AIR INSTALLATIONS COMPATIBLE USE ZONES REPORT FOR MARINE CORPS OUTLYING LANDING FIELD OAK GROVE, NORTH CAROLINA

JUNE 2011

Air Installations
Compatible Use Zones Study
for Marine Corps
Outlying Landing Field
Oak Grove, North Carolina

June 2011

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UNITED STATES DEPARTMENT OF THE NAVY
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Acronyms and Abbreviations

AICUZ	Air Installations Compatible Use Zones
APZ	Accident Potential Zone
ATC	Air Traffic Control
BASH	bird/animal aircraft strike hazard
CAL	Confined Area Landing
CP&LO	Community Plans and Liaison Office
dB	decibels
dBA	A-weighted decibels
DNL	day-night average sound level noise metric
DoD	(United States) Department of Defense
EIS	environmental impact statement
EMI	electromagnetic interference
FAA	Federal Aviation Administration
FCLP	Field Carrier Landing Practice
FICUN	Federal Interagency Committee on Urban Noise
FLIR	forward looking infrared
GCA	Ground-Controlled Approach
HUD	Housing and Urban Development
IFR	instrument flight rules
MCAS	Marie Corps Air Station
MCB	Marine Corps Base
MCOLF	Marine Corps Outlying Landing Field
mi^2	square miles

MTR	Military Training Route
NAIP	National Agricultural Imagery Program
NAVAIR	Naval Air Systems Command
Navy	United States Department of the Navy
NLR	Noise Level Reduction
OLF	Outlying Landing Field
OPNAVINST	Chief of Naval Operations Instruction
TDR	Transfer of Development Rights
USMC	United States Marine Corps
VFR	visual flight rules

1 Introduction

Historically, military bases were established in rural areas of the country. However, over time, many of these areas have experienced associated population growth and increased development in close proximity to military installations. This growth can be seen immediately outside many station fence lines as well as throughout the surrounding areas and primarily takes the form of new housing and commercial development. New homes are constructed in close proximity to installations to allow both military and civilian personnel to live near their employer. Similarly, businesses are established that support military installations and their personnel. Some of this development is incompatible with aircraft and other military operations and, over time, can result in nearby residents being adversely impacted as well as result in the potential degradation of an installation's mission. As incompatible development encroaches upon the airport, more people experience the impacts associated with aircraft operations.

The United States Department of Defense (DoD) initiated the Air Installations Compatible Use Zones (AICUZ) Program to help governmental entities and communities anticipate, identify, and promote compatible land use and development near military installations. The goal of this program is to protect the health, safety, and welfare of those living or working near military air installations while protecting military operational capabilities. This is achieved by promoting compatible land use patterns and activities in the vicinity of a military installation. The AICUZ Program recommends community land uses compatible with noise levels, accident potential, and flight clearance requirements associated with military airfield operations in the hope that the information will be incorporated into local community planning programs.

This AICUZ study has been prepared for Marine Corps Outlying Landing Field (MCOLF) Oak Grove, North Carolina. MCOLF Oak Grove receives aircraft activity from the Camp Lejeune Complex, which includes Marine Corps Base (MCB) Camp Lejeune and Marine Corps Air Station (MCAS) New River (see Figure 1-1). The original AICUZ for MCOLF Oak Grove was completed in 1978 as part of the overall AICUZ study for MCAS New River. Additionally, a subsequent noise analysis was

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\\BUFSDL4\GIS\L:\Buffalo\OakGrove_OLF\Maps\MXDs\OLF_Report_Figures\Oct_16_2007\Figure 1-1 General Location Map.mxd

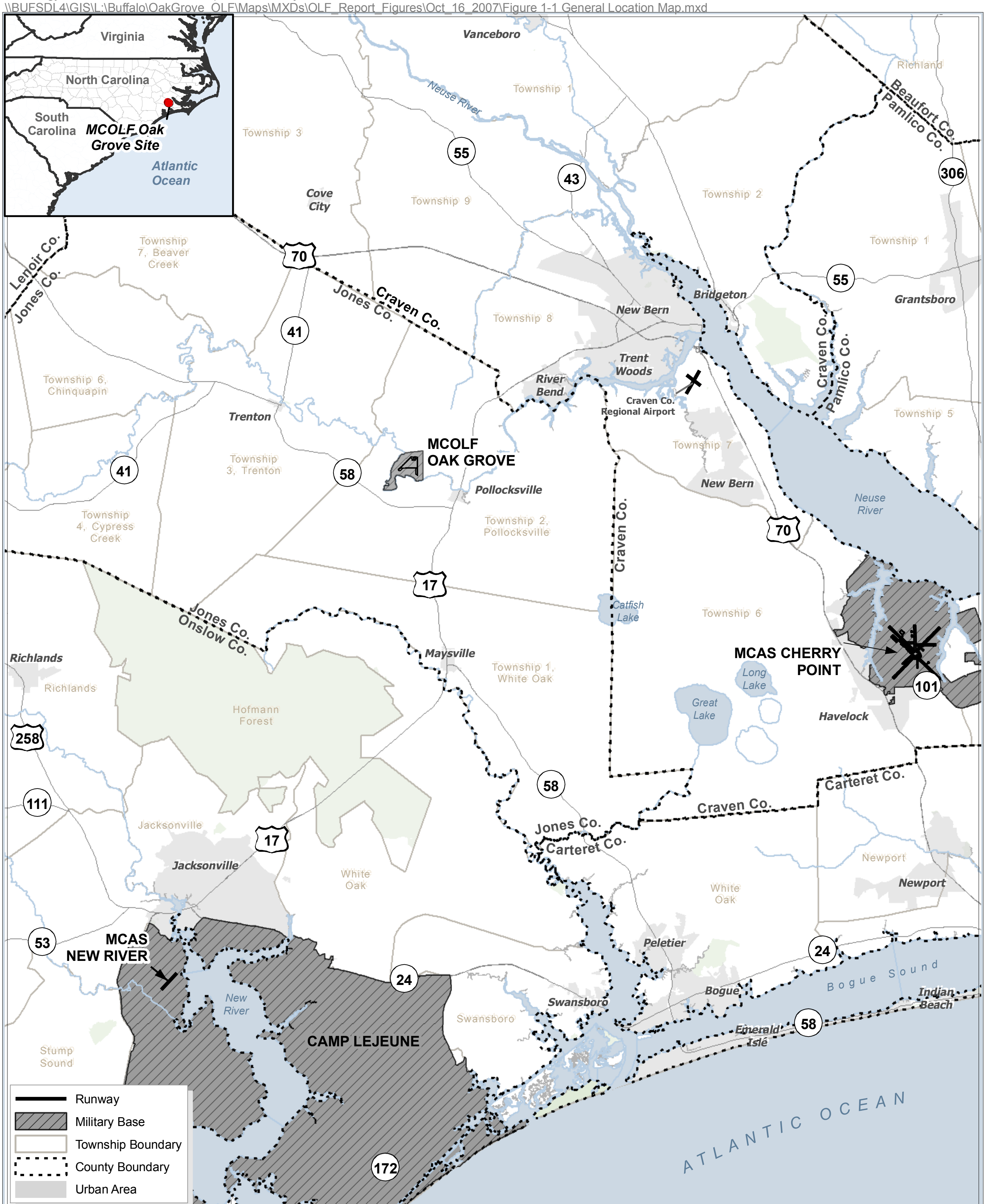

Figure 1-1
General Location Map
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

0 1 2 4 6 8
Miles

completed in 1999 for the Introduction of the V-22 to the Second Marine Aircraft Wing, Eastern North Carolina. A 2001 AICUZ update completed for the MCAS New River did not include an update for MCOLF Oak Grove or MCOLF Camp Davis.

This AICUZ study replaces the 1978 AICUZ study and is in support of the United States Marine Corps (USMC) participation in the local community planning process. This study has been prepared in consideration of expected changes in mission, aircraft, and projected operational levels that will occur within the next 10- to 15-year planning period.

As the communities that surround military installations grow and develop, the Marine Corps has the responsibility to communicate with, build relationships with, work with, and provide input to those involved in local executive and legislative functions on land use planning, zoning, and similar matters that could affect the installations' operations or missions.

This study provides background on the AICUZ program (Section 1) and describes the air installation (Section 2). Section 3 discusses current aircraft operations and airspace. Section 4 presents aircraft noise zones – how noise zones are determined, what changes have occurred, and what measures have been implemented by the Marine Corps in response to noise complaints. Section 5 discusses aircraft safety issues – including changes in the accident potential zones (APZs) and other land use issues that could affect pilot safety. Section 6 evaluates the compatibility of surrounding land uses and aircraft operations and Section 7 provides the Marine Corps recommendations for promoting land use compatibility consistent with the goals of the AICUZ Program.

1.1 AICUZ Program

In the early 1970s, the DoD established the AICUZ Program to balance the need for aircraft operations and community concerns over aircraft noise and accident potential. The AICUZ Program was developed in response to growing incompatible urban development (encroachment) around military airfields. The goals of the AICUZ Program are:

- To protect the health, safety, and welfare of those living and working near military fields; and

- To preserve the military flying mission.

To meet these goals, the Marine Corps has identified the following components as requirements for a successful AICUZ Program:

- Develop and periodically update a study and map for each air installation to quantify and depict aircraft noise zones and APZs;
- Coordinate with federal, state, and local officials to encourage compatible land use development around each air installation;
- Inform the local communities of the importance of maintaining the Marine Corps' ability to conduct aircraft operations; and
- Review operations and implement operational changes and noise abatement strategies to minimize noise impacts while ensuring mission requirements.

Under the AICUZ Program, the DoD identifies noise zones and APZs as planning tools for local planning agencies. The Federal Aviation Administration (FAA) and DoD also encourage local communities to restrict development or land uses that could endanger aircraft in the vicinity of the airfield, including lighting (direct or reflected) that would impair pilot vision; towers, tall structures, and vegetation that penetrate navigable airspace or are constructed near the airfield; uses that generate smoke, steam, or dust; uses that attract birds, especially waterfowl; and electromagnetic interference (EMI) with aircraft communication, navigation, or other electrical systems.

1.2 Purpose, Scope, and Authority

The purpose of the ACIUZ program is to achieve compatibility between air installations and neighboring communities. To satisfy the purpose of the AICUZ program, the military installation works with the host community to discourage incompatible development of land adjacent to the installation. As development encroaches upon the airfield, more people experience the noise and accident potential associated with aircraft operations.

The scope of the AICUZ study includes an analysis of:

- Aircraft noise and accident potential;
- Land use compatibility;
- Operational alternatives;

- Noise reduction strategies; and
- Potential solutions to existing and potential incompatible land use problems.

The AICUZ study uses an analysis of community development trends, land use tools, and mission requirements at the airfield to develop a recommended strategy for communities that prevents incompatible land development adjacent to the installation. AICUZ considerations are based on the impacts of noise, the safety considerations of aircraft accidents, and economic considerations relating to public funds and local economic viability. The basis for implementing AICUZ guidelines lies in the air installation commander's cooperation with the local governments to protect the installation's mission requirements and, at the same time, protect and promote the public's health, safety, and welfare. The authority for the establishment and implementation of the MCOLF Oak Grove Program is derived from:

- United States Department of Defense Instruction 4165.57, "Air Installations Compatible Use Zones," dated November 8, 1977;
- Commandant of the Marine Corps Order and Office of Naval Operations Instruction (OPNAVINST) 11010.36C, "Air Installations Compatible Use Zones Program," dated October 9, 2008;
- Naval Facilities Instruction P-971, "Airfield and Helicopter Planning and Design," dated May 1, 1999; and
- United States Department of Transportation, FAA Regulations, Code of Federal Regulations, Title 14, Part 77, "Objects Affecting Navigable Airspace."

1.3 Responsibility for Compatible Land Use

Ensuring land use compatibility within the AICUZ is the responsibility of many, including the DoD, local planning and zoning agencies, real estate agencies, residents, developers, and builders. Military installations and local government agencies with planning and zoning authority share the responsibility for preserving land use compatibility near the military installation. Cooperative action by all parties is essential to prevent land use incompatibility and hazards to the neighboring community. Table 1-1 identifies some responsibilities for various community stakeholders residing in proximity to an installation.

Table 1-1 Responsibility for Compatible Land Uses

Navy/Marine Corps	■ Examine air mission for operation changes that could reduce impacts. ■ Conduct noise and APZ studies. ■ Develop AICUZ maps. ■ Examine local land uses and growth trends. ■ Make land use recommendations. ■ Release an AICUZ study. ■ Work with local governments and private citizens. ■ Monitor operations and noise complaints. ■ Update AICUZ plans, as required.
Local Government	■ Incorporate AICUZ guidelines into a comprehensive development plan and zoning ordinance. ■ Regulate height and obstruction concerns through an airport ordinance. ■ Regulate acoustical treatment in new construction. ■ Require fair disclosure in real estate for all buyers, renters, lessees, and developers.
Private Citizens	■ Educate oneself on the importance of the Installation's AICUZ Program. ■ Identify AICUZ considerations in all property transactions. ■ Understand AICUZ effects before buying, renting, leasing, or developing property.
Real Estate Professionals	■ Ensure potential buyers and lessees receive and understand AICUZ information on affected properties. ■ When working with builder/developers, ensure an understanding and evaluation of the AICUZ Program.
Builders/Developers	■ Develop properties in a manner that appropriately protects the health, safety and welfare of the civilian population by constructing land use facilities which are compatible with aircraft operations (e.g., sound attenuation features, densities, occupations).

Key:
AICUZ = Air Installations Compatible Use Zones.
APZ = Accident Potential Zone.

1.4 Previous AICUZ Efforts and Studies

An AICUZ study was prepared for MCAS New River in 1978, which included an assessment of the air station itself and its two OLFs - MCOLF Oak Grove and MCOLF Camp Davis. The MCAS New River AICUZ was updated in 2001, but did not include updates to any OLFs.

A noise study was conducted specifically for MCOLF Oak Grove in 1996 as a result of the 1995 Base Realignment and Closure process. The study estimated the noise exposure at MCOLF Oak Grove as a result of the relocation of the Marine Medium Helicopter Training Squadron 302 to MCAS New River.

A noise study was completed in 1999 for the *Introduction of the V-22 to the Second Marine Aircraft Wing, Eastern North Carolina*. The study analyzed the effects of noise at MCAS New River, four landing fields, and military training routes (MTRs). For

MCOLF Oak Grove the study concluded that an increase in operations at MCOLF Oak Grove would increase noise contours. However the increase would be contained within the landing field and no off-base acreage or populations would be exposed to a day-night average sound level noise metric (DNL) greater than 65 decibels (dB).

Neither noise study resulted in an AICUZ update.

1.5 Changes that Require an AICUZ Update

Aircraft noise consists of two major sound sources: flight operations and ground engine maintenance "run-ups," which are associated with pre-flight and maintenance checks. MCOLF Oak Grove does not have any ground engine maintenance "run-up" locations, since there are no aircraft stationed at the airfield and maintenance is done at MCAS New River.

The level of noise exposure is related to a number of variables, including the aircraft type, rotor pitch, power setting, altitude, wind direction and velocity, nacelle angle (for MV-22s), flight track, temperature, relative humidity, frequency, and time of operations. Some of these factors fluctuate from year to year. Small fluctuations in the annual number of operations of like aircraft will not have a significant effect on community noise exposure.

AICUZ studies should be updated when an air installation has a significant change in aircraft operations (i.e., the number of takeoffs and landings), a change in the type of aircraft stationed and operating at the Installation, or changes in flight paths or procedures. The only previous AICUZ study for MCOLF Oak Grove was conducted in 1978, which included MCAS New River, Outlying Landing Field (OLF) Camp Davis and OLF Oak Grove. In 2001, the AICUZ for MCAS New River was updated; however, it did not cover MCOLF Oak Grove or the MV-22.

In accordance with OPNAVINST 11010.36C, this AICUZ update has been prepared to reflect changes in airfield operations since the last AICUZ update and to incorporate any reasonable projected mission changes.

1.5.1 Changes in Operations Level

Historical flight operations at MCOLF Oak Grove are not comprehensive and, in some cases, are incomplete due to the nature of an outlying field with no tower. Therefore, an estimation of flight operations was developed based on a survey conducted with air traffic control (ATC) personnel at MCAS New River, operators that utilize the airfield, and other operations personnel to develop a baseline 2007 estimate. The 2007 noise study estimated the annual 2007 flight operations at MCOLF Oak Grove at 4,321. Pattern operations count as two operations, a take-off and a landing. The projected 2012 annual flight operations, also developed based on interviews with personnel identified above regarding projected future use of MCOLF Oak Grove, are estimated to be 21,141. This figure incorporates projections of fleet mix and aircraft operations, and available estimates of future mission requirements (Wyle Laboratories 2007). The projected 2012 annual flight operations will be the data input for calculating what will be considered the 2011 AICUZ noise contours.

1.5.2 Changes in Aircraft Mix

MCOLF Oak Grove is used by 2d Marine Aircraft Wing aircraft for a variety of military training activities. Although the aircraft that utilize MCOLF Oak Grove have traditionally been and continue to be stationed at MCAS New River, the aircraft types that utilize Oak Grove have changed over time. The majority of use is now by the MV-22 aircraft, consisting of 58% of all operations. In 1978, the MV-22 had not entered into service and the majority of operations were from the CH-46, which in 2007 accounted for only 7% of the operations. See Table 1-2 for the percentage change in aircraft usage of the MCOLF Oak Grove since 1978. As the CH-46E helicopter is phased out of the USMC inventory, MCOLF Oak Grove aircraft operations will be predominately used by its replacement, the MV-22.

Table 1-2 Aircraft Use of MCOLF Oak Grove in 1978 and 2007

Aircraft Type	1978	2007
CH-46	49%	7%
CH-53	30%	18%
UH-1	14%	13%
AH-1	7%	4%
MV-22	0%	58%

Source: Wyle Laboratories 2007.

1.5.3 Changes in Flight Tracks and Procedures

There have been no changes that have occurred in flight tracks or procedures for MCOLF Oak Grove in recent years. Historic modifications to flight operation procedures associated with noise abatement are discussed in Section 4.4, Noise Abatement/Flight Procedures.

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2 MCOLF Oak Grove

2.1 Location

MCOLF Oak Grove is located in the North Carolina Coastal Plain on the Trent River in Jones County (pop. 10,381), about 10 miles southwest of the city of New Bern. The county is largely rural and contains high proportions of productive agricultural and forest lands. Trenton, the county seat, is about 7 miles west of MCOLF Oak Grove. MCAS New River and Camp Lejeune are located about 30 miles to the south-southwest of MCOLF Oak Grove, while MCAS Cherry Point is located 25 miles to the southeast of the facility. The regional setting for the facility is shown on Figure 2-1. Access to the facility is provided from NC-1121.

2.2 Mission

Marine Corps Base Camp Lejeune operates and maintains MCOLF Oak Grove for training purposes including support to the mission of MCAS New River. Flight operations at MCOLF Oak Grove typically range from aircraft familiarization, and air/ground tactical support missions, to search-and-rescue maneuvers, and night vision goggle/forward looking infrared (FLIR) training. There are several major tenants that conduct flight operations out of MCAS New River. These tenants include eight squadrons assigned to MAG-26 and MAG-29 and one MV-22 training squadron assigned to Naval Air Systems Command (NAVAIR).

2.3 History

The MCOLF Oak Grove facility was constructed in 1942 for use as a training field for Marine Corps aviators. The field was under the control of MCAS Cherry Point from 1942 through the Korean War, and the 1950s. When the growth of MCAS New River necessitated the addition of new training facilities, the control of MCOLF Oak Grove was transferred to the commanding officer of MCAS New River, although ownership remained the same. Since 1963, Oak Grove has been utilized by the 2d Marine Aircraft Wing primarily as a helicopter outlying landing field. In October 2006, the ownership of

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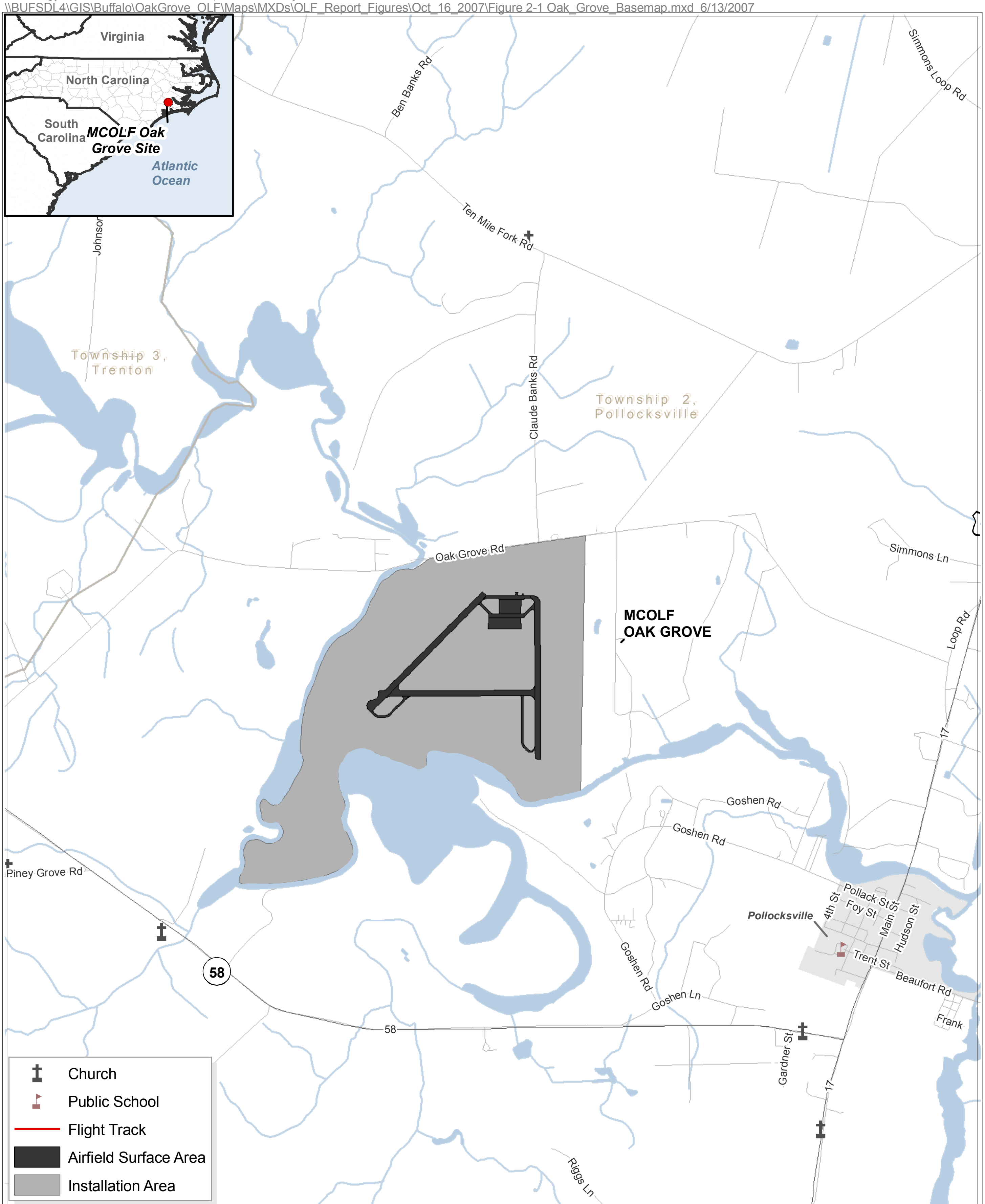

Figure 2-1
Base Map for
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

the MCOLF Oak Grove was transferred from MCAS Cherry Point to MCB Camp Lejeune.

2.4 Operational Areas

MCOLF Oak Grove airfield consists of three runways which intersect near the runway thresholds (see Table 2-1). Runway 05/23 is the primary runway measuring 4,200 feet long by 150 feet wide and is aligned in a northeast/southwest direction. Runway 19/01 is the other active runway. This runway is 4,000 feet long and 150 feet wide and is aligned in a north/south direction. The east/west Runway 09/27 is 4,000 feet long, but is closed to most aircraft operations because of its deteriorated physical condition.

Table 2-1 MCOLF Oak Grove Runways

Runway	Length (feet)	Width (feet)
05/23	4,200	150
19/01	4,000	150
09/27	4,100	150

Source: Wyle Laboratories 2007.

2.5 Local Economic Impacts

Similar to other areas where major military bases are located, the Camp Lejeune Complex, which includes MCAS New River and MCOLF Oak Grove, has a significant impact on the economy of the eastern North Carolina region. Oak Grove as an individual facility has little impact since it is an unmanned airfield. The jobs associated with Camp Lejeune and New River and its tenants, the salaries paid to its workers, and the spending associated with both the workers and the facility ripple through the entire region's economy. The Camp Lejeune Complex is home to an active duty, dependent, retiree, and civilian population of nearly 150,000. It is estimated that the complex generates $2.9 billion in commerce each year, which comes from payrolls and contracts to support the structure required to train and equip Marines (MCB Camp Lejeune 2004). Specifically, the economic benefits are from the following sources:

- Jobs;
- Worker salaries or personal income;
- Local sales to workers and their families;
- Revenues to local businesses; and
- Residential property in the community owned or occupied by military personnel and employees of the facilities.

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3 Aircraft Operations

MCOLF Oak Grove primarily is utilized for tilt-wing and rotary-wing aircraft operations. For this AICUZ study, aircraft descriptions are provided below for aircraft that account for the majority of the operations at the airfield.

3.1 Aircraft Types

Aircraft types that typically utilize MCOLF Oak Grove are described in the following subsections.

3.1.1 Tilt-rotor Aircraft

MV-22 "Osprey." The Osprey is a joint service, multi-mission, tilt-rotor aircraft with vertical take-off and landing capability. It performs vertical take-off and landings as effectively as a conventional helicopter while also having the long-range cruise abilities of a twin turboprop aircraft. It is an assault transport for troops, equipment, and supplies and is capable of operating from ships or from expeditionary airfields ashore.

3.1.2 Rotary-wing Aircraft

CH-53E "Super Stallion." The Super Stallion is the largest helicopter in the U.S. military inventory. It is used by the Marine Corps to transport personnel and equipment, and lift heavy loads. The helicopter carries a crew of three and has a rotor diameter of 79 feet, a length of 99 feet, and height of 28 feet. The CH-53E is the only helicopter capable of lifting some of the new weapon systems in the Marine Corps, including the M-198 Howitzer and the variants of the new Light Armored Vehicle, with its maximum lift capability at 16 tons.

AH-1W "Super Cobra." The AH-1W Super Cobra is a day/night marginal weather Marine Corps attack helicopter that provides en route escort for assault helicopters and their embarked forces. It has an air-to-air and anti-radar missile capability. The primary mission of the AH-1W aircraft is as an armed tactical helicopter capable of close air support, low altitude and high speed flight, target search and acquisition, reconnaissance by fire, multiple weapons fire support, troop helicopter support, and point target attack of threatening armor. The AH-1W provides fire escort and fire support coordination to the landing force during amphibious assaults and subsequent operations ashore.

UH-1N "Iroquois (Huey)." The UH-1Ns are widely used in transport, airborne battlefield command and control, troop insertion/extraction, fire support coordination, medical evacuation, search and rescue, armed escort/visual reconnaissance, reconnaissance by fire, close air support, or utility roles throughout the United States Department of the Navy (Navy) and Marine Corps. The Huey provides utility combat helicopter support to the landing force commander during ship-to-shore movement and in subsequent operations ashore.

CH-46 "Sea Knight (Phrog)." As a Marine Corps platform, the Sea Knight or "Phrog" is used primarily for cargo and troop transport. The tandem-rotor design of the Sea Knight permits increased agility and superior handling qualities in strong relative winds from all directions, allowing, in particular, rapid direction changes during low airspeed maneuvering. The CH-46 is considered a medium-lift helicopter, with a maximum lift capability of 6,000 pounds.

3.2 Airspace

The use of airspace over MCOLF Oak Grove is dictated by the FAA National Airspace System. This system is designed to ensure the safe, orderly, and efficient flow of commercial, private, and military aircraft. MCOLF Oak Grove is located in the airspace assigned to Washington Center by the FAA. Washington Center has delegated control of local airspace to Cherry Point Approach Control. MCOLF Oak Grove normally operates as an uncontrolled airport within Cherry Point Approach Control airspace, but can support control tower operations with deployable ATC staff and equipment for special operations.

MCOLF Oak Grove is located within Class E airspace. Class E airspace is controlled airspace surrounding controlled and non-towered airports. Both visual flight rules (VFR) and instrument flight rules (IFR) flight is permitted in Class E airspace and communication with air traffic control is not required for VFR flights. Airspace designation changes to Class D whenever an operating control tower is present.

3.3 Aircraft Operations

The main noise sources at MCOLF Oak Grove are aircraft operations, including flight arrivals, departures, pattern-work, and low-level activities (i.e., hovers). No engine maintenance operations or run-ups are conducted at MCOLF Oak Grove.

3.3.1 Flight Operations

A *flight operation* refers to any takeoff or landing at MCOLF Oak Grove. The takeoff and landing may be part of a training maneuver (or pattern) associated with the runway or may be associated with a departure or arrival of an aircraft to or from defense-related, special-use airspace. Basic flight operations at MCOLF Oak Grove are:

- **Departure.** An aircraft taking off to a local training area, a non-local training area, or as part of a training maneuver (i.e., touch-and-go).
- **Straight-In/Full-Stop Arrival.** An aircraft lines up on the runway centerline, descends gradually, lands, comes to a full stop, and then taxis off the runway or departs.
- **Overhead Arrival.** An expeditious arrival using visual flight rules. An aircraft approaches the runway 500 feet above the altitude of the landing pattern. Approximately halfway down the runway, the aircraft performs a 180-degree turn to enter the landing pattern. Once established in the pattern, the aircraft lowers landing gear and flaps and performs a 180-degree descending turn to land on the runway.
- **Touch-and-Go Operation.** An aircraft lands and takes off on a runway without coming to a full stop. After touching down, the pilot immediately goes to full power and takes off again. The touch-and-go actually is counted as two operations – the landing is counted as one operation, and the takeoff is counted as another.

- **Stop-and-Go Operation.** An aircraft lands to a specific spot on the runway and comes to a complete stop and then departs. Stop-and-Go operations are counted as two operations – the landing is counted as one operation, and the takeoff as another.

- **Low Approach.** An approach to a runway in which the pilot does not make contact with the runway.

- **Low-Work/Hover Areas.** These events typically last 15 minutes (low-work) or 20 minutes (hovers) in specific areas of the airfield in which the pilot does not make contact with the runway.

- **Confined Area Landings (CALs).** A landing technique utilized when the intended point of landing is surrounded by obstacles, preventing a normal approach glide slope.

- **Taxiing and Groundwork.** These are aircraft procedures where the aircraft operates under its own power on the ground at low speeds, typically prior to takeoff or after landing.

3.3.2 MCOLF Oak Grove Operations

There is limited historical aircraft operational data for MCOLF Oak Grove. The reason for this includes the fact that aircraft at MCOLF Oak Grove normally operate without an air traffic control tower. Other than an on-site site ground maintenance crew, there are no personnel working at MCOLF Oak Grove. In addition, MCOLF Oak Grove experienced a transfer of ownership in October 2006 from MCAS Cherry Point to MCB Camp Lejeune. No record of historic operations data were kept prior to this transfer. To supplement the lack of historical data, a five-month survey of flight operations was conducted by Wyle Laboratories. The survey was conducted from 1 October 2006 to 28 February 2007 and was extrapolated over a year to establish a baseline for the purposes of the noise and safety analysis.

From this survey and extrapolation, it was estimated that the total existing annual operations conducted at MCOLF was approximately 4,320. This includes departures, arrivals, and pattern work for the CH-46, CH-53, UH-1, AH-1, and MV-22 aircraft utilizing the airfield.

Utilizing this existing annual operations number, the flight operations were then adjusted further to account for future operations, including the Marine Corps 202k Plus-Up program, which will result in additional squadrons utilizing MCAS New River and MCOLF Oak Grove. Operations were projected to the year 2012. The flight operations for 2012 are utilized in this study to develop the 2011 AICUZ noise contours (see Section 4, Aircraft Noise) and APZs (see Section 5, Airfield Safety).

Table 3-1 presents the total projected annual flight operations at MCOLF Oak Grove. Flight operations broken down by aircraft and flight track can be found in the 2007 Wyle Noise Study.

Table 3-1 Projected Annual Air Operations for MCOLF Oak Grove

Category	Operation Type[1]	Day 0700-2200	Night 2200-0700	Total
CH-46	Departure	16	0	16
	Arrival	16	0	16
	Closed Patterns	42	0	42
	Total	**74**	**0**	**74**
CH-53E	Departure	647	46	693
	Arrival	647	46	693
	Closed Patterns	2,699	95	2,794
	Total	**3,993**	**187**	**4,180**
AH-1	Departure	237	87	324
	Arrival	237	87	324
	Closed Patterns	1,021	437	1,458
	Total	**1,495**	**61**	**2,106**
UH-1	Departure	108	26	134
	Arrival	108	26	134
	Closed Patterns	410	0	410
	Total	**626**	**52**	**678**
MV-22	Departure	3,394	609	4,003
	Arrival	3,394	609	4,003
	Closed Patterns	4,878	1,219	6,097
	Total	**11,666**	**2,437**	**14,103**
Grand Total	Departure	4,402	768	5,170
	Arrival	4,402	768	5,170
	Closed Patterns	9,050	1,751	10,801
	Total	**17,854**	**3,287**	**21,141**

Note:
[1] Closed Patterns are considered touch-and-go, or similar, operations.

Source: Wyle Laboratories 2007.

3.3.3 Runway and Flight Track Utilization

Aircraft approaching or departing from MCOLF Oak Grove are assigned specific routes or flight tracks. The designated runways for the airfield are identified in Section 2.4. Flight tracks are represented as single lines, but flights vary due to aircraft performance, pilot technique, and weather conditions, such that the actual flight track is a band that is often one-half to several miles wide. The flight tracks shown in this AICUZ study are idealized representations. Predominant arrival, departure, and pattern flight tracks are shown on Figures 3-1 through 3-7.

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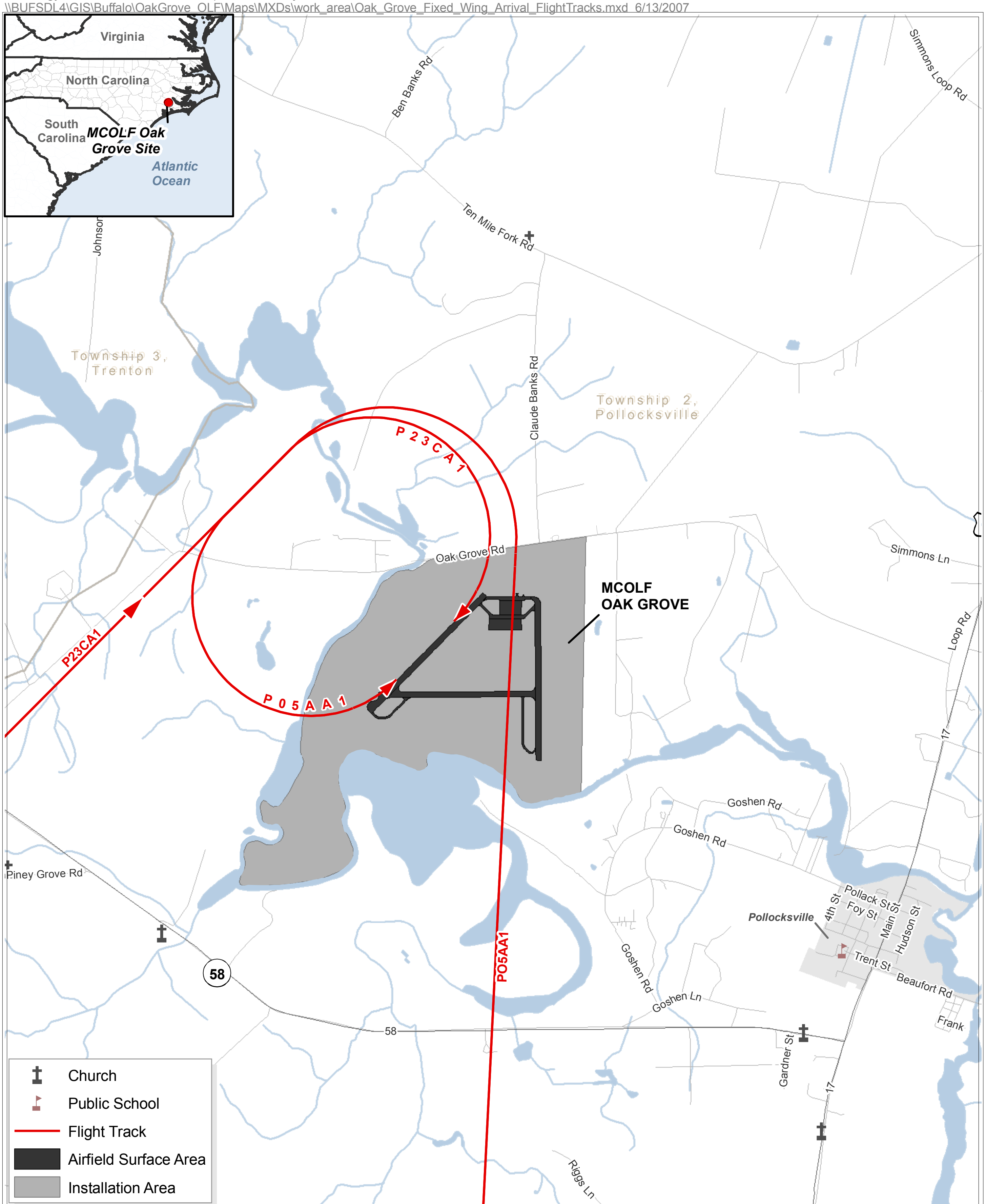

Figure 3-1
Arrival Flight Tracks for the MV-22 Aircraft at MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report MCOLF Oak Grove

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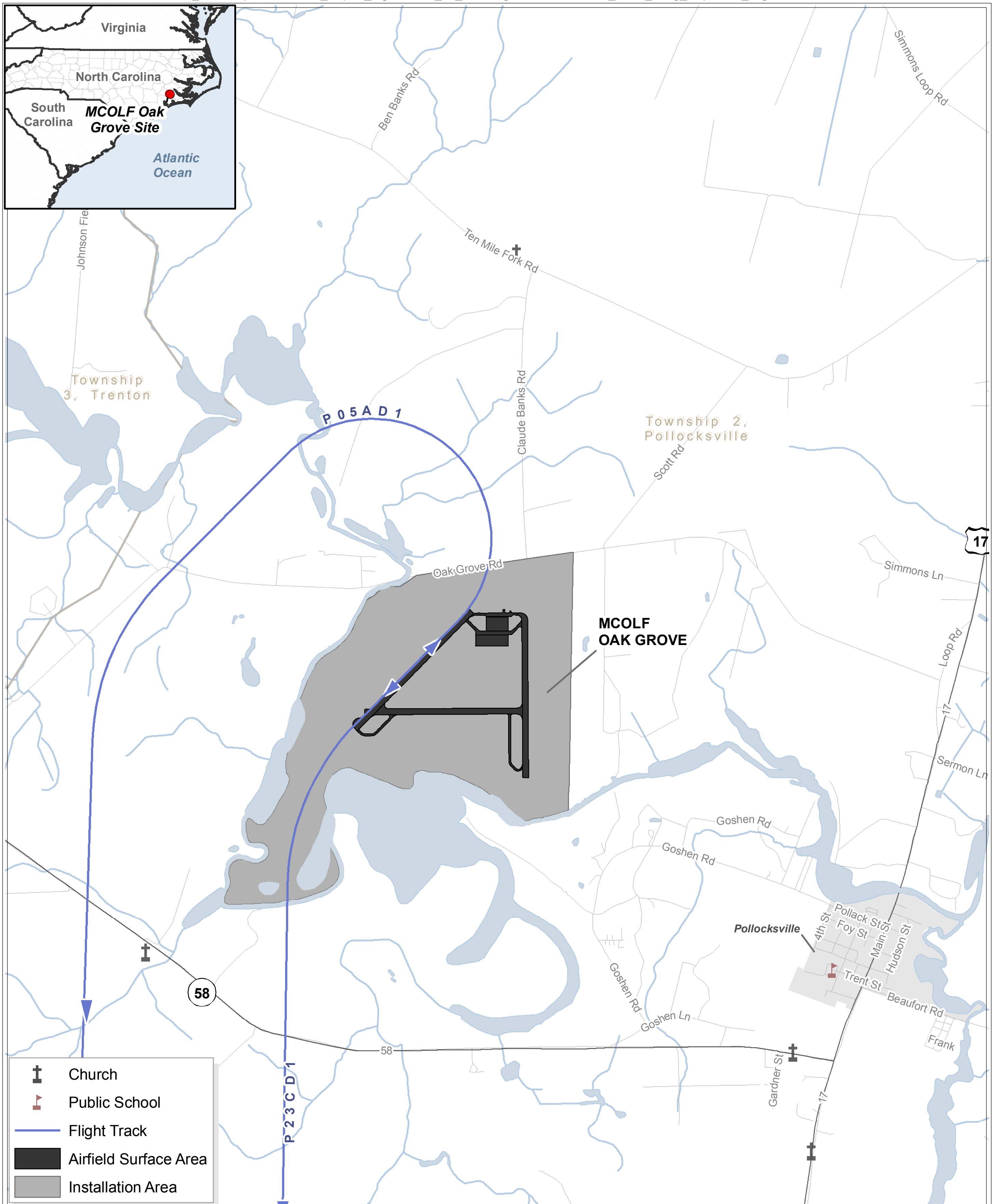
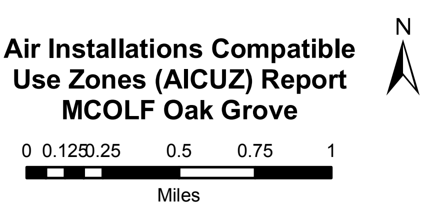


Figure 3-2
Departure Flight Tracks for the MV-22 Aircraft at MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report MCOLF Oak Grove



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\\BUFSDL4\GIS\Buffalo\OakGrove_OLF\Maps\MXDs\Draft_OLF_Report_Figures\Figure 3-3 OakGrove_Conversion_MV22_FlightTracks.mxd 10/16/2007

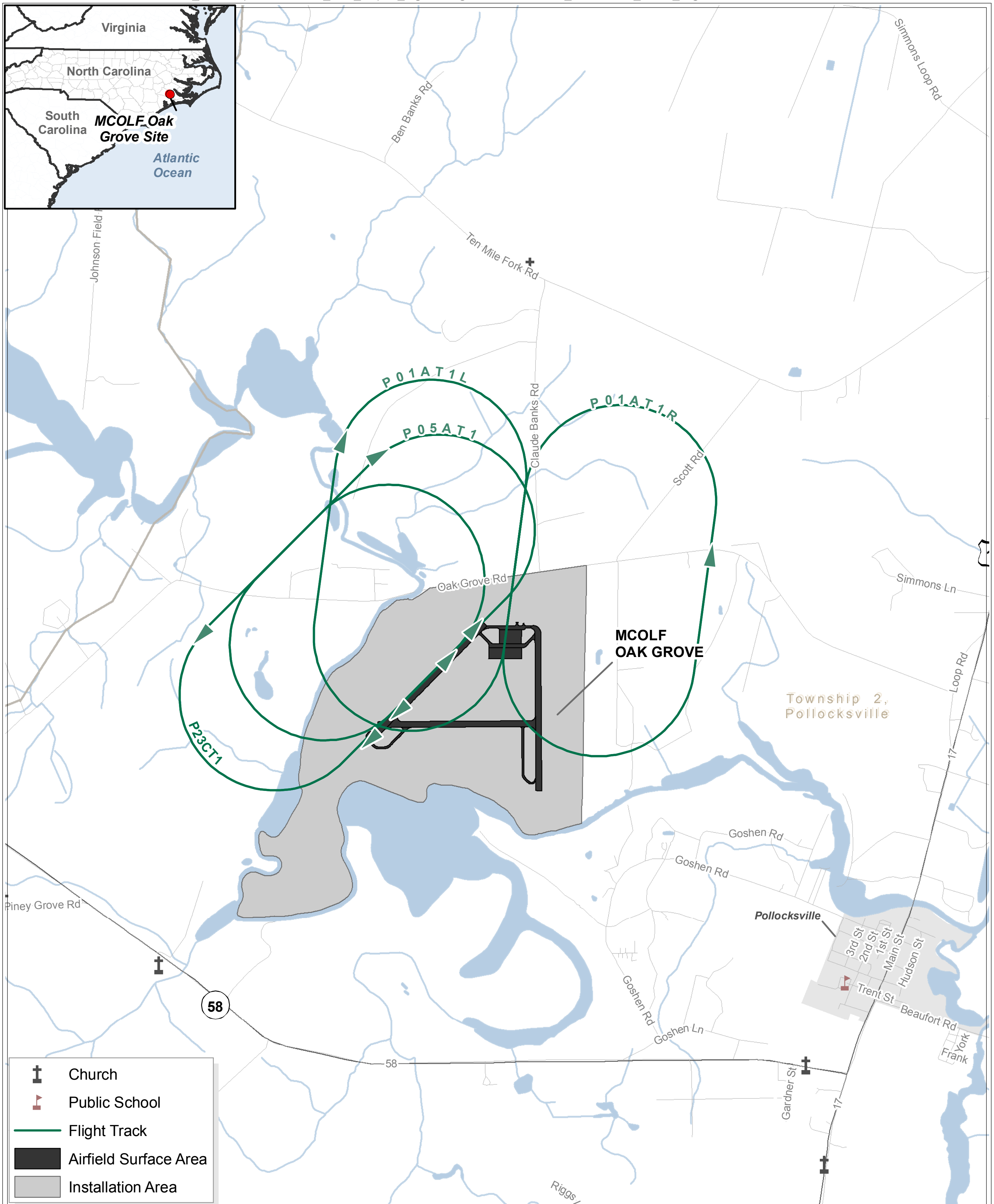

Figure 3-3
Conversion Pattern Flight Tracks for the MV-22 Aircraft at MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report MCOLF Oak Grove

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\\BUFSDL4\GIS\Buffalo\OakGrove_OLF\Maps\MXDs\OLF_Report_Figures\Oct_16_2007\Figure 3-4 OakGrove_Tactical_and_Airplane_FlightTracks.mxd 10/16/2007

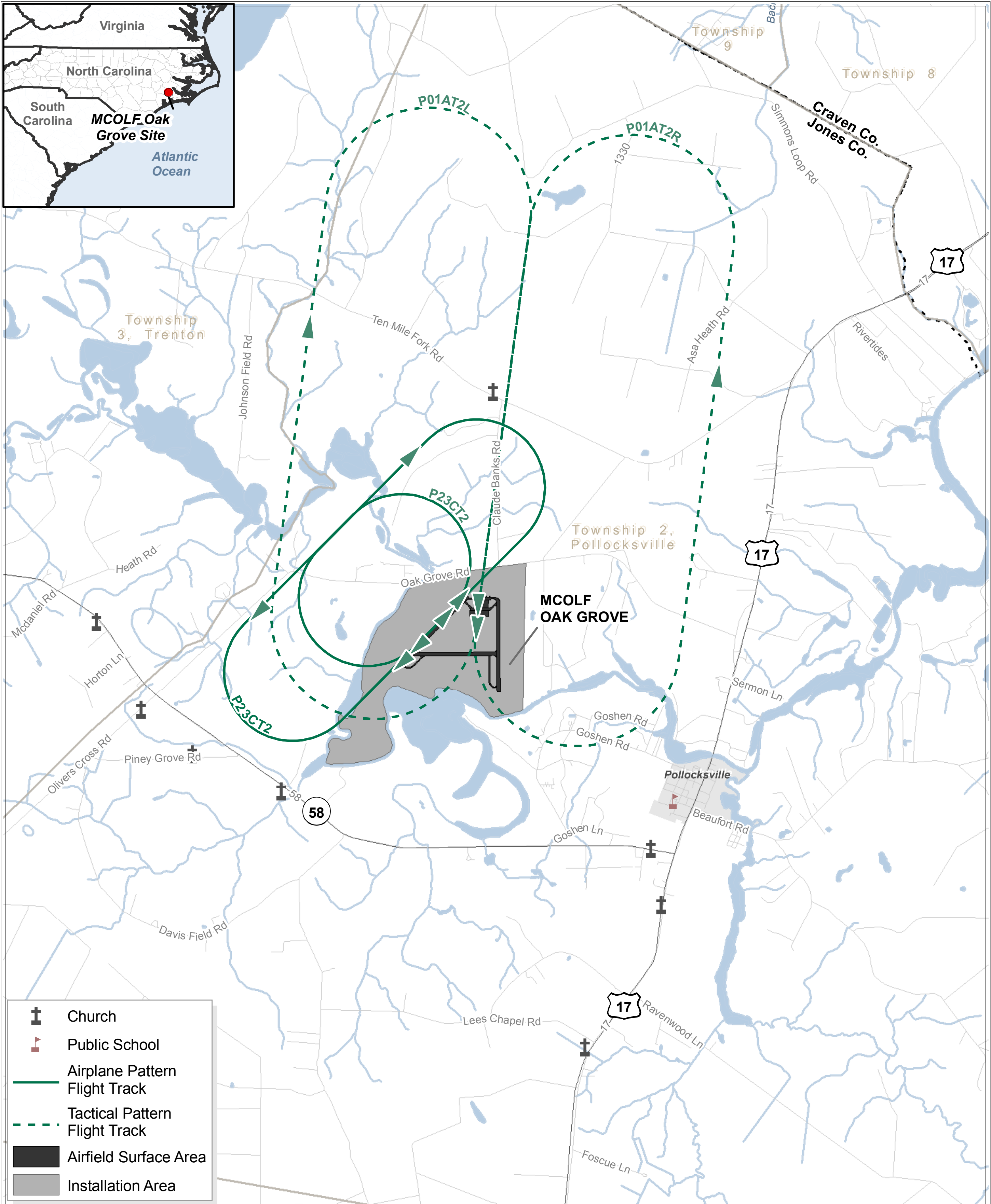


Figure 3-4
Tactical and Airplane Pattern Flight Tracks for the MV-22 Aircraft at MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report MCOLF Oak Grove

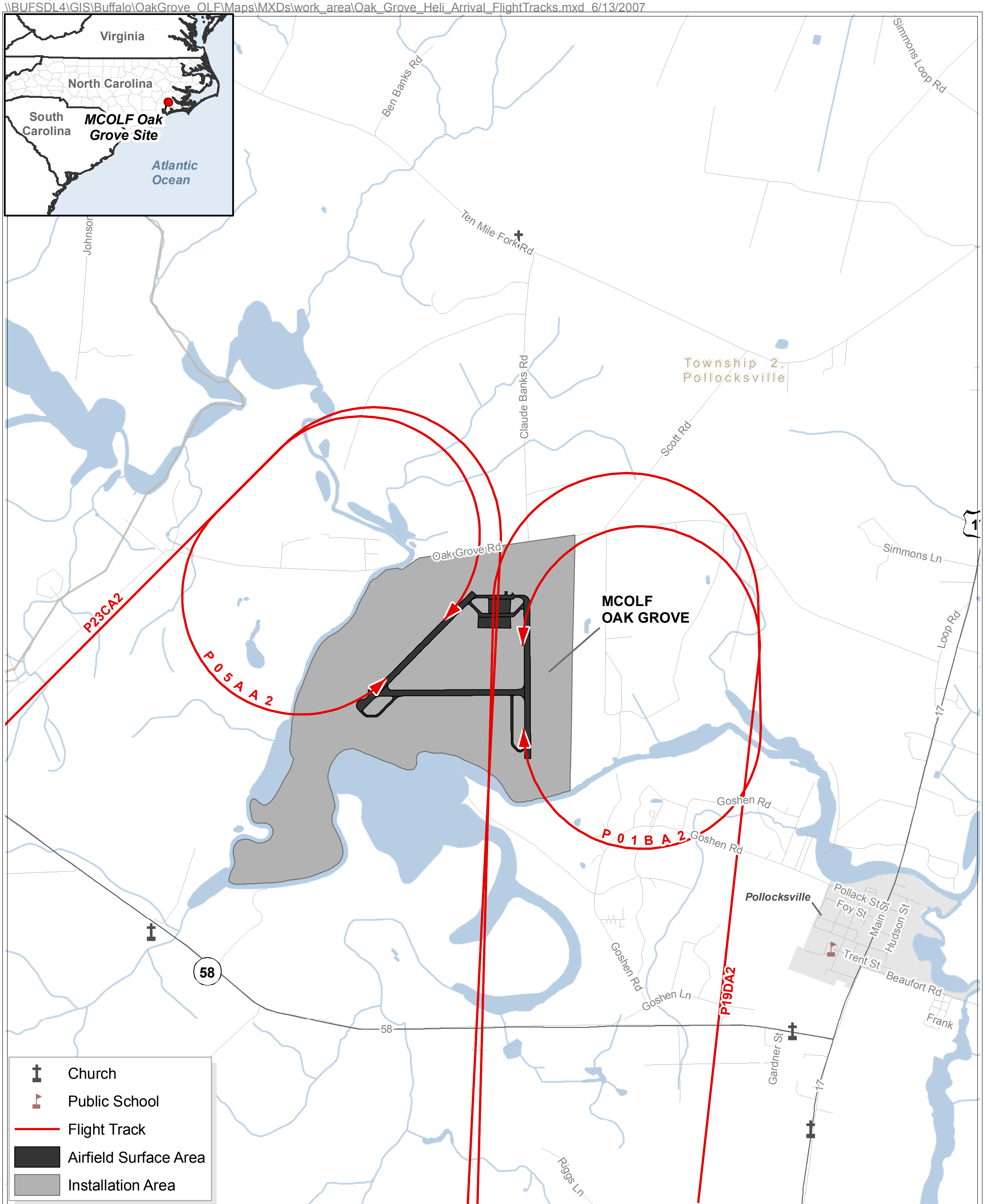
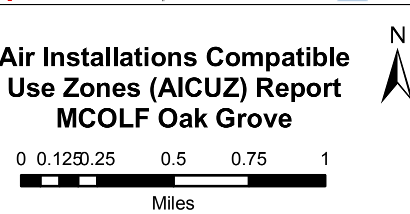


Figure 3-5
Arrival Flight Tracks (Rotary Wing), MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove



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\\BUFSDL4\GISL:\Buffalo\OakGrove_OLF\Maps\MXDs\OLF_Report_Figures\Oct_16_2007\Figure 3-6 OakGrove_Heli_Departure_FlightTracks.mxd

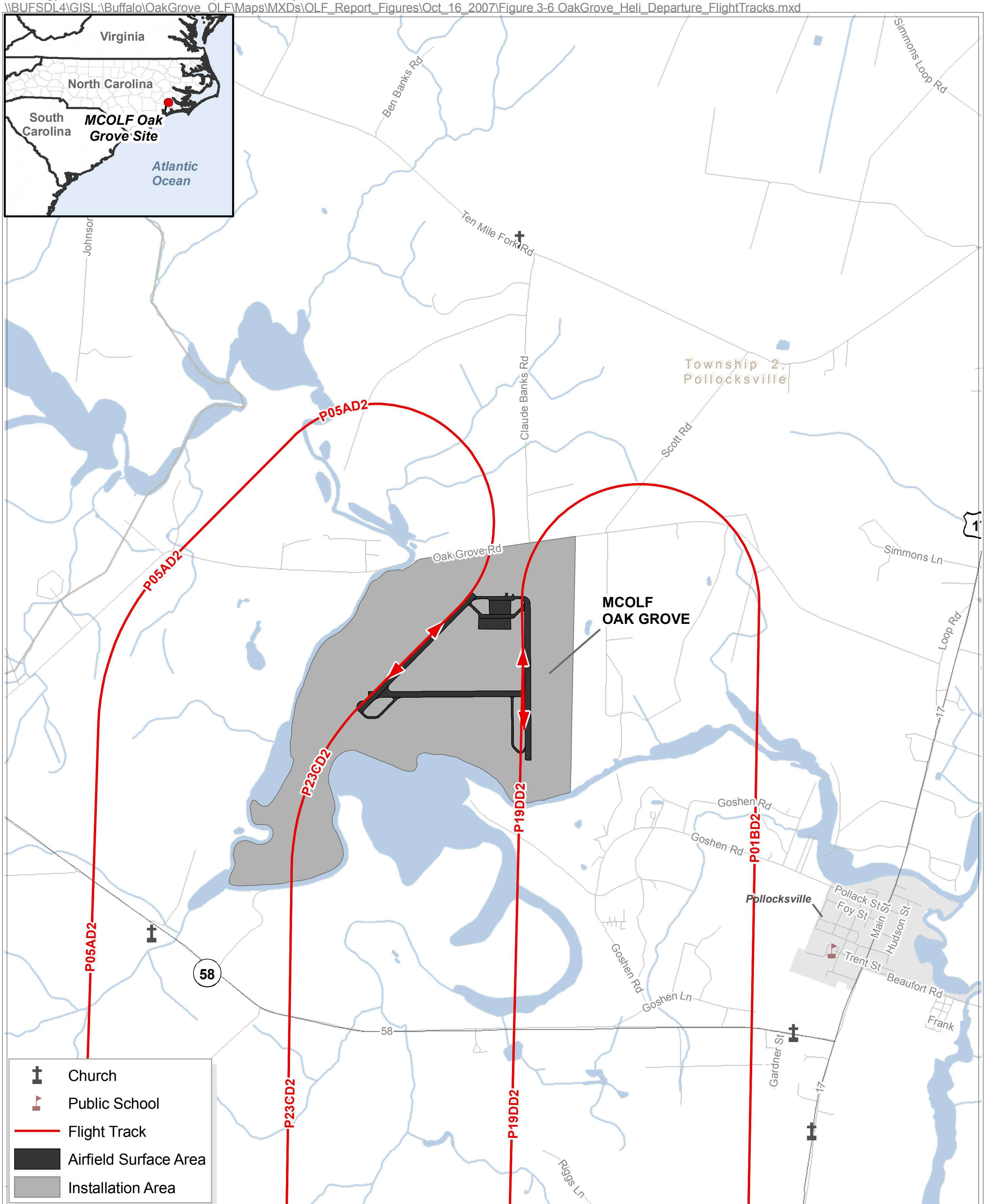

Figure 3-6
Departure Flight Tracks (Rotary Wing), MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report MCOLF Oak Grove

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\\BUFSDL4\GIS\Buffalo\OakGrove_OLF\Maps\MXDs\OLF_Report_Figures\Oct_16_2007\Figure 3-7 OakGrove_Heli_Visual_Closed_Pattern_FlightTracks.mxd 10/16/2007

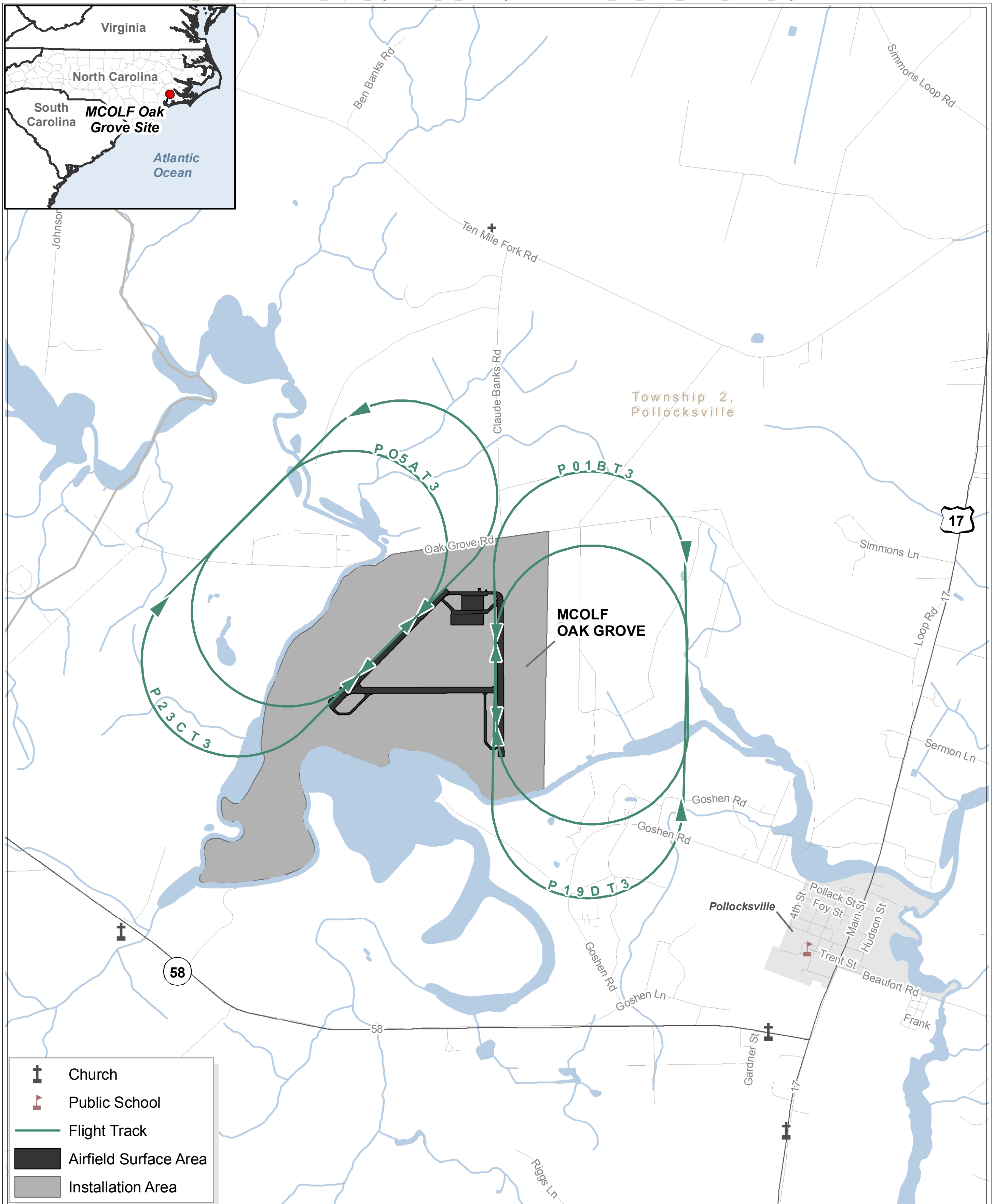

Figure 3-7
Visual Closed Pattern
Flight Tracks (Rotary Wing)
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

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4 Aircraft Noise

The impact of aircraft noise is a critical factor in the planning of future land use near air facilities. Because the noise from aircraft operations may significantly impacts areas surrounding an installation, MCOLF Oak Grove (and MCAS New River as the installation scheduler) has defined certain areas as noise zones under the AICUZ program. This section discusses noise associated with aircraft operations at MCOLF Oak Grove, including average noise levels, noise complaints, noise abatement/flight procedures, and noise contours.

4.1 What is Sound/Noise?

Sound is the result of a sound source inducing vibrations in the air. Noise can be defined as unwanted sound. Some of the potential sources of noise include roadway traffic, land use activities, railway activities, and aircraft operations. Whether sound becomes noise depends on the listener, but sound can become noise when it interferes with normal activities. For further discussion of noise and its effects on people and the environment, the Navy developed a detailed noise analysis that explains noise and noise exposure issues in great detail and is included as Appendix A.

In this document, all sound or noise levels are measured in A-weighted decibels (dBA), which are units of sound pressure adjusted to the range of human hearing with an intensity greater than the ambient or background sound pressure. Normal speech has a noise level of approximately 60 dBA. Generally, a sound level above 120 dBA will begin to provide discomfort to the human auditory system (Berglund and Lindvall 1995).

The noise exposure from aircraft at MCOLF Oak Grove, as with other installations, is measured using the DNL. The DNL, established in 1980 by the Federal Interagency Committee on Urban Noise (FICUN), presents a reliable measure of community sensitivity to aircraft noise and has become the standard metric used in the United States (except California, which uses a similar metric). DNL averages sound levels at a location over a 24-hour period. DNL also adds an additional 10 dB to events occurring between

10:00 p.m. to 7:00 a.m. This 10-dB "penalty" represents the added intrusiveness of sounds occurring during normal sleeping hours, both because of the increased sensitivity to noise during those hours and because ambient sound levels at night are typically lower (Wyle Laboratories 2007).

By combining factors most noticeable about noise annoyance – maximum noise levels, duration and the number of events over a 24-hour period – DNL provides a single measure of overall noise impact. Scientific studies and social surveys conducted to evaluate community annoyance to all types of environmental noise have found DNL to be the best measure of that annoyance (FICUN 1980, EPA 1982, ANSI 1990, FICON 1992).

Although DNL provides a single measure of overall noise impact, it does not provide specific information on the number of noise events or the individual sound levels that occur during the day. For example, a day-night average sound level of 65 dBA could result from a very few noisy events or a large number of quieter events.

The DNL is depicted visually as a noise contour that connects points of equal value. The noise contours in this document are depicted in 5-dBA increments. The AICUZ program generally divides noise exposure into three categories known as Noise Zones:

- Noise Zone 1: Less than 65 DNL;
- Noise Zone 2: 65 to 75 DNL; and
- Noise Zone 3: Greater than 75 DNL.

For land use planning purposes, the noise zones above are grouped into three noise zones. Noise Zone 1 (less than 65 DNL) is generally considered an area of low or no noise impact. Noise Zone 2 (65 to 75 DNL) is an area of moderate impact, where some land use controls are required. Noise Zone 3 (greater than 75 DNL) is the most severely impacted area and requires the greatest degree of land use control.

4.2 Airfield Noise Sources

The main sources of noise at airfields are flight operations and pre-flight and/or aircraft turn-ups and rotor engagements. Computer models are used to develop noise contours, based on information about these operations, including:

- Type of operation (arrival, departure, and pattern);

- Number of operations per day;
- Time of operation;
- Flight track;
- Aircraft power settings, speeds, altitudes, rotor blade pitch angle and/or nacelle angle;
- Number and duration of pre-flight and aircraft turn-ups and rotor engagements;
- Terrain;
- Surface type; and
- Environmental data (temperature and humidity).

4.3 Noise Complaints

Noise complaints originating from operations at MCOLF Oak Grove are handled through the receiving agency, typically MCAS New River or MCB Camp Lejeune. Noise complaints can arise from a variety of causes, ranging from intensity and frequency of the events to the individual noise sensitivity of the person complaining. They can originate from areas outside the depicted noise contours, often due to a single unusual event, such as an aircraft flying over an area not commonly overflown. In other cases, these complaints are due to the fact that some people are more noise sensitive than their neighbors. There are only occasional complaints received at MCAS New River and MCB Camp Lejeune normally related to the perception of low flying helicopters and tilt-rotor aircraft. These complaints are investigated by the receiving agency to determine if any corrective actions are appropriate.

The procedures address how noise complaints shall be received, the responsible parties to be advised of the noise complaint, and what type of action is required to address the complaint.

A small increase in noise level generally will not be no, but, as the change in noise level increases, individual perception is greater, as shown in Table 4-1.

Table 4-1 Subjective Response to Noise

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

4.4 Noise Abatement/Flight Procedures

Air Station Operations personnel (S-3) and operational squadrons actively pursue operational measures to reduce noise. The Marines conduct noise abatement procedures to its best ability, commensurate with safety and operational training requirements. Noise abatement procedures are summarized in Table 4-2. The purpose of these procedures is to minimize noise in recognition of community response to aircraft noise at MCOLF Oak Grove and MCAS New River.

Table 4-2 Noise Abatement/Flight Procedures, MCOLF Oak Grove

MCAS New River and MCOLF Oak Grove
Noise Abatement • To minimize noise annoyance to the local community, aircraft shall not fly over densely populated areas below an altitude of 1,000 feet above ground level. • Every effort shall be taken to fly in such a manner that individuals do not believe they or their property are endangered. • Close-in downwinds are not authorized after sunset.

Source: MCAS New River AICUZ 2001.

4.5 Noise Contours

The AICUZ process calls for the modeling and analysis of existing conditions and any future aircraft operational changes that can reasonably be predicted. As stated in Section 3.3, Aircraft Operations, there was limited historical aircraft operational data available for MCOLF Oak Grove. To supplement the lack of historical data, a five-month survey of flight operations was conducted from 1 October 2006 to 28 February 2007 and extrapolated over a year to establish a baseline. Utilizing this, along with other available unclassified information, MCAS New River provided a forecast of air operation activity levels for the prospective condition at MCOLF Oak Grove for the year 2012. These operational projections were revalidated for this study.

The Marines conducted a noise study by using actual operational data collected during the five-month survey and projected operational data to determine new noise exposure levels. The initial step in understanding the new noise exposure levels is the preparation of a noise study to define noise exposure contours. This also represents the first step in the AICUZ study process. The noise contours are developed using a computer-based model called NOISEMAP, where inputs such as aircraft activity and site-specific operational data at MCOLF Oak Grove, are used in calculating the noise contours. Projections of aircraft operations were based on information provided by MCAS New River personnel.

4.5.1 MCOLF Oak Grove

The main noise sources at MCOLF Oak Grove are aircraft operations, including tilt-wing (MV-22 "Osprey") and rotary-wing aircraft. This section describes the existing noise contours and the modeled 2011 AICUZ noise contours.

4.5.1.1 2011 AICUZ Noise Contours

The 2011 AICUZ noise contours have significantly increased the overall size of the 1978 AICUZ noise contours (see Figure 4-1). The concentrations of the 2011 AICUZ noise contours are on the 05/23 and 19/01 runways as well as the low work, hover, and Center Pad Hover areas. The 60 as well as some of the 65 dB DNL noise contours extend off-station, specifically at the edge of runways 05/23 and 19/01 to the north, south and southwestern portion of the MCOLF (see Figure 4-2). The total amount of off-station acreage within the 60 DNL contour is 861 acres, including 70 individuals (see Table 4-3).

Table 4-3 Off-Base Population and Area Impact for 2011 AICUZ Noise Contours, MCOLF Oak Grove

DNL	Population	Housing	Area (acres)
60-65 DNL	61	25	747
65-75 DNL	9	4	114
75+ DNL	-	-	-

Source: Wyle Laboratories 2007.

4.5.1.2 Comparison of 1978 and 2011 AICUZ Noise Contours

It should be noted that the 1978 adopted AICUZ noise contours only model to 65 DNL, whereas the 2011 AICUZ noise contours are modeled to 60 DNL. The 2011 AICUZ noise contours have changed in size and location from the 1978 AICUZ noise contours (see Figures 4-1 and 4-2). The 65 DNL contour under the 1978 AICUZ extended significantly off base to the north from runway 05/23. The off-base portion of the 65 DNL extends from the each end of runway 05/23 and consumed acreage parallel to the runway as well. The 2011 AICUZ noise contours of 65 DNL extend off base at the north end of runways 05/23 and 19/01 and slightly at the southwest end of 05/23. The

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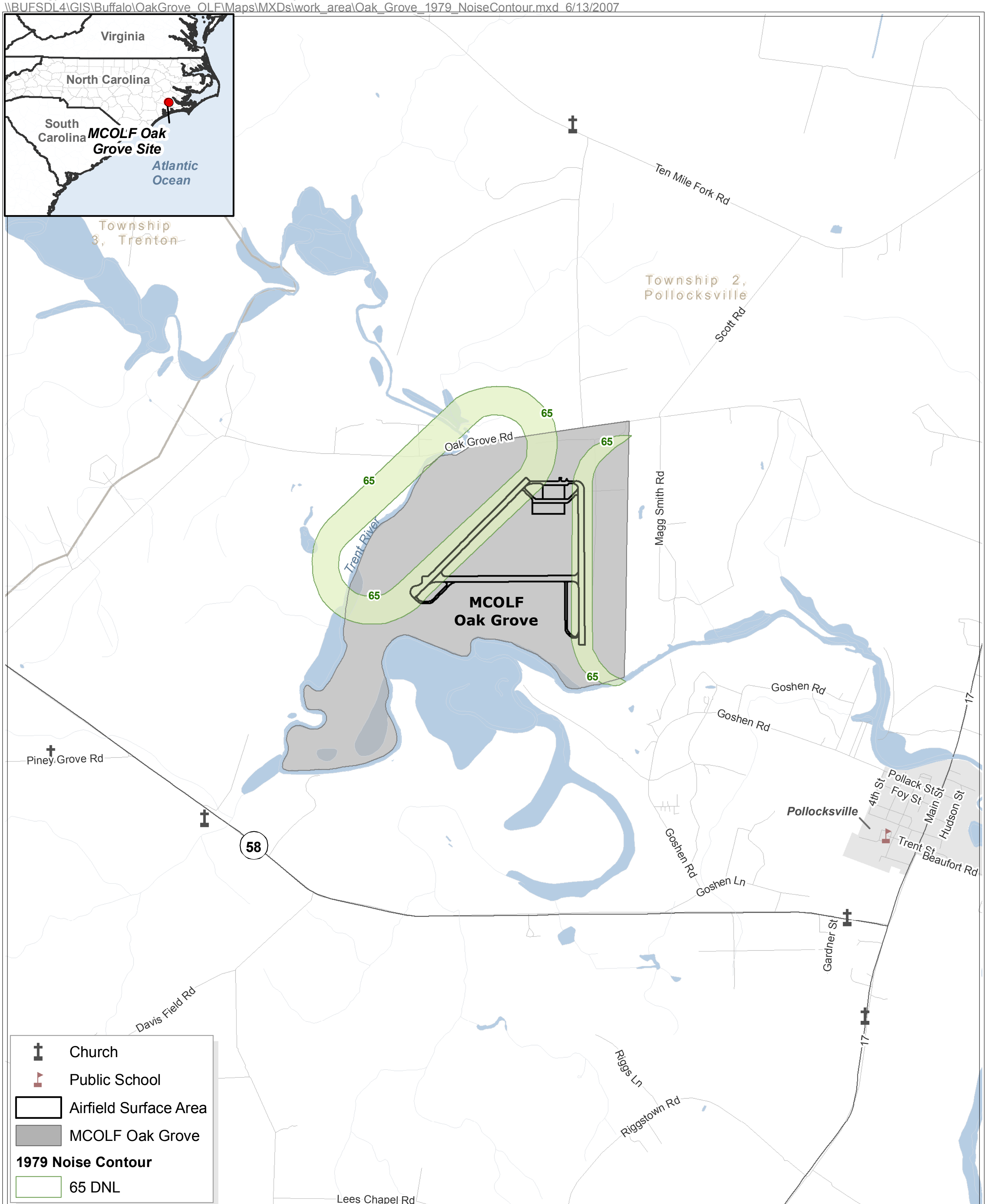
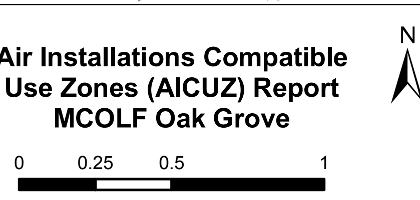


Figure 4-1
1978 Noise Contour
Average Annual Day LDN
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove



Path: L:\Buffalo\OakGrove_OLF\Maps\MXDs\OLF_Report_Figures\April_12_2011\Figure 4-2 OakGrove_2012_prospective_Existing_Noise.mxd

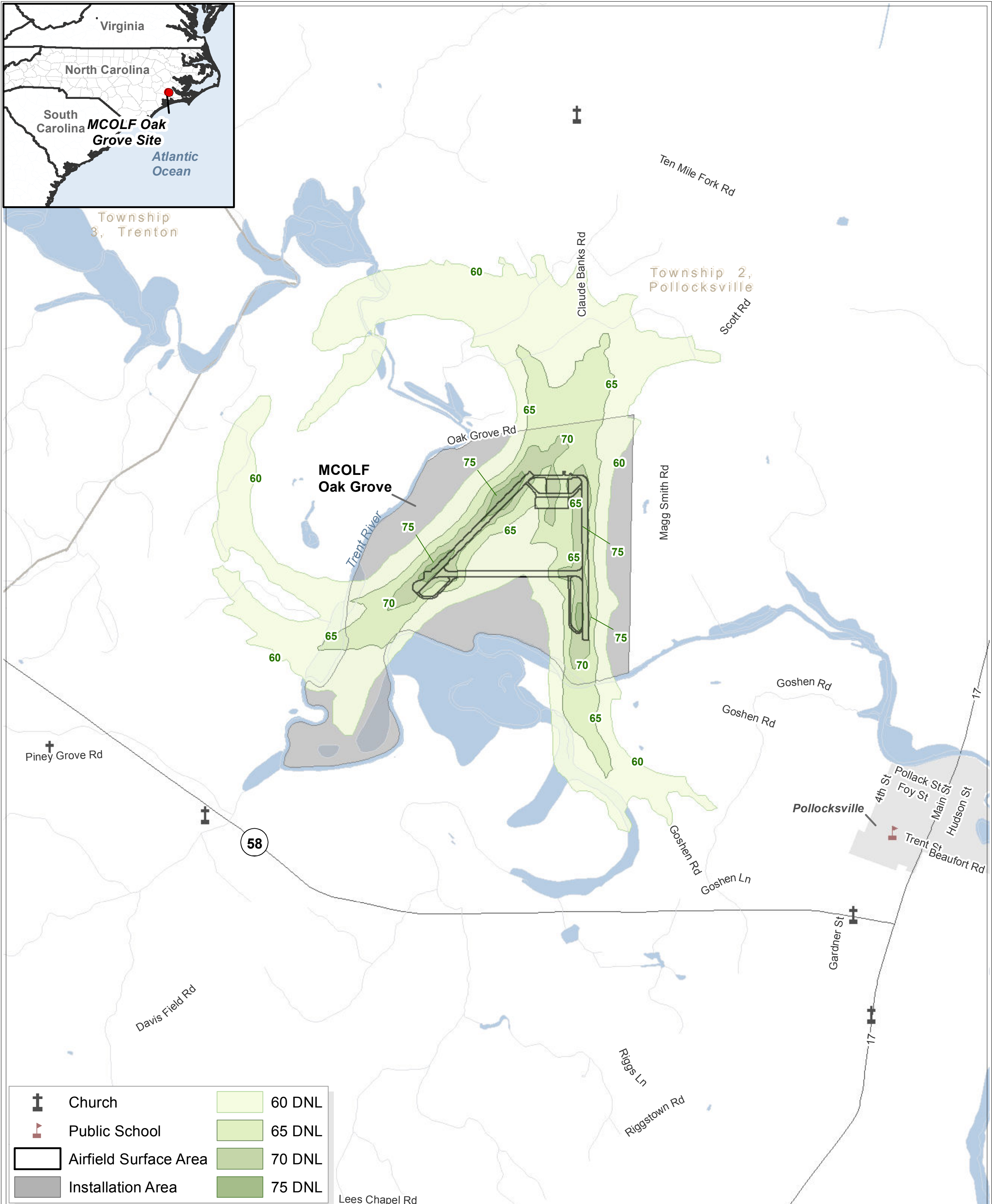


Figure 4-2
2011 AICUZ
Average Annual Day DNL
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

1978 noise contours on runway 19/01 are minimally off-base. The 2011 AICUZ noise contours for runway 19/01 extend further to the north and south than the 1978 contours (see Table 4-4).

Table 4-4 Areas within Noise Zones (DNL) (1978 and 2011), MCOLF Oak Grove

Noise Zone (DNL or LDN)	TOTAL LAND AREA	
	1978 AICUZ Noise Zones (acres)	2011 AICUZ Noise Zones (acres)
60-65 DNL	N/A	746.64
65-70 DNL	158.00	114.24
TOTAL AREA	**158.00**	**860.88**

Source: Southern Division NAVFAC 1978 and Wyle Laboratories 2007.

5 Airfield Safety

The Marines have identified airfield safety issues to assist the community in developing land uses compatible with airfield operations. These issues include accident potential and hazards within the airfield vicinity that obstruct or interfere with aircraft and departures, pilot vision, communications, or aircraft electronics.

While the likelihood of an aircraft mishap occurring is remote, the Marines identified areas of accident potential to assist in land use planning. The Marines have identified APZs around its runways based on historical data for aircraft mishaps. The Marines recommend certain land uses that concentrate large numbers of people (i.e., apartments, churches, and schools) be constructed outside the APZs.

In addition, the FAA and the military have defined flight safety zones (imaginary surfaces) below aircraft arrival and departure flight tracks and surrounding the airfield. For the safety of the aircraft, the heights of structures and vegetation are restricted in these zones. The flight safety zones are designed to minimize the potential harm if a mishap does occur.

Other hazards to flight safety that should be avoided in the airfield vicinity include:

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

5.1 Accident Potential Zones

5.1.1 Aircraft Mishaps

In the 1970s, recognizing the need to identify areas of accident potential, the military conducted a tri-service study of historic accident and operations data throughout the military. The study showed that most aircraft mishaps occur on or near the runway or along the centerline of the runway, diminishing in likelihood with distance. Based on the study, the DoD has identified APZs as areas where an aircraft accident is more likely to occur (if one was to occur). The APZs do not predict the probability of an accident, but define areas where land use activities should be restricted or limited to protect the public from aircraft mishaps. APZs follow departure, arrival, and pattern flight tracks and are based upon analysis of historical data.

There are three "severity classes" for aircraft mishaps. The most severe is a Class A mishap. This is an accident in which the total cost of damage to property or aircraft exceeds $1 million, an aircraft is destroyed or missing, or any fatality or permanent total disability results from the direct involvement of naval aircraft.

In this AICUZ document, only the number of Class A mishaps is presented for the purposes of assessing aircraft safety in this section, and there have been zero Class A mishaps at MCOLF Oak Grove in the past 10 years according to the Naval Safety Center. There have been other, minor incidents at or around the airfield that are not considered Class A mishaps.

5.1.2 APZ Configurations and Areas

Clear zones and APZs are areas in the vicinity of airfield runways where an aircraft mishap is more likely to occur (if one was to occur). While the likelihood of a mishap is remote, the Marines recommend land uses within APZs be minimal or low density to ensure the maximum protection of public health and property.

No traditional fixed-wing aircraft utilize the runways at MCOLF Oak Grove. The MV-22, a tilt rotor aircraft, comprises the majority of the operations. Draft APZ criteria specific to tilt rotor aircraft operating at an OLF have been developed and are pending incorporation into the Unified Facilities Criteria (UFC) airfield and Heliport Planning and Design Guidelines.

The components of these APZs for tilt rotor aircraft operating at an OLF are identified on Figure 5-1 and are defined as (Mytych 2010):

- **Clear Zone.** Measures 1,000 feet wide and extends 400 feet immediately beyond the end of the primary surface and has the highest potential for accidents. A clear zone is required for all active runways and should remain undeveloped.

- **APZ I.** An APZ I is required for runways/flight tracks that experience 5,000 or more annual operations (departures or approaches). An APZ I for tilt rotor aircraft is 1,000 feet wide and would extend 800 feet beyond the end of the clear zone, and may be altered to conform to the flight shadow.

- **APZ II.** An APZ II is not necessary for all OLF runways. If APZ I is not warranted, the APZ II may still be used if an analysis of operations and/or accidents indicates a need for it. An APZ II was deemed not required at MCOLF Oak Grove.

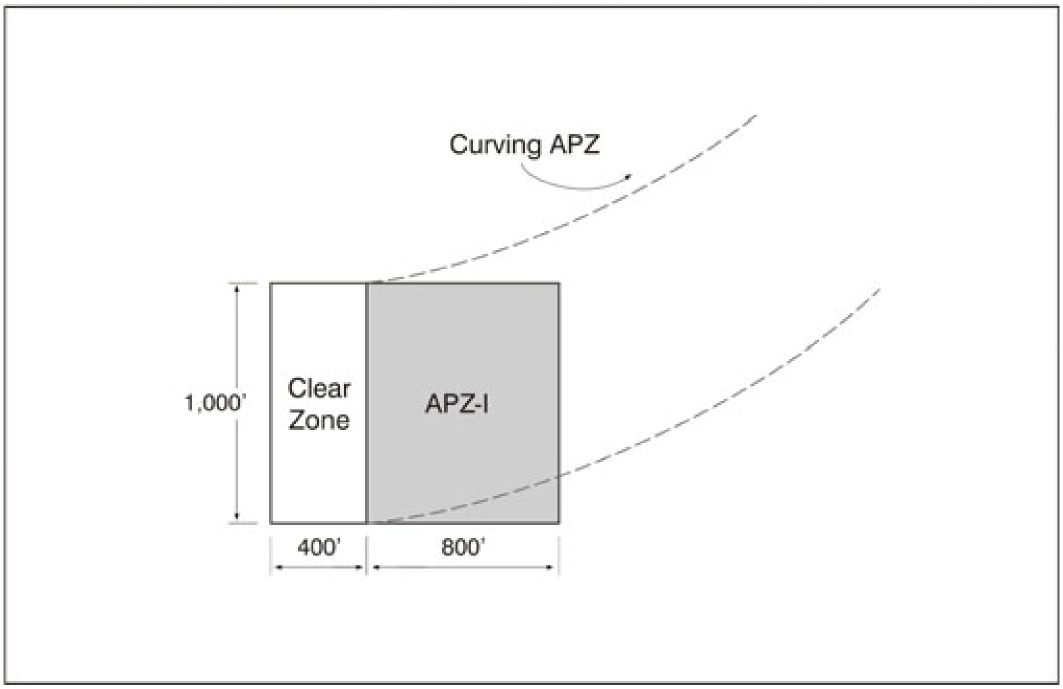


Figure 5-1 Tilt Rotor Aircraft Accident Potential Zones – OLF Runways

An accident is more likely to occur in APZ I than APZ II (where an APZ II exists), and is more likely to occur in the clear zone than in APZ I or APZ II. APZs extend from the end of the runway or primary surface, but apply to the predominant arrival and departure flight tracks used by the aircraft. Therefore, if an airfield has more than one predominant flight track to or from the runway, APZs can extend in the direction of each flight track (see Figure 5-1).

Within the clear zone, most uses are incompatible with military aircraft operations. For this reason, the Marine's policy is to acquire sufficient real property interests in land within the clear zone to ensure incompatible development does not occur. Within APZ I and APZ II, a variety of land uses are compatible; however, people-intensive uses (e.g., schools, apartments) should be restricted because of the greater risk in these areas. When events resulting in threats to the operational integrity from incompatible development (encroachment) occur, and when local communities are unwilling or unable to take the necessary steps to combat the encroachment threat via their own land use and zoning authority, consideration will be given by the Navy to land acquisition, with priority to clear zones and secondary priority to APZs (Navy 2002). There are approximately 8.78 acres within APZ I outside the property boundary of MCOLF Oak Grove; no clear zones extend off the property (see Figure 5-2). Outside the clear zone, APZ I, and APZ II, the risk of aircraft accidents typically does not warrant special consideration in land use planning.

5.2 Flight Safety

5.2.1 Imaginary Surfaces

Imaginary flight paths and transition surfaces define the required airspace that must remain free of obstructions to ensure safe flight approaches, departures, and patterns. Obstructions may include natural terrain and man-made features, such as buildings, towers, poles, and other vertical obstructions to airspace navigation. Brief descriptions of the imaginary surfaces for OLF runways where tilt rotor aircraft operate are provided in Table 5-1 and depicted on Figure 5-3.

Table 5-1 Imaginary Surfaces – Tilt Rotor Aircraft (MV-22) at OLFs

Planes and Surfaces	Geographical Dimensions
Primary Surface	Aligned longitudinally with each runway. Extends 200 feet beyond the end of the runway and is 1,000 feet wide.
Clear Zone	Extends 400 feet beyond the end of the primary surface and 1,000 feet wide.
Accident Potential Zone I	Extends 800 feet beyond the end of the clear zone and 1,000 feet wide.
Approach/Departure Surface	Trapezoid shall begin at the end of the primary surface and extend 8,000 feet. Width at the primary surface is 1,000 feet; width at the end of the approach/departure surface is 3,400 feet.
Horizontal Surface	An oval-shaped plane 150 feet above the established airfield surface. Constructed by scribing an arc with a radius of 4,600 feet about the centerline at each end of the runway and inter-connecting these arcs with tangents.
Transitional Surface	Inclined planes that connect the primary surface and the approach/departure surface to the horizontal surface. These surfaces extend outward and upward at right angles to the runway centerline, extended at a slope of 2:1 from the sides of the primary surface and the sides of the approach/departure surface.

Source: Mytych 2010.

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\Path: L:\Buffalo\OakGrove_OLF\Maps\MXDs\OLF_Report_Figures\April_12_2011\Figure 5-2 OakGrove_APZs.mxd

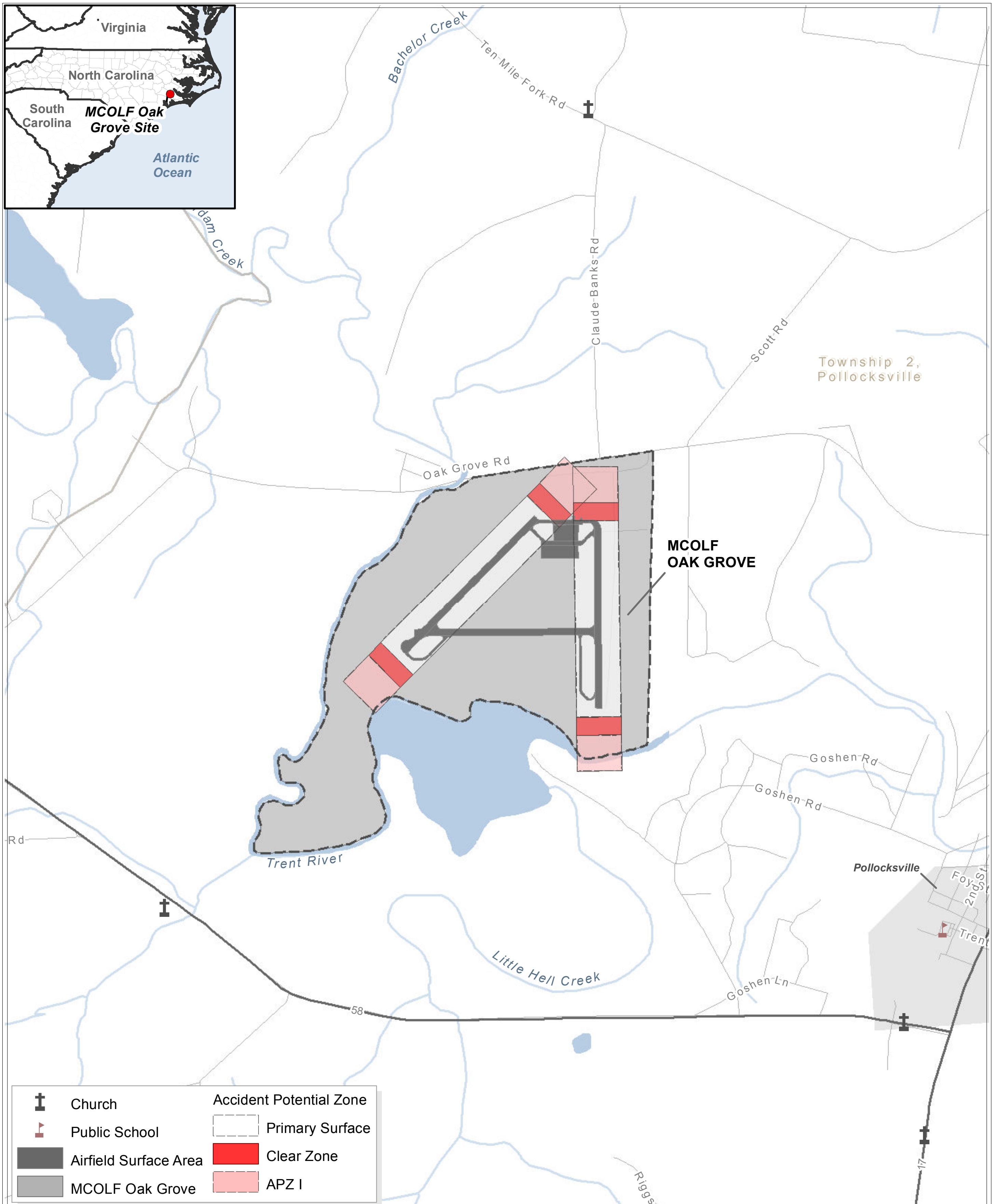

Figure 5-2
2011 AICUZ Accident Potential Zones (APZs)
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

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© Ecology & Environment, Inc. GIS Department Project #
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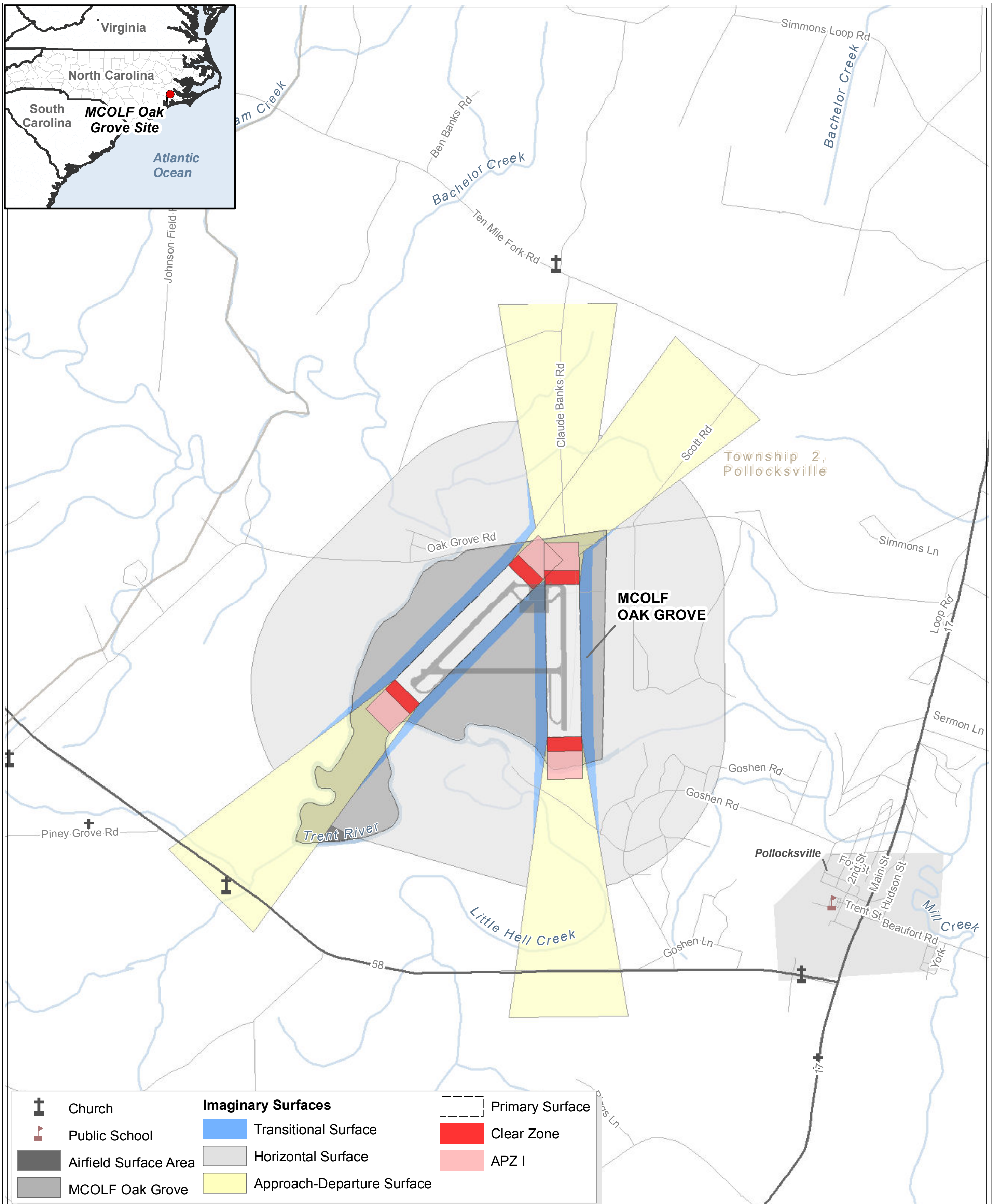

Figure 5-3
Imaginary Surfaces
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report MCOLF Oak Grove

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Miles

5.2.2 Bird/Animal Strike Hazard

Wildlife represents a significant hazard to flight operations. Birds, in particular, are drawn to the open, grassy areas and warm pavement of the airfield. Although most bird and animal strikes do not result in crashes, they cause structural and mechanical damage to aircraft if encountered. Most collisions occur when the aircraft is at an elevation of less than 1,000 feet. Due to the speed of the aircraft, collisions with wildlife can happen with considerable force.

To reduce bird and animal strike hazards (BASH), the FAA and the military recommend land uses that attract birds be located at least 10,000 feet from the airfield. These land uses include:

- Waste disposal operations;
- Wastewater treatment facilities;
- Landfills;
- Golf courses;
- Wetlands;
- Dredge disposal sites;
- Seafood processing plants; and
- Stormwater ponds.

Design modifications also can be used to reduce the attractiveness of these types of land uses to birds and other wildlife.

5.2.3 Electromagnetic Interference

New generations of military aircraft are highly dependent on complex electronic systems for navigation and critical flight and mission-related functions. Consequently, care should be taken in siting any activities that create electromagnetic interference. EMI is defined by the American National Standards Institute as any electromagnetic disturbance that interrupts, obstructs, or otherwise degrades or limits the effective performance of electronics/electrical equipment. It can be induced intentionally, as in forms of electronic warfare, or unintentionally, as a result of spurious emissions and responses, such as high tension line leakage. Additionally, EMI may be caused by atmospheric phenomena, such as lightning and precipitation static, and by non-telecommunication equipment, such as vehicles and industry machinery.

5.2.4 Lighting

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

5.2.5 Smoke, Dust, and Steam

Industrial or agricultural sources of smoke, dust, and steam in the airfield vicinity could obstruct the pilot's vision during takeoff, landing, or other periods of low-altitude flight.

6 Land Use Compatibility Analysis

The APZs and noise zones comprise the AICUZ map for an air installation. The AICUZ map defines the minimum recommended, acceptable area within which land use controls are needed to protect the health, safety, and welfare of those living near a military airfield and to preserve the defense flying mission. The AICUZ map (and information derived from the map) is the fundamental tool necessary for the AICUZ planning process.

This section addresses land use compatibility within aircraft noise zones and APZs by examining existing and planned land uses near MCOLF Oak Grove. This section begins with a description of the existing land use and growth indicators, and the local programs, policies, and regulations used to promote compatible development in the AICUZ. A land use compatibility assessment follows the background discussion.

6.1 Land Use and Development Externalities

6.1.1 Existing Land Use and Zoning

MCOLF Oak Grove is located in the North Carolina Coastal Plain on the Trent River in the township of Pollocksville, Jones County. Jones County has a total area of 473 square miles (mi^2) (472 mi^2 land and 1 mi^2 water). The county is largely rural and contains high proportions of productive agricultural and forest lands. Trenton, the county seat, is about 7 miles west of the MCOLF Oak Grove. The township of Pollocksville has a total area of 106.92 mi^2.

6.1.2 Population and Regional Growth

There are three municipal jurisdictions within which operations at MCOLF Oak Grove could have an impact, the largest of which is Jone County. MCOLF Oak Grove is located just east of the center of Jones County, within the western portion of the township of Pollocksville. The closest population center is the village of Pollocksville, which is located approximately 2 miles east-southeast of MCOLF Oak Grove. According to the U.S. Census, in 2000 there were 10,381 people, 4,061 households, and 2,936 families residing in Jones County. Population statistics for the county, town, and village are presented in Table 6-1.

According to Census numbers, the population is growing in only the town of Pollocksville, while there is an estimated decrease in the village. This indicates that the more rural areas of the town, outside of the village, are experiencing population growth more so than the village. The only population projection available is for Jones County, which indicates that the future population of the county will be fairly constant in the coming years (see Table 6-1).

Table 6-1 Population of Municipalities in the Vicinity of MCOLF Oak Grove

Municipality	1990	2000	2006	2009
Pollocksville, Village	299	269	260	NA
Township of Pollocksville	2,404	2,709	NA	NA
Jones County	9,414	10,381	10,204	10,411

Source: U.S. Bureau of the Census.

Note: Population projections only available for select years, and for select geographic areas.

Table 6-1 identifies the population numbers and estimates for the town of Pollocksville and Jones County from 1990 through 2006.

6.1.3 Economy and Employment

The local economy is based on agriculture and industrial development. The major crop in the area has been tobacco; however, due to loss of demand many farmers in the area are now producing cotton. The industrial portion of the economy is small and growing; it consists of manufacturing, food production, and building construction. MCOLF Oak Grove does not play a role in the area's economy since it is an unmanned landing field.

6.1.4 Planning Authority

The development and control of lands outside of military installations is beyond the control of the base commander. Development of these lands is dictated by local comprehensive land use planning and regulations. The local planning authority in Jones County is the Jones County Planning Commission. The Planning Commission evaluates land use changes and all planning actions. MCOLF Oak Grove is located in the town of Pollocksville within Jones County. The Town of Pollocksville is actively soliciting business and industry to locate in their municipality.

6.2 Land Use Compatibility Guidelines and Classifications

The Navy has developed land use compatibility recommendations for APZs and noise zones. These recommendations, which are found in OPNAVINST 11010.36C, Air Installations Compatible Use Zones Program (Navy 2008), are intended to serve as guidelines for placement of APZs and noise zones and for development of land uses around military air installations. 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., apartments and theaters) will not be placed in APZs. Certain land uses are considered incompatible with APZs and high-noise zones, while other land uses may be considered compatible or compatible under certain conditions (conditionally compatible). The land use compatibility analysis conducted for MCOLF Oak Grove was based on the Navy's land use compatibility recommendations, which are presented in Appendix B. Additionally, Table 6-2 shows existing land use classifications and the associated land use compatibility with each land use designation for noise zones and APZs.

Table 6-2 Land Use Classifications and Compatibility Guidelines

	Land Use Compatibility with Noise Zone (DNL)						Land Use Compatibility with APZs		
	Noise Zone 1		Noise Zone 2		Noise Zone 3		Clear Zone	APZ I	APZ II
	<55	55-64	65-69	70-74	75-79	>80			
Single Family Residential	Compatible	Compatible	Incompatible (5)	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Compatible (1)
Multi-Family Residential, Transient Lodging	Compatible	Compatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible
Public Assembly	Compatible	Compatible	Compatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible
Schools and Hospitals	Compatible	Compatible	Compatible (2)	Compatible (2)	Incompatible	Incompatible	Incompatible	Incompatible	Incompatible
Manufacturing (ex. Petrol/chem.; textile)	Compatible	Compatible	Compatible	Compatible	Incompatible	Incompatible	Incompatible	Incompatible	Compatible
Parks	Compatible	Compatible	Compatible	Compatible	Incompatible	Incompatible	Incompatible	Compatible (4)	Compatible (4)
Business Services	Compatible	Compatible	Compatible	Compatible (2)	Compatible (2)	Incompatible	Incompatible	Compatible (3)	Compatible (3)
Agriculture, Forestry and Mining	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible	Compatible

Source: Adapted from OPNAVINST 11010.36C

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

(1) = Maximum density of 1-2 dwellings per acre.
(2) = Land use and related structures generally compatible however, measures to achieve recommended noise- level reduction should be incorporated into design and construction of the structures.
(3) = Maximum Floor Area Ratio that limit people density may apply
(4) = Facilities must be low intensity.
(5) = Residential use is discouraged in DNL 65-69. Where the community determines that these uses must be allowed, a noise level reduction (NLR) of at least 25 dB should be incorporated into building codes.

Key:
Compatible (green)
Incompatible (red)

6.2.1 Existing Off-Station Land Use

To determine land use compatibility within MCOLF Oak Grove's noise zones and APZs, the Marines examined both existing and planned land uses near the installation. The following describes existing off-station land use and zoning surrounding the airfield.

6.2.1.1 MCOLF Oak Grove

MCOLF Oak Grove is located on nearly 950 acres in the central portion of Jones County. It is bounded by water to the south and west and rural land to the north and east. Land uses immediately adjacent to MCOLF Oak Grove include agricultural land, forest land, and some low density rural residential properties.

Tables 6-3 and 6-4 identify the approximate acreage of each land use category that underlies the identified noise zones and APZs. This information is also represented visually in Figure 6-1 and 6-2. The predominate land uses under all noise zones are comprised of either agricultural, forested, or land contained within the MCOLF Oak Grove installation. The same land uses also comprise most of the land categories found in the APZs.

Table 6-3 Existing Land Use within Noise Zones, MCOLF Oak Grove

Land Use	60 – 65 (DNL)	65 – 70 (DNL)	70 - 75 (DNL)	75 + (DNL)	Total
Agriculture	302.26	68.56	-	-	**370.82**
Forested	405.13	34.63	-	-	**439.76**
Recreational	0.18	-	-	-	**0.18**
Residential	7.10	1.68	-	-	**8.78**
Transportation (right-of-way)	14.16	5.29	-	-	**19.45**
Water	17.81	4.09	-	-	**21.9**
Total	**746.64**	**114.24**	**-**	**-**	**860.88**

Key:
DNL = Day-night average sound level noise metric.

Notes: Due to the lack of updated land use data available for Jones County, current aerial imagery was obtained and an interpretation of land use categories was completed based on the imagery.
Figures may not sum exactly due to rounding.
Acres only include those that fall outside the boundaries of MCOLF Oak Grove.

Table 6-4 Existing Land Use within APZs, MCOLF Oak Grove

Land Use	Clear Zone (acres)	APZ I (acres)	Total
Agriculture	-	0.35	**0.35**
Forested	-	4.98	**4.98**
Recreational	-	0	**0**
Residential	-	0	**0**
Transportation (right-of-way)	-	0.09	**0.09**
Water	-	3.35	**3.35**
Total	**-**	**8.78**	**8.78**

Key:
APZ = Accident Potential Zone.
Note: Figures may not sum exactly due to rounding.
Acres only include those that fall outside the boundaries of MCOLF Oak Grove.

6.2.2 Planned Land Use

There are several specific development sites that are in the general vicinity of MCOLF Oak Grove that would warrant coordination between the local planning authority and the military. These are as follows:

- Jones County Industrial Park, Trenton, NC (+/- 26 acres);
- Maysville Development Corporation, Inc.
  - Industrial Commercial Park, Maysville, NC (+/- 20 acres),
  - Curtis Property No. 1, Trenton, NC (+/- 44 acres),
  - Curtis Property No. 2, Trenton, NC (+/- 400 acres); and
- Mills Property, Trenton, NC (+/- 52 acres).

These industrial parks are soliciting new business and industry and there are several new buildings at many of these sites. Although these sites are currently outside of the AICUZ noise contours and APZs, there is the chance that future development and growth may begin to encroach toward the military installation.

6.3 Land Use Compatibility Assessment

To determine land use compatibility for noise zones and APZs, the Marine Corps examined existing and planned land uses near the airfield. Jones County and the township of Pollocksville do not have current land use data; therefore, the Marine Corps performed an aerial photography analysis to obtain workable land use data from which to conduct a useful land use compatibility assessment. The results of the aerial photography analysis were provided to and approved by the local municipalities. In this aerial photography analysis, 2006 National Agricultural Imagery Program (NAIP) data was utilized and areas surrounding MCOLF Oak Grove were designated as one of the

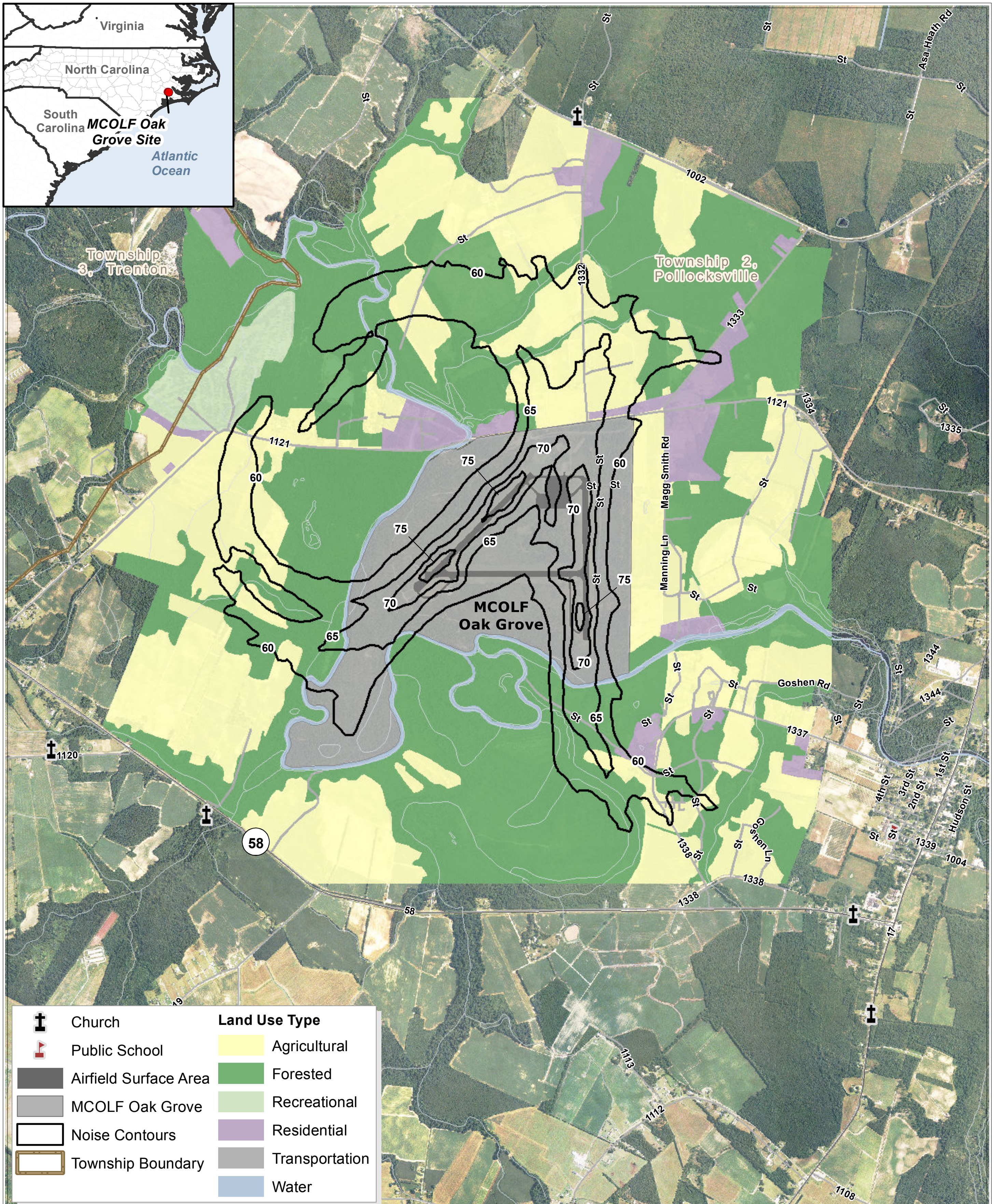

Figure 6-1
Current Land-Use 2011 AICUZ Noise Contours
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

N

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Miles

© Ecology & Environment, Inc. GIS Department Project #
\Path: L:\Buffalo\OakGrove_OLF\Maps\MXDs\OLF_Report_Figures\April_12_2011\Figure 6-2 OakGrove_ene-Landuse_Types_APZs.mxd

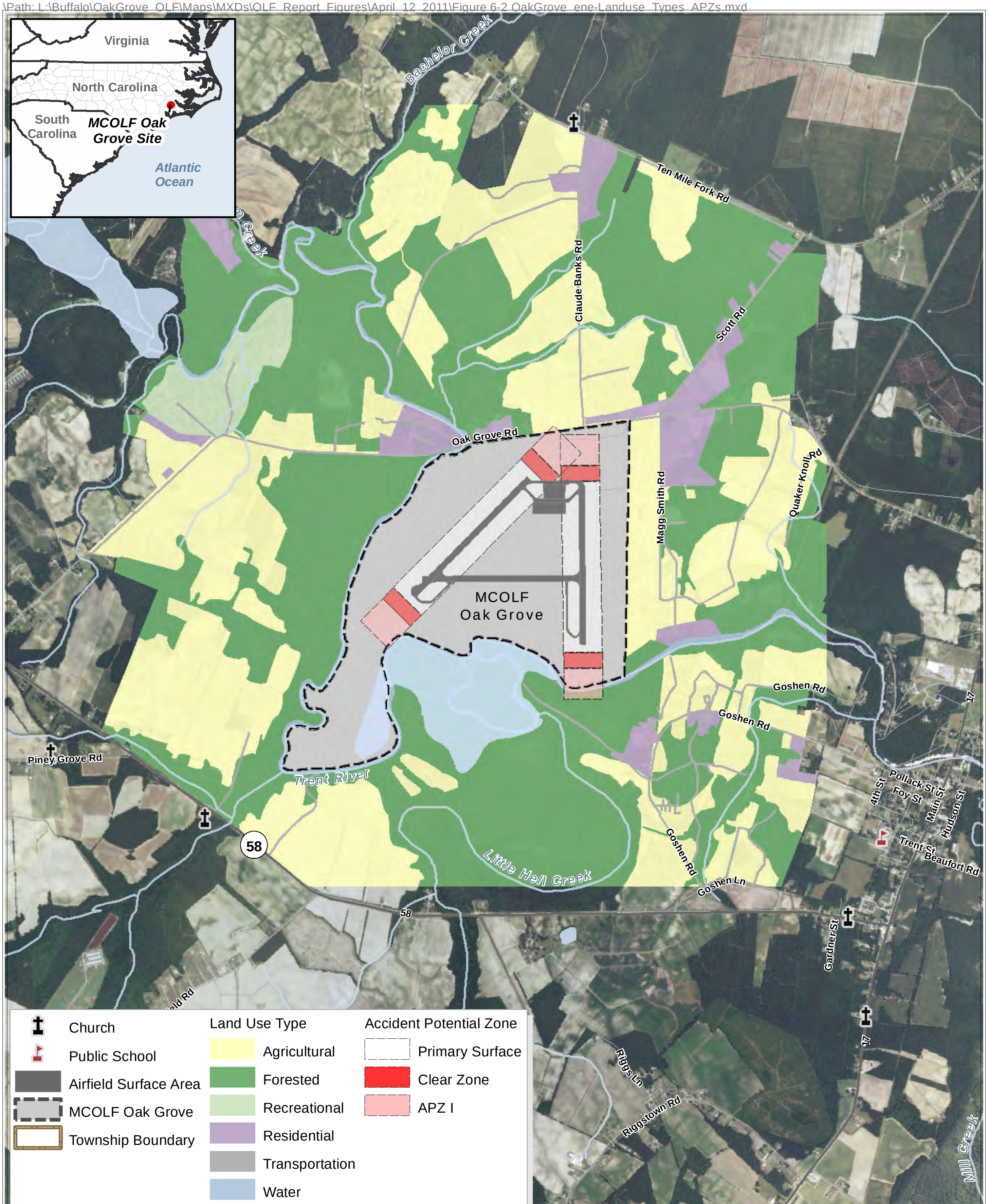

Figure 6-2
Current Land-Use 2011 AICUZ APZs
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

N

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Miles

following land uses: agriculture, forested, recreational, residential, transportation (right-of-way), or water. Existing land use information is important because it describes the actual land use activity on the property regardless of the planned use or zoning of the property.

Section 6.3.1 discusses land use compatibility results for existing land uses with the APZs and noise zones. There are no planned future changes in land use or zoning data allowing for a compatibility analysis for future conditions; thus, only existing conditions are presented.

6.3.1 Existing Land Use Compatibility Assessment

To determine whether existing land use is compatible with aircraft operations at MCOLF Oak Grove, noise zones and APZs were overlaid on the land use maps created with the aerial photography, and existing land uses were compared to the land use compatibility recommendations shown in Table 6-2 (and Appendix B). Tables and figures describing areas of compatible, conditionally compatible, and incompatible existing land uses within high-noise zones and APZs surrounding the airfields are provided below.

6.3.1.1 MCOLF Oak Grove

The area surrounding MCOLF Oak Grove is rural. The following analysis was conducted to determine areas of incompatible development. The information contained in Table 6-5 shows the compatibility in each of the noise zones off-station, surrounding MCOLF Oak Grove; this is visually depicted in Figure 6-3.

Table 6-5 Land Use Compatibility Noise Zone (DNL), MCOLF Oak Grove

Land Use	60-65 DNL		65-70 DNL		
	Y	N	Y	N	Total
Agriculture	302.26	-	68.56	-	370.82
Forested	405.13	-	34.63	-	439.76
Recreational	0.18	-	-	-	0.18
Residential	7.10	-	-	1.68	8.78
Transportation (right-of-way)	14.16	-	5.29	-	19.45
Water	17.81	-	4.09	-	21.9
Total	**746.64**	**-**	**112.56**	**1.68**	**860.88**

Key:

– = Existing land use not within the area
DNL = Day-night average sound level
N = Incompatible
Y = Compatible

Notes: Figures may not sum exactly due to rounding.
Acres only include those that fall outside the boundaries of MCOLF Oak Grove.

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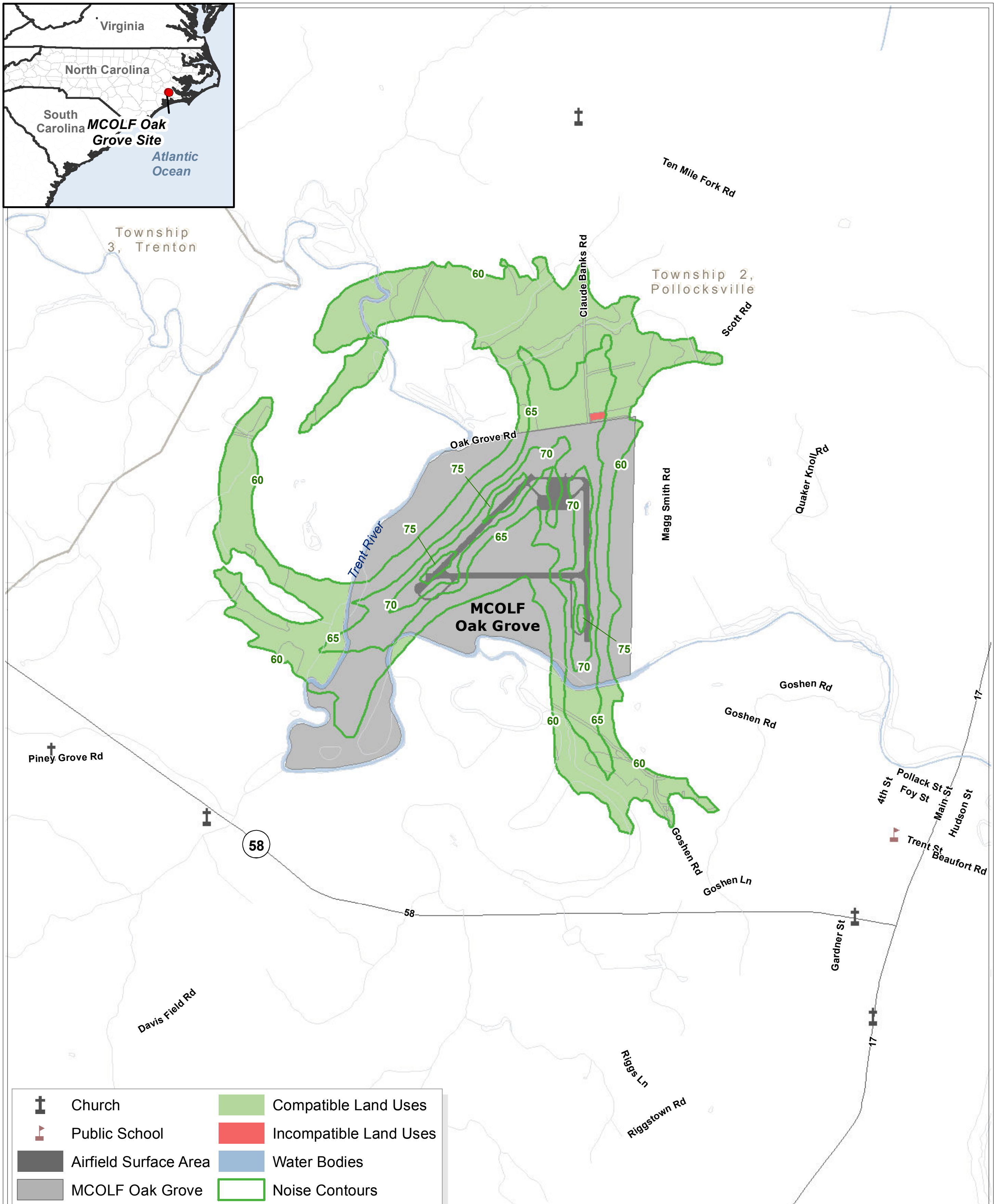

Figure 6-3
Land-Use Compatibility and 2011 AICUZ Noise Contours
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

Similar to the noise zones, a compatibility analysis was conducted for the APZs associated with MCOLF Oak Grove. The compatibilities are shown in Table 6-6 and depicted in Figure 6-4.

Table 6-6 Compatibility of All Land Use within APZs, MCOLF Oak Grove

	Compatible (acres)	Conditionally Compatible (acres)	Not Compatible (acres)	Total
Clear Zone	-	-	-	-
APZ I	8.78	-	-	**8.78**
Total	**8.78**	**-**	**-**	**8.78**

Notes: Figures may not sum exactly due to rounding.
Acres only include those that fall outside the boundaries of MCOLF Oak Grove.

The information in Table 6-7 summarizes the overall compatibility of property in both the noise zones and APZs at MCOLF Oak Grove. The table notes that 99.8% of the property within the noise zones is compatible as is 100% of the area within the APZs.

Table 6-7 Compatibility of All Land Use Activities within the AICUZ Footprint, MCOLF Oak Grove

Compatibility	Noise Zones		APZ	
	Acres	%	Acres	%
Compatible	859.2	99.8	8.78	100
Conditionally Compatible	-	-	-	-
Not Compatible	1.68	0.2	-	-
Total	**860.88**	**100**	**8.78**	**100**

Key:
APZ = Accident potential zone.

Notes: Figures may not sum exactly due to rounding.
Acres only include those that fall outside the boundaries of MCOLF Oak Grove.

Figure 6-5 shows a composite of both noise zones and APZs for MCOLF Oak Grove along with existing land use surrounding the airfield, providing an overall sense of the location and land uses in the vicinity.

6.4 Conclusions on Land Use Compatibility

6.4.1 On-Installation Land Use Compatibility Concerns

There are no structures at MCOLF Oak Grove located within the clear zones. As such, there is no need for any relocation. Any new structures at MCOLF should be located outside of the clear zones.

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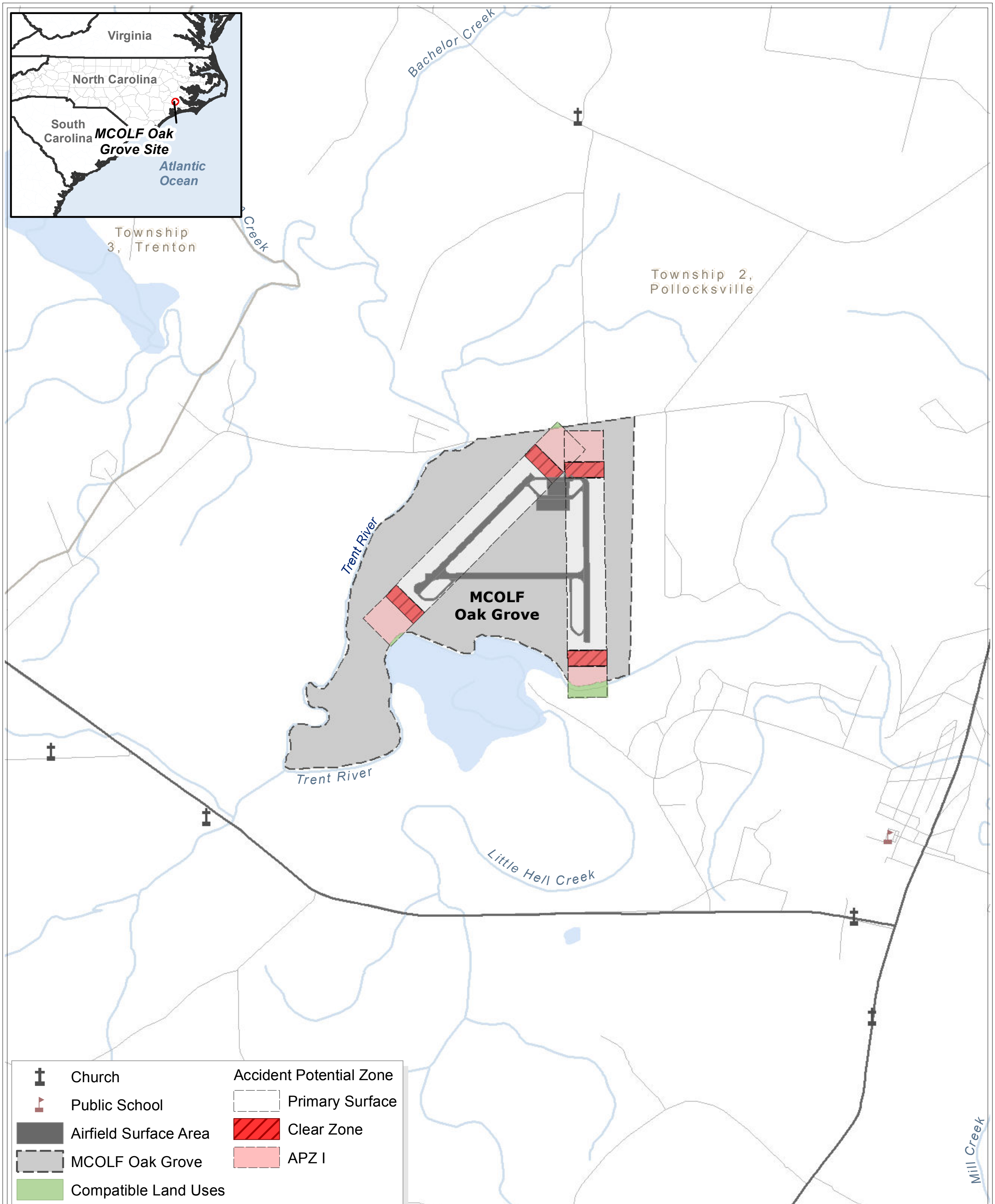

Figure 6-4
Land-Use Compatibility and 2011 AICUZ APZs
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

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\Path: L:\Buffalo\OakGrove_OLF\Maps\MXDs\OLF_Report_Figures\April_12_2011\Figure 6-5 OakGrove_Composite_Coverage.mxd

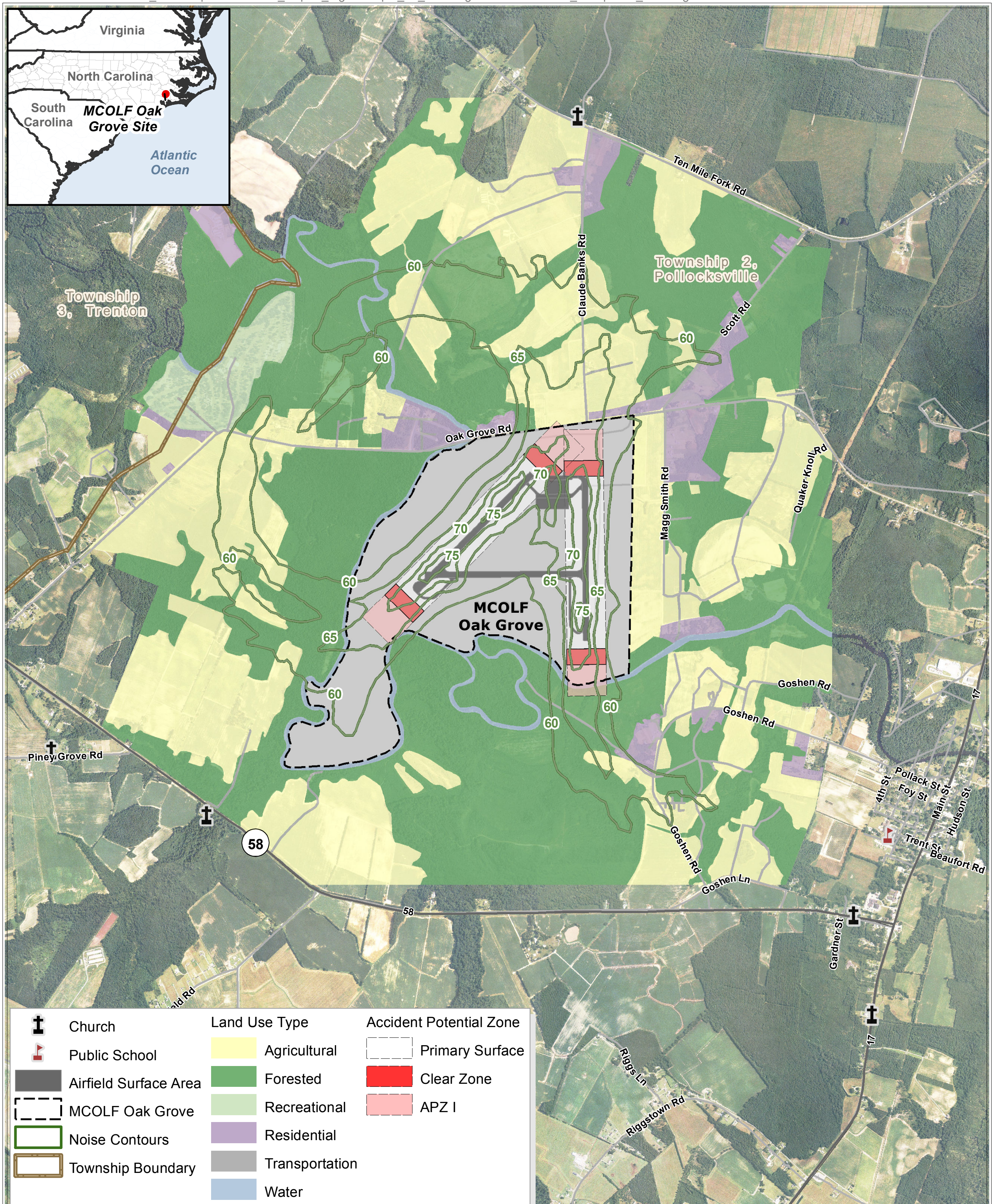

Figure 6-5
Composite Coverage for Current Land-Use
2011 AICUZ Noise Contours and APZs
MCOLF Oak Grove, North Carolina

Air Installations Compatible Use Zones (AICUZ) Report
MCOLF Oak Grove

N

0 0.25 0.5 1
Miles

6.4.2 Off-Installation Land Use Compatibility Concerns

In general, because of both the largely undeveloped and rural nature of this region and that Jones County officials do not project substantial future growth in this area, there are limited compatibility concerns associated with MCOLF Oak Grove at this time. However, there are some issues of note that are discussed below.

6.4.2.1 MCOLF Oak Grove Vicinity

Land use surrounding the MCOLF Oak Grove facility is predominantly compatible with aircraft operations; however, there are some residences present to the north of the facility that fall within the 65 DNL noise contour. There are about 10 to 12 houses located along Oak Grove Road and Claude Banks Road that are within the 65 DNL noise contour that would be considered incompatible. These are primarily single-family farmhouse-style homes.

Additionally, there appears to be an area located northeast of the airfield (Plantation Street and Riverfront Drive) that is currently platted for residential development with approximately eight to 10 houses currently built. This development is outside of the 60 DNL noise contours; however, action should be taken to work with and educate the residents and real estate professionals on the activities at MCOLF Oak Grove.

There are a handful of houses along Magg Smith Road (east of the airfield), along Scott Road (northeast of the airfield), along Oak Grove (north of the airfield), and Goshen Road (southeast of the airfield). In addition, the Quaker Neck Country Club is located to the northwest of the airfield along Oak Grove Drive. These residences and developments are outside of the 60 DNL noise contour in what is considered "white space."

Residential development in close proximity to MCOLF Oak Grove is a source for concern, and the Marine Corps should work with Jones County to ensure that any future residential development in proximity of MCOLF Oak Grove occurs within areas that are outside of the established AICUZ zone.

The more developed population center of Pollocksville is distant enough from the airfield to not be considered a current land use compatibility concern. Population and development projections for this area indicate that future operations MCOLF Oak Grove could at some point conflict with emerging growth patterns in the region. Therefore, it is recommended that the Marine Corps work with the local community to development an airport overlay district for MCOLF Oak Grove to ensure that both the airfield and the community are protected into the future.

7 Land Use Tools and Recommendations

The goal of the AICUZ Program – to protect the health, safety, and welfare of those living near military airfields while preserving the Department of Defense Mission – can most effectively be accomplished by active participation of all interested parties, including the Navy, local governments, private citizens, developers, real estate professionals, and others.

At the Installation level, the Installation Commander is responsible for ensuring a successful AICUZ Program. Oak Grove is unique in that the property itself falls under the responsibility of the MCB Camp Lejeune Installation Commander, while primary usage involves aircraft from MCAS New River. In light of this and pursuant to OPNAVINST 11010.36C (AICUZ Program), the Installation Commander's at MCAS New River and MCB Camp Lejeune are committed to and shall:

- Implement an AICUZ Program for the Air Installation and associated OLFs;
- Work with state and local planning officials to implement the objectives of the AICUZ plan;
- If appropriate, designate a community liaison officer to assist in the execution of the AICUZ plan by the Installation and to act as spokesperson for the Command in AICUZ matters;
- Provide assistance in developing AICUZ information, including operational data needed to update the AICUZ plan; and
- Justify the retention of land or interest of land required for operational performance.

This section presents and describes land use planning tools and recommendations for implementing and achieving a successful AICUZ Program.

7.1 Tools for Implementing AICUZ

7.1.1 Federal Tools

Environmental Review. Environmental review deals with assessment of projects that may have some potential impact on land use and the public's interest. For example, the National Environmental Policy Act mandates full disclosure of the environmental effects resulting from proposed federal actions, approvals, or funding. Impacts of the action are generally documented in an environmental impact statement (EIS) or an environmental assessment, which is more limited in scope than an EIS. The environmental review process represents a procedure for incorporating the elements of the AICUZ in the planning review process.

Executive Order 12372, Intergovernmental Review of Federal Programs (July 1982). As a result of the Intergovernmental Cooperation Act of 1968, the United States Bureau of the Budget requires that all Federal-Aid Development Projects must be coordinated with and reinforce state, regional, and local planning. Executive Order 12372 allows state governments to set up review periods and processes for federal projects.

GSA Federal Management Circular 75-2. This circular allows the Air Installation to extend its land use recommendations to federally funded projects in the vicinity. Specifically, it requires agencies sponsoring federally funded projects to ensure they are compatible with land use plans of the Air Installation.

Housing and Urban Development (HUD) Circular 1390.2. Approvals of mortgage loans from the Federal Housing Administration are subject to requirements of this HUD circular. The circular sets forth a discretionary policy to withhold funds for housing projects when noise exposure exceeds prescribed levels. Residential construction may be permitted inside the 65 DNL contour, provided sound attenuation is accomplished. However, the added construction expense of noise attenuation may make siting in these noise exposure areas financially less attractive. Because the HUD policy is discretionary, variances may also be permitted, depending on regional interpretation and local conditions. HUD also has a policy that prohibits funding for projects in clear zones and APZs unless the project is compatible with the AICUZ.

7.1.2 Local Government Tools

Local Government Comprehensive Plans and Zoning Planning. As stated in Section 6.1.4, the development and control of lands outside of military installations is beyond the control of the base commander. Development of these lands is dictated by local comprehensive land use planning and regulations. The local planning authority in Jones County is the Jones County Planning Commission.

Capital Improvements Programs. Capital improvements projects, such as potable water lines, sewage transmission lines, road paving and/or improvements, new right-of-way acquisition, and schools can be used to direct growth and types of growth toward areas compatible with the AICUZ Program. Local government agencies and organizations can develop capital improvement programs that avoid extending capital improvements into or near high-noise zones or APZs.

Transfer of Development Rights (TDR). The concept of TDR involves purchasing property development rights and transferring those rights to another piece of property. Thus, development of the original property is prevented.

Purchase of Development Rights. The local government may consider the purchase of development rights.

Building Code. The local building code can be used to ensure the noise-attenuation measures of the AICUZ Program. Although this tool will not prevent incompatible development, building codes can ensure compatibility to the greatest extent possible.

Real Estate Disclosure. Real estate disclosures allow prospective buyers, lessees, or renters of property in the vicinity of military operation areas to make informed decisions regarding the purchase or lease of property. The purpose is to protect the seller, real estate agent, buyer, local jurisdiction, and military. Disclosure of aviation noise and safety zones is a very important tool in informing the community about expected impacts of aviation noise and location of airfield safety zones, subsequently reducing frustration and anti-airport criticism by those who were not adequately informed prior to purchase of properties within impact areas.

Public Land Acquisition Programs. Public land acquisition programs can be used (as the conditions of the programs permit) for acquisition of land to support the AICUZ Program.

Health Code Programs. These programs protect people from adverse elements that may endanger them, including poor sanitary facilities, diseases, and inadequate or unsafe water supplies. The programs also can be used to protect people from noise impacts.

Special Planning Districts. Local governments have the power to create special districts for a special purpose, such as land use control and protection of the environment and human health.

7.1.3 Private Citizens/Real Estate Professionals/Businesses

Business-Development and Construction Loans to Private Contractors. Lending institutions can limit financing for real estate purchases or construction incompatible with the AICUZ Program by restricting or prohibiting mortgage and/or other types of loans. The state and/or local government could designate restricted areas around the Installation.

Private Citizens. Private citizens have the ability to not purchase property within high-noise zones and/or APZs.

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 APZ. They have the ability to show prospective buyers and lessees the property at a time when noise exposure is expected to be at its worst.

7.2 Recommendations

7.2.1 MCOLF Oak Grove Recommendations

Although ultimate control over land use and development in the vicinity of MCOLF Oak Grove is the responsibility of Jones County, the Marines have the ability and responsibility to conduct actions and implement programs in support of local efforts. To do so, Marine Corps Base Camp Lejeune Commander should continue and/or consider the following:

Air Operations Procedures. Aircrew discipline in pattern operations should be enforced along with field noise abatement procedures, as set forth in Section 4.4, Table 4-2. The Marines should continue to examine ways to improve noise abatement procedures.

Noise Complaint Hotline. A standard procedure is followed for noise complaints called into MCAS New River or MCB Camp Lejeune from operations at MCOLF Oak Grove airfield.

Complaints should be collected in a standard format for plotting locations in a spatial database for future planning use. Recording these complaints can help:

- Document whether newly developing sites may be noise-sensitive in the future;
- Provide land use planning information for the local government;
- Determine which operational flight tracks may be responsible for the noise complaint and at what time most complaints occur; and
- Provide valuable information for real estate transactions.

Community Outreach Activities. Continue successful community outreach efforts that have begun at MCAS New River and Camp Lejeune. Currently there is a productive working relationship between the Base Community Planning and Liaison Office and Jones County. Several successful initiatives have started and future initiatives aimed at further protecting Marine Corps assets should continue or expand.

Presentation of the AICUZ Program. This presentation could be shown individually or collectively to community decision makers, including local planning commissions, city councils, county legislatures, government councils, and other interested agencies. It would provide an opportunity to inform and educate individuals or groups who make land use decisions (e.g., infrastructure siting, schools, zoning changes) that can either protect or threaten aircraft operations at MCOLF Oak Grove. For this, the MCAS New River Web site could be expanded to include AICUZ-specific topics, and various materials for presentation and distribution should be developed or updated to include flight simulations, videos, poster boards, an electronic or slide presentation, and fact sheets. Presentation information could be used as part of the community outreach activities and would inform the general public on AICUZ issues, the installation's contribution to the local economy, and the need for responsible land use planning.

Keep Engaged in the Local Planning Process. MCB Camp Lejeune and MCAS New River Community Plans & Liaison Office (CP&LO) staff should attend public hearings and provide comments on actions that may affect AICUZ planning, including comprehensive plan and land-development regulations updates and amendments.

Local Plans, Regulations, and Policies. MCB Camp Lejeune and MCAS New River CP&LO staff should continue to be an active participant in local government and regional reviews, recommendations, and decision-making processes for land use decisions that may affect the operational integrity of MCOLF Oak Grove, including:

- Capital improvements plans, such as potable water lines, sewage transmission lines, road paving and/or improvements, and new right-of-way acquisition;
- Building code changes;
- Ensuring necessary ordinances and records-keeping capability to enact restriction within the AICUZ footprint;
- Community facilities construction (e.g., schools, stadiums, churches);
- Establishment of local zoning ordinances and comprehensive plans or other such ordinances that may affect the installation; and
- Approvals for subdivisions, site plans, wetland permits, or other proposed approvals necessary for development.

7.2.2 Local Government and Agency Recommendations

Communication. While it is the responsibility of MCB Camp Lejeune and MCAS New River to inform and educate community decision-makers about the AICUZ Program, community decision-makers should continue to actively inform and seek input from MCAS New River regarding land use decisions that potentially could affect the operational integrity of MCOLF Oak Grove.

To communicate with the public, local government Web sites should provide acknowledgement of the AICUZ Program for MCOLF Oak Grove and provide a link to the MCB Camp Lejeune Web site for information on aircraft operations and the MCOLF Oak Grove AICUZ Program.

Decisions with Future Impacts. It is recommended that when local governments make land use decisions in proximity to the established AICUZ footprint, local governments recognize:

- Noise contours and APZs comprising the AICUZ footprint are dynamic, and the potential exists for changes in the AICUZ footprint as operational needs to satisfy the military mission change; and
- Because of the AICUZ Program's dynamics, it is recommended that local governments work with MCAS New River to establish a special planning area (or district) for areas outside the established APZ that are most likely to present compatibility problems given changes in operations at MCOLF Oak Grove. As a beginning point, it is recommended local governments use the flight tracks presented in Section 4.4 to preserve the operational integrity of these flight tracks and protect the health and safety of the underlying population.

Land Use Plans and Regulations. As discussed in Section 7.1.2, local governments currently within the AICUZ footprint recognize their responsibility in providing land use controls in areas encumbered by the AICUZ footprint to protect the health, safety, and general welfare of the population. The degree to which these land use controls are consistent with those recommended under Marine Corps guidance varies greatly.

Capital Improvement. It is recommended all capital improvement projects in proximity to the installation be evaluated and reviewed for potential direct and indirect impacts that such improvements may have on the ability to implement a successful AICUZ Program.

Building Codes. Local building code should be reviewed and/or modified to ensure consistency with noise attenuation recommendations of the AICUZ Program, as specified in OPNAVINST 11010.36C.

Public Land Acquisition Programs. These programs should be reviewed to ascertain whether they can be used in support of the AICUZ Program.

7.2.3 Private Citizens/Real Estate Professionals/Businesses Recommendations

Real Estate Professionals. Real estate professionals should:

- Provide written disclosure to prospective purchasers, renters, or lessees when a property is located within an APZ or high-noise zone;

- Provide on their Web sites acknowledgement of the AICUZ Program for MCOLF Oak Grove and provide a link to the MCAS New River Web site for information on aircraft operations and the AICUZ Program at MCOLF Oak Grove;
- Provide an AICUZ brochure to prospective buyers and lessees; and
- To the greatest extent possible, make prospective buyers and lessees aware of the potential magnitude of noise exposures they might experience.

Business - Development and Construction Loans to Private Contractors. Lending institutions should consider whether to limit financing for real estate purchases or construction incompatible with the AICUZ Program. This strategy encourages review of noise and accident potential as part of a lender's investigation of potential loans to private interests for real-estate acquisition and development. Diligent lending practices will promote compatible development of the area surrounding MCOLF Oak Grove and protect lenders and developers alike. Local banking and financial institutions should be encouraged to incorporate a "Due Diligence Review" of all loan applications, including determination of possible noise or APZ impacts on the mortgaged property. The Marine Corps can play a role in this strategy by providing AICUZ seminars to lenders throughout the region.

Citizens. The citizens of the local community have a responsibility to:

- Become informed about the AICUZ Program at MCOLF Oak Grove 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 AICUZ Program.

8 References

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Appendix A

Discussion of Noise and Its Effect on the Environment

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A.1 Basics of Sound

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

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

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

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

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

60 dB + 60 dB = 63

dB, and 80 dB +

80 dB = 83 dB.

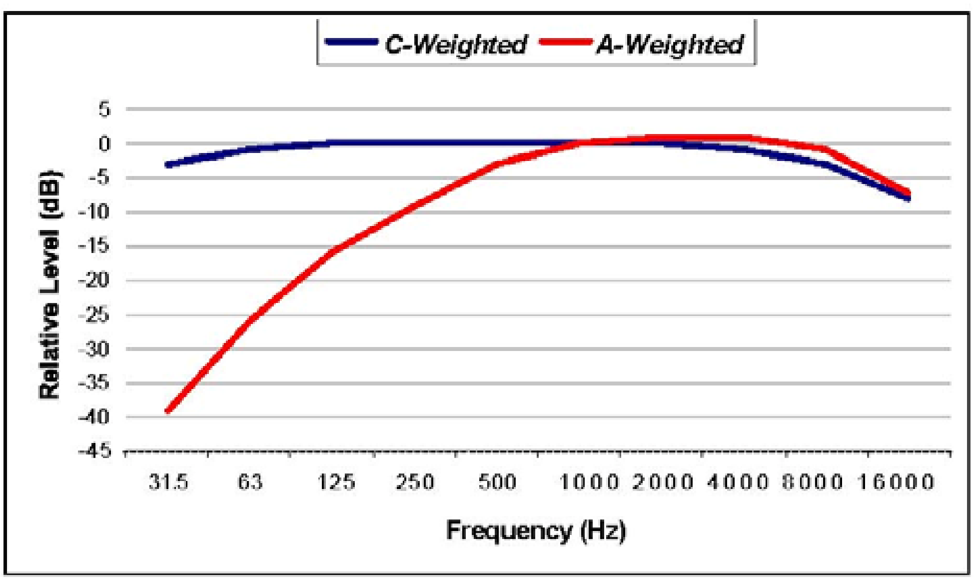
Second, the total sound level produced by two sounds of different levels is usually only slightly more than the higher of the two. For example:

60.0 dB + 70.0 dB = 70.4 dB.

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

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

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



Source: ANSI S1.4 -1983 "Specification of Sound Level Meters"

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

A.1.2 A-weighted Sound Level

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

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

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

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

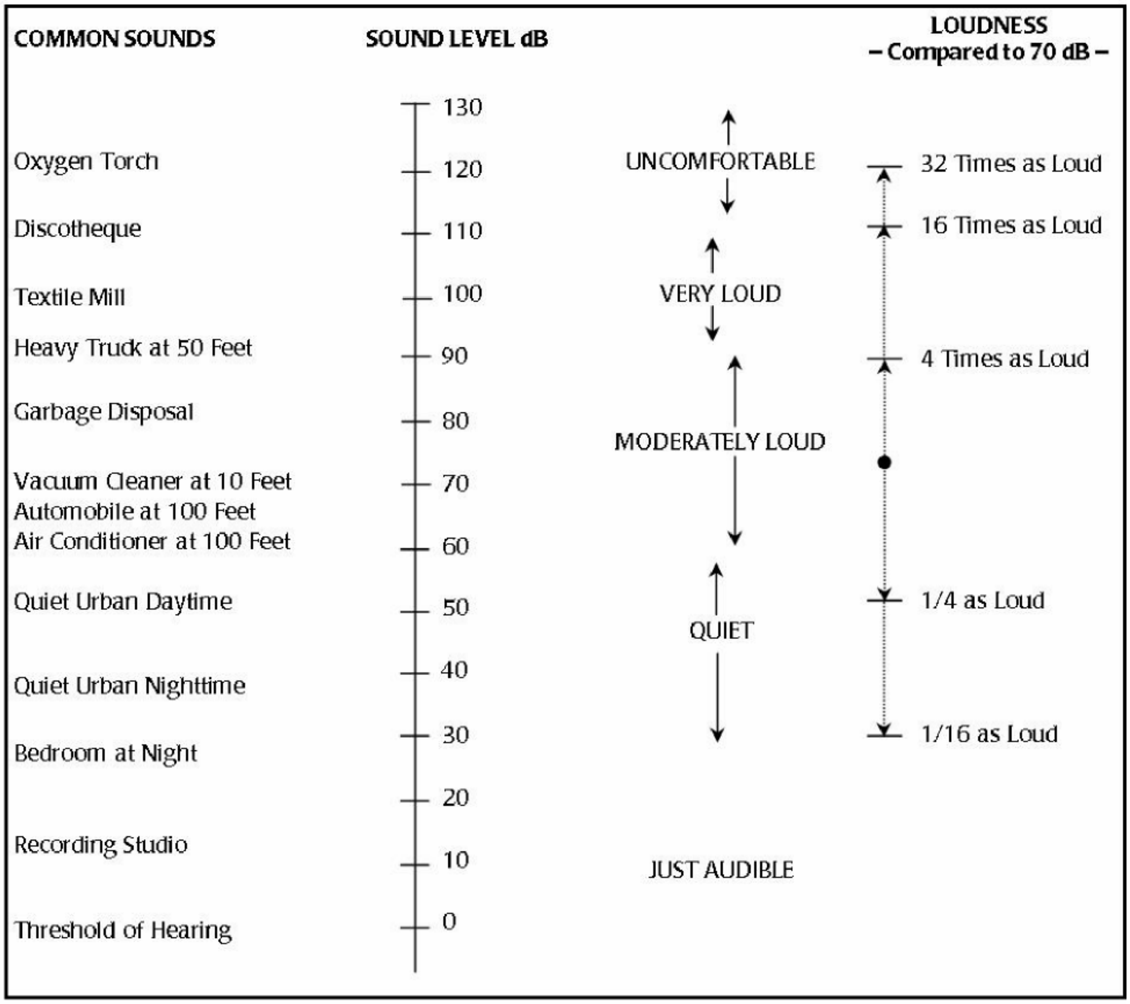
C-weighted Sound Level

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

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

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

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



Source: *Handbook of Noise Control*, C.M. Harris, Editor, McGraw-Hill Book Co., 1979, and FICAN 1992.

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

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

A.2 Noise Metrics

As used in environmental noise analyses, a metric refers to the unit or quantity that quantitatively measures the effect of noise on the environment. To quantify these effects, the Department of Defense and the Federal Aviation Administration use three noise-measuring techniques, or metrics: first, a measure of the highest sound level occurring during an individual aircraft overflight (single event); second, a combination of the maximum level of that single event with its duration; and third, a description of the noise environment based on the cumulative flight and engine maintenance activity. Single noise events can be described with Sound Exposure Level or Maximum Sound Level. Another measure of instantaneous level is the Peak Sound Pressure Level. The cumulative energy noise metric used is the Day/Night Average Sound Level. Metrics related to DNL include the Onset-Rate Adjusted Day/Night Average Sound Level, and the Equivalent Sound Level. In the state of California, it is mandated that average noise be described in terms of Community Noise Equivalent Level (State of California 1990). CNEL represents the Day/Evening/Night average noise exposure, calculated over a 24-hour period. Metrics and their uses are described below.

A.2.1 Maximum Sound Level (L_{max})

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

During an aircraft overflight, the noise level starts at the ambient or background noise level, rises to the maximum level as the aircraft flies closest to the observer, and returns to the background level as the aircraft recedes into the distance. The maximum sound level indicates the maximum sound level occurring for a fraction of a second. For aircraft noise, the "fraction of a second" over which the maximum level is defined is generally 1/8 second, and is denoted as "fast" response (American National Standards Institute 1988). Slowly varying or steady sounds are generally measured over a period of one second, denoted "slow" response. The maximum sound level is important in judging the interference caused by a noise event with conversation, TV or radio listening, sleep, or other common activities. Although it provides some measure of the intrusiveness of the event, it does not completely describe the total event, because it does not include the period of time that the sound is heard.

A.2.2 Peak Sound Pressure Level (L_{pk})

The peak sound pressure level, is the highest instantaneous level obtained by a sound level measurement device. The peak sound pressure level is typically measured using a 20 microseconds or faster sampling rate, and is typically based on unweighted or linear response of the meter.

A.2.3 Sound Exposure Level (SEL)

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

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

A.2.4 Day-Night Average Sound Level (DNL) and Community Noise Equivalent Level (CNEL)

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

The above-described metrics are average quantities, mathematically representing the continuous A- weighted or C-weighted sound level that would be present if all of the variations in sound level that occur over a 24-hour period were smoothed out so as to contain the same total sound energy. These composite metrics account for the maximum noise levels, the duration of the events (sorties or operations), and the number of events that occur over a 24-hour period. Like SEL, neither DNL nor CNEL represent the sound level heard at any particular time, but quantifies the total sound energy received. While it is normalized as an average, it represents all of the sound energy, and is therefore a cumulative measure.

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

The inclusion of daytime and nighttime periods in the computation of the DNL and CNEL reflects their basic 24-hour definition. It can, however, be applied over periods of multiple days. For application to civil airports, where operations are consistent from day to day, DNL and CNEL are usually applied as an annual average. For some military airbases, where operations are not necessarily consistent from day to day, a common practice is to compute a 24-hour DNL or CNEL based on an average busy day, so that the calculated noise is not diluted by periods of low activity.

Although DNL and CNEL provide a single measure of overall noise impact, they do not provide specific information on the number of noise events or the individual sound levels that occur during the 24-hour day. For example, a daily average sound level of 65 dB could result from a very few noisy events or a large number of quieter events.

Daily average sound levels are typically used for the evaluation of community noise effects (i.e., longterm annoyance), and particularly aircraft noise effects. In general, scientific studies and social surveys have found a high correlation between the percentages of groups of people highly annoyed and the level of average noise exposure measured in DNL (U.S. Environmental Protection Agency 1978 and Schultz 1978). The correlation from Schultz's original 1978 study is shown in Figure A-3. It represents the results of a large number of social surveys relating community responses to various types of noises, measured in day-night average sound level.

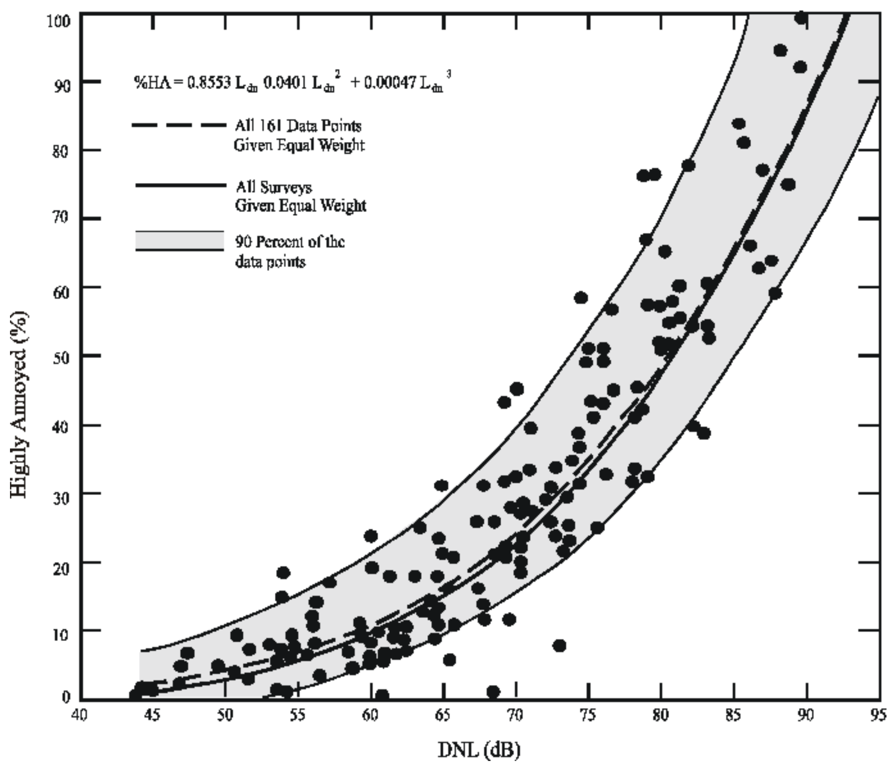


Figure A-3. Community Surveys of Noise Annoyance

A more recent study has reaffirmed this relationship (Fidell, et al. 1991). Figure A-4 (Federal Interagency Committee On Noise 1992) shows an updated form of the curve fit (Finegold, et al. 1994) in comparison with the original. The updated fit, which does not differ substantially from the original, is the current preferred form. In general, correlation coefficients of 0.85 to 0.95 are found between the percentages of groups of people highly annoyed and the level of average noise exposure. The correlation coefficients for the annoyance of individuals are relatively low, however, on the order of 0.5 or less. This is not surprising, considering the varying personal factors that influence the manner in which individuals react to noise. However, for the evaluation of community noise impacts, the scientific community has endorsed the use of DNL (American National Standards Institute 1980; American National Standards Institute 1988; U.S. Environmental Protection Agency 1974; Federal Interagency Committee On Urban Noise 1980 and Federal Interagency Committee On Noise 1992).

The use of DNL (CNEL in California) has been criticized as not accurately representing community annoyance and land-use compatibility with aircraft noise. Much of that criticism stems from a lack of understanding of the basis for the measurement or calculation of DNL. One frequent criticism is based on the inherent feeling that people react more to single noise events and not as much to "meaningless" time-average sound levels.

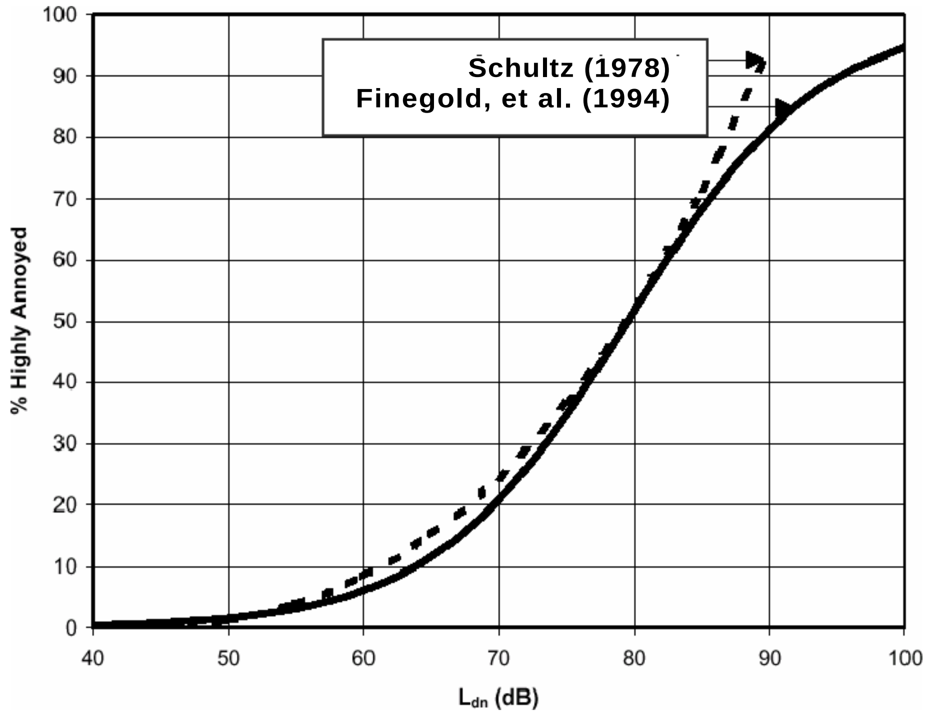


Figure A-4. Response of Communities to Noise; Comparison of Original (Schultz, 1978) and Current (Finegold, et al. 1994) Curve Fits

In fact, a time-average noise metric, such as DNL and CNEL, takes into account both the noise levels of all individual events that occur during a 24-hour period and the number of times those events occur. The logarithmic nature of the decibel unit causes the noise levels of the loudest events to control the 24-hour average.

As a simple example of this characteristic, consider a case in which only one aircraft overflight occurs during the daytime over a 24-hour period, creating a sound level of 100 dB for 30 seconds. During the remaining 23 hours, 59 minutes, and 30 seconds of the day, the ambient sound level is 50 dB. The day- night average sound level 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 day-night average sound level 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.2.5 Equivalent Sound Level (L_{eq})

Another cumulative noise metric that is useful in describing noise is the equivalent sound level. L_{ea} is calculated to determine the steady-state noise level over a specified time period. The L_{ea} metric can provide a more accurate quantification of noise exposure for a specific period, particularly for daytime periods when the nighttime penalty under the DNL metric is inappropriate.

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

A.2.6 Rate Adjusted Day-Night Average Sound Level (L_{dnr})

Military aircraft flying on Military Training Routes (MTRs) and in Restricted Areas/Ranges generate a noise environment that is somewhat different from that associated with airfield operations. As opposed to patterned or continuous noise environments associated with airfields, overflights along MTRs are highly sporadic, ranging from 10 per hour to less than one per week. Individual military overflight events also differ from typical community noise events in that noise from a low-altitude, high-airspeed flyover can have a rather sudden onset, exhibiting a rate of increase in sound level (onset rate) of up to 150 dB per second.

To represent these differences, the conventional SEL metric is adjusted to account for the "surprise" effect of the sudden onset of aircraft noise events on humans with an adjustment ranging up to 11 dB above the normal Sound Exposure Level (Stusnick, et al. 1992). Onset rates between 15 to 150 dB per second require an adjustment of 0 to 11 dB, while onset rates below 15 dB per second require no adjustment. The adjusted SEL is designated as the onset-rate adjusted sound exposure level (SEL_r).

Because of the sporadic, often seasonal, occurrences of aircraft overflights along MTRs and in Restricted Areas/Ranges, the number of daily operations is determined from the number of flying days in the calendar month with the highest number of operations in the affected airspace or MTR. This avoids dilution of the exposure from periods of low activity, much the way that the average busy day is used around military airbases. The cumulative exposure to noise in these areas is computed by DNL over the busy month, but using SEL_r instead of SEL. This monthly average is denoted L_{dnmr}. If onset rate adjusted DNL is computed over a period other than a month, it would be designated L_{dnr} and the period must be specified. In the state of California, a variant of the L_{dnmr} includes a penalty for evening operations (7 p.m. to 10 p.m.) and is denoted $CNEL_{mr}$.

A.3 Noise Effects

A.3.1 Annoyance

The primary effect of aircraft noise on exposed communities is one of long-term annoyance. Noise annoyance is defined by the EPA as any negative subjective reaction on the part of an individual or group (U.S. Environmental Protection Agency 1974). As noted in the discussion of DNL above, community annoyance is best measured by that metric.

The results of attitudinal surveys, conducted to find percentages of people who express various degrees of annoyance when exposed to different levels of DNL, are very consistent. The most useful metric for assessing people's responses to noise impacts is the percentage of the exposed population expected to be "highly annoyed." A wide variety of responses have been used to determine intrusiveness of noise and disturbances of speech, sleep, television or radio listening, and outdoor living. The concept of "percent highly annoyed" has provided the most consistent response of a community to a particular noise environment. The response is remarkably complex, and when considered on an individual basis, widely varies for any given noise level (Federal Interagency Committee On Noise 1992).

A number of nonacoustic factors have been identified that may influence the annoyance response of an individual. Newman and Beattie (1985) divided these factors into emotional and physical variables:

Emotional Variables

- Feelings about the necessity or preventability of the noise;
- Judgment of the importance and value of the activity that is producing the noise;
- Activity at the time an individual hears the noise;
- Attitude about the environment;
- General sensitivity to noise;
- Belief about the effect of noise on health; and
- Feeling of fear associated with the noise.

Physical Variables

- Type of neighborhood;
- Time of day;
- Season;
- Predictability of noise;
- Control over the noise source; and
- Length of time an individual is exposed to a noise.

A.3.2 Speech Interference

Speech interference associated with aircraft noise is a primary cause of annoyance to individuals on the ground. The disruption of routine activities such as radio or television listening, telephone use, or family conversation gives rise to frustration and irritation. The quality of speech communication is also important in classrooms, offices, and industrial settings and can cause fatigue and vocal strain in those who attempt to communicate over the noise. Speech is an acoustic signal characterized by rapid fluctuations in sound level and frequency pattern. It is essential for optimum speech intelligibility to recognize these continually shifting sound patterns. Not only does noise diminish the ability to perceive the auditory signal, but it also reduces a listener's ability to follow the pattern of signal fluctuation. In general, interference with speech communication occurs when intrusive noise exceeds about 60 dB (Federal Interagency Committee On Noise 1992).

Indoor speech interference can be expressed as a percentage of sentence intelligibility among two people speaking in relaxed conversation approximately 3 feet apart in a typical living room or bedroom (U.S. Environmental Protection Agency 1974). The percentage of sentence intelligibility is a non-linear function of the (steady) indoor background A-weighted sound level. Such a curve-fit yields 100 percent sentence intelligibility for background levels below 57 dB and yields less than 10 percent intelligibility for background levels above 73 dB. The function is especially sensitive to changes in sound level between 65 dB and 75 dB. As an example of the sensitivity, a 1 dB increase in background sound level from 70 dB to 71 dB yields a 14 percent decrease in sentence intelligibility. The sensitivity of speech interference to noise at 65 dB and above is consistent with the criterion of DNL 65 dB generally taken from the Schultz curve. This is consistent with the observation that speech interference is the primary cause of annoyance.

A.3.3 Sleep Interference

Sleep interference is another source of annoyance and potential health concern associated with aircraft noise. Because of the intermittent nature and content of aircraft noise, it is more disturbing than continuous noise of equal energy. Given that quality sleep is requisite for good health, repeated occurrences of sleep interference could have an effect on overall health.

Sleep interference may be measured in either of two ways. "Arousal" represents actual awakening from sleep, while a change in "sleep stage" represents a shift from one of four sleep stages to another stage of lighter sleep without actual awakening. In general, arousal requires a somewhat higher noise level than does a change in sleep stage.

Sleep is not a continuous, uniform condition but a complex series of states through which the brain progresses in a cyclical pattern. Arousal from sleep is a function of a number of factors that include age, sex, sleep stage, noise level, frequency of noise occurrences, noise quality, and pre-sleep activity. Because individuals differ in their physiology, behavior, habitation, and ability to adapt to noise, few studies have attempted to establish noise criterion levels for sleep disturbance.

Lukas (1978) concluded the following with regard to human sleep response to noise:

- Children 5 to 8 years of age are generally unaffected by noise during sleep.

- Older people are more sensitive to sleep disturbance than younger people. Women are more sensitive to noise than men, in general.
- There is a wide variation in the sensitivity of individuals to noise even within the same age group.
- Sleep arousal is directly proportional to the sound intensity of aircraft flyover. While there have been several studies conducted to assess the effect of aircraft noise on sleep, none have produced quantitative dose-response relationships in terms of noise exposure level, DNL, and sleep disturbance. Noise-sleep disturbance relationships have been developed based on single-event noise exposure.

An analysis sponsored by the U.S. Air Force summarized 21 published studies concerning the effects of noise on sleep (Pearsons, et al. 1989). The analysis concluded that a lack of reliable studies in homes, combined with large differences among the results from the various laboratory studies, did not permit development of an acceptably accurate assessment procedure. The noise events used in the laboratory studies and in contrived in-home studies were presented at much higher rates of occurrence than would normally be experienced in the home. None of the laboratory studies were of sufficiently long duration to determine any effects of habituation, such as that which would occur under normal community conditions.

A study of the effects of nighttime noise exposure on the in-home sleep of residents near one military airbase, near one civil airport, and in several households with negligible nighttime aircraft noise exposure, revealed SEL as the best noise metric predicting noise-related awakenings. It also determined that out of 930 subject nights, the average spontaneous (not noise-related) awakenings per night was 2.07 compared to the average number of noise-related awakenings per night of 0.24 (Fidell, et al. 1994). Additionally, a 1995 analysis of sleep disturbance studies conducted both in the laboratory environment and in the field (in the sleeping quarters of homes) showed that when measuring awakening to noise, a 10 dB increase in SEL was associated with only an 8 percent increase in the probability of awakening in the laboratory studies, but only a 1 percent increase in the field (Pearsons, et al. 1995). Pearsons, et al. (1995), reported that even SEL values as high as 85 dB produced no awakenings or arousals in at least one study. This observation suggests a strong influence of habituation on susceptibility to noise-induced sleep disturbance. A 1984 study (Kryter 1984) indicates that an indoor SEL of 65 dB or lower should awaken less than 5 percent of exposed individuals.

Nevertheless, some guidance is available in judging sleep interference. The EPA identified an indoor DNL of 45 dB as necessary to protect against sleep interference (U.S. Environmental Protection Agency 1978). Assuming a very conservative structural noise insulation of 20 dB for typical dwelling units, this corresponds to an outdoor day-night average sound level of 65 dB to minimize sleep interference.

In 1997, the Federal Interagency Committee on Aviation Noise (FICAN) adopted an interim guideline for sleep awakening prediction. The new curve, based on studies in England (Ollerhead, et al. 1992) and at two U.S. airports (Los Angeles International and Denver

International), concluded that the incidence of sleep awakening from aircraft noise was less than identified in a 1992 study (Federal Interagency Committee On Noise 1992). Using indoor single-event noise levels represented by SEL, potential sleep awakening can be predicted using the curve presented in Figure A-5. Typically, homes in the United States provide 15 dB of sound attenuation with windows open and 25 dB with windows closed and air conditioning operating. Hence, the outdoor SEL of 107 dB would be 92 dB indoors with windows open and 82 dB indoors with windows closed and air conditioning operating.

Using Figure A-5, the potential sleep awakening would be 15% with windows open and 10% with windows closed in the above example.

The new FICAN curve does not address habituation over time by sleeping subjects and is applicable only to adult populations. Nevertheless, this curve provides a reasonable guideline for assessing sleep awakening. It is conservative, representing the upper envelope of field study results.

The FICAN curve shown in Figure A-5 represents awakenings from single events. To date, no exact quantitative dose-response relationship exists for noise-related sleep interference from multiple events; yet, based on studies conducted to date and the USEPA guideline of a 45 DNL to protect sleep interference, useful ways to assess sleep interference have emerged. If homes are conservatively estimated to have a 20-dB noise insulation, an average of 65 DNL would produce an indoor level of 45 DNL and would form a reasonable guideline for evaluating sleep interference. This also corresponds well to the general guideline for assessing speech interference. Annoyance that may result from sleep disturbance is accounted for in the calculation of DNL, which includes a 10-dB penalty for each sortie

A.3.4 Hearing Loss

Considerable data on hearing loss have been collected and analyzed. It has been well established that continuous exposure to high noise levels will damage human hearing (U.S. Environmental Protection Agency 1978). People are normally capable of hearing up to 120 dB over a wide frequency range. Hearing loss is generally interpreted as the shifting of a higher sound level of the ear's sensitivity or acuity to perceive sound. This change can either be temporary, called a temporary threshold shift (TTS), or permanent, called a permanent threshold shift (PTS) (Berger, et al. 1995).

The EPA has established 75 dB for an 8-hour exposure and 70 dB for a 24-hour exposure as the average noise level standard requisite to protect 96% of the population from greater than a 5 dB PTS (U.S. Environmental Protection Agency 1978). Similarly, the National Academy of Sciences Committee on Hearing, Bioacoustics, and Biomechanics (CHABA) identified 75 dB as the minimum level at which hearing loss may occur (Committee on Hearing, Bioacoustics, and Biomechanics 1977). However, it is important to note that continuous, long-term (40 years) exposure is assumed by both EPA and CHABA before hearing loss may occur.

Federal workplace standards for protection from hearing loss allow a time-average level of 90 dB over an 8-hour work period or 85 dB over a 16-hour period. Even the most protective criterion (no measurable hearing loss for the most sensitive portion of the population at the ear's most sensitive frequency, 4,000 Hz, after a 40-year exposure) is a time-average sound level of 70 dB over a 24-hour period.

Studies on community hearing loss from exposure to aircraft flyovers near airports showed that there is no danger, under normal circumstances, of hearing loss due to aircraft noise (Newman and Beattie 1985).

A laboratory study measured changes in human hearing from noise representative of low-flying aircraft on MTRs. (Nixon, et al. 1993). In this study, participants were first subjected to four overflight noise exposures at A-weighted levels of 115 dB to 130 dB. One-half of the subjects showed no change in hearing levels, one-fourth had a temporary 5-dB increase in sensitivity (the people could hear a 5-dB wider range of sound than before exposure), and one-fourth had a temporary 5-dB decrease in sensitivity (the people could hear a 5-dB narrower range of sound than before exposure). In the next phase, participants were subjected to a single overflight at a maximum level of 130 dB for eight successive exposures, separated by 90 seconds or until a temporary shift in hearing was observed. The temporary hearing threshold shifts resulted in the participants hearing a wider range of sound, but within 10 dB of their original range.

In another study of 115 test subjects between 18 and 50 years old, temporary threshold shifts were measured after laboratory exposure to military low-altitude flight (MLAF) noise (Ising, et al. 1999). According to the authors, the results indicate that repeated exposure to MLAF noise with L_{max} greater than 114 dB, especially if the noise level increases rapidly, may have the potential to cause noise induced hearing loss in humans.

Because it is unlikely that airport neighbors will remain outside their homes 24 hours per day for extended periods of time, there is little possibility of hearing loss below a day-night average sound level of 75 dB, and this level is extremely conservative.

A.3.5 Nonauditory Health Effects

Studies have been conducted to determine whether correlations exist between noise exposure and cardiovascular problems, birth weight, and mortality rates. The nonauditory effect of noise on humans is not as easily substantiated as the effect on hearing. The results of studies conducted in the United States, primarily concentrating on cardiovascular response to noise, have been contradictory (Cantrell 1974). Cantrell (1974) concluded that the results of human and animal experiments show that average or intrusive noise can act as a stress-provoking stimulus. Prolonged stress is known to be a contributor to a number of health disorders. Kryter and Poza (1980) state, "It is more

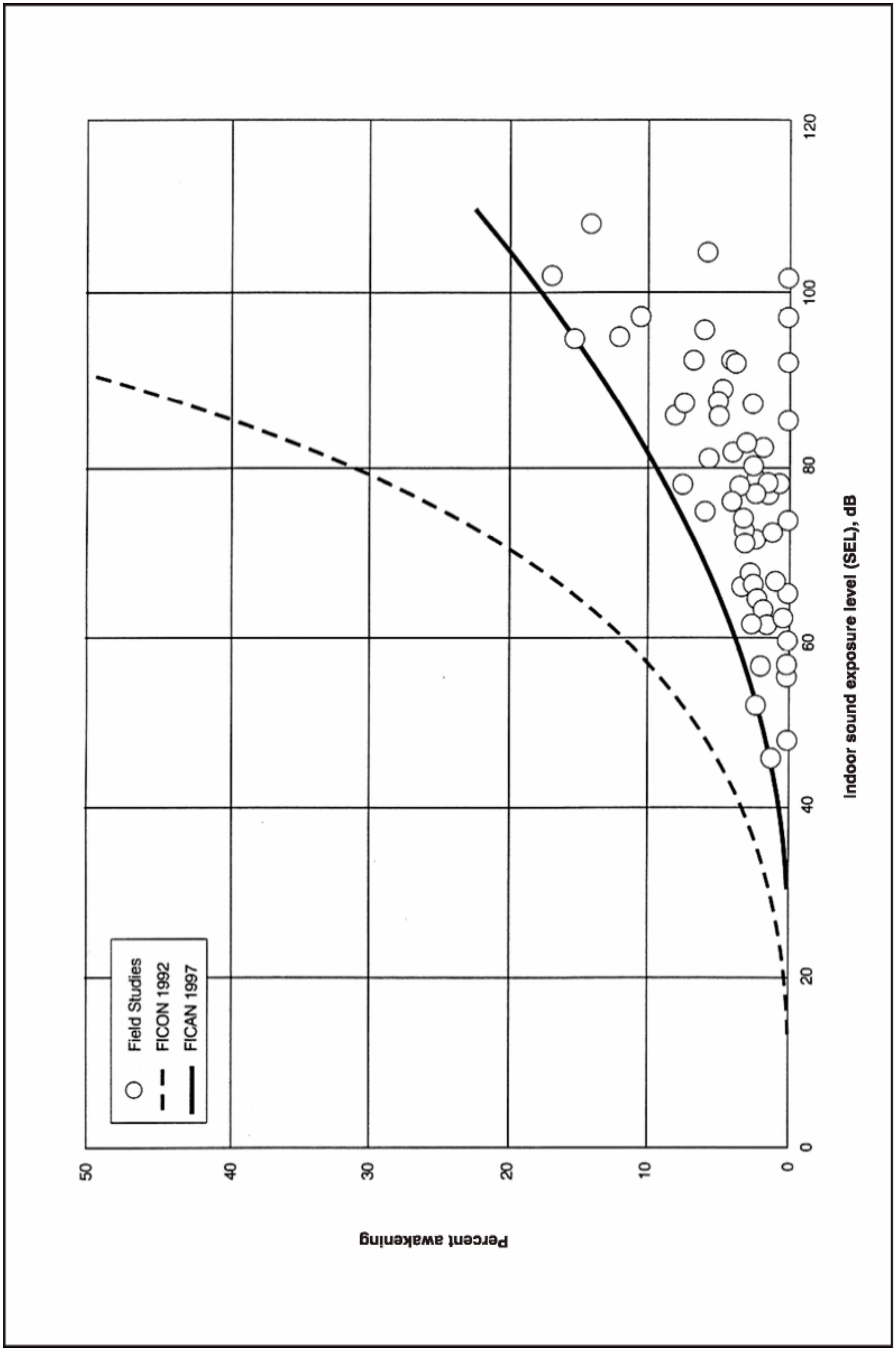


Figure A-5. Recommended Sleep Disturbance Dose-Response Relationship

likely that noise- related general ill-health effects are due to the psychological annoyance from the noise interfering with normal everyday behavior, than it is from the noise eliciting, because of its intensity, reflexive response in the autonomic or other physiological systems of the body." Psychological stresses may cause a physiological stress reaction that could result in impaired health.

The National Institute for Occupational Safety and Health and EPA commissioned CHABA in 1981 to study whether established noise standards are adequate to protect against health disorders other than hearing defects. CHABA's conclusion was that:

Evidence from available research reports is suggestive, but it does not provide definitive answers to the question of health effects, other than to the auditory system, of long-term exposure to noise. It seems prudent, therefore, in the absence of adequate knowledge as to whether or not noise can produce effects upon health other than damage to auditory system, either directly or mediated through stress, that insofar as feasible, an attempt should be made to obtain more critical evidence.

Since the CHABA report, there have been more recent studies that suggest that noise exposure may cause hypertension and other stress-related effects in adults. Near an airport in Stockholm, Sweden, the prevalence of hypertension was reportedly greater among nearby residents who were exposed to energy averaged noise levels exceeding 55 dB and maximum noise levels exceeding 72 dB, particularly older subjects and those not reporting impaired hearing ability (Rosenlund, et al. 2001). A study of elderly volunteers who were exposed to simulated military low-altitude flight noise reported that blood pressure was raised by L_{max} of 112 dB and high speed level increase (Michalak, et al. 1990). Yet another study of subjects exposed to varying levels of military aircraft or road noise found no significant relationship between noise level and blood pressure (Pulles, et al. 1990).

The U.S. Department of the Navy prepared a programmatic Environmental Assessment (EA) for the continued use of non-explosive ordnance on the Vieques Inner Range. Following the preparation of the EA, it was learned that research conducted by the University of Puerto Rico, Ponce School of Medicine, suggested that Vieques fishermen and their families were experiencing symptoms associated with vibroacoustic disease (VAD) (U.S. Department of the Navy 2002). The study alleged that exposure to noise and sound waves of large pressure amplitudes within lower frequency bands, associated with Navy training activities--specifically, air-to-ground bombing or naval fire support-- was related to a larger prevalence of heart anomalies within the Vieques fishermen and their families. The Ponce School of Medicine study compared the Vieques group with a group from Ponce Playa. A 1999 study conducted on Portuguese aircraft-manufacturing workers from a single factory reported effects of jet aircraft noise exposure that involved a wide range of symptoms and disorders, including the cardiac issues on which the Ponce School of Medicine study focused. The 1999 study identified these effects as VAD.

Johns Hopkins University (JHU) conducted an independent review of the Ponce School of Medicine study, as well as the Portuguese aircraft workers study and other relevant scientific literature. Their findings concluded that VAD should not be accepted as a syndrome, given that exhaustive research across a number of populations has not yet been conducted. JHU also pointed out that the evidence supporting the existence of VAD comes largely from one group of investigators and that similar results would have to be replicated by other investigators. In short, JHU concluded that it had not been established that noise was the causal agent for the symptoms reported and no inference can be made as to the role of noise from naval gunfire in producing echocardiographic abnormalities (U.S. Department of the Navy 2002).

Most studies of nonauditory health effects of long-term noise exposure have found that noise exposure levels established for hearing protection will also protect against any potential nonauditory health effects, at least in workplace conditions. One of the best scientific summaries of these findings is contained in the lead paper at the National Institutes of Health Conference on Noise and Hearing Loss, held on 22 to 24 January 1990 in Washington, D.C.:

> "The nonauditory effects of chronic noise exposure, when noise is suspected to act as one of the risk factors in the development of hypertension, cardiovascular disease, and other nervous disorders, have never been proven to occur as chronic manifestations at levels below these criteria (an average of 75 dBA for complete protection against hearing loss for an 8-hour day). At the recent (1988) International Congress on Noise as a Public Health Problem, most studies attempting to clarify such health effects did not find them at levels below the criteria protective of noise-induced hearing loss, and even above these criteria, results regarding such health effects were ambiguous. Consequently, one comes to the conclusion that establishing and enforcing exposure levels protecting against noise-induced hearing loss would not only solve the noise-induced hearing loss problem, but also any potential nonauditory health effects in the work place" (von Gierke 1990).

Although these findings were specifically directed at noise effects in the workplace, they are equally applicable to aircraft noise effects in the community environment. Research studies regarding the nonauditory health effects of aircraft noise are ambiguous, at best, and often contradictory. Yet, even those studies that purport to find such health effects use time-average noise levels of 75 dB and higher for their research.

For example, two UCLA researchers apparently found a relationship between aircraft noise levels under the approach path to Los Angeles International Airport (LA)() and increased mortality rates among the exposed residents by using an average noise exposure level greater than 75 dB for the "noise-exposed" population (Meacham and Shaw 1979). Nevertheless, three other UCLA professors analyzed those same data and found no relationship between noise exposure and mortality rates (Frerichs, et al. 1980).

As a second example, two other UCLA researchers used this same population near LA)(to show a higher rate of birth defects for 1970 to 1972 when compared with a control group residing away from the airport (Jones and Tauscher 1978). Based on this report, a separate group at the Center for Disease Control performed a more thorough study of populations near Atlanta's Hartsfield International Airport (ATL) for 1970 to

1972 and found no relationship in their study of 17 identified categories of birth defects to aircraft noise levels above 65 dB (Edmonds, et al. 1979).

In summary, there is no scientific basis for a claim that potential health effects exist for aircraft time- average sound levels below 75 dB.

The potential for noise to affect physiological health, such as the cardiovascular system, has been speculated; however, no unequivocal evidence exists to support such claims (Harris 1997). Conclusions drawn from a review of health effect studies involving military low-altitude flight noise with its unusually high maximum levels and rapid rise in sound level have shown no increase in cardiovascular disease (Schwartze and Thompson 1993). Additional claims that are unsupported include flyover noise producing increased mortality rates and increases in cardiovascular death, aggravation of post-traumatic stress syndrome, increased stress, increase in admissions to mental hospitals, and adverse affects on pregnant women and the unborn fetus (Harris 1997).

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 established links between continuous high noise levels and performance loss. Noise-induced performance losses are most frequently reported in studies employing noise levels in excess of 85 dB. Little change has been found in low-noise cases. It has been cited that moderate noise levels appear to act as a stressor for more sensitive individuals performing a difficult psychomotor task.

While the results of research on the general effect of periodic aircraft noise on performance have yet to yield definitive criteria, several general trends have been noted including:

- A periodic intermittent noise is more likely to disrupt performance than a steady-state continuous noise of the same level. Flyover noise, due to its intermittent nature, might be more likely to disrupt performance than a steady-state noise of equal level.
- Noise is more inclined to affect the quality than the quantity of work.
- Noise is more likely to impair the performance of tasks that place extreme demands on the worker.

A.3.7 Noise Effects on Children

In response to noise-specific and other environmental studies, Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks (1997), requires federal agencies to ensure that policies, programs, and activities address environmental health and safety risks to identify any disproportionate risks to children.

A review of the scientific literature indicates that there has not been a tremendous amount of research in the area of aircraft noise effects on children. The research reviewed does suggest that environments with sustained high background noise can have variable effects, including noise effects on learning and cognitive abilities, and reports of various noise-related physiological changes.

A.3.7.1 Effects on Learning and Cognitive Abilities

In the recent release (2002) of the "Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools," the American National Standards Institute refers to studies that suggest that loud and frequent background noise can affect the learning patterns of young children. ANSI provides discussion on the relationships between noise and learning, and stipulates design requirements and acoustical performance criteria for outdoor-to-indoor noise isolation. School design is directed to be cognizant of, and responsive to, surrounding land uses and the shielding of outdoor noise from the indoor environment. ANSI has approved a new standard for acoustical performance criteria in schools. The new criteria include the requirement that the one-hour-average background noise level shall not exceed 35 dBA in core learning spaces smaller than 20,000 cubic-feet and 40 dBA in core learning spaces with enclosed volumes exceeding 20,000 cubic-feet. This would require schools be constructed such that, in quiet neighborhoods indoor noise levels are lowered by 15 to 20 dBA relative to outdoor levels. In schools near airports, indoor noise levels would have to be lowered by 35 to 45 dBA relative to outdoor levels (American National Standards Institute 2002).

The studies referenced by ANSI to support the new standard are not specific to jet aircraft noise and the potential effects on children. However, there are references to studies that have shown that children in noisier classrooms scored lower on a variety of tests. Excessive background noise or reverberation within schools causes interferences of communication and can therefore create an acoustical barrier to learning (American National Standards Institute 2002). Studies have been performed that contribute to the body of evidence emphasizing the importance of communication by way of the spoken language to the development of cognitive skills. The ability to read, write, comprehend, and maintain attentiveness, are, in part, based upon whether teacher communication is consistently intelligible (American National Standards Institute 2002).

Numerous studies have shown varying degrees of effects of noise on the reading comprehension, attentiveness, puzzle-solving, and memory / recall ability of children. It is generally accepted that young children are more susceptible than adults to the effects of background noise. Because of the developmental status of young children (linguistic, cognitive, and proficiency), barriers to hearing can cause interferences or disruptions in developmental evolution.

Research on the impacts of aircraft noise, and noise in general, on the cognitive abilities of school-aged children has received more attention in recent years. Several studies suggest that aircraft noise can affect the academic performance of schoolchildren. Although many factors could contribute to learning deficits in school-aged children (e.g., socioeconomic level, home environment, diet, sleep patterns), evidence exists that suggests that chronic exposure to high aircraft noise levels can impair learning.

Specifically, elementary school children attending schools near New York City's two airports demonstrated lower reading scores than children living farther away from the flight paths (Green, et al. 1982). Researchers have found that tasks involving central processing and language comprehension (such as reading, attention, problem solving, and memory) appear to be the most affected by noise (Evans and Lepore 1993; Hygge 1994; and Evans, et al. 1995). It has been demonstrated that chronic exposure of first- and second-grade children to aircraft noise can result in reading deficits and impaired speech perception (i.e., the ability to hear common, low-frequency [vowel] sounds but not high frequencies [consonants] in speech) (Evans and Maxwell 1997).

The Evans and Maxwell (1997) study found that chronic exposure to aircraft noise resulted in reading deficits and impaired speech perception for first- and second-grade children. Other studies found that children residing near the Los Angeles International Airport had more difficulty solving cognitive problems and did not perform as well as children from quieter schools in puzzle-solving and attentiveness (Bronzaft 1997; Cohen, et al. 1980). Children attending elementary schools in high aircraft noise areas near London's Heathrow Airport demonstrated poorer reading comprehension and selective cognitive impairments (Haines, et al. 2001a, b). Similarly, a study conducted by Hygge (1994) found that students exposed to aircraft noise (76 dBA) scored 20% lower on recall ability tests than students exposed to ambient noise (42-44 dBA). Similar studies involving the testing of attention, memory, and reading comprehension of schoolchildren located near airports showed that their tests exhibited reduced performance results compared to those of similar groups of children who were located in quieter environments (Evans, et al. 1995; Haines, et al. 1998). The Haines and Stansfeld study indicated that there may be some long-term effects associated with exposure, as one-year follow-up testing still demonstrated lowered scores for children in higher noise schools (Haines et al., 2001a and 2001b). In contrast, a study conducted by Hygge, et al. (2002) found that although children living near the old Munich airport scored lower in standardized reading and long-term memory tests than a control group, their performance on the same tests was equal to that of the control group once the airport was closed.

Finally, although it is recognized that there are many factors that could contribute to learning deficits in school-aged children, there is increasing awareness that chronic exposure to high aircraft noise levels may impair learning. This awareness has led the World Health Organization and a North Atlantic Treaty Organization working group to conclude that daycare centers and schools should not be located near major sources of noise, such as highways, airports, and industrial sites (World Health Organization 2000; North Atlantic Treaty Organization 2000).

A.3.7.2 Health Effects

Physiological effects in children exposed to aircraft noise and the potential for health effects have also been the focus of limited investigation. Studies in the literature include examination of blood pressure levels, hormonal secretions, and hearing loss.

As a measure of stress response to aircraft noise, authors have looked at blood pressure readings to monitor children's health. Children who were chronically exposed to aircraft noise from a new airport near Munich, Germany, had modest (although significant) increases in blood pressure, significant increases in stress hormones, and a decline in quality of life (Evans, et al. 1998). Children attending noisy schools had statistically significant average systolic and diastolic blood pressure ($p<0.03$). Systolic blood pressure means were 89.68 mm for children attending schools located in noisier environments compared to 86.77 mm for a control group. Similarly, diastolic blood pressure means for the noisier environment group were 47.84 mm and 45.16 for the control group (Cohen, et al. 1980).

Although the literature appears limited, relatively recent studies focused on the wide range of potential effects of aircraft noise on school children have also investigated hormonal levels between groups of children exposed to aircraft noise compared to those in a control group. Specifically, Haines, et al. (2001b and 2001c) analyzed cortisol and urinary catecholamine levels in school children as measurements of stress response to aircraft noise. In both instances, there were no differences between the aircraft-noise-exposed children and the control groups.

Other studies have reported hearing losses from exposure to aircraft noise. Noise-induced hearing loss was reportedly higher in children who attended a school located under a flight path near a Taiwan airport, as compared to children at another school far away (Chen, et al. 1997). Another study reported that hearing ability was reduced significantly in individuals who lived near an airport and were frequently exposed to aircraft noise (Chen and Chen 1993). In that study, noise exposure near the airport was reportedly uniform, with DNL greater than 75 dB and maximum noise levels of about 87 dB during overflights. Conversely, several other studies that were reviewed reported no difference in hearing ability between children exposed to high levels of airport noise and children located in quieter areas (Fisch 1977; Andrus, et al. 1975; Wu, et al. 1995).

A.3.8 Effects on Domestic Animals and Wildlife

Hearing is critical to an animal's ability to react, compete, reproduce, hunt, forage, and survive in its environment. While the existing literature does include studies on possible effects of jet aircraft noise and sonic booms on wildlife, there appears to have been little concerted effort in developing quantitative comparisons of aircraft noise effects on normal auditory characteristics. Behavioral effects have been relatively well described, but the larger ecological context issues, and the potential for drawing conclusions regarding effects on populations, has not been well developed.

The relationships between potential auditory/physiological effects and species interactions with their environments are not well understood. Manci, et al. (1988), assert that the consequences that physiological effects may have on behavioral patterns is vital to understanding the long-term effects of noise on wildlife. Questions regarding the effects (if any) on predator-prey interactions, reproductive success, and intra-inter specific behavior patterns remain.

The following discussion provides an overview of the existing literature on noise effects (particularly jet aircraft noise) on animal species. The literature reviewed here involves those studies that have focused on the observations of the behavioral effects that jet aircraft and sonic booms have on animals.

A great deal of research was conducted in the 1960's and 1970's on the effects of aircraft noise on the public and the potential for adverse ecological impacts. These studies were largely completed in response to the increase in air travel and as a result of the introduction of supersonic jet aircraft. According to Manci, et al. (1988), the foundation of information created from that focus does not necessarily correlate or provide information specific to the impacts to wildlife in areas overflown by aircraft at supersonic speed or at low altitudes.

The abilities to hear sounds and noise and to communicate assist wildlife in maintaining group cohesiveness and survivorship. Social species communicate by transmitting calls of warning, introduction, and other types that are subsequently related to an individual's or group's responsiveness.

Animal species differ greatly in their responses to noise. Noise effects on domestic animals and wildlife are classified as primary, secondary, and tertiary. Primary effects are direct, physiological changes to the auditory system, and most likely include the masking of auditory signals. Masking is defined as the inability of an individual to hear important environmental signals that may arise from mates, predators, or prey. There is some potential that noise could disrupt a species' ability to communicate or could interfere with behavioral patterns (Manci, et al. 1988). Although the effects are likely temporal, aircraft noise may cause masking of auditory signals within exposed faunal communities. Animals rely on hearing to avoid predators, obtain food, and communicate with, and attract, other members of their species. Aircraft noise may mask or interfere with these functions. Other primary effects, such as ear drum rupture or temporary and permanent hearing threshold shifts, are not as likely given the subsonic noise levels produced by aircraft overflights. Secondary effects may include non-auditory effects such as stress and hypertension; behavioral modifications; interference with mating or reproduction; and impaired ability to obtain adequate food, cover, or water. Tertiary effects are the direct result of primary and secondary effects, and include population decline and habitat loss. Most of the effects of noise are mild enough that they may never be detectable as variables of change in population size or population growth against the background of normal variation (Bowles 1995). Other environmental variables (e.g., predators, weather, changing prey base, ground-based disturbance) also influence secondary and tertiary effects, and confound the ability to identify the ultimate factor in limiting productivity of a certain nest, area, or region (Smith, et al. 1988). Overall, the literature suggests that species differ in their response to various types, durations, and sources of noise (Manci, et al. 1988).

Many scientific studies have investigated the effects of aircraft noise on wildlife, and some have focused on wildlife "flight" due to noise. Apparently, animal responses to aircraft are influenced by many variables, including size, speed, proximity (both height above the ground and lateral distance), engine noise, color, flight profile, and radiated noise. The type of aircraft (e.g., fixed wing versus rotor-wing [helicopter]) and type of flight mission may also produce different levels of disturbance, with varying animal responses (Smith, et al. 1988). Consequently, it is difficult to generalize animal responses to noise disturbances across species.

One result of the 1988 Manci, et al., literature review was the conclusion that, while behavioral observation studies were relatively limited, a general behavioral reaction in animals from exposure to aircraft noise is the startle response. The intensity and duration of the startle response appears to be dependent on which species is exposed, whether there is a group or an individual, and whether there have been some previous exposures. Responses range from flight, trampling, stampeding, jumping, or running, to movement of the head in the apparent direction of the noise source. Manci, et al. (1988), reported that the literature indicated that avian species may be more sensitive to aircraft noise than mammals.

A.3.8.1 Domestic Animals

Although some studies report that the effects of aircraft noise on domestic animals is inconclusive, a majority of the literature reviewed indicates that domestic animals exhibit some behavioral responses to military overflights but generally seem to habituate to the disturbances over a period of time. Mammals in particular appear to react to noise at sound levels higher than 90 dB, with responses including the startle response, freezing (i.e., becoming temporarily stationary), and fleeing from the sound source. Many studies on domestic animals suggest that some species appear to acclimate to some forms of sound disturbance (Manci, et al. 1988). Some studies have reported such primary and secondary effects as reduced milk production and rate of milk release, increased glucose concentrations, decreased levels of hemoglobin, increased heart rate, and a reduction in thyroid activity. These latter effects appear to represent a small percentage of the findings occurring in the existing literature.

Some reviewers have indicated that earlier studies, and claims by farmers linking adverse effects of aircraft noise on livestock, did not necessarily provide clear-cut evidence of cause and effect (Cottereau 1978). In contrast, many studies conclude that there is no evidence that aircraft overflights affect feed intake, growth, or production rates in domestic animals.

Cattle

In response to concerns about overflight effects on pregnant cattle, milk production, and cattle safety, the U.S. Air Force prepared a handbook for environmental protection that summarizes the literature on the impacts of low-altitude flights on livestock (and poultry) and includes specific case studies conducted in numerous airspaces across the country. Adverse effects have been found in a few studies but have not been reproduced in other similar studies. One such study, conducted in 1983, suggested that 2 of 10 cows in late pregnancy aborted after showing rising estrogen and falling progesterone levels. These increased hormonal levels were reported as being linked to 59 aircraft overflights. The remaining eight cows showed no changes in their blood concentrations and calved normally (U.S. Air Force 1994b). A similar study reported abortions occurred in three out of five pregnant cattle after exposing them to flyovers by six different aircraft (U.S. Air Force 1994b). Another study suggested that feedlot cattle could stampede and injure themselves when exposed to low-level overflights (U.S. Air Force 1994b).

A majority of the studies reviewed suggests that there is little or no effect of aircraft noise on cattle. Studies presenting adverse effects to domestic animals have been limited. A number of studies (Parker and Bayley 1960; Casady and Lehmann 1967; Kovalcik and Sottnik 1971) investigated the effects of jet aircraft noise and sonic booms on the milk production of dairy cows. Through the compilation and examination of milk production data from areas exposed to jet aircraft noise and sonic boom events, it was determined that milk yields were not affected. This was particularly evident in those cows that had been previously exposed to jet aircraft noise.

A study examined the causes of 1,763 abortions in Wisconsin dairy cattle over a one-year time period and none were associated with aircraft disturbances (U.S.Air Force 1993). In 1987, Anderson contacted seven livestock operators for production data, and no effects of low-altitude and supersonic flights were noted. Three out of 43 cattle previously exposed to low-altitude flights showed a startle response to an F/A-18 aircraft flying overhead at 500 feet above ground level and 400 knots by running less than 10 meters. They resumed normal activity within one minute (U.S.Air Force 1994b). Beyer (1983) found that helicopters caused more reaction than other low-aircraft overflights, and that the helicopters at 30 to 60 feet overhead did not affect milk production and pregnancies of 44 cows and heifers in a 1964 study (U.S. Air Force 1994b).

Additionally, Beyer reported that five pregnant dairy cows in a pasture did not exhibit fright-flight tendencies or disturb their pregnancies after being overflown by 79 low-altitude helicopter flights and 4 low-altitude, subsonic jet aircraft flights (U.S. Air Force 1994b). A 1956 study found that the reactions of dairy and beef cattle to noise from low-altitude, subsonic aircraft were similar to those caused by paper blowing about, strange persons, or other moving objects (U.S. Air Force 1994b).

In a report to Congress, the U. S. Forest Service concluded that "evidence both from field studies of wild ungulates and laboratory studies of domestic stock indicate that the risks of damage are small (from aircraft approaches of 50 to 100 meters), as animals take care not to damage themselves (U.S. Forest Service 1992). If animals are overflown by aircraft at altitudes of 50 to 100 meters, there is no evidence that mothers and young are separated, that animals collide with obstructions (unless confined) or that they traverse dangerous ground at too high a rate." These varied study results suggest that, although the confining of cattle could magnify animal response to aircraft overflight, there is no proven cause-and-effect link between startling cattle from aircraft overflights and abortion rates or lower milk production.

Horses

Horses have also been observed to react to overflights of jet aircraft. Several of the studies reviewed reported a varied response of horses to low-altitude aircraft overflights. Observations made in 1966 and 1968 noted that horses galloped in response to jet flyovers (U.S. Air Force 1993). Bowles (1995) cites Kruger and Erath as observing horses exhibiting intensive flight reactions, random movements, and biting/kicking behavior. However, no injuries or abortions occurred, and there was evidence that the mares adapted somewhat to the flyovers over the course of a month (U.S. Air Force 1994b). Although horses were observed noticing the overflights, it did not appear to affect either survivability or reproductive success. There was also some indication that habituation to these types of disturbances was occurring.

LeBlanc, et al. (1991), studied the effects of F-14 jet aircraft noise on pregnant mares. They specifically focused on any changes in pregnancy success, behavior, cardiac function, hormonal production, and rate of habituation. Their findings reported observations of "flight-fright" reactions, which caused increases in heart rates and serum cortisol concentrations. The mares, however, did habituate to the noise. Levels of anxiety and mass body movements were the highest after initial exposure, with intensities of responses decreasing thereafter. There were no differences in pregnancy success when compared to a control group.

Swine

Generally, the literature findings for swine appear to be similar to those reported for cows and horses. While there are some effects from aircraft noise reported in the literature, these effects are minor. Studies of continuous noise exposure (i.e., 6 hours, 72 hours of constant exposure) reported influences on short-term hormonal production and release. Additional constant exposure studies indicated the observation of stress reactions, hypertension, and electrolyte imbalances (Dufour 1980). A study by Bond, et al. (1963), demonstrated no adverse effects on the feeding efficiency, weight gain, ear physiology, or thyroid and adrenal gland condition of pigs subjected to observed aircraft noise. Observations of heart rate increase were recorded, noting that cessation of the noise resulted in the return to normal heart rates. Conception rates and offspring survivorship did not appear to be influenced by exposure to aircraft noise.

Similarly, simulated aircraft noise at levels of 100 dB to 135 dB had only minor effects on the rate of feed utilization, weight gain, food intake, or reproduction rates of boars and sows exposed, and there were no injuries or inner ear changes observed (Manci, et al. 1988; Gladwin, et al. 1988).

Domestic Fowl

According to a 1994 position paper by the U.S. Air Force on effects of low-altitude overflights (below 1,000 ft) on domestic fowl, overflight activity has negligible effects (U.S. Air Force 1994a). The paper did recognize that given certain circumstances, adverse effects can be serious. Some of the effects can be panic reactions, reduced productivity, and effects on marketability (e.g., bruising of the meat caused during "pile-up" situations).

The typical reaction of domestic fowl after exposure to sudden, intense noise is a short-term startle response. The reaction ceases as soon as the stimulus is ended, and within a few minutes all activity returns to normal. More severe responses are possible depending on the number of birds, the frequency of exposure, and environmental conditions. Large crowds of birds, and birds not previously exposed, are more likely to pile up in response to a noise stimulus (U.S. Air Force 1994a). According to studies and interviews with growers, it is typically the previously unexposed birds that incite panic crowding, and the tendency to do so is markedly reduced within five exposures to the stimulus (U.S. Air Force 1994a). This suggests that the birds habituate relatively quickly. Egg productivity was not adversely affected by infrequent noise bursts, even at exposure levels as high as 120 to 130 dBA.

Between 1956 and 1988, there were 100 recorded claims against the Navy for alleged damage to domestic fowl. The number of claims averaged three per year, with peak numbers of claims following publications of studies on the topic in the early 1960s (U.S. Air Force

1994a). Many of the claims were disproved or did not have sufficient supporting evidence. The claims were filed for the following alleged damages: 55% for panic reactions, 31% for decreased production, 6% for reduced hatchability, 6% for weight loss, and less than 1% for reduced fertility (U.S. Air Force 1994a).

Turkeys

The review of the existing literature suggests that there has not been a concerted or widespread effort to study the effects of aircraft noise on commercial turkeys. One study involving turkeys examined the differences between simulated versus actual overflight aircraft noise, turkey responses to the noise, weight gain, and evidence of habituation (Bowles, et al. 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 1994a).

A.3.8.2 Wildlife

Studies on the effects of overflights and sonic booms on wildlife have been focused mostly on avian species and ungulates such as caribou and bighorn sheep. Few studies have been conducted on marine mammals, small terrestrial mammals, reptiles, amphibians, and carnivorous mammals. Generally, species that live entirely below the surface of the water have also been ignored due to the fact they do not experience the same level of sound as terrestrial species (National Park Service 1994). Wild ungulates appear to be much more sensitive to noise disturbance than domestic livestock (Manci, et al. 1988). This may be due to previous exposure to disturbances. One common factor appears to be that low-altitude flyovers seem to be more disruptive in terrain where there is little cover (Manci, et al. 1988).

A.3.8.2.1 MAMMALS

Terrestrial Mammals

Studies of terrestrial mammals have shown that noise levels of 120 dBA can damage mammals' ears, and levels at 95 dBA can cause temporary loss of hearing acuity. Noise from aircraft has affected other large carnivores by causing changes in home ranges, foraging patterns, and breeding behavior. One study recommended that aircraft not be allowed to fly at altitudes below 2,000 feet above ground level over important grizzly and polar bear habitat (Dufour 1980). Wolves have been frightened by low- altitude flights that were 25 to 1,000 feet off the ground. However, wolves have been found to adapt to aircraft overflights and noise as long as they were not being hunted from aircraft (Dufour 1980).

Wild ungulates (American bison, caribou, bighorn sheep) appear to be much more sensitive to noise disturbance than domestic livestock (Weisenberger, et al. 1996). Behavioral reactions may be related to the past history of disturbances by such things as humans and aircraft. Common reactions of reindeer kept in an enclosure exposed to aircraft noise disturbance were a slight startle response, raising of the head, pricking ears, and scenting of the air. Panic reactions and extensive changes in behavior of individual animals were not observed. Observations of caribou in Alaska exposed to fixed-wing aircraft and helicopters showed running and panic reactions occurred when overflights were at an altitude of 200 feet or less. The reactions decreased with increased altitude of overflights, and, with more than 500 feet in altitude, the panic reactions stopped. Also, smaller groups reacted less strongly than larger groups. One negative effect of the running and avoidance behavior is increased expenditure of energy. For a 90-kg animal, the calculated expenditure due to aircraft harassment is 64 kilocalories per minute when running and 20 kilocalories per minute when walking. When conditions are favorable, this expenditure can be counteracted with increased feeding; however, during harsh winter conditions, this may not be possible. Incidental observations of wolves and bears exposed to fixed-wing aircraft and helicopters in the northern regions suggested that wolves are less disturbed than wild ungulates, while grizzly bears showed the greatest response of any animal species observed.

It has been proven that low-altitude overflights do induce stress in animals. Increased heart rates, an indicator of excitement or stress, have been found in pronghorn antelope, elk, and bighorn sheep. As such reactions occur naturally as a response to predation, infrequent overflights may not, in and of themselves, be detrimental. However, flights at high frequencies over a long period of time may cause harmful effects. The consequences of this disturbance, while cumulative, is not additive. It may be that aircraft disturbance may not cause obvious and serious health effects, but coupled with a harsh winter, it may have an adverse impact. Research has shown that stress induced by other types of disturbances produces long-term decreases in metabolism and hormone balances in wild ungulates.

Behavioral responses can range from mild to severe. Mild responses include head raising, body shifting, or turning to orient toward the aircraft. Moderate disturbance may be nervous behaviors, such as trotting a short distance. Escape is the typical severe response.

Marine Mammals

The physiological composition of the ear in aquatic and marine mammals exhibits adaptation to the aqueous environment. These differences (relative to terrestrial species) manifest themselves in the auricle and middle ear (Manci, et al. 1988). Some mammals use echolocation to perceive objects in their surroundings and to determine the directions and locations of sound sources (Simmons 1983 in Manci, et al. 1988).

In 1980, the Acoustical Society of America held a workshop to assess the potential hazard of manmade noise associated with proposed Alaska Arctic (North Slope-Outer Continental Shelf) petroleum operations on marine wildlife and to prepare a research plan to secure the knowledge necessary for proper assessment of noise impacts (Acoustical Society of America, 1980). Since 1980 it appears that research on responses of aquatic mammals to aircraft noise and sonic booms has been limited. Research conducted on northern fur seals, sea lions, and ringed seals indicated that there are some differences in how various animal groups receive frequencies of sound. It was observed that these species exhibited varying intensities of a startle response to airborne noise, which was habituated over time.

The rates of habituation appeared to vary with species, populations, and demographics (age, sex). Time of day of exposure was also a factor (Muyberg 1978 in Manci, et al. 1988).

Studies accomplished near the Channel Islands were conducted near the area where the space shuttle launches occur. It was found that there were some response differences between species relative to the loudness of sonic booms. Those booms that were between 80 and 89 dBA caused a greater intensity of startle reactions than lower-intensity booms at 72 to 79 dBA. However, the duration of the startle responses to louder sonic booms was shorter (Jehl and Cooper 1980 in Manci, et al. 1988).

Jehl and Cooper (1980) indicated that low-flying helicopters, loud boat noises, and humans were the most disturbing to pinnipeds. According to the research, while the space launch and associated operational activity noises have not had a measurable effect on the pinniped population, it also suggests that there was a greater "disturbance level" exhibited during launch activities. There was a recommendation to continue observations for behavioral effects and to perform long-term population monitoring (Jehl and Cooper 1980).

The continued presence of single or multiple noise sources could cause marine mammals to leave a preferred habitat. However, it does not appear likely that overflights could cause migration from suitable habitats as aircraft noise over water is mobile and would not persist over any particular area. Aircraft noise, including supersonic noise, currently occurs in the overwater airspace of Eglin, Tyndall, and Langley AFBs from sorties predominantly involving jet aircraft. Survey results reported in Davis, et al. (2000), indicate that cetaceans (i.e., dolphins) occur under all of the Eglin and Tyndall marine airspace. The continuing presence of dolphins indicates that aircraft noise does not discourage use of the area and apparently does not harm the locally occurring population.

In a summary by the National Parks Service (1994) on the effects of noise on marine mammals, it was determined that gray whales and harbor porpoises showed no outward behavioral response to aircraft noise or overflights. Bottlenose dolphins showed no obvious reaction in a study involving helicopter overflights at 1,200 to 1,800 feet above the water. Neither did they show any reaction to survey aircraft unless the shadow of the aircraft passed over them, at which point there was some observed tendency to dive (Richardson, et al. 1995). Other anthropogenic noises in the marine environment from ships and pleasure craft may have more of an effect on marine mammals than aircraft noise (U.S. Air Force 2000). The noise effects on cetaceans appear to be somewhat attenuated by the air/water interface. The cetacean fauna along the coast of California have been subjected to sonic booms from military aircraft for many years without apparent adverse effects (Tetra Tech, Inc. 1997).

Manatees appear relatively unresponsive to human-generated noise to the point that they are often suspected of being deaf to oncoming boats [although their hearing is actually similar to that of pinnipeds (Bullock, et al. 1980)]. Little is known about the importance of acoustic communication to manatees, although they are known to produce at least ten different types of sounds and are thought to have sensitive hearing (Richardson, et al. 1995). Manatees continue to occupy canals near Miami International Airport, which suggests that they have become habituated to human disturbance and noise (Metro-Dade

County 1995). Since manatees spend most of their time below the surface and do not startle readily, no effect of aircraft overflights on manatees would be expected (Bowles, et al. 1991).

A.3.8.2.2 BIRDS

Auditory research conducted on birds indicates that they fall between the reptiles and the mammals relative to hearing sensitivity. According to Dooling (1978), within the range of 1 to 5 kHz, birds show a level of hearing sensitivity similar to that of the more sensitive mammals. In contrast to mammals, bird sensitivity falls off at a greater rate to increasing and decreasing frequencies. Passive observations and studies examining aircraft bird strikes indicate that birds nest and forage near airports. Aircraft noise in the vicinity of commercial airports apparently does not inhibit bird presence and use.

High-noise events (like a low-altitude aircraft overflight) may cause birds to engage in escape or avoidance behaviors, such as flushing from perches or nests (Ellis, et al. 1991). These activities impose an energy cost on the birds that, over the long term, may affect survival or growth. In addition, the birds may spend less time engaged in necessary activities like feeding, preening, or caring for their young because they spend time in noise-avoidance activity. However, the long-term significance of noise-related impacts is less clear. Several studies on nesting raptors have indicated that birds become habituated to aircraft overflights and that long-term reproductive success is not affected (Grubb and King 1991; Ellis, et al. 1991). Threshold noise levels for significant responses range from 62 dB for Pacific black brant (Branta bernicla nigricans) (Ward and Stehn 1990) to 85 dB for crested tern (Sterna bergii) (Brown 1990).

Songbirds were observed to become silent prior to the onset of a sonic boom event (F-111 jets), followed by “raucous discordant cries.” There was a return to normal singing within 10 seconds after the boom (Higgins 1974 in Manci, et al., 1988). Ravens responded by emitting protestation calls, flapping their wings, and soaring.

Manci, et al. (1988), reported a reduction in reproductive success in some small territorial passerines (i.e., perching birds or songbirds) after exposure to low-altitude overflights. However, it has been observed that passerines are not driven any great distance from a favored food source by a nonspecific disturbance, such as aircraft overflights (U.S. Forest Service 1992). Further study may be warranted.

A recent study, conducted cooperatively between the DoD and the USFWS, assessed the response of the red-cockaded woodpecker to a range of military training noise events, including artillery, small arms, helicopter, and maneuver noise (Pater, et al. 1999). The project findings show that the red- cockaded woodpecker successfully acclimates to military noise events. Depending on the noise level that ranged from innocuous to very loud, the birds responded by flushing from their nest cavities. When the noise source was closer and the noise level was higher, the number of flushes increased proportionately. In all cases, however, the birds returned to their nests within a relatively short period of time (usually within 12 minutes). Additionally, the noise exposure did not result in any mortality or statistically detectable changes in reproductive success (Pater, et al.

1999). Red-cockaded woodpeckers did not flush when artillery simulators were more than 122 meters away and SEL noise levels were 70 dBA.

Lynch and Speake (1978) studied the effects of both real and simulated sonic booms on the nesting and brooding eastern wild turkey (Meleagris gallopavo silvestris) in Alabama. Hens at four nest sites were subjected to between 8 and 11 combined real and simulated sonic booms. All tests elicited similar responses, including quick lifting of the head and apparent alertness for between 10 and 20 seconds. No apparent nest failure occurred as a result of the sonic booms.

Twenty-one brood groups were also subjected to simulated sonic booms. Reactions varied slightly between groups, but the largest percentage of groups reacted by standing motionless after the initial blast. Upon the sound of the boom, the hens and poults fled until reaching the edge of the woods (approximately 4 to 8 meters). Afterward, the poults resumed feeding activities while the hens remained alert for a short period of time (approximately 15 to 20 seconds). In no instances were poults abandoned, nor did they scatter and become lost. Every observation group returned to normal activities within a maximum of 30 seconds after a blast.

A.3.8.2.2.1 RAPTORS

In a literature review of raptor responses to aircraft noise, Manci, et al. (1988), found that most raptors did not show a negative response to overflights. When negative responses were observed they were predominantly associated with rotor-winged aircraft or jet aircraft that were repeatedly passing within 0.5 mile of a nest.

Ellis, et al. (1991), performed a study to estimate the effects of low-level military jet aircraft and mid- to high-altitude sonic booms (both actual and simulated) on nesting peregrine falcons and seven other raptors (common black-hawk, Harris' hawk, zone-tailed hawk, red-tailed hawk, golden eagle, prairie falcon, bald eagle). They observed responses to test stimuli, determined nest success for the year of the testing, and evaluated site occupancy the following year. Both long- and short-term effects were noted in the study. The results reported the successful fledging of young in 34 of 38 nest sites (all eight species) subjected to low-level flight and/or simulated sonic booms. Twenty-two of the test sites were revisited in the following year, and observations of pairs or lone birds were made at all but one nest. Nesting attempts were underway at 19 of 20 sites that were observed long enough to be certain of breeding activity. Reoccupancy and productivity rates were within or above expected values for self- sustaining populations.

Short-term behavior responses were also noted. Overflights at a distance of 150 m or less produced few significant responses and no severe responses. Typical responses consisted of crouching or, very rarely, flushing from the perch site. Significant responses were most evident before egg laying and after young were "well grown." Incubating or brooding adults never burst from the nest, thus preventing egg breaking or knocking chicks out of the nest. Jet passes and sonic booms often caused noticeable alarm; however, significant negative responses were rare and did not appear to limit productivity or reoccupancy. Due to the locations of some of the nests, some birds may have been habituated to aircraft noise. There were some test sites located at distances far from zones of frequent military aircraft usage, and the test stimuli were often closer, louder, and more frequent than would be likely for a normal training situation.

Manci, et al. (1988), noted that a female northern harrier was observed hunting on a bombing range in Mississippi during bombing exercises. The harrier was apparently unfazed by the exercises, even when a bomb exploded within 200 feet. In a similar case of habituation / non-disturbance, a study on the Florida snail-kite stated the greatest reaction to overflights (approximately 98 dBA) was “watching the aircraft fly by.” No detrimental impacts to distribution, breeding success, or behavior were noted.

Bald Eagle

A study by Grubb and King (1991) on the reactions of the bald eagle to human disturbances showed that terrestrial disturbances elicited the greatest response, followed by aquatic (i.e., boats) and aerial disturbances. The disturbance regime of the area where the study occurred was predominantly characterized by aircraft noise. The study found that pedestrians consistently caused responses that were greater in both frequency and duration. Helicopters elicited the highest level of aircraft-related responses. Aircraft disturbances, although the most common form of disturbance, resulted in the lowest levels of response. This low response level may have been due to habituation; however, flights less than 170 meters away caused reactions similar to other disturbance types. Ellis, et al. (1991), showed that eagles typically respond to the proximity of a disturbance, such as a pedestrian or aircraft within 100 meters, rather than the noise level. Fleischner and Weisberg (1986) stated that reactions of bald eagles to commercial jet flights, although minor (e.g., looking), were twice as likely to occur when the jets passed at a distance of 0.5 mile or less. They also noted that helicopters were four times more likely to cause a reaction than a commercial jet and 20 times more likely to cause a reaction than a propeller plane.

The USFWS advised Cannon AFB that flights at or below 2,000 feet AGL from October 1 through March 1 could result in adverse impacts to wintering bald eagles (U.S. Fish and Wildlife Serice 1998). However, Fraser, et al. (1985), suggested that raptors habituate to overflights rapidly, sometimes tolerating aircraft approaches of 65 feet or less.

Osprey

A study by Trimper, et al. (1998), in Goose Bay, Labrador, Canada, focused on the reactions of nesting osprey to military overflights by CF-18 Hornets. Reactions varied from increased alertness and focused observation of planes to adjustments in incubation posture. No overt reactions (e.g., startle response, rapid nest departure) were observed as a result of an overflight. Young nestlings crouched as a result of any disturbance until they grew to 1 to 2 weeks prior to fledging. Helicopters, human presence, float planes, and other ospreys elicited the strongest reactions from nesting ospreys. These responses included flushing, agitation, and aggressive displays. Adult osprey showed high nest occupancy rates during incubation regardless of external influences.

The osprey observed occasionally stared in the direction of the flight before it was audible to the observers. The birds may have been habituated to the noise of the flights; however, overflights were strictly controlled during the experimental period. Strong reactions to float planes and helicopter may have been due to the slower flight and therefore longer duration of visual stimuli rather than noise- related stimuli.

Red-tailed Hawk

Anderson, et al. (1989), conducted a study that investigated the effects of low-level helicopter overflights on 35 red-tailed hawk nests. Some of the nests had not been flown over prior to the study.

The hawks that were naïve (i.e., not previously exposed) to helicopter flights exhibited stronger avoidance behavior (nine of 17 birds flushed from their nests) than those that had experienced prior overflights. The overflights did not appear to affect nesting success in either study group. These findings were consistent with the belief that red-tailed hawks habituate to low-level air traffic, even during the nesting period.

A.3.8.2.2.2 MIGRATORY WATERFOWL

A study of caged American black ducks was conducted by Fleming, et al., in 1996. It was determined that noise had negligible energetic and physiologic effects on adult waterfowl. Measurements included body weight, behavior, heart rate, and enzymatic activity. Experiments also showed that adult ducks exposed to high noise events acclimated rapidly and showed no effects.

The study also investigated the reproductive success of captive ducks, which indicated that duckling growth and survival rates at Piney Island, North Carolina, were lower than those at a background location. In contrast, observations of several other reproductive indices (i.e., pair formation, nesting, egg production, and hatching success) showed no difference between Piney Island and the background location. Potential effects on wild duck populations may vary, as wild ducks at Piney Island have presumably acclimated to aircraft overflights. It was not demonstrated that noise was the cause of adverse impacts. A variety of other factors, such as weather conditions, drinking water and food availability and variability, disease, and natural variability in reproduction, could explain the observed effects. Fleming noted that drinking water conditions (particularly at Piney Island) deteriorated during the study, which could have affected the growth of young ducks. Further research would be necessary to determine the cause of any reproductive effects.

Another study by Conomy, et al. (1998) exposed previously unexposed ducks to 71 noise events per day that equaled or exceeded 80 dBA. It was determined that the proportion of time black ducks reacted to aircraft activity and noise decreased from 38 percent to 6 percent in 17 days and remained stable at 5.8 percent thereafter. In the same study, the wood duck did not appear to habituate to aircraft disturbance. This supports the notion that animal response to aircraft noise is species-specific. Because a startle response to aircraft noise can result in flushing from nests, migrants and animals living in areas with high concentrations of predators would be the most vulnerable to experiencing effects of lowered birth rates and recruitment over time. Species that are subjected to infrequent overflights do not appear to habituate to overflight disturbance as readily.

Black brant studied in the Alaska Peninsula were exposed to jets and propeller aircraft, helicopters, gunshots, people, boats, and various raptors. Jets accounted for 65% of all the disturbances. Humans, eagles, and boats caused a greater percentage of brant to take flight. There was markedly greater reaction to Bell-206-B helicopter flights than fixed wing, single-engine aircraft (Ward, et al. 1986).

The presence of humans and low-flying helicopters in the Mackenzie Valley North Slope area did not appear to affect the population density of Lapland longspurs, but the experimental group was shown to have reduced hatching and fledging success and higher nest abandonment. Human presence appeared to have a greater impact on the incubating behavior of the black brant, common eider, and Arctic tern than fixed-wing aircraft (Gunn and Livingston 1974).

Gunn and Livingston (1974) found that waterfowl and seabirds in the Mackenzie Valley and North Slope of Alaska and Canada became acclimated to float plane disturbance over the course of three days. Additionally, it was observed that potential predators (bald eagle) caused a number of birds to leave their nests. Non-breeding birds were observed to be more reactive than breeding birds. Waterfowl were affected by helicopter flights, while snow geese were disturbed by Cessna 185 flights. The geese flushed when the planes were under 1,000 feet, compared to higher flight elevations. An overall reduction in flock sizes was observed. It was recommended that aircraft flights be reduced in the vicinity of premigratory staging areas.

Manci, et al. 1988 reported that waterfowl were particularly disturbed by aircraft noise. The most sensitive appeared to be snow geese. Canada geese and snow geese were thought to be more sensitive than other animals such as turkey vultures, coyotes, and raptors (Edwards, et al. 1979).

A.3.8.2.2.3 WADING AND SHORE BIRDS

Black, et al. (1984), studied the effects of low-altitude (less than 500 feet AGL) military training flights with sound levels from 55 to 100 dBA on wading bird colonies (i.e., great egret, snowy egret, tricolored heron, and little blue heron). The training flights involved three or four aircraft, which occurred once or twice per day. This study concluded that the reproductive activity--including nest success, nestling survival, and nestling chronology--was independent of F-16 overflights. Dependent variables were more strongly related to ecological factors, including location and physical characteristics of the colony and climatology. Another study on the effects of circling fixed-wing aircraft and helicopter overflights on wading bird colonies found that at altitudes of 195 to 390 feet, there was no reaction in nearly 75% of the 220 observations. Ninety percent displayed no reaction or merely looked toward the direction of the noise source. Another 6 percent stood up, 3 percent walked from the nest, and 2 percent flushed (but were without active nests) and returned within 5 minutes (Kushlan 1978). Apparently, non-nesting wading birds had a slightly higher incidence of reacting to overflights than nesting birds. Seagulls observed roosting near a colony of wading birds in another study remained at their roosts when subsonic aircraft flew overhead (Burger 1981). Colony distribution appeared to be most directly correlated to available wetland community types and was found to be distributed randomly with respect to military training routes. These results suggest that wading bird species presence was most closely linked to habitat availability and that they were not affected by low-level military overflights (U.S. Air Force 2000).

Burger (1986) studied the response of migrating shorebirds to human disturbance and found that shorebirds did not fly in response to aircraft overflights, but did flush in response to more localized intrusions (i.e., humans and dogs on the beach). Burger (1981) studied the effects of noise from JFK Airport in New York on herring gulls that nested less than 1 kilometer from the airport. Noise levels over the nesting colony were 85 to 100 dBA on approach and 94 to 105 dBA on takeoff. Generally, there did not appear to be any prominent adverse effects of subsonic aircraft on nesting, although some birds flushed when the concorde flew overhead and, when they returned, engaged in aggressive behavior. Groups of gulls tended to loaf in the area of the nesting colony, and these birds remained at the roost when the concorde flew overhead. Up to 208 of the loafing gulls flew when supersonic aircraft flew overhead. These birds would circle around and immediately land in the loafing flock (U.S. Air Force 2000).

In 1969, sonic booms were potentially linked to a mass hatch failure of Sooty Terns on the Dry Tortugas (Austin et al, 1969). The cause of the failure was not certain, but it was conjectured that sonic booms from military aircraft or an overgrowth of vegetation were factors. In the previous season, Sooties were observed to react to sonic booms by rising in a "panic flight," circling over the island, then usually settling down on their eggs again. Hatching that year was normal. Following the 1969 hatch failure, excess vegetation was cleared and measures were taken to reduce supersonic activity. The 1970 hatch appeared to proceed normally. A colony of Noddies on the same island hatched successfully in 1969, the year of the Sooty hatch failure.

Subsequent laboratory tests of exposure of eggs to sonic booms and other impulsive noises (Bowles et al 1991; Bowles et al 1994; Cottereau 1972; Cogger and Zegarra 1980) failed to show adverse effects on hatching of eggs. A structural analysis (Ting et al, 2002) showed that, even under extraordinary circumstances, sonic booms would not damage an avian egg.

Burger (1981) observed no effects of subsonic aircraft on herring gulls in the vicinity of JFK International Airport. The concorde aircraft did cause more nesting gulls to leave their nests (especially in areas of higher density of nests), causing the breakage of eggs and the scavenging of eggs by intruder prey. Clutch sizes were observed to be smaller in areas of higher-density nesting (presumably due to the greater tendency for panic flight) than in areas where there were fewer nests.

A.3.8.3 Fish, Reptiles, and Amphibians

The effects of overflight noise on fish, reptiles, and amphibians have been poorly studied, but conclusions regarding their expected responses have involved speculation based upon known physiologies and behavioral traits of these taxa (Gladwin, et al. 1988). Although fish do startle in response to low-flying aircraft noise, and probably to the shadows of aircraft, they have been found to habituate to the sound and overflights.

Reptiles and amphibians that respond to low frequencies and those that respond to ground vibration, such as spadefoots (genus Scaphiopus), may be affected by noise. Limited information is available on the effects of short-duration noise events on reptiles. Dufour (1980) and Manci, et al. (1988), summarized a few studies of reptile responses to noise. Some reptile species tested under laboratory conditions experienced at least temporary threshold shifts or hearing loss after exposure to 95 dB for several minutes. Crocodilians in general have the most highly developed hearing of all reptiles. Crocodile ears have lids that can be closed when the animal goes under water. These lids can reduce the noise intensity by 10 to 12 dB (Wever and Vernon 1957). On Homestead Air Reserve Station, Florida, two crocodilians (the American Alligator and the Spectacled Caiman) reside in wetlands and canals along the base runway suggesting that they can coexist with existing noise levels of an active runway including DNLs of 85 dB.

A.3.8.4 Summary

Some physiological/behavioral responses such as increased hormonal production, increased heart rate, and reduction in milk production have been described in a small percentage of studies. A majority of the studies focusing on these types of effects have reported short-term or no effects.

The relationships between physiological effects and how species interact with their environments have not been thoroughly studied. Therefore, the larger ecological context issues regarding physiological effects of jet aircraft noise (if any) and resulting behavioral pattern changes are not well understood.

Animal species exhibit a wide variety of responses to noise. It is therefore difficult to generalize animal responses to noise disturbances or to draw inferences across species, as reactions to jet aircraft noise appear to be species-specific. Consequently, some animal species may be more sensitive than other species and/or may exhibit different forms or intensities of behavioral responses. For instance, wood ducks appear to be more sensitive and more resistant to acclimation to jet aircraft noise than Canada geese in one study. Similarly, wild ungulates seem to be more easily disturbed than domestic animals.

The literature does suggest that common responses include the “startle” or “fright” response and, ultimately, habituation. It has been reported that the intensities and durations of the startle response decrease with the numbers and frequencies of exposures, suggesting no long-term adverse effects. The majority of the literature suggests that domestic animal species (cows, horses, chickens) and wildlife species exhibit adaptation, acclimation, and habituation after repeated exposure to jet aircraft noise and sonic booms.

Animal responses to aircraft noise appear to be somewhat dependent on, or influenced by, the size, shape, speed, proximity (vertical and horizontal), engine noise, color, and flight profile of planes. Helicopters also appear to induce greater intensities and durations of disturbance behavior as compared to fixed-wing aircraft. Some studies showed that animals that had been previously exposed to jet aircraft noise exhibited greater degrees of alarm and disturbance to other objects creating noise, such as boats, people, and objects blowing across the landscape. Other factors influencing response to jet aircraft noise may include wind direction, speed, and local air turbulence; landscape structures (i.e., amount and type of vegetative cover); and, in the case of bird species, whether the animals are in the incubation / nesting phase.

A.3.9 Property Values

Property within a noise zone (or Accident Potential Zone) may be affected by the availability of federally guaranteed loans. According to U.S. Department of Housing and Urban Development (HUD), Federal Housing Administration (FHA), and Veterans Administration (VA) guidance, sites are acceptable for program assistance, subsidy, or insurance for housing in noise zones of less than 65 DNL, and sites are conditionally acceptable with special approvals and noise attenuation in the 65 to 75 DNL noise zone and the greater than 75 DNL noise zone. HUD's position is that noise is not the only determining factor for site acceptability, and properties should not be rejected only because of airport influences if there is evidence of acceptability within the market and if use of the dwelling is expected to continue. Similar to the Navy's and Air Force's Air Installation Compatible Use Zone Program, HUD, FHA, and VA recommend sound attenuation for housing in the higher noise zones and written disclosures to all prospective buyers or lessees of property within a noise zone (or Accident Potential Zone).

Newman and Beattie (1985) reviewed the literature to assess the effect of aircraft noise on property values. One paper by Nelson (1978), reviewed by Newman and Beattie, suggested a 1.8 to 2.3 percent decrease in property value per decibel at three separate airports, while at another period of time, they found only a 0.8 percent devaluation per decibel change in DNL. However, Nelson also noted a decline in noise depreciation over time which he theorized could be due to either noise sensitive people being replaced by less sensitive people or the increase in commercial value of the property near airports; both ideas were supported by Crowley (1978). Ultimately, Newman and Beattie summarized that while an effect of noise was observed, noise is only one of the many factors that is part of a decision to move close to, or away from, an airport, but which is sometimes considered an advantage due to increased opportunities for employment or ready access to the airport itself. With all the issues associated with determining property values, their reviews found that decreases in property values usually range from 0.5 to 2 percent per decibel increase of cumulative noise exposure.

More recently Fidell et al (1996) studied the influences of aircraft noise on actual sale prices of residential properties in the vicinity of two military facilities and found that equations developed for one area to predict residential sale prices in areas unaffected by aircraft noise worked equally well when applied to predicting sale prices of homes in areas with aircraft noise in excess of LDN 65dB. Thus, the model worked equally well in predicting sale prices in areas with and without aircraft noise exposure. This indicates that aircraft noise had no meaningful effect on residential property values. In some cases, the average sale prices of noise exposed properties were somewhat higher than those elsewhere in the same area. In the vicinity of Davis-Monthan AFB / Tucson, AZ, Fidell found the homes near the airbase were much older, smaller and in poorer condition than homes elsewhere. These factors caused the equations developed for predicting sale prices in areas further away from the base to be inapplicable with those nearer the base. However, again Fidell found that, similar to other researchers, differences in sale prices between homes with and without aircraft noise were frequently due to factors other than noise itself.

A.3.10 Noise Effects on Structures

Normally, the most sensitive components of a structure to airborne noise are the windows and, infrequently, the plastered walls and ceilings. An evaluation of the peak sound pressures impinging on the structure is normally used to determine the possibility of damage. In general, with peak sound levels above 130 dB, there is the possibility of the excitation of structural component resonances. 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 sound level of 130 dB are potentially damaging to structural components (Committee on Hearing, Bioacoustics, and Biomechanics 1977).

Noise-induced structural vibration may also cause annoyance to dwelling occupants because of induced secondary vibrations, or rattling of objects within the dwelling such as hanging pictures, dishes, plaques, and bric-a-brac. Window panes may also vibrate noticeably when exposed to high levels of airborne noise. In general, such noise-induced vibrations occur at peak sound levels of 110 dB or greater. Thus, assessments of noise exposure levels for compatible land use should also be protective of noise-induced secondary vibrations.

A.3.11 Noise Effects on Terrain

It has been suggested that noise levels associated with low-flying aircraft may affect the terrain under the flight path by disturbing fragile soil or snow, especially in mountainous areas, causing landslides or avalanches. There are no known instances of such effects, and it is considered improbable that such effects would result from routine, subsonic aircraft operations.

A.3.12 Noise Effects on Historical and Archaeological Sites

Because of the potential for increased fragility of structural components of historical buildings and other historical sites, aircraft noise may affect such sites more severely than newer, modern structures. Particularly in older structures, seemingly insignificant surface cracks initiated by vibrations from aircraft noise may lead to greater damage from natural forces (Hanson, et al. 1991). There are few scientific studies of such effects to provide guidance for their assessment.

One study involved the measurements of sound levels and structural vibration levels in a superbly restored plantation house, originally built in 1795, and now situated approximately 1,500 feet from the centerline at the departure end of Runway 19L at Washington Dulles International Airport. These measurements were made in connection with the proposed scheduled operation of the supersonic Concorde airplane at Dulles (Wesler 1977). There was special concern for the building's windows, since roughly half of the 324 panes were original. No instances of structural damage were found. Interestingly, despite the high levels of noise during Concorde takeoffs, the induced structural vibration levels were actually less than those induced by touring groups and vacuum cleaning.

As noted above for the noise effects of noise-induced vibrations of conventional structures, assessments of noise exposure levels for normally compatible land uses should also be protective of historic and archaeological sites.

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Appendix B

Land Use Compatibility Recommendations

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Table B-1
Land-Use Compatibility Recommendations

Land Use		Suggested Land Use Compatibility						
		Noise Zone 1 (DNL or CNEL)		Noise Zone 2 (DNL or CNEL)		Noise Zone 3 (DNL or CNEL)		
SLUCM No.	Land Use Name	<55	55-64	65-69	70-74	75-79	80-84	85+
10	**Residential**							
11	Household units	Y	Y[1]	N[1]	N[1]	N	N	N
11.11	Single units: detached	Y	Y[1]	N[1]	N[1]	N	N	N
11.12	Single units: semidetached	Y	Y[1]	N[1]	N[1]	N	N	N
11.13	Single units: attached row	Y	Y[1]	N[1]	N[1]	N	N	N
11.21	Two units: side-by-side	Y	Y[1]	N[1]	N[1]	N	N	N
11.22	Two units: one above the other	Y	Y[1]	N[1]	N[1]	N	N	N
11.31	Apartments: walk up	Y	Y[1]	N[1]	N[1]	N	N	N
11.32	Apartments: elevator	Y	Y[1]	N[1]	N[1]	N	N	N
12	Group quarters	Y	Y[1]	N[1]	N[1]	N	N	N
13	Residential hotels	Y	Y[1]	N[1]	N[1]	N	N	N
14	Mobile home parks or courts	Y	Y[1]	N	N	N	N	N
15	Transient lodgings	Y	Y[1]	N[1]	N[1]	N[1]	N	N
16	Other residential	Y	Y[1]	N[1]	N[1]	N	N	N
20	**Manufacturing**							
21	Food and kindred products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
22	Textile mill products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
23	Apparel and other finished products; products made from fabrics, leather and similar materials; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
24	Lumber and wood products (except furniture); manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
25	Furniture and fixtures; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
26	Paper and allied products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
27	Printing, publishing, and allied industries	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
28	Chemicals and allied products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
29	Petroleum refining and related industries	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
30	**Manufacturing (continued)**							
31	Rubber and misc. plastic products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
32	Stone, clay, and glass products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
33	Primary metal products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
34	Fabricated metal products; manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks	Y	Y	Y	25	30	N	N
39	Miscellaneous manufacturing	Y	Y	Y	Y[2]	Y[3]	Y[4]	N

Table B-1
Land-Use Compatibility Recommendations

Land Use		Suggested Land Use Compatibility						
		Noise Zone 1 (DNL or CNEL)		Noise Zone 2 (DNL or CNEL)		Noise Zone 3 (DNL or CNEL)		
SLUCM No.	Land Use Name	<55	55-64	65-69	70-74	75-79	80-84	85+
40	**Transportation, communication and utilities**							
41	Railroad, rapid rail transit, and street railway transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
42	Motor vehicle transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
43	Aircraft transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
44	Marine craft transportation	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
45	Highway and street right-of-way	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
46	Automobile parking	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
47	Communication	Y	Y	Y	25 [5]	30 [5]	N	N
48	Utilities	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
49	Other transportation, communication, and utilities	Y	Y	Y	25 [5]	30 [5]	N	N
50	**Trade**							
51	Wholesale trade	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
52	Retail trade – building materials, hardware, and farm equipment	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
53	Retail trade – shopping centers	Y	Y	Y	25	30	N	N
54	Retail trade – food	Y	Y	Y	25	30	N	N
55	Retail trade – automotive, marine craft, aircraft and accessories	Y	Y	Y	25	30	N	N
56	Retail trade – apparel and accessories	Y	Y	Y	25	30	N	N
57	Retail trade – furniture, home furnishings and equipment	Y	Y	Y	25	30	N	N
58	Retail trade – eating and drinking establishments	Y	Y	Y	25	30	N	N
59	Other retail trade	Y	Y	Y	25	30	N	N
60	**Services**							
61	Finance, insurance and real estate services	Y	Y	Y	25	30	N	N
62	Personal services	Y	Y	Y	25	30	N	N
62.4	Cemeteries	Y	Y	Y	Y[2]	Y[3]	Y[4,11]	Y[6,11]
63	Business services	Y	Y	Y	25	30	N	N
63.7	Warehousing and storage	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
64	Repair services	Y	Y	Y	Y[2]	Y[3]	Y[4]	N
65	Professional services	Y	Y	Y	25	30	N	N
65.1	Hospitals, other medical fac.	Y	Y[1]	25	30	N	N	N
65.16	Nursing homes	Y	Y	N[1]	N[1]	N	N	N
66	Contract construction services	Y	Y	Y	25	30	N	N
67	Governmental services	Y	Y[1]	Y[1]	25	30	N	N
68	Educational services	Y	Y[1]	25	30	N	N	N
69	Miscellaneous	Y	Y	Y	25	30	N	N
70	**Cultural, entertainment and recreational**							
71	Cultural activities (& churches)	Y	Y[1]	25	30	N	N	N
71.2	Nature exhibits	Y	Y[1]	Y[1]	N	N	N	N
72	Public assembly	Y	Y[1]	Y	N	N	N	N
72.1	Auditoriums, concert halls	Y	Y	25	30	N	N	N
72.11	Outdoor music shells, amphitheaters	Y	Y[1]	N	N	N	N	N

Table B-1
Land-Use Compatibility Recommendations

Land Use		Suggested Land Use Compatibility						
		Noise Zone 1 (DNL or CNEL)		Noise Zone 2 (DNL or CNEL)		Noise Zone 3 (DNL or CNEL)		
SLUCM No.	Land Use Name	<55	55-64	65-69	70-74	75-79	80-84	85+
72.2	Outdoor sports arenas, spectator sports	Y	Y	Y[7]	Y[7]	N	N	N
73	Amusements	Y	Y	Y	Y	N	N	N
74	Recreational activities (including golf courses, riding stables, water rec.)	Y	Y[1]	Y[1]	25	30	N	N
75	Resorts and group camps	Y	Y[1]	Y[1]	Y[1]	N	N	N
76	Parks	Y	Y[1]	Y[1]	Y[1]	N	N	N
79	Other cultural, entertainment and recreation	Y	Y[1]	Y[1]	Y[1]	N	N	N
80	**Resource production and extraction**							
81	Agriculture (except livestock)	Y	Y	Y[8]	Y[9]	Y[10]	Y[10,11]	Y[10,11]
81.5	Livestock farming	Y	Y	Y[8]	Y[9]	N	N	N
81.7	Animal breeding	Y	Y	Y[8]	Y[9]	N	N	N
82	Agricultural related activities	Y	Y	Y[8]	Y[9]	Y[10]	Y[10,11]	Y[10,11]
83	Forestry activities	Y	Y	Y[8]	Y[9]	Y[10]	Y[10,11]	Y[10,11]
84	Fishing activities	Y	Y	Y	Y	Y	Y	Y
85	Mining activities	Y	Y	Y	Y	Y	Y	Y
89	Other resource production or extraction	Y	Y	Y	Y	Y	Y	Y

Table B-2
Air Installations Compatible Use Zones
Suggested Land Use Compatibility in Accident Potential Zones[1]

SLUCM No.	Land Use Name	Recommendations			
		CLEAR ZONE	APZ-I	APZ-II	Density
10	**Residential**				
11	Household units				
11.11	Single units: detached	N	N	Y[2]	Max density of 1-2 Du/Ac
11.12	Single units: semidetached	N	N	N	
11.13	Single units: attached row	N	N	N	
11.21	Two units: side-by-side	N	N	N	
11.22	Two units: one above the other	N	N	N	
11.31	Apartments: walk up	N	N	N	
11.32	Apartments: elevator	N	N	N	
12	Group quarters	N	N	N	
13	Residential hotels	N	N	N	
14	Mobile home parks or courts	N	N	N	
15	Transient lodgings	N	N	N	
16	Other residential	N	N	N	
20	**Manufacturing[3]**				
21	Food and kindred products; manufacturing	N	N	Y	Max FAR 0.56 in APZ II
22	Textile mill products; manufacturing	N	N	Y	same as above
23	Apparel and other finished products; products made from fabrics, leather and similar materials; manufacturing	N	N	N	
24	Lumber and wood products (except furniture); manufacturing	N	Y	Y	Max FAR of 0.28 in APZ I & 0.56 in APZ II
25	Furniture and fixtures; manufacturing	N	Y	Y	same as above
26	Paper and allied products; manufacturing	N	Y	Y	same as above
27	Printing, publishing, and allied industries	N	Y	Y	same as above
28	Chemicals and allied products; manufacturing	N	N	N	
29	Petroleum refining and related industries	N	N	N	
30	**Manufacturing[3] (continued)**				
31	Rubber and misc. plastic products; manufacturing	N	N	N	
32	Stone, clay, and glass products; manufacturing	N	N	Y	Max FAR 0.56 in APZ II
33	Primary metal products; manufacturing	N	N	Y	same as above
34	Fabricated metal products; manufacturing	N	N	Y	same as above
35	Professional, scientific, and controlling instruments; photographic and optical goods; watches and clocks	N	N	N	
39	Miscellaneous manufacturing	N	Y	Y	Max FAR of 0.28 in APZ I & 0.56 in APZ II
40	**Transportation, communication and utilities [4,5]**				
41	Railroad, rapid rail transit, and street railway transportation	N	Y[5]	Y	same as above
42	Motor vehicle transportation	N	Y[5]	Y	same as above
43	Aircraft transportation	N	Y[5]	Y	same as above
44	Marine craft transportation	N	Y[5]	Y	same as above
45	Highway and street right-of-way	N	Y[5]	Y	same as above
46	Auto parking	N	Y[5]	Y	same as above
47	Communication	N	Y[5]	Y	same as above
48	Utilities	N	Y[5]	Y	same as above

Table B-2
Air Installations Compatible Use Zones
Suggested Land Use Compatibility in Accident Potential Zones[1]

SLUCM No.	Land Use Name	Recommendations			
		CLEAR ZONE	APZ-I	APZ-II	Density
48.5	Solid Waste disposal (Landfills, incineration, etc.)	N	N	N	
49	Other transportation, comm., and utilities	N	Y[5]	Y	See Note 5
50	***Trade***				
51	Wholesale trade	N	Y	Y	Max FAR of 0.28 in APZ I & 0.56 in APZ II
52	Retail trade – building materials, hardware, and farm equipment	N	Y	Y	See Note 6
53	Retail trade[7] – shopping centers, Home Improvement Store, Discount Club, Electronics Superstore	N	N	Y	Max FAR of 0.16 in APZ II
54	Retail trade – food	N	N	Y	Max FAR of 0.24 in APZ II
55	Retail trade – automotive, marine craft, aircraft and accessories	N	Y	Y	Max FAR of 0.14 in APZ I & 0.28 in APZ II
56	Retail trade – apparel and accessories	N	N	Y	Max FAR of 0.28 in APZ II
57	Retail trade – furniture, home furnishings and equipment	N	N	Y	same as above
58	Retail trade – eating and drinking establishments	N	N	N	
59	Other retail trade	N	N	Y	Max FAR of 0.16 in APZ II
60	**Services[8]**				
61	Finance, insurance and real estate services	N	N	Y	Max FAR of 0.22 for "General Office/ Office park" in APZ II
62	Personal services	N	N	Y	Office uses only. Max FAR of 0.22 in APZ II.
62.4	Cemeteries	N	Y[9]	Y[9]	
63	Business services (credit reporting; mail, stenographic reproduction; advertising)	N	N	Y	Max FAR of 0.22 in APZ II
63.7	Warehousing and storage services	N	Y	Y	Max FAR of 1.0 in APZ I; 2.0 in APZ II
64	Repair Services	N	Y	Y	Max FAR of 0.11 in APZ I; 0.22 in APZ II
65	Professional services	N	N	Y	Max FAR of 0.22 in APZ II
65.1	Hospitals, nursing homes	N	N	N	
65.1	Other medical facilities	N	N	N	
66	Contract construction services	N	Y	Y	Max FAR of 0.11 in APZ I; 0.22 in APZ II
67	Governmental services	N	N	Y	Max FAR of 0.24 in APZ II
68	Educational services	N	N	N	
69	Miscellaneous	N	N	Y	Max FAR of 0.22 in APZ II
70	**Cultural, entertainment and recreational**				
71	Cultural activities	N	N	N	
71.2	Nature exhibits	N	Y[10]	Y[10]	
72	Public assembly	N	N	N	
72.1	Auditoriums, concert halls	N	N	N	
72.11	Outdoor music shells, amphitheaters	N	N	N	
72.2	Outdoor sports arenas, spectator sports	N	N	N	
73	Amusements- fairgrounds, miniature golf, driving ranges; amusement parks, etc.	N	N	Y	
74	Recreational activities (including golf courses, riding stables, water recreation)	N	Y[10]	Y[10]	Max FAR of 0.11 in APZ I; 0.22 in APZ II
75	Resorts and group camps	N	N	N	
76	Parks	N	Y[10]	Y[10]	same as 74

Table B-2
Air Installations Compatible Use Zones
Suggested Land Use Compatibility in Accident Potential Zones[1]

SLUCM No.	Land Use Name	Recommendations			
		CLEAR ZONE	APZ-I	APZ-II	Density
79	Other cultural, entertainment and recreation	N	Y[9]	Y[9]	same as 74
80	**Resource production and extraction**				
81	Agriculture (except livestock)	Y[4]	Y[11]	Y[11]	
81.5, 81.7	Livestock farming and breeding	N	Y[11,12]	Y[11,12]	
82	Agricultural related activities	N	Y[11]	Y[11]	Max FAR of 0.28 in APZ I; 0.56 in APZ II no activity which produces smoke, glare, or involves explosives
83	Forestry activities[13]	N	Y	Y	same as above
84	Fishing activities[14]	N[14]	Y	Y	same as above
85	Mining activities	N	Y	Y	same as above
89	Other resource production or extraction	N	Y	Y	same as above
90	**Other**				
91	Undeveloped Land	Y	Y	Y	
93	Water Areas	N[15]	N[15]	N[15]	

Source: Adapted from OPNAVINST 11010.36C

Key:
SLUCM = Standard Land Use Coding Manual, U.S. Department of Transportation
Y (Yes) = Land use and related structures are normally compatible without restrictions.
N (No) = Land use and related structures are not normally compatible and should be prohibited.

Yx – (Yes with restrictions) = The land use and related structures are generally compatible. However, see notes indicated by the superscript.
Nx – (No with exceptions) = The land use and related structures are generally incompatible. However, see notes indicated by the superscript.
FAR – Floor Area Ratio = A Floor area ratio is the ratio between the square feet of floor area of the building and the site area. It is customarily used to measure non-residential intensities.

Du/Ac- Dwelling Units per Acre = This metric is customarily used to measure residential densities.

Notes:

1 A "Yes" or a "No" designation for compatible land use is to be used only for general comparison. Within each, uses exist where further evaluation may be needed in each category as to whether it is clearly compatible, normally compatible, or not compatible due to the variation of densities of people and structures. In order to assist installations and local governments, general suggestions as to FARs are provided as a guide to densities in some categories. In general, land-use restrictions which limit commercial, services, or industrial buildings or structure occupants to 25 per acre in APZ I and 50 per acre in APZ II are the range of occupancy levels, including employees, considered to be low density. Outside events should normally be limited to assemblies of not more than 25 people per acre in APZ I, and Maximum (MAX) assemblies of 50 people per acre in APZ II.

2 The suggested maximum density for detached single-family housing is one to two Du/Ac. In a Planned Unit Development (PUD) of single-family detached units where clustered housing development results in large open areas, this density could possibly be increased provided the amount of surface area covered by structures does not exceed 20 percent of the PUD total area. PUD encourages clustered development that leaves large open areas.

3 Other factors to be considered: Labor intensity, structural coverage, explosive characteristics, air pollution, electronic interference with aircraft, height of structures, and potential glare to pilots.

4 No structures (except airfield lighting), buildings or aboveground utility/communications lines should normally be located in the clear zone areas on or off the installation. The clear zone is subject to severe restrictions. See UFC 3-260-01, "Airfield and Heliport Planning and Design" dated 10 November 2001 for specific design details.

5 No passenger terminals and no major aboveground transmission lines in APZ I.

6 Within SLUCM Code 52, Max FARs for lumber yards (SLUCM Code 521) are 0.20 in APZ-1 and 0.40 in APZ-II. For hardware/paint and farm equipment stores, SLUCM Code 525, the Max FARs are 0.12 in APZ-1 and 0.24 in APZ-II.

7 A shopping center is an integrated group of commercial establishments that is planned, developed, owned, or managed as a unit. Shopping center types include strip, neighborhood, community, regional, and super regional facilities anchored by small businesses, supermarket or drug store, discount retailer, department store, or several department stores, respectively. Included in this category are such uses as big box discount and electronics superstores. The Max recommended FAR for SLUCM 53 should be applied to the gross leasable area of the shopping center rather then attempting to use other recommended FARs listed in Table 2 under "Retail" or "Trade."

8 Low intensity office uses only. Accessory use such as meeting places, auditoriums, etc., are not recommended.

9 No chapels are allowed within APZ I or APZ II.

10 Facilities must be low intensity and provide no tot lots, etc. Facilities such as clubhouses, meeting places, auditoriums, large classes, etc., are not recommended.

Table B-2
Air Installations Compatible Use Zones
Suggested Land Use Compatibility in Accident Potential Zones[1]

SLUCM No.	Land Use Name	Recommendations			
		CLEAR ZONE	APZ-I	APZ-II	Density

[11] Includes livestock grazing but excludes feedlots and intensive animal husbandry. Activities that attract concentrations of birds creating a hazard to aircraft operations should be excluded.
[12] Includes feedlots and intensive animal husbandry.
[13] Lumber and timber products removed due to establishment, expansion, or maintenance of clear zones will be disposed of in accordance with appropriate DoD Natural Resources instructions.
[14] Controlled hunting and fishing may be permitted for the purpose of wildlife management.
[15] Naturally occurring water features (e.g., rivers, lakes, streams, wetlands) are compatible.

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