The projected RCZ-I incorporates 4,012 modeled WDZs. Approximately 21,740 acres of the total 27,436 acres of projected RCZ-I are located outside of the range boundary. However, all of the land associated with Pinecastle Range's projected RCZ-I is on land owned by the USDA Forest Service within ONF (Table 3-1). Existing agreements between

the USDA Forest Service and the Navy are in place to allow WDZs to overlap USDA Forest Service land under specific training scenarios, with limits on the amount of time per year they can be implemented. Figure 3-2 shows the projected RCZ-I for Pinecastle Range.

3.2.1.3 Lake George Range

Lake George Range does not have a currently approved RCZ-I. The projected RCZ-I was developed from the composite WDZs for all air-to-ground training activities using inert ordnance at the seven unique targets or target areas. The projected RCZ-I incorporates 1,144 modeled WDZs. The projected RCZ-I for Lake George Range covers 8,673 acres and is fully contained within the Navy-controlled area over the waters of Lake George (Table 3-1). Figure 3-3 depicts the projected RCZ-I for Lake George Range.

3.2.1.4 Rodman Range

Rodman Range does not have a currently approved RCZ-I. The projected RCZ-I was developed from the composite WDZs for all air-to-ground training activities using inert ordnance at the Rodman Range target. The projected RCZ-I incorporates the 82 modeled WDZs. Figure 3-4 depicts the projected RCZ-I for Rodman Range. All 892 acres within the projected RCZ-I at Rodman Range are contained within the range boundary (Table 3-1).

Table 3-1: Comparison of Projected Land and Water Areas Impacted by RCZ-I within the Pinecastle Range Complex Ranges (in acres)

Range	Land			Waterbody		Total
	Off-Range Outside ONF (a)	Off-Range Within ONF (b)	On-Range	Off-Range (c)	On-Range (d)	
Pinecastle	0	21,344	5,695	396	0	27,436
Lake George	0	0	0	0	8,673	8,673
Rodman	0	0	646	0	246	892
Subtotal	0	21,344	6,341	396	8,919	
TOTAL	27,685			9,315		37,001

Notes:
(a) Land that is located outside of the range boundary and ONF.
(b) Land that is located outside of the range boundary, but within ONF.
(c) Surface waters, marsh, and/or swamp outside the range boundary.
(d) Surface waters, marsh, and/or swamp inside the range boundary.

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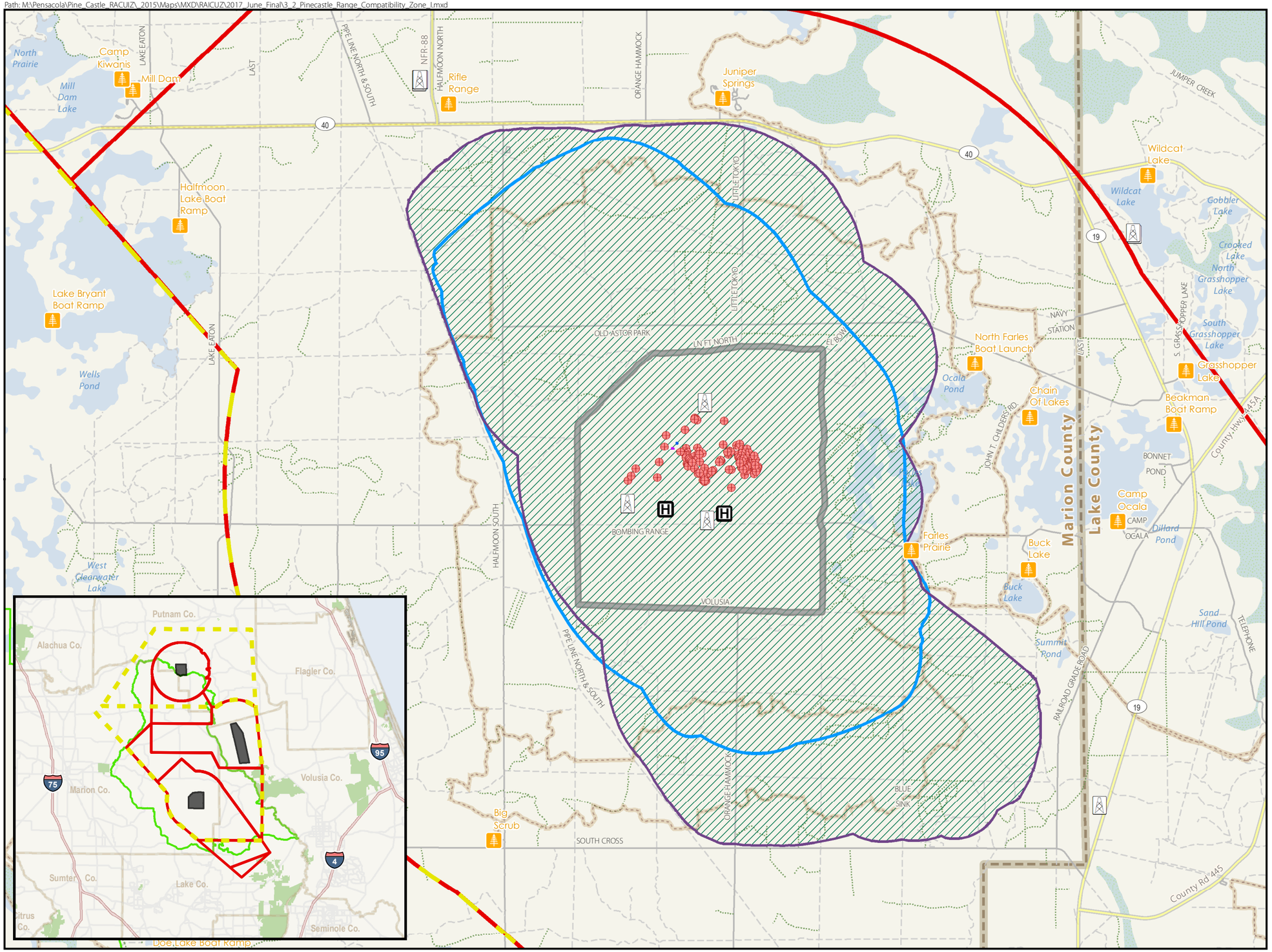

Figure 3-2

Pinecastle Range
Range Compatibility Zone I

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- Military Operating Area
- Existing MTE RCZ-I
- Modeled Composite Weapon Danger Zones
- Projected RCZ-I
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Area
- Recreation Site (includes camping)
- Interstate
- Major Highway
- County Boundary
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2016.

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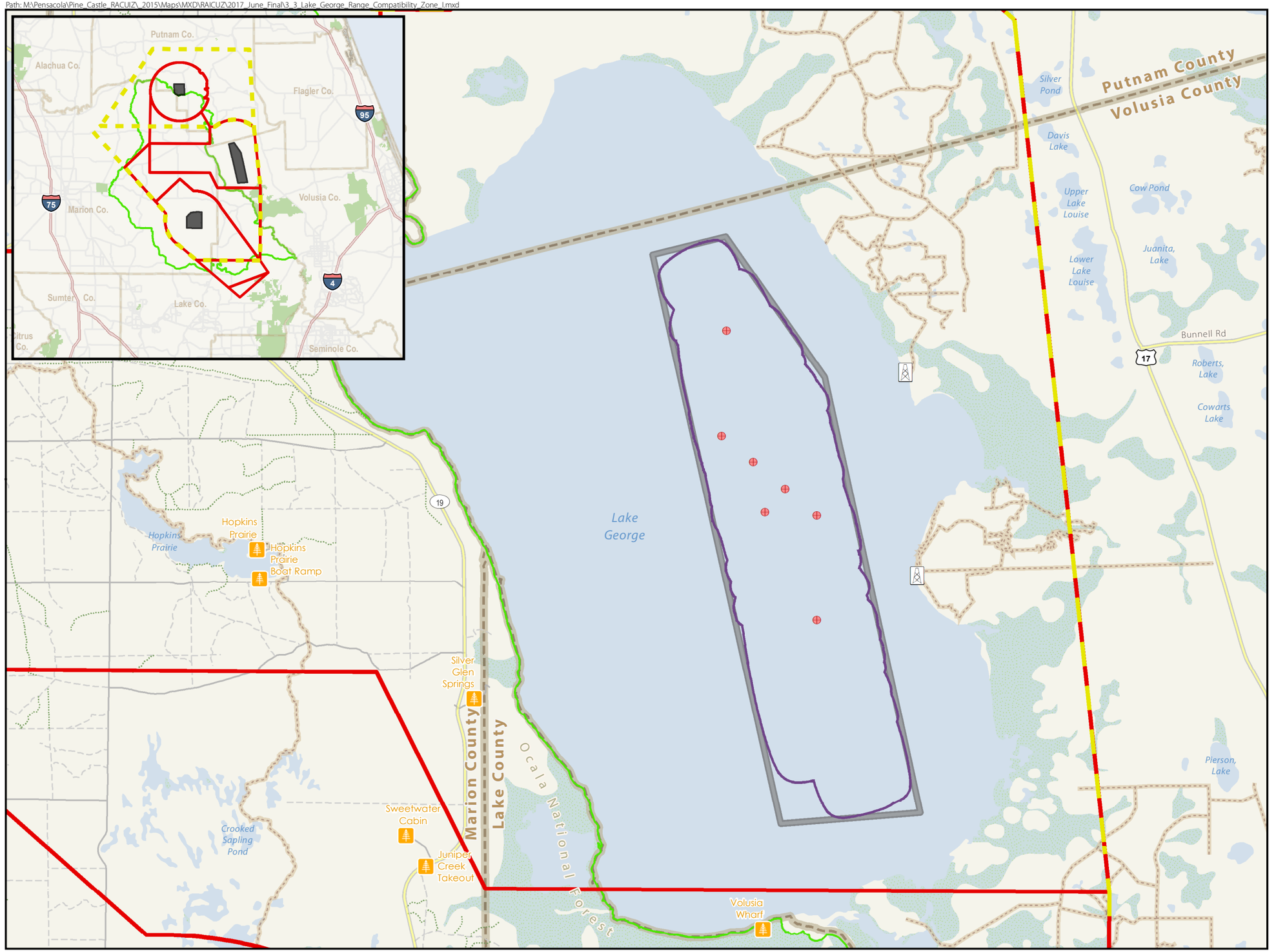

Figure 3-3

Lake George Range
Range Compatibility Zone I

Pinecastle Range Complex
Ocala National Forest
Volusia County, Florida

Legend

- Target
- Tower
- Military Operating Area
- Projected RCZ-I
- Range Boundary
- Restricted Area
- Recreation Site (includes camping)
- Interstate
- Major Highway
- County Boundary
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

SCALE

0 1 2 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2016.

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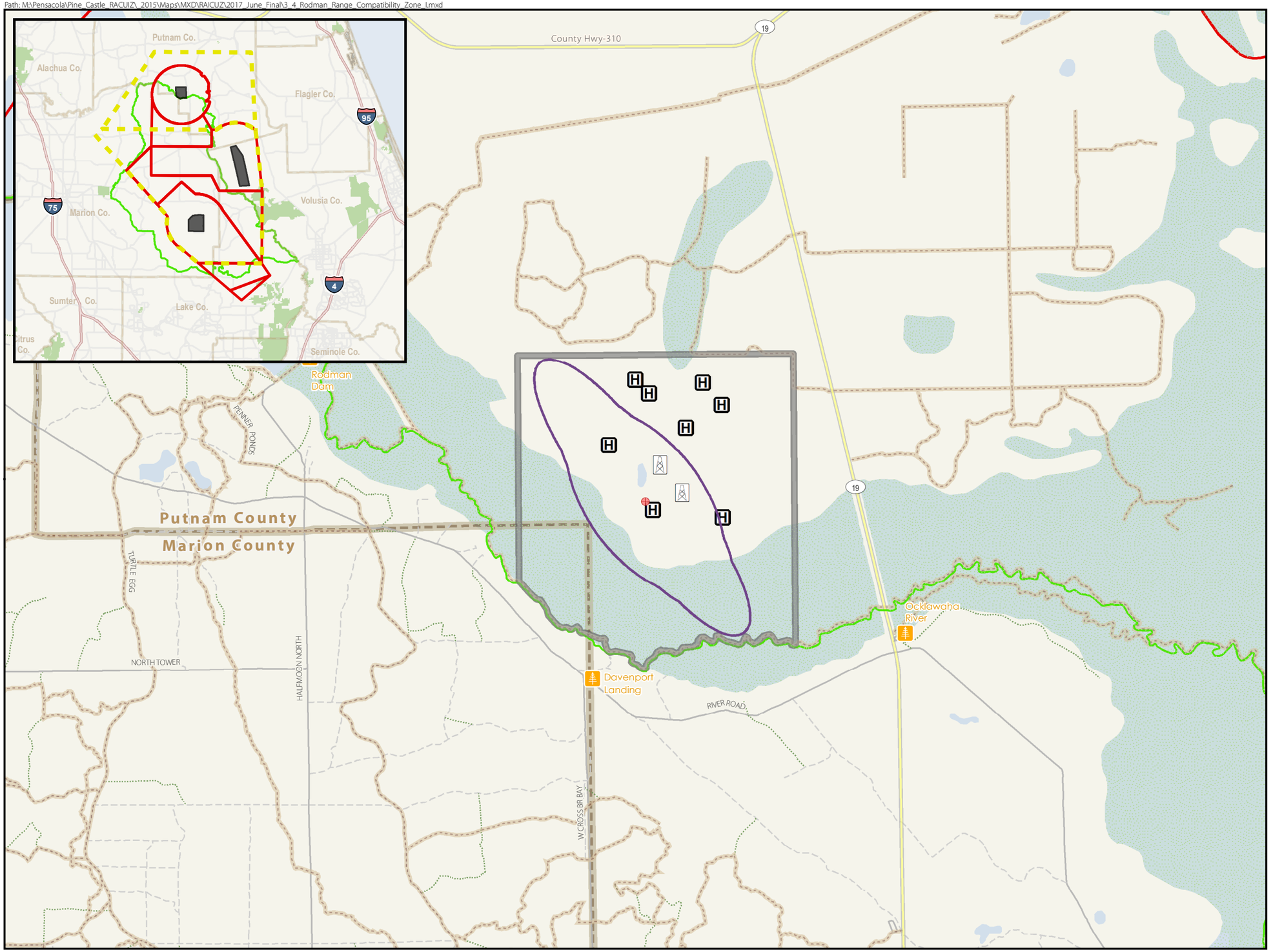

Figure 3-4

Rodman Range
Range Compatibility Zone I

Pinecastle Range Complex
Ocala National Forest
Marion and Putnam Counties, Florida

Legend

- Target
- Tower
- Landing Zone
- Military Operating Area
- Projected RCZ-I
- Range Boundary
- Restricted Area
- Recreation Site (includes camping)
- Interstate
- Major Highway
- County Boundary
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2016.

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3.2.2 Range Compatibility Zone II

RCZ-II defines the area of aircraft armed over-flight, when an aircraft commits to the target attack. The period of armed over-flight applies only 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 and is identified as the area that could be impacted by ordnance, if inadvertently released, following activation of the arming switch. At Pinecastle, Lake George, and Rodman ranges, the RCZ-IIs were developed to encompass the various approved attack headings for all targets out to the portion of the SUA where an aircraft would arm its weapon and begin target attack. The distance from the target where an aircraft would arm its weapon was obtained through discussions with range users regarding their training methods. Figure 3-5 depicts the projected RCZ-IIs for each range.

3.2.2.1 Pinecastle Range

Pinecastle Range does not have a currently approved RCZ-II. The projected RCZ-II developed for Pinecastle Range as part of this RAICUZ Study encompasses 193,563 acres. Approximately 157,048 acres of that total are located outside of the range boundary within ONF. There are 21,078 acres off range over water. Only 9,741 acres of projected RCZ-II are located over land that is outside of the range boundary and the ONF boundary. The remaining lands within projected RCZ-II for Pinecastle Range are within the range boundary (Table 3-2).

The projected RCZ-II for Pinecastle Range overlaps the projected RCZ-II for Lake George Range; therefore, discussion of acreages for affected areas by range will reflect the overlap in the RCZ-II coverage, making the total acreage appear higher. The total acreage associated with the PRC as a whole is 257,364 acres. Table 3-2 provides a more detailed breakdown of acreage affected by each of the range's associated projected RCZ-II.

3.2.2.2 Lake George Range

Lake George Range does not have a currently approved RCZ-II. The total acreage encompassed by the projected RCZ-II associated with Lake George Range is 93,388. Of the total, 55,540 acres are located off range, and 49,026 of those acres located off-range are within ONF. Most of the projected RCZ-II acreage that is over water located off range still remains within Lake George.

The projected RCZ-II for Lake George Range overlaps the projected RCZ-II for Pinecastle Range so discussion of acreages for affected areas by range will reflect the overlap in the RCZ-II coverage, making the total acreage appear higher. The total acreage associated with the PRC as a whole is 257,364 acres. Table 3-2 provides a more detailed breakdown of acreage affected by each of the range's associated projected RCZ-II.

3.2.2.3 Rodman Range

Rodman Range does not have a currently approved RCZ-II. The projected RCZ-II for Rodman Range encompasses 3,707 acres. Of the total acres, 766 acres are located within the range boundary.

Table 3-2: Comparison of Projected Land and Water Areas Impacted by RCZ-II within the Pinecastle Range Complex Ranges (in acres)

Range	Land			Waterbody		Total
	Off-Range Outside ONF (a)	Off-Range Within ONF (b)	On-Range	Off-Range (c)	On-Range (d)	
Pinecastle	9,741	157,048	5,695	21,078	0	193,563
Lake George	6,514	49,026	0	28,462	9,386	93,388
Rodman	1,219	1,504	554	218	212	3,707
Subtotal	17,474	207,578	6,250	49,758	9,598	
TOTAL*	231,301			59,357		290,658

Notes:
*The total acreage associated with PRC is 257,364 acres. The total number of 290,658 includes the overlap acres between the RCZ-II associated with the Pinecastle and Lake George ranges.
(a) Land that is located outside of the range boundary and ONF.
(b) Land that is located outside of the range boundary, but within ONF.
(c) Surface waters, marsh, and/or swamp outside the range boundary.
(d) Surface waters, marsh, and/or swamp inside the range boundary.

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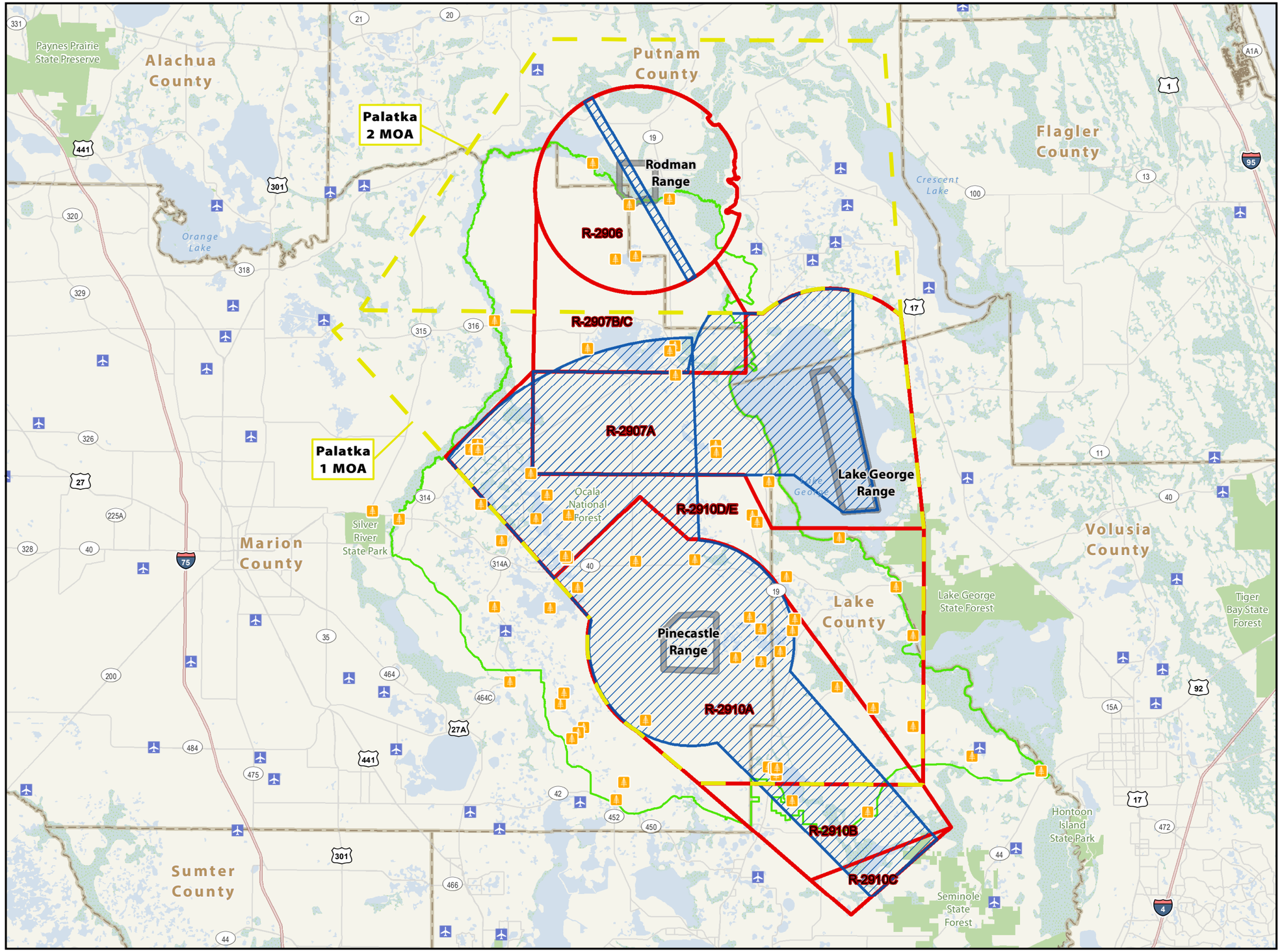

Figure 3-5

Pinecastle Range Complex
Projected Range Compatibility Zone IIs

Pinecastle Range Complex
Ocala National Forest
Lake, Marion, Putnam, and Volusia Counties, Florida

Legend

- Military Operating Area
- Range Boundary
- Restricted Area
- Projected RCZ-IIs
- Airport
- Recreation Site (includes camping)
- Interstate
- Major Highway
- County Boundary
- Water
- Wetland
- Ocala National Forest
- State Park or Forest

N

SCALE

0 5 10 Miles

SOURCE: ESRI 2010, 2012; FAA 2012; US Navy (2009-2015); Ecology and Environment, 2016.

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3.2.3 Range Compatibility Zone III

RCZ-III defines the minimum airspace within the designated SUA that is required for maneuvering into and out of the air-to-ground target area, outside of the areas designated as RCZ-I and RCZ-II. RCZ-III is the area required to provide access to and from the target, safely separate participating and non-participating aircraft, and provide the range user with tactical maneuvering room allowing for initial alignment for target acquisition. While RCZ-III correlates to required airspace, it is the land underlying the airspace that is considered for safety reasons. RCZ-III represents the least restrictive area associated with a range that requires land use compatibility measures.

The PRC ranges do not have a currently approved RCZ-III. The projected RCZ-III is represented by the SUA that surrounds each range. This encompasses the Palatka MOA and Restricted Areas R-2910A/B/C/D/E, 2907A/B/C, and 2906 (Figure 3-6). Therefore, the area shown for the projected RCZ-III is shown and calculated for the PRC as a whole and not broken out separately by individual range (Table 3-3). The projected RCZ-III covers an area of 662,728 acres.

Table 3-3: Comparison of Projected Land and Water Areas Impacted by RCZ-III within the Pinecastle Range Complex (in acres)

Land			Waterbody		
Off-Range Outside ONF (a)	Off-Range Within ONF (b)	On-Range	Off-Range (c)	On-Range (d)	Total
182,310	307,334	7,264	155,360	10,461	662,728

Note:
(a) Land that is located outside of the range boundary and ONF.
(b) Land that is located outside of the range boundary, but within ONF.
(c) Surface waters, marsh, and/or swamp outside the range boundary.
(d) Surface waters, marsh, and/or swamp inside the range boundary.

3.3 RISK ANALYSIS

For the purposes of this RAICUZ Study, risk is generally considered to be zero when the probability is less than 1 in 1 trillion

While WDZs do not provide a measurement of risk, the WDZ Tool used to model the safety footprints has an additional function that allows the user to calculate point- and area-based risks for designated Areas of Critical Concern (ACCs). The WDZ Tool has the capability to quantify the risk of a weapon's impact at various locations in, or very near, RCZ-I. The risk is provided in a ratio format. For example, 1:10,000 means that the probability of a hit is one in 10,000. For the purposes of this RAICUZ Study, risk is generally considered to be zero when the WDZ Tool indicates a probability of less than a 1:1,000,000,000,000 (1 in 1 trillion) chance of an impact at a given ACC.

As discussed in Section 3.2.1.1, the Navy requires that all aircraft-delivered gun ammunition be modeled to contain at least 99.999 percent of munitions within the WDZ (i.e., a 1:100,000 probability of a munition impacting an area outside of the WDZ). All other aviation-delivered ordnance must be modeled to contain at least 99.99 percent within the WDZ (i.e., 1:10,000 probability of a munition impacting an area outside of the WDZ). Therefore, there is some remaining risk (albeit small) of impact outside the WDZ footprint.

3.3.1 Pinecastle Range

To calculate risk, ACCs must be identified and selected for analysis. Typically, ACCs are manned facilities, range access points, equipment locations, and other potentially sensitive areas. FACSFACJAX and range personnel examined areas within the projected RCZ-I for Pinecastle Range and selected 25 locations for analysis based on the potential to impact public safety. Table 3-4 provides the names, locations, and sizes of the ACCs, and Figure 3-7 shows their locations relative to the projected RCZ-I.

Table 3-4: Areas of Critical Concern for Pinecastle Range

Name	Latitude	Longitude	Area (ft^2)
Farles Prairie Campground	29° 6' 12.897" N	81° 40' 27.375" W	16,000
FNST 1 (Old Location)	29° 6' 55.360" N	81° 40' 47.281" W	100
FNST 2 (New Location)	29° 7' 13.800" N	81° 40' 29.040" W	100
FNST 3	29° 5' 46.492" N	81° 40' 17.424" W	100
FR 13/ATV RG Gate	29° 10' 21.540" N	81° 45' 22.560" W	1,000
FR 13/FR 14 RG Gate	29° 3' 7.920" N	81° 45' 18.360" W	1,000
FR 14-9.8	29° 3' 45.360" N	81° 40' 31.800" W	1,000
FR 17/FR 22 RG Gate	29° 6' 24.120" N	81° 47' 18.240" W	1,000
FR 30-42	29° 9' 23.040" N	81° 41' 4.260" W	1,000
FR 30/FNST RG Gate	29° 8' 26.880" N	81° 39' 58.320" W	1,000
FR 37	29° 10' 7.620" N	81° 42' 29.160" W	1,000
FR 45/FR 14 RG Gate	29° 3' 1.080" N	81° 42' 32.880" W	1,000
FR 566	29° 4' 3.410" N	81° 42' 31.748" W	1,000
FR 588-599	29° 8' 30.296" N	81° 45' 21.823" W	4,000
North Tower	29° 7' 42.960" N	81° 42' 55.760" W	2,000
Pinecastle Boundary North	29° 8' 18.931" N	81° 42' 29.841" W	2,000
Pinecastle Boundary Northwest	29° 7' 54.003" N	81° 43' 59.528" W	1,000
Pinecastle Boundary South	29° 5' 31.734" N	81° 42' 31.424" W	5,000
South Adventure Trail 1	29° 5' 30.520" N	81° 41' 2.928" W	500
South Adventure Trail 2	29° 10' 0.720" N	81° 43' 32.401" W	500
South Adventure Trail 3	29° 9' 44.292" N	81° 45' 30.453" W	500
Tower 2-1	29° 6' 28.298" N	81° 42' 53.610" W	20,000
Tower 2-2	29° 6' 37.201" N	81° 43' 50.893" W	200,000
Utility Corridor	29° 8' 1.145" N	81° 45' 51.085" W	3,000
West Gate	29° 6' 25.049" N	81° 44' 25.930" W	1,000

Key:
ATV = all-terrain vehicle
FNST = Florida National Scenic Trail
FR = Forest Road
ft^2 = square foot/feet
RG = Road Guard

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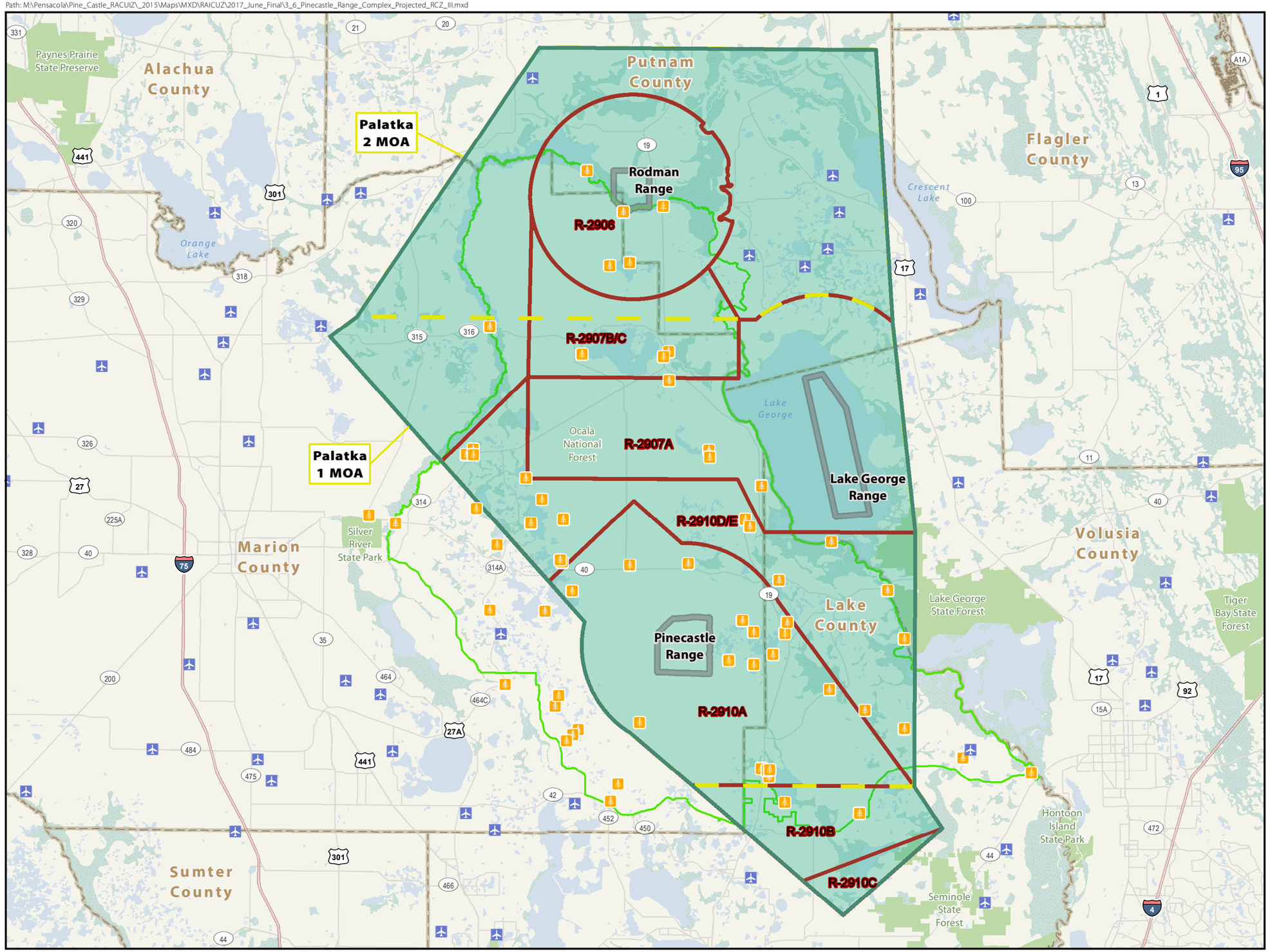

Figure 3-6

Pinecastle Range Complex
Projected Range Compatibility Zone III

Pinecastle Range Complex
Ocala National Forest
Lake, Marion, Putnam, and Volusia Counties, Florida

Legend

- Military Operating Area
- Range Boundary
- Restricted Area
- Projected RCZ-III
- Airport
- Recreation Site (includes camping)
- Interstate
- Major Highway
- County Boundary
- Water
- Wetland
- Ocala National Forest
- State Park or Forest

N

SCALE

0 5 10 Miles

SOURCE: ESRI 2010, 2012; FAA 2012; US Navy (2009-2015); Ecology and Environment, 2016.

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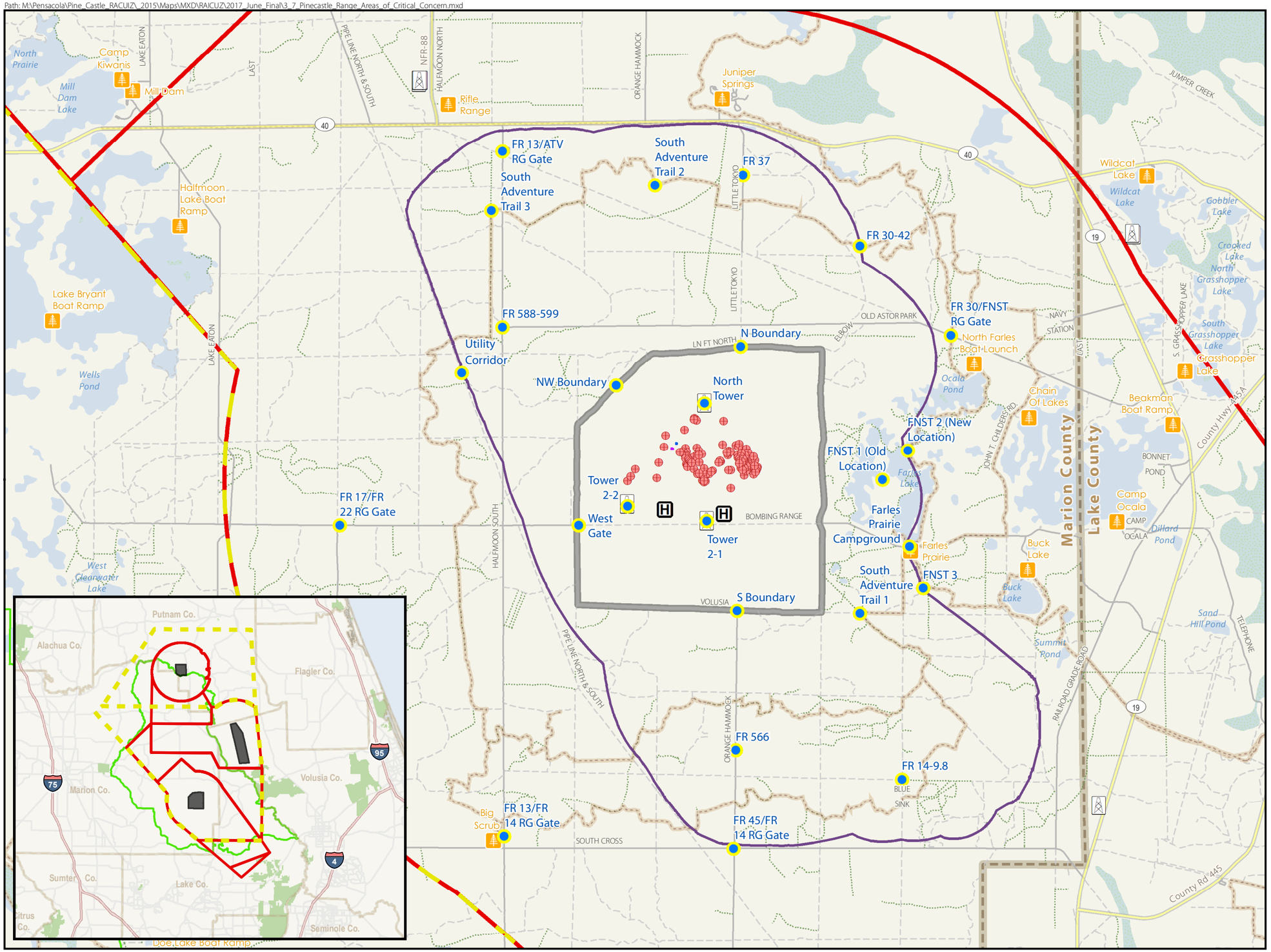

Figure 3-7

Pinecastle Range Areas of Critical Concern

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Areas of Critical Concern
- Target
- Tower
- Landing Zone
- Military Operating Area
- Projected RCZ-I
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Area
- Recreation Site (includes camping)
- Interstate
- Major Highway
- County Boundary
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2016.

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The risk analysis for Pinecastle Range shows that the chance of a weapon or fragment striking one of the ACCs outside the range boundary varies from no measureable risk to a high of a 1.09:10 probability. Generally, the highest risk probability occurs at the South Adventure Trail 1 ACC due to it being in line with a majority of attack headings for a variety of different targets. The risk to areas outside the range boundary occur only when the RCZ-I is active. Security measures, such as road guards and gates, which are implemented and/or are planned to be implemented (see Chapter 6), are designed to prevent non-participating personnel from being in areas of high risk while training operations are occurring.

3.3.2 Lake George Range

FACSFACJAX and range personnel selected ACCs generally located around the boundary because RCZ-I at Lake George Range is fully contained within the range boundary. In total, ten locations were selected for analysis. Table 3-5 provides the names, locations, and sizes of the ACCs, and Figure 3-8 shows their locations relative to the projected RCZ-I.

Table 3-5: Areas of Critical Concern for Lake George Range

Name	Latitude	Longitude	Area (ft^2)
Lake George 1	29° 18' 39.023" N	81° 33' 53.633" W	100
Lake George 2	29° 16' 11.866" N	81° 33' 15.920" W	100
Lake George 3	29° 13' 22.866" N	81° 33' 31.950" W	100
Lake George 4	29° 15' 50.411" N	81° 35' 7.608" W	100
Lake George 5	29° 17' 0.547" N	81° 35' 26.052" W	100
Lake George 6	29° 18' 38.499" N	81° 35' 51.825" W	100
Lake George 7	29° 20' 6.318" N	81° 36' 14.943" W	100
Lake George 8	29° 20' 19.489" N	81° 35' 15.190" W	100
Nine Mile Point Tower	29° 16' 17.102" N	81° 32' 37.045" W	7,000
Pine Island Tower	29° 18' 42.455" N	81° 32' 47.387" W	8,000

Key:
ft^2 = square foot/feet

At Lake George Range, most of the ten ACCs surround the Navy-controlled area. Since the WDZs are fully contained within this area, the risks at these ACCs are very low. The risks range from no measurable risk to a high of 8.44:1,000,000,000,000 (8.44:1 trillion) probability of a weapon or fragment impact at an ACC.

3.3.3 Rodman Range

Similar to the Lake George Range, the Rodman Range RCZ-I is fully contained within the range boundary; therefore, FACSFACJAX and range personnel selected ACCs generally located around the boundary. In total, ten locations were selected for analysis. Table 3-6 provides the names, locations, and sizes of the ACCs, and Figure 3-9 shows their locations relative to the projected RCZ-I.

Table 3-6: Areas of Critical Concern for Rodman Range

Name	Latitude	Longitude	Area (ft^2)
Rodman Boundary East	29° 29' 33.127" N	81° 45' 4.917" W	500
Rodman Boundary North	29° 30' 19.920" N	81° 46' 10.493" W	500
Rodman Boundary Northeast	29° 30' 20.284" N	81° 45' 5.694" W	1,000
Rodman Boundary Northwest	29° 30' 18.849" N	81° 47' 5.516" W	500
Rodman Boundary South	29° 28' 20.223" N	81° 46' 9.686" W	4,000
Rodman Boundary Southeast	29° 28' 29.609" N	81° 45' 4.549" W	5,000
Rodman Boundary Southwest	29° 28' 53.494" N	81° 47' 4.226" W	5,000
Rodman Boundary West	29° 29' 32.242" N	81° 47' 4.639" W	100
Tower 2-1	29° 29' 26.838" N	81° 45' 53.268" W	8,000
Tower 2-2	29° 29' 37.431" N	81° 46' 3.039" W	7,000

Key:
ft^2 = square foot/feet

At Rodman Range, most of the ten ACCs surround the Navy-controlled area. Since the WDZs are fully contained within this area, the risks at these ACCs are very low. The risk at an ACC along the range boundary or any area outside the range boundary is 0. There is no measurable risk that a weapon or fragment will impact an area outside the range boundary.

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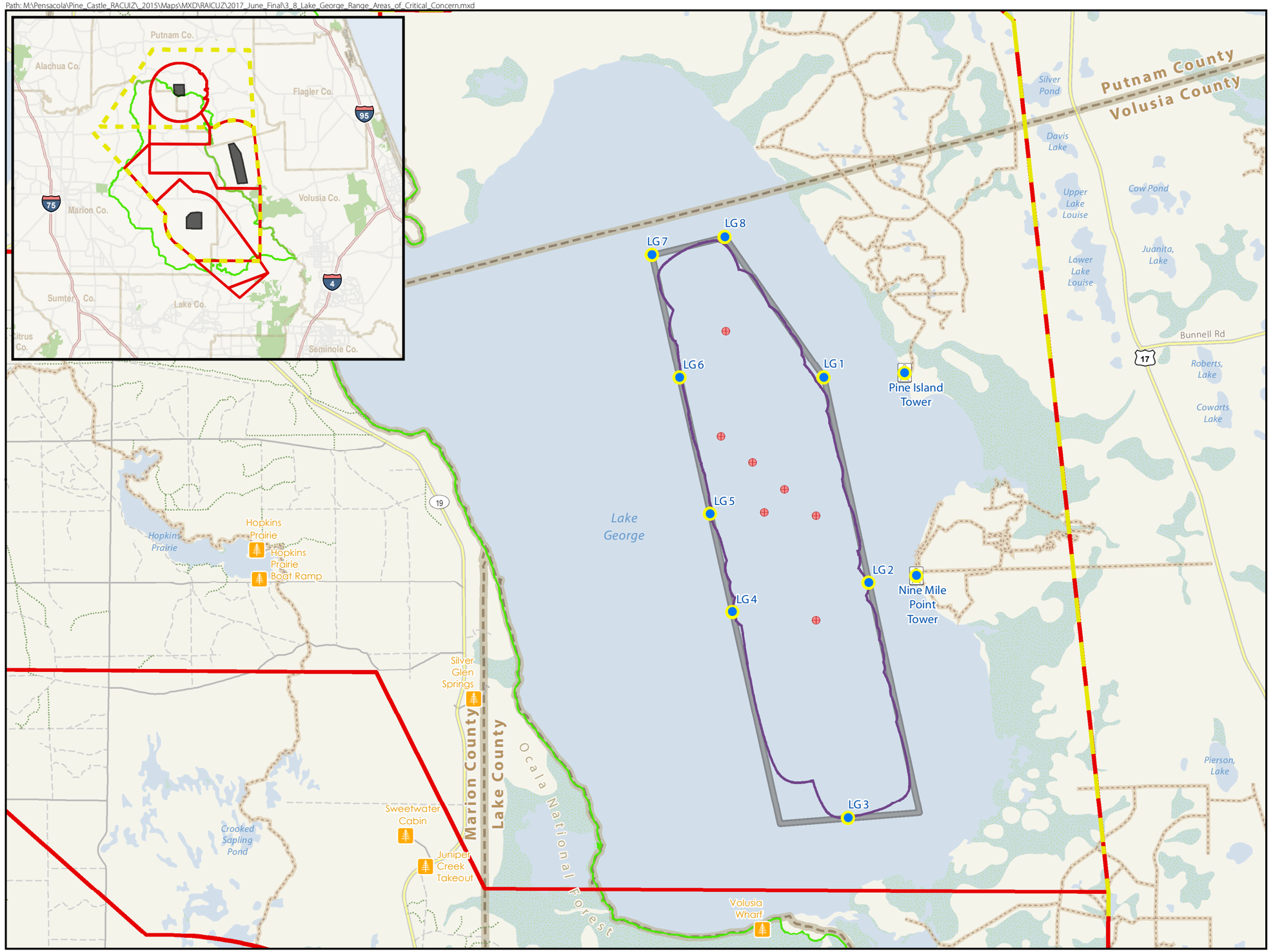

Figure 3-8

Lake George Range Areas of Critical Concern

Pinecastle Range Complex
Ocala National Forest
Volusia County, Florida

Legend

- Areas of Critical Concern
- Target
- Tower
- Military Operating Area
- Projected RCZ-I
- Range Boundary
- Restricted Area
- Recreation Site (includes camping)
- Interstate
- Major Highway
- County Boundary
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2016.

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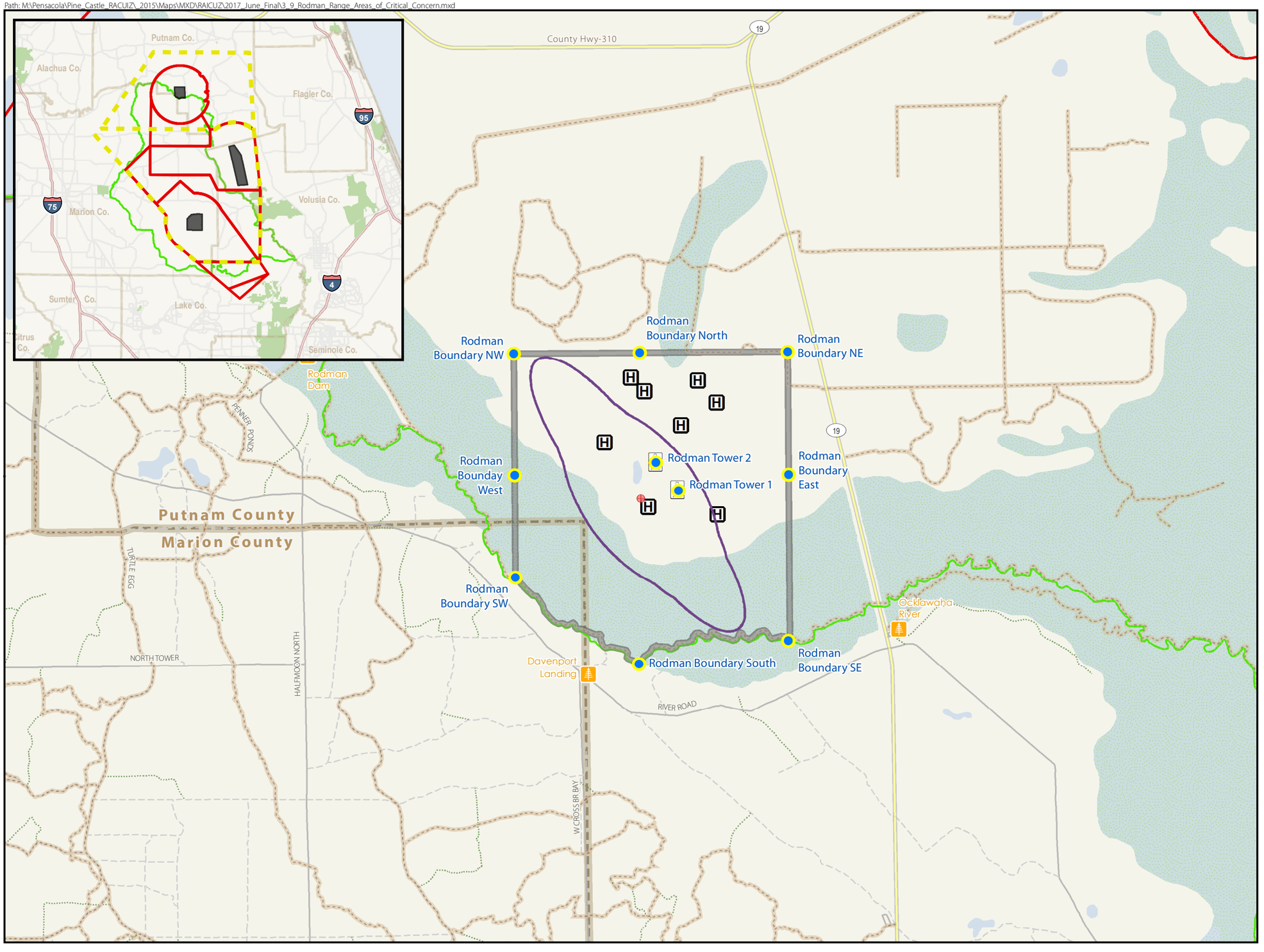

Figure 3-9

Rodman Range
Areas of Critical Concern

Pinecastle Range Complex
Ocala National Forest
Marion and Putnam Counties, Florida

Legend

- Areas of Critical Concern
- Target
- Tower
- Landing Zone
- Military Operating Area
- Projected RCZ-I
- Range Boundary
- Restricted Area
- Recreation Site (includes camping)
- Interstate
- Major Highway
- County Boundary
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2016.

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4 NOISE ANALYSIS

Understanding the effects of aircraft noise is a critical factor in the planning of future land use near military ranges. How a military range manages noise can play a significant role in shaping the range's relationship with the community. The community response to noise is a particular concern near training ranges and under SUA because of the noise exposure characteristics commonly associated with low-altitude high-speed aircraft operations, muzzle blast, strafe firing exercises, and the detonation of ordnance. The Navy defines noise zones based on noise exposure that often affects surrounding communities. Noise zone guidance is provided in OPNAVINST 3550.1A. These noise zones provide the community with a tool to plan for compatible development near ranges.

4.1 METHODOLOGY

4.1.1 What is Noise?

Sound results from vibrations, introduced into a medium such as air, that stimulate the auditory nerves of a receptor to produce the sensation of hearing. Sound is undesirable if it interferes with communication, is intense enough to damage hearing, or disrupts normal human activities. Undesirable sound is commonly referred to as "noise." Human responses to sound vary with the types and characteristics of the sound source, the distance between the source and receptor, receptor sensitivity, the background sound level, and other factors, such as time of day. Sound may be intermittent or continuous, steady or impulsive, and may be generated by stationary sources (e.g., industrial plants) or transient sources (e.g., cars and aircraft). (Wyle 2014)

Sound energy travels in waves. Its intensity at a receptor varies depending on factors such as the source of the sound's intensity, the characteristics of the sound wave, the distance between the source and receiver, and environmental conditions (i.e., weather). Physical interactions such as absorption or reflection between sound waves and surfaces can change the sound. (Wyle 2014)

The measurement and human perception of sound involves three basic physical characteristics: intensity, frequency, and duration, as defined below:

- **Intensity** is a measure of the acoustic energy of the sound and is related to sound pressure. The greater the sound pressure, the more energy carried by the sound and the louder the perception of that sound.
- **Frequency** determines how the pitch of the sound is perceived. Low-frequency sounds are characterized as rumbles or roars, while high-frequency sounds are typified by sirens or screeches.
- **Duration** is the length of time the sound can be detected. (Wyle 2014)

Decibel (dB) is a unit of measure used to represent the intensity of sound.

The human ear can detect sound over a vast range; therefore, using a linear scale to represent the intensity of sound becomes difficult. As a result, a logarithmic unit, known as the decibel (dB), is used to represent the intensity of sound. 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. 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 the human ear does not respond linearly.

The A-weighted scale (dBA) screens out the very high and very low sound frequencies to mimic the human ear's sensitivity and perception and more accurately reflects what people hear. The A-weighted scale is used for aircraft and small arms related sound.

Sound frequency is measured in terms of cycles per second or hertz. The normal ear of a young person can detect sounds that range in frequency from about 20 hertz to 20,000 hertz. As we get older, we lose the ability to hear high-frequency sounds. Not all sounds in this wide range of frequencies are heard equally. Human hearing is most sensitive to frequencies in the 1,000 to 4,000 hertz 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 (Wyle 2014). Most environmental sounds, including sounds from aircraft and small arms, are measured using A-weighting. The A-weighted scale, denoted as dBA, screens out the very high and very low sound frequencies to mimic the human ear's sensitivity and perception and more accurately reflects what people hear. Normal conversations have a sound level of approximately 60 dBA; sound levels above 110 dBA begin to be felt inside the human ear as discomfort; sound levels much above 140 dBA are felt as pain. Figure 4-1 is a chart of A-weighted sound levels from common sources.

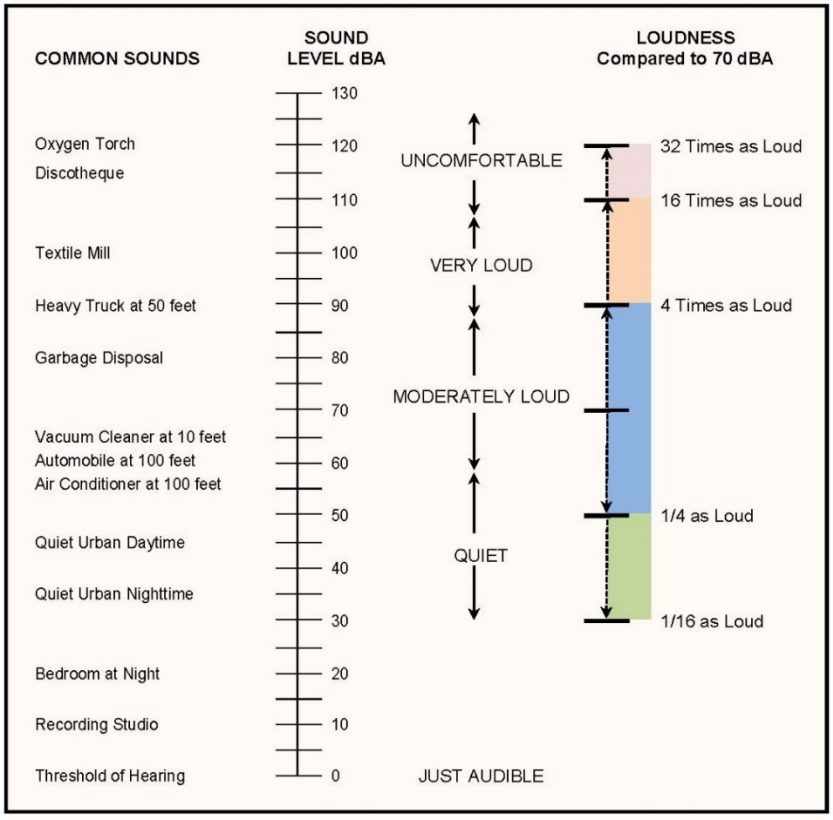


Figure 4-1: Typical A-Weighted Sound Levels

Very loud or impulsive sounds, such as explosions or sonic booms, can sometimes be felt and can cause secondary effects, such as shaking of a structure or rattling of windows. These types of sounds can add to annoyance, and are best measured by C-weighted sound levels. The C-weighted scale, denoted as dBC, is nearly flat through the audible frequency range and does not screen out frequencies like the A-weighted scale. The C-weighted scale is used to describe impulsive sounds that generally occur at lower frequencies. (Wyle 2014)

The C-weighted scale (dBC) is nearly flat through the audible frequency range and does not screen out frequencies like the A-weighted scale. The C-weighted scale is used to describe impulsive sounds that generally occur at lower frequencies that cause secondary effects, such as vibrations and rattling of windows. The C-weighted scale is used for large-caliber weapons and explosives -related sounds.

Appendix A, Discussion of Noise and Its Effect on the Environment (Wyle 2014), provides further discussion of noise, how it is calculated and modeled, and its effects on people and the environment.

4.1.2 Noise Sources

The main sources of noise at the PRC are flight operations, aerial gunnery (strafing) and inert ordnance, and small arms training. The operations numbers associated with these sources are described in Section 2.3.3. Generally, the number of operations fluctuates from year to year, and small fluctuations in the annual number of operations or ordnance will not have a significant effect on community noise exposure.

The computer models discussed in Section 4.1.4 develop noise exposure contours utilizing specific training details from these operations, including:

- Aircraft flight profile (power settings, speeds, and altitudes);
- Environmental data (temperature and humidity);
- Number of operations per day/year;
- Terrain and surface type;
- Time of operation (day and night); and
- Type of operation.

4.1.3 Noise Metrics

The noise environment at the PRC is dominated by aircraft flight and aerial gunnery events. 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 assessed using several noise metrics. (BRRC 2017)

A noise metric refers to a unit or quantity that measures an aspect of the received noise used in environmental noise analyses. A metric is used to relate the received noise to its various effects. To quantify these effects, the DOD and FAA use a series of metrics to describe the noise environment. These metrics range from simple, to descriptive, and to complex measures of the noise environment.

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). SEL is used to relate the modeled noise with the potential of sleep disturbance. Another simple measure of instantaneous noise level is the Peak Sound Pressure Level that is used primarily for impulsive noise associated with explosions and gun firings. (Downing 2017)

Complex metrics quantify the cumulative noise exposure using a number of different methods of analyzing the noise based on the expected flight and aircraft engine run-up maintenance schedules. Some common metrics are the equivalent average sound level (L_{eq}), the day/night average sound level (DNL), and community noise equivalent level (CNEL), which is used in the state of California. The DNL is the fundamental metric used to describe the aircraft noise environment in and around an airfield or range and is directly related to the long-term community annoyance resulting from this noise. The other metrics (simple and descriptive) supplement this long-term characterization of the noise environment and help to clarify different aspects of the noise effects. (Downing 2017)

Day-night average sound level, (DNL) is a composite metric that describes the average noise level over a 24-hour period and does not represent the sound level for a specific event. Noise is measured in intervals (e.g., seconds, minutes, and hours) and averaged over a 24-hour period. A 10-dB penalty is added to nighttime (10:00 p.m. to 7:00 a.m.) sound levels in order to account for heightened sensitivity to noise during nighttime hours.

The various noise metrics used for this analysis are discussed in greater detail in Appendix A.

4.1.4 Noise Modeling

Noise contours for aircraft operations were developed using a combination of NoiseMap and the MOA Range NoiseMap (MR_NMAP). These models are the standard DOD computer noise models for estimating the aircraft noise exposures. Tracked operations for fixed-wing aircraft were modeled in NoiseMap; MR_NMAP was used to model less defined operations that are along routes, not tracks, and that occur within a general area. When using a combination of NoiseMap and MR_NMAP, a flat earth grid (constant ground elevation) is used for both models since MR_NMAP does not include the effects of terrain. Aerial gunnery noise was modeled using the Air Gunnery Model, which models the noise from the muzzle blast, the sonic boom of a supersonic projectile, and rocket/missile firings from an elevated airborne platform. Ground-based large and small arms noise was modeled using the standard DOD computer noise models, Blast Noise (BNOISE2) and Small Arms Range Noise Assessment Model (SARNAM2), respectively. The following sections briefly describe these analysis tools. (BRRC 2017)

4.1.4.1 NoiseMap

Analyses of aircraft noise exposure around military airfield facilities are normally accomplished by using the NoiseMap program. NoiseMap can also be applied to operations within a range if the operations occur along a well-defined flight track. NoiseMap is a suite of computer programs that were developed by the Air Force, which serves as the lead DOD agency for fixed-wing aircraft noise modeling. NoiseMap allows noise prediction without the actual implementation of the operations and noise monitoring of those actions. (BRRC 2017)

4.1.4.2 MR_NMAP

Analyses of aircraft noise exposures and compatible land uses around and underneath SUAs are generally accomplished using MR_NMAP. The Air Force developed this general-purpose computer model for calculating noise exposure occurring away from airbases, since aircraft noise is also an issue within MOAs and ranges, as well as along MTRs. MR_NMAP uses two primary noise models to calculate noise exposure: track operations and area operations. Track operations are for operations that have a well-defined flight track, such as MTRs, aerial refueling, and strafing tracks. Area operations are for operations that do not have well-defined tracks, but occur within a defined area, such as air-to-air combat within an MOA. (BRRC 2017)

4.1.4.3 Air Gunnery Model

Air Gunnery Model is a computer model that was developed to address the generation and propagation of noise from air weaponry operations. This model handles the complexity of the distributed noise events while maintaining accurate acoustical modeling that is required for environmental noise analysis (BRRC 2017).

For this RAICUZ Study, a wide range of operations were modeled, from helicopter small arms fire to Hellfire missiles. Air Gunnery Model handles the noise from the actual firing as well as the ballistic wave of the projectile. The results from Air Gunnery Model include the C-weighted day-night average sound level (CDNL) and Peak noise contours. The noise from high-explosive blasts was modeled using BNOISE2. (BRRC 2017)

4.1.4.4 BNOISE2

Noise from ordnance delivery (blast noise) is impulsive in nature and of short duration. Blast noise can consist of two components, the firing of the projectile from the weapon and the detonation of the projectile if it contains a high-explosive charge. When a projectile or bomb is released from an aircraft and the projectile contains high-explosive material, only the noise resulting from the detonation of the projectile is calculated. The same process is applied to a projectile that is ground-delivered. If the projectile is non-high-explosive, only the noise resulting from the firing of the projectile is calculated. Vibrations of buildings and structures induced by blast noise may result in increased annoyance and risk of noise complaints or damage. (Wyle 2012)

4.1.4.5 SARNAM2

For small arms range complexes, SARNAM2 calculates and plots noise contours for a variety of noise management tasks, such as assessing long-term community noise impacts, examining noise levels resulting from single firing events, or planning range operations. SARNAM2 is capable of analyzing small arms rounds up to 20mm in diameter.

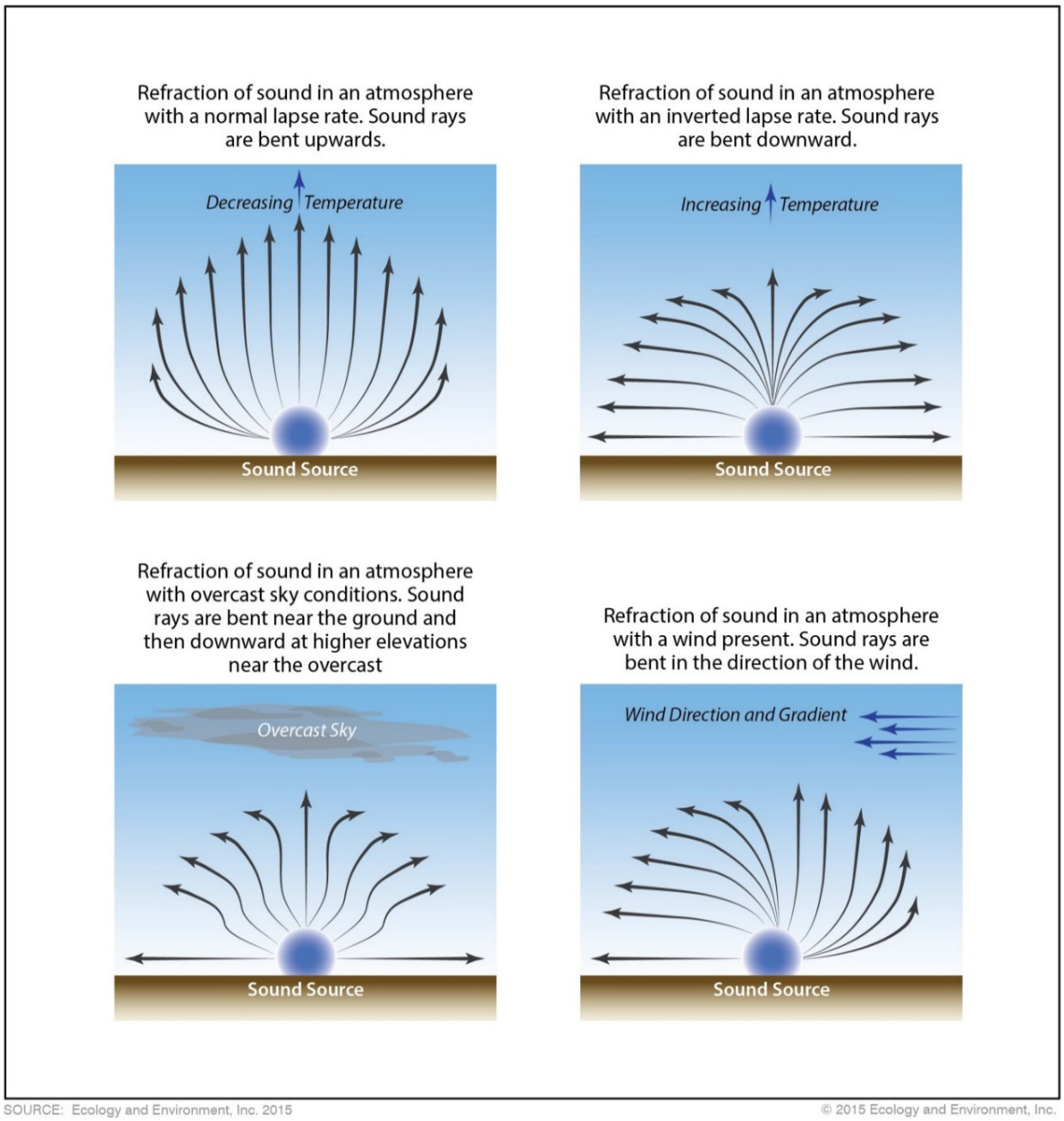
SARNAM2 includes consideration of weapon and ammunition type, spectrum and directivity for both muzzle blast and projectile bow shock, number of rounds fired, time at which rounds are fired, range attributes, frequency weighting, propagation conditions, noise metrics, noise assessment penalties, and long-term assessment periods and procedures. Effects of terrain on sound propagation are not considered in the program (a flat terrain assumption). (Wyle 2012)

4.1.5 How Weather Affects Noise

Weather, as well as atmospheric, geographic, and local influences, has an effect on noise at the PRC. Variations in temperature, relative humidity, wind, and even cloud cover, in addition to other conditions, such as foliage extent, can significantly affect the perception of aircraft noise on the ground. These effects can be simplified to those that affect the propagation of sound. It is important to note that the propagation of noise at the PRC includes aircraft noise, inert bombs, and the percussive sounds of weaponry (e.g., muzzle blast, explosions). Figure 4-2 illustrates how weather can affect sound perception.

Sound waves travel through air, similar to waves through water. Sound travels faster through cold air than warm air. This makes aircraft seem louder on cold days than days with warmer temperatures. Temperature inversion (i.e., where a warm air mass sits on top of a cold air mass, similar to a lid) amplifies this effect by trapping and reflecting sound horizontally over the earth's surface rather than vertically out into space (National Research Council 2008). Adding to this, humidity and cloud cover can further amplify sound waves by acting similarly to a backstop at a band shell and reflecting sound back down towards the ground (Figure 4-2).

Another factor that plays a role in sound perception on the ground is wind speed. Wind helps to propagate sound in a particular direction, thereby amplifying it in one direction (Jandakot Airport 2016) (Figure 4-2). Sound absorption in the atmosphere and by foliage mostly affects the perception of sound on the ground without affecting the decibel level produced by the aircraft. Conversely, sound is relatively unobstructed over surfaces that are not porous, such as water or hard, packed ground.



SOURCE: Ecology and Environment, Inc. 2015

Figure 4-2: Weather Effects on Sound

4.2 Noise Zones

The noise contours discussed and shown in Section 4.3 are visually depicted as lines that connect points of equal value. The area between any two noise contours is known as a noise zone. The community response to military noise, such as small arms, artillery, and aircraft noise, is a topic that is often addressed in the local land use plans in the vicinity of ranges. For land use planning purposes, the DOD generally divides noise exposure from aircraft and weapons into three "noise zones." Noise zones that are used for land use planning purposes in this document include:

- Noise Zone 1: Represents the lowest area of noise exposure. DNL is less than 65 dBA DNL/62 dBC DNL and a peak level less than 87 $dBPK_{15}$. This is an area with minimal 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: This is an area of moderate noise exposure where some land use controls are required. DNL is between 65-75 dBA DNL or 62-70 dBC DNL, and the peak level is between 87-104 $dBPK_{15}$; and
- Noise Zone 3: Represents the most severely impacted areas where the greatest degree of land use control is recommended; greater than 75 dBA DNL, 70 dBC DNL, or 104 $dBPK_{15}$.

Table 4-1 provides the noise level limits of each noise zone associated with land use planning for small arms and impulse noise.

Table 4-1: Noise Zone Definitions

Noise Zone	Aircraft and Small Arms Noise (ADNL)	Impulse Noise (CDNL)	Small Arms $dBPK_{15}$ (Peak)
Zone 1	< 65 dBA	< 62 dBC	< 87 $dBPK_{15}$
Zone 2	65 to 75 dBA	62 to 70 dBC	87 to 104 $dBPK_{15}$
Zone 3	> 75 dBA	> 70 dBC	> 104 $dBPK_{15}$

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 sounds from an individual range being heard several miles away. Supplemental noise metrics are used to help explain this situation in range environs. For example, high-energy impulsive sounds 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 4-2 shows the risk of noise complaints with increasing levels of impulsive noise from large caliber weapons and explosive ordnance disposal detonations.

Table 4-2: Risk of Noise Complaints from Impulsive Noise

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

4.3 Noise Exposure Levels

Noise contour maps provide the Navy, local community planning organizations, and the public with modeled noise-related exposure of range operations. Noise contours, when overlaid with local land uses, can help identify areas of incompatible land uses and assist in planning for future compatible development around a range. Also provided are comparisons and figure overlays of the existing noise exposure levels and projected (FY2020) noise exposure contours by range. The comparison identifies changes to noise exposure (based on projected changes in aircraft and training operations) and allows the identification of incompatible land use and potential recommendations to mitigate noise impacts. Land use compatibility and analysis based on these noise exposure levels are presented in Chapter 5. Land use recommendations within the noise zones are discussed in Chapter 6.

4.3.1 Existing FY2013 Noise Contours

The operations numbers shown in Section 2.3.3 were used in the development of the noise modeling. The primary sources of data are the training and readiness manual, interviews with aircrews and range personnel, and annual reports. Through the data collection process noted in Section 2.3.3, information was obtained from FACSFACJAX and range personnel on new targets, landing zones, weapons, and aircraft that were projected to increase training capabilities at the PRC. Major sources of noise include rotary-wing and fixed-wing aircraft involved in air warfare, electronic combat, strike warfare, and insertion/extraction training activities, as well as impulsive events associated with live-fire activities.

4.3.1.1 Aircraft Noise

Pinecastle Range

At Pinecastle Range, aircraft noise is concentrated over the target areas. Any noise exceeding 65 dBA DNL is contained within the range boundaries. Therefore, all 118 acres within Noise Zone 2 are contained within the range boundary. All of the 60 dBA DNL contours are within the base boundary, and most of the 55 dBA DNL are over the range. The remaining area within Noise Zone 1 between 50 and 55 dBA DNL remain within the Restricted Area around the range. Noise Zone 1 covers approximately 38,482 acres, all of which is contained within ONF (Figure 4-3).

Lake George Range

Aircraft noise generally extends outside of the range boundary, over Lake George, and align with the perimeter of the Restricted Area R-2907A (Figure 4-4). The dominant mission type is area/tactical flight activity and, correspondingly, the operations are modeled as spread equally and so the resulting noise occupies the space in which the flight activity occurs. The aircraft noise contours associated with Lake George Range are between 50 and 55 dBA DNL and are within Noise Zone 1, covering approximately 110,446 acres of land outside of the range boundary. Of the lands outside the range boundary, 49,713 acres are within ONF and 35,994 are located outside of ONF but over surface water.

Rodman Range

Rodman Range features tactical missions where noise is distributed across the Palatka 2 MOA, as shown in Figure 4-5. The noise contours located off the range are 50 dBA DNL and are within Noise Zone 1. Due to the missions and the wide distribution of noise, Noise Zone 1 for Rodman Range covers 162,582 acres outside of the range boundary, 58,169 of which are within ONF. Rodman Range also contains areas of concentrated noise on the range surrounding specific landing zones. Noise contours include the 55, 60, 65, and 70 dBA DNL and remain within the range boundary.

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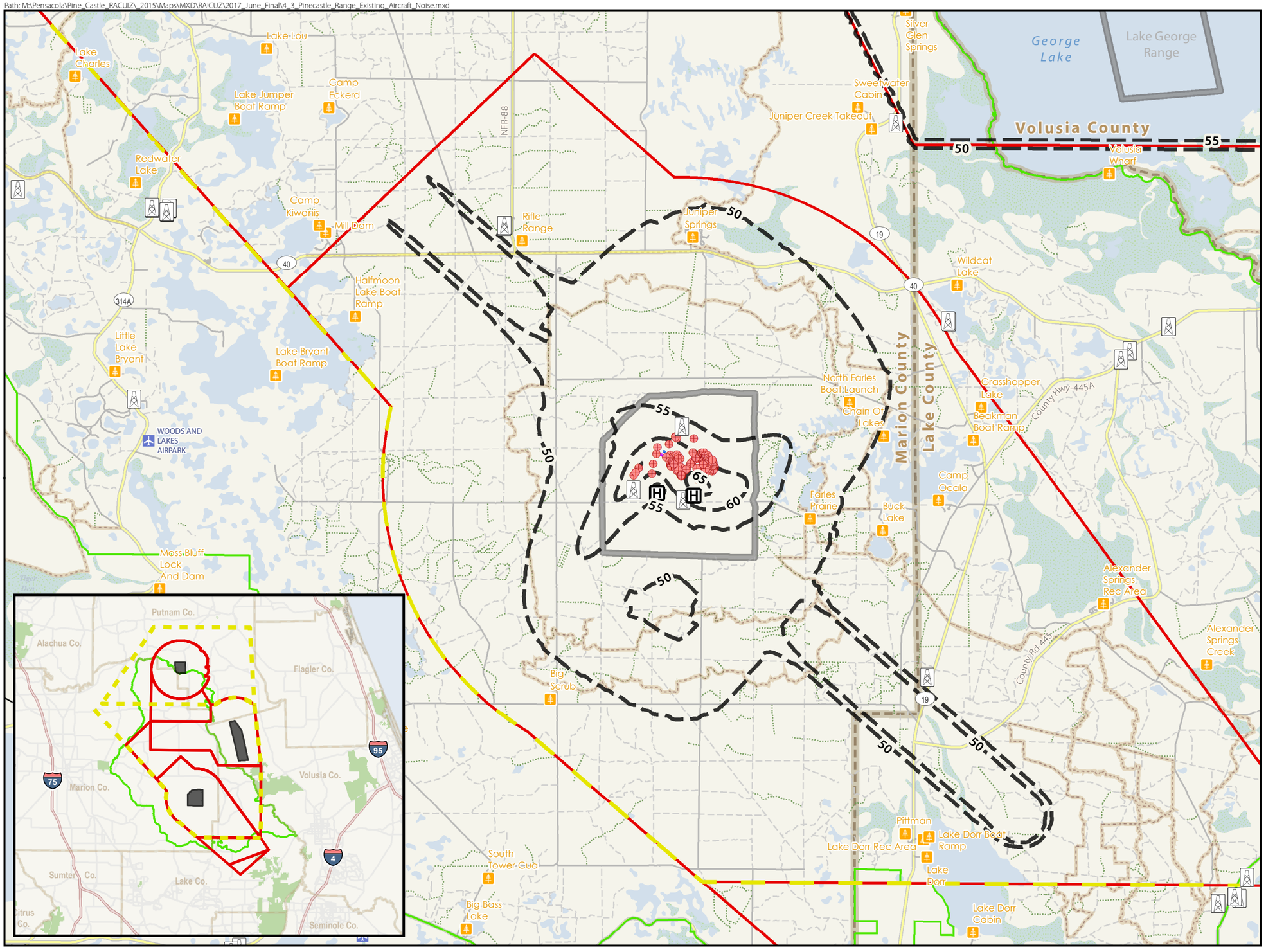

Figure 4-3

Pinecastle Range Existing Aircraft Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2013 Aircraft ADNL Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Airport
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010; FAA 2012; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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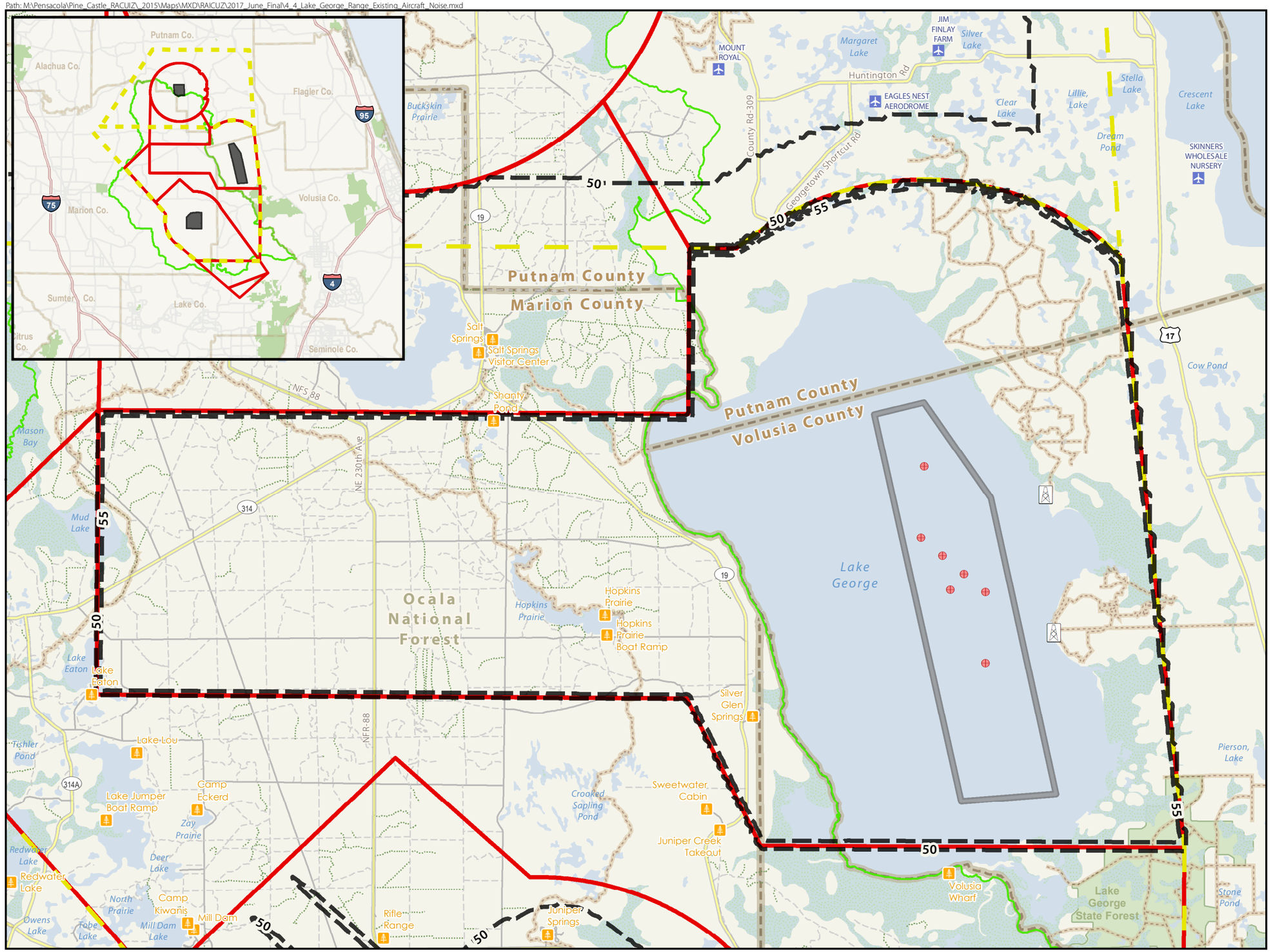

Figure 4-4
Lake George Range
Existing Aircraft Noise
Pinecastle Range Complex
Ocala National Forest
Volusia County, Florida

Legend

- Target
- Tower
- FY2013 Aircraft ADNL Noise Contour
- Military Operating Area
- Range Boundary
- Restricted Airspace
- Airport
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads
- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE
0 1 2 Miles

SOURCE: ESRI 2010; FAA 2012; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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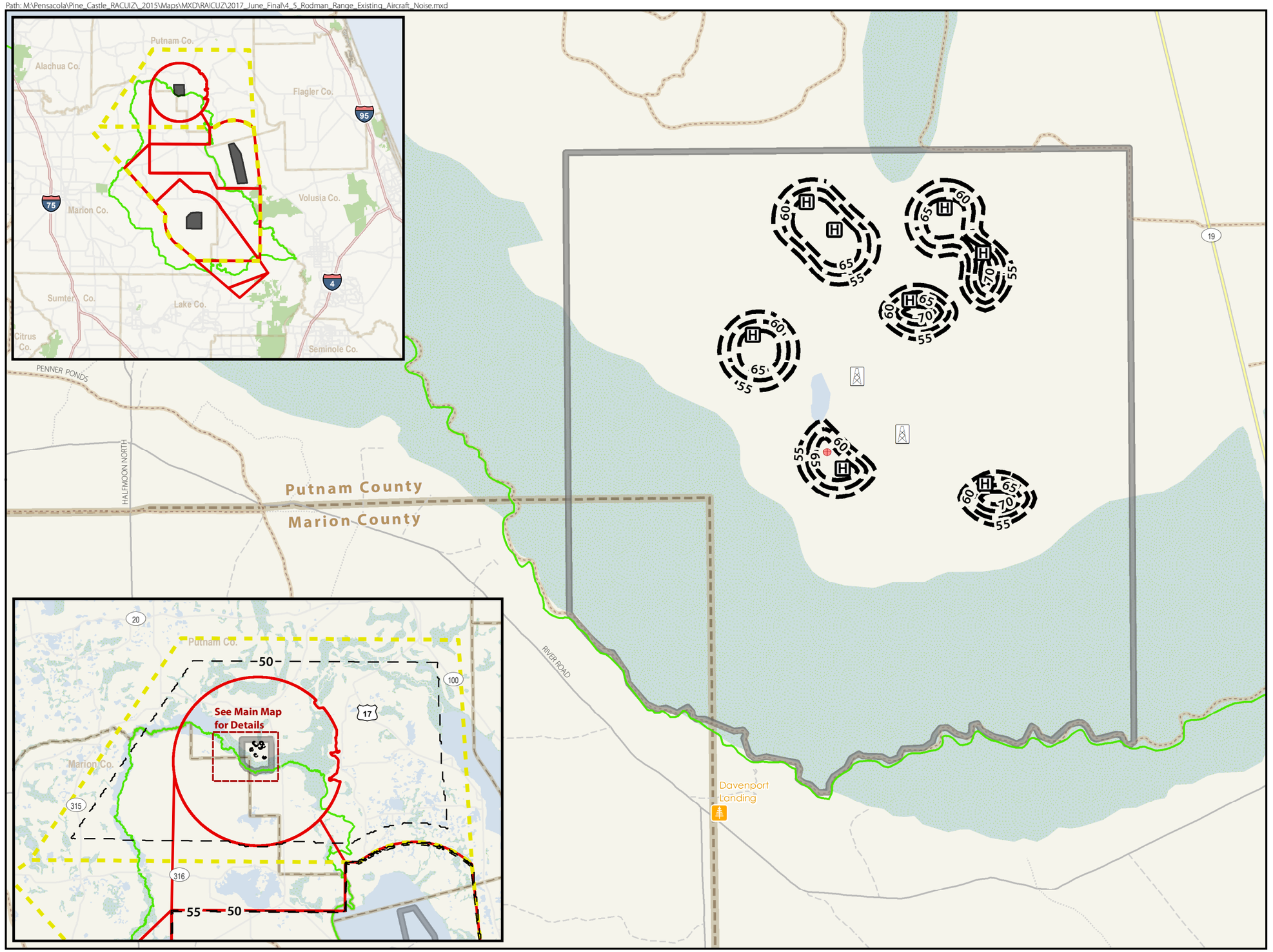

Figure 4-5

Rodman Range
Existing Aircraft Noise

Pinecastle Range Complex
Ocala National Forest
Marion and Putnam Counties, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2013 Aircraft ADNL Noise Contour
- Military Operating Area
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 0.25 0.5 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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4.3.1.2 Air Gunnery Noise

As previously discussed, very loud or impulsive sounds, such as those from munitions activities, can sometimes be felt and can cause secondary effects, such as shaking of a structure or rattling of windows. These secondary effects can lead to noise complaints from residents in the local community. To help the Navy identify the areas of the local community where the potential for complaint exists, PK_{15} noise zones were developed. CDNL and noises related to air gunnery operations are described below for the associated ranges. Note that there is no existing air gunnery noise at Rodman Range; therefore, a discussion for Rodman Range is not included in this section.

Pinecastle Range

The air gunnery noise contours cover 3,700 acres and most are contained within the range boundary, including all of the noise contours within Noise Zone 3. Noise Zone 2 covers 1,807 acres, with only 119 acres located outside of the range boundary. Noise Zone 1 encompasses approximately 1,442 acres and only 365 acres are located outside of the range boundary.

The peak noise contours are generally located around the range boundary both on and off range. The area between 115 $dBPK_{15}$ and 130 $dBPK_{15}$ represents a moderate risk of complaint. This area encompasses 1,192 acres on range and 2,392 acres outside of the range boundary. Additionally, the area between 130 $dBPK_{15}$ and 140 $dBPK_{15}$ represents a high risk of complaint. This area encompasses 2,217 acres on range and 7,917 acres outside of the range boundary. The peak noise contours are all within Restricted Area R-2910A and all are contained within the ONF boundary.

Figure 4-6 and Figure 4-7 provide the CDNL and Peak15 noise levels, respectively, from air gunnery operations at Pinecastle Range for the existing condition. These peak noise contours are not from any individual firing event, but from the array of possible firing operations at the range.

Lake George Range

The limited amount of air gunnery operations within Lake George Range were too few to merit modeling; therefore, CDNL noise contours for this range do not exist. However, the peak noise contours cover areas of moderate (less than 115$dBPK_{15}$), high (130-140 $dBPK_{15}$), and severe (greater than 140 $dBPK_{15}$) risk of noise complaint. Of the total 3,096 acres covered by peak noise contours, 2,136 acres are located within the range boundary, and all of the peak noise contours are over water within Lake George (Figure 4-8).

4.3.1.3 Large Arms Explosives Noise

Several of the air gunnery operations conducted within the PRC involve high explosives. For example, non-inert Hellfire missiles have high-explosive warheads. Both CDNL and peak noise contours were developed for various operations at Pinecastle Range. Noise contours for 57, 62, and 70 dB CDNL, as well as 130 and 140 dBPk15, are shown on Figures 4-9 and 4-10. Note that Pinecastle Range is the only range within the PRC that allows high explosives to be used and, therefore, is the only range included in this section.

Pinecastle Range

Noise Zone 1 covers 3,527 acres, approximately half of which are located within the range boundary. Noise Zone 2 covers 2,601 acres, most of which is contained within the range boundary. Noise Zone 3 covers 1,513 acres, which is almost entirely within the range boundary, as well. The peak noise contours cover a total of 239,960 acres, the majority of which are located within the range of moderate risk of noise complaint. The CDNL and Peak contours are all located within the Restricted Area R-2010A boundary as well as the ONF boundary.

4.3.2 Projected FY2020 Noise Contours

4.3.2.1 Aircraft Noise

Aircraft missions throughout Pinecastle, Rodman, and Lake George ranges do not always consist of repeated, tracked flight routes. Therefore, the 50 dBA noise contour is not shown by range, but rather it is line with the MOA boundary of the PRC. This is the area used to maneuver aircraft between ranges, conduct high altitude maneuvering in preparation of a low level training run, or conduct high level flight training within protected airspace. The area encompassed by the noise zones for the PRC is 626,395 acres. Lake George Range only has a Noise Zone 1 while Pinecastle and Rodman ranges contain some areas of Noise Zone 2 (65 to 75 dBA) and Noise Zone 3 (greater than 75 dBA) within their boundaries.

Pinecastle Range

For Pinecastle Range, noise is concentrated over the target areas for the projected conditions (Figure 4-11). The 60-65 dBA DNL contours are almost entirely contained within the base boundary, resulting in Noise Zone 2 being completely located on the range. The 55 dBA DNL contours extend toward the boundary of Restricted Area R-2910A, while the 50 dBA DNL extends to the perimeter of the MOA, as explained above. Noise Zone 2 and Noise Zone 3 contain approximately 323 acres and 19 acres, respectively, within the range boundary.

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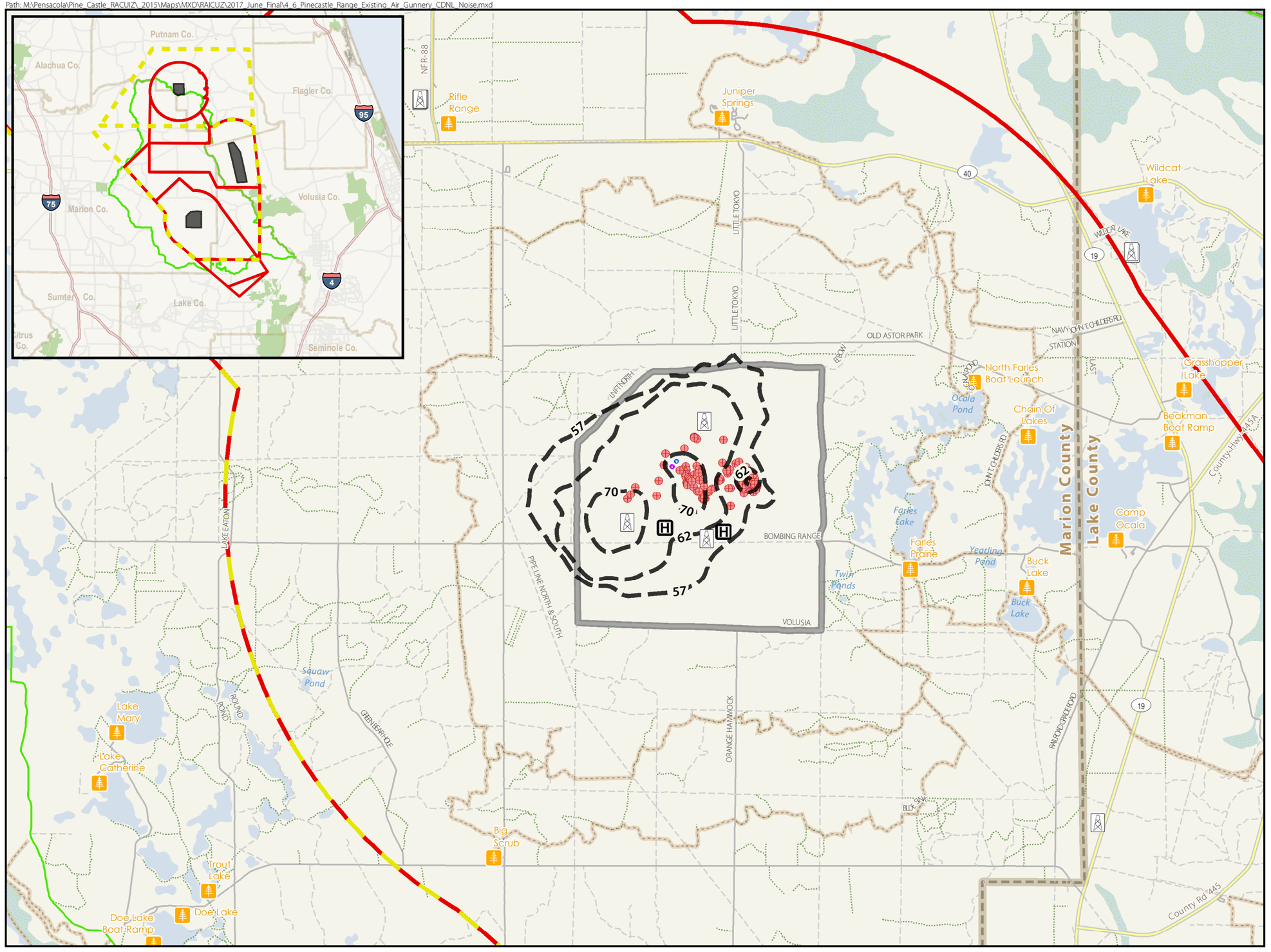

Figure 4-6

Pinecastle Range Existing Air Gunnery CDNL Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2013 Air Gunnery CDNL Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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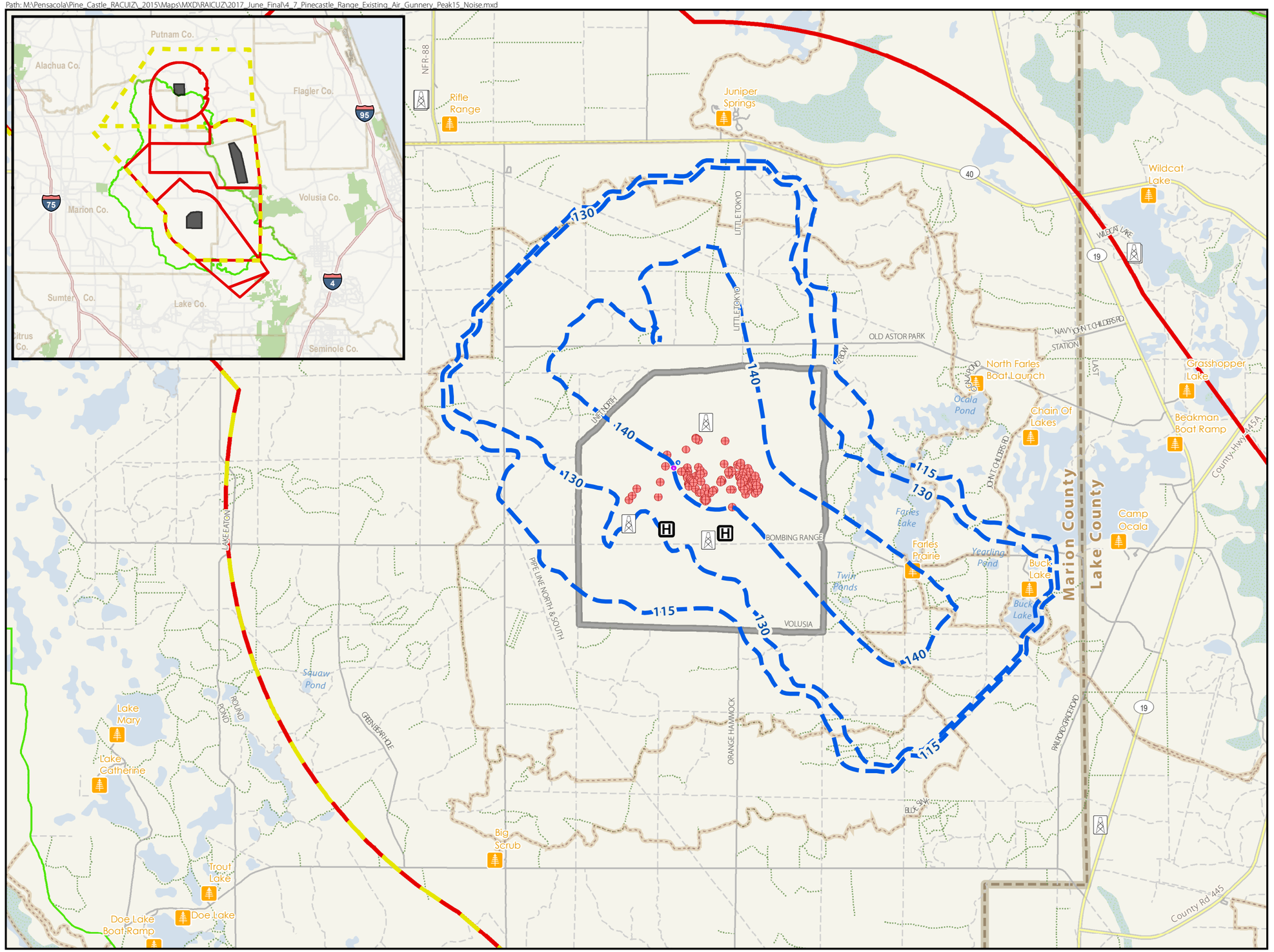

Figure 4-7

Pinecastle Range Existing Air Gunnery Peak15 Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2013 Air Gunnery Peak15 Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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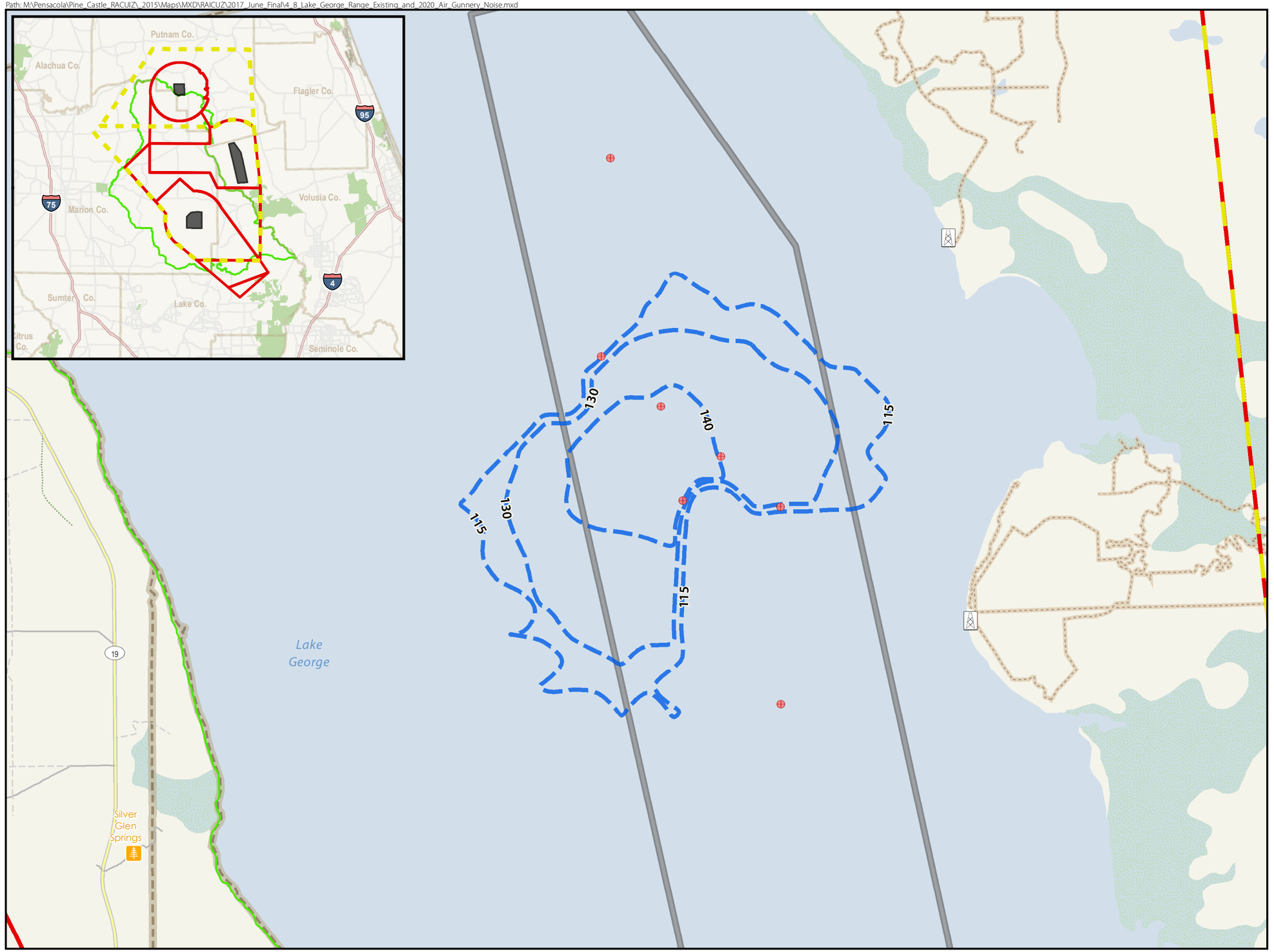

Figure 4-8

Lake George Range
Existing and Projected Air Gunnery Noise

Pinecastle Range Complex
Ocala National Forest
Volusia County, Florida

Legend

- Target
- Tower
- FY2013 and FY2020 Air Gunnery Peak15 Noise Contour
- Military Operating Area
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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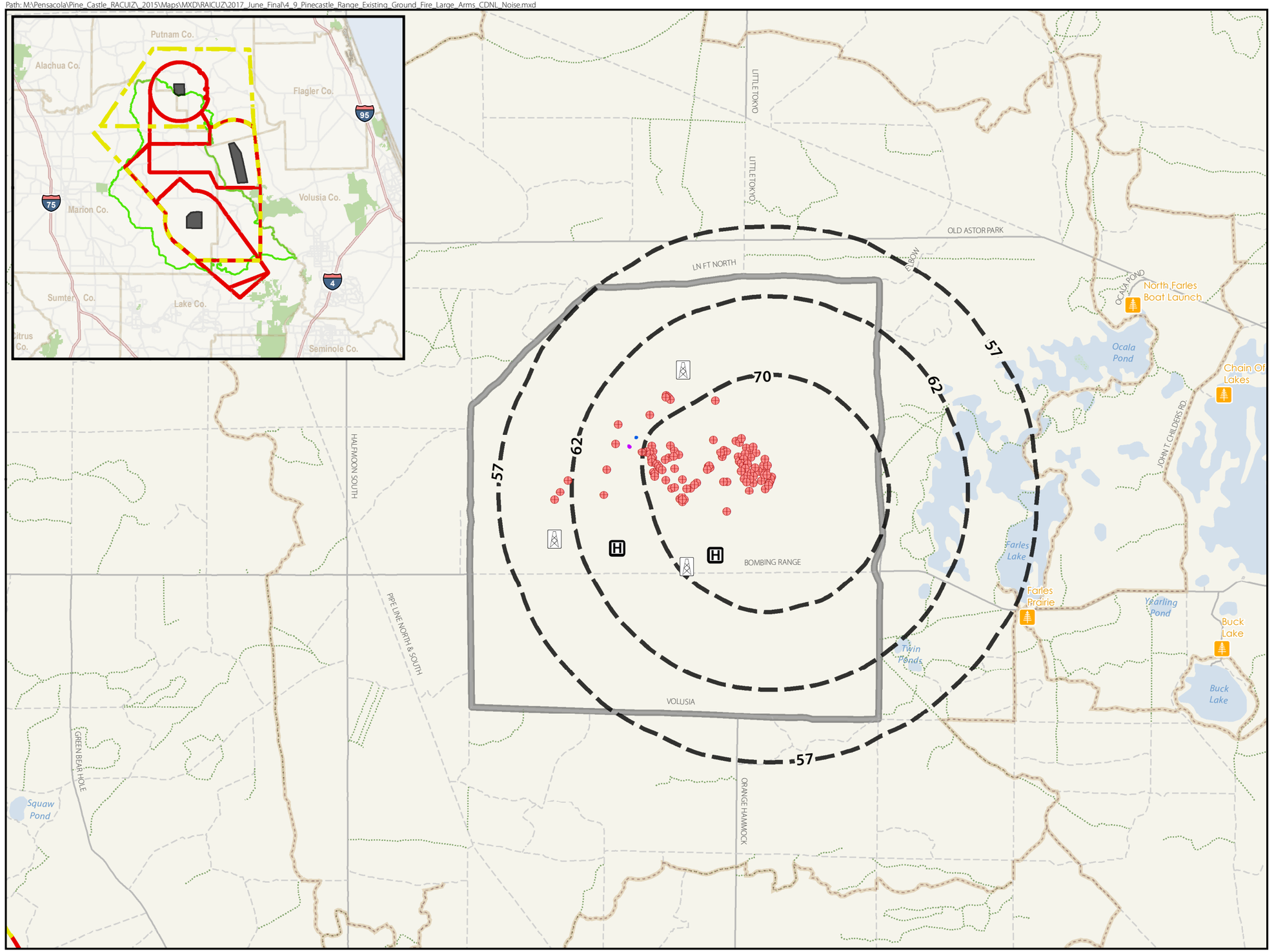

Figure 4-9

Pinecastle Range Existing Ground Fire Large Arms CDNL Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2013 Large Arms CDNL Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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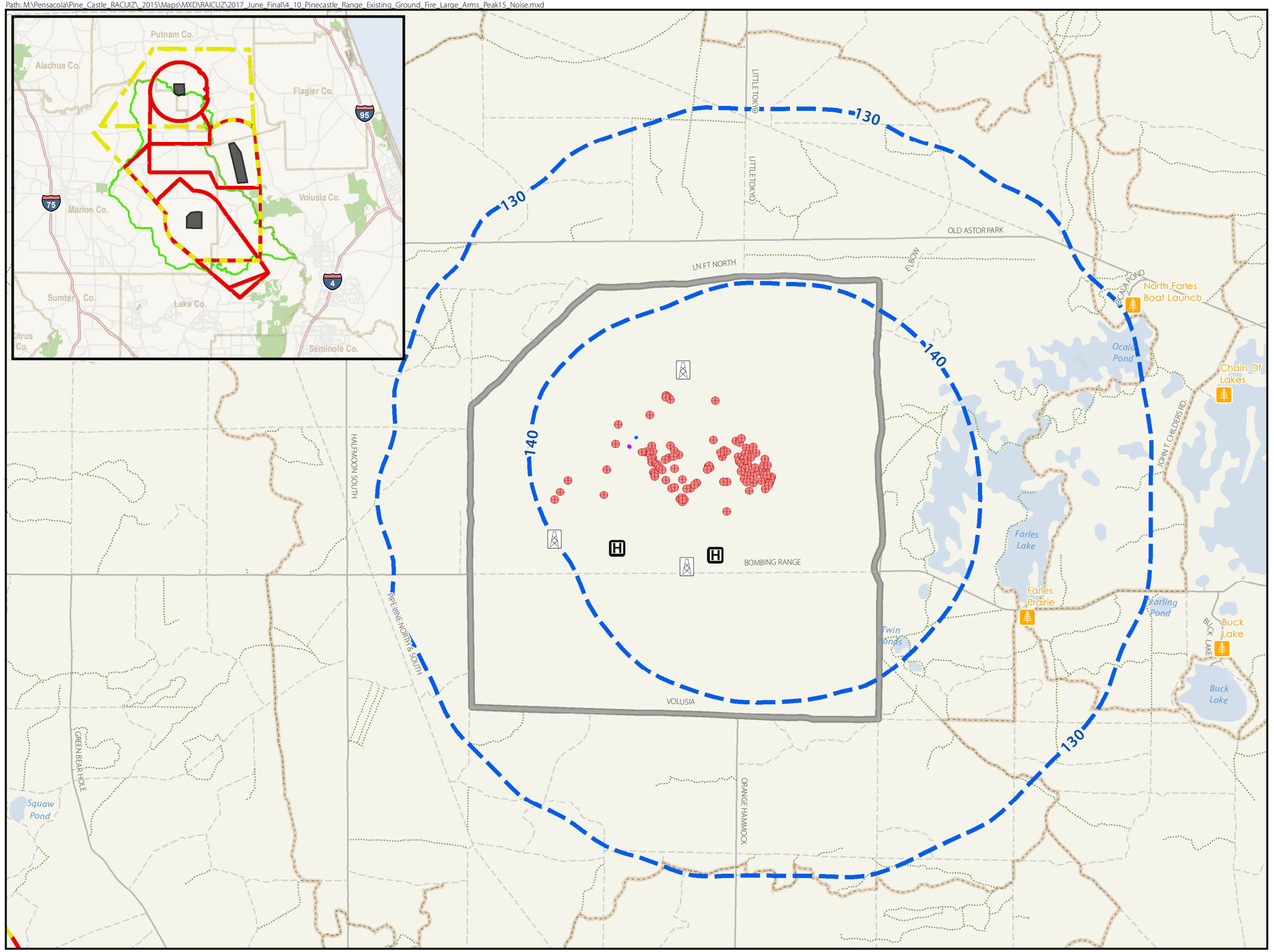

Figure 4-10

Pinecastle Range Existing Ground Fire Large Arms Peak15 Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2013 Large Arms Peak15 Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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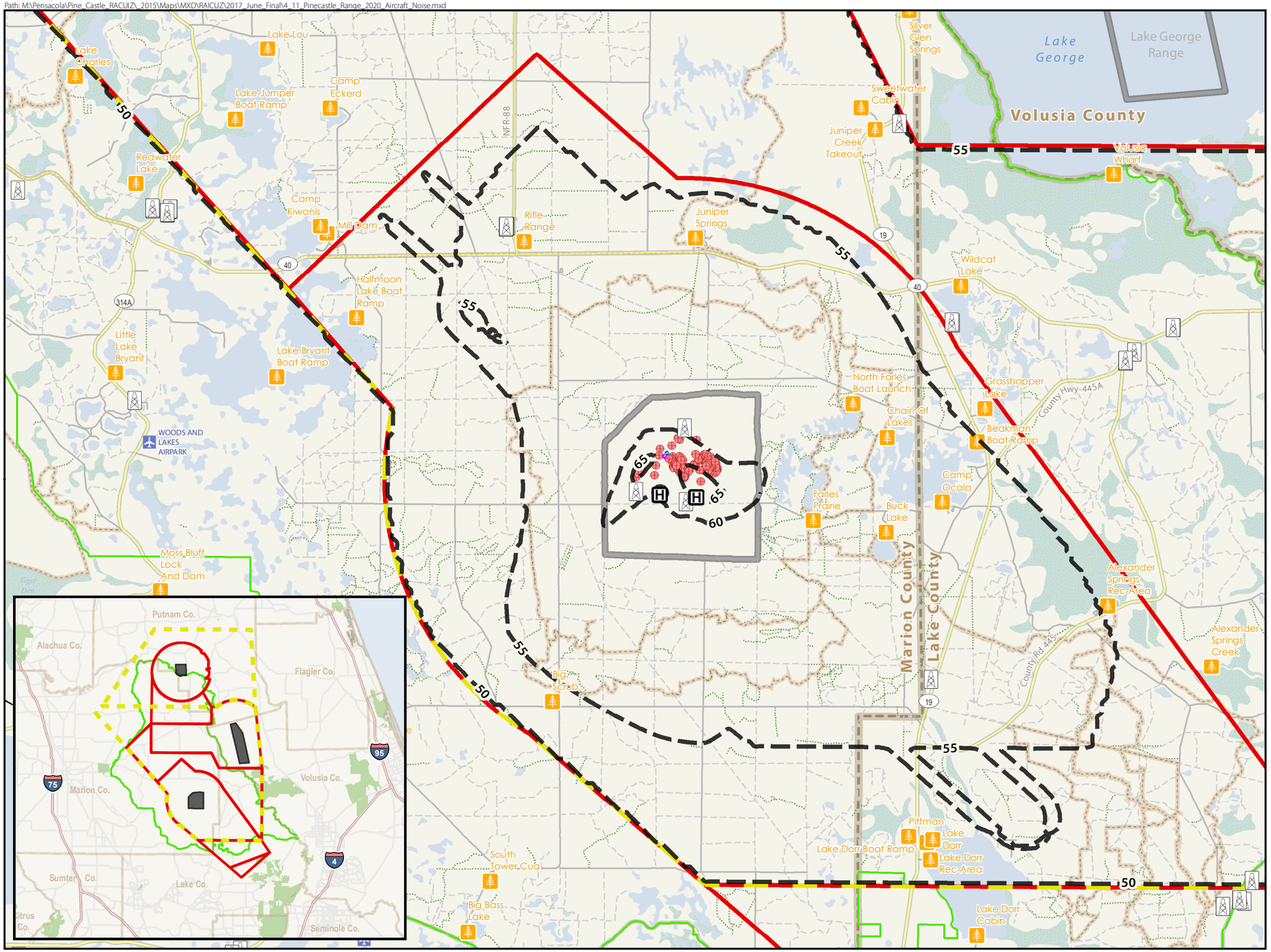

Figure 4-11

Pinecastle Range
Projected Aircraft Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2020 Aircraft ADNL Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Airport
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010; FAA 2012; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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Lake George Range

The Lake George Range 55 dBA DNL noise contours continue to align with the perimeter of Restricted Area R-2907, as the existing condition showed (Figure 4-12), while the 50 dBA DNL contours have expanded to follow the MOA perimeter, as discussed above. Noise originating from Lake George Range is completely within Noise Zone 1.

Rodman Range

Tactical missions are still featured in the projected (FY2020) scenario for Rodman Range, resulting in the 55 dBA DNL noise contours being distributed across the Palatka 2 MOA and the 50 dBA DNL noise contours following the entire MOA perimeter, as discussed above (Figure 4-13). In addition, noise contours on the range remain concentrated around the various landing zones. Noise contours include the 60, 65, and 70 dBA DNL and remain within the range boundary. Noise Zone 2 and Noise Zone 3 contain approximately 100 acres and 84 acres, respectively, and are fully contained within the range boundary.

4.3.2.2 Air Gunnery Noise

Pinecastle Range

Figures 4-14 and 4-15 show the CDNL and Peak15 noise contours, respectively, occurring at Pinecastle Range. As with the existing condition, these peak contours are not from any individual firing event but from the array of possible firing operations at the range. The air gunnery CDNL noise contours remain close to the range boundary and cover a total of 6,992 acres. Noise Zone 1 covers approximately 3,377 acres—1,891 acres are located on range and 1,482 acres are located off range. Noise Zone 2 encompasses 2,486 acres within the range boundary, with a small portion of the 62 dBA CDNL contour extending off the range, resulting in 767 acres of Noise Zone 2 being outside of the range boundary. All of Noise Zone 3 is contained within the range boundary. All noise zones associated with air gunnery CDNL noise are contained within ONF.

Peak noise covers an area of approximately 48,080 acres. Areas of moderate risk of noise complaint encompass 26,467 acres, most of which are outside the range boundary. Additionally, the area between 130 $dBPK_{15}$ and 140 $dBPK_{15}$ encompasses 3,183 acres on range and 6,442 acres off range. Areas within the high risk of noise complaint (> 140 $dBPk_{15}$) most closely surround the range; however, a majority of the acreage is located outside the range boundary. The high risk of noise complaint area covers 11,124 acres, with 2,491 acres on range and 8,633 acres outside the range boundary. The vast majority of the peak noise contours are located within the Restricted Area R-2910A boundary. All peak noise contours are also contained within the ONF boundary.

Lake George Range

As in the existing condition, the air gunnery operations were too few to merit modeling; therefore, the projected (FY2020) CDNL contours do not exist. Further, there are no changes between the existing and projected operations numbers, so the peak noise contours continue to cover a total of 3,096 acres, of which 2,136 acres are located within the range boundary. All of the peak noise contours are over water within Lake George Range (Figure 4-8).

Rodman Range

Air gunnery operations for the projected (FY2020) condition consist of small arms fire (7.62mm) from helicopters at all eight landing zones. Figure 4-16 provides the noise footprints associated with these operations. There are 6,425 acres encompassed by the 87 $dBPK_{15}$ noise contour, which is generally centered on the range boundary. Therefore, for air gunnery noise, Noise Zone 1 covers 2,638 acres within the range and 3,797 acres outside of the range.

4.3.2.3 Large Arms Explosives Noise

As with the existing condition, Pinecastle Range is the only range within the PRC projected to allow high-explosive use and, therefore, is the only range included in this section. Both CDNL and peak noise contours were developed for various operations at Pinecastle Range. Noise contours for 57, 62, and 70 dB CDNL as well as 130 and 140 dBPk15 are shown on Figures 4-17 and 4-18, respectively.

Pinecastle Range

Noise Zone 1 covers 4,604 acres, of which 1,581 acres are located within the range boundary. Noise Zone 2 covers 2,966 acres, most of which are contained within the range boundary. Noise Zone 3 covers 1,815 acres, which are almost entirely within the range boundary. All of the CDNL noise contours remain within the ONF boundary. The peak noise contours cover a total of 239,953 acres, the majority of which is in the moderate risk of noise complaint area. The CDNL and peak noise contours are all located within the Restricted Area R-2010A boundary as well as the ONF boundary.

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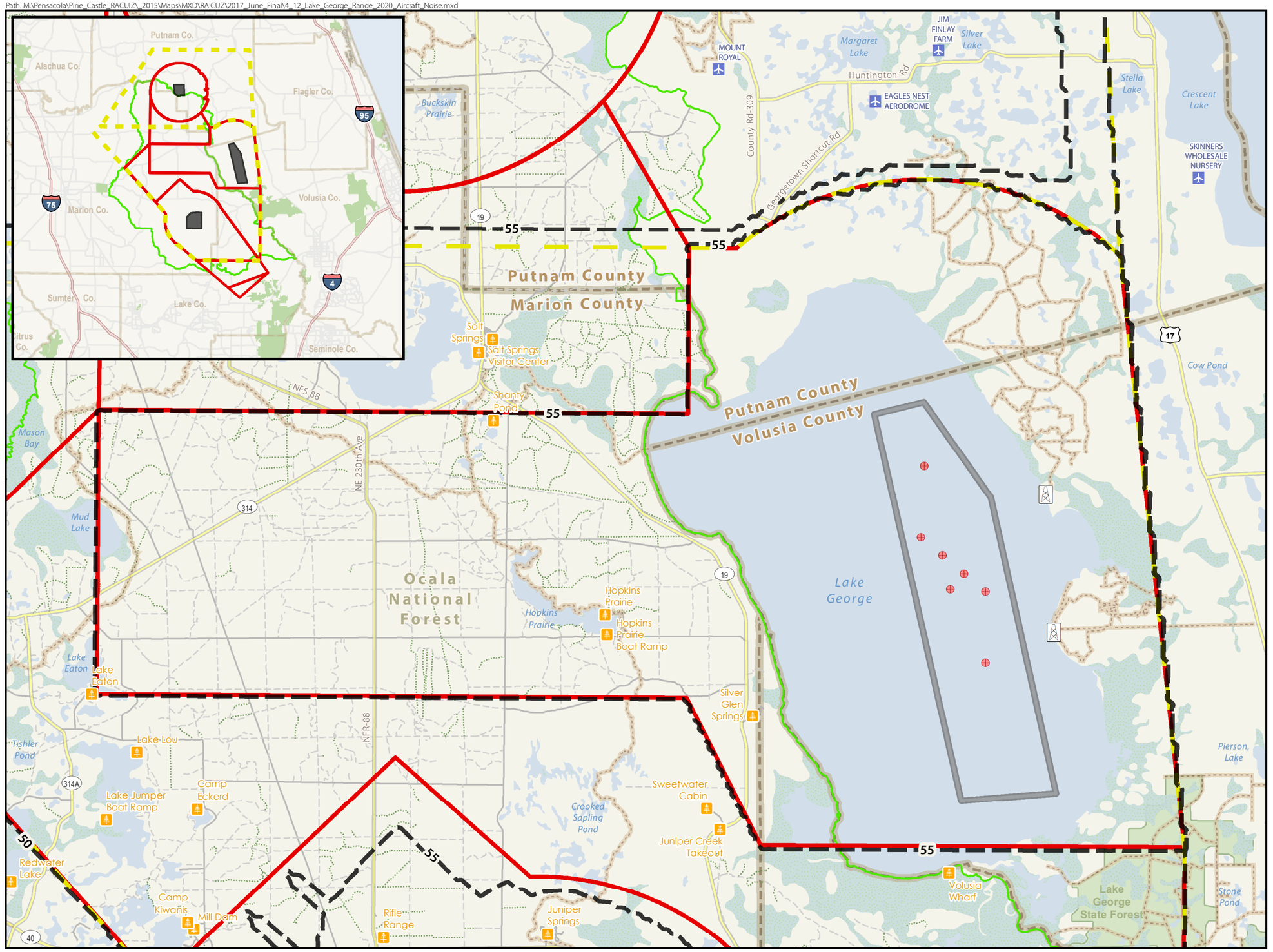

Figure 4-12
Lake George Range
Projected Aircraft Noise
Pinecastle Range Complex
Ocala National Forest
Volusia County, Florida

Legend

- Target
- Tower
- FY2020 Aircraft ADNL Noise Contour
- Military Operating Area
- Range Boundary
- Restricted Airspace
- Airport
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads
- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE
0 1 2 Miles

SOURCE: ESRI 2010; FAA 2012; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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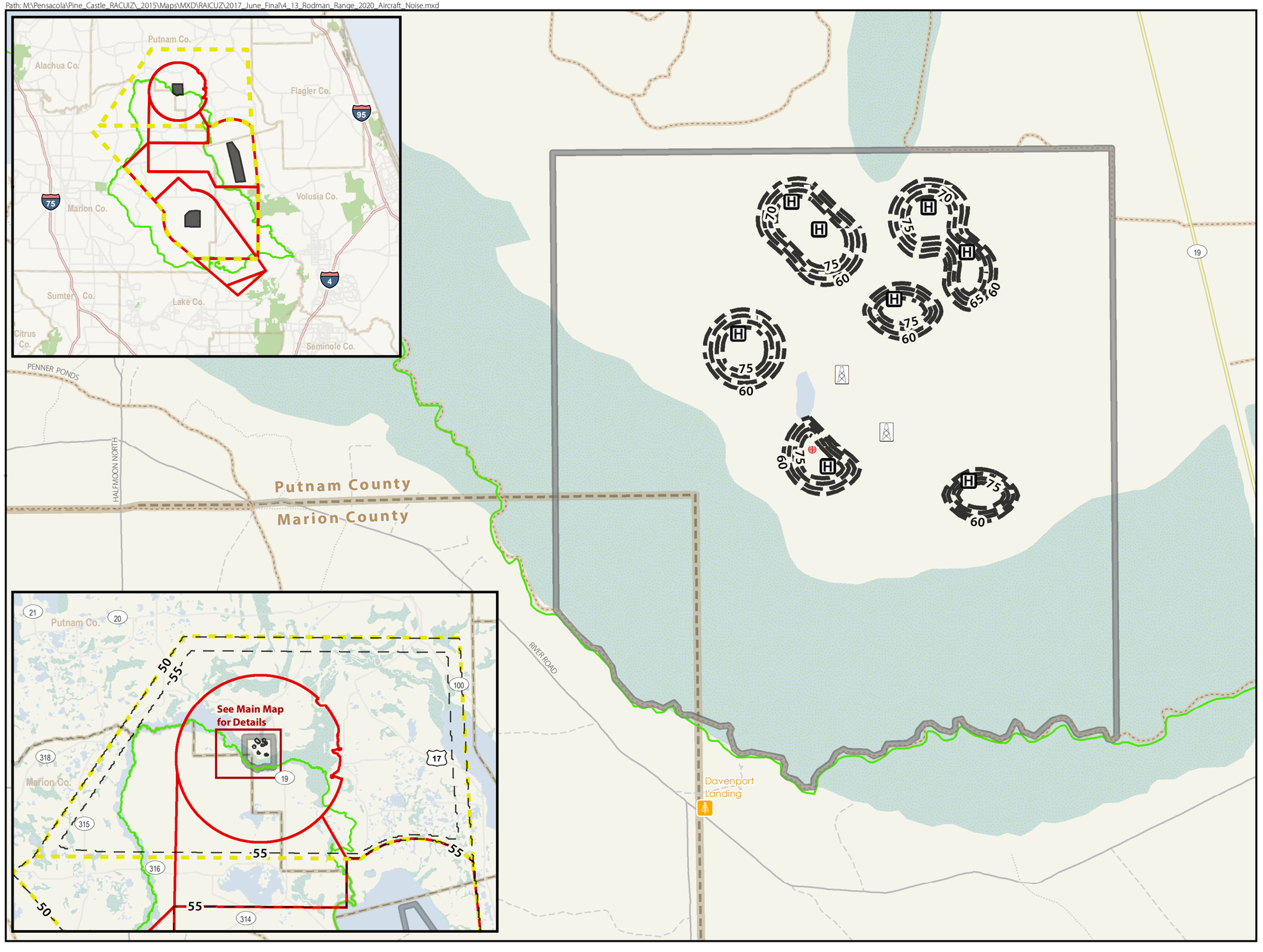

Figure 4-13

Rodman Range
Projected Aircraft Noise

Pinecastle Range Complex
Ocala National Forest
Marion and Putnam Counties, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2020 Aircraft ADNL Noise Contour
- Military Operating Area
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 0.25 0.5 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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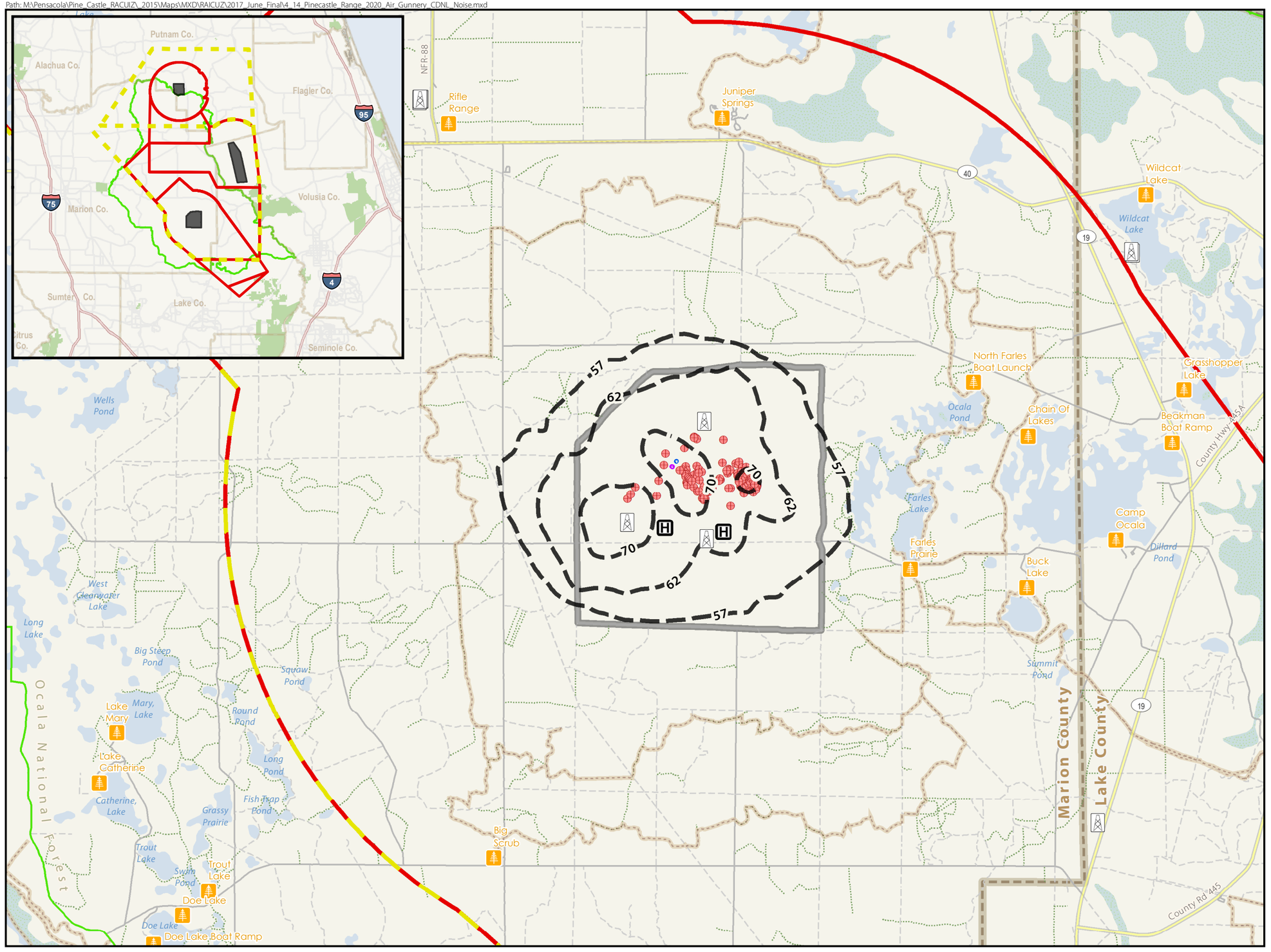

Figure 4-14

Pinecastle Range
Projected Air Gunnery CDNL Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2020 Air Gunnery CDNL Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

SCALE

0 1 2 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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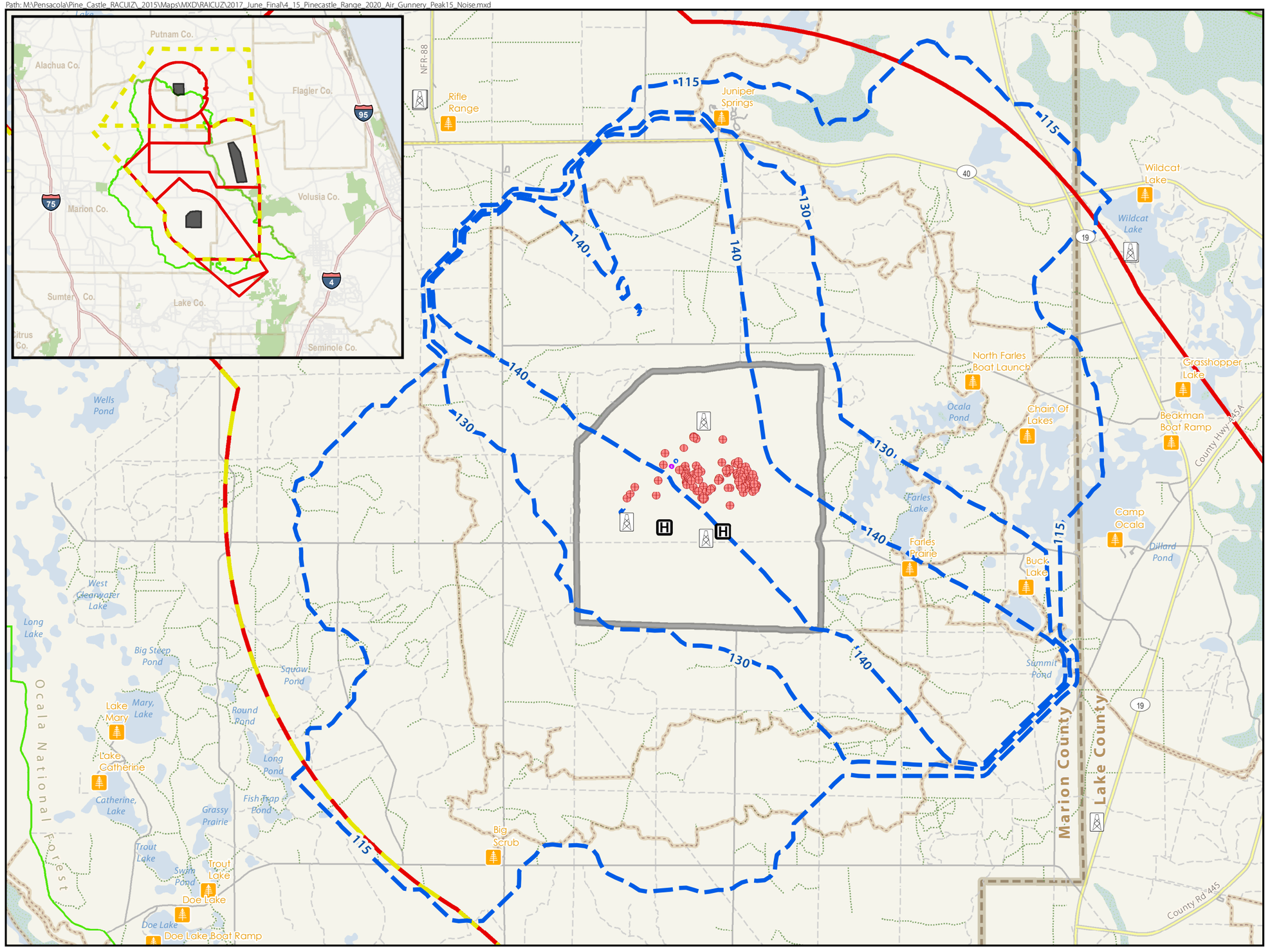

Figure 4-15

Pinecastle Range
Projected Air Gunnery Peak15 Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2020 Air Gunnery Peak15 Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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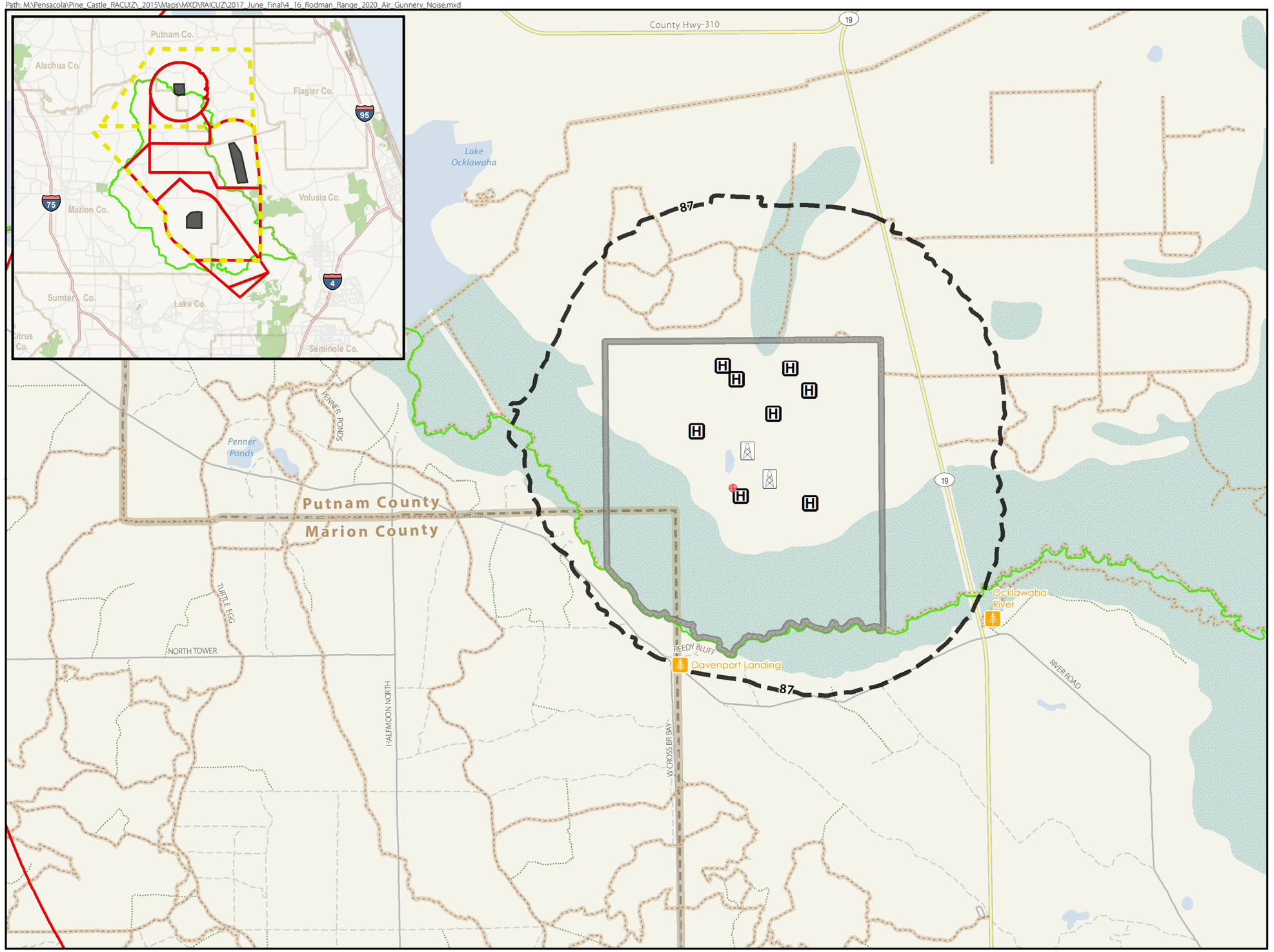

Figure 4-16

Rodman Range
Projected Air Gunnery Noise

Pinecastle Range Complex
Ocala National Forest
Marion and Putnam Counties, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2020 Air Gunnery Peak15 Noise Contour
- Military Operating Area
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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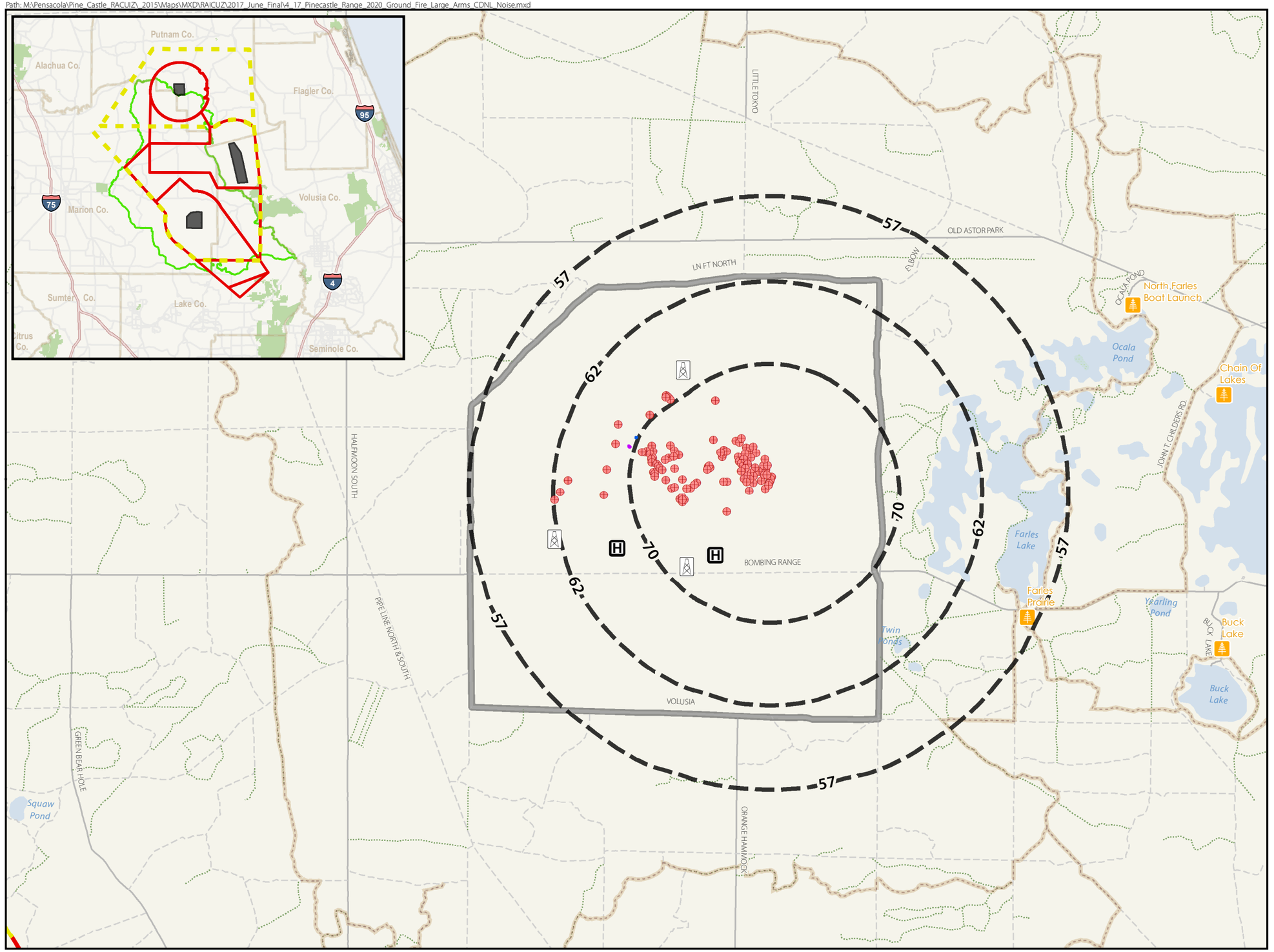

Figure 4-17

Pinecastle Range Projected Ground Fire Large Arms CDNL Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2020 Large Arms CDNL Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

N

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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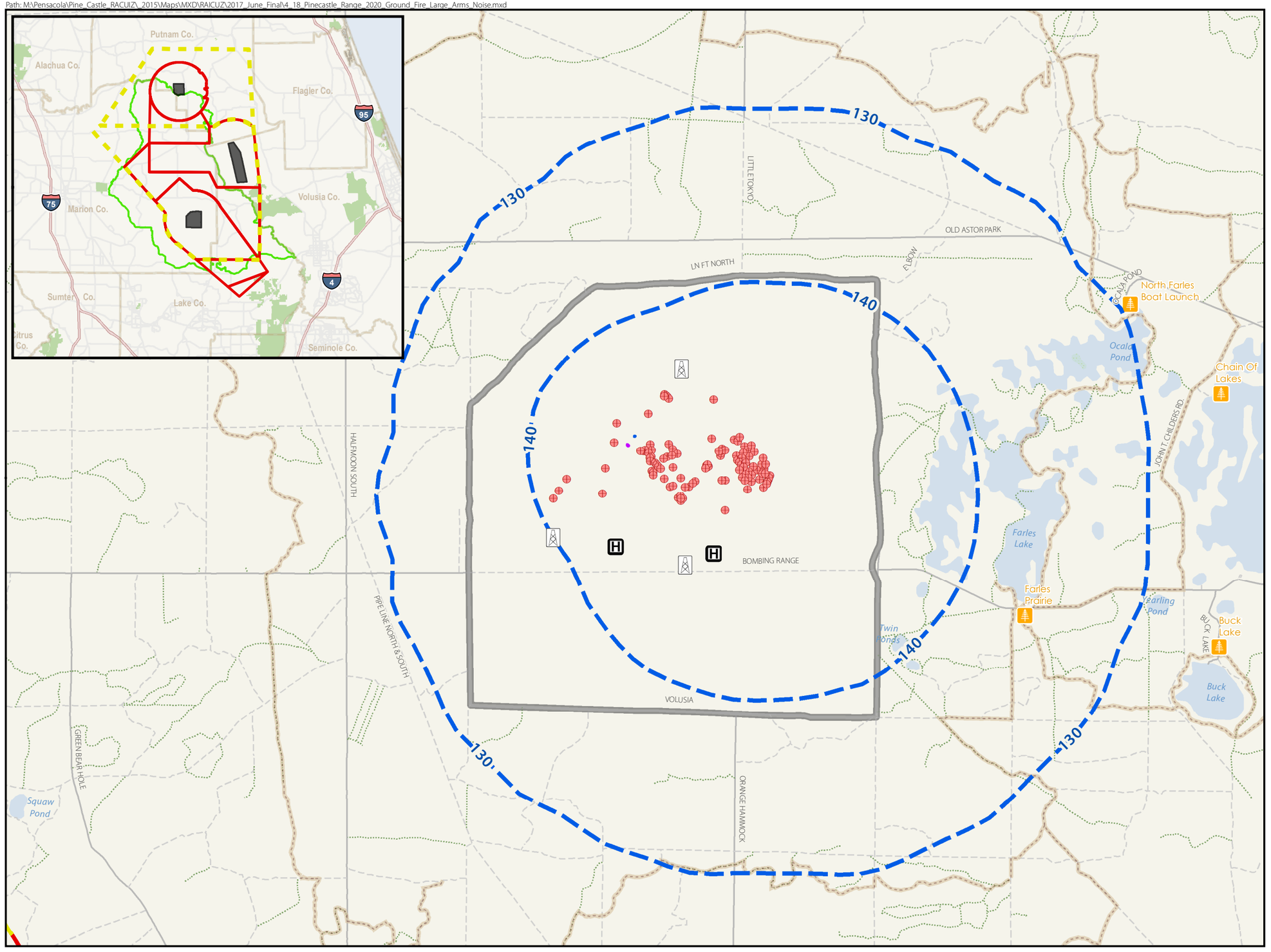

Figure 4-18

Pinecastle Range Projected Ground Fire Large Arms Peak15 Noise

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- Target
- Tower
- Landing Zone
- FY2020 Large Arms Peak15 Noise Contour
- Military Operating Area
- Ground Fire Firing Point
- Ground Fire Target
- Range Boundary
- Restricted Airspace
- Recreation Site (includes camping)
- Interstate
- Major Highway
- Trail

National Forest System Roads

- Closed or Decommissioned Road
- Not Maintained for Passenger Cars
- Dirt, Gravel, and Paved Roads Suitable for Passenger Cars

- Water
- Wetland
- Ocala National Forest

SCALE

0 0.5 1 Miles

SOURCE: ESRI 2010; University of Florida GeoPlan Center, 2012; Ecology and Environment, 2015.

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4.3.3 Comparison of Existing FY2013 and Projected FY2020 Noise Contours

Differences between the existing and projected noise contours are mostly due to changes in aircraft operations and flight training tactics, aircraft types, the maneuver area needed for safe and effective training operations, changes in ordnance and delivery training tactics, and other training-related changes. Generally, changes to the areas impacted by higher noise are minor. There are no substantial changes in the amount of acreage impacted or new areas being impacted by noise that were previously not impacted. The following sections describe the changes from existing to projected noise contours for each type of noise.

4.3.3.1 Aircraft Noise

In general, the noise footprint increases from existing noise conditions when compared to the projected (FY2020) noise conditions. As previously discussed, this is largely due to the fact that the tactical missions do not consist of repeated, tracked flight routes; flight operations are, therefore, modeled as occurring throughout the applicable boundaries of the restricted airspace. For projected conditions, the modeled noise contour of 50 dBA DNL expands from just the applicable boundaries of the restricted airspace for each range to align with the boundary of the MOA.

Although the noise is concentrated over the Pinecastle Range targets for both the existing (Figure 4-3) and projected (Figure 4-11) conditions, the contours expand in the projected condition due to the addition of F-35 training operations.

At Lake George Range, the noise contours for both the existing (Figure 4-4) and projected (Figure 4-12) conditions are all within Noise Zone 1.

Rodman Range has noise contours that are distributed across the Palatka 2 MOA and Restricted Area R-2906, with the majority of the area exposed to a predicted noise level of 50 dBA DNL for both the existing (Figure 4-5) and the projected (Figure 4-13) conditions. The noise contours centered on the landing zones are predicted to reach 70 dBA DNL for the existing condition and 75 dBA DNL for the projected condition. All of the noise contours surrounding the landing zones remain within the range boundary in both the existing and projected conditions.

4.3.3.2 Air Gunnery Noise

At Pinecastle Range, the CDNL and peak contours are larger in the projected condition (FY2020; Figures 4-14 and 4-15) than in the existing condition (Figures 4-6 and 4-7). The CNDL contours show minimal increases from the existing condition to the projected condition. The 115 $dBPK_{15}$ noise contour increases the most by extending to just outside of the Restricted Area R-2910A boundary in the projected condition. For the existing condition, the 115 $dBPk_{15}$ noise contour remained at least 2.5 miles from the Restricted Area R-2910A boundary. All CDNL and peak noise contours remain within the ONF boundary in both the existing and projected scenarios.

As previously discussed, the existing noise condition at Lake George Range is consistent with the projected noise condition due to no changes in operations (Figure 4-8).

For Rodman Range, air gunnery operations consisting of small arms fire (7.62mm) from rotary-wing aircraft at all eight landing zones were identified for the projected condition (Figure 4-16). There were no air gunnery operations modeled for the existing condition.

4.3.3.3 Large Arms Explosives Noise

In general, the large arms explosives noise in the existing condition (Figures 4-9 and 4-10) compared to the projected (FY2020) condition (Figures 4-17 and 4-18) has minor changes. The areas within Noise Zone 1, Noise Zone 2, and Noise Zone 3 increase in the projected conditions. However, the areas within Noise Zone 2 mostly remain on the range boundary and the areas within Noise Zone 3 remain almost entirely within the range boundary. The CDNL and peak noise contours all remain located within the Restricted Area R-2010A boundary as well as the ONF boundary.

4.3.4 Projected FY2020 Noise Zone Composite

The Projected FY2020 Noise Zones 1, 2, and 3 from each type of noise occurring at each range within the PRC were combined to create a composite noise zone figure (Figure 4-19). This composite of all the noise zones represents the projected noise footprint of the entire PRC. When noise zones from the individual sources overlapped each other, the more restrictive noise zone was used. These composite noise zones were used by the Navy for the land use compatibility analysis conducted according to OPNAVINST 3550.1A and discussed in Chapter 5.

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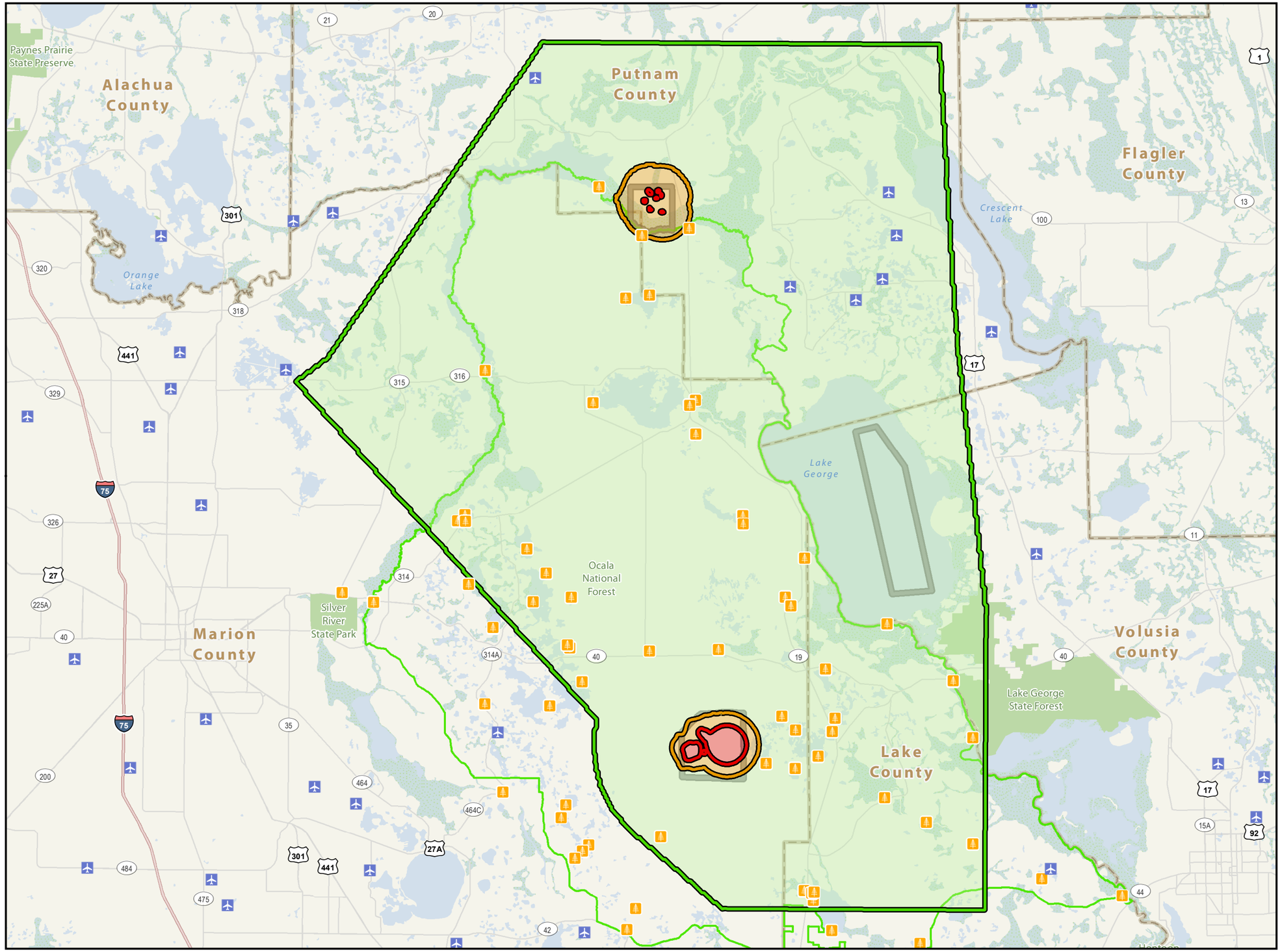

Figure 4-19

Pinecastle Range Complex
Projected Composite Noise Zones

Pinecastle Range Complex
Ocala National Forest
Lake, Marion, Putnam, and Volusia Counties, Florida

Legend

- Range Boundary
- Airport
- Recreation Site (includes camping)
- Interstate
- Major Highway
- County Boundary
- Water
- Wetland
- Ocala National Forest
- State Park or Forest

Projected Noise Zones (NZs)

- NZ 1: ADNL < 65 dBA; CDNL < 62 dBC; Peak < 87 dBPK15
- NZ 2: ADNL = 65 to75 dBA; CDNL = 62 to 70 dBC; Peak = 87 to 104 dBPK15
- NZ 3: ADNL > 75 dBA; CDNL > 70 dBC; Peak > 104 dBPK15

N

SCALE

0 5 10 Miles

SOURCE: ESRI 2010, 2012; FAA 2012; US Navy (2009-2015); Ecology and Environment, 2016.

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4.4 NOISE COMPLAINTS AND ABATEMENT

Effects from noise associated with the PRC occur in areas off the ranges, with areas closer to the range boundaries experiencing greater effects. The PRC personnel are aware of land uses surrounding its property, and the Navy takes precautions to reduce noise effects to sensitive areas. Activities at the PRC have resulted in relatively few airborne noise complaints, most likely because ONF and other undeveloped areas buffer the ranges from populated areas. However, given the training requirements and level of activity occurring at the PRC, noise complaints may occur.

4.4.1 Noise Complaints

To abate noise complaints and provide citizens with prompt responses, the PRC has a formalized noise and airspace complaint program. The PRC maintains procedures to receive, process, and address noise inquiries and complaints. The Navy has an established complaint line (1-800-874-5059) to receive noise complaints from the community. This is an automated system capable of receiving calls 24 hours a day. The messages are reviewed each day to provide an opportunity for a Navy official to follow-up with a phone call to the person placing the complaint if sufficient call return information is provided in the message.

Each incident is investigated for the purpose of determining the nature and cause of the offensive noise event. By assessing noise complaints, the Navy can identify noise-sensitive areas, determine which operational activities are responsible for the noise complaints, and ultimately help abate future noise complaints.

4.4.2 Noise Inquiries

Noise inquiries are related to the intensity and frequency of the events, as well as the individual sensitivity of the person effected. Noise inquiries typically originate from areas within or near the noise zones. By definition, these areas generally experience the highest levels of noise; however, noise inquiries can originate from anywhere within the surrounding community. In general, people's individual responses to the same noise levels vary and are influenced by factors, including:

- The activity the individual is engaged in at the time of the noise event;
- The individual's general sensitivity to noise;
- The time of day or night the noise event was experienced;

- The length of time the individual is exposed to a noise;
- The predictability of the noise; and
- Weather conditions.

Noise contours and land use recommendations are based on the average annoyance responses of a population, but some people have greater noise sensitivity than others. Generally, a small increase in noise level will not be noticeable; however, as the change in noise level increases, individual perception is greater, as shown in Table 4-3.

Table 4-3: Subjective Responses to Noise

Change	Change in Perceived Loudness
1 dB	Requires close attention to notice
3 dB	Barely noticeable
5 dB	Quite noticeable
10 dB	Dramatic – twice or half as loud
20 dB	Striking – fourfold change

4.4.3 Noise Abatement

Activities at the PRC comply with standard operating procedures (VFR, IFR, and Naval Air Training and Operating Procedures Standardization publications) to ensure no activities that occur would endanger life or property. Aircraft standard operating procedures are largely oriented toward safety, which also provide significant noise abatement benefits.

The Navy tries to reduce the impacts of noise on civilian populations. Additionally, FACSFACJAXINST 3000.1F instructs pilots to avoid populated areas, and prohibits the use of afterburners from 8:00 p.m. to 6:00 a.m. as well as other actions that could cause increased noise levels. However, aircraft may produce loud noise, and there may be instances when local residents are impacted.

The importance of maintaining continued good relations with the public and other federal agencies dictate strict compliance with the provisions contained in "*Naval Air Training and Operating Procedures Standardization General Flight and Operating Instructions*" (OPNAVINST 3710.7U) and FACSFACJAXINST 3000.1 F. Each aircrew shall be familiar with the noise profiles of their aircraft and shall be committed to minimizing noise impacts without compromising operational requirements and safety considerations.

The PRC takes a proactive approach to informing the public about noise. In anticipation of training events that may result in noise complaints, a press release is prepared. Press releases often provide an email address (nasjaxpao@navy.mil) for anyone who wants to be notified about exercises. Press releases notify the public of the details of the training event in an effort to prevent the noise from being unexpected. As previously discussed, when noise is not expected, it is more intrusive and perceived to be louder.

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5 PLANNING AUTHORITIES AND LAND USE COMPATIBILITY

The major elements in this RAICUZ Study are noise zones and RCZs, which collectively make up the RAICUZ footprint. The RAICUZ footprint defines the minimum area within which land use controls are recommended to protect public health, safety, and welfare, while maintaining the viability of the range and associated training. Noise zones and RCZs described in previous chapters define the areas impacted by training operations at the PRC. The RAICUZ footprint for the PRC was developed by combining the RCZs described in Chapter 3 and the noise contours described in Chapter 4. The RCZs and the noise contours, which are organized into noise zones, were used to conduct the land use compatibility analysis discussed later in this chapter.

The RAICUZ footprint defines the minimum area within which land use controls are recommended to protect public health, safety, and welfare, while maintaining the viability of the range and associated training.

The RAICUZ Program makes compatibility recommendations for the various RCZs and noise zones based on activities occurring on the land overlain by the RCZs and noise zones. This RAICUZ Study analyzes those activities and makes land use compatibility recommendations. Local governments are encouraged to adopt programs, policies, and regulations that support the Navy mission and promote compatible land use in noise and safety zones, where appropriate and practical. Local planning authorities play an important role in aiding the Navy to address land use compatibility concerns between the Navy mission and local land uses surrounding the PRC ranges. With the ability to implement policies and regulations and to guide development surrounding the ranges, the involvement and cooperation of the local planning authorities is vital. Section 5.1 discusses these organizations for each county.

5.1 PLANNING AUTHORITIES

The PRC is located within the jurisdiction of Marion, Putnam, Volusia, and Lake counties.

The PRC RAICUZ footprint is located in the jurisdictions of Marion, Putnam, Volusia, and Lake counties. The local governments manage land use and future growth through zoning regulations, land use 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.

The State Comprehensive Plan provides a framework for planning activities statewide and is updated biennially. Regional planning councils are required to develop a Strategic Regional Policy Plan that is consistent with the State Comprehensive Plan and that provides guidance to local government. Each counties' Board of County Commissioners (BOCC) is the governing body. The BOCC is responsible for direct oversight of county operations. In addition to the oversight of the departments, the BOCC's duties include adopting and enacting ordinances and resolutions, levying taxes, and establishing county policies. As the county's legislative authority, the BOCC is responsible for the development and implementation of planning and zoning policies and appointments to advisory boards and commissions. Zoning laws are adopted and amended by the BOCC. The Planning Commission is an advisory board to the BOCC and is responsible for reviewing development proposals and proposed zoning amendments to ensure consistency with the counties' comprehensive plans. The BOCC holds public hearings to seek comment from interested parties on proposed amendments, and then the BOCC will approve, deny, or approve a modified amendment. Land use planning programs, general plans, policies, councils, and commissions for the local jurisdictions with the potential to influence land use in the vicinity of the PRC are discussed below.

5.1.1 Marion County

The BOCC is the primary legislative and policy-making body for Marion County. There are five Commissioners, each representing the district they reside in. They are elected by all county voters to serve a four-year term. The BOCC elects a Chairman and Vice Chairman each year. The BOCC's role ranges from tasks such as enacting ordinances and resolutions to approving budgets and expenditures. However, the BOCC's main responsibility is to provide for the safety and welfare of all Marion County residents. The BOCC meets on the first and third Tuesdays of each month at 9:00 a.m.

Marion County's Growth Services Department plans and guides growth for the county. Within this department, there is both a Zoning and a Planning Division (Marion County 2017). Through the guidance of the Marion County Land Development Code, the Zoning Division regulates the height, location, and size of structures and enforces zoning regulations throughout the county. The Planning Division manages existing and future development through short- and long-term planning efforts, including developing and maintaining the Marion County Comprehensive Plan.

Marion County updated its *Comprehensive Plan 2035* and adopted it in May 2014. Marion County incorporated recommendations consistent with the Navy's RAICUZ Program in the development of its Military Operations Area Overlay, which is included in its Comprehensive Plan.

5.1.2 Putnam County

Putnam County's BOCC serves as the legislative and policy making body for the county. The BOCC performs duties such as approving the budget and adopting ordinances and resolutions necessary to carry out the operations of all Putnam County departments and programs. The BOCC also prepares and enforces comprehensive plans for the development of the county. The BOCC is comprised of five Commissioners, each representing a district. The BOCC meets on the second and fourth Tuesdays of each month at 9:00 a.m. Planning and zoning for the Putnam County is managed under the Planning and Development Services Department. The Planning and Zoning Division staff serves an advisory role to the BOCC, Planning Commission, and Zoning Board of Adjustment. The division also promotes compliance with the Land Development Code and Comprehensive Plan.

Putnam County's Comprehensive Plan was published in 2006, and the most recent updates were completed through the evaluation and appraisal review process in October 2010 for the 2025 Comprehensive Plan. Amendments and updates to ordinances are made as needed. (Putnam County 2017)

5.1.3 Volusia County

Volusia County operates under a Council/Manager form of government, where voters elect a County Council that consists of seven members who serve four-year terms. Five members are elected by their districts to be District Representatives. The remaining two positions are the County Chair and the At-Large Representative, and each are elected countywide (Volusia County 2017a).

The County Council makes broad policy decisions, reviews and approves the annual budget, and passes ordinances, as necessary. The County Council meets on the first and third Thursdays of the month at 9:00 a.m. The County Council appoints a County Manager who is the Volusia County's Chief Executive Officer and oversees the County's day-to-day operations. Planning and Development Services are under the Comprehensive Planning Office, the Current Planning Office, and the Land Development Office. The Comprehensive Planning Office is responsible for preparation, coordination, and implementation of the Volusia County Comprehensive Plan. Planning also reviews development plans, re-zonings, and special exceptions to ensure conformity with the policies and regulations in the Comprehensive Plan. The Current Planning Office is responsible for administering the County's zoning code and related land use regulations. Staff administer the zoning code regulations through the review of building permits, site plans, subdivisions, and business tax receipts. The Land Development Office serves as the administrator of the Land Development Code of Volusia County and provides central coordination of all review processes mandated by this ordinance (Volusia county 2017b).

The Volusia County Comprehensive Plan was adopted in 2008, and amendments since the adoption were last updated in 2016.

5.1.4 Lake County

A BOCC serves Lake County, representing five districts in the county. Each County Commissioner is elected by the County at large and serves a four-year term. The BOCC is the legislative branch of county government. Individual County Commissioners are both lawmaking officers and fiscal representatives of Lake County. The BOCC meets on the second and fourth Tuesdays of each month at 9:00 a.m. In addition, the BOCC meets in work sessions whenever necessary to discuss matters of general importance. These meetings are held on the second Tuesday of each month at 9:00 a.m. The County Commissioners appoint a County Manager and County Attorney to oversee daily operations, personnel, and legal matters. The Planning and Zoning Department is responsible for ensuring compliance and consistency with the County Land Development Regulations and the Comprehensive Plan. Lake County's Comprehensive Plan has a planning horizon through 2030 and was adopted by the BOCC and effective as of September 2011. Amendments are made on as-needed basis. (Lake County 2007)

5.2 LAND USE PLANNING

The local governments with jurisdiction around the PRC RAICUZ footprint manage land use and future growth most commonly through land use plans and zoning regulations, which, within each county, provides the basis for determining compatibility. The following sections describe the land use and zoning that occur within each county surrounding each of the ranges and the RAICUZ footprint.

Land use is a term given to describe the management of land and the extent to which it has been modified. Typical uses include developed land, agricultural areas, residential, commercial, open water, and forested areas. Land use is fundamental to the physical form of the county and cities, and is a key component of the comprehensive plans, which are the primary policy documents that guide local land use and development.

Zoning is the system used by local governments to achieve the desired land uses. Zoning controls the physical development of land and the type of uses to which individual properties may be utilized. Zoning codes provide the regulatory framework to direct development and influence how the various uses interact with each other. Zoning addresses not only the use of property, but the scale and intensity of the use.

5.2.1 Marion County

Marion County encompasses more than 1,600 square miles (1,024,000 acres) of land in North Central Florida and is split by Interstate (I-) 75. Pinecastle Range is located within the southeastern portion of the county, Lake George Range is located just outside of the county to the east, and Rodman Range is located in the northeastern portion of the county on the border with Putnam County. ONF covers much of the eastern portion of the county. Numerous unincorporated communities comprise a large part of the eastern jurisdiction of the county. The unincorporated community of Salt Springs is located in Marion County and is contained in the overlapping RAICUZ footprints of the Pinecastle and Lake George ranges. One of the main goals stated in Marion County's Comprehensive Plan is to recognize and protect the rural and equestrian/agricultural character of the county as viable short- and long-term uses of land and as an asset of the county's character and economy, while providing standards for the review and evaluation of any appropriate future development proposals (Marion County 2014a).

Pinecastle Range

Pinecastle Range is located within the southeastern portion of Marion County. The lands immediately surrounding Pinecastle Range are within Marion County and there are some lands in Lake County to the east of the range. Much of the area surrounding Pinecastle

Range is within ONF and mostly classified as Forested, Agricultural/Cropland, Wetlands, and Shrub/Brushland, with some Recreational uses. Additionally, there are areas along the border of Marion and Lake counties to the southeast of Pinecastle Range that include additional land uses, such as Institutional and Residential. Areas of more development located northwest of Pinecastle Range, particularly near SR 40, include Residential and Commercial uses (see Figures 5-1 and 5-2).

Lake George Range

Marion County borders the western side of Lake George and contains land surrounding Lake George Range. The land uses within Marion County surrounding Lake George Range are predominantly Forest, Wetland, Shrub/Brushland, and Agricultural/Cropland. Along the border of Marion County and Lake George there are Residential uses and Open Land (see Figures 5-3 and 5-4).

Rodman Range

Rodman Range is located on the border of Marion and Putnam counties. The land within Marion County bordering the range is mostly Forest, Wetland, and Agricultural/Cropland with small areas of Residential. ONF border runs south of the range boundary, but most of the Rodman Range RCZ and Noise Zone footprint remains outside of Marion County (see Figures 5-5 and 5-6).

5.2.2 Putnam County

Putnam County spans approximately 833 square miles (533,120 acres) and includes the incorporated municipalities of Crescent City, Interlachen, Pomona Park, Palatka, and Welaka (Putnam County 2010). Rodman Range is located within Putnam County near mostly unincorporated communities. Portions of both Rodman and Lake George ranges' RAICUZ footprints are located in Putnam County.

Lake George Range

The area within Putnam County that surrounds Lake George Range is mostly rural. It includes portions of ONF, Lake George, and unincorporated areas. The town of Georgetown is located north of Lake George Range within the range's RCZ-II and RCZ-III footprints. The area has land uses mostly of Residential, Open Land, Shrub/Brushland, and Agricultural/Cropland (see Figures 5-3 and 5-4).

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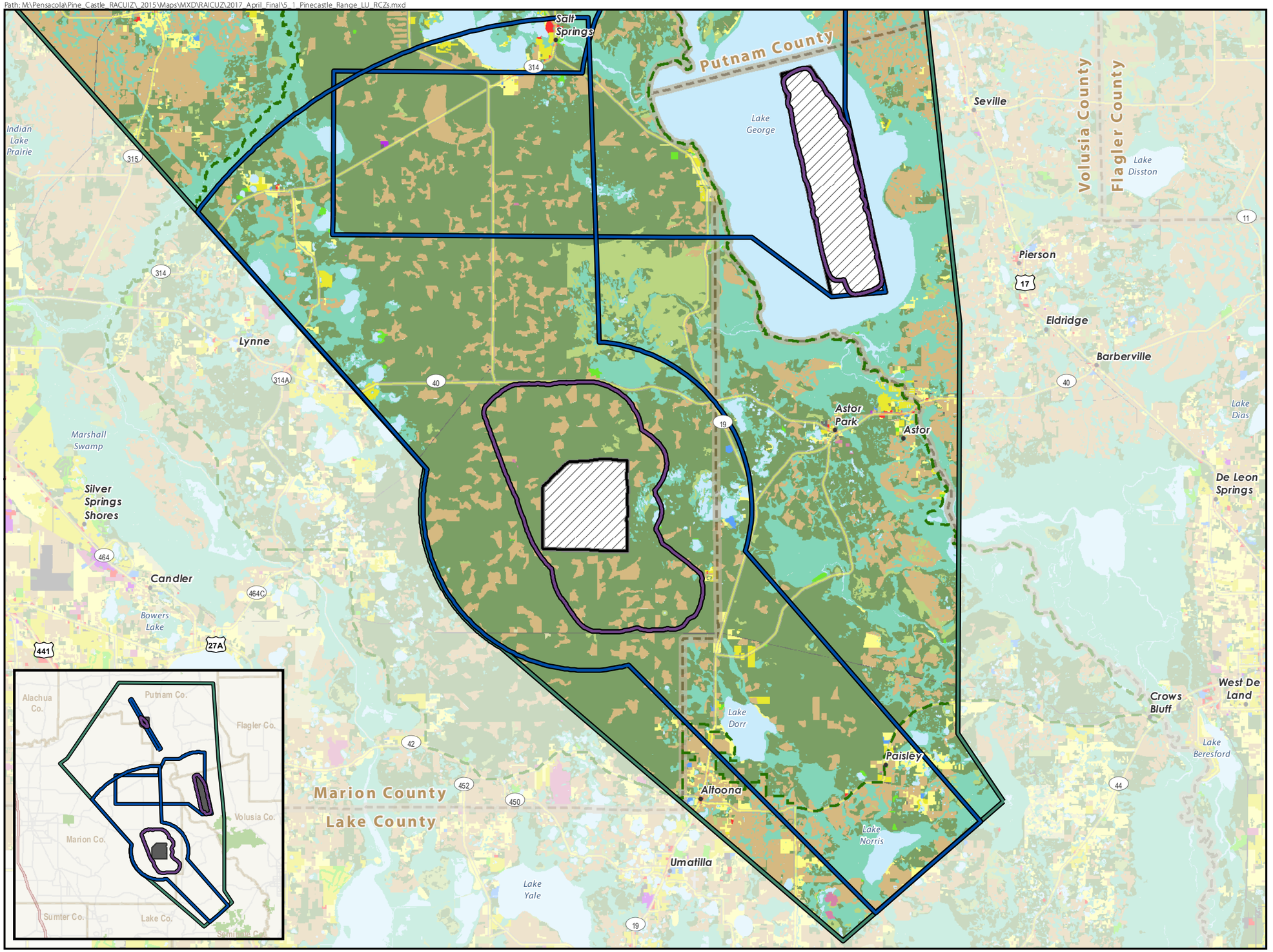

Figure 5-1

Pinecastle Range Existing Land Use within the Projected Range Compatibility Zones

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- City/Town
- County Boundary
- Major Highway
- Ocala National Forest
- Range Boundary

Range Compatibility Zones (RCZs)

- Projected RCZ-I
- Projected RCZ-II
- Projected RCZ-III

Existing Land Use

- Agricultural/Cropland
- Commercial/Services
- Forest
- Industrial
- Institutional
- Mining
- Open Land
- Recreational
- Residential - High Density
- Residential - Low Density
- Shrub/Brushland
- Transportation
- Utility/Communication
- Water
- Wetland
- Navy Bombing Range

N

SCALE

0 2 4 Miles

SOURCE: ESRI 2010, 2012; Florida Geographic Data Library 2009.

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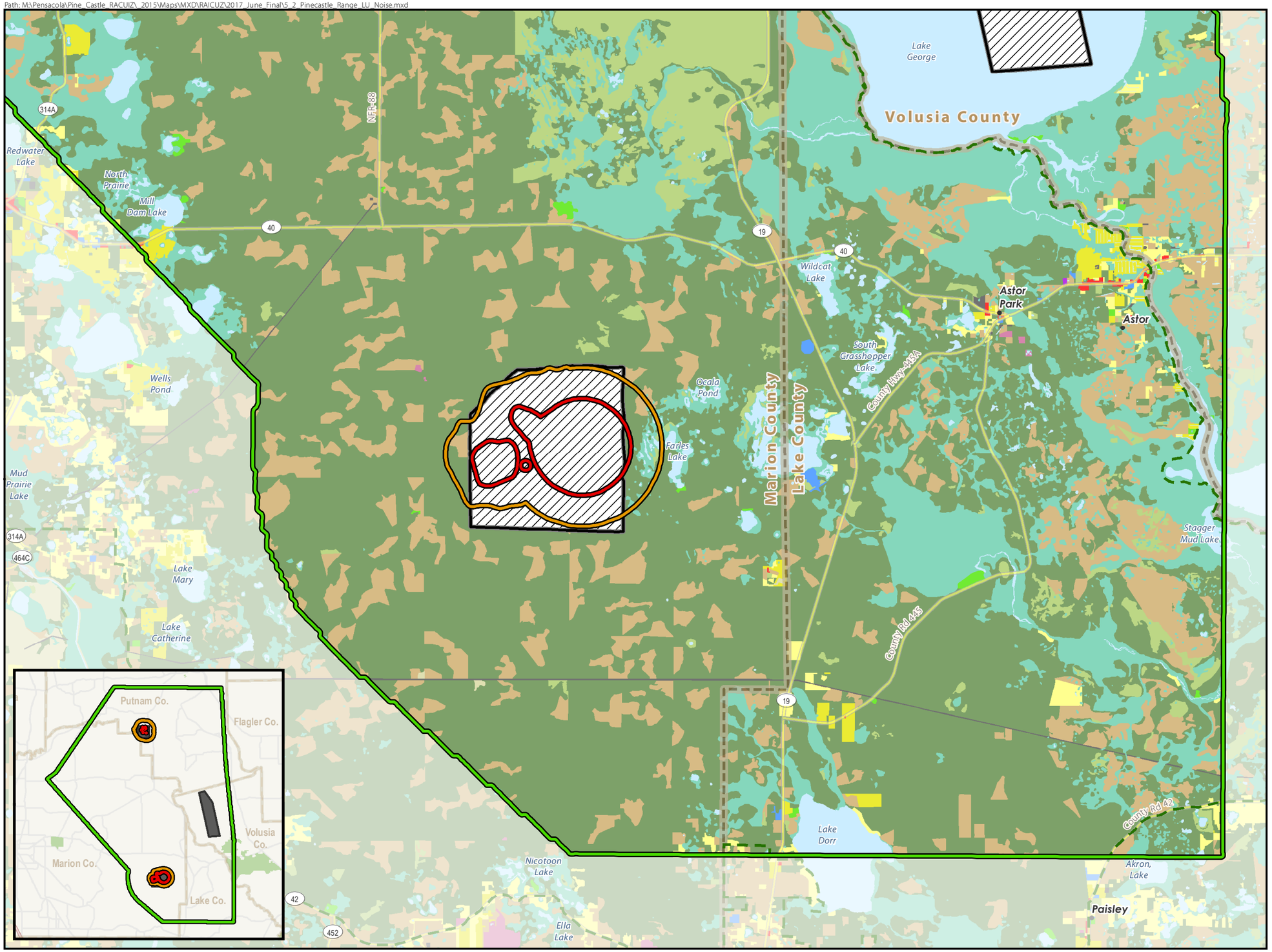

Figure 5-2

Pinecastle Range Existing Land Use within the Projected Noise Zones

Pinecastle Range Complex
Ocala National Forest
Marion County, Florida

Legend

- City/Town
- County Boundary
- Major Highway
- Ocala National Forest
- Range Boundary

Projected Noise Zones (NZs)

- NZ 1: ADNL < 65 dBA; CDNL < 62 dBC; Peak < 87 dBPK15
- NZ 2: ADNL = 65 to75 dBA; CDNL = 62 to 70 dBC; Peak = 87 to 104 dBPK15
- NZ 3: ADNL > 75 dBA; CDNL > 70 dBC; Peak > 104 dBPK15

Existing Land Use

- Agricultural/Cropland
- Commercial/Services
- Forest
- Industrial
- Institutional
- Mining
- Open Land
- Recreational
- Residential - High Density
- Residential - Low Density
- Shrub/Brushland
- Transportation
- Utility/Communication
- Water
- Wetland
- Navy Bombing Range

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SOURCE: ESRI 2010, 2012; Florida Geographic Data Library 2009.

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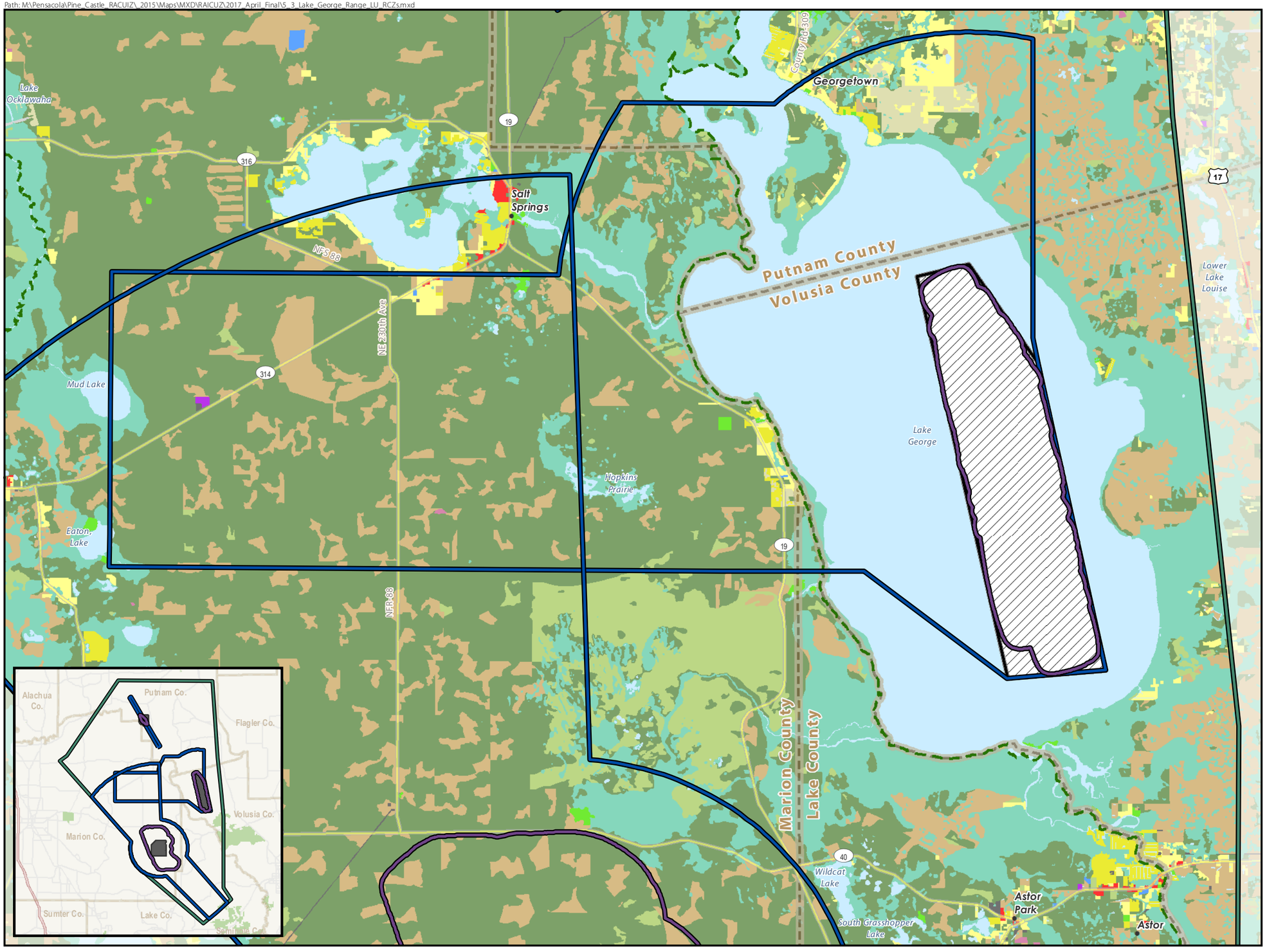

Figure 5-3

Lake George Range Existing Land Use within the Projected Range Compatibility Zones

Pinecastle Range Complex
Ocala National Forest
Volusia County, Florida

Legend

- City/Town
- County Boundary
- Major Highway
- Ocala National Forest
- Range Boundary

Range Compatibility Zones (RCZs)

- Projected RCZ-I
- Projected RCZ-II
- Projected RCZ-III

Existing Land Use

- Agricultural/Cropland
- Commercial/Services
- Forest
- Industrial
- Institutional
- Mining
- Open Land
- Recreational
- Residential - High Density
- Residential - Low Density
- Shrub/Brushland
- Transportation
- Utility/Communication
- Water
- Wetland
- Navy Bombing Range

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010, 2012; Florida Geographic Data Library 2009.

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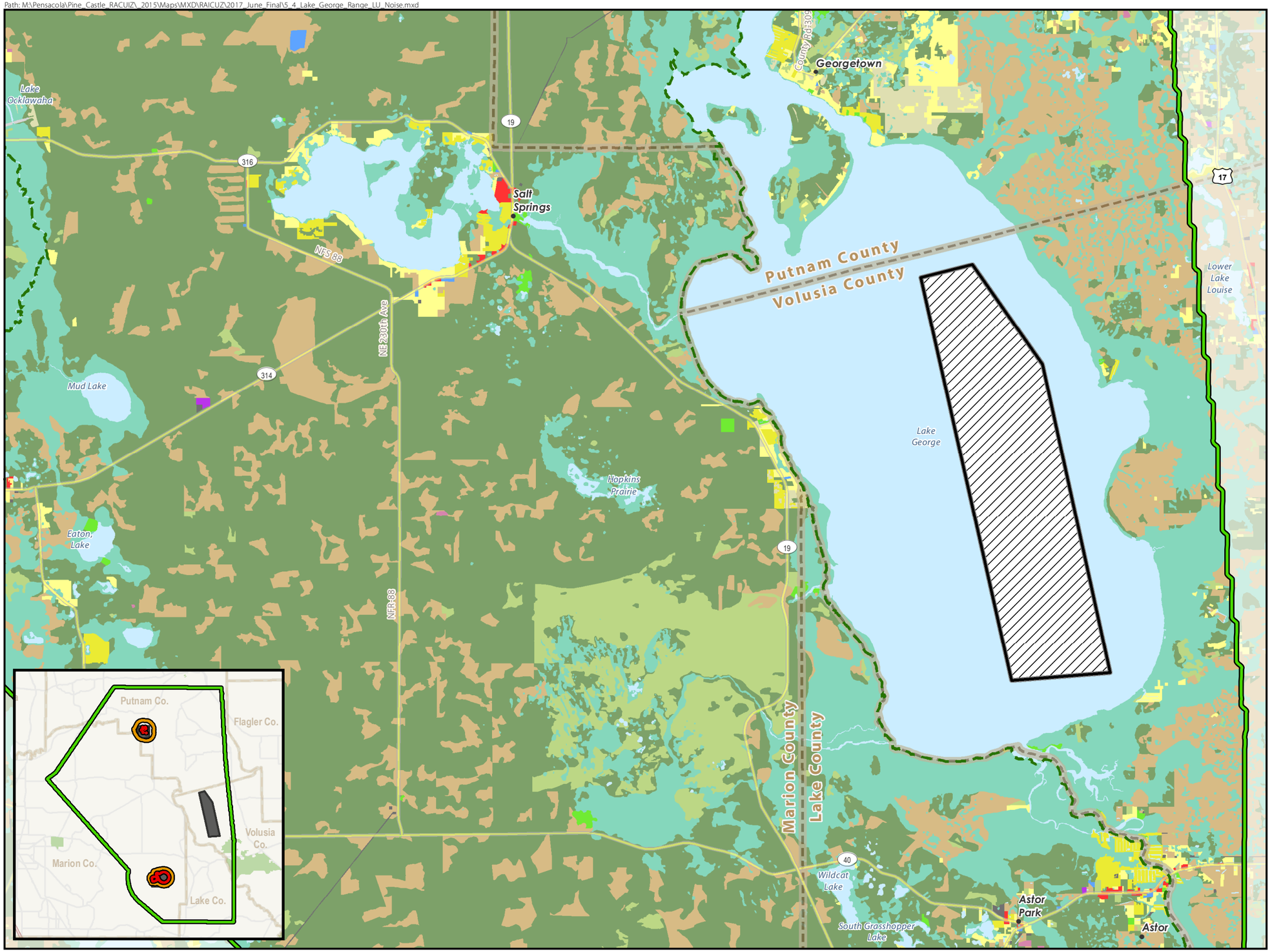

Figure 5-4

Lake George Range Existing Land Use within the Projected Noise Zones

Pinecastle Range Complex
Ocala National Forest
Volusia County, Florida

Legend

- City/Town
- County Boundary
- Major Highway
- Ocala National Forest
- Range Boundary

Projected Noise Zones (NZs)

- NZ 1: ADNL < 65 dBA; CDNL < 62 dBC; Peak < 87 dBPK15
- NZ 2: ADNL = 65 to75 dBA; CDNL = 62 to 70 dBC; Peak = 87 to 104 dBPK15
- NZ 3: ADNL > 75 dBA; CDNL > 70 dBC; Peak > 104 dBPK15

Existing Land Use

- Agricultural/Cropland
- Commercial/Services
- Forest
- Industrial
- Institutional
- Mining
- Open Land
- Recreational
- Residential - High Density
- Residential - Low Density
- Shrub/Brushland
- Transportation
- Utility/Communication
- Water
- Wetland
- Navy Bombing Range

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010, 2012; Florida Geographic Data Library 2009.

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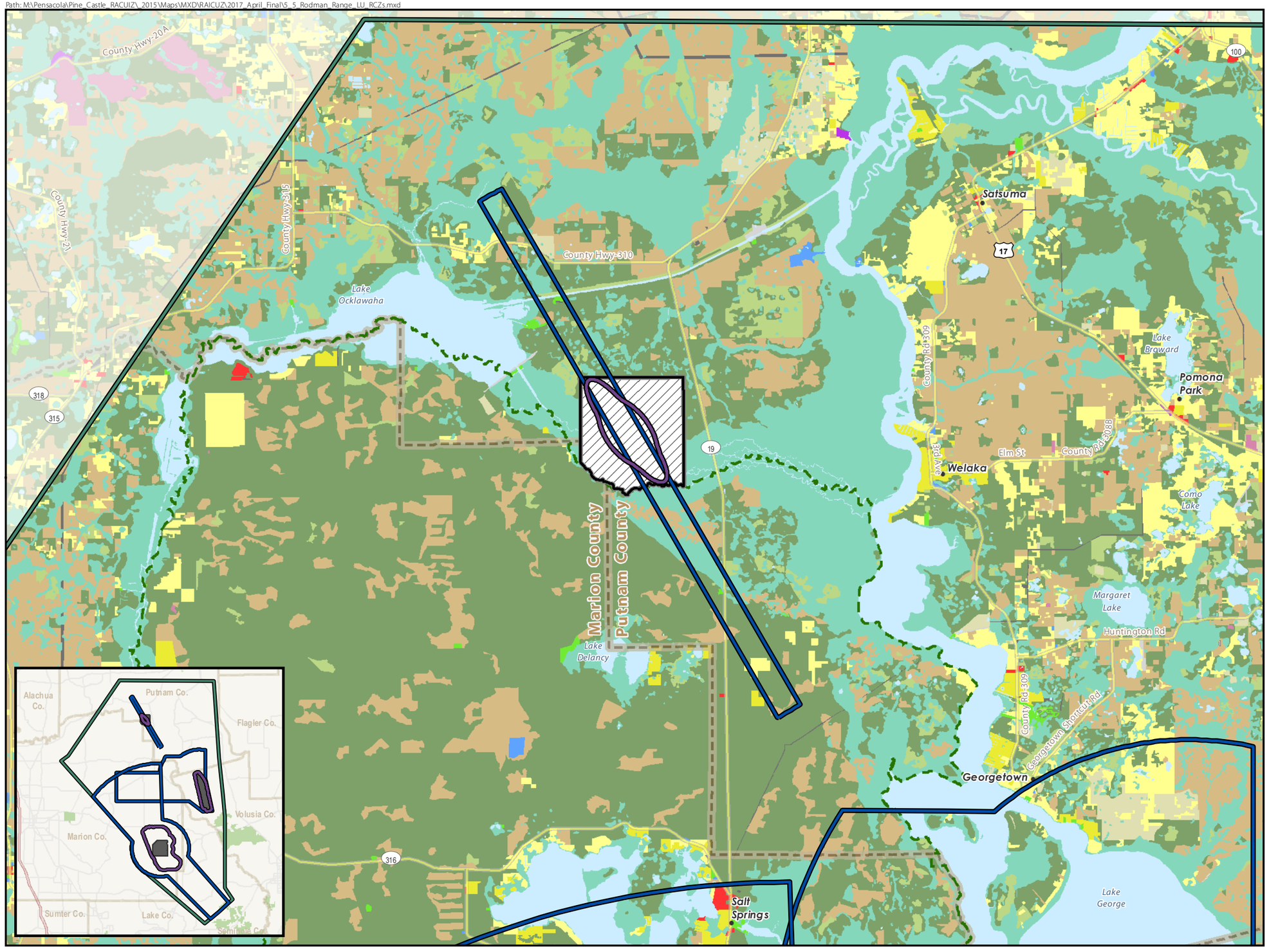

Figure 5-5

Rodman Range
Existing Land Use within the Projected Range Compatibility Zones

Pinecastle Range Complex
Ocala National Forest
Marion and Putnam Counties, Florida

Legend

- City/Town
- County Boundary
- Major Highway
- Ocala National Forest
- Range Boundary

Range Compatibility Zones (RCZs)

- Projected RCZ-I
- Projected RCZ-II
- Projected RCZ-III

Existing Land Use

- Agricultural/Cropland
- Commercial/Services
- Forest
- Industrial
- Institutional
- Mining
- Open Land
- Recreational
- Residential - High Density
- Residential - Low Density
- Shrub/Brushland
- Transportation
- Utility/Communication
- Water
- Wetland
- Navy Bombing Range

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010, 2012; Florida Geographic Data Library 2009.

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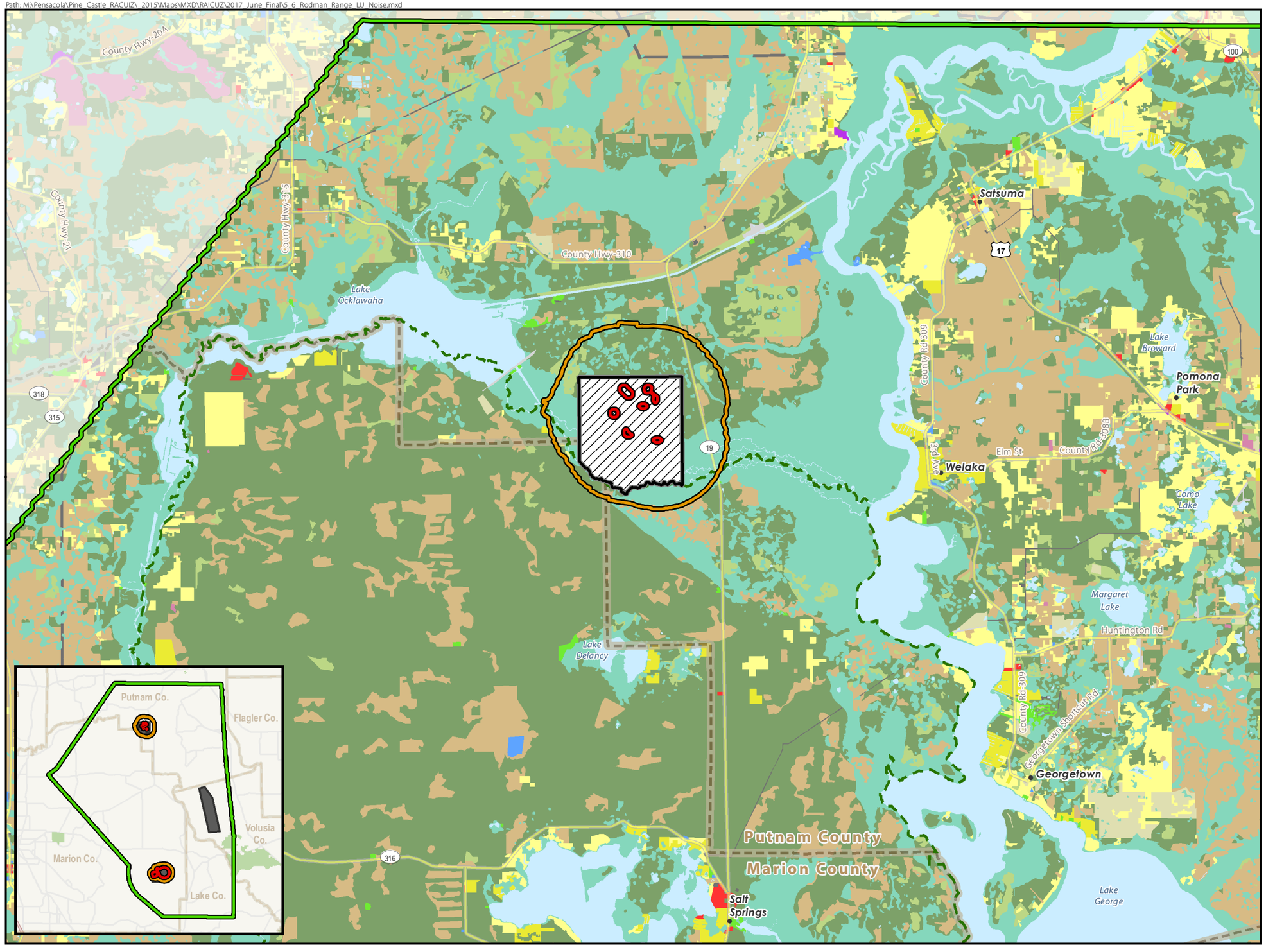

Figure 5-6

Rodman Range
Existing Land Use within the Projected Noise Zones

Pinecastle Range Complex
Ocala National Forest
Marion and Putnam Counties, Florida

Legend

- City/Town
- County Boundary
- Major Highway
- Ocala National Forest
- Range Boundary

Projected Noise Zones (NZs)

- NZ 1: ADNL < 65 dBA; CDNL < 62 dBC; Peak < 87 dBPK15
- NZ 2: ADNL = 65 to75 dBA; CDNL = 62 to 70 dBC; Peak = 87 to 104 dBPK15
- NZ 3: ADNL > 75 dBA; CDNL > 70 dBC; Peak > 104 dBPK15

Existing Land Use

- Agricultural/Cropland
- Commercial/Services
- Forest
- Industrial
- Institutional
- Mining
- Open Land
- Recreational
- Residential - High Density
- Residential - Low Density
- Shrub/Brushland
- Transportation
- Utility/Communication
- Water
- Wetland
- Navy Bombing Range

N

SCALE

0 1 2 Miles

SOURCE: ESRI 2010, 2012; Florida Geographic Data Library 2009.

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Rodman Range

Rodman Range is located almost entirely within Putnam County. US-19 runs east of the range, and Lake Ocklawaha (known as Rodman Reservoir) is located to the west of the range, as well as a portion of Florida's Greenway trails. These features can attract recreation activities such as hunting, fishing, and hiking. The RCZs and noise zones within the surrounding areas in Putnam County have Wetland, Forest, Agricultural/Cropland, and Shrub/Brushland land uses. Much of the land designated as Agricultural/Cropland includes silviculture uses. Additionally, there are a few areas southeast of the range that are Residential (see Figures 5-5 and 5-6).

5.2.3 Volusia County

Volusia County encompasses approximately 1,200 square miles (768,000 acres). It is located in northeast Florida, bordered on the east by the Atlantic Ocean and on the west by the St. Johns River. I-95 runs north-south through Volusia County; I-4, which connects east and west Florida, runs through the center of the county (Volusia County Division of Economic Development 2017). While the eastern jurisdiction of Volusia County is very developed, the western side of the county and areas surrounding Lake George Range are less developed.

Lake George Range

The area within Volusia County that is surrounding or within Lake George Range's RCZ and Noise Zone footprints is mostly water. Other uses surrounding the range include Wetlands, Agricultural/Cropland, Forest, and Residential. South of the range, there is a cluster of Commercial and Residential uses near the town of Astor that follow SR 40 on the border between Volusia and Lake counties (see Figures 5-3 and 5-4).

5.2.4 Lake County

Lake County contains more than 1,100 square miles (704,000 acres) of land. The northern tip of the county is located between Rodman Range and Lake George Range and encompasses parts of ONF and part of Lake George. The Lake County Comprehensive Plan establishes Future Land Use categories reflecting compatible land uses, providing enough acreage to meet estimated population growth, and identifying development. The Future Land Use provides guidance for preparing and updating the County's Land Development Regulations. The County regulates land use activities within their Future Land Use category through the implementation of zoning districts. Zoning districts are defined within the County Land Development Regulations and a zoning map. The permitted uses, such as maximum density and intensity of zoning districts, does not exceed the density and intensity allowed by

the Future Land Use category (Lake County 2011). Lake County encompasses portions of the Pinecastle and Lake George RCZs and noise zones.

Pinecastle Range

The area within Lake County surrounding Pinecastle Range is largely contained within ONF. Nearby towns include Pittman and Paisley, and US-19 runs along the border between Marion and Lake counties. Areas surrounding the towns of Pittman and Paisley have predominant land uses of Residential, Forest, Agricultural/Cropland, and Wetland, with small pockets of Institutional (see Figures 5-1 and 5-2).

Lake George Range

Lake County borders the western side of Lake George and contains land surrounding Lake George Range. The land uses within Lake County surrounding Lake George Range are predominantly Forest, Wetland, Shrub/Brushland, and Agricultural/Cropland. South of Lake George Range, along the border of Lake County and Volusia County, there are areas of Residential, Commercial/Services, and Industrial/Mining. These areas are mostly concentrated around the communities of Astor and Astor Park near SR 40 (see Figures 5-3 and 5-4).

5.3 REGIONAL CONTEXT

Urban growth and associated competing uses for land and airspace can have a significant effect on military installations and training ranges, especially those that were previously located in remote or rural areas. The following section summarizes some of these factors in order to better understand their effects on compatibility with the PRC and its operations and mission.

5.3.1 Local/Regional Airports

The counties surrounding the PRC contain public and private airports located within the SUA (see Section 2.4.2.2, Figure 2-6). Table 5-1 summarizes the locations and type of these airports. Public airports include large commercial airports used by major airplane carriers and those open to public flight, as well as helipads, helidecks, and seaplane ports and bases. Private airports and landing strips are typically used by private members and may be used for emergencies. Private airports may also grant pre-planned access or allow users to use an attached hangar.

Table 5-1: Public and Private Airports Located in Counties within the Pinecastle Range Complex Military Influence Area

County	City/Town	Airport	Facility Type
Marion	Citra	Paniola Air Ranch Airport	Private
		85th Avenue Airstrip	Private
Putnam	Melrose	Melrose Landing Airport	Private
		Sanders Ranch Airport	Private
	Crescent City	Eagles Nest Aerodrome Airport	Private
		Thunderbird Air Park Airport	Private
		Jim Finlay Farm Airport	Private
		Inhome Medical Landing Heliport	Private
		Skinners Wholesale Nursery Airport	Private
	Interlachen	Oak Ridge Airport	Private
	Island Grove	Marjorie Kennan Rawlings Airport	Private
	Pomona Park	Pomona Landing Airport	Private
	Welaka	Mount Royal Airport	Private
Volusia	Pierson	Pierson Muni Airport	Public

Source: http://www.tollfreeairline.com/florida

5.3.2 Regional Population Estimates and Projections

Four counties are located within or adjacent to the PRC MOA: Marion County, Putnam County, Volusia County, and Lake County. The communities in the MOA surrounding the PRC are predominantly rural; however, North Central Florida continues to experience population growth. The estimated and projected populations for these areas, as well as the percentage of change, are shown in Table 5-2. Figure 5-7 depicts the total growth of each county located within the region.

Table 5-2: Regional Population Estimates and Projections

County	2000 (1)	2010 (2)	2015 (2)	2020 (3)	2030 (3)	% Change 2010-2030
Marion	258,916	331,303	343,254	373,809	434,725	31.22%
Putnam	70,423	74,364	72,023	73,056	73,829	-0.72%
Volusia	443,343	494,593	517,887	528,311	563,850	14.00%
Lake	210,527	297,047	325,875	356,555	432,620	45.64%
TOTAL	983,209	1,197,307	1,259,039	1,331,731	1,505,024	

Notes:
(1) Based on 2000 U.S. Census (USCB 2000)
(2) USCB 2015e
(3) Based on BEBR median projections: Volume 48, Bulletin 171, April 2015

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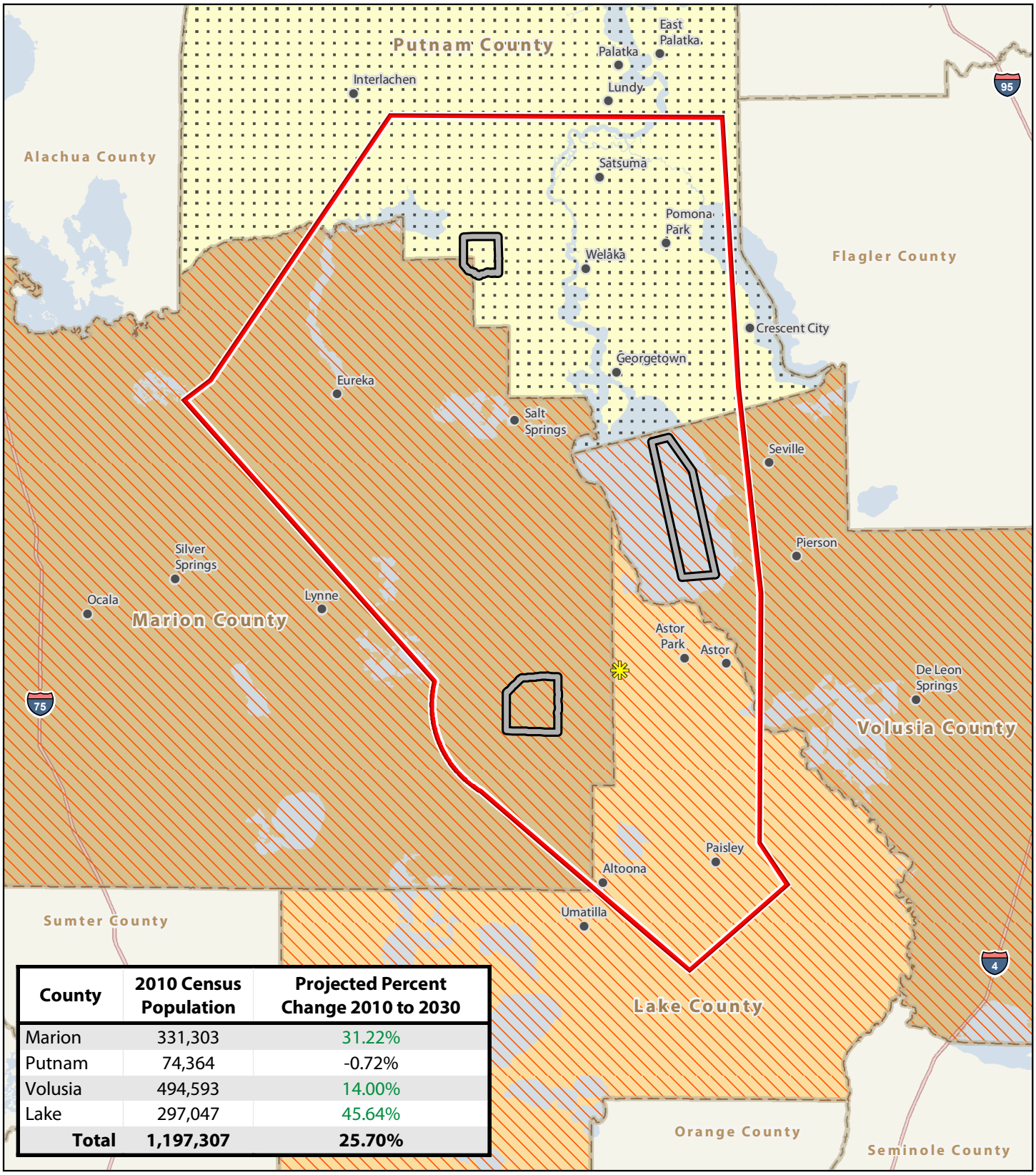

County	2010 Census Population	Projected Percent Change 2010 to 2030
Marion	331,303	31.22%
Putnam	74,364	-0.72%
Volusia	494,593	14.00%
Lake	297,047	45.64%
Total	**1,197,307**	**25.70%**

SCALE

0 4 8 Miles

SOURCE: ESRI 2010, 2012; Navy EIMS 2013; UF, BEBR, Florida Population Studies 2015; U.S. Census Bureau 2013.

Legend

- County Boundary
- Interstate
- Centroid Facility
- Range Boundary
- RAICUZ Footprint

2010 - 2030 Projected Population Change

- Increasing Population
- Decreasing Population

2010 Popuation

- 0 - 200,000
- 200,001 - 300,000
- 300,001 - 500,000

Figure 5-7

Regional Population and Growth

Pinecastle Range Complex
Ocala National Forest
Lake, Marion, Putnam, and Volusia Counties, Florida

5.3.2.1 Marion County

Marion County had an estimated population of 343,254 persons for 2015 (Table 5-2), including 132,287 households and 163,808 housing units (USCB 2015a). The population density of Marion County is 209 persons per square mile (USCB 2015a). The county's population increased by approximately 33 percent from 2000 to 2015. Marion County's population is projected to grow more than 31 percent between 2010 and 2030, to 434,725 residents (BEBR 2015).

5.3.2.2 Putnam County

The 2015 estimated population for Putnam County was 72,023 persons, including 27,683 households and 36,528 housing units (USCB 2015b). The population density of Putnam County is 102 persons per square mile (Census Bureau 2015b). The population is projected to be approximately 73,829 by 2030. Although Putnam County's population is projected to increase slightly from 2015 to 2030, it is not projected to exceed the amount of people that were living in the county in 2010 (Table 5-2).

5.3.2.3 Volusia County

Volusia County is the most populous county in the PRC regional scope. Lake George Range is located in the northwest planning region of Volusia County, which include one municipality, Pierson. Population growth in this part of the county is less prevalent.

The 2015 estimated population for Volusia County was 517,887 persons, including 200,180 households and 256,967 housing units (USCB 2015c). The county has a population density of 102 persons per square mile (USCB 2015c). The county's population increased by 16 percent from 2000 to 2015. Volusia's population is projected to grow by 14 percent from 2010 to 2030 (Table 5-2).

5.3.2.4 Lake County

Lake County's estimated population for 2015 was 325,875 persons, including 119,251 households and 148,706 housing units (USCB 2015d). The population density of Lake County is 317 persons per square mile (USCB 2015d). The county's population increased by about 55 percent from 2000 to 2015 and the population is projected to grow 46 percent between 2015 and 2030, to 432,620 residents (Table 5-2).

5.4 LAND USE COMPATIBILITY ANALYSIS

5.4.1 Land Use Compatibility Guidelines and Classifications

The Navy has developed guidelines for compatible development and land use within a range's noise zones and RCZs. These land use guidelines are provided in OPNAVINST 3550.1A. In general, the guidelines assume noise-sensitive land uses (e.g., houses and churches) will be placed outside high-noise zones, and people-intensive uses (e.g., residential, apartments, and theaters) will not be placed in RCZs.

The Navy developed land use guidelines for compatible development and land use within a range's noise zones and RCZs provided in OPNAVINST 3550.1A, RAICUZ Instruction.

Land use classifications in the Navy's guidelines are generalized and may not represent specific local communities' land use designations. When the current and future land uses in the vicinity of the PRC are evaluated on these guidelines, recommended compatible and incompatible land uses can be identified. Further compatibility analysis may be required during implementation by the local governments as local conditions and local knowledge may lead to changes in the compatibility determinations discussed below. Appendix B provides the Navy's land use compatibility recommendations from OPNAVINST 3550.1A. Appendix C provides the land use codes from the counties surrounding the PRC that were categorized and used to determine compatibility in this RAICUZ Study.

5.4.1.1 Land Use Compatibility Guidelines for RCZs

As discussed in Section 3.2, there are three RCZs applicable to training activities (RCZ-I, RCZ-II, and RCZ-III). Each RCZ has specific restrictions and recommendations for land use and activities within the confines of the zone. Navy safety policies require RCZ-I to be contained within the range boundary and/or lands under exclusive military use and control due to the inherent danger associated with training activities. It is incumbent upon the Navy to ensure this requirement is met. The RCZ-Is for Lake George Range and Rodman Range are fully contained within the range boundaries and, therefore, no land use incompatibilities exist and RCZ-I is not discussed in the analysis presented below. For Pinecastle Range, a portion of RCZ-I extends beyond the range boundary; however, an agreement with the land owner (USDA Forest Service) is in place to allow the RCZ-I overlap. A special use permit (USDA Forest Service 2002) and Annual Operating Plan (Navy 2017c) outline the details of the agreement. Potential land use incompatibilities within the Pinecastle Range RCZ-I are discussed below. Additionally, the recommended incompatibilities within the RCZ-II and RCZ-III for the three ranges are also outlined below. Table 5-3 provides a summary of

compatibility recommendations for land uses within RCZs; refer to Appendix B for the full list of suggested land use classifications and compatibility guidelines.

Table 5-3: 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 OPNAVINST 3550.1A/MCO 3550.11.

Notes:

This generalized land-use table provides an overview of recommended land uses. To determine specific land use compatibility, see Appendix B.

Compatibility Conditions:

(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 feet).
(3) = Suggested maximum density of RCZ-III is no more than 1-2 dwelling units per acre.
(4) = Clubhouses, chapels, and other public assembly facilities are not compatible in RCZ-II.

Key:

Compatible
Incompatible

5.4.1.2 Land Use Compatibility Guidelines for Noise

As discussed in Section 4.3, for land use planning purposes, the DOD generally divides noise exposure from aircraft and weapons into three "noise zones": Noise Zone 1, Noise Zone 2, and Noise Zone 3. The area in Noise Zone 1 represents the lowest area of noise exposure, and most land uses are compatible within this zone. Noise Zone 2 represents the area of moderate noise exposure, where residential uses are not compatible and certain uses are recommended to achieve a noise level reduction of 25 to 30 dB. Noise Zone 3 represents the most severely impacted areas and, as such, several additional uses are incompatible and all remaining uses are recommended to achieve a noise level reduction of 30 to 35 dB. In all, there are fewer restrictions for land uses in Noise Zone 1, and maximum land use restrictions are in Noise Zone 3.

Noise Zone 1 - an area of minimal effect where less than 15 percent of the population is expected to be highly annoyed.	Noise Zone 2 - an area of moderate effect where between 15 percent and 39 percent of the population is expected to be highly annoyed.	Noise Zone 3 - an area of most severe effect where greater than 39 percent of the population is expected to be highly annoyed.

For the purposes of this analysis, the A-weighted scale, C-weighted scale, and peak noise were used to analyze the noise impacts. Due to the variety of training activities that occur at the PRC, several different metrics were needed to evaluate the noise impacts. Table 5-4 presents the recommended land use compatibility guidelines for the various noise zones. Areas of concern outside of the noise zones (e.g., areas under ingress and egress routes to and from training ranges) may be defined where noise levels are not considered objectionable (A-weighted day-night average sound level [ADNL] < 65 dB) but where compatible land use planning is recommended.

Table 5-4: Land Use Classifications and Compatibility Guidelines in Noise Zones

		Land Use Compatibility with Noise Zone (DNL) and PK_{15} ($dBPk_{15}$)						
		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		
Land Use	PK_{15}*	<87*		87-104*		>104*		
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)	(1)		
Manufacturing (ex. Petrol/chem.; textile)					(1)	(2)	(2)	
Agriculture, Forestry Fishing, and Mining								

Source: Adapted from OPNAVINST 3550.1A/MCO 3550.11.
*Adapted from AR 200-1, Supplemental Metrics for dB PK_{15} equivalency to the DNL standard.

Notes:
This generalized land use table provides an overview of recommended land uses. To determine specific land use compatibility, see Appendix B.
Compatibility Conditions:
(1) = Land use and related structures generally compatible; however, measures to achieve recommended noise level reduction (25 to 30 noise level reduction) 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 reduction (30 to 35 noise level 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 noise level reduction of at least 25 dB should be incorporated into building codes.
Peak levels are also used to determine the risk of noise complaints.
Key:
ADNL = A-weighted day-night average sound level
CDNL = C-weighted day-night average sound level
Compatible
Incompatible

5.4.2 Methodology

For this RAICUZ Study, an analysis was performed to determine the land use compatibility of the land use codes using the Florida Land Use, Cover, and Forms Classification System (FLUCCS) descriptions (Appendix C) that were found within the RAICUZ footprint. The land use types were grouped by similar categories and restrictions in relation to the FLUCCS codes (Appendix D). The land use compatibility assessment analyzed the Navy's land use recommendations within the RCZs and noise zones for compatibility with the permitted uses allowed under each land use. Figures 5-1 through 5-6, presented in Section 5.2, show land use for the areas within the RCZs and noise zones.

The boundaries of each RCZ were used to conduct the land use compatibility analysis for this RAICUZ Study. Of note for the PRC, the projected RCZ-III is represented by the SUA that surrounds each range, which includes the Palatka MOA and Restricted Areas R-2910A/B/C/D/E, R-2907A/B/C, and R-2906. Therefore, the area shown for the projected RCZ-III is shown and calculated for the PRC as a whole, by county, and not broken out separately by individual range. The projected RCZs cover a total area of 662,728 acres and encompass Marion, Putnam, Volusia, and Lake counties.

As discussed in Section 4.3.4, the projected (FY2020) noise zones from each type of noise occurring at each separate range of the PRC were combined to create a composite Noise Zone 1, 2, and 3 for each range. This composite of all the noise zones represents the general noise footprint of the PRC. Where overlapping noise boundaries occurred, the most restrictive one was used. The land use compatibility analysis is based on these composite noise exposure levels (see Figure 4-19, presented in Chapter 4). Note that, because the Aircraft Noise portion of the noise composite extends out to the boundary of the MOA, the Noise Zone 1s for each range overlap. This overlap creates inflated acreage numbers when discussing Noise Zone 1 for each range. Therefore, for the purpose of this analysis, Noise Zone 1 will be discussed for the PRC as a whole and will not be broken down by a specific range. The projected noise zones for the PRC total approximately 626,395 acres.

5.4.3 Compatibility with Projected FY2020 RCZs

Land use types within the PRC RAICUZ RCZs primarily consist of Undeveloped Land, Agricultural/Cropland, Wetlands, and Water, which are generally compatible with range operations. Incompatibility mostly exists with Residential, Commercial, Educational, Religious, and Health Care land uses within the RCZs.

The RCZ-I land area is entirely contained within the boundaries of Lake George and Rodman ranges. However, RCZ-I extends outside of Pinecastle Range's boundary into Marion

County. No residences, commercial businesses, institutional, or public assembly facilities are currently located within RCZ-I (Table 5-5).

Table 5-5: Land Use within the Pinecastle Range Complex's RCZs and Noise Zones

Land Use	RCZs (acres)			Noise Zones (acres)		
				1	2	3
				< 65 dBA	65-75 dBA	> 75 dBA
				< 62 dBC	62-70 dBC	> 70 dBC
	RCZ-I	RCZ-II	RCZ-III	< 87 $dBPK_{15}$	87-104 $dBPk_{15}$	> 104 $dBPk_{15}$
Marion County						
Agricultural/Cropland	3,830.9	17,940.2	29,029.0	50,548.4	167.5	3.2
Commercial/Services	0.0	179.4	136.0	316.4	0.0	0.0
Forest	17,101.4	95,850.0	67,297.3	176,988.8	892.9	56.0
Industrial	0.0	27.6	16.6	44.2	0.0	0.0
Institutional	0.0	31.7	166.5	198.2	0.0	0.0
Mining	11.7	12.9	12.7	37.2	0.0	0.0
Open Land	0.0	125.6	81.8	207.4	0.0	0.0
Recreational	0.0	378.6	144.7	523.4	0.0	0.0
Residential-High Density	0.0	1,042.6	871.1	1,933.7	0.0	0.0
Residential-Low Density	0.0	1,253.1	4,276.4	5,530.7	11.1	0.0
Shrub/Brushland	239.8	2,623.8	7,495.7	10,301.6	30.8	0.0
Transportation	0.0	0.0	33.2	33.2	0.0	0.0
Utility/Communication	0.0	247.3	272.1	517.5	0.0	0.0
Water	144.4	4,618.8	4,078.3	8,810.6	50.6	0.0
Wetlands	412.1	16,979.4	22,312.3	39,508.1	266.4	0.0
County Total	**21,740.4**	**141,311.2**	**136,223.8**	**295,499.5**	**1,419.3**	**59.2**
Putnam County						
Agricultural/Cropland	0.0	2,236.5	35,312.2	37,378.9	92.3	0.0
Commercial/Services	0.0	0.0	181.8	181.1	0.0	0.0
Forest	0.0	3,190.2	40,179.8	41,810.6	1,516.7	0.0
Industrial	0.0	0.0	110.5	110.5	0.0	0.0
Institutional	0.0	1.8	207.0	208.8	0.0	0.0
Mining	0.0	0.0	63.4	63.4	0.0	0.0
Open Land	0.0	830.3	1,968.7	2,799.0	0.0	0.0
Recreational	0.0	36.8	231.8	268.6	0.0	0.0
Residential-High Density	0.0	93.0	1,666.7	1,763.6	0.0	0.0
Residential-Low Density	0.0	1,093.3	10,431.2	11,479.0	4.7	0.0
Shrub/Brushland	0.0	420.5	7,913.6	8,149.3	171.1	0.0
Transportation	0.0	0.0	164.8	164.2	0.0	0.0
Utility/Communication	0.0	2.3	423.2	423.4	0.0	0.0
Water	0.0	7,345.9	17,561.5	24,752.3	59.9	0.0
Wetlands	0.0	4,156.7	52,917.9	55,264.3	1,719.0	0.0
County Total	**0.0**	**19,407.3**	**169,334.2**	**184,817.1**	**3,563.7**	**0.0**
Volusia County						
Agricultural/Cropland	0.0	4.5	7,268.9	7,461.3	0.0	0.0
Commercial/Services	0.0	0.0	13.1	13.1	0.0	0.0
Forest	0.0	3.0	1,708.4	1,745.6	0.0	0.0
Industrial	0.0	0.0	0.0	0.0	0.0	0.0
Institutional	0.0	0.0	0.0	0.0	0.0	0.0
Mining	0.0	0.0	0.0	0.0	0.0	0.0
Open Land	0.0	0.0	1.4	1.4	0.0	0.0

Table 5-5: Land Use within the Pinecastle Range Complex's RCZs and Noise Zones

	RCZs (acres)			Noise Zones (acres)		
				1	2	3
				< 65 dBA	65-75 dBA	> 75 dBA
				< 62 dBC	62-70 dBC	> 70 dBC
Land Use	RCZ-I	RCZ-II	RCZ-III	< 87 $dBPK_{15}$	87-104 $dBPk_{15}$	> 104 $dBPk_{15}$
Recreational	0.0	0.0	53.1	53.2	0.0	0.0
Residential-High Density	0.0	0.0	118.9	119.0	0.0	0.0
Residential-Low Density	0.0	1.0	389.3	399.7	0.0	0.0
Shrub/Brushland	0.0	0.0	262.5	275.0	0.0	0.0
Transportation	0.0	0.0	0.0	0.0	0.0	0.0
Utility/Communication	0.0	0.0	17.1	17.1	0.0	0.0
Water	0.0	16,257.4	11,969.8	28,238.5	0.0	0.0
Wetlands	0.0	551.6	10,321.1	11,049.2	0.0	0.0
County Total	**0.0**	**16,817.4**	**32,123.6**	**49,373.2**	**0.0**	**0.0**
Lake County						
Agricultural/Cropland	0.0	6,212.3	12,135.6	9,021.8	0.0	0.0
Commercial/Services	0.0	27.1	135.3	102.7	0.0	0.0
Forest	0.0	21,699.7	23,977.5	36,780.7	0.0	0.0
Industrial	0.0	0.0	7.5	7.5	0.0	0.0
Institutional	0.0	177.2	99.7	142.7	0.0	0.0
Mining	0.0	3.0	167.0	31.9	0.0	0.0
Open Land	0.0	0.0	36.6	0.0	0.0	0.0
Recreational	0.0	89.4	151.3	165.5	0.0	0.0
Residential-High Density	0.0	488.2	586.8	863.5	0.0	0.0
Residential-Low Density	0.0	1,365.3	1,994.2	1,068.0	0.0	0.0
Shrub/Brushland	0.0	355.5	1,952.8	1,674.0	0.0	0.0
Transportation	0.0	0.0	0.0	0.0	0.0	0.0
Utility/Communication	0.0	73.3	95.5	155.5	0.0	0.0
Water	0.0	3,500.5	2,510.6	3,323.1	0.0	0.0
Wetlands	0.0	8,248.9	21,954.9	20,600.9	0.0	0.0
County Total	**0.0**	**42,240.4**	**65,805.2**	**73,937.7**	**0.0**	**0.0**
GRAND TOTAL	**21,740.4**	**219,776.2**	**403,486.7**	**603,627.4**	**4,982.9**	**59.2**

Note:
These acreage totals for each county exclude land that is located within the range boundary

Land uses in RCZ-II predominantly include Agricultural/Cropland, Forest, Wetlands, and Water. RCZ-II also includes some Residential and Institutional uses (Table 5-5; see Figures 5-1, 5-3, and 5-5, presented in Section 5.2).

Similar to RCZ-II, most of the land uses within RCZ-III (403,487 acres) that is off range consists of Agricultural/Cropland, Forest, Wetlands, and Water (Figures 5-1, 5-3, and 5-5), which are compatible uses. While the majority of land in RCZ-III is compatible with military operations, some of the aforementioned land use categories allow schools, libraries, churches, community centers, and medical land uses, all of which are incompatible according to recommendations outlined in the Navy RAICUZ Program. Further analysis will be provided in the sections below using the existing land use categories.

5.4.3.1 Marion County Land Use Compatibility Analysis

Marion County contains areas off range that are located within RCZ-I, RCZ-II, and RCZ-III. RCZ-I covers 21,740 acres outside of the Pinecastle Range boundary in Marion County. Land use types in the RCZ-I footprint include Agricultural/Cropland, Forest, and Wetlands within ONF (see Figure 5-1, presented in Section 5.2), which are all incompatible in RCZ-I. No incompatible land uses of residential, commercial, institutional, or public assembly facilities are currently located within RCZ-I (Table 5-5; Figure 5-1).

The RCZ-II footprint encompasses 141,311 acres of land in Marion County, of which 124,209 acres are associated with Pinecastle Range and 50,396 acres are associated with Lake George Range. The RCZ-II footprint from Pinecastle Range and Lake George Range overlap one another by 33,294 acres in Marion County. Land use types in the RCZ-II footprint include Agricultural/Cropland, Forest, and Wetlands (see Figures 5-1 and 5-3, presented in Section 5.2), which are mostly compatible except when under restricted airspace that allows for flight below 500 feet. The RCZ-II includes Residential, Industrial, Institutional, and Commercial/Services uses, which are recommended incompatible (Figures 5-1 and 5-3). Approximately 32 acres of land in RCZ-II are classified as Institutional where uses such as educational, religious, health, and non-military governmental occur and create incompatibility. High Density Residential covers 1,043 acres in RCZ-II, which allows for density over two dwelling units per acre. Low Density Residential covers 1,253 acres and allows density of less than two dwelling units per acre. Within RCZ-II, both of these land use designations result in incompatibility.

RCZ-III encompasses 136,224 acres of land in Marion County. Existing land uses in the RCZ-III footprint include Agricultural/Cropland, Forest, Shrub/Brushland, and Wetlands (see Figures 5-1, 5-3, and 5-5, presented in Section 5.2). RCZ-III encompasses all types of the land use categories shown in Table 5-5. Navy RAICUZ Program recommendations show that some of these land use types can vary in compatibility (see Appendix B). High and Low Residential types are present in RCZ-III. High Density Residential creates incompatibility, while Low Density Residential is compatible.

In RCZ-III, Recreational land uses (145 acres) can include golf courses, parks, swimming beaches and shores, marinas, and fairgrounds. Forest (67,297 acres) and Agricultural/Cropland (29,029) is generally compatible in RCZ-III but may be recommended incompatible. These uses are only incompatible in the areas where low-level flight occurs (Restricted Areas R-2906, R-2907A, R-2010A, R-2910B, and R-2910C). If flight does not occur below 500 feet, then these land uses are compatible (see Figures 5-1, 5-3, and 5-5, presented in Section 5.2).

Institutional uses can include schools, churches, medical uses, and/or non-military governmental uses. These types of land uses are incompatible in RCZ-III (see Appendix B). There are 166.5 acres within RCZ-III that are classified Institutional.

5.4.3.2 Putnam County Land Use Compatibility Analysis

Lake George and Rodman ranges' RCZ-I and RCZ-II footprints occur within Putnam County. Neither range's RCZ-I is outside of its range boundary; therefore, no incompatibilities exist. RCZ-II covers approximately 19,407 acres within Putnam County: 16,466 acres are associated with Lake Gorge Range, while 2,941 acres are associated with Rodman Range.

Similar to Marion County, the predominant land uses that occur in RCZ-II in Putnam County include Agricultural/Cropland, Forest, Water, and Wetlands. These land uses are compatible except in the areas allowing low-level flight. There are 93 acres of High Density Residential and 1,093 acres of Low Density Residential within RCZ-II, both of which are incompatible (see Figures 5-3 and 5-5, presented in Section 5.2).

RCZ-III encompasses 169,334 acres of land in Putnam County. The predominant uses are similar to those located in RCZ-II. High Density Residential encompasses 1,667 acres and is incompatible. There are 207 acres of Institutional land use within RCZ-III, which is also recommended incompatible (Figures 5-3 and 5-5).

5.4.3.3 Volusia County Land Use Compatibility Analysis

Lake George Range's RCZ-I and RCZ-II footprints encompass areas within Volusia County. The RCZ-I footprint does not go outside the range boundary and, therefore, no incompatibilities exist. RCZ-II covers approximately 16,817 acres within Volusia County located off range, which are all associated with Lake George Range. The RCZ-II footprint consists of 16,257 acres classified as Water and 552 acres classified as Wetlands (see Figure 5-3, presented in Section 5.2). The water areas of Lake George are compatible. Lake George offers recreational opportunities, including boating and fishing. While these activities may not involve large gatherings of people or height restrictions, awareness of these recreation activities is important for safety purposes (Figure 5-3).

RCZ-III encompasses 32,124 acres of land in Volusia County. Most of the land within RCZ-III is Water, Wetlands, Agricultural/Cropland, and Forest (Figure 5-3). These uses account for much of the area recommended incompatible due to low-level flight operations being permitted in the Restricted Areas. There are 119 acres of High Density Residential, which are recommended incompatible (Figure 5-3).

5.4.3.4 Lake County Land Use Compatibility Analysis

None of the ranges' RCZ-I footprints are located within Lake County. Pinecastle and Lake George ranges' RCZ-II footprints encompass areas within Lake County. The RCZ-II footprint encompasses 42,240 acres of Lake County, including 322 acres associated with Lake George Range and 41,918 acres associated with Pinecastle Range. Forest, Wetland, and Agricultural/Cropland cover much of the area within RCZ-II (see Figures 5-1 and 5-3, presented in Section 5.2) and these land uses are recommended incompatible due to the potential for low-level flight. There are 1,365 acres of Low Density Residential and 488 acres of High Density Residential land uses within RCZ-II, both of which are recommended incompatible (Figure 5-1 and 5-3).

RCZ-III encompasses 65,805 acres of land that are off range in Lake County. Forested land use covers 23,978 acres of the area within RCZ-III in Lake County (Figures 5-1 and 5-3). Some of the Forested, Agricultural/Cropland, and Wetland areas are recommended incompatible because of the potential for low-level fight, but most of the area is compatible (Figures 5-1 and 5-3). High Density Residential land use covers 587 acres and is incompatible. Residential land uses are mostly concentrated in the areas around Astor Park, Astor, and along SR 40. These areas include Institutional land use, which covers 100 acres within RCZ-III and is recommended incompatible.

5.4.4 Compatibility with Projected FY2020 Noise Contours

The land use within the PRC noise zones are similar to those described for the RCZ footprint in Section 5.4.3. As described previously, the 50 dBA DNL contour in Noise Zone 1 extends to align with the perimeter of the MOA, which is similar to the area of RCZ-III; however, Noise Zone 1 does not include Restricted Area R-2910B/C.

Lake George Range does not have any noise contours within Noise Zones 2 or 3. Pinecastle Range has Noise Zone 3 contours, which are almost entirely within the range boundary. Noise Zone 2 at Pinecastle Range is concentrated around the range area. It encompasses areas both within and outside of the range boundary and is contained within Marion County. Rodman Range has noise contours within Noise Zone 3, which are completely within the range boundary. Noise Zone 2 for Rodman Range surrounds the range boundary, including land both on and off the range. Noise Zone 2 encompasses areas within both Putnam and Marion counties.

In general, most of the land uses within Marion, Putnam, Volusia, and Lake counties that are within the RAICUZ noise zones are compatible (see Figures 5-2, 5-4, and 5-6, presented in Section 5.2). Land uses primarily consist of a mix of Residential,

Shrub/Brushland, Agricultural/Cropland, Wetlands, Forest, and Institutional (Figures 5-2, 5-4, and 5-6). The Agricultural and Institutional land use areas may also contain uses such as churches, low density residential, and schools, which are compatible in Noise Zone 2.

5.4.4.1 Marion County Land Use Compatibility Analysis

Marion County contains areas off range that are located within Noise Zones 1, 2, and 3 (see Figures 5-2, 5-4, and 5-6, presented in Section 5.2). The only Noise Zone 3 footprint within Marion County is associated with Pinecastle Range and is almost entirely within the range boundary. Land uses outside of the range boundary within Noise Zone 3 include mostly Forest. The Noise Zone 2 footprint encompasses 1,419 acres of land in Marion County, which are associated mostly with Pinecastle Range and, to a lesser extent, Rodman Range. Land use types in the Noise Zone 2 footprint for Pinecastle Range include Agricultural/Cropland, Forest, Shrub/Brushland, and Wetlands, which are compatible. Land use types within Noise Zone 2 associated with Rodman Range in Marion County includes mostly Forest and Wetlands, which are compatible. Other land uses include a small amount of Low Density Residential (11 acres), which is recommended incompatible unless a noise level reduction of 25 dB from outside to inside is achieved (Figures 5-2, 5-4, and 5-6). Noise Zone 1 covers approximately 295,500 acres in Marion County and includes most of the land uses discussed, which are mostly Forest, Agricultural/Cropland, and Wetlands, as well as Residential, Institutional, Industrial, Commercial, and Recreational. Table 5-5 provides more detail on specific land uses in Noise Zone 1 for Marion County.

5.4.4.2 Putnam County Land Use Compatibility Analysis

Putnam County contains areas off range that are located within Noise Zones 1 and 2. The only Noise Zone 3 footprint within Putnam County is associated with Rodman Range and is located entirely within the range boundary. The Noise Zone 2 footprint encompasses 3,564 acres of land in Putnam County, which are all associated with Rodman Range. Land use types in the Noise Zone 2 footprint for Rodman Range in Putnam County include Forest, Shrub/Brushland, and Wetlands (see Figure 5-6, presented in Section 5.2), which are all compatible. Noise Zone 2 also contains Agricultural/Cropland areas, which are also compatible (Figure 5-6). Noise Zone 1 covers 184,817 acres in Putnam County. Noise Zone 1 in Putnam County includes most of the land uses discussed, which are mostly Forest, Agricultural/Cropland, Wetlands, as well as Residential, Institutional, Industrial, Commercial, and Recreational (Figure 5-6). Table 5-5 provides more detail on specific land uses in Noise Zone 1 for Putnam County.

5.4.4.3 Volusia County Land Use Compatibility Analysis

Volusia County contains areas off range that are located within Noise Zone 1 only. Noise Zone 1 covers 49,373 acres in Volusia County that are off range. Land use types in the Noise Zone 1 footprint within Volusia County include Wetland, Water, Forest, Shrub/Brushland, Residential, and Agricultural/Cropland (see Figures 5-2 and 5-4, presented in Section 5.2), which are all compatible within Noise Zone 1. Table 5-5 provides more detail on specific land uses in Noise Zone 1 for Volusia County.

5.4.4.4 Lake County Land Use Compatibility Analysis

Lake County contains areas off range that are located within Noise Zone 1 only. Noise Zone 1 covers 73,938 acres in Lake County. Land use types in the Noise Zone 1 footprint in Lake County include Wetland, Forest, Shrub/Brushland, Residential, and Agricultural/Cropland with additional areas of Commercial, Institutional, and Industrial (see Figures 5-2 and 5-4, presented in Section 5.2). These land uses are all compatible within Noise Zone 1 (Figures 5-2 and 5-4). Table 5-5 provides more detail on specific land uses in Noise Zone 1 for Lake County.

5.4.5 Future Land Use Compatibility

5.4.5.1 Marion County

Changes from the existing FLUCCS categorization to Marion County's proposed future land use do not significantly alter the compatibility of the areas in Marion County. Changes in land use were identified in an area to the west of the ONF boundary within the RAICUZ footprint and an area around Salt Springs. The existing land use for the area west of the ONF boundary consists of Residential, Shrub/Brushland, Agricultural/Cropland, Wetlands, and Forest. The existing land use in the Salt Springs area is Commercial/Services, Residential (High and Low Density), Shrub/Brushland, Agricultural/Cropland, Wetlands, and Forest.

Future land use designations show both areas as being mostly Rural Land. Rural Land in Marion County's Future Land Use Element is described as primarily intended for agricultural uses, low density residential units on large lots or family divisions, and associated housing related to farms or other agricultural-related commercial and industrial uses. Much of the forested, wetlands, or shrub land from the existing land use analysis are shown to be Preservation in the County's Future Land Use Element (i.e., where additional uses would be limited and result in minimal impacts to the preservation area). The RCZ and noise zone compatibility for Marion County's Future Land Use Element is similar to that shown for existing land use.

5.4.5.2 Putnam County

Changes from the existing land use to Putnam County's proposed future land use do not significantly alter the compatibility in the areas located within the county. The main changes in land use that were identified were located in the land areas near Welaka and Satsuma, which are east of Rodman Range and north of Lake George Range. The existing land uses for these areas are a mix of Residential, Shrub/Brushland, Agricultural/Cropland, Wetlands, and Forest.

Future land use designations for the area include Agriculture II, which is primarily intended for low density residential and agricultural uses. Therefore, the RCZ and noise zone compatibility for Putnam County's Future Land Use Element is similar to that shown for the existing land use.

5.4.5.3 Volusia County

Changes from the existing land use to Volusia County's Future Land Use did not significantly change the compatibility in the areas located within the county. Most of the identified changes in existing land use were located in the areas east of Lake George. The existing land in this area consists of uses such as Residential, Shrub/Brushland, Agricultural/Cropland, Wetlands, and Forest.

Much of the forest, wetlands, or shrub land from the existing land use analysis are shown to be Conservation in Volusia County's Future Land Use Element (i.e., described as maintaining the preservation and protection of Volusia County's natural resources). Therefore, the RCZ and noise zone compatibility for the Future Land Use Element is similar to that shown for the existing land use.

5.4.5.4 Lake County

Changes from the existing land use to Lake County's Future Land Use Element did not significantly alter the compatibility for the area located within Lake County. The existing land use for the northern tip of Lake County showed Shrub/Brushland, Agricultural/Cropland, Wetlands, and Forest. Additionally, the existing land use areas surrounding Astor Park are Shrub/Brushland, Agricultural/Cropland, Wetlands, and Forest as well as Residential, Commercial, and Mining.

Lake County's Future Land Use Element in the northern tip of Lake County and the area surrounding Astor Park consists of a mostly Rural designation. The County Future Land Use Element describes Rural as low density residential, agricultural operations, civic uses compatible with a rural community, and rural support functions, where appropriate. The RCZ

and noise zone compatibility for Lake County's Future Land Use Element does not significantly change from the existing land use compatibility.

5.5 Other Compatibility Concerns to Range Operations

5.5.1 Public Safety

Public safety concerns are created when unauthorized persons access the range during training activities or before cleanup of hazardous materials can occur. In addition to current air-to-ground and ground-to-ground ordnance and munitions, explosives and pyrotechnic devices used during explosive ordnance disposal training and other hazardous materials being used during training may be present on the range. Additionally, there are safety hazards associated with the historic use of the ranges and the materials that may be buried or otherwise obscured. In accordance with the Navy's "*Operational Range Clearance Policy for Navy Ranges*" (OPNAVINST 3571.4), the Navy regularly performs cleanup to remove ordnance, target debris, and other hazards. Historic munitions are generally uncovered during these activities; therefore, unauthorized range access can lead to elevated safety concerns.

More recent mission developments have led to the use of laser-based weapons. The ocular hazard of most military grade lasers can be severe. Unauthorized range access during laser training or testing activities creates significant public safety concerns. Although standard operating procedures are implemented to protect the public from operational hazards related to laser spotting and all laser use areas undergo a command review to ensure the safety of the public, these measures do not consider unauthorized persons being inside the range boundary.

Warning signs are posted nearly every tenth of a mile along the PRC perimeter and other designated roads. Marked gates along the access roads are equipped with video surveillance to further secure the area. The Florida Fish and Wildlife Commission notes that the PRC is closed to the public in their hunting/ recreational brochures. Additionally, a safety zone closure order was developed in coordination with the USFS and is intended to gate off the areas near Pinecastle Range to prevent incursion from the public during training events. When training events do occur, a Major Training Exercise closure area is coordinated with the USFS, U.S. Fleet Forces, and the range, and the public is notified of the closure area and duration. Traditionally, the Navy posted road guards to notify the public of training events

requiring a safety zone buffer near the Pinecastle Range. Recently, the PRC and Navy worked with the USFS to install additional gates on USFS roads to be closed when the safety zone is activated in a joint effort to enhance public safety.

5.5.2 Range Trespassing

Hunters and the general public trespassing on PRC property has been an issue in the past. Unauthorized range access by civilians creates risks to public safety at the PRC. Recreational use near the PRC can often occur, due to its location within and around ONF and other natural attractions. Public access is controlled, both for security reasons and to safeguard against potential hazards associated with military activities. Public access control is conducted through the use of road guards, gates, and posted signs.

5.5.3 Aircraft Operations in the Vicinity of the PRC

As discussed in Section 5.3, the counties around the PRC each contain public and private airports. In the vicinity of the PRC, public airports include those open to public flight, as well as helipads, helidecks, and seaplane ports and bases. Municipalities within the PRC do not have a uniform process or standard for managing the development of airstrips and airparks.

Each county within the PRC has zoning and land use provisions for private airstrip and aircraft facilities. For example, Putnam County allows the use of airstrips used for crop dusting under Agricultural zoning designations. Special use permits must be obtained in order to have aircraft landing facilities or private airstrips under the Agricultural zoning designation or other land use classifications. Marion County's planning goals, objectives, and policies seek to promote the development of general public and private aviation facilities by limiting and restricting nearby incompatible land uses and activities. Lake County allows for private airstrip development use under several land use designations, if a conditional use permit is obtained. Lake County restrictions on aviation facilities include runway length and pavement specifications, and restrictions pertaining to the number of aircraft based at a facility.

5.5.4 Recreational and Urban Development

The area surrounding the PRC is sparsely populated and largely undeveloped, with large amounts of land dedicated to Forest, Wetlands, and Agricultural/Cropland use. An increase in civilian uses near the PRC could lead to circumstances that require the Navy to modify its operations, adversely affecting training and readiness activities. Despite the large buffer provided by ONF, increased recreational activities within this area could give rise to community concerns or complaints about noise associated with the PRC mission. As more

people are drawn to ONF for recreation, the larger public presence may increase risks to security and public safety and, if not carefully coordinated and managed, it may increase the risks associated with training at the PRC, create additional avoidance areas, or result in training disruptions and reduced usage days.

The compatibility of future development should be considered during the planning and permitting process to avoid compatibility concerns between urban development and military operations. The Navy has developed guidelines for compatible development and land use within a range's noise zones and RCZs. These land use guidelines are provided in OPNAVINST 3550.1A (Appendix B).

5.5.5 Fire Management

Wildfires and controlled burns can impact the Navy's ability to use airspace for training, and smoke and flames can reduce pilot visibility, damage Navy targets, and necessitate the cancellation of training. Occasionally, the USFS denies a Burn/Drought Index Waiver Notification, if the conditions exceed the established limits; however, the USFS works with the Navy to ensure that planned training is not adversely impacted. The USFS conducts controlled burns in accordance with the USFS Land Resource Management Plan. The controlled burns are coordinated with the PRC personnel.

6 LAND USE TOOLS AND RECOMMENDATIONS

The goal of the RAICUZ Program—to protect the public health, safety, and welfare of those living near air-to-ground training ranges while preserving military operational capabilities—can most effectively be accomplished by the active participation of interested parties. Federal, state, and local governments, businesses, real estate professionals, and citizens, along with the Navy, all play important roles in the successful implementation of the RAICUZ land use compatibility study. To effectively accomplish the goal of the RAICUZ Program, all involved parties must have active participation.

The following sections provide specific recommendations for PRC personnel, as well as federal, regional, and local governments and agencies, businesses, and private citizens, to meet the goals of the RAICUZ Program. These RAICUZ Study recommendations, when implemented, will continue to advance the RAICUZ Program goal.

6.1 FEDERAL/NAVY TOOLS AND RECOMMENDATIONS

The Navy has the responsibility to communicate and collaborate with local governments on land use planning, zoning, and compatibility concerns that can impact its mission. Mutual cooperation between the PRC and their neighboring communities is key to the RAICUZ Program's success.

As discussed in Section 2.1, the FACSFACJAX Commanding Officer is responsible for the operational and administrative functions of the PRC. With the assistance of the NAS Jacksonville Community Planning and Liaison Officer (CPLO), PRC Range Complex Director, and other range personnel, pursuant to OPNAVINST 3550.1A, the Commanding Officer is committed to and shall:

- Implement a RAICUZ Program for the PRC;
- Work with state and local planning officials to implement the objectives of the RAICUZ Study;
- Provide assistance in developing RAICUZ information, including operational data needed to update the RAICUZ Study;
- Work with local decision makers in the surrounding communities to evaluate and justify the retention of land or interest in land required for operational performance; and,
- Notify the chain-of-command in the RAICUZ Program office when local conditions merit update or review of the RAICUZ Study.

As a result of this RAICUZ Study, the Navy will:

- Communicate the results of the RAICUZ Study with planning commissions for each county; and
- Continue to engage with planners in the surrounding counties about development and impact concerns.

6.1.1 Federal/Navy Land Use Compatibility Tools

6.1.1.1 Federal

Environmental Review

Fundamentals of the RAICUZ Study can be incorporated into the environmental review process for future federal projects.

The environmental review process is a viable means for incorporating the fundamentals and findings of this RAICUZ Study into the planning review and impact analysis process of future projects. Under the National Environmental Policy Act (NEPA), the Navy is required to consider the environmental impacts of any project that could significantly impact the environment by conducting a comprehensive environmental review of impacts of the proposed action. Applicable guidance supporting environmental review is provided in the following sections.

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 Navy to introduce RAICUZ concepts and discuss RAICUZ issues.

Encroachment partnering is a cooperative, multi-party, real estate-based program used to mitigate the impacts of off-base land uses that are potentially incompatible with military operations. It implies that the DOD and its partner(s) are both willing and able to contribute to the cost and effort of acquiring land interests.

Housing and Urban Development Circular 1390.2: Noise Abatement and Control

The U.S. Department 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. The approval of 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 allow for new housing construction assisted or supported by HUD to be located within a noise zone of 65 dBA DNL or less. Construction within a 65 to 75 dBA DNL noise zone is subject to appropriate sound attenuation measures, and construction within an area exceeding 75 dBA DNL is not acceptable.

6.1.1.2 Navy

OPNAVINST 3550.1A/MCO 3550.11, RAICUZ Program

The Navy began the RAICUZ Program to help government entities and communities anticipate, identify, and promote compatible land use and development near military training ranges and installations. The purpose of the RAICUZ Program is to achieve compatibility between air installations and neighboring communities. To satisfy the purpose of the RAICUZ Program, the military installation must work with the local community to encourage compatible development of lands adjacent to the installation. The Navy has established guidelines that define high-noise zones and RCZs at the PRC.

DOD Encroachment Partnering Program

Encroachment partnering is one of several tools available to the Navy and Marine Corps to prevent or mitigate encroachment problems. Encroachment partnering is a cooperative, multi-party, real estate-based program authorized by Congress under 10 U.S.C. §2684a (as amended), to help mitigate the impacts of potential off-installation land uses that would be incompatible with military operations or to preserve habitat within off-installation property. The program is based on the military "partnering" with an eligible entity to acquire easements or other interests in land in the vicinity of the military installation to prevent incompatible land uses and activities or loss of habitat. The program involves sharing easement costs with the partners for property owned by willing sellers. Use of condemnation authority is not permitted under the encroachment partnering program. Annual funding is provided by the DOD through the Readiness and Environmental Protection Integration (REPI) Program and by Navy and Marine Corps appropriations for planning and encroachment management as programmed by the Chief of Naval Operations and Commandant of the Marine Corps.

The REPI Program is a tool for ensuring the sustainability of the military's training, testing, and operational capabilities through cooperative land use planning and integrated land protection around installations and ranges. REPI partnerships are only one example of the suite of DOD tools that have evolved to prevent and avoid restrictions on military operations. REPI partnerships benefit DOD installations and the surrounding communities within which they are located by contributing to the maintenance of open space, protecting against mission relocations that can affect local economies, and protecting against the need for reactive spending associated with new range construction when restrictions constrain the regular use of testing, training, and operating lands.

Encroachment partnering agreements provide for an eligible entity, such as an environmental or conservation group, to acquire a fee simple title in land for 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 a conservation or other restrictive easement for such property. The eligible entity is responsible for negotiating and acquiring the real estate interest for encroachment partnering projects with a voluntary seller. The eligible entity must transfer the agreed-on restrictive easement interest to the United States of America at the request of the Secretary of Defense.

Land Acquisition

The Navy may seek to acquire interest in properties (acquisition) to protect its mission and prevent or manage incompatible land use in the vicinity of air-to-ground or ground-to-ground ranges. When possible, the Navy seeks to acquire property through negotiation and voluntary agreements with landowners.

If the readiness sustainment of a military range is threatened from incompatible development, and the local community cannot resolve the threat, the Navy can obtain the land through purchase, voluntary agreement, or condemnation.

DOD Siting Clearinghouse

The Secretary of Defense established the DOD Siting Clearinghouse in 2010 to address compatibility concerns between military missions and energy development proposals. Proposed wind farm sites are processed through the FAA's Obstruction Evaluation/Airport Airspace Analysis, and the FAA provides notification to the DOD for input.

The FAA's Obstruction Evaluation/Airport Airspace Analysis website outlines filing procedures and notification requirements prior to construction or alterations that may impact air navigation. The website provides access to application forms (Form 7460-1, Notice of Proposed Construction or Alteration), notification criteria, proposed cases, and determination of Notice of Presumed Hazard cases. The website also includes a DOD Preliminary Screening Tool that allows developers to map long-range and weather radars, MTRs, and SUA relative to the proposed location of their development to preview potential areas of impact to military operations. Military installations can also use this site to monitor local notices of proposed developments that may obstruct flight courses.

Through the Clearinghouse process, the DOD and the Navy formally review all tall structures, including renewable energy and wind energy projects, filed with the FAA for potential adverse impacts to operations. Only the Secretary of Defense or his/her deputy can officially object to a project after a full consideration of potential mitigation.

Florida Community Planning Act of 2011

Under the Florida Community Planning Act of 2011, there are sections (e.g., Chapter 163, Part II, §§163.3175 and 163.3177) relating to military affairs and promoting the compatibility of land uses adjacent to or in proximity of military installations. These statutes require counties and municipalities where a military installation is located to send information that is necessary for determining potential land use compatibility issues directly to the installation Commanding Officer, including those issues involving local or other non-military jurisdictions that affect the installation.

6.1.2 Federal/Navy Action Recommendations

6.1.2.1 Engage in the Local Planning Process

The FACSFACJAX Commanding Officer has cognizance for the PRC and its associated SUA. As such, the FACSFACJAX Commanding Officer has appointed the NAS Jacksonville CPLO/PRC Range Complex Director as the primary point of contact for maintaining routine communication with the governments for Marion, Putnam, Volusia, and Lake counties. Routine communication will help the Navy stay informed of local land use plans and regulations and ensure the Navy's input is offered in the early stages of any long-range planning initiatives.

The installation CPLO/PRC Range Complex Director, in coordination with other Navy and range personnel, should continue to attend public hearings and provide comments on actions that affect RAICUZ planning, including land use studies, transportation plans, and other land development regulation updates/amendments. The Navy will advise counties of future operations and offer guidance on identifying areas of potential incompatibilities.

6.1.2.2 Community Outreach

Outreach and information sharing helps educate the community about the Navy's mission and build alliances with the community and regional decision makers to ensure continuation of mission-essential operations. Additionally, the PRC should continue to provide community decision makers with the information necessary to make informed decisions regarding the impacts of their actions on mission readiness. Through outreach efforts, the Navy educates the public on the importance of the PRC's training operations and the ability of the range to support military activities to sustain a combat-ready Navy.

6.1.2.3 Presentation of the RAICUZ Study and Educational Materials

To encourage community interaction and to facilitate a better understanding of the Navy's scope of operations, the installation CPLO/PRC Range Complex Director should develop a package of RAICUZ outreach materials, including community presentations and educational brochures, on training activities and the Navy's mission. Specifically, the Navy should create brochures for a civilian audience, including the recreational hunting, boating, and fishing community, local governments, and real estate brokers, with appropriate verbiage and maps to explain the basic elements of the RAICUZ Program and how incompatible development within the RAICUZ footprint can impact range operations and the public. The brochures should detail the significance of RCZs and noise zones to inform civilians.

The Navy should prepare a presentation outlining elements of the RAICUZ Program for federal and state partners, community decision makers, including the Board of County Commissioners, Florida Realtor Associations, and local civic organizations. The RAICUZ Program presentation should also discuss how land uses and local policies (e.g., infrastructure siting, schools, rezoning) can influence Navy operations.

The Navy, including FACSFACJAX and/or NAS Jacksonville should post the 2017 RAICUZ Study, presentation and distribution materials, including RAICUZ poster boards, maps of the range, fact sheets, and other related educational materials, on their public website(s).

6.1.2.4 Real Estate Disclosure

FACSFACJAX will provide local government with RAICUZ-related materials and maps showing MTRs, MOAs, Restricted Areas, WDZs, SDZs, and RCZs. A FACSFACJAX representative should meet with the local government to discuss the importance of real estate disclosure when buying or selling property within or near the RAICUZ footprint.

6.1.2.5 Noise Complaint Monitoring and Response Program

FACSFACJAX/NAS Jacksonville and the PRC have a formalized noise and airspace complaint program. FACSFACJAX/NAS Jacksonville provides a dedicated noise complaint hotline (1-800-874-5059) for citizens who want to register a complaint. The messages are reviewed each day to provide an opportunity for a Navy official to follow-up with a phone call to the person placing the complaint if sufficient call return information is provided in the message. The incidents are investigated as to the nature of the offensive noise event.

FACSFACJAX/NAS Jacksonville and range personnel will continue to record and assess noise complaints. Assessing noise complaints identifies noise-sensitive areas, determines which operational activities are responsible for the noise complaints, and ultimately helps abate future noise complaints. Through the noise complaint program, PRC personnel can evaluate flight procedures to reduce noise impacts on the surrounding communities.

6.1.2.6 Wildland Fire Management

NAS Jacksonville and PRC personnel should continue their coordination with the USFS as they conduct controlled burns. The projected (FY2020) increases in training at the PRC could increase the risk of wildfire. Controlled burns help to reduce the chances of wildfires, which can threaten facilities and mission capabilities.

6.1.2.7 Increase Public Safety by Restricting Civilian Access

PRC personnel currently exercise several deterrents to reduce the number of unauthorized individuals accessing the training areas during live-fire exercises. These include signs, fencing, and sweeps of training areas prior to conducting exercises. In addition, watchmen are used during live-fire training. Signs are posted; however, as discussed in Section 5.5.1, there is limited boundary fencing or gates in certain areas. Civilian access onto the range is a significant public safety concern.

Pinecastle Range Sign

A safety zone closure order was developed in coordination with the USFS and is intended to gate off the areas near Pinecastle Range to prevent incursion from the public during training events. When training events do occur, a Major Training Exercise closure area is coordinated with the USFS, U.S. Fleet Forces, and the range, and the public is notified of the closure's area and duration. Traditionally, the Navy posted road guards to notify the public of training events requiring a safety zone buffer near Pinecastle Range. To enhance public safety, the PRC and Navy, in cooperation with the USFS, recently installed 33 additional gates on USFS roads that are closed when the safety zone is activated.


Road Guard

Pinecastle Range Gate

While these measures help, there is still more to be done to increase public safety, restrict access, and reduce trespassing. The USFS ONF Ranger and the PRC should continue to discuss which roads are planned to be closed. The Navy currently has plans to upgrade areas at Pinecastle Range to include security perimeter fencing and lockable roller gates. Per the Navy's special use permit with the USFS, the USFS regulates the construction, renovation, and alteration of range infrastructure on land covered by the permit. Continued coordination with the USFS will provide the PRC with more information about current range security issues and the prevalence of trespassing, as well as inform necessary actions to reduce the risks.

6.2 STATE/REGIONAL TOOLS AND RECOMMENDATIONS

Florida State regulations and programs that provide land use controls and manage growth around the PRC can be used to direct development within the RAICUZ footprint. Also, regional planning agencies can help control incompatible growth by aiding and influencing local governments in the development of policies, plans, and regulations necessary for the physical and economic expansion of the region.

6.2.1 State/Regional Land Use Compatibility Tools

6.2.1.1 Community Planning Act of 2011

The Florida Department of Economic Opportunity is the main agency responsible for oversight of the planning framework and growth management laws of Florida. The State of Florida institutes the State Comprehensive Plan that provides a framework for planning activities and guidance for the social, economic, and physical growth of the state. The State Comprehensive Plan is updated biennially by the Florida State Legislature. Additionally, Florida's Growth Management Act (Chapter 163, Part II, Local Government Planning and Land Development Regulation Act) was re-designated as the Community Planning Act in 2011. Under the Community Planning Act (Chapter 163.3161, Florida Statutes [F.S.]), each city and county must adopt a Comprehensive Plan to guide future development, address issues associated with the use and development of land, promote public health and safety, and protect human, environmental, social, and economic resources. Development approval must be legally consistent with the Comprehensive Plan. The Community Planning Act also calls for an Evaluation and Appraisal Review (Chapter 163.3191, F.S.) where, at least every seven years, each local government must evaluate its Comprehensive Plan to determine if amendments or updates are needed in accordance with any State requirements since the last Comprehensive Plan update took place. After this evaluation, local governments submit Evaluation and Appraisal Review-related amendments to the Department of Economic Opportunity reflecting the necessary changes (FDEP 2014).

Under the Community Planning Act, there are sections (e.g., Chapter 163, Part II, §§163.3175 and 163.3177) relating to military affairs and promoting the compatibility of land uses adjacent to or in proximity of military installations. These statutes require counties and municipalities where a military installation is located to send information that is necessary for determining potential land use compatibility issues directly to the installation Commanding Officer, including those issues involving local or other non-military jurisdictions that affect the installation.

6.2.1.2 Regional Planning Councils

The Florida Regional Councils Association is the statewide organization consisting of the ten regional planning councils. The Florida Regional Councils Association collaborates with governments and the business community to work towards enhancing the regional economy and ensuring consistency and quality of regional planning council programs. Each of the ten regional planning councils are required to develop a Strategic Regional Policy Plan that is consistent with the State Comprehensive Plan and that provides guidance to local governments. The four counties associated with the RAICUZ footprint are associated with three of the ten regional planning councils. Marion County, formerly part of the Withlacoochee Regional Planning Council, is now part of the North Central Florida Regional Planning Council; Putnam County is associated with the Northeast Florida Regional Planning Council; and Volusia and Lake counties are part of the East Central Regional Planning Council (Florida Regional Councils Association 2017). These regional planning councils are designed to be associations of local governments that can improve intergovernmental coordination and technical capacity at a regional level. These regional planning councils typically hold meetings on a monthly or as-needed basis.

6.2.1.3 Florida Defense Support Task Force

The Florida Defense Support Task Force is a legislatively mandated council (created by F.S. 288.987) whose mission is to preserve, protect, and enhance Florida's military missions and installations. Florida Defense Support Task Force's main responsibilities include: working with Florida's installation Commanders to protect mission capabilities for military forces based in Florida by encouraging compatible land use; maintaining and expanding the missions of Florida military installations; and improving transportation access to Florida's military installations.

6.2.2 State/Regional Action Recommendations

6.2.2.1 Continue Implementing Legislation

The State of Florida should continue implementing Senate Bill 1604 (Chapter 2004-230, Florida Laws Senate Bill 2004-1604, created s.163.3175, F.S.) relating to military affairs and promoting compatibility of lands adjacent to or in proximity to military installations.

6.2.2.2 Coordinate with Local Government to Update Land Use Guidelines

Regional planning agencies should coordinate with their local government members to update comprehensive/master plans, zoning ordinances, subdivision regulations, land development codes, building codes, and any other applicable land use regulations to reflect the RAICUZ footprint.

Regional planning agencies should encourage local governments to strengthen and modify their guidelines on land uses and activities within RCZs and noise zones and ensure compatibility with the recommendations of Navy land use compatibility guidelines presented in Chapter 5, Tables 5-4 and 5-5.

6.3 LOCAL GOVERNMENT TOOLS AND RECOMMENDATIONS

Local governments have the authority to implement regulations and programs to control development and direct growth to ensure land use activity is compatible with range operations. Local governments should recognize their responsibility in providing land use control in areas encumbered by the RAICUZ footprint by incorporating RAICUZ information into their planning policies and regulations.

6.3.1 Local Government Land Use Compatibility Tools

6.3.1.1 Local Government Planning

Comprehensive plans can be adopted 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. Components of a Comprehensive Plan may include future land use, annexation, transportation, infrastructure, conservation, recreation and open space, and capital improvements. Comprehensive plans can also influence the capital budget and funding of capital improvement plans.

While Comprehensive plans provide guidance for future land uses and development, these plans do not constitute zoning regulations or establish zoning district boundaries. In addition to creating and maintaining Comprehensive plans, counties are responsible for maintaining the zoning and internal consistency of Land Development Regulations with the goals, objectives, and policies of the Comprehensive Plan. Each county within the RAICUZ footprint has specific goals and regulations related to the military, which are further described in the following subsections.

Zoning is the legal tool to implement a municipality's land use plan. Zoning regulates land use, density, and height of structures, and can prohibit the creation of other hazards.

Marion County

Marion County incorporated recommendations consistent with the Navy's RAICUZ Program in the development of its Military Operations Area Overlay, which is included in its Comprehensive Plan as part of the Future Land Use Element and Intergovernmental Coordination. The Military Operations Area Overlay is a method to advise property owners, residents, and visitors of the potential to experience effects from identified military installations, which are the basis for the overall overlay and specific sub-areas subject to specialized development regulations intended to limit and/or manage incompatible development.

Policy 7.5.2 of the Future Land Use Element guides Marion County to seek comments from the appropriate DOD or Navy officials for any proposed changes to the Comprehensive Plan, zoning, land development codes, building permits, and other requests that may adversely impact military facilities and operations. This allows developers to address any issues that may arise that adversely impact the operations of military installations within Marion County. The County's Planning and Zoning Commission and the Land Development Regulation Commission includes DOD/Navy representatives, as ex officio members, who advise the Commission regarding land use and zoning with the potential to impact military facilities and operations.

Under the Intergovernmental Coordination policies, Marion County is required to coordinate with the appropriate DOD/Navy officials regarding development applications within the Military Operations Area Overlay to ensure the current and long-term viability of military installations consistent with applicable state and federal requirements (Marion County 2014b).

Putnam County

Land use decisions and code enforcement in Putnam County are carried out by Planning and Development Services. According to the Putnam County Land Development Code, the Development Review Committee and the Planning Commission, both of which have a non-voting ex officio representative from FACSFACJAX, conduct implementation of the Putnam County Comprehensive Plan. The installation CPLO serves as the primary ex officio representative.

Volusia County

The Future Land Use Element of the Volusia County Comprehensive Plan identifies a notification zone, the Jacksonville Bombing Range Complex Military Zone, which is designed to encourage the long-term viability of the military mission at the Pinecastle and Lake George ranges, and seeks to prevent encroachment that may degrade the training and readiness activities of the Navy. The Future Land Use Element delineates the areas for which Volusia County will notify and coordinate with the military, if there are any proposed changes to land use or development, including the proposal of a structure more than 200 feet tall, thereby granting the Navy an opportunity to comment on the proposal. The military notification area, the Jacksonville Bombing Range Complex Military Zone, includes Palatka 1 MOA, MTR 1009, Pinecastle Range RCZs, and Lake George Range and associated Restricted Airspace (R-2907A and R-2907B). Note that neither the Palatka 2 MOA nor R-2910 is referenced in the Future Land Use Element (Volusia County 2016).

The Future Land Use Element also states that the County Development Review Committee and the Planning and Development Review Committee will include, as ex officio non-voting members, designated Navy representatives to advise on land use issues with the potential to affect military facilities or operations. The PRC CPLO serves as the primary ex officio representative.

Lake County

The Lake County Planning and Zoning Board has eight members, including one ex officio, non-voting representative of military installations within Lake County. The PRC Director serves as the primary ex officio representative.

Lake County incorporated an overlay district associated with Pinecastle Range as an objective in its current Comprehensive Plan, adopted in September 2011. The objective states that the PRC MOA is the SUA (designated by the FAA) that is used by the U.S. military for training and exercises over northern Lake County. Towers and antennas within the PRC MOA are limited by location, height, and potential effects on military operations. The County is

required to coordinate with the Navy when towers or antennas within the MOA are proposed. The Comprehensive Plan also states that Lake County shall protect the mission and the long-term viability of the installation through the management of underlying future land uses.

6.3.1.2 Purchase of Development Rights

Local governments (or a land trust) can establish purchase of development rights programs to manage growth and to preserve open space. A local government or agency compensates landowners for leaving their land compatible—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, hunting). The local government may consider purchase of development rights for agricultural land within the RAICUZ footprint.

6.3.1.3 Building Codes

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

6.3.1.4 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, thereby reducing frustration and criticism by those who were not adequately informed prior to the purchase of properties within affected areas.

6.3.1.5 Land Acquisition Programs

Local governments can establish land acquisition programs to support the RAICUZ Program. Land acquisition programs are designed to eliminate 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 military ranges while protecting the environment, maintaining agricultural lands, and conserving open spaces. Local governments can partner with the Navy to identify areas of conservation interest and determining protection priorities around air-to-ground and ground-to-ground ranges.

To avoid land use incompatibilities near ranges, land can be acquired through voluntary real estate transactions.

6.3.1.6 Airspace Safety Coordination

As discussed in Chapter 5.4.3, there are aviation assets near the PRC that are located within Restricted Areas, MTRs, and the MOA. Potential competition for airspace by recreational flyers and/or crop-dusters exists in the communities surrounding the PRC. The surrounding counties allow for various aviation activities under conditional permits or special use permits; however, municipalities within the PRC do not have a uniform process or standard for managing the development of airstrips and airparks. As new uses or changes to existing facilities with aviation components arise, local governments should seek Navy input in order to manage or prevent further compatibility concerns.

6.3.2 Local Government Action Recommendations

6.3.2.1 Communication and Planning Partnerships with the Range

- FACSFACJAX is responsible for informing and educating community decision makers about the RAICUZ Program; however, local governments should continue to actively inform and request input from FACSFACJAX and the PRC regarding land use decisions that could impact the readiness of the PRC. Before local governments make land use decisions for areas near a military installation and the RAICUZ footprint, they should consider the following:

- Their decisions may decrease the mission capabilities of the range, thereby increasing the chances of the local commands having to relocate resources to ensure training is completed;
- Noise contours and RCZs comprising the RAICUZ footprint are dynamic and may change over time; and

- A proactive approach to planning with the range will serve the local population by mitigating, in advance, potential problems with noise and safety concerns.

The Navy recommends that local government websites include information about the RAICUZ Program and provide a link to the FACSFACJAX/NAS Jacksonville website for information regarding range operations. Local governments are recommended to coordinate with FACSFACJAX on aircraft operations at the public airports that surround the PRC and work to ensure the safety of all parties.

6.3.2.2 Land Use Plans and Regulations

In accordance with State of Florida laws pertaining to planning in Marion, Putnam, Volusia, and Lake counties, each have a Comprehensive Plan that local planning agencies use as guidance for development patterns and other land use issues that are important to each county. The local planning authorities are encouraged to adopt and implement all or parts of this RAICUZ Study, including amending their Comprehensive Plan and zoning ordinances to be consistent with the RAICUZ composite map and recommended land uses. The RAICUZ Study is a range's defining statement regarding potential land use incompatibilities. The RAICUZ Study is intended to support local government land use planning programs and processes by providing scientifically based technical information on military activities. Local governments should, to the extent possible, use the land use recommendations in the RAICUZ Instructions to mitigate noise impacts, range safety, height obstructions, and incompatible development within RAICUZ footprint.

6.3.2.3 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 range or under any of the flight operations areas. A comprehensive zoning map amendment designed to prevent encroachment can be one of the most effective tools available to local governments to synchronize the plan's land use recommendations with the zoning code and official zoning map.

6.3.2.4 Local Development Review

Marion, Putnam, Volusia, and Lake counties' planning authorities should continue to invite FACSFACJAX and representatives of the PRC 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.

6.3.2.5 Building Codes

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

6.3.2.6 Real Estate Disclosures

Marion, Putnam, Volusia, and Lake counties may consider establishing a real estate disclosure area around the PRC to require property owners and real estate professionals to provide written disclosures to prospective purchasers, renters, or lessees when a property is located within an RCZ or high-noise zone.

6.4 Private Citizens/Real Estate Professionals/ Businesses Tools and Recommendations

Private citizens and businesses should recognize their responsibility in adhering to and complying with land use controls in those areas encumbered by the RAICUZ footprint. The sections below provide actions, procedures, and recommendations that private groups can use or consider to help control development within the RAICUZ footprint.

6.4.1 Private Citizen/Real Estate Professionals/Businesses Land Use Compatibility Tools

6.4.1.1 Business Development and Construction Loans to Private Contractors

Lending institutions should consider whether to limit financing for real estate purchases or construction that is incompatible with the RAICUZ Study. This strategy encourages evaluation of noise and safety 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 the PRC 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 states and/or local governments could designate restricted areas around the PRC.

6.4.1.2 Real Estate Professionals

Real estate professionals have the ability to ensure prospective buyers or lessees are fully aware of what it means to be within a high-noise zone and/or RCZ. Real estate professionals have the ability and should be required to show prospective buyers and lessees the property at a time when noise exposure is expected to be at its worst.

6.4.1.3 Private Citizens

Private citizens can utilize resources, such as this RAICUZ Study and additional outreach materials, to stay informed of the PRC's mission footprint and training activities. Additionally, private citizens can access press releases that are prepared in anticipation of training events that may result in noise complaints by checking local media or emailing nasjaxpao@navy.mil to request notifications of major training events.

6.4.2 Private Citizen/Real Estate Professionals/Businesses Action Recommendations

6.4.2.1 Business Development and Construction Loans to Private Contractors

FACSFACJAX and PRC representatives should provide RAICUZ Program seminars to lending institutions throughout the region. Increased knowledge of the RAICUZ Program can encourage lenders to evaluate noise and safety considerations during their due diligence review and may prevent funding approval of incompatible projects.

6.4.2.2 Real Estate Professionals

Real estate professionals should continue to ensure that prospective buyers or lessees have all available information concerning the noise environment and range compatibly zones surrounding air-to-ground and ground-to-ground ranges 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. Appendix E includes sample Real Estate Disclosure Forms.

6.4.2.3 Private Citizens

The Navy recommends that citizens of the local communities surrounding the PRC become and continue to stay informed about the RAICUZ 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 RAICUZ Program.

Citizens considering purchasing, renting, or leasing properties near the PRC should ask local real estate professionals and lending institution representatives 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.

6.5 Reference for Implementing Land Use Tools and Recommendations for Areas of Compatibility Concern

The goal of the Navy RAICUZ Program can most effectively be accomplished by the active participation of all interested parties. Federal, state, regional, and local governments, businesses, real estate professionals, and citizens, along with the Navy, all play key roles in successfully implementing the RAICUZ land use compatibility study.

The Navy has the responsibility to communicate and collaborate with local governments on land use planning, zoning, and compatibility concerns that can affect its mission. FACSFACJAX is responsible for informing and educating community decision makers about the RAICUZ Program; however, local governments should continue to actively inform and request input from FACSFACJAX regarding land use decisions that could impact the readiness of the PRC. Local governments have the authority to implement regulations and programs to control development and direct growth to ensure land use activity is compatible with range operations. Local governments should recognize their responsibility in providing land use control in areas encumbered by the RAICUZ footprint by incorporating RAICUZ information into their planning policies and regulations. Mutual cooperation between the PRC and neighboring communities is key to the RAICUZ Program's success.

Table 6-1 provides examples of various areas of compatibility concern related to the PRC as well as several examples of land use tools and recommendations that are available for stakeholders to implement. The table is effective in highlighting examples of compatibility concerns that have been raised throughout the report and provides a suite of cumulative tools and recommendations that can be used to address these concern areas.

Table 6-1 illustrates how tools/recommendations and stakeholders can mitigate areas of compatibility concern. When combined, these tools and recommendations can have compounding effects on minimizing and addressing the concerns.

To use this overview effectively, it is important to first understand the compatibility criteria that were explained in detail in Section 3.2, Range Compatibility Zones, and Section 4.2, Noise Zones. The compatibility criteria, along with the land use compatibility guidelines for the RAICUZ footprint explained in Section 5.4.1, Land Use Compatibility Guidelines and Classifications, provide a basis to then identify the compatibility concerns at the PRC. This chapter provides tools and recommendations for various groups of stakeholders to use to then address the concerns that were identified throughout Chapter 5, Planning Authorities and Land Use Compatibility.

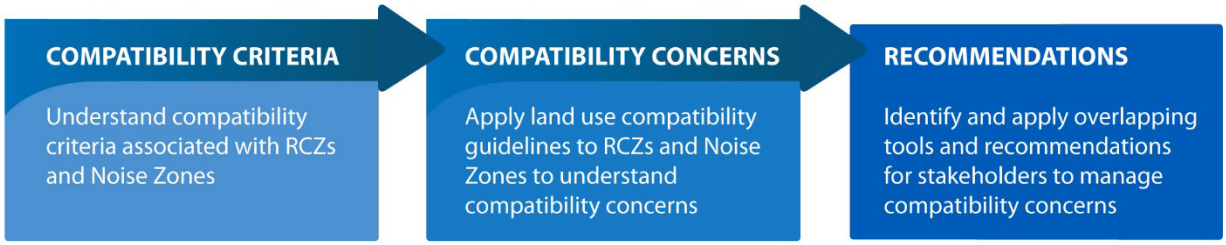

Table 6-1 is not a comprehensive list of compatibility concerns and recommendations but, rather, it is a sample list for reference purposes of the issues and recommendations that could be implemented to address compatibility concerns holistically. Each land use tool and recommendation is linked with multiple or specific areas of compatibility concern and provides a summary of recommended actions and options that could reduce the overall compatibility concerns at the PRC. Minimizing current compatibility concerns and alleviating future concerns involves active participation from several stakeholders often implementing one or more of the recommendations that address a specific area or a broader area of concern. Managing compatibility concerns is an ongoing process that requires monitoring, maintenance, and targeted planning. To support the ongoing implementation process that addresses compatibility concerns, the tools and recommendations listed below can be applied to the 17 county and municipality areas of concern within the RAICUZ footprint. The

numbers listed in the "Land Use Tools and Recommendations" column serve to link the tools and concerns more specifically.

Table 6-1: Overview of Incompatible Land Use and Tools and Recommendations

Area of Compatibility Concern[1]	Land Use Tools and Recommendations	Stakeholder	RAICUZ Section for Additional Information
The counties and municipalities within the RAICUZ footprint – RCZs: ▪ RCZ incompatibility mostly exists with Residential, Commercial, Educational, Religious, and Health Care land uses. ▪ Land uses such as Water, Wetlands, Agricultural/Cropland, and Forest account for much of the area recommended incompatible due to low-level flight operations being permitted in the Restricted Areas. ▪ Most of the land uses within RCZ-II and RCZ-III that are off range consists of Agricultural/Cropland, Forest, Wetlands, and Water. ▪ RCZ-I land area for Pinecastle Range is located outside of the range boundary on land owned by the USDA Forest Service within ONF. ▪ Marion County contains 141,311 acres outside of the range boundaries within RCZ-II, of which 124,209 acres are associated with Pinecastle Range and 50,396 acres are associated with Lake George Range. ▪ The RCZ-II footprint from Pinecastle Range and Lake George Range overlap one another by 33,294 acres in Marion County. ▪ Marion County contains 136,224 acres of land within RCZ-III.	Engage in the local planning process by maintaining routine communication and attending public meetings and providing comments on actions that affect RAICUZ planning. (1-17)	Federal/Navy	Section 6.1.2.1
	Continue community outreach efforts with regional and local decision makers and the public. (1-17)	Federal/Navy	Section 6.1.2.2
	Develop community outreach materials that can be provided to interested parties outlining various elements of the RAICUZ Program. (1-17)	Federal/Navy	Section 6.1.2.3
	Meet with the local governments to discuss the importance of real estate disclosure when buying or selling property within or near the RAICUZ footprint. (1-17)	Federal/Navy	Section 6.1.2.4
	Continue to maintain a noise complaint monitoring and response program. (14, 15, 16, 17)	Federal/Navy	Section 6.1.2.5
	Continue to actively inform and request input from FACSFACJAX regarding land use decisions that could impact the readiness of the PRC. (1-17)	Local Government	Section 6.3.2.1
	Include information about the RAICUZ Program on websites and provide a link to the FACSFACJAX/NAS Jacksonville website for information regarding range operations. (1-17)	Local Government	Section 6.3.2.1

Table 6-1: Overview of Incompatible Land Use and Tools and Recommendations

Area of Compatibility Concern[1]	Land Use Tools and Recommendations	Stakeholder	RAICUZ Section for Additional Information
▪ Putnam County contains 19,407 acres outside of the range boundaries within RCZ-II, of which 16,466 acres are associated with Lake George Range and 2,941 acres are associated with Rodman Range. ▪ Putnam County contains 169,334 acres of land within RCZ-III. ▪ Volusia County contains 16,817 acres within RCZ-II associated with Lake George Range. ▪ Volusia County contains 32,124 acres of land within RCZ-III. ▪ Lake County contains 42,240 acres within RCZ-II, of which 41,918 acres are associated with Pinecastle Range and 322 acres are associated with Lake George Range. ▪ Lake County contains 65,805 acres of land within RCZ-III. <u>Noise Zones</u>: ▪ Marion County contains 295,500 acres within Noise Zone 1, 1,419 acres within Noise Zone 2, and 59 acres within Noise Zone 3. ▪ Putnam County contains 184,817 acres within Noise Zone 1 and 3,564 acres within Noise Zone 2. ▪ Volusia County contains 49,373 acres within Noise Zone 1. ▪ Lake County contains 73,938 acres within Noise Zone 1.	Adopt and implement all or parts of the RAICUZ Study, including amending comprehensive plans and zoning ordinances to be consistent with the recommended land uses in the RAICUZ Study. (1-17)	Local Government	Sections 6.3.2.2 and 6.3.2.3
	Continue to have military representatives 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. (1-17)	Local Government	Section 6.3.2.4
	Monitor and/or amend building codes to require noise attenuation techniques for new construction within the RAICUZ footprint. (14, 15, 16, 17)	Local Government	Section 6.3.2.5
	Marion, Putnam, Lake, and Volusia counties may consider establishing a real estate disclosure area around the PRC to require property owners and real estate professionals to provide written disclosure to prospective buyers and renters when property is located in an RCZ or high-noise zone. (1-17)	Local Government	Section 6.3.2.6
	Evaluate noise and safety considerations during due diligence review of loan applications and prevent funding approval for incompatible projects. (1-17)	Local Businesses	Section 6.4.2.1
	Ensure prospective buyers or lessees have all available information concerning the noise environment and range compatibly zones surrounding the PRC prior to purchasing or leasing property. (1-17)	Real Estate Professionals	Section 6.4.2.2
	Become informed about the RAICUZ Program and how it could affect property owners/renters/lessees. (1-17)	Private Citizens/ Real Estate Professionals/ Businesses	Section 6.4.2.3

Table 6-1: Overview of Incompatible Land Use and Tools and Recommendations

Area of Compatibility Concern[1]	Land Use Tools and Recommendations	Stakeholder	RAICUZ Section for Additional Information
	When purchasing, renting, or leasing properties near the PRC, ask real estate professionals and lending institution representatives if the property is within the RAICUZ footprint. (1-17)	Private Citizens/ Real Estate Professionals/ Businesses	Section 6.4.2.3
	Provide sufficient and accurate information when registering a noise complaint to aid in determining the source of the noise and potential remedies for future actions. (14, 15, 16, 17)	Private Citizens/ Real Estate Professionals/ Businesses	Section 6.4.2.3
Pinecastle, Lake George, and Rodman Ranges and their associated RCZ-Is.	Continue to protect public safety by restricting unauthorized access to the PRC.	Federal/Navy	Section 6.1.2.7
The RAICUZ footprint. Specifically the SUA and MTRs associated with the PRC.	Seek Navy input in order to manage or prevent further compatibility concerns regarding potential competition for airspace in communities surrounding the PRC.	Local Governments	Section 6.3.1.6
The area immediately surrounding Pinecastle and Rodman Ranges within Marion and Putnam Counties.	Continue coordination with the USDA Forest Service as they conduct wildland fire management.	Federal/Navy	Section 6.1.2.6
State of Florida.	Continue implementing Senate Bill 1604, relating to military affairs and promoting compatibility of lands adjacent to or in proximity to military installations.	State/Regional	Section 6.2.2.1
	Coordinate with local governments to update land use guidelines, including comprehensive plans, zoning ordinances, and building codes, to reflect the RAICUZ footprint.	State/Regional	Section 6.2.2.2

Note:
1 = See Chapter 5 for detailed analysis of land use compatibility.

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Chapter 7

REFERENCES

Blue Ridge Research and Consulting (BRRC). 2017. RAICUZ Noise Study for Pinecastle Range Complex. February 2017.

Bureau of Business and Economic Research (BEBR). 2015. "Based on BEBR Median Projections." Volume 48, Bulletin 171. April 2015.

Downing, M. 2017. Personal communication (email) between Micah Downing, President, Blue Ridge Research and Consulting, LLC, Asheville, North Carolina, and Ryan Long, Ecology and Environment, Inc., Tallahassee, Florida, regarding noise metrics. February 2, 2017.

Federal Aviation Administration (FAA). 2008. Pilot's Handbook of Aeronautical Knowledge. FAA-H-8083-25A. Department of Transportation, FAA, Airmen Testing Standards Branch. Oklahoma City, Oklahoma.

Fleet Area Control and Surveillance Facility, Jacksonville (FACSFACJAX). 2013. Pinecastle Range Complex Handbook. REV 6.8. Jacksonville, Florida. October 2, 2013.

Florida Department of Environmental Protection (FDEP). 2014. Personal communication (letter) from Lisa Prather, Environmental Consultant, Submerged Lands and Environmental Resource Program, Orlando, Florida, to CDR Justin Clancy, Region Environmental Counsel, Navy Region Southeast, Jacksonville, Florida, regarding the continued use of certain sovereignty submerged lands in Lake George. February 18, 2014.

Florida Regional Councils Association (FRCA). 2017. Regional Planning Councils. http://www.flregionalcouncils.org/directory/. Accessed on April 4, 2017.

Jandakot Airport. 2016. Community, Aircraft Noise. http://www.jandakotairport.com.au/community/aircraft-noise.html. Accessed on April 10, 2017.

Lake County. 2007. Lake County Board of County Commissioners. https://www.lakecountyfl.gov/departments/commissioners/. Accessed on April 3, 2017.

_____. 2011. Comprehensive Plan Future Land Use Element. https://www.lakecountyfl.gov/pdfs/2025/2030_comp_plan.pdf. Accessed on April 3, 2017.

Lockheed Martin. 2017. About the F-35. https://www.f35.com/about. Accessed on April 2, 2017.

Marion County. 2014a. Comprehensive Plan Future Land Use Element. http://www.marioncountyfl.org/departments-agencies/departments-a-n/growth-services/planning/comprehensive-plan. Accessed on April 3, 2017.

_____. 2014b. Comprehensive Plan Future Land Use Element Intergovernmental Coordination. http://www.marioncountyfl.org/home/showdocument?id=5920. Accessed on April 3, 2017.

_____. 2017. Growth Services. http://www.marioncountyfl.org/departments-agencies/departments-a-n/growth-services. Accessed on April 2, 2017.

National Research Council. 2008. ACRP Synthesis 9: Effects of Aircraft Noise: Research Update on Select Topics. The National Academies Press. Washington, D.C.

Naval Air Systems Command (NAVAIR). 2017a. Aircraft and Weapons, Fixed Wing, F/A-18, F/A-18 A-D Hornet Fact Sheet. http://www.navair.navy.mil/index.cfm?fuseaction=home.displayPlatform&key=32F08227-0DE1-437F-93AB-C7241517AA8D. Accessed on March 30, 2017.

_____. 2017b. Aircraft and Weapons, Fixed Wing, F/A-18, F/A-18 E-F Super Hornet Fact Sheet. http://www.navair.navy.mil/index.cfm?fuseaction=home.displayPlatform&key=C42247D4-36AF-4038-AD33-B559F68AA774. Accessed on March 30, 2017.

_____. 2017c. CH-53E Super Stallion Fact Sheet. http://www.navair.navy.mil/index.cfm?fuseaction=home.displayPlatform&key=25A327F8-4E42-4FB9-AB34-8609E6657215. Accessed on April 11, 2017.

Naval Facilities Engineering Command, Southeast. 2011. United States Navy Range Sustainability Environmental Assessment Program, Range Condition Assessment, Five-year Update, Pinecastle Range, Florida. Prepared for U.S. Fleet Forces Command. Contract Number: N62467-06-D-0123. August 2011.

Putnam County. 2010. Putnam County Comprehensive Plan 2010. http://pds.putnamfl.com/images/WebDocs/future_land_use_element.pdf. Accessed on March 17, 2017.

_____. 2017. Planning and Development Services. http://pds.putnam-fl.com/. Accessed on April 2, 2017.

U.S. Air Force (Air Force). 2015. A-10 Thunderbolt Factsheet. http://www.af.mil/AboutUs/FactSheets/Display/tabid/224/Article/104490/a-10-thunderbolt-ii.aspx. Accessed on April 2, 2017.

U.S. Census Bureau (USCB). 2000. U.S. Census Bureau State and County Quick Facts.

_____. 2015a. Quickfacts Marion County. https://www.census.gov/quickfacts/table/BZA010214/12083. Accessed April 2, 2017.

_____. 2015b. Quickfacts Putnam County. https://www.census.gov/quickfacts/table/BZA010214/12107. Accessed April 2, 2017.

_____. 2015c. Quickfacts Volusia County. https://www.census.gov/quickfacts/table/BZA010214/12083. Accessed April 2, 2017.

_____. 2015d. Quickfacts Lake County. https://www.census.gov/quickfacts/table/BZA010214/12069. Accessed April 2, 2017.

_____. 2015e.Quickfacts. https://www.census.gov/quickfacts/table/BZA010214/12127,12069,12107,12083. Accessed April 2, 2017.

U.S. Department of Agriculture (USDA) Forest Service. 1999. Revised Land and Resource Management Plan for National Forests in Florida. February 1999. USDA Forest Service, Southern Region, Atlanta, Georgia, and National Forests in Florida, Tallahassee, Florida. http://www.fs.usda.gov/detail/florida/landmanagement/?cid=STELPRDB5269793. Accessed March 13, 2017.

_____. 2002. Special Use Permit for Department of the Navy Pinecastle Electronic Warfare Range, Ocala National Forest, Seminole Ranger District. July 26, 2002.

U.S. Department of the Navy. (Navy). 2010 Final Supplemental Environmental Impact Statement to the Final Environmental Impact Statement for Renewal of Authorization to Use Pinecastle Range.

_____. 2012. Final Environmental Assessment Addressing the Expansion of the Pinecastle Range Complex Restricted Area. U.S. Fleet Forces Command, Department of the Navy. Cooperating Agency: Federal Aviation Administration (FAA). August 2012.

_____. 2017a. Safety Study for the Pinecastle Range Complex. March 2017.

_____. 2017b. Training Asset Catalog for Pinecastle Range Complex. March 2017.

_____. 2017c. Annual Operating Plan for Department of the Navy Pinecastle Range Complex and USDA Forest Service, Ocala National Forest. April 20, 2017.

Volusia County. 2016. Future Land Use Element. http://www.volusia.org/core/fileparse.php/4600/urlt/Chapter-1-Future-Land-Use-Element.pdf. Accessed April 4, 2017.

_____. 2017a. Volusia County City Council. http://www.volusia.org/government/county-council/. Accessed on April 3, 2017.

_____. 2017b. Planning and Development Services. http://www.volusia.org/services/growth-and-resource-management/planning-and-development/. Accessed on April 3, 2017.

Volusia County Division of Economic Development. 2017. "Volusia County Division of Economic Development." http://www.floridabusiness.org/index.stml. Accessed on March 17, 2017.

Wyle. 2012. Aircraft, Ordnance, and Small Arms Noise Study for Naval Weapons Systems Training Facility Boardman, Oregon. WR 11-17. Wyle Environmental and Energy Research & Consulting, Arlington, Virginia. May 2012.

_____. 2014. Discussion of Noise and Its Effect on the Environment. WR 13-11. Wyle Laboratories, Inc. Environmental and Energy Research & Consulting, Arlington, Virginia. January 2014.

APPENDIX A

DISCUSSION OF NOISE AND ITS EFFECT ON THE ENVIRONMENT

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APPENDIX A — Discussion of Noise and Its Effect on the Environment

FINAL

WR 13-11
January 2014

APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE, SLEEP DISTURBANCE, HEARING IMPAIRMENT, HEALTH EFFECTS, APPENDIX A, NOISE EFECTS, SOUND LEVELS, SUPPLEMENTAL METRICS, ENVIRONMENT, HUMANS, ANNOYANCE, SPEECH INTEFERENCE,

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APPENDIX A – Discussion of Noise and Its Effect on the Environment

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Tables

Acronyms & Abbreviations

ID	Definition
AAD	Annual Average Daily
AGL	Above Ground Level
ANSI	American National Standards Institute
ASHLA	American Speech-Language-Hearing Association
CHABA	Committee on Hearing, Bioacousitcis, and Biomechanics
CNEL	Community Noise Equivalent Level
$CNEL_{mr}$	Onset-Rate Adjusted Monthly Community Noise Equivalent Level
dB	Decibel
dBA	A-Weighted Decibels
dB(A)	A-Weighted Decibels
DLR	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt e.V.)
DNL	Day-Night Average Sound Level
DOD	Department of Defense
FAA	Federal Aviation Administration (US)
FICAN	Federal Interagency Committee on Aviation Noise
FICON	Federal Interagency Committee on Noise
HA	Highly Annoyed
HYENA	Hypertension and Exposure to Noise near Airports
Hz	Hertz
ISO	International Organization for Standardization
L	Sound Level
L_{dn}	Day-Night Average Sound Level
L_{dnmr}	Onset-Rate Adjusted Monthly Day-Night Average Sound Level
L_{eq}	Equivalent Sound Level
$L_{eq(16)}$	Equivalent Sound Level over 16 hours
$L_{eq(24)}$	Equivalent Sound Level over 24 hours
$L_{eq(30min)}$	Equivalent Sound Level over 30 minutes
$L_{eq(8)}$	Equivalent Sound Level over 8 hours
$L_{eq(h)}$	Hourly Equivalent Sound Level
L_{max}	Maximum Sound Level
L_{pk}	Peak Sound Level

(Continued on next page)

ID	Definition
m	meter (distance unit)
mmHg	millimeters of mercury
MOA	Military Operations Area
MTR	Military Training Route
NA	Number of Events At or Above a Selected Threshold
NATO	North Atlantic Treaty Organization
NDI	Noise Depreciation Index
NIPTS	Noise-induced Permanent Threshold Shift
NSDI	Noise Sensitivity Depreciation Index
OR	Odd Ratio
POI	Point of Interest
PTS	Permanent Threshold Shift
RANCH	Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health
SEL	Sound Exposure Level
SIL	Speech Interference Level
SUA	Special Use Airspace
TA	Time Above
TTS	Temporary Threshold Shift
U.S.	United States
UKDfES	United Kingdom Department for Education and Skills
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WHO	World Health Organization

Appendix A

This appendix discusses sound and noise and their potential effects on the human and natural environment. Section A.1 provides an overview of the basics of sound and noise. Section A.2 defines and describes the different metrics used to describe noise. The largest section, Section A.3, reviews the potential effects of noise, focusing on effects on humans but also addressing effects on property values, terrain, structures, and animals. Section A.4 contains the list of references cited.

A.1 Basics of Sound

Section A.1.1 describes sound waves and decibels. Section A.1.2 review sounds levels and types of sounds.

A.1.1 Sound Waves and Decibels

Sound consists of minute vibrations in the air that travel through the air and are sensed by the human ear. Figure A-1 is a sketch of sound waves from a tuning fork. The waves move outward as a series of crests where the air is compressed and troughs where the air is expanded. The height of the crests and the depth of the troughs are the amplitude or sound pressure of the wave. The pressure determines its energy or intensity. The number of crests or troughs that pass a given point each second is called the frequency of the sound wave.

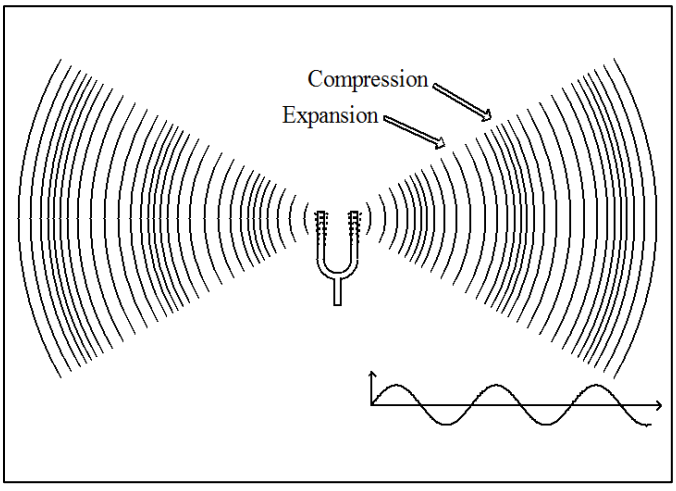


Figure A-1. Sound Waves from a Vibrating Tuning Fork

The measurement and human perception of sound involves three basic physical characteristics: intensity, frequency, and duration.

- Intensity is a measure of the acoustic energy of the sound and is related to sound pressure. The greater the sound pressure, the more energy carried by the sound and the louder the perception of that sound.
- Frequency determines how the pitch of the sound is perceived. Low-frequency sounds are characterized as rumbles or roars, while high-frequency sounds are typified by sirens or screeches.
- Duration or the length of time the sound can be detected.

As shown in Figure A-1, the sound from a tuning fork spreads out uniformly as it travels from the source. The spreading causes the sound's intensity to decrease with increasing distance from the source. For a source such as an aircraft in flight, the sound level will decrease by about 6 dB for every doubling of the distance. For a busy highway, the sound level will decrease by 3-4.5 dB for every doubling of distance.

As sound travels from the source it also gets absorbed by the air. The amount of absorption depends on the frequency composition of the sound, the temperature, and the humidity conditions. Sound with high frequency content gets absorbed by the air more than sound with low frequency content. More sound is absorbed in colder and drier conditions than in hot and wet conditions. Sound is also affected by wind and temperature gradients, terrain (elevation and ground cover) and structures.

The loudest sounds that can be comfortably heard by the human ear have intensities a trillion times higher than those of sounds barely heard. Because of this vast range, it is unwieldy to use a linear scale to represent the intensity of sound. 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 and 140 dB are felt as pain (Berglund and Lindvall 1995).

Because of the logarithmic nature of the decibel unit, sound levels cannot simply be 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.

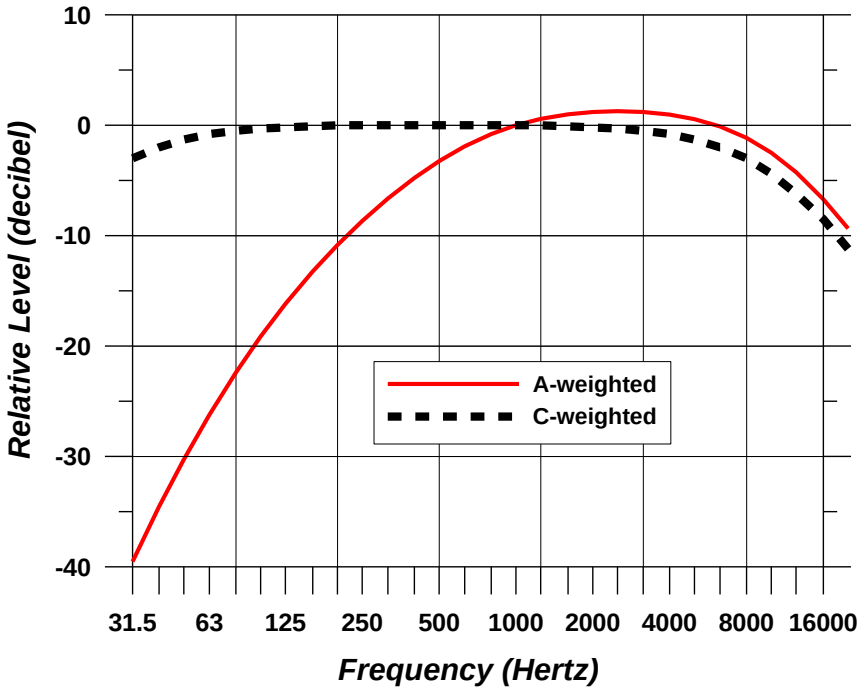
Because the addition of sound levels is different than that of ordinary numbers, this process is often referred to as "decibel addition."

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. This relation holds true for loud and quiet sounds. A decrease in sound level of 10 dB actually represents a 90% decrease in sound intensity but only a 50% decrease in perceived loudness because the human ear does not respond linearly.

Sound frequency is measured in terms of cycles per second or hertz (Hz). The normal ear of a young person can detect sounds that range in frequency from about 20 Hz to 20,000 Hz. As we get older, we lose the ability to hear high frequency sounds. Not all sounds in this wide range of frequencies are heard equally. Human hearing is most sensitive to frequencies in the 1,000 to 4,000 Hz range. The notes on a piano range from just over 27 Hz to 4,186 Hz, with middle C equal to 261.6 Hz. Most sounds (including a single note on a piano) are not simple pure tones like the tuning fork in Figure A-1, but contain a mix, or spectrum, of many frequencies.

Sounds with different spectra are perceived differently even if the sound levels are the same. 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. These two curves, shown in Figure A-2, are adequate to quantify most environmental noises. A-weighting puts emphasis on the 1,000 to 4,000 Hz range.

Very loud or impulsive sounds, such as explosions or sonic booms, can sometimes be felt, and can cause secondary effects, such as shaking of a structure or rattling of windows. These types of sounds can add to annoyance, and are best measured by C-weighted sound levels, denoted dBC. C-weighting is nearly flat throughout the audible frequency range, and includes low frequencies that may not be heard but cause shaking or rattling. C-weighting approximates the human ear's sensitivity to higher intensity sounds.



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

Figure A-2. Frequency Characteristics of A- and C-Weighting

A.1.2 Sound Levels and Types of Sounds

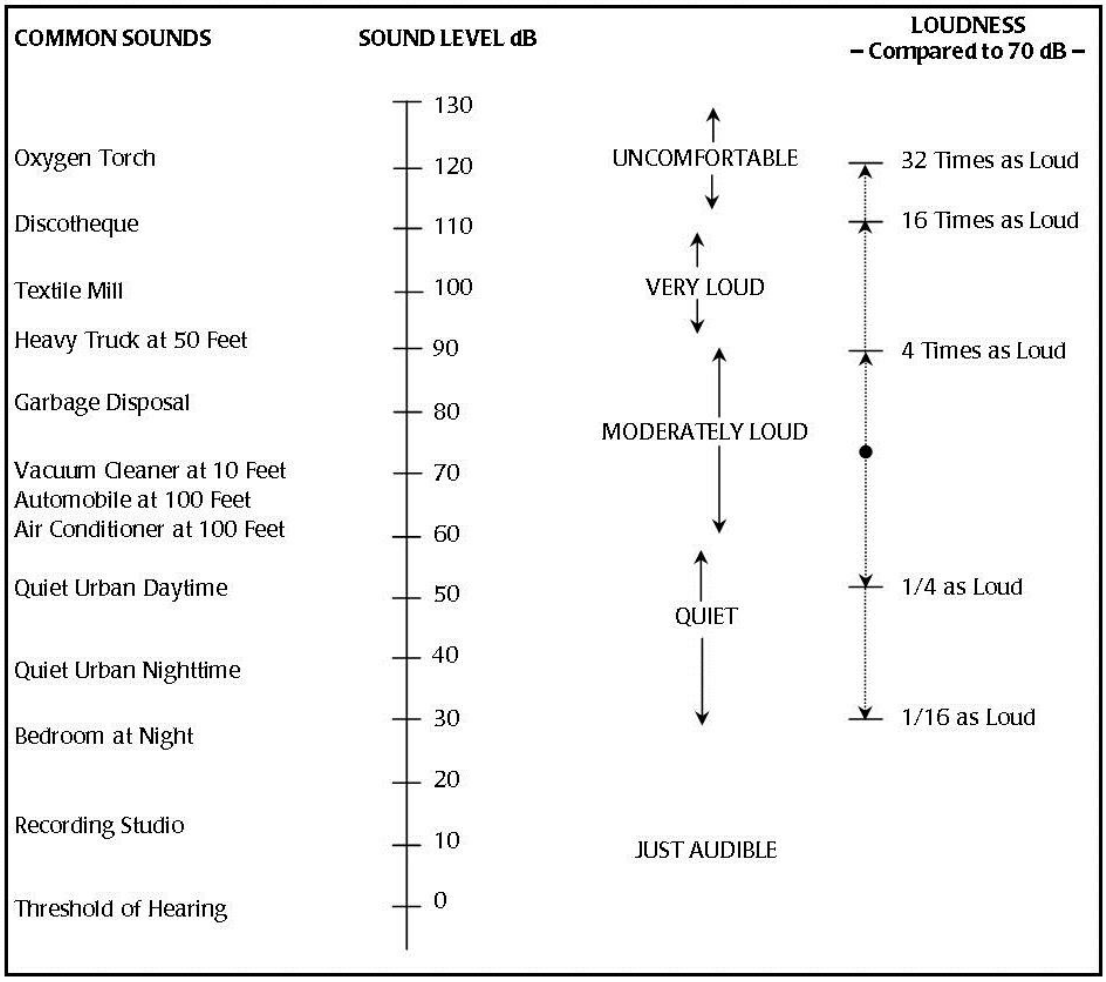
Most environmental sounds are measured using A-weighting. They're called A-weighted sound levels, and sometimes use the unit dBA or dB(A) rather than dB. When the use of A-weighting is understood, the term "A-weighted" is often omitted and the unit dB is used. Unless otherwise stated, dB units refer to A-weighted sound levels.

Sound becomes noise when it is unwelcome and interferes with normal activities, such as sleep or conversation. Noise is unwanted sound. Noise can become an issue when its level exceeds the ambient or background sound level. Ambient noise in urban areas typically varies from 60 to 70 dB, but can be as high as 80 dB in the center of a large city. Quiet suburban neighborhoods experience ambient noise levels around 45-50 dB (U.S. Environmental Protection Agency (USEPA) 1978).

Figure A-3 is a chart of A-weighted sound levels from common sources. Some sources, like the air conditioner and vacuum cleaner, are continuous sounds whose levels are constant for some time. Some sources, like the automobile and heavy truck, are the maximum sound during an intermittent event like a vehicle pass-by. Some sources like "urban daytime" and "urban nighttime" are averages over extended periods. A variety of noise metrics have been developed to describe noise over different time periods. These are discussed in detail in Section A.2.

Aircraft noise consists of two major types of sound events: flight (including takeoffs, landings and flyovers), and stationary, such as engine maintenance run-ups. The former are intermittent and the latter primarily continuous. Noise from aircraft overflights typically occurs beneath main approach and departure paths, in local air traffic patterns around the airfield, and in areas near aircraft parking ramps and staging areas. As aircraft climb, the noise received on the ground drops to lower levels, eventually fading into the background or ambient levels.

Impulsive noises are generally short, loud events. Their single-event duration is usually less than 1 second. Examples of impulsive noises are small-arms gunfire, hammering, pile driving, metal impacts during rail-yard shunting operations, and riveting. Examples of high-energy impulsive sounds are quarry/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, and any other explosive source where the equivalent mass of dynamite exceeds 25 grams (American National Standards Institute [ANSI] 1996).

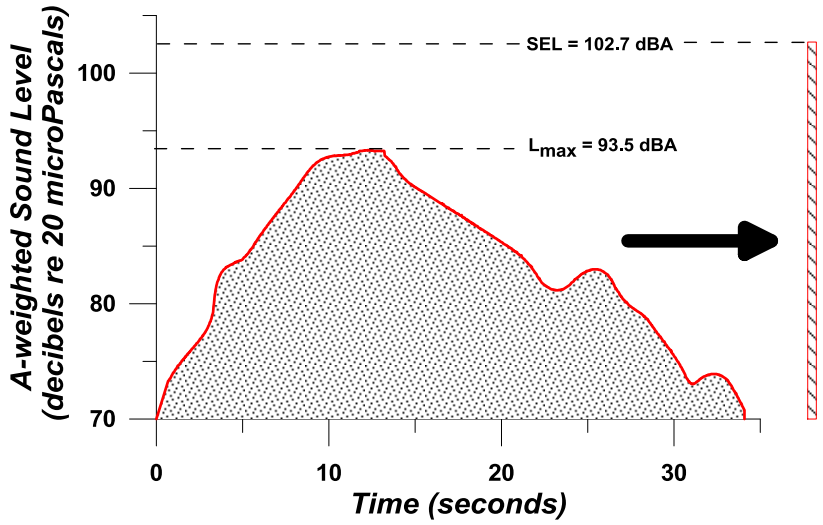


Sources: Harris 1979; Federal Interagency Committee on Aviation Noise (FICAN) 1997.

Figure A-3. Typical A-weighted Sound Levels of Common Sounds

A.2 Noise Metrics

Noise metrics quantify sounds so they can be compared with each other, and with their effects, in a standard way. The simplest metric is the A-weighted level, which is appropriate by itself for constant noise such as an air conditioner. Aircraft noise varies with time. During an aircraft overflight, noise starts at the background level, rises to a maximum level as the aircraft flies close to the observer, then returns to the background as the aircraft recedes into the distance. This is sketched in Figure A-4, which also indicates two metrics (L_{max} and SEL) that are described in Sections A.2.1 and A.2.3 below. Over time there can be a number of events, not all the same.



Source: Wyle Laboratories

Figure A-4. Example Time History of Aircraft Noise Flyover

There are a number of metrics that can be used to describe a range of situations, from a particular individual event to the cumulative effect of all noise events over a long time. This section describes the metrics relevant to environmental noise analysis.

A.2.1 Single-events

Maximum Sound Level (L_{max})

The highest A-weighted sound level measured during a single event in which the sound changes with time is called the maximum A-weighted sound level or Maximum Sound Level and is abbreviated L_{max}. The L_{max} is depicted for a sample event in Figure A-4.

L_{max} is the maximum level that occurs over a fraction of a second. For aircraft noise, the "fraction of a second" is one-eighth of a second, denoted as "fast" response on a sound level measuring meter (ANSI 1988). Slowly varying or steady sounds are generally measured over 1 second, denoted "slow" response. L_{max} is important in judging if a noise event will interfere with conversation, TV or radio listening, or other common activities. Although it provides some measure of the event, it does not fully describe the noise, because it does not account for how long the sound is heard.

Peak Sound Pressure Level (L_{pk})

The Peak Sound Pressure Level is the highest instantaneous level measured by a sound level measurement meter. L_{pk} is typically measured every 20 microseconds, and usually based on unweighted or linear response of the meter. It is used to describe individual impulsive events such as blast noise. Because blast noise varies from shot to shot and varies with meteorological (weather) conditions, the U.S. Department of Defense (DOD) usually characterizes L_{pk} by the metric PK 15(met), which is the L_{pk} exceeded 15% of the time. The "met" notation refers to the metric accounting for varied meteorological or weather conditions.

Sound Exposure Level (SEL)

Sound Exposure Level combines both the intensity of a sound and its duration. For an aircraft flyover, SEL includes the maximum and all lower noise levels produced as part of the overflight, together with how long each part lasts. It represents the total sound energy in the event. Figure A-4 indicates the SEL for an example event, representing it as if all the sound energy were contained within 1 second.

Because aircraft noise events last more than a few seconds, the SEL value is larger than L_{max}. It does not directly represent the sound level heard at any given time, but rather the entire event. SEL provides a much better measure of aircraft flyover noise exposure than L_{max} alone.

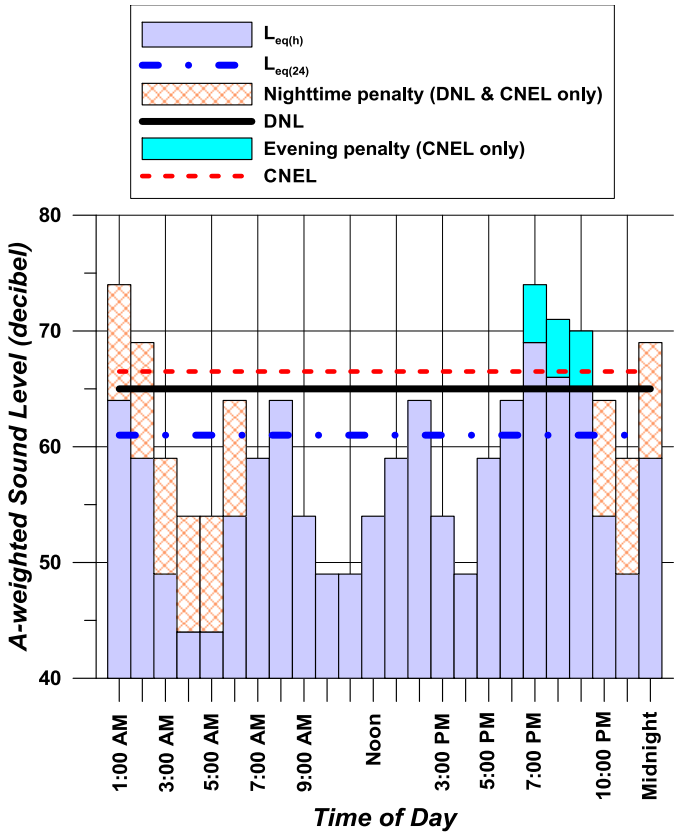
A.2.2 Cumulative Events

Equivalent Sound Level (L_{eq})

Equivalent Sound Level is a "cumulative" metric that combines a series of noise events over a period of time. L_{eq} is the sound level that represents the decibel average SEL of all sounds in the time period. Just as SEL has proven to be a good measure of a single event, L_{eq} has proven to be a good measure of series of events during a given time period.

The time period of an L_{eq} measurement is usually related to some activity, and is given along with the value. The time period is often shown in parenthesis (e.g., $L_{eq(24)}$ for 24 hours). The L_{eq} from 7 a.m. to 3 p.m. may give exposure of noise for a school day.

Figure A-5 gives an example of $L_{eq(24)}$ using notional hourly average noise levels ($L_{eq(h)}$) for each hour of the day as an example. The $L_{eq(24)}$ for this example is 61 dB.



Source: Wyle Laboratories

Figure A-5. Example of $L_{eq(24)}$, DNL and CNEL Computed from Hourly Equivalent Sound Levels

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

Day-Night Average Sound Level is a cumulative metric that accounts for all noise events in a 24-hour period. However, unlike $L_{eq(24)}$, DNL contains a nighttime noise penalty. To account for our increased sensitivity to noise at night, DNL applies a 10 dB penalty to events during the nighttime period, defined as 10:00 p.m. to 7:00 a.m. The notations DNL and L_{dn} are both used for Day-Night Average Sound Level and are equivalent.

CNEL is a variation of DNL specified by law in California (California Code of Regulations Title 21, *Public Works*) (Wyle Laboratories 1970). CNEL has the 10 dB nighttime penalty for events between 10:00 p.m. and 7:00 a.m. but also includes a 4.8 dB penalty for events during the evening period of 7:00 p.m. to 10:00 p.m. The evening penalty in CNEL accounts for the added intrusiveness of sounds during that period.

For airports and military airfields, DNL and CNEL represent the average sound level for annual average daily aircraft events.

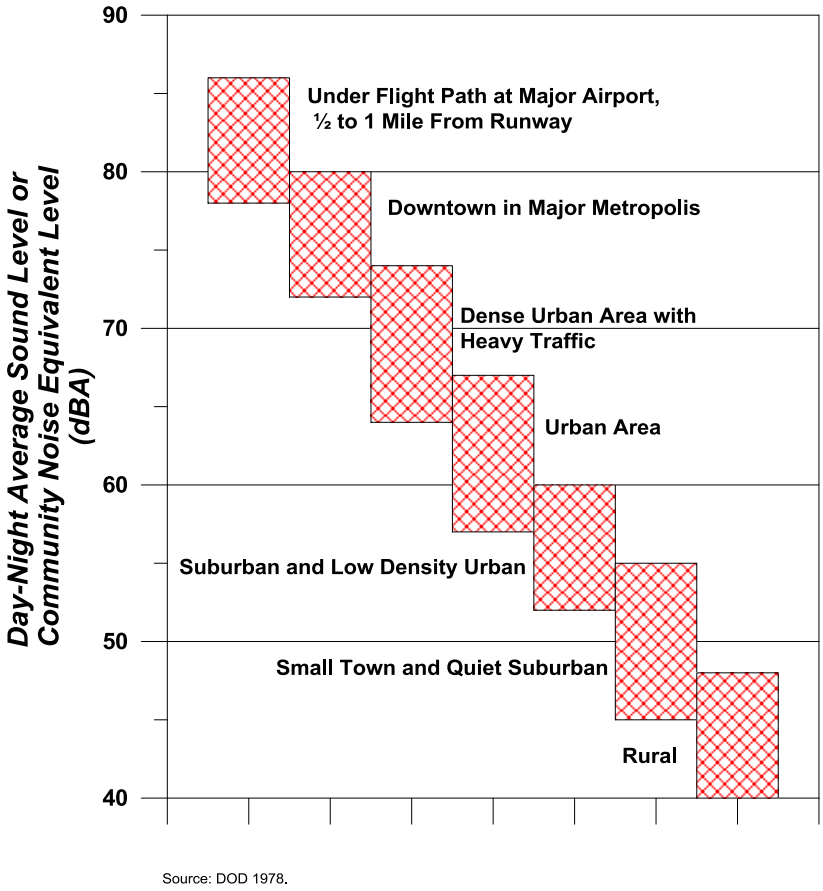
Figure A-5 gives an example of DNL and CNEL using notional hourly average noise levels ($L_{eq(h)}$) for each hour of the day as an example. Note the $L_{eq(h)}$ for the hours between 10 p.m. and 7 a.m. have a 10 dB penalty assigned. For CNEL the hours between 7p.m. and 10 p.m. have a 4.8 dB penalty assigned. The DNL for this example is 65 dB. The CNEL for this example is 66 dB.

Figure A-6 shows the ranges of DNL or CNEL that occur in various types of communities. Under a flight path at a major airport the DNL may exceed 80 dB, while rural areas may experience DNL less than 45 dB.

The decibel summation nature of these metrics causes the noise levels of the loudest events to control the 24-hour average. As a simple example, 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.

A feature of the DNL metric is that a given DNL value could result from a very few noisy events or a large number of quieter events. For example, 1 overflight at 90 dB creates the same DNL as 10 overflights at 80 dB.

DNL or CNEL do not represent a level heard at any given time, but represent long term exposure. Scientific studies have found good correlation between the percentages of groups of people highly annoyed and the level of average noise exposure measured in DNL (Schultz 1978; USEPA 1978).



Source: DOD 1978.

Figure A-6. Typical DNL or CNEL Ranges in Various Types of Communities

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 Operations Areas (MOAs), and Restricted Areas/Ranges generate a noise environment that is somewhat different from that around airfields. Rather than regularly occurring operations like at airfields, activity in SUAs is highly sporadic. It is often seasonal, ranging from 10 per hour to less than 1 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, with rates of up to 150 dB per second.

The cumulative daily noise metric devised to account for the "surprise" effect of the sudden onset of aircraft noise events on humans and the sporadic nature of SUA activity is the Onset-Rate Adjusted Monthly Day-Night Average Sound Level (L_{dnmr}). Onset rates between 15 and 150 dB per second require an adjustment of 0 to 11 dB to the event's SEL, while onset rates below 15 dB per second require no adjustment to the event's SEL (Stusnick et al. 1992). The term 'monthly' in L_{dnmr} refers to the noise assessment being conducted for the month with the most operations or sorties -- the so-called busiest month.

In California, a variant of the L_{dnmr} includes a penalty for evening operations (7 p.m. to 10 p.m.) and is denoted $CNEL_{mr}$.

A.2.3 Supplemental Metrics

Number-of-Events Above (NA) a Threshold Level (L)

The Number-of-Events Above (NA) metric gives the total number of events that exceed a noise level threshold (L) during a specified period of time. Combined with the selected threshold, the metric is denoted NAL. The threshold can be either SEL or L_{max}, and it is important that this selection is shown in the nomenclature. When labeling a contour line or point of interest (POI), NAL is followed by the number of events in parentheses. For example, where 10 events exceed an SEL of 90 dB over a given period of time, the nomenclature would be 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 is a supplemental metric. It is not supported by the amount of science behind DNL/CNEL, but it is valuable in helping to describe noise to the community. A threshold level and metric are selected that best meet the need for each situation. An L_{max} threshold is normally selected to analyze speech interference, while an SEL threshold is normally selected for analysis of sleep disturbance.

The NA metric is the only supplemental metric 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.

Time Above (TA) a Specified Level (L)

The Time Above (TA) metric is the total time, in minutes, that the A-weighted noise level is at or above a threshold. Combined with the threshold level (L), it is denoted TAL. TA 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 for that time.

TA is a supplemental metric, used to help understand noise exposure. It is useful for describing the noise environment in schools, particularly when assessing classroom or other noise sensitive areas for various scenarios. TA can be shown as contours on a map similar to the way DNL contours are drawn.

TA helps describe the noise exposure of an individual event or many events occurring over a given 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, but also the total duration of those events above the threshold.

A.3 Noise Effects

Noise is of concern because of potential adverse effects. The following subsections describe how noise can affect communities and the environment, and how those effects are quantified. The specific topics discussed are:

- Annoyance;
- Speech interference;
- Sleep disturbance;
- Noise-induced hearing impairment;
- Non-auditory health effects;
- Performance effects;
- Noise effects on children;
- Property values;
- Noise-induced vibration effects on structures and humans;
- Noise effects on terrain;
- Noise effects on historical and archaeological sites; and
- Effects on domestic animals and wildlife.

A.3.1 Annoyance

With the introduction of jet aircraft in the 1950s, it became clear that aircraft noise annoyed people and was a significant problem around airports. Early studies, such as those of Rosenblith et al. (1953) and Stevens et al. (1953) showed that effects depended on the quality of the sound, its level, and the number of flights. Over the next 20 years considerable research was performed refining this understanding and setting guidelines for noise exposure. In the early 1970s, the USEPA published its "Levels Document" (USEPA 1974) that reviewed the factors that affected communities. DNL (still known as L_{dn} at the time) was identified as an appropriate noise metric, and threshold criteria were recommended.

Threshold criteria for annoyance were identified from social surveys, where people exposed to noise were asked how noise affects them. Surveys provide direct real-world data on how noise affects actual residents.

Surveys in the early years had a range of designs and formats, and needed some interpretation to find common ground. In 1978, Schultz showed that the common ground was the number of people "highly annoyed," defined as the upper 28% range of whatever response scale a survey used (Schultz 1978). With that definition, he was able to show a remarkable consistency among the majority of the surveys for which data were available. Figure A-7 shows the result of his study relating DNL to individual annoyance measured by percent highly annoyed (%HA).

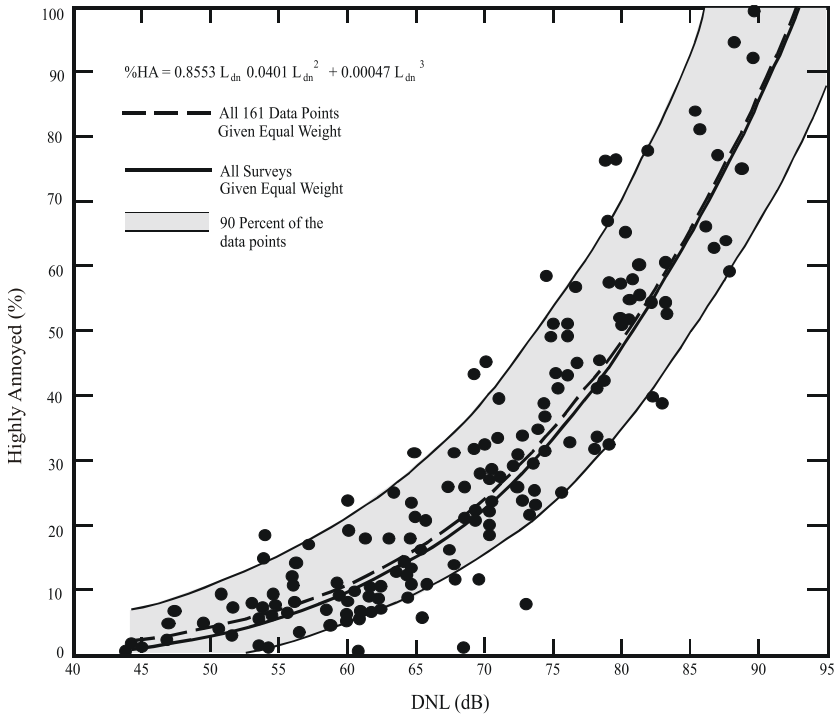


Figure A-7. Schultz Curve Relating Noise Annoyance to DNL (Schultz 1978)

Schultz's original synthesis included 161 data points. Figure A-8 compares revised fits of the Schultz data set with an expanded set of 400 data points collected through 1989 (Finegold et al. 1994). The new form is the preferred form in the US, endorsed by the Federal Interagency Committee on Aviation Noise (FICAN 1997). Other forms have been proposed, such as that of Fidell and Silvati (2004), but have not gained widespread acceptance.

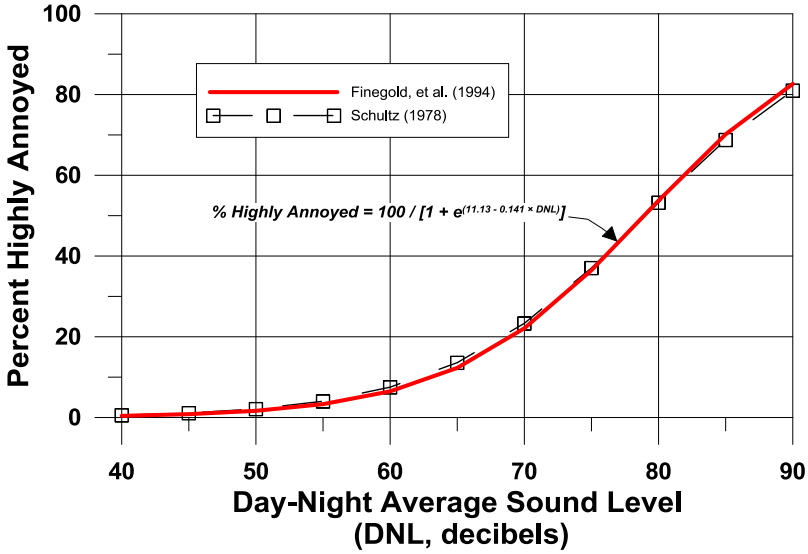


Figure A-8. Response of Communities to Noise; Comparison of Original Schultz (1978) with Finegold et al (1994)

When the goodness of fit of the Schultz curve is examined, the correlation between groups of people is high, in the range of 85-90%. The correlation between individuals is lower, 50% or less. This is not surprising, given the personal differences between individuals. The surveys underlying the Schultz curve include results that show that annoyance to noise is also affected by non-acoustical factors. Newman and Beattie (1985) divided the non-acoustic factors into the emotional and physical variables shown in Table A-1.

Table A-1. Non-Acoustic Variables Influencing Aircraft Noise Annoyance

Emotional Variables	Physical Variables
Feeling about the necessity or preventability of the noise;	Type of neighborhood;
Judgement of the importance and value of the activity that is producing the noise;	Time of day;
Activity at the time an individual hears the noise;	Season;
Attitude about the environment;	Predicitabiltiy of the noise;
General sensitivity to noise;	Control over the noise source; and
Belief about the effect of noise on health; and	Length of time individual is exposed to a noise.
Feeling of fear associated with the noise.	

Schreckenberg and Schuemer (2010) recently examined the importance of some of these factors on short term annoyance. Attitudinal factors were identified as having an effect on annoyance. In formal regression analysis, however, sound level (L_{eq}) was found to be more important than attitude.

A recent study by Plotkin et al. (2011) examined updating DNL to account for these factors. It was concluded that the data requirements for a general analysis were much greater than most existing studies. It was noted that the most significant issue with DNL is that it is not readily understood by the public, and that supplemental metrics such as TA and NA were valuable in addressing attitude when communicating noise analysis to communities (DOD 2009a).

A factor that is partially non-acoustical is the source of the noise. Miedema and Vos (1998) presented synthesis curves for the relationship between DNL and percentage "Annoyed" and percentage "Highly Annoyed" for three transportation noise sources. Different curves were found for aircraft, road traffic, and railway noise. Table A-2 summarizes their results. Comparing the updated Schultz curve suggests that the percentage of people highly annoyed by aircraft noise may be higher than previously thought.

Table A-2. Percent Highly Annoyed for Different Transportation Noise Sources

DNL (dB)	Percent Hightly Annoyed (%HA)			
	Miedema and Vos			Schultz
	Air	Road	Rail	Combined
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 and Vos 1998.

As noted by the World Health Organization (WHO), however, 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 1999).

Consistent with WHO's recommendations, the Federal Interagency Committee on Noise (FICON 1992) considered the Schultz curve to be the best source of dose information to predict community response to noise, but recommended further research to investigate the differences in perception of noise from different sources.

A.3.2 Speech Interference

Speech interference from noise is a primary cause of annoyance for communities. Disruption of routine activities such as radio or television listening, telephone use, or conversation leads to frustration and annoyance. The quality of speech communication is important in classrooms and offices. In the workplace, speech interference from noise can cause fatigue and vocal strain in those who attempt to talk over the noise. In schools it can impair learning.

There are two measures of speech comprehension:

1. *Word Intelligibility* - the percent of words spoken and understood. 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. *Sentence Intelligibility* – the percent of sentences spoken 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.

U.S. Federal Criteria for Interior Noise

In 1974, the USEPA identified a goal of an indoor $L_{eq(24)}$ of 45 dB to minimize speech interference based on sentence intelligibility and the presence of steady noise (USEPA 1974). Figure A-9 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 indoor sound levels of less than 45 dB L_{eq} are expected to allow 100% sentence intelligibility.

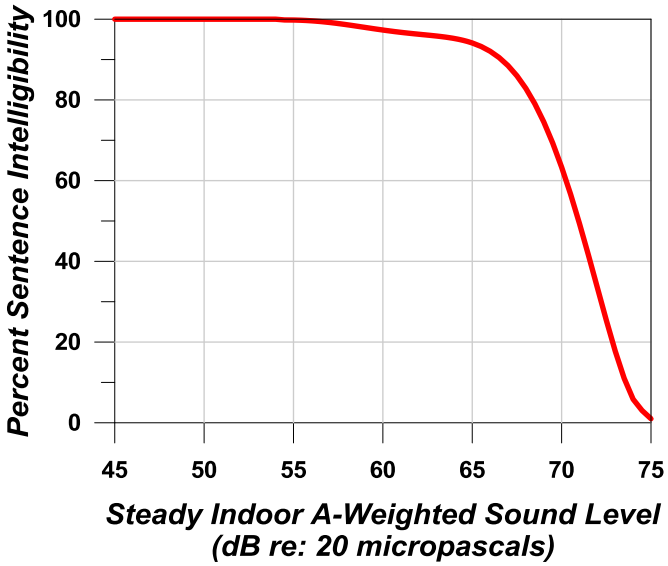


Figure A-9. Speech Intelligibility Curve (digitized from USEPA 1974)

The curve in Figure A-9 shows 99% intelligibility at L_{eq} below 54 dB, and less than 10% above 73 dB. Recalling that L_{eq} is dominated by louder noise events, the USEPA $L_{eq(24)}$ goal of 45 dB generally ensures that sentence intelligibility will be high most of the time.

Classroom Criteria

For teachers to be understood, their regular voice must be clear and uninterrupted. Background noise has to be below the teacher's voice level. Intermittent noise events that momentarily drown out the teacher's voice need to be kept to a minimum. 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.

Lazarus (1990) found that for listeners with normal hearing and fluency in the language, complete sentence intelligibility can be achieved when the signal-to-noise ratio (i.e., a comparison of the level of the sound to the level of background noise) is in the range of 15 to 18 dB. The initial ANSI classroom noise standard (ANSI 2002) and American Speech-Language-Hearing Association (ASLHA 1995) guidelines concur, recommending at least a 15 dB signal-to-noise ratio in classrooms. If the teacher's voice level is at least 50 dB, the background noise level must not exceed an average of 35 dB. The National Research Council of Canada (Bradley 1993) and WHO (1999) agree with this criterion for background noise.

For 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} during normal school hours (FAA 1985).

Most aircraft noise is not continuous. It consists of individual events like the one sketched in Figure A-4. Since speech interference in the presence of aircraft noise is caused by individual aircraft flyover events, a time-averaged metric alone, such as L_{eq}, is not necessarily appropriate. In addition to the background level criteria described above, single-event criteria that account for those noisy events are also needed.

A 1984 study by Wyle for the Port Authority of New York and New Jersey recommended using Speech Interference Level (SIL) for classroom noise criteria (Sharp and Plotkin 1984). SIL is based on the maximum sound levels in the frequency range that most affects speech communication (500-2,000 Hz). The study identified an SIL of 45 dB as the goal. This would provide 90% word intelligibility for the short time periods during aircraft overflights. While SIL is technically the best metric for speech interference, it can be approximated by an L_{max} value. An SIL of 45 dB is equivalent to an A-weighted L_{max} of 50 dB for aircraft noise (Wesler 1986).

Lind et al. (1998) also concluded that an L_{max} criterion of 50 dB would result in 90% word intelligibility. Bradley (1985) recommends SEL as a better indicator. His work indicates that 95% word intelligibility would be achieved when indoor SEL did not exceed 60 dB. For typical flyover noise this corresponds to an L_{max} of 50 dB. While WHO (1999) only specifies a background L_{max} criterion, they also note the SIL frequencies and that interference can begin at around 50 dB.

The United Kingdom Department for Education and Skills (UKDfES) established in its classroom acoustics guide a 30-minute time-averaged metric of $L_{eq(30min)}$ for background levels and the metric of $L_{A1,30min}$ for intermittent noises, at thresholds of 30-35 dB and 55 dB, respectively. $L_{A1,30min}$ represents the A-weighted sound level that is exceeded 1% of the time (in this case, during a 30-minute teaching session) and is generally equivalent to the L_{max} metric (UKDfES 2003).

Table A-3 summarizes the criteria discussed. Other than the FAA (1985) 45 dB L_{max} criterion, they are consistent with a limit on indoor background noise of 35-40 dB L_{eq} and a single event limit of 50 dB L_{max}. It should be noted that these limits were set based on students with normal hearing and no special needs. At-risk students may be adversely affected at lower sound levels.

Table A-3. 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 (2010)	L_{eq} = 35 dB, based on Room Volume (e.g., cubic feet)	Acceptable background level for continuous and intermittent noise.
U.K. DFES (2003)	$L_{eq(30min)}$ = 30-35 dB L_{max} = 55 dB	Minimum acceptable in classroom and most other learning environs.

A.3.3 Sleep Disturbance

Sleep disturbance is a major concern for communities exposed to aircraft noise at night. A number of studies have attempted to quantify the effects of noise on sleep. This section provides an overview of the major noise-induced sleep disturbance studies. Emphasis is on 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 sleep observations performed under laboratory conditions.
2. Later studies performed in the 1990s up to the present, where the research was focused on field observations.

Initial Studies

The relation between noise and sleep disturbance is complex and not fully understood. The disturbance depends not only on the depth of sleep and the noise level, but also on the non-acoustic factors cited for annoyance. The easiest effect to measure is the number of arousals or awakenings from noise events. Much of the literature has therefore focused on predicting the percentage of the population that will be awakened at various noise levels.

FICON's 1992 review of airport noise issues (FICON 1992) included an overview of relevant research conducted through the 1970s. Literature reviews and analyses were conducted from 1978 through 1989 using existing data (Griefahn 1978; Lukas 1978; Pearsons et. al. 1989). Because of large variability in the data, FICON did not endorse the reliability of those results.

FICON did, however, recommend an interim dose-response curve, awaiting future research. That curve predicted the percent of the population expected to be awakened as a function of the exposure to SEL. This curve was based on research conducted for the U.S. Air Force (Finegold 1994). The data included most of the research performed up to that point, and predicted a 10% probability of awakening when exposed to an interior SEL of 58 dB. The data used to derive this curve were primarily from controlled laboratory studies.

Recent Sleep Disturbance Research – Field and Laboratory Studies

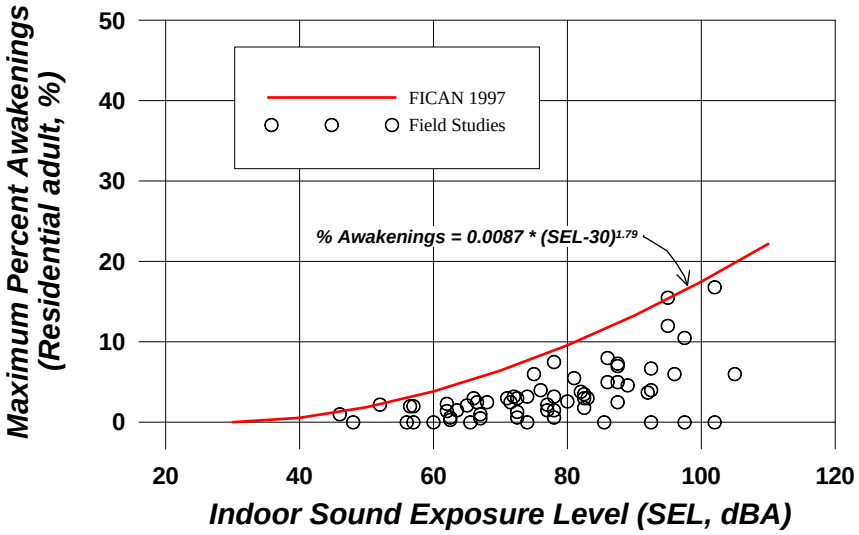
It was noted that early sleep laboratory studies did not account for some important factors. These included habituation to the laboratory, previous exposure to noise, and awakenings from noise other than aircraft. In the early 1990s, field studies in people's homes were conducted to validate the earlier laboratory work conducted in the 1960s and 1970s. The field studies of the 1990s found that 80-90% of

sleep disturbances were not related to outdoor noise events, but rather to indoor noises and non-noise factors. The results showed that, in real life conditions, there was less of an effect of noise on sleep than had been previously reported from laboratory studies. Laboratory sleep studies tend to show more sleep disturbance than field studies because people who sleep in their own homes are used to their environment and, therefore, do not wake up as easily (FICAN 1997).

FICAN

Based on this new information, in 1997 FICAN recommended a dose-response curve to use instead of the earlier 1992 FICON curve (FICAN 1997). Figure A-10 shows FICAN's curve, the red line, which is based on the results of three field studies shown in the figure (Ollerhead et al. 1992; Fidell et al. 1994; Fidell et al. 1995a, 1995b), along with the data from six previous field studies.

The 1997 FICAN curve represents the upper envelope of the latest field data. It predicts the maximum percent awakened for a given residential population. According to this curve, a maximum of 3% of people would be awakened at an indoor SEL of 58 dB. An indoor SEL of 58 dB is equivalent to an outdoor SEL of 83 dB, with the windows closed (73 dB with windows open).



Source: FICAN 1997

Figure A-10. FICAN 1997 Recommended Sleep Disturbance Dose-Response Relationship

Number of Events and Awakenings

It is reasonable to expect that sleep disturbance is affected by the number of events. The German Aerospace Center (DLR Laboratory) conducted an extensive study focused on the effects of nighttime aircraft noise on sleep and related factors (Basner 2004). The DLR study was one of the largest studies to examine the link between aircraft noise and sleep disturbance. It involved both laboratory and in-home field research phases. The DLR investigators developed a dose-response 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.

A different approach was taken by an ANSI standards committee (ANSI 2008). The committee used the average of the data shown in Figure A-10 (i.e., the blue dashed line) rather than the upper envelope, to predict average awakening from one event. Probability theory is then used to project the awakening from multiple noise events.

Currently, there are no established criteria for evaluating sleep disturbance from aircraft noise, although recent studies have suggested a benchmark of an outdoor SEL of 90 dB as an appropriate tentative

criterion when comparing the effects of different operational alternatives. The corresponding indoor SEL would be approximately 25 dB lower (at 65 dB) with doors and windows closed, and approximately 15 dB lower (at 75 dB) with doors or windows open. According to the ANSI (2008) standard, the probability of awakening from a single aircraft event at this level is between 1 and 2% for people habituated to the noise sleeping in bedrooms with windows closed, and 2-3% with windows open. The probability of the exposed population awakening at least once from multiple aircraft events at noise levels of 90 dB SEL is shown in Table A-4.

Table A-4. Probability of Awakening from NA90SEL

Number of Aircraft Events at 90 dB SEL for Average 9-Hour Night	Minimum Probability of Awakening at Least Once	
	Windows Closed	Windows Open
1	1%	2%
3	4%	6%
5	7%	10%
9 (1 per hour)	12%	18%
18 (2 per hour)	22%	33%
27 (3 per hour)	32%	45%

Source: DOD 2009b.

In December 2008, FICAN recommended the use of this new standard. FICAN also recognized that more research is underway by various organizations, and that work may result in changes to FICAN's position. Until that time, FICAN recommends the use of the ANSI (2008) standard (FICAN 2008).

Summary

Sleep disturbance research still lacks the details to accurately estimate the population awakened for a given noise exposure. The procedure described in the ANSI (2008) Standard and endorsed by FICAN is based on probability calculations that have not yet been scientifically validated. While this procedure certainly provides a much better method for evaluating sleep awakenings from multiple aircraft noise events, the estimated probability of awakenings can only be considered approximate.

A.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 et al. 1995).

TTS can result from exposure to loud noise over a given amount of time. An example of TTS might be a person attending a loud music concert. After the concert is over, there can be a threshold shift that may last several hours. 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 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. A common example of PTS is the result of regularly working in a loud factory. A TTS can eventually become a PTS over time with repeated exposure to high noise levels. 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 TTS results in a PTS is difficult to identify and varies with a person's sensitivity.

Criteria for Permanent Hearing Loss

It has been well established that continuous exposure to high noise levels will damage human hearing (USEPA 1978). A large amount of data on hearing loss have been collected, largely for workers in manufacturing industries, and analyzed by the scientific/medical community. The Occupational Safety and Health Administration (OSHA) regulation of 1971 places the limit on workplace noise exposure at an average level of 90 dB over an 8-hour work period or 85 dB over a 16-hour period (U.S. Department of Labor 1971). Some hearing loss is still expected at those levels. The most protective criterion, with no measurable hearing loss after 40 years of exposure, is an average sound level of 70 dB over a 24-hour period.

The USEPA established 75 dB $L_{eq(8)}$ and 70 dB $L_{eq(24)}$ as the average noise level standard needed to protect 96% of the population from greater than a 5 dB PTS (USEPA 1978). The National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) identified 75 dB as the lowest level at which hearing loss may occur (CHABA 1977). WHO concluded that environmental and leisure-time noise below an $L_{eq(24)}$ value of 70 dB "will not cause hearing loss in the large majority of the population, even after a lifetime of exposure" (WHO 1999).

Hearing Loss and Aircraft Noise

The 1982 USEPA Guidelines report (USEPA 1982) addresses noise-induced hearing loss in terms of the "Noise-Induced Permanent Threshold Shift" (NIPTS). This defines the permanent change in hearing caused by exposure to noise. Numerically, the NIPTS is the change in threshold that can be expected from daily exposure to noise over a normal working lifetime of 40 years. A grand average of the NIPTS over time and hearing sensitivity is termed the Average NIPTS, or Ave. NIPTS for short. The Ave. NIPTS that can be expected for noise measured by the $L_{eq(24)}$ metric is given in Table A-5. Table A-5 assumes exposure to the full outdoor noise throughout the 24 hours. When inside a building, the exposure will be less (Eldred and von Gierke 1993).

The Ave. NIPTS is estimated as an average over all people exposed to the noise. The actual value of NIPTS for any given person will depend on their physical sensitivity to noise – some will experience more hearing loss than others. The USEPA Guidelines provide information on this variation in sensitivity in the form of the NIPTS exceeded by 10% of the population, which is included in the Table A-5 in the "10^{th} Percentile NIPTS" column (USEPA 1982). For individuals exposed to $L_{eq(24)}$ of 80 dB, the most sensitive of the population would be expected to show degradation to their hearing of 7 dB over time.

To put these numbers in perspective, changes in hearing level of less than 5 dB are generally not considered noticeable or significant. Furthermore, there is no known evidence that a NIPTS of 5 dB is perceptible or has any practical significance for the individual. Lastly, the variability in audiometric testing is generally assumed to be ±5 dB (USEPA 1974).

Table A-5. Ave. NIPTS and 10th Percentile NIPTS as a Function of $L_{eq(24)}$

$L_{eq(24)}$	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
85-86	6.0	12.0
86-87	7.0	13.5
87-88	7.5	15.0
88-89	8.5	16.5
89-90	9.5	18.0

** rounded to the nearest 0.5 dB*

Source: DOD 2012.

The scientific community has concluded that noise exposure from civil airports has little chance of causing permanent hearing loss (Newman and Beattie 1985). For military airbases, DOD policy requires that hearing risk loss be estimated for population exposed to $L_{eq(24)}$ of 80 dB or higher (DOD 2012), including residents of on-base housing. Exposure of workers inside the base boundary is assessed using DOD regulations for occupational noise exposure.

Noise in low-altitude military airspace, especially along MTRs where L_{max} can exceed 115 dB, is of concern. That is the upper limit used for occupational noise exposure (e.g., U.S. Department of Labor 1971). One laboratory study (Ising et al. 1999) concluded that events with L_{max} above 114 dB have the potential to cause hearing loss. Another laboratory study of participants exposed to levels between 115 and 130 dB (Nixon et al. 1993), however, showed conflicting results. For an exposure to four events across that range, half the subjects showed no change in hearing, a quarter showed a temporary 5 dB decrease in sensitivity, and a quarter showed a temporary 5 dB increase in sensitivity. For exposure to eight events of 130 dB, subjects showed an increase in sensitivity of up to 10 dB (Nixon et al. 1993).

Summary

Aviation noise levels are not comparable to the occupational noise levels associated with hearing loss of workers in manufacturing industries. There is little chance of hearing loss at levels less than 75 dB DNL. Noise levels equal to or greater than 75 dB DNL can occur near military airbases, and DOD policy specifies that NIPTS be evaluated when exposure exceeds 80 dB $L_{eq(24)}$ (DOD 2009c). There is some concern about L_{max} exceeding 115 dB in low altitude military airspace, but no research results to date have definitely related permanent hearing impairment to aviation noise.

A.3.5 Non-auditory Health Effects

Studies have been performed to see whether noise can cause health effects other than hearing loss. The premise is that annoyance causes stress. Prolonged stress is known to be a contributor to a number of health disorders. Cantrell (1974) confirmed that noise can provoke stress, but noted that results on cardiovascular health have been contradictory. Some studies have found a connection between aircraft noise and blood pressure (e.g., Michalak et al. 1990; Rosenlund et al. 2001), while others have not (e.g., Pulles et al. 1990).

Kryter and Poza (1980) noted, "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."

The connection from annoyance to stress to health issues requires careful experimental design. Some highly publicized reports on health effects have, in fact, been rooted in poorly done science. Meecham and Shaw (1979) apparently found a relation between noise levels and mortality rates in neighborhoods under the approach path to Los Angeles International Airport. When the same data were analyzed by others (Frerichs et al. 1980) no relationship was found. Jones and Tauscher (1978) found a high rate of birth defects for the same neighborhood. But when the Centers For Disease Control performed a more thorough study near Atlanta's Hartsfield International Airport, no relationships were found for levels above 65 dB (Edmonds et al. 1979).

A carefully designed study, Hypertension and Exposure to Noise near Airports (HYENA), was conducted around six European airports from 2002 through 2006 (Jarup et al. 2005, 2008). There were 4,861 subjects, aged between 45 and 70. Blood pressure was measured, and questionnaires administered for health, socioeconomic and lifestyle factors, including diet and physical exercise. Hypertension was defined by WHO blood pressure thresholds (WHO 2003). Noise from aircraft and highways was predicted from models.

HYENA results were presented as an odds ratio (OR). An OR of 1 means there is no added risk, while an OR of 2 would mean risk doubles. An OR of 1.14 was found for nighttime aircraft noise, measured by L_{night}, the L_{eq} for nighttime hours. For daytime aircraft noise, measured by $L_{eq(16)}$, the OR was 0.93. For road traffic noise, measured by the full day $L_{eq(24)}$, the OR was 1.1.

Note that OR is a statistical measure of change, not the actual risk. Risk itself and the measured effects were small, and not necessarily distinct from other events. Haralabidis et al. (2008) reported an increase in systolic blood pressure of 6.2 millimeters of mercury (mmHg) for aircraft noise, and an increase of 7.4 mmHg for other indoor noises such as snoring.

It is interesting that aircraft noise was a factor only at night, while traffic noise is a factor for the full day. Aircraft noise results varied among the six countries so that result is pooled across all data. Traffic noise results were consistent across the six countries.

One interesting conclusion from a 2013 study of the HYENA data (Babisch et al. 2013) states there is some indication that noise level is a stronger predictor of hypertension than annoyance. That is not consistent with the idea that annoyance is a link in the connection between noise and stress. Babisch et al. (2012) present interesting insights on the relationship of the results to various modifiers.

Two recent studies examined the correlation of aircraft noise with hospital admissions for cardiovascular disease. Hansell et al. (2013) examined neighborhoods around London's Heathrow airport. Correia et al. (2013) examined neighborhoods around 89 airports in the United States. Both studies included areas of various noise levels. They found associations that were consistent with the HYENA results. The authors of these studies noted that further research is needed to refine the associations and the causal interpretation with noise or possible alternative explanations.

Summary

The current state of scientific knowledge cannot yet support inference of a causal or consistent relationship between aircraft noise exposure and non-auditory health consequences for exposed residents. The large scale HYENA study, and the recent studies by Hansell et al. (2013) and Correia et al. (2013) offer indications, but it is not yet possible to establish a quantitative cause and effect based on the currently available scientific evidence.

A.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 found links between continuous high noise levels and performance loss. Noise-induced performance losses are most frequently reported in studies where noise levels are above 85 dB. Little change has been found in low-noise cases. 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 workers.

A.3.7 Noise Effects on Children

Recent studies on school children indicate a potential link between aircraft noise and both reading comprehension and learning motivation. The effects may be small but may be of particular concern for children who are already scholastically challenged.

A.3.7.1 Effects on Learning and Cognitive Abilities

Early studies in several countries (Cohen et al. 1973, 1980, 1981; Bronzaft and McCarthy 1975; Green et al. 1982; Evans et al. 1998; Haines et al. 2002; Lercher et al. 2003) showed lower reading scores for children living or attending school in noisy areas than for children away from those areas. In some studies noise exposed children were less likely to solve difficult puzzles or more likely to give up.

More recently, the Road Traffic and Aircraft Noise Exposure and Children's Cognition and Health (RANCH) study (Stansfeld et al. 2005; Clark et al. 2005) compared the effect of aircraft and road traffic noise on over 2.000 children in three countries. This was the first study to derive exposure-effect associations for a range of cognitive and health effects, and was the first to compare effects across countries.

The study found a linear relation between chronic aircraft noise exposure and impaired reading comprehension and recognition memory. No associations were found between chronic road traffic noise exposure and cognition. Conceptual recall and information recall surprisingly showed better performance in high road traffic noise areas. Neither aircraft noise nor road traffic noise affected attention or working memory (Stansfeld et al. 2005; Clark et al. 2006).

Figure A-11 shows RANCH's result relating noise to reading comprehension. It shows that reading falls below average (a z-score of 0) at L_{eq} greater than 55 dB. Because the relationship is linear, reducing exposure at any level should lead to improvements in reading comprehension.

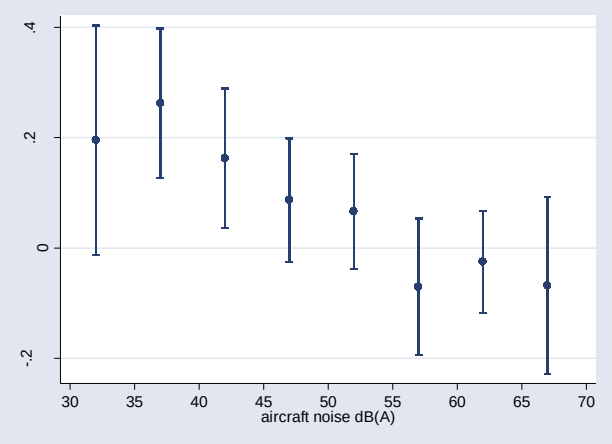


Figure A-11. RANCH Study Reading Scores Varying with L_{eq}
Sources: Stansfeld et al. 2005; Clark et al. 2006

An observation of the RANCH study was that children may be exposed to aircraft noise for many of their childhood years and the consequences of long-term noise exposure were unknown. A follow-up study of the children in the RANCH project is being analyzed to examine the long-term effects on children's reading comprehension (Clark et al. 2009). Preliminary analysis indicated a trend for reading comprehension to be poorer at 15-16 years of age for children who attended noise-exposed primary schools. There was also a trend for reading comprehension to be poorer in aircraft noise exposed secondary schools. Further analysis adjusting for confounding factors is ongoing, and is needed to confirm these initial conclusions.

FICAN funded a pilot study to assess the relationship between aircraft noise reduction and standardized test scores (Eagan et al. 2004; FICAN 2007). The study evaluated whether abrupt aircraft noise reduction within classrooms, from either airport closure or sound insulation, was associated with improvements in test scores. Data were collected in 35 public schools near three airports in Illinois and Texas. The study used several noise metrics. These were, however, all computed indoor levels, which makes it hard to compare with the outdoor levels used in most other studies.

The FICAN study found a significant association between noise reduction and a decrease in failure rates for high school students, but not middle or elementary school students. There were some weaker associations between noise reduction and an increase in failure rates for middle and elementary schools. Overall the study found that the associations observed were similar for children with or without learning difficulties, and between verbal and math/science tests. As a pilot study, it was not expected to obtain final answers, but provided useful indications (FICAN 2007).

While there are many factors that can 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 WHO and a North Atlantic Treaty Organization (NATO) 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 (NATO 2000; WHO 1999). The awareness has also led to the classroom noise standard discussed earlier (ANSI 2002).

A.3.7.2 Health Effects

A number of studies, including some of the cognitive studies discussed above, have examined the potential for effects on children's health. Health effects include annoyance, psychological health, coronary risk, stress hormones, sleep disturbance and hearing loss.

Annoyance. Chronic noise exposure causes annoyance in children (Bronzaft and McCarthy 1975; Evans et al. 1995). Annoyance among children tends to be higher than for adults, and there is little habituation

(Haines et al. 2001a). The RANCH study found annoyance may play a role in how noise affects reading comprehension (Clark et al. 2005).

Psychological Health. Lercher et al. (2002) found an association between noise and teacher ratings of psychological health, but only for children with biological risk defined by low birth weight and/or premature birth. Haines et al. (2001b) found that children exposed to aircraft noise had higher levels of psychological distress and hyperactivity. Stansfeld et al. (2009) replicated the hyperactivity result, but not distress.

As with studies of adults, the evidence suggests that chronic noise exposure is probably not associated with serious psychological illness, but there may be effects on well-being and quality of life. Further research is needed, particularly on whether hyperactive children are more susceptible to stressors such as aircraft noise.

Coronary Risk. The HYENA study discussed earlier indicated a possible relation between noise and hypertension in older adults. Cohen et al. (1980, 1981) found some increase in blood pressure among school children, but within the normal range and not indicating hypertension. Hygge et al. (2002) found mixed effects. The RANCH study found some effect for children at home and at night, but not at school. Overall the evidence for noise effects on children's blood pressure is mixed, and less certain than for older adults.

Stress Hormones. Some studies investigated hormonal levels between groups of children exposed to aircraft noise compared to those in a control group. Two studies analyzed cortisol and urinary catecholamine levels in school children as measurements of stress response to aircraft noise (Haines et al. 2001a, 2001b). In both instances, there were no differences between the aircraft-noise-exposed children and the control groups.

Sleep Disturbance. A sub-study of RANCH in a Swedish sample used sleep logs and the monitoring of rest/activity cycles to compare the effect of road traffic noise on child and parent sleep (Ohrstrom et al. 2006). An exposure-response relationship was found for sleep quality and daytime sleepiness for children. While this suggests effects of noise on children's sleep disturbance, it is difficult to generalize from one study.

Hearing loss. A few studies have examined hearing loss from exposure to aircraft noise. Noise-induced hearing loss for children who attended a school located under a flight path near a Taiwan airport was greater than for 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 greater than 75 dB DNL and L_{max} were about 87 dB during overflights. Conversely, several other studies reported no difference in hearing ability between children exposed to high levels of airport noise and children located in quieter areas (Andrus et al. 1975; Fisch 1977; Wu et al. 1995). It is not clear from those results whether children are at higher risk than adults, but the levels involved are higher than those desirable for learning and quality of life.

Ludlow and Sixsmith (1999) conducted a cross-sectional pilot study to examine the hypothesis that military jet noise exposure early in life is associated with raised hearing thresholds. The authors concluded that there were no significant differences in audiometric test results between military personnel who as children had lived in or near stations where fast jet operations were based, and a similar group who had no such exposure as children.

A.3.8 Property Values

Noise can affect the value of homes. Economic studies of property values based on selling prices and noise have been conducted to find a direct relation.

The value-noise relation is usually presented as the Noise Depreciation Index (NDI) or Noise Sensitivity Depreciation Index (NSDI), the percent loss of value per dB (measured by the DNL metric). An early study by Nelson (1978) at three airports found an NDI of 1.8-2.3% per dB. Nelson also noted a decline in NDI over time which he theorized could be due to either a change in population or the increase in commercial value of the property near airports. Crowley (1978) reached a similar conclusion. A larger study by Nelson (1980) looking at 18 airports found an NDI from 0.5 to 0.6% per dB.

In a review of property value studies, Newman and Beattie (1985) found a range of NDI from 0.2 to 2% per dB. They noted that many factors other than noise affected values.

Fidell et al. (1996) studied the influence of aircraft noise on actual sale prices of residential properties in the vicinity of a military base in Virginia and one in Arizona. They found no meaningful effect on home values. Their results may have been due to non-noise factors, especially the wide differences in homes between the two study areas.

Recent studies of noise effects on property values have recognized the need to account for non-noise factors. Nelson (2004) analyzed data from 33 airports, and discussed the need to account for those factors and the need for careful statistics. His analysis showed NDI from 0.3 to 1.5% per dB, with an average of about 0.65% per dB. Nelson (2007) and Andersson et al. (2013) discuss statistical modeling in more detail.

Enough data is available to conclude that aircraft noise has a real effect on property values. This effect falls in the range of 0.2 to 2.0% per dB, with the average on the order of 0.5% per dB. The actual value varies from location to location, and is very often small compared to non-noise factors.

A.3.9 Noise-Induced Vibration Effects on Structures and Humans

High noise levels can cause buildings to vibrate. If high enough, building components can be damaged. The most sensitive components of a building are the windows, followed by plaster walls and ceilings. Possibility of damage depends on the peak sound pressures and the resonances of the building. In general, damage is possible only for sounds lasting more than one second above an unweighted sound level of 130 dB (CHABA 1977). That is higher than expected from normal aircraft operations. Even low altitude flyovers of heavy aircraft do not reach the potential for damage (Sutherland 1990).

Noise-induced structural vibration may cause annoyance to dwelling occupants because of induced secondary vibrations, or "rattle", of objects within the dwelling – hanging pictures, dishes, plaques, and bric-a-brac. Loose window panes may also vibrate noticeably when exposed to high levels of airborne noise, causing homeowners to fear breakage. In general, rattling occurs at peak unweighted sound levels that last for several seconds at levels above 110 dB, which is well above that considered normally compatible with residential land use Thus, assessments of noise exposure levels for compatible land use will also be protective of noise-induced rattle.

The sound from an aircraft overflight travels from the exterior to the interior of the house in one of two ways: through the solid structural elements and directly through the air. Figure A-12 illustrates the sound transmission through a wall constructed with a brick exterior, stud framing, interior finish wall, and absorbent material in the cavity. The sound transmission starts with noise impinging on the wall exterior. Some of this sound energy will be reflected away and some will make the wall vibrate. The vibrating wall radiates sound into the airspace, which in turn sets the interior finish surface vibrating, with some energy lost in the airspace. This surface then radiates sound into the dwelling interior. As the figure shows, vibrational energy also bypasses the air cavity by traveling through the studs and edge connections.

Normally, the most sensitive components of a structure to airborne noise are the windows, followed by plastered walls and ceilings. An evaluation of the peak sound pressures impinging on the structure is normally sufficient to determine the possibility of damage. In general, at unweighted sound levels above 130 dB, there is the possibility of structural damage. While certain frequencies (such as 30 Hertz for window breakage) may be of more concern than other frequencies, conservatively, only sounds lasting more than one second above a unweighted sound level of 130 dB are potentially damaging to structural components (von Gierke and Ward 1991).

In the assessment of vibration on humans, the following factors determine if a person will perceive and possibly react to building vibrations:

1. Type of excitation: steady state, intermittent, or impulsive vibration.
2. Frequency of the excitation. International Organization for Standardization (ISO) standard 2631-2 (ISO 1989) recommends a frequency range of 1 to 80 Hz for the assessment of vibration on humans.
3. Orientation of the body with respect to the vibration.
4. The use of the occupied space (i.e., residential, workshop, hospital).
5. Time of day.

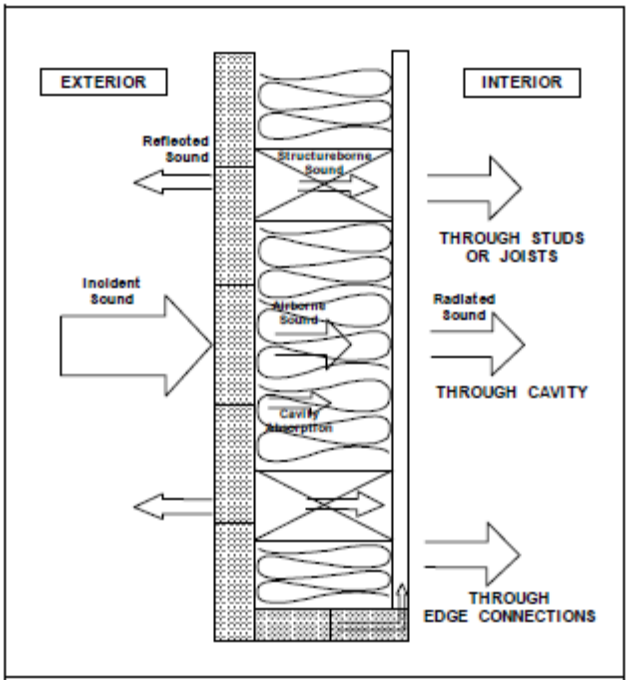


Figure A-12. Depiction of Sound Transmission through Built Construction

Table A-6 lists the whole-body vibration criteria from ISO 2631-2 for one-third octave frequency bands from 1 to 80 Hz.

Table A-6. Vibration Criteria for the Evaluation of Human Exposure to Whole-Body Vibration

	RMS Acceleration (m/s/s)		
Frequency (Hz)	Combined Criteria Base Curve	Residential Night	Residential Day
1.00	0.0036	0.0050	0.0072
1.25	0.0036	0.0050	0.0072
1.60	0.0036	0.0050	0.0072
2.00	0.0036	0.0050	0.0072
2.50	0.0037	0.0052	0.0074
3.15	0.0039	0.0054	0.0077
4.00	0.0041	0.0057	0.0081
5.00	0.0043	0.0060	0.0086
6.30	0.0046	0.0064	0.0092
8.00	0.0050	0.0070	0.0100
10.00	0.0063	0.0088	0.0126
12.50	0.0078	0.0109	0.0156
16.00	0.0100	0.0140	0.0200
20.00	0.0125	0.0175	0.0250
25.00	0.0156	0.0218	0.0312
31.50	0.0197	0.0276	0.0394
40.00	0.0250	0.0350	0.0500
50.00	0.0313	0.0438	0.0626
63.00	0.0394	0.0552	0.0788
80.00	0.0500	0.0700	0.1000

Source: ISO 1989.

A.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 events. It is improbable that such effects would result from routine subsonic aircraft operations.

A.3.11 Noise Effects on Historical and Archaeological Sites

Historical buildings and sites can have elements that are more fragile than conventional structures. Aircraft noise may affect such sites more severely than newer, modern structures. In older structures, seemingly insignificant surface cracks caused 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 measurements of noise and vibration in a restored plantation house, originally built in 1795. It is located 1,500 feet from the centerline at the departure end of Runway 19L at Washington Dulles International Airport. The aircraft measured was the Concorde. 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 (Wesler 1977).

As for conventional structures, noise exposure levels for normally compatible land uses should also be protective of historic and archaeological sites. Unique sites should, of course, be analyzed for specific exposure.

A.3.12 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 are 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 1960s and 1970s 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. 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 Manci et al. (1988) 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.

A.3.12.1 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 summarized 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. A similar study reported abortions occurred in three out of five pregnant cattle after exposing them to flyovers by six different aircraft. Another study suggested that feedlot cattle could stampede and injure themselves when exposed to low-level overflights (U.S. Air Force 1994a).

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 1-year time period and none were associated with aircraft disturbances (U.S. Air Force 1993). In 1987, researchers contacted seven livestock operators for production data, and no effects of low-altitude and supersonic flights were noted. Of the 43 cattle previously exposed to low-altitude flights, 3 showed a startle response to an F/A-18 aircraft flying overhead at 500 feet above ground level (AGL) and 400 knots by running less than 10 meters (m). They resumed normal activity within 1 minute (U.S. Air Force 1994a). Beyer (1983) found that helicopters caused more reaction than other low-aircraft overflights, and that the helicopters at 30-60 feet overhead did not affect milk production and pregnancies of 44 cows in a 1964 study (U.S. Air Force 1994a).

Additionally, Beyer (1983) 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. 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 1994a).

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 50-100 m), as animals take care not to damage themselves (U.S. Forest Service 1992). If animals are overflown by aircraft at altitudes of 50-100 m, 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 1994a). 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 100-135 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 (Gladwin et al. 1988; Manci 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 feet) on domestic fowl, overflight activity has negligible effects (U.S. Air Force 1994b). 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 1994b). 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 1994b). 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 120-130 dB.

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. 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 1994b).

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. 1990). 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 1994b).

A.3.12.2 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. 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).

Mammals

Terrestrial Mammals

Studies of terrestrial mammals have shown that noise levels of 120 dB can damage mammals' ears, and levels at 95 dB 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 AGL over important grizzly and polar bear habitat. Wolves have been frightened by low-altitude flights that were 25-1,000 feet AGL. 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, rising 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-kilogram 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 (Weisenberger et al. 1996).

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, are 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 dB caused a greater intensity of startle reactions than lower-intensity booms at 72-79 dB. However, the duration of the startle responses to louder sonic booms was shorter (Jehl and Cooper 1980).

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 Park 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. 1993).

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 1,000 to 5,000 Hz, 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 (Ellis et al. 1991; Grubb and King 1991). Threshold noise levels for significant responses range from 62 dB for Pacific black brant to 85 dB for crested tern (Brown 1990; Ward and Stehn 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 cooperative study between the DOD and the U.S. Fish and Wildlife Service (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 m away and SELs were 70 dB.

Lynch and Speake (1978) studied the effects of both real and simulated sonic booms on the nesting and brooding eastern wild turkey 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 10-20 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 4-8 m). Afterward, the poults resumed feeding activities while the hens remained alert for a short period of time (approximately 15-20 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.

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 re-occupancy. 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 (Ellis et al. 1991).

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 dB) 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 m 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 m, 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 (USFWS 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 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 (9 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.

Migratory Waterfowl

Fleming et al. (1996) conducted a study of caged American black ducks found 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 (Fleming et al. 1996).

Another study by Conomy et al. (1998) exposed previously unexposed ducks to 71 noise events per day that equaled or exceeded 80 dB. It was determined that the proportion of time black ducks reacted to aircraft activity and noise decreased from 38% to 6% in 17 days and remained stable at 5.8% 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 less than 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).

Wading and Shorebirds

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 dB 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% of the 220 observations. Approximately 90% displayed no reaction or merely looked toward the direction of the noise source. Another 6% stood up, 3% walked from the nest, and 2% 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 85-100 dB on approach and 94-105 dB 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, sooty terns 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 tern hatch failure.

Subsequent laboratory tests of exposure of eggs to sonic booms and other impulsive noises (Cottereau 1972; Cogger and Zegarra 1980; Bowles et al. 1991, 1994) failed to show adverse effects on hatching of eggs. A structural analysis by 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.

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 spadefoot toads, 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 a DNL of 85 dB.

A.3.12.3 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.

A.4 References

Acoustical Society of America. 1980. *San Diego Workshop on the Interaction Between Manmade Noise and Vibration and Arctic Marine Wildlife*. Acoustical Society of America, Am. Inst. Physics, New York. 84 pp.

American Speech-Language-Hearing Association. 1995. *Guidelines for Acoustics in Educational Environments*, V.37, Suppl. 14, pgs. 15-19.

Anderson, D.E., O.J. Rongstad, and W.R. Mytton. 1989. *Responses of Nesting Red-tailed Hawks to Helicopter Overflights*, The Condor, Vol. 91, pp. 296-299.

Andersson, H., L. Jonsson, and M. Ogren. 2013. "Benefit measures for noise abatement: calculations for road and rail traffic noise," *Eur. Transp. Res. Rev.* 5:135–148.

Andrus, W.S., M.E. Kerrigan, and K.T. Bird. 1975. *Hearing in Para-Airport Children*. Aviation, Space, and Environmental Medicine, Vol. 46, pp. 740-742.

ANSI. 1985. *Specification for Sound Level Meters*, ANSI S1.4A-1985 Amendment to ANSI S1.4-1983.

ANSI. 1988. *Quantities and Procedures for Description and Measurement of Environmental Sound: Part 1*, ANSI S12.9-1988.

ANSI. 1996. *Quantities and Procedures for Description and Measurement of Environmental Sound: Part 4*, ANSI S12.9-1996.

ANSI 2002. *Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools,* ANSI S12.60-2002.

ANSI 2008. *Methods for Estimation of Awakenings with Outdoor Noise Events Heard in Homes*, ANSI S12.9-2008/Part6.Austin, Jr., O.L., W.B. Robertson, Jr., and G.E. Wolfenden. 1970. "Mass Hatching Failure in Dry Tortugas Sooty Terns (Sterna fuscata)," *Proceedings of the XVth International Arnithological Congress*, The Hague, The Netherlands, August 30 through September 5.

Babisch, W., W. Swart, D. Houthuijs, J. Selander, G. Bluhm, G. Pershagen, K. Dimakopoulou, A.S. Haralabidis, K. Katsouyanni, E. Davou, P. Sourtzi, E. Cadum, F. Vigna-Taglianti, S. Floud, and A.L. Hansell. 2012. "Exposure modifiers of the relationships of transportation noise with high blood pressure and noise annoyance," *J. Acoust. Soc. Am.*, Vol. 132, No. 6, pp. 3788-3808, December.

Babisch, W., G. Pershagen, J. Selander, D. Houthuijs, O. Breugelmans, E. Cadum, F. Vigna-Taglianti, K. Katsouyanni, A.S. Haralabidis, K. Dimakopoulou, P. Sourtzi, S. Floud, and A.L. Hansell. 2013. Noise annoyance – A modifier of the association between noise level and cardiovascular health? *Science of the Total Environment*, Volumes 452-453, pp. 50-57, May.

Basner, M., H. Buess, U. Miller, G. Platt, and A. Samuel. 2004. "Aircraft Noise Effects on Sleep: Final Results of DLR Laboratory and Field Studies of 2240 Polysomnographically Recorded Subject Nights", *Internoise 2004, The 33rd International Congress and Exposition on Noise Control Engineering*, August 22-25.

Berger, E.H., W.D. Ward, J.C. Morrill, and L.H. Royster. 1995. *Noise And Hearing Conservation Manual, Fourth Edition*, American Industrial Hygiene Association, Fairfax, Virginia.

Berglund, B., and T. Lindvall, eds. 1995. *Community Noise*, Jannes Snabbtryck, Stockholm, Sweden.

Beyer, D. 1983. "Studies of the Effects of Low-Flying Aircraft on Endocrinological and Physiological Parameters in Pregnant Cows," Veterinary College of Hannover, München, Germany.

Black, B., M. Collopy, H. Percivial, A. Tiller, and P. Bohall. 1984. "Effects of Low-Altitude Military Training Flights on Wading Bird Colonies in Florida," Florida Cooperative Fish and Wildlife Research Unit, Technical Report No. 7.

Bond, J., C.F. Winchester, L.E. Campbell, and J.C. Webb. 1963. "The Effects of Loud Sounds on the Physiology and Behavior of Swine," U.S. Department of Agriculture Agricultural Research Service Technical Bulletin 1280.

Bowles, A.E. 1995. Responses of Wildlife to Noise, In R.L. Knight and K.J. Gutzwiller, eds., "Wildlife and Recreationists: Coexistence through Management and Research," Island Press, Covelo, California, pp. 109-156.

Bowles, A.E., C. Book, and F. Bradley. 1990. "Effects of Low-Altitude Aircraft Overflights on Domestic Turkey Poults," HSD-TR-90-034.

Bowles, A.E., F.T. Awbrey, and J.R. Jehl. 1991. "The Effects of High-Amplitude Impulsive Noise On Hatching Success: A Reanalysis of the Sooty Tern Incident," HSD-TP-91-0006.

Bowles, A.E., B. Tabachnick, and S. Fidell. 1993. *Review of the Effects of Aircraft Overflights on Wildlife*, Volume II of III, Technical Report, National Park Service, Denver, Colorado.

Bowles, A.E., M. Knobler, M.D. Sneddon, and B.A. Kugler. 1994. "Effects of Simulated Sonic Booms on the Hatchability of White Leghorn Chicken Eggs," AL/OE-TR-1994-0179.

Bradley J.S. 1985. "Uniform Derivation of Optimum Conditions for Speech in Rooms," National Research Council, Building Research Note, BRN 239, Ottawa, Canada.

Bradley, J.S. 1993. "NRC-CNRC NEF Validation Study: Review of Aircraft Noise and its Effects," National Research Council Canada and Transport Canada, Contract Report A-1505.5.

Bronzaft, A.L. and D.P. McCarthy. 1975. "The effects of elevated train noise on reading ability" *J. Environment and Behavior*, 7, 517-527.

Brown, A.L. 1990. *Measuring the Effect of Aircraft Noise on Sea Birds*, Environment International, Vol. 16, pp. 587-592.

Bullock, T.H., D.P. Donning, and C.R. Best. 1980. "Evoked brain potentials demonstrate hearing in a manatee (trichechus inunguis)", *Journal of Mammals*, Vol. 61, No. 1, pp. 130-133.

Burger, J. 1981. *Behavioral Responses of Herring Gulls (Larus argentatus) to Aircraft Noise*. Environmental Pollution (Series A), Vol. 24, pp. 177-184.

Burger, J. 1986. *The Effect of Human Activity on Shorebirds in Two Coastal Bays in Northeastern United States*, Environmental Conservation, Vol. 13, No. 2, pp. 123-130.

Cantrell, R.W. 1974. *Prolonged Exposure to Intermittent Noise: Audiometric, Biochemical, Motor, Psychological, and Sleep Effects*, Laryngoscope, Supplement I, Vol. 84, No. 10, p. 2.

Casady, R.B. and R.P. Lehmann. 1967. "Response of Farm Animals to Sonic Booms", Studies at Edwards Air Force Base, June 6-30, 1966. Interim Report, U.S. Department of Agriculture, Beltsville, Maryland, p. 8.

CHABA. 1977. "Guidelines for Preparing Environmental Impact Statements on Noise," The National Research Council, National Academy of Sciences.

Chen, T. and S. Chen. 1993. *Effects of Aircraft Noise on Hearing and Auditory Pathway Function of School-Age Children*, International Archives of Occupational and Environmental Health, Vol. 65, No. 2, pp. 107-111.

Chen, T., S. Chen, P. Hsieh, and H. Chiang. 1997. *Auditory Effects of Aircraft Noise on People Living Near an Airport*, Archives of Environmental Health, Vol. 52, No. 1, pp. 45-50.

Clark, C., , R. Martin, E. van Kempen, T. Alfred, J. Head, H.W. Davies, M.M. Haines, I.L. Barrio, M. Matheson, and S.A. Stansfeld. 2005. "Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: the RANCH project," *American Journal of Epidemiology*, 163, 27-37.

Clark, C., S.A. Stansfeld, and J. Head. 2009. "The long-term effects of aircraft noise exposure on children's cognition: findings from the UK RANCH follow-up study." In *Proceedings of the Euronoise Conference*. Edinburgh, Scotland, October.

Cogger, E.A. and E.G. Zegarra. 1980. "Sonic Booms and Reproductive Performance of Marine Birds: Studies on Domestic Fowl as Analogues," In Jehl, J.R., and C.F. Cogger, eds., "Potential Effects of Space Shuttle Sonic Booms on the Biota and Geology of the California Channel Islands: Research Reports," San Diego State University Center for Marine Studies Technical Report No. 80-1.

Cohen, S., Glass, D.C. & Singer, J. E. 1973. "Apartment noise, auditory discrimination, and reading ability in children." *Journal of Experimental Social Psychology*, 9, 407-422.

Cohen, S., Evans, G.W., Krantz, D. S., et al. 1980. *Physiological, Motivational, and Cognitive Effects of Aircraft Noise on Children: Moving from Laboratory to Field*, American Psychologist, Vol. 35, pp. 231-243.

Cohen, S., Evans, G.W., Krantz, D. S., et al. 1981. "Aircraft noise and children: longitudinal and cross-sectional evidence on adaptation to noise and the effectiveness of noise abatement," *Journal of Personality and Social Psychology*, 40, 331-345.

Conomy, J.T., J.A. Dubovsky, J.A. Collazo, and W.J. Fleming. 1998. "Do black ducks and wood ducks habituate to aircraft disturbance?," *Journal of Wildlife Management*, Vol. 62, No. 3, pp. 1135-1142.

Correia, A.W., J.L. Peters, J.I. Levy, S. Melly, and F. Dominici. 2013. "Residential exposure to aircraft noise and hospital admissions for cardiovascular diseases: multi-airport retrospective study," *British Medical Journal*, 2013;347:f5561 doi: 10.1136/bmj.f5561, 8 October.

Cottereau, P. 1972. *Les Incidences Du 'Bang' Des Avions Supersoniques Sur Les Productions Et La Vie Animals*, Revue Medicine Veterinaire, Vol. 123, No. 11, pp. 1367-1409.

Cottereau, P. 1978. *The Effect of Sonic Boom from Aircraft on Wildlife and Animal Husbandry*, In "Effects of Noise on Wildlife," Academic Press, New York, New York, pp. 63-79.

Crowley, R.W. 1978. "A case study of the effects of an airport on land values," *Journal of Transportation Economics and Policy*, Vol. 7, May.

Davis, R.W., W.E. Evans, and B. Wursig, eds. 2000. *Cetaceans, Sea Turtles, and Seabirds in the Northern Gulf of Mexico: Distribution, Abundance, and Habitat Associations*, Volume II of Technical Report, prepared by Texas A&M University at Galveston and the National Marine Fisheries Service. U.S. Department of the Interior, Geological Survey, Biological Resources Division, USGS/BRD/CR-1999-0006 and Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, Louisiana, OCS Study MMS 2000-003.

DOD. 1978. "Environmental Protection, Planning in the Noise Environment", Air Force Manual AFM 19-10, Technical Manual TM 5-803-2, NAVFAC P-870, Departments of the Air Force, the Army and the Navy. 15 June.

DOD. 2009a. "Improving Aviation Noise Planning, Analysis, and Public Communication with Supplemental Metrics," Defense Noise Working Group Technical Bulletin, December.

DOD. 2009b. "Sleep Disturbance From Aviation Noise," Defense Noise Working Group Technical Bulletin, November.

DOD. 2009c. Memorandum from the Under Secretary of Defense, Ashton B. Carter, re: "Methodology for Assessing Hearing Loss Risk and Impacts in DoD Environmental Impact Analysis," 16 June.

DOD. 2012. "Noise–Induced Hearing Impairment Sleep Disturbance From Aviation Noise," Defense Noise Working Group Technical Bulletin, July.

Dooling, R.J. 1978. "Behavior and psychophysics of hearing in birds," *J. Acoust. Soc. Am.*, Supplement 1, Vol. 65, p. S4.

Dufour, P.A. 1980. "Effects of Noise on Wildlife and Other Animals: Review of Research Since 1971," U.S. Environmental Protection Agency.

Eagan, M.E., G. Anderson, B. Nicholas, R. Horonjeff, and T. Tivnan. 2004. "Relation Between Aircraft Noise Reduction in Schools and Standardized Test Scores," Washington, DC, FICAN.

Edmonds, L.D., P.M. Layde, and J.D. Erickson. 1979. *Airport Noise and Teratogenesis*, Archives of Environmental Health, Vol. 34, No. 4, pp. 243-247.

Edwards, R.G., A.B. Broderson, R.W. Harbour, D.F. McCoy, and C.W. Johnson. 1979. "Assessment of the Environmental Compatibility of Differing Helicopter Noise Certification Standards," U.S. Dept. of Transportation, Washington, D.C. 58 pp.

Eldred, K, and H. von Gierke. 1993. "Effects of Noise on People," Noise News International, 1(2), 67-89, June.

Ellis, D.H., C.H. Ellis, and D.P. Mindell. 1991. *Raptor Responses to Low-Level Jet Aircraft and Sonic Booms*, Environmental Pollution, Vol. 74, pp. 53-83.

Evans, G.W., S. Hygge, and M. Bullinger. 1995. "Chronic noise and psychological stress," *J. Psychological Science*, 6, 333-338.

Evans, G.W., M. Bullinger, and S. Hygge. 1998. *Chronic Noise Exposure and Physiological Response: A Prospective Study of Children Living under Environmental Stress*, Psychological Science, Vol. 9, pp. 75-77.

FAA. 1985. *Airport Improvement Program (AIP) Handbook*, Order No. 100.38.

FICAN. 1997. "Effects of Aviation Noise on Awakenings from Sleep," June.

FICAN. 2007. "Findings of the FICAN Pilot Study on the Relationship Between Aircraft Noise Reduction and Changes in Standardised Test Scores," Washington, DC, FICAN.

FICAN. 2008. "FICAN Recommendation for use of ANSI Standard to Predict Awakenings from Aircraft Noise," December.

FICON. 1992. "Federal Agency Review of Selected Airport Noise Analysis Issues," August.

Fidell, S., and Silvati, L. 2004. "Parsimonious alternatives to regression analysis for characterizing prevalence rates of aircraft noise annoyance," *Noise Control Eng. J.* 52, 56–68.

Fidell, S., K. Pearsons, R. Howe, B. Tabachnick, L. Silvati, and D.S. Barber. 1994. "Noise-Induced Sleep Disturbance in Residential Settings," AL/OE-TR-1994-0131, Wright Patterson AFB, OH, Armstrong Laboratory, Occupational & Environmental Health Division.

Fidell, S., K. Pearsons, B. Tabachnick, R. Howe, L. Silvati, and D.S. Barber. 1995a. "Field study of noise-induced sleep disturbance," *Journal of the Acoustical Society of America*, Vol. 98, No. 2, pp. 1025-1033.

Fidell, S., R. Howe, B. Tabachnick, K. Pearsons, and M. Sneddon. 1995b. "Noise-induced Sleep Disturbance in Residences near Two Civil Airports," NASA Contractor Report 198252.

Fidell, S., B. Tabachnick, and L. Silvati. 1996. "Effects of Military Aircraft Noise on Residential Property Values," BBN Systems and Technologies, BBN Report No. 8102.

Finegold, L.S., C.S. Harris, and H.E. von Gierke. 1994. "Community annoyance and sleep disturbance: updated criteria for assessing the impact of general transportation noise on people," *Noise Control Engineering Journal*, Vol. 42, No. 1, pp. 25-30.

Fisch, L. 1977. "Research Into Effects of Aircraft Noise on Hearing of Children in Exposed Residential Areas Around an Airport," Acoustics Letters, Vol. 1, pp. 42-43.

Fleischner, T.L. and S. Weisberg. 1986. "Effects of Jet Aircraft Activity on Bald Eagles in the Vicinity of Bellingham International Airport," Unpublished Report, DEVCO Aviation Consultants, Bellingham, WA.

Fleming, W.J., J. Dubovsky, and J. Collazo. 1996. "An Assessment of the Effects of Aircraft Activities on Waterfowl at Piney Island, North Carolina," Final Report by the North Carolina Cooperative Fish and Wildlife Research Unit, North Carolina State University, prepared for the Marine Corps Air Station, Cherry Point.

Fraser, J.D., L.D. Franzel, and J.G. Mathiesen. 1985. "The impact of human activities on breeding bald eagles in north-central Minnesota," *Journal of Wildlife Management*, Vol. 49, pp. 585-592.

Frerichs, R.R., B.L. Beeman, and A.H. Coulson. 1980. "Los Angeles Airport noise and mortality: faulty analysis and public policy," *Am. J. Public Health*, Vol. 70, No. 4, pp. 357-362, April.

Gladwin, D.N., K.M. Manci, and R. Villella. 1988. "Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife," Bibliographic Abstracts, NERC-88/32. U.S. Fish and Wildlife Service National Ecology Research Center, Ft. Collins, Colorado.

Green, K.B., B.S. Pasternack, and R.E. Shore. 1982. *Effects of Aircraft Noise on Reading Ability of School-Age Children*, Archives of Environmental Health, Vol. 37, No. 1, pp. 24-31.

Griefahn, B. 1978. Research on Noise Disturbed Sleep Since 1973, *Proceedings of Third Int. Cong. On Noise as a Public Health Problem*, pp. 377-390 (as appears in NRC-CNRC NEF Validation Study: (2) *Review of Aircraft Noise and Its Effects*, A-1505.1, p. 31).

Grubb, T.G., and R.M. King. 1991. "Assessing human disturbance of breeding bald eagles with classification tree models," *Journal of Wildlife Management*, Vol. 55, No. 3, pp. 500-511.

Gunn, W.W.H., and J.A. Livingston. 1974. "Disturbance to Birds by Gas Compressor Noise Simulators, Aircraft, and Human Activity in the MacKenzie Valley and the North Slope," Chapters VI-VIII, Arctic Gas Biological Report, Series Vol. 14.

Haines, M.M., S.A. Stansfeld, R.F. Job, B. Berglund, and J. Head. 2001a. *Chronic Aircraft Noise Exposure, Stress Responses, Mental Health and Cognitive Performance in School Children*, Psychological Medicine, Vol. 31, pp. 265 277, February.

Haines, M.M., S.A. Stansfeld, S. Brentnall, J. Head, B. Berry, M. Jiggins, and S. Hygge. 2001b. *The West London Schools Study: the Effects of Chronic Aircraft Noise Exposure on Child Health*, Psychological Medicine, Vol. 31, pp. 1385-1396. November.

Haines, M.M., S.A. Stansfeld, J. Head, and R.F.S. Job. 2002. "Multilevel modelling of aircraft noise on performance tests in schools around Heathrow Airport London," *Journal of Epidemiology and Community Health*, 56, 139-144.

Hansell, A.L., M. Blangiardo, L. Fortunato, S. Floud, K. de Hoogh, D. Fecht, R.E. Ghosh, H.E. Laszlo, C. Pearson, L. Beale, S. Beevers, J. Gulliver, N. Best, S. Richardson, and P. Elliott. 2013. "Aircraft noise and cardiovascular disease near Heathrow airport in London: small area study," *British Medical Journal*, 2013;347:f5432 doi: 10.1136/bmj.f5432, 8 October.

Hanson, C.E., K.W. King, M.E. Eagan, and R.D. Horonjeff. 1991. "Aircraft Noise Effects on Cultural Resources: Review of Technical Literature," Report No. HMMH-290940.04-1, available as PB93-205300, sponsored by National Park Service, Denver CO.

Haralabidis, A.S., Dimakopoulou, K., Vigna-Taglianti, F., Giampaolo, M, Borgini, A., Dudley, M.-L., Pershagen, G., Bluhm, G., Houthuijs, D., Babisch, W., Velonakis, M., Katsouyanni, K., and Jarup, L., for the HYENA Consortium. 2008. "Acute effects of night-time noise exposure on blood pressure in populations living near airports," *European Heart Journal*, doi:10.1093/eurheartj/ehn013.

Harris, C.M. 1979. *Handbook of Noise Control*, McGraw-Hill Book Co.

Hygge, S., G.W. Evans, and M. Bullinger. 2002. *A Prospective Study of Some Effects of Aircraft Noise on Cognitive Performance in School Children*, Psychological Science Vol. 13, pp. 469-474.

Ising, H., Z. Joachims, W. Babisch, and E. Rebentisch. 1999. *Effects of Military Low-Altitude Flight Noise I Temporary Threshold Shift in Humans*, Zeitschrift fur Audiologie (Germany), Vol. 38, No. 4, pp. 118-127.

ISO. 1989. "Evaluation of Human Exposure to Whole-Body Vibration – Part 2: Continuous and Shock-Induced Vibration in Buildings (1 to 80 Hz)," International Organization for Standardization, Standard 2631-2, February.

Jarup L., M.L. Dudley, W. Babisch, D. Houthuijs, W. Swart, G. Pershagen, G. Bluhm, K. Katsouyanni, M. Velonakis, E. Cadum, and F. Vigna-Taglianti for the HYENA Consortium. 2005. "Hypertension and Exposure to Noise near Airports (HYENA): Study Design and Noise Exposure Assessment," Environ Health Perspect 2005, 113: 1473–1478.

Jarup L., W. Babisch, D. Houthuijs, G. Pershagen, K. Katsouyanni, E. Cadum, M-L. Dudley, P. Savigny, I. Seiffert, W. Swart, O. Breugelmans, G. Bluhm, J. Selander, A. Haralabidis, K. Dimakopoulou, P. Sourtzi, M. Velonakis, and F. VignaTaglianti, on behalf of the HYENA study team. 2008. "Hypertension and Exposure to Noise near Airports - the HYENA study," Environ Health Perspect 2008, 116:329-33.

Jehl, J.R. and C.F. Cooper, eds. 1980. "Potential Effects of Space Shuttle Sonic Booms on the Biota and Geology of the California Channel Islands," Technical Report No. 80-1, Center for Marine Studies, San Diego State University, San Diego, CA.

Jones, F.N. and J. Tauscher. 1978. "Residence Under an Airport Landing Pattern as a Factor in Teratism," Archives of Environmental Health, pp. 10-12, January/February.

Kovalcik, K. and J. Sottnik. 1971. *Vplyv Hluku Na Mliekovú Úzitkovost Kráv* [*The Effect of Noise on the Milk Efficiency of Cows*], Zivocisná Vyroba, Vol. 16, Nos. 10-11, pp. 795-804.

Kryter, K.D. and F. Poza. 1980. "Effects of noise on some autonomic system activities," *J. Acoust. Soc. Am.*, Vol. 67, No. 6, pp. 2036-2044.

Kushlan, J.A. 1978. "Effects of helicopter censuses on wading bird colonies," *Journal of Wildlife Management*, Vol. 43, No. 3, pp. 756-760.

Lazarus H. 1990. "New Methods for Describing and Assessing Direct Speech Communication Under Disturbing Conditions," Environment International, 16: 373-392.

LeBlanc, M.M., C. Lombard, S. Lieb, E. Klapstein, and R. Massey. 1991. "Physiological Responses of Horses to Simulated Aircraft Noise," U.S. Air Force, NSBIT Program for University of Florida.

Lercher, P., G.W. Evans, M. Meis, and K. Kofler. 2002. "Ambient neighbourhood noise and children's mental health," *J. Occupational and Environmental Medicine*, 59, 380-386.

Lercher, P., G.W. Evans, and M. Meis. 2003. "Ambient noise and cognitive processes among primary school children," *J. Environment and Behavior*, 35, 725-735.

Lind S.J., K. Pearsons, and S. Fidell. 1998. "Sound Insulation Requirements for Mitigation of Aircraft Noise Impact on Highline School District Facilities," Volume I, BBN Systems and Technologies, BBN Report No. 8240.

Ludlow, B. and K. Sixsmith. 1999. Long-term Effects of Military Jet Aircraft Noise Exposure during Childhood on Hearing Threshold Levels. Noise and Health 5:33-39.

Lukas, J.S. 1978. *Noise and Sleep: A Literature Review and a Proposed Criterion for Assessing Effect*, In Daryl N. May, ed., *Handbook of Noise Assessment*, Van Nostrand Reinhold Company: New York, pp. 313-334.

Lynch, T.E. and D.W. Speake. 1978. *Eastern Wild Turkey Behavioral Responses Induced by Sonic Boom*, In "Effects of Noise on Wildlife," Academic Press, New York, New York, pp. 47-61.

Manci, K.M., D.N. Gladwin, R. Villella, and M.G Cavendish. 1988. "Effects of Aircraft Noise and Sonic Booms on Domestic Animals and Wildlife: A Literature Synthesis," U.S. Fish and Wildlife Service National Ecology Research Center, Ft. Collins, CO, NERC-88/29. 88 pp.

Meecham, W.C., and Shaw, N. 1979. "Effects of Jet Noise on Mortality Rates," British Journal of Audiology, 77-80. August.

Metro-Dade County. 1995. "Dade County Manatee Protection Plan," DERM Technical Report 95-5, Department of Environmental Resources Management, Miami, Florida.

Miedema H.M. and H. Vos. 1998. "Exposure-response relationships for transportation noise," *J. Acoust. Soc. Am.*, pp. 104(6): 3432–3445, December.

Michalak, R., H. Ising, and E. Rebentisch. 1990. "Acute Circulatory Effects of Military Low-Altitude Flight Noise," *International Archives of Occupational and Environmental Health*, Vol. 62, No. 5, pp. 365-372.

National Park Service. 1994. "Report to Congress: Report on Effects of Aircraft Overflights on the National Park System," Prepared Pursuant to Public Law 100-91, The National Parks Overflights Act of 1987. 12 September.

NATO. 2000. "The Effects of Noise from Weapons and Sonic Booms, and the Impact on Humans, Wildlife, Domestic Animals and Structures," Final Report of the Working Group Study Follow-up Program to the Pilot Study on Aircraft Noise, Report No. 241, June.

Nelson, J.P. 1978. *Economic Analysis of Transportation Noise Abatement*, Ballenger Publishing Company, Cambridge, MA.

Nelson, J.P. 1980. "Airports and property values: a survey of recent evidence," *Journal of Transport Economics and Policy*, 14, 37-52.

Nelson, J.P. 2004. "Meta-analysis of airport noise and hedonic property values - problems and prospects," *Journal of Transport Economics and Policy*, Volume 38, Part 1, pp. 1-28, January.

Nelson, J.P. 2007. "Hedonic Property Values Studies of Transportation Noise: Aircraft and Road Traffic," in "Hedonic Methods on Housing Markets," Andrea Barazini, Jose Ramerez, Caroline Schaerer and Philippe Thalman, eds., pp. 57-82, Springer.

Newman, J.S., and K.R. Beattie. 1985. "Aviation Noise Effects," U.S. Department of Transportation, Federal Aviation Administration Report No. FAA-EE-85-2.

Nixon, C.W., D.W. West, and N.K. Allen. 1993. *Human Auditory Responses to Aircraft Flyover Noise*, In Vallets, M., ed., Proceedings of the 6th International Congress on Noise as a Public Problem, Vol. 2, Arcueil, France: INRETS.

Öhrström, E., Hadzibajramovic, E., Holmes, and M., H. Svensson. 2006. "Effects of road traffic noise on sleep: studies on children and adults," *Journal of Environmental Psychology*, 26, 116-126.

Ollerhead, J.B., C.J. Jones, R.E. Cadoux, A. Woodley, B.J. Atkinson, J.A. Horne, F. Pankhurst, L. Reyner, K.I. Hume, F. Van, A. Watson, I.D. Diamond, P. Egger, D. Holmes, and J. McKean. 1992. "Report of a Field Study of Aircraft Noise and Sleep Disturbance," Commissioned by the UK Department of Transport for the 36 UK Department of Safety, Environment and Engineering, London, England: Civil Aviation Authority, December.

Parker, J.B. and N.D. Bayley. 1960. "Investigations on Effects of Aircraft Sound on Milk Production of Dairy Cattle, 1957-58," U.S. Agricultural Research Services, U.S. Department of Agriculture, Technical Report Number ARS 44 60.

Pater, L.D., D.K. Delaney, T.J. Hayden, B. Lohr, and R. Dooling. 1999. "Assessment of Training Noise Impacts on the Red-cockaded Woodpecker: Preliminary Results – Final Report," Technical Report 99/51, U.S. Army, Corps of Engineers, CERL, Champaign, IL.

Pearsons, K.S., D.S. Barber, and B.G. Tabachnick. 1989. "Analyses of the Predictability of Noise-Induced Sleep Disturbance," USAF Report HSD-TR-89-029, October.

Plotkin, K.J., B.H. Sharp, T. Connor, R. Bassarab, I. Flindell, and D. Schreckenberg. 2011. "Updating and Supplementing the Day-Night Average Sound Level (DNL)," Wyle Report 11-04, DOT/FAA/AEE/2011-03, June.

Pulles, M.P.J., W. Biesiot, and R. Stewart. 1990. *Adverse Effects of Environmental Noise on Health: An Interdisciplinary Approach*, Environment International, Vol. 16, pp. 437-445.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. *Marine Mammals and Noise*, Academic Press, San Diego, CA.

Rosenblith, W.A., K.N. Stevens, and Staff of Bolt, Beranek, and Newman. 1953. "Handbook of Acoustic Noise Control, Vol. 2, Noise and Man," USAF Report WADC TR-52-204.

Rosenlund, M., N. Berglind, G. Bluhm, L. Jarup, and G. Pershagen. 2001. "Increased Prevalence of Hypertension in a Population Exposed to Aircraft Noise," Occupational and Environmental Medicine, Vol. 58, No. 12, pp. 769 773. December.

Schreckenberg, D. and R. Schuemer. 2010. "The Impact of Acoustical, Operational and Non-Auditory Factors on Short-Term Annoyance Due to Aircraft Noise," Inter-Noise 2010, June.

Schultz, T.J. 1978. "Synthesis of social surveys on noise annoyance," *J. Acoust. Soc. Am.*, Vol. 64, No. 2, pp. 377-405, August.

Sharp, B.H., and K.J. Plotkin. 1984. "Selection of Noise Criteria for School Classrooms," Wyle Research Technical Note TN 84-2 for the Port Authority of New York and New Jersey, October.

Smith, D.G., D.H. Ellis, and T.H. Johnston. 1988. *Raptors and Aircraft*, In R.L Glinski, B. Gron-Pendelton, M.B. Moss, M.N. LeFranc, Jr., B.A. Millsap, and S.W. Hoffman, eds., Proceedings of the Southwest Raptor Management Symposium, National Wildlife Federation, Washington, D.C., pp. 360-367.

Stansfeld, S.A., B. Berglund, and C. Clark, I. Lopez-Barrio, P. Fischer, E. Öhrström, M.M. Haines, J. Head, S. Hygge, and I. van Kamp, B.F. Berry, on behalf of the RANCH study team. 2005. "Aircraft and road traffic noise and children's cognition and health: a cross-national study," *Lancet*, 365, 1942-1949.

Stansfeld, SA., C. Clark, R.M. Cameron, T. Alfred, J. Head, M.M. Haines, I. van Kamp, E. van Kampen, and I. Lopez-Barrio. 2009. "Aircraft and road traffic noise exposure and children's mental health," *Journal of Environmental Psychology*, 29, 203-207.

Stevens, K.N., W.A. Rosenblith, and R.H. Bolt. 1953. "Neighborhood Reaction to Noise: A Survey and Correlation of Case Histories (A)," *J. Acoust. Soc. Am.*, Vol. 25, 833.

Stusnick, E., D.A. Bradley, J.A. Molino, and G. DeMiranda. 1992. "The Effect of Onset Rate on Aircraft Noise Annoyance, Volume 2: Rented Home Experiment," Wyle Laboratories Research Report WR 92-3, March.

Sutherland, L.C. 1990. "Assessment of Potential Structural Damage from Low Altitude Subsonic Aircraft," Wyle Research Report 89-16 (R).

Tetra Tech, Inc. 1997. "Final Environmental Assessment Issuance of a Letter of Authorization for the Incidental Take of Marine Mammals for Programmatic Operations at Vandenberg Air Force Base, California," July.

Ting, C., J. Garrelick, and A. Bowles. 2002. "An analysis of the response of sooty tern eggs to sonic boom overpressures," *J. Acoust. Soc. Am.*, Vol. 111, No. 1, Pt. 2, pp. 562-568.

Trimper, P.G., N.M. Standen, L.M. Lye, D. Lemon, T.E. Chubbs, and G.W. Humphries. 1998. "Effects of low-level jet aircraft noise on the behavior of nesting osprey," *Journal of Applied Ecology*, Vol. 35, pp. 122-130.

UKDfES. 2003. "Building Bulletin 93, Acoustic Design of Schools - A Design Guide," London: The Stationary Office.

U.S. Air Force. 1993. *The Impact of Low Altitude Flights on Livestock and Poultry*, Air Force Handbook. Volume 8, Environmental Protection, 28 January.

U.S. Air Force. 1994a. "Air Force Position Paper on the Effects of Aircraft Overflights on Large Domestic Stock," Approved by HQ USAF/CEVP, 3 October.

U.S. Air Force. 1994b. "Air Force Position Paper on the Effects of Aircraft Overflights on Domestic Fowl," Approved by HQ USAF/CEVP, 3 October.

U.S. Air Force. 2000. "Preliminary Final Supplemental Environmental Impact Statement for Homestead Air Force Base Closure and Reuse," Prepared by SAIC, 20 July.

U.S. Department of Labor. 1971. "Occupational Safety & Health Administration, Occupational Noise Exposure," Standard No. 1910.95.

USEPA. 1974. "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety," U.S. Environmental Protection Agency Report 550/9-74-004, March.

USEPA. 1978. "Protective Noise Levels," Office of Noise Abatement and Control, Washington, D.C. U.S. Environmental Protection Agency Report 550/9-79-100, November.

USEPA. 1982. "Guidelines for Noise Impact Analysis," U.S. Environmental Protection Agency Report 550/9-82-105, April.

USFWS. 1998. "Consultation Letter #2-22-98-I-224 Explaining Restrictions on Endangered Species Required for the Proposed Force Structure and Foreign Military Sales Actions at Cannon AFB, NM," To Alton Chavis HQ ACC/CEVP at Langley AFB from Jennifer Fowler-Propst, USFWS Field Supervisor, Albuquerque, NM, 14 December.

U.S. Forest Service. 1992. "Report to Congress: Potential Impacts of Aircraft Overflights of National Forest System Wilderness," U.S. Government Printing Office 1992-0-685-234/61004, Washington, D.C.

von Gierke, H.E. and W.D. Ward. 1991. "Criteria for Noise and Vibration Exposure", *Handbook of Acoustical Measurements and Noise Control*, C.M. Harris, ed., Third Edition.

Ward, D.H. and R.A. Stehn. 1990. "Response of Brant and Other Geese to Aircraft Disturbances at Izembek Lagoon, Alaska," Final Technical Report, Number MMS900046. Performing Org.: Alaska Fish and Wildlife Research Center, Anchorage, AK, Sponsoring Org.: Minerals Management Service, Anchorage, AK, Alaska Outer Continental Shelf Office.

Ward, D.H., E.J. Taylor, M.A. Wotawa, R.A. Stehn, D.V. Derksen, and C.J. Lensink. 1986. "Behavior of Pacific Black Brant and Other Geese in Response to Aircraft Overflights and Other Disturbances at Izembek Lagoon, Alaska," 1986 Annual Report, p. 68.

Weisenberger, M.E., P.R. Krausman, M.C. Wallace, D.W. De Young, and O.E. Maughan. 1996. "Effects of simulated jet aircraft noise on heart rate and behavior of desert ungulates," *Journal of Wildlife Management*, Vol. 60, No. 1, pp. 52-61.

Wesler, J.E. 1977. "Concorde Operations at Dulles International Airport," NOISEXPO '77, Chicago, IL, March.

Wesler, J.E. 1986. "Priority Selection of Schools for Soundproofing,", Wyle Research Technical Note TN 96-8 for the Port Authority of New York and New Jersey, October.

Wever, E.G., and J.A. Vernon. 1957. "Auditory responses in the spectacled caiman," *Journal of Cellular and Comparative Physiology*, Vol. 50, pp. 333-339.

WHO. 1999. "Guidelines for Community Noise," Berglund, B., T. Lindvall, and D. Schwela, eds.

WHO. 2003. "International Society of Hpertension (ISH) statement of management of hypertension," *J Hypertens* 21: 1983–1992.

Wu, Trong-Neng, J.S. Lai, C.Y. Shen, T.S Yu, and P.Y. Chang. 1995. *Aircraft Noise, Hearing Ability, and Annoyance*, Archives of Environmental Health, Vol. 50, No. 6, pp. 452-456, November-December.

Wyle Laboratories. 1970. "Supporting Information for the Adopted Noise Regulations for California Airports," Wyle Report WCR 70-3(R).

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APPENDIX B

DEPARTMENT OF THE NAVY
OPNAVINST 3550.1A LAND USE COMPATIBILITY
RECOMMENDATION TABLES

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APPENDIX A

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.
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

SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES

LAND USE	Noise Zone 1		Noise Zone 2		Noise Zone 3		
	< 55	55-64	65-69	70-74	75-79	80-84	85+
RESIDENTIAL - SINGLE FAMILY, DUPLEX, MOBILE HOMES	Y	Y[1]	N[1]	N[1]	N	N	N
RESIDENTIAL - MULTIPLE FAMILY HOMES	Y	Y[1]	N[1]	N[1]	N	N	N
TRANSIENT LODGING	Y	Y[1]	N[1]	N[1]	N	N	N
SCHOOL CLASSROOMS, LIBRARIES, CHURCHES	Y	Y[1]	25	30	N	N	N
HOSPITALS	Y	Y[1]	25	30	N	N	N
NURSING HOMES	Y	Y	N[1]	N[1]	N	N	N
AUDITORIUMS, CONCERT HALLS	Y	Y[1]	25	30	N	N	N
OFFICE BUILDINGS - PERSONAL, BUSINESS, PROFESSIONAL	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
COMMERCIAL, RETAIL	Y	Y[1]	Y	25	30	N	N
MANUFACTURING	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
UTILITIES	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
PLAYGROUNDS, NEIGHBORHOOD PARKS	Y	Y[1]	Y[1]	Y[1]	N	N	N
GOLFCOURSES, RIDING STABLES, WATER RECREATION, CEMETARIES	Y	Y[1]	Y[1]	25	30	N	N
OUTDOOR SPECTATOR SPORTS	Y	Y[1]	Y[5]	Y[5]	N	N	N
INDUSTRIAL, WAREHOUSE, SUPPLIES	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
LIVESTOCK, FARMING, ANIMAL BREEDING	Y	Y	Y[6]	Y[7]	N	N	N
AGRICULTURAL (EXCEPT LIVESTOCK), MINING, FISHING	Y	Y	Y	Y	Y	Y	Y
RECREATIONAL, WILDERNESS AREAS	Y	Y[1]	Y[1]	Y[1]	N	N	N

NOTES:

Y (Yes)	Land Use and related structure compatible withot 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 are generaly compatible. However, see note(s) indicated by the superscript.

NOTES FOR APPENDIX B - SUGGESTED LAND USE COMPATIBILITY IN NOISE ZONES

1.
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.

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

c) Normal permanent construction can be expected to provide a 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 (STC) ratings in windows and doors and closed windows year round. Additional OPNAVINST 11010.36B 19 Dec 2002 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 and site planning, design and use of berms and barriers can help mitigate outdoor noise exposure NLR 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.

APPENDIX C

FLORIDA LAND USE, COVER, AND FORMS CLASSIFICATION SYSTEM (FLUCCS) DESCRIPTIONS

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Code Number	Land Use Code	Land Use Code Description
1100	Residential, Low Density (Less Than Two Dwelling Units Per Acre)	Residential, Low Density; Less than two dwelling units per acre
1200	Residential, Medium Density (Two-Five Dwelling Units Per Acre)	Residential, Medium Density; Two-five dwelling units per acre
1300	Residential, High Density (Six or More Dwelling Units Per Acre)	Residential, High Density
1400	Commercial and Services	The Commercial and Services category includes all secondary structures associated with an enterprise in addition to the main building and integral areas assigned to support the base unit. Included are sheds, warehouses, office buildings, driveways, parking lots and landscaped areas. Also includes shopping center and commercial strip developments.
1500	Industrial	Industrial embraces those land uses where manufacturing, assembly or processing of materials and products are accomplished. Industrial areas include a wide array of industry types ranging from light manufacturing and industrial parks to heavy manufacturing plants. Also included are those facilities for administration and research, assembly, storage and warehousing, shipping and associated parking lots and grounds. Typical examples of industrial types found in Florida are pulp and lumber mills, oil refineries with tank farms, chemical plants and brick making plants.
1600	Mining (Extractive)	Mining encompasses both surface and subsurface mining operations. This can include sand, gravel and clay pits, phosphate mines, limestone quarries plus oil and gas wells. Industrial complexes where the extracted material is refined, packaged or further processed, are also included in this category.
1700	Institutional	Educational, religious, health and military facilities are typical components of the Institutional category. Also includes non-military governmental, corrections, and commercial childcare.
1800	Recreational	Areas whose physical structure indicates that active user-oriented recreation is or could be occurring within the given physical area. This category would include golf courses, parks, swimming beaches and shores, marinas, fairgrounds, etc.
1900	Open Land	Open Land includes undeveloped land within urban areas and inactive land with street patterns but without structures. Open Land normally does not exhibit any structures or any indication of intended use. Often, urban inactive land may be in a transitional state and ultimately will be developed into one of the typical urban land uses.
2100	Cropland and Pastureland	Cropland and Pastureland includes agricultural land which is managed for the production of row or field crops and improved, unimproved and woodland pastures. This category also includes livestock grazing.

Code Number	Land Use Code	Land Use Code Description
2200	Tree Crops	Tree Crops are citrus and other groves, fruit orchards, and abandoned groves.
2400	Nurseries and Vineyards	Nurseries and Vineyards category is described as tree nurseries, sod farms, ornamentals, vineyards, floriculture (cultivating flowers), and timber nursery.
2500	Specialty Farms	Specialty farms includes thoroughbred horse farm, dog kennel, aquiculture, dairies.
2600	Other Open Lands (Rural)	Includes agricultural lands whose intended usage cannot be determined (fallow cropland).
3100	Herbaceous (Dry Prairie)	Herbaceous category includes upland prairie grasses which occur on non-hydric soils but may be occasionally inundated by water. These grasslands are generally treeless with a variety of vegetation types dominated by grasses, sedges, rushes and other herbs including wire grasses with some saw palmetto present.
3200	Shrub and Brushland	Shrub and Brushland includes saw palmettos, gallberry, wax myrtle, coastal scrub and other shrubs and brush. Generally, saw palmetto is the most prevalent plant cover intermixed with a wide variety of other woody scrub plant species as well as various types of short herbs and grasses. Coastal scrub vegetation would include pioneer herbs and shrubs composed of such typical plants as sea purslane, sea grapes and sea oats without any one of these types being dominant.
3300	Mixed Rangeland	When more than one-third intermixture of either grassland or shrub-brushland range species occurs, the specific classification is Mixed Rangeland. Where the intermixture is less than one-third, it is classified as the dominant type of rangeland, whether Grassland or Shrub and Brushland categories.
4100	Upland Coniferous Forests	Any natural forest stand whose canopy is at least 66 % dominated by coniferous species is classified as a Coniferous Forest.
4200	Upland Hardwood Forests	This classification of upland forest lands has a crown canopy with at least a 66% dominance by hardwood tree species. This class, like the Upland Conifer class, is reserved for naturally generated stands.
4400	Tree Plantations	Tree plantations includes coniferous, sand pine, Christmas trees, pine plantation monocultures, seed plantation, and forest regeneration areas.
5100	Streams and Waterways	This category includes rivers, creeks, canals and other linear water bodies. Where the water course is interrupted by a control structure, the impounded water area will be placed in the Reservoirs category.
5200	Lakes	The Lakes category includes extensive inland water bodies, excluding reservoirs. Islands within lakes that are too small to delineate will be included in the water area.

Code Number	Land Use Code	Land Use Code Description
5300	Reservoirs	Reservoirs are artificial impoundments of water. They are used for irrigation, flood control, municipal and rural water supplies, recreation and hydro-electric power generation.
5500	Major Springs	The natural phenomena known as springs can be identified as points of origin of a water source welling from the ground. In many instances, major springs, such as Silver Springs and Homosassa Springs, can readily be identified by the associated recreational-commercial enterprises in the adjacent areas.
5600	Slough Waters	Sloughs are channels of slow moving water in the coastal marshland. The term also refers to "backwater sloughs," those narrow, often stagnant bodies of water found near inland rivers.
6100	Wetland Hardwood Forests	Wetland Hardwood Forests are those wetland areas which meet the crown closure requirements for forestland as outlined under the Upland Forest Classification. To be included in the Wetland Hardwood Forest category, the stand must be 66 % or more dominated by wetland hardwood species, either salt or freshwater.
6200	Wetland Coniferous Forests	Wetland Coniferous Forests are wetlands which meet the crown closure requirements for coniferous forests and are the result of natural generation. These communities are commonly found in the interior wetlands in such as places as river flood plains, bogs, bayheads and sloughs.
6300	Wetland Forested Mixed	This category includes mixed wetlands forest communities in which neither hardwoods or conifers achieve a 66 % dominance of the crown canopy composition.
6400	Vegetated Non-Forested Wetlands	Vegetated Non-forested Wetlands include marshes and seasonably flooded basins and meadows. These communities are usually confined to relatively level, low-lying areas. This category does not include areas which have a tree cover which meets the crown closure threshold for the forested categories When the forest crown cover is less than the threshold for wetland forest or is non-woody, it will be included in this category.
7200	Sand Other Than Beaches	Sand Other Than Beaches is usually in reference to dune sands, but not restricted to dune sands as bare sands exist in other forms.
7400	Disturbed Land	Disturbed Lands are those areas which have been changed due primarily to human activities other than mining. In Florida, these areas may be rather extensive and often appear outside of urban areas.
8100	Transportation	Transportation includes highways, rail-oriented facilities, airport facilities, ports, docks, shipyards, canals and locks, oil or gas long distance transmission lines.

Code Number	Land Use Code	Land Use Code Description
8200	Communications	Communications includes typical major types of communication facilities such as airwave communications, radar and television antennas with associated structures. This category does not include stations associated with commercial or government facility when they are located within their bounds.
8300	Utilities	Utilities usually include power generating facilities and water treatment plants including their related facilities such as transmission lines for electric generation plants and aeration fields for sewage treatment sites. Small facilities or those associated with an industrial, commercial or extractive land use are included within these larger respective categories.

Source:
Florida Land Use, Cover, and Forms Classification System Department of Transportation, 1999
http://www.fdot.gov/geospatial/documentsandpubs/fluccmanual1999.pdf

APPENDIX D

GENERALIZED LAND USE CODES

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FLUCCS Code Number	FLUCCS Land Use Code	Generalized Land Use Code
1100	Residential, Low Density (Less Than Two Dwelling Units Per Acre)	Residential- Low Density
1200	Residential, Medium Density (Two-Five Dwelling Units Per Acre)	Residential- High Density
1300	Residential, High Density (Six or More Dwelling Units Per Acre)	Residential- High Density
1400	Commercial and Services	Commercial/ Services
1500	Industrial	Industrial
1600	Mining (Extractive)	Mining
1700	Institutional	Institutional
1800	Recreational	Recreational
1900	Open Land	Open Land
2100	Cropland and Pastureland	Agricultural/ Cropland
2200	Tree Crops	Agricultural/ Cropland
2400	Nurseries and Vineyards	Agricultural/ Cropland
2500	Specialty Farms	Agricultural/ Cropland
2600	Other Open Lands (Rural)	Agricultural/ Cropland
3100	Herbaceous (Dry Prairie)	Shrub/ Brushland
3200	Shrub and Brushland	Shrub/ Brushland
3300	Mixed Rangeland	Shrub/ Brushland
4100	Upland Coniferous Forests	Forest
4200	Upland Hardwood Forests	Forest
4400	Tree Plantations	Agricultural/ Cropland
5100	Streams and Waterways	Water
5200	Lakes	Water
5300	Reservoirs	Water
5500	Major Springs	Water
5600	Slough Waters	Water
6100	Wetland Hardwood Forests	Wetlands
6200	Wetland Coniferous Forests	Wetlands
6300	Wetland Forested Mixed	Wetlands
6400	Vegetated Non-Forested Wetlands	Wetlands
7200	Sand Other Than Beaches	Recreational
7400	Disturbed Land	Open Land
8100	Transportation	Transportation
8200	Communications	Utility/ Communication
8300	Utilities	Utility/ Communication

APPENDIX E

SAMPLE REAL ESTATE DISCLOSURE FORMS

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Sample Disclosure Policy Language

Note: The sample policy language may be drafted to recognize, or not recognize, the AICUZ and its associated noise contours and accident potential zones (APZs).

At all real estate closings involving a property in an accident potential zone (APZ) or noise zone (or Military Installation Area of Impact), the buyer, seller, and witnesses shall sign the following form, which shall be filed with the deed and/or plat at the County Register of Deeds Office.

Military Installation Area of Impact Disclosure Form

The property at _____ (address/location) is located in proximity to Naval Air Station Key West, Monroe County, Florida. Monroe County (County) determined that persons on the premises may be exposed to accident potentials and/or significant noise levels as a result of military air operations. The County has established certain noise zones and APZs (or a Military Installation Area of Impact Overlay) within its land development regulations.

The above property is located in Noise Zone _____ and in Accident Potential Zone _____.

The County has placed certain restrictions on the development and use of property within these areas. Before purchasing the above property, you should consult the County Growth Management Division to determine the restrictions that have been placed on the subject property.

Certification

A. Property Owner

As the owner of the subject property, I hereby certify that I have informed _____, as a prospective purchaser, that the subject property is located in the Monroe County Military Installation Area of Impact Overlay district.

Dated this _____ day of _____, _____.

Witness_____ Owner_____

As a prospective purchaser of the subject property, I hereby certify that I have been informed that the subject property is in a Military Installation Area of Impact Overlay district, and I have consulted with the County to determine the restrictions that have been placed on the subject property.

Dated this _____ day of _____, _____.

Witness_____ Purchaser_____

B. Lessee

All prospective renters signing a commercial or residential lease shall be notified by the property owner through a written provision contained in the lease agreement if

the leased property is located within the Military Installation Area of Impact Overlay district.

C. Subdivision Plats, Planned Unit Development Plats, Townhouse Plats and/or Condominium Documents

All subdivision plats, planned unit development plats, townhouse plats, and /or condominium documents shall contain the following disclosure statement:

Military Installation Area of Impact Overlay Disclosure Statement

This property lies within a Military Installation Area of Impact Overlay District, which applies to property in proximity to the Naval Air Station Key West, Monroe County, Florida. Monroe County has determined that persons on the premises may be exposed to accident potentials and/or significant noise levels as a result of the airport operations. Purchasers are required to sign a Disclosure Form and file the form with the deed and/or plat at the Monroe County Register of Deeds Office. All or a portion of this property lies within:

Accident Potential Zone: _____

Noise Zone: _____ DNL (Day-Night Average Sound Level): _____

D. New Construction

In the case of new construction, a signed Military Installation Area of Impact Overlay Disclosure Statement shall accompany the building permit application.

(Ord. No. XXXXXXXXXXX)

REAL ESTATE TRANSFER DISCLOSURE FOR PROPERTIES LOCATED IN A LOCALITY IN WHICH A MILITARY AIR INSTALLATION IS LOCATED

1. As of the date of this Disclosure, the undersigned property owner(s) represent that the real property described below is located in a Noise Zone and/or Accident Potential Zone (APZ), as shown or referenced on the Official Zoning Map designated by the locality in which the property is located.

_____ No (Please sign below) _____ Yes (Please complete the information below)

2. The following are representations made by the property owner(s), as required by Section 55-519.1 of the Code of Virginia:

A. As of the date of this Disclosure the real property located at (Street Address, Locality and Zip Code)_____, _____, Virginia is located within the following Noise Zone and/or Accident Potential Zone (APZ), as shown or referenced on the Official Zoning Map of (Name of Locality)_____:

Noise Zone – (Initial One)

____/____ <65 dB DNL ____/_____65-70 dB DNL ____/____ 70-75 dB DNL ____/____ >75 dB DNL

Accident Potential Zone (APZ) – (Initial One)

_____/____ None (outside APZs) _____/_____ APZ-2 _____/_____ APZ-1 _____/_____ Clear Zone

B. The abbreviation "DNL" refers to a day-night average sound level. The frequency of actual single noise events may vary over time depending on the operational needs of the military. **Single noise events may result in significantly higher noise levels than the average level(s) in any of the Noise Zones listed above.**

C. Noise Zones and Accident Potential Zones are subject to change. For this reason, it should not be assumed that the property will remain in the same Noise Zone and/or Accident Potential Zone.

Additional information may be obtained from the locality.

In the event the owner fails to provide the disclosure required by § 55-519.1, or the owner misrepresents, willfully or otherwise, the information required in such disclosure, except as result of information provided by an officer or employee of the locality in which the property is located, the purchaser may maintain an action to recover his actual damages suffered as the result of such violation. Notwithstanding the provisions of this disclosure, no purchaser of residential real property located in a noise zone designated on the official zoning map of the locality as having a day-night average sound level of less than 65 decibels shall have a right to maintain an action for damages pursuant to this section.

The owner(s) state that they reasonably believe the information contained herein is true and accurate and further acknowledge that they have been informed of their rights and obligations under the Virginia Residential Property Disclosure Act.

Owner _____ Date _____

Owner _____ Date _____

Purchaser(s) acknowledge receipt of a copy of this disclosure statement and further acknowledge that they have been informed of their rights and obligations under the Virginia Residential Property Disclosure Act.

Purchaser _____ Date _____

Purchaser _____ Date _____

11/18/10